Approved 2/7/84
Date

MINUTES OF THE House COMMITTEE ON Energy and Natural Resources.

The meeting was called to order by Representative David J. Heinemann at
Chairperson

3:30 ~~a.m.~~/p.m. on January 18th, 1984 in room 519-S of the Capitol.

All members were present except:

Representative Keith Roe (excused).

Committee staff present:

Ramon Powers, Legislative Research
Raney Gilliland, Legislative Research
Theresa Kiernan, Revisor of Statutes' Office
Pam Somerville, Committee Secretary

Conferees appearing before the committee:

Mr. Charles Fagan, In-Washington Associates, Inc.
Mr. Sam Rod, Westinghouse Electric Corporation
Ms. Mae Damerow, Westinghouse Electric Corporation
Ms. Karen Adelson, Consultant for Westinghouse Electric Corporation

The Chairman introduced Mr. Charles Fagan, In-Washington Associates, Inc. Mr. Fagan, in turn, introduced members of his staff who would make the presentation on Energy, Mr. Sam Rod, Ms. Mae Damerow, and Ms. Karen Adelson, a Consultant. They began their briefing on energy by showing a slide presentation of nuclear generating stations, uranium composition, plutonium effects, waste disposal facilities and testing, and nuclear energy as a source of power.

Mr. Rod explained Wolf Creek would represent 15% of KCP&L's production, and 20% of KG&E's production. Discussion centered around nuclear energy and the benefits of uranium. He stated that one quarter ounce of uranium is equivalent to three-quarter ton of coal or 150 gallons of oil for electric generation. He also explained in detail the process of generating electricity from uranium. In terms of safety, Mr. Rod stated that power generated by natural gas was the safest, nuclear pwer second, and coal, the least safe.

Discussion turned to the cost of producing nuclear power and Mr. Rod explained that different types of fuels have different environmental impacts. He said it was up to the individual to compare facts and make recommendations and decisions based upon those facts rather than personal emotions. He cited the main reason for construction cost increases was due largely to the high interest rates, accounting for as much as one third to one half of the total cost of building the plant. Mr. Rod referred to a 1982 study indicating that electricity costs for nuclear power was 3½ cents per kilowatt hour, including building maintenance and customer service. This figure is comparable to that of coal. Oil is 7 cents per kilowatt hour although plant construction is much cheaper.

Karen Adelson, formerly with Westinghouse in Safety and Planning, addressed the issue of safety of low level radiation. She said two third of radiation is from cosmic rays, buildings, soil, food, water and medical applications. Of that balance, 90% represented radiation from atomic tests of the 1950's. She explained the effects of those residents living in close proximity to Wolfe Creek stating that they would receive no more than 5 units per year. To compare, she cited the plane trip from Washington, saying that they had received 3 units during that trip.

Discussion turned to the subject of Nuclear Compacts. Legislation mandates that each state create a site or an agreement with another state to dispose of hazardous wastes, which becomes effective January 1, 1986. Kansas is already a member of a compact.

CONTINUATION SHEET

MINUTES OF THE House COMMITTEE ON Energy and Natural Resources,

room 519-S, Statehouse, at 3:30 axx/p.m. on January 18th, 1984

In closing, Ms. Daeman stated there was continuing efforts to make disposal of hazardous wastes safer, and research was an ongoing process to establish new technology in storing and disposing wastes. A question and answer period followed the presentation.

Committee questions centered around the life expectancy of nuclear power stations. Mr. Rod responded by stating the accounting life of most generating stations was 40 years, however, actual life expectancy was 60 to 70 years.

Representative Fox asked what Mr. Rod's opinion was for an alternative to ground burial and the cost factors associated. Mr. Rod responded by saying ground burial was, by far, the least expensive but, in terms of safety, incineration was the safest mode. He went on to say that incineration was also the most expensive mode of disposal.

Following the presentation, three handouts were distributed to the committee for their review: An Overview of Decommissioning Nuclear Power Plants (Attachment 1); Nuclear Power from Fission Reactors: An Introduction (Attachment 2); and Low Level Radioactive Waste Disposal: The Problems and the Solution (Attachment 3).

There being no further business before the committee, the meeting was adjourned at 5:30 p.m.

The next meeting of the House Energy and Natural Resources Committee is scheduled for January 19, 1984 at 3:30 p.m. in Room 519-S.

Rep. David J. Heinemann, Chairman

Date January 18, 1984

GUESTS

HOUSE ENERGY AND NATURAL RESOURCES COMMITTEE

NAME	ADDRESS	ORGANIZATION
Joe Kramer		K.C. Power + Light
Jeff Morris		Kansas Gas + Electric
Sam Rod		Westinghouse Electric Corp.
John Frye	Pgh, PA	Westinghouse
Roy D. Shenkel	Shawnee	K.C.P.L.
George A. Dugger	Topeka	KDOA
Carolyn Crouch	Lebo	Rural Key EHU
James H Hays	Topeka	Division of Budget
Marsha Marshall	DeSoto	Kansas Natural Resource Council
[illegible]	Lawrence	NAN
Harvel Shoaf	Topeka	KEC
Charles Fagan	Washington, DC	Westinghouse
MARK RITTER	LAWRENCE	INTERN - SEN VIDRICKSON
Rep Dorothy Nichols	Ottawa	Legislature
D. WAYNE ZIMMERMAN	TOPEKA	THE ELECTRIC COS ASSOC. OF KS.
JERRY Conrad	"	KG&E
A N Wilson	Wichita	KWCH-TV
Charlie Hamm	Topeka	KDHE
Steve Cloud	Lenexa?	Legislature

An Overview of Decommissioning Nuclear Power Plants

Prepared by

Subcommittee on Decommissioning
of
AIF Committee on Environment

March 1983

Atomic Industrial Forum, Inc.
7101 Wisconsin Avenue
Bethesda, Maryland 20814

Attachment 1
1-18-84

PREFACE

This overview of nuclear power plant decommissioning has been prepared by the AIF Subcommittee on Decommissioning. It is intended to provide up-to-date, general information on this subject. Some decommissioning issues have been frequently misunderstood. This is particularly true in the area of costs and availability of funds needed to carry out necessary decommissioning procedures at the end of normal plant service life. In this report, the Subcommittee has attempted to place these issues in a proper perspective and hopes that the information will prove to be useful to those having an interest in the subject.

R. A. Szalay
Vice President

INTRODUCTION

All electric generating facilities must, at the end of their economic service life, be retired from service and decommissioned. The objective of decommissioning a nuclear power plant is to remove the facility from service in a safe manner and to maintain it without hazard to the public and environment. This process may include removal or isolation of radioactive materials so that the site can be released for unrestricted use or use in a controlled manner.

The electric utility industry believes that current decommissioning regulations are adequate [1], that the technology currently exists for proper decommissioning and that the associated costs are within acceptable values. The industry currently is reviewing the Nuclear Regulatory Commission's (NRC) evaluation of a more explicit policy for decommissioning nuclear power reactors and other nuclear facilities.

Over the past several years, information on nuclear power plant decommissioning has appeared to include conflicting and/or inconsistent information with regard to (a) the estimated costs of decommissioning, (b) the available technical alternatives, and (c) the alternatives for funding. This paper will provide information from well-documented sources (see list of references and background reading) to show that a basis is available for making reasonable engineering cost estimates of decommissioning, that basic decommissioning techniques do exist and that there are existing constraints on decommissioning alternatives. This paper also points out the necessity for maintaining flexibility in any overall regulatory policy for decommissioning. Because of its unlikely occurrence, the subject of premature decommissioning due to an accident or other reason is not included in this paper; therefore, the scope is limited to the normal decommissioning situation.

DEFINITION OF TECHNICAL ALTERNATIVES

The following power reactor decommissioning alternatives are considered acceptable by the NRC in its current regulatory policy [2]:

- **Mothballing.** This alternative, also called safe storage, consists of removing the nuclear fuel and placing the facility in a state of protective storage with continuing confinement of radioactive materials so that the risk to the public is minimized and within acceptable radiation protection limits. Appropriate security procedures and environmental radiation monitoring programs are established to ensure no access and that the public health and safety are adequately protected.
- **Entombment.** This alternative consists of removing the nuclear fuel and sealing all highly radioactive components (e.g., the reactor vessel and its internal components) in a protective structure of concrete or other high integrity material. The structure is designed to be sufficiently strong and long-lived to ensure retention of the radioactivity until the structure is eventually dismantled or until any residual radioactivity has decayed to levels that permit unrestricted release or use of the site. Appropriate security procedures and environmental monitoring programs are established to ensure that the public health and safety are adequately protected.
- **Dismantlement.** This alternative involves the removal from the site of all equipment, materials and structures that are radioactive at levels greater than permitted for unrestricted use of the property. Dismantlement can occur immediately following final reactor shutdown and removal of the nuclear fuel or it can be deferred to a later date to allow for some decay of radioactivity. If deferral is chosen, a period of continuing care is required prior to dismantlement. Demolition and removal of non-radioactive structures is at the option of the owner and local government agencies.

In addition to these three alternatives, there are other decommissioning options. For example, a combination of mothballing, entombment and delayed dismantlement are also viable decommissioning approaches.

Converting the plant to a new nuclear or fossil-fuel system, or recommissioning the existing plant, are other options. These alternatives, however, are not forms of decommissioning. They are not being considered by the NRC in its evaluation of decommissioning policy, nor are they examined in this paper.

ANALYSIS OF ALTERNATIVES

- **Mothballing** requires plant operation to be safely suspended and the site structures to be kept under constant maintenance, security watch and radiological surveillance. Annual reports of plant status are made to the NRC. The primary advantage of mothballing is that it requires less initial work, lower initial occupational radiation exposures and lower initial expenditures than other options. However, future dismantlement and surveillance requirements could make it more expensive in the long run. With radiological surveillance, the facility would pose no health or safety concern during the period required for its radioactivity to decay. In addition to the costs associated with maintenance, security and radiological surveillance, another disadvantage of mothballing is the length of time that portions of the site are unavailable for unrestricted use.
- **Entombment** carries many of the same advantages and disadvantages. A key distinction is that less maintenance, radiological surveillance and security than mothballing are required. Entombment produces a higher immediate and lower long-term occupational radiation exposure than mothballing. Some believe that by proper design, the entombed structure could remain on the site indefinitely; however, at the present time, the NRC does not consider entombment to be a viable *long-term* decommissioning option.

- **Dismantlement** pros and cons follow similar lines. However, this alternative would meet the requirements for termination of an NRC license and make the site available for unrestricted use. Additional advantages may include:
  - elimination of the need for continuing security, maintenance and surveillance;
  - earlier availability of the site;
  - aesthetic considerations;
  - availability of a highly knowledgeable facility operations staff to form a decommissioning work force.

On the other hand, immediate dismantlement requires the expenditure of large sums of money in a relatively short time period and requires the highest occupational exposure of all the alternatives. Deferring dismantlement to allow for radioactive decay reduces the occupational radiation exposure, but increases the total cost and, therefore, the revenue requirements.

It is desirable to maintain flexibility in the ability to choose which decommissioning method or combination of methods is most suitable for a particular nuclear power plant. Although decommissioning analyses and cost estimates are important during the early stages of a plant's construction and operation, a final decision on methodology can be made later in plant life. This will permit the utility to take advantage of any improvements in technology that may have occurred during the plant's lifetime.

COST TO DECOMMISSION

Decommissioning cost estimates sometimes appear to be inconsistent when compared on a site-by-site basis. This is usually because of variations in the assumptions used in making the estimates. A thorough understanding of the bases, assumptions, site-specific conditions and costing methods is mandatory to appropriately compare cost estimates of the various alternatives. This section will identify:

- basic elements of the cost estimate;
- summary of published cost estimates;
- basic reasons for the differences among the historical estimates.

The development of a decommissioning cost estimate should be made on a site-specific basis and include the cost elements of labor, materials, equipment and services. The type of nuclear steam supply system, site configuration and geographic location are vital elements to consider in evaluating these cost estimates.

Materials used in decommissioning may include consumable supplies such as cutting gases, explosives, fuel oil, electricity, decontamination chemicals, disposable containers, shipping casks, waste solidification media and those items used for occupational radiation protection. Disposable containers and waste solidification media represent the largest direct material cost components.

Equipment used in decommissioning may include special tooling to segment and remove the reactor vessel (if required), special casks, heavy rigging and hauling equipment and earthmovers. This equipment is often not locally available and must be transported to the site at additional cost. While equipment is, in many cases, not substantially different from that presently used for major reactor repairs and demolition of conventional structures, it has been used successfully in earlier decommissionings of nuclear facilities.

Other cost considerations are waste transportation and low-level waste disposal costs, both of which have increased rapidly in recent years due to higher fuel expenses for truckers and limitations in available commercial burial facilities. Obviously, sites further away from disposal facilities will incur higher waste transportation costs. Plant size, specific features of the design and operating history will determine the quantities and cost of radioactive material removal and disposal. Site location, configuration, and intended disposition also could affect the amount of backfill needed at the site for covering building voids.

Table 1 shows typical cost estimates for large power plants equipped with pressurized water reactors (PWR) and boiling water reactors (BWR).

TABLE 1
Range of Decommissioning Cost Estimates in 1980 Dollars [3]

	Millions of Dollars*					
	PWR			BWR		
	High	Avg.	Low	High	Avg.	Low
Mothballing	11.8	5.7	2.9	19.9	9.3	3.5
Entombment	40.9	14.3	6.5	38.0	23.8	10.9
Dismantling	101.9	54.5	23.7	121.8	64.6	29.4

*Excludes escalation, contingency, maintenance, surveillance, and security costs. The annual costs for mothballing or entombing a nuclear power plant (which include security, maintenance and radiological surveillance) are estimated to range between $168,000 and $315,000 in 1980 dollars.

The reasons for the wide variation (a factor of four) in decommissioning cost estimates include:

- regional differences in labor rates;
- physical plant size and systems configuration;
- disposition of spent fuel (whether charged to plant operation or decommissioning);
- extent of chemical or mechanical decontamination assumed for each decommissioning alternative;
- distance to a licensed radioactive waste burial site;
- variations in the degree of dismantling required (for example, removal to three feet below grade vs. removal of the reactor basemat);
- degree of site restoration required;
- inclusion or omission of decommissioning engineering and planning as a decommissioning cost.

Variations such as these may also account for some of the differences between the BWR and PWR cost estimates.

Inflation and the steep rise in shipping and low-level waste disposal costs recently have increased decommissioning costs. For example, the 1976 AIF/NESP study, *An Engineering Evaluation of Nuclear Power Reactor Decommissioning Alternatives* [4] estimated that a 1100 MWe pressurized water reactor could be dismantled at a cost of approximately $27 million in 1975 dollars. This cost, when adjusted for inflation at 7% per year and increased shipping and burial costs, would be approximately $50 million in 1980 dollars.

The increase, large as it may seem, is not unexpected, given similar increases in other construction projects. Use of a detailed cost estimating approach permits accurate prediction of the impact of cost changes on decommissioning costs. Because of changes in the economy, technology and regulatory climate, periodic review of the estimates may be required to ensure continued confidence in the estimates.

FUNDING ALTERNATIVES

The costs of decommissioning, like any other costs of generating electricity, should be reflected in rates to the utility customers served by the generating units.

Selection of the funding methods are based on the following considerations:

- the accounting concept known as "matching", which requires that depreciation of capital equipment be consistent with its rate of use (or consumption) and that this usage (or expense) be matched against revenue generated by the usage;
- the regulatory concept known as "intergenerational customer equity", states that those receiving the benefits should bear the cost;
- the accounting rules of the Uniform System of Accounts of federal and state regulators;
- assurance that funds will be available for expenditure when required;
- cost to the ratepayer; and
- policy of the appropriate ratesetting regulatory agency.

There are two major methods for accumulating the funds to be used in decommissioning — internal and external — and several variations of each. The variations involve different patterns of payments into the funds, and some are more consistent with accounting and regulatory concepts than others.

External funding is a method whereby the portion of customer payments for service that is applicable to decommissioning would either be invested by the utility in securities of other entities or paid to a trustee for investment. Payments to the external fund can vary from a single front-end payment to periodic payments. A single payment at the end of plant life is a theoretical possibility that has not been given serious consideration because of inconsistency with accounting and regulatory concepts.

Internal funding is a method whereby funds are accumulated through periodic bill payments by customers and are available for use by the utility for capital investments. In essence, the funds are invested in the utility itself until needed for decommissioning whereby the actual funds are then acquired by conventional financing.

These payments for decommissioning for both internal and external funding can be recorded in any pattern, but accounting and regulatory concepts suggest certain patterns. For example, the accounting concept of depreciation often assumes that depreciation occurs at a constant rate usually over a period of time, but sometimes it occurs as a function of power production. The same principle applied to decommissioning assumes that a constant amount of decommissioning cost is incurred during each accounting period.

Customer payments for decommissioning include the depreciation provision as well as the impact of this provision on the utility's rate base and income taxes. The pattern and magnitude of customer payments for decommissioning are controlled by the pattern of the depreciation. Of the external methods, a single payment to the fund at the beginning results in the *highest cost to customers.* Of the internal methods, straight-line depreciation results in the lowest total customer payments. While generalized calculations may vary, external methods always produce higher customer payments than internal methods. This results because of (1) increased taxability and (2) the reduction the customer receives from a reduced rate base is greater than the earnings received from outside securities. If the interest collected from the external methods was tax exempt, the cost to ratepayers would be reduced substantially.

While it is not necessarily true that the actual hazard level of a decommissioned nuclear power generating plant is higher than that for a fossil fueled generating plant (or certainly many other industrial facilities), the public certainly perceives it as higher. As a result significant importance is placed on assurance that a nuclear powered generating facility is properly decommissioned. The degree of assurance will depend on the ability to turn either internal or external investments into cash when needed. Those who favor a *high degree of assurance* often favor early collections and external funding, the higher cost of the method notwithstanding. Those who favor *reasonable assurance* support internal funding because of its lower cost.

REGULATORY ASPECTS — FINANCIAL

Since collections from customers are the utility's only source of funds, no matter what the funding alternative, service rate regulators are properly concerned with the financial aspects of decommissioning. Often rate regulators are more concerned with short-term effects than with long-term effects. They tend to favor funding methods and decommissioning alternatives that produce the lowest current consumers payments for service. The actual collection of funds from customers for decommissioning increases annual depreciation provisions. However, depreciation provisions also have a beneficial effect, since the reserve for depreciation is the accumulation of annual amounts and is a deduction in determining the utility's rate base. Because of this rate base deduction, internal funding is less costly to consumers in the long-term than external methods.

It is generally agreed that the jurisdiction of the NRC over the financial aspects of decommissioning is limited to reactor licensing qualifications, requiring proof that license applicants are financially able to safely remove reactors from operation.

Despite the multiplicity of funding methods and the controversy which often surrounds the issue, it must be remembered that decommissioning funding represents a small portion of the cost of producing electricity, less than 1/2%.

RADIATION PROTECTION CONSIDERATIONS

Radiation protection associated with decommissioning a nuclear power plant has two aspects; protection of workers during the decommissioning procedure, and protection of the public and the environment offsite during and following the decommissioning operation.

Worker protection during decommissioning can be accomplished in the same general manner as successfully utilized in operating and maintaining nuclear power plants and in other industrial operations where radiation is present.

Additionally, special equipment and techniques used in decommissioning are continually being developed and improved. Such new equipment and technology can reduce exposures further during future major decommissioning operations because of increased efficiency allowing procedures to be accomplished in less time, thus shortening the duration of radiation exposure.

Additional health protection measures would include:

- maintaining low-level radioactive contaminants within NRC and Environmental Protection Agency standards, and
- carefully controlling, radiologically surveying and decontaminating material within the plant that is suitable for re-use.

RADIOACTIVE WASTE DISPOSAL

Prior to commencing decommissioning, the highly radioactive nuclear fuel and its associated components are removed to protect workers and the public's health and safety.

Essentially all remaining decommissioning wastes are low-level radioactive wastes suitable for routine disposal in accordance with applicable regulations. The wastes may consist of many materials such as general trash, solidified liquids and contaminated piping.

Low-level waste is packaged in casks, drums or boxes, depending on the nature of the waste, radiologically monitored, marked, and shipped to burial facilities according to the strict standards and procedures established by the NRC, the Department of Transportation, and the states in which the burial grounds are located.

Work is currently under way to develop more effective volume reduction systems which will greatly reduce the volume of waste to be buried. This, in addition to the development of regional waste compact agreements and a *de minimis* level of radioactivity below which materials would constitute no public health hazard and could be considered trash, could reduce the overall cost of decommissioning power reactor facilities.

CONCLUSIONS

Current technology and existing regulations adequately provide for the safe decommissioning of a nuclear power plant within acceptable costs after the nuclear fuel has been removed from the facility. There are several ways to decommission a power reactor and to safely dispose of the residue. Similarly, there are several ways to finance and collect funds for decommissioning. *The decision concerning which technical and financial alternatives to choose must be based on the site-specific characteristics and should be determined on a plant-by-plant basis.* It is important to consider the utility's preference, the rate setting bodies' desires, the cost to the consumer and the need for utility and regulatory flexibility in the development of a regulatory policy for decommissioning.

REFERENCES

1. 47 *Federal Register* 13754, March 31, 1982; 10 *Code of Federal Regulations* Part 20.82, Washington, D.C.: U.S. Government Printing Office, 1982.
2. "Termination of Operating Licenses for Nuclear Reactors," Regulatory Guide 1.86. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1974.
3. Greenwood, D., et al, "Analysis of Nuclear Power Reactor Decomissioning Costs," AIF/NESP-021. Washington, D.C.: Atomic Industrial Forum, Inc., 1981.
4. Manion, W.J., and LaGuardia, T.S., "An Engineering Evaluation of Nuclear Power Reactor Decommissioning Alternatives," AIF/NESP-009. Washington, D.C.: Atomic Industrial Forum, Inc., 1976.

BACKGROUND READING

1. Wood, R.S., "Assuring the Availability of Funds for Decommissioning Nuclear Facilities," NUREG-0584, Rev. 3, March 1983. Washington, D.C., U.S. Nuclear Regulatory Commission, 1983.
2. Calkins, G.D., "Plan for Re-evaluation of NRC Policy on Decommissioning of Nuclear Power Plants," NUREG-0436, Rev. 1, 1978, Supplement, August, 1980. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1980.
3. Calkins, G.D., "Thoughts on Regulation Changes for Decommissioning," NUREG-0590, Draft Report, Rev. 2. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1980.
4. "Draft Generic Environmental Impact Statement on Decommissioning Nuclear Facilities," NUREG-0586. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1981.
5. Eckerman, K.F., and Young, M.W., "A Methodology for Calculating Residual Radioactivity Levels Following Decommissioning," NUREG-0707. Washington, D.C.: U.S. Nuclear Regulatory Commission, 1980.

