Nuclear Energy: Capstone

Introduction

France

The United States has a problem with energy independence. The problem has nothing to do with a lack of energy production or availability. We are the largest producer of energy in the world, and have centuries' worth of fossil fuels, as well as an enormous supply of nuclear and alternative energies, at our disposal. Our energy dependence on other countries is a result of the fact that we are also the leading consumers of energy in the world, being second only to Canada (population 32 million, compared to the 283 million in the U.S.) in per capita consumption of energy. In order to meet our need in a cheap fashion, we need to import over 11 million barrels of oil and 10 million cubic feet of natural gas each day[1].

There are other countries like us who are not able to meet their own needs for energy. They, too, rely on energy imports of fossil fuels to power their economy. However, some of them have a different strategy for trying to achieve energy independence. An excellent example of a country that is travelling a different path than the U.S. is France. Its approach differs from ours in two respects: it uses a lot less energy per person, and it relies much more on nuclear energy to power its economy.

In the U.S., the average person is responsible for 338 million Btu's of energy usage per year. This accounts for all of the energy that is used in the home and office, as well as in industrial plants, trucks, and manufacturing plants in the U.S. to produce goods and perform jobs. The average person in France is responsible for about half this quantity, using only 178 million Btu's each year[2]. Some of this comes from stricter recycling standards; some of it comes from having different industrial and manufacturing operations.

A great deal of this difference is due to the use of mass transit and other means of transportation in France. The 200+ million passenger vehicles in the U.S. travel an average of more than 12,000 miles per year. In France, the 30 million passenger vehicles travel less than 9,000 miles per year on average[3,4]. Given the fact that we have a population of 290 million, while France has a population of 50 million, this means that we have a higher rate of automobile ownership per person and that we are driving those automobiles further. This difference translates into France using one-tenth the oil that we do (20.0 million barrels per day in the U.S. compared to 2.1 million barrels per day in France) while having one-fifth of our population.

French Nuclear Program

The other key issue where we diverge from France is in the use of nuclear energy. This is not to say that the U.S. uses less nuclear energy than France does. The U.S. is still the leading producer of electricity from nuclear energy, creating over 750 billion kilowatt-hours of energy every year, compared to France's 414 billion kilowatt-hours. However, this amount is only 20% of our total electrical output, whereas France's nuclear energy accounts for 79% of their output. From a standpoint of reliance,

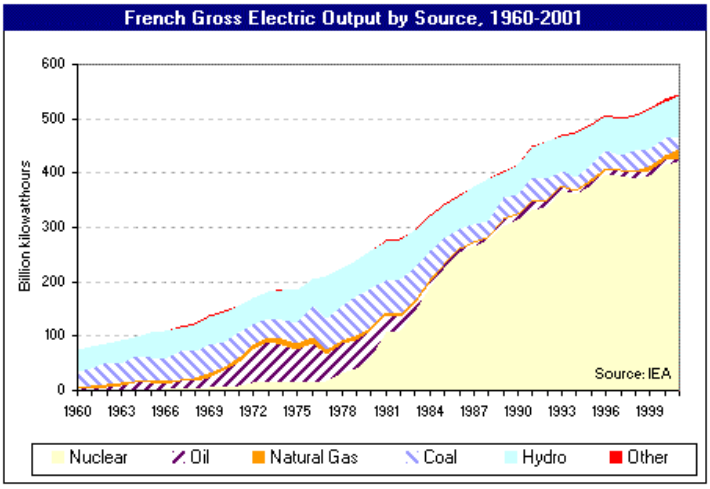

Fig. 1: French electrical output by source (*Source: DOE*)

France is much more of a nuclear nation than we are.

France has not always been a nuclear powerhouse, as is shown in Figure 1. In fact, it was about the time that the U.S. was scuttling plans for any new reactors that France was beginning to ramp up its program. Since 1977, there have been no new orders for nuclear power plants in the U.S. The only plants that have been built since then were ones that were already planned before that date (the Watts Bar I facility opened in 1996 took over 20 years to build). France, on the other hand, has been increasing its nuclear capacity by leaps and bounds since then. The amount of nuclear energy produced per year since 1977 has increased by a factor of 20.

