Little Green Lies: Dissecting the Hype of Renewables

May 11, 2011

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Little Green Lies: Dissecting the Hype of Renewables

Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 9-12 May 2011 in New Orleans, LA.
Renewable Power Roadmap

The most difficult subjects can be explained to the most slow-witted man if he has not formed any idea of them already; but the simplest thing cannot be made clear to the most intelligent man if he is firmly persuaded that he knows already, without a shadow of doubt, what is laid before him.

-- Leo Tolstoy

"Once people store their factual inferences in memory, these inferences are indistinguishable from hard data. The more they then use this stored information, the more central it becomes to future inferences and judgments...People constantly overrate the accuracy and reliability of their beliefs."

--University of Illinois study, James Kuklinksi, et al, “Misinformation and the Currency of Democratic Citizenship”, 2000:
This Time We Mean it

WE MUST REDUCE OUR DEPENDENCY ON MID EAST OIL.
Why Bother?

What’s all the fuss about?

Oil Reserves:
- World: 1,475 bbls, 50 years (R/P ratio)
- US: 28.5 bbls, 18 years (R/P ratio)

Coal Reserves:
- World: 826 billion tons, 119 years (R/P)
- US: 238 billion tons, 245 years (R/P)

Natural Gas Reserves*:
- World: 9,270 TCF (187.5 TCM), 87.9 years (R/P)
- US Reserves (Including Unproved): 2,587 TCF, 124 years (R/P)

*2011 EIA Update
Why Bother?

1990 Global Proved Oil Reserves: 1T Bbls
2010 Global Proved Oil Reserves: 1.5T Bbls

Oil Produced, 1990-2010: ~.5T Bbls

Source: U.S. Energy Information Administration
Why Bother?

THE GROWING GAP
Regular Conventional Oil

Past Discovery
Future Discovery
Production

Revisions backdated.
Rounded with 3yr moving average.
ASPO Newsletter 89, May 2008
Affordable Renewable Energy Strategies

Figure 7. U.S. Crude Oil plus Condensate Proved Reserves, 1979-2009

- U.S. Total
- Lower 48 Onshore
- Alaska
- Federal Offshore

Source: U.S. Energy Information Administration
Affordable Renewable Energy Strategies

Figure 3. 12 EIA World Conventional Oil Production Scenarios

- USGS Estimates of Ultimate Recovery
  - Probability: Low (95%), Mean (expected value), High (5%)
  - Ultimate Recovery BBIs: 2,248, 3,003, 3,896

- Peak Range 46 yrs or 91 yrs
- 3% Growth
- 2% Growth
- 1% Growth
- Decline R/P = 10

- 900 Billion Bbils Moves Peak 10 Years From 2037 - 2047

Source: Energy Information Administration
Note: U.S. volumes were added to the USGS foreign volumes to obtain world totals.
# Population Trends

