Energy - sources, availability, demand, affordability, delivery

Sustainability and Water

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What is the problem?

Our energy needs fall into two categories:

• Power
• Transportation

Both are presently dominated by fossil fuels but can be met with a realistic combination of fossil, renewable and nuclear.

The pressing issues:

• Adverse environmental effects of fossil fuel use, particularly the use of coal in power generation is, arguably, the most destructive activity humans can engage in, outside of large-scale war.

• World peak oil (gas and even coal) will be achieved relatively soon
  - oil ~ 2010 (gone by 2065; unc. > 2140)
  - gas ~ 2020 (gone by 2040; unc. > 2120)
  - coal ~ 2050 (gone by 2110)
Present Energy Distribution (World, 2005)

- **Coal**: 8% (California, 21%; New Mexico, 88%)
- **Gas**: 20% (California, 41%; New Mexico, 10%)
- **Nuclear**: 15% (California, 13%; New Mexico, 2%)
- **Hydroelectric**: 17% (California, 17%; New Mexico, 20%)
- **Oil**: 39% (California, 6%; New Mexico, 8%)
- **Other**: 5% (California, 6%; New Mexico, 8%)

Present Energy Distribution (Trans)

- **Petroleum**: 95%
- **Biofuels**: 5%
- **Solar**: 0%
World presently at 15 trillion kWhrs/year

U. S. presently at 4 trillion kWhrs/year

World Power Consumption (trillion kilowatt-hours per year)

historic
projected
1.6 billion people have no access to electricity, 80% of them in South Asia and sub–Saharan Africa.

2.4 billion people burn wood and manure as their main energy source.

3 billion more people will be born by 2040.

Source: ©2005 Kay Chernush for the U.S. Department of State
80% of the world’s population of over 6 billion people is below 0.8 on the U.N. Human Development Index (HDI).

Source: United Nations Development Program; McFarlane 2006
Global Energy Distribution

as indicated by nighttime electricity use
Energy Used for Power

Primarily electricity
- to produce light, heat and power

Unit: kWhr = thousand watts for an hour

U.S. = 9¢ per kWhr
CA = 12¢ per kWhr
NM = 8¢ per kWhr
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Usually uses some energy source to turn a dynamo
- a turbine or a big wheel that turns a metallic shaft inside a stationary metallic wrapping
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  - photovoltaic solar, one of few sources that changes incident solar radiation into electricity through heat without a turbine.
Some Useful Things to Remember

Crisis = 危機

Danger

Opportunity

“A crisis is a terrible thing to waste”

- Paul Romer

“How wonderful that we have met with a paradox. Now we have some hope of making progress.”

- NIELS BOHR

A vision without action is a dream, Action without vision is a nightmare

Japanese Proverb

行為のない視野は夢、視野のない行為である不快感である
Distribution of Good to Excellent Renewable Energy Resources

Resource Potential

- **Biomass - excellent**
- **Biomass - good**
- **Wind - excellent**
- **Wind - good**
- **Photovoltaic - excellent**
- **Photovoltaic - good**
- **Moderate RE resources of mixed types**

The U.S. is well covered by various renewable energy sources.
Renewables for 10 trillion kW-hrs

Can Renewables generate 10 trillion kW-hrs/yr?
This is the amount of energy presently supplied by all fossil fuels.
2006 U.S. Consumption of Renewables out of U.S. total of 4 trillion kWhrs/year

Anticipated Consumption from Renewables by 2040 (after the American Council On Renewable Energy)
Economic competition of biofuels with food production

Food crops do not make good fuel crops

However, the infrastructure and distribution system is already in place so growers and distributors can produce now

This amount of corn, which will be used to make 5 billion gallons of ethanol next year, represents less than 3% of our fuel needs but could feed 220 million people for a year.

Raising vehicle standards to 35 mpg would do more without any adverse effects.
Energy Returned On Investment relative to 1 (similar to the value EROEI)

(After: Cleveland et al., 1984, 1999; ASPO 2006)
Construction costs have skyrocketed for all alternative energy sources. For instance, nuclear energy with a capacity factor (cf) of 90% has construction costs of $7 billion, while wind with a cf of 30% costs $10 billion, and solar with a cf of 20% costs $9 billion. These costs are in billions of dollars (B$). Manhattan Island, for comparison, covers 59 miles².

- Nuclear: $7 B, cf = 90%, footprint = 0.6 miles²
- Wind: $10 B, cf = 30%, footprint = 36 miles²
- Solar: $9 B, cf = 20%, footprint = 124 miles²

2008 Construction Costs and Footprint to produce similar power:
installed capacity x capacity factor (cf) = 1200 MW average production.
Smart Grid = Technology, Policy...

The Smart Grid

More intelligence = more complexity
In the United States

• Increase efficiency and conservation - 1 tkWhrs by 2020
• Increase CAFE to 50 mpg by 2015 - not 35 mpg by 2020
• develop plug-in capabilities - fully-electric cars
• Embrace green building practices and new urbanization strategies that localize essential production, and reduce energy use and transportation - culture change
• Dramatically increase electric grid and distribution development - new transmission infrastructure
• Plan resource stockpiling, e.g., steel, copper

by 2040, for energy security and economic stability, we need:

- 100,000 3+ MW wind turbines totaling 0.8 trillion kWhrs/year
- Concentrated and ordinary solar arrays totaling 0.5 trillion kWhrs/year
- 200 GenIII+ nuclear reactors, depending upon plug-in vehicle demand (~ 2 trillion kWhrs/year)
- 10 bbl/yr of biofuels from algae, cellulosics and high-efficiency biomass
- 0.8 trillion kWhrs/year from other geothermal, wave, tidal and biogas
- no new coal- or gas-fired power plants
New Mexico power consumption changes - two futures
(assuming a 3% growth rate per year and concerted conservation efforts)

<table>
<thead>
<tr>
<th>2007</th>
<th>2015 with all anticipated goals met for renewable and NGas development</th>
<th>2015 with a single 1,500 MW Gen III+ reactor</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 billion kWh</td>
<td>25 billion kWh</td>
<td>25 billion kWh</td>
</tr>
<tr>
<td>85% coal</td>
<td>76% coal</td>
<td>24% coal</td>
</tr>
<tr>
<td>12% natural gas (NG)</td>
<td>20% NG</td>
<td>20% NG</td>
</tr>
<tr>
<td>2% hydro</td>
<td>1% hydro</td>
<td>1% hydro</td>
</tr>
<tr>
<td>&lt;1% renewables</td>
<td>3% renewables</td>
<td>3% renewables</td>
</tr>
<tr>
<td>0% nuclear</td>
<td>0% nuclear</td>
<td>52% nuclear</td>
</tr>
<tr>
<td>33 million tons of CO₂ emitted per year</td>
<td>36 million tons of CO₂ emitted per year</td>
<td>16 million tons of CO₂ emitted per year*</td>
</tr>
<tr>
<td>1.8 million tons of hazwaste per year</td>
<td>1.7 million tons of hazwaste per year</td>
<td>0.5 million tons of hazwaste per year°</td>
</tr>
</tbody>
</table>

*NM would be able to export significant amounts of energy for carbon tax credit
° health cost savings would be significant, primarily from decreases in respiratory illness from particulates associated with coal-emissions (~11%; The 1998 ICAP Report)