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Full Committee Hearing on

Coal Gasification

Committee on

Energy and Natural Resources

United States Senate

May 24, 2007

Thank you for the opportunity to testify today on the subject of coal gasification technology and the challenges it faces. My name is Antonia Herzog. I am a staff scientist in the Climate Center at the Natural Resources Defense Council (NRDC). NRDC is a national, nonprofit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment. Founded in 1970, NRDC has more than 1.2 million members and online activists nationwide, served from offices in New York, Washington, Los Angeles and San Francisco.

One of the primary reasons that the electric power, chemical, and liquid fuels industries have become increasingly interested in coal gasification technology in the last several years is the volatility and high cost of both natural gas and oil. Coal has the advantages of being a cheap, abundant, and domestic resource compared with oil and natural gas. However, the disadvantages of conventional coal use cannot be ignored. From underground accidents and mountain top removal mining, to collisions at coal train crossings, to air emissions of acidic, toxic, and heat-trapping pollution from coal combustion, to water pollution from coal mining and combustion wastes, the conventional coal fuel cycle is among the most environmentally destructive activities on earth.[1]

But we can do better with both production and use of coal. And because the world is likely to continue to use significant amounts of coal for some time to come, we must do better. Energy efficiency remains the cheapest, cleanest, and fastest way to meet our energy and environmental challenges, while renewable energy is the fastest growing supply option. Increasing energy efficiency and expanding renewable energy supplies must continue to be the top priority, but we have the tools to make coal more compatible with protecting public health and the environment. With the right standards and incentives we can fundamentally transform the way coal is produced and used in the United States and around the world.

In particular, coal use and climate protection do not need to be irreconcilable activities. While energy efficiency and greater use of renewable resources must remain core components of a comprehensive strategy to address global warming, development and use of technologies such as coal gasification in combination with carbon dioxide (CO_2) capture and permanent disposal in geologic repositories under certain circumstances could enhance our ability to avoid a dangerous build-up of this heat-trapping gas in the atmosphere while creating a future for continued coal use.

However, because of the long lifetime of carbon dioxide in the atmosphere and the slow turnover of large energy systems we must act without delay to start deploying these technologies as appropriate. Current government policies are inadequate to drive the private sector to invest in carbon capture and disposal systems in the timeframe we need them. To accelerate the development of these systems and to create the market conditions for their use, we need to focus government funding more sharply on the most promising technologies. More importantly, we need to adopt binding measures and standards that limit global warming emissions so that the private sector has a business rationale for prioritizing investment in this area.

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[1] "Coal in a Changing Climate," NRDC position paper, February 2007, http://www.nrdc.org/globalWarming/coal/coalclimate.pdf.

In addition, Congress should only allow new authorizations for expenditures or the commitment of federal fiscal resources, including an authorization for an appropriation, direct spending, tax measures, loan guarantees or other credit instruments, to support the research, development, demonstration or commercial deployment of an energy producing technology *if* that technology, when commercially deployed: (A) reduces greenhouse gas emissions, (B) reduces our dependence on oil; and (C) provides an economic benefit to the U.S. economy.

Congress is now considering a variety of proposals to gasify coal as a replacement for natural gas and oil. These proposals need to be evaluated in the context of the compelling need to reduce global warming emissions steadily and significantly, starting now and proceeding constantly throughout this century. Furthermore, because today's coal mining and use also continues to impose a heavy toll on America's land, water, and air, damaging human health and the environment, it is also critical to examine the implications of a substantial coal gasification program on these values as well.

Reducing Natural Gas and Oil Demand

The nation's economy, our health and our quality of life depend on a reliable supply of affordable energy services. The most significant way in which we can achieve these national goals is to exploit the enormous scope to wring more services out of each unit of energy used and by aggressively promoting renewable resources. While coal gasification technology has been touted as the technology solution to supplement our natural gas and oil supply and reduce our dependence on natural gas and oil imports, the most effective way to lower natural gas and oil demand, and prices, is to waste less. America needs to first invest in energy efficiency and conservation to reduce demand, and to second promote renewable energy alternatives to supplement supply. Gasified coal may have a role to play, but in both the short-term and over the next two decades, efficiency and renewables are the lead actors in an effective strategy to moderate natural gas and oil prices and balance our demand with reasonable expectations of supply.

Natural Gas

Increasing energy efficiency is far-and-away the most cost-effective way to reduce natural gas consumption and avoid emitting carbon dioxide and other damaging environmental impacts. Available technologies range from efficient lighting, including emerging L.E.D. lamps, to advanced selective membranes which reduce industrial process energy needs. Critical national and state policies include appliance efficiency standards, performance-based tax incentives, utility-administered deployment programs, and innovative market transformation strategies that make more efficient designs standard industry practice.

Conservation and efficiency measures such as these can have dramatic impacts in terms of price and savings.[2] Moreover, all of these untapped gas efficiency "resources" will expand steadily, as a growing economy adds more opportunities to secure long-lived savings. California has a

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[2] American Council for an Energy-Efficient Economy (ACEEE), Fall 2004 Update on Natural Gas Markets, November 3, 2004. *See also* Consumer Federation of America, "Responding to Turmoil in Natural Gas Markets: The Consumer Case for Aggressive Policies to Balance Supply and Demand," pp. 28, December 2004.

quarter century record of using comparable strategies to reduce both natural gas consumption and the accompanying utility bills. Recent studies commissioned by the Pacific Gas & Electric Company showed that by 2001 longstanding incentives and standards targeting natural gas equipment and use had cut statewide consumption for residential, commercial, and industrial purposes (excluding electric generation) by more than 20 percent.

Studies have consistently shown that reducing demand for natural gas by increasing renewable energy use will reduce natural gas prices. According to a report released by the U.S. Department of Energy's Lawrence Berkeley National Laboratory, "studies generally show that each 1% reduction in national gas demand is likely to lead to a long-term (effectively permanent) average reduction in wellhead gas prices of 0.8% to 2%. Reductions in wellhead prices will reduce wholesale and retail electricity rates and will also reduce residential, commercial, and industrial gas bills."[3]

Adoption of a national renewable energy standard (RES) can significantly reduce the demand for natural gas, alleviating potential shortages. The Energy Information Administration (EIA) has found that a national 10 percent renewable energy standard could reduce gas consumption by 1.4 trillion cubic feet per year in 2020 compared to business as usual, or roughly 5 percent of annual demand. Furthermore, there would be a $4.9 billion cumulative present value savings for industrial gas consumers, $1.8 billion to commercial customers, and $2.4 billion to residential customers.[4] EIA also found that renewable energy can help reduce electricity bills. Lower natural gas prices for electricity generators and other consumers offset the slightly higher cost of renewable electricity technology.[5]

Implementing effective energy efficiency measures is the fastest and most cost effective approach to balancing natural gas demand and supply. Renewable energy provides a critical mid-term to long-term supplement. Analysis by the Union of Concerned Scientists found that a combined efficiency and renewable energy scenario could reduce gas use by 31 percent and natural gas prices by 27 percent compared to business as usual in 2020.[6]

In contrast to these strategies, pursuing coal gasification implementation strategies that address only natural gas supply concerns, while ignoring impacts of coal, is a recipe for huge and costly mistakes. Fortunately, we have in our tool box energy resource options that can reduce natural gas demand and global warming emissions as well as protecting America's land, water, and air.

