"The Management of Nuclear Waste By Major Trans-Atlantic Allies"

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CERTIFICATE

The dissertation entitled "MANAGEMENT OF NUCLEAR WASTES BY MAJOR TRANS-ATLANTIC ALLIES", submitted by Abhijit Mohanty, Centre for American and West European Studies, Jawaharlal Nehru University New Delhi, for the award of degree of Master of Philosophy, is an original work and has not been submitted so far, in part or full, for any other degree or diploma of any university. This may be placed before the examinrs for evaluation for the award of Master of Philosophy.

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C O N T E N T S

LIST OF ANNEXTURES

PREFACE

Nuclear waste is nasty stuff. The inevitable by product of all atomic-power plants, it remains radioactive for up to 3 million years. The U.S. Congress believed it had conquered the problem of where to put such waste when in 1987 it ordered the Department of Energy to focus on building a national dump site in Nevada. By 2003, the government promised, spent fuel from the country's 110 commercial nuclear reactors could be easily and safely buried deep within Yucca Mountain, an isolated peak about 100 miles northwest of Las Vegas. But that forecast, like an earlier one predicting a national dump site by 1998, proved too rosy. Recently week energy officials pushed back the opening to at least 2010.

The radioactive waste management programme originated as a by-product of the wartime effort to develop the atomic bomb. Nuclear reactors, constructed at the Hanford Reservation near Richland, Washington, produced plutonium, which was then extracted from the spent fuel in on-site facilities. Reprocessing produced large volumes of radioactive waste, but under the pressure of the war effort, there existed neither the time, the money, nor the inclination to deal with the problem on anything but an interim basis. Furthermore, the technical ability to dispose of the wastes safely did not then exist, and so the wastes were neutralized and placed in temporary storage tanks.

These wastes are still in temporary storage. Because high level wastes are so radioactive, so hazardous, and hence so visible, repeated leaks of waste and the failure to develop disposal technologies have capitured much attention. To be sure, future problems will not be identical to those of the past. Current handling of the wastes has improved considerably over past practices, but the problems of developing a suitable disposal technology are still formidable, are not yet solved, and may well lead to failures.

To the reader unfamiliar with the history of the waste management programme, it might seem odd that radioactive wastes are the cause of so much controversy. To be sure, the materials can be dangerous if improperly handled, but safe management of these wastes would not appear superficially to be an insurmountable problem. Unfortunately, what is possible in theory is not always realized in practice. To a great extent, the history of radioactive waste management supports this. In the past, the technologies necessary for safe management of these wastes were implemented poorly or not at all. The institutions responsible for waste management were generally at fault, proving unequal to the requirements of the task. Institutional actions often tended to exacerbate, rather than resolve, problems. In the excitement of the developing Atomic Age, there was little interest in the mundane problem of radioactive waste. The results were carelessness, mistakes, inflated claims, and unfulfilled promises on the part of the agencies in charge of the waste management programme as well as repeated leaks of radioactivity into the environment.

Chapter one of this work deals with the fundamentals of radioactivity and it tends to explain and question, at the same time, the enormity of a invisible, odourless, tasteless substance which has or is daily in the process of creating misery throughout the world.

Chapter two deals with the classification of wastes, its generation, storage and disposal facilities, its effect on the socio-political-environmental - technological and organisational dimensions and the best suitable candidates for storage of wastes.

Chapter three deals exclusively on how America is coping up with this problem and what different governmental bodies are doing to solve this problem.

Chapter four deals with the European states e.g. U.K., France, Germany, Sweden and Belgium and how they are coping up with this multifaceted problem.

Although an enormous quantity of information dealing with the radioactive waste question is available, most of it is quire technical or scattered throughout the general scientific literature. The last chapter, therefore attempts to evaluate the necessary technical, political and social information needed to gain our understanding of the complexities of the nuclear waste management problem.

Radioactive Waste Disposal Concept

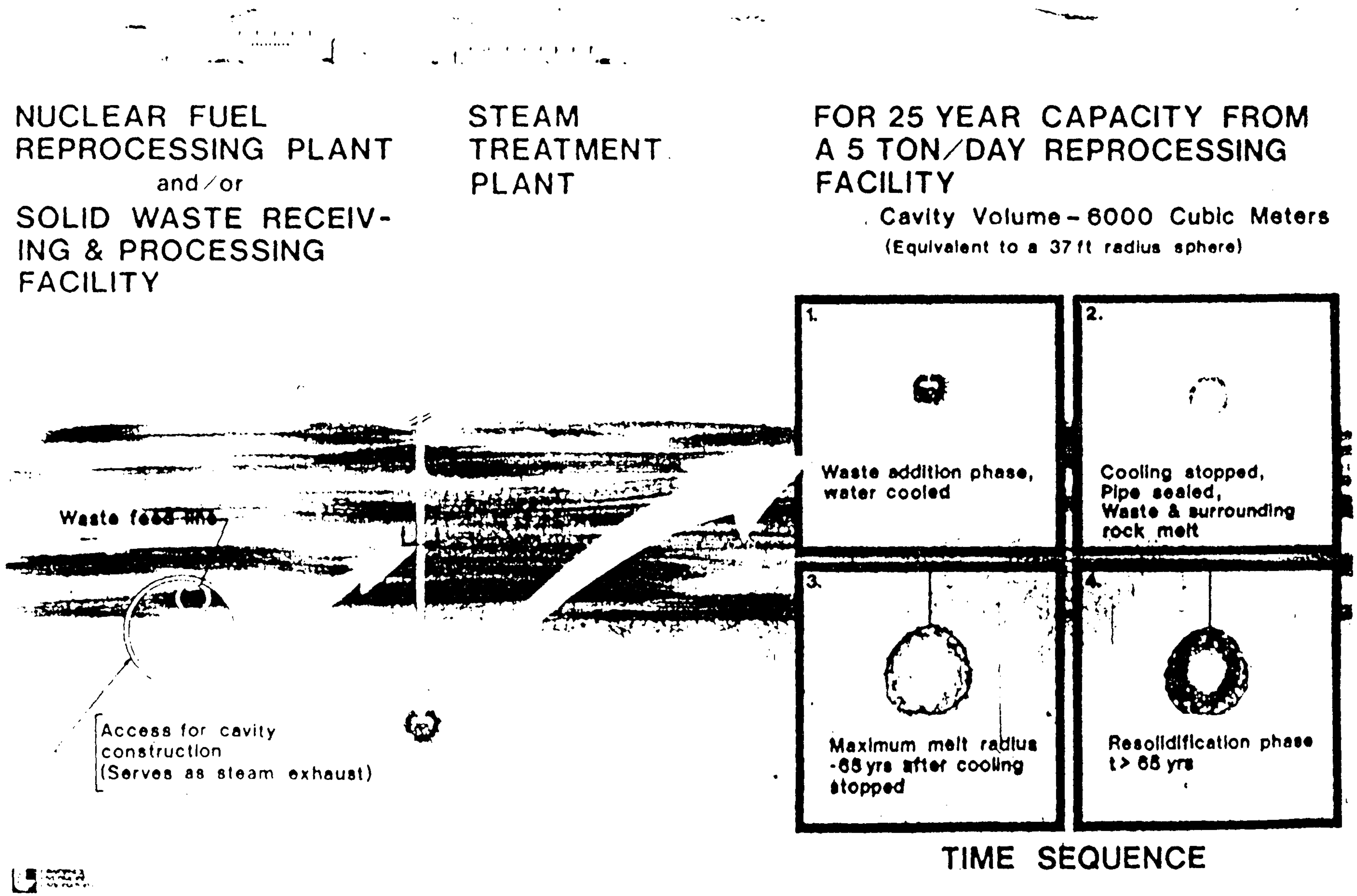

Figure oo   Rock-melting Disposal of High Level Liquid Wastes.

The Devil: "I have examined Man's wonderful inventions. And I tell you that in the arts of life man invents nothing : but in the arts of death he outdoes Nature herself, and produces by chemistry and machinery all the slaughter of plague, pestilence, and famine. The peasant I tempt today eats and drinks what was eaten and drunk ten thousand years ago : and the house he lives in has not altered as much in a thousand centuries as the fashion of a lady's bonnet in a score of weeks. But when he goes to stay, he carries a marvel of mechanism that lets loose at the touch of his finger all the hidden molecular energies, and leaves the javelin, the arrow, the blowpipe of his fathers far behind. In the arts of peace Man is a burglar......his heart is in his weapons - Act III, Man and Superman,

George Bernard Shaw.

(One aspect of nuclear weapons is the creation of waste)

INTRODUCTION

The leadership and direction of organized activities are rooted in the distant part of virtually every civilization. Modern Management concepts are a direct derivation of the Industrial Revolution.

The beginning and progress of industrial revolution is found at that period in time also resulted in mass exploitation of natural resources.[1] That was followed by an intensive application of machinery for the transformation of the natural resources from their natural state into the ultimate consumer product which W.W.Rostow calls "the age of high mass consumption".[2]

Then came the two world wars. Research at that time demonstrated both the explosive potential of the atom bomb and the feasibility of power/energy generation from controlled reactions in the atomic file. This association of the military and peaceful facets of "atom splitting", together with the highlighting of the hazards of the radioactive fragments, gave rise to an acute concern

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1. Arthur W.Gutenberg and Eugene Richman : Dynamics of Management,(Pennsylvania,1968) P.3.
2. W.W.Rostow:The stages of Economic Growth:A Non - communist Manifesto, (London,1969) p.1

for safety in the development of nuclear power. The result has been as unprecedented effort on safety issues and studies and a low accident record unmatched in any other modern industry.[3]

Over the last fifty years research and development has continued to resolve the technical problems which somewhat delaying the early promise of cheap, abundant nuclear power. Today, as the promise is becoming reality, safety research has evolved. As power stations have come into operation around the world, public awareness of the potential hazards of the reactor has increased and fear of possible accident consequences has generated vigorous reactions from those concerned with conservation of the environment.[4] In the heat of public debate many of the conclusions have been distorted by arguments based on questionable interpretations or selection of data.

"One of the many issues that fuels the nuclear debate, none appears more unsettling and of so much concern to the public as the problem of radioactive waste management",[5] says Woolsey.

A study of the problem of nuclear waste management warrants a discussion of problem and

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3. Leonard Beaton and John Maddox; The Spread Of Nuclear Weapons,(London,1962). pp 77 - 83.

4. F.R.Farmer (ed); Nuclear Reactor Safety :(New York,1979) p 1

5. James R.Woolsey(ed): Nuclear Arms; Ethics,Strategy and politics, (San Francisco, 1984) p 92

dimensions of radioactivity; what is it, how is it produced, why it is a health hazard and how dangerous it is. The hazard of radioactive emissions arises primarily from their energetic nature. Unlike the more mundane chemical industry associated with the burning of coal or oil, nuclear power exploits the very energies that binds the atomic nucleus. The splitting of atoms, which takes place in the heart of the nuclear reactor, also causes unstable energy balances in the fragments of the split atoms. Radio activity is a process by which energetic stability is restored. Radioactive emissions, are ejected from atomic nuclei, carrying away this excessive energy. These emissions are able to penetrate matter, and it is this property that makes them biologically unsafe. Unlike many chemical toxins that can be neutralized, the hazard of radioactivity only disappears through natural decay, which may take hundreds, thousands, even millions of years.[6]

The biological hazards posed by radioactivity depend on the nature and extent of exposure to its emissions. Exposure may occur from medical radiation, routine or accidental release of radioactivity from nuclear facilities, nuclear weapons testing fall out, or handling of radioactive materials for research and industrial purposes.[7]

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6 H.P.Metzer: The Atomic Establishment,(New York,1972) p 21

7. The Encyclopedia Americana Vol.23(International Edition) p 181 - 86

That hazards do not exist is open to question but then magnitude and the biological effects - especially at low exposure levels - are the subject of fierce controversy. Studies of radiation exposed animal populations are numerous and have provided much useful information in this regard. However, for obvious reasons, no rigidly controlled studies of radiation - exposed human populations have ever been conducted,[8] Instead, assessments of biological effects to humans have depended upon data from incidents of exposure arising out of intent, accident or ignorance for example, "Survivors of the atomic bombings of Hiroshima and Nagasaki " or "radium dial painters who unknowingly ingested lethal quantities of radium".

Theoritical Premise on Radioactivity

RADIOACTIVE DECAY : There are 105 naturally accuring elements and several hundred naturally occurring isotopes.[9]

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8. James R.Temples : The Politics of Nuclear Power: A Subgovernment in Transition, Political Science Quarterly, Vol 95, 1980. p 239 - 41.

9. Frank Barnaby and Geoffrey Thomas(ed):The Nuclear Arms Race-Control or Catastrophe? (London,1982)p25

However, there also exist artificial elements and isotopes created in nuclear research reactors and particle accelerators. Fourteen artificial elements and many hundred of artificial isotopes have been discovered this way.

All the matter that makes up the universe is composed of atoms. Not all atoms are alike, however, they differ by virtue of the number of neutrons and protons that make up their nuclei. An atom of hydrogen, for example contains a single proton while an atom of iron may contain twenty six protons and thirty neutrons. All atoms of the same element contain an identical number of protons; they do not all contain the same number of neutrons. Atoms of the same element with different numbers of neutrons are called "isotopes"[10] Uranium, for example, has two common isotopes. Uranium 235 and Uranium 238. Both isotopes have 92 protons, but the former has 143 while the latter has 146 neutrons.

Most of the naturally occuring isotopes are stable - that is, they have no tendency to break up into smaller atoms. But if a large number of neutrons are added to the neutrons of a stable atom, the energy balance between the nuclear protons and neutrons will become uneven, and particles may be expelled from the nucleus in order to restablize the

10. _Collier's Encyclopedia_ (New York, 1933) Vol 19 P 607.

energy balance. For example, an atom of Plutonium - 238, may expel an alpha particle, which consists of two protons and two neutrons. The nucleus will have two fewer protons and two fewer neutrons and will thus be an atom of uranium 235, a naturally occuring uranium isotope. A lighter unstable atom such as Cesium 137 may emit a beta particle, which is an electron, and thus become an atom of barium - 137 m. This happens because a neutron can spontaneously convert a proton, an electron and a massless neutrino. The electron and neutrino will leave nucleus, and the proton will be left behind. Thus, a new element results. This phenomenon of particle emission is called "radio activity" and the radiation is through alpha, beta and gamma rays.

PROPERTIES OF RADIATION

Radioactivity poses a special hazard to living things because of its peculiar nature. Radioactive emissions, or radiation, are able to penetrate matter and inter act with its chemical structure. In living tissue, radioactive emissions can strip electrons from their orbits around atomic nuclei. As a result these atoms become charged or ionized, and may combine with other atoms or molecules to form abnormal chemical complexes.[11] Or, x-rays may be

11. Joseph A,Camilleri, The State and Nuclear Power-Conflict and Control in Western World (New Delhi, 1984) pp 79-81

produced that can also cause atomic ionization. In some instances, the passage of a single particle may kill many cells. Radiation also disrupts molecular bonds, causing decomposition of or damage to complex molecules such as DNA. These interactions can cause a host of effects damage to or death of exposed cells, cell mutuation, induction of cancer and injury to or even death of the exposed organism.

NUCLEAR FISSION :

Nuclear Fission is another kind of radioactivity the spilitting of special nuclei - certain isotopes of uranium and Plutonium - into two parts of nearly equal mass. However, unlike the radioactive decay, fission rarely occurs spontaneously. It can, however be induced by neutrons. When atoms of certain natural and man made elements, such as Uranium - 233 or 235 or Plutonium - 239 are struck by neutrons, they may split, into two smaller nuclei or "fission products". These are highly radioactive.

Different radioactive elements, or "radionuclides" decay at different rates. A measure of this decay rate is the "half life" - that is, that period during which half the radioactive atoms present in a sample decay.

MEASURING RADIOACTIVITY :

A unit of radioactivity is called curie; a direct measure of the radioactive disintegration rate of a particular sample of material. One curie is equal to 37 - billion radioactive disintegrations per second, the equivalent of decay rate of 1 gm of pure radium. Amounts of radioactivity much less than a curie can be biologically important and hence the micro curie or one millionth of a curie - "nano curie".

WHAT DOES RADIATION DO ?

The effects of radiation upon living things have been extensively researched upon, and a large body of technical literature exists that documents a wide range of harmful consequences. Among these are cancer, reproductive failure, genetic defects, birth abnormalities and cell death. The precise effects of radiation exposure depend upon a number of factors - dose, dose rate, type of radiation, mode of exposure and age health of the individual, among others.[12]

HOW IS EXPOSURE MEASURED

Exposure to radiation is generally expressed in terms of two quantities - rads and rems.

12. Jonathan Alford :The Impact of New Military Technology. (London, 1981) p 14.

A rad is a measure of radiation transfer.[13] It is the quantity of energy carried by a ratio active emission that is absorbed in an irradiated material. A 'rem' - which stands for the "roentgen equivalent man"is a unit of radiation based on the rad that incorporates a measure of biological consequences. A rem is equal to the radiation dosage in rads multiplied by a factor called the "relative biological effectiveness" of the ionizing radiation. Total radiation exposure is generally expressed in thousands of a rem, or "millirems". The rate of exposure is normally expressed as "millirems per hour, day or year" or "rems per lifetime.[14]

HOW MUCH RADIATION ARE WE EXPOSED TO ?

On an average, we annually receive approximately one-tenth rad, or 100 millirad of radiation, from all external sources, although this value varies, depending on the geographic and topographic parameters. In some regions, residents may annually receive only 70 millirads, but in others, radiation doses may be as high as 200 millirads. "The principal single contribution to our radiation exposure is natural background radiation, which accounts for one half of the total.

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13. Encyclopaedia Britannica, Vol 18, (London,1950) pp 887-888
14. V.Brodine : Radioactive Contamination, (New York, 1975) pp 3-10.

The next largest sources of radiation is medical procedures which contribute 42% ; the manufacture and testing of nuclear weapons for 3.5% ; mining and burning of coal 3%, and the entire nuclear power process, including mining, fuel preparation, and waste disposal, contributes to less than 1% of the total radiation present in our current environment.

