CONTENDING APPROACHES TO NUCLEAR POWER

A MASTER'S THESIS

BY

GÖKÇE BERBEROĞLU

THE DEPARTMENT OF

INTERNATIONAL RELATIONS

BILKENT UNIVERSITY

ANKARA

SEPTEMBER 2005

To My Parents

CONTENDING APPROACHES TO NUCLEAR POWER

The Institute for Economic, Administrative and Social Sciences
of
Bilkent University

by

GÖKÇE BERBEROĞLU

In Partial Fulfillment of the Requirements for the Degree of
MASTER OF ARTS

in

THE DEPARTMENT OF
INTERNATIONAL RELATIONS
BILKENT UNIVERSITY
ANKARA

September 2005

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in International Relations.

Assoc. Prof. Mustafa Kibaroğlu
Supervisor

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in International Relations.

Assist. Prof. Ali Tekin
Examining Committee Member

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in International Relations.

Assist. Prof. Aylin Güney
Examining Committee Member

Approval of the Institute of Economics and Social Sciences

Prof. Dr. Erdal Erel
Director

ABSTRACT

CONTENDING APPROACHES TO NULEAR POWER

Berberoğlu, Gökçe

M.A., Department of International Relations

Supervisor: Assoc. Prof. Dr. Mustafa Kibaroğlu

September 2005

Energy is an important figure in international relations, as being one of the most political choices of any country and as a crucial element of a nation's progress. Among a variety of energy options, nuclear power has been subject to several arguments related its advantages and disadvantages. Especially after the Second World War, this debate on nuclear energy has reached to international levels where scholars and scientists were to discuss their arguments concerning the risks, effects and costs of nuclear energy. This thesis mainly aims to examine this debate between the supporters and critics of the nuclear energy option with an objective point of view. While examining this debate the study respectively focuses on the historical development of nuclear energy, the main arguments of both sides and possible middle grounds for the debate. The implementation of these arguments to Turkey is another subject which the thesis attempts to analyze. Being a descriptive study in nature, this thesis refrains from making any judgments but only objective observations.

Keywords: Nuclear energy, Turkey, energy debates, nuclear technology.

ÖZET

NÜKLEER ENERJİDE KARŞIT YAKLAŞIMLAR

Berberoğlu, Gökçe

Master, Uluslararası İlişkiler Bölümü

Tez Yöneticisi: Doç.Dr.Mustafa Kibaroğlu

Eylül 2005

Enerji, ülkelerin en siyasi seçimlerinden biri olması ve bir milletin kalkınmasındaki hayati rolünden dolayı uluslararası ilişkilerde önemli bir yer teşkil etmektedir. Birçok enerji seçeneğinin arasından, nükleer güç sahip olduğu avatajlar ve dezavantajlar bakımından çeşitli tartışmalara yol açmıştır. Özellikle İkinci Dünya Savaşı sonrasında, akademik çevrede ve bilim adamlarınca nükleer enerjinin riskleri, etkileri ve bedelleri üzerine yapılan bu tartışmalar uluslararası boyutlara taşınmıştır. Bu tez esas olarak nükleer enerji taraftarları ve karşıtları arasındaki sözü geçen tartışmaları tarafsız bir bakış açısıyla incelemeyi amaçlamaktadır. Bu tartışmaları incelerken çalışma sırasıyla nükleer enerjinin tarihsel gelişimine, iki karşıt tarafın argümanlarına ve tartışmada varılabilecek orta noktalara değinecektir. Tüm bu tartışmaların Türkiye'ye uyarlanması da yine tezin analiz etmeye çalıştığı bir başka nokta olacaktır. Özünde tanıtımsal bir çalışma olarak, bu tez kesin hükümlerden kaçınarak tarafsız gözlemleri sunmaktadır.

Anahtar kelimeler: Nükleer enerji, Türkiye, enerji tartışmaları, nükleer teknoloji.

ACKNOWLEDGEMENTS

I would like to express my special thanks and gratitude to my thesis advisor, Mustafa Kibaroğlu, who has been more than an instructor for lending support and guiding me during this study. Although it has been a very busy year for him, Dr. Kibaroğlu devoted a great amount of time and effort to this project.

I also greatly appreciate the assistance and thoughtful advice of numerous professionals at Bilkent University in particular, Prof. Dr. Ali Karaosmanoğlu, Dr. Ali Tekin, Dr.Aylin Güney and Müge Keller.

Finally, I would like to thank to my parents who have always been with me through this difficult year for their motivation and to Ayberk Yağız for his unwavering support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Throughout history, having access to a source of energy has been one of the vital factors that affected the human accommodation motive. Energy has always been the key to civilization's progress and prosperity. History shows that the use of energy is very important to our standard of living and well-being. When people first learned to use the energy of fire to overcome cold, their chance of freezing to death diminished. The invention of steam engine in the beginning of the 18^{th} century made it possible to use the heat produced by the burning of coal. Today, there are several energy options including coal, oil, natural gas, and more recently the "renewable" wind, solar, hydraulic and bio-energy sources.

Most controversial among these has been nuclear power, which has a vital contribution to meet the world's energy requirements. Nuclear power is an energy issue, which has faced political debates and has been charged with unpleasant

association and fears. It has caused changes of government policies, encouraged public demonstrations, attracted the attention of mass media and even affected the course of international relations. The political dimension of nuclear energy at national and international levels has become subject to many studies. This relation between nuclear energy and politics is mainly "the development of international co-operations in the field of nuclear energy, including international instruments towards enhanced communication, reactor and radiation safety, mutual assistance, early warning, non-proliferation and stockpile reduction, as well as international legal efforts to regulate the testing and use of nuclear weapons."[1]

At the end of the Second World War, the introduction of the nuclear era gave rise to the belief that nuclear power could be used for broadly peaceful and generally beneficial purposes. Nuclear technology has a wide range of use including the generation of electricity, radiation entomology, food production, plant breeding, animal protection and disease control, food irradiation, nuclear medicine, radiation biology, hydrology, industry and weaponry.[2] However, the focus of criticism and opposition to nuclear power, which began in the 1970s and continues today, has been largely concerned on the assurance of safety of nuclear reactors, waste management and long term storage, environmental effects, health effects, economic costs, and nuclear proliferation risks.

[1] http://www.dundee.ac.uk/cepmlp/main/html/nuclear_course_2.htm

[2] Gobel, Medard. 1975. *Energy, Earth and Everyone*. *San Francisco: Straight Arrow Books.* p. 53

At first, opposition to the building of nuclear power stations was limited to minority groups and to areas close to those sites where the plants were planned to be built. The opposition has grown to national and international levels in which well-organized pressure groups, acting as a coalition against nuclear power interests, have made use of the media, mass protests and regulatory frameworks to obtain publicity and impose delays on construction and licensing.

The objective of this study is to examine the intense debate on nuclear power between those dedicated advocates who emphasize the promise of nuclear power and those opponents who fear its possible consequences. The reasons of distinguishing of nuclear energy sharply among other sources of energy and the effects of this situation on state decisions and relations will be examined also. The study aims to be objective when dealing with the issue, letting the reader decides which side has stronger arguments.

In the first chapter, a brief description of how the nuclear energy is produced and its history of becoming an important means of producing electricity in the world today will be studied. This brief history will include the becoming of atom as a source of energy, the logic of nuclear fuel cycle, and the steps that nuclear energy has passed through during the years.

Second chapter will mainly focus on the broad range of controversial issues

between two sides. These issues include the safety question of nuclear energy, which is caused by accident risks and health hazards, waste management problem, environmental effects, economic costs and nuclear proliferation risks. Every fact causing the debate will be analyzed one by one by bringing up each side's arguments with references from scholars in this area, media, pressure groups and government policies.

In the third chapter, all these facts stated in chapter two will be implemented to Turkey. Starting with defining the energy needs of Turkey, its nuclear adventure full of failed attempts since the 1970s will be studied. Taking into consideration anti and pro-nuclear views in Turkey, this chapter will also try to analyze the political implications of Turkey's nuclear power choice to its international relations. The reasons of choosing Turkey as a case study in this thesis is that; the arguments about nuclear energy in Turkey is still a continuing one, and it is an open case since no decisions have been given yet about the usage of nuclear energy. Therefore, Turkey sets a good example for all the controversial issues that are analyzed in Chapter 2. Another reason for choosing Turkey is because the writer of this thesis is a Turkish citizen herself, and therefore aims to present a study, which could be accepted, as a source for Turkey's future energy options.

In the final chapter possible middle grounds for the controversy and the

findings of several scholars that might be helpful to foresee the future of nuclear energy use will be presented. This chapter will also include the writer's findings and recommendations for Turkey's nuclear energy policies with reference to a number of academic studies.

CHAPTER I

THE CONTEXT OF NUCLEAR ENERGY

1.1 THE MIRACULOUS SOURCE OF ENERGY: ATOM

Without going into technical details in depth, it is essential to summarize the process of producing energy by nuclear technology. The starting point of the human use of nuclear energy is the fact that the nuclei* of the atoms of some naturally radioactive materials found in the earth, most particularly uranium, can be made to undergo nuclear fission. "Nuclear fission is the bombarding of uranium with subatomic particles, called neutrons, which split the uranium atom into two."[3] In

* "Nuclei" or "nucleus" of an atom is the central part of it.

[3] Gobel, Medard. 1975.*Energy, Earth and Everyone*. San Francisco: Straight Arrow Books. p.53.

doing so, large amounts of heat are produced, along with nuclear radiation and a range of radioactive waste from the fission process. The heat can be used to boil water to raise steam. During this process, nuclear reactors control the burning of a nuclear fuel- just as the standard coal fired thermal-electric power plant used for the controlled combustion of coal.[4] It should be noted that there are a range of technologies for turning nuclear heat into electricity like the water-cooled, gas-cooled and most recently the "second generation" breeder or fusion reactors.[5]

This process of producing energy is called the ***nuclear fuel cycle*** (see Fig 1). It is a term widely used by the nuclear industry to cover all aspects of the production of electricity by means of a nuclear power, from the mining of uranium to the disposal of radioactive waste.

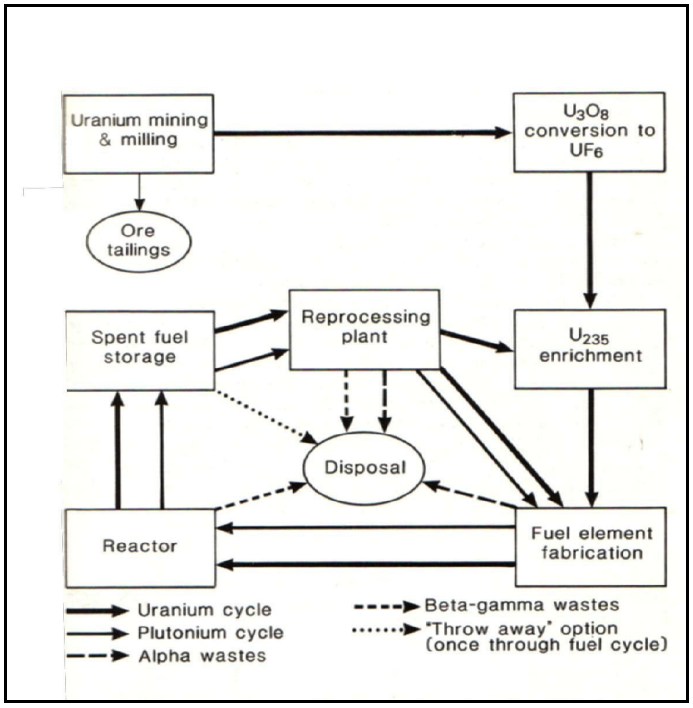
Uranium found in nature is the vital source of nuclear fuel cycle. Naturally occurring uranium contains two isotopes: U238 and U235. U235 is the only element found in nature, which is fissile, meaning that a process of radioactive reaction occurs in the natural state. "Individual atoms fission or split up into smaller atoms, giving off heat and other forms of radiation. Under the right conditions these nuclear particles can cause further fissions in other U235 atoms, so that a self-sustaining

[4] Ibid…p.53

[5]. Most of the worlds' reactors are of water-cooled, chiefly based on pressurized water reactor (PWR) which is developed in the U.S. Gas-cooled ones, initially developed in the United Kingdom tend to be larger and more expensive. The second generation reactors have not yet been commercially developed. For more detail please see Elliot, David. 1997. *Energy, Society and Environment*. London: Routledge p. 66.

chain reaction can be established."[6] There are some other elements like PU239 and U233 which are man-made fissile elements and they are also basic fuels for nuclear reactors.

Fig.1. Nuclear fuel cycle[7]



Since the resources of uranium that provide the fuel for nuclear reactors are not infinitely rich, the nuclear scientists thought some solutions. The nuclear strategy

[6] Toke, Dave. 1995. *The Low Cost Planet: Energy and Environmental Problems*. London: Pluto Press, p.139

[7] The nuclear fuel cycle. The diagram shows the main stages in the nuclear fuel cycle and the main radioactive waste streams requiring disposal. Mounfield, Peter R. 1991.*World Nuclear Power.* London: Routledge, p.xix

that evolved during the 1950s and 1960s predicted that this problem could be largely overcome by recycling uranium. Besides recycling, the nuclear power stations using ***enriched uranium*** fuel also play an important role in the world's nuclear generating capacity. Uranium enrichment has a key role in the nuclear fuel cycle but it is one of the most difficult of nuclear power technologies. Uranium, which is enriched by increasing the proportion of U235 in expense of U238, becomes a more fissile and a more useful material for the fuel element.

To summarize it can be said that the production of nuclear energy usually rests upon an infrastructure of uranium mining and milling, followed by enrichment and fuel manufacturing. With a nuclear fuel cycle completed a new form of energy is produced which has a wide range of usage areas.

1.2 HISTORICAL PROSPECT OF NUCLEAR ENERGY

For almost eight hundred years, coal was the most efficient source of energy and it served civilization well. In the early 1800s coal powered the new machines which made humankind able to do everything faster and more efficiently than before. Several generations later, when the energy of oil and its derivatives such as gasoline, became available, human civilization had the chance to take another big step.

Without doubt, coal and oil had opened the way for the Industrial Revolution by making countries richer, enabling them to industrialize[8] and forwarding them towards prosperity. But by the beginning of 1970s, the information had begun to mount up which indicated that both fuels had serious disadvantages and were no longer the perfect solution to civilization's increasing need for energy.

The first suspicion about them came from the occurrence of a series of air pollution incidents in which sudden increasing death rates caused by bronchitis, other respiratory diseases, and heart disease followed large increases in the concentration of air pollutants.[9] As a result of a number of studies during those years it was indicated that even small amount of concentrations of those pollutants in the air could be deadly. Soon, sufficient data proved that when these dangerous air pollutants are breathed over a long time period, they could cause possible deaths from diseases like bronchitis, emphysema, lung cancer, and heart disease.[10] According to the Environmental Protection Agency's records, large quantities of these substances have been released into our air since 1910 and they are still being released.[11]

---

[8] Between 1870 and 1979 as more coal and oil came into use, hourly productivity began to increase until it reached a spectacular 1,100 percent on the average. Please see Morris, R.C. 2000. *The Environmental Case for Nuclear Power*. St.Paul: Paragon House, p.2 for details.

