Introduction

First, it is worth reviewing the situation we find ourselves in. Electric power worldwide is over 40% of total global carbon dioxide releases, and it is the fastest growing portion (in terms of human-released greenhouse gases). India, China, and other countries are rapidly industrializing and bringing basic electric power services to their peoples. Their development, like US electric power, follows the perceived least-cost options. Unfortunately, coal-fired power plants are by far our most destructive and dangerous ones - coal burning directly kills millions of people worldwide in particulate, sulfate and mercury releases, and emits over twice as much CO_2 per KWh as any other form of power generation. Nevertheless, US utilities are planning to build more than 150 new coal-fired power plants in the US over the next 5 years, and China is building roughly 60 large plants every year. Electric power is an engine of economic growth, bringing light, cooling, and communication to billions, but every coal-fired power plant is a ticking problem. **In this paper, we will address the arguments for coal power as well as other conventional energy sources – and discuss the cheaper, cleaner, and scalable alternative energy sources that can meet our power generation needs.**

Standard & Poor's Assessment of Electrical Generation Costs [1]

	Pulverized Coal	Gas-CCT	IGCC-Eastern Coal	IGCC - PRB Coal	Wind	Nuclear	Ausra CSP-KV Estimate	Altarock – KV Estimate
Capital Cost ($/Kw)	2,438	700	2,795	2,925	1,700*	4,000	3,000	4,000
Total Cost (cents / KWh)	5.8	6.8	6.8	6.5	7.1*	8.9	7-11	5-10
CO_2 Capital Capture Cost ($Kw)	940	470	450	450	-	-	-	-
Cost for CCS (cents/ KWh)	6.2	2.8	3.4	3.6	-	-	-	-
Cents/KWh (with CCS)	**12.0**	**9.6**	**10.2**	**10.1**	**7.1**	**8.9**	**7-11**	**5-10**
Cents/KWh (with carbon credits @$30)	**7.9**	**7.7**	**8.7**	**8.4**	**7.1**	**9.1**	**7-11**	**5-10**

Ausra and Altarock cost-estimates are not from S&P

*S&P notes that there are disadvantages with wind that are not explicitly modeled - high transmission costs (because wind has limited availability), low capacity factors (30-35%), and unpredictability (leading to a greater need for backup/reserve power) and limit wind from serving as a base-load power source.

[1] "Which Power Generation Technologies Will Take The Lead In Response to Carbon Controls?", S&P Viewpoint, May 11, 2007

Coal is Cheap, plentiful, accessible

The Energy Information Administration predicts that coal consumption worldwide will nearly double from 2003 to 2030. In the same period, coal's share of world energy consumption is likely to grow from 24% to 27%.Total coal reserves are estimated at 1,001 billion tons - or about 180 years at current consumption levels (based on IEO2006 reference case, and assuming a 2.0% growth rate after 2030). The US has the world's largest coal reserves, of approximately 270.7 billion tons. The EIA's outlook suggests that from 2003 to 2030, coal's share of electricity generation in the US will rise from 51% to 57%. As a result (despite the large reserves), the EIA notes that the US is a net importer of coal today[2]. Total coal consumption in the US is expected to rise from 22.9 quadrillion Btu in 2005 to 34.1 quadrillion Btu in 2030. Across the world, India and China are expected to see their coal consumption rise to 3.6 billion tons in the period and both are expected to become net importers of coal by 2030 (India is already an importer). In summary, we seem to have enough coal for a while - and the rapid growth of its usage in the US coupled with the growth of India and China suggests that coal will increase its role as a major factor in worldwide energy production, unless coal becomes uneconomic because of other factors. Or at least that is what conventional wisdom would say. Will it really? Are there any economic alternatives? And should it?

Figure 48. World Coal Consumption by Region, 1980-2030

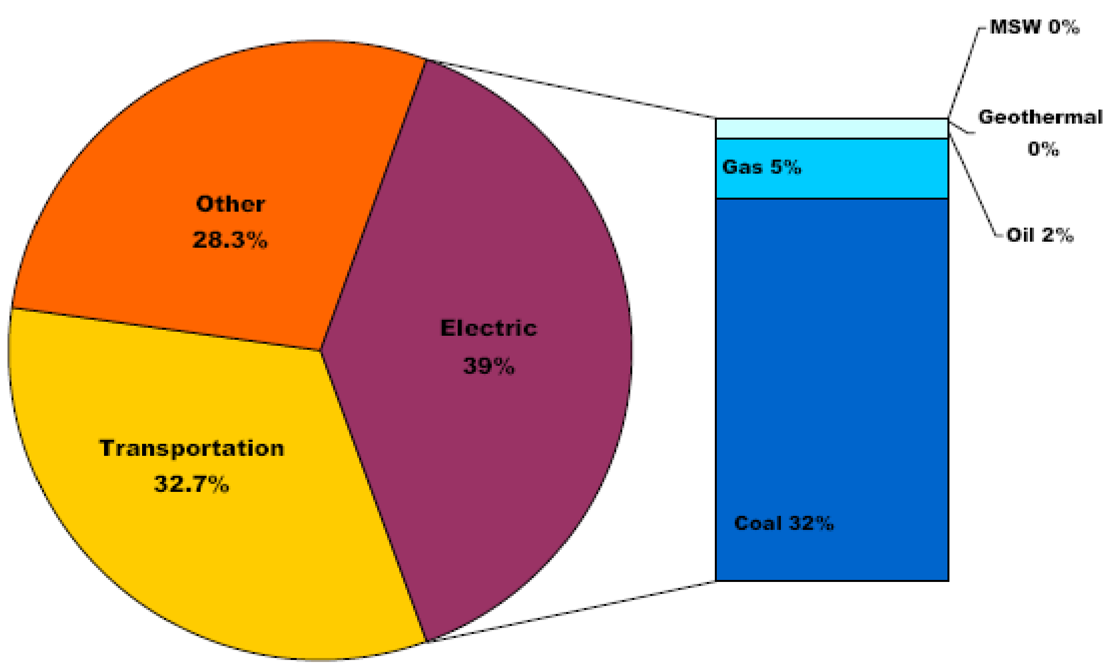
Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

[2] http://www.eia.doe.gov/oiaf/ieo/coal.html

Our View: Coal is like fast food: cheap, plentiful, accessible… but unhealthy, polluting and damaging to the land

Coal is like fast food. It's cheap, plentiful, and relatively accessible for everyone. Unfortunately, it causes significant pollution, as well as extensive land and water damage. By all accounts, coal is a significant and persistent pollutant for the earth's atmosphere. The EIA notes that "Coal has the highest carbon intensity among fossil fuels, resulting in coal-fired plants having the highest output rate of CO_2 per kilowatt-hour"[3] In 2004, Coal was responsible for 50% of the electricity generated in the United States but produced roughly 83% of the resulting Carbon Dioxide emissions from electric power generation. On a larger scale, coal is responsible for 32% of total energy-related US Carbon Dioxide emissions (as opposed to 32.7% from transportation). In essence, coal plants are responsible for as much CO_2 emissions as **every car/truck/plane/train in the US, combined**. The EIA estimates above suggest that coal's carbon emissions are expected to rise from 2,115 million metric tons of CO_2 to 3,206 by 2030 – an increase of approximately 50%. On a smaller scale, the Union of Concerned Scientists (UCS) notes that one 500 MW coal plant is responsible for as much emissions as 600,000 cars (and we have a 150 new plants planned!).

US CO_2 Emissions By Sector[4]



[3] http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2report.html#table_2
[4] Synapse Energy Economics, EIA Emissions of Greenhouse Gases in the United States 2004, December 2005

According to a Union of Concerned Scientists (UCS) study:

"In an average year, a typical 500 MW coal plant generates:

- 3,700,000 tons of carbon dioxide (CO2), the primary human cause of global warming--as much carbon dioxide as cutting down 100 million trees.
- 10,000 tons of sulfur dioxide (SO2), which causes acid rain that damages forests, lakes, and buildings, and forms small airborne particles that can penetrate deep into lungs.
- 500 tons of small airborne particles, which can cause chronic bronchitis, aggravated asthma, and premature death, as well as haze obstructing visibility.
- 10,200 tons of nitrogen oxide (NOx), as much as would be emitted by half a million late-model cars. NOx leads to formation of ozone (smog) which inflames the lungs, burning through lung tissue making people more susceptible to respiratory illness.
- 720 tons of carbon monoxide (CO), which causes headaches and place additional stress on people with heart disease.
- 220 tons of hydrocarbons, volatile organic compounds (VOC), which form ozone.
- 170 pounds of mercury, where just 1/70th of a teaspoon deposited on a 25-acre lake can make the fish unsafe to eat.
- 225 pounds of arsenic, which will cause cancer in one out of 100 people who drink water containing 50 parts per billion.
- 114 pounds of lead, 4 pounds of cadmium, other toxic heavy metals."[5]
- A 1,000 MW coal-fired plant could release as much as 5.2 tons of per year of Uranium and 12.8 tons per year of Thorium. (A 500 MW plant would be expected to generate 2.6 tons of Uranium and 6.4 tons per year of Thorium). [6]

The effects of coal are felt beyond the greenhouse gas emissions. Data from the EPA shows that fossil-fuel (mainly coal) powered plants are responsible for ~two-thirds of SO2 emissions (a major cause of acid rain) and 23% of NOx emissions in the United States.[7] "Between 1985 and 2001, coal mining in Appalachia resulted in the loss of 7% of the region's forests and buried more than 1,200 miles of streams. In 2004, coal mines across the U.S. reported the release of more than 13 million pounds of toxic chemicals, including over 300,000 dumped directly into

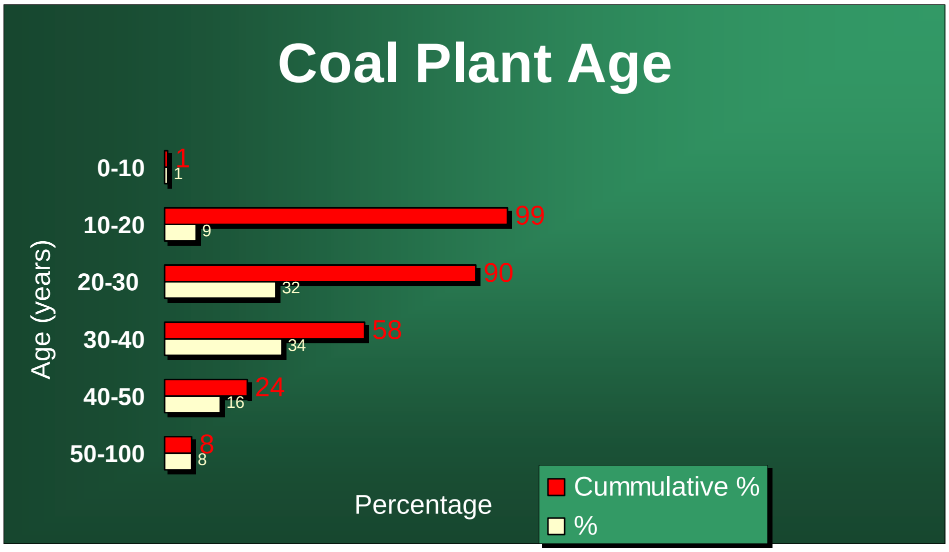
[5] http://www.ucsusa.org/clean_energy/renewable_energy_basics/public-benefits-of-renewable-energy-use.html
[6] http://www.ornl.gov/info/ornlreview/rev26-34/text/colmain.html
[7] http://www.epa.gov/solar/emissions.htm

streams and rivers. "[8] An Oak Ridge National Laboratory study from 1978 (reaffirmed on the ORNL website) notes that despite the fears over nuclear power, "Americans living near coal-fired power plants are exposed to higher radiation doses than those living near nuclear power plants that meet government regulations" and that "This ironic situation remains true today." [9] Coal plants produce approximately 130 million tons of solid waste yearly – approximately three times the total municipal garbage in the US.[10]

The cost of coal is felt directly on our health as well. The American Lung Association notes that a 2004 study attributed 24,000 premature deaths each year due to power plant pollution. In addition, the ALA notes that "research estimates over 550,000 asthma attacks, 38,000 heart attacks and 12,000 hospital admissions are caused annually by power plant pollution."[11] In the last century, more than a 100,000 deaths have been a result of mining, with over 200,000 black lung deaths. This is part of the burden of coal.

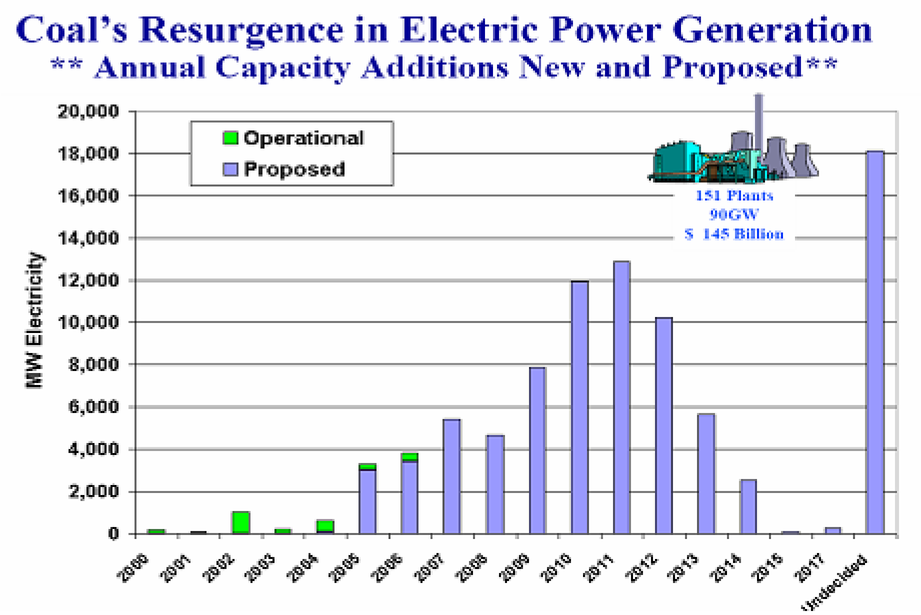
[8] http://www.uspirg.org/home/reports/report-archives/new-energy-future/new-energy-future/making-sense-of-the-coal-rush-the-consequences-of-expanding-americas-dependence-on-coal
[9] http://www.ornl.gov/info/ornlreview/rev26-34/text/colmain.html
[10] "Big Coal: The Dirt Secret Behind America's Energy Future", Jeff Goodell
[11] http://www.catf.us/publications/view/24

Despite the known environmental menace, coal plants have been a significant part of our energy infrastructure, although new plants had slowed down in the recent past. As a result, the US fleet of coal plants is old – significantly so. Only 1% of US Coal plants are less than 10 years old – 9% are between 10 and 20, while the other 90% are more than 20 years old. [12]



As a result of these circumstances, conventional wisdom predicts the likelihood of a new "coal rush" today – the National Energy Technology Laboratory (NETL) reports that there are 151 new coal plant proposals (including 9 on-hold and 10 operational plants), that would generate 90GW in new coal power with a capital investment of $145 billion. Some perceive this as a problem –we see an opportunity to solve the coal problem with better alternatives. We are likely to have a significant increase in the usage of coal as a resource unless we take action – **now.** If we fully take into the risks and likely (full) costs of coal, this rush to coal can be changed. With a proper assessment of the risks and full accounting, renewable power sources are likely to be cheaper and more attractive.

[12] TXU Corporate Presentation



Risk Adjusted, Coal is Uneconomic:

Adjusted for rising power plant capital costs, variable coal prices, sulfur emissions risks, future carbon dioxide emission pricing, more stringent regulations on other pollutants like mercury, arsenic, constraints and increased costs for disposal of waste sludge, and many other risks detailed below, we think properly accounted for, coal becomes an uneconomic investment on the risk reward curve available to most Wall Street investors.

Emission Trading:

For the "climate change" problem, coal is perhaps the biggest culprit. Carbon emissions (along with other greenhouse gases) are a significant cause of climate change, and there is a growing consensus (detailed later in the paper) that something needs to be done to lower energy-related greenhouse gas emissions. General consensus falls into one of two alternatives – the presence of a carbon tax, or a carbon cap-and-trade scheme that allows polluters and emitters to purchase credits in line with their emissions. In both cases, the coal-power producing plants are likely to find themselves with significant liabilities that remain undisclosed and even un-quantified for their investors.

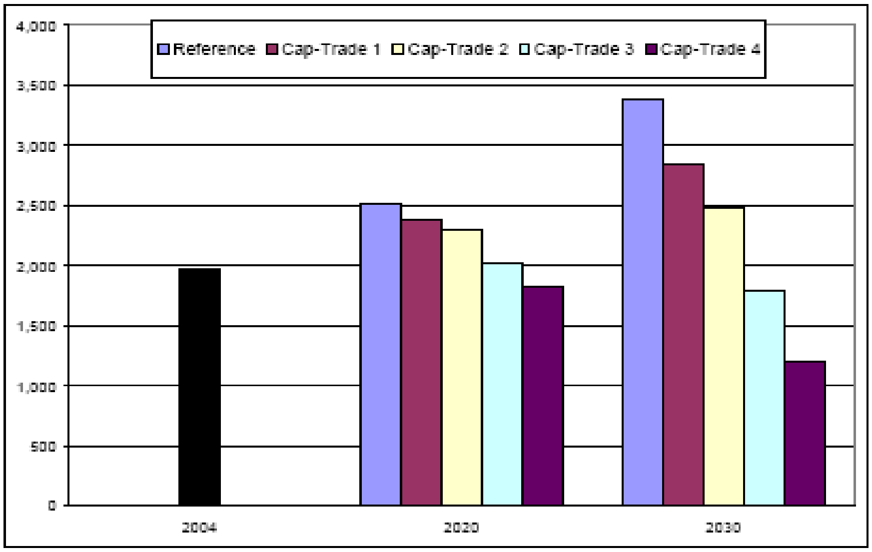
Emissions trading is a not a new development in the coal industry – the Clean Air Act's Acid Rain Program (in 1990) called for reductions of SO_2 emissions to 10 million tons below 1980 levels (approximately a 50% reduction), and a 2 million ton reduction in NO_2 emissions. Starting with Phase I in 1995 and Phase II in 2000, we now have in place an emissions-trading program, one that will place a hard cap on emissions of 8.95 million tons of SO_2 from 2010 onwards. The effect of these emission caps have been felt in the power generation industry, especially due to the volatility of SO_2 prices – between 2004 to 2005, SO_2 emission prices rose from $250 to $750 a ton, and peaked at $1,600 per ton in Dec 2005[13] (prices were at $465-475 in March 2007). They have even affected coal choices – making low-sulfur content Powder River Basin (PRB) coal extremely popular (a typical 500MW coal plant ends up paying roughly $5 million a year in SO_2 credits – and its likely to get worse). PRB coal is in demand, despite its lower energy content, because only 0.35% of its weight is Sulfur, as compared to 1.59% in Kentucky (and generally significantly lower than Appalachian and Pennsylvania coal) As the EIA noted, "PRB spot prices nearly tripled between December 2004 and October 2005, when prompt-quarter spot prices averaged $16.89 per short ton.."[14] In the near future, given the almost-certainty of a carbon emissions limiting program and the popular clamor for action, similar problems are likely to manifest themselves regarding CO_2 emissions – leaving coal plants (and their investors) with significant risk that needs to be managed and hedged.

Studying the impact of Carbon pricing on coal confirms the real costs of coal. A 2005 EIA analysis shows that without any sort of carbon cap, approximately 174GW of new coal-plant capacity is added to the nation's energy infrastructure. However, the same report notes that "In the two most stringent cases [of carbon pricing], the only coal plants added other than those already under construction, are plants with carbon capture and sequestration equipment."[15] In other words, a scenario where the impact of Carbon is taken into account reduces coal from the most "economic" solution, to an inefficient source of power. The graph below shows the EIA's own (conservative) data on coal consumption under five scenarios – a reference case, as well as a few different cap-trade scenarios. In these scenarios, coal use falls from 57.1% of total electric generation in 2030 (reference case) to as low as 21.7% in the most stringent cap-trade case – a significant reduction in CO_2 emissions. It should be noted that while the EIA defines these standards as extremely stringent – they really aren't, in light of what is needed. Cap-trade 4, the strictest of the 4 standards, calls for a return by 2030 to 2004 standards – nothing close to the 60%-80% of 1990 standards by 2050 that has been cited as necessary to make a meaningful impact on global warming. Even a midpoint

[13] http://www.uwp.edu/news/communique/commtemp.cfm?storyID=1467&issueID=78
[14] http://tonto.eia.doe.gov/FTPROOT/coal/newsmarket/coalmar051204.html
[15] http://tonto.eia.doe.gov/FTPROOT/service/sroiaf(2006)01.pdf

between Cap-Trade 4 and the IPCC/UK standards would suggest that building coal plants in the near future is simply not a financially justifiable decision.

Figure 17: Coal Generation
(Billion Kilowatthours)

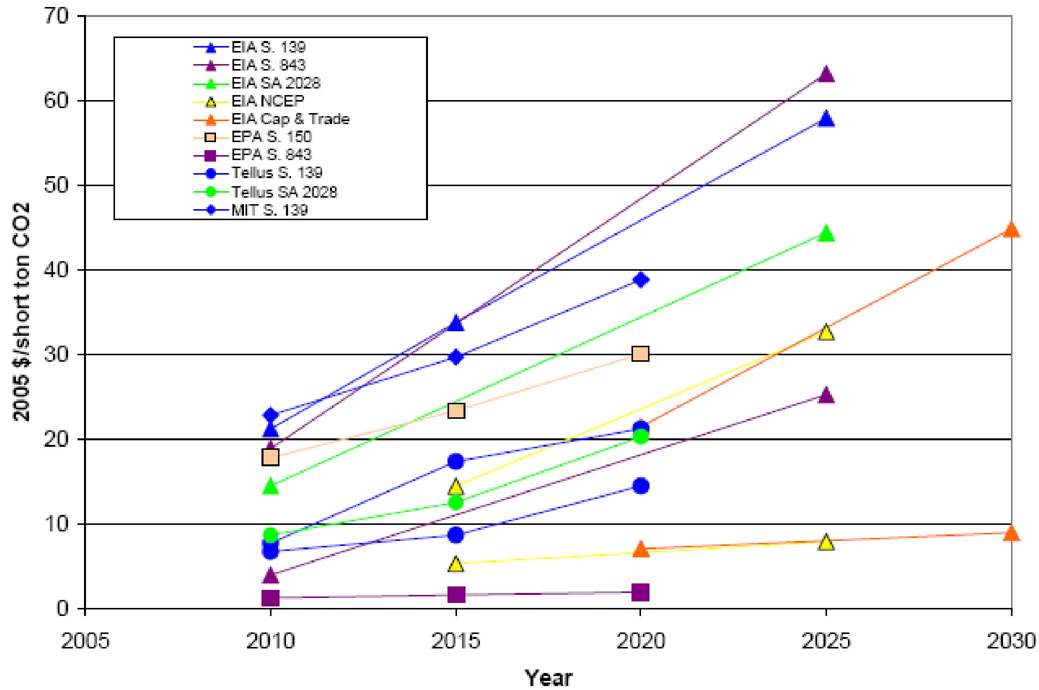


Source: National Energy Modeling System runs AEO2006.D111905A, SALACAP.D012006a, SALACAP30.D012306a, SALACAP35.D012306a, and SALACAP40.D012006a.