The growth in France's nuclear program was initially for the same reasons as in the U.S.: a cheap source of energy that would give energy independence. France has very small reservoirs of oil, natural gas, and coal. As of 2003, it had proven reserves of only 148 million barrels of oil, 500 billion cubic feet of natural gas, and 40 million short tons of coal. These reserves would last 72, 115, and 624 days, respectively, if they were the only source of their kind and consumption continued at its current rate. This situation is much more desperate than we have here in the U.S., where our oil and gas supplies would last a decade, and our coal supplies would last several centuries, at their current rate of consumption.

France has tried to fortify its energy needs by strongly seeking oil from other countries. Their two largest oil companies (Elf Aquitaine and Total) merged in 2000, creating the fourth largest oil company (Total SA) in the world. This company has strong holdings in Africa, Europe, and the Middle East, both in oil and natural gas. It can currently produce 2.6 million barrels of oil and 4.8 billion cubic feet of natural gas per day. This more than covers the total current usage of France.

France's Nuclear Future

France's nuclear future is very much in doubt due to environmental and economic factors. For some time now, environmentalists have been fighting the use of nuclear energy in Europe because of the potential for catastrophic accidents and the large amount of highly radioactive waste the reactors create. The explosion at Chernobyl and the subsequent spreading of nuclear fallout material over all of Europe has helped to strengthen their argument with the public and government. They have won concessions in some EU nations to either stop construction of new plants or to begin the dismantling of old plants. The fact that the French have not built a new reactor in over a decade is due in some part to the work of these environmentalists. Currently, they are leading protests to stop the construction of a proposed pressurized water reactor to be built by Siemens and Areva[5].

However, environmental concerns are not the only reasons why the construction of nuclear power plants has been stopped. When the costs for the strict standards for building and maintaining power plants are considered, electricity from nuclear energy becomes more expensive than that from coal or natural gas plants. This is true in any country today. However, the competitive guidelines passed by the European Union over the last decade have heightened this issue in France. For many years, electricity in France was supplied by the state-owned Electricité de France (EdF). The new EU guidelines call for a gradual phase in for competition in the electricity market in all EU countries. Currently, these guidelines call for open markets for all non-residential customers, which account for 70% of the French market. By July 1, 2007, these open markets must extend to all customers, meaning that any private or public electric company in the EU can supply electricity. To further complicate the issue, the French government has decided to partially privatize EdF. In this kind of situation, short term profit considerations will overrule long term viability considerations and prevent any new nuclear plants from being built.

If no new plants are built, then we can expect the nuclear capacity of France to shrink over the next several decades, as older plants have to be decommissioned and dismantled some time in the 2015-2020 timeframe. While this sounds like it is a long time away, the fact is that a nuclear power plant takes almost a decade to build and bring online. Decisions will have to be made within the next several years regarding new construction if these older plants are to be replaced.

Greenhouse Emissions

Not all environmentalists see this heavy reliance on nuclear energy as a bad thing. Because of it, the French people emit for less carbon dioxide per person than we do in the U.S. Our total contribution is about 20 metric tons of carbon dioxide per capita, whereas the French have about 7 metric tons per capita. Given the connection between increased CO_2 emissions and global warming, this is more than enough to balance the damage done by storing nuclear waste. However, there is also the matter of NO_x compounds being emitted, which lead to increased ground-level ozone, and acid rain, which accounts for plant and animal life destruction.

Additional Reading

The following link discusses research on France's energy usage and nuclear program. The site is maintained by the Department of Energy and also contains links to additional resources.

Department of Energy	**Topic**: France Country Analysis Brief **Summary**: Contains information about France's energy situation **Link**: https://www.eia.gov/international/overview/country/FRA

The following website contains information about the French electric company EDF. The link below goes to the English version of the site, although there is a good deal more information about the situation in France that is on the French version of the site. For those who have a working knowledge of French, it is advised to visit that portion of the website.