[9] The most spectacular of those air pollution events occurred in 1952, when a heavy air mass settled over London. The air mass blanketed London for four days which was called by the media as a "killer fog." An average of 292 Londoners per day had died.

[10] Morris, R.C. 2000. *The Environmental Case for Nuclear Power*. St.Paul: Paragon House, p.4

[11] U.S. Environmental Protection Agency*, Air Pollution and Control*, http://www.epa.gov

Besides those health hazards, some other problems with the use of oil began in 1973 when the Middle Eastern oil exporting countries- the Organization of Petroleum Exporting Countries (OPEC)- put an oil embargo and stopped all exports of oil to the industrial countries. As a result of the increase in oil prices over 500 percent, the cost of oil was passed on to the consumer and inflation occurred. People started to make fewer purchases and a severe recession came into the scene. Six years later, in 1979, when a revolution overthrew the pro-American government in Iran, the world's oil market went through another catastrophic disturbance. This time the oil lobby increased the price of oil and the problems of 1973 were repeated. This event was so influential that many writers had written scenarios about the end of Western civilization.

The problems linked with the dependence on foreign oil continued when in 1990 a war broke out in the Middle East as Iraqi dictator Saddam Hussein invaded his small but oil-rich neighbor Kuwait. Soon the U.S troops intervened and the war ended leaving behind high oil prices, inflation, unemployment and severe economic depressions among the industrialized nations, one more time.

Given this background about the adventure of humankind's efforts of finding the most efficient source of energy, let us return to eighty years before and examine how nuclear energy became a competitor against the fossil fuels. The first clue that a

huge new source of energy might be available to civilization came in 1905, when Albert Einstein announced his famous equation relating energy and mass: $E=mc^2$. In 1930s, a number of scientists, following Einstein's findings, started bombarding various elements with neutrons. The engineering efforts to pull out energy from the fission of uranium began after its discovery in 1939, but the initial motivation behind its usage was military.[12] In 1939, Otto Hahn and Fritz Strassman "bombarded uranium atoms with neutrons and found that atoms of several lighter elements had miraculously appeared."[13] More important was the discovery that even a small quantity of uranium could release, through fission, thousands of times more energy than could be produced from combustion or other chemical reactions. This was exactly the same that Einstein had predicted 34 years earlier.

The discovery of nuclear fission took place as the Second World War was about to begin. Most of the initial research was carried out in Nazi Germany but one Hungarian physicist, Leo Szilard, figured out the military potential of a fission bomb. Fearing the consequences of Nazi Germany's possible development of such a weapon he advised his friend Einstein to send a letter to the U.S. President Roosevelt

[12] With the foundation of plutonium it was discovered that it can be used as an explosive material in nuclear weapons. Price, T. 1990. *Political Electricity: What future for Nuclear Energy?* Oxford: Oxford University Press, p.12

[13] Mounfield, Peter R. 1991. *World Nuclear Power.* London: Routledge, p.16

outlining this possibility.[14] Einstein's letter played an essential role in moving the Roosevelt administration to begin a huge government project to build the atomic bomb. Hundreds of top scientists from all over the world came together in top secrecy for the "Manhattan Project". With this project, the first nuclear reactor was built and tested successfully.

After the Second World War, new developments took place. Many scientists who had worked carefully on the atomic bomb now redirected their expectations towards the peacetime use of fission rather than developing the bomb. But it should be noted that, right from the start it was so difficult to separate the military atom from the peaceful atom and history is full of examples on this issue.

Using of nuclear energy for peaceful purposes began in the early 1950s.The years between 1954 and 1957 were a period of striking progress for nuclear energy. Leaded by the United States of America and Canada, many Western countries around the world had started to develop nuclear technology. In December 1953, U.S. President Eisenhower announced the "Atoms for Peace" program, which called for agreements with other countries to share technology and scientific expertise. International organizations were set up to promote nuclear programs during these

[14] By that time Hitler's troops had already invaded the uranium mines of Czechoslovakia. Norton, B. 1982. *The Early Years,* in *Nuclear Power: Both Sides,* edited by Kaku, M. and Trainer J. New York: Norton & Company, p.8

years.[15] In 1954 the first nuclear reactor-powered submarine, Nautilus, was launched. This vessel traveled a very long distance without refueling, which was impossible by any other source of energy.

When it is looked around the world, it is clearly seen that the nuclear energy was living its golden ages. U.S. and Canada were the two countries that started their nuclear development programs in the early 1950s. The development of nuclear power program began in 1947 in the U.S. with the establishment of USAEC (United States Atomic Energy Commission) which offered financial motivation to co-operate utilities and also research and development assistance. In 1954 the "Atomic Energy Act" became a federal law in the U.S., which opened the possibility of sales of U.S. reactors abroad to encourage international cooperation on peaceful uses of nuclear energy. Canada too, had developed a large number of nuclear generating capacities since the early 1950s. Federal and provincial governments in Canada had been deeply involved from the beginning of the nuclear power program. CANDU reactors formed the backbone of Canadian nuclear power effort that differed from other nuclear power reactors around the world.[16]

France was the first country to patent a nuclear power station design in 1939.

[15] "Euratom" is one of the examples which was set under the Treaty of Rome in 1957 as a key part of the newly formed European Community.

[16] CANDU reactors have a high burn up natural uranium system depending on a once-through fuel cycle and they use deuterium (heavy water) as the moderator and coolant. For more details, please see Mounfield, Peter R. 1991.*World Nuclear Power.* London: Routledge, p.93

Similarly, Germany established an atomic research center in 1956 and in 1962 it started to produce homemade reactors. Britain started its first program for commercial development of nuclear power in 1955 and joined the mainstream of nuclear power reactor technology. The Calder Hall station was opened in the United Kingdom in 1956, which produced electricity and helped reduce the cost of military plutonium production.[17] Soviet Union opened its first reactor in 1957. They had been working on nuclear research since 1940s and they installed a dominant nuclear power generating capacity within the region through their key role in research and development. Japan dominated the geographical pattern of nuclear energy in East Asia followed by South Korea and Taiwan.

Nuclear power was thought to be with progress because of the reduction of foreign fuel reserves, fear of increase in foreign fuel prices, concerns about the Middle Eastern oil, and enormous power of the atom. Nuclear energy continued to receive great public acclaim during the 1960s and its use for the production of electricity was greeted with widespread public acceptance. City planners and public utility engineers saw them as a way to solve a rapidly worsening air pollution problem largely caused by coal-burning power plants. Besides electricity production, the medical use of nuclear research reactors had saved the lives of many people with early diagnosis. Nuclear research reactors have been also responsible for much of the

[17] Price T. 1990. *Political Electricity.* Oxford: Oxford University Press, p.7

impressive progress in biology, agriculture, and medicine.

This shiny age of nuclear energy lasted until the late 1970s when the nuclear industry started to face a set of problems. It was soon realized that several issues that public was concerned had not been given the attention they deserved. The capital costs of building the power stations were much higher than expected.[18] A lot of environmental problems were in origin and there began pressures from the environmental groups. People were demanding that safety measures be upgraded. In addition, the complexities involved in technology proved much more difficult than expected. With the support of the media too, anti-nuclear power groups began to form who directed their efforts to stop the construction of nuclear power plants that generated electricity. There have been political problems in some countries –like Sweden, Austria, Italy and Denmark- where referendums had stopped nuclear power stations being built, or made them closed.

To relieve growing fears regarding nuclear energy several studies had been made. However, two major nuclear accidents; the Three Mile Island on March 1979 and the Chernobyl event in 1986 increased the public fear even worse. Added to the campaigns against nuclear power, the reduction in oil and gas prices, especially since

[18] For instance, General Electric/Westinghouse consortium that had organized contracts for PRW's (pressurized water reactors) in the U.S. reduced their involvement after severe financial losses. Toke, Dave. 1995. *The Low Cost Planet: Energy and Environmental Problems, Solutions and Costs.* London: Pluto Press, p.141

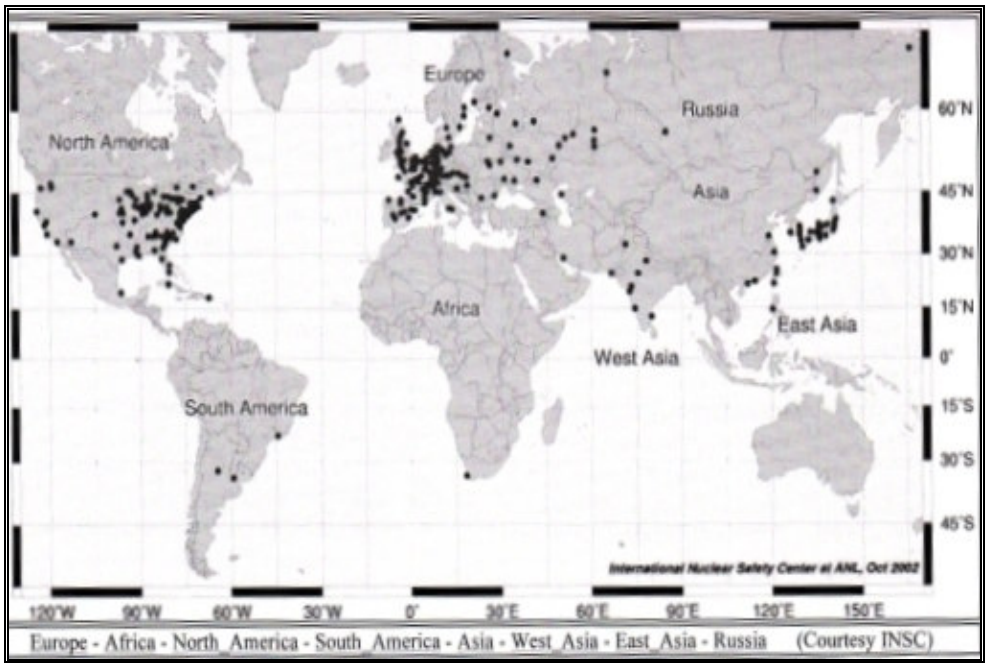
the late 1980s, the rising costs of nuclear energy and the fear factor were the major reasons of decline of nuclear energy. In all but a few countries, nuclear energy growth was brought to a stop or at least to a slowdown in the late 1980s and the 1990s. Worldwide, for 1994, nuclear energy accounted for 6% of the primary energy consumption and 18% of the electricity generation.[19] This percentage increased in the following years. At the end of 1998, 33 countries around the world hosted 434 operating commercial nuclear energy-fueled electric generating facilities.

Today, the United States remains the largest single producer of nuclear energy in the world, with 103 plants. France has the second largest number of nuclear power plants with 58. Japan now has 54 nuclear power plants, followed by 35 in the United Kingdom. Russia follows with 29, and then Germany with 20. China currently has seven operational plants and two under construction. Finland is going ahead with a fifth reactor.[20] (*See* Fig.2) Although fewer nuclear power plants are being built now than during the 1970s and 1980s, those now operating are producing more electricity.

[19] http://www.mans.eun.eg/facscim/PhyDept/reactor/reactor1.htm

[20] http://www.heartland.org/Article.cfm?artId=14017

Fig.2. INSC World Imagemap of Nuclear Reactors [21]



Current trends in the field of nuclear energy are characterized with a modest growth in the number of plants in operation, although the installed capacity and electricity generation continues to grow by increased capacity factors.[22] Nuclear energy is today surrounded with more innovative systems with better technology. The nuclear energy technologies are progressing with research and development programs supported by the governments and the industry. These programs are more

[21] International Nuclear Safety Center's (INSC) database showing 440 operating nuclear reactors around the world. http://www.nucleartorist.com/world/wwide.htm

[22] http://www.nea.fr/html/ndd/docs/2002/G8_speech.htm

focused on responding to society's needs and concerns. "Accordingly, efficient use of natural sources, reduction of volumes and toxicity of radioactive waste, and safety systems minimizing the risks of accidents are the key goals of innovative nuclear reactors and nuclear cycles."[23] Yet, the future of nuclear energy usage seems to depending on the broad social and economic context of the world we live in.

[23] http://www.nea.fr/html/ndd/docs/2002/G8_speech.htm

CHAPTER II

SOURCES OF CONTROVERSY

Increasing opposition against nuclear energy was established by the late 1970s and enlarged after accidents like the Three Mile Island and Chernobyl. These events increased public anxiety and anti nuclear groups have had mass support in many countries. The amounts of public and political support they can command have proved a considerable factor in nuclear energy's decline. On the other hand, the proponents continued to promote the advantages of nuclear energy despite the growing influence of anti nuclear activists.

The nuclear debate between the opponents and advocates has drawn attention to a number of issues, which will be discussed in details in this chapter. The critics attack nuclear power as an unacceptably dangerous source of energy. They emphasize the health hazards of nuclear fuel cycle, possibility of accidents, and threat from nuclear wastes. They question its economic benefits by pointing out the

increasing costs of nuclear construction and fuel, and poor reactor performance. They assert that nuclear power will lead inevitably to the proliferation of nuclear weapons throughout the world and that the nuclear fuel cycle facility is a potential target for terrorists interested in sabotage or bomb making.

Proponents advocate nuclear power as a safe, clean source of energy that is crucial to the future of country's economies. It can generate electricity at significantly lower costs than any fossil fuel alternative and that without it the rising demand of electricity cannot be met. They argue that it is less dangerous to the environment and to the human health than fossil fuel alternatives. They point to the safety record of reactors and calculate that, while an accident could be serious, the probability of its occurrence is extremely small. Nuclear wastes, they assert, can be handled in ways that essentially eliminate the possibility of future accidents. Nuclear power is also an essential component of energy independence according to them.

2.1 THE SAFETY QUESTION: ACCIDENT RISKS AND HEALTH HAZARDS

Since nuclear power relies on nuclear reactors that are difficult to control compared with other energy providers, detailed assessment regarding the questions and fears about its safety began in the early 1970s. Reactors need to maintain just

enough neutron activity to keep the reactor working but too much of it runs out of control. If these escape nuclear reactions occur; and if cooling systems fail, the resulting heat can melt down the fuel rods and trigger violent explosion known as the "core meltdown."[24]

Proponents

Nuclear energy advocates argue that nuclear power certainly involves some risk, but no technology can be 100 % safe, and accidents can always happen. Yet, the chance of major accidents in the nuclear field is very low, and can be reduced if sufficient money is spent on safety. Supporters of nuclear power often claim that, compared with alternatives, it is a relatively safe option. When saying this, they rely upon a number of scientific studies, which have made probabilistic judgments with related technical experience and theoretical calculation. Most well known of these studies is "The Reactor Safety Study" (also known as WASH-1400 or the Rasmussen Report) published by the Nuclear Regulatory Commission (NRC) in 1975. "This report examined possible ways that could lead to an accident, estimated the overall probability of a nuclear core meltdown and break of containment, and developed a

[24] Toke, Dave. 1995. *The Low Cost Planet: Energy and Environmental Problems.* London: Pluto Press, p.143

probabilistic assessment of the consequences of such an accident, averaged over location and weather."[25]

An extremely serious accident under very unpleasant conditions is estimated by WASH- 1400 to kill as many as 3,000 over a few weeks, cause thousands of cancer deaths over 30 years, and cause a comparable number of genetic defects in the next generation, as well as $ 10 billion property loses. (*See* Table 1.1) However, the most serious accident considered in WASH-1400 is given an extremely low probability of occurrence (only one chance in 200 million years of reactor operation.) Nuclear advocates reveal that this analysis underscores the importance of continuing efforts to reduce the probability and consequences of accidents by improving safety designs and location policies.