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Succeeded in November 1982 by
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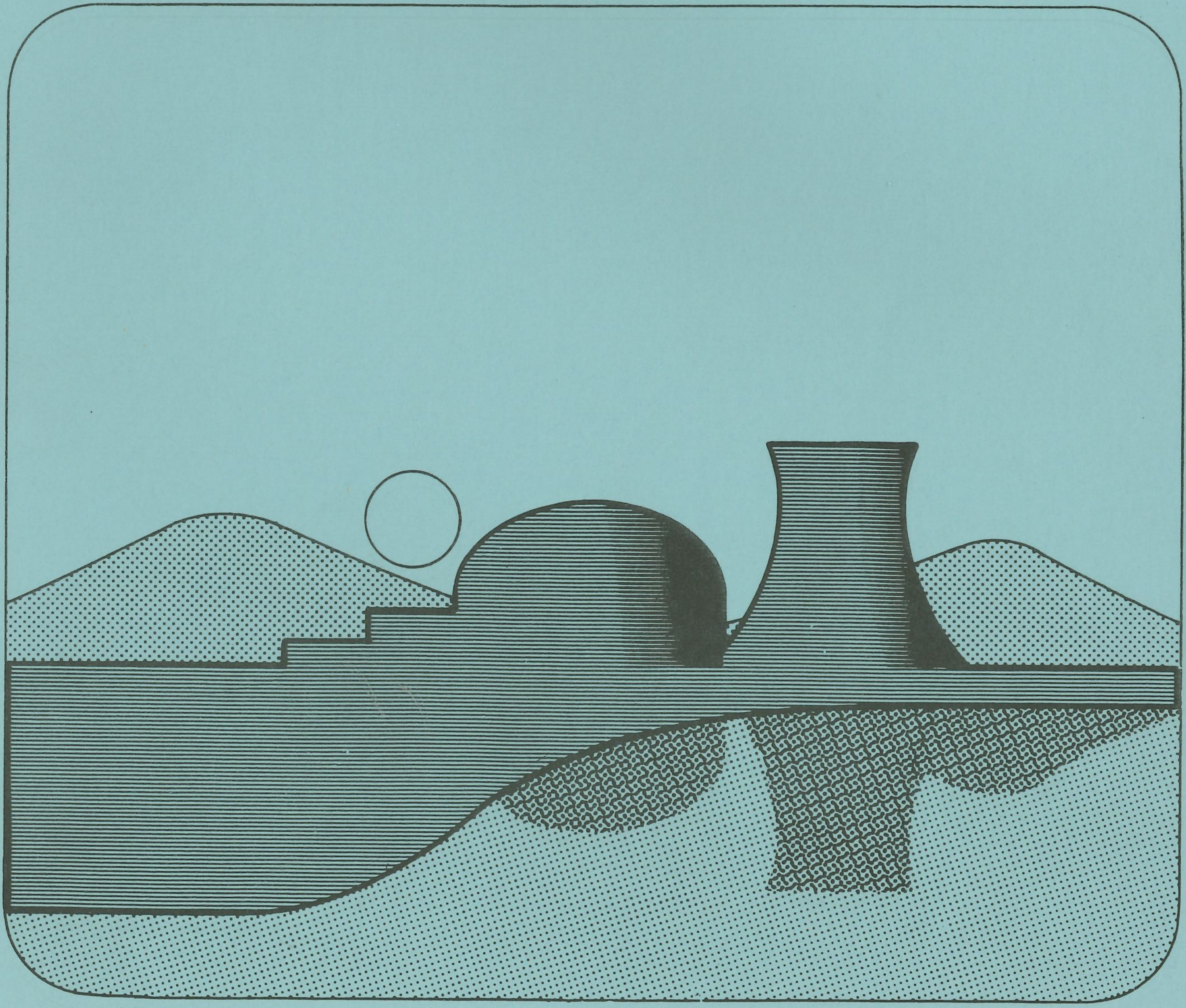
DOE/NE-0029

U.S. Department of Energy
Assistant Secretary for
Nuclear Energy

March 1982

Nuclear Power From Fission Reactors

An Introduction



Attachment 2
1-18-84

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Strategic Information & Education Programs
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DOE/NE-0029

Nuclear Power From Fission Reactors

An Introduction

March 1982

The purpose of this booklet is to provide a basic understanding of nuclear fission energy and different fission reactor concepts.

U.S. Department of Energy
Assistant Secretary for Nuclear Energy
Washington, D.C. 20585

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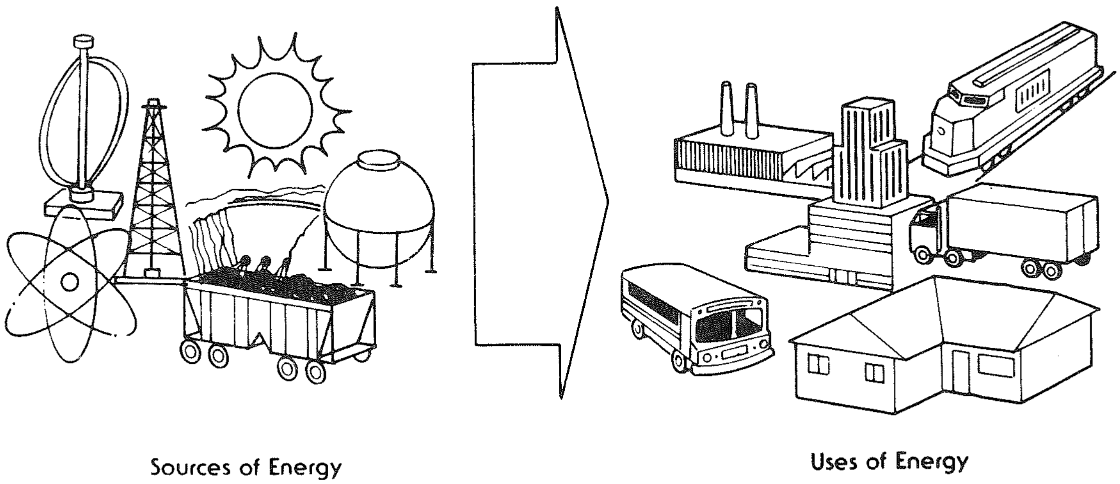
Energy Use and Production

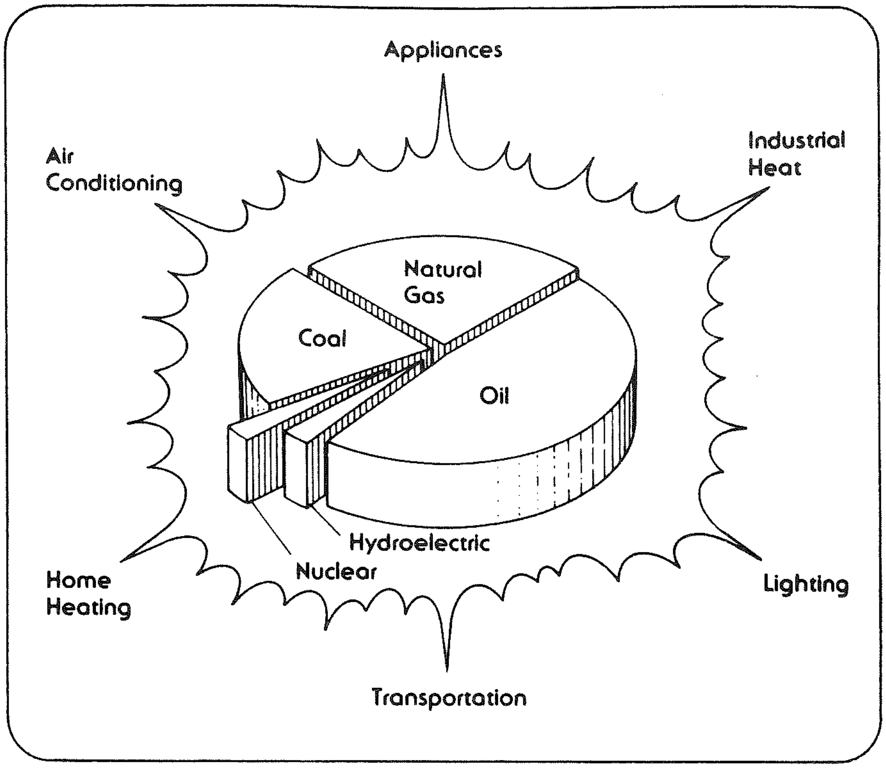
Energy is an important element in nearly every aspect of daily living. It is vital to many of our needs, including heating and cooling, transportation, and electricity for lighting and to run machines.

The energy for these and many other uses is produced in many different ways. We get energy from fuels such as oil, coal, natural gas, and uranium. In addition, we can harness energy from the sun, running water, and the wind. Nuclear power is just one of many ways to produce energy. In order to understand its role, we can ask how it relates to other means of getting energy. In particular, we can look at the way in which we use our fuels today.



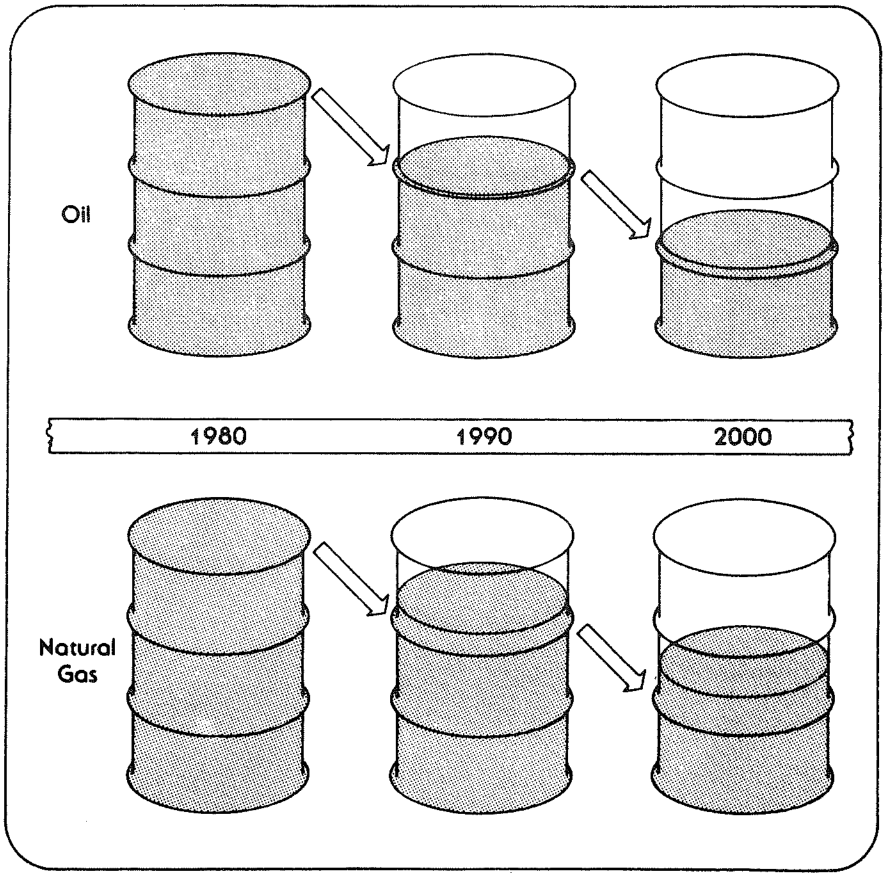
Current Use of Fuels

While there are many ways to produce energy, we do not use them all to the same extent. Some are not fully developed, while others are too expensive or of limited potential. In fact, most of the energy we use today comes from a few major sources--oil, natural gas, coal, uranium, and hydroelectric power. Two of these fuels, oil and gas, supply nearly three-quarters of the energy needs for the U.S.



Oil and Gas Consumption

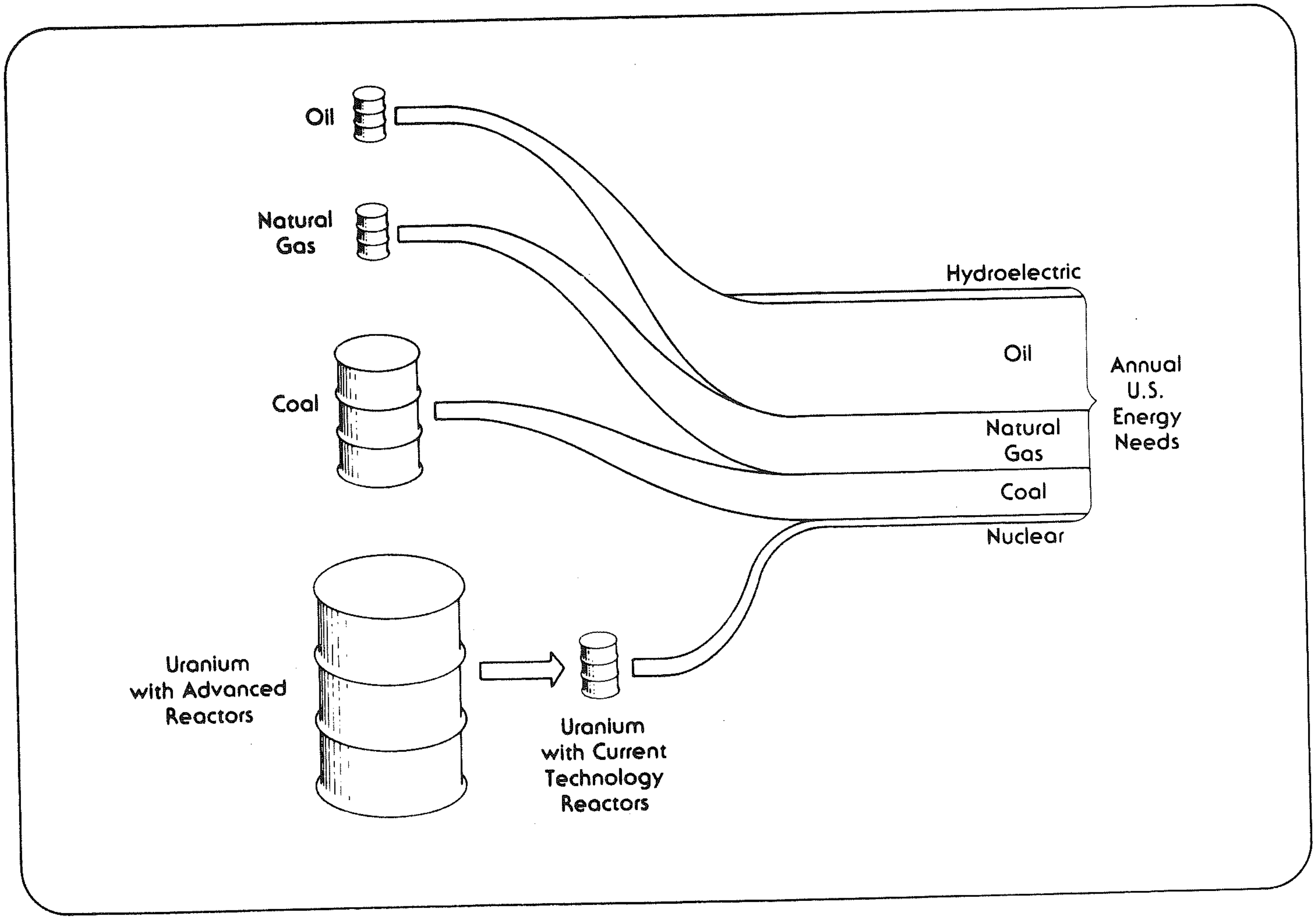
We know that the domestic supplies of oil and gas are limited. In fact, oil and gas deposits are being depleted rapidly. If we continue to use these fuels at the same rate we use them today, we will have consumed nearly one-quarter of all our oil and gas resources within the next ten years. If there are no significant new discoveries within 20 years, these valuable fuels will be half-way gone. Therefore, it is vital that we develop other energy sources that can replace oil and natural gas so that we may have a supply of energy far into the future.



Alternative Sources of Energy

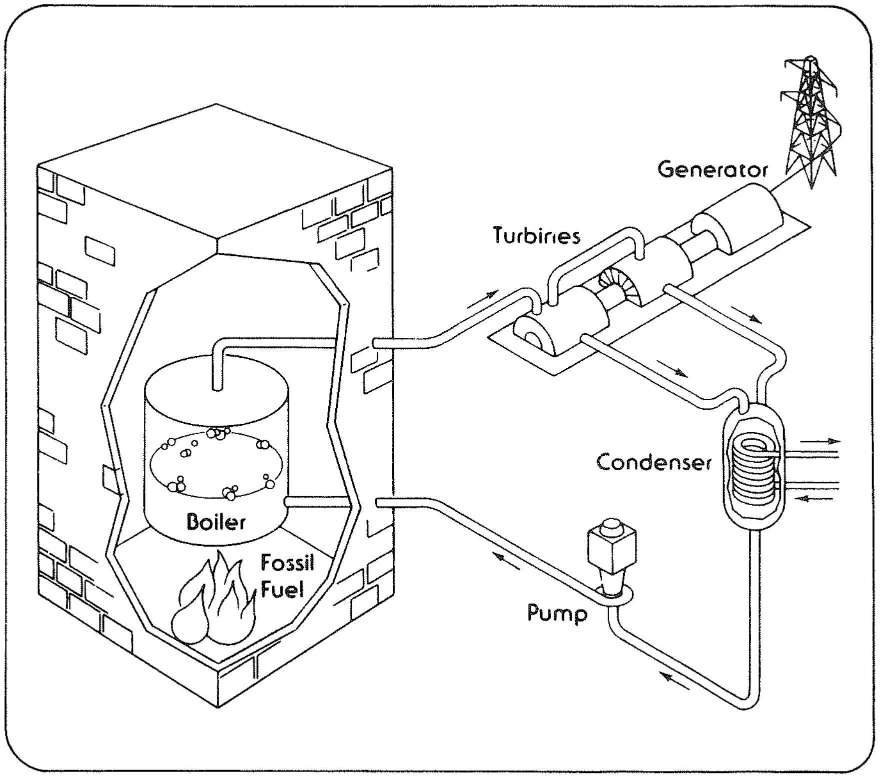
We are fortunate in the U.S. to have fuels besides oil and gas that can provide us energy for many years. As shown below by the size of the barrels, coal is a very large energy resource. The three fossil fuels--coal, oil, and natural gas--provide most of the energy used in the U.S.

Uranium, which is a nuclear fuel rather than a fossil fuel, can also produce energy. If used in today's reactors, uranium could provide as much energy as either oil or natural gas. In addition, if used in advanced reactors known as breeder reactors, the amount of energy obtained from uranium could be multiplied by a factor of 60.



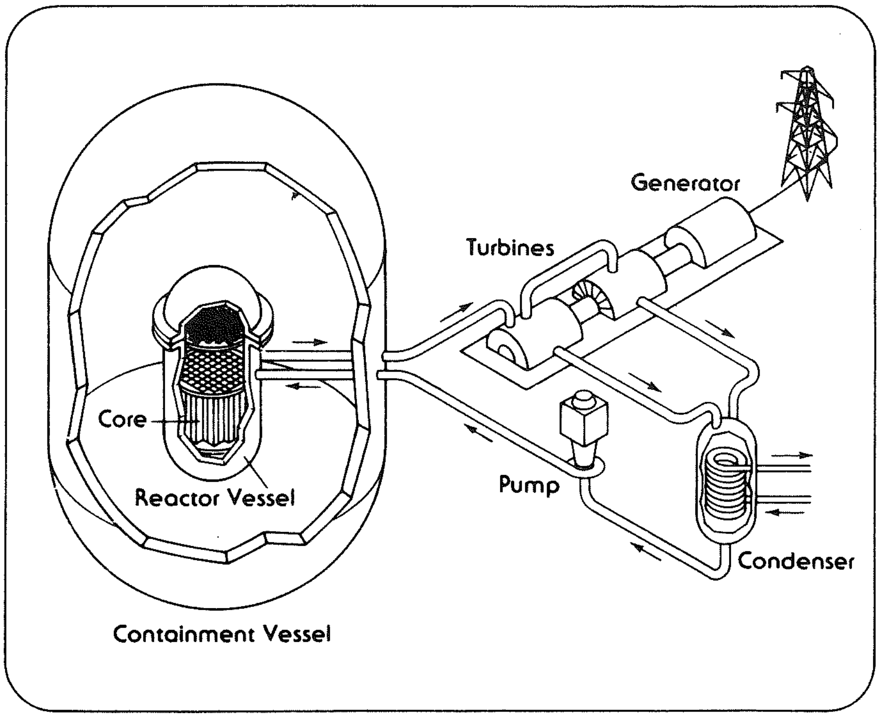
Fossil Fuel Plants

In conventional fossil plants, oil, coal, and natural gas can be burned to produce heat. Regardless of its source, the heat is converted into steam in a boiler. The steam expands as it passes through a turbine. This process drives a generator, which produces electricity. As steam leaves the turbine, it is condensed and returned to the boiler in the form of water.



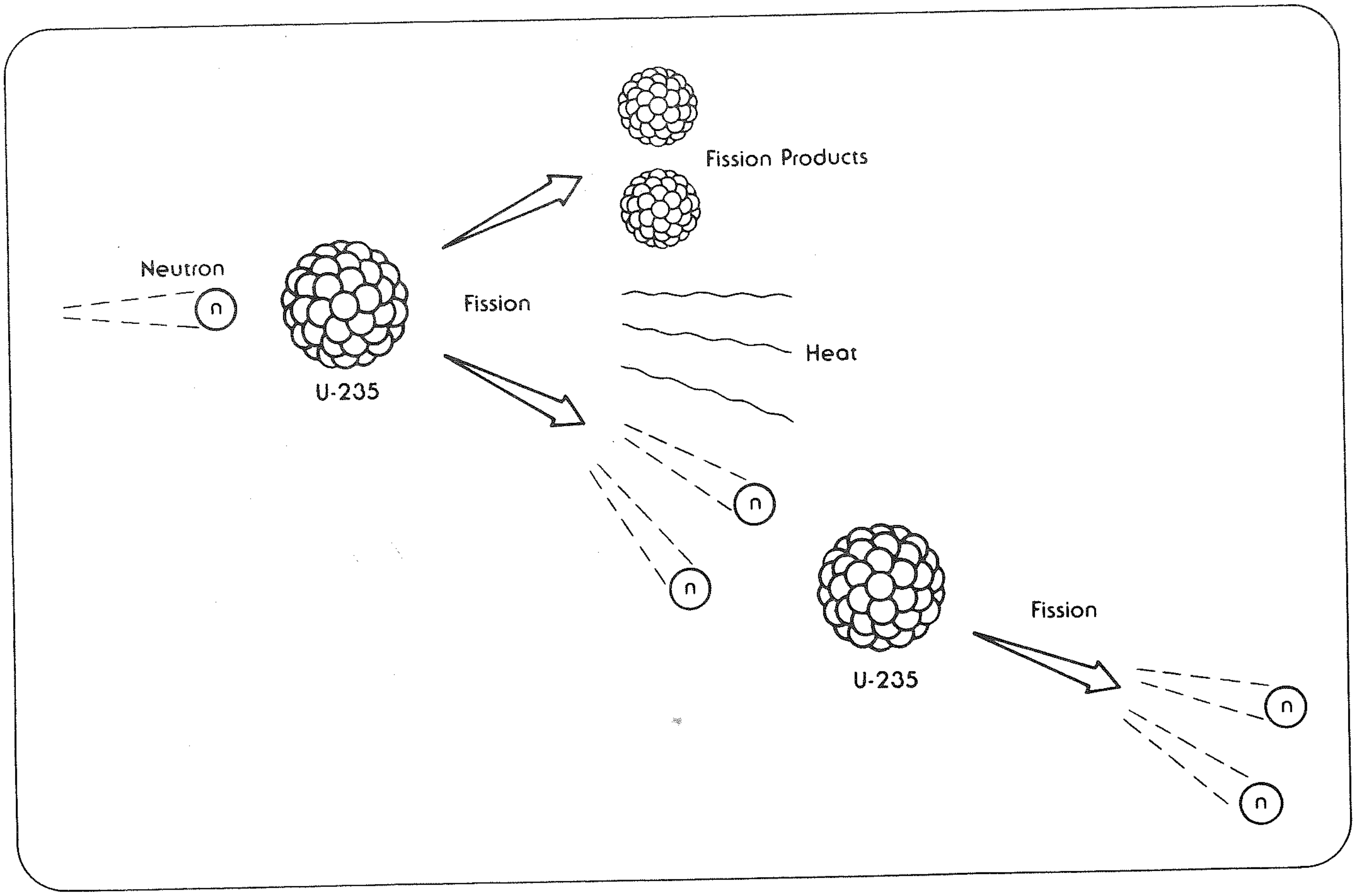
Nuclear Plants

In a nuclear plant, heat is also used to produce steam, which in turn is used to generate electricity. The main difference between a fossil plant and a nuclear plant is the source of heat. The heat in a nuclear plant is produced by a process called nuclear fission, which can occur in special types of nuclear fuel.



