Replace Old Coal Plants with New Ones

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

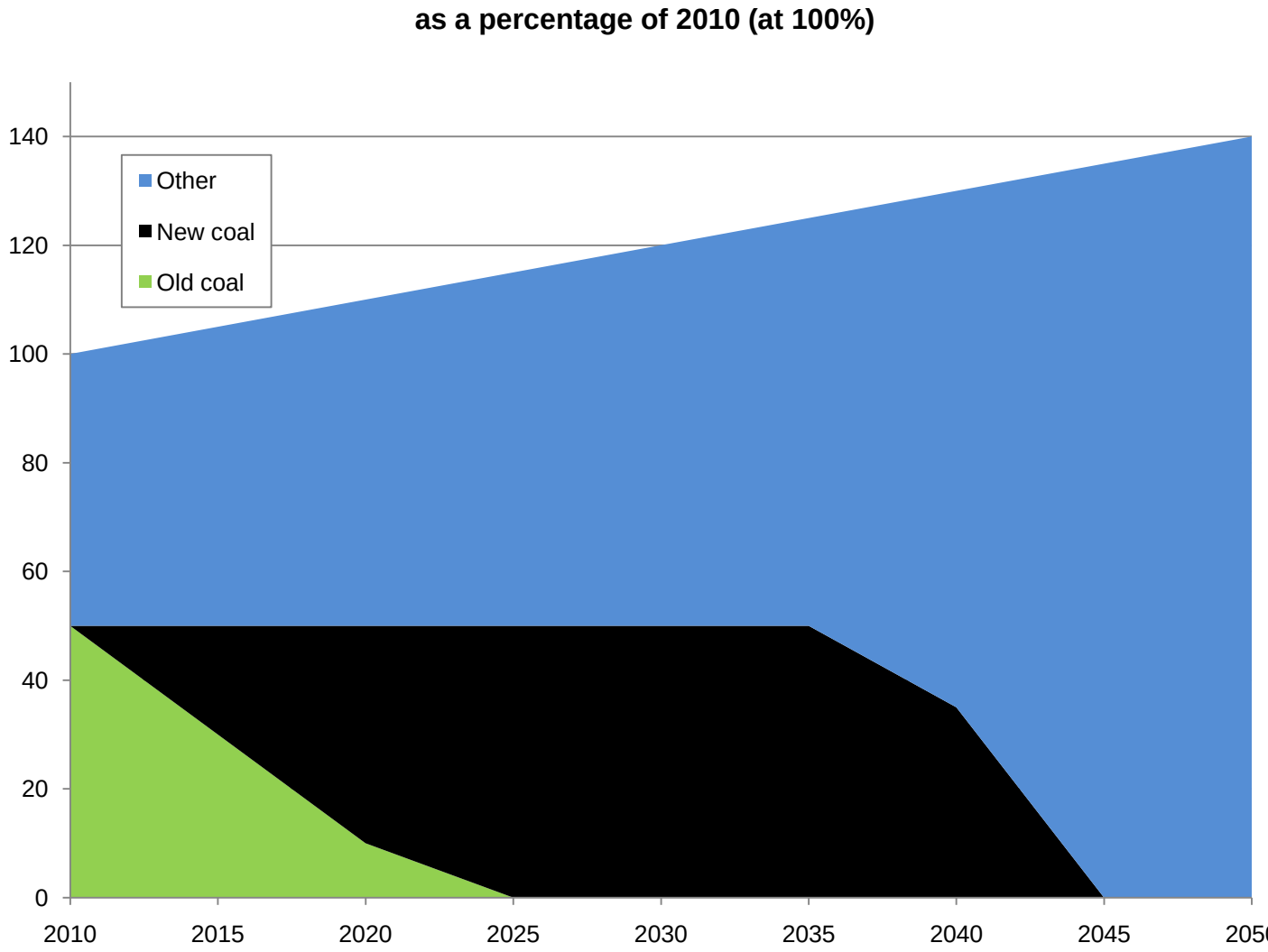
- Nuclear, solar, wind, and coal can all play a role in meeting greenhouse gas reduction goals
- The role of each can be determined by the eco-efficiency defined as the cost divided by the environmental and societal burden reduction
- Some technologies are not yet eco-efficient but may become so in the 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