On 6 Aug, 1945, a 15 kilo-ton bomb ignited the centre of the Japanese city Hiroshima, flattening it and killing more than 100,000 people. Just three days later, a second bomb exploded over the city of Nagasaki resulting in the death of another 70,000. For months after the attack survivors developed symptoms that puzzled doctors; blood cell abnormalities, high fever, chronic fatigue, diarohhea, vomiting and depression. Physicians began to term these symptoms as "radiation sickness".

Another generation has now passed and five nations, besides the United States have developed and tested atomic weapons and nineteen nations have installed nuclear electric power generating facilities. "It has yet to be decided, whether the atom will ripen to Man's doom or become his obedient, tireless servant. That fate, moreover, depends not only on whether the nations of the world can avoid nuclear war, but also on whether nuclear power plants prove to be safe and whether safe procedures can be developed to handle and eventually dispose off, the radioactive waste products of issue, daily from the world's nuclear arms and nuclear power industries"[16] and reactors.

The nuclear power and weapons programmes of the major nuclear powers have generated immense quantities of nuclear waste and there is the prospect in a continuing programme of much more.

Since the early 1940's the nuclear waste management programme has been marked by numerous accidental release of radioactive materials into the environment, coupled with irresponsibility, false claims and carelessness".

"As Alvin Weinberg, one of the founders of nuclear technology and the past Director of the Atomic Energy Commission, summed it up," We seem to have struck a Faustian bargain. We are given the miraculous nuclear fire ....as a means of producing very clear and.....in exhaustible energy. The price that we must pay this great boon is a vigilance that in many ways trancends what we have

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15. Dr. Elizabeth Whelan - Toxic Terror (Illinois, 1985) p 233
16. Charles-A-Walker, Leroy C.Gould, Edward.J.Woodhouse (ed) : To Hot to Handle?Social and Policy Issues in the Management of Radioactive Wastes (New Haven, 1983) p IX.

we have even had to maintain : Vigilance and care in operating these devices, and creation, and continuation into eternity, of a cadre or priesthood who understand the nuclear systems and who are prepared to guard the wastes"[17]

Large quantities of highly radioactive wastes have accumulated in the past thirty years as a by product of commercial production of nuclear weapons. Wastes from commercial power plants include more than eight thousand tons of highly radioactive spent fuel assemblies stored in water-cooled basins at reactor-sites and many tons of less radioactive uranium mill tailings, contaminated equipment, discarded clothing, and other materials that have been buried in shallow earth repositories.[18]

The paramount requirement of any successful radioactive waste management programme is the protection of health and safety of this and the future generation. Many schemes have been proposed to effect the long term isolation of waste necessary to fulfill this requirement. Research into the more promising proposal is currently underway, but none of these disposal technologies will come to fruition before 1995 and perhaps not even during this century.

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17. ibid pp ix - x
18. David-A Deese:<u>Nuclear Power and Radioactive Waste</u>,(Lexington, Mass, 1978) pp 37 - 45

Until then, radioactive waste will continue to accumulate. They have already piled up in considerable quantities 10 million cubic feet of highly radioactive liquids, 4000 tons uranium mill tailings, 65 million cubic feet of contaminated garbage.

Responsibility for vigilance and case in nuclear matters has rested, in the past, almost exclusively with the military, the utility industry and those government bodies that license and regulate nuclear power producers and military programmes.

Increasingly,however, owing in part to a general public have come to question the management of nuclear industry and to demand a more direct voice in deciding the issue of nuclear safety.

Until adequate disposal technology is developed, the waste will continue to be stored tanks spent fuel pools, barrels, boxes, trenches and uncovered piles - all temporary and prove to failure. Many facilities and containers have already failed. That we are now dependent on inadequate and unreliable means of storage strongly underlive the need for timely hazards of extended storage of intensely radioactive materials on the earth's surface are great (as in Yucca Mountain, United

States) There the wastes are subject to the actions of both nature and man that could cause their widespread dispersion. Indefinite dependence upon surface storage could require human guardianship for hundred and thousand of years...............and there is no guarantee that this can be accomplished. programme.

NUCLEAR POWER FORECASTS - INTERNATIONAL

Nuclear Generating Capacity Outside the United States

	1980			1981		1985		1990		1995		2000	
	Net MWs installed	% of capacity	% of Generation	Net MWs installed	% of capacity	Net MWs installed	% of capacity	Net MWs installed	% of capacity	Net MWs installed	% of capacity	Net MWs installed	% of capacity
Belgium	1,667	15.0	23.3	1,667	14.9	5,427	38.0	na	na	na	na	na	na
France	14,400	23.0	24.0	21,930	31.0	38,200	43.0	58,000	54.0	na	na	na	85.0
Germany Federal Rebuclic of	8,625	12.0	14.3	9,850	10.0	17,700	na	26,704	na	na	na	na	50.0
Sweden	4,600	16.8	27.0	4,600	na	8,380	26.3	9,430	28.2	na	na	na	na
United Kingdom	6,457	9.0	12.0	6,457	9.4	9,835	na	10,311	na	na	na	na	na

Fig. 1-1

I regard it (management of nuclear

waste) as scientific nonsense.

— Richard Doll.

INTRICACIES OF THE WASTE MANAGEMENT PROBLEM

Just as most activities involve the creation of same by-product waste materials, so efforts to benefit from commercial nuclear energy involve the creation of some waste materials that are either radioactive themselves or contaminated with radioactive material. The nuclear fuel cycle is not the sole generator of nuclear waste; they also come from medical procedures and defence weapons production.[1]

Sir John Hill, former chairman of United Kingdom's Atomic Energy Authority has described the waste management problem that arises when spent fuel from a reactor is first received at a reprocessing plant, in what is perhaps the simplest step carried out at such a plant.

Radioactive waste is classified into four categories, low level, intermediate level, high level and transuranic depending on the type and degree of activity of the waste. They are defined in terms of the radioactivity they contain. In recent years the "intermediate" category has been lumped together with "low level" waste, while high level wastes sometimes contain transuranic wastes.[2]

1.Mason Wilrich(ed) : International Safeguards of Nuclear Industry (London, 1973) pp: 67-72
2.Robert E Long(ed) :The Problem of Waste Disposal,(New York: 1989) pp : 155-65.

The main objective of the radioactive waste disposal is to deal with wastes in a manner that it protects public health and the environment, while reflecting social and economic factors. Several choices are available.

1. Dispersal versus Containment : Dispersal is the deliberate release of wastes into the environment,with its dilution by air or water to a level significantly below background levels. Containment is on the other extreme, placing barriers around concentrated wastes to prevent their release in the environment.

2. Passive systems versus perpetual care: The former place no reliance on monitoring, while the later requires continued administrative controls.

3. Retrievability : The ability to recover wastes after disposal.

<u>LOW LEVEL WASTE :</u>

"Low level wastes generally average less than one cubic feet of activity per cubic foot of material or less than 10 nano curies of transuranic contamination per gram.[2] Low level waste is produced at the rate of 120,000 m^3/yr in the United States, about half of which comes from the military. It includes a wide spectrum of items ;Uranium mine and mill tailings; scrub water and decontamination solutions from all types of nuclear facilities, contaminated protective clothing, gloves and shoes covers ; contaminated tools and burnt-out light bulbs from radioactive areas; pumps, valves, seals, bearings and other components that have to be replaced ; scrap, fines and dust from fuel fabrication operations; contaminated ion-exchange resins and gas filters; waste materials arising from use of radio isotopes in nuclear medicines; exhaust ventilation and off-gases from reactor containments.[3]

Water effluents from reactor the primary coolant system and spent fuel storage pools is put through demineralizers until is at purity level of drinking water, then released to the environment; the demineralizer resins become low level waste.[5] Gaseous wastes are collected in a hold up tank and passed through charcoal filters or charcoal beds, when safe are exhausted through a tall stack under controlled conditions or diluted and dispersed.

Shallow land burial is the accepted mode of disposal for low level wastes. The long lasting nature of some of the nuclides contained in waste have necessitated restrictions on the maximum permissible

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3. Farmer F.R. pp 31-46
5. Nelkin Dorothy(ed) :Controversy Politics of Technical Decision, (Beverly Hills,1979) pp : 87 -110.

concentration (MPC) for those nuclides. Of the greatest concern are ^{90}Sr, ^{55}Fe, ^{14}C and ^{3}H and plutonium because they do not emit easily detectable gamma rays characteristic of other radioactive nuclides. Radioactive waste for shallow land burial is classified accordingly to the concentration of long lived radio - nuclides whose potential hazard will persist longer than the repository controls.

HIGH LEVEL WASTE :

Disposal of high-level waste that is, either the separated wastes resulting in the operation of a reprocessing plant, or the spent fuel elements themselves if a throwaway fuel cycle is used - is a question overshadowing commercial nuclear power in some countries, causing some public anxiety, as this waste is potentially the most hazardous and the longest lived.[6]

When fuel is discharged from a power reactor, it is stored in the spent fuel pool. Even with fuelreprocessing, the spent fuel resides in the power plant spent fuel poor before being replaced in a cask for shipment, to permit the shorter lived radioactive

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6. P.Beckman :The Non-problem of Nuclear wastes, (Boulder, Colorado, 1979) p - 6

material to decay. A year or two after unloading from the reactor the total radioactivity level in the fuel is only about 12% of what it was when discharged, and after 5 years, it is down to 30% of the discharged level. The total activity of the fuel continues to decay slowly with time. While a few radioistopes have half lives on the order of thousands of years, the hazardous components of nuclear waste rapidly decay to a radioactive toxicity level lower than that of natural uranium ore. For example, the strontium in waste becomes less toxic than natural uranium ore in 450 years. The total waste, including plutonium, becomes less toxic in 500-1000 years depending on the fuel history and the reprocessing plants characteristics.

TRANSURANIC - CONTAMINATED WASTE

Transuranium-contaminated waste contains more than 10 nanocuries of transuranic nuclides per gram of material. Until 1970, such waste was routinely handled and buried in the same manner as low-level waste. Since then most of this material has been packed in barrels and stored, awaiting a disposal method appropriate for a long lived waste.

GENERATION OF WASTES

Uranium must be dug out of the ground and processed before it can be used as fuel in a reactor. After it is burned in a reactor, the residual radioactive materials must be carefully handled and be ultimately very carefully disposed off. The set of activities that begins with (uranium ore) and ends with radioactive waste is called the "nuclear fuel cycle".

MINING;

Mining is a process by which ore is taken out of the mine. This mining process in case of uranium produce slightly radioactive dust and release randon into the atmosphere. These effluents cause low level contamination of local air and water, with dilution and dispersion being relied upon to minimize the hazards. In the past, mining operations posed a serous threat to the mines because of bad ventilation facilities. This leads to the ground water being pumped out which leads the water being radioactive.

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REFINING;

The ore is sent to mills where uranium is extracted from the ore. The spent ore, depleted in uranium is discharged into a settling pond as a solution of finely ground material still containing about 0.7 ranocurries of radioactivity per gram. This sediment gradually dries out. Left behind is a mass of fine geained sand called "mill tailings".[7]

ENRICHMENT;

The yellow cake produced by milling is chemically processed by one of two methods to produce uranium hexafluoride gas (UFC). The dry hydrofluor process produces waste solids containing long - lived alpha emitting radio nuclides ; these wastes are disposed of in low level burial grounds. The wet method generates a liquid stream containing dissolved radioactive solids. The waste stream called rafinate is dumped into a settling pond, leaving a sludge as the water evaporates. The sludge contains small qualities of radium, thorium, and uranium, all long lived radionuclides.[8]

Only small quantities of radio-active effluents are produced in the enrichment process, primarily uranium and are discharged into the atomsphere. Low-level liquids are released into holding ponds. New enrichment technology currently being developed, may produce increased or decreased quantities of waste.

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7. T.C.Hollocher and J.J.Mackenjie:The Nuclear Fuel Cycle(Cambridge,1975) p : 41
8.L.J.Carter : Nuclear imperatives and Public Trust, Dealing with Radioactive Wastes,(Washington,1987) p. 191.

FUEL ROD FABRICATION:

The enriched uranium hexafluoride gas is converted into solid uranium dioxide which is then composed and formed into fuel pellets. The fuel pellets are loaded into zincronium alloy tubes that are sealed and assembled into fixed arrays called fuel assemblies. Three types of wastes result from this procedure - process off gases treated before release in order to remove certain radioactive constituents; a liquid waste stream contining uranium, thorium and protactinium, dumped into holding ponds and allowed to settle and form a sludge ; and solids, incinerated and then buried at low level disposal sites.[9]

REACTOR OPERATION:

The operation of a nuclear reactor produces the most significant quantities of radioactive waste. A light water reactor, the type commonly used these days, contains about 90 to 100 metric tons of enriched uranium. As the chain reaction in the reactor proceeds, uranium 235 atoms are fissioned. The fragments, or "ashes" are intensely radioactive. Some of the non-fissionable uranium 230 atoms are transmuted into transmanic elements. A few of these heavy elements, in particular plutonium 239 and 241 will fission and as they accumulate, contribute to

9.F.J.Rahn, A.G.Adamantiades,J.E.Kenton and C.Braun:A Guide to Nuclear power Tecnology-Resource for Decision Making (New York,1984) pp. 649-51 energy generation; the remainder, being non fissionable, build up in the reactor fuel. At the end of fuel life, about 30% of the produced energy comes from plutonium fission.[10]

Originally it was intended that the spent fuel be allowed to "cool" for five or six months until radiation levels had decayed sufficiently to allow safe handling and only then, be reprocessed. However, for political and economic reasons no spent fuel will be reprocessed for the future.

REPROCESSING:

The uranium 238 and residual uranium 235 and plutonium in spent fuel can be extracted by what is known as "Purex" process. This chemical reprocessing technology, developed by the U.S government in the early 1950s, was initially disigned to produce plutonium in a pure form, for use in nuclear weapons[11]

After reprocessing, the radioactive waste solution the reprocessing "waste stream" - with activities of up to 10,000 curies per gallon, is pumped into stainless steel storage tanks to await disposal.

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10. S.Gladstone and W.H.Jordan : Nuclear Power and its Environmental Effects, Fundamental Principles of Nuclear Reactor, (Illinois, 1980) p. 18

11. A Chayes and L.W.Bennet (ed) International Arrangements for Nuclear Fuel Reprocessing (Cambridge, Mass 1977) pp 18-19

HOW ARE WASTES STORED ?

Large quantities of nuclear wastes have already been generated and continues to produced in a unfathomable manner, which has already started creating an uneasiness in the minds of people. These wastes constitute a considerable hazard and cannot be turned loose in the environment - that is, used as land fill or dumped into rivers or oceans. They must somehow be isolated from significant contact with the biosphere.

The physical form of high level wastes is an important aspect of the waste management programme. Over the longer term, waste form may or may not be important, depending upon the degree of sophistication of the waste packaging and chemical conditions within the repository rock matrix.[12]

SOLIDIFICATION OF HIGH LEVEL WASTE :

All waste that is generated is in liquid form. Solidification of this liquid is done through the processes of calcination, verification and incorporation of waste into crystalline ceramics and synthetic minerals.

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12. E L Hinnawi Essam (ed) : Nuclear Energy and the Environment (Oxford, 1980) pp 40-77

Calcination is a process by which liquid waste is sprayed through an atomizer and dried at high temperature.

Vitrification is a process by which "calcinated" waste is mixed with boro silicate glass frit. This mixture can be melted and converted into glass or poured directly into metal cannisters.

Crystalline ceramics form another group of possible encapsultants. Leachability is low even if the ceramic structure breaks down. Supercalcine - ceramic is now under development. Although it would seen logical to expand on site spent fuel storage capacity to alleviate the space problem, reactor operators are reluctant to make the required investment and also do not want indefinite responsibility for the spent fuel in the absence of reprocessing. It may also be necessary to store spent fuel or packaged high level waste until such time as its heat output declines to a level acceptable for permanent disposal.[16]

A) SPENT UNPROCESSED FUEL FACILITY:

This (SURFF) was proposed in the United States by the

16. S.J.Hedges Messing up the nuclear clean up US News and World Report, Vol 108, 19 Feb 1990, pp.26 - 28

Energy Research and Development Administration (ERDA) in 1977. SURFF would consist of a large number of concrete air or water cooled vaults into which reactor fuel would be placed for periods up to one hundred years. Several thousand fuel vaults would be located at a single SURFF site.

B) WASTE AWAY FROM REACTOR STORAGE:

Away from the reactor, AFR spent fuel storage pool has been proposed as an alternative to expanded on-site spent fuel storage. The AFR is merely an extemely large spent fuel storage pool - not unlike those found at reactor sites - with a capacity of 5,000 or more metric tons.

C) GEOLOGIC ISOLATION

The disposal of radioactive waste deep within the earth's crust is considered the most promising of the various proposal disposal techniques.[17] It is also the closest to realization. Geologic disposal is attractive because in priciple at least, it appears that the wastes could be safely isolated from the biosphere for thousands of years. Furthermore, disposal in mined vaults is generally believed to

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17.Nuclear fuel waste disposal : a review process, Environment Vol 31, Dec 1989 p.34

require straightforward applications of existing technologies.

A number of geologic disposal concepts have been proposed, including solution-mined cavities, matrixes of drilled holes" "hydrofracture emplacement"[18] deep well injection, disposal on isolated islands, superdeep holes 40,000 feet deep with a bottom of 15 inches in diameter, rock melting and mined vaults.

