INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor MI 48106-1346 USA
313/761-4700 800/521-0600

SALVE REGINA UNIVERSITY

THE RADIOACTIVE WASTE DEBATE IN THE UNITED STATES AND NUCLEAR TECHNOLOGY FOR PEACEFUL PURPOSES

A DISSERTATION SUBMITTED TO
THE FACULTY OF THE DOCTORAL PROGRAM
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

DEPARTMENT OF HUMANITIES

BY
TERRENCE NORBERT TEHAN

NEWPORT, RHODE ISLAND

March 1998

SALVE REGINA UNIVERSITY

GRADUATE SCHOOL

The dissertation of Terrence Norbert Tehan entitled "The Radioactive Waste in The United States and the Future of Nuclear Technology for Peaceful Purposes" submitted to the Humanities Department in partial fulfillment of the requirements of the degree of Doctor of Philosophy in the Graduate School of Salve Regina University has been read and approved by the committee:

Reader: Vincent Rose, Ph.D. — Date: 3/23/98

Reader: Antony O'Connor, F.S.C. , Ph.D. — Date: 3/23/98

Mentor: Lucien Richard, O.M.I., Ph.D. — Date: 4/20/98

Ph.D. Program Director: Eugene Lappin, F.S.C., Ph.D. — Date: 5-11-98.

Vice President for Academic Affairs: Judith M. Mills, Ph.D. — Date: 5.14.98.

DEDICATION

To My Mother, Agnes Tehan

ABSTRACT

Many ethical, cultural, and economic concerns have accompanied the rapid growth of Western technology. Nuclear technology in particular has experienced considerable opposition because of its perceived dangers, especially disposal of atomic waste. While this field of science remains in its infancy, many legal, political and ecological groups oppose any further application of nuclear technology--including the significant medical, environmental, and economic benefits possible from a safe and responsible application of nuclear energy. Complete and objective knowledge of this technology is needed to balance a healthy respect for the danger of atomic power with its many advantages.

This study focuses on one aspect of nuclear technology that has particularly aroused political and social controversy: nuclear waste. Finding ways of disposing safely of nuclear waste has become an extremely volatile issue because of the popular misconception that there is no permanent solution to this problem. This investigation will demonstrate that the supposedly enduring waste problem has been resolved in several industrial countries that now outstrip the United States in safe commercial applications of nuclear science. This dissertation offers a reasoned and objective contribution to the continuing national debate on the peaceful uses of nuclear technology. This debate becomes more crucial as the nation seeks a dependable substitute for the non-renewable sources of energy now rapidly being exhausted.

TABLE OF CONTENTS

PREFACE

Since the origin of Western civilization the advancement of humankind has become progressively dependent upon the invention, development, and use of new tools and techniques. With the emergence of modern culture through the Industrial Revolution, this rate of progress has accelerated exponentially. In humanity's present situation of increasing dependence upon the more advanced, science-based and capital-driven technologies, the tools, techniques and applications derived from nuclear fission are among the most awesome and controversial.

Is technology in general or nuclear technology in particular an autonomous force beyond human control, or is this characterization a social perception that can be restructured for the enhancement of the human enterprise? This question serves as the theme for this dissertation, which concerns the peaceful uses of nuclear technology in the United States of America. The particular focus of this study is on the disposal of radioactive waste. This focus responds to the basic arguments of groups opposed to any further development of nuclear technology, even for peaceful purposes.

As a nuclear engineer for twenty-eight years, this writer shared the early enthusiasm for and optimism about nuclear science. As a result of similar convictions, over one hundred commercial nuclear power plants were built in the United States with little forethought and without an overall plan for a national energy policy. Conversely, having served as a Chief Engineer, Commanding Officer, and Deputy Senior Member of the Atlantic Fleet Nuclear Power Examining Board, I was involved with many different reactor plants

that operated reliably because they were well designed and supervised by highly trained people who maintained the highest standards of safety. Admiral Hyman Rickover, who was in charge of the program, designed a master plan for development of naval nuclear propulsion that became a major component in the defense of the free world during the Cold War (1950s-1990s).

Since 1992, as Director of the Rhode Island Nuclear Science Center, I have served on the Rhode Island State Radiation Advisory Committee. In these positions, I have learned about the numerous important medical, research, and industrial applications of nuclear technology while requiring the investigation of basic technical issues, such as non-proliferation and nuclear waste disposal.

