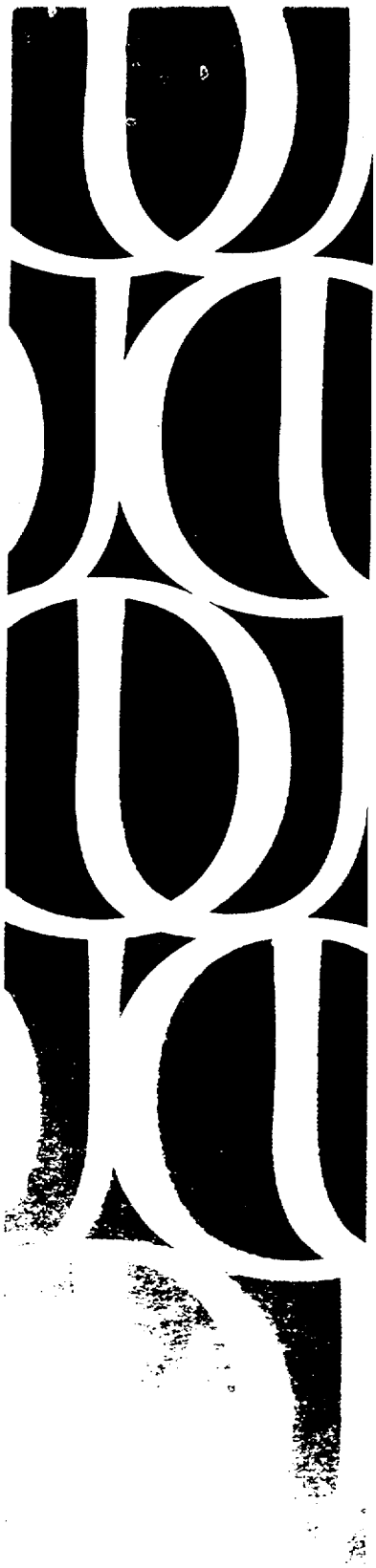

EXECUTIVE SUMMARY

THE UNTOLD STORY: Economic and Employment Benefits of the Use of Radioactive Materials

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THE UNTOLD STORY

Economic and Employment Benefits of the Use of Radioactive Materials

EXECUTIVE SUMMARY

The widespread uses and benefits of radioactive materials are one of our society's great untold stories. Few Americans realize that our advanced industrial economy and high standard of living would not be possible without the use of radioactive materials.

In medicine, agriculture, industry, science and government, radioactive materials perform many tasks more quickly and easily...more precisely...more simply...and more cheaply than non-radioactive materials. In many cases, there is no substitute for radioactive materials.

This report identifies the extensive uses of radioactive materials and estimates their benefits—direct and indirect—to the U.S. economy and job market.

Radioactive materials produce low-level radioactive waste that must be safely disposed of. Thirty years of experience have provided the technical knowledge to design waste disposal facilities that protect the public and environment. But an impending lack of adequate disposal facilities jeopardizes our continued use of radioactive materials.

If disposal of low-level waste becomes impossible or prohibitively expensive, the activities that produce the waste must be curtailed. This will have serious economic, employment and social consequences. This report identifies and quantifies these conseqences by estimating the total U.S. economic impact of radioactive materials in 1991. Although the production of nuclear electricity generates about 40 to 50 percent of the total volume of low-level waste and produces $73 billion of gross domestic product and generates 417,000 jobs, it is outside the scope of this report. A separate report titled *Economic and Employment Benefits of the Use of Nuclear Energy to Produce Electricity* covers this in detail. Instead, this report focuses on other sources of low-level waste that are less well known and whose economic benefits are less appreciated. (1991 is the last year for which data are available.)

Thus the major purposes of this report are to:

- Identify the beneficial applications of radioactive materials—exclusive of nuclear power—throughout the U.S. economy.
- Quantify the potential economic and job losses for the nation and individual states, if these applications are curtailed because of prohibitive cost or unavailability of low-level waste disposal.

The methodology used to calculate these data is summarized on page v and explained in detail in Appendix B.