A variety of disposal media has been proposed for the location of geologic repositories like bedded salt (which acts like a plastic),granite (having good heat tolerance), basalt (low permeability), shale (low permeability and high ionic retention), tuff (high density rock).[19]

1. <u>ICE DISPOSAL:</u>

Disposal of hot radioactive wastes in the continental ice sheets of Greenland or Antartica has been offered as an "international" solution to the problem. It was first proposed by Bernard.P.Wilbuth who received a German patent on the idea in 1958, Ice disposal was revived by a group of scientists in 1973 (Zeller, Saunders, and Angino). The concept has several

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18. Merril Eisenbund : Environmental Radioactivity, (New York, 1973) p. 314.
19. M Perutz : Nuclear Pollution : an exchange THE NEW YORK REVIEW OF BOOKS, Vol 36, 18 Jan 1990 p.52-53

inherently attractive features : ice disposal would offer geographical isolation of the waste from the environment, and would not require the development of any "exotic" technology for its implementation[20].Ice itself has several advantages as a disposal medium : like salt, its fractures are self healing through re-crystallization and plastic flow, it is impermeable to water, and its low temperature makes ice a good heat sink for hot radioactive wastes. Three ice disposal techniques have been proposed - meltdown, anchored emplacement, and surface storage.

E. <u>PARTITIONING AND TRANSMUTATION :</u>

Partationing and transmutation involve, first, the chemical separation of some elected radioactive species from a mix and, second, the transmutation of that element from a generally a long lived radio-nuclide -into another short lived or non radioactive[21] species by means of a single neutron capture or neutron induced fission.[22] The two processes taken together, do not constitute a disposal technology per se, but rather are approaches to reducing the hazards of radioactive wastes by eleminating the long

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20. E J Zeller :putting Radioactive wastes on Ice,<u>Bulletine of Atomic Scientists,</u> January 1973 p.4

21.Lewis Regenstein-<u>America the Poisoned</u>(Washington,1987) pp.246 - 50

22.Samuel Mc Cracker : <u>The War against the Atom,</u> New York 1982 p. 116

lived actinides and fission products.[23] Waste management specialists feel confident that isolation of radioactive wastes can, at least in principle, be guaranted over the thousand or so years necessary for the shorter lived fission products to decay to relatively innocuous levels.

There are four types of transmutuation devices - charged particle accelerators, nuclear explosive devices, fusion reactors and fission reactors.[24] Theoritically, partitioning and transmutation could reduce the long term hazard of the waste by a factor of one hundred.

SEABED DISPOSAL:

Disposal of radioactive waste in the deep seabed is an attractive concept for several reasons : the sea bed is remote from human activities, it seems possible that the sea bed could provide the required long term isolation as large areas are available, and not the least important, sea bed disposal could avoid some of the political difficulties of waste disposal on land.[25]

23.K.Grossman :The Poison conspiracy(New York, 1983)PP 159, 162

24.George.A.Cowan - A Natural Fission Reactor, Scientific American VOL 235,1976 PP 36-47.

25. D.A.Deese : Nuclear power and Radioactive waste ; A subseabed disposal options? (Lexington,1978) pp.35-41

Uptil now the wastes have been laid to the bottom of the sea floor by simple dumping. But with the advancement of technology three formations have been proposed as suitable for emplacement ; deep ocean trenches, deep ocean sediments, and subsediment bedrock.[26]

SPACE

With the advancement of technology, this has been viewed by modern physicists as the ultimate answer to the question of magement of nuclear wastes. Outer space has been viewed by some as the ultimate garbage dump. Why not, ask some, rocket radioactive wastes into the Sun or even out of the solar system ? Infact although the technical uncertainties of space disposal are great, Loss promises to be high. The notion of permanently eliminating radioactive wastes from the earth is attractive enough to have merited serious and extensive study. Through reprocessing the volume should be reduced. A terrestrial disposal system would be required for left- over radioactive waste materials. A failsafe ejection system or a waste cannister able to survive re-entry and impact would be required ?[27]

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26. R.A.Kerr; Geological Disposal of Nuclearwastes: Salts lead is chanllenged".Science, Vol.204, 11 May 1979 p. 603

27. R.W.Nicholls-Solar Nuclear waste Disposal,NatureVol 69 13 Oct, 1977 p.556.

Though the theoritical basis of safe waste management exists, it is by no means a complete basis. In particular, the future of geologic isolation appears quite promising and is followed by almost all countries.

To evaluate a policy of geologic wastes, that would introduce city supplied water to a community that already has come landfills containing hazardous wastes, problems arise. Without the policy, house holds would obtain their water from wells. Some of these walls draw from an aquifer that could be contaminated by leakage from landfills. The policy would lower the probability of households being exposed to these hazardous wastes because it would substitute clear water for the potentially contaminated well water.How, then would the resulting increases be calculated to know the well being of these citizens/residents ? While many possibilities do exist, only two are distinct. To describe them we first define the losses residents would experience under each possible state of the world. For simplicity that these losses can be described by the outcome of 2 processes : for first contamination (c) or no contamination (NC) of the well water and second, an exposure sufficient to lead to a health effect such as liver cancer(E) versus the case in which exposure is not sufficient for an effect (NE) for those drinking the water. Thus we have three states : C & E(designated C E), C & NE designated (CNE) and NC & NE (designated NCNE). For each we might calculate the losses and then estimate the estimated loss under each set of probabilities with and without the policies as:

$$\Delta ECS = \sum (p^b_j - p^a_j) CS_j \qquad ECS = \sum (p^b_j) CS_j$$
$$j = CE, CNE, NCNE$$

p^b_j , p^a_j = Probability of State j before and after the policy, respectively.

CSj = Hicksian consumer surplus for state j.

This approach is broadly similar to Raucher's framework.[28] He simplifies the task of estimating C.S. ; because he assumes that if contamination is detected, a perfect replacement for the contaminated water can be provided. The replacement cost is than his estimate 6 C S J using his frame work, the value of policy regulating wastes is the difference in the expected value of policy regulating wastes is the difference in the expencted values for the ex-post losses. A charge in any of the probabilities that reduce the likelihood of outcome with greater losses would yield positive benefits.

However, some (and probably most) people prefer to avoid situation involving risk. For these individuals the expected value of the ex-post

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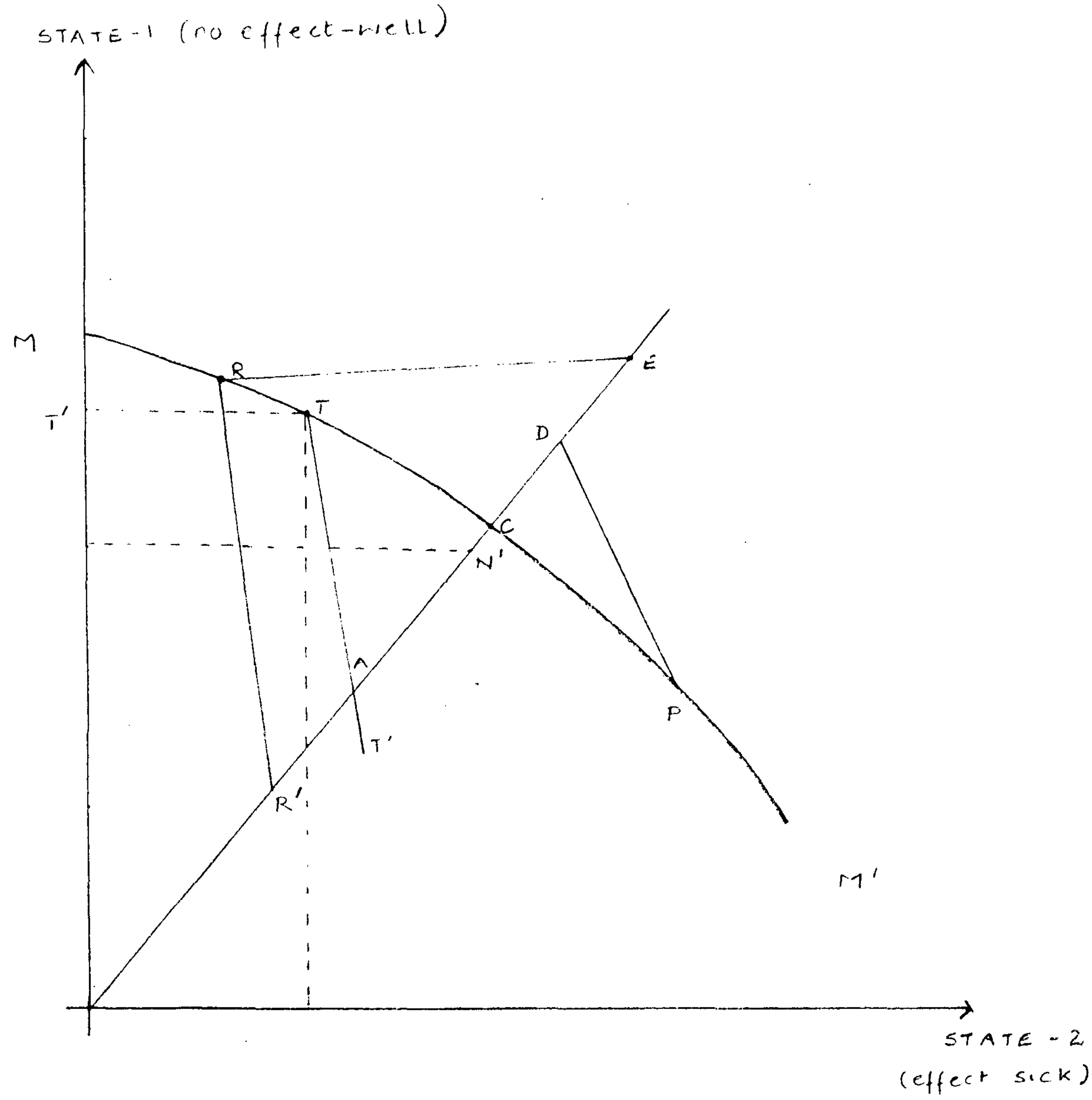
28. R.L.Raucher : The Benefits & Cost of policies related to groundwater contamination,<u>Land Economics</u>,62 (Feb) 1986 pp. 33 - 45.



GRAHAM'S WILLINGNESS TO PAY LOCUS

Fig 2.1

monetary loss would not reflect their loss in well being from any increased uncertainity. The second approach for measuring the value of policies that reduce risk applies to these cases. It assumes that individuals are risk averse and maximize their expected utility.

In some circumstances, it is likely their utility functions fare dependent on the state. Under these assumptions the monetary value of a change in risk will differ from what is given by the first approach. Moreover, a different concept of well-being, the "expected utility" is held constant.

"However, there are many monetary measures that can be used in this case e.g. Graham's willingness to pay locus, which describes the set of state development payments that would hold an individuals expected utility constant at a specified baseline level.[30]

This figure depicts the locus as MM's for the case of 2 states. To accomodate the example, we combine the 2 states for which no effect is experienced (CNE & NCNE) into one composite outcome, since no health effect is experienced. In this formation, payment is made only if its specified state of nature is realized.

30.L.J Carter,J.D. Steinberg,C.A, Zraket (ed) :Managing Nuclear Operations(Washington DC, 1987)

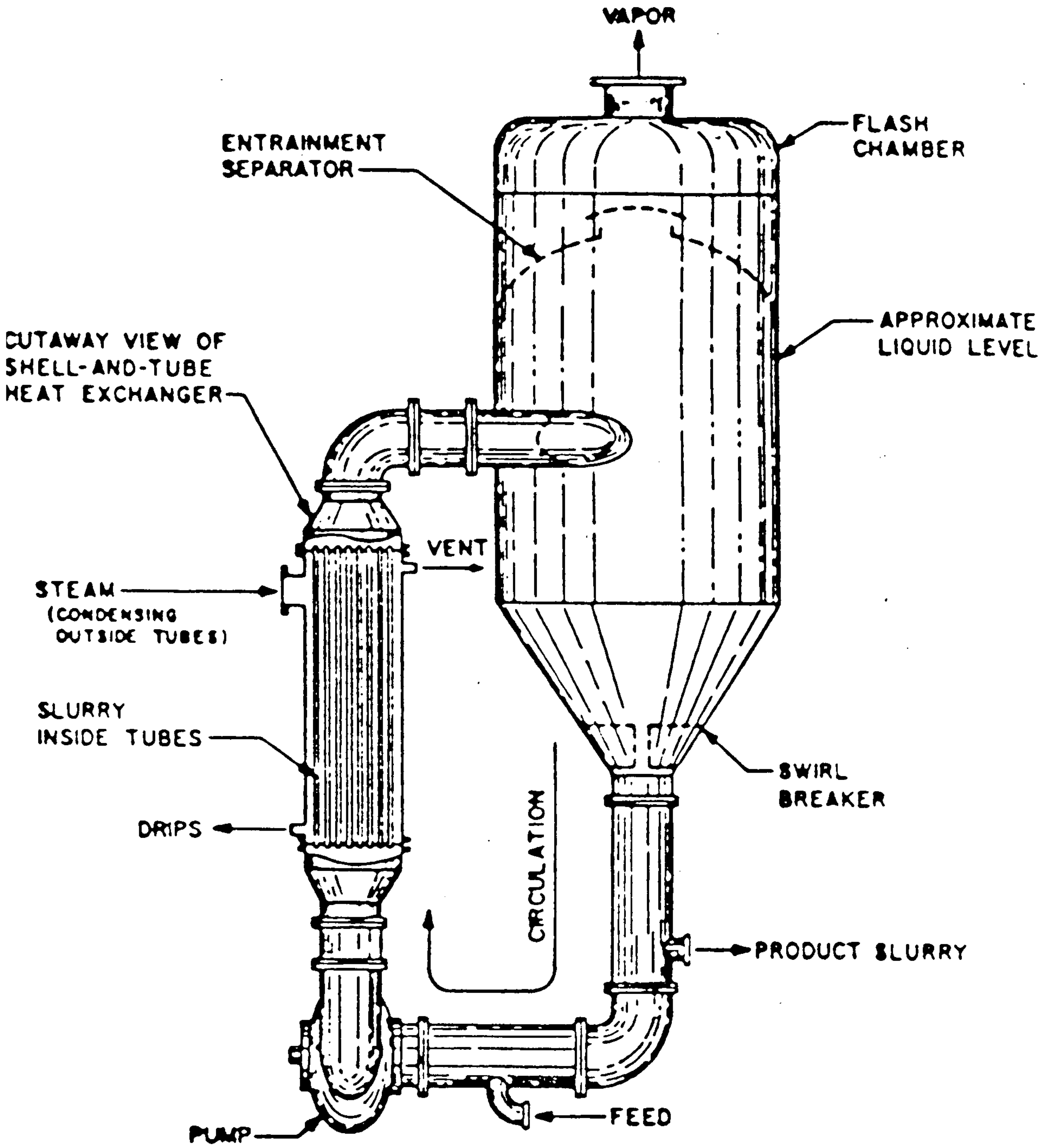


Figure 2·2 Evaporator/crystallizer.

This framework can be used to illustrate this argument. Considering the first observation and the second (ex ante) measure of well being for a risk change will differ from Raucher's approach. The expected value of consumer surpluses does not hold expected utility constant.

Therefore, nuclear waste management is complex, multifaceted phenomenon involving dimension that become inextricably interelated in the public mind and debate.[31] It is infact, the interrelationships and interactions between the numerous dimensions of the problem that will likely determine the cause of action finally pursued in addressing the nuclear wate proble.[32] Although it is impossible to describe all of the complex intricacies that make up the image and issues surrounding nuclear waste management, it is essential at this point to provide some indication of the interrelation among the key dimension, and of the characterstics of the total context in which the nuclear waste management issue must be addressed.[33] The major framework that is at least neuristically useful is that of human ecology. This perspective is based on Malthusian and Darwinian

31. G.P.Thomas and C.F.Barnaby : The Nuclear Arms Race Control or Catastrophe (London,1982) pp 3
32. Michael Greenberg (ed) :Public health and the Environment,(Washington DC,1984)pp.21-30.
33. Luther J.Carter : Imperatives and Public Trust : Dealing with Radioactive waste,(New York, 1987) pp. 101-110.

conceptions of man's close relationship to his environment in the social sciences particularly in relation to environmental concerns and society environment relationship.

POPULATION DIMENSION

It is evident that the major dimensions of the critical concern in waste management are those related to individual, groups and society needs, rights and resposibilities.[34] Although interactively involved or linked with all of the oher dimension, it is clear that some of the areas of conflict relate, to which level of government (Federal or State) should be responsible, for various stages of waste management, whose needs should be protected and who should pay ? Such issuesare complex and may involve verying perspectives on man and society. Thus how society should attempt to manage a problem, such as waste isolation that required one area of the nation bears the risks for the good of the entire nation often leads to major conflicts between those who see the needs of the society as paramount versus those who see rights of individuals as of ultimate importance. In the matter the conflict that evolve around the Locus of control over waste management may be based on fundamental socio-poli differnces

34. M.Olsen, C.Sawyer & C Cluett pp 31-46

between those that stress the need for centralised control and corordination versus those championing local control.[35]

Yet an additional set of quesion relates to who should pay for waste management costs ?[36]

This involves issues such as whether such costs should be borne by only those customers of particular utilities that use nuclear generators of whether there is a society - wide obligation to bear such costs and whether private support will lead to market vulnerability and hence political astability.[37]

In sum, many of the basic issues that surround nuclear waste involves interrelations between levels and types of individual or group concerns that are based deeply held and basically conflicting perspective's on man and society. Clearly, such issues are unlikely to be definitely resolved by those involved in waste management. However, such issues remain at the base of much of the nuclear debate, and awareness of their potential effects on nuclear waste issues should be maintained.[38]

35.Robert Dahl.After the Revolution? Authority in a good society,(New Haven,1970)
36.J.Coleman,Community conflict (New York,1957) pp 56-72
37.Colin Bell & H.Newby, :Community Studies,An introduction to the sociology of local community (New York 1972) p. 3
38.Helen Caldicolt:What you can do ! Nuclear Madness(Brookline Mass, 1974) p.36

ENVIRONMENTAL DIMENSIONS

Clearly, some of the deepest concerns in regard to waste siting are due to environmental danagers posed by nuclear materials. These concerns have in fact been the major basis for extensive technical efforts to develop environmentally safe means to isolate waste materials from the environment through containerization, geological media and repository design selection procedures. The issues surrounding such diamensions involve numerous concerns.[39] Some of these concerns relate to the danger of direct exposure to radiation as a result of accident in waste transporation or storage procedures, while others result from a concern that the environmental resources such as alternative uses of land, ground water quality or even surface water uses could be endangered by repository development.[40]

Thus, there is concern that the sufficient level of controls cannot be established to prevent the numerous forms of human errors that might lead to radiation exposure for residents along transportation routes and for siting area, residents and workers during processing and storage.

