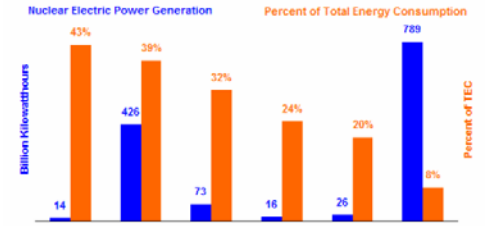
France's Nuclear Energy Program: Lighting the Way to Global Sustainability

Abstract

Much of the European Union and the Untied States rely on fossil energy to meet their energy needs. France stands in contrast to this trend by using nuclear energy to provide 39% of their total energy and over 70% of their electricity (Fig. 1). The shift to nuclear energy in France began during the oil crises of the 1970's. High oil prices led the French government to find alternative energy answers. The policy led to the adoption of a sustainable energy policy that implements nuclear energy as a primary energy source in the country's energy mix. This policy also formed safety regulations, waste management strategies, and research organizations that have shape the complex nuclear fuel cycle in France. France stands as an example for countries around the world pursuing clean energy and sustainability in energy policy.

Figure 1 France's Nuclear Power Generation Compared to Other Nuclear Producing Countries



http://www.eia.doe.gov/emeu/cabs/France/Electricity.html

France is the second leading producer in nuclear energy only to the United States even with only a fraction of the geographic land. France also utilizes this energy to meet domestic energy needs, which displays a high degree of sustainability

Contemporary French Nuclear Energy Picture

France produces around 428.7 TWh of electricity a year, which provides energy and electricity to over sixty-two million people (Table 1). All of the 59 nuclear reactors are operated by the Electricite de France; 58 are pressurized water reactors (PWR) and 1 is a fast breeder reactor (FBR). The PWR's have a net capacity between 800 and 1450 MWe, while the FBR has a net capacity of 233 MWe. All aspects of the nuclear fuel cycle are controlled by the government of France and private corporations like Areva and Cogema that operate the mining of uranium at Lodeve and Jouac in France, the enrichment of the uranium in Mavesi and Pierrelatte, the building of reactors, and the reprocessing of spent fuel at the La Hague plant. Nuclear energy caused a 50% decrease in coal consumption, an energy self-sufficiency rating of over 50%, and a precipitous decline in oil consumption, which has had positive environmental consequences.

Nuclear Data for OECD Countries Compared to France

Table 1 2003	Number of nuclear units connected to the grid	Nuclear electricity generation (net TWh)	Nuclear percentage of total electricity supply
France	59	428.7	78.1
OECD Europe	150	929.3	27.3
OECD TOTAL	346 (out of 437 worldwide)	2278.1	23.1

http://www.nea.fr/html/general/profiles/france.html#nppsupply

These statistics compare France with OECD countries which include the United States, select countries of the European Union, Mexico, Korea, Canada, Japan. and many more.

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France's Nuclear Energy History

The history of France's nuclear program dates begins in the 1950's when France began to experiment with gas-graphite and light water reactors. By 1973, 10 reactors were in operation in France. After the oil crisis of 1974, the French government decided to adopt nuclear energy as their long term energy policy to diminish their reliance on imported oil and coal. This resulted in the implementation of the Messmer program, a program that called for advancement in nuclear energy in France by building 13 nuclear reactors capable of producing 13,000 MWe. This was 50% of France's energy need at the time. This policy cemented nuclear energy as the centerpiece of France's energy policy. Now, France has 59 active reactors as a result of this policy (Table 2). In the United States, nuclear energy became popular, but in the 1980's the nuclear program in the U.S stagnated due to fear over reactor accidents in Chernobyl and Three Mile Island (Table 2).

The Number of Nuclear Reactors in France and the United States in the Past Thirty Years

Table 2	Number of Active Nuclear Reactors In France	Number of Active Nuclear Reactors In the U.S.
1973	10	23
1986	47	85.2
2005	59	100

http://www.eia.doe.gov/emeu/aer/pdf/pages/sec9_5.pdf

The nuclear programs of France and the United States grew exponentially in this thirty year period, but as France's nuclear program replaces old plants with new technology the United States is being left with aging plants that need to be replaced.

French Nuclear Waste Management

Andra, France's Agency for the removal of nuclear waste, was created as an independent organization in 1979. This organization has opened two new nuclear waste facilities, l'Aube disposal facility in Soulaines and VLLW disposal facility in Morvilliers (Fig. 2). Andra has also revamped the operations at the Manche repository in Beaumont-Hague order to maximize public safety and nuclear waste decomposition. Manche repository was closed in 1994 after it reached a capacity of 500,000 m3. The facility is now in a monitoring phase. The La Hague reprocessing plant has a capacity of 1,800 tonnes of spent fuel a year, which alleviates the waste management industry. Andra completed research on underground storage of high level waste (HL), highly toxic nuclear waste, and found that HL waste can be stored safely in clay formations. This underground repository is the direction of nuclear waste management for the future of France (fig. 2).