U.S. Economic and Jobs Benefits

At the national level, this report assesses output, sales and jobs in each of 80 industries and jobs created in 475 occupations. At the state level, it estimates output, sales, jobs and state tax revenues generated.

In 1991, radioactive materials in the United States were responsible for:

- $257 billion in total industry sales (gross output)
- 3.7 million jobs
- $11 billion in corporate profits
- $45 billion in tax revenues to local, state and federal governments

These estimates reflect both direct and indirect effects of the industries and persons involved in the production, processing, transportation and use of radioactive materials throughout the economy. They also indicate how reductions in the uses of radioactive materials can potentially harm the economy. For example, if the nuclear medicine department at a major hospital is scaled back or closed, the estimates illustrate the likely direct and indirect economic effects of this reduction throughout the economy of the region, state and country.

These estimates may be somewhat conservative. In many processes or industries, the non-radioactive substitutes are slightly—2 or 3 percent—more expensive, inconvenient or time consuming. But in other industries, non-radioactive alternatives are often 10, 50 or 100 times more expensive and time consuming. An analysis of the effects of the loss of radioactive materials in the latter

cases is outside the scope of this report. However, such an analysis would produce higher estimates of the economic and job impacts of radioactive materials.

Even those data would underestimate the impact of radioactive materials, because in many cases, there simply are no substitutes for radioactive materials. For example:

- Many important medical diagnostic and treatment procedures would be impossible without radioactive materials. The consequences here involve the premature loss of millions of lives.
- In the exploration for oil and gas, there are often no adequate substitutes for radioactive tracer methods.
- Without radioactive materials, there would be no way to accurately date historical and archaeological artifacts.
- Without radioactive materials, entire areas of research and development critical to the technological and economic future of the United States would not exist. This includes much research in chemistry, metallurgy, genetics, biotechnology and engineering.

Impacts of the loss—or prohibitive costs—of radioactive materials in these cases are also outside the scope of this study.

U.S. Economic and Jobs Effects: Aggregate and By Industry

Three sectors of the economy are responsible for most of U.S. sales created (directly and indirectly) by the use of radioactive materials. These are:

1. industries that manufacture radioactive materials (e.g., makers of radioactive compounds);
2. industries that manufacture products containing or otherwise requiring the use of radioactive materials (e.g., gauge manufacturers);
3. users of the products made with radioactive materials (e.g., nuclear medicine)

The many users of the products (Group 3) attribute a significant amount of their sales to radionuclides and radioactive materials technology. These users include the health, education and nonprofit services industries ($30 billion of sales in 1991), the federal government (almost $13 billion), and the professional and scientific supplies industry (over $12 billion).

Almost 25 percent of the jobs in 1991 generated by the use of radioactive materials were in the health, education and nonprofit sector (825,552). The second-largest impact was in the electronic components industry (405,575). Almost 10 percent of the total jobs were in the federal government sector (342,543), a reflection of the government's extensive research and development activities.

Many jobs also exist in industries not usually associated with radioactive materials. Workers in these industries generally are unaware of their important stake in radioactive materials. For example, these materials account for more jobs in wholesale and retail trade (186,602) than in the chemicals industry. There are more jobs in transportation and warehousing (101,037) than in the petroleum and natural gas industry.

Many jobs are technical, skilled and specialized occupations, including 114,000 engineers (3 percent of total jobs result from radionuclides), 33,100 accountants, 11,500 biological technicians, 75,400 registered nurses, 14,300 computer programmers, 16,100 clinical laboratory technicians, 12,300 tool and die makers and 18,500 welders.

However, the use of radioactive materials impacts large numbers of jobs for virtually all categories of workers, including 19,600 farm workers, 43,900 laborers, 14,200 automobile mechanics and 3,600 personnel clerks.

Economic and Employment Benefits by State

All states benefited substantially in 1991 from the use of radioactive materials. The following table illustrates the distribution of sales, jobs and tax revenues among the states. Cutbacks in use would harm businesses and cause unemployment within every state, and increased use could benefit every state. (see Table 4, page 15).