Oil

NRDC fully agrees that reducing oil dependence should be a national priority and that new policies and programs are needed to avert the mounting problems associated with today's dependence and the much greater dependence that lies ahead if we do not act. A critical issue is

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[3] U.S. Department of Energy, Lawrence Berkeley National Laboratory, *Easing the Natural Gas Crisis: Reducing Natural Gas Prices Through Increased Deployment of Renewable Energy and Energy Efficiency*, January, 2005, p. 13.

[4] EIA, Impacts of a 10-Percent Renewable Portfolio Standard, SR/OIAF/2002-03, February 2002. EIA, Analysis of a 10-Percent Renewable Portfolio Standard, SR/OIAF/2003-01, May 2003.

[5] UCS, *Renewable Energy Can Help Alleviate Natural Gas Crisis*, June 2003, at 2.

[6] UCS, *Clean Energy Blueprint: A Smarter National Energy Policy for Today and the Future*, October 2001.

the path we pursue in reducing oil dependence: a "green" path that helps us address the urgent problem of global warming and our need to reduce the impacts of energy use on the environment and human health; or a "brown" path that would increase global warming emissions as well as other health and environmental damage. In deciding what role coal might play as a source of transportation fuel NRDC believes we must thoroughly assess whether it is possible to use coal to make liquid fuels without exacerbating the problems of global warming, conventional air pollution and impacts of coal production and transportation.

If coal were to play a significant role in displacing oil, it is clear that the enterprise would be huge, so the health and environmental stakes are correspondingly huge. The coal company Peabody Energy is promoting a vision that would call for production of 2.6 million barrels per day of synthetic transportation fuel from coal by 2025, about 10% of forecasted oil demand in that year. According to Peabody, using coal to achieve that amount of crude oil displacement would require construction of 33 very large coal-to-liquids plants, each plant consuming 14.4 million tons of coal per year to produce 80,000 barrels per day of liquid fuel. Each of these plants would cost $6.4 billion to build. Total additional coal production required for this program would be 475 million tons of coal annually—requiring an expansion of coal mining of 43% above today's level.[7] This testimony does not attempt a thorough analysis of the impacts of a program of this scale. Rather, it will highlight the issues that should be addressed in a detailed assessment.

Environmental Impacts of Coal

Some call coal "clean." It is not and likely never will be compared to other energy options. Nonetheless, it appears inevitable that the U.S. and other countries will continue to rely heavily on coal for many years. The good news is that with the right standards and incentives it is possible to chart a future for coal that is compatible with protecting public health, preserving special places, and avoiding dangerous global warming. It may not be possible to make coal clean, but by transforming the way coal is produced and used, it is possible to make coal significantly cleaner - and safer - than it is today.

Global Warming Pollution

To avoid catastrophic global warming the U.S. and other nations will need to deploy energy resources that result in much lower releases of CO_2 than today's use of oil, gas and coal. To keep global temperatures from rising to levels not seen since before the dawn of human civilization, the best expert opinion is that we need to get on a pathway now to allow us to cut global warming emissions by up to 80 percent from today's levels over the decades ahead. The technologies we choose to meet our future energy needs must have the potential to perform at these improved emission levels.

Most serious climate scientists now warn that there is a very short window of time for beginning serious emission reductions if we are to avoid truly dangerous greenhouse gas reductions without

[7] Peabody's "Eight-Point Plan" calls for a total of 1.3 billion tons of additional coal production by 2025, proposing that coal be used to produce synthetic pipeline gas, additional coal-fired electricity, hydrogen, and fuel for ethanol plants. The entire program would more than double U.S. coal mining and consumption.

severe economic impact. Delay makes the job harder. The National Academy of Sciences recently stated: "Failure to implement significant reductions in net greenhouse gases will make the job much harder in the future – both in terms of stabilizing their atmospheric abundances and in terms of experiencing more significant impacts."[8]

In short, a slow start means a crash finish – the longer emissions growth continues, the steeper and more disruptive the cuts required later. To prevent dangerous global warming we need to stabilize atmospheric concentration at or below 450 ppm, which would keep total warming below 2 degrees Celsius (3.6 degrees Fahrenheit). If we start soon, we can stay on the 450 ppm path with an annual emission reduction rate that gradually ramps up, but if we delay a serious start by 10 years or more and continue emission growth at or close to the business-as-usual trajectory, the annual emission reduction rate required to stay on the 450 ppm pathway jumps many-fold[9]. Even if you do not accept today that the 450 ppm path will be needed consider this point. If we do not act to preserve our ability to get on this path we will foreclose the path not just for ourselves but for our children and their children. We are now going down a much riskier path and if we do not start reducing emissions soon neither we nor our children can turn back no matter how dangerous the path becomes.

In the past, some analysts have argued that the delay/crash action scenario is actually the cheaper course, because in the future (somehow) we will have developed breakthrough technologies. But it should be apparent that the crash reductions scenario is implausible for two reasons. First, reducing emissions by a very high rate each year would require deploying advanced low-emission technologies at least several times faster than *conventional* technologies have been deployed over recent decades. Second, the effort would require prematurely retiring billions of dollars in capital stock – high-emitting power plants, vehicles, etc. – that will be built or bought during the next 10-20 years under in the absence of appropriate CO_2 emission limits.
It also goes without saying that U.S. leadership is critical. Preserving the 450 ppm pathway requires other developed countries to reduce emissions at similar rates, and requires the key developing countries to dramatically reduce and ultimately reverse their emissions growth. U.S. leadership can make that happen faster.

To assess the global warming implications of a large coal gasification program we need to carefully examine the total life-cycle emissions associated with the end product, whether electricity, synthetic gas, liquid fuels or chemicals, and to assess if the relevant industry sector will meet the emission reductions required to be consistent with what we need to achieve in the U.S.

Electricity Sector

More than 90 percent of the U.S. coal supply is used to generate electricity in some 600 coal-fired power plants scattered around the country, with most of the remainder is used for process heat in heavy industrial and in steel production. Coal is used for power production in all regions

[8] National Academy of Sciences, *Understanding and Responding to Climate Change: Highlights of National Academies Reports*, p.16 (October 2005), http://dels.nas.edu/dels/rpt_briefs/climate-change-final.pdf.
[9] D. D. Doniger, A.V. Herzog, D. A. Lashof, "An Ambitious, Centrist Approach to Global warming Legislation," *Science*, vol. 314, p. 764 (November, 2006).

of the country, with the Southeast, Midwest, and Mountain states most reliant on coal-fired power. Texas uses more coal than any other state, followed by Indiana, Illinois, Ohio, and Pennsylvania.[10]

About half of the U.S. electricity supply is generated using coal-fired power plants. This share varies considerably from state to state, but even California, which uses very little coal to generate electricity within its borders, consumes a significant amount of electricity generated by coal in neighboring Arizona and Nevada, bringing coal's share of total electricity consumed in California to 20 percent.[11] National coal-fired capacity totals 330 billion watts (GW), with individual plants ranging in size from a few million watts (MW) to over 3000 MW. More than one-third of this capacity was built before 1970, and over 400 units built in the 1950s—with capacity equivalent to roughly 100 large modern plants (48 GW)—are still operating today.

