Case Study Title: Energy, Electricity, and Environment: The global struggle for power

Article Information:

Global tension pushes oil to record
Barbara Hagenbaugh
USA TODAY July 14, 2006
Money
USA TODAY page number: 1B

Midwest farms reap benefits of ethanol boom
Judy Keen
USA TODAY October 2, 2006
News
USA TODAY page number: 10A

Cows power plan for alternative fuel
Martha T. Moore
USA TODAY December 4, 2006
News
USA TODAY page number: 11A

What's heating the Earth? Fossil fuels are to blame, world scientists conclude
Patrick O'Driscoll and Dan Vergano
USA TODAY January 31, 2007
News
USA TODAY page number: 1A

Biomass plants find power in poop
Paul Davidson
USA TODAY February 9, 2007
Money
USA TODAY page number: 4B

Summary Statement:

In today's world, a nation's power can be measured in kilowatts. Industrial strength and political influence are tied to energy production and consumption. Developed countries annually consume forty times more kilowatt-hours (kWh) of electricity than their less developed counterparts. As the global energy addiction increases, the stakes are rising: power, as we know it, is running out.

"Black gold" has dominated global power dynamics for a century. Like the California Gold Rush, discoveries of "black gold" caused great wealth and great rivalry, creating global instability in the race to secure this coveted resource. What is this "black gold"? We call it oil. We use it to fuel our cars, to light our homes, and to make a myriad of plastics and pharmaceuticals. The extent of our dependence on oil cannot be overstated—the average American uses 1050 gallons of oil annually.

Soon, countries will no longer be able to drill their way to prosperity and power because 90% of the world's oil has already been found. As the era dominated by "black gold" speeds to a close, the search is on for alternatives. Some sources, including tidal, solar and geothermal, are already in use but not sufficiently developed or implemented on a large enough scale to keep pace with our needs. By replacing fossil fuels with sustainable energies, we not only reduce greenhouse gas emissions, we save an irreplaceable resource for more important future needs.

Microbiologists understand that sometimes the biggest jobs can be left to the planet's smallest creatures. Bacteria have been breaking down organic matter for eons. What many people don't know is that these bacteria can do even better—they can turn waste into *power*. When bacteria consume organic matter, they expel leftover electrons. This natural process gives new meaning to the phrase "One's trash is another's treasure." When we supply an electrode onto which bacteria dump unwanted electrons, we have electricity. A microbial cell the size of a septic tank can supply the energy needs of an entire household.

Microorganisms can also convert organic compounds such as plant matter into energy sources by a process called fermentation. The by-products of fermentation are biofuels: ethanol, methane, or hydrogen. Humans have been utilizing this process to make ethanol for centuries—mainly for alcoholic beverages. Ethanol is an energy-efficient fuel, is 95% free of greenhouse gas emissions, and is currently made from corn. However, as the ethanol demand rises, the practice of making it from corn becomes less practical for two reasons. First, land is a limiting factor—running all of the world's cars on biofuels would require doubling existing farmland. Another even greater downfall in farming corn for fuel: corn is food. It is a staple in some countries including Mexico, where corn prices have already risen. While some landowners can grow corn to power their personal vehicles, most of us are stuck with a decision: either come up with another solution or literally drive off with someone's dinner. And so, the search is on.

Discussion Questions:

1. Perpetual motion machines that create energy for free have appeared in drawings since the 8th century. In the 1500s, Leonardo da Vinci devised the chimney jack that rotated due to the effect of hot gases flowing up a chimney. It looked like a spit turned by hot air. He hoped this would create energy for free. Explain why generating energy for free is not possible according to the Laws of Thermodynamics.

2. Electric cars can reduce the emission of greenhouse gases. Why do these vehicles not reduce our consumption of energy?

3. Select one energy source for a fictional country and explain what happens to it between its collection and its use by the citizens. Identify one disadvantage of your choice. How will you mitigate this disadvantage?

4. Although fuel and electricity prices fluctuate, a snapshot of electricity-generating costs is given below. What factors need to be considered before a country makes a commitment to switch from oil to an alternative energy source?

Fuel	Cost per kilowatt-hour
Oil	$0.12
Solar	$0.21
Nuclear	$0.03
Wind	$0.10
Biomass	$0.07

5. Electrical power is measured in watts, which is the energy consumed to do a task (1 watt=1 joule/second). Data from the United Nations for selected countries are given below. In addition to total population, what factors affect a country's energy needs?

Country	Kilowatt-hr consumed per person
United States	13,500
Japan	6600
China	1484
Haiti	73
Somalia	33

Future Implications:

Energy use in industrialized countries increases about 1% annually. Developing countries' consumption is rising faster, as they improve health standards and their economic and political status. Accomplishing these goals requires energy—to desalinate water, irrigate deserts, and manufacture goods. Therefore energy use in developing countries is expected to rise an alarming 3% annually over the next 25 years, causing worldwide energy consumption to skyrocket. Finite oil reserves as well as the global temperature increase mandate that we consider biofuels not as alternative energy, but as absolutely essential. Biodegradable wastes provide a renewable energy resource. Moreover, because every country generates organic waste, biofuels produced from this waste could even eliminate political power struggles resulting from competition for oil.

Many communities are already using landfill and garbage to produce methane, replacing natural gas. Agricultural waste—including animal excrement and plant parts such as corn stalks, sugar beet leaves, and rice hulls—has no nutritional value to humans and is still packed with energy. This material is mostly cellulose. Scientists are investigating bacteria in the guts of cows and termites that digest cellulose. With 430 million tons of waste biomass produced on U.S. farmland annually, we can be sure we're barking up the right tree.

Additional Resources:

"Energy's Future: Beyond Carbon." *Scientific American* 295(3), September 2006. An entire issue with articles on renewable energy, alternative fuels, transportation, and greenhouse gases..

Hinrichs, R. A. and M. Kleinbach. *Energy: Its Use and the Environment*, 4th ed. Belmont, CA: Thomson Brooks Cole, 2006.

International Energy Agency. An advisory agency for nations; includes energy statistics and projections. <http://www.iea.org>

National Renewable Energy Laboratory. Includes basic science and electricity and the virtual National Bioenergy Center. <http://www.NREL.gov>

U.S. Department of Energy. Provides information on energy sources, consumer help, and the national policy. <http://www.energy.gov>

Withgott, J. and S. Brennan. *Environment: The Science Behind the Stories*, 2nd ed. San Francisco: Benjamin Cummings Publishing Co., 2006.