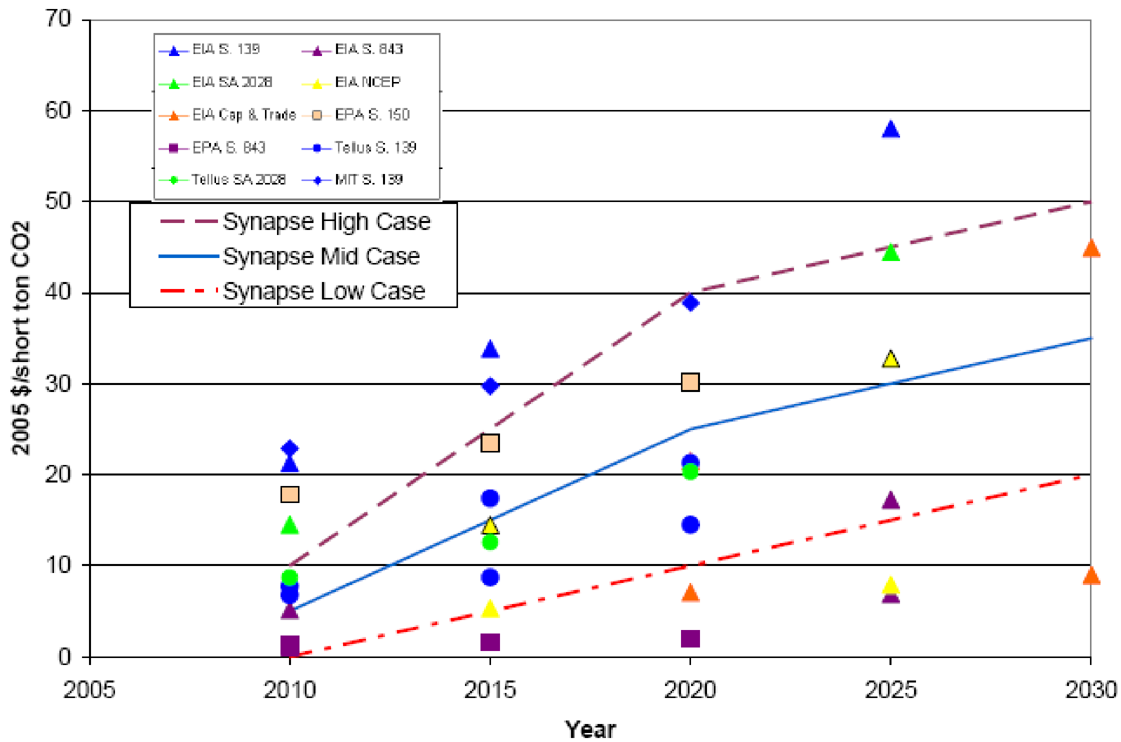
What would Carbon be priced at? A price of $20-25 is suggested by BusinessWeek, based on preliminary data from Europe[16]. The EIA (as cited by Synapse Energy Economics) suggest that CO_2 emissions could be priced as high as $91 to $100 per short ton, for targets 7% below 1990 emission levels (i.e., to meet the Kyoto accord targets) – perhaps the most aggressive of the projections. Synapse conducted its own projections based on various studies (the figures on the graph below represent the estimate of other studies, primarily EIA ones) and came with an average, mid-case rate of about $20 a ton.[17] Additionally, Synapse has noted that some power producers have begun to use carbon pricing in their own, internal estimates. While there is a great deal of variation in these values, they have ranged from $3 to $61 a ton – suggesting a great deal of uncertainty on the pricing by the power plant generators themselves. And uncertainty means risk - lots of it.

[16] http://www.businessweek.com/magazine/content/06_46/b4009089.htm
[17] "Climate Change And Power", Synapse Energy Economics, March 2007

Various EIA and Tellus Institute studies: (Appendix A lists details on the federal mandatory emission proposals)



The following table is a summary of other studies:

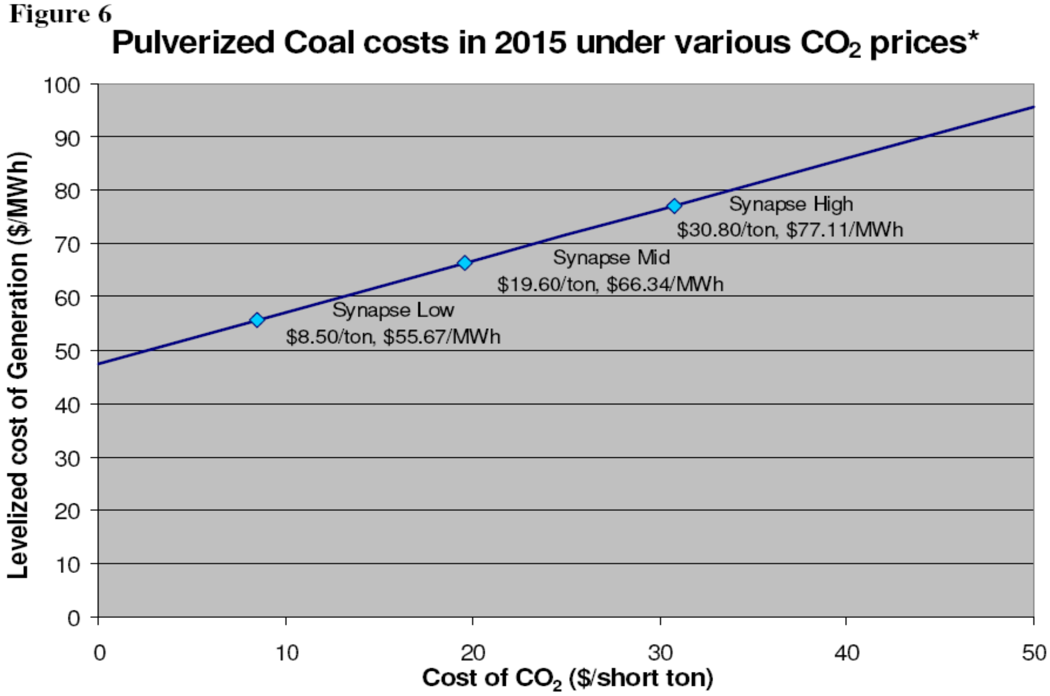


The projections here are based upon more conservative, US policy estimates – the 60-80% reduction in emissions by 2050 considered necessary will likely result in even higher prices. We assume $20 per ton as a reasonable estimate (for Carbon Dioxide pricing) in the mid-term, rising to $40 per ton by 2030. **A conservative $20 per ton CO_2 emission price would increase the effective price of coal by 2-4X.**

How will this affect the price of electricity generation? New pulverized-coal plants emit about one ton of CO_2 for each MWh of electricity generated (a specific plant's efficiency can raise or lower this number) – a very conservative CO_2 cost of $20 per ton would raise the cost of generation approximately $0.02 per KWh. Given these assumptions, UCS and Synapse projections ("Gambling with Coal") show that pricing CO_2 (as per the earlier Synapse projections) would increase generation costs from 17% to 62%. They note that these assumptions are based on EIA generation costs of $47.50 per MWh (with no carbon tax) in 2015 which assumes capital costs of $1,235 per KWh for a new plant – well below the actual capital costs and thus extremely conservative. The report notes that "Any utility proposing to build a coal plant would be reckless to make such a long term investment without fully assessing a variable **that could easily increase costs by $86 million per year on average, or $4.3 billion over a 50-year period**, for a 600 MW coal plant [projections for the Big Stone II plant with the mid-range CO2 price projections]."[18]

[18] UCS, "Gambling With Coal", www.ucsusa.org and *http://www.state.sd.us/puc/commission/dockets/electric/2005/el05- 022/testimonyschlisselsommer.pdf*.

Figure 6

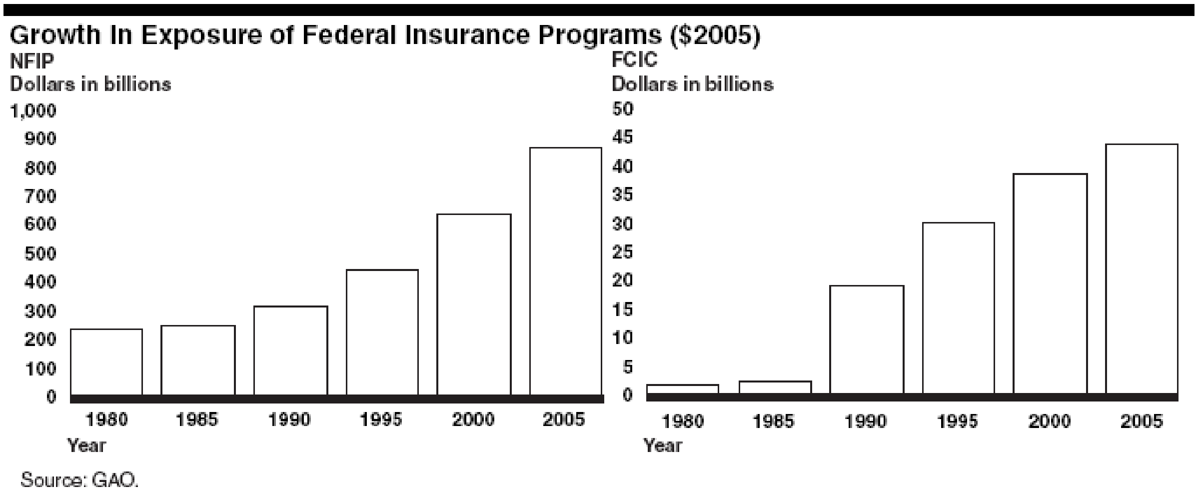


The effects of climate change are already beginning to filter through in our financial models and insurance markets. A GAO report[19] notes that "Using computer-based catastrophe models, many major private insurers are incorporating some near-term elements of climate change into their risk management practices. One consequence is that, as these insurers seek to limit their own catastrophic risk exposure, they are transferring some of it to policyholders and to the public sector." It goes on to point that insurers (public and private) have paid $320 billion in weather-related claims since 1980, and as a result, private insurers are factoring in climate change into their weather models and accounting for it – in a way public insurers haven't. As the report notes:

> "Major private and federal insurers are both exposed to the effects of climate change over coming decades, but are responding differently. Many large private insurers are incorporating climate change into their annual risk management practices and some are addressing it strategically by assessing its potential long-term industry-wide impacts. The two major federal insurance programs, however, have done little to develop comparable information. GAO acknowledges that the federal insurance programs are not profit-oriented, like private insurers. Nonetheless, a strategic analysis of the potential implications of climate change for the major federal insurance

[19] http://www.gao.gov/new.items/d07285.pdf

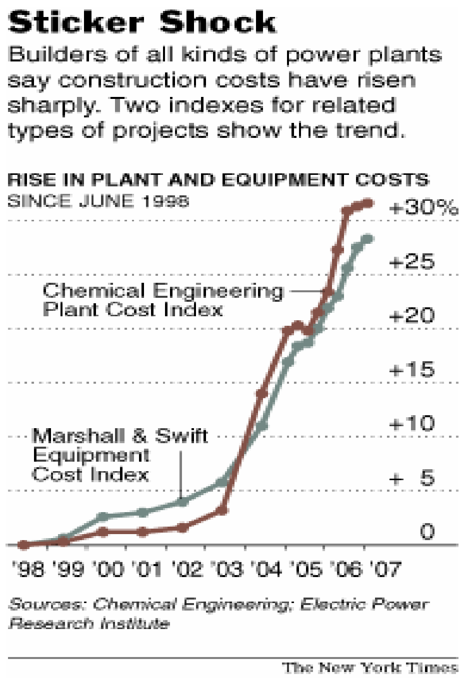
programs would help the Congress manage an emerging high-risk area with significant implications for the nation's growing fiscal imbalance."



Without significant action on the climate change problem, the public taxpayer could be stuck with the bills of willful ignorance on the part of the polluters. Later on, we will discuss the proposed answers and determine whether they are "solutions", or simply additional risk.

Coal: Not Your Father's Capital Costs

With coal, another significant factor in recent times has been the rapid increase in the capital costs of coal plants. From the NY Times: ""There's real sticker shock out there," Randy H. Zwirn, president of the Siemens Power Generation Group, said in an interview. He estimated that in the last 18 months, the price of a coal-fired power plant has risen 25 percent to 30 percent."



The articles also notes that

> ""There's a lack of production and manufacturing facilities in this country, and that may be partly to blame," said Jason Makansi, a consultant with Pearl Street, a consulting firm in St. Louis that specializes in electric utilities. But, he said, "the bigger culprit is the incredible demand in China and the rest of Asia. Basically everything is being sent over that way."
> A result of demand in China and India, he said, is that "Duke and others want to build a new power plant based on inexpensive coal, **but the capital cost to build that plant is doubling before they even put a shovel in the ground**.""

Elsewhere (In a March 2007 report), Innovest Strategic Advisors noted that "In 2006, the cost of new coal-fired power plants increased by 40%. This is representative of a continuing trend in which capital costs have increased by 90-100% since 2002.[20]" Nothing reflects the actual

[20] http://www.net.org/proactive/newsroom/release.vtml?id=29196,

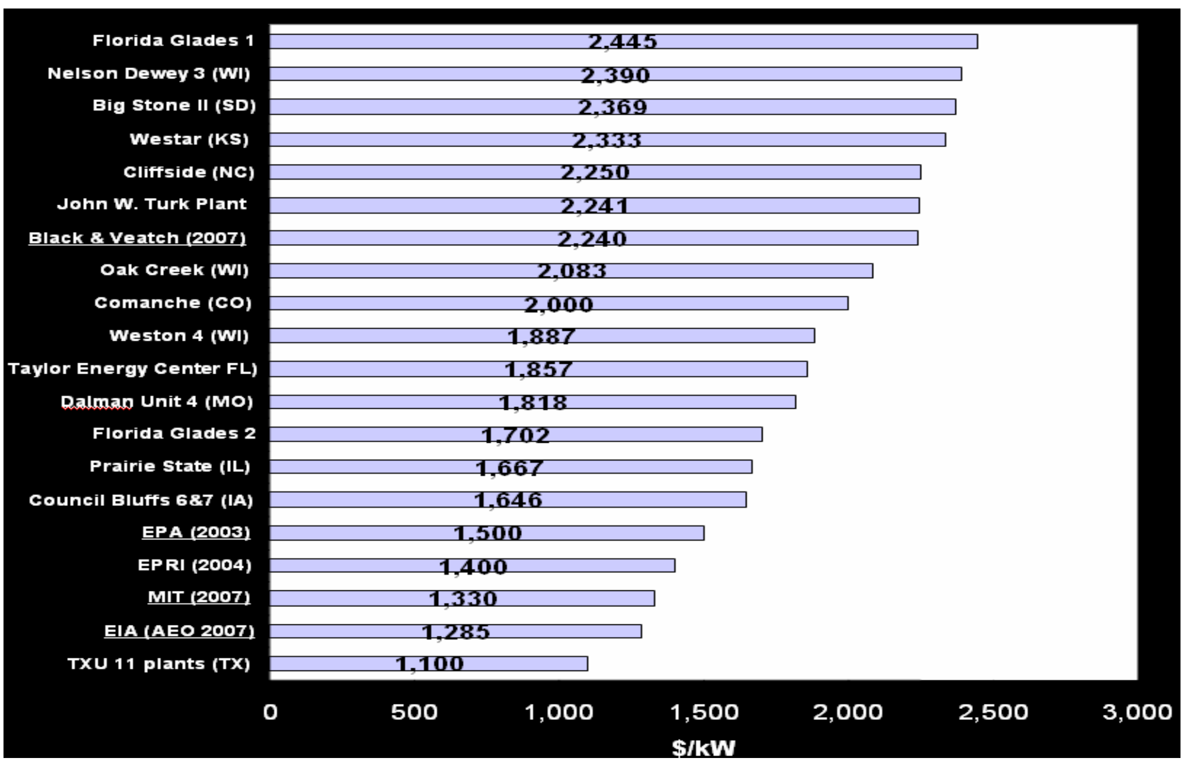
practicality of building new coal plants quite as much as Big Stone II. Big Stone II is a new 630 megawatt coal plant that is being built by regional power utilities in South Dakota, and is expected to come online in 2011 or 2012. Just after getting regulatory approval, the backers announced an increase in construction costs of 50% - from $1.2 billion to $1.8 billion. Moreover, the costs associated with the new plant fail to even acknowledge the costs imposed by future global warming laws (such as the carbon emission trading laws discussed previously). Expert testimony submitted to the Minnesota Public Utilities Commission on behalf of the Union for Concerned Scientists and several Minnesota groups estimates would increase the cost of the plant by 27-33% (under mid-range costs of $20/ton of CO2) and by as much as 51% (under higher cost projections of $30/ton of CO2).[21] Otter Tail Power (the utility leading the project) reported that it had not spent significant time estimating the impact of any future CO_2 limits. The emissions themselves would be significant, with CO_2 equivalent to 670,000 cars – significantly more cars than are currently present in the state as a whole. While the Big Stone II website notes that it will reduce emissions by 20% (as compared to other coal plants in the region), it fails to note that the plant would single-handedly cause a 34% rise in South Dakota's emissions – emitting 4.5 million tons of CO_2 annually. The plant would also appropriate 3.2 billion gallons of water annually from the nearby Big Stone lake, and would emit generate another 189lbs of mercury annually. To their credit, state officials (and the Republican governor) of Minnesota (where most of the projected consumers are located) have recommended against allowing a transmission line, unless significantly more steps are taken to offset the plant's CO_2 emissions, as well as failing to meet its burden of showing that the plant was a better investment than renewable sources and/or increased efficiency.

Big Stone II is not alone in this regard – the price of constructing a coal-power plant has consistently risen as compared to its estimates. Many other coal plants have announced 30-50% capital cost increases in the past couple of years – as more plants being construction, it is likely that this trend will continue to persist. The Cliffside plant in North Carolina (Duke Energy) is another example of costs gone astray. In May 2005, Duke informed regulators of a desire to build two 800-MW units for a total cost of $2 billion – a cost of approximately $1,250 per KW. In November 2006, they came back with a new, higher cost – the same twin 800-MW units were now expected to cost $3 billion – a 50% rise, with a capital cost of $1,875 per KW. The state utility commission limited its request to one 800-MW unit, and as of May 2007, an estimated cost of $1.83 billion was cited ($2,287 per KW and up to $3,000 per KW if financing costs are included) – a total rise in

[21] http://www.synapse-energy.com/Downloads/SynapseTestimony.2006-11.MCEA.Big-Stone-II-Minnesota.06-056-Schlissel%20Sommer.pdf,

costs of 80% from the initial proposal! Elsewhere, Westar's proposed plant in Kansas (estimated to be 800MW) saw costs rise from $1 billion to $1.4 billion (in just 18 months) – and the subsequent cancellation of the plant.[22] In Florida, the proposed $5.7 billion, 1,960 MW super-critical PC plant was turned down by the Florida Public Service Commission, due to its high costs and environmental profile (it was to be located near the Florida Everglades). Like most PC plants being built today, the proposed plant was strongly opposed by environmentalists – any new coal plant is almost certain to face litigation. Numerous other examples portray a picture of coal plants costs rising rapidly – and all suggest that coal is a far riskier bet than it appears. Standard & Poor (S&P) recently published its estimates of coal plant costs, and estimated the cost of a brand new coal plant at $2,438/Kw[23] (capital costs including interest during construction) – significantly higher than the coal industry's optimistic estimates. As Marc Brammer, head of Innovest, puts it "It's the definition of financial insanity to invest in a new coal plant."[24] The table below outlines the trend in PC plant costs[25]. (For more detail on rising capital costs, review Senator Reid's report on the Decline in Coal Power Construction – Appendix B).

Coal Plant Capital Costs – Union of Concerned Scientists



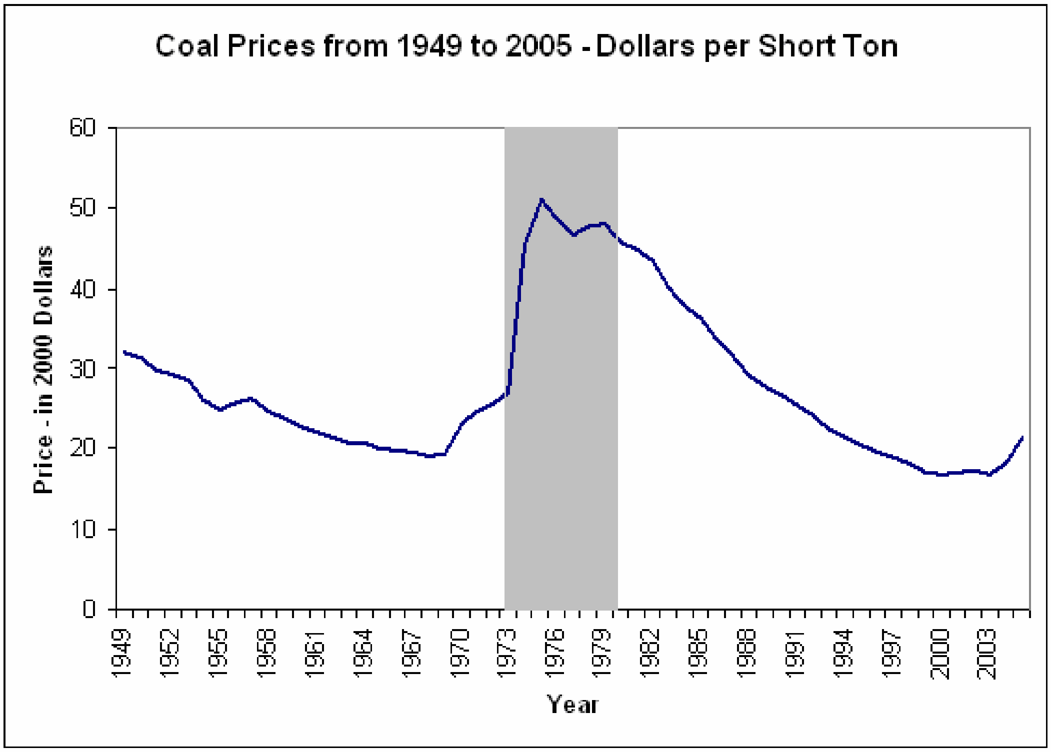
22 http://www.signonsandiego.com/news/nation/20070525-0938-coal-fireddispute.html
23 "Which Power Generation Technologies Will Take The Lead In Response to Carbon Controls?", S&P Viewpoint, May 11, 2007
24 http://www.businessweek.com/magazine/content/06_46/b4009089.htm
25 "Gambling with Coal", Union of Concerned Scientists, September 2006 – EIA, EPA, and B&V estimates do not include interest during construction – unclear whether other estimates do.