The future of coal in the U.S. electric power sector is an uncertain one. The major cause of this uncertainty is the government's failure to define future requirements for limiting greenhouse gas emissions, especially carbon dioxide (CO_2). Coal is the fossil fuel with the highest uncontrolled CO_2 emission rate of any fuel and is responsible for 36 percent of U.S. carbon dioxide emissions. Furthermore, coal power plants are expensive, long-lived investments. Key decision makers understand that the problem of global warming will need to be addressed within the time needed to recoup investments in power projects now in the planning stage. Since the status quo is unstable and future requirements for coal plants and other emission sources are inevitable but unclear, there will be increasing hesitation to commit the large amounts of capital required for new coal projects.

Electricity production is the largest source of global warming pollution in the U.S. today. In contrast to nitrogen and sulfur oxide emissions, which have declined significantly in recent years as a result of Clean Air Act standards, CO_2 emissions from power plants have increased by 27 percent since 1990. Any solution to global warming must include large reductions from the electric sector. Energy efficiency and renewable energy are well-known low-carbon methods that are essential to any climate protection strategy. But technology exists to create a more sustainable path for continued coal use in the electricity sector as well. Coal gasification can be compatible with significantly reducing global warming emissions in the electric sector if it replaces conventional coal combustion technologies, directly produces electricity in an integrated manner, and most importantly captures **and** disposes of the carbon in geologic formations. IGCC technology without CO_2 capture and disposal achieves only modest reductions in CO_2 emissions compared to conventional coal plants.

A coal integrated gasification combined cycle (IGCC) power plant with carbon capture and disposal can capture up to 90 percent of its emissions, thereby being part of the global warming solution. In addition to enabling lower-cost CO_2 capture, gasification technology has very low emissions of most conventional pollutants and can achieve high levels of mercury control with low-cost carbon-bed systems. However, it still does not address the other environmental impacts from coal production and transportation.

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[10] http://www.eia.doe.gov/cneaf/coal/page/acr/table26.html
[11] California Energy Commission, 2005. 2004 Net System Power Calculation (April.) Table 3: Gross System Power. http://www.energy.ca.gov/2005publications/CEC-300-2005-004/CEC-300-2005-004.PDF

The electric power industry has been slow to take up gasification technology, but two commercial-scale units are operating in the U.S.—in Indiana and Florida. The Florida unit, owned by TECO, is reported by the company to be the most reliable and economic unit on its system. Two coal-based power companies, AEP and Cinergy, have announced their intention to build coal gasification units. The first proposed coal gasification plant that will capture and dispose of its CO_2 was announced in February, 2006 by BP and Edison Mission Group. The plant will be built in Southern California and its CO_2 emissions will be pipelined to an oil field nearby and injected into the ground to recover domestic oil. BP's proposal shows the technologies are available now to cut global warming pollution and that integrated IGCC with CO_2 capture and disposal are commercially feasible.

Liquid Fuels

To assess the global warming implications of a large coal-to-liquids program we need to examine the total life-cycle or "well-to-wheel" emissions of these new fuels. Coal is a carbon-intensive fuel, containing double the amount of carbon per unit of energy compared to natural gas and about 20% more than petroleum. When coal is converted to liquid fuels, two streams of CO_2 are produced: one at the coal-to-liquids production plant and the second from the exhausts of the vehicles that burn the fuel. With the technology in hand today and on the horizon it is difficult to see how a large coal-to-liquids program can be compatible with the low-CO_2-emitting transportation system we need to design to prevent global warming.

Today, our system of refining crude oil to produce gasoline, diesel, jet fuel and other transportation fuels, results in a total "well to wheels" emission rate of about 27.5 pounds of CO_2 per gallon of fuel. Based on available information about coal-to-liquids plants being proposed, the total well to wheels CO_2 emissions from such plants would be about 49.5 pounds of CO_2 per gallon, nearly twice as high as using crude oil, if the CO_2 from the coal-to-liquids plant is released to the atmosphere.[12] Obviously, introducing a new fuel system with close to double the CO_2 emissions of today's crude oil system would conflict with the need to reduce global warming emissions. If the CO_2 from coal-to-liquids plants is captured, then well-to-wheels CO_2 emissions would be reduced but would still be higher than emissions from today's crude oil system.[13]

This comparison indicates that using coal to produce a significant amount of liquids for transportation fuel would not be compatible with the need to develop a low-CO_2 emitting transportation sector unless technologies are developed to significantly reduce emissions from the overall process. But here one confronts the unavoidable fact that the liquid fuel from coal contains the same amount of carbon as is in gasoline or diesel made from crude. Thus, the

[12] Calculated well to wheel CO_2 emissions for coal-based "Fischer-Tropsch" are about 1.8 greater than producing and consuming gasoline or diesel fuel from crude oil. If the coal-to-liquids plant makes electricity as well, the relative emissions from the liquid fuels depends on the amount of electricity produced and what is assumed about the emissions of from an alternative source of electricity.

[13] Capturing 90 percent of the emissions from coal-to-liquid plants reduces the emissions from the plant to levels close to those from petroleum production and refining while emissions from the vehicle are equivalent to those from a gasoline vehicle. With such CO_2 capture, well to wheels emissions from coal-to-liquids fuels would be 8 percent higher than for petroleum.

potential for achieving significant CO_2 emission reductions compared to crude is inherently limited. This means that using a significant amount of coal to make liquid fuel for transportation needs would make the task of achieving any given level of global warming emission reduction much more difficult. Proceeding with coal-to-liquids plants now could leave those investments stranded or impose unnecessarily high abatement costs on the economy if the plants continue to operate.

NRDC has examined the greenhouse gas emissions from a wide variety of feedstock and conversion process combinations using the Argonne GREET model (see figure 1 and Appendix 1). EPA conducted a similar analysis for a factsheet released in conjunction with its final rule for implementing the Renewable Fuels Standard enacted in EPACT 2005.[14] EPA's results are shown in Figure 2 and are very similar to ours (note that EPA displays results relative to conventional diesel gasoline, which is set to zero on their chart). Most recently Argonne National Laboratory scientist released a new analysis using their GREET model to assess the life-cycle greenhouse gas emissions of Fischer-Tropsch diesel products from natural gas, coal and biomass (see figure 3).[15] Again their results are similar to ours. They find that liquid coal without carbon capture and disposal can emit from 2.2 to 2.5 times more greenhouse gases than the equivalent gallon of petroleum-based diesel fuel. And even with carbon capture and disposal the life-cycle emissions are still 1.19-1.25 times higher.

