Replace Old Coal Plants with New Ones

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McIlvaine Company
Replacement of Old Coal Plants with New Ones is a Very Eco-Efficient Option

- Nuclear, solar, wind, and coal can all play a role in meeting greenhouse gas reduction goals
- The role of each can be determined by the eco-efficiency defined as the cost divided by the environmental and societal burden reduction
- Some technologies are not yet eco-efficient but may become so in the future
- Some technologies are eco-efficient for narrow use but not yet eco-efficient for wide spread use
- Different values for environmental and societal burdens will create debate over the eco-efficiency of various alternatives
- One option which is clearly eco-efficient in the short term is the replacement of old coal plants with new ones
Advantages of Coal Plant Replacement

Replacement of 320,000 MW of existing coal fired plants with new ultra super critical plants would:

- Achieve the goal of 20% greenhouse gas reduction by 2020
- Result in an 80% air environmental burden reduction from the coal fired power segment and a 51% reduction in the air environmental burden from all stacks in the U.S.
- Be accomplished using existing technology and at no increase in electricity cost
- The $600 billion investment would create a big economic stimulus to the U.S. economy
U.S. Modest Coal Scenario
Relative Share of Electricity Generation

as a percentage of 2010 (at 100%)
Approach to Insure Implementation of the Policy

- Agreement between power producers and environmentalists is necessary and is achievable.
- The basis of the agreement should be a target for the contribution of coal in the 2040 energy mix assuming no CO2 capture.
- This agreed portion of the generation mix could be only 120,000 MW out of 840,000 base load MW.
- Then 40,000 MW/yr of new carbon ready efficient coal plants would begin construction for operation in 2012-15.
- The $240 billion stimulus would be significant to economic recovery.
- Replacement of 120,000 MW of old coal plants in the same time frame would result in a big environmental burden reduction.
U.S. Minimum Coal Scenario
Relative Share of Electricity Generation

as a percentage of 2010 (at 100%)
Further resolution of the future role of coal would be accomplished during the next 3 years. Important considerations will be:

- The cost and availability of nuclear, wind, and solar technologies
- The cost of CO₂ capture from coal fired plants
- The availability of biomass for co-firing
- The eco-efficiency of each alternative energy source
- Changes in the potential impacts of greenhouse gases
- The impact of energy conservation
The Environmental Burden Determination

- CO₂ and air pollutants have been ranked in an environmental burden index.
- If CO₂ is $20/ton and NOₓ allowances are $2000/ton, then 1 ton of NOₓ has a burden of 100x CO₂.
- Various toxic air pollutants have been ranked based on the EPA Lesser Quantity Emission Rate (LQER).
- The index can be extended to societal burdens such as starvation based on the EPA value of $7 million per life.
- With CO₂ at $20/ton, one life lost to starvation would be a burden equivalent to 350,000 tons of CO₂.
## Environmental Burden Index

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Factor</th>
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<tbody>
<tr>
<td>Mercury</td>
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<tr>
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<tr>
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<tr>
<td>Arsenic</td>
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<tr>
<td>Nickel Compounds</td>
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</tr>
<tr>
<td>Selenium Compounds</td>
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<tr>
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</tr>
<tr>
<td>Hydrochloric Acid</td>
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</tr>
<tr>
<td>Sulfuric Acid</td>
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</tr>
<tr>
<td>Hydrogen Fluoride</td>
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</tr>
<tr>
<td>Ammonia</td>
<td>1,000</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
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<tr>
<td>SO$_2$</td>
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<tr>
<td>NO$_x$</td>
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<td>CO$_2$</td>
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Environmental Burden Calculation for Stacks in U.S.