39.Roberta G.Gordon:Legal incentives for reduction,reuse and recycling:A new approach to hazardous waste management Yale Law Journal,Vol.95, No.4, pp.10-13

40.J.L.Rodgers ; Environmental Impact Assessment, Growth Management and Comprehensive Plan, (Cambridge,1976) p. 97

The nuclear waste storage problem is also largely a product of a new and even changing social environment.[41] Until the turn of the century, there was relatively little concern for the need for man to live in harmony rather than to exploit the environment become a belief "The increasing concern with man's ability to irrevocably later his environment and the belief that the society must reverse decades of abuse of the environment from the context in which nuclear waste perhaps perceived to be a troubling symbol of man's excessive and unthoughtful exploitation of the environment........ management must occur.[42]

The social and historical environment of nuclear power and nuclear arms developments also have a bearing on the nuclear waste problem. The early attempts to site a repository in Kansas with the seeming sudden reversal of technical certainity, and the failure to effectively co-ordinate siting efforts with state and local officials, the fact that nuclear power in the United States grew out of the nuclear weapons programme and that its history has been marred by serveral accidents such as those at the Ferni Plant in michigan in 1966, the Browns Ferry plant in 1975 and the Three Mile island Plant in Pennsylvania have produced a climate distrust and

41. S.Murdock et all p. 95

42.B.Paul.R.Shaw and Yuwa Wong Genetic seeds of Warfare-Evolution, Nationalism and Patriotisim,(Boston, 1989) pp. 94 - 103 doubt, in which waste management planning must proceed.[43]

For nuclear waste siting, then, the interrelations of physical, resources, use and socio-historical environmental factors are of critical concern. Knowledge of these factors is essential for understanding the nuclear waste problem.

TECHNOLOGICAL DIMENSIONS

The technological dimensions of nuclear waste siting have been the focus of the United states attempt to manage nuclear waste.[44]

In fact, technology is both a cause of and the cure for the nuclear waste problem. Thus, nuclear weapons testing and development and production are the direct generators of nuclear waste. In a larger sense however, the technological issues involved in nuclear waste are part of the larger issues of the effects, both intended and unintended, of technology on human life and society issues such as whether man should develop and utilize technology which has by products that are dangerous to himself and future generations, the role of careful and technology assessment in the

43.W.Epstein and Toyoda(ed) A New Design for Nuclear Disarmanent(Nottingham 1977) p.33
44. Weapons of Mass Destruction and the Environment, SIPRI (London 1977) p. 21.

development of advanced technology and man's apparent inability to predict or control the social effects of technology development are issues broader than nuclear waste, but ones which have come to affect the nuclear waste question. Nuclear waste is, in fact an issue surrounded by questions based on concerns about technology interfaces.

Technology is also seen as a case for nuclear waste problems by both opponents and proponents of nuclear power. According to Guardian, a plan was underway to to build in Morrocco's section of the Sahara desert the "largest toxic disposal plant in the world." A British consortium, Midco, was to export daily 2000 tonnes of hazardous waste from Europe and North America to the town of Tarfaya and using temperature incinerators burn it to generate electricity and other products.[46] The main ship used was Karin B.[47] To many oponents of nuclear power, belief in existing storage technology has led to claims that the questions remaining in waste storage are largely has led to claims that the questions remaining in waste storage are largely irrelevent once related to socio-political rather than substantive concerns. On the other hand, for proponents of nuclear power there is

45.Keessing's record of world Events, Vol 35, No.6, 1989 p. 36541

46.Keessing's record of World Events, Vol.35, No. 6, 1989, p.36782.

47. Michael R Greenberg(ed) : _Public health and the environment, The U.S. Experience,_ (New York, 1987), p.75.

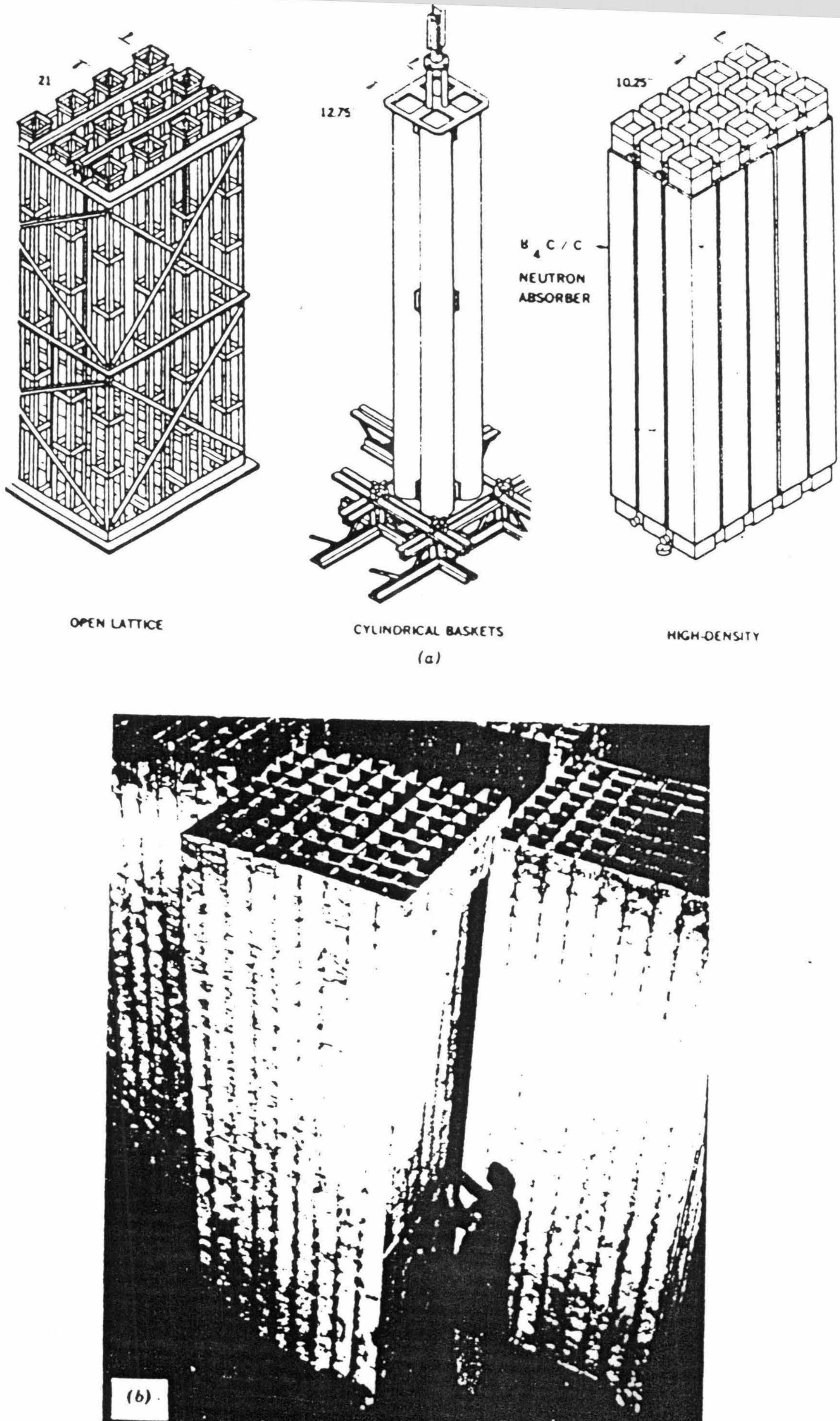


Figure 2.3 (a) Concepts of fuel storage racks. (b) High-density fuel storage rack

nearly a equally strong belief that conservation and alternative energy technologies will make the need for additional nuclear power and, thus, for additional wastes unnecessary.

The belief in technology for the first group is a belief in man's existing capabilities, for the second group, it is a belief in man's future creativity.

Finally, the extent to which technology is seen as cultural phenomenon also effects the context of the nuclear waste problem. This effect is seen as the cultural myths that are basis to society.[48] Technology, then, in both its engineering - Scientific and its cultural forms has become a major focus in the debate over nuclear waste. Its complex inter relation with social issues form yet an additional part of the complex mosaic of nuclear waste management.

ORGANIZATIONAL DIMENSIONS

Organizational dimensions are also playing a major role in forming the context for waste management. Concern over existing and future institutional arrangements are varying forms of differentiation within the existing system of institutional

48. Gary.L.Downey: Structure and practice in the cultural identities of scientists. Negotiating Nuclear wastes in New Mexico-Anthropological Quarterly,Vol 61,No1,Jan1988 p.2 30.

arrangements are of utmost importance in understanding the perception as well as the realities of nuclear waste problem.

Of even greater concern is the question of the possibility of creating an institutional structure that is capable of maintaining and insuring the security of a repository over several thousands of years essential for repository management.

Also, contributing to the organizational concerns over nuclear waste are the conflicting perceptions of power and political efficacy that exists within the present political and social system.[50]

Regionalism has also come to play a major role as well. Since the first major repository is likely to be sited in the southern or western part of the United States, the long felt perceptions among residents of these rations, that the region is often seen by other areas of the nation as "dumping grounds" for Federal projects that are either undesirable or dangerous have been reinforced.

In sum, the population, environmental, technological and organizational dimension of nuclear waste management become linked in a multitude of direct and

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49. W S Maynard, S M Nealey, J A Herbert and M K Lindell:Public Values Associated with Nuclea Waste Disposal, (Washington,1976) pp.137 - 41
50. Frank Rahn et all p.678

indirect ways. These interrelations interdependently determine the context as well as the content of the nuclear waste problem. Recognition of this interdependence and inter action is thus essential to understanding nuclear waste management issues and concerns.

WHAT IS BEST SUITED FOR ENCAPSULEMENT?

SALT VERSUS GRANITE :

Salt and granite are leading candidates as host media for high level radioactive disposal. Salt deposit conduct heat rapidly away from the waste containers. Moreover, salt beds are proof that no ground water exists in the area. However, unresolved issues relative to using salt include long term thermal stability of the deposit and the possibility that future ground water intrusion might occur.

Granite, on the other hand has a greater mechanical stability than salt although the exclusion of ground water is more difficult to guarantee because granite rock is not monolithic, but contains salt's higher thermal conductivity is balanced by the higher heat capacity of granites. Salt,because it is self-healing properties does not suffer permanent cracks under the pressure of earth movements is currently regarded as the best insulator hot wastes, unlike rock. The best choice, however; is not clearcut and either may prove to be adequate. The United States and Germany intended to use salt deposit for their demonstration repositories, while Sweden is considering granite.

GLASS VERSUS SYNROC :

Glass is not a solid but super cooled liquid. When glass hardens, it froms no set chemical pattern or structure - that is important for its stability and radiation resistance. All glass is composed of a mixture of solids; sand-based silicates, modifiers such as sodium and stabilizing compounds such as lime. Boron is used in place of sodium in glass for radiactive waste disposal because the glass then melts at a low temperature, reducing the amount of fission products volatilized by this process. One concern with glass is its ability to resist weathering, in particular, leaking of radioactivity by hot, high pressure ground water. The solution - to the weathering process is the development of a low leachable glass form, and the forming of glass in large blocks; with a low surface to volume ratio, only a small outer layer would be exposed. Although some glasses weather easily, others have survived 3000 years in harsh conditions without extensive weathering. Nuclear wastes, buried deep in the earth, would not be exposed to as destructive environments as some of these ancient glasses have endured.

"Synroc is a material originally developed by A.E.Ringwood as an alternative to borosilicate glass. Some types of SYNROC retain strontium, cesium, actinides and rare earth elements considered more efficient than glass. The concept borrows from nature minerals that comprise Synroc are those that contain nuclear wastes and exhibit long-term stability.[51] Although more expensive than borosilicate glass, synroc can accept high radiowaste concentrations, thereby requiring a small repository. While the "best" waste form for radioactive waste disposal cannot yet be chosen, both borosilicate glass and synroc appear adequate. Borosilicate glass is the near term choice for most designs because it is more technological is nature, while Synroc may be a more improved concept.

HOW IS LICENSIND AND SITING DONE ?

SYSTEM MODELING

Licensing and siting can be established using a systems approach referred to as retention quotient

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51. ibid p.679

methodology. This approach establishes an acceptable radioactivity release rate to the environment rather than making each barrier in the migration path, as formidable as possible, with no regard to cost or potential hazard. The RQ method is simple, effective way of evaluating the safety performance of the overall repository system.

The ability of the geologic repository to contain nuclear waste material is evaluated in terms of the multibarrier framework. Barriers are impediments to the flow of radio nuclides from their initial location in the repository to man. They have a number of important characterstics such as,

1. Barriers may either be natural or man made.
2. They may be consecutive (in series) or rendundant (in parallel)
3. Barrier may be nuclide specific, that is, effective against certain components of the waste, but not against others.
4. Barriers may be effective only in certain time periods.
5. They may act as to retard or slow the transport respository velocity of the various nuclides.
6. Barriers act independently, for the most part, although among the various barriers are sometimes important.

In, evaluating a nuclear waste repository, the total SR dose can be divided by "allowable" dose consistent with health effects to obtain a dimensionless quantity, the R Q.

$$R\,Q = \frac{1}{DC} \frac{E}{i} Q\,i\,(D\,F\,i)$$

Where :

Q : Total inventory of isotopei in a body of waste material Ci

Dfi= The ingestion dose factor for isotope i that results in a 50 years commitment to an individual (rom / Ci - year)

DC = dose criterion, a legisiated allowable annual dose (rem / year)

E = sigma.

Everybody's come to town,
Those left we all do pity;
For we'll have a jolly time
At Love's new model city.

This tale I tell is no less
true Though in a silly ditty,
They give free sites and
power too In Love's new model
city.

— William T.Love.(1892-May)

MANAGEMENT OF WASTES BY THE UNITED STATES

"Perhaps no aspect of waste disposal is more alarming than that of nuclear waste. The nuclear power industry has been existence for four decades, despite alarm caused by a partial meltdown at the three mile island facility in Pennsylvania, no significant releases of radioactivity from nuclear power plants have been taken place in the U S[1] Nevertheless, the wisdom of expanding nuclear power is still debated, and the problem of disposing of nuclear waste in particular has plagued the industry. The United States has 239 waste sites.

THE AEC AND WASTE DISPOSAL

The first public step towards a rational programme for radioactive waste disposal came in 1974 when the Atomic Energy Commission (AEC) issued a draft Generic Environmental Impact Statement (GEIS) covering interim and permanent repositories for transuranic and high level wastes. The Energy Research and Development of Energy(DOE), ERDA's successor, did not reissue the statement until April, 1979. "In May 1976, the Energy Resources council presented what might be called the first comprehensive plan for

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1.Robert E.Long (ed)<u>The Problem of Waste Disposal,</u>(New York,1989) p 153 radioactive waste management. This programme,which would involve six federal agencies called for a national repository for high level radioactive wastes by 1985".[2]

In anticipation of issuing a revised draft GEIS, ERDA commissioned a complete review of radioactive waste management technology, the results were brought together in a five-volume set of documents called the Technical Alternatives Documents (TAD) in 1977.

In the same year, President Carter established a DOE task force to review the government nuclear waste management programme. This task force was supervised by John Deutch, Director of DOE office of Energy Research, presented its findings in term of a draft in February 1978. In March, 1978, President established the Inter Agency Review Group (IRG) to formulate "recommendation for the establishment of an Administrative policy with respect to long term managements of nuclear wastes and supporting program to implement this policy.

"The Reagan Administration had adopted a radioactive waste management policy that favours reprocessing spent fuels from commercial nuclear power plants and

2. Charles A Walker, Leroy C Gould & E J Woodhouse (ed) Too Hot to Handle ? Social & Policy issues in the Management of Radioactive Waste, New Haven, 1983 p 4.

solidifying HLWS for emplacement in geologic repositories. Nevertheless, a national plan for radioactive waste management still does not exist, although a preliminary outline for a draft of such a plan has been circulated. Given that this draft plan, once completed, will have to be submitted for public review and comments before a final plan can be prepared, it is fair to say that the U S still will not have an official plan for permanent disposal".[3]

The draft GEIS issued in 1979 lists ten potential candidates for ultimate HLW and TRU waste disposl.

1. Geologic disposal using conventional mining techniques
2. Chemical resynthesis
3. Placement in very deep holes.
4. Placement in a mined cavity in a manner that leads to rock melting.
5. Island disposal
6. Sub-sea bed geologic disposal.
7. Ice sheet disposal
8. Reverse well disposal
9. Partitioning and transmutation
10. Ejection into space.

"Whereas the IRG has outlined four possible technical strategies leading to the disposal of HLW.

3. ibid. p. 7

STRATEGY - 1:

Provides that only mined repositories would be considered and that only geological environments with salt as the emplacement media would be considered for the first several repositories. As a result of part focusing on salt, there is a large volume of information available. In addition, one body of opinion holds that salt is the best or at least an acceptable, emplacement medium and that suitable sites can be found where the salt is the host rock.

STRATEGY II :

Provides that, for the first time ten facilities,that too only mixed repositories would be considered. A choice of site for the first repository would be made from among whatever types of environment have been adequately characterized at the time of choice. Because generic understanding of engineering features of a salt repository are most advanced, the first choice is expected to be made from environment based on salt geology. Sites from a wider range of geologic environment would be available for selection later.

STRATEGY III :

Provides that, for the first facility, only mined repositories would be considered. However, three to five geological environments possessing a wide variety of emplacement media would be contenders as soon as they had been shown to be technologically sound and economically feasible.