[25] Bundy, McGeorge. 1977. *Nuclear Power Issues and Choice.* Cambridge: Ballinger Publishing Company, p.18

Table 1.1 WASH-1400 Report[26]

Consequences of Extremely Serious Accidents

	Rate	Assumed Total
Prompt Fatalities		3,300
Early Illness		45,000
Thyroid Nodules	8,000/yr	240,000 (30 yrs)
Latent Cancer Fatalities	1,500/yr	45,000 (30 yrs)
Genetic Defects	200/yr	30,000 (150 yrs)
Economic loss due to contamination	$14 billion	
Decontamination area	3,200 sq. miles	

Pro-nuclear side makes probability calculations to sufficient indication that the risks imposed by nuclear reactors are no worse, and probably fewer, than those we accept routinely from airplane crashes and natural disasters.[27] In terms of accident probability, the pro-nuclear energy side also makes comparisons with the fossil fuel facilities. They argue that coal dust and air mixtures are extremely explosive and a real disaster involves the shipping and storage of oil and liquid natural gas (LNG).

[26] The most serious adverse health affect calculated in WASH-1400 could be fatalities from latent cancer. They could occur in the exposed population over a 30-year period following the accident. The detailed analysis of these potential concerns on an organ-by-organ basis in WASH-1400 indicates that %83 of the eventual latent cancer deaths result from exposure during the first week of the accident. The consequences of an accident could be reduced if the population were evacuated and steps taken to decontaminate the areas. This would include very large costs and major operational problems. In serious accidents, WASH assumes that people closer than 25 miles from the reactor would be evacuated. The economic cost of this is estimated $14,000 billion. Ibid…p.224

[27] Bundy, McGeorge. 1977. *Nuclear Power Issues and Choice.* Cambridge: Ballinger Publishing Company, p.213

These two are flammable, very explosive substances, and it's not a low possibility that their risky placement and handling can lead to the worst fire. They argue that this kind of an accident is more likely to occur than a nuclear accident and several coal-mining accidents had already happened in the past years.[28]

Nuclear energy supporters point out that if an accident occurs —even if it is a very small probability— the layers of complex safety systems which every reactor is equipped with, will minimize the effects. The emergency core cooling system (ECCS) for example, is designed to dump hundreds of thousands of gallons of cooling water automatically onto the exposed core in a matter of minutes in order to prevent a core meltdown.[29] If a core meltdown occurs because of an operator failure, it is expected that only a small number of them-barely 2 percent- would actually pass over the "containment building"[30] and lead to a catastrophic release of radiation. The nuclear activists also refer to the nuclear engineers who say that the probability that the ECCS fail is less than one in a thousand. The nuclear advocates strongly argue that during the designing phase of a nuclear reactor every single detail with the worst

[28] Five worst disasters were due to coal mining which killed the miners. These disasters are: In 1942 in Manchuria with 1,549 deaths; in 1906 in France with 1,060 deaths; in 1963 in Japan with 447 deaths; in 1913 in Wales with 439 deaths and in 1946 in West Germany with 439 deaths. See, Morris, Robert C. 2000. *The Environmental Case for Nuclear Power.* St.Paul: Paragon House, p. 132.

[29] Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides;* New York: WW Norton & Company, p.82

[30] Containment building is a very strongly built shelf around the reactor which protects it from outside damage. Even if a core meltdown occurs inside, the containment building keeps the radioactivity inside. See, Cohen, Bernard. 1995. *Çok Geç Olmadan (Before Its Too Late).* Ankara: Tübitak Yayınları, p.57

scenarios is considered. In case of the worst probabilities, there is always a “defense line” with numerous basic features and safety systems, which is not perfect, but near perfect. They admit that if one single part of this line is broken, it might lead to a catastrophe. However, this probability is very small since this defense line is developing and getting stronger everyday.

Nuclear advocates have also explanations for the two major nuclear accidents: the Three Mile Island (TMI) in 1979 and Chernobyl in 1986. The investigations of TMI have shown that the primary causes of the accident were not design errors but rather failures in plant maintenance and operation, which had not been taken seriously enough. The accident was useful in one way according to the advocates since it caused the industry and the utilities to wake up. The problem of human error can now be reduced, by several improvements as a result of the accident. Chernobyl had long been a disaster waiting to happen since it was a badly designed and uncontrolled reactor. Added to this were the uneducated and careless operators who ignored the warnings of an explosion. Nonetheless, the explosion was not nuclear, but was either chemical or a steam explosion. “Two people were killed in the two explosions. 29 of the hundreds of workers died of burns and radiation. 237 were hospitalized with burns, radiation sickness, smoke inhalation, and other injuries, but all recovered. No people outside the plant were injured.

The Soviet government waited 36 for evacuating the nearby towns."[31] The facts that they waited three days before notifying their European neighbors and the delayed evacuation caused everyone there to get bigger doses of radiation and increased the chances for more fatalities and latent cancers, of course. The total death toll was 31 people, which is not particularly high.

Simply, the chances of greatly harmful accidents are so small in a nuclear energy plant and reactors are safe enough, even safer than most of the alternatives according to them. In their point of view, the critics have excessively alarmed the public by exploiting the worst-case scenario while ignoring the likelihood of such an event: once in 200 million years.

Opponents

At the opposite side, the critics are convinced that the effects of a major nuclear accident are far more devastating-physically, psychologically, and economically – than the effects of a coal mine accident, airplane crashes, or dam crashes. Comparison of a coal facility accident with a nuclear one is not appropriate according to their view. They say that while even a major coalmine disaster produces relatively few casualties, a single major nuclear accident could be very large

[31] Morris, Robert C. 2000. *The Environmental Case for Nuclear Power.* St.Paul: Paragon House, p.127

resulting in as many as several thousand immediate fatalities and several tens of thousands of hidden cases of cancer that will be deadly within 30 years.

The critics of nuclear energy agree that a nuclear power plant operating normally would probably be relatively safe. However, they say that some reactors are poorly designed and constructed, badly managed and the scene of a tired operator at the controls is frightening. The Three Mile Island and Chernobyl accidents both showed that regulations and good equipment cannot guarantee safety. As a result of these accidents they argue, the support for nuclear energy fell because people saw that it was not a safe energy source.

Although they agree that the WASH-1400 was a turning point in the history of reactor safety and the first substantial step in the understanding of risks from reactor accidents; they criticize the report for having substantial uncertainties. They argue that WASH-1400 presented the matter poorly and it was misleading. According to them, "the body of the report was presented in such a way that other fundamental issues, such as the reliability of regulatory system for assuring the quality of reactor components were obscured."[32] They find the WASH-1400 so optimistic and say that according to the report, an accident as severe as Chernobyl or Three Mile Island should not have happened for several more decades. Opponents say that; "with wide accident experience an expected rate-of-loss can be computed.

[32] Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides.* New York: WW Norton & Company, p.88

This expected rate is the sum of all possible accidents of the probability of each type of the accident multiplied by the consequences of that accident."[33] However, there has been a major public debate about the reliability of ECCS since it has never been tested in a full sole reactor accident and thus it does not constitute an experience.

The critics also blame governments and nuclear industry working hand in hand to promote nuclear power. According to this coalition, the problem is simply assuring that the benefits appear to be much larger than the risks.

Proponents

Health effects of a nuclear power plant which is operating normally or in an accident situation is the second issue where the two sides diverge. When talking about health, the main concern is radiation. According to the nuclear energy advocates all people know that the production of nuclear energy inevitably involves the production of radioactivity and radiation, and people fear radioactivity and radiation will cause cancer. Because of these fears, the industry struggles for a safer and safer technology which makes it a more expensive one. However, they point out that a nuclear power plant operating under normal conditions, controlled on a

[33] Bayea, Jay. 1982. *Second Thought.* in Kaku, Michio and Trainer, Jennifer; *Nuclear Power: Both Sides.* New York: WW Norton & Company, p.97

regularly basis and subject to certain countermeasures like dose limitations to radiation by the International Atomic Energy Agency (IAEA), has no harmful effect on human health and is safe as other energy providers in terms of health.[34] If people are worried about the radiation they receive there are a lot of ways to minimize this, the advocates of nuclear energy say. It is possible that people can wear metal clothing to shield them, they can choose the building materials of their homes (brick and stone contain more radioactivity than wood and therefore expose people to more radiation) and they can chose to live in areas with lower natural radiation. But their point is that: most people do not worry about such things and they recognize that life is full of risks. One of the most well known nuclear activists Leonard Cohen says: "Every breath of air may carry a germ that will cause fatal pneumonia, but we continue to breathe. Every bit of food may have a chemical that will give us cancer, but we continue to eat. Every time we get into an automobile we recognize that we may be killed in an accident, but we still drive."[35] Nuclear activists claim that in evaluating the dangers of radiation, it is important to be quantitative, not just qualitative. With qualitative reasoning, almost any human activity can be shown to be harmful. At this point, they call attention to the fact that radioactivity has always been in the human environment and in the human body, and the quantitative analysis

[34] A working group meeting convened by World Health Organization (WHO) in November 1981 was made with the attendance of 22 advisors from 13 countries to give guidance to national authorities. As a result of this meeting it was said that the development of commercial nuclear power can be said to have had a satisfactory record of safety over the last few decades compared with non-nuclear power industry. See, *Nuclear Power: Accidental Releases;* (England: WHO Publications, European Series, 1984), p.7

[35] Cohen, Bernard. 1995. *Çok Geç Olmadan (Before Its Too Late).* Ankara: Tübitak Yayınları, p.46

on radiation is measured in "rems". (See Table 2.1)

Nuclear energy supporters reveal that the man-made sources of radiation (which includes the nuclear energy production, x-rays and nuclear weapons) constitute less than half the radiation to which we are exposed; nature supplies the rest. Any single one of the radioactive particles can cause a fatal cancer or a genetic defect, but the probability that it will do so is only one chance in 30 quadrillion (30 million billion).[36] The effects of radiation on human health are well described by the data-studies of the Hiroshima-Nagasaki causalities. (See Table 3.1) And it is underlined by the nuclear energy activists that the manmade radiation exposes to us an additional 80 millirems additionally.

It has also been known that radioactivity can produce mutations in plants and animals. However, the nuclear energy advocates claim that, on the average, fossil fuels release over 40 million tons of these two mutagens into the air each year. At Hiroshima and Nagasaki, where the bombs were dropped, radiation levels were thousands of times higher than the levels near nuclear power plants. But, studies of the offspring of the survivors of these bombings reveal only normal mutation rates.[37]

[36] Ibid… p.50

[37] Nero, V. Anthony. *Safe Enough.* in Kaku, Michio and Trainer, Jennifer eds. 1982. *Nuclear Power: Both Sides.* New York: WW Norton & Company, p. 86

Table 2.1 Radiation Received Yearly from Various Sources[38]

Source of Radiation	Dose received in mrem/year
Average background in U.S: Cosmic rays, earth and building materials	130
Average, all medical x-rays	95
Food, internal sources	25
Living in a brick house	30
Watching color television	1
3-hour flight in a jet	2
Fallout from weapons testing	3
Cosmic rays at sea level	35
Maximum allowable level at the fence line of a nuclear power plant	10
All nuclear power plants: emissions over the entire U.S	less than 0.02
One coal-fired power plant: average within 20 miles	0.10

[38] Morris, Robert C. 2000. *The Environmental Case for Nuclear Power.* St.Paul: Paragon House, p.85

Table 3.1 Radiation Levels and Health Effects, as Indicated by the Survivors of Hiroshima and Nagasaki[39]

Radiation dose in mrems	Immediate health effects	Later health effects
Over 1,000,000 milirems	Almost certain death	No genetic mutations at any level of radiation.
400, 000 milirems	50-50 chance of death nausea, fatigue	Excess cancers
100,000 milirems	Radiation sickness only below this level. Temporary changes in blood cell count.	No excess cancers below this level at Nagasaki.
25, 000 milirems	No medically detectable immediate effects below this level.	None.
20,000 milirems	None.	No excess cancers below this level at Hiroshima.
250 milirems (average exposure to radiation in the U.S.)	None.	No excess cancers likely at this level.
0.02 milirems (average radiation received from ALL nuclear power plants in the U.S)	None.	None.

Nuclear energy advocates claim that newspapers frequently print stories about scary radioactivity news, which make the public think that radiation is a major threat to their safety. Media is highly responsible for this fear, which never talks about the danger of pollution created by coal or oil burning. The advocates reveal that more dangerous health threat comes from coal mining since coal miners suffer

[39] Morris, Robert C. 2000. *The Environmental Case for Nuclear Power.* St.Paul: Paragon House, p.87

severely from pneumoconiosis, known as the black lung disease, a disease of lungs due to permanent deposition of inhaled coal dust.[40] According to them, more proof of nuclear power's superiority is provided by former Iron Curtain countries, all of whom are building nuclear power plants despite the fact that they have some of the largest coal reserves in the world. China, where air pollution caused respiratory disease is the number one killer, has also plans to build 140 nuclear power plants over the next 50 years.[41]

Opponents

Nuclear critics maintain that the growing effects of natural and man-made radiation, combined with insufficient monitoring at nuclear facilities and in uranium mines, make radiation exposures more dangerous than the nuclear advocates would have us believe. They argue that uncertainties exist in the data of pro-nuclear scientists' can not exactly predict the long-term effects of the low-level radiation.[42]

---

[40] Bundy, McGeorge. 1977. *Nuclear Power Issues and Choices.* Cambridge: Ballinger Publishing Co., p.174

[41] Morris, Robert C. 2000. *The Environmental Case for Nuclear Power.* St.Paul: Paragon House, 2000, p.65

[42] Although pro- and antinuclear scientists analyze on the same data-studies of the Hiroshima-Nagasaki causalities-they interpret the information differently. Pro-nuclear scientists assume that less damage is caused per rem at low doses than at high doses because the body has the ability to repair cells damaged by low-level radiation. Anti-nuclear scientists support that more damage is caused per rem at low does
than at high doses. They theorize that perhaps low doses weaken and damage cells (which live on to damage other healthy cells), whereas high doses simply kill cells. See, Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides.* New York: WW Norton & Company, p. 46

Antinuclear scientists believe that the majority of scientists are subject to political pressure from powerful government channels and the nuclear industry. They claim that public is misinformed by the pro-nuclear scientists and blame them for presenting false scientific results about radiation effects.[43] They point several well known studies which show that even small rates of radiation can cause huge health problems.[44]

Radioactivity is encountered at most stages of the nuclear fuel cycle- in mining and milling, in fuel fabrication and transportation, in reactor operation, and in waste management and disposal operations. They argue that small quantities of radioactivity are released at each stage, affecting workers or beyond facilities; the public. More importantly, those routinely released radioactive gases which are neglected to be measured, could increase the levels of background (natural) radiation in the following years that will be kept responsible for delayed human suffering and disease (cancer), and a general deterioration of the human race due to mutations.