Nuclear Fission

The process of fissioning, or splitting, atoms can produce enough heat to generate electricity. Fission occurs readily in only a few elements, such as uranium and plutonium. One particular isotope of uranium, U-235, is commonly used in today's reactors. When a neutron strikes a uranium-235 atom, it is absorbed. This makes the nucleus of the U-235 atom unstable, and causes it to split into two lighter atoms called fission products. At the same time, energy in the form of heat is released along with two or three neutrons. The neutrons can strike other uranium atoms and cause additional fissions. The continuing process of fissioning is known as a chain reaction.

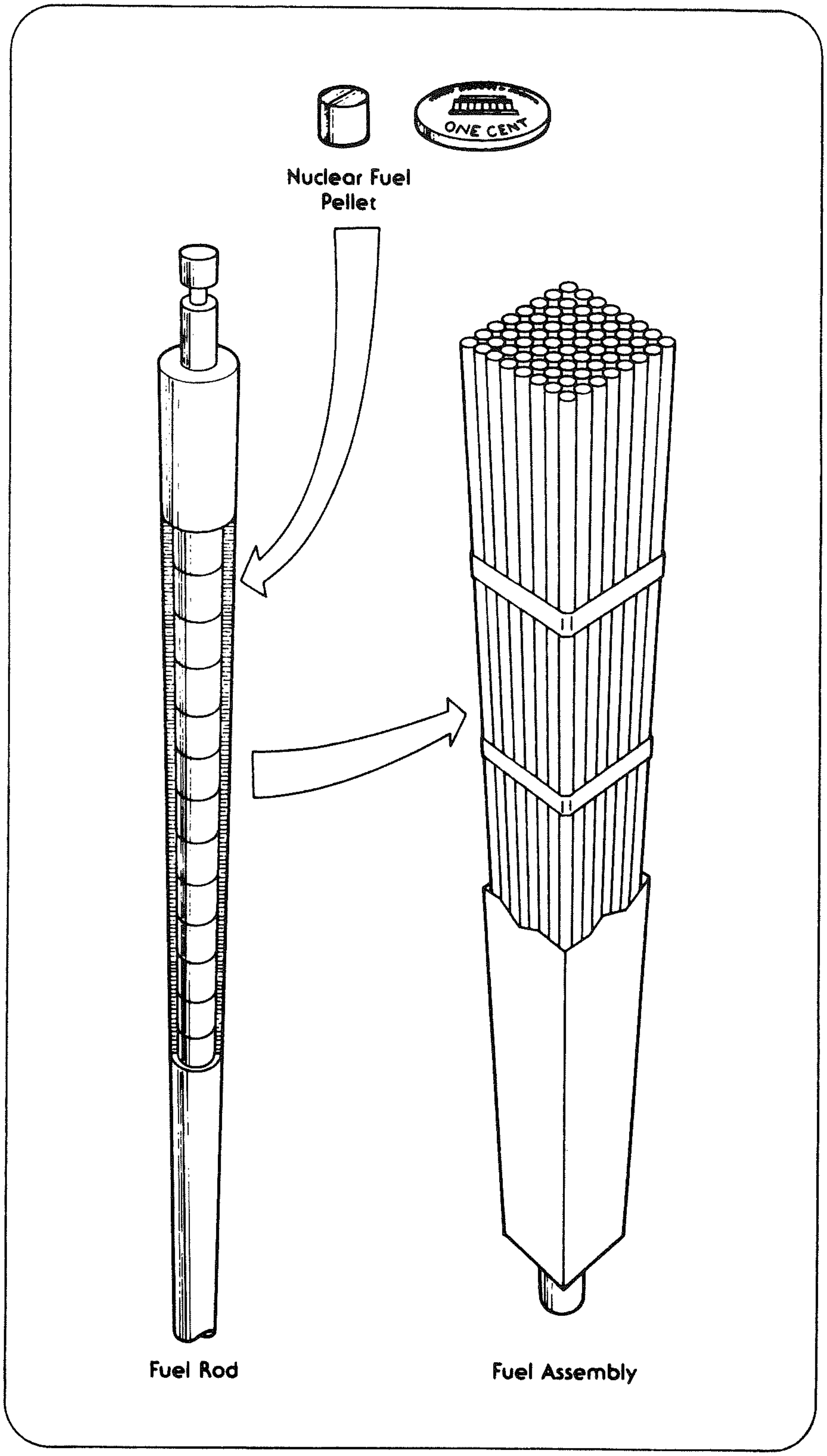


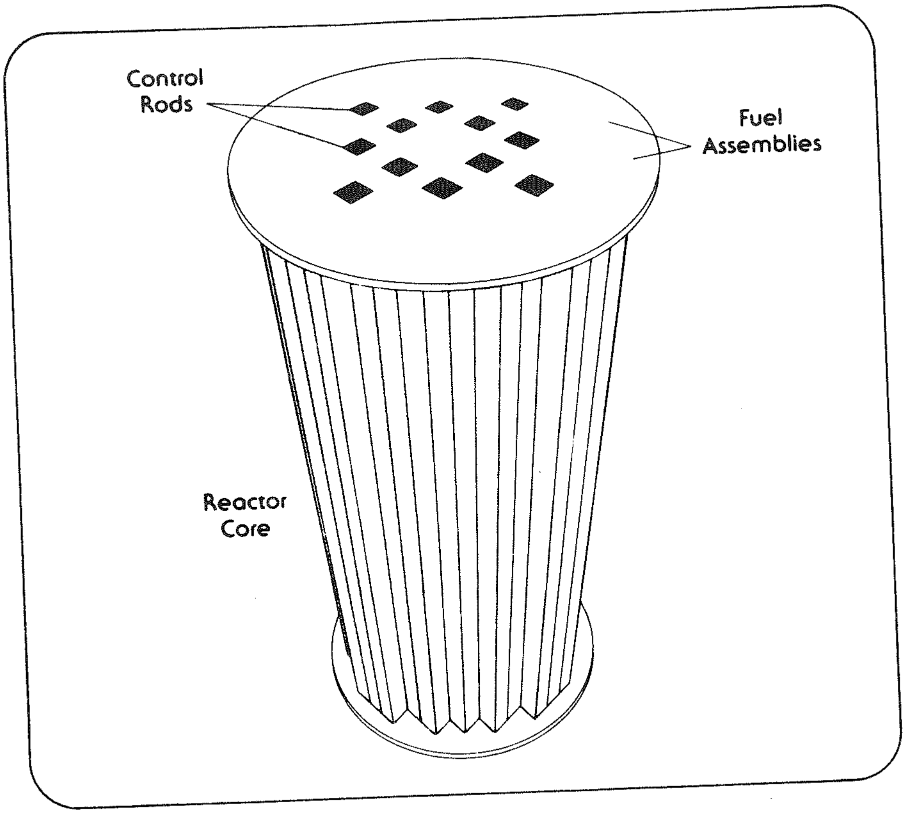
Nuclear Fuel

Only a few elements fission easily enough to be used as fuel in a nuclear power plant. Of these special materials, uranium is the most common fuel in today's reactors.

Any nuclear fuel, including uranium, must be processed through several steps before it can be used in a reactor. The fuel must first be carefully refined. It is then shaped into small cylinders known as fuel pellets. The pellets are less than 1/2 inch in diameter, but each one can produce as much energy as 120 gallons of oil.

Fuel pellets are stacked and sealed in hollow tubes about 12 feet long. The filled tubes are called fuel pins or rods. The rods are grouped together in bundles known as fuel assemblies. The fuel rods are carefully spaced in the assemblies to allow a liquid coolant to flow between them.

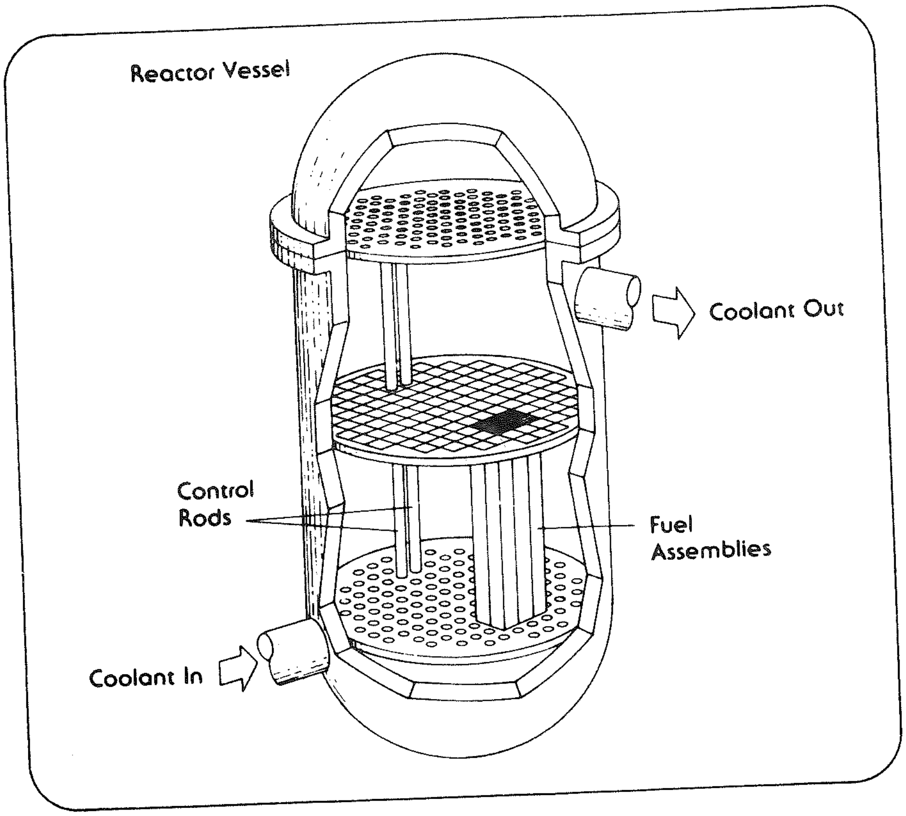




Reactor Core

Approximately 200 nuclear fuel assemblies are grouped together to make up the core of one reactor. Nuclear fuel in the core generates heat in a reactor just as coal or oil generates heat in a boiler.

Interspersed among the fuel assemblies are movable control rods, which are made of material that readily absorbs neutrons. When the control rods are inserted into the core, the nuclear chain reaction in the fuel assemblies is slowed down. This reduces the amount of heat produced by the core. When the control rods are withdrawn from the core, the chain reaction speeds up, and more heat is produced.



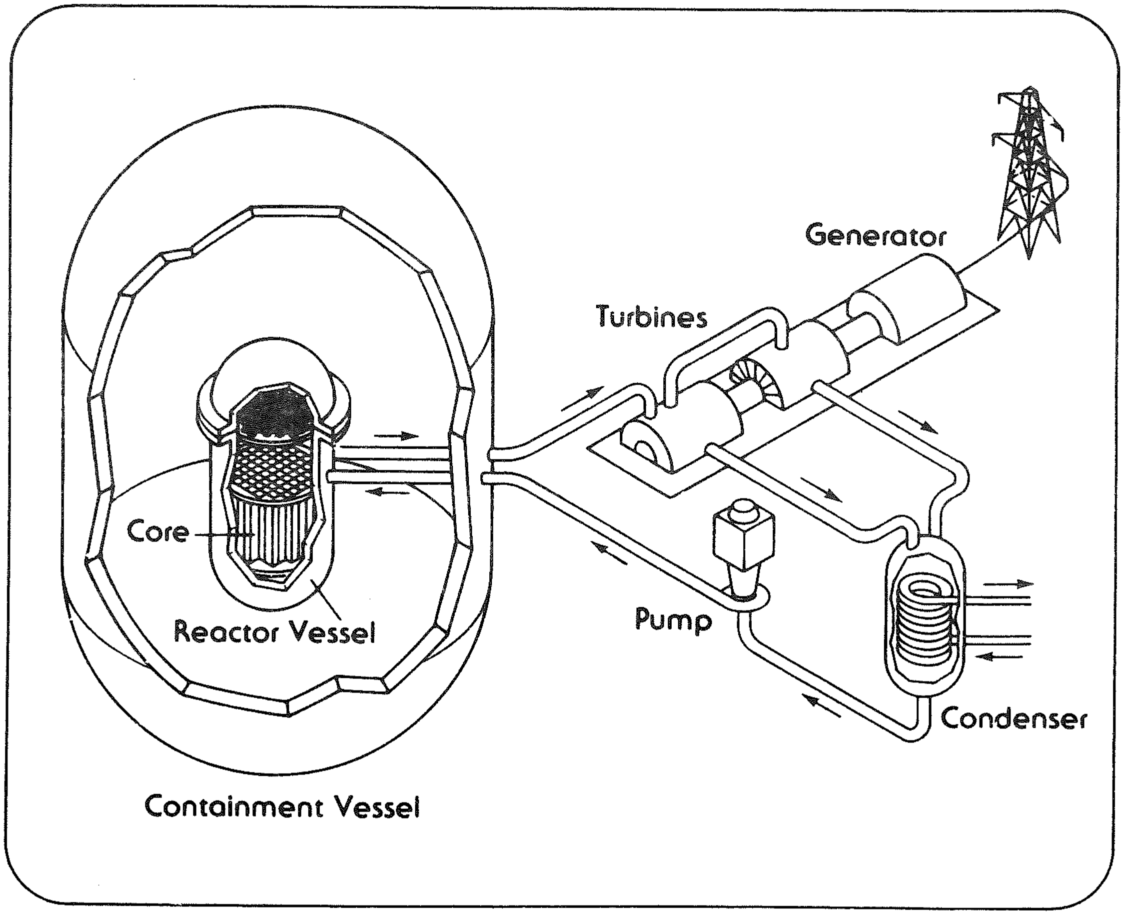
Reactor Vessel

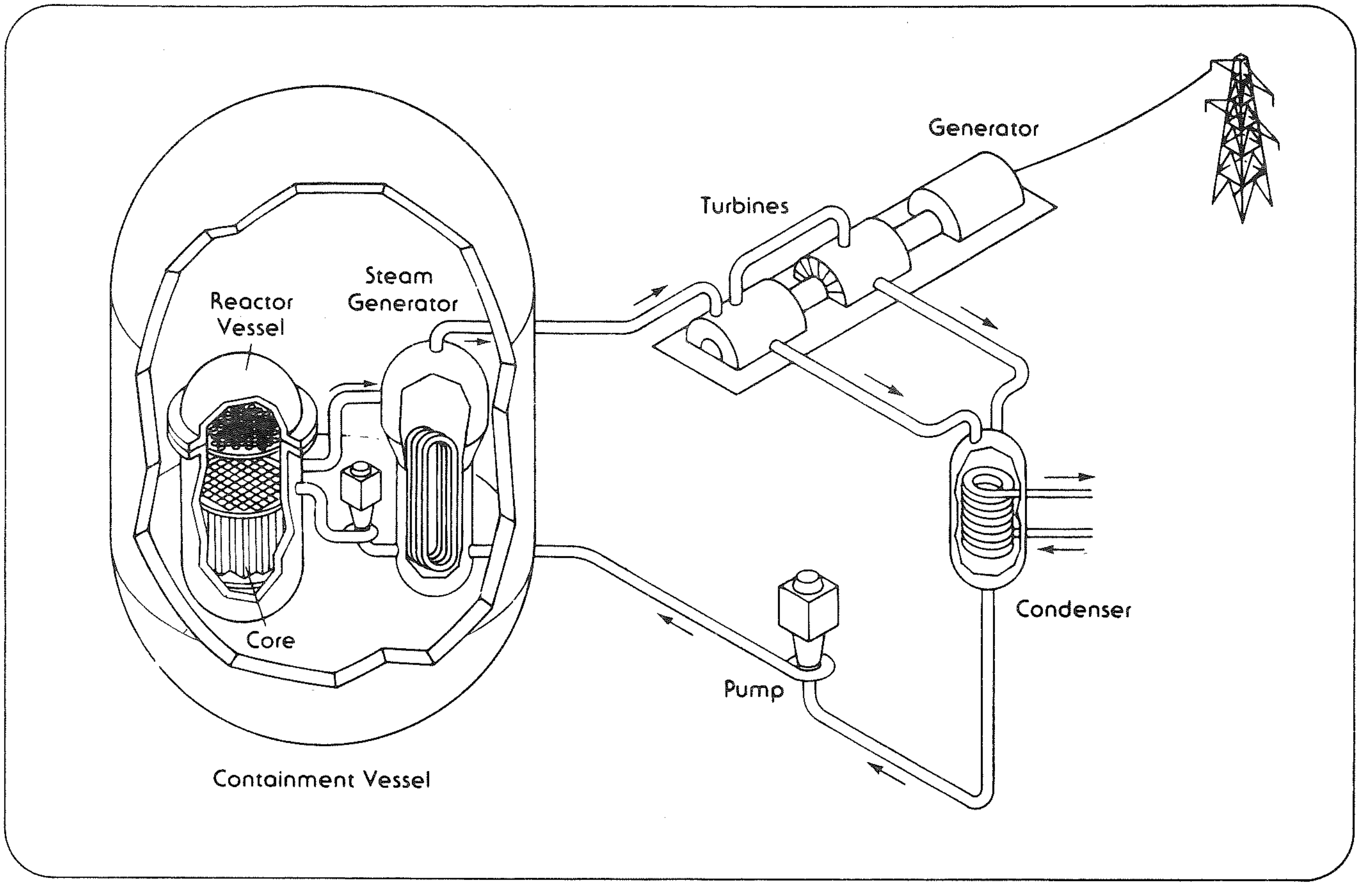
The entire reactor core, which contains fuel assemblies and control rods, is enclosed in a heavy stainless steel vessel. To ensure safety, the entire reactor vessel is housed in a reinforced concrete structure.

A liquid coolant is pumped into the reactor vessel through the core to remove heat. The coolant is then pumped out of the reactor vessel and is used to produce steam. Most of the nuclear power plants in the United States use water as a coolant. These plants are known as Light Water Reactors (LWR's).

Boiling Water Reactors

There are two distinct types of light water reactors in the U.S., and many of each type are built. In both reactors, fuel assemblies in the core are cooled by water, and the heated water is used to generate steam. In the Boiling Water Reactor (BWR), the pressure inside the reactor vessel is carefully controlled so that the water boils as it passes through the core. This reactor generates steam directly by the heat from the core, with no intermediate steps. This is known as a "direct cycle" system.





Pressurized Water Reactors

In the Pressurized Water Reactor (PWR), the pressure is kept high enough to prevent boiling, even though the water is very hot. In the PWR, the heated water from the core is pumped into a steam generator. At this point, the heat is transferred to another coolant system and steam is produced. The water from the core is circulated again and again through the primary loop without ever being converted into steam.

LWR Fuel Cycle

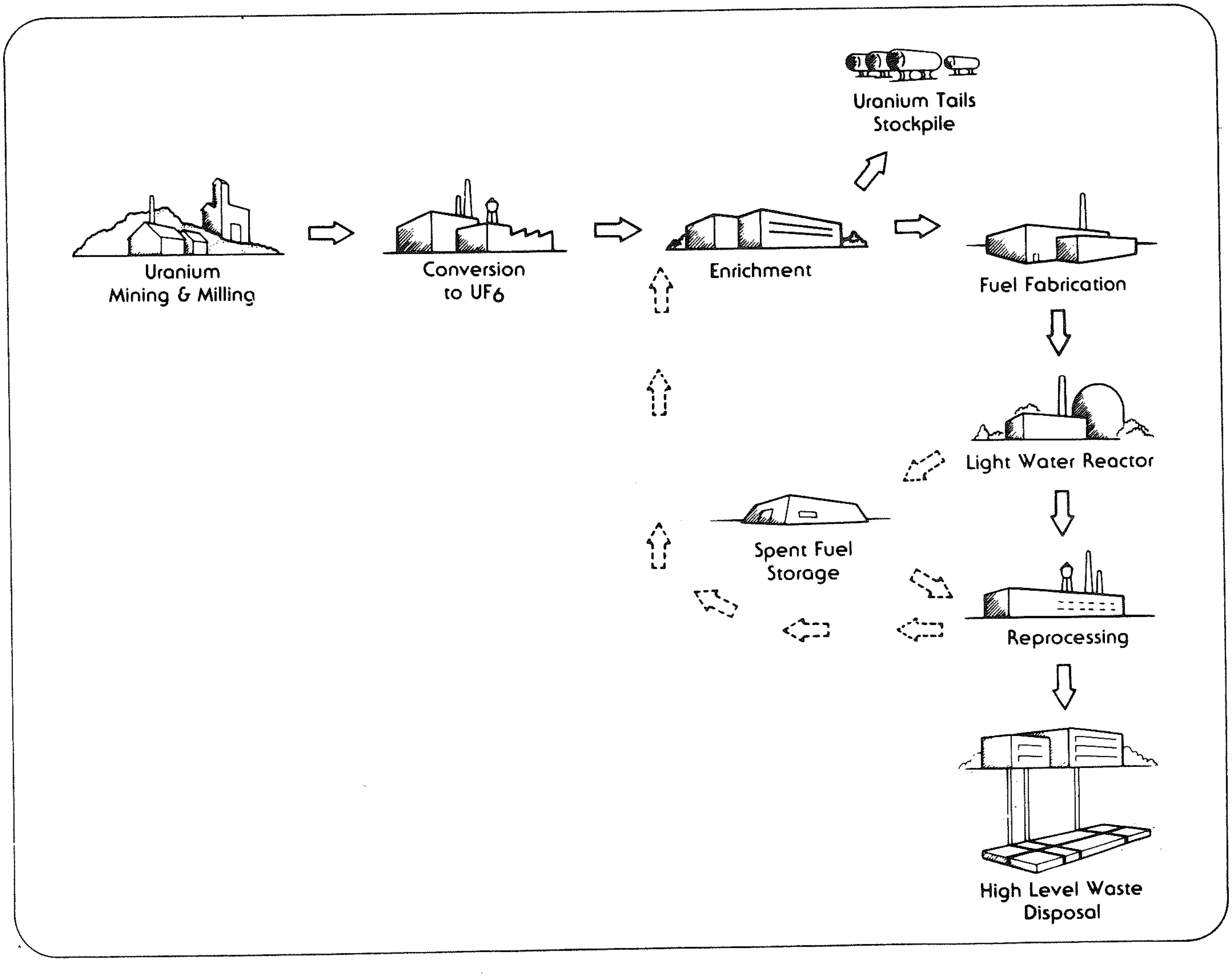
Light water reactors have been built in the U.S. for many years, and the industry that supplies equipment and services is well-established. However, it is not enough to build a reactor that produces heat and electricity. We must also be able to find and prepare nuclear fuel. In addition, we must handle fuel after it is discharged from the reactor. The fuel cycle represents all the elements that must be developed to have a complete nuclear power system.