Coal: Commodity Price & Transportation Risk is Substantial

There are other risks associated with coal plants beyond the cost of the coal plants – and one such issue is the transportation of coal. Unlike renewable sources like wind and solar (where the resource itself does not need to be transported) or oil (where the resource is liquid), coal transportation costs are a significant factor in the rise of coal costs. Due to the sheer volume of coal being shipped, the railways tend to be the primary means of transport. A WSJ article noted that "as contracts expire … utilities are forced to pay 20-100% more" and that the "railroads have put the electric industry… in a potential crisis situation."[26] Coal is responsible for 70% of the railroad traffic, and railway issues cost the coal companies approximately $3 billion in 2005. Specific problems produced enough of an effect for the spot price of coal to rapidly-run up in the short-term. Senate testimony by the president of Xcel Energy (on behalf of "Consumers United for Rail Equity") suggested that railroads have been failing to meet their basic (legal) obligation to serve all customers – and noted that coal companies like his have seen a "marked deterioration" in service. Currently, two railroads are responsible for shipping all the coal that comes out the Powder River basin (PRB coal) in Wyoming (the major source for most western and mid-western utilities) - for a given power plant, the distance is such that only one railroad can reasonably provide service. Perhaps most importantly, the testimony notes that "railroads remain largely exempt from anti-trust laws" – allowing their quasi-monopolistic actions to continue.[27] Recent bottlenecks/congestion in transporting coal via rail that have been a major reason for increased spot market prices (Witness the rise is PBR coal prices references earlier) and have caused stockpile shortages and even curtailment of generation at some coal plants (such as Big Stone I). Furthermore, the emergence of ethanol as a significant source of fuel in the near and long-term (and its transportation needs) could provide further price pressure on coal and competition for rail capacity. It is with irony that Western producers (like Xcel) found themselves in the position of having to import coal from Indonesia, amongst other places, in order to get the necessary supply. The 2006 EIA Energy Outlook and Modeling Conference notes that in the recent past, railroad transportation contracts have taken on new characteristics, including higher rates, shorter terms, and unilaterally imposed service terms. In Feb 2005, the DOJ started an investigation into the subject. In essence, transportation of coal presents a risk above and beyond other energy sources.

[26] http://www.post-gazette.com/pg/06074/670653-28.stm
[27] http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=1560&Witness_ID=4410

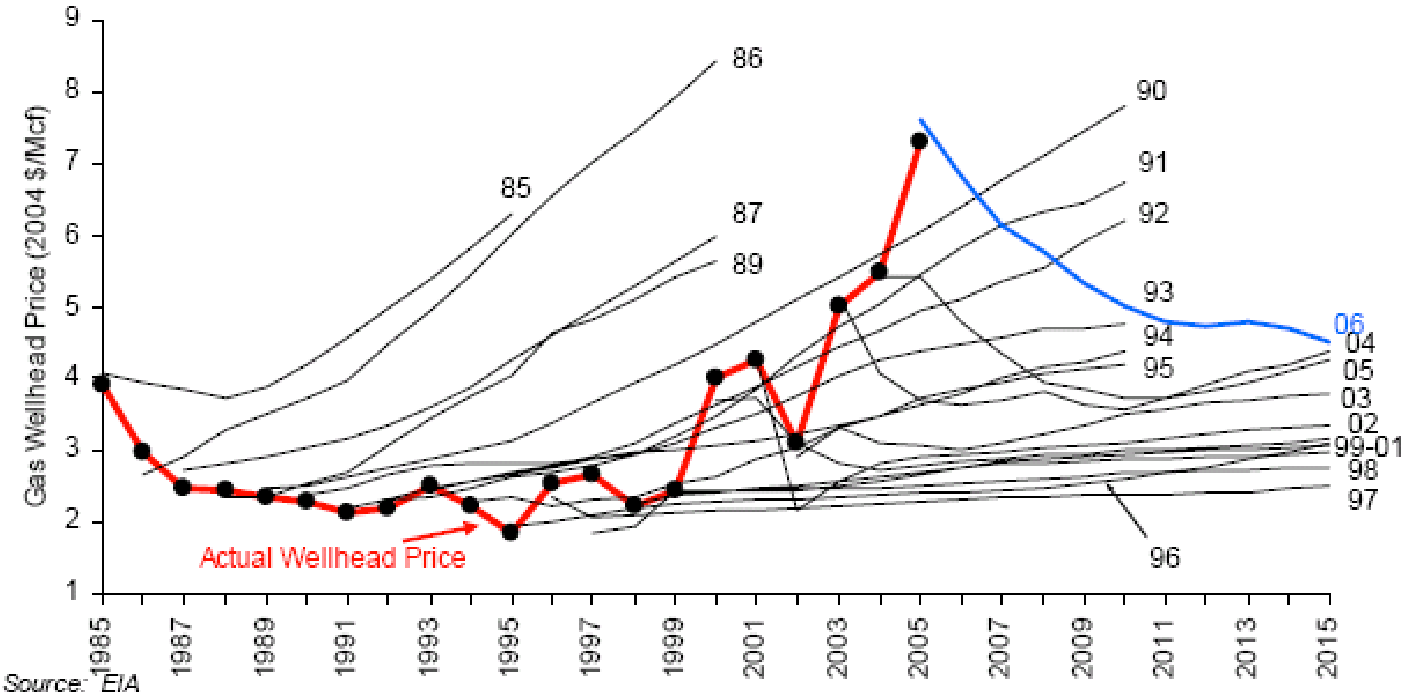
The investment risk associated with coal remains another issue. Building a coal plant now is not simply a one year or a five year decision – it is a 50 year investment for the utilities with limited ability to plan for carbon costs. Our ability to predict commodity pricing bears a fair deal of risk, and having consumers locked in (for 50 years) to a power source that may be uneconomical even before it's produced tests the bounds of logic. A lot of the arguments for coal (as they currently exist) are based on the assumption that it will continue to remain the lowest cost source in the near future. Even simple research seems to raise doubt on this issue. China and India are both building coal plants at a rapid pace (that former at about the rate of one a week – 80GW in 2006), and despite their large reserves, both are expected to be net importers of coal by 2030.



Looking at a graph of coal prices, we notice the large degree of variability around the time of the oil crisis – the 1973 price of coal was $26.97 per ton – the 1974 price, in the middle of the oil crisis, jumped to $45.56 per ton. Given that oil and coal are imperfect substitutes, it is not surprising that a sharp rise in price in oil would lead to one in coal. Another oil crisis, brought on by a terrorist attack or future Middle East conflict (Iran?) would wreck havoc on oil prices, but the knock on effect would be felt on coal prices as well.

The other noteworthy aspect of the graph is that the price of coal was at historic lows at the beginning of the century– in real terms, coal was more expensive in 1949 in the aftermath of WW II and a world where much of Asia and Africa were not yet industrialized than it was in 2000, when India and China (and the world at large) is experiences high levels of growth. The up tick at the end of the period, and the previous EIA evidence regarding China and India's coal usage suggests that coal prices are due for an upward revision, even before taking any Carbon related costs into account.

AEO projected natural gas prices versus actual wellhead prices



The history of gas prices is cause for pause – the chart above compares the predicted prices of natural gas in each year to actual prices that were realized on the market. The basic message: five years is impossible to predict, let alone fifty! When making a 50-year plant investment, commodity price-variability has to be considered; it does not seem to be accounted for today. Carbon price variability is likely even larger, dramatically increasing risk. Today, many of the gas plants built in the 1990's are essentially uneconomic, reduced to a role as peaking plants – with the capital investment essentially a sunk cost. A similar scenario with coal is possible.

Ratepayers vs. Shareholders

Who should pay for the folly of coal power companies? The true impact of the increased capital costs, carbon emission costs, and transportation will be felt when the time comes to pay for the costs – will it be the consumers (in terms of higher electricity costs) or investors (with lower margins)? Tomorrow, the utilities may find themselves paying anywhere from 2-4X more for their coal (when pricing the externalities of carbon). Should consumers bear these costs, given the willful disregard of (some of) the power producers towards the risks associated with carbon emissions? If the cost of generating coal-power electricity goes up by 50%, will investors or ratepayers end up paying the costs? Many states still have some degree of regulation in place regarding rate hikes- it's entirely possible that shareholders could well be stuck with far higher costs than expected. That's not the scenario if the utilities have their way – utility companies have tried to stick consumers for the costs of their mistakes. In North Carolina, Duke proposed a rise in the electricity rates that would raise the average electricity bill by $7.20 per month around the time it presented its revised Cliffside proposal. Nonetheless, the company noted that the rate increase did not include the cost of the Cliffside plant – that cost was to be borne in a future rate-rise.[28] If the FPL Glade power plant had gone through, "The power company could face between $120 million and $400 million in annual penalties for emitting carbon dioxide under a raft of proposals floating through Congress that are aimed at combating global warming, said David Schlissel, a senior consultant for Synapse Energy and Economics."[29] – and they will attempt to pass the costs on to consumers. In our IGCC discussion later, we note that American Electric Power (AEP) requesting a $108 million rate increase in West Virginia to support the higher construction costs of a new power plant![30] Other utility hopes include the prospect of being "grandfathered" under any trade-cap laws, or being allocated the credits instead of purchasing them in a competitive auction (something we strongly oppose – the pollution is an externality with clean-up costs, and power producers should bear the costs). As Professor M.Granger Morgan of Carnegie Mellon explains:

> "Most U.S. utility executives believe it likely that CO_2 emission constraints will be imposed in the United States within a decade. No one knows exactly what form they will take, although economists argue for a gradually escalating tax on every ton of CO_2 emitted. But in

[28] http://www.newsobserver.com/business/story/584903.html
[29] http://www.synapse-energy.com/aboutus/news.shtml
[30] http://www.energyonline.com/Industry/News.aspx?NewsID=7158&Costs_Rise_fo

U.S. politics, "tax" is a dirty word, so a more likely strategy is a cap-and-trade system with emission permits. Those permits will have to be allocated to start the process, and some planners of new plants may hope that their allocations will be proportional to their generators' emissions when regulation begins. Because permits will become more valuable as their numbers gradually shrink over time, that allocation scheme could hand a future windfall to firms that built substantial new capacity now. Of course, another possible approach to emission constraints would be to mandate controls only on new plants, while exempting existing plants for some extended period on the grounds that firms would otherwise face large "stranded costs." Some investors may be counting on this or on the hope that such costs could be passed on to electricity rate-payers."[31]

An example of this strategy is at play in Colorado, with Xcel Energy. Unable (or unwilling) to finance a proposed plant ("Comanche 3") using bond financing, Xcel undertook a scheme called "Construction Work In Progress" (CWIP), under which rate adjustments in Colorado (where electricity has not been deregulated) included an additional fee to support the construction of plant that wouldn't be under operating until 2009, if it all. Thus, while the taxpayers of Colorado take on the risks of financing (and any environmental risks), Xcel Energy's shareholders are the beneficiaries. Under the initial setup, Colorado taxpayers could be stuck in a situation where they would be paying for a coal power plant that they know would be uneconomic (once carbon taxes are taken into account) and that they opposed! The described CWIP financing is severely restricted or forbidden in other states.

However, this is some hope that such a strategy is not yet viable – in a January op-ed, senators Bingham and Boxer noted that companies should not expect to receive free carbon allowances for new coal plants that are built in order to "grandfather" into impending federal regulation. [32] To quote: "As the new Senate committee chairs engaged in the fight against global warming, we think it is important for investors to understand that there is little chance that the majority of such allowances will be allocated without cost and exclusively to large emitters of greenhouse gases. We do not envision that any successful legislative proposal will contain a provision that would allow those building traditional coal-fired power plants to economically benefit from coming in "under the wire" and being considered part of the emissions baseline – in fact, the opposite is likely to occur." Coal investors themselves ought to be wary of the costs

[31] http://www.sciencemag.org/cgi/content/summary/314/5802/1049

[32] http://www.dallasnews.com/sharedcontent/dws/dn/opinion/viewpoints/stories/DN-bingaman_19edi.ART.State.Edition1.290de70.html

associated with carbon emissions, higher capital expenditures increased transportation risk - despite the best laid plans of the coal companies, those investors are likely to find themselves footing the bill.

Other Risks of Coal

Because of its significantly negative environmental impact, coal will continue to face risks that raise costs, above and beyond other, cleaner, sources of power. As noted previously, any coal plant proposed today is certain to face significant (justifiable) opposition and litigation from a wide variety of environmental groups, causing significant delays and additional costs that must be met before construction. Opposition to these plants have been strong enough and garnered enough support to cause the outright cancellation of a few plants (such as the FPL Glades), leaving the companies with nothing in return for the time and dollars spent on the projects in question. The risk of litigation is a significant hurdle; in the future, the pollution from coal could well be called into account. Much like with asbestos, the millions of tons of waste that coal plants continue to emit could well result in large class action suits. Small doses of arsenic and mercury are extremely toxic to humans – meanwhile, the emissions of a typical 500-MW coal plant are in the hundreds of pounds. The vast quantities of municipal sludge pose another significant liability that remains relatively unnoticed. Coal companies could find themselves defending lawsuits dealing with water and ground contamination, while striving to explain the health impacts attributed to increased power plant pollution (as per the previously cited ALA study). If as expected, shareholders are made to pay for higher coal costs due to carbon emissions, coal companies and their management may well face litigation from their own shareholders for their insistence on continuing a coal construction rush. As with the other risks of coal, these risks are likely to increase in the future as more and more new coal plants are built; coal's willful disregard of its environmental responsibilities may come back to haunt it.

Having discussed many of the common problems associated with coal, we will also raise an uncommon one - the availability of cheap, economic, coal. In the US, the PRB contains approximately 58% of US coal reserves, and has some of the thickest, richest coal seams around. A new report[33] shows that much of the easy to get coal (that can be surface mined) is now gone – of the 550 million short tons estimated in the PRB, more than 70% is deeper than a 10:1 stripping ratio

[33] "Inventory of Assessed Federal Coal Resources and Restrictions to Their Development", August 2007, Leslie Glustrom (Clean Energy Action)

(the amount of overburden that must be removed to get access to the coal) – thus having significantly higher costs than PRB coal today. In addition, current leases for coal in the PRB cover approximately 11 years worth of coal consumption in the US – beyond that, any new leases are likely to be fiercely contested.

On a worldwide scale, conventional wisdom suggests that there is anywhere from a 110 to 250 years of coal left - the latter assuming almost no growth rates. Nonetheless, there is some research that they may not be as high as perceived. The Energy Watch Group report "Coal: Resources and Future Production" notes that the data gathering (especially in the developing world) is remarkably unreliable. China, for example, last updated its reserves in 1992 – since then, at least 20% of the reserves have been utilized, but there has been no update in official figures. More suspiciously, since 1986, all nations with significant coal resources (excepting India and Australia) that have their updated reserves estimates have reported substantial downward resource revisions. In Germany, reserves were downgraded by 99%! As the EWG report states: "The World Energy Council briefly notes in its "2004 Survey of Energy Resources": 'Earlier assessments of German coal reserves (e.g. end-1996 and end- 1999) contained large amounts of speculative resources which are no longer taken into account".' The same report notes that the world's in-situ resources of coal have had a 60% downward reduction in the last 25 years and concludes that "the present and past experience does not support the common argument that reserves are increasing over time as new areas are explored and prices rise." [34] What if we were to re-evaluate all reserves to low sulfur coals or with low percentages of other pollutants? How long might our reserves last?

COAL AND PUBLIC OPINION

Having discussed the costs and likely future risks of coal, we will now examine coal's future in the court of public opinion. Why are we convinced that a carbon-capped world is an eventuality? The primary reason is that the overall political, private, and capital climate has come around to accepting the problem of climate change, and the role that coal plants play in increasing our risk. Today, a Carbon tax in some form appears an eventuality. The Senate Energy Committee has held hearings on the cap-and-trade design, and June 22, 2005 Senate resolution (with 54 votes, noting that the GOP controlled the Senate at this point) noted the following:

[34] Energy Watch Group – "Coal Resources and Future Production"

"It is the sense of the Senate that Congress should enact a comprehensive and effective national program of mandatory, market-based limits and incentives on emissions of greenhouse gases..."

Today, multiple cap-and-trade proposals exist in the Senate, sponsored by presidential candidates on both sides (John McCain and Barack Obama – S.280). Moreover, even the private sector has come around on the issue – 6(including TXU) of the nation's top 10 power companies now support CO_2 cap-and-trade regulation. The Edison Electrical Institute, the lobbying arm of the utilities, has come out in favor of carbon emission regulation. A 2004 survey of power company executives suggested that 50% of them expect carbon-trading laws in place within the next 5 years. David Crane, the CEO of NRG Energy noted that "I've never seen a phenomenon take over the public consciousness" and that "This is the kind of thing that could stop coal." Gary Serio of Entergy Corp. notes that "It's very likely the investment decisions many are making, to build long-lived high-carbon-dioxide-emitting power plants, are decisions we'll all live to regret." The head of Exelon has stated, "We accept that the science on global warming is overwhelming. There should be mandatory carbon constraints."[35] The head of PNM Resources said at Senate hearings, "We believe now is the time for a healthy debate at the federal level on climate change, and we support the move to a mandatory program."[36]

Overall, the general climate is one that is likely to result in increased regulation. A Democratic controlled congress is one factor, but the general public awareness is more vital in pushing the issue to the forefront. A CNN/Opinion Research Poll in January 2007 asked the following question:

"Do you think the government should or should not put new restrictions on emissions from cars and industrial facilities such as power plants and factories in an attempt to reduce the effects of global warming?"

In response, 75% of respondents came out in favor of new restrictions and emissions. In the same poll, only 57% said they were sure that Global Warming was a fact – 38% believed it to be a theory – which suggests that even people who aren't certain about global warming are in favor of doing something about it. Similar polls from the Wall Street Journal (where 64% of respondents wanted some action right now – up from 51% in 1999) and Fox News (where a plurality 41% believed global warming was caused by people's behavior, and 38% believed it was both people

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[35] John W. Rowe, August 16, 2004, quoted in *Business Week*. Online at *http://www.businessweek.com/print/magazine/content/04_33/b3896001_mz001.htm?gl*.

[36] Jeff Sterba, April 4, 2006, quoted in the *Albuquerque Tribune*. Online at *http://www.abqtrib.com/albq/nw_national_government/article/0,2564,ALBQ_19861_4594645,00.html*

and the normal patterns.)[37] [38] The Fox News poll (which also reported 82% of Americans believe in global warming) also notes that the demographic breakdown is not as different as would be expected – 72% of Republicans believe global warming is real. In response, Opinion Dynamics (which conducted the poll with Fox News) Chairman John Gorman noted that "The growing concern about global warming is clearly affecting Republicans despite the skepticism of many key interest groups in their coalition." Worldwide political opinion is similar: BBC World (in conjunction with PIPA) conducted worldwide polling (19,000 people – 19 countries) from May-July 2006, before the G8 summit in St. Petersburg that year. While the focus was on energy issues at large, they noted that there was "overwhelming support for alternate energy development as well as higher fuel efficiency standards in automobiles"[39] (every country polled had a majority in favor of creating tax incentives for renewable energy, with 62% being the **lowest** level of support, and 16 of the 19 supported increased automobile efficiency standards) – with 80% supporting tax incentives overall, and 67% supporting increased efficiency standards. A majority in every country (India, Poland, and Russia were the only three with less than 73% support)[40] believed that energy production and use was harming the environment at large .Given the continual probability of further events like Katrina (which many believe, rightly or wrongly to be linked to global warming), it seems unlikely the public opinion is likely to change in the near future.

Even the likes of Exxon Mobil (one of the more prominent skeptics of global warming,) have stopped funding groups like the Competitive Energy Institute (which once argued that CO_2 is essential to life with the memorable tag line "they call it pollution. We call it life" and whose president once noted that "Most of the indications right now are it looks pretty good. Warmer winters, warmer nights, no effects during the day because of clouding, sounds to me like we're moving to a more benign planet, more rain, richer, easier productivity to agriculture"). Moreover, private enterprise and capital appears to be coming to similar conclusions. In a February 2007 press release, The Global Roundtable on Climate Change explicitly called on governments to "set scientifically informed targets for greenhouse gases and carbon dioxide (CO2) emissions" and encourages government to price carbon emissions and set forth policies aimed at energy-efficiency and the "de-carbonization" of the energy sector.[41] The same report explicitly calls for a dramatic increase in the use of non-fossil fuel energy sources. The report is notable not only for the calls it

[37] http://www.pollingreport.com/enviro.htm
[38] http://www.foxnews.com/projects/pdf/020207_global_warming_web.pdf
[39] http://199.202.238.2/news_archives/bbcwsenergy/
[40] http://199.202.238.2/news_archives/bbcwsenergy/detail.html
[41] http://www.earthinstitute.columbia.edu/news/2007/story02-20-07.php

makes (an explicit request for government intervention in setting up a market for Carbon emission trading) but for its signatories – they include Alcoa, Exelon, General Electric, NRG Energy, as well as a significant portion of Wall Street (Citigroup, Goldman Sachs). The US Climate Exchange partnership, a group whose members run the gamut from automakers (GM, Ford) to utilities and power producers (PG&E, Duke Energy), from insurance (AIG, Marsh) to oil (Shell, Conoco Phillips, BP) in partnership with various environmental groups issued similar recommendations in January 2007 - explicitly stating that any "**any delay in action to control emissions increases the risk of unavoidable consequences** that could necessitate even steeper reductions in the future." The group published *A Call to Action*, which lays out the specifics of the goals, including emissions reductions of 60% to 80% by 2050 – in line with the goals of the IPCC. The partnership notes that **"In our view, the climate change challenge, like other challenges our country has confronted in the past, will create more economic opportunities than risks for the U.S. economy. Indeed, addressing climate change will require innovation and products that drive increased energy efficiency, creating new markets. This innovation will lead directly to increased U.S. competitiveness, as well as reduced reliance on energy from foreign sources. Our country will thus benefit through increased energy security and an improved balance of trade."**

In line with these expectations, investors are starting to take notice. The WSJ (July 25, 2007) notes that "Citigroup downgraded the stocks of coal-mining companies last week, noting that "prophesies of a new wave of coal-fired generation have vaporized."" Swami Venkataraman, Standard & Poors director in corporate and government ratings noted that "2006 will be seen as the year when climate change moved from the controversial to the conventional in the public mind,"[42] and that "Industry seems to accept that controls are now very likely." Perhaps the best example of this is the case of TXU. TXU is one of the nation's largest greenhouse gas emitters, and intended to continue in the same vein; as of year-end 2006, TXU's intention was to build 11 coal-fired plants in Texas alone, as well as plants in Pennsylvania. A Feb 2007 leveraged buyout lead by KKR and Texas Pacific changed all that. As a condition of the acquisition, the private equity firms insisted on an "environmental agreement" that included a support for a federal cap-and-trade scheme, the cancellation of 8 of the 11 coal plants in Texas (as well as a doubling of funds allocated to energy efficiency). In addition, TXU promised to reduce its CO_2 emissions to 1990 levels by 2020 – something that far surpasses any statewide obligations TXU had. As the head of Environmental Defense (one of parties involved in the agreement) put it, "they [Texas Pacific and KKR] would not

[42] http://www.environmental-finance.com/onlinews/0517cli.htm

go through with the deal unless they could re-create the company as a green electricity generator."[43] To quote one source: "Anyone doing an energy investment in today's situation has got to be sensitive of the change in the attitudes of the culture and the change in the attitudes of the country, and particularly the attitudes of Congress."