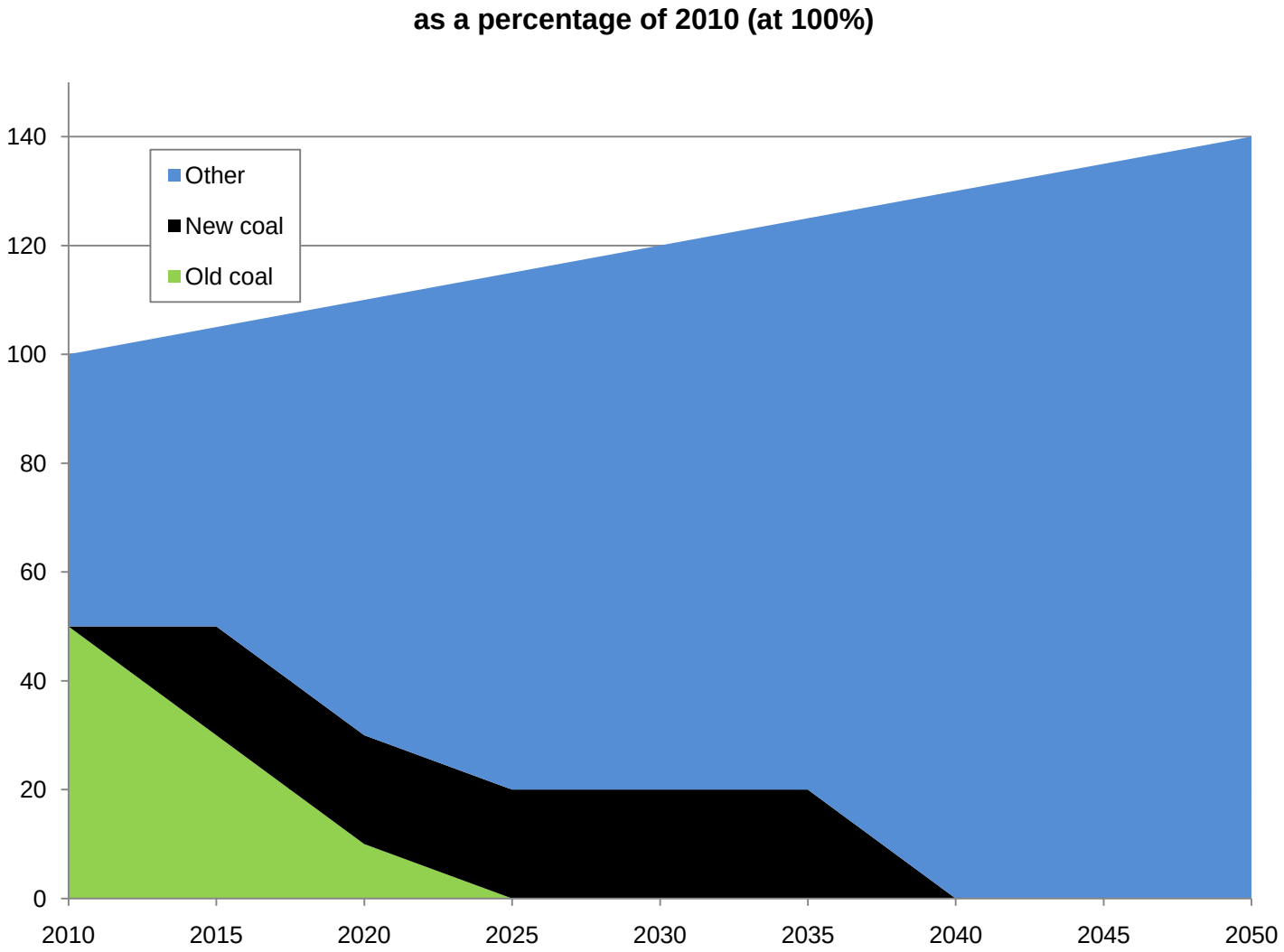
U.S. Modest Coal Scenario
Relative Share of Electricity Generation



