## Homework Assignment #6: Energy Economics 399

Due Wednesday, April 1

1. Assume that there are two factories each producing 10 units of pollution. The government, in an attempt to reduce pollution levels to the optimal level wants pollution to be reduced 50%.

   Firm 1 can reduce pollution at a cost of $C_1 = 5q_1 + q_1^2$
   Firm 2 can reduce pollution at a cost of $C_2 = q_2 + 3q_2^2$

   a. If each firm is forced to reduce pollution by 50%, how much will this cost?
   b. What is the optimal amount of pollution reduction by each firm if a 50% reduction in total pollution is desired?
   c. How big a tax on pollution will be required to achieve a 50% reduction in total pollution? How much pollution will each firm emit? What will be the total cost for each firm of this method? How much revenue will the government collect?
   d. If each firm is issued a tradable permit to emit 5 units of pollution, what will happen? How much pollution will each firm emit? What will be the total cost of this method? If the firms trade permits, at what price (or possible range of prices) do these permits sell?
   e. i. Which method would a metropolitan area use if they faced a mandate from the federal government to reduce pollution 50% or lose federal highway funding?
      ii. Which method would be most politically popular?
      iii. Which method would you recommend if the industry was experiencing rapid advances in pollution control technology?
      iv. Which method would work best if pollution reduction must take place over international borders?
      v. Under what circumstances would you recommend a command and control approach as in part a.?
   f. How would a move from the command and control policies in part a. to the optimal methods in parts b., c., and d. affect the optimal amount of pollution reduction? Explain. (This is not a numerical solution. You need to explain in words.)
   g. Some economists have advocated auctioning off permits rather than distributing them free of charge to firms. What are the advantages and disadvantages of such a proposal?

2. European countries have relied to a much greater extent on emission charges than has the United States, which has generally relied on transferable emission permits. Why do you think this is the case? Should the U.S. follow Europe's lead and shift the emphasis toward emission charges? Explain.

3. a. If one wished to reduce $SO_2$ pollution to efficient levels through taxes or emission charges, should all emissions of $SO_2$ from all sources be taxed at the same rate? Why or why not? What are the advantages and disadvantages of levying different tax rates on different emitters of $SO_2$?
   b. If one wished to reduce $CO_2$ pollution to efficient levels through taxes or emission charges, should all emissions of $CO_2$ from all sources be taxed at the same rate? Why or why not? What are the advantages and disadvantages of levying different tax rates on different emitters of $CO_2$?

4. In his March 22 editorial in the Washington Post, author Todd Tucker analyzes 5 myths about nuclear power. Are his arguments persuasive or are they factually or logically inaccurate? (You may need to do a bit of outside research on this question, and I would certainly recommend discussing this question in groups before writing a brief point-by-point answer.)

   http://www.washingtonpost.com/wp-dyn/content/article/2009/03/20/AR2009032001781.html

The Washington Post

# 5 Myths on Nuclear Power

By TODD TUCKER
Sunday, March 22, 2009; Page B03

Thirty years ago this week, a chain of errors and equipment malfunctions triggered the defining event in the history of American nuclear power: the accident at Three Mile Island. Although no one died and the health consequences were insignificant, the mishap was vivid confirmation that things could go wrong with a nuclear reactor. It almost instantly galvanized popular opposition to this form of power, giving rise to lingering misconceptions about one of our nation's largest sources of electricity.

**1. Three Mile Island killed the idea of nuclear power in the United States.**

The 1979 accident and the fear it spawned were undoubtedly setbacks to the nuclear power industry. Only recently did utilities even attempt to license new reactors again. But Three Mile Island didn't even kill nuclear power at Three Mile Island. While TMI 2 was destroyed, TMI 1 is still in operation today. In fact, in generating electricity, nuclear power is second only to coal, which produces about half the power we use. Nuclear today produces more electricity than it did at the time of the accident -- about 20 percent compared with 12.5 percent in 1979.