<table>
<thead>
<tr>
<th>Figures in Millions</th>
<th>2010</th>
<th>2030</th>
<th>2050</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>World</strong></td>
<td>6,853</td>
<td>8,259</td>
<td>9,284</td>
<td>36%</td>
</tr>
<tr>
<td><strong>Less Developed Countries</strong></td>
<td>5,621</td>
<td>6,984</td>
<td>8,005</td>
<td>42%</td>
</tr>
<tr>
<td><strong>More Developed Countries</strong></td>
<td>1,231</td>
<td>1,275</td>
<td>1,279</td>
<td>4%</td>
</tr>
<tr>
<td><strong>USA</strong></td>
<td>307</td>
<td>373</td>
<td>439</td>
<td>43%</td>
</tr>
<tr>
<td><strong>India</strong></td>
<td>1,173</td>
<td>1,460</td>
<td>1,656</td>
<td>41%</td>
</tr>
<tr>
<td><strong>Pakistan</strong></td>
<td>184</td>
<td>243</td>
<td>290</td>
<td>58%</td>
</tr>
<tr>
<td><strong>China</strong></td>
<td>1,330</td>
<td>1,391</td>
<td>1,303</td>
<td>-2%</td>
</tr>
<tr>
<td><strong>Russia</strong></td>
<td>142</td>
<td>124</td>
<td>109</td>
<td>-23%</td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td>126</td>
<td>113</td>
<td>93</td>
<td>-26%</td>
</tr>
<tr>
<td><strong>Eastern Europe</strong></td>
<td>119</td>
<td>112</td>
<td>99</td>
<td>-17%</td>
</tr>
<tr>
<td><strong>Sub Saharan Africa</strong></td>
<td>850</td>
<td>1,320</td>
<td>1,889</td>
<td>122%</td>
</tr>
<tr>
<td><strong>Northern Africa</strong></td>
<td>164</td>
<td>212</td>
<td>248</td>
<td>51%</td>
</tr>
<tr>
<td><strong>Nigeria</strong></td>
<td>155</td>
<td>212</td>
<td>264</td>
<td>70%</td>
</tr>
<tr>
<td><strong>Ethiopia</strong></td>
<td>88</td>
<td>162</td>
<td>278</td>
<td>216%</td>
</tr>
<tr>
<td><strong>Congo</strong></td>
<td>75</td>
<td>131</td>
<td>198</td>
<td>164%</td>
</tr>
</tbody>
</table>

Source: US Census Bureau, Population Division
# Energy Trends

<table>
<thead>
<tr>
<th></th>
<th>Per Capita Energy Use (Kg Oil Equivalent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>1,819</td>
</tr>
<tr>
<td>USA</td>
<td>7,766</td>
</tr>
<tr>
<td>Russia</td>
<td>4,730</td>
</tr>
<tr>
<td>France</td>
<td>4,258</td>
</tr>
<tr>
<td>Germany</td>
<td>4,027</td>
</tr>
<tr>
<td>Japan</td>
<td>4,019</td>
</tr>
<tr>
<td>UK</td>
<td>3,464</td>
</tr>
<tr>
<td>China</td>
<td>1,484</td>
</tr>
<tr>
<td>Brazil</td>
<td>1,239</td>
</tr>
<tr>
<td>Indonesia</td>
<td>849</td>
</tr>
<tr>
<td>Nigeria</td>
<td>722</td>
</tr>
<tr>
<td>India</td>
<td>529</td>
</tr>
<tr>
<td>Pakistan</td>
<td>512</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>290</td>
</tr>
<tr>
<td>Congo</td>
<td>289</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>163</td>
</tr>
</tbody>
</table>

2010 Per Capita Energy Estimate: 
1,819 * 6.7B people = 12,187B KG Oil Equivalent

2050 Per Capita Energy Forecast (1% Annual Growth): 
2,708 * 9.3B people = 25,184B KG Oil Equivalent

2050 Per Capita Energy Forecast (2% Annual Growth): 
4,016 * 9.3B people = 37,348B KG Oil Equivalent

Sources: 2009 BP Statistical Energy Analysis, US Energy Information Administration
Energy Trends

Sources: 2006 BP Statistical Energy Analysis

Oil 37%  Coal 25%  Gas 23%

Nuclear 6%  Biomass 4%  Hydro 3%

Solar heat 0.5%  Wind 0.3%

Geothermal 0.2%  Biofuels 0.2%  Solar photovoltaic 0.04%
Three-Pronged Solution

System and Building Efficiencies

Demand Reduction & Flattening

Generation and Distribution
Three-Pronged Solution

1) System and Building Efficiencies
   A) Current ASHRAE & LEED Minimums
      i. Occupancy Sensors/Timers
      ii. Space lighting/heating/cooling properties
      iii. Window, Roof, Envelope properties
   B) Federal Improvement Mandates (EPAct/EISA/EOs)
      i. EPAct05 / EISA07
      ii. Executive Orders 13423, 13514
      iii. Federal Energy Management Program (FEMP)
      iv. Energy Star Program
   C) Private Efforts
      i. Utility Rebates (appliances, PV arrays)
      ii. Dynamic Pricing
Baseline Energy Efficient Building