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



Future Planning of the Role of Coal

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 CO_2 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

- CO_2 and air pollutants have been ranked in an environmental burden index
- If CO_2 is \$20/ton and NO_x allowances are \$2000/ton, then l ton of NO_x has a burden of 100x CO_2
- 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 CO_2 at \$20/ton, one life lost to starvation would be a burden equivalent to 350,000 tons of CO_2

Environmental Burden Index

Chemical	Factor
Mercury	10,000,000
Chromium Compounds	1,000,000
Lead Compounds	1,000,000
Arsenic	1,000,000
Nickel Compounds	100,000
Selenium Compounds	100,000
Barium Compounds	10,000
Zinc Compounds	10,000
Vanadium Compounds	10,000
Hydrochloric Acid	1,000
Sulfuric Acid	1,000
Hydrogen Fluoride	1,000
Ammonia	1,000
$PM_{2.5}$	1,000
SO_2	100
NO_x	100
CO_2	1

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 envrionmenal 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

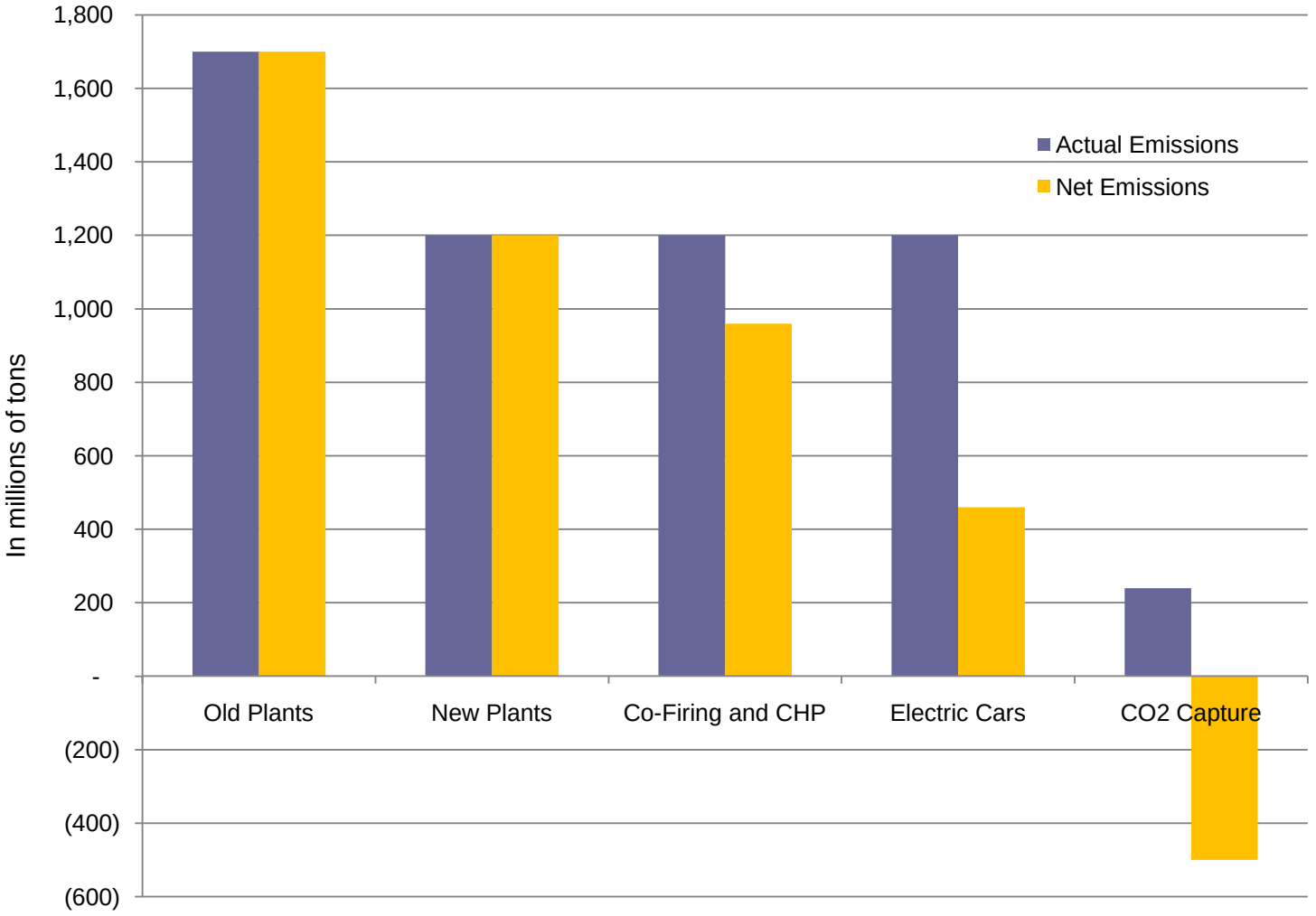
