

Why Fusion? The Politics and Policy of Energy in the United States

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History of Energy Consumption

Development and maintenance of long-term sources of energy have always been at the forefront of United States energy policy. The main focus of the energy debate is obtaining efficient, safe, economical, and environmentally-friendly sources to meet the needs of our growing population. Throughout history, the United States has seen many shifts in energy consumption. In the 1850s, almost 90% of the energy needs for the country were met through burning wood. In 1910, coal replaced wood as a dominant source of energy, making up 70% of all energy produced and consumed. The third transitional phase came in the 1970s when oil and gas reached the 70% mark.¹

Currently, about 20% of U.S. energy consumption is made up of crude oil, most of which is imported from the Persian Gulf. Foreign dependency is an issue that continually makes obtaining energy both costly and unpredictable. As an example, in 1973 the nations of OPEC increased the price of oil from \$4 a barrel to nearly \$12, leading to an energy crisis that focused the political agenda on U.S. energy needs. As a response, in 1975 Congress passed the Energy Policy and Conservation Act, which called for a deregulation of oil.²

Consequences of Burning Fossil Fuels

As with all combustion reactions, burning fossil fuels creates air pollution in the form of CO₂ and particulate matter. The Clean Air Act of 1970 was the federal government's first major step toward reducing the nation's air pollution. The act was amended in 1977 and because of a stalemate over the issue of acid rain; the regulations of the Clean Air Act Amendments did not take effect until 1995 and aimed to reduce the emissions of sulfur dioxide from coal burning

¹ Switzer, J.V. *Environmental Politics: Domestic and Global Dimensions*. 4th ed. (Belmont: Thomson Wadsworth, 2004), 171.

² *Ibid*, 174.

power plants in half by the year 2000.³ By the 1980s, it had become apparent that sulfur dioxide and nitrogen oxides were the precursors to acid rain. In the year 1980, the U.S. emitted 27 million tons of sulfur dioxide and 21 million tons of nitrogen oxides. Furthermore, the pollutants emitted from power plants were traveling thousands of miles downwind, turning to acid rain in the process.⁴ Acid rain has a major impact on aquatic ecosystems, sometimes changing the pH by as much as one whole unit- a significant factor of ten. Additionally, the carbon dioxide emitted when burning fossil fuels is a greenhouse gas which contributes to global warming.

The process of burning fossil fuels for energy has a significant negative impact on the environment, but the processes involved in obtaining these fuels are equally as harmful and should be addressed. Mining coal results in habitat destruction, landscape leveling and hydrological disruption caused by the presence of mine shafts.⁵ Burning oil raises some of the same issues as burning coal, but carries with it the additional risk of spills which have severe and deleterious effect on natural habitats. As an example, the Exxon-Valdez off of Prince William Sound spill in 1989 resulted in massive damage that is still being mediated today.

The highly charged atmosphere surrounding oil since the Persian Gulf War has led to the search for alternative sources. The debate over drilling in the Arctic National Wildlife Refuge (ANWR) pits those who want to want to explore for oil and gas against those who want to preserve the natural habitat. The Alaska National Interest Lands Conservation Act (ANILCA) which was passed in 1980 includes a provision that requires congressional approval for oil exploration. The U.S. Department of Interior has made several models to predict the amount of oil that lies below Alaska's coastal plain and the numbers range from between 600 to 9.2 million

³ Layzer, J. *The Environmental Case: Translating Values into Policy*. (Washington D.C.: CQ Press, 2002), 264.

⁴ Layzer, J. *The Environmental Case: Translating Values into Policy*. (Washington D.C.: CQ Press, 2002), 268.