As the Rhode Island representative at the National Low-Level Waste Forum since 1994, I have been heavily involved with practical aspects of implementing the Low-Level Waste Policy Act of 1980. The insights and understanding gained from this experience provide the motivation for researching this topic. It has become increasingly apparent, for example, that the current policy for siting radioactive waste facilities is not effective. Nor is the consequent provision to store radioactive waste at installations that were not designed for this purpose an acceptable alternative. American society must come to terms with these necessary and ultimately inevitable applications of nuclear technology and the resulting waste that is generated in the process. Only through an informed national consensus can the country achieve an appropriate utilization of this important field of science and technology.

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to the many people who helped me materially or by encouragement in the long scholarly enterprise. The doctoral program staff at Salve Regina, and Dr. Eugene Lappin, F.S.C. in particular, deserve special thanks for their support and guidance throughout the academic process.

My dissertation team has been both supportive and generous in providing their time and effort toward the completion of the project. My first mentor, Dr. Eugene Hillman, C.S.Sp., provided much valuable input and counsel prior to his present assignment abroad. When Dr. Lucien Richard, O.M.I., graciously took over the mentorship, his insights and advice contributed significantly to the quality of the work. Dr. Vincent Rose's extensive background in both technical and political areas was of invaluable assistance. Dr. Antony O'Connor, F.S.C., judiciously edited the text for logic and clarity.

CHAPTER ONE

INTRODUCTION

This study proposes that safe disposal of radioactive waste is feasible and essential to the development of the nuclear industry in this country. This examination focuses on nuclear technology in light of the ethical and social principles governing the safety and survival of the nation. The unfortunate association of the term nuclear with atomic weapons and media reports of accidents at nuclear power plants have contributed to the entire industry's poor public image. Most people do not realize, however, that this industry is not limited to nuclear arms and power plants. Vital medical techniques, research methods, agricultural, and industrial procedures require radioisotopes and radioactive sources derived from nuclear energy. The use of radiation in medicine and in many research fields, such as material science and biology, is an expanding contribution to human needs. In agriculture, the irradiation to kill bacteria and pests promises to reduce serious crop disease and spoilage. All these and other areas of nuclear technology will be threatened by the nation's continued inability to settle the radioactive waste disposal dispute.

The future need for nuclear technology explains why the waste controversy cannot be allowed to hinder development of an essential industry. Solar, wind, hydro and geothermal energy sources all have a place in national energy production. They do not, however, have the energy density of fossil fuels, since it takes extremely large surface areas to collect the equivalent amount of energy of just a small amount of coal or oil. For a solar plant to supply the electricity needed to run a city the size of Los Angles, the surface collection area

would be approximately ten square miles. Wind power suffers from the same problems of solar energy in that it is diffuse (relatively weak) and unreliable. A wind farm that could meet Los Angles energy needs would require approximately 150 square miles of land area (Waltar 1995, 45).

Many environmentalists and politicians advocate the transition to renewable energy sources as the way of the future. Fritjof Capra, for example, states that solar energy is the "here-and-now alternative to conventional energy sources" (Capra 1982, 405). While this statement was made in 1982, solar energy remains a long way from reality. Modern society can not function meanwhile without reliable energy supplies that can meet significant demands on short notice, as is the case for air conditioning in hot weather and urban mass transportation during rush hour.

A 1992 report by the International Energy Agency estimates that the global processes of industrialization and urbanization will result in increased demand for energy-intense fuels. Oil, natural gas and nuclear power will be needed to meet energy-intense activities such as transportation and manufacturing. This report does not predict any substantial increase in commercial solar or wind energy production (Global Energy: The Changing Outlook 1992, 167). Evelyne Bertel of the Organization for Economic Co-operation and Development sums up the current situation in her comment: "Renewable sources . . . do not offer realistic prospects for large-scale base-load electricity generation (Bertel and Joop 1995, 4).

There is abundant heat stored below the surface of the earth that provides a clean energy source in regions where it can be

utilized. While geothermal energy has the required energy density, it is not a widely available source. Such alternative energy supplies also lack reliability and the abundance necessary to meet the massive demands of an industrialized economy. Only fossil and nuclear fuels are currently capable of meeting the electricity requirements of the United States.

Dwindling supplies of fossil fuels along with the pollution that they cause leave nuclear power as the only currently viable large-scale and dependable energy source for future generations. This advanced technology can be developed to meet the energy demands of society, but first the waste controversy must be resolved. This study will show that this problem is primarily cultural and political. Other countries have successfully solved the technical difficulties, and they have moved past nuclear phobias to a safe application of this technology. Only through an informed national dialogue on the future importance of nuclear technology can the United States remain an industrial world leader.

