Energy and Sustainability
How much energy do you need?
How much energy do you use?
Energy

How much energy do you need?

• Energy from food

  = 2,000 Calories / day
  = 8,000 BTUs / day

• Energy for all of the other things you do

  = (Take a guess) _______________ BTUs?
Total annual energy consumption in the United States (2011)

97.3 quadrillion BTUs

\[ \sim 10^{17} \text{ BTUs} \]

\[ \sim 10^{20} \text{ Joules} \]

(1 BTU = 1055 Joules)
Total U.S. energy consumption

\[ = 97 \times 10^{15} \text{ BTUs / year} \]

Then your energy consumption / day is

\[
\frac{97 \times 10^{15} \text{ BTUs / year}}{(316,000,000 \text{ people}) \times (365 \text{ days / year})}
\]

\[= \frac{840,000 \text{ BTUs / person / day}}{\text{ ( + 8,000 BTUs from food )}} \]
So, if you are a typical U.S. resident, you will use about 848,000 BTUs of energy today.

Food: 8,000 BTUs

For all other things: 840,000 BTUs

How much?
### U.S. Energy Uses

**Sector**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Power</td>
<td>40%</td>
</tr>
<tr>
<td>Transportation</td>
<td>28%</td>
</tr>
<tr>
<td>Industry</td>
<td>21%</td>
</tr>
<tr>
<td>Res &amp; Commercial</td>
<td>11%</td>
</tr>
</tbody>
</table>

**Total** (97 quads) 100%

Your energy use = Direct use + Indirect use
U.S. Energy Sources

By Major Source, 2011

- Petroleum: 35 quadrillion Btu
- Natural Gas: 25 quadrillion Btu
- Coal: 20 quadrillion Btu
- Renewable Energy: 9 quadrillion Btu
- Nuclear Electric Power: 8 quadrillion Btu
### U.S. Renewable Energy

#### Source (quads)

<table>
<thead>
<tr>
<th>Source</th>
<th>Quads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroelectric</td>
<td>3.2</td>
</tr>
<tr>
<td>Wood</td>
<td>2.0</td>
</tr>
<tr>
<td>Biofuels</td>
<td>1.9</td>
</tr>
<tr>
<td>Wind</td>
<td>1.2</td>
</tr>
<tr>
<td>Waste</td>
<td>0.5</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.2</td>
</tr>
<tr>
<td>Solar / PV</td>
<td>0.2</td>
</tr>
</tbody>
</table>

**Total (quads)** 9.1

Renewables are ~ 9% of U.S. Total Energy Consumed
World Energy Consumption

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>35%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>24%</td>
</tr>
<tr>
<td>Coal</td>
<td>28%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>6%</td>
</tr>
<tr>
<td>Hydro</td>
<td>6%</td>
</tr>
<tr>
<td>Renewable</td>
<td>2%</td>
</tr>
</tbody>
</table>

Total 510 quads

= 200,000 BTUs / person / day
Personal Consumption

BTUs / person / day

United States 840,000
Australia 718,000
France 498,000
Japan 440,000
Mexico 157,000
China 130,000
Brazil 84,000
India 36,000
Parts of Africa 7,000
Human Population of Planet Earth (Billions)
Human Population of Planet Earth (Billions)

Year

Billions of People


0 2 4 6 8 10
How much energy do we have left?
## Energy Reserves

Estimated world reserves of fossil fuels (in quadrillion BTUs):

<table>
<thead>
<tr>
<th></th>
<th>Reserves</th>
<th>Quads consumed per year</th>
<th>Years left at current consumption rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>6,370</td>
<td>178</td>
<td>36</td>
</tr>
<tr>
<td>Natural gas</td>
<td>6,390</td>
<td>121</td>
<td>53</td>
</tr>
<tr>
<td>Coal</td>
<td>20,250</td>
<td>143</td>
<td>142</td>
</tr>
</tbody>
</table>
Are there any other problems?
The Carbon Problem

Fuels:

- Oil: 35%
- Natural Gas: 24%
- Coal: 28%
- Nuclear: 6%
- Hydro: 6%
- Renewable: 2%

510 Quadrillion BTUs / year

Atmospheric Concentration of Carbon Dioxide (1744-2005)
The Carbon Problem

Global Fossil Carbon Emissions

Million Metric Tons Carbon/Year

- Total
- Natural Gas
- Oil
- Coal
- Cement
- Gas Flaring

1800 1850 1900 1950 2000
The Carbon Problem

Where humanity’s CO₂ comes from:
- 91% 33.4 billion metric tonnes (Fossil Fuels & Cement, 2010)
- 9% 3.3 billion metric tonnes (Land Use Change, 2010)

Where humanity’s CO₂ goes:
- 50% 18.4 billion metric tonnes (Atmosphere, 2010)
- 26% 9.5 billion metric tonnes (Land, 2010)
- 24% 8.8 billion metric tonnes (Oceans, 2010)
Green Strategies

Conservation
Efficiency
Geothermal
Solar
  • Passive
  • Photovoltaic
Fuel cells
Tidal
Wind
Waves
Hydroelectric
Nuclear
Biomass