Simply put, this isn't about some environmentalist fantasy anymore – it's a pragmatic view of a problem that threatens all of us. Irrespective of one's view of global warming and the desirability of "green technologies," the risks of traditional coal plants have increased dramatically and put them, in our view, on the uneconomic side of the risk/return curve. There is support across both companies, political groups, and the public for action to combat climate change. Carbon emissions regulation is coming – and with it, the increases in the price of coal power.

Renewable Portfolio Standards (RPS) for Electricity – State and Federal?

While the federal government has yet to take action, various states have jumped ahead of the game with the implementation of Renewable Power Standard's (RPS) to diversify their power supply – and the trends' suggest that more RPS' are coming. Twenty-one states (plus the District of Columbia) have adopted renewable energy standards of some level – Massachusetts, New Hampshire, Oregon, and Washington have specific laws limiting the emission of CO_2 or at least requiring offsets.[44] Other states have made their views on renewable energy clear – California will require 20% of energy production by 2010 to be renewable, rising to 33% by 2020. New Jersey's target is 22.5% by 2021. The Union of Concerned Scientists (UCS) projections for CO_2 reductions from state RPS' are significant - 105 million metric tons of CO2 by 2020 from more than 45,000 MW of new renewables. Other UCS and EIA analyses also show that a 20 percent by 2020 federal RPS could reduce the projected growth in power plant CO2 emissions by more than 59 percent.[45] This poses additional risks for the companies involved in coal – given California's goal of carbon emissions 80% below 1990 levels by 2050 (as per the AB 1368 law), it would have seemed to have made coal persona-non grata. Other, more stringent legislation has also passed in California – SB 1368 has **immediately** barred any California electricity providers from entering into long-term

[43] http://www.washingtonpost.com/wp-dyn/content/article/2007/02/25/AR2007022501520.html
[44] From the "Gambling with Coal", Union of Concerned Scientists, September 2006 – originally sources from Massachusetts Department of Environmental Protection, "Emissions Standards for Power Plants," 310 CMR 7.29; New Hampshire Revised Statutes Annotated. "Multiple Pollutant Reduction Program," Chapter 125-O; Washington Revised Code, "Carbon Dioxide Mitigation," Chapter 80.70; Oregon Revised Statutes, Carbon Dioxide Emissions Standard, § 469.503
[45] http://energy.senate.gov/public/index.cfm?FuseAction=Hearings.Testimony&Hearing_ID=1403&Witness_ID=4034

deals with power generators (in-state or out-of-state) who caused air pollution above a specified level (the level in question was to be no higher than the pollution from a combined-cycle natural gas fired plant – and it could be lower) – a law aimed directly at the coal companies. While California has no coal plants of its own, the net effect of the law is to effectively bar any coal power generation company from selling energy to California on long-term contracts (short-term, and spot purchasers of coal power would still be allowed). In effect, coal plants would be barred from the largest energy market in the US, It seems entirely reasonable to imagine that in the near future, other states could take the same plunge – an immense investment risk above and beyond the already-known hit of California. Similarly, California had adopted AB 32 – perhaps the most stringent climate change proposal in the US. As noted, "AB 32 is the first statewide effort to cap greenhouse gas emissions across all sectors of California's economy. It would set a firm cap that would ensure that California's greenhouse gas emissions are reduced by 25% by the year 2020, putting teeth in Governor Schwarzenegger's goal to reduce California's emissions."[46] We may well see a future where coal power production is barred from many of the states in question (beyond CA) – rendering investments in coal almost useless. Is this a risk that most institutional investors are really willing to bear?[47]

Regulation at the Federal level is also moving. The house passed the Renewable Electricity Standard but the Senate rejected it. Will the same happen after the next election cycle? Some compromise appears likely. The Leiberman-Warner climate bill that caps US carbon emissions has more support than any previous climate action bill.

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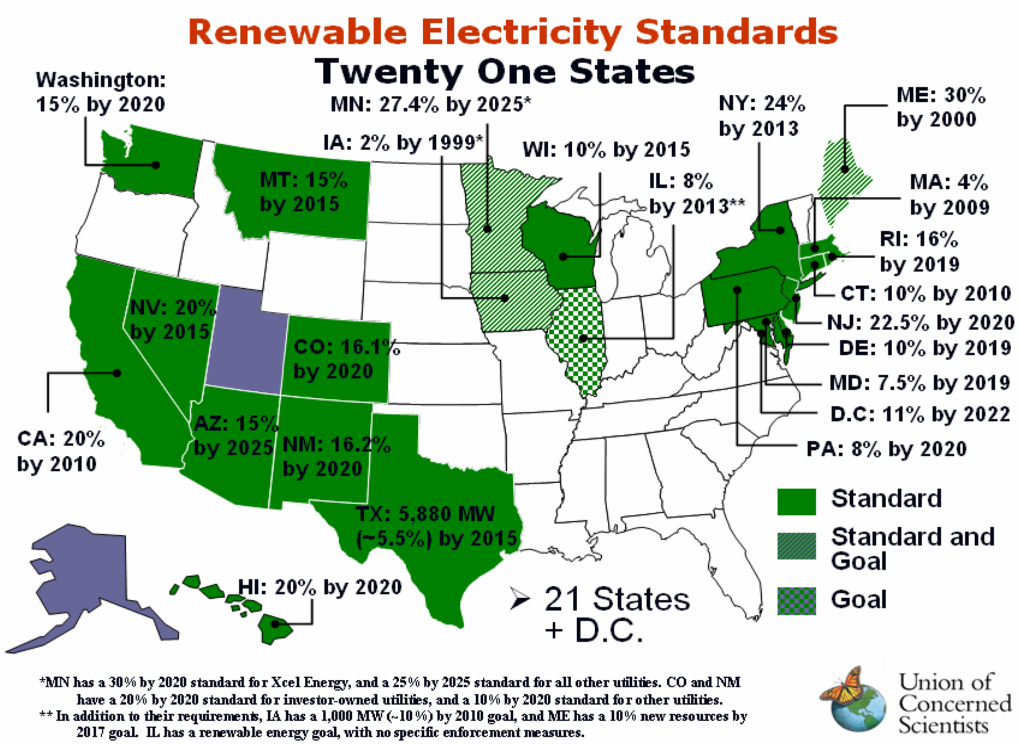
[46] http://www.environmentaldefense.org/pressrelease.cfm?ContentID=5308
[47] http://www.dwt.com/practc/energy/htpres/10-06_HotTopicsCA.htm
http://www.stoel.com/showarticle.aspx?Show=2066
http://gov.ca.gov/index.php?/fact-sheet/4445/



Carbon cost planning is also in progress at some level. In California, the Public Utilities Commission directed utilities to provide a number between $8per ton for CO_2 emissions in their planning proposals[48] (and procurement for the next generation), while noting that the plausible range to quantify the risk was anywhere from $8-$25 per ton. Individual companies have themselves started to take CO_2 emissions costs into their long term resource planning – from numbers as low as $3 per ton (unlikely) to as high as $61/62 per ton (Portland General Electric, Idaho Power). In the near future, more utilities are likely to follow this path – if only to have a better assessment of their liabilities for Wall Street. To take one example, it does not seem out of line to imagine a future where a law requiring firms to disclose their potential future pollution obligations (much like the stock options expensing currently in place) – ahead of any explicit carbon cap-and-trade scheme.

Coal Subsidies

One of the common criticisms regarding renewables vs. coals is that the latter is "cheap"– a misguided perception, considering coal's long history of feeding at the public trough and not pricing in externalities like pollution. To quote directly from the chairman of the White House council on

[48] http://www.energy.ca.gov/2005publications/CEC-100-2005-007/CEC-100-2005-007-CTF.PDF

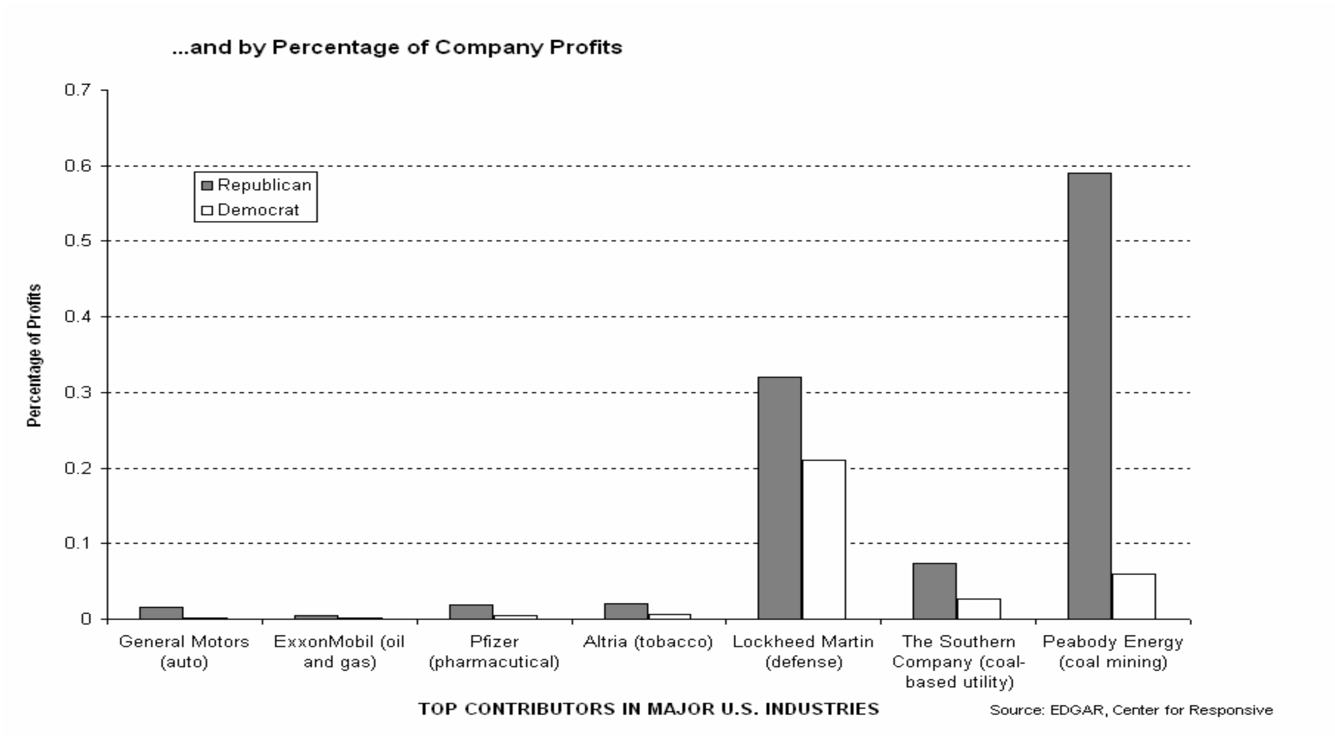
Environmental Quality – (in a letter responding to a Tom Freidman article on the need for cleaner technology):

> "Although not reported in major media, on Nov. 30 the Treasury Department awarded nearly $1 billion in tax credits to help offset the cost of nearly $10 billion in private investment to build nine advanced coal projects. The Energy Department also awarded a $235 million grant to match $300 million by a private utility to build a coal gasification facility in Florida. With another $650 million in tax credits this year leveraging billions more in private dollars, we should produce more than a dozen commercial-scale coal projects holding the promise of lower carbon dioxide.
>
> This builds on the $2.2 billion President Bush dedicated to clean coal research that culminates with the Energy Department's FutureGen initiative, a $1 billion international partnership to build and operate the world's first coal-fueled, near-zero emissions power plant by 2012."

The letter alone details approximately $3.5 billion in subsidies just in the near term. The WorldWatch Institute estimates that worldwide, there were about $60 billion in coal subsidies annually (as of 1999 – it is likely the number has come down slightly since then).[49] Even today, "market" coal gets far more subsidies than developmental technologies like solar energy. Time magazine notes that in 2007, federal funding for coal R&D is at $427 million – while solar power received just $159 million.[50]

[49] http://www.worldwatch.org/node/1657
[50] http://www.time.com/time/magazine/article/0,9171,1645166,00.html

Coal's dependence on government money leads to generous political donations



Coal – Summary

As detailed, the problems with coal exist on multiple levels. The environmental effects of coal are immense, and the continual usage of coal as our primary energy source will lead to disastrous results. There can be little doubt that coal plants are perhaps the largest contributor to the climate change problem. From a financial perspective, the cost of building and generating electricity from coal plants is rising rapidly, to the point where other sources are more economic even without a carbon tax. Any coal plant built today is based on the premise of a 50+ year operational timeline, and holds a significant amount of investment risk for the parties involved – more investors are choosing to opt out of the risk altogether. The political, public, and private pressure for action on the issue means that carbon emissions (for which coal plants are the most responsible) are likely to become a significant liability on the books of utilities everywhere, significantly raising the cost of coal. With Chinese and Indian demand unlike to slow down soon, coal prices will continue to rise in the future, even as the total supply of coal left is called into question. At this point, the risks associated with conventional coal outweigh the benefits – its time has passed.

If not Traditional Coal – then what? - THE CONVENTIONAL WISDOM

As conventional wisdom goes, the US is the "Saudi Arabia of coal", and thus the idea of abandoning coal as a power source is seen as ridiculous. To these soothsayers, the correct course of action is through technologies that will make coal cleaner, and reduce its carbon footprint on the world. In particular, the focus is on two technologies – Integrated Gasification Combined Cycle (IGCC) and Carbon Capture and Storage (CCS).

IGCC technology involves two major processes– the gasification of coal, followed by the combined cycle process to generate electricity. Coal gasification is a process in which coal is reacted with steam and oxygen to form syngas (a combination of carbon monoxide and hydrogen). The syngas is then cleaned to remove pollutants. The produced syngas is then used as the main fuel for a gas turbine (which produces electricity)– meanwhile, the waste heat generated from the gas turbine is used to power a second, steam turbine (additional electricity production), thus increasing the energy efficiency of the plant as a whole. In theory, IGCC produces less solid waste, lower emission levels (as a result of better efficiencies) as compared to pulverized coal. The optimistic projections for IGCC (as per the World Coal Institute) include efficiencies of up to 50% (potential up to 56%), while reducing Nitrogen Oxide by 33%, 75% less Sulfur Dioxide, 30-40% less water, and the capture of up to 90% of the mercury emissions.[51]

Unfortunately, the technology in question comes with additional costs. The major question that has been raised about IGCC plants is their consistency and reliability. Gasifiers, by their nature, are significantly more temperamental than standard pulverized coal plants, and are more likely to be subject to temporary shutdowns – significantly limiting their ability to serve as base load plants. Commercial demonstrations of IGCC plants have not proved very successful – availability problems have cropped up. The MIT Coal study noted that "IGCC has to overcome the perception of poor availability and operability. For each of the current IGCC demonstration plants, 3 to 5 years was required to reach 70 to 80% availability after Coal-Based Electricity Generation commercial operation was initiated. Because of the complexity of the IGCC process, no single process unit or component of the total system is responsible for the majority of the unplanned shutdowns that these units have experienced, reducing IGCC unit availability. However, the gasification complex or block has been the largest factor in reducing IGCC availability and operability. Even after reaching

[51] http://www.worldcoal.org

70 to 80% availability, operational performance has not typically exceeded 80% consistently". Additionally, the performance of IGCC plants decreases with lower quality fuels and at higher altitudes, all of which limits its ability as a PC-replacement.

Other problems are present with IGCC as well –despite its improvements over pulverized coal, it is still a significant environmental menace, and there are significant doubts about its environmental profile as a stand-alone technology. While IGCC does appear to significantly reduce SO_2, nitrogen oxide, sulfur and water, its effects on CO_2 emissions (without sequestration) are limited at best. The MIT study compared the CO_2 emissions from a supercritical-PC plant to that of an IGCC plant, without carbon capture. The results show a SCPC plant without capture emitting 830 g/KWh of CO2 vs. 832 g/KWh for an IGCC plant without capture (we have seen estimates ranging from 800 to 1000 g/ KWh in CO_2 emissions, depending upon the specific plant) - with heat rates of 8,868 vs. 8,891 Btu/KWh respectively. By itself, IGCC technology does not reduce CO_2 emissions. IGCC's most significant advantage is based on utilizing CCS technology – the latter actually reduces CO_2 emissions. Nonetheless, the vast majority of proposed IGCC plants do not intend to have any sort of CCS technology implemented, leaving it as a "future option". Moreover, the costs of IGCC are higher than PC – EIA and UCS reports suggest that IGCC technology raises the cost at least 20% (without taking any proposed Carbon costs into account). Black and Veatch projects capital costs of $2,120/kW for PC plants and $2,750/kW for IGCC plants (30% higher even without sequestration!) both of which are very conservative - recent data from actual projects suggests these costs are way too low. The key questions is whether the capital costs of IGCC will be able to fall as projected with learning and increased economies of scale in manufacturing, engineering, and so forth. Evidence from proposed IGCC projects highlights the actual costs of construction. The AEP power plant in West Virginia had construction costs rise to $2.23 billion for a 630 MW plant, more than 70% higher than previous estimates. This is a capital cost of $3,539/kW – more than 30% higher than the Black and Veatch IGCC estimates. In response to the price rise, AEP filed testimony in West Virginia requesting a $108 million rate increase to support the construction![52] Referring back to the ratepayers vs. investors dilemma, it seems absurd to expect ratepayers to justify AEP's ridiculous cost assertions. Other examples of actual IGCC construction costs abound –the Mesaba IGCC plant proposed in Minnesota. The capital costs of Mesaba come to $2.155B for a 600MW plant – or approximately $3,593 per kW. In addition, the plant has a list of DOE goodies – DOE guaranteed loans, a $36 million DOE grant, a tax-credit

[52] http://www.energyonline.com/Industry/News.aspx?NewsID=7158&Costs_Rise_fo

worth $100-200M annually and $21 million DOE grant to "study sequestration." The aforementioned S&P report estimates the cost of construction of an IGCC plant at $2,795/KW (as high as $2,925/KW when utilizing PRB coal), for a plant running at an 80% capacity factor. [53] We highlight the expected costs of recently proposed IGCC coal plants below.

Type	Install Date	Capital Cost ($/Kw) – 2006$
B&V Projected – Coal - IGCC	2005	2,750
B&V Projected – Coal – IGCC	2010	2,840
B&V Projected – Coal – IGCC	2020	2,840
Cliffside, North Carolina (Duke) - IGCC	Reduced Approval granted	3,000
West Virginia (AEP) – IGCC	Commence ops in 2012	3,500
Mesaba (Excelsior) – IGCC	Review on hold	3,593
FutureGen – near zero emission demo plant	Commence ops 2012 (at earliest)	6,000+

In response to the rapidly increasing costs, many planned IGCC plants have been put on hold or cancelled. [54]

Developer	US State	Status	Reasons for Stalling
NRG	Connecticut	Canceled	Could not meet RFP timeline for delivery
TECO	Florida	Canceled	State carbon policy uncertainty, rising costs
Tondu Corp	Texas	Canceled	Rising costs, limited technology guarantees
Bowie Power	Arizona	Canceled	Delayed local planning process, environmental opposition
Buffalo Energy Partners	Wyoming	Canceled	Transmission constraints, rising costs, limited available technology guarantees and unsuccessful bid for funding
Mesaba	Minnesota	On hold	Increased costs have caused regulators to force renegotiation of costs
Madison Power	Illinois	On hold	Construction of a nearby supercritical coal plant has hindered power demand and tied up transmission and coal transport infrastructure
Tenaska, ERORA	Illinois	On hold	Local opposition to IGCC without carbon capture hampering regulatory proceedings
NRG	New York	On hold	Must find cost reductions to maintain state-awarded financial support

The next step proposed in the evolution of "clean coal" is the pairing of IGCC with Carbon Capture and Storage (CCS) – allowing for emissions of CO_2 to be both captured, and stored in geological

[53] "Which Power Generation Technologies Will Take The Lead In Response to Carbon Controls?", S&P Viewpoint, May 11, 2007
[54] "TECO, Noun Cancellations Underscore IGCC's woes", Emerging Energy Research, October 5, 2007

formations or elsewhere (unlike a standard IGCC design, under which there are still significant emissions). The largest such CCS plant (a collaboration between Exxon Mobil, Shell, and ChevronTexaco) is expected to become operational by 2010 (though the scale is probably 1000x smaller than is really needed to have a noticeable effect on sequestration). The projection (in scenario testing conducted by the industries) "finds that in most scenario studies, the role of CCS in mitigation portfolios increases over the course of the century and including CCS in a mitigation portfolio is found to reduce the costs of stabilizing CO_2 concentrations by 30% or more. Power plants with CCS could reduce CO_2 emissions by 80-90% net."[55] The World Coal Institute also mentions that "Due to the additional costs associated with CCS, companies will generally require some financial incentives (read "handouts") to make projects economically viable" – no specific numbers are cited.

Unfortunately, CCS brings its own host of problems and cost issues. Perhaps the largest issue with CCS is the obvious one – where would we store all the carbon dioxide, and how much space would we need? In Australia, the federal government is trying to determine where to allocate around A$500 million as part of an Australian greenhouse gas reduction program – geo-sequestration is one of the proposals. The Australian television program "Catalyst" produced piece about sequestration, where it noted some of the potential pitfalls. Amongst other things, geo-sequestration reduces the efficiency of the energy produced by 6 to 12% (6% for IGCC, to 12% for Pulverized Coal). In effect, one could end up burning more coal in order to generate the same amount of power so that the CO_2 could be captured in the first place. It also noted the sheer volume of area that would be needed for liquefaction and subsequent sequestration to work. To quote:

> **"Well this drum holds 200 liters. Imagine a pile of these drums that runs for 10 kilometers that way, 5 kilometers that way, and stacks up 10 drums high. More than 1300 million of them. That's how much CO2 pours out of our 24 coal power stations. Not every year, that's just in one day. Now the gas has to be compressed into a liquid to inject it underground. But even that leaves a huge volume to process. It squashes down into a lake of drums 1 kilometer square. And remember, that's' every day."**

The sequestrated emissions would take approximately 140 square miles of space every year. Extending the same comparison beyond Australia (which consumes approximately 2-3% of the world's coal) shows the sheer magnitude of the problem with sequestration. Similar estimates abound - Lynn Orr, a petroleum engineer who directs the Global Climate and Energy Project at

[55] http://www.worldcoal.org/pages/content/index.asp?PageID=414

Stanford University, estimates that to store a billion tons of carbon underground, the total inflow of CO_2 would be roughly equal to the total outflow of oil and gas today. Unlike a solution like solar power, the needs of sequestration will continue to rise in the future, with no possibility or reusing space. The "wedge" theory proposed by Professors Pacalan and Socolow suggests that "capturing and burying 1 billion tons of carbon from coal plants by 2050 would contribute one-seventh of the reduction they estimate we need to achieve to stabilize the earth's climate. One billion tons of carbon is equivalent to 3.6 billion tons of CO_2, or more than twice the annual CO_2 emissions from coal plants in America today."[56]

Additionally, Professor Vaclav Smil made the following point to understand the real scale of sequestration. In 2005, global carbon emissions were at least 7.6 billion metric tons, which equates to 27.9 billion metric tons of carbon dioxide (the ratio of Carbon to Oxygen in CO_2 is 3.6666). If we take 2.79 billion metric tons, or 10% of that, and compress it to supercritical form (CO_2 density 0.468 grams/cubic centimeter or 468 kg/cubic meter at pressure of 71.4 MPa) then this mass would occupy 2.136 times larger volume [1/0.468 = 2.136 – multiply that by the 2.79 billion metric tons] = 5.96 billion cubic meters of CO_2 to be sequestered annually. Meanwhile, global crude oil extraction was 3.895 billion tons with an average density of 0.85 (1/0.85 = 1.176 times larger, meaning 4.58 billion cubic meters). In other words, sequestering just 10% of the world's fossil-fuel combustion CO_2 would require an industry whose throughput would have to 1.3 times what the oil industry, with its vast distribution network and immense network of wells, storage tankers, and storage locations. Moreover, both the sheer scale and cost (trillions of dollars?) of the project remain unknown, as are the safety and operating reliability conditions (see the details below of safety risks associated with sequestration). Despite all this, this project would reduce emissions by only 10%! There's no reasonable perspective by which sequestration can make enough of a dent in coal's carbon emissions without significant improvements in technology.