Since the polarization of attitude for and against nuclear energy appears to be particularly an American dilemma, it can be solved only by democratic methods: an appeal to public opinion based on objective evidence backed by authoritative verification. Expert opinion should include not only technical authorities, such as scientists and engineers, but also informed scholars representing the vantage points of such disciplines as ethics, economics, sociology, and political science. Their combined guidance might provide a comprehensive solution that recognizes technological advantages while protecting the lives of future generations and preserving the

environment. It follows that an ethical acceptance of the role of nuclear technology should include a broad consensus of all society and especially the less advantaged groups who frequently bear an unequal share of the burdens of technological progress (Organization For Economic Co-operation and Development Proceedings 1994, 13).

Ethical principles play a large role in determining nuclear policies. Ethics generally refers to any rational or philosophic system for determining the right or wrong of human conduct. Moral principles in turn are generally associated with traditional codes of conduct that reflect ultimate human values. In common parlance, however, the terms are often used interchangeably. Since the wartime origins of nuclear science, both ethical teachers and moral authorities have argued against nuclear weapons as destructive to human life. In reference to the peaceful use of nuclear energy, however, the controversy becomes more complex. The possible benefit to society must be weighed in light of the technical difficulties of safe operation.

Credibility is an important ethical imperative here, and this frankness should include an admission of serious errors in previous applications of this new science. Society must learn from past mistakes if it is to achieve a proper realization of nuclear technology. Robert Duffy points out that the United States has never established a national consensus concerning the deployment of this technology:

> Largely because the atomic energy program was perceived as a national security issue, its first twenty years were characterized by sub government dominance. . . . The Atomic Energy Commission (AEC), The Joint Committee on Atomic Energy (JCAE), and the nuclear power industry formed a sub government. (Duffy 1991, abstract)

Government control later became a more open process but it was hardly more successful. With the demise of the old Atomic Energy Commission, which was replaced by the Nuclear Regulatory Commission in 1974, nuclear policy making was modified to create multiple access opportunities for concerned groups that had previously been excluded. As the policy-making process became more comprehensive and more complicated, however, the unfortunate result was bureaucratic gridlock (Duffy 1991, 1). This explains why the current Washington administration, in the face of entrenched hostility, cannot reach a satisfactory compromise.

While ethics can be applied effectively at the interpersonal level, serious moral decisions at the national level usually become politicized. There is, therefore, a political dimension to the application of nuclear technology that deepens in significance as its influence continues to expand at such a rapid rate. A new ethics of technology could resolve the moral dilemmas created by prejudice against worthwhile innovations on one hand and emotional fear on the other. This approach should ensure the safety of future generations and preserve the environment while providing essential benefits to society. A balanced analysis appreciative of this new ethical approach should play a large role in achieving practical solution to the radioactive waste problem, given the economic, social, and technical realities that the country faces today.

A Successful National Dialogue

To appreciate how a safe and effective use of nuclear energy has won public support, one must look outside the United States. A

relevant example of a successful nuclear energy policy was achieved at the national level in France. Unlike the United States, France does not have large stocks of coal and other fossil fuels. The French decision to develop nuclear power was an important political judgment made after a series of national debates in parliament (Schoenbaum and Ainley 1988, 196). The 1970s oil embargo and price increases left the French vulnerable to the loss of energy imports. To secure economic and industrial autonomy, France chose nuclear technology particularly because this energy resource was not dependent on foreign suppliers. In 1974, the French government undertook an extensive nuclear construction program. The victory of the Socialist party in the national elections of 1981 led the new government to reexamine the nuclear power option. After hearings in Parliament, however, the decision was made to continue the program despite the fact that the Socialists had been critical of the program in the past (Ibid., 198).

Other countries have also achieved a viable relationship with nuclear technology after informed discussions resulted in a proactive national nuclear policy. Like the French, the Japanese have few natural energy resources to fuel their industrialized economy. Again, the oil price increases of the 1970s resulted in the decision to develop a nuclear industry that included power reactors and medical technology. No political party opposed the nuclear option and other Pacific Rim counties such as South Korea and Formosa have followed the Japanese example in similar fashion.

The American Experience

The American love-hate relationship with nuclear science began largely with the first atomic bomb explosion over Hiroshima in 1945. Although the country rejoiced at the consequent early end of the war, many scientists and concerned citizens expressed shame and horror over this ghastly form of warfare. During the subsequent forty years of the Cold War, generations of young Americans grew up under the real apprehension that the country was the prime target for nuclear annihilation by Russian intercontinental ballistic missiles. As a result of the long anti-nuclear conditioning, Americans tended to be suspicious of even the benefits promised by commercial nuclear development. The accident at the Three Mile Island nuclear plant in 1979 seemed to confirm their fears, and the more serious 1986 disaster at Chernobyl in the Ukraine was publicized world-wide as proof of the potential catastrophe inherent in any attempt to harness atomic power.