As the table shows, more jobs and sales are in Pennsylvania than any other state. Virginia comes in second. Oregon and California also benefited substantially.

Table 5 (page 17) shows the sales, jobs and tax revenues generated within each low-level waste compact region and non-compact state in 1991.

Widespread Benefits of Radioactive Materials

The use of radioactive materials in virtually all industries—both in the United States and around the world—is immensely important for process development and improvement, measurement and automation, operations research, quality control and testing, cost reduction and other purposes. Their use has been increasing rapidly over the past several decades, and it continues to increase. Some examples of the uses of radioactive materials throughout the economy are given below.

INDUSTRIAL APPLICATIONS

- Pipeline leaks can be detected with radioactive materials in a matter of days or weeks at a cost of $25,000 to $50,000. Alternative methods can take six to 12 months and cost between $500,000 and $1 million. The additional downtime costs of the pipeline will total many millions more.
- Wear and corrosion tests on engines are 10 times cheaper using radioactive materials instead of alternative methods.
- Radioactive tracers are used in the coal, oil, natural gas, cement, glass, rubber, iron and steel, and automotive industries for maintenance (leak detection, investigation of malfunctions) and assessment of wear and corrosion of engines and other equipment.
- Radionuclide "thickness gauges" are unequalled in their ability to do quality control in almost every industry in which sheet material is produced, including the paper and textile industries.
- Radioactive materials can measure the thickness of coal seams in mining, preventing the mixing of rock with coal.
- Density gauges based on the absorption of radiation are used wherever it is important to determine and control the density of liquids, solids or slurries, e.g., the oil and food industries, and in the manufacture of many products, such as razor blades. Package monitors utilizing radioactive materials ensure that packages containing dry material are filled to a predetermined level.
- Radiographic inspection can expose defects in a casting or weld. Airline manufacturers require radiographic inspection of all wing structure members on commercial aircraft. Radiography also is used to check the welds on virtually all new natural gas or oil pipelines, and to examine the structural integrity of bridges.
- Smoke detectors are based on radiation emitted from a small source. These devices are extremely sensitive, and their reliability is unmatched.
- Glass bulbs filled with radioactive self-luminous paint and tritium gas are lasting, fail-safe light sources in exit markers in public buildings, runway markers for airports, traffic control signs and highway dividing lines, emergency lighting, and many other uses.
- Radioactive materials are used to produce wire and cable with improved resistance to heat and chemicals.
- Tire manufacturing companies use radiation to vulcanize rubber sheet.
- Radiation is used in the production of disposable diapers, tampons, air-freshener elements and other materials that can absorb and hold large amounts of liquid.
- Food irradiation kills contaminants like bacteria, molds, yeasts, parasites and insects, without the use of environmentally damaging chemicals. It also can extend the shelf-life of foods.
- Radiation helps prevent the accumulation of static electricity—a costly hazard that can cause fires, explosions, and production interruptions on moving machinery, such as printing presses and papermaking machines.
- Gauging techniques using radioactive materials are essential for avoiding unnecessary plant shutdowns, which in many industries can cost $1 million per day or more.
- Radioactive cobalt is used to detect the wear on blast furnace linings. Previously, the only available technique was tedious, expensive, and non-precise microscope measurement.
- Radioactive tracers are used in the machine tools industry to measure wear and tear on cutting tools and drills, for example. Scientific literature estimates that in recent decades, the use of radioactive tracers in the machine tools industry has saved the U.S. economy between $60 billion and $70 billion.

MEDICAL AND HEALTH USES

Radioactive materials save human lives by diagnosing diseases early. They also improve the quality of life, decrease pain and suffering, and reduce the risks associated with diagnostic methods. Approximately 12 million nuclear medicine procedures are performed annually in the United States, and one in three hospitalized patients benefits from a nuclear medicine procedure. Significantly, use of radioactive materials in medicine greatly reduces the costs of health care—an important consideration, given the explosion of health care costs in recent years.

- Radioactive materials can reduce the need for prostate cancer surgery.