Another concern is the liability associated with sequestered CO_2; since CO_2 is an asphyxiant, a significant release of it (in concentrations above 20%) can result in the loss of consciousness almost immediately. As noted by Jeff Goodell – "A related issue--and one that I've heard raised by a number of power industry CEOs--is liability. If a micro-seep of CO_2 asphyxiates five girls having a slumber party in a basement in Illinois, who is going to be held accountable? Monitoring and verifying the integrity of CO2 storage is also important from the standpoint of actually solving the problem of global warming--what's the point of going to the trouble and

[56] http://www.thenation.com/doc/20070507/goodell

expense of pumping CO2 underground if it seeps back out a year later? How would we enforce the actual sequestration and prevent cheating? Even tiny leaks undermine the value of burying carbon; some experts estimate that an annual leakage rate of 1 percent could add $850 billion per year to overall costs by 2095."[57] Science magazine notes that CO_2 stored in geological formations had produced a disconcerting mix of metals and organic substances in a layer of sandstone, and was also "chewing up minerals" that help to keep the gas where it is currently located. The CO_2 significantly increased the acidity of the brine, dissolving many carbonate metals. Yousif Kharaka of the U.S. Geological Survey noted the dissolution of the carbonates was of particular worry – the naturally occurring chemicals seal fractures and pores in the rock that, if destroyed, could result in the leakage of CO_2 into the aquifers that supply water for drinking and irrigation.

Moreover, sequestration is reliant on a particular type of natural geology – i.e., no new structures are built to hold the excess Carbon Dioxide. Unfortunately, a US DOE report found that certain areas of the US where coal is used (such as the Carolinas) "lack the proper geology to trap the gas"[58], and would instead require the construction of a pipeline network to transport the gas all the way to Kentucky, West Virginia, and other offshore sites. The cost of this network (for just the Carolina plants) is roughly $4 billion, on top of all the other costs associated with sequestration. Thus even if we could overcome the higher costs and still-large carbon emissions associated with many coal plants, significant hurdles remain.

Despite all these problems, CCS does have some potential (when combined with IGCC) – however, it's simply not viable without significant government intervention. Fortunately for the coal industry (and unfortunately for the rest of us), the government has responded with Futuregen. "FutureGen is a public-private partnership to design, build, and operate the world's first coal-fueled, near-zero emissions power plant, at a cost exceeding US$1 billion." Initially, more than $650 million of the cost was coming directly from the government's coffers. More recent price estimates from the alliance to build FutureGen have listed the cost of construction as $1.7 billion, with the DOE's share rising to more than $1 billion before construction has even started. Given coal's recent track record, it seems a prudent bet to assume that this price will rise again. At least one of the states where the proposed plant is to be built (Texas) has already agreed to assume any CO_2 liabilities resulting from the plant – reducing the capital risk for the "investors" even further. The 275 MW plant is a result of an alliance established in 2005, and hopes at best to have the plant online in 2012 (a 7 year production process – as of July 2007, no site had yet been selected). The irony of the

[57] http://www.thenation.com/doc/20070507/goodell
[58] http://www.newsobserver.com/126/story/556925.html

expenditure is the viability of the project is considered iffy at best, with one industry source noting that the project is often referred to as "NeverGen." To top it off, the research plant is being built at a almost two times the $/Kw cost of currently available CSP facilities, which are already proven technologies. It is worth calling FutureGen what it is – a PR stunt that seems unlikely to have any part in solving the future clean energy needs.

In addition to the higher capital costs of IGCC and CCS, generation costs have risen. The projections of $0.06 / KWh for IGCC and $0.08 for CCS have proved to be optimistic – recent experience suggests $0.08 for just IGCC (without CCS). The Mesaba IGCC plant has projected generation costs of $0.10 per KWh for just IGCC and $0.15 for IGCC + CCS.[59] The IGCC-only plants still do not reduce CO_2 emissions, and the implementation of IGCC (without CCS) does not mitigate any carbon-pricing risks which could add anywhere from $0.02 to $0.03 per KWh - all of which make coal plants (with all its additional problems) an unworthy risk adjusted investment. The politics and entrenched interests involved mean that coal will be a part of energy future at some level, but limiting its impact is a vital goal. And economics will favor a move away from coal as we shall see later.

Given the example of FutureGen, significant questions are raised about the actual costs and viability of CCS and how it pertains to existing and future coal plants. How expensive is it retrofit existing or upcoming plants (either PC or IGCC) to utilize CCS technology? The answer – a lot!. A recently conducted RW Beck study[60] concluded that including sequestration would raise capital costs for PC, Super Critical PC, and IGCC by 75%, 60%, and 30% respectively. Elsewhere, the MIT coal study (which used pre-2004 capital cost data) notes "When CO_2 capture is considered, the cost of electricity produced by IGCC would be increased by 30 to 50% over that of supercritical PC without capture, or 25 to 40% over that of IGCC without capture (Table 3.7). However, for supercritical PC with CO_2 capture, the cost of electricity is expected to increase by 60 to 85% over the cost for supercritical PC without capture."[61]

The table below includes MIT's estimate as well as studies by both GE and AEP – even the most conservative estimate suggest that retrofitting existing PC or IGCC plants for capture will be expensive.

[59] http://www.mncoalgasplant.com
[60] "Carbon Dioxide Regulation - Potential Impact on the U.S. Electricity Markets", R.W Beck, June 2007
[61] http://web.mit.edu/coal

Table 3.7 Relative Cost of Electricity from PC and IGCC Units, without and with CO_2 Capture*	MIT	GTC	AEP	GE
PC no-capture, reference	1.0	1.0	1.0	1.0
IGCC no-capture	1.05	1.11	1.08	1.06
IGCC capture	1.35	1.39	1.52	1.33
PC capture	1.60	1.69	1.84	1.58

**Included are: the MIT Coal Study results (MIT), the Gasification Technology Council (GTC) [56], General Electric (GE) [57], and American Electric Power (AEP) [58].*

Converting existing or planned PC plants is not an economical option – the study states "Our analysis confirms that the cost to retrofit an air-driven SCPC [super-critical pulverized coal] plant for significant CO_2 capture, say 90%, will be greater than the cost to retrofit an IGCC plant." When CCS is accounted for, the S&P's estimates of electricity generation cost (see the table in the introduction) rise from $0.058KWh (PC) and $0.068KWh (IGCC) to $0.12 KWh and $0.102 KWh respectively – further reaffirming the data that retrofitting an IGCC plant will be significantly cheaper than its PC counterparts. However, a USPIRG analysis from 2006 (thus including the cancelled TXU plants) notes that only 16% of the proposed coal plants intend to use coal-gasification technology and thus be economically viable for carbon sequestration down the line.[62] For all its bluster, even big coal does not appear to have faith in its own technologies – the overwhelming preference for PC plants suggests no intention to retrofit them for CCS down the line.

A Better Coal Gasification Approach: Coal to Natural Gas

Despite our apprehension about most coal plants, we do believe there are approaches that can work – given the scale of U.S coal reserves, utilizing them does seem like a prudent approach if the externalities are not overwhelming. One such approach is converting the coal to a environmentally friendlier fuel, such as natural gas. The advantages include the fuel's transportation and utilization while using the existing pipeline network as well as higher reliability (as compared to IGCC). Natural gas (methane) is also the lowest carbon fuel in commercial use today. A variation of this has been attempted before (the Dakota Gasification plant in North

[62] http://www.uspirg.org/home/reports/report-archives/new-energy-future/new-energy-future/making-sense-of-the-coal-rush-the-consequences-of-expanding-americas-dependence-on-coal

Dakota), but it hasn't been cost-effective as it requires a series of expensive, complex, and integrated chemical plants that operate over a wide range of temperatures and conditions. As Technology Review notes, "In these plants, cryogenic equipment operating just a few degrees above absolute zero feeds pure oxygen to the gasifier, where coal baked to up to 2,500 ºF breaks down into a mixture of carbon monoxide and hydrogen called syngas. From there, the syngas is subsequently catalytically transformed into high-grade methane in a separate reactor."[63] However, lower cost versions of the technology are available.

Great Point Energy (full disclosure – it is one of Khosla Ventures' portfolio companies) reduces the number of required steps to produce methane by using a specially developed catalyst to combine gasification, water gas shift and methanation all in a single gasification reactor operating at low temperature. Combining reactions allows the process to take advantage of the heat of reaction produced during methanation to offset the heat required for the gasification reaction. This approach has significant advantages – elimination of the expensive and parasitic oxygen plant, higher efficiency due to lower internal power consumption, and a more efficient methanation process overall. Moreover, the overall cost of production for methane (trade name BlueGas) is expected to be less than $4.00/MMBtu. At this cost, GreatPoint Energy's gasification technology represents one of the lowest cost incremental sources of natural gas in North America – lower than new exploration and production, LNG imports, and other means of producing natural gas from carbon feedstocks through conventional gasification. We believe that the cost competitiveness of the technology, improved environmental footprint versus other coal based technologies, and compatibility with existing infrastructure presents an opportunity for rapid adoption and growth.

GreatPoint Energy's approach is far more environmentally-friendly than pulverized coal plants, Integrated Gasification Combined Cycle (IGCC) facilities, and even some natural generation using gas produced from wells, which often have very large vented carbon dioxide emissions associated with such production. The figure below shows carbon dioxide levels for GreatPoint Energy's technology vs. PC and IGCC (both without CCS). In addition, nearly all contaminants, such as sulfur, nitrogen, arsenic, mercury, and particulates contained in coal and other feedstocks are eliminated or safely removed and recovered as saleable byproducts (e.g., sulfur as elemental sulfur, nitrogen as fertilizer-quality ammonia, mineral matter as a useful road bed material, and CO2 for enhanced oil and natural gas recovery).   .

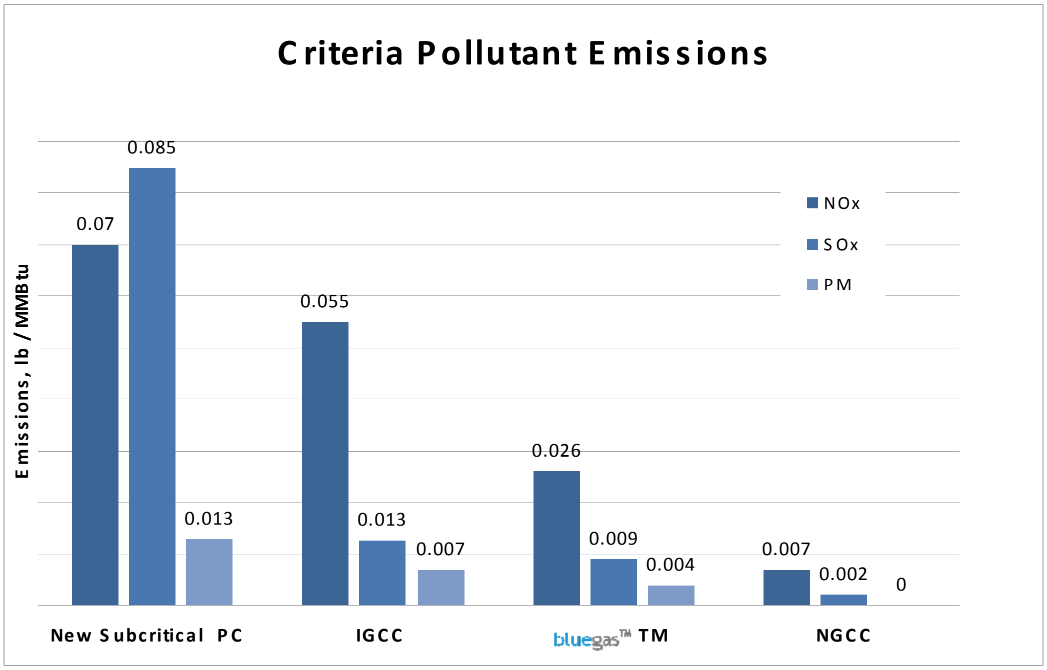
[63] http://www.technologyreview.com/Biztech/18119/

Half of the CO2 in coal is captured in the GPE production process with no incremental investment due to the fact that coal is made up primarily of carbon and natural gas is composed in large part of hydrogen, with the carbon as a carrier. Additionally, one of the significant benefits of the GPE process is that it is both possible and desirable to locate production facilities in areas that will allow for sequestration, and then transport the natural gas anywhere in the country through the existing national gas pipeline infrastructure. The GreatPoint technology reduces CO2 emissions by over10-20% without sequestration versus conventional coal technology (depending on the coal plant and type of coal) due to the ability to utilize highly efficient combine cycle power generation technology. GPE produces a EOR/sequestration-ready stream of CO_2, that can result in emission reductions of approximately 40% (if sequestered).

Today roughly 50% of U.S. electric power generation comes from coal and it is the predominant use for coal representing over 90% of the coal market. Accordingly, GPE has compared its estimate for emissions from its production facility and assumed all product gas is consumed in a natural gas-fired combined cycle plant.

Criteria Pollutant Emissions

The GPE process supplying a combined cycle power plant has significantly less criteria pollutant emissions than other coal utilization technologies and is very nearly as low as natural gas as illustrated in the chart below. Note: NGCC pollution levels depicted below do not include emissions produced to generate the energy required for liquefaction, transportation, and regasification in the increasingly likely case of LNG as the source of fuel for the plant.



NUCLEAR ENERGY

The history of imprudent environmentalism is perhaps most visible in a technology that's regaining attention now – nuclear power, now touted as a solution to the problems with fossil fuels. A relatively old, stable, and cheap to operate technology, the EIA notes that nuclear power "makes no contribution to global warming through the emission of carbon dioxide."[64] (there are emissions that occur across other parts of the fuel cycle and the construction of the plant itself). Nuclear power is responsible for only 15% of worldwide electricity production (about 20% in the US). A fair portion of this can be explained by the limited number of countries that have access to the technology – nonetheless, nuclear power is a viable alternative for any country in the developed world, where most power is used in the first place. The partial meltdown at Three Mile island lead to the cancelling of many nuclear plant orders (indeed, no new nuclear plant has been built in the US for 30 years) and a political climate hostile to further nuclear expansion, despite its significantly cleaner profile than either coal or fossil fuels. To their credit, some environmentalists have started to come around the issue (Patrick Moore, one of the founders of Greenpeace – although he has since split from the organization, as well as Stewart Brand of Whole Earth) but many are still hostile.

Unfortunately, nuclear technology carries its own set of problems. Nuclear capital costs are significantly higher, and the high decommissioning costs of nuclear energy are not considered. The

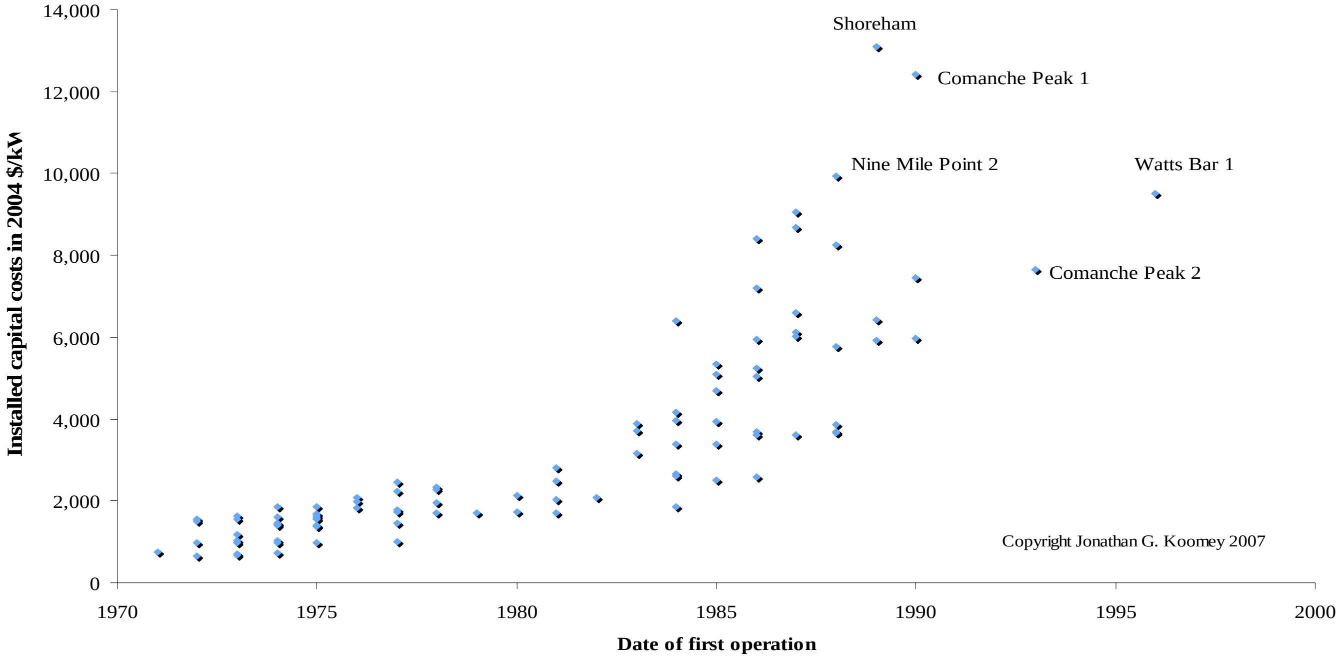
[64] http://www.eia.doe.gov/cneaf/nuclear/page/nuclearenvissues.html

time for innovations to be implemented is very long and the rate of experimentation is very slow – a theoretical fusion power plant is likely to take many decades to power up. Even current generation nuclear technology (today's fission and fast breeder reactors) have project timelines in the region of 15 years from conception to energy generation. In effect, a plant that starts producing electricity today is likely using early 1990's technology. A new nuclear plant proposed today would take anywhere from 10-15 years to come online – and that assumes no legal challenges. In that time period, other technologies could go through multiple cycles of innovation and improvement in whereas nuclear barely through just one. Given the high-cost of failure, nobody takes any risk and that slows down innovation. Given the relative urgency of the climate change problem (and the transient nature of markets over time – the internet was almost non-existent 15 years ago!), a long innovation and implementation cycle offers significantly less impact.

Nuclear energy has significant capital and decommissioning costs – even more so than coal. Each nuclear plant is an investment risk, and the financing poses significant problems. As with coal, the capital costs have been rising significantly, and there is debate as to whether nuclear energy is still economic given the higher costs. A new nuclear plant costs anywhere $2-$3 billion, coming in at $3000-$4000/kw, (S&P estimate[65] - the Keystone Center fact-finding estimate estimated costs of $3600-4000/kw[66]) – and perhaps more. Dominion Resources CEO Thomas Capps estimated the price at $2.6 billion, and noted that "Moody's would go bananas if we announced we were going to build a nuclear plant"[67]. Using data from eight recent Asian nuclear plants, Jim Harding estimated the capital cost of a new nuclear plant at $4540/kw ($4000/kw in 2007 dollars). Assumptions: (4% real escalation – 2002-2007; 50/50 debt equity, 3% equity premium, 75-85% capacity factor, significantly higher fuel costs (3-4X)) More problematically, nuclear cost estimates in the US have often borne little resemblance to realized costs. In a study of plant cost estimates at the beginning and end of construction (from 1966 to 1977), the EIA found that actual construction costs were anywhere from 209-381% of the original estimates.[68]

[65] "Which Power Generation Technologies Will Take The Lead In Response to Carbon Controls?", S&P Viewpoint, May 11, 2007
[66] "Nuclear Power Joint-Fact Finding", The Keystone Center, June 2007
[67] http://www.washingtonpost.com/wp-dyn/content/article/2005/07/23/AR2005072300752.html
[68] http://tonto.eia.doe.gov/FTPROOT/features/hewlett1.pdf, Jim Harding " Economics of Nuclear Power", June 2007

Actual costs – nuclear power plants built in the US[69]



What are the lifecycles cost of nuclear power? The S&P estimates nuclear generated power costs of $0.091 per KWh, but they note that high decommissioning costs and frequent cost overruns persist. Analysis by the Keystone Institute and Jim Harding suggests that nuclear power is not quite the cost-effective option that it seems to be, with costs ranging from $0.094 to $0.122 per KWh, making nuclear almost as expensive as any IGCC + CCS solution.

***Summary of Nuclear Costs without Carbon Controls*: Lifecycle Costs[70]**

(Cents/kWh)

Cost Category	Low Case	High Case
Capital Costs	6.0	7.9
Fuel	1.6	2.0
Fixed O&M	1.3	1.8
Variable O&M	0.5	0.5
Total (Levelized Cents/kWh)	9.4	12.2

Note: Assumed capital costs of $3,250/Kw and $4,000/Kw respectively

[69] Koomey, Jonathan, and Nate Hultman. 2007. "A Reactor-Level Analysis of Busbar Costs for US nuclear plants," 1970-2005, forthcoming in *Energy Policy* - via Jim Harding

[70] Keystone Institute

In addition to the aforementioned costs, an underreported issue is the high costs of shutting down a nuclear power plant. In this vein, the aforementioned S&P report notes that the "recent experience with Connecticut Yankee indicates that the cost of decommissioning could approach **$1 billion** in 2007 dollars. For regulated companies, even if the decommissioning funds are insufficient, we can be reasonably assured that regulators will allow utilities to recover their incremental costs. The bigger challenge is for unregulated generators, who are likely to be required by the NRC to allocate decommissioning funds early in the life of the project to ensure that sufficient funds will be available upon license expiration. Over the long term, spent nuclear fuel storage and handling will be a key issue that will determine the amount of added nuclear capacity in the U.S."