⁵ Meyer, S.M. "Energy and the Environment: The Story of an Addict." Environmental Politics and Policy Lecture, MIT. 2 May 2005.

barrels. This would mean that production would equal 4% of U.S. consumption, 8% of domestic production and would increase GNP by \$74.9 billion.⁶ Environmentalists argue that the amount of recoverable oil that might lie underneath the refuge is not enough to increase energy security and furthermore, that the amount of oil obtained does not outweigh the environmental costs of drilling. ANWR's Coastal Plain serves as the calving grounds for Porcupine caribou, and pregnant polar bears consistently use the refuge land for den building in the winter. Biologists believe that the polar bear population cannot sustain any mortality of females as the number of animals dying annually is equal to the number born each year.⁷ As of today, the debate still continues over whether or not to open ANWR for exploration.

Fission Energy

In light of the controversy surrounding oil and natural gas, the government has turned to the development of alternative energy sources such as geothermal, wind, hydroelectric and nuclear power. Nuclear power, a term that could refer to power generated through fusion and fission, most often refers to fission reactions as those are the reactions that currently drive nuclear power plants in this country and abroad. A simplistic description of fission is as follows: U-235 is bombarded with neutrons which cause the nucleus to split into 2-3 fission products, 2-3 neutrons and a vast quantity of energy. Because the total mass of these products is less than the mass of the starting material, the missing mass has been converted to energy per Einstein's equation, $E=mc^2$. The neutrons then go on to collide with other U-235 atoms, producing a chain reaction.⁸ The "fission products" are radioactive waste and must be stored and disposed of

⁶ Layzer J. *The Environmental Case: Translating Values into Policy*. (Washington D.C.: CQ Press, 2002), 106, 109.

⁷ FWS, "Endangered and Threatened Wildlife."

⁸ U.S. DOE, Fusion Fact Sheet. <<http://www.gnep.energy.gov/pdfs/factSheetPrimerFission.pdf>>.

properly. The energy derived from the chain reaction is used to generate steam which turns a turbine which produces electricity for a power grid.

Fission has positive attributes, namely that it doesn't produce greenhouse gases or air pollutants such as carbon monoxide, sulfur dioxides or nitrogen oxides and the fuel supply is abundant. However, the drawbacks outweigh the benefits. Extraction of U-235 results in habitat destruction and radioactive contamination of local ecosystems. The operation of nuclear power plants results in the generation of radioactive waste, the release of radiation, and thermal pollution as the water used to cool the reactor core is dumped into the environment, altering the temperature of lakes and streams by several degrees.⁹ Additionally, the use of fissionable material as fuel presents nuclear proliferation risks. The plants are also expensive to build and costly to maintain and decommission once operation has ceased.

Nuclear power had promising beginnings in the 1970s, with orders for power plants reaching almost 45 in 1974.¹⁰ With the growth of the environmental movement in the early 1970s, strong public opposition developed against nuclear power. Media coverage of the malfunctioning cooling system at Three Mile Island in 1979 as well as the explosion of the nuclear reactor at Chernobyl in 1986 resulted in widespread public unease which remains today and accounts for the reluctance of policymakers to consider nuclear power as a viable option.¹¹

Aside from nuclear accidents, the operation of nuclear power plants raises other critical questions, such as, how should the radioactive waste be disposed of in a safe manner? Radioactive waste decays at variable rates, so different types of disposal are warranted depending on the type of waste. Low-level radioactive waste can be stored in containers buried

⁹ Meyer, S.M. "Energy and the Environment: The Story of an Addict." Environmental Politics and Policy Lecture, MIT. 2 May 2005.

¹⁰ Switzer, J.V. *Environmental Politics: Domestic and Global Dimensions*. 4th ed. (Belmont: Thomson Wadsworth, 2004), 178.