Present Design (~30% - 40% Beyond ASHREA90.1-2007), Point 2

- Improved Envelope
- Increased Insulation
- Condensing Boilers
- HE Hot Water Heaters
- Proper Building Orientation
- Double-Pane Windows

- VFD Pumps & Fans
- Cool Roofs
- Low Flow Fixtures
- ERV / Enthalpy Wheels
- FEMP / Energy Star
- Decreased Lighting Intensities
More Energy Efficient Building

LCCA Neutral (~40% - 50% Beyond ASHREA90.1-2007), Point 3

- Triple Paned Windows
- Increased Insulation
- GSHP / WSHP
- Awnings/Overhangs/Shading
- Central Plants
- SIPs/EFIS/Styrofoam
- Daylighting & Photodimmers
- Air Conditioned Attics
- Radiant Heating
- Water Pre-Heat (Solar/Rejected)
- Floor Plan Changes: Lighting, Ventilation, Roof Types

NPV Lifetime Facility $/SF

% Energy Efficiency Beyond ASHRAE90.1
Most Energy Efficient Building

(~55+% Beyond ASHREA90.1-2007), Point 4

LCCA Negative but $$ < Generation

- Solid State (LED) Lighting
- Superior Envelope, R-30+
- Passive / Evaporative Cool
- Night Purging
- Variable Refrigerant Volume
- Complete Building Automation
- Wastewater Heat Recovery
- Building Mass / Labyrinths
- Thermal Energy Storage*
- Trombe Walls

*Doesn't necessarily reduce energy demand, but reduces peak – thus reducing support or generation plant required.
Federal & Department of Army Energy Efficiency

NREL Research Facility
Golden, CO

- 222KSF
- EUI Goal: 32kBTU/ft^2*yr
- LEED Platinum
- $259/SF
- 800 Occupants
## Federal & Department of Army Energy Efficiency

### NREL Research Facility
Golden, CO

<table>
<thead>
<tr>
<th>Building</th>
<th>Size</th>
<th>Cost</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>City Civic Center</td>
<td>90KSF</td>
<td>$310/SF</td>
<td>Silver</td>
</tr>
<tr>
<td>City Signature Ctr</td>
<td>186KSF</td>
<td>$247/SF</td>
<td>Platinum</td>
</tr>
<tr>
<td>Ft. Carson BDHQ</td>
<td>140KSF</td>
<td>$225/SF</td>
<td>Gold</td>
</tr>
<tr>
<td>NREL</td>
<td>222KSF</td>
<td>$259/SF</td>
<td>Platinum</td>
</tr>
</tbody>
</table>
Three-Pronged Solution

2) Demand Reduction & Flattening
   A) Dynamic Pricing (Smart Grids & Demand Response)
      i. Tollway Minimum Speed Analogy
      ii. Avoid Unintended Consequences

   B) Cultural Shifts (Load Flattening)
      i. Telecommuting
      ii. Dynamic Tollway Pricing

   C) Equipment Selection (Load Flattening)
      i. Smart appliances
      ii. Heat Pump applications
      iii. TES
Three-Pronged Solution

Electric Demand Is Highly Variable

PG&E Peak Load
July 25 @ 1700 hours
20,883 MWs

2006 Annual
Three-Pronged Solution

How energy rates can change throughout the day

A.M. | NOON | P.M.
--- | --- | ---
$ | $ | $$$$
$ | $$$ | $$$$
$ | $$$ | $$$$
$ | $ | $$$
Three-Pronged Solution

So now we have:
1. Maximized the efficiencies within individual buildings & homes.
2. Aligned incentives for people to collectively maximize efficiencies and eschew waste and defer elective usages during peak times.
3. The last bit, barring living in a cold, dark box, requires power.
Three-Pronged Solution