The political risk associated with nuclear energy combined with the long build time is a risky proposition for most investors. To spur on nuclear construction in the face of these obstacles, federal loan guarantees and incentives have been proffered. From a White House press release regarding the Sept 2005 energy bill:

> "**The Energy Bill The President Signed In 2005 Provides Loan Incentives, Production Tax Credits, And Federal Risk Insurance For Builders Of New Nuclear Plants.** Loan incentives will give investors confidence that the Federal government is committed to the construction of nuclear power plants. Production tax credits will reward investments in the latest in advanced nuclear power generation. Federal risk insurance for the first six new nuclear power plants will help protect builders of these plants against lawsuits, bureaucratic obstacles, and other delays beyond their control.
>
> **The Bush Administration Has Launched The Nuclear Power 2010 Initiative – A $1.1 Billion Partnership Between The U.S. Government And Industry To Facilitate New Plant Orders.** At this time last year, only two companies were seeking to build nuclear power plants. Now, 16 companies have expressed interest in new construction – and they are considering as many as 25 new plants. By the end of this decade, America will be able to start construction on nuclear plants again."[71]

By way of comparison, the same energy bill offered a **total** of $150 million for all solar technology research and development. Suffice to say that if solar thermal got the same backing as nuclear energy did, we would be leaps and bounds ahead of where we are now. Nuclear energy's

[71] http://www.whitehouse.gov/news/releases/2006/05/20060524-4.html

history of government funding is immense as well. Consultants suggest that total nuclear energy subsidies (not including the Price-Anderson act, the insurance policy from the federal government which indemnifies nuclear plants against liability claims from any "nuclear incidents" – any claims above $10 billion would be paid completely by the federal government) have totaled about $63 billion in the United States.[72] Before 1973, OECD governments spent over $150 billion (adjusted to current costs) in researching and developing nuclear energy, and practically nothing for renewable energy. Between 1974 and 1992, $168 billion was spent on nuclear energy and only $22 billion on renewables. The European Union's extravagant nuclear promotion efforts are not even included in this calculation, while French statistics are still being kept secret.[73] The previously cited Time magazine data notes that nuclear power received $303 million in federal R&D money in 2007.

Nuclear emissions are fairly low – in fact, radioactive emissions from nuclear plants are actually far lower than those from coal plants. That being said, nuclear energy still poses some environmental risk. The predominant environmental issue for nuclear plants is spent fuel – radioactive waste (the cost of disposal of which is a subsidy by the government). While nuclear power produces less total waste for energy generated, the EIA noted that on a "on a pound per pound basis the potential environment costs of waste produced by nuclear plant is usually viewed as higher than the environmental cost of most wastes from fossil fuels plants." In the US, the search for a location to serve as a nuclear fuel repository has been ongoing for years – Yucca Mountain, Nevada, the preferred candidate, is now considered unlikely because of political opposition and various technical flaws. The long half-life of most spent-fuel means that radiation emission ranges from 10,000 to 1 million years. Uranium, like coal and fossil fuels, is a finite resource **– a 2003 report suggests there are more than 50 years of proven reserves left (we have seen estimates as low as 35), and perhaps 200 years of estimated, non-proven reserves (all estimated at a price of US$ 80/lb)[74]** Given the likely increase in demand due to both Indian and Chinese demand to fulfill their growing energy needs, this estimate may prove to be overly optimistic.

The perception problem of nuclear energy is another major issue. A Los Angeles Times/Bloomberg poll in July-August 2006 found that 61% responded favorably to the question of "Would you, personally, support or oppose the increased use of nuclear power as a source of energy in order to prevent global warming?" Nonetheless, when presented with other options to "reduce the

[72] http://www.issues.org/22.3/realnumbers.html
[73] Dr. Herman Scheer, General Chairman of the World Council for Renewable Energy
[74] http://www.publications.parliament.uk/pa/cm200506/cmselect/cmenvaud/584/5111706.htm

reliance on foreign oil", nuclear power garnered only 6% of the poll, below alternative energy sources, relaxed drilling standards, and stricter mileage standards.

A significant cause of nuclear power's perception is the risks of nuclear proliferation, a problem unique to it amongst the world's energy sources. Many would-be civilian nuclear countries, be they in Israel, Iran, or North Korea, have the capacity to be "dual-use" – using the plutonium generated from civilian use to build a nuclear weapons program. The risk of proliferation is considered greatest with "fast breeder" reactors – a nuclear reactor designed to breed more fissile material than it produces. The collapse of the former Soviet Union has been a large contributor to the proliferation – there have been various attempts by terrorists groups to obtain the fissile material produced and the security has been called into question. No one would like to see nuclear power in the hands of the Sudanese or North Korean government, and the technology transfer necessary to export it to much of Africa and Asia has no chance of political approval.

In summary, a 2005 article from Nuclear Engineering offers a good overview of the problems facing nuclear power today. Steven Kidd, the WNA's strategy and research head notes that investors "remain concerned about public opposition, sitting and licensing, quick construction at predictable cost, safety, security, liability, nonproliferation, waste, decommissioning, and smooth operation."[75] It is clear that given a longer timeframe, nuclear power could offer a reasonable alternative to addressing these issues through technology development. By all accounts, it's a cleaner and more environmentally friendly technology than coal. Given the need to reform the energy infrastructure on a more immediate basis, stronger public support for renewable energy sources, and the limited capital available (relative to the world's needs), nuclear energy is unlikely to be able to meet a substantial portion of our electric power needs. We need too much too fast and nuclear has too much risk, too many unresolved technical issues and slow innovation and implementation cycles. Furthermore, nuclear power plant costs are increasing rapidly to the point of becoming uneconomic. We do believe that nuclear energy has a part to play in the horse race to replace dirty coal along with clean coal and renewable technologies– but it's simply not enough, and not quick enough, to serve as the 30-50-80% solution that we need now. It is also possible that new, safer, probably smaller nuclear plant designs will be developed over time that may even use less controversial fuels like thorium or that produce less radioactive waste[76].

[75] "Might Mice", Nuclear Engineeering International, December 2005 (Author: Amory B Lovins)
[76] http://www.wired.com/science/discoveries/news/2005/07/68045

If not coal, then what? THE UN-CONVENTIONAL WISDOM

The question remains – what can we find that can scale to 30-50-80% of our electric supply needs? Any would-be replacement has to meet the needs of what we call PUG (power of utility grade) Power? We define a PUG power source as one that is (1) dispatchable (2) has production costs of 7-10 cents/KWh and (3) reliable availability and predictable. When evaluating our investments in this area, we've followed some additional criteria that make more sense given the nature of large utility needs for electrical generation**.**

- Dispatchable power- Predictable "time of day" supply: Power needs to be available when the primary customers (the utilities, and their consumers and industrial customers) need it – not simply when it's most convenient for the power producer to generate it – as when the sun is shining or the wind is blowing. Capacity factor is important here – it is the ratio of the net electricity generated to the energy that could have been generated at continuous full-power operation twenty-four hours a day. For example, a plant running non-stop at full capacity in a period would have a capacity factor of 1, or a 100%. Utility "base load plants" are designed to achieve power generation over 65% of the hours in a typical year (there is little demand for power in the middle of the night, and a 100% capacity factor is not needed). Some technologies like nuclear generate power when there is little need for power because they cannot be turned on and off easily. They run at close to 100% capacity factor. At the other end, there are lower capital cost and high operating cost peak load plants today that are less efficient plants (often low capital cost gas plants) and not economically feasible to utilize unless demand exceeds normal generational capacity ("peaking plants"). Any renewable source of energy should offer the potential to offset these plants to begin with, since peaking plants have higher generation costs per KWh. To replace these peaking plants, the power must be available when there's peak demand, not at 4 AM when no one is using power. Wind mostly fails this test and is often limited to a small percentage of a networks power generation capacity. Solar photovoltaics (PV) can only supply power when the sun is shining. To meet dispatchable power needs, the source must be capable of cost-effectively storing power and delivering it when needed.
- Cost effective power: Any renewable source to be considered PUG power and to effectively replace fossil based electric power generation on a large scale must be as cost effective as

the fossil source. We believe coal power generation that is "future de-risked" must be a technology like IGCC. The costs of this technology are, at commercial interest rate and unsubsidized about $0.08 per KWh. We think claims of $0.06 per KWh are unlikely to be achieved. Including carbon capture and sequestration (CCS) to this would add at least $0.02-0.03 per KWh (and up to $0.06/KWh as per the S&P report). To compete with this base load technology a renewable source must produce power at about $0.10 per KWh. Peak load power can afford somewhat higher costs of around $0.12-$0.15 per KWh. For planning purposes, an energy source that is available without price-variability and supply-availability is at a significant advantage. As we've seen earlier with natural gas prices (and coal prices), significant price variability can easily render a power source as uneconomic. In addition, any highly pollution power generation source will have to further account for CO_2 prices (and their volatility). This combination of supply and CO_2 price volatility significantly increases the risk premium associated with many of today's conventional technologies.

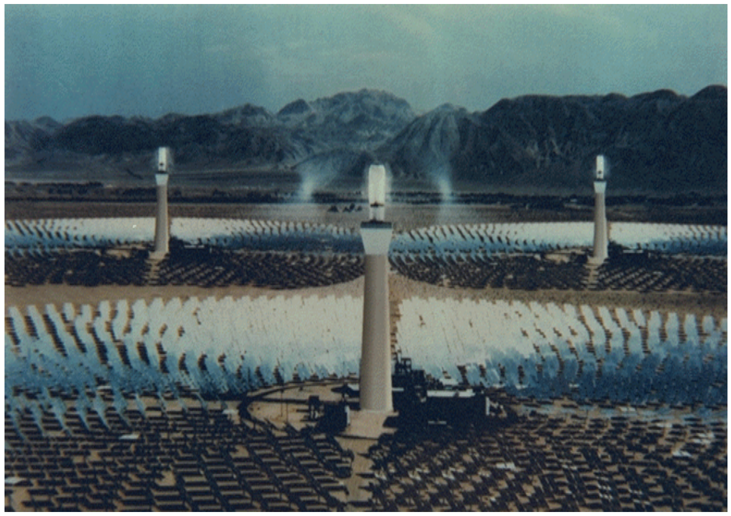
- Reliability – Any source vying to replace coal-based electric power should be reliable enough to match the dependability of coal-based options like IGCC. In addition to uptime reliability, the source must have reliable costs over an extended period of time. The MIT study noted that operational uptime is a significant reliability problem in certain technologies like IGCC.

In addition to the power-specific needs listed above, we have general rules about investments in climate change solutions that are also applicable. They (1) Attack manageable but material problems (2) Invest in technologies that can achieve unsubsidized market competitiveness within 7-10 years; (3) Invest in technologies that scale and if it isn't cheaper it doesn't scale (4) Utilize technologies that have manageable startup costs and short innovation cycles and (5) technologies that have declining cost with scale – trajectory matters. What source of power can meet all of these requirements? Conventional wisdom tells us that it's clean coal, or nuclear energy. We think the solution is Concentrated Solar Power (CSP) technology and potentially geothermal, though the technology of enhanced geothermal is yet to be proven..

Solar Thermal Technologies

Solar thermal technology solves some of these problems. About a hundred square miles of Nevada desert area could provide the US with all of its electricity needs! Concentrated solar thermal power plants tend to use one of many technologies – parabolic trough designs, power tower designs ,dish designs, and recently the CLFR technology that we favor. Parabolic trough designs are the most popular– they use a curved trough like surface to direct the sun's rays to a hollow tube running across the top – which are movable throughout the day in order to always have the maximum possible focus on the tube in question. The hollow tube is filled with a liquid (oil, or water potentially) that is then heated by the process – it then either goes through a heat exchanger (if its oil-powered) or generates steam directly to power turbines to generate electricity. Parabolic trough designs have been around for a while, with the most significant being the SEGS system in California – it is among the world's largest solar power systems.

Power tower designs are somewhat different – they use a series of flat, movable mirrors to direct sunlight at a larger "collection" tower, at which point this concentration of energy is transferred to a substance (such as Sodium) that can store the heat for later use, allowing the energy to be stored even when the sun isn't shining (like the evening). The saved energy can then be used to power conventional turbines (such as steam, by using the stored energy to boil water).



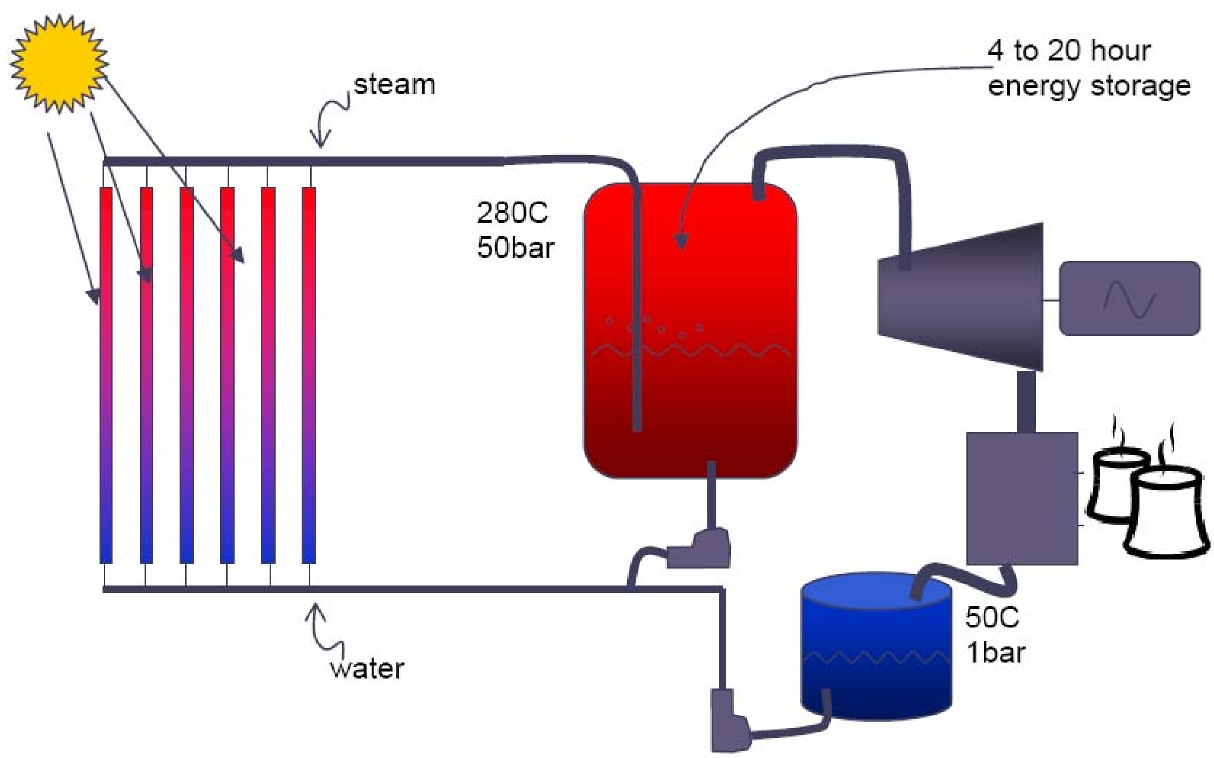
Dish designs are similar to parabolic trough designs – it uses a large, reflective, parabolic dish to direct all light to a single point above the dish where a heat collector of some sort is used to store the energy, which can then be used with turbines or Stirling engines to generate electricity.

In the 1980's, CSP projects were in vogue – 9 plants with 354MW of capacity were built in only 7 years, for a total investment of about $1.2 billion – all of it with private money (before the price of oil crashed to $10 per barrel). 12TWhe of solar power was produced, with electric sales of roughly $2 billion and many plants are operating reliably even today. The extent of government intervention consisted of investment tax credits and attractive time-of-use tariffs.

The approach favored by Ausra (one of our investments) is an upgraded version of conventional CSP technologies – a newly designed system which sharply reduces the costs of the mirrors, receivers and other hardware. This technology is called Compact Linear Fresnel Reflector

(CLFR), and uses simple flat moving mirrors with fixed pipes. CLFR's advantages are numerous – it generates high pressure steam in the receiver itself, thus reducing the need for expensive thermal fluids or heat exchangers. The sun boils the water directly, resulting in low costs and simple plant operations. The CLFR reflectors rotate a full 360 degrees, protecting the mirrors in the event of a wind or hail storm (only the steel is exposed). Moreover, CLFR requires the use of commonly sourced materials as opposed to proprietary technologies, allowing for rapid scaling. Overall, CLFR technology improves the scalability of solar power while sharply reducing the cost. The overall cost reductions are approximately 60%, while only reducing the thermal efficiency by 10%. Though considerable uncertainty exists around the delivered cost of the various solar thermal technologies, all will evolve considerably and reduce their costs of time. Eventually, the cost of generated power should be lower than that of a IGCC coal plant at similar size, interest rates, and capacity factors.

Using the CLFR collectors (combined with thermal storage), Ausra is in the process of developing commercially viable solar plants. Saturated steam is fed from the thermal accumulator or thermal storage to the turbine block. A simplified figure is shown below.



These new CSP plants meet all of the criteria we have set forth for "PUG power" electric generation. CSP has a few significant advantages over other solar schemes, as well as renewable energy at large. Principal amongst these advantages are dispatchable, storable, cost effective power and a proven, tested technology. Additionally, CSP power can be produced now for around $100 MWh (see “Solar Thermal vs. Coal” below), and costs in the $100-$70 MWh range are feasible for larger scale projects. It is reasonable to assume that with future R&D and more discovered efficiencies, costs could fall even lower.

Thermal energy storage is one of the key advantages of solar thermal power and especially the Ausra technology. Storing heat – as hot water, hot oil, hot rocks – is very cheap. Costs of both thermal and electric storage are declining, which is good, but using today’s thermal storage systems we can build plants that compete with gas and coal power, now – not 20 years from now. Meanwhile, the reality is that battery storage per kilowatt-hour is almost a hundred times more expensive today than would be cost effective – and, battery technology costs are not declining very rapidly. Battery technology is not showing a path to even a 5x price/performance improvement anytime soon, let alone the 50-100 times that is desirable. From our perspective, we have been looking for breakthrough battery investment for years without seeing a 5X technology. Using Ausra’s CLFR technology, thermal storage is much cheaper as sub-critical steam can be stored as hot water. Costs lower than IGCC coal plants (even without sequestration) are feasible today. The technology can reach capacity factors of 65% and hence can supply base power needs. Capital costs and operating costs are both likely to be lower than nuclear. It is about 75% cheaper than solar PV technologies and unlike wind, it is dispatchable and reliable. One does not have to have the wind blowing or the sun shining to deliver power if a customer demands it. The need for backup “spinning reserves” (i.e. spare standby gas power plants) are not required as they often are for wind power. The major constraint of this technology is the need for good sun intensity, though even in “poor sun” states like Tennessee, calculations show cost effective (below $0.10 per KWh) power depending upon the cost of capital and the scale of the plant. The “sun intensity” constraint can be reduced if the country builds a high voltage DC power grid for long distance electricity transmission, a grid, much like the interstate highway system for cars and trucks, will help all renewable and non-renewable technologies.

Solar Thermal vs. Coal

In a head-to-head comparison, the benefits of CSP technology dwarf those of coal. We expect prices to decline to the $0.07/KWh range, below that of IGCC ($0.08 + carbon pricing, commodity risk), CCS ($0.10 + commodity risks, cost of sequestration, insurance against leakage liability), and gas-fired CC ($0.12 + commodity risk). The recently announced PG&E power purchase agreement (for 550MW) to purchase solar thermal power came in at approximately $0.10/KWh.[77] Costs are expected to decline to $0.071/KWh when the first 700MW plant is built.[78] Environmentally, CSP plants produce no CO_2 emissions (or NOX, SO_2, Mercury, sludge or any of the other coal "externalities"). CSP bears no transportation, supply or commodity price risk – the sun is a viable source of solar energy a few billion years, slightly longer than coal. As discussed earlier, traditional coal plants cannot adopt the proposed CCS technology economically – rendering any traditional pulverized coal plant built now as either an environmental menace for 50 years (with increasing emissions as the plants get older), or an investment failure once carbon pricing is introduced.

Standard & Poor's Assessment of Electrical Generation Costs [79]

	Pulverized Coal	Gas (CCT)	IGCC (Eastern Coal)	IGCC (PRB Coal)	Wind	Nuclear	Ausra CSP-KV Estimate	Altarock – KV Estimate
Capital Cost ($/Kw)	2,438	700	2,795	2,925	1,700*	4,000	3,000	4,000
Total Cost (cents / KWh)	5.8	6.8	6.8	6.5	7.1*	8.9	7-11	5-10
CO_2 Capture Cost ($Kw)	940	470	450	450	-	-	-	-
Cost for CCS (cents/ KWh)	6.2	2.8	3.4	3.6	-	-	-	-
Cents/KWh	**12.0**	**9.6**	**10.2**	**10.1**	**7.1**	**8.9**	**7-11**	**5-10**
Cents/KWh (credits $30)	**7.9**	**7.7**	**8.7**	**8.4**	**7.1**	**9.1**	**7-11**	**5-10**

Ausra and Altarock cost-estimates are not from S&P

*S&P notes that there are disadvantages with wind that are not explicitly modeled - high transmission costs (because wind has limited availability), low capacity factors (30-35%), and unpredictability (leading to a greater need for backup/reserve power) and limit wind from serving as a base-load power source.

[77] http://www.iht.com/articles/2007/07/25/business/solar.php
[78] Dr. David Mills, Ausra
[79] "Which Power Generation Technologies Will Take The Lead In Response to Carbon Controls?", S&P Viewpoint, May 11, 2007

Black and Veatch's conservative estimation (they assume a 40% CF and that CSP is replacing new coal plants) of emission reductions is below:

Table 7-1
Emissions Reduction by CSP Plants

Pollutant	Proxy Fossil Plant Emissions Rate		CSP Plant Capacity		
	lb/MMBtu	Parts per million	100 MW (tons/year)	2,100 MW (tons/year)	4,000 MW (tons/year)
NO_x	0.006	2	7.4	156	297
CO	0.004	4	4.5	95	181
VOC	0.002	1.4	2.6	54	103
CO_2	154		191,000	4,000,000	7,600,000

Notes:
1. Proxy Fossil Plant assumed to be a combined cycle combustion turbine with a heat rate of 7,000 Btu/kWh.
2. CSP plants assumed to operate at 40 percent capacity factor.

As noted earlier, the Florida Public Service Commission rejected the proposed coal-fired FPL Glades plant. The $5.7 billion, 1,960 MW plant would have produced electricity at approximately $80-90/MWh – with fuel price volatility, supply risks, and the potential for a carbon tax. With a carbon tax effectively adding $0.02/KWh (or $20/MWh), the real cost of generation is closer to $110MWh. The plant would have consumed 26 MGD of water, emitted 16 million tons of CO_2 per year as well as 8,000 tons per year of criteria pollutants. What is the cost of replacing this with a CSP plant? Today, Ausra can build a 600 MW plant for less than $2.5 billion and generate electricity below $120/MWh with no volatility, no fuel costs, even in Florida's (relatively) poor sun. Environmentally, the plant would use 1/3 of the water consumption of the cancelled-coal plant (with the potential to reduce it further with dry cooling) with no air pollution. In addition, it would create 95 jobs per 100 MW, almost twice the job creation of a coal plant. This is not the future – these are today's prices using current technology.