Waste Classifications and the Waste Disposal Sites within France

Figure 2	Short-lived Half-life < 30 years	Long-lived Half-life > 30 years
Very-low level (VLL)	VLLW Disposal Facility	
Low level (LL)	• Centre de l'Aube Disposal Facility • Ongoing studies for tritiated waste	Ongoing studies for graphite and radium-bearing waste
Intermediate level (IL)		
High level (HL)	Ongoing studies (Law of 30 December 1991)	

http://www.andra.fr/interne.php3?id_rubrique=110

France has an elaborate disposal system that deals with very low level to intermediate level waste in an environmentally friendly fashion. France now plans to deal with high level waste by burying the waste in an elaborate disposal facility beneath the earth in clay formations.

This poster was developed as an assignment for Honors 295, Fall 2007, Population, Environment, and Sustainability—Ethics for Living into the Future. References can be obtained by contacting the author.

Pressurized Water Reactor vs. Fast Breeder Reactor

Both the PWR and the FBR, utilize closed systems that generate power through spinning a turbine with steam but that is where the similarities end. The PWR operates when the water coolant transfers heat produced by the reactor to the secondary system to produce steam and conversely energy. The Breeder reactor has creates fissile fuel by turning the spent fuel of uranium 238 into plutonium 239 in breeding rods connected to the core, which results in the reactor generating more fuel than it uses. The popularity of the breeder reactor is due to its ability to reprocess fuel and use it for fissile material, but one of its main drawbacks is the fact that it creates materials that can be used in nuclear weapons. One of the only commercial breeder reactors, The Super Phenix, was built in 1986 in France, but it encountered a liquid sodium coolant leak that forced its closure for safety reasons in 1999. Now only one small breeder reactor is in activity in France while 58 PWR reactors are active, but continued research is being done on the breeder reactors due to the promise of a more efficient reactor.

The Future of Nuclear Energy in France and the World

The European Pressurized Reactor (EPR) is the future of nuclear energy in France, China, the United States, and many other nations that are utilizing nuclear energy. This is a fourth generation reactor that has a service life 20 years longer than the PWR's. It can hold 241 fuel assemblages and can be put on 12 or 24 month fuel replacement cycles. The EPR has an energy capacity of 1,600 MWe, a 17% reduction in uranium usage, a 15% increase in cost effectiveness, and a 15% reduction in the spent fuel produced. The new EPR's will replace the PWR's that are soon to be decommissioned within France. The first EPR will be built in Flamanville, France in 2007. These new reactors meet the world's need for a cheap and clean energy source that can meet the rising global energy needs. It is estimated that there will be as many as 1000 nuclear reactors in the world by 2050 (fig. 3). The greatest growth will come in the developing world where countries like China are turning to nuclear energy to fuel the development of their countries. China, India, and Pakistan will have over 200 reactors by 2050, which is a dramatic increase from the current number of reactors (fig. 3). Renewed interest has also been seen in the United States due to the resurgence in international popularity for nuclear power. The increased interest in nuclear energy comes on the heels of the success of countries like France that have greatly reduced their carbon footprint and meet their energy needs in a cost effective fashion. Due to this popularity, France can serve as the trendsetter for sustainable, environmentally friendly, fiscally conscious nuclear development for the world so that more nations turn away from fossil energies and turn their attention towards nuclear energy.

Projected Global Nuclear Energy Growth for 2050

Global Growth Scenario

Figure 3

REGION	PROJECTED 2050 GWe CAPACITY	NUCLEAR ELECTRICITY MARKET SHARE 2000	2050
Total World	1,000	17%	19%
Developed world	625	23%	29%
U.S.	300		
Europe & Canada	210		
Developed East Asia	115		
FSU	50	16%	23%
Developing world	325	2%	11%
China, India, Pakistan	200		
Indonesia, Brazil, Mexico	75		
Other developing countries	50		

http://web.mit.edu/nuclearpower/pdf/nuclearpower-full.pdf

By 2050, it is estimated that the world will have over 1,000 nuclear reactors. The biggest increase will come from the developing world, but increased development will also take place in the developed world.

Helpful Websites for Further Study

Energy Information Administration country profile on France
http://www.eia.doe.gov/emeu/cabs/France/Background.html
Andra-Agency of nuclear waste management website
http://www.andra.fr/sommaire.php3
OECD International Nuclear Agency that compiles statistics on nuclear energy
http://www.nea.fr/