STRATEGY IV :

Provides that the choice of technical options and if appropriate, geological environment be made only after information about a number of environments and other technical options has been obtained.[4]

Long before the launching of the commercial nuclear industry in the United States, large quantities of radioactive waste were generated by the national security activities of the AEC (Atomic Energy Commission)[5]

Responsibility for the management of this waste also resided within the AEC. However, because the agency was oriented towards the development and production of nuclear weapons, it was supported in this perspective by the congress intially received relatively little attention.

4. ibid pp 11-12
5. William C Martel and Paul Savage , Strategic Nuclear War-what the superpowers target and why?(New York ; 1986) pp 32-36

Overtime, changes were made in techniques used for processing storage of HLW and TRU wastes, driven primarily by the related objectives of rescuing volume and cost.[6] For many years there seemed little urgency to more towards permanent disposal, and the belief was widely held within the AEC that safe disposal would be possible at three AEC reservations at which the waste was generated and stored in quality : Idaho Falls, Idaho; Hanford, Washington;and Savannah River, South Carolina.[7]

WHAT THE N.R.C. DOES

Extensive private mining and milling operations gradually developed during the 1940s and 1950s to supply the AEC national security activities. LLW from AEC activities were disposed of by shallow burial on AEC land without independent regulatory oversight : Commercially generated LLWs were generated at similar, commercially run sites under the regularly control of the AEC and later the Nuclear Regulatory Commission (NRC) or of state authorities acting under agreement with the federal agency. In this area too, little research and

6. L.S.Clesceri:Biological Scavengers for ra.waste,Science News,Vol.137,27 Jan,1990, P.63.
7. Something dead cant be buried,US News and World Report,Vol.107,11 Dec,1989, P.17.

development (R&D) was conducted on new methods of safe disposal. In retrospect, some of the existing sites and methods have turned out to have been given or that probably would be today. The financial arrangements for guaranteeing long-term care of some of the commercial sites have also turned out to have been inadequate.[8]

With the enactment of the Atomic Energy Act of 1954, the legal basis for launching a commercial nuclear industry in the United States, the need emerged to think about the disposal of HLW the nuclear industry would produce.[9]

In the US, HLW is stored for some time at the reprocessing plant, then solidified, appropriately packed, and evantually disposed of in an underground cavity mixed out of rock salt. Disposal in salt deposite were first proposed in 1957 by a committee of National Acedemy of Sciences.

The AEC did take actions to encourage the construction of commercial reprocessing plants, but until the mid-to late 1960s did relatively little to put in place a disposal facility for HLW. This is because the technical problem of disposal were not

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8.Werner Kaltefleiter and R.L.Pfatzraff(ed);<u>The Peace Movements in Europe and The US.</u>(London,1985) PP 79-84.

9.Lawerence C.Hamilton : Concern about toxic waste : Three denographic predictors, <u>Sociological Perspectives,</u>Vol 28, No 4,Oct 1985, PP 483-92.

considered to be very great and under the AEC's baseline concept, no commercial waste would be available for disposal until reprocessing operations under way.[10]

Leaks at the storage tanks at Manford and migration of ratio nuclides at government LLW burial sites although they resulted in little or no harm, seriously damaged the credibility of the AEC and its successor agencies as trust worthy guidelines of public health and safety.[11]

A much touted plan to construct the first repository in a salt formation near Lyons, Kansas was abandoned because of technical inadequacies and political opposition. Following the Lyons failure the AEC redirected its efforts towards long term surface storage of HLW. The waste management concepts of the AEC and the ERDA, were narrowly conceived and lacked both flexibility and redundancy.[12]

In late 1976 ERDA did propose a diversified geologic strategy that included a broad search in thirty six

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9. Lawerence C.Hanilton: Concern about toxic wastes:Three demographic predictors, Sociological Perspectives, Vol 28, No 4, Oct 1985 pp 463 - 72
10.S.Rothman and R.S.Lichter: Elite, Ideology and Risk Perception in nuclear energy policy,American Political Science Review, Vol 81, No 2, June 1987 pp 383-400
11.K.D.Steele:Harford:Americs n-graveyard-Bulletin of Atomic Scientists,Vol45,Oct 1989 p14-15
12.Cyrus Mehri : Prior informed consent, Cornell International Law Journal,Vol 121, No 2, Summer 1988, pp 366-77

states for acceptable repository sites and ultimately for construction of several facilities. However, it met with a growing disapproval from states and some states even went to the extent of officially prohibiting activities related to waste disposal.

Federal expenditures for nuclear waste management increased dramatically under the Carter administration. ERDA's expanded programme was budgeted at $ 237 million in FY 1977 and was itself a major increase over FY 1976 rose to $ 483 million. Since then, expenditures have been about level in real terms, with a $ 511 million in FY 1980 and $ 569million in FY 1981. The Annual Radioactivity of L.L.W. is 375,796 curies as in 1989-90. The defence components of the nuclear waste budgets, driven primarily by requirements for interim care of existing defence budgets, declined steadily in percentage terms from 1971, when it comprised the total appropriation, until 1981, when it represented 53%. This relative decline resulted from the initiation of the remedial action programme in 1976 and a small spent fuel progress in 1978 and the steady strengthening of the commercial HLW programme which jumped from 10 to 28% in FY 1977 and reached 36% in FY 1981.

"Costs of cleaning waste sites are large. Congress estimated that each cleaning ups" cost would average $ 4 million"[13] And over 600,000 gallons of HLW await disposal.

THE RESPONSIBILITY OF D.O.I

The Department of the Interior (DOI) has two responsibilities in the area of nuclear waste management, providing earth sciences expertise and supplying parcels of bederal land that may be selected for study or, ultimately, for facility sitings. The U S geological survey conducts laboratory R&D and field geological investigations in support of DOE's HLW disposal programme and, to a lesser degree, under its own authority in order to supplement DOES programme. DOE pass through funding began modestly in FY 1975, and in FY 1981 $ 5.5 million. The survey's own programme related to HLW began in FY 1959 and was $ 4.4 million in 1981. The survey may also be asked by NRC and states to act in an advisory capacity when they evaluate DOE applications for the construction of repositories. In the area of low-level waste, the survey's own programme was at the level of $ 2.3 million in recent years and $ 0.6 million was provided by DOE.

13.B.A.William and A.R.Matheny : Testing Theories of Social Regulation : Hazardous waste regulation in American States. - Sociological Perspectives,Vol 128, No 4, Oct 1985 p.429.

Personnel for the total nuclear waste effort has risen steadily, reaching 87 full-time and III part-time people in FY 1981.

Recent US federal legislation has made low level waste disposal the responsibility of the states to be handled on a regional basis. The first regional compact of Idaho, Washington and Oregon has been formally chartered and should serve as model for the other states.

Subsequently Montana, Wyoming and Utah joined to complete what is now the Northwest compact region. The Southeast compact Region was completed in 1983. It consists of eight states south of Virginia and east of Missisippi. Four other regional compacts are presently forming spurred on by the 1986 target date for the regional compacts to take full control of waste burial. As of early 1984, two large radioactive waste producers, California and Texas, have not yet made a final decision as to which compact to join or to go it alone.

"The federal regulations embodied in 10 CFR 61 for establishing siting criteria have been issued in 1982. 10 CFR 61 provides a rational approach which is acceptable to industry". In the short (5 years) some nuclear facilities may experience problems in dispersing of low level waste as the regional compacts formally came to grips with the problem that they had been mandated to solve. However, in the long term the elements to provide a solution to this issue are at hand. Several issue require attention like, Waste form, Volume Reduction, Administrative control, and waste package".[14] the generation rate of dry radioactive waste is not related to reactor size. Rather, generation of dry waste is affected mainly by outages, current rates are consistent with an assumption that all stations undergo one refueling and repair outage each year. The assumption results in a weighted average production of dry radioactive waste of about 12,300ft^3 per, unit per year, this is in adition to the 15,000 of liquid wastes produced.

It costs approximately $ 55/ft^3 for off-site burial. Some disposal sites have allocations for each nuclear facility served. Every cubic in excess of allocationmust be shipped to another site. For example,. a utility that would usually use the Barnwell, South carolina disposal site would have to ship over allocation quantities to either Nevada or Washington, increasing the shipping distances Several thousand miles. With transportation costs exceeding $150/mile per truckload, aneconomic incentive exists

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14. Frank Rahn et all. p 687

to meet the volumetric allocation. Further more, large cost savings are possible if the wastes volume can be reduced. Savings upto 75% are possible using volume reduction techniques.

To further explore the economics of waste disposal, it is interesting to look at the current price for disposal of low-level waste at the burn well burial site. All material shipped there must comply with (1) Department of Transportation packaging specifications (2) The licenses of the operator of the site and of South Carolina state radioactive material licenses and (3) site disposal criteria.

Disposal charges, excluding surcharges, are $13.20/ft^3$, but not less than $ 300 per shipment. There are additional radiation surcharges depending on the maximum radiation level at the surface of the package steel drums, boxes and liners.

THE D.O.E.AND WASTE MANAGEMENT

The National Waste Thermal Storage Programme (NWTS) was established in 1976 by ERDA, the precursor of DOE. Its mission is to provide facilities for commercial nuclear waste in geologic formation within the United States.[15] Its programme consists of investigating the properties of salt, granite, shale and basalt to determine their suitability for terminal storage of high level radioactive waste, and to provide assurance that existing and future high level radioactive waste from commercial activities can be isolated from the environment so as to pose no significant threat to public health and safety.[16]

Lead responsibility in the (NWTS) is vested in the Office of Nuclear Waste Isolation (ONWI) established at Columbus, Ohio. Specific sites being investigated by the ONWI include salt formations in Mississippi, Louisiana, Texas and Utah other areas, and host materials such as slate and crystallic rock are also under investigation. Following the nationwide public hearings on Draft Environmental impact statement on the disposal of commercial radioactive waste, plans to use mined geologic repositories for such waste became the policy DOE. Such repositories will involve the sinking of vertical shafts 300-1000 ft deep, development underground fishbone grid of horizontal galleries and chambers extending from the base of the vertical shaft and placing the waste in cannisters with over pack in hole drilled into the floor of the galleries.

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15. W.S.Lanouette : The Admiral and Stelto Wars,<u>Bulletin of Atomic Scientists</u>, Vol 46, Jan-Feb,1990 p 40.
16. No home for hot Trash <u>Time</u>, Vol 134, 11 Dec 1989 p.81.

The HLW programme's Capitol Hill ills echoed through the waste conference in 1987 in Tuscon, Arizona. The programme is caught in an impasse in congress, where there is a majority neither to halt it nor to propel it, hit the same statement is Tuscon - a division on where the programme stands and what would be done to get back on track.

Central to the controversy in both cities were DOE's unilateral suspension of the politically volatile second repository programme in 1986 and its threat to resume the programme if congress does not accept dcelays in the first repository programme, embodied in DOE's proposed amendments to its Mission plan. The amendments push back the opening of the first repository to 2003, slide the opening of a monitered retrievable storage facility back to 1998, and affirm DOE's previous decision in indefinitaly postpone site-specific work on the second repository.

The DOE in 1987 proposed a five year delay in the 1998 operation of the first HLW repository, but the first reactor by congress suggested that the department will have great difficulty in finding either acquiesence or funding.[17]

17. S.Saleska : Low Level Radioactive waste, gamma rays in the garbage, Bulletin of Atomic Scientists, Vol 46, Apr 1990, pp 18-25.

The NRC and the EPA are a step closer to resolving issues surrounding the disposal of LLW and in 1987 signed a joint declaration on mixed waste proposal. EPA's presence conservation and Recovery Act programme oversoes the disposal of LLW. Under the LLW policy Act Amendments of 1985, states compacts planning to build low level waste sites must develop sitting plans by January 1988.

The JGC corporation won a full turnkey contract to design and build integrated LLW treatment facility for Virginia, Power in 1987. Although the JGC refused to specify, the contract was to be worth $ 80 million. The facilities at Virginia Power's North Ann and Surry station will include liquid waste concentrator, demineralizers, filters, asphalt solidification and dry active waste compactors designed for routine reduction of atomic wastes and abatement of radioactive discharge levels, JGC said. On top of these facilities, JGC is responsible for buildings covering, equipment, construction and test runs, it said. About 70-80% will be procured form the US.[18]

Cost estimates have been made for radioactive waste disposal. DOE has estimated direct

18. G.G.Wicks and D.Bickford : Something new about high level nuclear waste, <u>Technology Review</u>, Vol 92, Nov-Dec 1989 pp 50-58

life-cycle costs for a repository in a salt at $ 9 billion over 24 years life. This is for a repository containing 65,000 spent fuel packages, 60,000 drums of TRU and 23,000 packages of fuel end-fittings and hardware.

One expensive item where cost reductions are being sought is in cannisters. A titanium cannister to contain a single spent PWR fuel assembly is estimated to cost for $ 30,000 to $ 50,000.

"The choice of host medium will have only a minimal effect on costs. Estimated construction costs in 1987 dollars for a 9000 acre repository with a capacity of 160,000 cannisters holding 63,000 tonnes of spent fuel is $ 717 billion in bedded salt, $ 2.49 billion in domed salt, and $ 3.15 billion for basalt and granite."[19]

As it is, the US has been exporting a waste to Phillipines and some African countries. China is also seen as a potential dump site "Ken Kagaria, President of a waste recycling firm near LOs Angeles, received a letter that began.

"Dear Sir, aware of your serious problems in the

19. Frank Rahn et all p 667

disposal of your toxic and hazardous waste......we have acquired an island in the Phillipine suitable as dump site".[20]

LLW licence designee, US Ecology INC identified in 1987 three sites for LLW burial grounds. All three are in sparsely inhabited areas with relatively little agriculture. Two of them are in San Bernadino country - Ward Valley, Silurian Valley and neighbouring INYO'Country - Paramit Valley. These are two alternative sites also, Fenner Valley and Darby.

The US department is sacrificing safety and cost to politics in its searth for a site for a waste dump from spent fuel from nuclear power stations. One of the three sites on the short list, at Hanford, would release 200 times as much radioactivity as another site, at Davis Canyon in utah, which is not on the short list.

In 1986, it emerged that 4×10^{16} becqueral of radioactivity had been released into the environment from Handford in its 40 year life. In a state referandum, therefore more than 80% of voters opposed building a new nuclear dump there.

21 David L.George and P.Southwell:Opinion on the Diablo Canyon nuclear power plant:The effects of situation and socialization, Social Science Quaterly, Vol 67, No 4,Dec 1986 pp 722-25

Westinghouse Electric Company, has developed a concrete container based disposal technology that is expected to meet mixed waste disposal standards, spokesman. The sure-pack design involves entombment of as many as 14 uncompacted drums of waste in hexagonal reinforced - concrete containers with walls three to six inches thick. For below ground disposal, the containers would be placed in a trench lined with non-porus clay, for above ground disposal, the containers would be sealed in concrete unit. Betchel Power Corpn. has developed a moduled container approach to LLW disposal that it says could be used for mixed wastes, according to its project engineer, Fred Ferzollah. Betchel's design consist of reinforced concrete canister with walls about eight inches thick, each capable of holding 18 drums of waste.

Pacific Nuclear System Inc. has begun marketing a Japanese waste drum technology, it believes could be used to meet the new standards, for mixed waste disposal. The design by Chi Chibu Cement Co. features a steel fibre reinforced, polymer impregnated concrete coating the inside of a steel alloy drum. The product as marketed now as high integrity container (HIC) for LLW disposal,and is to last 300 years for B and C level waste disposal.

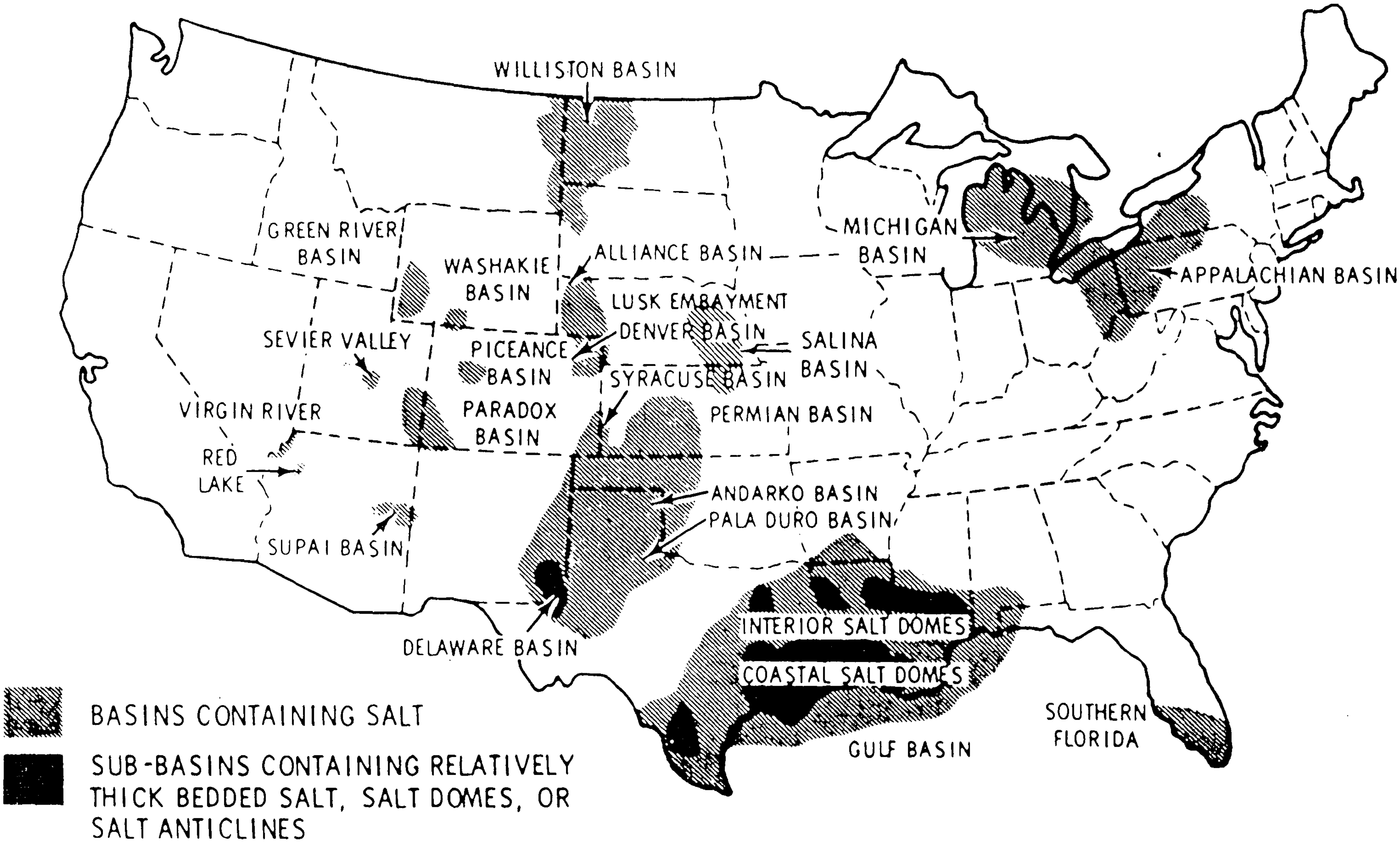

Figure 3.1 Bedded and Dome Salt Deposits in the United States.