U.S. Air Source Environmental Burden

Chemical	Environmental Burden Index	US Coal Emissions (1000 tons)	Other Industrial Sources (1000 tons)	Coal Environmental Burden (1000 tons)	Environmental Burden Other Sources	New Fleet of Coal Plants
Mercury	10,000,000	.05		500,000		
Nickel Compounds	100,000	.35		35,000		
Selenium Compounds	100,000	.215		21,500		
Barium Compounds	10,000	.215		21,500		
Zinc Compounds	10,000	.67		6,700		
Vanadium Compounds	10,000	.615		6,150		
Hydrochloric Acid	1,000	267		267,000		
Sulfuric Acid	1,000	58		58,000		
Hydrogen Fluoride	1,000	28		28,000		
Ammonia	1,000	2.3		2,300		
AIR TOXICS SUBTOTAL			35	946,150	500,000	100,000
$PM_{2.5}$	1,000	500	250	500,000	250,000	50,000
SO_2	100	9,000	3,200	900,000	320,000	90,000
NO_x	100	4,000	3,900	400,000	390,000	40,000
CO_2	1	1,700,000	300,000	1,700,000	300,000	1,200,000
TOTAL				4,446,150	1,360,000	1,480,000

CO_2 Reductions with Coal Initiatives

- Replacement of old coal plants would reduce coal consumption and CO_2 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% CO_2 capture would add another 63% reduction for a total 143% net reduction