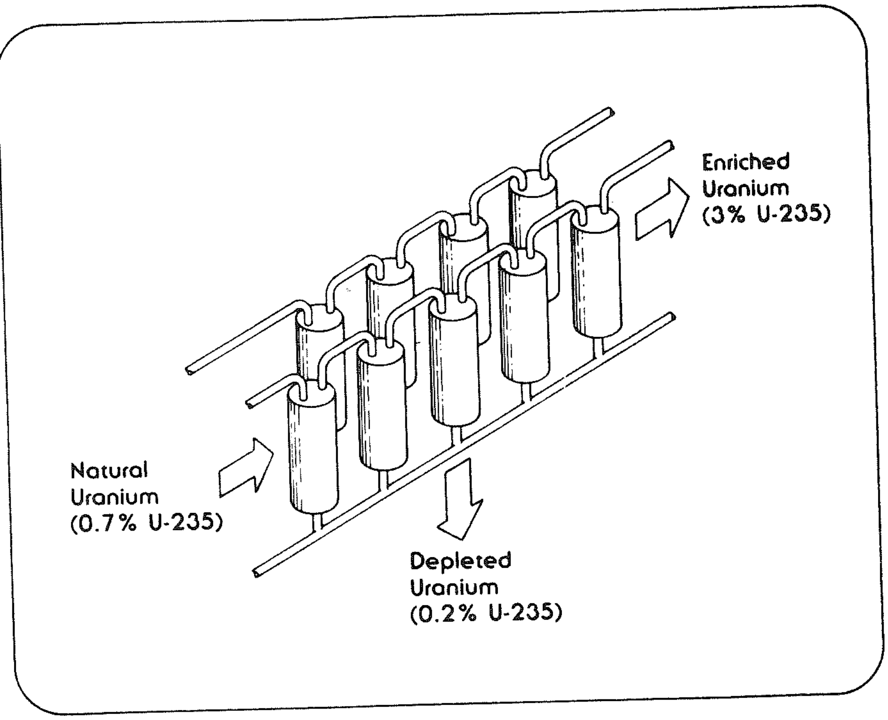
Mining uranium ore is the first step in the fuel cycle for light water reactors. After being mined, uranium is sent to a mill to be crushed and ground. The mill produces "yellowcake," which has a large concentration of the uranium compound U_3O_8.

Yellowcake contains, among other things, several isotopes or varieties of uranium. One such isotope is uranium-235, which is important because it fissions readily in a reactor. Uranium-238 is another isotope found in natural uranium, but it does not fission as easily. Unfortunately, natural uranium is composed primarily of U-238 and has less than 1% U-235. The concentration of uranium-235 can, however, be increased artificially. This is done by first converting the yellowcake to another chemical form and then processing it in an enrichment plant.

After uranium is enriched enough to be used in a reactor, it is fabricated into nuclear fuel elements. The fuel elements are grouped into fuel assemblies and placed in the core of a reactor. The fuel remains in the core and produces power for three to five years before it is removed.

After being discharged from the reactor core, nuclear fuel is cooled in a pool of water near the reactor. After it has cooled long enough to be handled easily, it may be shipped to another location. If it is shipped to a reprocessing plant, valuable fuel would be separated from radioactive waste. The waste material would then be stored safely and the fuel would be available to be used again. If reprocessing plants are not immediately available, it is possible that the spent nuclear fuel would be shipped to an interim storage facility.

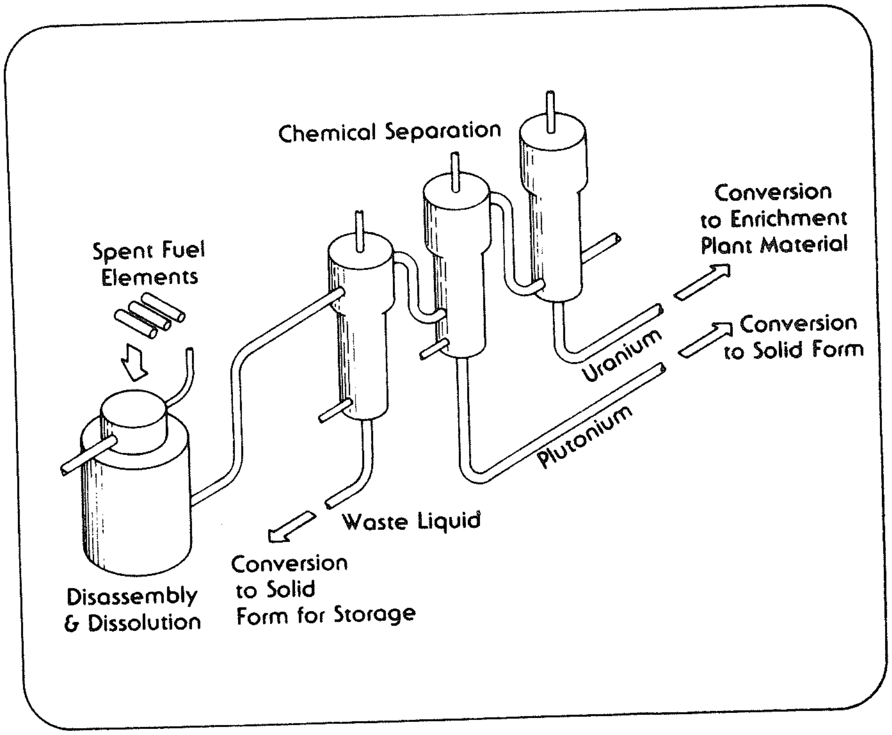




Enrichment

The process of enriching uranium is very sophisticated, but it accomplishes a simple purpose--it increases the concentration of the isotope U-235 in uranium. This is a necessary operation in the LWR fuel cycle, since natural uranium does not contain enough U-235 to run an LWR.

During the process of enrichment, natural uranium is fed into the enrichment plant. Only 0.7% of this uranium is U-235, while 99.3% is another isotope of uranium, U-238. The natural uranium is processed and split into two streams. One contains the concentrated uranium, which is usually about 3% U-235. This is sent to be fabricated for use in light water reactors. The other stream is depleted uranium, or "tails," which contains only 0.2% U-235. Since it is not usable in today's reactors, it is stored.



Reprocessing

Even after fuel is removed from a reactor, it still contains some usable nuclear material, such as uranium or plutonium. The usable fuel can be salvaged, however, only if it is reprocessed. This is a method of chemically separating valuable nuclear materials from radioactive waste material.

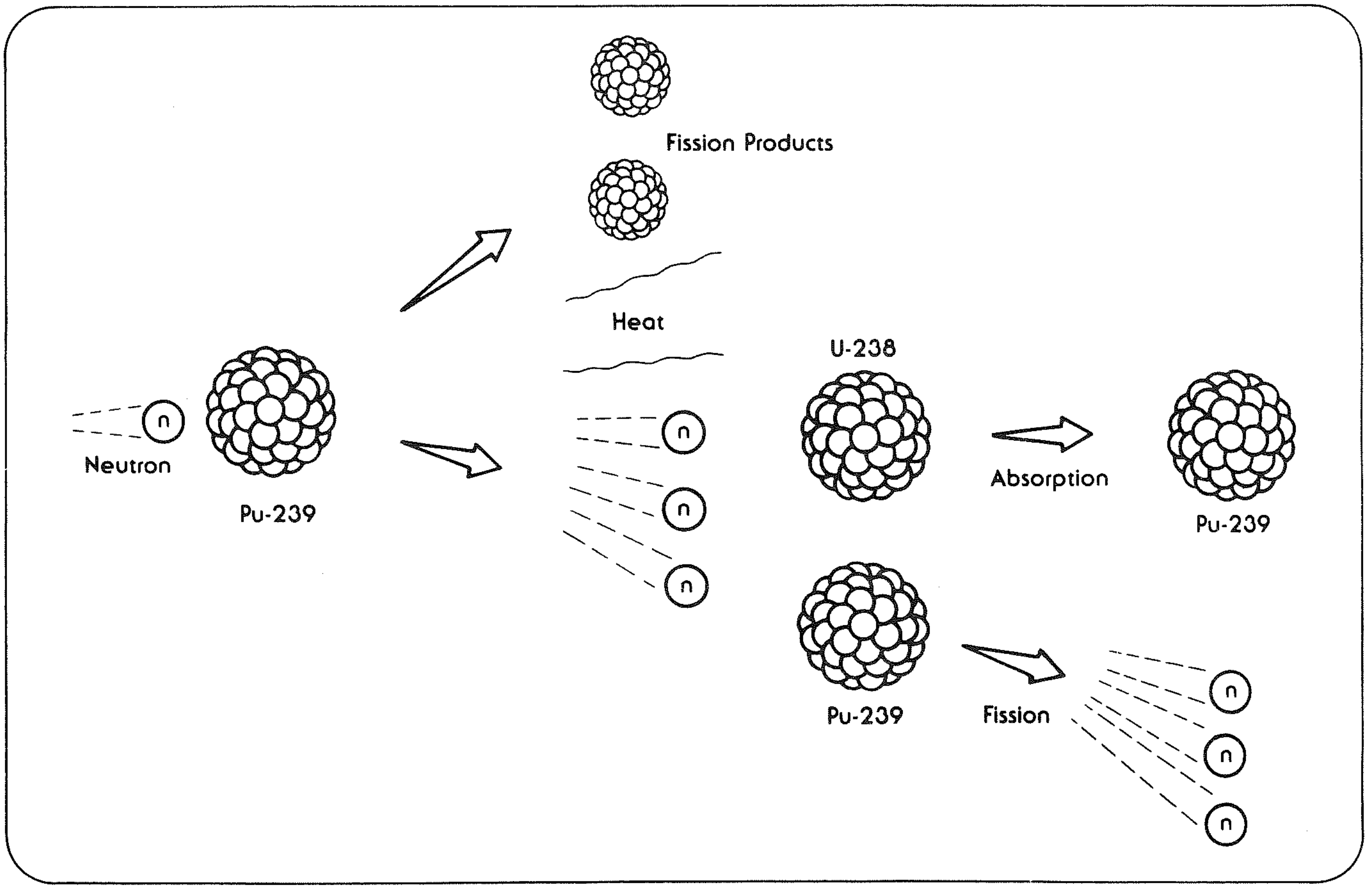
Nuclear material that is recovered during reprocessing can be reused many times. Uranium can be enriched again and used in light water reactors. Recovered plutonium would probably be stored until it could be used in advanced reactors.

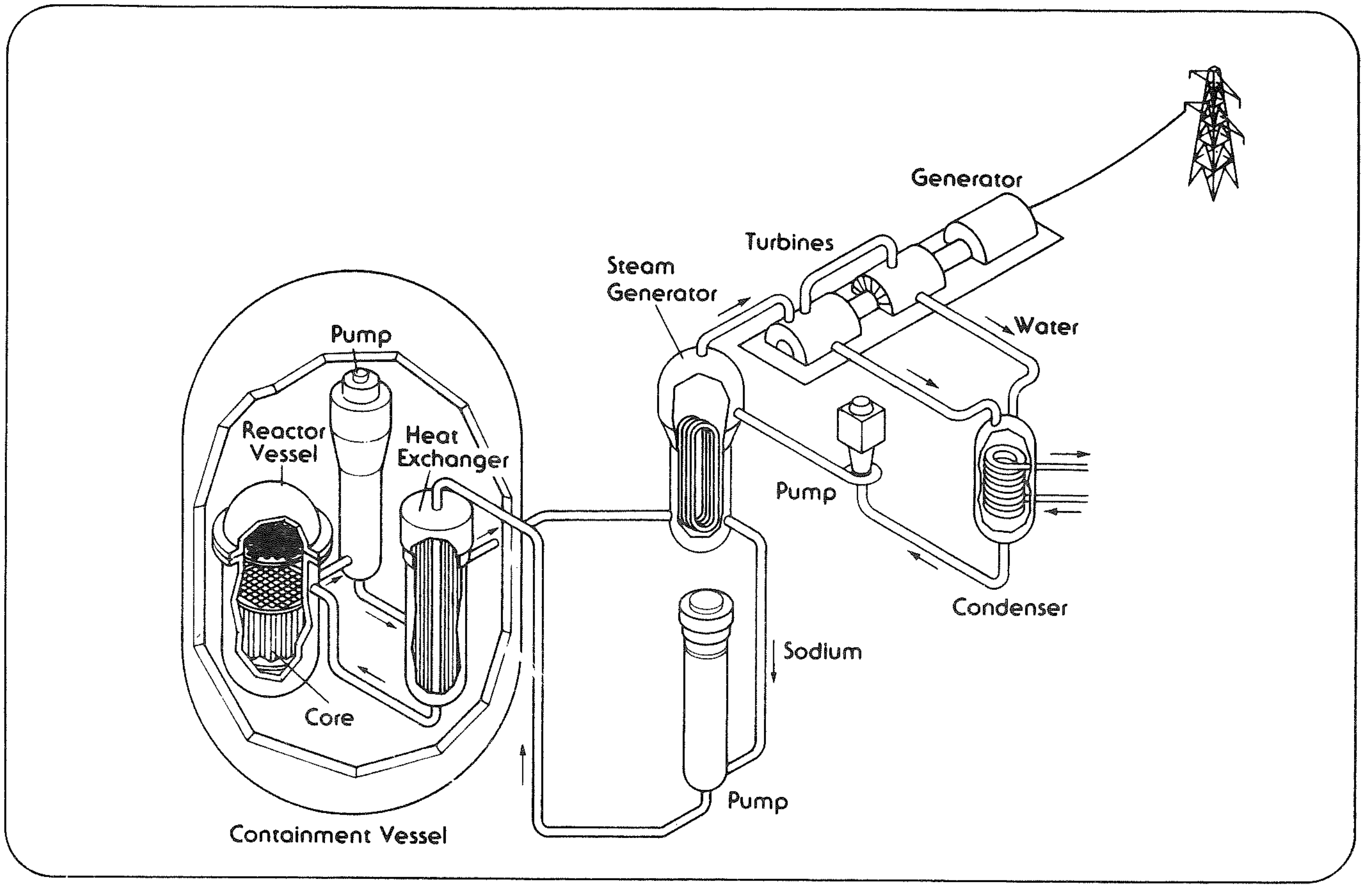
Waste material can be changed in form from a liquid to a type of glass and then buried so that it will not contaminate the environment.

The Breeding Process

The breeder reactor is able to get much more energy from uranium than a light water reactor because it uses it in a different way. In a light water reactor, the fission process depends primarily on U-235, which is found in small quantities in natural uranium. The breeding process depends on a different element, plutonium. When struck by a neutron, plutonium splits into two fission particles and releases heat and several neutrons. If these neutrons strike other plutonium atoms, the fission process can continue in a chain reaction. This is very similar to fission in a light water reactor.

But where do we get the plutonium to start the whole process? It does not occur in nature, and cannot be mined like uranium. Plutonium is, however, formed inside all nuclear reactors that use uranium as a fuel. This occurs when a U-238 atom is struck by a neutron. In general, this does not result in a fission. Rather, the atom of U-238 usually absorbs the neutron, and an atom of plutonium is created. This happens to some extent in light water reactors. Breeder reactors, however, are designed to enhance this effect. In fact, breeder reactors can create more plutonium than they consume.

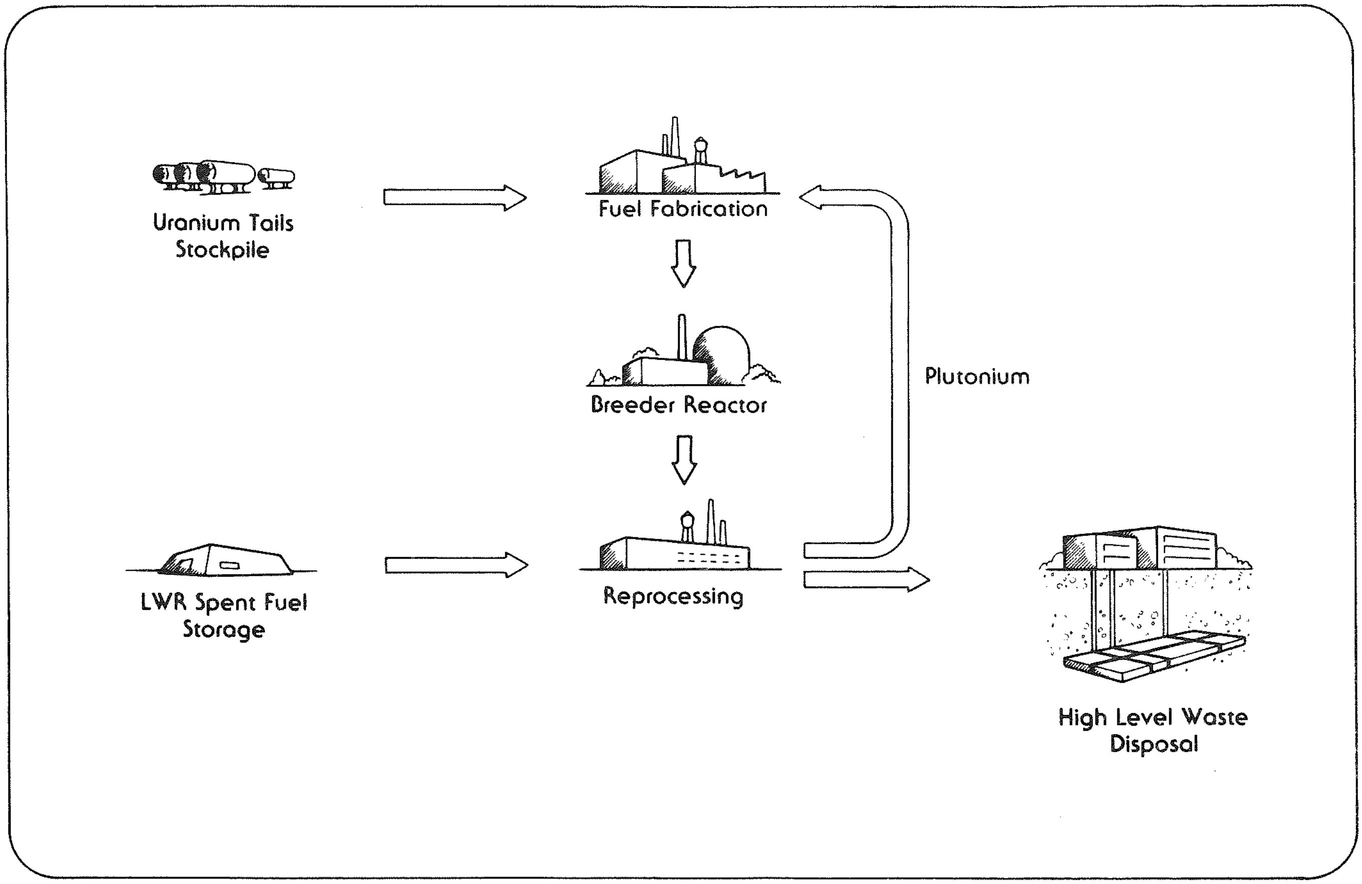




Breeder Reactor Design

The most common design for a breeder reactor uses liquid sodium as a coolant, rather than water. This type of reactor is known as a Liquid Metal Fast Breeder Reactor (LMFBR). Liquid sodium is an excellent heat transfer fluid, and it allows the LMFBR to be operated at high temperatures and low pressures. This produces a more efficient conversion of heat into electricity.

In a breeder reactor, liquid sodium is pumped through the core and into a heat exchanger. There heat from the core is transferred to another sodium coolant system. This second loop of liquid sodium is used to generate steam. Since the sodium in the secondary loop never passes through the core of the reactor, it does not become radioactive.



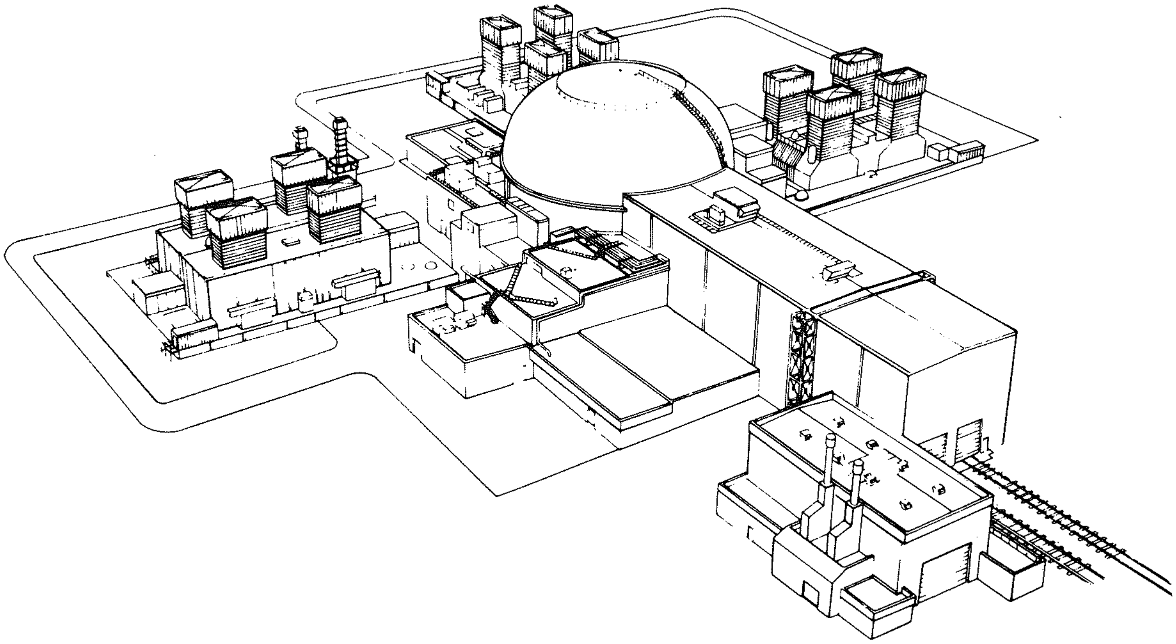
Breeder Reactor Fuel Cycle

The fuel cycle for the breeder reactor is different from the LWR fuel cycle. With the breeder reactor, there is no need to mine, convert, or enrich uranium, since it does not require high concentrations of U-235. The uranium that is used in the breeder reactor can be taken from the depleted stockpile produced by enrichment plants. This is useless in a light water reactor, but can be converted to plutonium and used as fuel in a breeder reactor.