Major nuclear waste storage/disposal sites.

Fig 3.2

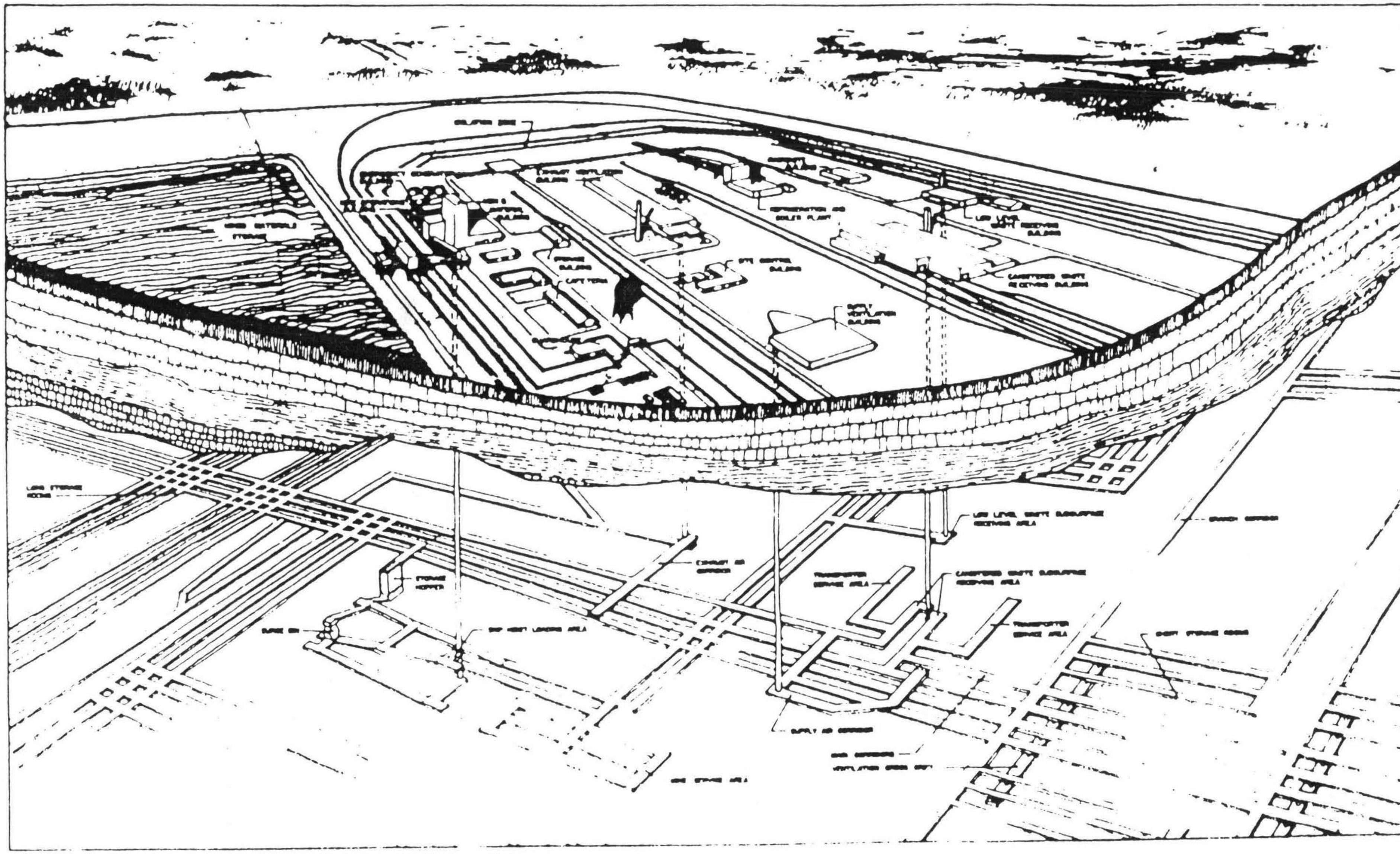

Figure 3.3 Artist's Conception of a Geologic Repository and its Support Facilities.

"The national radioactive waste management programme, then finds itself somewhere between the frying pan and the fire. The federal government, first through the AEC and more recently through ERDA and DOE, has always maintained that radioactive waste disposal is technologically feasible but for safety and economic reasons is best deferred into the future : in the meantime they rely on temporary storage in engineered surface facilities."

Man's unique reward, however, is that while animals survive by adjusting themselves to their background, Man survives by adjusting his background to himself.

Ayn Rand : The virture of Selfishness

MANAGEMENT BY THE MAJOR TRANSATLANTIC ALLIES

"In the fragmented political structure, major issues are seldom resolved by a single political institution or with a single yes-no decision."[1] Instead, major decisions evolve gradually as partial, interim choices are made by many individuals and institutions in a long and complex decision process. To complicate matters further, most of the political institutions in trans-atlantic nations reponsible for nuclear wastes have undergone a series of reorganizations; and there may be further changes. This chapter is a sketch only of the main features of the institutions that will be most responsible for shaping the management of nuclear waste for the trans-atlantic nations in the near future.

1. L.C.Gould, Charles A, Walker & E.Woodhouse (ed) Too Hot to Handle ? p.151.

BRITAIN

Liqiud waste are stored as acidic solutions at Sellafield and Dounreay reprocessing plants in stainless steel tanks.

"On the coast of Cumbria, in the English Lake District, there is a nuclear reprocessing plant called Sallafield, formerly Windscale, that daily pumps up to a million gallons of radioactive waste down a mile and a half of pipeline, into the Irish Sea. It has done this for theirty-five years. The waste contains cesium, ruthenium, strontium, uranium, and plutonium. Estimates published in the London Times and in the Sunday Observer are that a quarter of a ton of plutonium has passed into the sea through this pipeline - enough, in theory, according to the Times, to kill 250 million people; much more than in theory, according to the Observer, to destroy the population of the world. The plant was designed on the assumption that radioactive wastes would lie harmlessly on the sea floor. That assumption proved false, but the plant has continued to operate in the hope that radioactive contamination may not be so very harmful, after all. If this hope is misguided, too, then Britain, in a time of peace has silently, needlessly, passionlessly, visited upon us all a calamity equal to the worst we fear."[2]

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2. Robert Emmet Long (ed) : The Problem of waste dosposal. p.167.

In November of 1983 a family was walking along the beach near sellafield - when a scientist who worked at the plant stopped to tell them that they should not let their children play there. They were shocked, of course, and raised questions, and sent letter their MP. The scientist was fired amid official mutterings about his having committed an impropriety in disclosing this information. No doubt he had violated the Official Secrets Act, though so far as the matter was not couched in those terms. British Aerospace, the postal system, and the nuclear industry, as in India - are obliged to sign the act, which imposes on them fines and imprisonment if they reveal without authorization information acquired in the course of their work. Only death can release them from this contract. Employees of private industries are in the same position, for all intents and purposes, since the unauthorized use of privately held information is "Prosecuted as theft". In the democratic institutions, the exercise of judgement and conscience is the exclusive prerogative of the state.

"In 1986, the 12 Member states of the European Community consumed a little more than 1000 million tons(tonnes oil equivalent). Of this amount, 44% was accounted for by oil, 22% by coal, 19% by gas, 13% by nuclear energy and 2% by hydroelectricity. Today in the community, nuclear power represents 13% of total energy production (it was 2% in 1970) and 33% electricity production. These are averages : in France and Belgium, nearly 70% of the electricity produced is of nuclear origin, while Denmark, Greece, Ireland, Luxemberg and Portugal have no nuclear power stations. This does not stop some of these countries from purchasing electricity of nuclear origin from their neighbours."[3]

The British government faced the possibility of resignations among its top advisers on nuclear waste between 1987-90. This followed a changes by ministers to drop plans to build a shallow burial ground for a growing stockpile of low-level radioactive trash.

Until May 1,1984 the strategy endorsed both by Whitehall and by the nuclear industry rested on disposing of low-level wastes, and more highly radioactive intermediate wastes separately.

Low level wastes, of which some 25,000 cubic metres are produced in Britain each year, were to be buried in shallow trenches. Intermediate wastes totalling 3500 tonnes a year, were destined eventually for deep underground burial. Britain's the then Environment

3. Nuclear Energy in the European Community, Brussels Nov.1987 p.3-4.

Secretary, Nicholas Ridley, told House of Commons that both categories of waste would be disposed of in deep repositories. Work on evaluating four possible sites for a new dump for low-level waste was abruptly ended.

This decision, which marks a significant change in policy, was taken without consulting the government's own independent scientific advisers, the Radioactive Waste Management Advisory Committee. The then acting Chairman of the Committee, Professor John Greeting, Warned that he may resign. "I am considering my position", he said. He expressed anger, frustration and surprise at the way the ministers had dealt with the issue.

The government justified its U-turn on economic grounds. Most MPs and observers believe the real motive was political. There was bitter local residents opposition to all the short-listed sites for dumps for low-level waste in Bradwell in Essex; Elstow in Bedfordshire; Fullbeck in Lincolnshire; and Killingholme in Humber site. Infact all were in constituencies represented by Tory MPs.[4]

"One wonders what the future role of the advisory committee will be" said Greening, former head of the

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4. M.Perutz - Is Britain befouled ?, Vol 36 23 Nov 1989, p.12.

medical physics department at Edinburgh University. "The key decisions are being taken on political and economic grounds. It no longer seems to us that decisions are in need of scientific advice".

Britain routinely discharges low-level liquid waste into the Irish Sea, but buries low-level solid waste. High-level waste from the Capenhurst reprocessing plant is stored in stainless steel tanks, awaiting solidification, vitrification, and long-term storage. Meanwhile, exploratory holes have been drilled in northern Scotland and in Cornwall.

After several years of experimentation with their own methods of solidifying hot wastes, Britain has chosen the French process. British Nuclear Fuels Ltd. is building a 5400 million AVM facility at Windscale that will go into operation before the end of the decade.

Finding acceptable land-based sites for dumping radioactive appeared controversial. Underground burial existed as the only option for the nuclear industry and the British government. The underground burial strategy largely favoured by the Nuclear Industry Radioactive Waste Executive (NIREX) appears to be very unwelcome prospect for those who may end up living close to the sites.[5] The problem of nuclear wastes management is enormous. Over the next 40 years, a final resting place must be found for nearly 1.2 million cubic metres of rubbish from nuclear power plants, nuclear reprocessing and a variety of research, medical, industrial and military sources. That is the estimated total of low and intermediate-level waste (LLW and ILW) which will be generated.[6]

Two British companies have produced competing solution which sidestep the problem of winning approval for burial on land. Both proposals involve disposal under the seabed. And both methods rely heavily on conventional mining and offshore oil and gas technology. The rival companies are :

(a) Wheeler offshore

(b) Consolidated Environment Technologies (CET).

Wheeler's system is known as POWER, (Pipeline Operated Nuclear Waste Repository). Under this scheme cannisters of radioactive waste would be "pumped" hyraulically down pipelines and placed, by remote control in Sub-sea wells. The waste would be loaded into the system at a off-shore station, possibly sited at a nuclear power plant wheeler estimates that one of its repositories could hold as

5. N.S.Maynard, S.M.Nealey, J.A.Herbeurt and M.K.Lindell; Public value Associated with waste Disposal, Washington, 1976. p.43 - 44

6. Stewart Firth ; Nuclear Plaground, London 1987 p.67-69

much as 50,000 cubic metres of packaged waste. CET's concept is on a much larger scale. It would involve sinking a shaft 15 metres in diameter under the seabed. Large modules of waste, up to 2,000 tonnes in weight could be lowered into the shaft. This could be sunk up to 3,000 meters deep. The scheme would be suitable for bulky waste from decommissioned poower plants and mothballed nuclear submarines. It would also cut down the radiation dose experienced by workers who would have to handle large volumes of waste. To date Wheeler has spent more than £ 120,000 on developing their scheme. CET also has spent just over £120,000. Both systems require at least three or four year's development work before their commercial viability could be assessed.

Wheeler has joined forces with a French company called ACB Alsthom. Together they are bidding to install a POWER system in Taiwan. The Soviet Union is also interested and the CET says that the Japanese have shown interest in its system, but so far neither proposals have won the backing of NIREX.

Full-scale technical presentations of both schemes are due to the made by the NIREX shortly. Both are formidable legal obstacles, as well as considerable political, public and diplomatic opposition to the use of the sea, and the seabed, for radioactive waste disposal have been made.[7]

The British plan to relocate the intermediate-level nuclear waste, currently kept in hundreds of concrete silos on nuclear sites throughout Britain. The task will be handled by Nirex is responsible for all but high level waste, remains the sole responsiblity of BNFL. For long-lived intermediate- level wastes, Nirex is considering using abanoned anhydrite (Calcium sulfate) mine in the northeast of England. The rock has three times the strength of concrete, and the rate of water seepage is very low. For short-lived intermediate-level wastes Nirex is considering clay deposits which dominate the centre of England, specifically the CEBG site near Bedford once earmarked for a power station.

The UK firms Wheeler Offshore Ltd., Lincoin, and Press Offshore Ltd., Wallsend, Tyneside (Part of the AMEC, PLC construction group), have agreed to carry out joint feasibility and design studies on the POWER system designed by Kenneth Wheeler, Chairman of Wheeler Offshore. Wheeler's earlier claim that his firm and a French company were negotiating to supply the system to Taiwan but, after denials from that country, the announcement was premature.[8]

7. J.J.Rahn et all p.686

8. R.E.Long p.171 - ...

The Taiwanese misunderstanding does not affect the provisional agreement signed with Wheeler Offshore by Claude de Vaulex, head of France's ACB Alsthom's Subsea Activities Group, The two companies had agreed, in principle, on a joint venture in the hope of providing the POWER system under licence to Taiwan, and they were negotiating terms of the joint venture.[9]

Apart from interest already shown in POWER by C.Itoh and Nippon Steel, a third Japanese firm, Mitsui Mining & Smelting, made an imprompt visit to Wheeler Offshore headquarters in late March, 1990.

Highly active waste is currently stored in a liqiud. It is planned from the early 90's to vitrify the waste by using the French AVM system. Because of the temprature, the vitrified blocks will be placed in a specially designed store, cooled by air or water, on or near the surface for at least 50 years. The possibilities for disposal being considered are placing the blocks on or under the belt of the ocean or in deep geological fomation on land. Research is being conducted in to the feasibility of ocean disposal and drilling programme to investigate the properties of certain rock formations and the fesibility of geological disposal.

9. S.H.Murdoch, F.L.Leistritz 3, R.R.Hamm: Nuclear Waste : Economic Dimension of long Term Storage, Colorado, 1983 p.127-31.

FRANCE

Liquid waste are stored as acidic solutions at the Marcoule and La Hague reprocessing plants in stainless steel tanks. The PIVER pilot plant to solidity waste into borosilicate glass was in operation from 1969 to 1973. It has been superseded operation at Marcoule in 1978, capable of vitrifying wastes from essentially in 800 ton/y fuel reprocessing facility.

France has constructed or is in the process of construction reprocessing facilities with an annual capacity of 32,000 metric tons. Liquid reprocessing wastes have been stored in engineered storage facilities until now. The French have developed a programme for converting the liquid wastes to borosilicate glass and are also assessing the suitability of salt as a medium for geologic disposal. In search of a permanent disposal site, the French have drilled a number of exploratory boreholes. One of them is more than 1000m deep into granite of the Massif Central, at Auriat.

France was studying geological sites in the Delux serves region, near Nantes, for the disposal of nuclear wastes. The waste disposal authority ANDRA is already studying granite formations at Nouvey-Boin. In addition, three other sites would be selected each in a different type of geological formation : clay, shale and salt domes. An underground laboratory will be built, to become operational in 1991, to determine the technical feasibility of storing waste underground. These proposals have already provoked considerable local opposition.[10]

The French, were relieved that a democratic debate in Sweden produced the same results that they had achieved by a flat. Unlike Germany and Sweden, France is without a nuclear safety law or an independent nuclear safety control group. The international nuclear critics who have played such an important role in the U.S, Swedish, and German deliberations have had little impact on French nuclear policies.

Public participation in France provides strong contrast with Sweden. Not only has there been no moratorium or public debate, but quite the opposite : France has plunged into an ambitious nuclear power programme that aims to produce 60 percent increase of the country's electricity needs, a 46 percent increase in current nuclear output. By 1990 the

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10. Y.A.Gowan; A Natural Fission Reactor, Scientific American 235, No 1, 1976. p.36.

French had aimed to generate 30 percent of their total energy from nuclear power rather than the 5 percent it contributes today.[11] This could not be done because by the early 1991, the French were following the same set of rules as set up in 1986. This is due to rise of environmental protection groups in France.

The official attitude - that "there is nothing to be gained for real infoming of the public by holding controversial debates" and "There Mile Island could not happen here" - has been accepted by a majority of the people, particularly in the light of the cutback of Iranian oil exports and the increase in oil prices".