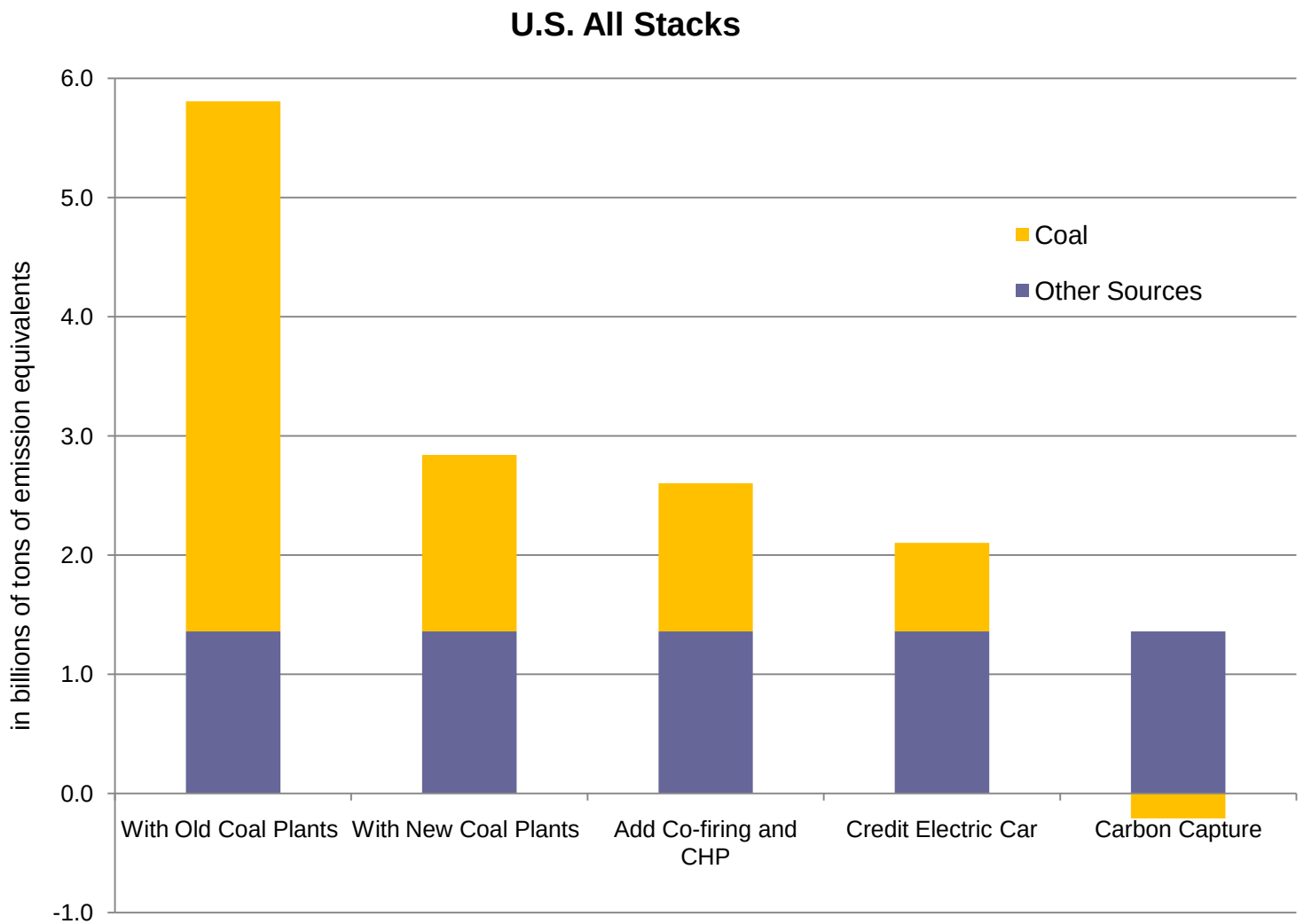
U.S. Coal-fired Utilities CO_2 Emissions



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



New Coal Without CO_2 Capture is Most Eco-efficient

- The combination of coal with 30% biomass co-firing and 90% carbon capture sequestration would result in CO_2 reductions in the atmosphere
- CO_2 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 CO_2 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

Plant Type	Supplement	Electricity Cost	Environmental Burden (lbs/kWh)	Burden Reduction from Base	Cost per Unit of Burden Reduction ($/kWh)
Old coal		$ .06/kWh	5.46	xxxxx	xxxxx
Old coal	With BACT APC	$ .07	2.5	3.0	.0033
New coal	25 yr life	$.06/kWh	1.80	3.66	0
New coal	15 yr life	$.07/kWh	1.80	3.66	.0027
New coal	CO_2 sequestration and co-firing	$0.11/kWh	(-1)	6.46	.0077
Solar/wind/ nuclear		$0.11kWh	0	5.46	.0091

Cost per Unit of Burden Reduction