In order to obtain plutonium to fuel a breeder reactor, it is necessary to reprocess nuclear fuel that has been removed from another reactor. Light water reactors produce some plutonium during normal operation, and the spent fuel from this type of reactor may be reprocessed to recover plutonium for a breeder reactor. In addition, fuel discharged from breeder reactors can be reprocessed and reused again and again.

Breeder Reactors In the U.S.

The objective of the U.S.. breeder reactor program is to develop the technology to the point where the reactors may be built commercially. As part of this program, the U.S. built several experimental breeder reactors, starting in 1951. The most recent reactor to be completed is the Fast Flux Test Facility, which is used to test materials and fuels that may be used in future reactors. The next step is to complete the Clinch River Breeder Reactor, which is currently under construction. The final stage in developing the breeder reactor would be to construct a large-scale demonstration plant.



Fast Flux Test Facility

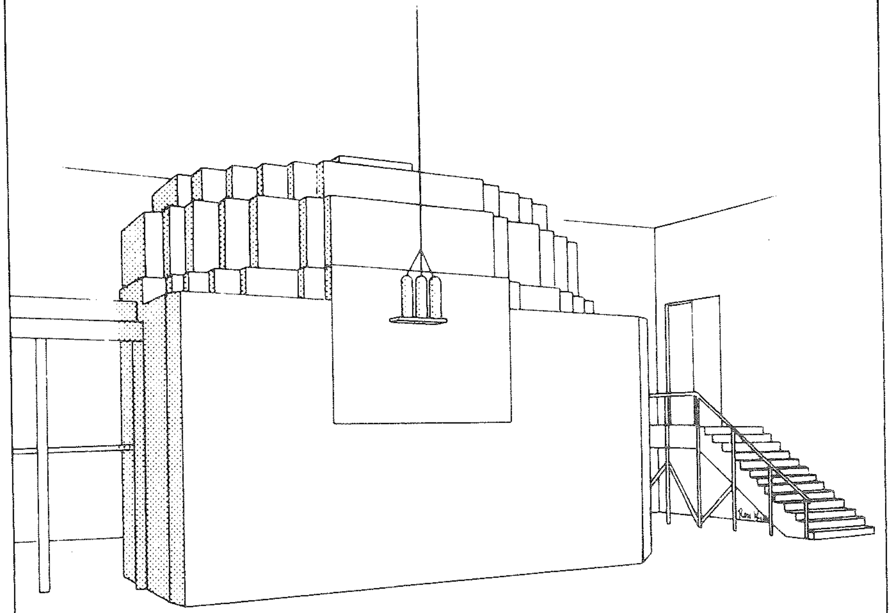
ADDITIONAL INFORMATION

History of Nuclear Power in the U.S.

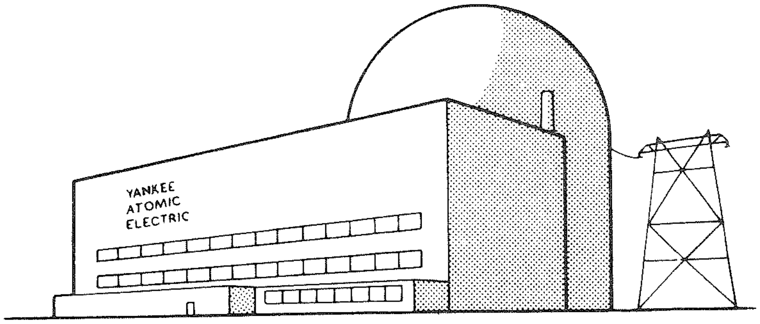
In December of 1942, a team of scientists, led by Nobel prize physicist Enrico Fermi, produced the world's first controlled nuclear chain reaction. The experiment took place at Stagg Field in Chicago in a simple reactor. This early nuclear research was directed toward developing weapons for use in World War II. However, the concept of using nuclear power for peaceful purposes was also important to the scientists. Fermi wrote, "We all hoped that with the end of the war, emphasis would be shifted decidely from the weapon to the peaceful aspects of atomic energy."

Shortly after World War II, the U.S. government began to develop civilian applications of nuclear power. By the mid-1950's, it was a goal of the government to demonstrate that nuclear power could safely produce electricity for use in the private sector. As a first step towards achieving this goal, the U.S. government developed the light water reactor, and commissioned the first one in 1957. This was the first reactor in the U.S. to provide electricity to the public.

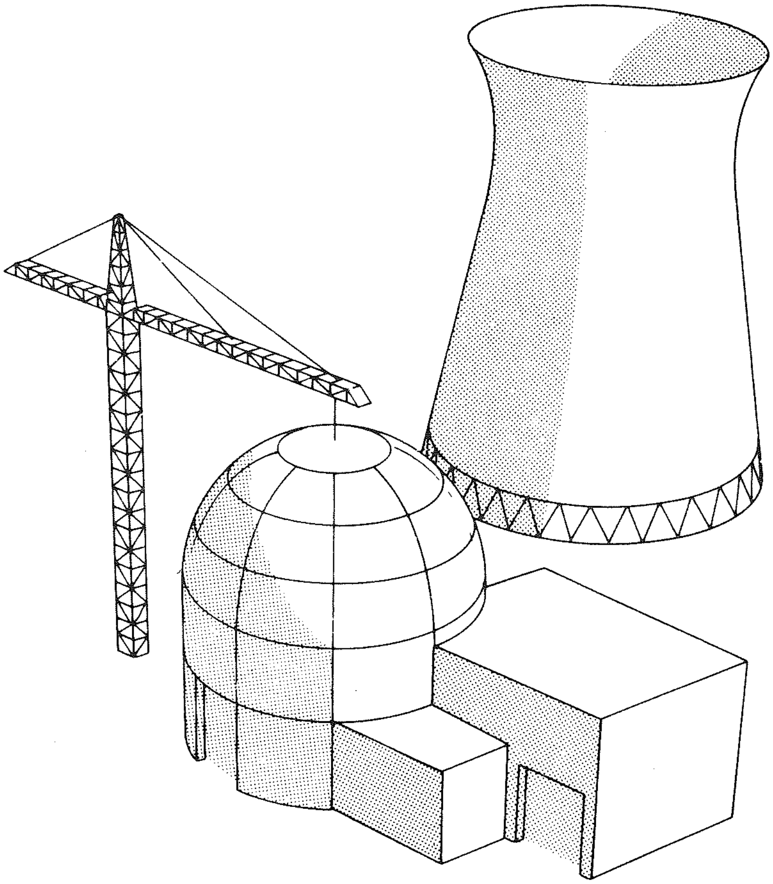
Although this first plant was entirely financed and constructed by the government, subsequent projects encouraged industry participation. Through cooperative efforts by government and industry, a series of reactors were constructed. These plants were the forerunners of today's commercial reactors. The first generation of light water reactors includes Dresden-1 in Illinois and Yankee Atomic Power Station in Massachusetts, which were commissioned in the early 1960's.



First Nuclear Reactor at Stagg Field



Early U.S. Power Reactor



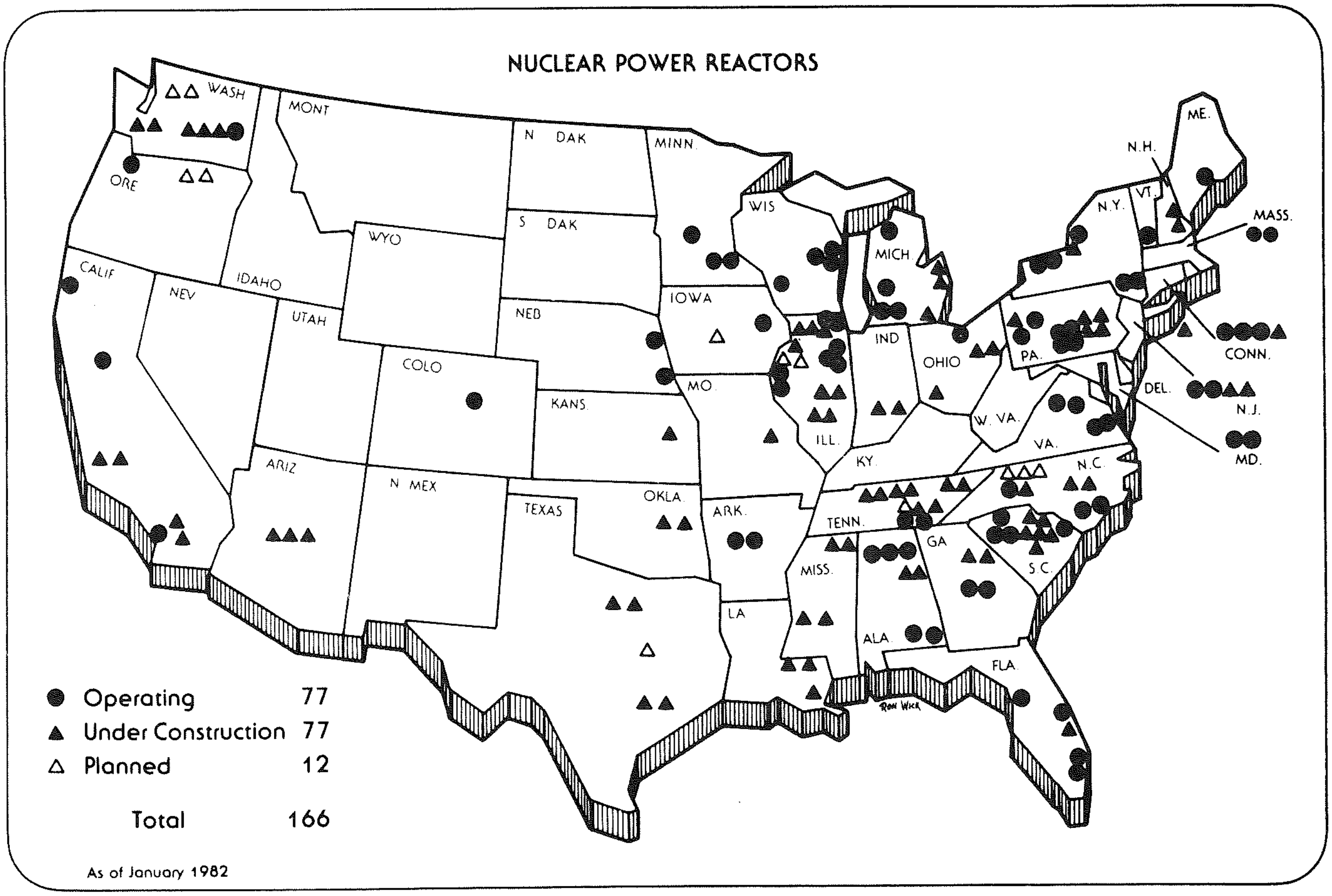
LWR Construction

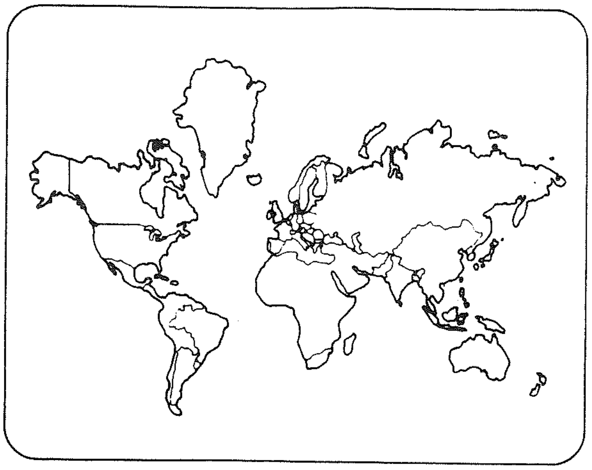
Throughout the development of the first nuclear power plants, an industry grew to meet the new demand for nuclear components and services. By the mid-1960's, a nuclear industry was sufficiently established that government assistance was no longer necessary to build a reactor. In 1963, the first order was placed for a reactor that did not involve government funds. This order opened the door for a large number of reactor sales in the late 1960's and early 1970's. In fact, within five years of the first order, the utilities had committed themselves to building nearly 77,000 MWe of nuclear generating capacity. By 1973, 56 reactors were operating, and today nearly 80 nuclear units are producing electricity.

Nuclear Reactors in the U.S.

In the past few years, nuclear reactors have provided steady and reliable power to many areas of the United States. Approximately 80 nuclear power plants are licensed to operate today, and these reactors provide 11% of all the electricity used in the U.S. In certain areas of the Midwest and Northeast, more than half of the electricity is produced by nuclear generating untis.

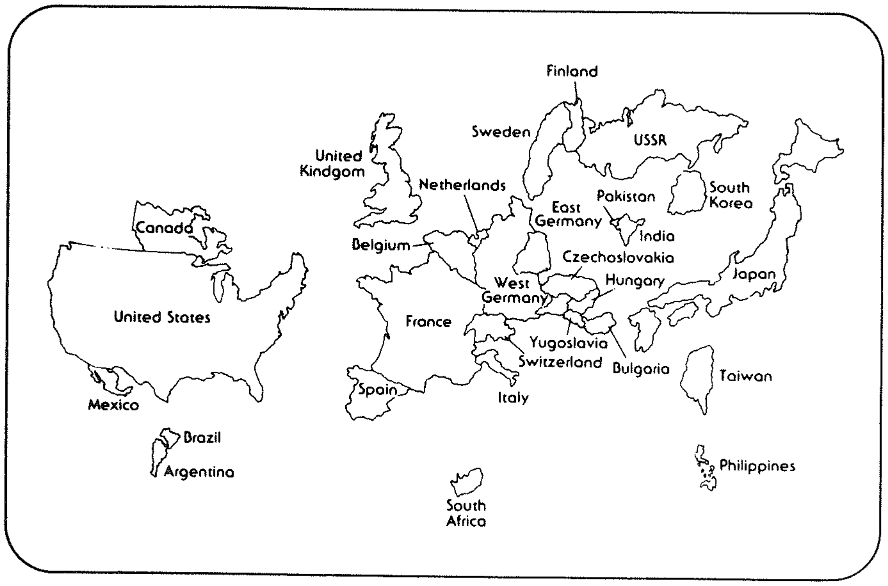
In addition to those plants in operation, another 80 nuclear units are being built and there are plans to construct even more reactors. When these plants are completed, more than 150 nuclear power plants will be operating in the United States.

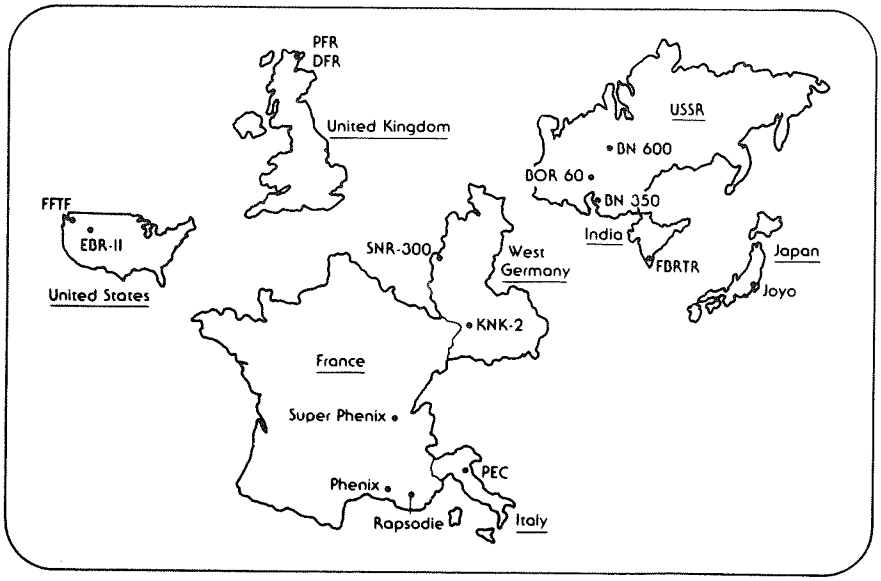




Nuclear Reactors Throughout the World

Nuclear power is an important source of electricity in many nations, as shown by these two maps. The upper map shows the traditional view of the world. In the map below, the area of a nation is proportional to the size of its nuclear program in 1985. It can be seen that the United States has the world's largest nuclear power program. Many other nations, such as France and Japan, plan to develop a large amount of additional nuclear generating capacity.





Breeder Reactors Throughout the World

A number of nations with large nuclear programs have invested in developing breeder reactor technology. France, the United Kingdom, and the Soviet Union have already completed demonstration plants; West Germany and Japan will soon follow. In the figure, the size of each country is determined by the size of the largest breeder reactor that will be operating in 1985.

DEFINITIONS OF BASIC TERMS

THE FISSION PROCESS

Neutron - A basic atomic particle that has no electrical charge. Neutrons and protons, which are positively charged particles, form the central portion of the atom known as the nucleus. Negatively charged electrons orbit the nucleus at various distances. The chemical and nuclear properties of an atom are determined by the number of its neutrons, protons, and electrons.

Fission - The process by which a neutron strikes a nucleus and splits it into two fragments. During the process of nuclear fission, several neutrons are emitted at high speed, and heat and radiation are released.

Chain Reaction - The continuing process of nuclear fissioning, in which the neutrons released from every fission trigger at least one other nuclear fission.

Fission Products - The two small atoms created when a nucleus fissions. The mass of the fission products is less than that of the original nucleus. The difference in mass is released as energy.

Isotopes - Atoms having the same number of protons, but a different number of neutrons. Two isotopes of the same atom are very similar and difficult to separate by ordinary chemical means. Isotopes can have very different nuclear properties, however. For example, one isotope may fission readily, while another isotope of the same atom may not fission at all.

Uranium - A metallic element found in nature that is commonly used as a fuel in nuclear reactors. As found in nature, it contains two isotopes--uranium-235 and uranium-238.

Uranium-235 - The less abundant uranium isotope, accounting for less than one percent of natural uranium. Uranium-235 splits, or fissions, when struck by a neutron. When uranium is used as a fuel in a nuclear reactor, the concentration of U-235 is often increased to enhance the fission process. For example, the fuel for light water reactors contains about 3% uranium-235.

Uranium-238 - The more abundant uranium isotope, accounting for more than 99% of natural uranium. Uranium-238 tends to absorb neutrons rather than fission. When it absorbs a neutron, the uranium atom changes to form a new element--plutonium.

Plutonium - An element that is not found in nature, but can be produced from uranium in a nuclear reactor. Plutonium fissions easily, and can be used as a nuclear fuel.

Fissile - Material composed of atoms which readily fission when struck by a neutron. Uranium-235 and plutonium-239 are examples of fissile materials.

Fertile - Material composed of atoms which readily absorb neutrons to produce fissionable materials. One such element is uranium-238, which becomes plutonium-239 after it absorbs a neutron. Fertile material alone cannot sustain a chain reaction.

FUEL CYCLE

Conversion - The chemical process by which uranium is prepared for treatment in an enrichment facility. The conversion process changes uranium from a solid oxide form to a fluoride gas.

Enrichment - The process by which the concentration of uranium-235 is increased. Generally, uranium is enriched from its natural concentration of less than 1% U-235 to about 3% U-235. This concentration of fissile material is suitable for use in a light water reactor.

Tails - A product of uranium enrichment that is composed of uranium with a very low concentration of U-235. While this material is of little use in a light water reactor, it can be converted to plutonium in a fast breeder reactor.

Fabrication - The final step in preparing nuclear fuel for use in a reactor. During fabrication, the fuel is shaped into small pellets and then stacked in thin metal tubes. The tubes, or rods, of fuel are carefully spaced within a metal grid before being inserted in a reactor.

Spent Nuclear Fuel - Material that is removed from a reactor after it can no longer sustain a chain reaction. Spent fuel from a light water reactor is composed primarily of uranium and contains some radioactive materials, such as fission products. Spent fuel also contains some valuable nuclear materials, such as uranium-235 and plutonium.

Reprocessing - A series of chemical steps in which valuable nuclear materials are extracted from spent nuclear fuel. The useful materials, including uranium and plutonium, can be used again as fuel in other reactors. The remaining waste materials are solidified and isolated from the environment.

NUCLEAR REACTORS

Nuclear Fuel - Nuclear material which fissions easily. The most common nuclear fuels are uranium and plutonium. The material is packed into long, thin tubes known as fuel rods which are arranged in a compact configuration. This allows a controlled chain reaction to occur.

Core - The region of a reactor in which the nuclear chain reaction is initiated, maintained, and controlled. Coolant is constantly circulated through the core to remove heat produced by the fission process.

Control Rods - Long, thin rods that are positioned among fuel rods to regulate the nuclear chain reaction. Control rods are composed of material that absorbs neutrons readily. They interrupt or slow down a chain reaction by capturing neutrons that would otherwise trigger more fissions.

Coolant - Fluid that is circulated through the core of a reactor to remove the heat generated by the fission process. Most reactors operating today used water as coolant, but some are cooled by liquid sodium. In reactors that have more than one coolant system, the fluid which passes through the core of a reactor is known as the primary coolant. It absorbs heat in the core and then transfers it to a secondary coolant system. The secondary system produces steam, which generates electricity.

Pressure Vessel - A heavy steel enclosure around the core of a reactor. It is designed to withstand high pressures and temperatures to prevent radioactive material from escaping from the core.

Containment Building - A thick concrete structure surrounding the pressure vessel and other reactor components. It is designed to prevent radioactive material from being released to the atmosphere in the unlikely event that it should escape from the pressure vessel.

Light Water Reactor - A general term that refers to all nuclear reators which use ordinary water as a coolant. This includes pressurized water reactors and boiling water reactors, which are the predominant reactors in the U.S. LWR's are generally fueled with enriched uranium, although they can operate with other nuclear fuels.

Pressurized Water Reactor - A reactor cooled by water that is kept at high pressure to prevent it from boiling. Primary coolant passes through the core of a PWR, and then transfers its heat to a secondary coolant system. Steam is produced from the heated water in the secondary system.

Boiling Water Reactor - A reactor cooled by water that is allowed to boil as it passes through the core. This coolant is used directly to produce the steam which generates electricity.

Fast Breeder Reactor - A reactor cooled by liquid sodium rather than water. In this type of reactor, the transformation of uranium-238 to plutonium occurs readily. Since plutonium fissions easily, it can be recycled and used as fuel for a breeder reactor. The conversion of uranium to plutonium is so efficient in an FBR that this reactor creates more fuel than it consumes.