France's second low-level waste disposal centre, at Soulaines (in the Aube prefecture) 50 km east of Royes, will be nearly 10 times as large as the present centre, La Manche, near Cap La Haque reprocessing complex, in Normandy. According to the official responsible for its construction, the "Centre de Stockage de I'Aube (Aube Storage Centre) is designed with "the lessons of the Manche Centre in mind". Among other improvements, it will feature a new system of mobile shelters to protect waste

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11. N.E.Abrams, Nuclear Politics in Sweden, Environment, Vol 21, No 4, May 1979. p.6.

packages during handling as well as wide use of automated systems.[11]

ANDRA (Agence Nationale pour la Gestion des Dechets Radioactifs), the national nuclear waste management agency received permission from the French government in 1984 to search waste management programme approved at that time. Site-specific studies at Soulains were authorised and ANDRA submitted its licence application for construction of the Aube centre in June, 1986. According to Yves Marque,

ANDRA's manager of projects, the agency hopes to receive the two licenses required - a Declaration of public utility (allowing expropriation of land for the centre) and a construction permit this summer. Work at Soulaines would begin immediately after the permits are granted and the centre would be ready in 30 months, according to ANDRA's schedule.

The 12-hectare (30 acre) Manche site, opened in 1969, has a capacity of 400,000 cubic metres of LLW and will be saturated by 1990, according to Marque. Already some waste packages (notably those coming from reprocessing of foreign fuel) are being stored

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12. P.Lewis, French Press Plan for Nuclear waste, New York Times, 20 Nov 1978, p.17

at La Hague awaiting disposition. Deliveries of waste to the Manche centre amounted to some 20,000 c.u.m.Of this, 39% came from reprocessing, 46.5% from nuclear power plants, 3.2% from fronend fuel operations, 8.6% from research laboratories and the military branch of the Commissariate a l' Energie Atomique (CEA), 0.4% small from producers, and 2.3% from miscellanious sources.

France placed a pilot waste-virtification plant called PIVER in operation in 1970. It uses the technic of fixing reprocessed wastes in borosilicate glass logs that was originally developed at Brookhaven National Laboratory in the late 1950s. After years of successful operation of PIVER a scaled-up prototype was placed in service in 1978, and it, too, has been operating successfully. It is known as AVM, for Atelier de Virtification de Marcoule, the French nuclear research centre where PIVER is also located. The process that it uses has many steps in common with a U.S.virtification process developed at INEL.[13] The cost of vitrication using the AVM process adds about 2% to the cost of electricity in France.

The canister of glassified waste by PIVER was lowered

13. William E.Colgrazier Jr. (ed) : The Politics of Nuclear Waste, (New York, 1982), p.101.

into a concrete honeycomb below the floor of a large bay ; each pit had a metal lid.. Personnel could work on the floor above the waste without danger. No radiation exposures occured, according to the French.[14]

AVM is capable of processing 150 m^3 of vitrified wastes per year. This not only satisfies the needs of the Marcoule Centre, but will also absorb, within a few years, the backlog of liquid waste accumulted over the past 20 years.

'Between its commssioning in June 1978, and December 31,1982 AVM has operated 15.016 hour daily. In this time it has vitrified 436 M^3 of calcined high level waste, producing 200 tonnes of glass. A total of 586 canisters of vitrified waste have been placed in storage vaults during that period, according to Cogema, the French nuclear fuel-cycle company that operated AVM.

The first of three candidate sites for French high-level waste (HLW) has been designated by the French Government. A granite formation near Neuvy-Bouin in the Deux-Sevres department (prefecture) is the first site to be investigated for its suitability for

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14. Spent fuel & Radioactive waste, Washington DC, 1988 p.72.

disposal of high level and long - lived radioactive waste.

The Deux-Sevres, whose capital is Niort, is in the West central France, north of Limoges. The Neuvy-Bouin ganite dome, part of the Armorican Massif, has a surface of about 250 squre kilometres and is between 3000 and 5000 metres deep of 10 villages on the dome. Neuvy-Bouin is closest to its highest point. Opposition to the geophysical explotion project has already begun,organised at subprefecture, Parthenay.[14].

The government is expected to name three more candidate sites, in clay, salt and schist formations, shortly. ANDRA, the national waste management agency that part of the Commissariat a I'Energie Atomique, is to run parallel exploration projects at all four sites. One or more of the sites will be selected for construction of underground test beds in which the suitability of the site(s)for a long term high level and alpha waste disposal will be further investigated through simulation. Final designation of a repository site is not anticipated before the mid 1990s. Vitrified high level and alpha wastes will be stored an interim basis in engineered facilities at Marcoule and La Hague.

Meanwhile, the government is to select a second candidate site for a shallow land burial facility for low and medium level wastes. The first site, at Soulaines in the Aube prefecture, was designated in 1986. Low and medium level wastes are currently disposed of at the La Manche site near the La Hague reprocessing complex.[15]

Borosilicate glass at the AVM is that the proporties of its components can easily be modified to suite specific uses. The glass produced usually contains 35-50% silica and 14-20% boric oxide.

"Fashion product" solutions from the adjacent reprocessing plant are fed to a metering unit that feeds a calciner at a rate of 36 liters/hr. The calciner is a continuously fed rotary kiln where the concentrated wastes are evaporated, dried, and partially calcined. The calcine flows continuously by gravity into a melting pot to which glass frit is also continously injected. The mixture is melted at 1150°C. Throughout the process, off gases are purified, condensed, and treated to remove radionuclides. Active secondary effluents are sent to the reprocessing plant, or to a waste treatment system.

15. J.J.Rahn et all p.684.
16. ibid p.684

The glass is periodically cast into a stainless steel canister. They are then subjected to radiological inspection. Then they are placed in a transfer cask, and routed to the storage vault by a travelling crane. It is the stored in vertical concrete vaults in one of the AVM buildings. Several processes for actinide extraction from high level waste exist. TBP, tri-butyl phosphate or DHDECMP, an organo-phosophorus bidentate compound, can be used to partition the actinides from the bulk fission products. Partition factors up to 10,000 have been achieved. The storage building contains 220 vaults each 10 m high, each with a capacity of 10 canisters each. These vaults are cooled by forced convection ventilation. The total capacity of 2200 canisters represents 10-15 yr of virtification programme.

Cogema has announced that the experience acquired at Marcoule with AVM will be shortly used to build two similar vitrification plants, AVH I and AVH 2 at the La Hauge reprocessing plant on the Cotentin peninsual near Cherbourg. AVM has a capacity of processing 150 m^3 of liquid fission products annually while the two new plants will each have a capacity of 90 m^3 of fission products a year. AVH I will be installed at the first reprocessing plant at La Hague and will be able to work up in a few years all the backlog of liquid high-level waste accumulated since the start of operations there, and thereafter to keep up with the output of liquid waste frp, the reprocessing plant. The second vitrification plant will be installed at the second reprocessing plant at La Hague. Construction of AVH I began in 1981 and was completed in 1986, AVH 2 was operational by late 1988.[17]

FEDERAL REPUBLIC OF GERMANY

Liquid waste from WAK reprocessing pilot plant are stored in stainless steel tanks. Studies of solidifying wastes into borosilicate and phosphate glass are in progress.

The FRG has no reprocessing capacity for commercial fuel, but it had a commitment from France to reprocess all uncommitted German fuel by 1981. Germany plans to construct a fuel cycle centre at Gorleben in Lower Saxony. At this site, fuel will be reprocessed and recycled, and waste will be buried in salt below the site. Some political problems may arise form this, however, because the Gorleben salt dome extends under the Elbe River which flows into East Germany. Currently, the Germans are disposing the low and intermediate level wastes in abandoned

17. L.J.Carter : Nuclear Imperatives and Public Trust - Dealing with Radioactive waste, (Washington DC, 1987) pp. 95-97.

salt mine at Asse.[18]

In the Federal Republic of Germany, solid waste disposal has been allocated to a number of agencies within the Federal government. The major responsibility for waste disposal control is vested in the Federal Ministry of Public Health and its constitutent departments : the Institute for Water, soil and Air Hygiene in Berlin: the Central Office for Solid Waste Disposal (a cooperative organisation of the federal government and individual state governments); and Land cooperative for Waste Management.[19] In the private sector, the management of solid wastes is carried out by many organizations, including industrial corporations. The leading private organization for waste management is the Arbeitsgemein Schaft fur Abfallbeseitigung. This organisation is composed of experts from municipalities, industries, and agricultural associations and functions in advisory and consultative capacities for communities engaging in solid waste management. The actual responsibility for waste management devolves on local government bodies; however the central office for Solid Waste Disposal is charged with the responsibility to provide guidelines and criteria for waste disposal

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18. S.Keretz (ed) : Nuclear Non-Proliferation in a world of Nuclear Powers,(London, 1967). p.68
19. J.L.Pavoni, J.E.Heer Jr., D.J.Hagerty : Handbook of Solid waste Disposal, Material and Energy Recovery. (New York,1975) p.450

and is responsible for optimizing refuse management in large regions through the development comprehensive waste management plans. Additionaly, at the state government level some regional authorities have been established to cope with the overall responsibilities of municipal government in providing services for the populace. For example the Ruhr Regional Planning Authority operates in the state of North Rhine-Westphalia. This planning authority has a separate solid waste unit which is responsible for developing a comprehensive waste management plan for North Rhine-Westphalia.One of the facilities established by a regional planning authority in the Federal republic of Germany will in recent years, a type of fully-covered metal container, typified by the German "dustless" container which has a volume of 110 litres. In addition some smaller containers in the range of 35 to 50 litres in volume are used in Germany.[20]

West Germany originally planned to establish a single centre for reprocessing and high-level waste disposal, at Gorbehen, not far from the East German border. This plan became controversial and politicized, and was sidetracked. However, although deciding eventually in favour of smaller regional

20. ibid p.457

reprocessing plants, West Germany returned to its plan to build a waste repository at Gorleben. Drilling of shafts began early in 1982. The repository there would be in a salt dome. A review of the project by international specialists resulted in a finding in the late 70s that the site was safe for a repository. A decision by lower Saxony regulatory authorities on the plan to bury low and medium level radioactive waste (LLW and MLW) in the old Konrad iron mine, located near the East German border, was delayed by about 10 months past the original target of 1987, according to officials at the Physikalisch Technische Bundesanstalt (PTB) in Braunschweig.[21]

PTB is responsible under the West German Atomic Act for the management of the country's nuclear waste. Besides the regulatory review delay, additional red tape and mine safety requirements have pushed back the PTB's target date for actual waste burying by two full years, to late 1991.

A PTB official said that it will take "longer than expected" for officials at the Ministry of Environment in the state of lower Saxony to review the Konrad technical documents, which were handed

21.Something dead cannot be buried, US News and World Report, Vol 107,No 17,11 Dec,1989.

over by the PTB in October 1986. In December, state officials informed the PTB that they were satisfied that the documents were complete. In January, PTB officials said, additional documents prepared by other experts, including the nuclear inspectorate Technischer Ueberwachungsverin (TUEV) and the Gesellschaft fuer Reaktorsicherheit (GRS) were folded into the PTB material and the complete package handed over to the ministry. Meanwhile, adapting the Konrad mine to nuclear waste burial took 10 months longer than originally planned due to the need to comply with stiffer state mine safety requirements.[22]

Vitrification process are being developed for conversion of the high level wastes to glass after a three to five year cooling period. Salt formations similar to Asse are being studied for disposal of vitrified product and other solid radioactive wastes.

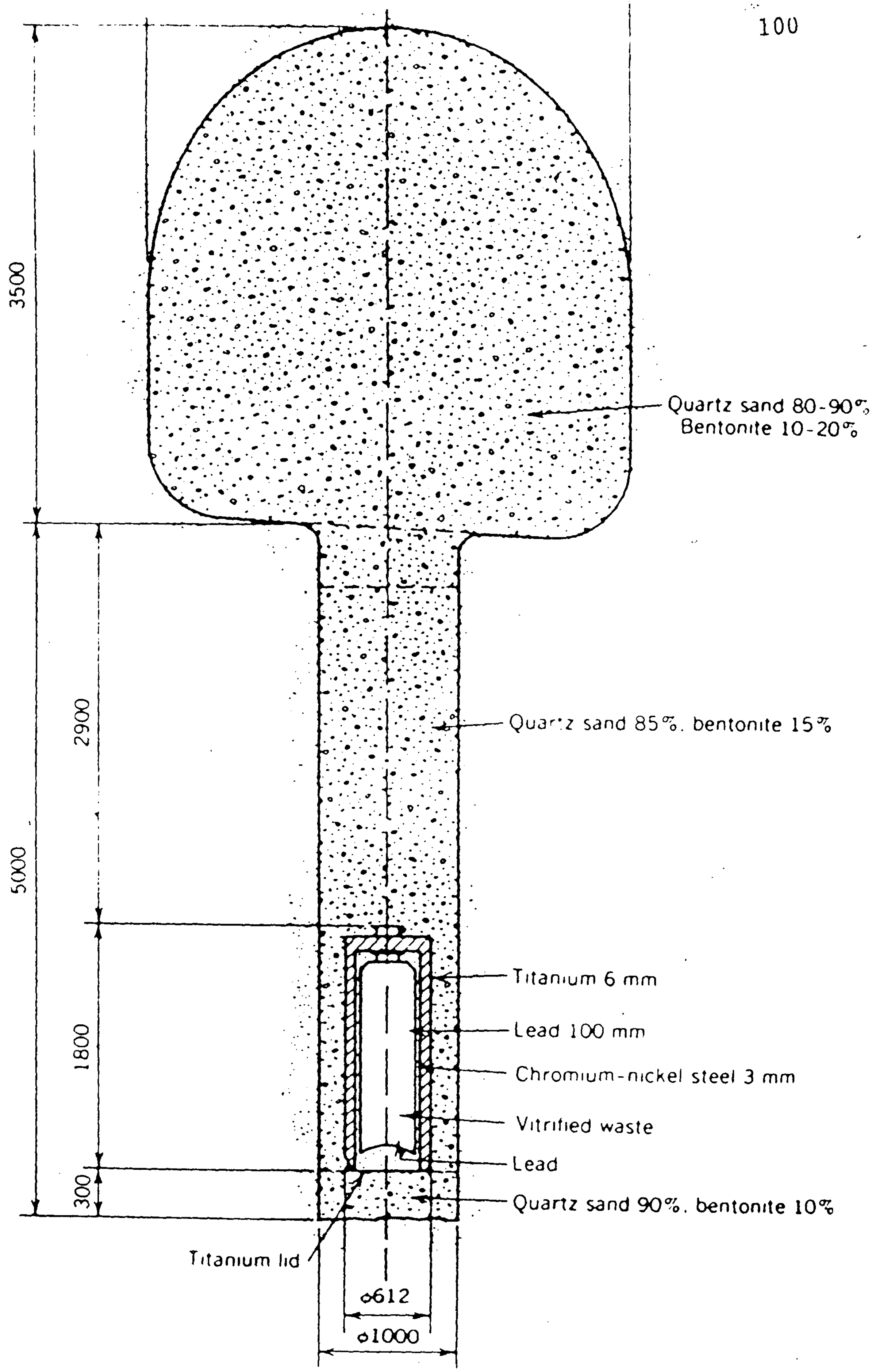
22. J.L.Pavoni et all pp 499 - 501

SWEDEN

A study of how the Swedish population learned about nuclear energy revealed that 79 percent received their information from TV; 47 percent believed that most trustoworthy information it received came from broadcasting and TV sources. Only 2 percent cited the study circles. Which has been such a large part of the public education effort.[22]

The Swedish government has a reactor licensing policy similar to that of California. In order to comply with the "Nuclear Stipulation Law", as it is called the Swedish power industry established the Nuclear Fuel Safety project - also called the KBS project - to develop and evaluate a method for the management of glassified liquid waste from reprocessing through storage in deep crystalline rock.[23] Under the KBS plan, spent fuel will be reprocessed in France, the liquid wastes vitrified and placed in stainless steel canisters returned to Sweden and allowed to cool for theirty years, with emplacement of the encapsulated wastes in a crystalline rock repository at a 500 meter depth no earlier than 2020. The storage holes and tunnels will be backfilled with quartz sand - bentonite mixture that possesses good ion-exchange

22. William E. Col. Grazier (Jr), (ed) p.177.



4.1 The Swedish KBS final repository. Tunnels and storage holes are completely filled buffer material consisting of quartz sand and bentonite. All dimensions are in millimeters characteristcs and that upon contact with water expends to become almost totally impermeable. A review of the KBS Report by the California Commission concluded that many of the technical gaps troubling the U>S>geologic disposal programme would also be encountered in the Swedish Programme. An assessment of the report written for the Swedish Energy Commission by Dr. J.Winchester of the Florida State University Department of Oceanography presented similar conclusions Sweden is also cooperating with the U.S.in tests being conducted in abandoned iron mines to determine the response of granite to heating.[25]

Sweden has dug a cavern in the bedrock under the temporary spent fuel storage facility built adjacent to the Oskarshamm nuclear power station. Four large pools are being carved in this cavern to hold spent fuel for cooling. The center is expected to accommodate 9000 tons of spent fuel and other reactor components.

High level waste will be finally disposed of, in granite, or comparably homogeneous rock, problems of disposal in granite are being studied at the unused stripa mine by an International group including

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25. J.J.Rahn et all p.686

Finland, Japan, Sweden, Switzerland, and the United States, with Canada and France as associates. Electric heaters are being used to simulate the heat of high-level waste. Sweden has also pioneered in the development of ceramic overpacks and canisters to hold waste.

Moreover, the Swedish government has issued the construction permit for a final storage facility for reactor waste (SFR) to be constructed in crystalline rock coverns some 50-1-- m below the bed of the Baltic sea, at a site close to the Forsmark nuclear power station. The repository will be used for all low and intermediate-level wastes arising from the country's 12 reactor nuclear power programme.

