Friday 23 February 2006, 19th class meeting
(Miller Chapter 10, National Geographic [coal])
Environmental Biology (ECOL 206)
U. Arizona, spring 2006
Kevin Bonine, Ph.D.
Alice Boyle, Kristen Potter, Graduate TAs

1. Energy (Miller Ch. 10)
2. Lecture schedule updates on your website
3. 206 Lab Website for handouts and assignments
   Lab 21-24 Feb, Meet 5 side BSE (4th and Highland)
   Lab next week in the normal lab room (KOFFL410)
4. Mt. Lemmon this weekend

Mt. Lemmon this weekend...
Saturday 25 Feb
Lab 1 and 2
Sunday 26 Feb
Lab 3 and 4
Meet 0700h at S side of BSE (corner of 4th and Highland)
"Be on time or get left behind."
Return around 1800h to campus

Please Bring:
Food (snack and lunch)
Water (you will bring big jug for refills)
Hat
Clothes for variable weather conditions. Top it might be in the 30s F and raining or snowing.
Be prepared to enjoy yourself no matter the weather.

Small Notebook, Writing Instruments, Handout from 206 lab website
Sunscreen?
Binoculars?
Camera?
Money?
Please don’t bring personal music devices etc. We will be interacting as a group all day.

Current Events?
Scientific Articles?

Arizona Daily Star
Published: 02.22.2006
Pooches’ poo to help power Frisco
THE ASSOCIATED PRESS
SAN FRANCISCO — City officials are hoping to harness the power of dog doo-doo.
San Franciscans already recycle two-thirds of their garbage, but in this dog-friendly town, animal feces make up nearly 4 percent of residential waste, or 6,500 tons a year — nearly as much as disposable diapers, according to the city.

Within the next few months, Norcal Waste, a garbage hauling company that collects San Francisco’s trash, will begin a pilot program under which it will use biodegradable bags and dog-waste carts to pick up droppings at a popular dog park.

The droppings will be tossed into a contraption called a methane digester, which is basically a tank in which bacteria feed on feces for weeks to create methane gas. The methane could then be piped directly to a gas stove, heater, turbine or anything else powered by natural gas. It also could be used to generate electricity.

Methane digesters are nothing new. The technology was introduced in Europe about 20 years ago, and more than 900 farm-based digesters are in operation there. Nine are in use on California dairy farms, and chicken and hog farms elsewhere in the United States also use them.

Neither Norcal Waste spokesman Robert Reed nor Will Brinton, a Maine-based recycling and composting consultant, knew of anyone in the United States who is using the $1 million devices to convert pet waste to energy. But Brinton said some European countries process dog droppings along with food and yard waste.

"The main impediment is probably getting communities around the country the courage to collect it, to give value to something we’d rather not talk about," Brinton said. "San Francisco is probably the king of pet cities. San Francisco — the city named after St. Francis, patron saint of animals — has an estimated population of 440,000 dogs and cats.

Pooches’ poo to help power Frisco

Energy (Ch 10)

- Solar 99% (not in market place)
- Commercial 1% (82% nonrenewable)
  (incl. indirect solar: wind, water, biomass)

NonRenewable Energy

U.S. 4.6% population, 24% commercial energy
India 16% population, 3% commercial energy
1. Availability
2. Net Energy
3. Costs to Develop
4. Subsidies, Tax Breaks
5. National Security
6. Terrorism
7. Environment, Climate, Human Health

Net Energy
1. Find
2. Extract
3. Transfer
4. Process
5. Transport
6. Burn

Energy Efficiency
- Lightbulbs
  Incandescent vs. Fluorescent
- Hybrid Cars
  Fuel Efficient and Battery
  80-300 miles/gallon
- Hydrogen Cells (cars etc.)
  \( \text{H}_2 + \text{O}_2 = \text{energy} + \text{H}_2\text{O} \)
- Cogeneration (heat and power)
- Electric Motors

U.S. Energy Sources
Solar - passive or active
Hydrogen - (green algae?) need to decompose water
Hydropower
Wind
Biomass
Geothermal
Fossil Fuels
- Oil
- Natural Gas
- Coal
Nuclear

Energy Sources

U.S. Flow of Energy

Net Energy
- 2nd Law of Thermodynamics

Energy Efficiency
- 2nd Law of Thermodynamics

Figure 6.3: Shifts in the use of commercial energy resources in the United States since 1900, with projected energies to 2100. Shifts from wood to coal and then from coal to oil and natural gas have each taken about 50 years. The projected shift to 2100 is only one of many possible scenarios depending on a variety of assumptions. (Data from U.S. Department of Energy)
Fossil Fuels
- Oil
- Natural Gas
- Coal

When you turn up the AC, think of Gibson and the grimy fuel it devours at the rate of three 100-car trainloads a day.

WHO HAS COAL? The world has more than a billion tons of readily available coal. This U.S. has the largest share, but of all energy sources currently, oil and electricity are rapidly in demand.