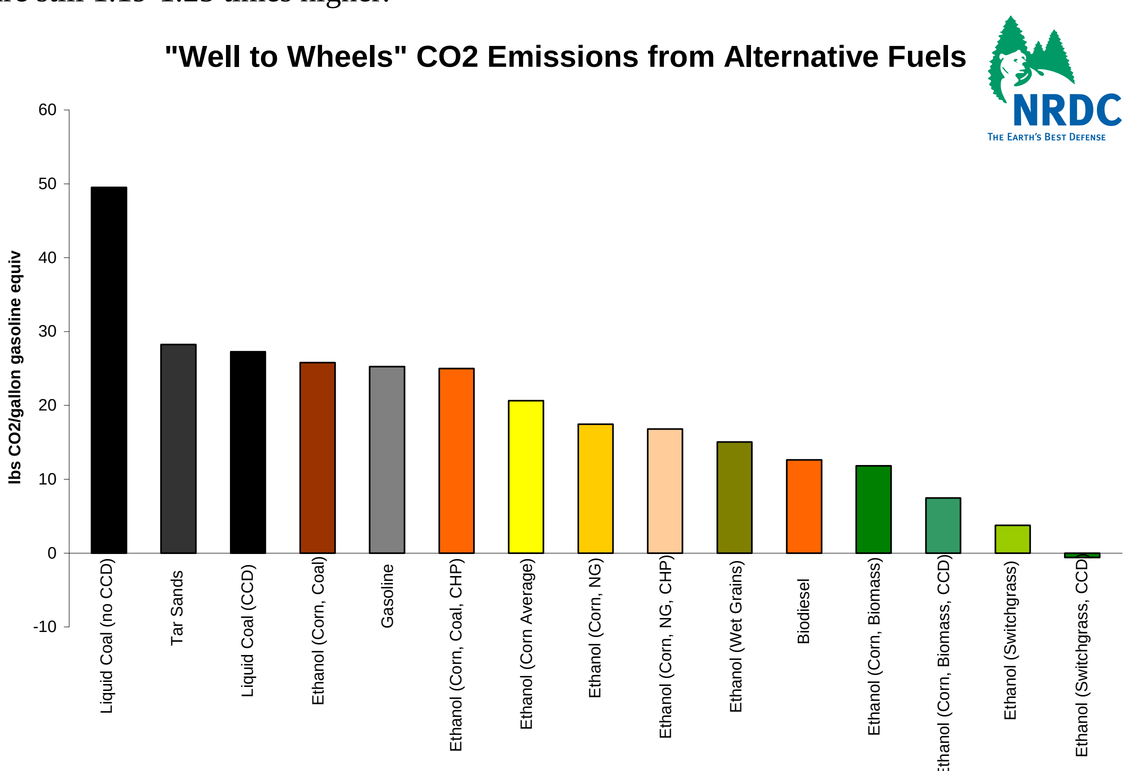

Figure 1. NRDC lifecycle greenhouse gas analysis (See Appendix 1).

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[14] http://www.epa.gov/otaq/renewablefuels/420f07035.htm

[15] M. Wang, M. Wu, H. Huo, "Life-cycle energy and greenhouse gas results of Fischer-Tropsch diesel produced from natural gas, coal,, and biomass," Center for Transportation Research, Argonne National laboratory, presented at 2007 SAE Government/Industry meeting, Washington, DC, May 2007.

From these charts we can clearly see that there are much more environmentally friendly methods for producing transportation fuels. Biofuels are an obvious alternative, which has gotten a lot of attention recently, and about which NRDC recently testified before the committee[16]. Another alternative transportation fuel that is worthy of note is electricity used in plug-in hybrid electric vehicles. If coal is to be used to replace gasoline, generating electricity for use in plug-in hybrid vehicles (PHEVs) can be far more efficient and cleaner than making liquid fuels. In fact, a ton of coal used to generate electricity used in a PHEV will displace more than twice as much oil as using the same coal to make liquid fuels, even using optimistic assumptions about the conversion efficiency of liquid coal plants.[17] The difference in CO_2 emissions is even more dramatic. Liquid coal produced with CCS and used in a hybrid vehicle would still result in lifecycle greenhouse gas emissions of approximately 330 grams/mile, or **ten times** as much as the 33 grams/mile that could be achieve by a PHEV operating on electricity generated in a coal-fired power plant equipped with CCS.[18] GM has recently announced plans to commercialize plug-in hybrid electric vehicles.

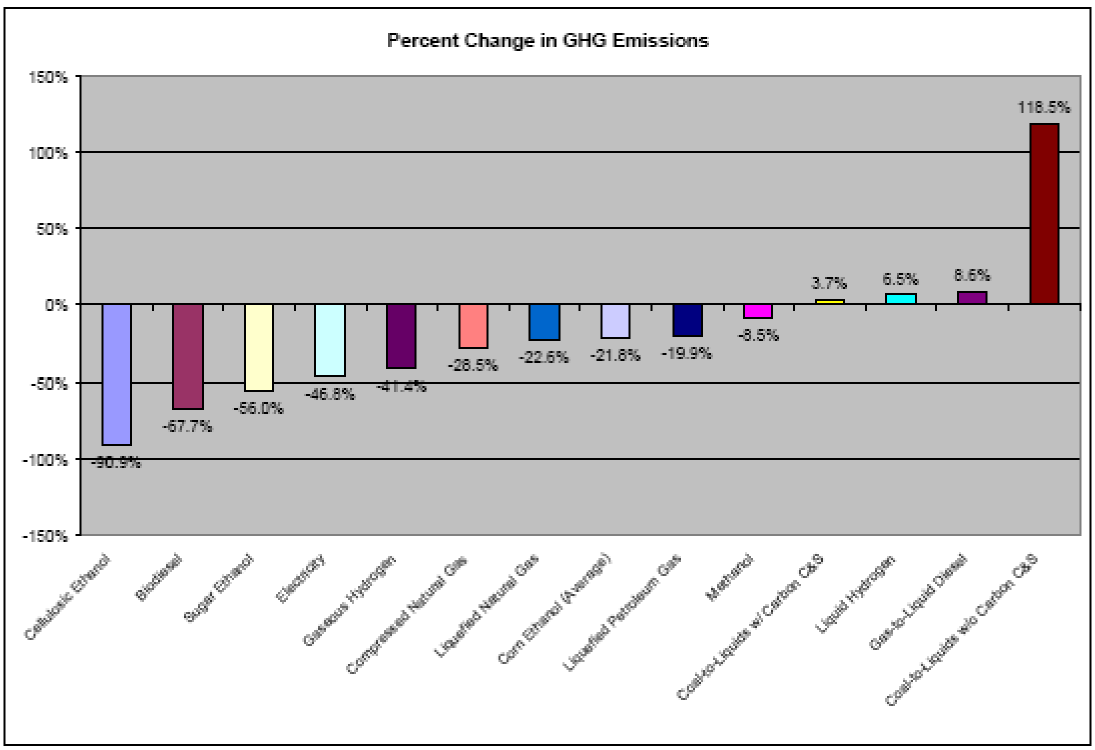

Figure 2. EPA lifecycle greenhouse gas analysis (results relative to conventional diesel gasoline, which is set to zero on their chart).

