CENG301 Project  
Fall 2004

<table>
<thead>
<tr>
<th>Coal</th>
<th>Ultimate Analysis, weight %, dry ash-free basis</th>
<th>Ash (wt% dry basis)</th>
<th>Heating Value (Btu/lb, dry basis)</th>
<th>Moisture kg/100 kg dry coal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>H</td>
<td>O</td>
<td>N</td>
</tr>
<tr>
<td>Beulah-Zap</td>
<td>72.94</td>
<td>4.83</td>
<td>20.34</td>
<td>1.15</td>
</tr>
<tr>
<td>Blind Canyon</td>
<td>80.69</td>
<td>5.76</td>
<td>11.58</td>
<td>1.57</td>
</tr>
</tbody>
</table>

Sulfur Dioxide Scrubber:

- Do problems 14.1 through 14.20 for one of these two types of coals.
- Compute the cost of scrubbing per kWh produced if the amount of SO\(_2\) released must be controlled to meet both the EPA standard and the 90% removal standard.
- Compute the amount of CO\(_2\) (in kg) that will be released for each kWh produced.

DATA:

- The Beulah-Zap coal comes from a mine located about 8 miles NW of Beulah, ND (Mercer County). It costs $4 per ton at the mine.
- The Blind Canyon coal comes a mine located about 150 miles SE of Salt Lake City, UT (Emery County). It costs $6 per ton at the mine.
- The power plant is located in Fort Bend County, TX, near the Brazos Bend State Park.
- The transportation cost for the coal is 2 ¢/(ton ∙ mile) and the cost for limestone is 20 $/ton (delivered to the plant).

CONSERVATION:

Since the majority of the SO\(_2\) produced from human activities comes from coal combustion in electric power plants, any reduction in our use of electricity will result in reductions of SO\(_2\) emissions. Here we will examine the effectiveness and cost of two electricity conservation approaches.

The largest power plant in Texas is the W. A. Parish plant located in Fort Bend County. It has four coal-fired generators with a total capacity of 2,620 MW. It also has four gas-fired generators and one gas turbine generator that bring the overall capacity of the plant to over 3,800 MW and make it the largest fossil-fuel plant in the U.S. For the sake of simplicity, we will assume that all the power produced by the four coal-fired units of this plant is used to serve the Houston area and that these units operate at an average of 90% of their capacity throughout the year.
CONSERVATION APPROACHES:

1. Conserve electrical energy by replacing all incandescent lamps in our homes with fluorescent lamps.

   • Assume that residential users consume 36% of the produced electricity and that 7% of that amount is used for lighting.
   • Assume that all lighting comes from 60W incandescent lamps and that every such lamp is on for an average of 6 hours every day. Calculate how many incandescent lamps in Houston are powered by the coal-fired units.
   • Assume that all incandescent lamps (IL) will be replaced by 15W fluorescent lamps (FL) over a period of five years. That is, 20% of the IL’s are replaced with FL’s at the beginning of the first year, another 20% at the beginning of the second year, and so on. A 15W FL has the same light output (lumens) as a 60W IL.
   • A 15W fluorescent lamp costs $6.99 and has an average life of 10,000 hours. A 60W fluorescent lamp costs $0.87 ($3.49 for a pack of 4) and has an average life of 1,000 hours.
   • Calculate the cost for (a) replacing all incandescent lamps with fluorescent ones over 5 years, and (b) operating the mix of incandescent and fluorescent lamps for 5 years. How much does it cost to operate incandescent lamps for 5 years?
   • How much will we reduce the amount of SO$_2$ (in tons) released by the coal-fired plants over a period of five years if we replace all incandescent bulbs with fluorescent ones?
   • What is the cost per ton of SO$_2$ saved? Here the total cost is the difference between the total amount spent to buy and run fluorescent bulbs and the corresponding total amount spent for incandescent bulbs (status quo).

2. Conserve electrical energy by replacing all current air conditioning (AC) units with new, higher efficiency units.

   • Assume that residential users consume 36% of the produced electricity and that 30% of that amount is used for air conditioning.
   • Assume that a conservation program is introduced to replace 100,000 residential A/C units every year with new, higher efficiency units. The old units have an average cooling capacity of 4 tons (48,000 Btu/hr) and an average SEER rating of 9. The new units have the same cooling capacity and an average SEER of 13. The A/C units operate an average of 1,400 hours every year.
   • With an average electricity cost of $0.091 per kWh, calculate the cost of operating 500,000 old 9 SEER units for 5 years.
   • Calculate the 5-year cost for (a) replacing 100,000 old units per year with 13 SEER units, and (b) operating the 500,000 old and new units for five years. Note that the 1st year you have 100,000 new 13-SEER units and 400,000 old 9-SEER units, the 2nd year you have 200,000 new 13-SEER units and 300,000 old 9-SEER units and so on.
   • How much will this program reduce the amount of SO$_2$ (in tons) released by the coal-fired plants over a period of five years?
   • What is the cost per ton of SO$_2$ saved? Here the cost is the difference between the amount to progressively replace these units with 13-SEER units and the amount spent to operate 500,000 9-SEER A/C units.