[43] In 1981 when scientists showed that (at the Lawrence National Lab in U.S) there were significant errors in the original calculation of the neutron and gamma dose of the bomb, as much as 10 times in certain cases. In other words, the Hiroshima data have been fundamentally flawed for 35 years. It is now obvious that radiation may be several times more dangerous in causing forms of cancer than previously thought. See, Morgan, Karl Z. 1982. *Underestimating the Risks.* in eds. Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides.* New York: WW Norton & Company, p. 36

[44] Dr. Thomas Mancuso of the University of Pittsburgh and his team found that as little rates as 120-140 person-rems could cause cancer death, an estimate considerably lower than the 5000 person-rems quoted by the standard-setting bodies. Dr. Mancuso found no significant increase in leukemia among the radiation workers but he found an increase in pancreatic cancer and multiple myeloma and an unusually low incidence of leukemia, while the Hiroshima-Nagasaki data showed just the opposite. Ibıd…p.40

They claim that, the pro group will go to any extreme to sell nuclear energy, exaggerate its qualities, devalue its weaknesses, and underestimate its risks.

2.2 WASTE MANAGEMENT AND LONG TERM STORAGE

The management of radioactive waste, particularly high level waste, poses problems for the nuclear power industry by causing a second debate issue between the opponents and supporters. It should be noted that all stages of nuclear fuel cycle produce radioactive wastes in the form of gases, liquids, and solids which must be removed before released to the environment or diluted.

Proponents

According to the supporters of nuclear energy the only problem about wastes is political and no real experts in the field of nuclear waste disposal view this problem as unsolvable. Nuclear energy activists assert that nuclear wastes from power plants, reactors used for research and medical purposes, and those used in weapons production have been accumulating since the early 1940s. And, since that time, these wastes have simply been stored in tanks of water near the site where they were produced. “The radioactivity coming from these wastes has been carefully monitored periodically, and the level of radiation has never been high enough to pose a minor health threat to anyone, not even to those who work near those temporary

storage tanks."[45] So, no deaths have resulted from the simplest, easiest method of temporary storage.

Besides this fact, they propose several options existing for handling the spent fuel. First is to dispose it permanently, or the so-called "throwaway cycle". By this way the wastes produced by nuclear power plants are mixed into melted glass, cooled and thus made part of a solid, unbreakable glass (See Fig.3) Nuclear energy advocates point out the fact that this process has been used by the French for over 20 years and has been successful. Factors that affect this method include: the geology of the area, the level of water table, the presence of seismic activity, the extent of underground pressure due to tectonic movements that could force water upward, and the proximity of the waste site to population centers.[46] However, they argue that government controls are very strict and the engineers and technologists involved are trying their best to make this system perfect.

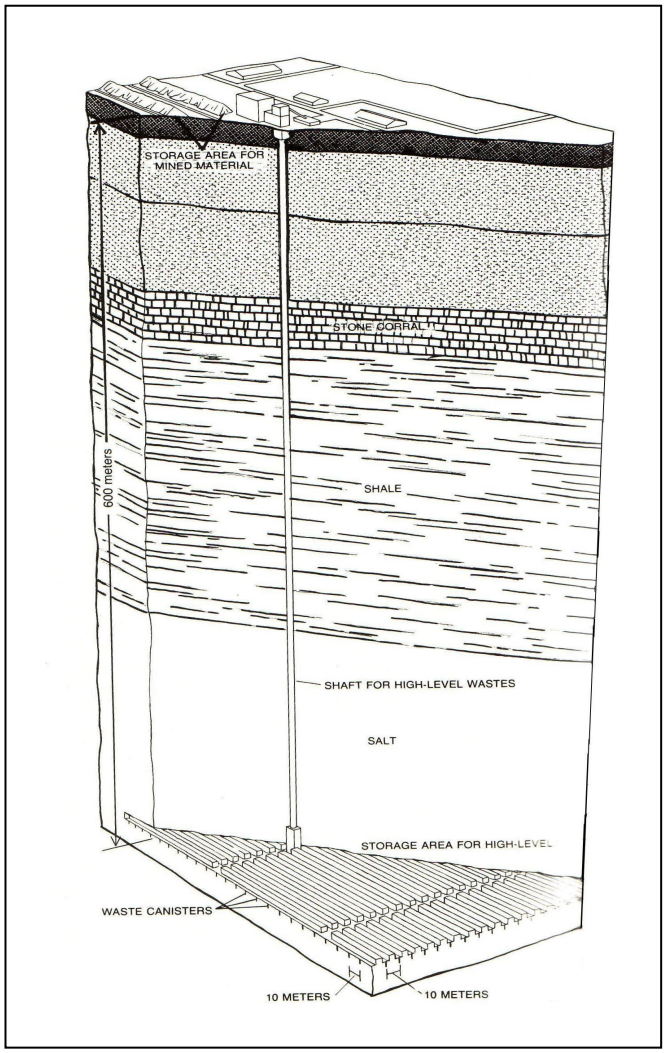
Another option is to reprocess the spent fuel and recover the unused fissile uranium and plutonium for use in other reactors, which is being made in many nuclear energy using states. Various other alternatives to permanent storage have been proposed like sealing the nuclear wastes in containers and deposited on the ocean floor or launched into the outer space — which were never been tried.

---

[45]Kruschke, Earl R. and Jackson Bryan M. 1990. *Contemporary World Issues: Nuclear Energy Policy;* Santa Barbara: ABC-CLIO, p.31

[46] Ibid…p. 36

Fig.3 The burial method of nuclear waste. [47]



[47] This method starts with the incorporation of nuclear wastes into an insoluble glass which is hard and unbreakable as rock. Than, this glass is encased in rustproof stainless steel, buried over a thousand feet below the surface, in one of the driest areas from which escape is nearly impossible. Kaku, Michio and Trainer, Jennifer. 1982.*Nuclear Power: Both Sides.* New York: WW Norton & Company, p.118

Besides their solution techniques, the pro-nuclear energy group admits that the biggest problem they have to face with is to convince the public opinion, which does not want the wastes shipped through their streets or stored near their houses. However, advocates of nuclear energy claim that the responsible for this prejudice is the anti-nuclear activists who had made this issue a potentially dangerous one and convinced the media that it was unsolvable. The reason for the nuclear waste issue turning into a political issue is the fault of misleading media reports which are influenced by the opponents of nuclear energy. Since the media is always in need of interesting and flashy news, and activists are in the need of gaining political power; a mutually advantageous alliance had fallen into place that denied the voice of scientists and experts.

Another point the nuclear energy advocates raise is that: all fuels produce waste and these wastes are more dangerous than the nuclear one. When coal and oil burn, they form gaseous and solid waste products which are potentially ten times more deadly than the ***untreated*** **wastes** from a nuclear plant.[48] If all air pollutants produced during a single day by a coal-burning power plant reached the lungs of

[48] When fossil fuels are burned, most of the wastes are simply released into the air as gaseous smoke. Coal burning also produces ashes. In 1996, coal was responsible for 88 percent of the 19 million tons of sulfur dioxide released. Additionally, coal produced 27 percent of the 23 million tons of the oxides of nitrogen released. They also produced several other hydrocarbons. Sulfur dioxide was present in high concentrations during all of the killer fogs. They caused several respiratory diseases and the production of poisonous and possible carcinogens. Not even only small quantities of these poisonous, dangerous substances should be breathed. They have an accumulative affect, over long periods of time the damage builds up. Every scientific study ever carried out indicates that coal is as much dangerous as to use than nuclear power. Morris, Robert C. 2000. *The Environmental Case for Nuclear Power.* St.Paul: Paragon House, p.36

people, these poisons would kill ten times as many people as would die if they were to inhale or ingest all of the wastes produced during one day by a nuclear power plant. Moreover, once the nuclear wastes are treated, their toxicity diminishes to a very small degree.

According to the pro-nuclear campaigners all these comparisons of the waste disposal method for fossil fuels and nuclear power should be enough to convince any person that waste disposal is not an "unsolvable problem"; but the problem of safely disposing of the enormous quantities of dangerous wastes produced by burning fossil fuels is still an unsolvable one.

No matter all these evidence, the pro-nuclear group admits that the waste problem requires a great deal of additional research and the greatest challenge for the technical community will be to convince a distrustful public.

Opponents

On the other side of the argument, the critics of nuclear energy strongly believe that the problem of nuclear waste has not been resolved and the fact that this waste will remain radioactive for years should not be forgotten. They also emphasize

the fact that, in some cases these wastes can cause serious accidents, which is what happened in Russia in 1957 with nuclear contamination.[49]

Nuclear energy opponents argue that the methods that are being used for waste management are defective and they can cause major harms to human health. Although the nuclear industry argues that deep waste storage areas can be built to stop radioactive leakage, the opponents doubt whether these sites can be monitored for thousands of years, and whether it can be guaranteed that the geological conditions will remain the same over such long periods. Also, they argue that at the waste burial method, "there is the possibility of penetrating of water through the cracks in the fractured rock, dissolving the waste and carrying it back to the biosphere."[50] This is a kind of problem, which is difficult to predict its likelihood, and brings out questions about safe handling of the wastes.

Critics also object to the "reprocessing" of certain nuclear material like plutonium, which is separated from the rest of the waste for future use. They point out the fact that although it can be also used to fuel fast breeder reactors; plutonium is also the key ingredient of nuclear weapons. They are concerned about the expanding stocks of plutonium at a considerable rate that may become subject to theft by terrorists.

---

[49] Toke, Dave; *The Low Cost Planet;* (London: Pluto Press, 1995); p.147

[50] Donath, Fred A., *No Technical Barriers,* in eds. Kaku, Michio and Trainer, Jennifer; *Nuclear Power: Both Sides;* (New York: WW Norton&Company, 1982), p.119

2.3. ENVIRONMENTAL EFFECTS

Third argument issue between nuclear energy advocates and opponents is the environmental effects of nuclear energy use, which is usually compared with the production of energy by the usage of fossil fuels.

Proponents

According to the nuclear energy supporters, the unavoidable contamination of the environment is very low with the usage of nuclear technology and public's fear is groundless. By making a comparison with oil and coal burning, they assert that nuclear plants generate electricity and produce no additional pollution or greenhouse gases like carbon dioxide. Representatives of nuclear power also add that there is no smog problem with nuclear energy generation and expensive cleanup of the air is unnecessary.

Nuclear energy advocates blame other fossil fuel sources for causing very harmful effects on the earth's climate, initially "global warming". At this point it is necessary to briefly describe what global warming means. The absorption of heat energy by the atmosphere which is followed by the return of radiation back to the earth is a beneficial process. This process helps to keep the earth warm. But as the absorption of carbon dioxide and other "greenhouse gases" in the atmosphere

increases, less and less heat energy escapes. And, as more heat is trapped, the average temperature of the earth will gradually increase. The process of trapping heat is known as he "greenhouse effect", and when the heat increases so that the earth becomes warmer is called "global warming."[51] It has been estimated that the carbon dioxide from fossil fuels burned in the last two centuries has increased the mean temperature about 0.3°C above what it would otherwise have been.[52] One of the most frightening predictions is that global warming might melt some ice, causing the ice shelf breakage and raising the ocean levels. This would result in several environmental problems like floods, shifts in the atmospheric movement, and climate change.

With the beginning of the Industrial Revolution, the burning of the fossil fuel began to increase. Burning of fossil fuels added a great amount of carbon dioxide to the atmosphere each year. This problem attracted the attention of the international society and by mid-1989 UN officials adopted the phrase "global warming". In June 1992, the UN representatives met at the Rio Conference, which ended with the signing of the "Global Climate Change Treaty" which called for nations to reduce their carbon dioxide emissions. However, most industrial countries continued to

[51] Porter, Gareth and Brown, J. Welsh. 1991. *Global Environmental Politics.* Boulder: Westview Press, p.25

[52] Bundy, McGeorge. 1977. *Nuclear Power Issues and Choice.* Cambridge: Ballinger Publishing Company, p.20

release them as their economies grew. In 1997, a second meeting was held at Kyoto, Japan. The agreements that emerged from this meeting were much more serious and, if they pass, will considerably affect the industrialized nations. At Kyoto, 38 countries agreed to reduce the emission of their greenhouse gases. But the agreement exempted several developing nations, including China and the U.S. According to these countries cutting down on energy usage meant cutting down on industrial production.

Emphasizing this threatening effect of fossil fuel usage, nuclear energy advocates underline another negative point: the acid rains. Since the fossil fuels increase the level of acidity in the atmosphere, they generate acid rainfalls that cause ecological destruction like death of fish, death of lakes and streams, destruction of forests, and loss of agricultural lands.

Oil spills is another problem associated with the use of the fossil fuels. Each year, tankers transport huge quantities of oil. Some of the accidents during the transportation of oil result in large quantities of oil being spilled into the seas. Fish and birds are killed, together with the marine organisms as a result of this.

Opponents

Anti-nuclear energy side argues that since the production of energy by nuclear fuel cycle is a more complex process, the local harmful environmental impacts of it are relatively higher. According to this argument the nuclear cycle causes land contamination from mining and milling and it results in high local heat concentrations if many reactors are gathered in one single area due to security and economic reasons.[53] Also the active gases extracted from the coolant or waste process systems, which are mixed with air from plant chimneys, pollute the air of the local area.

Opponents of nuclear energy claim that the nuclear fuel cycle certainly releases some radioactive gases to the environment, which creates climatic effects. They assert that this process contributes to the cloud formation and rainfall and thunderstorm development. Besides these comparatively small effects, nuclear energy production causes what is called "thermal pollution". "Thermal pollution effects water based ecosystems, it changes feeding habits and reproduction rates of fish, and it increases nutrient levels, photosynthesis, and decomposition rates. When a power plant shuts down, fish that have become accustomed to warm water go into shock and die as they are subjected suddenly to cold water. Also organisms that

[53] Hewitt, F. Geoffrey. 2000. *Introduction to Nuclear Power.* New York: Taylor & Francis, p.99

normally live on the bottom water are destroyed by the temperature increase."[54] It should be noted here that the advocates of nuclear energy respond to this argument by saying that the operators at nuclear plants spend great efforts to cool the water that will be released into the surrounding systems, to prevent negative impacts upon the wildlife. They monitor the water temperatures, in the bay for example, to assure that nuclear facility does not disrupt the marine environment.[55]

Admitting that the absence of carbon dioxide release is a point in favor of nuclear power, the opponents emphasize that it is a minor one. "The 500 nuclear plants that might, under optimistic assumptions, be operating in the world by the year 2010 would reduce the projected rate of carbon dioxide production by less than 10 percent."[56] That means, the atmospheric level of carbon dioxide would continue to rise almost as fast as in the absence of nuclear power.

