And How Bad Is It Going To Get? Some Projections for the Future.

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GCEP Orientation
POPULATION=ENERGY DEMAND

- WOOD – Cooking, Heating, Pottery, Metallurgy – Charcoal
- HUMAN POWER – Pyramids
- ANIMAL POWER – Horses, Oxen
- WATER POWER – MILLS
- WIND POWER – MILLS

- THEN CAME THE STEAM ENGINE
STEAM ENGINE

- James Watt ---- Watt is unit of Power

1712, Thomas Newcomen

1769 Watt Improves Engine
Steam Powered Locomotives

- Early 1800s

WOOD FIRED STEAM ENGINES
Coal Fired Steam Engines…
# Heating Values of Carbon Fuels

### Table 15-1

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Heating value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kJ/g</td>
</tr>
<tr>
<td>Wood</td>
<td>17</td>
</tr>
<tr>
<td>Soft coal</td>
<td>23</td>
</tr>
<tr>
<td>Hard coal</td>
<td>35</td>
</tr>
<tr>
<td>Fuel oil, gasoline</td>
<td>44</td>
</tr>
<tr>
<td>Natural gas</td>
<td>54</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>143</td>
</tr>
</tbody>
</table>

Wood, Coal, Gasoline, Natural Gas – MIXTURES.. So they Vary in Heating Content!

Wood 17.5-18.3 – 12% moisture

Gasoline, Kerosene 41-48

Methane – 55.6

Propane 50.3

N-Butane- 49.5
INTERNATIONAL ENERGY AGENCY (IEA) REPORTS…

Good source of Information on Energy Reliance and OIL ISSUES

1. EARTH IS A SPACE SHIP
2. IT HAS SIGNIFICANT – BUT NOT UNLIMITED RESOURCES
3. WERE USING UP OUR NON-RENEWABLE RESOURCES FAST
4. THAT USE IS TIED TO POPULATION INCREASES
5. INCREASE IN POPULATION – INCREASE IN ENERGY DEMAND
6. FOSSIL FUELS CAUSE ENVIRONMENTAL PROBLEMS
7. RENEWABLES…LIMITED RESOURCE


OIL PRODUCTION IS DROPPING OFF.. Price vs Demand.. $$$$$

OGJ, 9 Feb 2004 (Jan-Nov 2003)
Past discovery based on ExxonMobil (2002). Revisions backdated.
ENERGY CONSUMPTION AND POPULATION STRONGLY COUPLED

Global Peak Energy Projections – Two Scenarios
Global peak energy: Implications for future human populations
Energy Usage in 2007

Total: 532 Quads

- 170 Quads Conventional Oil (32.0%)
- 127 Quads Coal (23.9%)
- 112 Quads Natural Gas (21.1%)
- 28.5 Quads Nuclear (5.4%)
- 53 Quads Traditional Biomass (10.0%)
- 28.1 Quads Hydro (5.3%)
- 443 Quads Nonrenewable Sources (83%)
- 89 Quads Renewable Sources (17%)

QUAD = $10^{15}$ BTU

Global Peak Energy Projections – Two Scenarios
Global peak energy: Implications for future human populations
Various Scenarios

• Use Tar Sands and Oil Shale
• Take Coal and Make Synthetic Petroleum
• Use more Coal..
• Natural Gas – similar problem as Oil
• Make Syn-Methane from Coal – requires lots of Water.
• Nuclear Energy – “Regulations” – Started Strong – 107 Nuclear Plants leads the world.. But no new ones since 1978
  Were Behind World Development
  France – Sweden – Japan - Germany
Solar Energy

Southwest and Southern U.S.
Solar may Start to Play Role
Better Batteries...Storage...Night

How Solar Works

Solar panel → Battery (12V) → Inverter (230V) → Various Devices (12V):
- Cooler
- Cell Phone
- Spotlight
- Fan
- Sump Pump
- Laptop
- Fluorescent Lighting
- Television
Drawbacks

• Solar Panels – Mirrors, etc. Require Smelters to process materials – Mirrors or panels susceptible to dirt and dust.
• Processes are still in need of improvement
• SOLAR PANELS IN DESERTS.. Deserts have Sand Storms.. Sand blasted Solar Panels need repair.. And so on.
Biomass – Chemically Trapped Solar Energy

• Photosynthesis. Need water and nutrients and carbon dioxide. CAN LEAD TO WATER QUALITY PROBLEMS DUE TO FERTILIZER and PESTICIDE USE.