Wind, Solar PV , Geothermal and more…

Despite our belief in CSP technology as a strong competitor in the race to replace traditional coal in electric generation, we do think technologies like wind, solar PV, geothermal and others can replace 10-15% of coal power, depending upon location. There are three primary sources that fit these criteria – wind power, solar PV technology, and "enhanced geothermal" today. Biomass offers an intriguing possibility.

Wind is a wonderful technology and a great investment. It is very appropriate for certain locations and would benefit a lot from a national high voltage electric grid so it could be transported to where it is needed (as would all sources of electricity). It is a classic technology that started with high costs but was on a rapidly declining cost trajectory and is now cheaper than coal generation in some locations – in fact, a Credit Suisse report on alternate energy notes that wind is competitive with natural gas when the price of the latter is above $8/MCF (It was $6.96 as of Q3 2006).[80] The devil lies in the details. Power is only available when the wind blows because storage is difficult and expensive. Additionally, most utilities don't need power in the middle of the night but are forced to take it today – essentially, the power generation and power demand do not match up well or predictably, highlighting the need for an effective storage technology. A wind-only future runs the risk of being off and on power generation in highly variable ways, though the risk may be mitigated by using a large diversity of locations (and thus having to build extra capacity). We believe wind can scale to serve 10%-15% of our grid electricity needs – beyond that, its high variability and technical issues will limit it (in the short-to-medium term). That is a good step and will have an impact, but wind power (by itself) cannot wean the global power generation system away from coal. We are optimistic about the future of wind - there are significant improvements to come such as new, more efficient turbines, or even potential new storage technologies (such as Compressed Air Energy Storage) and we believe that the market will grow significantly by 2020.

Solar photovoltaic (PV) cells and the vision of self contained homes with PV on their roofs is a great dream and less variable (more predictable) source of electricity than wind power. However today its costs are higher than for wind power. Solar PV makes sense in many remote locations and in areas where peak sun coincides with peak power demand. This is true of many parts of the US (and the world). But grid independent homes powered by solar power alone are blue sky dreams. The good news with solar power is that like CSP, it utilizes a highly abundant resource

[80]"Energy in 2007", Credit Suisse, December 19, 2006. Price data from EIA Historical Natural Gas data – this price point is nominal

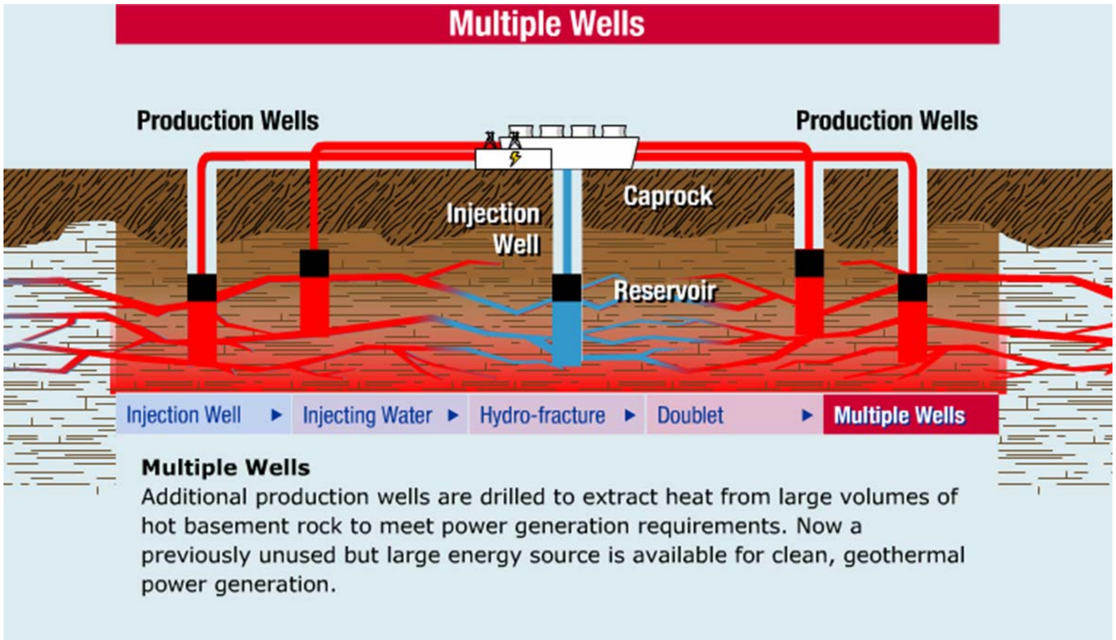
with no real supply risks, and is not subject to commodity price fluctuations. Solar cell costs are clearly declining very rapidly with technology improvements. Unfortunately, they have become a minority part of the cost of a solar system so solar cell cost declines don't help the solar "system cost" as much as we would like. As with wind though, solar power lacks an effective storage technology that will allow utilities to utilize it when it is needed the most, rather than at peak availability – this limits its ability to function as PUG power source While a small percentage of the populace may be willing to live without power when the sun is not shining, most people want 24 hour power. Despite the two to four times or more greater capital cost of solar photovoltaic (as compared to CSP technology), we will still need the grid investment and we will still need what the utilities call "spinning reserve" power plants with their associated capital investment which somebody will have to pay for, so that when a cloud passes overhead or we have a rainy day (or week) we don't miss out on electricity. This makes solar power (and wind power) more expensive once these auxiliary costs are included in the total costs. Backup reserve costs must be accounted for when estimating the cost of power. The (current) lack of storage and dispatchable power makes it inappropriate for utility contracts at a large scale. Clever schemes have been proposed, like pairing solar or wind power with hydro (which allows water to be stored behind dams and released when needed to generate electricity) such that when the wind is not blowing or the sun is not shining we use the hydro as the "makeup spinning reserve". However such schemes, though they can work well in certain locations, have limited scalability.

In our opinion, solar PV makes a lot of sense in certain large niches (even niches are huge markets in the humongous electricity market). Khosla Ventures has investments in solar PV technologies –we believe they offer the potential for distributed and remote power as well as certain loads like air-conditioning demand that generally coincide with peak sunlight hours. Our bet is on solar PV cells that have improved efficiencies (we believe 30%+ is not unreasonable), rather than a race to the lowest cost 10% efficiency cells. Like wind power, we think solar PV has the potential to be a great investment and a good technology but not (singularly) a material solution to the climate change problem – given current bottlenecks, we simply don't believe it can scale to the 30-50-80% of worldwide electric demand levels which is needed. Both solar PV and wind power currently lack the storage capacities and solar PV lacks the cost today and consequently, the ability to supply electricity on-demand. Wind is limited to certain special locations.

What will solve the storage bottleneck and allow PV and wind to compete for PUG power needs? We think that the advent of electric storage technologies such as flow-cells will make solar PV and wind viable options for PUG power, once we reach capital costs of $250/KW and operational costs of $75/KWh. In our estimation, we can achieve this within the decade, and we have investments (and are looking at opportunities) within this segment. In summary, both PV and wind technology have a few significant steps and additional risks (primarily the storage issue) before they become full-scale commercial technologies. Nonetheless, even before the widespread availability of fuel cells, there will still be significant specialty markets for wind and PV. By any metric, solar and wind technology both present large and significant opportunities, even if they don't meet all mainstream utility power needs (yet). Again, both wind and solar PV highlight an important point: only when we meet utility grade power will green technologies start to replace fossil electricity at any scale, (but they can still be great investments).

Geothermal is a different case. Geothermal power refers to the thermal energy stored in the Earth's crust, distributed between the hot rock and the fluids (mostly water with dissolved salts) that are contained in its fractures and pores. Traditionally geothermal has been built around natural "wells" that generate steam using the heat of the earth. This provides for reliable, dispatchable, 100% capacity factor power, meeting all PUG power needs. But the scale at which geothermal power is available is limited in this country (and worldwide). It is a good solution that cannot scale sufficiently. Enhanced geothermal energy is the solution to scalable geothermal power. Enhanced geothermal system operate as follows[81]: (1) drill a production-injection well into hot rock (the rock in question should have limited fluid content and permeability) (2) Water is then injected into the well at a pressure high enough to cause fracturing or open up fractures already present in the rock. This is continued until fractures extend a significant distance from the initial well. (3) Multiple injection wells are drilled around the initial production well, with the intent of overlapping the fracture system from (2), and water is circulated to capture the heat from the rock. The heat can then be used to generate power. The idea is simply an extrapolation of naturally occurring hydrothermal systems, which are a widely-used source of electricity and direct heat today. The technology leverages the earth's heat (which exists almost everywhere) and creates artificial geothermal wells, and is thus significantly more scalable.

[81] http://www1.eere.energy.gov/geothermal/pdfs/egs.pdf



From a technology perspective, "Most of the technical requirements to make EGS work economically over a wide area of the country are in effect, with remaining goals easily within reach."[82] The first significant new research effort (in 30 years) into enhanced geothermal in the US provided quantifiable data– in the US, there are **1250 GW of geothermal resources that can be produced at less than $0.10 KWh.** [83] Meanwhile, total US electrical generational capacity in 2005 was 978GW.[84] All of the geothermal reserves can't (or won't) be utilized for energy capacity for multiple reasons (the scale of the initial effort, lack of infrastructure recovery rates, total land usage, and energy efficiency prime amongst them). As a whole, EGS offers significant potential because it can provide base-load power (to potentially work in conjunction with other renewables), produce almost no greenhouse gas emissions, and not be subject to any commodity, transportation, or supply risks (unlike coal). In addition, EGS systems can be scaled up or down to meet a multitude of needs, from serving as peak power sources (steam can be stored at night and used during peak times) to base-load behemoths. We are investing in this next generation "enhanced geothermal" technology, and we believe it can play a part in the horse race to replace conventional coal.

Another approach can be seen in one of the DOE's pilot programs – SECA (Solid State Energy Conversion Alliance) fuel-cell coal based systems. The goal of the program is to develop and display fuel cell technology for power plant applications to produce "affordable, efficient,

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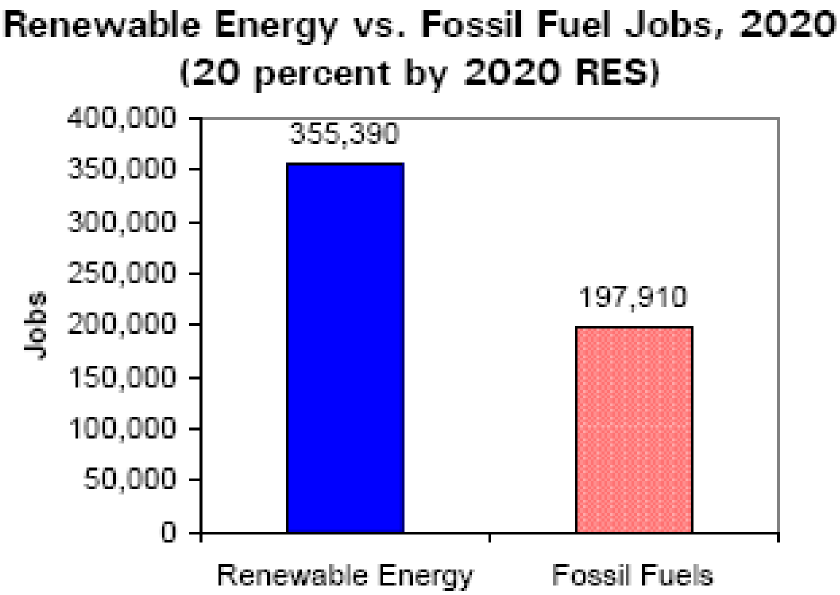
[82] http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf,
[83] http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf, Altarock
[84] http://www.eia.doe.gov/neic/quickfacts/quickelectric.html

environmentally-friendly electricity from coal. The new program leverages the advances made in solid oxide fuel cell (SOFC) technology under the SECA Cost Reduction program, extending coal-based SOFC technology to large central power generation."[85] The goal of the program is the ability to have more than 50% efficiency in converting the coal to electric power on the grid, the capture of 90% of the carbon contained in the coal and to do this all for approximately $400 per KW (about one-tenth of today's rates), making it competitive with gas turbine and diesel generators. Given that fuel cells are accepted as the most environmentally friendly use of fossil fuels (reducing CO_2 emissions by up to 60% for coal, and 25% for gas powered plants), encouraging their usage leverages our natural resources in a more efficient manner. While fuel cells have a way to go before becoming scalable energy-generation technologies, their utilization of coal could prove significant benefits (both politically and economically). We believe natural gas based fuel cells with efficiencies approaching 60% for distributed power applications and combined heat and power applications (CHP) approaching 90% efficiency will be attractive and economical for distributed power generation. Companies like Bloom Energy are making great progress towards cost effective solutions with this technology.

RENEWABLE ENERGY – THE ECONOMIC CASE

In its press release, the US Climate Exchange partnership stated that "In our view, the climate change challenge will create more economic opportunities than risks for the U.S economy." We reaffirm this belief, and consider the shift away from coal to be the opportunity for the next Google. Studies of the economic impact of a renewable energy standard bear out the research. The National Mining Association reports that employment in the coal industry (coal miners) has declined 50% since 1983 to about 100,000. [86] Meanwhile, UCS estimates suggest that the implementation of a basic RPS (20% of electricity be renewable by 2020) would create 355,000 new jobs over the period – far more than electric generation from fossil fuels (197,000 is the estimate for the latter).

[85] http://www.fossil.energy.gov/programs/powersystems/fuelcells/
[86] http://www.nma.org/pdf/c_trends_mining.pdf - NMA



The estimates suggest that such a threshold would spur more than $72 billion in new capital investment, and $49 billion in lower electricity and natural gas bills for consumers (at a 7% discount rate). One significant advantage is that significant economic benefits would flow to rural America (including an estimated 30,000 jobs in agriculture). On a larger scale, by 2020, renewable energy would likely be providing an additional $8.2 billion income and $10.2 billion in GDP for the US economy.[87] Elsewhere, a study at UC Berkeley (assuming a 20% national renewable standard by 2020) concluded that "Investing in renewable energy such as solar, wind and the use of municipal and agricultural waste for fuel would produce more American jobs than a comparable investment in the fossil fuel energy sources in place today."[88] Importantly, it's worth noting that the studies came to this conclusion even while examining different renewable approaches, from a bio-mass centric approach to a wind dominated one. California has been one of the leaders in the usage of renewable energy, and benefits are set to flow - adopting of AB 32 will reduce CO_2 emissions by 25%, while creating 83,000 new jobs and $4b in income. A Black and Veatch study on the economic benefits of CSP plants in California noted that each 100 MW of CSP resulted in 94 permanent operation and maintenance jobs, compared to 56 and 13 for a combined-cycle and simple-cycle turbine (technology used in IGCC and PC respectively) plant. It also noted that each 100MW would bring $628 million in impact to the state's gross output, compared to just $64 million for a combined-

[87] http://www.ucsusa.org/clean_energy/renewable_energy_basics/renewing-americas-economy.html
[88] http://www.scienceblog.com/cms/node/2618

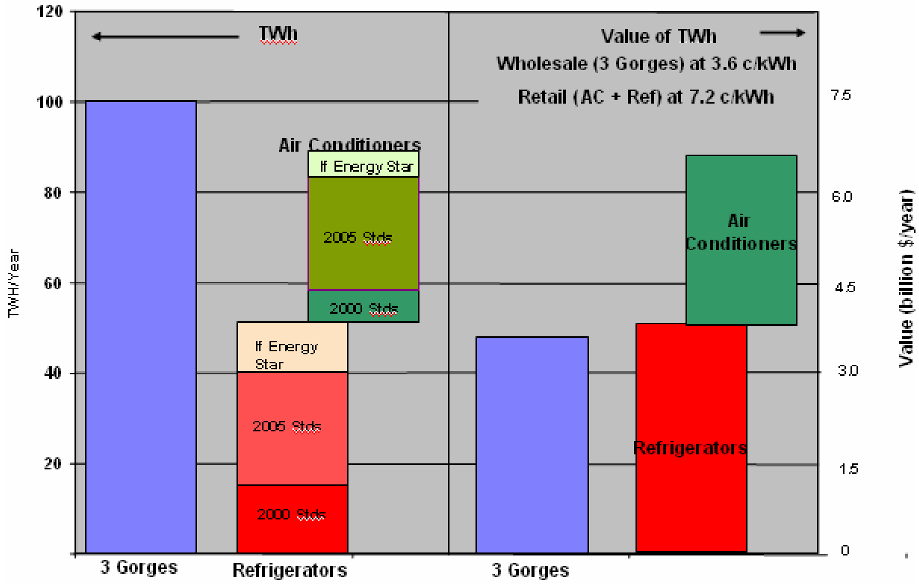
cycle and $47 million for a single-cycle turbine plant. While the higher capital costs (for now) of CSP are a factor, CSP wins out on a dollar per dollar basis – B&V notes that "For each dollar spent on the installation of CSP plants, there is a total impact (direct plus indirect impacts) of about $1.40 to gross state output for each dollar invested compared to roughly $0.90 to $1.00 for each dollar invested in natural gas fueled generation."[89]

EFFICIENCY

In this paper, we have focused on supply-centric solutions with the goal of replacing (or limiting) PC plants. An alternate approach (much favored by environmentalists) is to reduce demand, through conservation programs and higher efficiency standards. We strongly support increased efficiency standards; much of the progress that has been made to combat the climate change problem has been through these measures. Lighting utilizes about 22 percent of the electricity consumption in the U.S and are notoriously inefficient (only 5% of energy is turned into light). Professor Steve Denbaars notes that if 25% of the conventional light bulbs were to switch to more efficient LED's (150 lumens per watt), it would reduce carbon emissions by 258 million metric tons and consumers would save $115 billion (cumulatively, by 2005). Furthermore, it would alleviate the need to build 113 coal-powered plants.[90] Lighting innovation is a major area of investment for us.

Other examples abound. Replacing a standard refrigerator with a high-efficiency one can reduce CO_2 emissions by up to 500 pounds a year. [91] Similar actions with regards to a washing machine (440 pounds reduction in CO_2 emissions), water heaters (wrapping it in an insulated jacket could reduce up to 1000 pounds of CO_2) and other energy appliances would make a substantial difference. One illustrative example is from the graph below - energy savings from refrigerator/air conditioning standards could save as much energy as is being generated by the Three Gorges Dam in China!

[89] "Economic, Energy, and Environmental Benefits of Concentrating Solar Power in California", Black and Veatch, April 2006
[90] http://news.com.com/2100-1008_3-6132427.html
[91] http://reference.aol.com/globalwarming/_a/top-12-ways-you-can-reduce-global/20050802173409990001



Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL

On a policy and developmental scale, the implementation of increases in refrigeration efficiency standards would help– despite earlier implementation of regulations, they still account for 14% of the electricity in an average home. An ACEEE study suggests that the adoption of a 30% higher standard would save consumers $10.1 billion over the next 25 years – in effect, there would be enough excess power saved to power every American household for 18 months.[92] In power plants themselves, the utilization of more effective steam-powered turbines is a step towards lower coal and fossil fuel usage.

We believe conservation programs and more stringent efficient standards have a significant role to play in the solving the climate change problem. However, the nature of appliances, engines, and other long-lifespan products means that there is a significant time delay before the older, inefficient appliances are replaced with more energy-efficient versions (light bulbs, with a significantly shorter lifespan, offer a quicker alternative). While we view efficiency standards as a part of the solution, they are not THE solution.

Good Uses for Coal

Even in the age of solar thermal, coal will likely persist as a power source. Coal was the initial feedstock for the modern chemical industry, which began in the 1800's. In the early 1900's, coal was replaced with petroleum. As we enter the 21st century with diminishing reserves of oil,

[92] http://www.aceee.org/press/0406doefridge.htm

concerns about greenhouse gases, and abundant domestic supplies of coal, can coal regain its position as the primary feedstock for the US chemical industry? We believe substantial markets can be created for the coal industry. Coal is already used for the production of a handful of chemicals and plastics. For example, Eastman chemical operates a process were coal is first gasified to synthesis gas (“syngas”, a mixture of carbon monoxide and hydrogen) and the syngas is then converted to acetic anhydride, an important chemical intermediate. Eastman then reacts the acetic anhydride with cellulose (a renewable feedstock from biomass) to produce cellulose acetate, which is used for coatings, film, textile fibers and transparent packaging materials. The acetic anhydride can also be reacted with acetaldehyde to give vinyl acetate, another major chemical and polymer intermediate.

Two other examples of the further potential of coal as a feedstock for the chemical industry flow. The first is for a large volume chemical—the conversion of coal to ethylene, the building block for the production of polyethylene plastics and polyvinyl chloride. The second is a process to a novel polymer, an example that illustrates the potential for innovative uses of coal. The world’s largest volume chemical is ethylene, with a global market of greater than 75 million metric tons. The ethylene is used primarily for the production of polyethylene plastics. We ask two questions. First, is it reasonable to consider coal as a feedstock for ethylene? Second, would ethylene production be a significant market for coal? The answer to the first question is yes. As mentioned above, coal can be converted to syngas, a versatile starting point for chemical synthesis. Coal can also be gasified to methane (as we discussed with Great Point Energy) which can be transformed to ethylene. Several research laboratories around the world are working on methane to ethylene, including groups funded by the US DOE. The answer to the second question is also yes. The coal consumption in the US in 2006 was 1,114 million short tons (Energy Information Agency). We estimate that greater than 150 million short tons of coal would be needed to provide global demand of ethylene, or around 13.5% of US coal consumption. Coal can also be converted to other large volume chemical intermediates such as propylene, the second largest organic chemical after ethylene. In fact, Shenhua Ningxia Coal Group (SNCG) is working with Siemens to convert coal to propylene for the production of the plastic, polypropylene.

Unfortunately, the use of coal for plastics and chemicals has been a low priority for R&D for over 50 years. However, recent advances in catalytic chemistry and process engineering, together with the high price of oil, have made new products and processes possible. One example is a process under development to make polyethylene carbide (PEC) by a small start-up company called Novomer. PEC is currently a small volume specialty plastic with uses as a biodegradable adhesive or durable film. Novomer has developed a catalyst that converts ethylene oxide and CO2 to PEC. Ethylene oxide is a major commercial chemical that is produced by reacting ethylene (which can be made from coal as mentioned above) with oxygen. CO2 is a readily available from the combustion of coal and other sources. This type of process makes use of all the carbon in coal—including the CO2, making it very attractive in a carbon capped world.