The theory of "nuclear winter" is another concept amongst the opponents of nuclear energy, which is closely related with the environmental hazards. Starting in the mid 1970's, scenarios of a nuclear war explored the probable threats of it to the environment. Carl Sagan and his co-workers were the first to examine nuclear wars

---

[54] Bundy, McGeorge. 1977. *Nuclear Power Issues and Choice.* Cambridge: Ballinger Publishing Company, p.205

[55] Kruschke, Earl R. and Jackson Bryan M. 1990. *Contemporary World Issues: Nuclear Energy Policy.* Santa Barbara: ABC-CLIO, p.15

[56] Taylor, Vince. *Living Without Nuclear Energy.* in eds. Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides.* New York: WW Norton & Company, p.158

in terms of their potential impact on climate and environment.[57] Sagan explored the unforeseen and devastating physical and chemical effects of even a small-scale nuclear war on the earth's biosphere and life on earth.[58] This theory claims that the result of such a war would be a total destruction of the climate. "One of the most essential consequences of a nuclear war is the vast amount of dust injected into the upper troposphere and stratosphere. Intense atmospheric contamination with dust and soot changes the terrestrial climate system."[59] As a result of this climate change, the theory assumes that the survivors will find themselves exposed to fierce cold, darkness, lack of fresh water, food and fuel, radiation, pollution, diseases and extreme psychological stress. As Prof. Sagan states: "Cold, dark, radioactivity and ultraviolet light following a nuclear war…would imperil every survivor on the planet."[60]

As an answer to nuclear winter theory, the proponents of nuclear energy have drawn comparisons with volcanic eruptions which have also put large amounts of dust into the atmosphere to suggest that nuclear war would be no worse. They

---

[57] See, *Sagan, Carl. 1985. et. al. The Nuclear Winter: The World After Nuclear War. London: Sidgwick & Jackson.*

[58] "The Nuclear Winter"; http://www.cooperativeindividualism.org/sagan_nuclear_winter.html

[59] Kelleher, Catherine M., Kerr, Frank J.,and Quester, George H. 1986. *Nuclear Deterrence: New Risks, New Opportunities*. New York: Pergammon-Brassey's, p.54

[60] Green, Jonathon; 1986. *The A-Z of Nuclear Jargon*. New York: Kegan&Paul, p.121

criticize the theory methodologically for being uncertain in their existing models.[61] Besides they argue that the proponents of nuclear winter have no proof to demonstrate that nuclear winter will certainly occur.

2.4 ECONOMIC COSTS

Since energy is an important factor in an economy, debates on nuclear energy choice is not unexpected. According to many sources, the economic costs of a nuclear energy option is considered the "Achilles' heel" of the industry which the supporters have hard times to convince national policy-makers and the public.

Proponents

Nuclear energy supporters state that nuclear power is considerably cheaper than any other common sources of energy. It is one half as expensive as coal, which is generally thought to be the cheapest fuel. And, nuclear energy is even cheaper when compared with natural gas and oil. (See Table 4.1)

[61] Martin, Brian; *Nuclear Winter: Science and Politics*; Science and Public Policy, Vol. 15, No. 5, October 1988, pp. 321-334.

Table 4.1 The 1982 Cost of Electricity Generated by Nuclear Versus Coal[62]

Fuel	Plant Construction	Operating and Maintenance	Fuel	Total Cost per kilowatt hr.
Nuclear	0.92	0.50	0.82	2.24 cents
Coal	1.11	0.42	2.80	4.33 cents

It is argued by the nuclear energy advocates that the construction costs of coal plants have also increased in recent years. It is estimated that the use of new equipment (scrubbers) to reduce sulfur dioxide emissions in the coal plants may increase construction costs as much as 20 to 25 percent.[63] According to them, the uncertainties in construction costs of coal plants are as great as for nuclear plants.

Representatives of nuclear industry state that; on average, nuclear power offers lower-cost electricity in terms of operation, maintenance, and fuel costs. This economic advantage is valid except in situations where cheap coal is easily available, close to load centers.[64] Advocates maintain that nuclear power has been the fastest

[62] The utility companies have carried out a lot of studies in the 1980s indicating that NP is the cheapest fuel. This table shows Commonwealth Edison's average operating costs for six large nuclear reactors and six comparable coal-fired plants. Costs for plant construction and operating and maintenance were similar for both kinds of plants. But fuel costs were over three times higher for the coal plants. Total cost per kilowatt hour, which is what counts, showed that electricity generated by coal-fired plants was almost twice as expensive as electricity produced by nuclear power plants. Morris, R.C. 2000. *The Environmental Case for Nuclear Power*. St.Paul: Paragon House, p.98

[63] Bundy, McGeorge. 1977. *Nuclear Power Issues and Choice.* Cambridge: Ballinger Publishing Company, p.9

[64] Mounfield, Peter R. 1991. *World Nuclear Power.* London: Routledge, p.259

growing contributor to domestic energy supplies, exceeding coal to a considerable extent.

Another argument of the advocates is that; it is economically dangerous for many countries to be dependent on oil which is bought from a politically unstable region: the Middle East. In 1973, angered by the U.S. support of Israel, an oil embargo by the Middle Eastern oil exporting countries—the Organization of Petroleum Exporting Countries (OPEC) — was made which severely cut back all exports of oil to the industrial countries. OPEC raised oil prices to such a point where the industrial countries suffered severe inflation, economic recession and a high rate of unemployment. Six years later, in 1979, when a revolution threw away the pro-American government in Iran the world faced another disturbance in the oil market. The oil prices went even higher than the first time and the economic problems of 1973 were repeated. Besides all these price increases, the nuclear energy advocates argue that there's a much more dangerous aspect to having to rely on the Middle East for energy supply: the threat of war. In 1990, Saddam accused both Kuwait and Saudi Arabia of exceeding the oil production quotas which OPEC had set. According to Saddam, this overproduction was preventing the price of oil rising. Saddam moved his troops to the Kuwait border just before an important OPEC meeting. The threat of Saddam's troops forced them to agree to the first price increase in oil for four years. Encouraged by his success, Saddam tried to invade Kuwait and with the U.S intervention the situation got more serious. With this war, Western economies

suffered a lot as oil prices climbed. Inflation rates climbed, military spending doubled and unemployment rates rose.

Another point raised by the nuclear energy activists is that the estimates of oil and natural gas reserves are very uncertain. No one is certain how much oil remains underground. If the world runs out of oil, and does not have an alternative source of energy in place, there will be serious trouble. If coal burning increases to compensate the loss of oil, the first problem will be severe air pollution. Besides, acid rains and global warming will be on the way.

Despite all these advantages of nuclear power, the advocates maintain that the industry's current problems are because of the large interference of antinuclear activists. Advocates argue that nuclear energy is killed by the critics, the courts, the bureaucracy, the press and the politicians. Delays in the nuclear construction, they argue, are one of the most disturbing factors that increase the nuclear costs. "Reports indicate that in 1975 through 1976, 109 power plants were delayed for months for equipment reasons, 24 plants were stemmed from regulatory safety requirements, and only 4 plants from environmental and land-use challenges."[65] Every delay, no matter what the cause, introduces opportunities for more interventions which

[65] Nader, Ralph and Pollock, Richard. *The Industry's Worst Enemy;* in eds. Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides.* New York: WW Norton & Company, p.143

influence the public opinion as well. From the supporters' point of view, the critics have taken advantage of delays to create more delays.

No matter all these criticisms, advocates maintain that "the economic attractiveness of nuclear power will depend as much on the harmful environmental effects of burning coal as it does on the construction costs of nuclear power plants."[66] They argue that since there are no other alternatives as cheap, reliable and clean as nuclear power, the choice would be easy.

Opponents

Opponents of nuclear energy argue that in most of the world nuclear power is perceived as a failed or at least slowed down option. And the most important reason for this has been economic. They assert that the nuclear industry is failing because the technology is an economically weak one, which costs a lot of money.

According to their point of view, during the period of Second World War nuclear industry looked very promising: there were even suggestions that nuclear

[66] Manne, Alan and Richels, Richard G. *The Effects of a Nuclear Phase-out.* in eds. Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides;* New York: WW Norton & Company, p.161

electricity would be "too cheap to meter."[67] However, the reality turned out to be different. After very large investments around the world, nuclear energy still only provides a small portion of the world's primary energy, and the cost of electricity produced remains high. Economic problems added with public opposition have cancelled or postponed many nuclear programs.

Nuclear energy opponents argue that, since the nuclear fuel cycle is a complex process, each step of it will cost money. The fuel costs including mining, conversion, enrichment and loading; capital costs including initial construction of the plant and the modifications; safety-related equipment; operation and maintenance costs that include labor, fees and taxes of highly qualified personnel; waste related costs and finally the decommissioning costs are more than—or not less than— the costs of any other energy source. (See Table 5.1)

Anti-nuclear activists argue that there are a number of economic reasons which constitute the drawbacks for nuclear industry. First of all, the biggest cost is the capital cost, the cost of building nuclear power plants. If higher safety measures are demanded, this cost will increase. Since nuclear power stations take approximately six years to build, a lot of money is spent during the construction period.

[67] Elliot, David. 1997. *Energy, Society and Environment.* London: Routledge, p.65

Table 5.1 Comparison of nuclear versus coal power[68]

Item	Cost Element	Nuclear	Coal
		$/Mw-hr	$/Mw-hr
1	Fuel	5.0	11.0
2	Operating & Maintenance – Labor & Materials	6.0	5.0
3	Pensions, Insurance, Taxes	1.0	1.0
4	Regulatory Fees	1.0	0.1
5	Property Taxes	2.0	2.0
6	Capital	9.0	8.0
7	Decommissioning and waste costs	5.0	0.0
8	Administrative	1.0	1.0
Total		30.0	28.1

Secondly, the operating and maintenance costs are higher since it is a technically complex industry that needs the employment of highly skilled workers and operators who will be responsible of the reactor. Their training and inspection will cause extra money.

Thirdly, the estimated cost of decommissioning a nuclear power station is also high. "The cheapest short-term solution is to entomb nuclear facilities for at least several decades and leave the task of dismantling the most serious irradiated parts of the plant to future generations."[69] However, this may not please people living close to the wrecks which will spread radiation from the left over materials. Critics charge that the full price of such an operation is not known yet, because utility

[68] The table compares nuclear versus coal power with specific item costs for similar age and size plants on a $ per Megawatt-hour basis. http://www.nucleartourist.com/basics/costs.htm

[69] Toke, Dave. 1995. *The Low Cost Planet.* London: Pluto Press, p.143

companies cannot accurately asses what the cost of decommissioning a reactor will be, primarily because a large commercial reactor has not yet been decommissioned.

Nuclear energy opponents also point out that the recent rapid increase in the price of uranium has further clouded the economic picture.[70] Such a rapid increase in prices raises basic questions about the future price and availability of uranium. If uranium is indeed in short-supply and becomes very expensive, the current generation of light water reactors (LWRs) will have difficulty competing with coal plants.

As a response to the nuclear energy supporters' argument of dependence on foreign oil, the anti-nuclear activists claim that nuclear power creates more dependence for the developing countries to the industrialized ones. They assert that most developing countries evidently see nuclear power as a part of the industrialization process. High technology developments like this may be for the benefit of the technical and economic elite in some developing countries, but importing nuclear power technology does not seem the best choice for those third world countries which are struggling with large foreign debts, or whose populations are in the need of cheap, simple, and locally accessible sources of power. Since

[70] The price of urnium which was $6 per pound in the early 1970s increased to $60 per pound. Morgan, Karl Z. *Underestimating the Risks.* in eds., Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides.* New York: WW Norton & Company, p.41

nuclear power is a "highly centralized, technically complex, and capital-intensive industry"[71] it may pose a potential long term economic danger for those countries. Besides, although they may reduce their dependence on other nations for imported fuels; they will always be dependent on the industrialized states for equipment, services and technology development.

2.5 SECURITY AND NUCLEAR PROLIFERATION RISKS

The last debate area on nuclear power is about its dangerous association with nuclear weapons. It is argued that nuclear power provides countries a path for access to equipment, materials, and technology necessary for the manufacture of nuclear weapons.

The connection between nuclear power and nuclear weapons capability, potential for nuclear proliferation and its political and security risks have been recognized since the end of the Second World War. In 1946 the United States government proposed that international society, under the auspices of the United Nations, control this deadly technology. This proposal was rejected by the Soviet Union. Upon this, the U.S. shifted its policy to the maintenance of its nuclear monopoly, refusing to share the technology even with its allies. With The Atomic

[71] Cole, H.A. 1988. *Understanding Nuclear Power.* Vermont: Gower Technical Press, p.89.

Energy Act of 1946 export of technical information from the U.S. was prohibited because it was assumed that information on peaceful applications of nuclear energy could be used to develop a weapons program. Following the Soviet Union's explosion of its first nuclear bomb in 1949 the idea became clear that any industrial power that was determined to become a nuclear power could do so. Upon these developments, the policy of the U.S. again shifted from protecting its monopoly to discouraging military applications other nations. In 1953, U.S. President Eisenhower announced the "Atoms for Peace Program" which offered American technical assistance in the nuclear area, including nuclear fuel.

In 1957 the International Atomic Energy Agency (IAEA) was established to manage a safeguards program which was designed to assure that sharing nuclear information would not result in proliferation of nuclear weapons. Nonetheless, as more and more countries chose to have nuclear weapons capability, it was decided by the international community that a more tight policy is needed to prevent proliferation. As a result, The Nonproliferation Treaty (NPT) of 1968 was signed which included a lot of arrangements and safeguards. "NPT was similar to a bargain in which the nuclear powers agreed to facilitate peaceful programs in non-nuclear states in exchange for the acceptance of IAEA safeguards at all nuclear facilities and for the abandonment of a weapon option."[72] The NPT has been ratified by more than 100 governments. In 1971 at the fourth conference on Peaceful Uses of Atomic

[72] Falk, Richard. *Denuclearization.* in eds. Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides.* New York: WW Norton & Company, p.228

Energy and the General Conference of IAEA it was also agreed that efforts should be intensified to assist developing countries in planning for nuclear power.