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LOW LEVEL RADIOACTIVE WASTE DISPOSAL: THE PROBLEM AND THE SOLUTION

Attachm 3
1-18-84

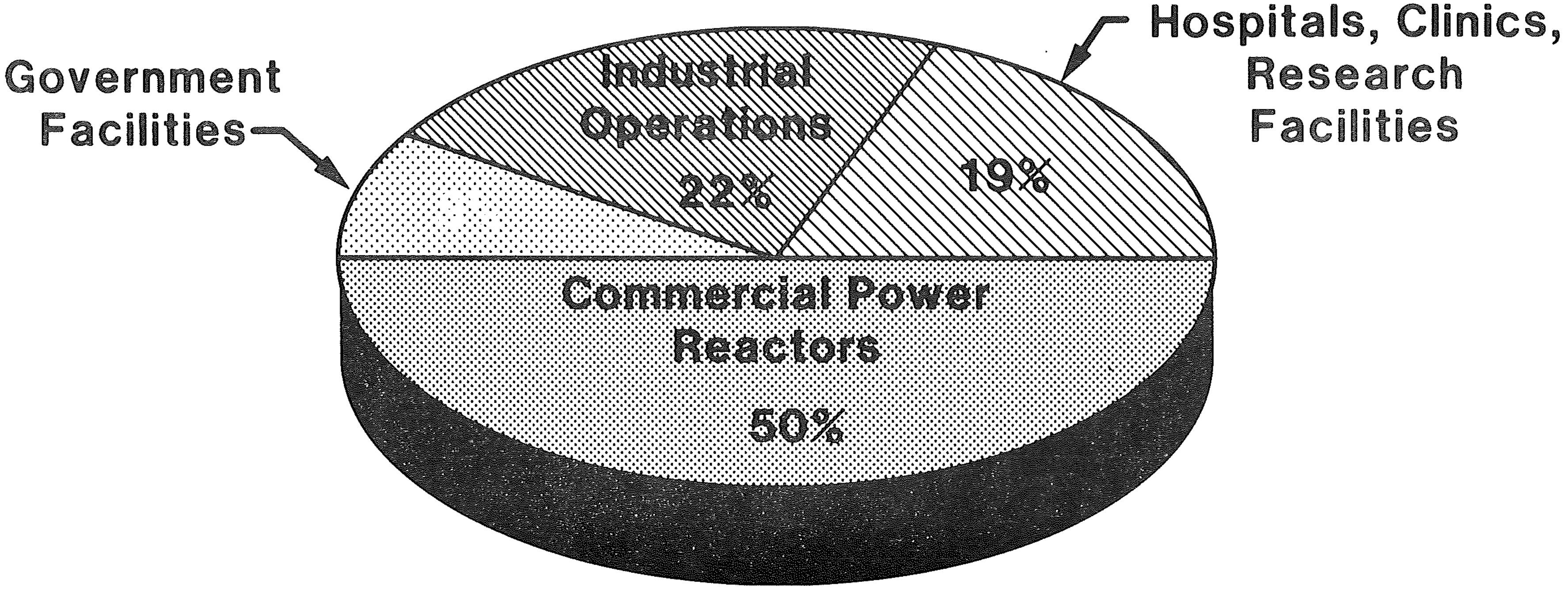
THERE ARE THREE CATEGORIES OF NUCLEAR WASTE

- Low Level
- Transuranic
- High Level

LOW LEVEL WASTE IS SLIGHTLY CONTAMINATED DEBRIS . . .

Gloves
Rags
Clothing
Tools
Medical Instruments
Machine Parts

GENERATED BY HOSPITALS, POWER PLANTS, INDUSTRIAL PROCESSES AND RESEARCH INSTITUTIONS



HOSPITALS, CLINICS AND RESEARCH FACILITIES GENERATE 19% OF THE NATION'S WASTE

- Cancer Treatment
- Diagnostic Procedures

INDUSTRIAL OPERATIONS GENERATE 22% OF THE NATION'S WASTE

- **Measurement and Gauging**
- **Radioisotopic Tracers**
- **Quality Control Inspection**

NUCLEAR POWER PLANTS GENERATE 50% OF THE NATION'S WASTE

- Tools
- Equipment Parts
- Solidified Ion Exchange Resins

GOVERNMENT SOURCES GENERATE AND DISPOSE OF 9% OF THE NATION'S WASTES AT MILITARY AND LABORATORY FACILITIES

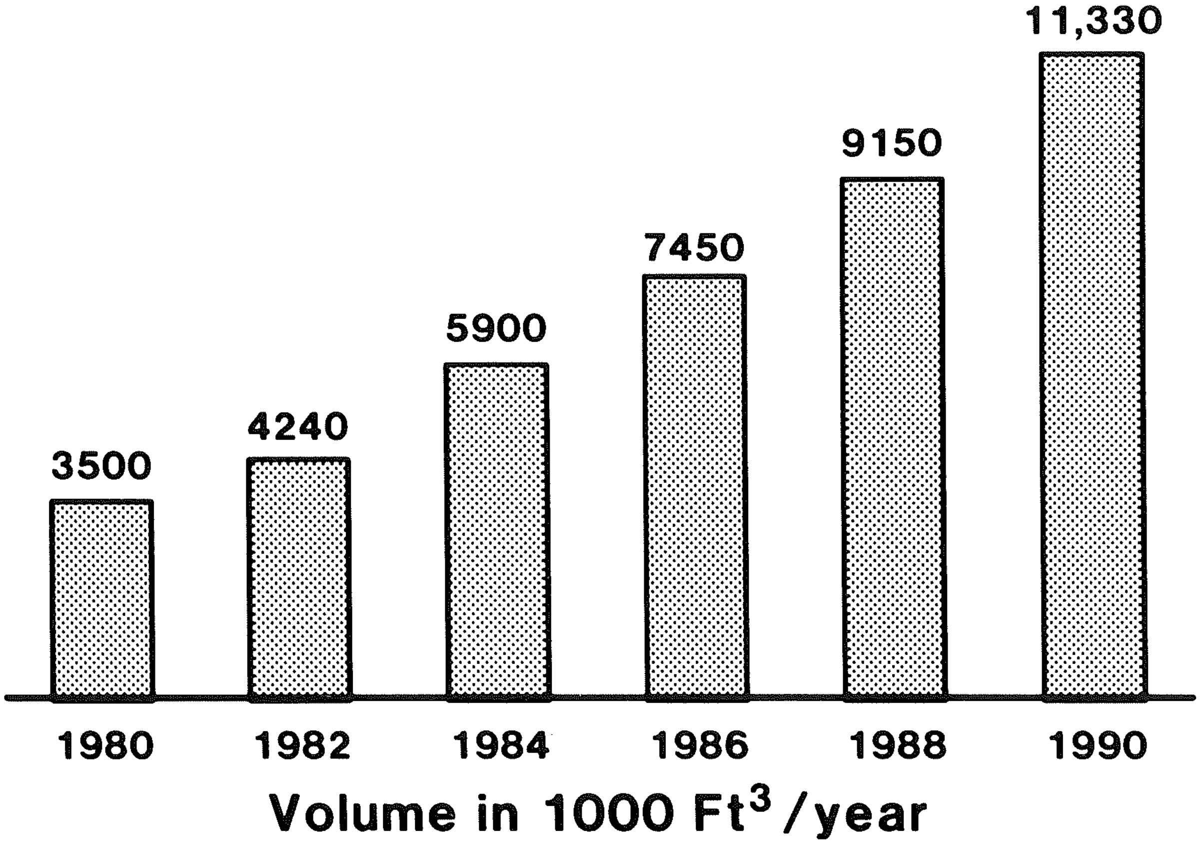
- **Defense Production Facilities**

- **National Laboratory Research Programs**

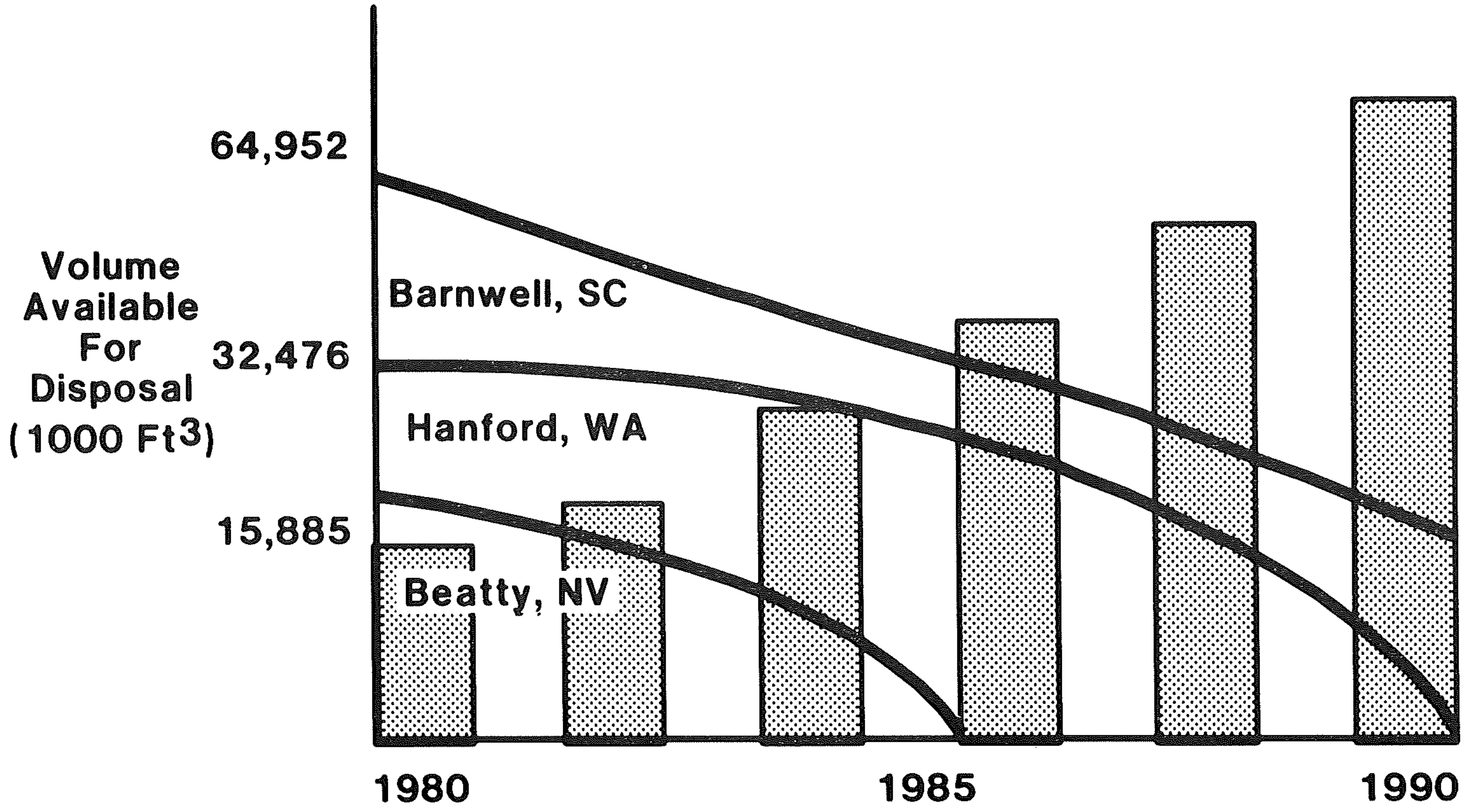
THE VOLUME OF LOW LEVEL WASTE GENERATED EACH YEAR IS GROWING RAPIDLY . . .

WHILE DISPOSAL SPACE IS SHRINKING

BY 1990, THE NATION WILL GENERATE 11 MILLION FT^3 OF LOW LEVEL WASTE EACH YEAR

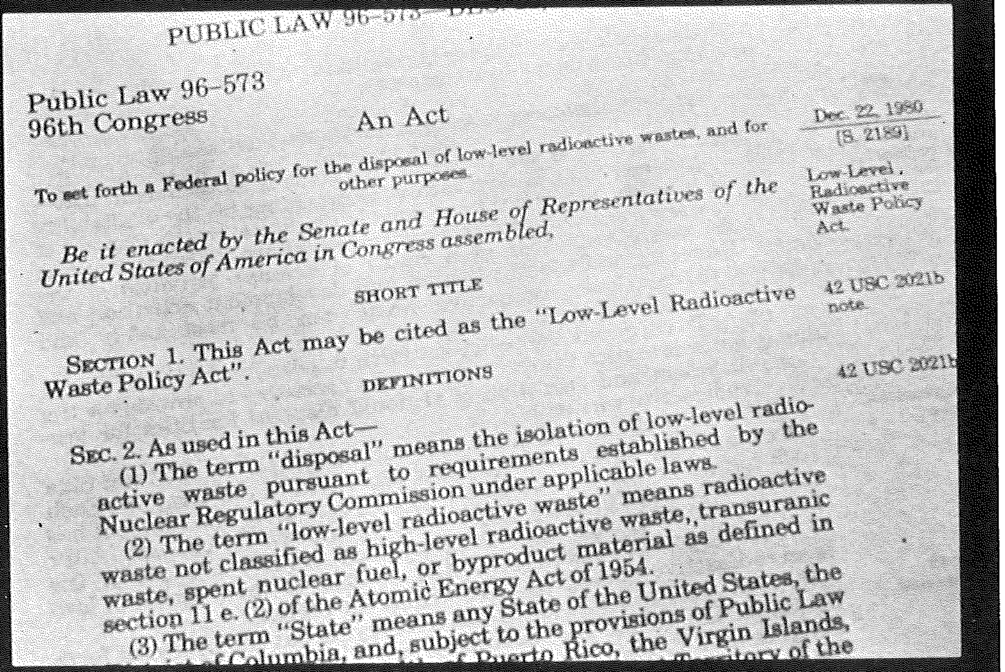


EXISTING DISPOSAL SITES ARE FILLING RAPIDLY



A NEW LAW ADDRESSES THIS PROBLEM

- **The 1980 Low Level Radioactive Waste Policy Act**



PUBLIC LAW 96–57

Public Law 96–573
96th Congress

An Act

Dec. 22, 1980
[S. 2189]

To set forth a Federal policy for the disposal of low-level radioactive wastes, and for other purposes.

Low-Level Radioactive Waste Policy Act.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SHORT TITLE

42 USC 2021b note.

SECTION 1. This Act may be cited as the "Low-Level Radioactive Waste Policy Act".

DEFINITIONS

42 USC 2021

SEC. 2. As used in this Act—

(1) The term "disposal" means the isolation of low-level radioactive waste pursuant to requirements established by the Nuclear Regulatory Commission under applicable laws.

(2) The term "low-level radioactive waste" means radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11 e. (2) of the Atomic Energy Act of 1954.

(3) The term "State" means any State of the United States, the of Columbia, and, subject to the provisions of Public Law Puerto Rico, the Virgin Islands, Territory of the

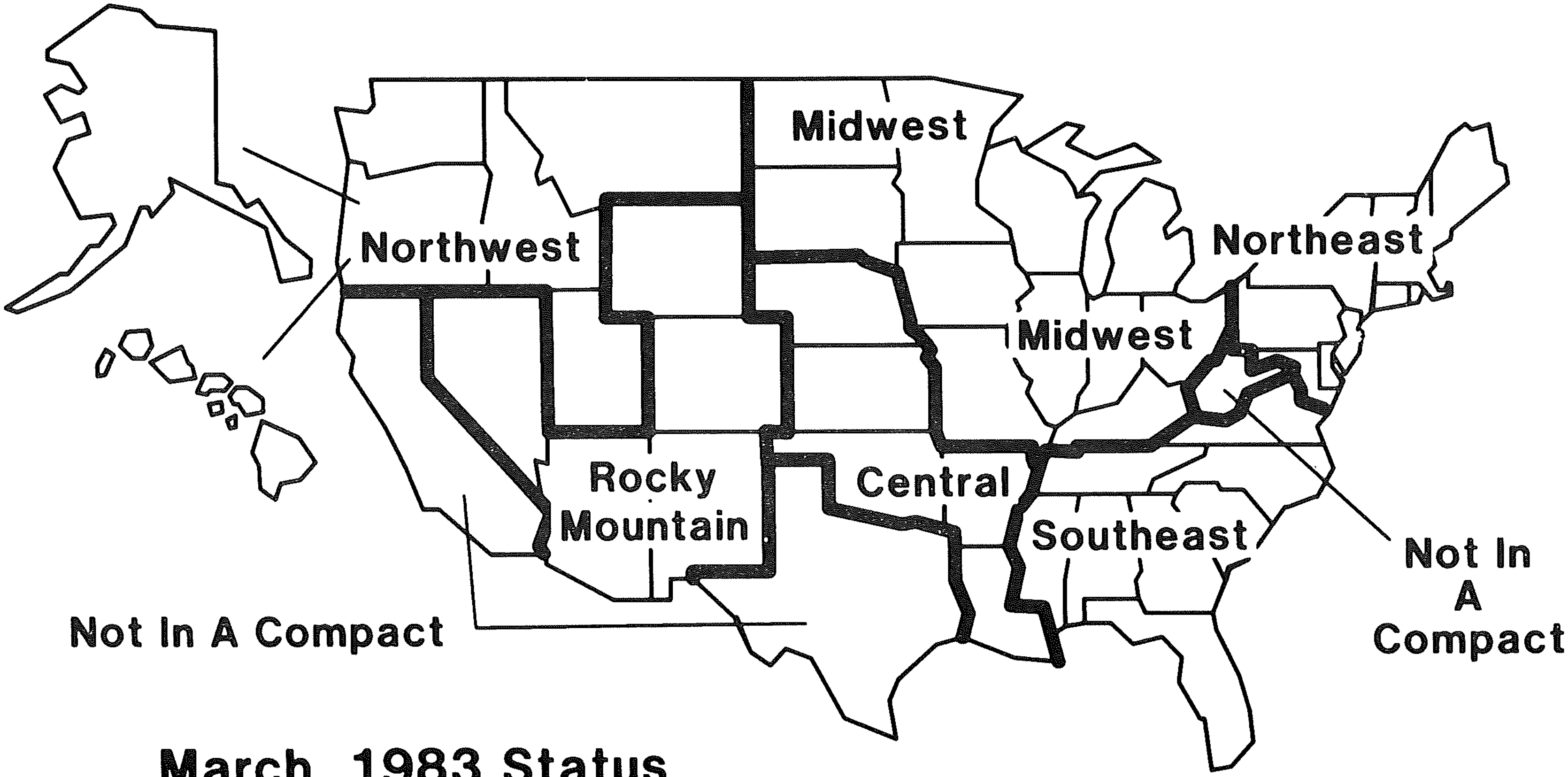
THE NEW LAW STATES . . .

- On January 1, 1986, each state must provide for its own low level waste disposal facility
- Regional compacts are encouraged as an efficient method of establishing central facilities
- Congress must endorse creation of each compact
- After January, 1986, any state can refuse to accept low level waste from states outside the compact

THREE OPTIONS FOR STATES

- Join Large Compact
- Develop a Small Compact and Maintain Control
- Do Nothing and Risk Industrial Interruption

REGIONAL COMPACTS ARE NOW FORMING



March, 1983 Status

RADIOACTIVE WASTE DISPOSAL IS MORE HIGHLY CONTROLLED THAN HAZARDOUS CHEMICAL WASTE

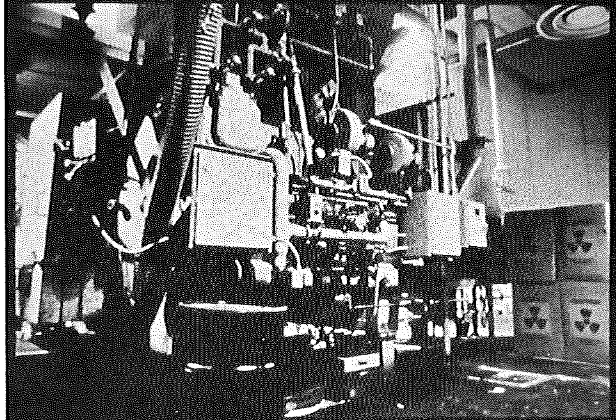
- No Illicit Disposal
- No Health Hazards Evidenced
- Most Regulated in the World
- Strict New Environmental Standards

REGULATORY AGENCIES INSURE BROAD SUPERVISION

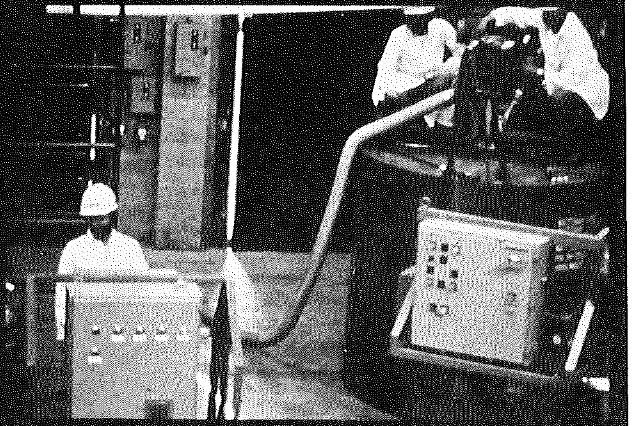
- Federal Agencies
  - Nuclear Regulatory Commission
  - Department of Energy
  - Department of Transportation

- State Agencies
  - Health Department
  - Transportation Department
  - Natural Resources Department