Innovation Ecosystem: Why Research Matters

One of the many reasons we find ourselves relying on old, outdated and polluting technology is the reduction (or misallocation) of energy R&D by both the public and private sector. The NY Times notes that federal R&D spending on energy is down more than 50% since 1979 (inflation adjusted from $7.7 billion to $3 billion).[93] Meanwhile, funding for medical research has jumped 400% (to $27 billion) while military research has jumped 260% (to more than $75 billion). The worldwide trend isn't particularly different – Japan is the only economic power to actually increase spending over that time. The pattern has been noted - the National Academies released a report called *Rising Above the Gathering Storm*, which proposes the creation of a DARPA-like public research body to fund more energy projects and target various climate change issues.

The private sector, unfortunately, has not been much better on the R&D front – as the article notes, "studies show that energy companies have a long tradition of eschewing long-term technology quests because of the lack of short-term payoffs." Since 1980, energy R&D as a portion of total US R&D has fallen from 10%, to just 2% (see graph). They have never felt the urgency to

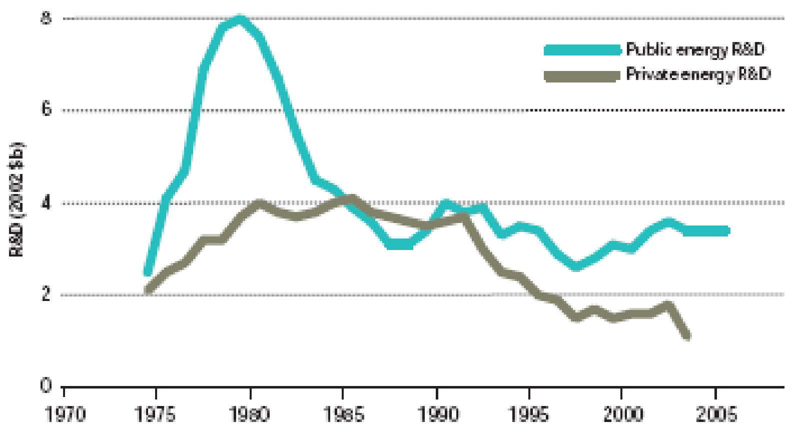
[93]http://www.nytimes.com/2006/10/30/business/worldbusiness/30energy.html?ex=1172293200&en=7aec927e5882d849&ei=5070

think outside the proverbial box (or think outside the coal pit in this case).

Declining energy R&D investment

Since 1980, energy R&D as a percentage of total U.S. R&D has fallen from 10 percent to 2 percent. Since the mid-1990s, both public and private sector R&D spending has been stagnant for renewable energy and energy efficiency, and has declined for fossil fuel and nuclear technology. The lack of industry investment suggests that the public sector needs to play a role in not only increasing investment directly but also correcting the market and regulatory obstacles that inhibit investment in new technology.

Declining energy R&D investment by both public and private sectors



Sources: R. M. Wolfe, Research and Development in Industry" (National Science Foundation, Division of Science Resources Statistics, 2004); M. Jefferson, *et al.*, "Energy Technologies for the 21st Century" (World Energy Council, 2001); R. L. Meeks, "Federal R&D Funding by Budget Function: Fiscal Years 2003-05" NSF 05-303 (National Science Foundation, Division of Science Resources Statistics, 2004); R. Margolis, and D. M. Kammen "Underinvestment: The energy technology and R&D policy challenge", *Science*, 285, 690-692 (1999).

We are at a time and place which is ripe for change – as the *Republic* put it, "Necessity is the mother of invention." There is likely to be immense opportunities for everyone involved – from scientists working on new breakthroughs, entrepreneurs developing the new technologies to market, technologists helping to shape the future, to people at large. The various alternative to coal have rapid innovation cycles and can be on the market (with support) in 3-5 years – a clear benefit. Fixing the climate change problem offers not only environmental rewards, but economic ones too – in the long run, this will offer more opportunities than risk. On a macro-level, reducing our carbon footprint now (prevention) will be significantly cheaper than countering the effects of climate change – the Stern report (commissioned by the UK government) estimated that global warming could reduce worldwide GDP by 20%. It is much cheaper to take action on a preventive basis to insure the planet, as opposed to an ex-post cure.

We have a crisis and a crisis is a terrible thing to waste (as Paul Romer put it). We are at a crossroads – the coal infrastructure is old (as mentioned before, 90% of coal plants are over 20 years old, and 60% are 30 years old!), dirty, and due for updating. Projections suggest that approximately 300GW of energy will be needed to fulfill new requirements in the US over the next 15 years. The urgency of the problem, combined with the need to upgrade our power infrastructure provides a convergence – the opportunity to solve two problems with one shot should not be missed. Today, building all of the coal plants that are planned would result in a capital investment of approximately $140 billion. The new plants would raise CO_2 emissions from electric generation by **25%** over already unsustainable 2004 levels, and a 10% raise in CO_2 emissions in the US.[94] As the USPIRG notes, that capital could fuel the generation of clean wind energy with a cost of electricity equivalent to that of coal, solar thermal power at similar prices. There are a significant amount of resources that can be directed towards the creation of a new, renewable energy infrastructure, instead of simply reinforcing an older, more dangerous culture. We have to meet utility needs for power sources that replace regular coal, and the innovation ecosystem will be a significant factor in it.

Nothing signals opportunity as much as the best and brightest people working on solving a problem. This is exactly where we find ourselves today in the renewables industry. Investments in the clean tech sector have risen four-fold in the past 5 years, and rose 78% in 2006 to $2.9 billion – and are projected to grow to about $10 billion by the end of this decade (creating 500,000 new jobs)[95]. The smartest people, companies, and capital are recognizing the scale of the opportunity, are recognizing the sheer size and potential present in finding new energy solutions. We must take steps to empower our entrepreneurs and signal our willingness to tackle the climate-change problem head-on. All of the entrepreneurs present today will not succeed, but will all of the efforts fail? Can the multitude of approaches and technologies all be wrong? The MIT geothermal study is the first new look at geothermal in 30 years – akin to solar thermal, it was a technology explored with potential in the 1970's and cast aside when oil prices declined. New technologies and new approaches are being explored everyday. While we cannot make up for lost time in the past, we can continue to encourage innovation and provide opportunities. Companies such as Ausra, Altraock, and Great Point Energy could all be the Google's of energy! Our faith in the innovation ecosystem is an important reason for our belief in the end of the coal-powered world.

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[94] http://www.uspirg.org/home/reports/report-archives/new-energy-future/new-energy-future/making-sense-of-the-coal-rush-the-consequences-of-expanding-americas-dependence-on-coal
[95] http://www.americanventuremagazine.com/articles/742

The Horserace

There are competing arguments for the capability of clean coal, nuclear, wind, supercritical pulverized coal, fuel cells, enhanced geothermal , and solar. We at Khosla Ventures are open to new alternatives emerging – we favor the idea of a horserace emerging between these and new solutions, in order to foster innovation and allow the best ideas to thrive. Our belief is that there are four major candidates for the 30-50-80% solution- clean coal (IGCC + CCS), CSP, nuclear power, and enhanced geothermal technology. These sources are capable of meeting the needs of PUG power - cheap (below $0.10 per KWh), dispatchability, and reliability. We reiterate that all of these technologies will be helped by a national power distribution grid (discussed later), which should become a national imperative.

Clean coal has a few advantages - the advantage of incumbency, and the fact that it's a cheap and readily available source of energy with significant political backing. It can be built in any location that we can ship coal to. On the other hand, the risks with both IGCC and CCS technology (reliability of IGCC, the area required for sequestration, high pressure transportation pipelines for carbon dioxide and additional rail lines for coal transportation) as well as the coal industry's unwillingness to invest in its own preferred alternatives (as mentioned earlier, only 16% of new plants are expected to utilize IGCC technology) are all negatives. We would not handicap the trajectory of clean coal to win the horse race. While increased research and funding may well alleviate some of the reliability and cost concerns with IGCC (Black and Veatch actually projects capital costs to go up for IGCC in the next 30 years!), the sequestration problem will take decades to characterize and cost optimize. Meanwhile, nuclear power offers relatively clean energy generation, but the long build times and associated risks (proliferation, nuclear waste disposal, high capital costs) are not likely to be mitigated by further research and development. Given recent experience on construction costs, the oft-touted "cheap cost" may be just a mirage of the past and far from tomorrow's reality. The next "big" innovation in nuclear technology is purported to be fusion, but even the most optimistic estimates believe it is at least 50 years away from being a viable source of electricity. Perhaps cold fusion will surprise us. Nuclear energy does have the potential to be a 30% source, but the various political, financial and technical roadblocks limit it from going beyond that. EGS is a huge, relatively untouched source of energy that has significant potential – the short term challenges of demonstrated commercial viability and some additional research (most of the technology required is already in place) are not significant obstacles for the innovation ecosystem to handle. Its "always-on" functionality allows it serve as a base-load power source without the need for storage, and there is no price or supply risk associated with it. Given the time, capital, and people we feel EGS can be a significant energy source. Environmentally, it has no greenhouse gas emissions and a negligible environmental footprint, and even land use is minimal.

Solar thermal energy is our bet as the primary replacement for coal. Less than a 100 mile square area of Nevada desert can meet all of the domestic energy needs – less than 70 mile square area can do the same for Europe). The technology in question has been a proven, viable source of energy for 20 years, and its ability to store the generated electricity means that solar thermal can serve as a base-load power source (as storage develops further plants will be built with capacity factors of 80%, allowing it to contribute to peaking needs as well). Cost wise, solar thermal is around $0.10 KWh right now in the right locations and at scale, and is declining. Environmentally, it has no greenhouse gas emissions and a negligible environmental footprint (beyond land use). The challenges faced by solar thermal are primarily developmental obstacles – the debt financing necessary to build the first commercial plant (that all new technologies face), as well as the access to the grid to advance beyond regional transmission. The cheap, scalable nature of CSP combined with its rapid innovation cycles make it the most attractive option.

The Role of Policy

The role of public policy in creating and defining markets is an important part of this debate.. Politics can create markets through mandates. It can make technologies cost effective (through incentives, subsidies, production and investment tax credits). It can be used for good and bad purposes and generate business profitability or foreclosures. The primary goal of public policy should be to set the rules in which the market can operate, and to insure that externalities (such as environmental impact) are accounted for in the decisions made. We'll outline three-policy steps that provide a net benefit.

- One significant role for public policy is the implementation of a carbon cap-and-trade scheme, something that has widespread support from both private and public sources (as noted earlier). This will allow us to evaluate the "true cost" of coal, and limit its "free rider" status with our environment.
- The implementation of a 20% federal renewable power standard by 2020, similar to the various state-wide programs in place. This will have the effect of encouraging

further investment in renewable energy sources, increased innovation and job creation, and though initially power costs may be a bit higher the increased competition is likely to reduce costs over the long run. Companies and entrepreneurs will no longer have to worry about a hodgepodge of rules and regulations in each state and open the doors to a wider market for each technology. A federal RPS would also act as a market signal and guarantee of market size, helping all renewable technologies.

- One of the major problems for energy technologies (especially newer, less capitalized ones) is the inability to take energy from alternative energy sites to load centers where the power is used. Our proposal is a high voltage DC grid, much like the national highway system, with government capital to throw open the doors to private initiative. DC grids have significant advantages from a technical perspective – they can carry higher power loads, reduced line costs, and is useful in connecting remote plants to the main grid. Similar to the concept of toll roads, such a grid could in effect, rent out its capacity to the various power solutions while not subjecting any one source to the complete capital risk, and without being accused of "picking winners." Such a grid is sorely needed and would be a boon to all (renewable and conventional) power generation technologies.

Conclusion

Coal (and to some extent, nuclear energy) has often been touted as the only real cost-effective option to fuel our power needs going forward. We disagree. Throughout this paper, the actual data suggests that the cost of building a new coal plant today is no longer the lowest cost option – it fails to meet our economic or environmental needs. The entrenched position of coal suggests it will continue to be a part of the horserace in the near future, but we feel confident that in the long run, the world's energy needs will be met by a combination of solar thermal technology, supplemented by nuclear energy, natural gas, wind, solar PV, and other sources of energy that have a significantly reduced carbon footprint. That being said, we should evaluate where we are today. Firstly, the fossil technologies in question have received significant subsidies, and the trend continues to this day. Secondly, the same technologies are fairly well optimized – innovation in the field has been limited (a byproduct of the miserly R&D numbers seen earlier) and not much has changed. Thirdly, the advantage of an aging fleet is present in accounting – the plants in question are fully amortized. The lobbying and political power of the coal industry in particular is tremendous – the Center for Responsive Politics notes that the largest coal company (Peabody Energy) spent approximately 0.5% of its profits on political contributions! In return for this particular act of generosity, the 2005 Energy Act included billions in coal subsidies. A list of the top spenders shows that electric utilities have spent approximately $800 million on lobbying from 1998 to 2006.[96] In Texas alone, energy companies were planning on spending between $10-20 million (although this amount includes pre-buyout TXU) to limit electricity price regulation, emission controls, and faster permit processing.[97] By any account, fossil fuels in electric generation present a formidable, entrenched opponent – something that we must be prepared for – to win over, not to conquer. There are significant and politically powerful barriers to change.

What do we do? We need to kick start the alternatives that exist, from solar thermal energy to wind, from photovoltaics to geothermal. We need to level the playing field and create a real horse race. The Economist has estimated that the cost of extreme weather is well over $50 billion a year – a significant amount, no matter how the fossil fuel industry tries to ignore it. We insure our homes – why not our planet? We could supply ALL the world's current electricity needs using land smaller than the size of Madagascar (note: this is not to suggest any CSP plant would be in Madagascar – simply an analogy regarding the size/payoff tradeoffs) In a world where India and China (1/3 of the world's population, yet currently consuming 1/6th the energy of the US on a per capita basis) are likely to grow into prosperity, the world's energy needs are likely to explode. The good news is that the technology exists, and will continue to improve to harness the most potent power source available to humanity allowing for cheaper and greener power. The combination of brilliant ideas and entrepreneurial spirit should lead us to a safer and more secure future. The innovation ecosystem, typified of Silicon Valley, can upend the staid conventional assumptions of the energy industry with the right policy help from Washington.

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[96] http://www.opensecrets.org/lobbyists/overview.asp?txtindextype=i
[97] http://www.dallasnews.com/sharedcontent/dws/bus/coal/stories/013007dntexenergylobby.1ecbebe.html

Appendix A: Summary of Federal Mandatory Emission Reduction Proposals

Proposed National Policy	Title or Description	Year Proposed	Emission Targets	Sectors Covered
McCain Lieberman S.139	Climate Stewardship Act	2003	Cap at 2000 levels 2010-2015. Cap at 1990 levels beyond 2015.	Economy-wide, large emitting sources
McCain Lieberman SA 2028	Climate Stewardship Act	2003	Cap at 2000 levels	Economy-wide, large emitting sources
National Commission on Energy Policy (basis for Bingaman-Domenici legislative work)	Greenhouse Gas Intensity Reduction Goals	2005	Reduce GHG intensity by 2.4%/yr 2010-2019 and by 2.8%/yr 2020-2025. Safety-valve on allowance price	Economy-wide, large emitting sources
Sen. Feinstein	Strong Economy and Climate Protection Act	2006	Stabilize emissions through 2010; 0.5% cut per year from 2011-15; 1% cut per year from 2016-2020. Total reduction is 7.25% below current levels.	Economy-wide, large emitting sources
Jeffords S. 150	Multi-pollutant legislation	2005	2.050 billion tons beginning 2010	Existing and new fossil-fuel fired electric generating plants >15 MW
Carper S. 843	Clean Air Planning Act	2005	2006 levels (2.655 billion tons CO2) starting in 2009, 2001 levels (2.454 billion tons CO2) starting in 2013.	Existing and new fossil-fuel fired, nuclear, and renewable electric generating plants >25 MW
Rep. Udall - Rep. Petri	Keep America Competitive Global Warming Policy Act	2006	Establishes prospective baseline for greenhouse gas emissions, with safety valve.	Not available

Source: Syanpse Energy Economics

Appendix B: Senator Reid's Report on the Decline in Coal Power Construction

DECLINE IN NEW COAL POWER PLANT CONSTRUCTION

September 14, 2007

COAL'S UNPOPULARITY: A RISING TREND

The following is a report highlighting trends in coal power plant construction. Detailed are instances in states where key decisions by regulators, public officials or utilities themselves have led to coal plant construction being postponed or canceled all together. In addition, the renewable portfolio standards set by each of the 20 states that have passed them are detailed as well. Finally, maps illustrating the potential for solar, geothermal and wind energy in Nevada are included. Below are specific examples as to why, nationwide, a growing trend against coal power plant construction may be occurring.

Most Newly Proposed Coal Power Plants Are Never Built. According to the Department of Energy, proposals to build new power plants are often speculative and typically operate on "boom & bust" cycles, based upon the ever changing economic climate of power generation markets. As such, many of the proposed plants will not likely be built. For example, out of a total portfolio (gas, coal, etc) of 500 GW of newly planned power plant capacity announced in 2001, 91 GW have been already been scrapped or delayed. [Tracking New Coal-Fired Power Plants: Department of Energy, 5/1/07]

Since 2006 Nearly Two Dozen Coal Projects Have Been Canceled. According to the National Energy Technology Laboratory, a division of the Department of Energy, nearly two dozen coal projects have been canceled since early 2006. [Tracking New Coal-Fired Power Plants: Department of Energy, 5/1/07]

The Cost of Raw Materials Needed to Build Coal-Fired Plants Has Risen. One industry study showed that the cost of raw construction materials such as cement and steel is far higher than thought just two years ago. [Spokesman-Review, 9/5/07]

COAL PROJECTS SCALED BACK: STATE SPECIFIC EXAMPLES

Below are highlights from states across the country where regulators or utilities themselves have taken the lead in curbing the new coal plant construction. In each instance, the decisions made were done with an eye towards concerns over public health and climate change. While the list below is not exhaustive, it provides insight into the recent decisions the could be implemented elsewhere.

Colorado: **Colorado's Xcel Energy Agreed to Supplement its Coal Power Generated Electricity With Wind**

Power. Even in states where coal projects are going forward, they are happening more often with a nod to environmental concerns. Xcel Energy, through its Public Service of Colorado unit, agreed to obtain 775 megawatts worth of wind power to supplement the power that will come from a 750 megawatt coal plant it is building near Pueblo. It also has agreed to install more pollution controls at existing units, and to cut energy demand by more than 300 megawatts in coming years. "It will change their portfolio in a fundamental way," says Vickie Patton, senior attorney for Environmental Defense in Colorado. [Wall Street Journal, 7/25/07]

Florida: **Florida Governor Charlie Crist Celebrated the Cancellation of a Key Coal Plant Project.**

Florida Governor Charlie Crist backed up the symbolism of his meeting on global climate change in Miami with a stern rebuke to the future of coal-powered energy plants in the state. After Florida's Public Service Commission turned down an application for a coal plant in Glades County, Crist said the future of coal plants in the state is "not looking good." Crist said followed with "We're moving in a different direction." [Sarasota Herald-Tribune, 7/4/07]

Florida Governor Charlie Crist Said Utilities Must Stop Relying on Coal and Natural Gas

Plants. After the Public Service Commission denied Florida Power and Light Co.'s request to build a coal-fired plant in Glades County, Governor Charlie Crist hailed the decision and said that utilities must stop relying on coal and natural gas plants that generate carbon dioxide, a probable cause of global warming. [Palm Beach Post, 7/4/07]

Kansas: **Because of Colorado's Newly Enacted Renewable Energy Mandate, a Two Utility Companies Have Canceled a Coal Plant Project.**

One of the most ambitious proposals for new coal power plants in 2006 was to construct three units with a total generating capacity of 2,100 megawatts in western Kansas. The two cooperatives involved, Tri-State in Colorado and Sunflower Electric Power in Kansas, have scaled down the project to two units. One reason was that Colorado adopted a law requiring rural electric co-ops to get 10 percent of their power from renewable resources. [Washington Post, 9/4/07]

North Carolina: **Due to Rising Costs Duke Energy Was Forced By the NC Utilities Commission to Cancel a Coal Plant Project.**

Duke Energy Inc. created a stir last year when it announced that the expected cost of a new twin-unit power plant in North Carolina had ballooned to about $3 billion, up 50% from about 18 months earlier. That run up in cost and other factors compelled the North Carolina Utilities Commission to nix one of the two proposed units. According to a recent press report, the plant that was approved is expected to cost more than $1.8 billion. [Wall Street Journal, 7/25/07; Baltimore Sun, 9/4/07]

Oklahoma: **Oklahoma Corporation Commission Rejected Application For Coal-Fired Plant, Opponents Argue Their Decision Will Save Rate Payers Money.**

The Oklahoma Corporation Commission rejected a request from the state's three largest public utilities to proceed with plans to build a coalfired power plant. The commission turned down the proposal by Oklahoma Gas & Electric, American Electric-Power Service Company of Oklahoma and the Oklahoma Municipal Power Authority. The $1.8 billion dollar plant would have been built in Red Rock in Noble County, about 80 miles north of Oklahoma City. Chesapeake Energy Corp. was one of the most ardent campaigners against the coal plant. Aubrey McClendon, the company's chairman and chief executive officer, said the decision will save consumers money in the long run. "This is a win for Oklahoma ratepayers," McClendon said. "Coal is cheap today, but we believe it won't always be cheap. It's only logical that there will be a day when something that's as detrimental to the environment and to public health is priced in a different way. Coal has done wonderful things for our national economy in the 19th and 20th centuries, but this is the 21st century. Oklahoma needs to show leadership here. It is a great first step from these courageous Oklahoma Corporation commissioners to say no to what we think was an ill-conceived idea for the 21st century." Oklahoma Treasurer Scott Meacham also came out publicly against the proposal, saying he was concerned with the plant's potential impact on global warming. [Daily Oklahoman, 9/11/07]

Texas: **In Order to Be Bought Out By Private Investors, Texas Utility Corporation Was Forced to Cancel Eight Coal Plant Projects.**

TXU Corp, the Texas energy giant, was faced with attacks from environmentalists after it proposed building 11 new coal plants in the state. The resulting legal skirmishes and investor concerns about the high cost of the plants sent its share price plummeting. As a result, a weakened TXU agreed in February to reduce the number of coal plants it planed to build from 11 to three as part of a deal to sell itself to two large private equity firms for $45 billion. [Baltimore Sun, 9/4/07]

Washington: **One Western Utility Took it Upon Itself to Shift From Coal to Renewable Energy Sources.**

Avista Utilities planed to sell more electricity generated by natural gas plants and giant windmills rather than investing in new coal power plants, according to a long-term power plan released by the company. Clint Kalich, the company's resource planning manager, said he agrees with the assessment of Puget

Sound Energy that the future of Northwest energy will be more "gassy, windy." Washington utilities submit 20-year power plans every other year to state regulators. The studies predict population and business growth and future energy needs. While the Northwest has long relied on river dams for generating ample megawatts, the future lies in underground gas stores and the wind. In a change from power planning in 2005, Avista this time around is ruling out new megawatts from coal plants. The company has also determined that building and partnering in a nuclear power plant is too expensive and too unpredictable. [Spokesman-Review, 9/5/07]

Source: http://www.reid.senate.gov/pdfs/Coal%20Report%20-%20New%20Plant%20Construction.pdf