- In vitro diagnostic medical techniques using radioactive materials are 10 million to 100 million times more sensitive than the alternatives.
- The radioactive pharmaceutical technetium-99m enables doctors to see how far bone cancer has progressed.
- Nuclear medicine procedures are essential for selecting patients for coronary artery surgery, assessing the adequacy of treatment, and helping increase medical understanding of causes and prevention.
- Nuclear medicine increasingly is being used to diagnose cerebrovascular disease and locate tumors.
- Radioimmunoassay, in which radioactive substances test blood or other biological fluids taken from the patient, can reveal the levels of hormones, vitamins, enzymes and drugs.
- Radiation from phosphorus-32 is used to treat leukemia.
- Strontium-89 is used to decrease the pain of bone metastasis.
- Radioactive iodine-131 is used annually to treat about 20,000 patients for hyperthyroidism. This has reduced the annual number of hyperthyroid patients treated surgically in the United States significantly.
- Radioactive iodine-131 may cure throat cancer even after it has spread. This is one of our few instances were metaspatic cancer may be cured.
- Radiation is used to sterilize medical products, like surgical dressings, sutures, catheters and syringes.
- Before approving new pharmaceuticals, the Food and Drug Administration requires extensive clinical tests to demonstrate their safety and effectiveness. Tagging these medications with radioactive compounds enables researchers to test the drugs efficiently and productively. At least 80 percent of all new drugs approved by the FDA are tested with radioactive materials.

AGRICULTURAL USES

Radioactive materials are enormously important in many agricultural applications, including laboratories and emerging biotechnologies.

- Methods using radioactive materials can substantially reduce the need for chemical agricultural fertilizers, pesticides, fungicides and weed control agents.
- Methods using radioactive materials can reduce the need for water in irrigation systems by 50 percent or more.
- Radiation treatment can speed the breeding of improved crops, resulting in greater yields, increased resistance to disease and better nutritional value.
- Radiation techniques are used in animal husbandry to increase animals' body weight and milk, facilitate breeding by determining animals' correct stage of the reproductive cycle, and produce safe and cost-effective vaccines to eliminate diseases.

INSECT CONTROL

Controlling insects with chemicals can create environmental problems and leave toxic residues in food. Many insects have developed resistance to insecticides, thus requiring greater amounts for control.

The principal way to control insects without the use of chemicals is by using radiation to sterilize them. When sterile insects are released into the native population, and mate with wild insects, no offspring are produced. This technique eradicated screwworm, whose larvae killed cattle, costing Texas ranchers more than $100 million annually; Mediterranean fruitflies; one species of tsetse flies; gypsy moths in several U.S. locations; and other insect pests.

ENVIRONMENTAL PROTECTION

The use of radioactive materials is becoming increasingly widespread and important in protecting the environment and abating pollution. For example:

- Radioactive materials producing beta rays can eliminate the air pollutants that cause acid rain and global warming, without producing harmful by-products.
- Radionuclides can play an important role in establishing the amounts and methods of plant and sea assimilation of greenhouse gases.
- Radioactive materials can measure carbon dioxide releases from an industrial area.
- Nucleonic gauges are used regularly to monitor and control the ash and moisture content in coal and coke.
- Radioactive materials make it possible to measure the speed of phytoplankton pollution of water reservoirs. They also can reveal the causes of other kinds of pollution, like the intrusion of sea water into coastal aquifers.
- Nuclear methods can help assess ground pollution accurately, and in many cases they can determine the exact source of soil contamination.
- Radiation is beginning to be used to decompose septic or poisonous waste, replacing hazardous chemicals like chlorine.

