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Energy 101

By Richard Reis, PE. Energy technologies are key causes of environmental well-being or harm. To best understand these technologies, it helps to know a little thermodynamics, which is the branch of science and technology that governs or limits how we harness and use energy.

- The first law proclaims that energy can be neither created nor destroyed.[1] We can only harness and transform the natural energy of our environment, such as converting wind energy into electrical energy. We should approach the energy problem with the same seriousness as personal finances. There is obviously a cost to spending money, and there is a cost to using energy. The quantity, type, and method of natural energy use influence environmental impacts.
- The second law is subtler, but just as important. It states that the entropy or disorder of any system always increases over time. This means that all energy transformations lose useful energy. For example, when coal is burned for electrical generation, only 30 to 35 percent of the embedded chemical energy is converted into electrical energy as other products are dispersed into the environment as pollution. Of course, actual system efficiency is much lower when we consider the energy used in coal mining and transportation and the electrical energy lost by transmission, distribution, and utilization.
- The third law states that absolute zero (-460º F) is the coldest temperature possible. The formula for computing the maximum efficiency of any energy-conversion process uses absolute zero. That formula shows that efficiency improves with increasing input temperature and decreasing rejection temperature. This is the reason power plants reject unwanted heat through water sources or cooling towers.

As we choose energy supply and consumption technologies, we should ask about their efficiencies and their real costs. This analysis must include both the immediate costs and the hidden costs (externalities). A National Academies' report indicates that coal generators imposed a cost of $62 billion upon the U.S. general public in 2005 through non-greenhouse air pollutants alone.[2] Considering that we consumed 2 trillion kilowatt-hours (kWh) of coal-generated electricity that year[3] that works out to an added 3¢ / kWh. The widespread environmental destruction of coal mining adds perhaps adding $120 / ton or 6¢ / kWh. [3,4] These would add about 9¢ / kWh to the cost of coal-generated electricity, making alternative energy and extreme energy-conservation measures very economically attractive. (If we had assumed the external costs are the price of renewable energy credits that would add just another 2¢ / kWh.[5])

The proceeding does not include the environmental cost of disposing of bottom ash, the solid residue from burning coal. Also, when the power industry scrubs their smokestacks to remove some of the air pollutants, many of these toxins wind up in our rivers, lakes, and ground waters.[6]

It is important to note that the coal remaining in the ground is clean and stable. Its chemical energy and components were bound through photosynthesis over many thousands of millennia. Coal releases its energy as well as its toxic components when mined and burned.

Electrical Power

Mr. Bennet, my high school physics teacher, liked to remind his students that our parents' electric bills reflect the energy, not the power we use. However, because electrical capacity and loads vary by season and by time of day, commercial and industrial energy costs also vary by season and time of day. These customers also pay for peak power costs. PEPCO and other utilities are now offering incentives to allow them to remotely turn off our air conditioning systems using Digital Cycling Units (DCU), during some summer afternoons.

Local power companies are trying to build PATH and MAPP transmission lines to address peak power demands, as well as allowing them to deliver coal-generated electricity from Kentucky and West Virginia. Alternative energy can play an important role here because wind-generated electricity tends to be strongest during off-peak times. Further, solar energy in our region is generally distributed close to the points of use and peak output roughly coincides with peak air-conditioning demand on summer afternoons.

You can learn more about MAPP and PATH and what we can do about them at: http://maryland.sierraclub.org/action/p0204.asp

Some propose that we can sidestep global warming, by climate engineering (also known as geoengineering), such as lofting sun-blocking particles or spraying the air with seawater.[8] However, these tactics would be very large, costly, and potentially harmful in other ways. Moreover, climate engineering would leave high levels of carbon dioxide in the atmosphere, which inevitably leads to higher levels of carbonic acid in the oceans and other bodies of waters. Acidification would destroy corals and marine life, upon which we all depend.[7]

Carbon capture and storage (CCS) is another technology that will not work. Although CCS targets greenhouse gases, it has too many significant shortcomings, as shown in a recent Greenpeace report.[10] CCS's problems are so profound as to make one think that long-term storage of nuclear wastes is safe and cheap (but only by comparison).

- CCS can't be delivered in time to avert the worst aspects of global climate change.
- CCS degrades power plant efficiency, thus requiring the plant to consume more coal.
- CCS is expensive and could raise electricity prices by 21 to 91 percent.
- Safe and permanent storage cannot be guaranteed. Even a leakage rate of 1 percent per year would undermine the goal of CCS.
- A fast release could be lethal. (On August 21, 1986, the natural and sudden release of carbon dioxide from Lake Nyos in the Cameroon killed 1,700 people.8)
- Stored carbon dioxide can seep into and acidify soils and groundwater.
- Industry is unwilling to shoulder the severe liability risks of CCS. They are asking the public to assume those risks.

- Coal, unmined and unburned, could continue to safely store its carbon into millennia to come.

President George W. Bush in his 2003 State of the Union address announced a $1.2 billion program to develop hydrogen-fueled cars, whose tailpipes would only emit water. Many experts recognize severe flaws in this approach. [9,10] (This administration recently attempted to defund this project; special interests persuaded Congress to restore these funds.) The most salient problems are the following:

- There are two potential sources of hydrogen, natural gas and water electrolysis. Using natural gas forgoes its better uses; the process would also emit carbon dioxide. With electrolysis, only 30 percent or less of the primary energy would be delivered to wheels.
- It is unlikely that we would develop the required hydrogen infrastructure in the next decades.
- Hydrogen is very dangerous and it is difficult to store and transport.