[16] Daniel Lashof, Testimony on S.987, the Biofuels for Energy Security and Transportation Act of 2007 before the Senate Energy and Natural Resources Committee, “,” April 12th, 2007. http://docs.nrdc.org/globalwarming/glo_07041201A.pdf

[17] Assumes production of 84 gallons of liquid fuel per ton of coal, based on the National Coal Council report. Vehicle efficiency is assumed to be 37.1 miles/gallon on liquid fuel and 3.14 miles/kWh on electricity.

[18] Assumes lifecycle greenhouse gas emission from liquid coal of 27.3 lbs/gallon and lifecycle greenhouse gas emissions from an IGCC power plant with CCS of 106 grams/kWh, based on R. Williams et al., paper presented to GHGT-8 Conference, June 2006.

Simply put, liquid coal is highly unlikely to be compatible with long-term climate protection. A recent analysis by Jim Dooley of Battelle National Laboratory shows that liquid coal is not part of an energy system that is consistent with stabilizing greenhouse gas concentrations at or below 450ppm. (see figure 4).[19] Furthermore, using high-carbon fuels for transportation means we would have to do that much more in improving other areas of transportation, such as increased vehicle efficiency and reduced vehicle miles traveled. The Administration's alternative fuels proposal highlights this fact. If half of the alternative fuels mandate proposed by the administration were satisfied with coal-derived liquid fuels then CO_2 emissions would be 175 million tons higher in 2017 than the administration's target. To offset this increase through automobile fuel efficiency standards would have to increase by 8.6 percent per year, rather than the 4 percent per year as suggested by the administration.

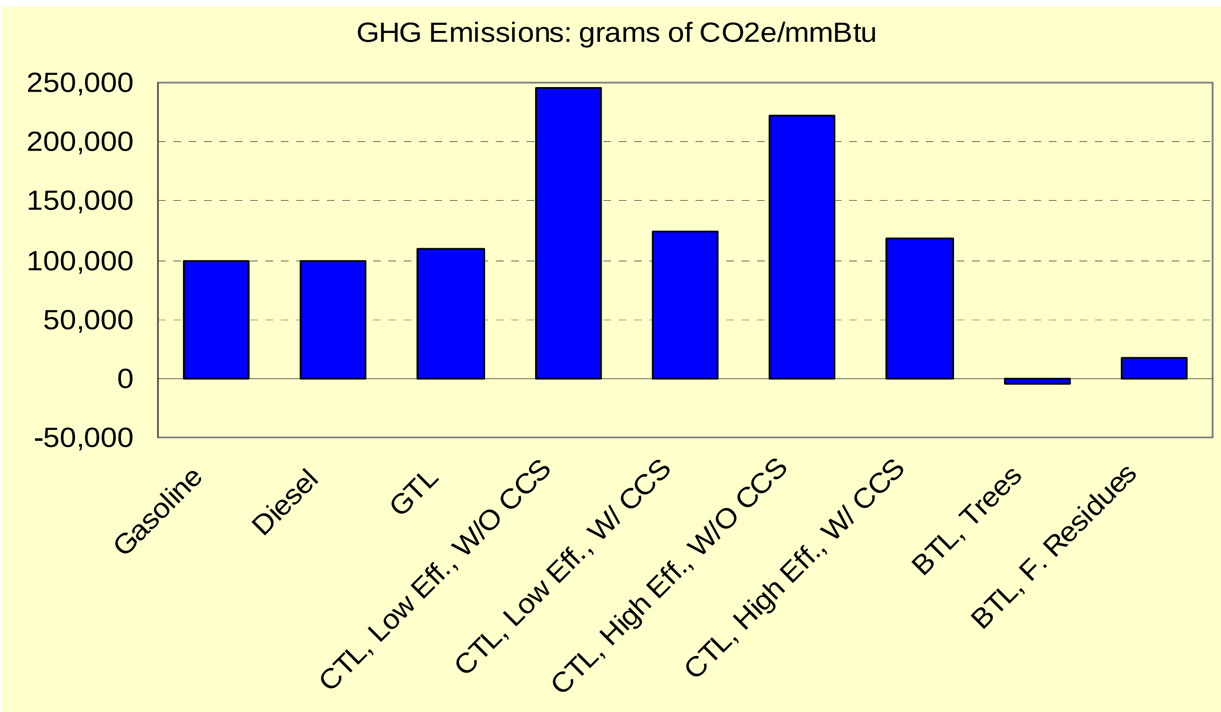

Figure 3. Argonne life-cycle greenhouse gas results of Fischer-Tropsch diesel produced from natural gas, coal and biomass (GTL=gas-to-liquids, CTL=coal-to-liquids, CCS=carbon capture and sequestration, BTL=biomass-to-liquids, F=forest; emissions include CO_2, methane and N20).

[19] Jim Dooley, Robert Dahowski, Marshall Wise, Casie Davidson "Coal-to-Liquids and Advanced Low-Emissions Coal-fired Electricity Generation," presentation at NETL conference, May 9, 2007, PNWD-SA-7804.