Opponents

However, the anti-nuclear activists argue that international non-proliferation measures were destroyed by the Indian nuclear explosion of 1974 followed by French and German agreements in 1975 and 1976 to supply nuclear technologies to Third World countries like Brazil, Pakistan and South Korea. They assert that, recently, in 2004 the United Nations report on global security identified nuclear proliferation as one of the principal threats. The report notes that the entire nonproliferation regime is at risk because of withdrawals and the lack of compliance. "There are doubts about Iran's going nuclear followed by Egypt, Saudi Arabia and possibly Syria which might cause destabilization in the area."[73]

Anti-nuclear activists criticize the measures for non-proliferation for not being successful enough to prevent the dangers. They claim that the NPT has not altogether been successful since many countries like China, France, Argentina, Brazil, India, Israel, Pakistan, South Africa, and Spain refused to sign it. Besides this fact, they also argue that there are some ambiguities within the treaty itself. First, safeguards are obligatory only if the nuclear technology is transferred from one

[73] Allison, Graham; *A cascade of Nuclear Proliferation;* International Herald Tribune, December 17,2004.

country to another. Local facilities are not covered. Secondly, even after countries sign the NPT there is no guarantee that the proliferation of nuclear weaponry will be restricted. Third, "the very terms of the NPT continue proliferation. It is now evident that the nuclear powers' promised help with peaceful programs provides a technical foundation on which the non-nuclear countries could build weapons. Fourth, the central feature of the NPT bargain seems to have collapsed. Increasingly, non-nuclear countries, especially in the Third World, believe that the main nuclear powers have no intention of disarming, or even of ending the arms race going on between them."[74] IAEA safeguard measures are also criticized for being "incapable of detecting diversion of weapons-usable fissile material from bulk handling facilities."[75] According to the anti-nuclear activists, all nuclear weapons and weapons-usable materials should be placed under some other forms of bilateral or international safeguards.

Another concern of nuclear energy opponents is the possibility of a criminal or terrorist group's incentive to obtain nuclear materials to construct a nuclear explosive or to use the materials as radiological poisons. It is argued that since very small quantities of plutonium (PU) and/or highly enriched uranium (HEU) are needed for a nuclear weapon, it is not a distance probability to think about the theft

[74] Falk, Richard. *Denuclearization.* in eds. Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides,* New York: WW Norton & Company, p.228

[75] Bundy, McGeorge. 1977. *Nuclear Power Issues and Choices.* Cambridge: Ballinger Publishing Company, p.275

of these materials. “It is very difficult to provide adequate security for separated plutonium and HEU at bulk-handling facilities (nuclear fuel reprocessing and fabrication facilities)”[76] and it is argued that the physical security measures provide insufficient insurance against theft of this weapons-usable nuclear material. A highly organized terrorist group with knowledgeable individuals might have the capability to construct a basic nuclear weapon from stolen plutonium or HEU. They may sabotage a nuclear facility in an attempt to cause damage or to blackmail authorities. Another weak link which may cause theft is the transportation of nuclear material. Terrorist targets may also include shipments of those materials from fuel fabrication plants to reactor sites, and shipments from reprocessing plants to storage sites.[77]

In brief, the anti-nuclear activists assert that the consequences of the proliferation of nuclear weapons are so serious compared to the benefits of commercial nuclear energy. According to their point of view, civil usage of nuclear power can be a means of developing nuclear weapons for states and also non-state actors. It is argued that by having the nuclear weapons capability these actors may have possible motives like; achieving prestige and status; overcoming isolation and

[76] Ibid...p, 255

[77] There are several theft incidents which happened in the past. A huge source of radioactive Iridium was reported lost during shipping by the Purolator courier on 12/11/1996. (see, “Irridium Shipment Disappears Briefly” by AP.) In 2002 there were several thefts of nuclear materials and isotope products in Russia. (see, CDI Russia Weekly, No 247 at http://www.cdi.org/russia/247-6.cfm) There is a fissile material theft chronology which have occurred all over the world since 1957, most of which have happened during the recycling process or transportation. (see, http://www.nuclearfiles.org/key-issues/nuclear-weapons/issues/proliferation/chronology-fissile-material-theft.htm)

creating insecurity for others. By this way, they gain confidence and reputation internationally and regionally.

Proponents

Nuclear energy advocates claim that there is a strong national and international constraint on nuclear fuel cycle to meet security concerns and to reduce international tensions. The risk that commercial nuclear power will lead to proliferation is substantially reduced by an effective and binding international policy. Nuclear activists assert that although the world wide nonproliferation regime may not be perfect, it is an exclusively beneficial element in the current international system and a principal advantage in efforts to make it easy the difficult task of living with nuclear power.

Nuclear energy supporters argue that rather than using a commercial nuclear energy plant's fuel, there are much better ways for a state or a non-state actor to have a nuclear weapons capability. There are two important fuels for the construction of nuclear fission bombs: the natural U235 and the plutonium (PU) which is made re-usable after the repossessing. First type of fuel is used by five countries that are known to have nuclear weapons: the U.S, Russia, England, France and China. Second type of fuel-reactor type plutonium- is the one which causes the debate. However, the nuclear energy advocates claim that this type of plutonium does not

have enough destructive force which may help the construction of a nuclear weapon. Rather, the weapons-type plutonium is the one that is used for bomb making, and it is found at military bases. Briefly, they argue that the plutonium that will be stolen from a commercial plant will be useless.

Besides, the nuclear activists assert that no industrial country will invest for a nuclear installation in another country without making the necessary investigations about that country's intentions. Also, it is underlined by them that IAEA has specially educated groups who have the authority to enter any nuclear reactor around the world for inspection, anytime.

Nuclear energy supporters blame the opposite group for underestimating the construction of even a simple nuclear weapon. They underline the fact that requirements for nuclear weapons manufacture are "uranium, trained personnel and information to build or operate facilities, and design and fabricate weapons, facilities to produce highly enriched uranium or plutonium from natural uranium."[78] A very good design and very precise work should be made which requires knowledge, planning and extraordinary care. This means that a small terrorist group of even highly intelligent people is unlikely to have all the skills needed to carry out such a program successfully. "Their chances of success would be increased if individuals with backgrounds in nuclear materials or weapons design, construction or handling,

[78] Ibid...p.256

or individuals with experience with high explosives could be recruited."[79]After extensive planning, spending a lot of money and months of intense work they might be able to produce a weapon. Even then, there is a good chance that the group would suffer fatal accidents during the weapon's construction.

Opposite to the critics of nuclear energy who underline the danger of nuclear material theft with proofs of real incidents, the proponents argue that with today's security measures at the nuclear facilities theft is nearly impossible. First, they argue that it is very difficult to remove plutonium from a reactor which is in operation. There are very strict security measures inside the power plants. Even if someone working inside tries to steal a material by swallowing it, he will get caught by special detectors. While plutonium is being shipped might be a better time to steal it, but it is shipped in heavy containers and surrounded by layers of shielding to prevent the escape of radiation.[80] And, the truck carrying it is carefully guarded. Armed guards with radios are ready all the time.

Other than defending the nuclear energy against these claims, the supporters also question the vulnerability of fossil fuel facilities to terrorism. They ague that one of the most vulnerable fossil fuel facilities to these kind of attacks are the tanks containing liquefied natural gas. Their security measures are not as tight as the nuclear industry and it is stated that a terrorist attack would be more productive on

[79] Cohen, Bernard. 1995. *Çok Geç Olmadan (Before Its Too Late).* Ankara: Tübitak Yayınları, p.88

[80] Morris, R.C. 2000. *The Environmental Case for Nuclear Power*. St.Paul: Paragon House, p.140

them. Moreover, it seems that the anti-nuclear activists are unconcerned about this possibility. The nuclear energy supporters also underline the fact that terrorists often attack oil pipelines in an attempt to steal oil or force various governments to accept to their demands. However, to date terrorists have not attacked any nuclear power plants.

To summarize, the nuclear energy advocates state that the main barrier to further proliferation will be the prompt acting of all states that are party to the NPT for their common security. However, they accept the fact that in today's world besides symbolizing danger and catastrophe, nuclear weapons also represent international power and status. Against a major nuclear power, being non-nuclear may offer better protection because the biggest risk is a preemptive attack. No matter all these facts, the supporters of nuclear energy repeatedly assert that the association of nuclear weapons with the commercial use of nuclear energy is groundless and it creates a prejudice against many countries who wish to use this clean and productive technology.

CHAPTER III

NUCLEAR ENERGY AND TURKEY

Turkey, as a rapidly growing country, had several attempts to adopt peaceful nuclear energy for meeting its energy needs, which had never been successful due to a number of reasons. These reasons were mainly the failure of domestic governments to define successful and stable energy strategies and their failure of perceiving the nuclear energy issue as a temporary excitement.

In this chapter, Turkey's energy needs, history of Turkey's nuclear energy attempts, the reasons of failure, arguments of those who oppose and support nuclear energy in Turkey and possible future options will be studied.

3.1 TURKEY'S ENERGY NEEDS

The energy strategy of Turkey is defined as a multi-dimensional one by the Turkish Ministry of Foreign Affairs. On one hand, there are the reliable and cost-effective supply sources for meeting the increasing energy needs. On the other hand, Turkey is working on liberalizing its energy market. And thirdly, it obtains a strategy to be one of the major consumption and transit stations within the region.[81]

Since Turkey is a rapidly growing country, the gap between its energy supply and demand widens, which determines the country's energy needs and policy. Turkey is facing a rising growth of its demand for energy by %8 per year, whereas the world average is %1.8.[82]

The exceeding of electricity demands began during the 1970s and by the late 1970s the power gap began to constrain Turkish industry. By 1977 this situation started to affect industrial, commercial, and residential consumers. In the mid-1980s, in order to deal with the energy shortage, "the Özal administration launched the build, operate, and transfer (BOT) system, under which foreign investors would

[81] *Turkey's Energy Policy,* http://www.mfa.gov.tr/ForeignPolicy/MainIssues/EnergyIssues

[82] Turkey's energy consumption in 2003 was 81 million tonnes of oil equivalent (mtoe). It is expected to reach 154 mtoe by 2010, and 282 mtoe by 2020. *Turkey's Energy Policy,* http://www.mfa.gov.tr/MFA/ForeignPolicy/MainIssues/EnergyIssues

provide the capital and technology to build plants, operate them for a number of years with guaranteed revenues, and finally transfer the units to the government when the investment had been fully returned."[83] The Atatürk Dam was one of the major projects designed to increase electricity output.

Although Turkey's problem with energy resources continued, it has always been discussed that the country had a good potential of energy production. Turkey has economically reasonable hydroelectric potential, tons of lignite deposits, some petroleum stocks, reserves of natural gas and coal, reserves of thorium and uranium, geothermal resources and wind power potential.[84] However, it is said that these sources may not be sufficient to meet the steady increase in Turkey's energy requirements.[85] As a result the discussions on the nuclear power option began and it seems to continue as an alternative energy strategy for Turkey.

---

[83] http://www.country-studies.com/turkey/energy.html

[84]In 2000, %43.8 of primary energy consumption was met by petroleum, %26.3 by coal and %17.7 by natural gas. Birol, Erdener; *National Energy Outlook of Turkey and Expectations from Nuclear Technology,* paper presented at World Nuclear Association Annual Symposium, 4-6 September, 2002, London.

[85] Currently, Turkey has a population of approximately 65 million, and an estimated of 85 million in 2010. Of all its energy resources, however, only hydro power and coal have been properly exploited over the past few decades. Research indicates that demand will again exceed domestic supply in the early 2000s. Kibaroğlu, Mustafa; *Turkey's Quest For Peaceful Nuclear Power;* The Non-Proliferation Review, Spring-Summer 1997, Vol.4, No.3, Center of Nonproliferation Studies (CNS), Monterey Institute of International Studies (MIIS), Monterey: California, pp.33-44.

3.2 FAILED ATTEMPTS AND NUCLEAR ENERGY HISTORY OF TURKEY

First attempts of peaceful nuclear power energy development began in Turkey after the U.S President Eisenhower's "Atoms for Peace" speech in 1953. In 1956, the Turkish Atomic Agency Commission (TAEC) was established for "coordinating the efforts of building nuclear research and training centers, and to issue licenses for nuclear power plants."[86] The 1960s and 70s saw developments in the nuclear field. The first nuclear research and training center in Turkey was established in 1961: Çekmece Nuclear Research and Training Center (CNRTC). The first research reactor "TR-1" was installed just after that. In 1966, for the purpose of conducting research about the use and benefits of nuclear energy, Ankara Nuclear Research and Training Center (ANRTC) was established.

By the beginning of 1970s Turkish Electricity Authority (TEK) began to carry out feasibility studies about the construction of a nuclear power plant. According to their surveys, Akkuyu Bay in the Southern part of Turkey[87] was the most suitable place for the nuclear power plant. In 1976, the site was issued a license by TAEC and bids for the construction began with French and Swiss firms.

[86] Ibid...p.35

[87] Akkuyu is a province of Silifke town in Mersin in the Mediterranean coast of Turkey.

However, these plans and negotiations were suspended because of several political developments in the country.[88]

In early 1980 a second nuclear power plant plan began. İnceburun of Sinop in the Black Sea region of Turkey was selected as the new site by TEK. However, it should be noted that these days, were also important days for Turkish-Pakistani relations[89] that developed after the Turkish military coup and created concerns in the Western world that two countries were going through an illegal cooperation for developing nuclear weapons. "In 1981, the U.S expressed concerns about a Turkish-Pakistani alliance on the grounds of alleged shipments from Turkey to Pakistan of strategic material with potential nuclear weapons implications."[90] These concerns were even discussed by the high level state officials between Turkey and the United States. Greece also felt uncomfortable about these developing bilateral relations

[88] On September 12, 1980, a right-wing military junta led by General Kenan Evren took place in Turkey. The armed forces took over the political power because the state organs had stopped functioning. Parliament had been dissolves, all political parties, trade unions and confederations were suspended. The leaders of political parties were arrested and a state of emergency was declared. Zürcher, Erik J. 1997. *Turkey: A Modern History.* London: I.B Tauris & Co Ltd, p. 283

[89] History of Turkish-Pakistani relations is full of good memories and supportive attitude of both countries in each others' causes. Founder of modern Turkey, Atatürk, has always been a respected leader in Pakistan. His stories also encouraged Pakistani people during their independence war against the British, relations were even more intensified after the 1980 military coup in Turkey.

[90] Kibaroğlu, Mustafa; *Turkey's Quest For Peaceful Nuclear Power;* The Non-Proliferation Review, Spring-Summer 1997, Vol.4, No.3, Center of Nonproliferation Studies (CNS), Monterey Institute of International Studies (MIIS), Monterey: California, pp.36

between Turkey and Pakistan, and claimed that two countries are working on the building of a nuclear weapon.[91]

By 1983, more bids were made to install nuclear power plants in Turkey, by several international companies. Yet, the plans were halted again due to political and economic problems that Turkey was facing. Each move of Turkey in the international arena affected its nuclear plans.[92] Turkey made talks with other possible partners who could help the development of nuclear industry in Turkey. One of those countries was Argentina, which agreed to transfer "technical assistance, including front-end nuclear fuel cycle research and development; and research on power and research reactor planning, construction, quality assurance, operation and regulation."[93] Nevertheless, no matter the contracts signed between two countries, no progress was made.

Fears about the Turkish-Pakistani connection by the Western states continued in the 1990s. The intensifying relations between Turkey and the republics in Central Asia and Caucasus also created suspicions that Turkey will cope with them in the nuclear field, since some of them have nuclear installations. No matter how

[91] Greek officials said that Pakistan expected Turkey to act as a transshipper of material for a nuclear bomb and would reciprocate by proudly sharing the nuclear bomb technology with Turkey. Ibid, p.37.