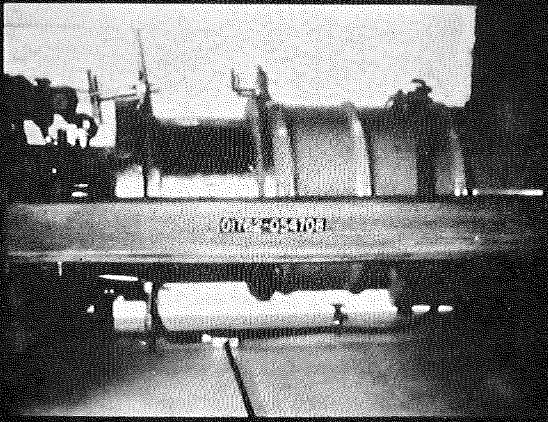
VOLUME REDUCTION TECHNIQUES ARE USED TO TREAT WASTE



Incineration

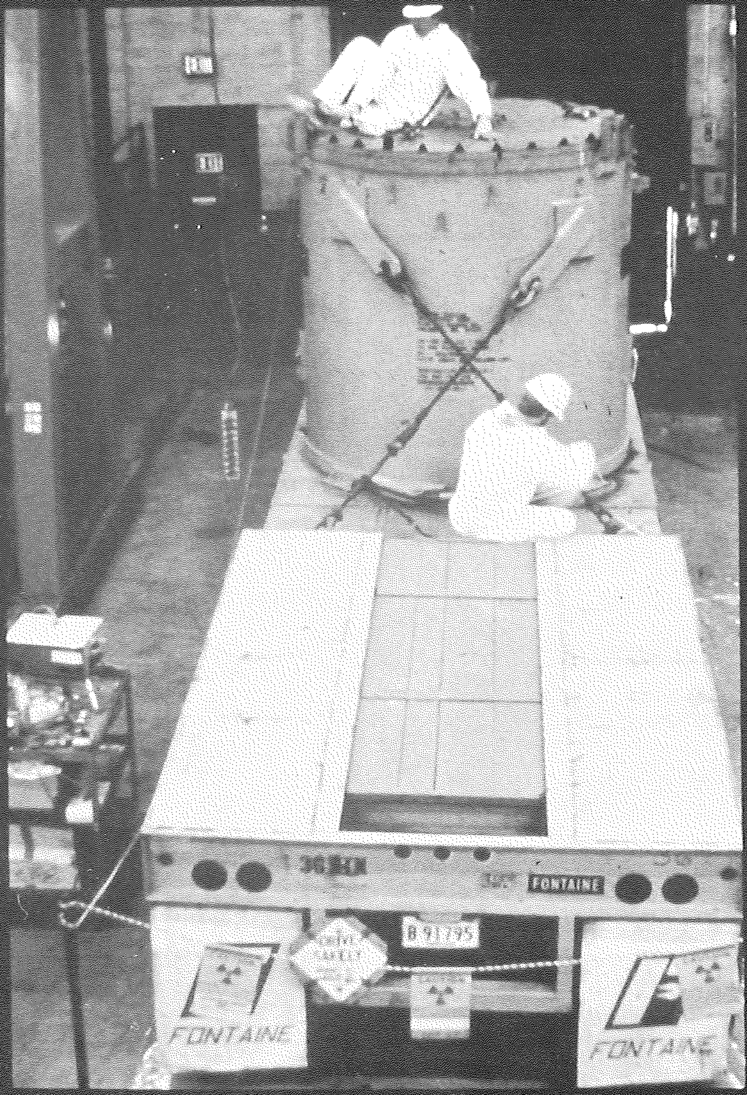


Solidification



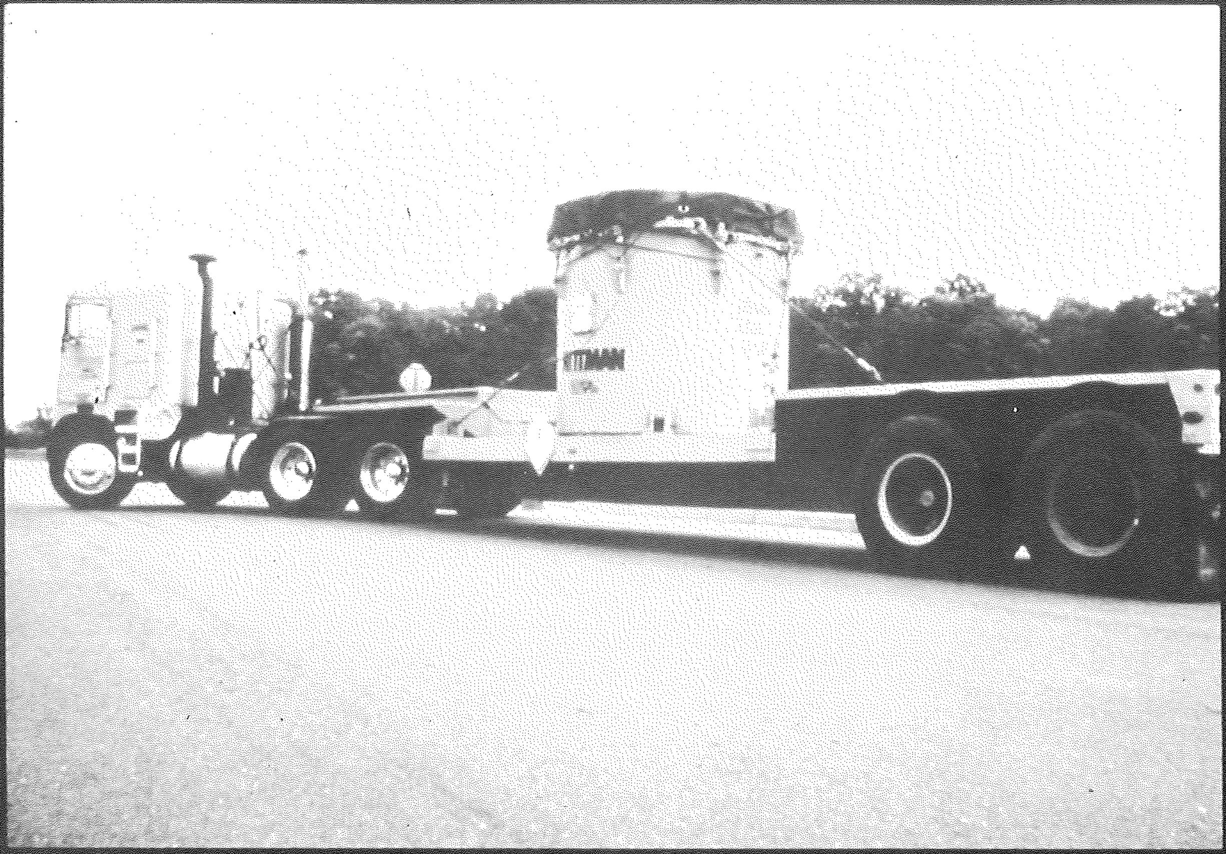
Compaction

LOW LEVEL WASTES ARE PACKAGED IN DRUMS OR SHIELDED CONTAINERS



CONTAINERS ARE PLACED INSIDE SHIELDED SHIPPING CASKS

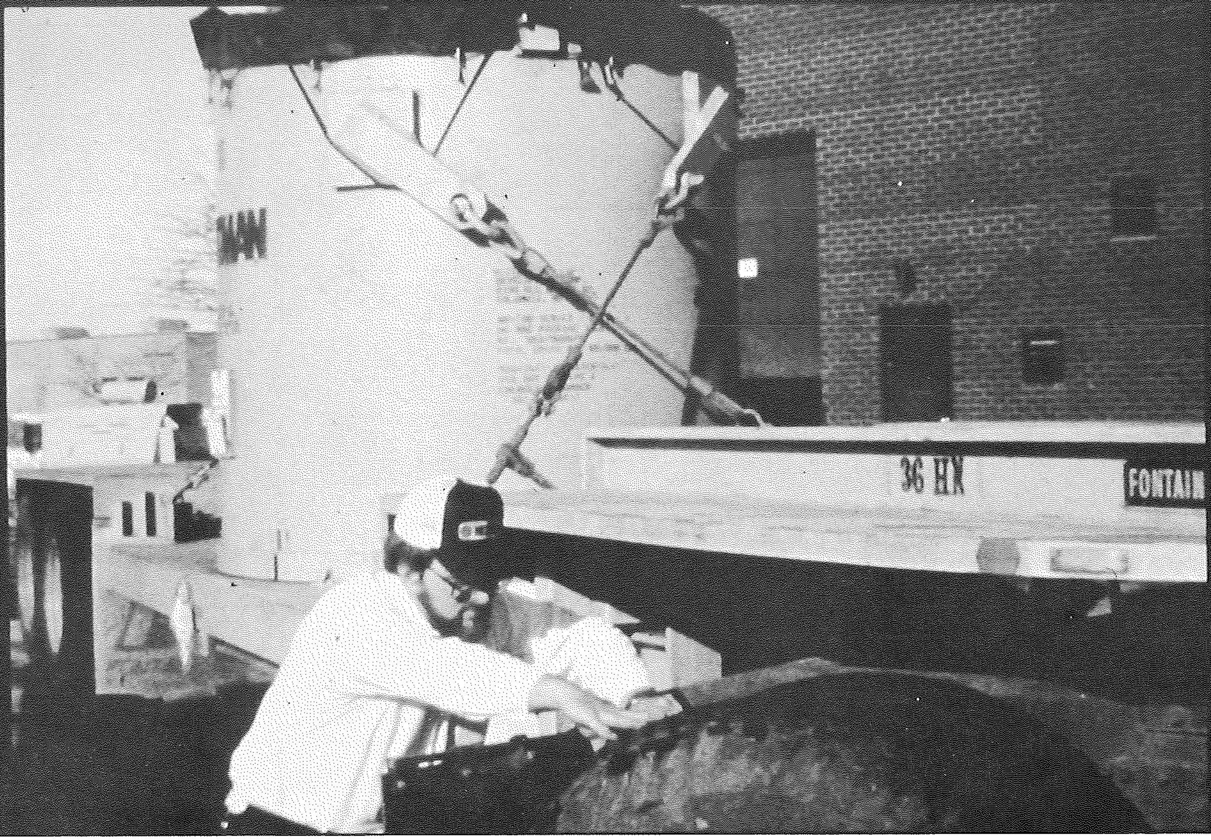
CONTAINERS ARE SHIPPED ACCORDING TO DEPARTMENT OF TRANSPORTATION REGULATIONS



Shielded Shipping Cask

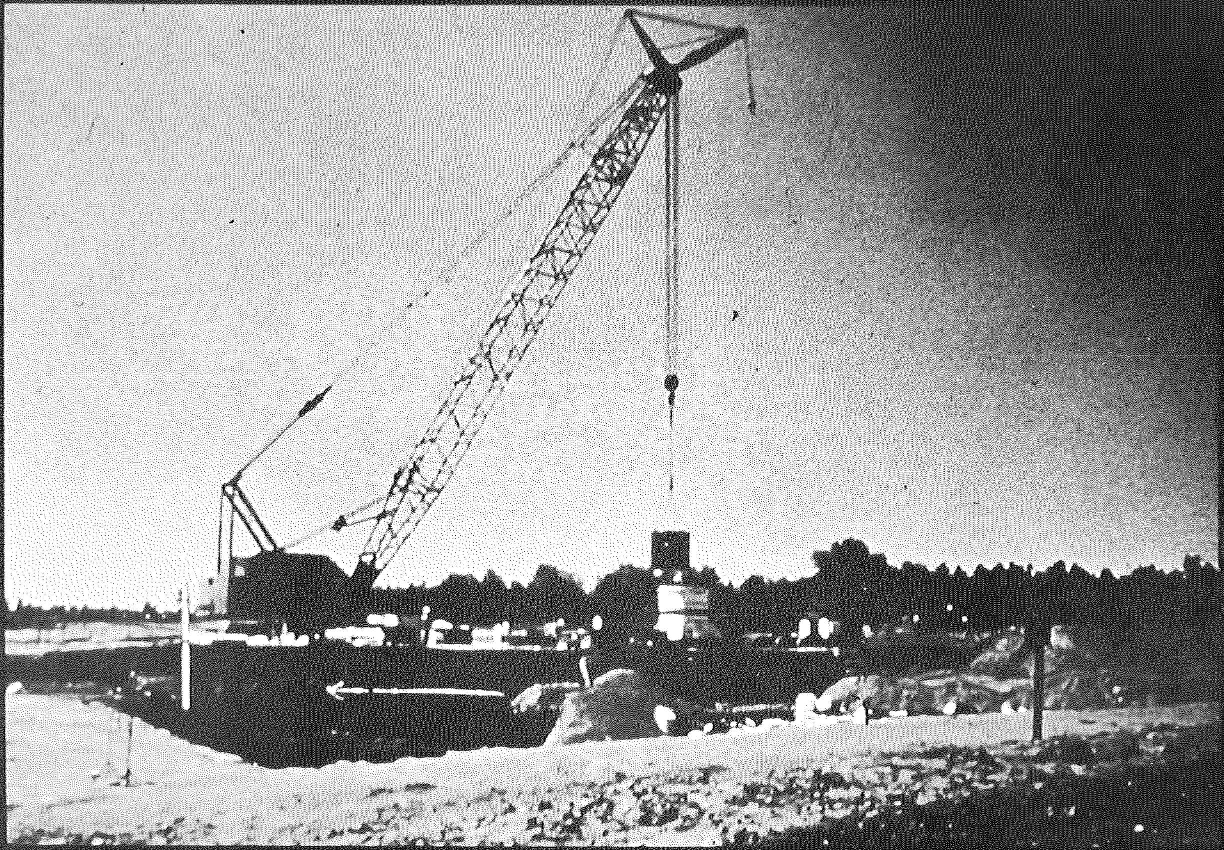
DISPOSAL SITE OPERATION

AT THE DISPOSAL SITE, SHIPMENTS ARE INSPECTED BY THE SITE OPERATOR AND GOVERNMENT AGENTS



Site Inspection of Waste Shipments

WASTE IS SEGREGATED BY CATEGORY AND PLACED INTO TRENCHES



FILLED TRENCHES ARE IMMEDIATELY BACKFILLED WITH AN IMPERMEABLE CLAY CAP

AN IMPERMEABLE CAP OF SOIL AND COMPACTED CLAY IS CONTOURED TO SHED SURFACE WATER

TRENCHES ARE REVEGETATED AND MARKED WITH A PERMANENT MARKER

LABORATORIES MAINTAINED AT EACH SITE MONITOR THE ENVIRONMENT

Hittman Nuclear and Development Corporation Laboratory
Maxey Flats, KY

ESTABLISHING NEW SITES

PLANNING FOR REGIONAL DISPOSAL FACILITIES

- Select Candidate Sites
- Perform Environmental Analysis
- License Site and Facility
- Construct New Facilities

THE PROCESS IS TIME CONSUMING

Candidate Site Selection

6 Months

Environmental Analysis

1 Year

Facility Licensing

2 Years

Facility Construction

1 Year

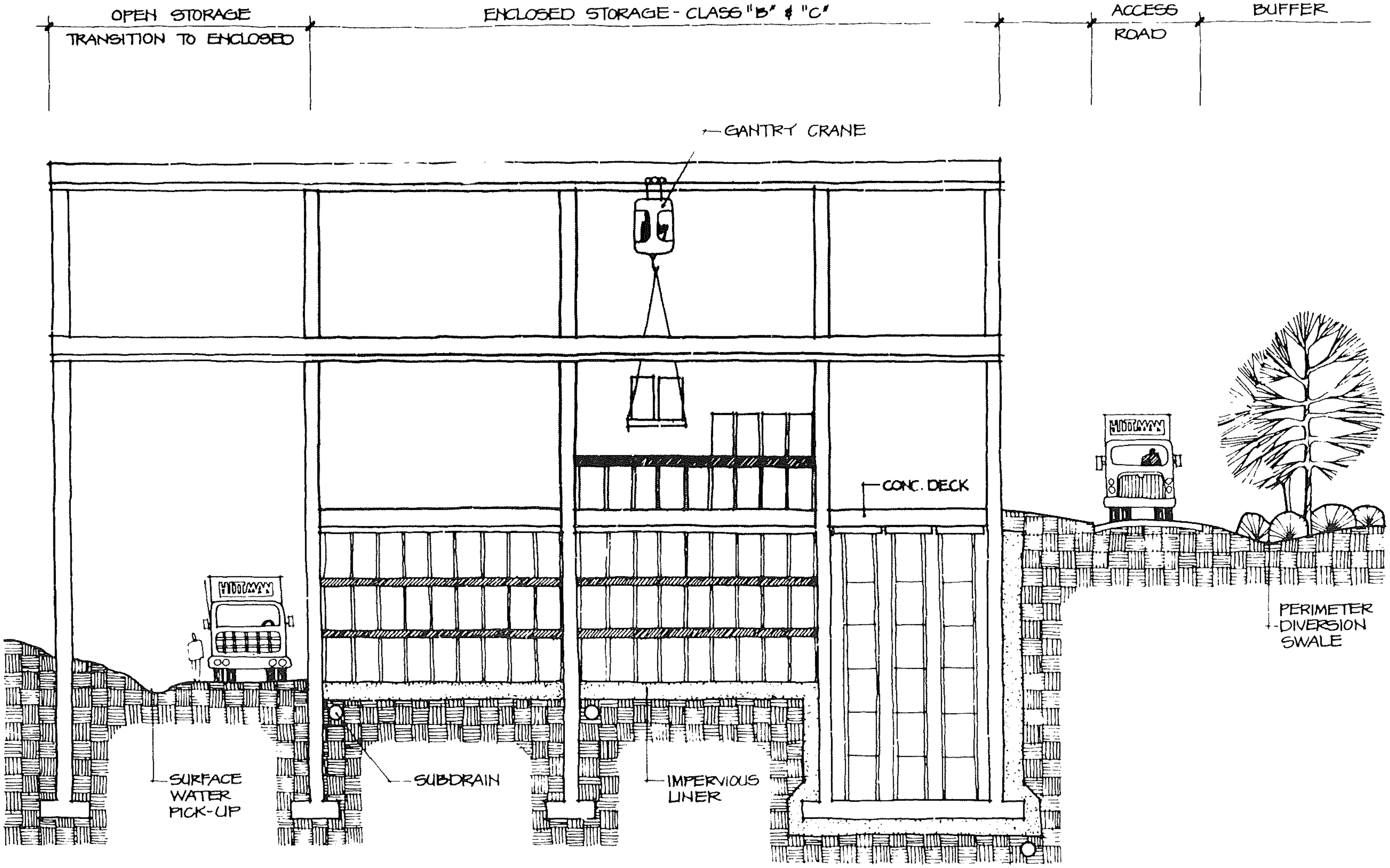
NEW FEDERAL REGULATIONS ADDRESS CONCERNS OF THE PAST

- Additional Environmental Protection
- Segregation of Waste
- Funding for Closure
- Provisions for Perpetual Care

WASTES ARE SEGREGATED ACCORDING TO THE HAZARD THAT EACH REPRESENTS

- Short-Lived Wastes Can Be Placed in Trenches
- Long-Lived Wastes Can Be Placed in Engineered Storage Facilities

THE HITTMAN CONCEPT

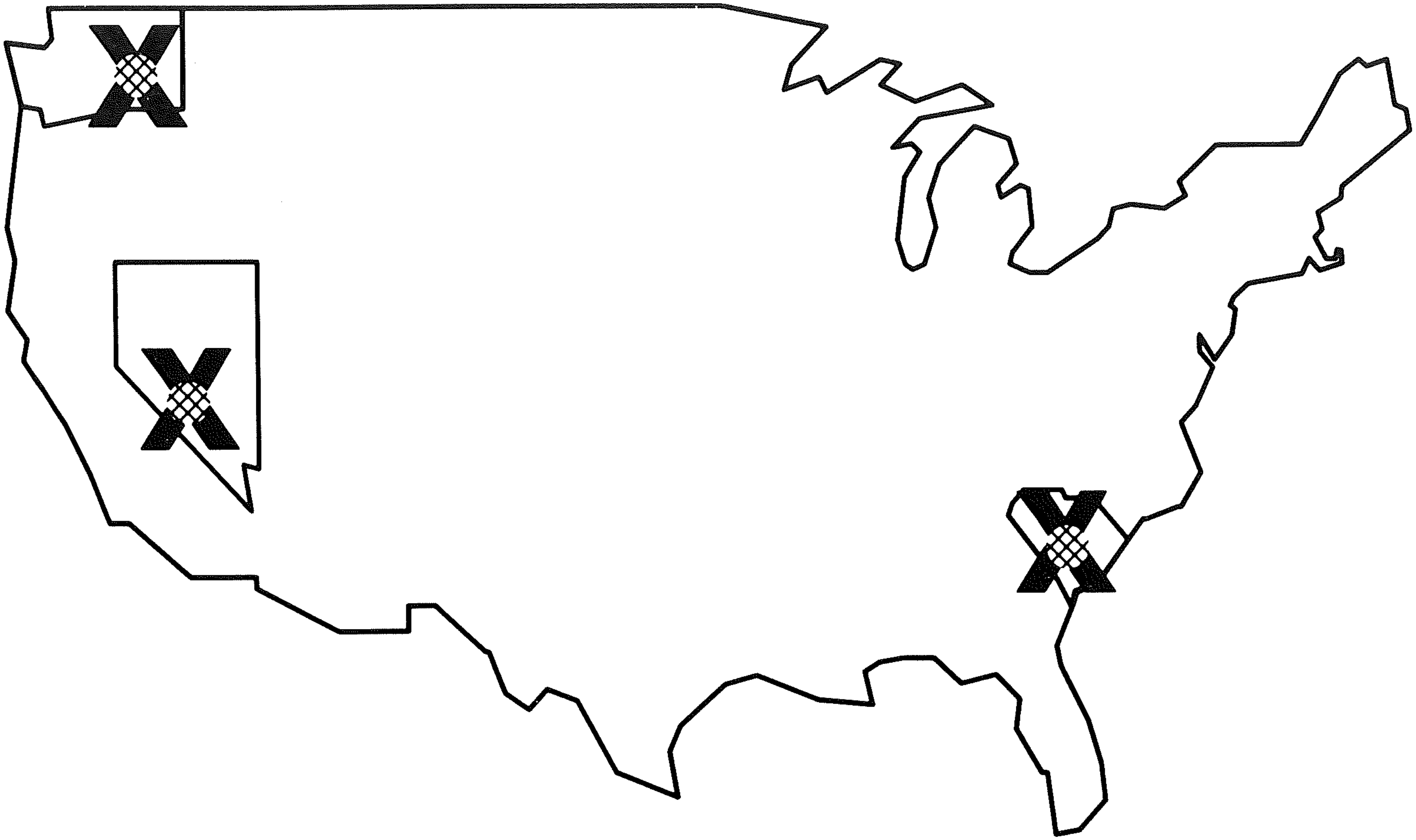


An Engineered Storage Facility That Insures Environmental Protection

ENVIRONMENTAL PROTECTION IS BUILT IN

- Protection of groundwater
- Waste Segregation
- Leachate Collection
- Comprehensive Surveillance System

BY 1986, EXISTING SITES WILL RESTRICT THE LOW LEVEL WASTE VOLUME THEY ACCEPT



FEASIBLE SITES ARE SELECTED BY WORKING WITH STATE AND LOCAL GROUPS

Preferred Sites

- Must Meet Government Requirements
- Must be Government-Owned
- Must Develop Environmental Information
- Must be Constantly Monitored
- Must Have Lifetime Funding