SCIENTIFIC RESEARCH, EXPLORATION, PUBLIC SAFETY AND OTHER APPLICATIONS

Radioactive materials are widely used in many other applications throughout society. For example:

- Radiation devices are used to check baggage at airports and thus prevent the smuggling of explosives onto airplanes.
- Methods using radioactive materials are used to estimate the age of the earth. Recently, they validated the hypothesis that a cataclysmic impact of a huge asteroid caused extinction of the dinosaurs and permitted the evolution of current species, including homo sapiens.
- Techniques using radioactive materials have revolutionized archaeology. Carbon-dating is used to determine the age of archeological and historical objects, including the Shroud of Turin and the Dead Sea Scrolls.
- Radionuclides help police detect hidden explosives and the use of poisons.
- Radioactive materials have greatly increased our understanding of photosynthesis.
- Neutron activation analysis enables scientists to determine the amount and type of substances thousands of years old.
- Radioactive materials are used in prospecting for minerals and oil.
- Radioactive tracers can show the causes of movement of materials along river beds or seashores.
- In some arid zones of the world, irradiated copper oxide powder is used for cloud seeding, to increase precipitation.
- Devices using radioactive materials permit the measurement of rock formation characteristics—density, porosity, and chemical elements—in well-logging in a borehole.
- Radioactive materials help researchers study the origin, age and distribution of groundwater, water quality, interconnections between aquifers, dynamics of lakes and reservoirs, leakage through dams, and other matters crucial to water supply and quality.

Conclusion

Clearly, the use of radioactive materials throughout society has a greater economic impact than most people realize. The sheer numbers may not even be sufficient to convey their significance. To put some of the figures in perspective:

- $257 billion—the total industry sales attributable to radioactive materials in 1991—equal to about four percent of total 1991 U.S. Gross Domestic Product.
- 3.7 million jobs—the total supported by radioactive materials—represented about 3 percent of the total 1991 U.S. labor force. The decline in defense spending and closing of military bases projected over the next five years will result in the total cumulative loss of between three and five million jobs over this period.
- $45 billion the total local, state and federal taxes generated by the use of radioactive materials in 1991. The deficit reduction bill enacted in 1993 after six months of intense debate in the U.S. Congress raises taxes, on average, between $50 billion and $60 billion per year over the next several years.

Of course, not every benefit of radioactive materials is quantifiable. The relief of pain, the saving of lives, the production of products that create greater efficiency, convenience and safety—all these are outside the scope of this report. Yet all are essential to a full appreciation of the value of radioactive materials to society.

Summary of Methodology

The economic and employment effects of the utilization of radioactive materials were estimated using the Management Information Services, Inc. (MISI) data base and information system. A simplified version of the MISI model as applied in this study is shown in Figure ES-1.

The first step is the translation of expenditures for radioactive materials applications and programs into per unit output requirements from every industry in the economy—in this study an 80-order industry level of detail was used. In 1991:

- The value of basic radionuclides placed into service totaled $5 billion of products and services.
- The existing U.S. stock of radionuclide equipment and radioactive materials products was used to provide $105 billion of net services.
- Thus, radionuclides and radioactive materials accounted for about $110 billion of direct sales in the U.S. economy.

Second, the direct output requirements of every industry affected as a result of this $110 billion are estimated. These direct requirements show, proportionately, how much an industry must purchase from every other industry to produce one unit of output.

Direct requirements, however, give rise to subsequent rounds of indirect requirements. For example, steel mills require electricity to produce steel. But an electric utility requires turbines from a factory to produce electricity. The factory requires steel from steel mills to produce turbines, and the steel mill requires more electricity, and so on.

The latter are the indirect requirements. The sum of the direct plus the indirect requirements represents the total output requirements from an industry necessary to produce one unit of output. Economic input-output (I-O) techniques allow the computation of the direct as well as the indirect requirements, and these total requirements are crucial to understanding the economic and employment estimates in this study.

Next, the total output requirements from each industry are used to compute sales volumes, profits, and value added for each industry. Then employment requirements and the total number of jobs created within each industry are estimated.

Finally, utilizing data on the occupational composition of the labor force within each industry, the job requirements for 475 specific occupations encompassing the entire U.S. labor force are estimated.

Utilizing this modeling approach, MISI estimated the effects on employment, business sales and profits, and government tax revenues in the United States, in each state, and in each low-level radioactive waste compact region. Estimates were also developed for detailed industries and occupations.

FIGURE ES-1: *Estimating the Economic and Employment Impacts of Radioactive Materials Applications*