[92] For instance with Germany the problem was with West German government which reacted to Turkey's improving relations with East Germany. It was said that the Canadian firms had withdrawn the bids in response to pressure from Western countries, which were concerned, that Turkey may build a nuclear bomb based on CANDU technology. Ibid…p 38

[93] Ibid...p 38.

questionable and suspicious these claims were, it is for sure that they had affected Turkey's nuclear energy politics.

More recently, in 1995, the Akkuyu nuclear power plant plans started again. With the high support of the media and the Refahyol government[94] a new era began. The reactor was planned to be built at Akkuyu Bay on the southeast Mediterranean coast, and the contract was expected to be awarded in the second half of 1998. The international consortium bid for the contract: Atomic Energy of Canada Ltd; Westinghouse of the U.S. and Nuclear Power International by Siemens of Germany and Framatome of France.[95] Turkish firms were required to finance for the project. However, in 1998 Turkish Electricity Generation and Transmission Company TEAS said the bid to build Turkey a nuclear reactor was delayed. This time the pressure from environmentalist groups and opposing public opinion delayed the project.

Nuclear plant building project on Turkey's southern coast, which was shelved for a couple of years because of heavy criticisms, is being revived today, in 2005. "Turkey plans over the next few years to build three nuclear power plants that should become operative from 2011 to avoid possible energy shortage", Energy Minister

---

[94] Refahyol government (combination of Welfare Party and True path Party) strongly supported the nuclear energy issue telling that Turkey has an energy shortage. Arıkan, Yunus; *Adil Düzenin Dönmediği Tek Konu: Nukleer Enerji;* Çevre ve Mühendis Dergisi (Environment and Engineer Journal); Vol.12, 1996, p.23

[95] *Turkey leaves International Lobby,* Greenpeace News, 25 July 2000
http://www.greenpeace.org.au/media/nukes_details.php?site_id=11&news_id=49

Hilmi Güler said in March[96]. Mr. Güler also stated that Turkey will be facing a possible power shortage after 2010-2011 that could leave it dependent on foreign sources. Energy minister stated that the ministry is planning to meet 8 to 10 percent of the energy demand of Turkey with nuclear power. Telling that the ministry has made all the required calculations and feasibility studies for nuclear energy, Minister Güler also said that they are primarily considering uranium to fuel the plant and thorium as a second possibility.

As a recent development, Prime Minister Tayyip Erdoğan's speech saying that Turkey is open to the possibility of cooperation in the field of nuclear energy with South Africa is also worth considering.[97]

3.3 ARGUMENTS OF NUCLEAR POWER IN TURKEY

As in many other countries of the world, use of peaceful nuclear energy has been subject to discussions between opponents and supporters of it in Turkey too. Scientists, politicians, academicians and the public have been keeping the subject alive with their arguments.

Proponents

[96] *Turkey Plans To Build Three Nuclear Power Plants by 2011;* Turkish Daily News; March 23, 2005; p.8

[97] *Open Door for Cooperation in Nuclear Energy Sector;* Turkish Daily News; March 3, 2005; p. 9

According to the nuclear energy advocates, it would not be wrong to think that the role of nuclear energy will increase in Turkey's energy production in the following years. In this argument they rely on the one and only national nuclear energy policy report prepared by TAEK. According to this report it is necessary for Turkey to use nuclear energy, it is a way of politics which will be beneficial for our country, and will help the reduction of foreign dependence on energy sources.[98]

Nuclear activists in Turkey state that obtaining nuclear technology will make the country strategically powerful. They argue that nuclear technology is a progressive technology and it brings about the advanced and sensitive technology into the country. Therefore, it increases the competitiveness of local industry both nationally and internationally. It provides the training of good quality and well-educated manpower in the country. It makes the country honorable, powerful and it causes the country to be one step further because nuclear technology consists of scientifically, technological, strategically and economical components.[99]

[98] Özemre, A.Yuksel; Bayülken, Ahmet and Gençay, Şarman. 2000. *50 Soruda Türkiye'nin Nükleer Enerji Sorunu.* İstanbul: Kaknüs Yayınları, p.43

[99] *TAEK Annual Report;* ANKA Press Agency; 8 June, 1998.

According to the nuclear energy supporters, unless Turkey installs nuclear power plants as an alternative primary source of energy, it will alternatively look for foreign sources of energy such as imported oil and natural gas. Reliance on foreign sources have sometimes had complicated implications on Turkey's foreign policy.[100] However, if the nuclear energy option is chosen, besides being technically and economically advantageous, it will prevent problems with other states and energy dependence.

Nuclear activists in Turkey maintain that there are a number of trained nuclear engineers and technicians in Turkey since 1956. Most of them work with TAEK or at several universities. The rest of them had gone abroad or found jobs in other fields because of the failed nuclear energy attempts. On the other hand, although not having as much trained and qualified personnel as Turkey, Romania and South Korea had adopted nuclear technology due to their planned and national interest based energy strategies. Therefore, with Turkish scientists and technicians who have accumulated a good deal of knowledge and experience in the nuclear field, it would be one of the best choices to pick nuclear power for Turkey.

[100] Turkey's fresh water resources, or reliance on Russian and Iranian natural gas had been problematic. Kibaroğlu, Mustafa; *Turkey's Quest For Peaceful Nuclear Power;* The Non-Proliferation Review, Spring-Summer 1997, Vol.4, No.3, Center of Nonproliferation Studies (CNS), Monterey Institute of International Studies (MIIS), Monterey: California, pp.40

Above all these, nuclear activists assert that Turkey's natural uranium and thorium deposits are high. Therefore, this great reserve should be used for the nuclear industry, and Turkey must have the technology of nuclear reactors working with thorium.

Finally, it is strongly disagreed by this group that Turkey has the intention to develop nuclear weapons technology, once it has a nuclear energy plant. First of all, they point out that Turkey has strong commitments to international treaties that it had become a party in order to prevent the proliferation of nuclear weapons. Turkey became a state party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) by signing it in 1969 and ratifying in 1980. In 1982, Turkey signed the safeguards agreement International Atomic Energy Agency (IAEA). There are also several other international agreements which Turkey agreed to become a part.[101] Not only obeying these treaties itself, it is also argued that Turkey influenced several other states to behave the same way[102]. These outcomes indicate that Turkey has no intention to acquire weapons of mass destruction.

[101] Turkey has also become a state party to several international agreements that seek to prevent the spread of all sorts of weapons of mass destruction, such as the Biological Weapons Convention of 1972 and the Chemical Weapons Convention of 1993. Ibid…41

[102] Turkey also used its influence on the Turkic republics of Central Asia and the Caucasus on not to acquire weapons of mass destruction.

Secondly, as all other nuclear energy supporters around the world, those in Turkey assert that; even if Turkey has such an intention to acquire nuclear weapons, it does not necessarily need nuclear reactors. The material needed to build weapons may well be acquired from other states illegally. Especially after the disintegration of the Soviet Union, the illegal transfer of nuclear material from Soviet soil towards the West and some Middle Eastern countries had increased.[103]

Thirdly, nuclear energy supporters indicate that Turkey would not want to take the risk of clashing with its Western allies by acquiring nuclear weapons. Turkey is a part of the North Atlantic Treaty Organization (NATO) countries since 1952 and it had played an important role of defending the West against the Soviet Union. Moreover, Turkey has efforts of joining the European Union as one of its foreign policy objectives.

Above all, nuclear energy supporters state that there is a responsible and principled military and civil cadre, an effective media, and a number of civil society organizations in Turkey. With the presence of these factors, Turkey would only intend to acquire peaceful nuclear energy, not a destructive one. As a response to those who wish Turkey to obtain nuclear weapons, those groups will definitely form a strong opposition.

[103] Turkey was used as a route of those traffickers for their transfers to the Middle Eastern countries. Kibaroğlu, Mustafa; *Candu Kadük mü Oluyor? (Will CANDU be Caduque?);* Enerji Dergisi (Journal of Energy), February 2000, Vol.5, No:2, İstanbul, p.26

Advocates of nuclear energy state that Turkey should at least have some portion of nuclear technology and within time it should have the capability of producing its own nuclear reactors. They offer that state should encourage the establishment of an industry which will contribute to the development of nuclear technology. Besides, the private sector should also contribute to the technology transfer and development. After certain time, state should give the private sector the right to build and manage nuclear reactors. Also, research should be encouraged in many institutions and universities to develop nuclear technology.[104]

Opponents

The opposition to Turkey's acquiring of nuclear energy not only comes from domestic sources but also from several other countries. It is argued by many sources that the Western countries, especially the United States may exploit every opportunity to stop Turkey going down that nuclear energy road, because they have concerns of cooperation on nuclear weapons between Turkey and Pakistan.[105] There were claims by some other Western countries that Turkey intentionally wishes to obtain the CANDU reactors of Canada for nuclear energy, since nuclear weapons are

[104] Özemre, A.Yuksel; Bayülken, Ahmet and Gençay, Şarman; *50 Soruda Türkiye'nin Nükleer Enerji Sorunu;* (İstanbul: Kaknüs Yayınları, 2000) p.49

[105] Kibaroğlu, Mustafa; *ABD Nükleer Teknolojiye Sahip Olmamızı İstemiyor;* Interview by Özyanık, Turan in Yeni Düşünce Journal.

easier to build with these kinds of reactors.[106] Southern Cyprus has also strongly protested against Turkish plans to build nuclear reactors on Turkey's southern coast. They sent a letter expressing their concerns to the EU. They said the situation is causing a lot of easiness and anxiety to the people of Southern Cyprus who have legitimate concerns about the impacts on life, health and the environment.[107]

Nuclear energy opponents assert that while most of the countries once used nuclear power, have now given up and turned their face towards production of energy by renewable sources; some groups in Turkey insist on nuclear energy. These are national and international interest groups who have been keeping the nuclear energy issue alive for their own benefits. Because the plants are very expensive, they think they will get a big slice from the cake with the promotions and commissions. The nuclear energy opponents also blame several political parties in Turkey for believing that nuclear technology will bring nuclear power and nuclear weapons technology.[108] However, it is indicated by nuclear opponents that adopting nuclear

---

[106] Kibaroğlu, Mustafa; *Candu Kadük mü Oluyor? (Will CANDU be Caduque?);* Enerji Dergisi (Journal of Energy), February 2000, Vol.5, No:2, İstanbul, p.26

[107] http://www.greenpeace.org/~nuclear/reactor/turkey

[108] After the 1999 elections, National Movement Party (MHP) deputy and Minister of Transportation Prof. Dr. Enis Öksüz stated that Turkey needs at least 50 nuclear reactors. By this way, he said, besides understanding the technology needed for nuclear weapons production, Turkey will be able to use nuclear energy in the field of medicine, computers, chemicals and in many other fields. *Akdeniz Postasi Weekly Newspaper*, November 3, 1997; http://www.geocities.com/RainForest/Canopy/7624/makale01.html.

energy does not mean adopting nuclear technology. Management of a nuclear plant neither brings the technology, nor the construction ability to Turkey.

Another point indicated by the nuclear energy challengers is that: Turkey does not have an energy crisis but the nuclear lobbies create it. Many studies carried out on Turkey's energy needs have proved to be wrong or exaggerated. It is argued that our potential from natural resources (hydraulic, coal, wind, geothermal, sun and energy from other renewable sources) will be enough to meet Turkey's energy needs.[109] Moreover, nuclear energy would make Turkey dependent on other countries as much as natural gas or oil has. They blame the government for not aiming at ending dependence, but trying to vary it.

According to the nuclear energy opponents in Turkey, if we have to build a nuclear power plant one day, Akkuyu Bay is not appropriate location. A computer modeling study commissioned by Greenpeace[110] showed that an accident at a nuclear reactor at Akkuyu Bay would spread radioactive contamination over Turkey and Middle East. They argue that the Ecemiş fault line, where Akkuyu is situated on, was

[109] Turkey is the one of the countries in Europe with the biggest potential of wind power. Uyar, Sıdkı; *Rüzgar Enerjisinin Entegrasyonu;* Türkiye'de Nükleer Enerji ile İlgili Maklaleler (Articles Related to Nuclear Energy in Turkey), http://www.geocities.com/RainForest/Canopy/7624/makale01.html

[110] Turkish police several times detained Greenpeace activists for protesting the promotion in Turkey of nuclear power. Their main argument is that: Turkey does not need nuclear power. If Turkish government wants to diversify its electricity sources than the best strategy is to introduce alternatives like wind, solar and biomass-and not a dangerous outdated and polluting energy like the nuclear one. *Greenpeace News,* (http://www.geocities.com/RainForest/Canopy/7624/makale01.html), 22 July 1998.

found active by a study made by Turkish seismologists in 1991.[111] If an earthquake occurs in the area while there is a nuclear reactor, it will be a real catastrophe. Moreover, Greenpeace members state that each foreign nuclear company claims that its reactors can stand earthquakes measuring more than 8 on the Richter scale, which is questionable. Besides Greenpeace, other scholars in the field also claim that the Akkuyu bay is not a good option for a nuclear reactor. Strategic, seismologic and geologic research should be made carefully, because it is very crucial to convince the public opinion about nuclear energy. Another concern about Akkuyu is its distance to the main industrial Marmara region in Turkey. This is a handicap, since the transportation will take longer and the nuclear material will lose its efficiency. Besides all these, constructing a nuclear plant on one of the most beautiful locations of Turkey in the Mediterranean would hit the tourism sector and it will be a serious deterrent for tourists. It is indicated by the opponents that there are no countries in the world which have nuclear power plants built on their Mediterranean coasts. [112]

It is argued by anti-nuclear activists that; if Turkey develops nuclear power it will have to deal with the massive amounts of radioactive waste that are produced. This waste is toxic and in many cases remains hazardous for thousands of years.

[111] It is said that there is a probability of 50% that an earthquake of magnitude 7 Richter or more will occur within 100 kms of Akkuyu Bay within the next 40 years. *Turkey Leaves International Lobby,* Greenpeace News, http://www.greenpeace.org.au/media/nukes_details.php?site_id=11&news_id=49, 25 July 2000.

[112] There are four plants built on the Mediterranean coast of Spain for providing electricity to Madrid and two at Central Italy. However, none of these plants are closer to the south than our Marmara regions do. Yarman, Tolga; *Kokten-Nukleerci Yaklaşımın Dayanılmaz Yanlışları;* Cumhuriyet Newspaper, July 5, 1998.

Greenpeace reports that, in 1998 the representatives of Siemens claimed that the radioactive wastes could be buried to the Toros Mountains, and for the next 20 years, they said Turkey will find a solution.[113] Besides all these, nuclear energy opponents claim that the environmental and social costs of a nuclear plant would be unaffordable for Turkey.