- When the environmental burden index is multiplied by the tons of emissions, the U.S air environmental burden from coal is 4.5 billion tons.
- The air environmental burden from all other stacks is 1.3 billion tons resulting in a 4.8 billion ton total environmental burden.
- Replacing all the coal fired plants with ultra super critical boilers using BACT would reduce the air burden from 4.5 to 1.5 billion tons or a 66% reduction.
- The total air burden from all stacks would be reduced from 5.8 billion tons to 2.8 billion tons for a 52% reduction.
- This does not include the additional benefits of byproducts, waste neat utilization and co-firing of biomass.
# U.S. Air Source Environmental Burden

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Environmental Burden Index</th>
<th>US Coal Emissions (1000 tons)</th>
<th>Other Industrial Sources (1000 tons)</th>
<th>Coal Environmental Burden (1000 tons)</th>
<th>Environmental Burden Other Sources</th>
<th>New Fleet of Coal Plants</th>
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</thead>
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<tr>
<td>Hydrogen Fluoride</td>
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<td><strong>AIR TOXICS SUBTOTAL</strong></td>
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<td>3,200</td>
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<td>90,000</td>
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<tr>
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<td>300,000</td>
<td>1,700,000</td>
<td>300,000</td>
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<tr>
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CO₂ Reductions with Coal Initiatives

- Replacement of old coal plants would reduce coal consumption and CO₂ by 30%
- Addition of co-firing of biomass and use of waste heat could cause an additional 20% net reduction
- Credit for electric cars to replace 25% of transportation miles would add another 30% reduction
- 90% CO₂ capture would add another 63% reduction for a total 143% net reduction
U.S. Coal-fired Utilities CO$_2$ Emissions

- Actual Emissions
- Net Emissions

Old Plants
New Plants
Co-Firing and CHP
Electric Cars
CO2 Capture

In millions of tons

(600)
Air Burden Reductions with Various Coal Initiatives

- Replacement of old coal fired plants with new supercriticals and BACT would reduce the total air burden from all U.S. stacks from 5.8 to 2.8 billion tons
- Co-firing biomass would reduce the burden to 2.5 million tons
- Credit for 25% of the transportation using electricity would reduce the burden to 2 million tons (not including the additional reduction in particulate and VOC emissions)
- The addition of carbon capture results in coal being an environmental burden reducer and the net burden for all stacks would drop to 1.4 billion tons
Air Environmental Burden

U.S. All Stacks

- With Old Coal Plants
- With New Coal Plants
- Add Co-firing and CHP
- Credit Electric Car
- Carbon Capture

In billions of tons of emission equivalents

Coal
Other Sources
New Coal Without CO₂ Capture is Most Eco-efficient

- The combination of coal with 30% biomass co-firing and 90% carbon capture sequestration would result in CO₂ reductions in the atmosphere.
- CO₂ capture must be accomplished with clean gas. There would be a reduction rather than an increase in the environmental burden.
- Emissions to water and land can also be essentially zero due to the avoidance of liquid discharges and the sale of byproducts.
- Therefore the coal/biomass combination with CO₂ sequestration is cleaner than solar or wind, but would be expensive.
- With only a 15 year useful life, a new ultra supercritical coal plant achieves a lower environmental burden cost reduction than renewables.
- Analysis ([click HERE](#))
## Environmental Burden Reduction Costs

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Supplement</th>
<th>Electricity Cost</th>
<th>Environmental Burden (lbs/kWh)</th>
<th>Burden Reduction from Base</th>
<th>Cost per Unit of Burden Reduction ($/kWh)</th>
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<tbody>
<tr>
<td>Old coal</td>
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<td>$ .06/kWh</td>
<td>5.46</td>
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<td>xxxxx</td>
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<tr>
<td>New coal 15 yr life</td>
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<td>$ .07/kWh</td>
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<td>3.66</td>
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<td>New coal CO₂ sequestration and co-firing</td>
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<td>$0.11/kWh</td>
<td>(-1)</td>
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<td>$0.11kWh</td>
<td>0</td>
<td>5.46</td>
<td>.0091</td>
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Cost per Unit of Burden Reduction

$ per KW Hr

- New Coal - 25 Yr. Life
- New Coal - 15 Yr. Life
- Old Coal - With BACT
- New Coal - CO2 Sequestration
- Solar/Wind/Nuclear

0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.010