<table>
<thead>
<tr>
<th>Source</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>25%</td>
</tr>
<tr>
<td>Russia</td>
<td>10%</td>
</tr>
<tr>
<td>China</td>
<td>10%</td>
</tr>
<tr>
<td>India</td>
<td>5%</td>
</tr>
<tr>
<td>Australia</td>
<td>2%</td>
</tr>
</tbody>
</table>

WHO USES COAL NOW? Coal is the world's largest source of energy. It is used for power, heat, and industrial processes. Its production and consumption are expected to increase in the future.

<table>
<thead>
<tr>
<th>Country</th>
<th>Consumption (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>850 million</td>
</tr>
<tr>
<td>India</td>
<td>1.26 billion</td>
</tr>
<tr>
<td>Japan</td>
<td>1.0 billion</td>
</tr>
<tr>
<td>Russia</td>
<td>500 million</td>
</tr>
</tbody>
</table>

WHO WILL USE IT TOMORROW? Coal is expected to remain the dominant source of energy in the world for the foreseeable future.

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>50%</td>
</tr>
<tr>
<td>Gas</td>
<td>25%</td>
</tr>
<tr>
<td>Oil</td>
<td>20%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>5%</td>
</tr>
</tbody>
</table>

Arctic National Wildlife Refuge (ANWR)
- 1/5 land in wildlife refuge system
- 19% chance of finding enough oil to supply U.S. for 24 months
- Persian Gulf cheaper
- Fuel efficiency better route
- Lots oil spills likely
- Pipelines vulnerable
- Fragile tundra
- Impact acreage

U.S. ELECTRICITY GENERATION

<table>
<thead>
<tr>
<th>Source</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>20%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>15%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>10%</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>10%</td>
</tr>
<tr>
<td>Oil</td>
<td>15%</td>
</tr>
</tbody>
</table>

U.S. CO2 EMISSIONS

<table>
<thead>
<tr>
<th>Source</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>60%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>20%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>15%</td>
</tr>
<tr>
<td>Renewable Energy</td>
<td>5%</td>
</tr>
<tr>
<td>Oil</td>
<td>5%</td>
</tr>
</tbody>
</table>

WHAT'S IN COAL SMOKY?
- The sulfur in coal forms a gas, which contains toxic elements.
- Sulfur can react with water to form acid rain.
- Sulfur can also react with oxygen to form sulfur dioxide.

OIL VS. COAL

- Oil is cleaner and easier to transport.
- Coal is cheaper and more abundant.
- Oil provides more energy per unit of mass.
- Coal produces more CO2 per energy unit than oil.

CARBON DIOXIDE

<table>
<thead>
<tr>
<th>Source</th>
<th>CO2 Emissions per Unit of Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>20%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>15%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>10%</td>
</tr>
<tr>
<td>Oil</td>
<td>5%</td>
</tr>
</tbody>
</table>

MINISTRY

The heat of power-plants to and forms the air co2 emissions are.

Fossil Fuels
- Oil
- Natural Gas
- Coal
Costs not included:
- > $300 billion/year
- Foreign military intervention
- Terrorism
- Habitat destruction
- Oil spills
- Health care (smog, accidents, poor fitness)
- Climate change (sea level, global warming)
- etc.

= $600 billion/year

Subsidized:
- > $300 billion/year

Fossil Fuels

Price of Gas

Fossil Fuel Dependence

Precautionary Principle

Hydrogen as fuel

Nuclear Energy

Accidents catastrophic?

Chernobyl, Three-Mile Island

What to do with
Radioactive Waste?
- 10k-240k years
- bury it (ground)
- bury it (ice)
- bury it (ocean)
- shoot into space
- descending subduction zones

Yucca Mountain, NV
- leaks, faults, volcanoes
- 6 shipments/day for 30 years

Nuclear Weapons

Yucca Mountain Potential Leaks...
Yucca Mountain

- Number of people in Arizona that live within 1 mile of a nuclear transportation route: 448,024
- Schools within 1 mile of the proposed route in Arizona: 212
- Hospitals within 1 mile: 11
- Fatal tractor-trailer wrecks in Arizona 1994 to 2000: 513
- Train wrecks in Arizona 1990-2001: 762
- Nuclear waste shipments in Arizona over the life of the project:
  - If by truck: 102,018 metric tons
  - If by train: 13,078 metric tons
- Nuclear waste in Arizona now: 1,045 metric tons
- Nuclear waste in Arizona if Yucca Mt. Project proceeds to completion: 1,899 metric tons.

The Department of Energy’s worst-case scenario predicts 48 radiation-induced deaths in a terrorist incident and 5 radiation-related deaths in a serious truck accident. Other experts estimate thousands of deaths over time if the release is in an urban area. First responders, local police, fire, and hazardous materials response teams could easily be exposed to lethal doses of radiation. Billions of dollars and many years could be required to clean up the area. Transportation routes, including major interstates and train lines could be closed for months.

“The important thing now is to recognize that there is no immediate crisis, that there is time to do this and to do a good and responsible job in terms of safety and security and to do it at a much lower cost to ratepayers.” – Former Nuclear Regulatory Commission, Commissioner Victor Gilinsky, testimony before the U.S. Senate Energy and Natural Resources Committee hearing, May 22, 2002.

What to Do??
- Free Market, Subsidy, Tax
- Efficiency
- Renewable
- Include all costs in analyses

END