The anti-nuclear activists point out that many countries in the world are now getting rid of nuclear energy. Countries like Germany, Sweden, Belgium, Spain and the Netherlands, are either closing down their nuclear plants, or have announced they would not order new plants to replace those that expire. Thus, the argument that "nuclear energy is the cleanest and safest," is proven to be wrong. It has been found that nuclear energy is the most expensive, dangerous, and one that increases global warming and damages ecologic balance. According to their argument, Turkish Government could develop cleaner, safer and cheaper alternatives to meet its power needs. Turkey can implement energy efficiency and conservation, and development of rich reserves of renewable energy. The amount of electricity that could be produced by these methods would save Turkey from the environmental, social and financial costs of nuclear power.

[113] Kunar, Arif and Ciloglu, Tolga; *Akkuyu Nükleer Santral Projesi: Sorular ve Cevaplar:* http://www.geocities.com/RainForest/Canopy/7624/makale01.html)

CONCLUSION

Nuclear energy is now a fact of international life and will provide a significant portion of the world's electricity. At the same time, nuclear energy is the only one of the several energy options, and decisions about it should be made on the basis of sound cost-benefit analysis as any other option.

Each nation has to determine the compatibility of entering into nuclear program within the context of its social, economic and technological context. Variables to consider in this context would include the nation's long-term energy plans, its international policies, its level of scientific and technological education, and its ambition and capacity for future development.

In a cost-benefit analysis for nuclear energy option, there are many factors to be considered carefully. These factors are described in the second chapter of this

study in details. As a result of this analysis, a nation would be able to draw conclusions about the advantages and disadvantages of going nuclear. Utilities or power ministries are responsible for site selection and play a key and central role in the decision making process. They provide electrical service to the public. "Their criteria of siting must be decided around engineering parameters (adequate cooling water, topography, geology and available land) that must be met and around economic factors (costs of transmission lines, labor availability, demand and tax structures.)"[114]

Local public may be concerned with decreases in their property values and with possible health risks and reactor accidents. They may be in favor of nuclear power because of such factors as employment and local business activity.[115] This depends on the levels of education, local employment conditions and state of economic development. Consequently, it is clear that the decision-making process for the choice of energy policy--especially for the nuclear energy option—is a difficult one. On the domestic front the final decision on nuclear power may be decided more by political considerations, such as public opinion and pressure groups like environmentalists, than by any technical evaluation of the nuclear power. For example, even if it can be proven objectively that nuclear reactors are much safer

[114] Dodd, Charles. 1994. *Industrial Decision Making and High Risk Technology.* London: Rowman and Littlefield Publishers, p.34

[115] Nealy, S.M; Melber, B.D and Rankin, W. 1983. *Public Opinion and Nuclear Energy.* Lexington: D.C. Heath, p.22

than other energy technologies, if the public does not perceive the benefits to be greater than the risks, political opposition to the technology could eventually make the industry fail.

According to several studies there are some important points, which need to be solved or improved in the nuclear energy option. First, more restrictive siting policies (especially for nuclear waste siting), more emphasis on research and development on improving safety measures, and safer plant designs should be made. Although these developments might increase the cost of nuclear energy, they will be large risk reducers. Secondly, in order to reduce the risk of nuclear terrorism, "improvements in the inventory and accounting systems to keep better track of nuclear materials flowing through facilities and reactors; advanced security systems for identification and access control, and systems for continuous communication; improvement of guard capabilities at reactor sites, and better alerting and intelligence"[116] are needed. Thirdly, the public must be told about the risks realistically. It is important to bridge the gap between what the experts know and what the public needs to know. When the facts are presented accurately and

[116] Bundy, McGeorge. 1977. *Nuclear Power Issues and Choice;* Cambridge: Ballinger Publishing Company, p.120

comprehensively, people can judge for themselves the risks and benefits of nuclear power.

Besides fossil fuel energy resources, the renewable energy option seems like the most serious rival against nuclear energy. It is frequently argued that especially solar, wind, hydroelectric, geothermal, hydrogen or fusion energy would be viable alternatives to nuclear power if they received a fair share of the research and development. However, these alternatives also include some serious scientific, technological and economic problems. Another option is the conservation alternative. Though, cutting fuel use is considered the most dangerous alternative solutions of all. Generally speaking, countries that use very little energy have lower incomes and a shorter life expectancy.

As it is studied in the fourth chapter, Turkey had passed through several stages in order to acquire nuclear energy, which were unsuccessful. It is argued that Turkey has passed through unplanned and unrealistic projections about nuclear energy. However, taking the corrective steps is also possible. Turkish government can carry out comprehensive studies on Turkey's overall energy needs, its resources and reserves. After such a careful examination, government officials would be able to decide on going nuclear or not. However, in order to create a nuclear energy program, relevant scientists, technicians and academicians should come together and consider every aspect of such a project.

On the other hand, the concerns of the Western countries that Turkey will use the commercial nuclear energy to produce nuclear weapons should be eliminated. Although Turkey's being part of the NPT, several other international agreements, and its fulfilling of IAEA's obligations may be considered as important facts that show its honesty, there are still claims that these are not considered enough for the Western countries. At this point, the burden will be on the shoulders of Turkish politicians, scientists, technicians and scholars to prove that there are no grounds for Turkey to obtain nuclear weapons.

According to the supporters, in many ways nuclear energy is a fantastic success: a completely new source of energy is now providing, or soon will provide, a considerable portion of all the energy man needs. Contrarily, there are the opponents who believe that nuclear energy is a highly centralized, technically complex, and capital-intensive industry, full of accident and health risks. They also argue that a country's energy future should not be based on a technology as complex as nuclear power.

The debate on nuclear energy will continue to be on the agenda of world's energy issues. As a conclusion, it can be said that no energy source is totally free from risk. However, decisions on nuclear energy must be based on more detailed

analysis of its risks and benefits since it is a political choice in character, as most of other energy options are.

BIBLIOGRAPHY

Aubrey, C. 1991. *Meltdown: The Collapse of the NuclearDream.* London: Collins and Brown.

Blowder A. and Reddish A. 1991. *Energy, Resources and Environment.* London: Hodder and Stoughton.

Brown, Michael. 1992. *Greenpeace (Yeşilbarış'ın Öyküsü)* İstanbul: Metis Yayınları.

Bundy, McGeorge. 1977. *Nuclear Power Issues and Choice.* Cambridge: Ballinger Publishing Company.

Cartledge, Bryan. 1993. *Energy and The Environment.* Oxford: Oxford University Press.

Cohen, Bernard. 1995. *Çok Geç Olmadan (Before Its Too Late).* Ankara: Tübitak Yayınları.

Cole, H.A. 1988. *Understanding Nuclear Power.* Vermont: Gower Technical Press.

Clawson, Patrick L. 1995. *Energy and National Security in the 21st Century.* Washington: National Defense University Press.

Dodd, Charles. 1994. *Industrial Decision Making and High Risk Technology*. London: Rowman and Littlefield Publishers.

Elliot, David. 1997. *Energy, Society and Environment,* London: Routledge

Evans, N. and Hope, C. 1984. *Nuclear Power: Future, Costs and Benefits.* Cambridge: Cambridge University Press

Gobel, Medard. 1975. *Energy, Earth and Everyone*. San Francisco: Straight Arrow Books.

Green, Jonathon. 1986. *The A-Z of Nuclear Jargon*. New York: Kegan&Paul.

Hedley, Don. 1981. *World Energy: The Facts and Future.* New York: Facts on File INC.

Hewitt, F. Geoffrey. 2000 *Introduction to Nuclear Power.* NewYork:Taylor&Francis

Karam, R. and Morgan, K.Z. 1984. *Environmental Impact of Nuclear Power Plants.* Oxford: Pergamon

Kaku, Michio and Trainer, Jennifer. 1982. *Nuclear Power: Both Sides.* New York: WW Norton&Company.

Kelleher, Catherine M., Kerr, Frank J., and Quester, George H. 1986. *Nuclear Deterrence: New Risks, New Opportunities*. New York: Pergammon-Brassey's

Kruschke, Earl R. and Jackson Bryan M. 1990. *Contemporary World Issues: Nuclear Energy Policy.* Santa Barbara: ABC-CLIO.

Morris, R.C. 2000. *The Environmental Case for Nuclear Power.* St.Paul: Paragon House.

Mounfield, Peter R. 1991. *World Nuclear Power.* London: Routledge.

Nealy, S.M; Melber, B.D and Rankin, W. 1983. *Public Opinion and Nuclear Energy* Lexington: D.C. Heath.

Ott, K.O and Spinard, B.I. 1985. *Nuclear Energy: A Sensible Alternative.* New York: Plenum.

Özemre, A.Yuksel; Bayülken, Ahmet and Gençay, Şarman. 2000. *50 Soruda Türkiye'nin Nükleer Enerji Sorunu.* İstanbul: Kaknüs Yayınları.

Patterson, W. 1976. *Nuclear Power.* London: Penguin

Penetreath, R.J. 1980. *Nuclear Power, Man and Environment.* London: Taylor & Francis

Price, T. 1990. *Political Electricity.* Oxford: Oxford University Press.

Porter, Gareth and Brown, J. Welsh. 1991. *Global Environmental Politics.* Boulder: Westview Press.

Sagan, Carl. 1985. et. al. *The Nuclear Winter: The World After Nuclear War.* London: Sidgwick & Jackson.

Toke, Dave. 1995. *The Low Cost Planet: Energy and Environmental Problems*; London: Pluto Press

WHO Publications, *Nuclear Power: Accidental Releases;* (England: WHO Publications, 1984)

Zürcher, Erik J. 1997. *Turkey: A Modern History.* London: I.B Tauris & Co Ltd.

ARTICLES

Allison, Graham; *A cascade of Nuclear Proliferation;* International Herald Tribune, December 17,2004

Allison, Graham; *No Pass on Nukes;* Washington Post, October 30, 2004, p. A17

Arıkan, Yunus; *Adil Düzenin Dönmediği Tek Konu: Nukleer Enerji;* Çevre ve Mühendis Dergisi (Environment and Engineer Journal); Vol.12, 1996, pp.22-25

Buying Nuclear Waste; The New York Times; March 22, 2005.

Collier, J.; *Nuclear Power: Way Forward or Cul-de sac?;* The Ecologist, 1992.

Damian, M.; *Nuclear Power, the Ambiguous Lessons of History;* Energy Policy, July 1992, p.600

Dede, Özbaşaran Nilgün; *Nükleer Enerji Yeniden Atağa Kalktı;* Cumhuriyet Bilim Teknik; September 18, 2004, No.913, pp.8-12

Fells, I. *Energy and the Environment;* Energy World, No.168: 7-10.

Keepin, B. and Kats, G.; *Greenhouse Warming: Comparative Analysis of Nuclear and Efficiency Strategies;* Energy Policy; 16(6): 561-83.

Kibaroğlu, Mustafa; *Candu Kadük mü Oluyor? (Will CANDU be Caduque?);* Enerji Dergisi (Journal of Energy), February 2000, Vol.5, No:2, İstanbul, pp.26-27

Kibaroğlu, Mustafa; *Turkey's Quest For Peaceful Nuclear Power;* The Non-Proliferation Review, Spring-Summer 1997, Vol.4, No.3, Center of Nonproliferation Studies (CNS), Monterey Institute of International Studies (MIIS), Monterey: California, pp.33-44.

Martin, Brian; *Nuclear Winter: Science and Politics*; Science and Public Policy, Vol. 15, No. 5, October 1988, pp. 321-334.

Open Door for Cooperation in Nuclear Energy Sector; Turkish Daily News, 3 March, 2005.

Sciolino, Elaine and Sanger, E. David, *Iran Admits It Considered Purchasing Weapons Technology;* International Herald Tribune, March 1, 2005.

TAEK Annual Report; ANKA Press Agency; 8 June, 1998.

Turkey Plans To Build Three Nuclear Power Plants by 2011; Turkish Daily News; March 23,2005.

Van der Pligt, J.; *Public Attitudes to Nuclear Energy: Salience and Anarchy;* Journal of Environmental Psychology; No.5, pp.87-97

Wesolowsky, Tony; *Buying Power;* Bulletin of the Atomic Scientists; May/June 2004; pp.13-16.

Yarman, Tolga; *Kokten-Nukleerci Yaklaşımın Dayanılmaz Yanlışları;* Cumhuriyet Newspaper, July 5, 1998.

INTERNET SOURCES

Akdeniz Postasi Weekly Newspaper, Türkiye'de Nükleer Enerji ile İlgili Maklaleler (Articles Related to Nuclear Energy in Turkey), 3 November 1997: <http://www.geocities.com/RainForest/Canopy/7624/makale01.html>

Cost Comparison for Nuclear vs. Coal;
<http://www.nucleartorist.com/world/wwide.htm>

Greenpeace News, Türkiye'de Nükleer Enerji ile İlgili Maklaleler (Articles Related to Nuclear Energy in Turkey), 22 July, 1998:
<http://www.geocities.com/RainForest/Canopy/7624/makale01.html)>

Kunar, Arif and Ciloglu, Tolga; *Akkuyu Nükleer Santral Projesi: Sorular ve Cevaplar:*
<http://www.geocities.com/RainForest/Canopy/7624/makale01.html)>

Kunar, Arif; *Haydi Akkuyu'ya;* August 3, 1999
<http://www.geocities.com/RainForest/Canopy/7624/makale01.html)>

McCarthy, John; *Frequently Asked Questions About Nuclear Energy;*
<http://www-formal.stanford.edu/jmc/progress/nuclear-faq.html>

Nuclear Power: Tomorrow's Energy Source:
<http://www.cea.fr/gb/institutions/nuclear_power.htm>

The Nuclear Winter:
<http://www.cooperativeindividualism.org/sagan_nuclear_winter.html>

Turkey Leaves International Lobby, Greenpeace News, 25 July 2000:
<http://www.greenpeace.org.au/media/nukes_details.php?site_id=11&news_id=49>

Turkey, <http://www.country-studies.com/turkey/energy.html>

Turkey's Energy Policy,
<http://www.mfa.gov.tr/ForeignPolicy/MainIssues/EnergyIssues>

Uyar, Sıdkı; *Rüzgar Enerjisinin Entegrasyonu;* Türkiye'de Nükleer Enerji ile İlgili Maklaleler (Articles Related to Nuclear Energy in Turkey):
<http://www.geocities.com/RainForest/Canopy/7624/makale01.html)>

U.S.Environmental Protection Agency, *Air Pollution and Control:*
<http://www.epa.gov/air/caa/title1.html>

<http://www.nea.fr/html/ndd/docs/2002/G8_speech.htm>

<http://www.mans.eun.eg/facscim/PhyDept/reactor/reactor1.htm>

OTHER

Birol, Erdener; *National Energy Outlook of Turkey and Expectations from Nuclear Technology,* paper presented at World Nuclear Association Annual Symposium, 4-6 September, 2002, London.

Kibaroğlu, Mustafa; *The Impact of Energy Transportation Lines on International Security;* Proceedings of the Conference on "The Impact on Energy and Water Resources on National and International Security";War Academies, January 2004; İstanbul, pp.198-212.