Coal
Basics

Oldest form of fossil fuels, both in age (up to 350 million years) and in use

Largest reserves of the fossil fuels

We know coal supplies well, both globally and in US... most coal is within a few hundred feet of the surface... easily mapped.

Current R/P is about 400 years.
## Types of coal

<table>
<thead>
<tr>
<th>Type</th>
<th>Age</th>
<th>% Carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracite</td>
<td>350</td>
<td>95</td>
</tr>
<tr>
<td>Bituminous</td>
<td>300</td>
<td>50-80</td>
</tr>
<tr>
<td>Lignite</td>
<td>150</td>
<td>up to 50</td>
</tr>
</tbody>
</table>
Figure 1. United States Coal Production, 1890 – 2005

## World coal reserves

<table>
<thead>
<tr>
<th>Country</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former USSR</td>
<td>56</td>
</tr>
<tr>
<td>United States</td>
<td>20</td>
</tr>
<tr>
<td>Asia (mostly China)</td>
<td>10</td>
</tr>
<tr>
<td>Canada</td>
<td>8</td>
</tr>
<tr>
<td>Western Europe</td>
<td>5</td>
</tr>
</tbody>
</table>

Everywhere else less than 1% per country
Russia, US and China have most of the coal (about 85%)… poorly distributed

Russia has natural gas and nuclear, has been using relatively little coal… but that is changing as nuclear energy becomes more unreliable.
Issues

*China relies heavily on coal…*

• 75% of energy from coal

• is 2\textsuperscript{rd} largest energy consumer worldwide

• produces 10 to 15% of CO₂ emissions, 2\textsuperscript{nd} only to United States (will be 1\textsuperscript{st} in a few years)

• most coal burned locally (home fires)… very hard to clean up
Coal consumption and rapidly developing economies

Top Consuming Countries, 2004

<table>
<thead>
<tr>
<th>Country</th>
<th>Billion Short Tons</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>2.06</td>
</tr>
<tr>
<td>United States</td>
<td>1.11</td>
</tr>
<tr>
<td>India</td>
<td>0.48</td>
</tr>
<tr>
<td>Germany</td>
<td>0.28</td>
</tr>
<tr>
<td>Russia</td>
<td>0.28</td>
</tr>
<tr>
<td>Japan</td>
<td>0.20</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.20</td>
</tr>
<tr>
<td>Poland</td>
<td>0.15</td>
</tr>
<tr>
<td>Australia</td>
<td>0.15</td>
</tr>
<tr>
<td>Greece</td>
<td>0.08</td>
</tr>
<tr>
<td>Ukraine</td>
<td>0.08</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.07</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0.07</td>
</tr>
<tr>
<td>North Korea</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Coal by country time trends

Selected Countries, 1980-2004

- China
- United States
- India
- Germany

Billion Short Tons

US coal reserves
US coal reserves

Appalachian Coal Region:
• Annually produces about 35% of total U.S. coal production.
• Large underground mines and small surface mines.
• Coal mined in the Appalachian coal region is primarily used for steam generation for electricity, metal production, and for export.

Interior Coal Region:
• Annually produces approximately 13% of total U.S. coal production.
• Mid-sized surface mines.
• Mid- to large-sized companies.

Western Coal Region:
• Annually produces about 52% of total U.S. coal production.
• The State of Wyoming (number one coal state) accounts for over 30% of total U.S. coal production.
• Large surface mines.
• Largest coal mines in the world.
US coal: exports and imports

Exports dropping
And imports increasing

Figure 8. U.S. Coal Export and Imports, 1996-2005
(Million Short Tons)

Uses of coal

In industrialized countries coal is mostly used in industry and in the generation of electricity.

Not very useful in transportation today
  Electric cars?

Residential and commercial use can be met via electricity.
Coal and electricity

Figure 4. Share of Electric Power Sector Net Generation by Energy Source, 2004 vs. 2005

Source: Energy Information Administration, Form EIA-906, "Power Plant Report."
Coal prices are increasing as demand rises.

**Figure 6. Delivered Coal Prices, 1996-2005**
(Nominal Dollars)

Coal and pollution

Purer coal has fewer impurities (like sulfur), so it pollutes less

Abundance in US does not match purity:

<table>
<thead>
<tr>
<th>Type</th>
<th>% abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthracite</td>
<td>1</td>
</tr>
<tr>
<td>Bituminous</td>
<td>71</td>
</tr>
<tr>
<td>Lignite</td>
<td>28</td>
</tr>
</tbody>
</table>
Coal and pollution

Other than CO₂, which we will discuss later...

Sulfur oxides

Sulfur oxides yield sulfuric acid when exposed to vapor in the atmosphere..

• Acid rain
• Sulfur oxides are the primary cloud-condensing nucleus in the atmosphere...
Humans and SO$_2$

Humans make more SO$_2$ than do ocean plants, the non-anthropogenic source.

Human SO$_2$ dominates on the continents (more than 90% of all SO$_2$ over continents comes from humans).
SO$_2$ regulation

Sulfur oxides emissions in North America are slightly decreasing even though coal burning is increasing... sulfur trading emissions scheme in North America...

can this work for CO$_2$ worldwide?... what are the differences?...the similarities?
Coal R/P: 400 yrs, no growth in use
Coal R/P: 400 yrs, 3% growth in use

Note the scale change!
Coal R/P: 400 yrs, 3% growth in use, replaces oil 2025-2035

Note the scale!
Coal… the bottom line

Even coal, our most abundant fossil fuel, cannot withstand growth in energy demand

Options:
- Reduce demand
- Develop alternatives

- Others?
- What are the consequences for each?