A U.S. Utility Perspective of Clean Coal Utilization

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Ameren is…
Ameren Is Ranked in the U.S. …

- 4th largest purchaser of coal
- 14th in MWH sales
- 20th among Fortune 500 utilities
- 329th on the overall Fortune 500 list
Ameren is…

2007

Electric customers 2.4 Million
Gas customers 1,000,000
Service area 64,000 Sq. Miles
Generation 16,400 MW
Electric system miles 81,708
Gas system miles 20,580
Total assets $22 Billion
Total revenues $7.5 Billion
Employees 9,069
Ameren Generation Capacity Profile (MW)

Total Capacity = 16,400 MW (does not include Taum Sauk capacity)
Ameren Generation ...
U.S. Utility Industry Challenges

- Rising costs
- Deregulation
- Environmental controls
- Rising demand for electricity
- Industry consolidation
- Expectation of perfect service
- Climate change / CO₂
CO₂ Reduction is Most Critical Issue

- No challenge more daunting than reducing carbon dioxide – CO₂ – the greenhouse gas at center of today’s global climate change concerns.

Uncontrolled Emissions from a Ton (2,000 lbs) of Typical PRB Coal

One Ton of Coal Produces:

- 17 barrels of SO₂
- 16 barrels of NOₓ
- 1/20th of a drop of mercury
- 2 rail cars of CO₂
Sources of CO$_2$ in the U.S.

- U.S. Territories: 1%
- Agriculture: 7%
- Residential: 6%
- Commercial: 7%
- Industry: 19%
- Transportation: 28%
- Electricity Generation: 32%
Percentage CO$_2$ Stationary Source Emissions by Category

USA

Balancing the Carbon Challenge

- There will be carbon legislation in the U.S.
- Technology will be part of the solution
- Will require balanced approach, that is, a combination of policy and technologies.
Renewables As Part of the Solution

- Some government requirements to use renewables are in-place or are being implemented
- Wind and solar energy resources are limited
- Biomass fuel availability is currently limited in most areas, but has potential to co-fire with coal
Wind Power

United States - Wind Resource Map

This map shows the annual average wind power estimates at 50 meters above the surface of the United States. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.

Wind Power Classification

<table>
<thead>
<tr>
<th>Wind Power Potential</th>
<th>Wind Power Density at 50 m</th>
<th>Wind Speeds at 50 m</th>
<th>Wind Speeds at 50 m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Wm²</td>
<td>m/s</td>
<td>mph</td>
</tr>
<tr>
<td>Fair</td>
<td>300 - 400</td>
<td>6.4 - 7.0</td>
<td>14.3 - 15.7</td>
</tr>
<tr>
<td>Good</td>
<td>400 - 500</td>
<td>7.0 - 7.5</td>
<td>15.7 - 16.8</td>
</tr>
<tr>
<td>Excellent</td>
<td>500 - 600</td>
<td>7.5 - 8.0</td>
<td>16.8 - 17.9</td>
</tr>
<tr>
<td>Outstanding</td>
<td>600 - 800</td>
<td>8.0 - 8.8</td>
<td>17.5 - 18.7</td>
</tr>
<tr>
<td>Superb</td>
<td>800 - 1500</td>
<td>8.8 - 11.1</td>
<td>19.7 - 24.8</td>
</tr>
</tbody>
</table>

Wind speeds are based on a Weibull k value of 2.0

U.S. Department of Energy
National Renewable Energy Laboratory
Coal Energy Future

- Realistically, coal-based electricity generation will continue to be an important source of energy, roughly 50% in the U.S. today.
- Coal use could increase in use due to rising demand for electricity. Nuclear is a good option for reducing CO$_2$ but deployment may be limited (high capital cost, current credit situation, long timelines).
- Coal could be part of “decarbonizing” other sectors of the economy, such as transportation.
- We need improved technologies for coal-based power plants to serve the future demand for electricity.
Utility Industry Response

- Many Research, Development, Demonstration and Deployment efforts are underway in the U.S. and globally

- Some key organizations actively pursuing utility R&D:
  - Utilities
  - U.S. Department of Energy (www.netl.doe.gov)
  - Electric Power Research Institute (EPRI) and its member (www.epri.com)
  - Universities
  - Vendors/Manufacturers

- Many technology choices will be needed. Must be:
  - Reliable
  - Operable
  - Cost-effective
The basic technical challenge for coal use in the U.S. is reducing emissions reliably and in a cost effective manner:

- SO$_2$
- NO$_x$
- Mercury (and other heavy metals?)
- Fine particulate
- Water quality
- Ash management
- CO$_2$
CO₂ Reduction – Technical Potential
U.S. Electric Sector (2008 EIA Baseline)

EIA Base Case 2008

<table>
<thead>
<tr>
<th>Technology</th>
<th>EIA 2008 Reference</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Load Growth ~ +1.2%/yr</td>
<td>Load Growth ~ +0.75%/yr</td>
</tr>
<tr>
<td>Renewables</td>
<td>60 GWe by 2030</td>
<td>100 GWe by 2030</td>
</tr>
<tr>
<td>Nuclear Generation</td>
<td>20 GWe by 2030</td>
<td>64 GWe by 2030</td>
</tr>
<tr>
<td>Advanced Coal Generation</td>
<td>No Existing Plant Upgrades</td>
<td>130 GWe Plant Upgrades by 2020; 49% in 2030</td>
</tr>
<tr>
<td>CCS</td>
<td>None</td>
<td>Widely Deployed After 2020</td>
</tr>
<tr>
<td>PHEV</td>
<td>None</td>
<td>10% of New Vehicle Sales by 2017; +2%/yr Thereafter</td>
</tr>
<tr>
<td>DER</td>
<td>&lt; 0.1% of Base Load in 2030</td>
<td>5% of Base Load in 2030</td>
</tr>
</tbody>
</table>
## Energy Losses Along Electricity Value Chain

<table>
<thead>
<tr>
<th>Generation</th>
<th>Transmission</th>
<th>Distribution</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ 70% loss</td>
<td>~ 3% loss</td>
<td>~ 4% loss</td>
<td>~ 88% loss (incandescent light example)</td>
</tr>
</tbody>
</table>

More than 210 billion kWh per year is lost in the delivery of electricity from power plant to end use devices.

Losses shown are illustrative of national averages.

Source: EPRI
CO2 Sequestration
2008 Atlas - CO2 Sinks

http://geoportal.kgs.ku.edu/natcarb/atlas08/gsinks.cfm

CO2 Sinks
- Unmineable Coal Seams
- Deep Saline Formations
- Oil and Gas Reservoirs
Summary - Key Coal Technology Needs

- Efficiency improvements for existing and new plants
- CO$_2$
  - Capture processes that are cost effective
  - Sequestration or storage options (biological and geo, other?)
  - Underground CO$_2$ fate and transport
  - Well design and long term integrity
- Advanced power plants
  - Integrated Gasification Combined Cycle (IGCC)
  - Advanced Supercritical Pulverized Coal (steam temp ~ 700$^\circ$C)
  - Oxyfuel
- Integrated environmental controls (multipollutant control?)
- Beneficial uses for solid wastes and byproducts
- Enabling technologies such as fundamental combustion chemistry, cofiring biofuels, advanced sensors, advanced metallurgy, advanced particulate capture, heavy metals, etc.