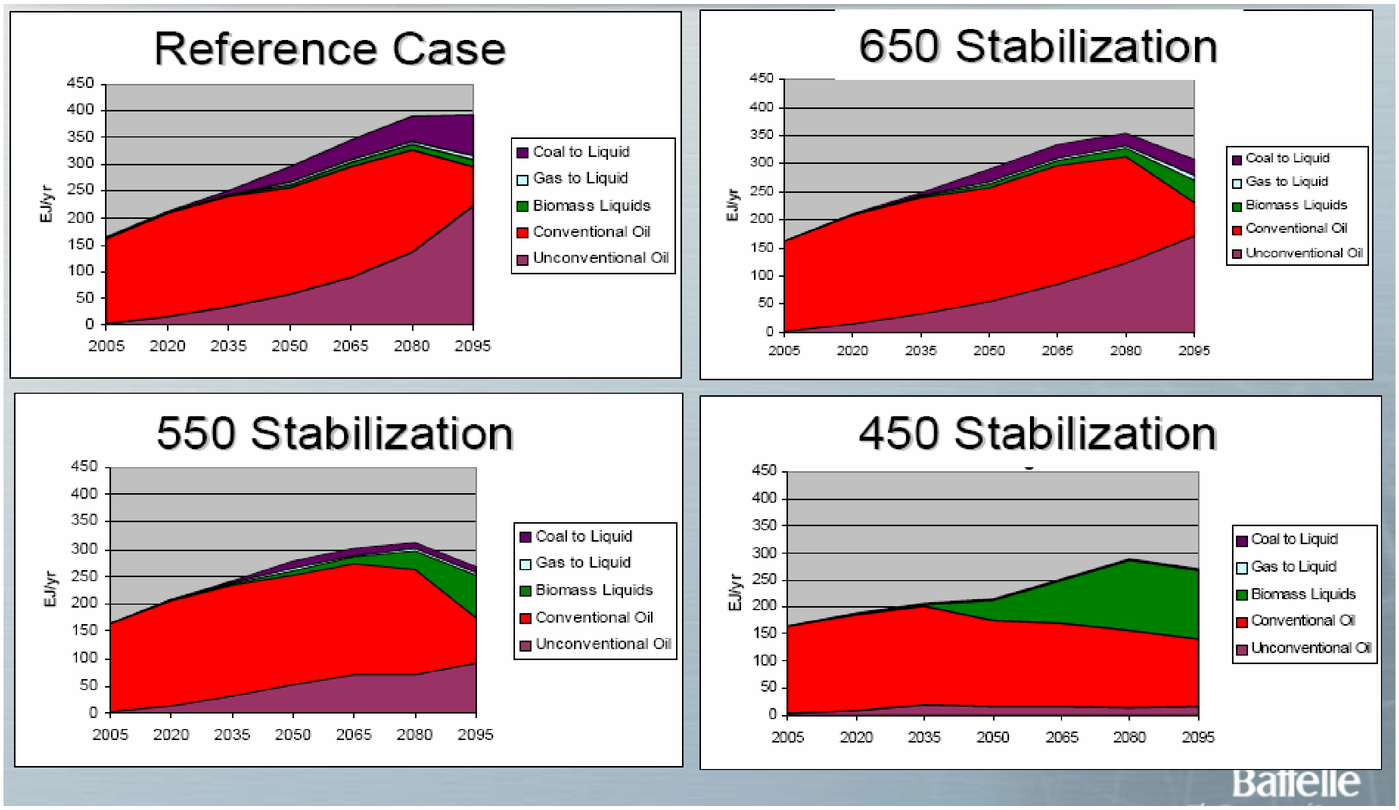

Figure 4. Liquid coal is not compatible with climate protection and the need to stabilize atmospheric concentrations of greenhouse gases at 450ppm (from Dooley et al., Battelle).

With liquid coal proposals proliferating in Congress it is critical to evaluate the environmental ramifications of these proposals. In particular, recently offered before the Senate Energy and Natural Resources committee during their May 2, 2007 energy legislation markup was an amendment co-authored by Senators Thomas and Bunning mandating 21 billion gallons of liquid coal synfuels per year by 2022.

Producing 21 billion gallons of liquid coal synfuels per year would require building up to 40 new medium sized (35,000 barrels/day) liquid coal plants. This in turn would:

- Increase global warming pollution by almost 600 million metric tons CO_2 per year. Even with carbon capture and disposal CO_2 emissions are still higher than conventional fuels, and while cofiring with biomass with carbon capture and disposal can produce diesel fuels with life-cycle emissions below conventional diesel fuels, this technology is still in the development stages.
- Create water shortages in the West by requiring an additional 100 billion gallons of water usage per year, the equivalent of 375 empire state buildings of water per year. One gallon of liquid coal requires five gallons of water to produce. It is expected that many of the forty new coal plants required to produce this fuel would be built in the West where water shortages are already a severe problem.

- Scar the landscape by requiring 250 million additional tons of coal, a 23% increase in coal mining compared to 2006 coal mining production. This increase would have severe impacts on our land, air and water.

While Senators Thomas and Bunning have acknowledged the importance of global warming pollution by requiring that emissions from liquid coal synfuels not exceed those from conventional gasoline we need to be doing much better than that to meet the emission reductions that will be necessary from the transportation sector (see figure 4).

Synthetic Gas

Another area that has received interest is coal gasification to produce synthetic natural gas as a direct method of supplementing our natural gas supply from domestic resources. However, without CO_2 capture and disposal this process results in more than twice as much CO_2 per 1000 cubic feet of natural gas consumed compared to conventional resources.[20] From a global warming perspective this is unacceptable. With capture and disposal the CO_2 emissions can be substantially reduced, but still remain 12 percent higher than natural gas.

In Beulah, North Dakota the Basin Electric owned Dakota Gasification Company's Great Plains Synfuels Plant is a 900MW facility which gasifies coal to produce synthetic "natural" gas. It can produce 150 million cubic feet of synthetic gas per day and 11,000 tons of CO_2 per day. However, it no longer releases all of its CO_2 to the atmosphere, but captures most of it and pipes it 200 miles to an oil field near Weyburn, Saskatchewan. There the CO_2 is pumped underground into an aging oil field to recover more oil. EnCana, operator of this oil field, pays $2.5 million per month for the CO_2. They expect to sequester 20 million tons of CO_2 over the lifetime of this injection project.

A potential use for coal-produced synthetic gas would be to burn it in a gas turbine at another site for electricity generation. This approach would result in substantially higher CO_2 emissions than producing electricity in an integrated system at the coal gasification plant with CO_2 capture at the site (i.e., in an IGCC plant with carbon capture and disposal). Coal produced synthetic natural gas could also be used directly for home heating. As a distributed source of emissions the CO_2 would be prohibitive to capture with known technology.

Before producing synthetic pipeline gas from coal a careful assessment of the full fuel cycle emissions against the baseline and alternatives and the emission reductions that are required from that sector must be carried out before decisions are made to invest in these systems.

Chemical Products

The chemical industry has also been looking carefully at coal gasification technology as a way to replace the natural gas feedstock used in chemical production. The motivator has been the escalating and volatile costs of natural gas in the last few years. A notable example in the U.S. of such a use is the Tennessee Eastman plant, which has been operating for more than 20 years

[20] The National Coal Council, "Coal: America's Energy Future," March 22, 2006. This report actually assumes a less efficient coal to synthetic gas conversion process of 50% leading to three times as much CO_2 per 1000 cubic feet of natural gas consumed compared to conventional resources.

using coal instead of natural gas to make chemicals and industrial feedstocks. If natural gas is replaced by coal gasification as a feedstock for the chemical industry, first and foremost CO_2 capture and disposal must be an integral part of such plants. In this case, the net global warming emissions will change relatively little from this sector compared to the conventional natural gas based process. Steam reforming of natural gas, however, could also potentially capture its emissions too, resulting in even lower emissions. Therefore, before such a transformation occurs with coal as a feedstock, a careful analysis of the entire life cycle emissions needs to be carried out against the baseline and alternatives, along with an assessment of how future emissions reductions from this sector can be most effectively accomplished.

Conventional Air Pollution

Dramatic reductions in power plant emissions of criteria pollutants, toxic compounds, and global warming emissions are essential if coal is to remain a viable energy resource for the 21^{st} Century. Such reductions are achievable in integrated gasification combined cycle (IGCC) systems, which enable cost-effective advanced pollution controls that can yield extremely low criteria pollutant and mercury emission rates and facilitates carbon dioxide capture and geologic disposal. Gasifying coal at high pressure facilitates removal of pollutants that would otherwise be released into the air such that these pollutant emissions are well below those from conventional pulverized coal power plants with post combustion cleanup.

Conventional air emissions from coal-to-liquids plants include sulfur oxides, nitrogen oxides, particulate matter, mercury and other hazardous metals and organics. While it appears that technologies exist to achieve high levels of control for all or most of these pollutants, the operating experience of coal-to-liquids plants in South Africa demonstrates that coal-to-liquids plants are not inherently "clean." If such plants are to operate with minimum emissions of conventional pollutants, performance standards will need to be written—standards that do not exist today in the U.S. as far as we are aware.

In addition, the various federal emission cap programs now in force would apply to few, if any, coal-to-liquids plants.[21]

Thus, we cannot say today that coal-to-liquids plants will be required to meet stringent emission performance standards adequate to prevent either significant localized impacts or regional emissions impacts.