The location below the seabed is considered co after several valuable safety factors. The hydraulic gradient in the rock mass underneath the sea is low and therefore the groundwater flow is also very small. In the unlikely event of the radionuclides escaping, they would be diluted in the large volume of seawater. Finally, the risk of someone drilling a well through the repository is considered negligible.[26]

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26. C.Cluett, C.Sawyer M, Olsen and D.Manniren, Social and Economic Aspects of Nuclear waste Management Activities - Impacts and Analytic Approaches, (Washington DC, 1979) p.91-100.

The Swedish Nuclear Fuel Supply Company (SKBF) will build and operate the SFR facility, which will accept for final disposal all low-and medium level reactor wastes from all Swedish nuclear power plants and central interim storage facility for spent fuel. SKBF is a jointly owned company of the Swedish nuclear power plants and central interim storage facility for spent fuel. SKBF is a jointly owned company of the Swedish nuclear power utilities which, according to Swedish law, bear the primary responsibility for the safe handling and disposal of wastes from nuclear power production.

BELGIUM

Liquid wastes from Eurochemic reprocessing plant are stored in stainless steel tanks.

Belgium has an innovative approach , born out of necessity. The country has no suitable salt or granite deposits. Consequently it is attempting to dig a repository in the homogeneous and impermeable clay that had been deposited millions of years ago on what was then a sea floor.

Some 525 ft. under the Belgium national nuclear research centre at Mol, this clay is 360 ft thick. A shaft has been drilled down 720 ft, penetrating this layer. A horizontal gallery is being excavated for tests of the suitability of the clay for the storing of medium and low level waste. A possible disadvantage, however, is the low thermal conductivity of clay. Thus heat might build up to unacceptable levels if high-level waste were stored there, unless it had been cooled a long time.

In addition, the Belgium government may soon give the go-ahead to the construction of an AVM plant at the MOL research centre. But in order to neutralize some 65 m[26] od high level waste still on the site as a result of previous reprocessing activities. Belgium specialists have come up with a variation of AVM that will produce borosilicate glass blocks and heads embedded in a lead-alloy matrix. The pamela plant (Named for the process) started operating inlate 1986.

Although Belgium has an active waste management program that is investigating, among other things, geologic disposal, it seems unlikely that any waste will be buried within the borders of the country as a result of its limited land area.[27]
Vitrification processes are being considered for waste solidification including the incorporation of a granular product into a metallic matrix. Solidified waste will be placed in engineered surface storage. Investigating clay formations for waste repository.

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26. Nuclear Energy in the European Community, Brussels Nov.1987 p.3-4.
27. J.J.Rahn et all p.688.

The aforesaid account by and large indicates that all these European states have basically followed what we can term as "follow the leader-principle" (the leader being United States of America). Salt domes, as this chapter emphasizes, has been considered the best option for the European States ; There are a lot of "if's" and "buts" here also.

Now, as America discovered in early 1991, the Yucca Mountain Scandal, the European States programmes of a salt done disposal has gone away specially in Britain & France. Now they consider that "IF" technology develops, they will be able to put nuclear waste into the space. But then the "IF" remains and nothing much has been done by these states.

Simplicity is the most deceitful mistress that ever betrayed man - Henry Brooks Adams (1838 - 1918)

This statement summarizes the past situation in regard to nuclear wastes.

CONCLUSION

The radioactive waste problem that we are facing today has been many years in the making. Over thirty years ago government commenced "temporary" storage of highly radioactive liquide waste in steel tanks in the belief that disposal was best deferred until a later date. Save for what has been lost through leaks, the wastes remain in those, or similar, temporary tanks. Almost twenty years ago, electric utilities began by placing spent fuel assemblies in "interim" storage pools, assuming that the fuel would remain in storage for a limited time. The spent fuel however remains, for the most part, where it was originally placed. Ten years ago, the Atomic Energy Commission promised that all trans-uranic waste in the state of Idaho would be removed and placed in a repository by 1979. That waste has not been moved. Today, the Department of Energy promises final waste disposal by 1990 or 1995 and at the same time emphasizes the need for "interim" away from reactor spent fuel pools to relieve pressure on the reactor operators. In view of the "history of unbroken failure to produce an acceptable method of waste disposal", as one public official has put it, there is little reason to be optimistic about this prediction. Given the undeveloped technical state of the various waste management and disposal options and the developing political and social problems of the current federal program, is it likely that successful waste disposal will be achieved by the end of the century ? One can have little confidence. From a technical point of view the means needed to accomplish this goal are likely to be fairly well developed within the next decade or two. However, dealing with the political and societal requirements needed to ensure success will be much more difficult. It is our judgement that without major changes in the current programme particularly with regard to the non-technical requirements - an acceptable means of disposal will be extremely difficult to develop and to implement. The basis for this conclusion are presented in this chapter. We begin with a brief review of the salient points of the problem. We then discuss what we believe to be technical, political and societal requirements of a successful disposal effort and evaluate the current program in light of these requirements.

The passage of the Low level Radioactive Waste Policy in December 1980 established a sound policy framework on which to rebuild an equitable and stable regional management system. The act was the culmination of a year long effort by several state officials and organisations, including the National Governor's Association and the State Planning Council, to persuade the federal government to let each state be responsible for assuring the safe management of the commercial low level waste generated within its borders. Through asserting their own self-interest by temporarily closing sites and forcing volume reductions, the three states with operating dumps eventually convinced other states, (the generators). and the Congress that a lasting solution to the problem of opening new sites was needed, that it should not come from accepting commercial waste at federal sites, and that states could develop the competence to do the job. The fact that the generators include hospital and research institutions (generating 25 percent of the volume in 1978), industry (24 percent) as well as commercial power reactors (43 percent), and that these generators maintained a united front in their aggressive lobbying was a contributing factor in persuading other state governments to focus on the issue. The spectre of a possible curtailment of essential and popular services proved to be a powerful incentive to responsible action. But an essential ingredient was the federal government allowing states to generate their own appropriate role and, thereby, to develop a promising solution to a national problem.

The flurry of activity since the passage of the act indicates seriousness with which some states have accepted their new responsibility. Nevertheless, a sustained effort will be required on the part of the state governments to convert the new policy into practice.

The data of January 1, 1986, indicated that a regional compact can exclude waste from non-member states. The key stimulus to action - is not too distant considering the many tasks that need to be completed. By then, the compacts will have to be negotiated, passed by the state legislatures, and approved by congress. States or compacting regions will have to develop comprehensive management plans and processes for finding new sites. They will have to develop mechanisms for addressing the concerns of local communities and the general public in the site selection process. They will have to choose a competent private operator, to establish a financing mechanism, and decide whether the regulator will be state (under the Agreement States programme) or the Nuclear Regulatory Commission.

The radiological hazard posed by these wastes is of potentially great significance. For example, the plutonium 239 contained in the radioactive spent fuel discharged by one reactor after one year of operation would be sufficient to cause fatal lung cancers in the entire population of say a country like the United States, if dispersed as fine particles and inhaled. While we do not suggest that such material would be realsed to induce such damage, even the escape of small amounts of radioactive waste in to the environment may result in a perceptible increase in the number of cancer deaths in a population. Or radionuclides, free in the environment may be concentrated in marine organisms and terrestrial animals and plants and so enter food chains, thereby risking exposure of populations to potentially hazardous levels of radioactivity. Inevitably, in the absence of a working disposal technology, an increase in the quantity of radioactive waste in storage will mean an undesirable increase in the risk of radioactivity escaping into the biosphere. Should the levels of escaping material reach significant proportions, an increase in the overall cancer death rate could well be the result.

A great deal of radioactive waste is presently buried or stored at numerous locations around the United States. Some 17,000 spent fuel assemblies-the product of only about 450 reactor years of plant operation - are stored temporarily in spent fuel pools. This number is currently increasing by about 4,000 each year. About ten million cubic feet of high level liquid and solid waste produced by the reprocessing of plutonium for defence purposes resides in aging steel storage tanks at Hanford. Savannah River, and Idaho Falls, and 600,000 gallons ot high level waste are stored at the now abandoned West Valley Plant. There are sixty five million cubic feet of low level wastes of which fifteen million contain trasuranic nuclidesin shallow burial or storage at various government sites, and another sixteen million cubic feet of commercial generated low level radioactive materials are buried in six licensed waste facilities (of which three are permanently closed). Approximately 140 million tons of radioactive uranium mill tailings have been left in unstabilized or partially stabilized piles. Some of these tailings, used in construction, contaminate thousands of public and private buildings. Finally, many hundreds of obsolete, radioactivily contaminated buildings at government defence facilities await decommissioning, dismantling, and disposal will inevitably increase. The U.S.nuclear power programme is still slated to expand, and as reactors now planned or under construction are completed, they will begin to produce not only electricity but also over-increasing quantities of radioactive waste.

By 1995, the annual production of commercial spent fuel could equal today's total inventory. By the century's end, the United States may have as many as 300,000 spent fuel assemblies in temporary storage some 100,000 metric tons or seventeen times the number in storage today. The uranium requirements of a growing nuclear programme could result in the production of up to one billion tons of uranium mill tailings. Low Level waste inventories will run into the hundreds of millions of cubic feet. Quantities of this magnitude will greatly strain the storage capacities or temporary facilities and underline the pressing need for development of a permanent means of disposal.

The customary approach involves solidification of liquid waste into glass blocks followed by encapsulation in metal canister and employment of the canisters in geologic formations or, perhaps seabed sediments. Ultimately transmutation of some actinides or possibly disposal into solar orbit might become practical. Other disposal options are too costly, too risky, or too impractical. But even the most advanced technology-geologic isolation - is still no more than a promissing concept. Large-scale vaiirification of liquid waste is still years from implementation and serious questions being raised about the suïtability of the glass matrix suggest that it could turn out to be a poor choice. No one has actually constructed and tested a waste canister that will last for more than a few decades, even though many proposals are predicated on canister survival for centuries. Aside from some brief and generally inconclusive experiments in the 1960s, no one has actually placed a canister of radioactive waste in salt or granite or seabed sediment.

The management and disposal of radioactive wastes then has come to be recognised from both a health and economic viewpoint as a problem most critical to the future of nuclear power programme. This concern appears to be evenly spread over many sectors of the society. Nonetheless, the common concern has not produced a convergence of action. Various interest groups see the waste problem as a means to an end : ??? the government, to make its energy policy more attractive; the nuclear industry, to achieve economic viability; and the environmental movement, to halt nuclear power. The desire to eliminate this environmental pollutant is frequently secondary. One result of these conflicting interests has been development of a programme of "technical fixes" geared to getting the wastes out of sight and out of the mind of the public as soon as possible. The Waste Isolation Pilot Plant is a case in point. The WIPP site appears to be technically defective; a convincing technical case for successful disposal cannot be made in five or even ten years; the superiority of salt as a disposal medium, particularly with regard to resource availability, must be questioned; and an unsuccessful demonstration at WIPP might not only preclude recovery of the spent fuel, but could also cripple future disposal programs. The political commitment to WIPP is great- so great, apparently, as to prevent the Department of Energy from gracefully cancelling the project. Prudently discontinuing WIPP would mean at worst a postponement of demonstrated fuel disposal for perhaps five or ten years, no great price to pay in order to increase the chances for a successful programme. Furthermore, other portions of the programme appear to be better conceived from a technical point of view and could well provide the basis for construction of a successful repository in the 1990s.

Therefore successful radioactive waste management and disposal programmes must address three types of requirements. The programme must be technically feasible, it must be politically palatable, and it must be societally acceptable. It is a view that, of these three areas, only the matter of technical feasibility has been addressed in the past in any depth, and even here the treatment has been inadequate. Consequently, no programme of technical promise has ever been successfully implemented. Unless all three requirements are given at least equal consideration in programme development, lack of convincing success in the future is almost a certainty.

President Carter has stated: "The waste generated by nuclear power must be managed so as to protect current and future generations". This must be the foremost criterion for any waste management programme. This is the minimum demanded by society. Yet, it is clear that we cannot give a total guarantee that a waste repository will ever be reached or that no person or persons of future generations will ever be harmed. Requirements to this end would block necessary moves and hinder the needed progress because they are unrealistic and unachievable in the real world. What society can, or should, insist on, is that the risks, which, can be sufficiently small, can be bounded are made very small. Given adequate time and sufficient funds to sustain a competent programme this goal can be accomplished to the satisfaction of the bulk of technically competent observers and critics and, most importantly to the public at large. . . .

DECONTAMINATION AND DISMANTLEMENT

Decommissioning is waste management on a new scale, in terms of both complexity and cost. Following plant closure, the company or agency responsible must first decide which of three courses to follow :

(i) decontaminate and dismantale the facility immediately after shutdown.

(ii) Put it in "storage" to undergo radioactive decay for fifty to one hundred years before dismantling:

(iii) Simply erect a "permanent" tomb.

Each option involves shutting down the plant, removing the spent fuel from the reactor core, draining all liquids, and flushing the pipes. Elaborate safeguards to protect public and worker health must be provided at every step.

Under the immediate dismantlement scenario, irridiated structures would be partially decontaminated, radioactive steel and concrete disassembled using advanced scoring and cutting techniques, and all radioactive debris shipped to a waste-burial facility. The plant site would then theoretically be available for "undestricted" use.

Plants to be mothballed, on the other hand, would undergo preliminary clean up, but the structure would remain intact and be placed under constant guard to prevent public access. After fifty years most of the shortlived radioisotopes would have decayed, further safety gains would be negligible, and the facility would be dismantled.

Entombment, the third option, would involve covering the reactor with reinforced concrete and erecting barriers to keep out intruders. Although once viewed as the cheap and easy way out, entombment is no longer considered a realistic option because of the longevity of several radioisotope.

The volume of solvents used in decontaminating surfaces must be carefully regulated because the effcuent also becomes radioactive, spills during either operation or cleanup can result in contamination of the surrounding soil. Keeping waste volumes to a minimum is an elusive goal: each piece of machinery and every tool that comes into direct contact with a contaminated surface must be decontaminated or added to the radioactive waste pile.

In addition to contaminated structural waste, "activation" products are the other source of radiation confronting decommissioning crews. When nuclear fuel undergoes fission - the splitting or uranium atoms - stray neutrons and other particles escape and bombard the nuclei of atoms in the surrounding structures, and the resulting change in composition causes some elements in the steel and concrete that encircle the reactor core to become radioactive.

For the several decade following plant shutdown, the most problematical elements are those that decay the fastest. Measured in curies, or disintegrations per second, cobalt and cesium are the dominant short lived radioisotopes in contaminated materials. Other elements with longer half lives (the time it takes radioisotopes to decay to half their original levels) are present in smaller quantities and will dominate radiation levels in the future. Significant amounts of long lived nickel radioisotope is present in neutron- activated wastes and will probably render the wastes unsuitable for traditional shallow land disposal. The longest lived hazardous element detected to date, nickel-59, has a half-life of 80,000 years. Overall neutron-activity components contain over one thousand times the radioactivity of contaminated components.

Regardless of the method chosen, decommissioning a large nuclear power plant is a complex engineering task, without precedent. The high levels of radioactivity present at closed reactors, place numerous constraints on the decommissioning crew. Workers must take elaborate precautions and limit their time in contaminated environments. Radiation exposure must be carefully monitored and adhering to regulations can greatly reduce shift length. Worker productivity is unavoidably low, less than half of what it could be in a monradioactive environment. Much of the radioactivity in a retired nuclear plant is bound to the surface of structural components. The type of material and its exterior surface determines the depth of penetration. The range is typically from as little as several millimeters to as much as 15 centimeters for unsealed concrete. Although some surface contamination can be washed off by using high-pressure water jets and chemical decontaminants, only a fraction of the material becomes clean enough to recycle or dispose of in commercial landfills.

A survey of 30 electric utilities in the United States has revealed that 73 percent planned to dismantle and remove their reactors promptly following shutdown. In contrast, utilities in Canada, France, and West Germany are planning to mothball most of their reactors for several decades before dismantlement.

THE PAST AND RADIOACTIVITY MANAGEMENT

As a result of quasifficial disinterest, the waste management program was severely compromised, with leaks of waste and instances of inexcusable incompetence becoming the rule rather than the exception. Even where storage measures seemed to be clearly inadequate from an early date, as in the case of the Hanford tanks, the AEC chose to disregard to downplay the scope and significance of the problem. As with many other nuclear-related matters under its jurisdiction the hazards of weapons-testing fallout and reactor safety are two such examples the AEC chose to ignore, mislead, deceive the public about radioactive wastes.

We still face the consequences of this official mismanagement today. Leaks of radioactive wastes have become commonplace, and uncontrolled; old radiation dumps, their locations lost, are being rediscovered with alarming reqularity. A more serious casualty of the AEC's failures has been government crediability on the waste issue. The perhaps naive faith in the infallibility of the government's actions and existed in the 1950s has been replaced by a public cynicism and distrust that will constitute a continuing burden on future efforts to safely dispose of radioactive wastes. This is the legacy of the American Atomic Energy Commission.

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ROLE OF TECHNOLOGY

The technical prospects for developing a satisfactory means of radioactive waste disposal are, as much of a study illustrates, difficult to assess with total confidence, more because of significant unknowns than because of fundamental technical obstacles clearly in view. It is the judgement that technical problems can be largely overcome by investigations leading to judicious choice of disposal medium and site selection waste packaging and employment, and repository design and that none of these matters represents a fundamental technical obstacle. The necessary technology can be developed, surely for the shorter lived fissionproduct waste, and that at least in principle, the necessary degree of confidence in the technology can be achieved. Transuranic materials, with their long-lived radionuclides, and the longer lived fission products present greater problems, and although the required degree of confidence can probably be achieved for these wastes too, further reasearch is required to establish this conclusively. The problems and weakness of the current program lie not so much in the lack of technical possibilities as in the failure of the agencies responsible for the problem to infrastructure or are in the process of acquiring one. Among the safety factors related to nuclear energy is the question of nuclear waste disposal. Of these countries have to bank on nuclear energy (the most cost-effective of all other forms of energy, for them), they have also got to develop a nuclear infrastructure for disposal. It is in this context that the proposed research could contribute to the existing body of knowledge on the problem of management of nuclear wastes.

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