¹¹ *Ibid*, 179.

in shallow trenches, but high-level radioactive waste requires more stringent containment. Under the Nuclear Waste Policy Act of 1982, the DOE was required to assume control of the high-level radioactive waste in 1998 and to find a proper storage facility. In 1987, Congress directed the DOE to focus on Yucca Mountain in Nevada as its prime storage site. State officials protested, backed by environmental organizations and scientists who believed that the location was unsafe.¹² The EPA originally stated that the site would be stable for 10,000 years, but a 1998 study by Caltech and the Harvard-Smithsonian Center for Astrophysics in Cambridge, MA, found that the ground around the site could only be considered stable for the next 1,000 years because of seismic activity.¹³ Despite protests, in July 2002, President George W. Bush signed legislation that officially designated Yucca Mountain as a nuclear waste dump. Debate over the safety of the site still continues to rage today and probably will continue up until its scheduled opening in 2010.

Fusion Energy

Fusion, the “energy of the stars,”¹⁴ is exceedingly promising as a future energy resource. Widespread introduction of fusion plants would substantially reduce the environmental impacts of meeting an increasing worldwide demand for energy.¹⁵ Though fusion generates radioactive byproducts, they are considerably less than those generated in a traditional fission power plant. The public is also more likely to accept the development of fusion power knowing that the radioactivity risk is lower. Fusion is attractive as domestic energy source for a number of other reasons as well. Fuel for the reactors is abundant and available to all nations. Deuterium, an

¹² Switzer, J.V. *Environmental Politics: Domestic and Global Dimensions*. 4th ed. (Belmont: Thomson Wadsworth, 2004), 155.

¹³ Ibid.

¹⁴ DOE slogan, <<http://www.ofes.fusion.doe.gov/>>.

¹⁵ DOE, <http://www.ofes.fusion.doe.gov/More_HTML/environment.html>.

isotope of hydrogen, is abundant in seawater (0.034 g/L)¹⁶ and can be isolated easily. The tritium can be produced from lithium which is available in land deposits or seawater in quantities that will last thousands of years.¹⁷ There are no carbon emissions in the form of particulate matter or greenhouse gases so fusion doesn't contribute to global warming. Also, no SO₂ or NO_x emissions mean no risk of air pollution and acid rain. The radioactivity generated is short-lived and small in quantity, and because the fuel is in the chamber for less than 5 minutes, there is no risk of a meltdown or explosion. Because no fissile material is used in the fusion reaction, there is no risk of nuclear materials proliferation. Additionally, the cost is estimated to be similar to coal and fission. Most importantly, the reaction can produce electricity and hydrogen, which complement other near-term energy resources quite well.¹⁸

Fusion Funding

Domestic fusion funding from the Department of Energy has increased over the past decade. Even in 1998 when the U.S. pulled out of the ITER project, funding for domestic fusion research awarded to the Department of Energy (DOE) increased by \$223 million.¹⁹ However, when the U.S. rejoined the ITER initiative in 2003, Bush wanted to decrease funding for domestic fusion research in exchange for funding ITER. In spite of Bush's suggestion, Energy Secretary Spencer Abraham did not deplete funding for fusion research.²⁰

¹⁶ "Nuclear fusion and the energy problem" Ch 1. http://www.tdx.cesca.es/TESIS_UPC/AVAILABLE/TDX-0114104-103202/05CAPITOL1.pdf.

¹⁷ Princeton Plasma Physics Laboratory. "Advantages of Fusion." http://www.pppl.gov/fusion_basics/pages/fusion_advantages.html

¹⁸ OFES, "Basic Information About Fusion." <http://www.ofes.fusion.doe.gov/AboutFusion/AboutFusionWeb.pdf>.

¹⁹ Dinesh, M. "Energy and water spending bill heads to White House." Greenwire. 1 Oct. 1998. <<http://www.eenews.net/EEDaily/1998/10/01/archive/2/?terms=fusion%20funding>>.

²⁰ Struglinski, Suzanne. "United States to Join International Research Project on Fusion Energy." 31 Jan. 2003. Greenwire. <<http://www.eenews.net/Greenwire/2003/01/31/archive/2/?terms=%20ITER>>.