EDF	**Topic**: EDF Group **Summary**: English version of the website for the French electric company EDF **Link**: https://www.edf.fr/en

Activity

In this week's activity, we are going to monitor the electrical usage of key appliances in our home, and compare how our different actions will affect the amount of emissions that we release. We will make a comparison between what our emissions are here in the U.S. and what they would be if we had the same fuel composition for our electrical production as France does. For this, we will need several bits of information, which are listed on the activity sheet. For each electrical appliance listed there (Note: if your version of a particular appliance uses some other energy source, such as natural gas, do not include it in the activity sheet), we will need the average power (in kilowatts) and the average amount of time that the appliance is used in a week. The power rating of your appliance should be listed on a tag somewhere on it (ex: dryers often place a label on the inside of the door that lists this).

After you find the power rating of each appliance, you will need to monitor the usage of it for an entire week. While some appliances like televisions and microwaves "leak" electricity constantly to power digital clocks and standby modes, we are going to neglect this usage for the present study, even though it can account for a large amount of electricity and emissions[6]. Finding the amount of time that some appliances are "on" can be quite difficult, as things such as air conditioners, heaters, and refrigerators turn on and off by themselves. For these appliances, it might do well to monitor them for an hour or two and see how long each one turns on to get an estimate.

Both the power rating that the average time used per week need to be placed in the appropriate slots on the activity sheet. This information then needs to be entered into the emissions calculator, which will

compute the amount of CO_2, SO_2, and NO_x emissions due to this consumption. The calculator will also estimate how much of these would be emitted if 79% of our electricity came from nuclear energy and 9.3% from fossil fuels, like it is in France.

It should be noted that different mixtures of coal, oil, and natural gas used to generate electricity would release different quantities of emissions. Some coals have more sulfur, while others have more water content. Natural gas will produce no sulfur emissions, while oil will produce some. The small differences in mixtures from year to year will slightly change the calculations we are about to make. For reference, we are using the mixture used in the U.S. in 2002 in our calculator. In that year, the average kWhr of electricity generated with fossil fuels created 1.9 pounds of CO_2, 0.008 pounds of SO_2, and 0.004 pounds of NO_x.[7]

References

1 http://www.eia.doe.gov/emeu/cabs/usa.html
2 http://www.eia.doe.gov/emeu/cabs/france.html
3 http://www.fhwa.dot.gov/ohim/hs98/tables/in4.pdf
4 http://www.fhwa.dot.gov/ohim/hs98/tables/in3.pdf
5 http://liege.indymedia.org/mail.php?id=986
6 http://eande.lbl.gov/EA/Reports/46212/
7 http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html

ESA21: Environmental Science Activities

Activity Sheet
Nuclear Capstone

Name:

Calculator website: http://esa21.kennesaw.edu/activities/nukecapstone/nukecapstonecalculator.htm

Appliance	Power (W)	Avg. Use (Hrs./week)
Average light bulbs		
Washing machine		
Dryer		
Dishwasher		
Stove		
Air conditioner		
Heater		
Refrigerator		
Hot water heater		
Television		
Microwave		
Stereo		
Computer		
Miscellaneous		

	Your Emissions	
	U.S.	France
CO_2	_____ lbs	_____lbs
SO_2	_____ lbs	_____lbs
NO_x	_____ lbs	_____lbs

1. How large is the difference between your emissions in the U.S. and what they would be if we had the same energy profile as France?

2. One way to minimize your emissions is to use high efficiency appliances that use less energy. A list of these appliances can be found at the Energy Star website (http://www.energystar.gov/). Use this website to "replace" the three largest energy users in your home with more efficient appliances and recalculate your emissions.

Appliance	Old Power Rating	New Power Rating

   How does your new level of emissions compare to what your original emissions would have been if we had an energy profile similar to France? Are you willing to spend the money to purchase such appliances?

3. Given what you have learned about nuclear energy, nuclear waste, and the emissions from fossil fuel power plants, should we build up our nuclear energy capacity so that our profile looks more like France? Why or why not?