Mining, Processing and Transporting Coal

The impacts of mining, processing, and transporting 1.1 billion tons of coal today on health, landscapes, and water are large. To understand the implications of continuing our current level of as well as expanding coal production, it is important to have a detailed understanding of the impacts from today's level of coal production. It is clear that we must find more effective ways

[21] The sulfur and nitrogen caps in EPA's "Clean Air Interstate Rule" ("CAIR") may cover emissions from coal-to-liquids plants built in the eastern states covered by the rule but would not apply to plants built in the western states. Neither the national "acid rain" caps nor EPA's mercury rule would apply to coal-to-liquids plants.

to reduce the impacts of mining, processing and transporting coal before we follow a path that would result in even larger amounts of coal production and transportation.

The Path Forward: An Action Plan to Reduce U.S. Global Warming Pollution

The United Nations Framework Convention on Climate Change (UNFCCC) establishes the objective of preventing “dangerous anthropogenic interference with the climate system.” While a “non-dangerous” concentration level has not been defined under the UNFCCC and is not a purely scientific concept, the European Union has set a goal of avoiding an increase of more than 2 degrees Celsius from pre-industrial levels in order to avoid the most dangerous changes to climate. We believe this is a sound goal and U.S. emission reduction policies should have a similar objective.

To prevent dangerous global warming while allowing for a reasonable transition in developing nations, the U.S. needs to start to cut global warming pollution as soon as possible and keep steadily reducing emissions over time. Specifically, U.S. emissions in 2020 should be at least 15-20% below current levels.[22] By mid-century, U.S. emissions need to be reduced on the order of 80 percent. A variety of existing technologies can be deployed to achieve these goals – and, in addition, the right policies will spur investment and innovation to create new fuels and technologies. By solving this smartly, we can create jobs and improve our standard of living even as we tackle this dangerous problem.

A valuable framework in which to visualize a long-term emissions reductions pathway is through the “wedges” analysis pioneered by Professors Robert Socolow and Steve Pacala at Princeton University.[23] NRDC has modified their study, which analyzed global emission reduction pathways, to consider potential U.S. emission reduction pathways.

The structure of our analysis is a detailed extension of the Socolow-Pacala concept of emission reduction “stabilization wedges” – decreases in emissions in measurable increments from a business as usual projection attributable to specific technologies. These wedge increments can then be summed up in various ways (as “paths”) to the desired emission reduction total (See figure 5).

[22] 15% below 2005 levels is equivalent to 1990 levels, and is also equivalent to approximately 35% below business-as-usual levels for 2020. The Sander-Boxer Global Warming Pollution Reduction Act, S. 309, meets these emission reduction goals.

[23] S. Pacala and R. Socolow, “Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies,” *Science*, v. 305, p. 968 (2004).

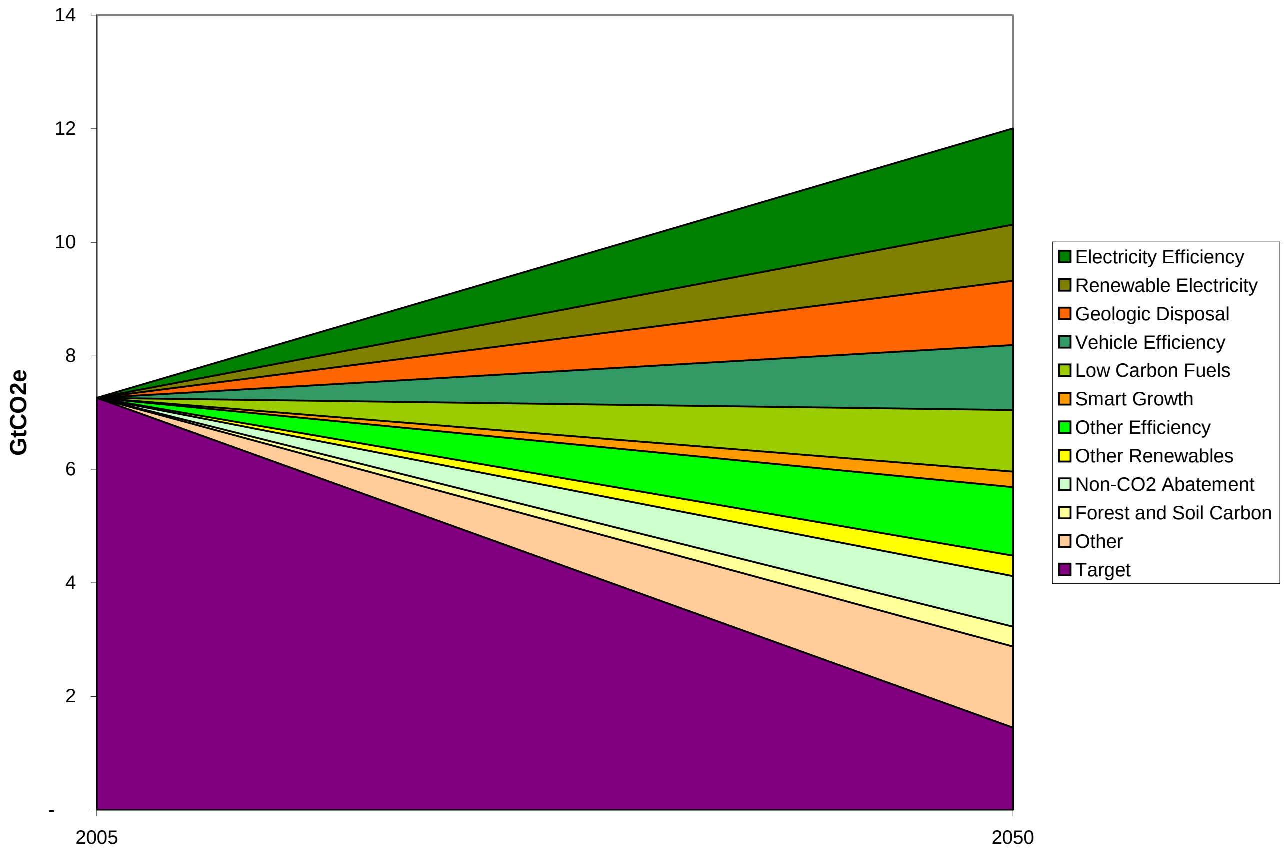

Figure 5. NRDC technology wedges to reduce US global warming emissions by 80 percent in 2050.

NRDC used a spreadsheet model developed by Kuuskraa et al. to examine U.S. emissions scenarios out to 2050.[24] This analysis segregates the wedges into four sectors: electricity, transportation, stationary end-use fuel combustion, and non-CO_2 gases. This segregation helps to avoid double counting different measure so as to develop self-consistent scenarios for the U.S. energy system (for example, taking credit for reducing the demand of electricity from appliances while at the same time reducing emissions at power plants that supply the power).

Their spreadsheet model is used here to construct an emissions scenario consistent with the U.S. carbon budget that meets an 80 percent reduction below 1990 levels by 2050 using technologies that are likely to be available and affordable during that timeframe. In this scenario the largest reductions are obtained from energy efficiency improvements in electrical end uses, non-electric stationary end uses, and motor vehicles. Additional reductions come from renewable fuels and electricity and carbon capture and disposal at coal-fired power plants and other high-concentration industrial CO_2 vents. The elements of this scenario are briefly outlined below.