For fiscal year 2007, the White House asked Congress to boost energy science spending by over \$500 million dollars following Bush's state of the union pledge to bolster research funding. Bush requested a budget of \$4.1 billion dollars for the Department of Energy's Office of Science which would be a \$500 million dollar increase over the DOE's 2006 budget. The budget request would also increase funding for the fusion energy program by \$31 million dollars. The administration said it would like to double the DOE's science budget by 2016. ²¹

The budget proposal follows the introduction of several related bills in Congress collectively dubbed the "Protecting America's Competitive Edge" Act (PACE). The PACE act would double the R&D budgets of the National Science Foundation, NASA and other federal laboratories and agencies over seven years.

ITER

In the late 1970s, the major fusion programs worldwide were building large tokamaks to explore the physics needed to approach reactor conditions for fusion. The programs considered future projects independently until the International Fusion Research Committee proposed that the participants work together on an International Toroidal Reactor (INTOR). Participants met twice a year for a couple of weeks to evolve a design for INTOR, yet progress was slow. As a result, each program set up their own teams to study the engineering design of future experiments. In the US, researchers began with the Fusion Engineering Devise (FED) which evolved into the Tokomak Fusion Core Experiment (TFCX), and finally became Tokomak Ignition/Burn Experimental Reactor (TIBER). The teams continued to contribute to INTOR, but they could not agree on a common, future goal.²²

²¹ Geman, Been. "Bush Will Seek \$500M Boost for Agency in Fiscal 2007." Greenwire. 3 Feb 2006. <<http://www.eenews.net/Greenwire/2006/02/03/archive/9/?terms=fusion%20funding>>.

²² "Initiation of ITER." Apr 2006. <<http://www.iter.org/index.htm>>.

The arms race between the USA and Soviet Union had significant economic implications in the 1970's, and cooperation between the USSR and the USA became necessary to diffuse tension and begin integrating the Soviet Union into the world economy. Fusion was the ideal arena for compromise as the end product was not defense-related but involved important technologies whose development costs, technical information, and work could be shared.

Premier Gorbachov on the advice of Acad. Evgenij Velhikov took the initiative to propose a Geneva Superpower Summit with President Reagan in November 1985. He suggested that Europe, Japan, America, and the USSR collaborate on an international project to develop fusion energy for peaceful purposes by joint construction of a "next step device." This project became particularly important following the nuclear disarmament standoff at the Reykjavik Superpower Summit in October 1986. The standoff prompted the United States, in conjunction with Japan and the European Community, to respond with a proposal on how to implement the program. Collaboration resulted in the establishment of ITER or the International Thermonuclear Experimental Reactor, which also means "The Way" in Latin.

The program's objective was to, "demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes." The ITER project was controlled by the Conceptual Design Activities (CDA) group starting in April 1988. The CDA was led by the ITER Council, and was responsible for defining the technical characteristics of the machine, defining future R&D needs, producing a schedule, and estimating costs. This led to a detailed engineering design phase called the Engineering Design Activities (EDA) which began in 1990 to replace the CDA. Under the EDA, contributing parties would conduct further R&D and nations would share

information and use it to design and build the tokamak. This sharing of information required explicit agreements about the sharing of intellectual property and costs.²³

The participant countries also needed to decide where R&D would occur. After two years of debating this issue, they decided to split the EDA design team into three groups that would operate in three different locations which included Garcing, Germany, Naka, Japan, and San Diego, USA. The groups were called Joint Work Sites. The ITER EDA Agreement, which specified the rules governing the EDA design phase, was finally signed on July 1992 and scheduled to last for six years. The EDA collaborative project culminated in a complete, fully integrated engineering design of ITER called the ITER Final Design Report in 1998.

America was an equal party in the ITER initiative throughout the EDA program.²⁴ The US contributed to R&D efforts until 1998, when Congress directed the Department of Energy to end U.S. participation in the project. ITER was deemed too expensive as the price tag continued to rise. The DOE had invested \$350 million dollars in research at the time the U.S. formally left the EDA.²⁵ America's withdrawal from the project prompted the ITER Parties to redesign sections to reduce costs even though their Final Design Report had been accepted by the ITER council. They recognized that the formidable price tag could prevent the project from going forward. Engineers reduced ITER's detailed technical objectives while maintaining the same purpose.