3) Generation and Distribution
   A) Greater Renewable Emphasis
      i.  PV
      ii. CSP
      iii. Geothermal
      iv.  Biomass
      v.   Wind
      vi.  Hydro
   B) Nuclear
   C) Natural Gas
   D) Distributed Generation
Federal CONUS Solar PV Arrays

Ft. Irwin, 500MW: $2B, ~$4/W, 14K Acres

Ft. Nellis, 14MW, $100M (~$7/MW), 140 Acres CF~24%

Ft. Carson, 2MW, $13M (~$6.5/W), 15 Acres CF~20%
USA Solar Resource (CSP / PV) Intensity
Wind Projects

Cape Wind Project, 468MW (130 x 3.6MW Turbines)
Cost: $2B (~$4.25/W)
14,000 Acres
CF~25%-35%
USA Wind Resource Intensity

Wind resource data developed by AWS Truewind, LLC for windNavigator®
## Problems with PV / CSP, and Wind

- Base Load Requirements
- Intermittency & Storage

<table>
<thead>
<tr>
<th></th>
<th>Wind</th>
<th>Solar</th>
<th>Nuclear</th>
<th>Natural Gas</th>
<th>Coal</th>
<th>GeoThermal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nameplate Capacity (MW)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Acreage</td>
<td>3419</td>
<td>600</td>
<td>78</td>
<td>5</td>
<td>450</td>
<td>10K*</td>
</tr>
<tr>
<td>Construction Cost ($10^6)</td>
<td>$491</td>
<td>$1,500</td>
<td>$300</td>
<td>$161</td>
<td>$250</td>
<td>$350</td>
</tr>
<tr>
<td>Capacity Factor</td>
<td>30%</td>
<td>15%</td>
<td>96%</td>
<td>95%</td>
<td>74%</td>
<td>&gt;95**%</td>
</tr>
<tr>
<td>Annual Generation (GW*HR)</td>
<td>265</td>
<td>130</td>
<td>840</td>
<td>830</td>
<td>650</td>
<td>790</td>
</tr>
<tr>
<td>NPV ($/KW*HR)</td>
<td>$0.08</td>
<td>$0.22</td>
<td>$0.07</td>
<td>$0.06</td>
<td>$0.05</td>
<td>$0.035</td>
</tr>
</tbody>
</table>

*Well field area, not surface plant size.

Geothermal Projects

Neal Hot Springs, OR (35MW)
Cost: $105M ($3/W)
5440 Acres
CF~88%

San Emidio, NV (37MW)
Cost: $200M ($5.4/W)
CF~85%

Blue Mountain, NV (50MW)
Cost: $180M ($3.6/W)
CF~92%
USA EGS Resource Maps

Temperatures at 3.5km

Temperatures at 6.5km

Temperatures at 10km
Geothermal

1. Ubiquitous
2. Prolific
3. Credit Suisse study: better long-term pricing than coal
4. Power, Direct Heating, and Adsorption Cooling

1. Favors Western US
2. R&D still required
3. Price competition will not be realized until widely implemented
Electricity Generation $$$

• A 2009 Credit Suisse report indicates that geothermal ($0.036/kW*Hr) electricity can be had more cheaply than coal ($0.055/kW*Hr) electricity can!
Electricity Generation GHG Emissions

Geothermal energy
Comparison of CO2 emissions from electricity generation

Source, World Energy Council, 2008
Renewable Power Roadmap

• Geothermal
  • Power Generation
  • Heating
  • Adsorption Cooling

• Biomass

• Solar / Wind
  • Complementary
  • Niche Applications

• Disruptive Technologies
  • Bloombox
  • JTEC
  • Chlorophyll-based Thin-Film PV Cells
  • Micro Nuclear (<300MW)
Net Zero Buildings (v1.0)
Net Zero Buildings (v2.0)
Questions and Comments
Thank you!

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