• Air pollutants effect uptake by plants

• Ozone, NO₂, SO₂, etc. cause reduction in photosynthesis and plant damage and senescence – Ethylene

• SUSTAINABLE? – Frost, Flood, drought, etc. with changing climate makes that difficult to predict. One year bumper crop. Next year loss.
Sugar Cane vs Corn

• High Sugar Content.. More ETOH
• Search for Enzymes.. Break down cellulose – Switchgrass, Rice Straw Biomaterials may be workable for materials we currently make from petroleum.. Plastics, synthetic cloths, etc.

TRADE OFF --- Food for Fuel?
MORE ON THIS LATER....

- Local generation. i.e. near hot spots – Iceland. Now using energy to make Aluminum there
- Need Energy Storage. Also need to couple with low loss power transmission to make larger scale use.
- Super Conductors
- HOT DRY ROCK. Deep holes –
- Water limiting factor
Hydrogen

- It’s stored electrons.. Hard to contain.
- Reactive
- Good for quick use in Fuel Cell Technology
- NOTE FUEL CELLS are fairly clean, they typically generate $\text{H}_2$ by cracking fuel and then use the $\text{H}_2$ to obtain Electricity in the fuel cell.
- BURNING Hydrogen in Air will produce NOx
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![Graph showing energy projections]

Total Available Energy: Conservative Scenario (Quadrillion BTUs)
- 1800: 445
- 1900: 346
- 2000: 158
- 2100: 116
- 2200: 101

Total Available Energy: Optimistic Scenario (Quadrillion BTUs)
- 1800: 690
- 1900: 397
- 2000: 297
- 2100: 261
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**Population versus Living Standard Tradeoff**

**Conservative Scenario**

**Global Peak Energy Projections – Two Scenarios**

Global peak energy: Implications for future human populations

Population versus Living Standard Tradeoff
Optimistic Scenario

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Supportable Worldwide Population at Today’s Global Average Living Standard
Conservative Scenario

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by Chris Clugston Published on 10 Sep 2007 by Energy Bulletin.
Archived on 10 Sep 2007.
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IF WE KEEP BURNING Carbon

- We will add to Regional Ozone Problems
  NOx – Will act as greenhouse gas and also reduce plant and crop growth.

$\text{CO}_2$ increases and other greenhouse gases are tied to lot of other issues such as agriculture.. If we use biomass.. More fertilizers.. More water problems. Nitrate photolyzes to form NO and NO2 so more regional ozone problems.

Warmer environments favor pests.. Insects, etc. that need to be controlled.. Increased demand by increasing hungry populations will add to that burden.

WATER will be a limiting resource.. So Desalinization methods may help.. But you need energy to get the water clean..

LOTS OF TRADEOFFS .. Difficult Decisions and Need for better, cleaner, and more rational use of fuels and development of sustainable energy strategies at realistic levels..

Conservation.. Also has its problems. As we tighten up homes we move towards indoor air pollution problems such INDOOR RADÔN and INDOOR AIR QUALITY.
NOTE: Current Energy Usage leads to Food being transported globally.
Local production no longer seasonal
  Fresh fruit in stores in Winter
Prices for Food Strongly tied to Energy
Energy Shortage – Food Shortages
Freshwater, etc. tied to energy use.
Were rapidly coming to need for infrastructure evaluations.. And will discuss this later in week!

DISCUSSION?