The EU, Russia, and Japan continued with the project and established the Coordinated Technical Activities (CTA) program to prepare for the joint construction and operation of ITER. Each negotiating nations' scientists were formed into Participant Teams that were coordinated by

²³ "Conceptual Design Activities" May 2006. <<http://www.iter.org/index.htm>>.

²⁴ "Detailed information on the ITER project." Apr 2006. <<http://www.ofes.fusion.doe.gov/iter.html>>.

²⁵ Struglinski, S. "United States to Join International Research Project on Fusion Energy." Greenwire. 31 Jan 2003. <<http://www.eenews.net/Greenwire/2003/01/31/archive/2/?terms=Fusion%20ITER%20US>>.

a Project Board. Though the CTA ended in December 2002, the ITER Transitional Arrangements (ITA) program began in January 2003 to replace the CTA. When the ITA came into power, President Bush announced that the U.S. would rejoin the effort to build ITER with the new reduced cost. The Energy Department promised up to 10 percent of the then \$5 billion dollar project. Bush announced that, "the results of ITER will advance the effort to produce clean, safe, renewable, and commercially available fusion energy." Bush is currently a proponent of the ITER project as it may offer energy security and reduce air pollution.

China and South Korea also joined the effort, yet the participant countries were unable to agree on a location to build ITER for several years. When debates began, Canada, Japan, and France were contestants; Canada was soon ruled out, but a bitter fight ensued between representatives who wanted the site in Cadarache, France and those who wanted it in Rokkasho, Japan. Rokkasho is a desolate village on the northern tip of the country's main island. In June 2005, the countries finally decided to build ITER in Cadarache, France at a 4,000-acre site that already hosts a nuclear energy development lab. In exchange for building the site in France, the EU will pay half the costs of the project while the U.S., Russia, Japan, South Korea, and China split the other fifty percent equally. India joined the ITER initiative in December 2005 and will fund part of the project. Japan will also have twenty percent of construction contracts and jobs even though they are only paying ten percent of the project. The demonstration reactor, which is a follow up project to ITER, will be built in Rokkasho after fusion technology is refined.²⁶

The compromise was seen as a great success, yet the years of disagreement significantly pushed back the construction of ITER. Currently, ITER is scheduled to open in 2016 and construction will begin the summer of 2006. R&D is still being conducted at two Joint Work

²⁶ Marlo, L. "France chosen as site for \$12.1B project". Greenwire. 28 June 2005. <<http://www.eenews.net/Greenwire/2005/06/28/archive/3/?terms=fusion>>.

Sites which include Naka, Japan and Garching, Germany. The ITA program which currently oversees the ITER project is also scheduled to end when participants ratify the Joint Implementation Agreement which will form the ITER Organization as the legal entity to oversee the implementation of the ITER design.²⁷

ITER will be ten times larger than the largest similar fusion reactor.²⁸ If ITER is successful in generating its target of 500 megawatts during 400 second pulses, officials will begin designing the demonstration reactor which will be the first model fusion reactor. Researchers hope that ITER will be the first experiment where fusion breaks energetically even or produces more energy than invested. If ITER succeeds, it will provide concrete evidence that we can come to depend on an abundant and benign alternative form of fuel. Not only will the world become economically independent of fossil fuels, but destruction of the environment will be slowed. The collaborative efforts of the world's most powerful nations will hopefully produce the key to the next generation's source of sustainable, reliable, and clean energy.

²⁷ "ITER Before Construction." May 2006. <<http://www.iter.org/index.htm>>.

²⁸ Kappos, D. "After Year of Debate, ITER set to Begin Construction this Summer". Greenwire. 14 Feb. 2006. <<http://www.eenews.net/Greenwire/2006/02/14/archive/23/?terms=fusion>>.