The problems of the American commercial nuclear program can be traced to the original political control on its development and the short-sighted role of technological experts in the formulation of national nuclear policy. Brian Balough sums up the crux of the problem as it was associated with nuclear weapons:

> The roots of commercial nuclear power, the men who developed it, and the public's earliest and most significantly perceptions of it were integrally linked to the bomb and the circumstances in which it was unleashed. (Balough 1991, 29)

Over the centuries, many technological advances have been achieved for military purposes and then converted to peaceful use. However, the World War II Manhattan Project to develop the atomic

bomb was unique because it demonstrated that research at the edge of theoretical understanding could be translated into dramatic applications in a relatively short period of a few years. Like many modern inventions, atomic technology was forced on society without sufficient reflection on its long-term implications. The secrecy of the Manhattan Project was inevitable, but this stealth led to some post-war problems in gaining broad public acceptance of this mysterious new energy source.

Commercial nuclear power in the United States was in turn initiated through a small group of scientists and administrators who enjoyed the technical expertise and financial backing of the federal government. An industrial-political lobby supported nuclear power and, despite an abundance of cheap fossil fuels, the initial development of nuclear power for military applications was transferred to the commercial market (Balough 1991, 61). The nuclear power industry was introduced without sufficient public information and discussion regarding the soundest and most sensible commercial development of this military technology. The forced imposition of an energy resource that was first conceived as a highly dangerous explosive helps explain, in large measure, why Americans continue to harbor a negative reaction to all nuclear applications.

The United States thus remains in what Allen Drengson refers to as the "technophobic" stage of nuclear acceptance. Meyer points out that many people who are fearful of nuclear weapons cannot move beyond the belief that anything nuclear is suspect (1966, 100). The negative image of this technology has been dramatized in popular novels and in nuclear disaster movies such as On The Beach

(1957) and The China Syndrome (1978) and in more recent productions such as the "Terminator" movies and the Simpsons TV series. The advocacy groups that initially concentrated on banning nuclear weapons have refocused their energies toward banning all nuclear enterprises. Many have blockaded nuclear power plants and denied access to disposal facilities. The public media tend to sensationalize any nuclear incident, and publishers find a ready market for books and articles that take an anti-nuclear stance. This continuing hostile climate indicates the need for a national reexamination of the basic issues as they affect nuclear industries and research in the United States.

These anti-nuclear polemical attitudes serve little purpose in advancing such other projects as nuclear medicine research or in solving the future energy crisis of the country. The public deliberations should focus on the ethical and moral aspects of the technology while ensuring that the scientific facts and constraints are represented objectively and accurately. Only through an informed national determination can the United States reach the optimum stage of secure and reliable nuclear technology.

Technology Defined

This study is not a technical treatise, and the implications associated with the term technology are broader than those found in the common denotation of the word. The analysis of technology in this dissertation centers on the realization that technology can be understood as a social phenomenon with four dimensions: cultural, organizational, technical, and environmental (Drengson 1995, 12). These four elements taken as a whole create a technological practice.

The cultural dimension covers the social values and influences, while the organizational component includes political-economic structures and legal considerations. The technical aspects are derived from scientific principles, and the natural environment includes both the source of the input material and the area affected by the process. The word practice or organized skill must be differentiated from the word science or organized knowledge because it refers to the rise of specialized professionalism in Western society. Philosopher Allen Drengson takes the position that this depersonalization of skill results in the rise of the "objective" expert or specialist and explains the failure of our culture to achieve a holistic view of technology (1995, 15).

There are many definitions of the term technology ranging from the narrow view of machinery to overly broad characterizations of rationality that tend to be operationally meaningless. Emmanuel Mesthene defines technology as "the organization of knowledge for practical purposes" (1970, 25). This simple denotation recognizes the extent and variety of the effects of technology on our institutions and values. Mesthene asserts that one would not realize this pervasive influence on our culture if we viewed technology as no more than hardware. Noted economist John Kenneth Galbraith expands on Mesthene's definition by calling technology "the systematic application of scientific or other organized knowledge for practical tasks" (1985, 11). However, both definitions stress the need for practical goals and rationally-derived processes or techniques (procedures, methods, systems). The distinguishing characteristic of technology that sets it apart from other cultural influences is that it