**2. Long half-lives make radioactive materials dangerous.**

It's impossible to read anything about the problem of nuclear waste without having to consider enormously long periods of time: thousands of years, or tens of thousands, or even longer. The Web site Greenpeace.org, for instance, points out that plutonium 239, a byproduct of uranium fission, "has a half-life of approximately 24,000 years. . . . However, the hazardous life of radioactive waste is at least ten times the half-life, therefore these wastes will have to be isolated from the environment for 240,000 [years]." There seems to be something intrinsically evil about anything that persists for so long. But a long half-life doesn't necessarily make a substance dangerous.

A half-life is a measure of how fast a radioactive material decays. Take Carbon 14. This is a slowly decaying radioactive isotope present in natural carbon, which occurs in all living things. Archeologists and scientists measure the amount of carbon 14 remaining in an object to calculate its age. A useful, radioactive and harmless part of every person, Carbon 14 has a half-life of 5,730 years. Conversely, some short-lived isotopes can be extremely dangerous. Nitrogen 16, which is produced in operating nuclear reactors, emits very high-energy radiation despite its half-life of just 7.1 seconds.

None of this is to say that radioactive waste isn't dangerous or isn't a problem -- even industry boosters identify it as one of the biggest challenges they face. But the problem isn't the material's half-life -- it's the level of radioactivity it possesses.

**3. Nuclear power is bad for the environment.**

Many nuclear reactor byproducts are dangerous and require careful long-term storage. This is at the root of the fairly widespread belief that nuclear power is incompatible with a concern for the environment, even though its effects compare favorably with coal's.

The top environmental concern for most of us is global warming, and nuclear power is by far the biggest source of emission-free power we currently have, contributing none of the greenhouse gases that coal plants spew by the ton every day. Neither does nuclear power require the decapitation of Appalachian mountains or the construction of billion-gallon sludge ponds. So why won't environmentalists even consider the nuclear alternative? Some have, notably former Greenpeace member Patrick Moore, Whole Earth Catalog founder Stewart Brand and Gaia theorist James Lovelock. But most environmentalists remain constitutionally averse to nuclear power, for reasons that Brand has described as "quasi-religious."

**4. Nuclear power is "unnatural."**

From Godzilla to Blinky the three-eyed fish on "The Simpsons," many of pop culture's oddest creatures owe their existence to the mutating powers of radiation. Itss easy to forget that radiation and nuclear processes are pervasive in the natural world. President Harry S. Truman put it memorably when he presided over the keel-laying of the USS Nautilus, the world's first nuclear-powered ship, in 1952: "Her engines will not burn oil or coal. The heat in her boilers will be created by the same force that heats the sun -- the energy released by atomic fission, the breaking apart of the basic matter of the universe." Cosmic rays bombard us constantly, and radioactive isotopes of common elements are an unavoidable -- and benign -- part of our food supply. Uranium, the primary fuel in most nuclear reactors, is a natural substance found all over the globe, roughly as plentiful as tin.

**5. A nuclear power plant is similar to a nuclear bomb.**

Not really. Nuclear power plants use fission -- the splitting of uranium atoms to release enormous energy -- to create power. Modern nuclear weapons use nuclear fusion: the fusing together of hydrogen atoms to release even greater amounts of energy. It's true that early nuclear weapons, such as the one dropped on Hiroshima, were fission weapons that used uranium as fuel, but scientists had to overcome incredible technical challenges to get the fuel to compress long enough to reach a "critical mass" that would release explosive levels of energy. A nuclear power plant is a radically different machine, designed with great care to convert nuclear fission into steady power over a period of years. You couldn't turn a nuclear reactor into a bomb any more easily than you could power your house with a hand grenade.

There is one important link between nuclear power and nuclear weapons: Uranium-fueled reactors produce plutonium, a key ingredient in the construction of nuclear bombs. This is why the United States is justifiably concerned about any nations that are building or attempting to build nuclear power plants.

Nuclear power certainly isn't without hazards, and the industry does itself a disservice by proclaiming that it can construct a reactor that is "inherently safe," implying a condition in which nothing bad can ever happen. That's not possible in any manmade creation. It's also easily disproven the instant something bad does happen -- as it did at Three Mile Island. All methods of power generation involve trade-offs, a balancing of risks against returns. We shouldn't evaluate nuclear power any differently.

Todd Tucker is the author of "Atomic America: How a Deadly Explosion and a Feared Admiral Changed the Course of Nuclear History."