STATE CONTROL WILL PREVENT TEMPORARY INTERIM STORAGE

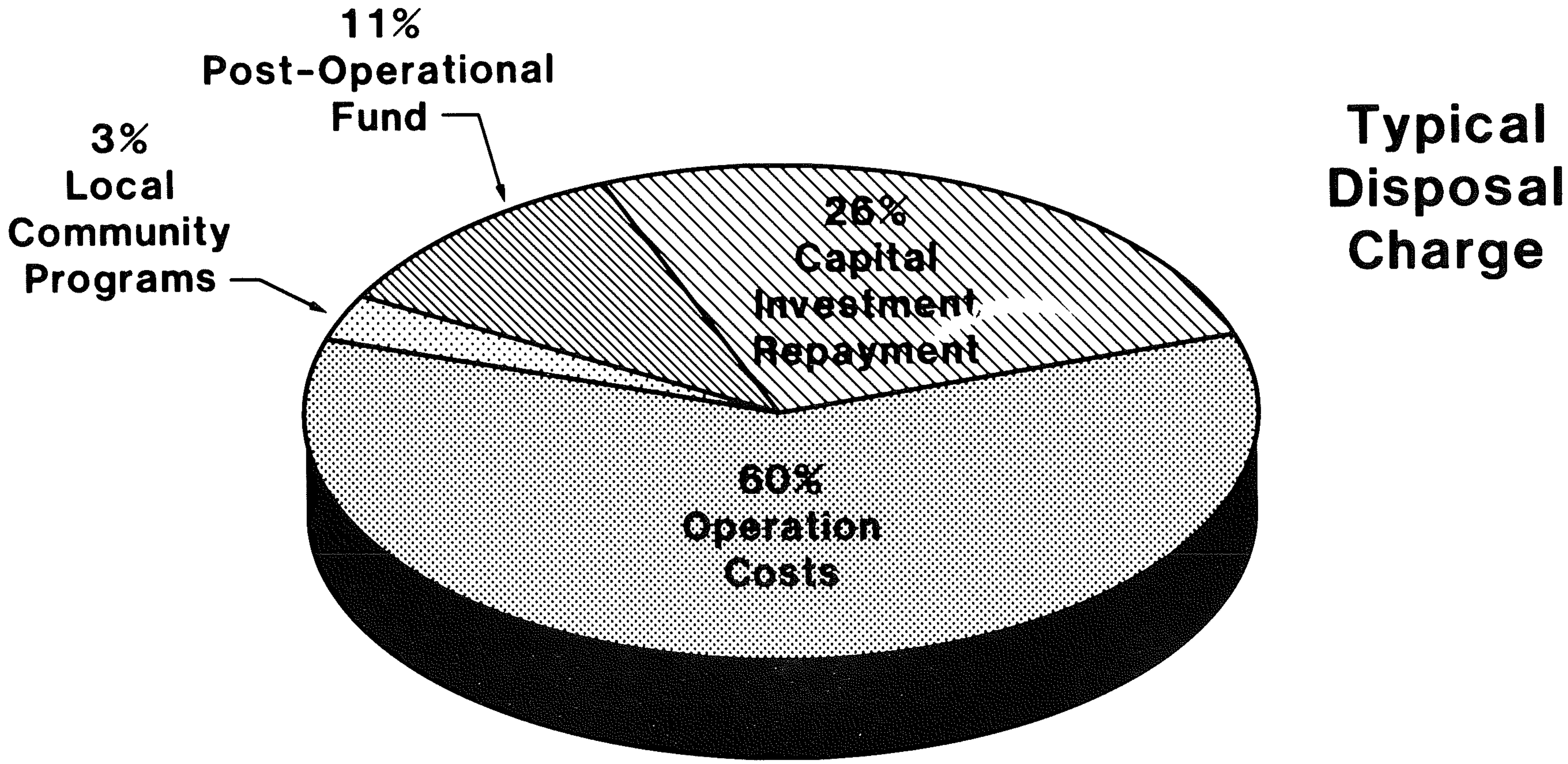
REGULATORY AGENCIES WILL INSURE SELECTION OF A RESPONSIBLE SITE OPERATOR

- Site Operation Experience
- Geotechnical Resources
- Waste Treatment Services
- Project Management Skills
- Long History of Integrity

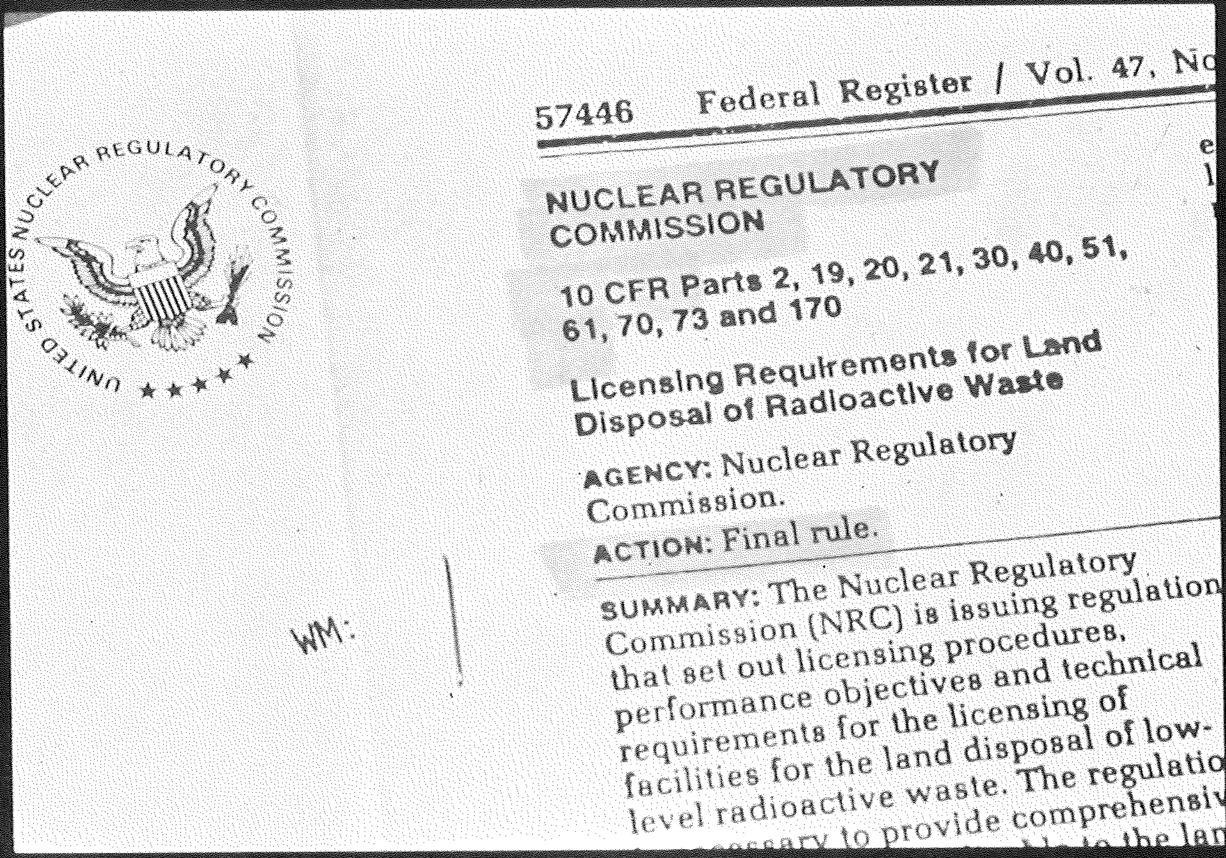
THE SITE OPERATOR FINANCES DEVELOPMENT COSTS

- Preliminary Site Studies
- Licensing
- Legal Fees
- Developmental Construction

COSTS ARE REPAID BY RADWASTE GENERATORS OVER THE 30 YEAR LIFE OF THE SITE



NEW NRC LOW LEVEL WASTE SITING CRITERIA ASSURE SAFE DISPOSAL



WM:

57446 Federal Register / Vol. 47, No

NUCLEAR REGULATORY COMMISSION

10 CFR Parts 2, 19, 20, 21, 30, 40, 51, 61, 70, 73 and 170

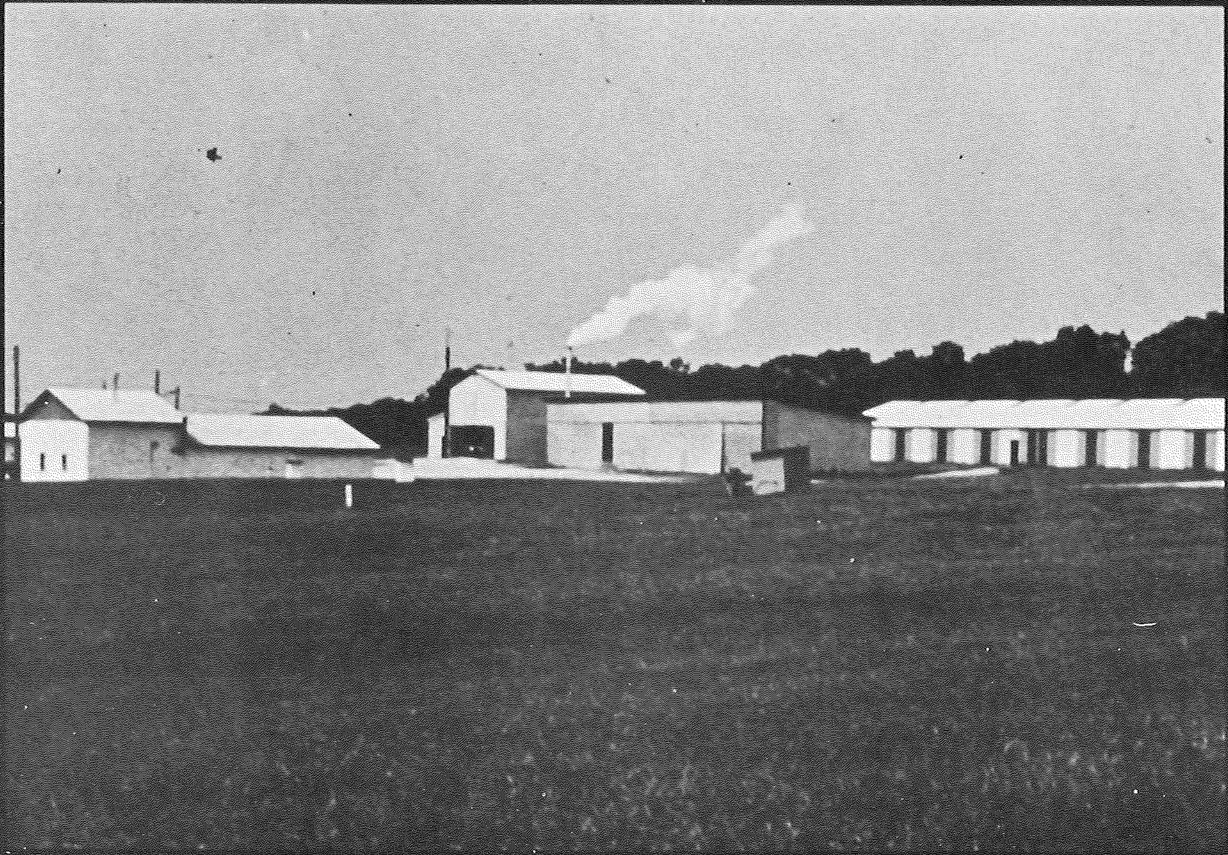
Licensing Requirements for Land Disposal of Radioactive Waste

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is issuing regulation that set out licensing procedures, performance objectives and technical requirements for the licensing of facilities for the land disposal of low-level radioactive waste. The regulatio necessary to provide comprehensiv

INDUSTRY IS ENFORCING PERMANENT SOLUTIONS TO PAST PROBLEMS



Site Surveillance
Maxey Flats, KY

THE RISKS AND THE BENEFITS

LOW LEVEL WASTE SITES ARE NEEDED TO INSURE CONTINUITY OF VITAL HUMAN SERVICES

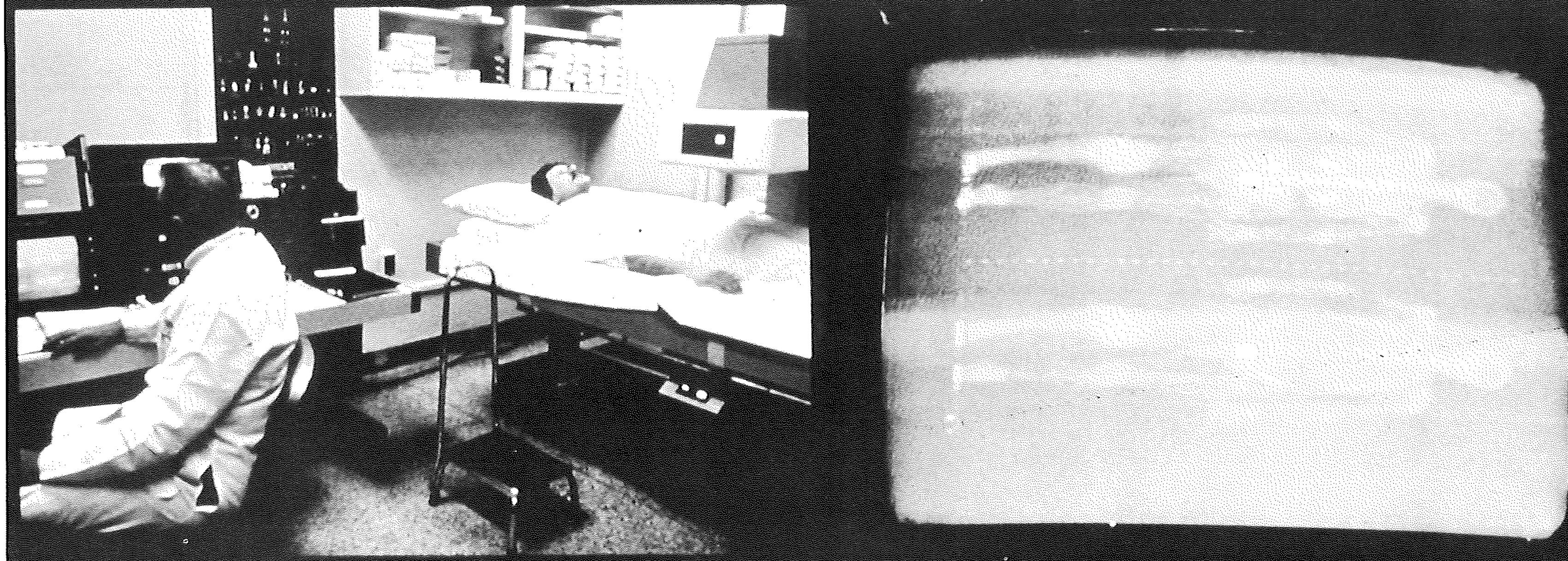
- Hospitals
- Universities
- Pharmaceuticals
- Utilities

RADIATION'S MANY USES

	Application	Benefit
Public Safety		
Radiography	Jet Engine Strength & Reliability	Reduced Accident Rate
Public Health		
Radioactive Pharmaceuticals & Radiation	Diagnosis	Fewer Exploratory Surgeries
Cobalt Treatment	Cancer Therapy	Treatment for One-Half of all Cancer Patients
Nuclear-Powered Pacemakers	Heart Disease Treatment	Powers Heart 10 Years or More Eliminates 8 Operations for Battery Replacement
Radiation	Agricultural Research	Erradication of Plant Diseases

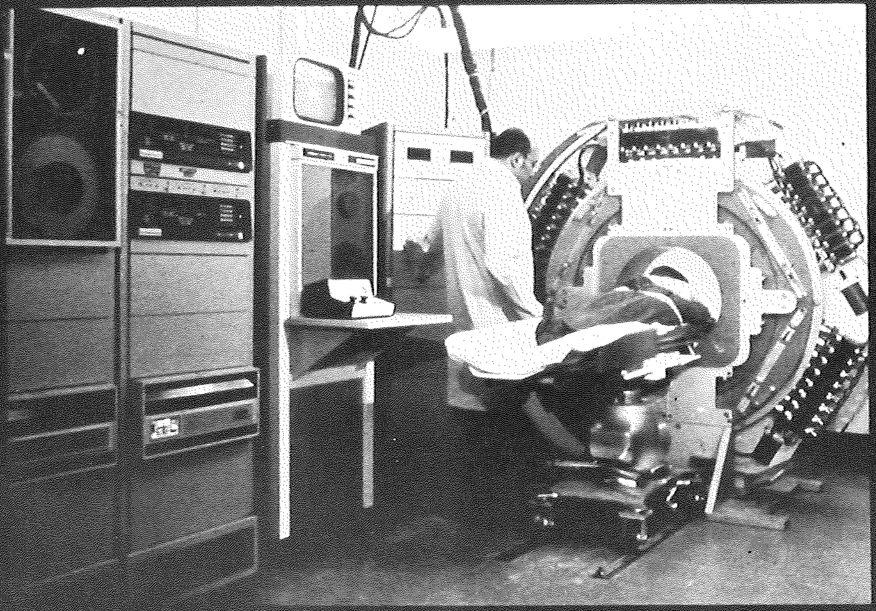
AGRICULTURAL RESEARCH ➡ DISEASE PREVENTION

RADIOACTIVE PHARMACEUTICALS → ACCURATE DIAGNOSIS AND REDUCED EXPLORATORY SURGERY



CAT Scans

NUCLEAR MEDICINE TREATMENT ➡ CRUCIAL THERAPY FOR 1/2 OF ALL CANCER PATIENTS

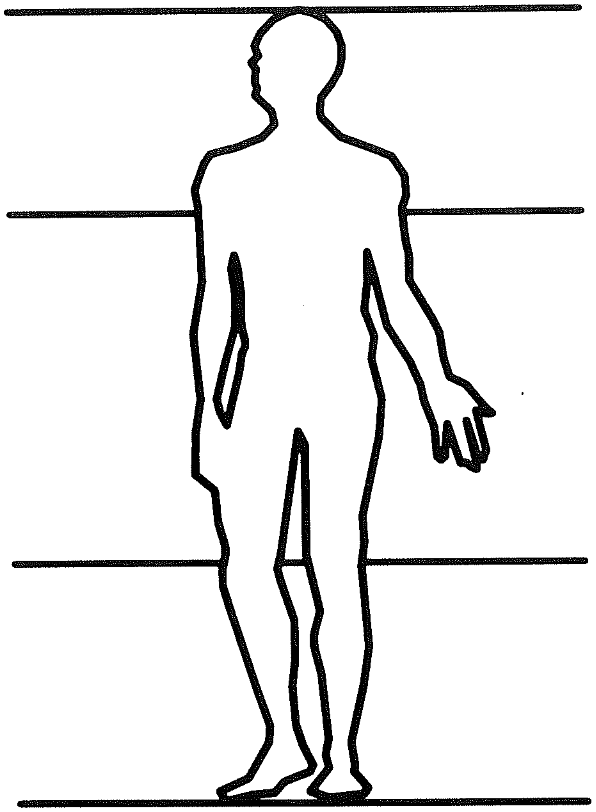


THE RISKS WE TAKE

Activity	Shortened Life Span (in minutes)
Drinking a Diet Soft Drink	0.15
Crossing the Street	0.4
Being Exposed to 1 Millirem of Radiation	1.5
Smoking a Cigarette	10
Eating a Calorie-Rich Dessert	50
Driving Coast to Coast	1000
Skipping Annual Pap Test	6000
Choosing Vietnam Army Duty	600,000

Source: B. Cohen and I. Lee, "A Catalog of Risks", Health Physics 36 (1979): 707-22

AVERAGE ANNUAL WHOLE BODY RADIATION DOSE IN THE U.S.



Natural Sources - 85 Millirem

- Cosmic Rays
- Decay Products of Natural Uranium

Medical - 70 Millirem

Occupational - 8 Millirem
Fallout - 3 Millirem
Misc. - 2 Millirem
Nuclear Power - .01 Millirem

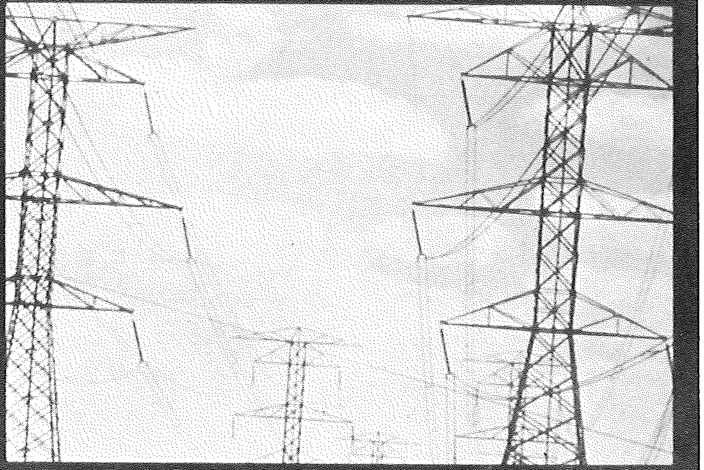
RADIATION EXPOSURE AT LOW LEVEL WASTE SITES

Offsite Radiation Limit - 5 Millirem

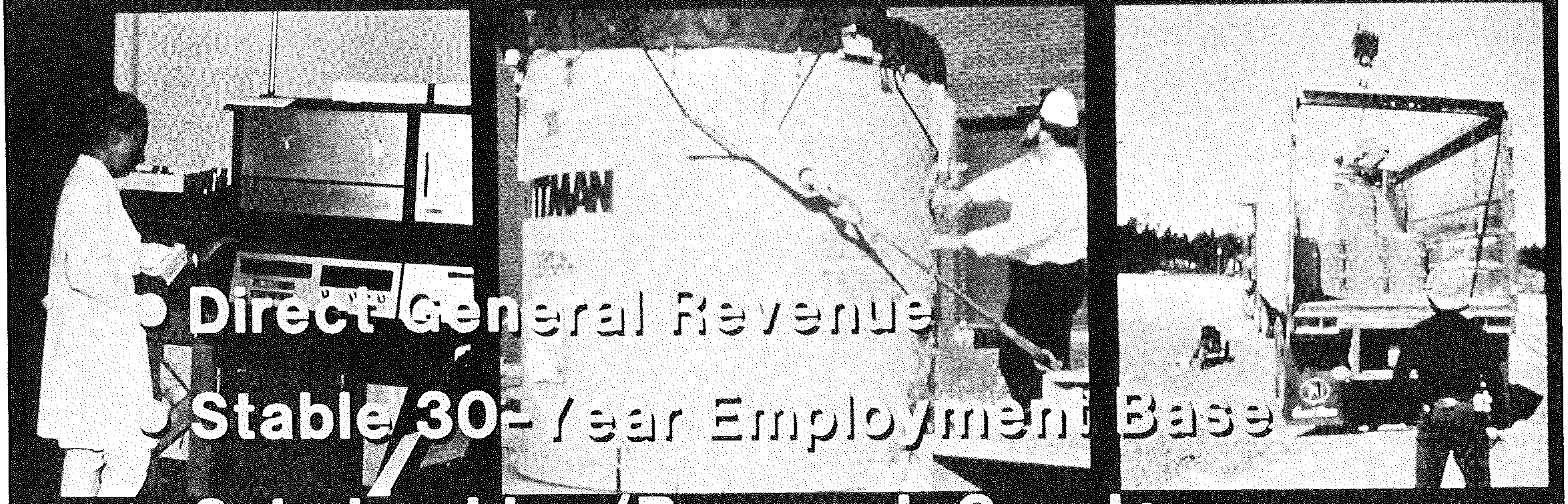
Compared To . . .	Dental X-Ray	- 30-70 Millirem
	Medical X-Ray	- 75-200 Millirem
	Upper GI Series	- 535 Millirem

The problem faces us now, solutions must be initiated

We Risk Disruption of Vital Human Services



LOCAL COMMUNITIES BENEFIT FROM A SITE



- Direct General Revenue
- Stable 30-Year Employment Base
- Scholarships/Research Grants
- Employment Training Center

TECHNOLOGY EXISTS TO SAFELY STORE WASTES . . .

EFFECTIVE LEADERSHIP IS NEEDED NOW

WESTINGHOUSE
WASTE TECHNOLOGY SERVICES
DIVISION
P.O. BOX 10864
PITTSBURGH, PENNSYLVANIA 15236
(412) 892-5600