There Are Better Answers!

The good news is that these answers actually reduce air, water, and land pollution, improve the U.S. balance of payment deficits, provide jobs, and cost less.

Conservation displaces the need for dirty fossil and nuclear energy and costly alternatives. More efficient buildings as required under section 201 of the current U.S. House energy bill could more than eliminate the need to build 100 new nuclear power plants.[11] Appropriate technologies (or simple choices) include:

- More efficient lighting. Compact fluorescent lamps use 25 percent of the power of conventional lamps and last longer. Light-emitting diodes (LED)are on the threshold of providing that light with only 17 percent of that power and last even longer.[12]
- Automatic occupancy and daylight sensors reduce lighting loads by more than 50 percent.
- More efficient appliances cut electrical usage,[16] provided they are not too large for the need.
- Reduce “vampire” loads, such as always-ready televisions, phone chargers, etc.
- Appropriately sized dwellings and workplaces consume less energy than mansions and the like.
- Carpooling, transit, walking, and bicycling are far more efficient that the current practice of each person driving. This would also reduce road congestion, eliminating the need for new or expanded roads.
- The Obama administration’s mandate for more efficient cars and trucks beginning in 2012 will obviously help.

We could avoid releasing soot (black carbon and other particles) that now emanates from coal smokestacks and diesel engines. As well as harming our health, soot may account for 12 percent or more global warming by increasing sunlight absorption, especially on glaciers at high latitudes and altitudes.[13] Because soot naturally decays much faster than other pollutants like carbon dioxide, limiting soot would moderate global warming faster. The Environmental Protection Agency (EPA) should add soot to its list of drivers of global warming.

Mature forests provide stable carbon storage.[14]

Getting Green by Being Green

Since coal is the primary fuel for 60 percent of the electrical energy in our area, saving electricity means being green—from less mountaintop removal mining to global climate change. Burning less fuel oil and natural gas to heat our homes also reduces environmental harm. Fortunately, there are federal and Maryland incentives for saving energy.

The 2009 American Recovery and Reinvestment Act (also known as the "stimulus bill") provides a 30 percent tax credit of up to $1,500 through 2010 for homeowners to make their houses more efficient, including new windows, door, insulation, and heating equipment. In addition, there is an unlimited 30 percent tax credit through 2016 for installing solar or wind systems and geothermal heat pumps. There are also attractive tax deductions for owners of commercial buildings. For details, see energystar.gov/taxcredits.

There are many programs through the 2007 Empower Maryland legislation that incentivize individuals and businesses to save energy. Contact your local electric utility to learn more about these grants:
BGE: http://bgesmartenergy.com/
PEPCO and Delmarva Power: https://energywiserewards.pepco.com/ (includes a free digital thermostat)
SMECO: http://www.smeco.coop/save/
Allegheny Power: http://www.alleghenypower.com/EngConserv/MD/ResEECMd.asp

A database of incentives for renewables and efficiency is here: http://www.dsireusa.org/

Solar and wind energy has far less environmental costs than coal, other fossil fuels, and nuclear energy.

Algae-grown biofuels could be extremely efficient in terms of life cycle costs and land-use requirements, especially compared to corn-derived ethanol.

Since energy consumption is the product of per-capita consumption times population, limiting population growth reduces one factor of that equation.

Although pending climate legislation may raise the out-of-pocket cost of energy per kWh or gallon of fuel, each of us can reduce the amount we spend for energy and mitigate our environmental footprint by using less energy. See sidebar, Getting Green by Being Green, to learn about some of the many grants and tax benefits available.

Technology is something that defines us a human. We should choose a set of technologies that will serve humanity and our connection to the earth.

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[1] Even as nuclear energy exploits mass energy relativity, it neither repeals the laws of thermodynamics nor lessens their influence.

[2] National Academies, "Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use," 2009

[3] Appalachian Voices Staff, June 2002 ($120 / 2000 pounds x 1 kWh / pound-coal = 6¢)

[4] Greenpeace staff, "The True Cost of Coal," 12/08 (mining environmental cost of 674 Euros with 6.2 billion tons produced with conversions computes to $148 / ton or 7.4¢ / kWh)
[5] U.S. Department of Energy (DOE), "Renewable Energy Certificates, Retail Products", May 2008, approximate median price
[6] Buhigg, Charles, "Cleansing the Air at the Expense of Waterways," New York Times, 10/12/09
[7] Blackman, Christine, "Global Warming Tactic Cools Climate But Won't Help Corals," Stanford University News, 7/2/09
[8] Science Magazine, 4/10/1987
[9] Romm, J., "The Hype about Hydrogen," Issues online in Science and Technology, 2007
[10] Chu, Steven, quoted in Climate Progress, 5/7/09
[11] Mazria, Architecture 2030 Bulletin, 7/23/09
[12] U.S. DOE, "Transforming the Lighting Landscape," see www.lightingprize.org, 2009
[13] Jacobson, Mark (professor of civil and environmental engineering at Stanford University), U.S. EPA Testimony, May 18, 2009
[14] Homer-Dixon, Thomas, "Our Panarchic Future," Worldwatch, May / June 2008