[24] V. Kuuskraa, P. Dipietro, S. Klara, S. Forbes, “Future US Greenhouse Gas Emission Reduction Scenarios Consistent with Atmospheric Stabilization Concentrations,” GHGT-7, .506 (2004).

Electricity (first 3 wedges)

The U.S. gets just over half of its electricity from coal, about a fifth from nuclear power, and the balance mainly from natural gas and renewable energy sources. Natural gas is considered limited by supply and price constraints and hydroelectric power, the dominant renewable resource, is limited by the fact that the best available sites have already been dammed. In addition, the expansion of nuclear power continues to hit a variety of impediments. Therefore, for the electricity sector we assume:

- High levels of efficiency in end-use consumption and supply production and distribution to meet growing energy needs, thereby reducing the need to construct new baseload power plants while expanding renewable energy sources.
    - 40% of electricity (1600 Billion kWh) is generated from non-hydro renewables: Wind, geothermal, solar thermal, PV, and biomass (coproduced with biofuels).
- Building some coal plants with geologic carbon dioxide disposal to replace existing coal-fired plants as they reach retirement age.
    - 16% of electricity (660 Billion kWh) is generated from coal with carbon capture and geologic disposal.
- Nuclear would remain roughly the same proportion of electricity that it does currently.

Transportation (second 3 wedges)

Controlling emission from the burning of oil by the transportation sector requires a combination of reducing the number of miles people drive in their cars and other vehicles (Vehicle Miles Traveled or VMT), the efficiency of those vehicles in consuming as little fuel as possible, and the using low-carbon fuels. The low-carbon fuels wedge assumes that there will be adequate environmental protections for the production of these fuels, while at the same time promoting maximum efficiency and electrification of the vehicle fleet.

The scenario analyzed assumes:

- New vehicle fuel efficiency triples by 2050 and VMT is reduced by 20% through smart growth policies.
    - New vehicle fuel efficiency is 3 times current level by 2050. On road fleet average 55 mpg.
- Of the remaining fuel demand, 45% is satisfied with electricity used in plug-in hybrid vehicles and 40% is satisfied by biofuels, such that biofuels displace 36 billion gallons of gasoline equivalent in 2050. [25]

Biological Sequestration and Other

There is a wedge that allows for a small amount of carbon dioxide to be absorbed by biological sources. While we do not support an over reliance on biological sequestration, because of a lack of reliability of such a mechanism, some biological sequestration is likely to occur. The other efficiency wedge incorporates efficiency improvements made in direct fuel demand by stationary sources and the other renewables wedge comes from renewables supplying 30 percent of other

[25] Assuming that about half of corn stover can be collected for energy use (200 million tons of waste material altogether), 22 million acres would have to be dedicated to energy crop production.

stationary source energy demand. Finally, there are other unidentified reduction opportunities, including international emissions trading.

This analysis clearly shows how we can meet the required emission reduction targets through the deployment of a wide variety of low-carbon technologies in multiple sectors of the economy over the next four decades. It is also clear that liquid coal is not compatible with this visions and would require the expansion of other low-carbon wedges to cover its emissions profile. Coal gasification for electricity production is consistent and integrated into the analysis. Further analysis is needed to assess whether the use of coal gasification for other products such as synthetic natural gas or chemicals would be at odds with the necessary reduction pathway.

Conclusion

The impacts that a large coal gasification program could have on global warming pollution, conventional air pollution and environmental damage resulting from the mining, processing and transportation of the coal are substantial. Before deciding whether to invest scores, perhaps hundreds of billions of dollars in deploying this technology, we must have a program to manage our global warming pollution and other coal related impacts. Otherwise we will not be developing and deploying an optimal energy system.

One of the primary motivators for pushing coal gasification technologies has been to reduce natural gas prices. Fortunately, the U.S. can have a robust and effective program to reduce natural gas demand, and therefore prices, without rushing to embrace coal gasification technologies. A combination of efficiency and renewables can reduce our natural gas demand more quickly and more cleanly.

The other major motivator for the push to use coal gasification is to produce liquid fuels to reduce our oil dependence. The U.S. can have a robust and effective program to reduce oil dependence without rushing into an embrace of liquid coal technologies. A combination of more efficient cars, trucks and planes, biofuels, and "smart growth" transportation options outlined above and in the report "Securing America," produced by NRDC and the Institute for the Analysis of Global Security, which shows how to cut oil dependence by more than 3 million barrels a day in 10 years, and achieve cuts of more than 11 million barrels a day by 2025.

To reduce our dependence on natural gas and oil we should follow a simple rule: start with the measures that will produce the quickest, cleanest and least expensive reductions in natural gas and oil use; measures that will put us on track to achieve the reductions in global warming emissions we need to protect the climate. If we are thoughtful about the actions we take, our country can pursue an energy path that enhances our security, our economy, and our environment.

With current coal and oil consumption trends, we are headed for a doubling of CO_2 concentrations by mid-century if we don't redirect energy investments away from carbon based fuels and toward new climate friendly energy technologies. We have to accelerate the progress underway and adopt policies in the next few years to turn the corner on our global warming emissions, if we are to avoid locking ourselves and future generations into a dangerously disrupted climate. Scientists are very concerned that we are very near this threshold now. Most say we must keep atmosphere concentrations of CO_2 below 450 parts per million, which would keep total warming below 2 degrees Celsius (3.6 degrees Fahrenheit). Beyond this point we risk severe impacts, including the irreversible collapse of the Greenland Ice Sheet and dramatic sea level rise. With CO_2 concentrations now rising at a rate of 1.5 to 2 parts per million per year, we will pass the 450ppm threshold within two or three decades unless we change course soon.

In the United States, a national program to limit carbon dioxide emissions must be enacted soon to create the market incentives necessary to shift investment into the least-polluting energy technologies on the scale and timetable that is needed. There is growing agreement between business and policy experts that quantifiable and enforceable limits on global warming emissions are needed and inevitable.[26] To ensure the most cost-effective reductions are made, these limits can then be allocated to major pollution sources and traded between companies, as is currently the practice with sulfur emissions that cause acid rain. Further complimentary and targeted energy efficiency and renewable energy policies are critical to achieving CO_2 limits at the lowest possible cost, but they are no substitute for explicit caps on emissions.

A coal integrated gasification combined cycle (IGCC) power plant with carbon capture and disposal can also be part of a sustainable path that reduces both natural gas demand and global warming emissions in the electricity sector. Methods to capture CO_2 from coal gasification plants are commercially demonstrated, as is the injection of CO_2 into geologic formations for disposal[27]. On the other hand, coal gasification to produce a significant amount of liquids for transportation fuel would not be compatible with the need to develop a low-CO_2 emitting transportation sector. Finally, gasifying coal to produce synthetic pipeline gas or chemical products needs a careful assessment of the full life cycle emission implications and the emission reductions that are required from those sectors before decisions are made to invest in these practices.

[26] US Climate Action Partnership, http://www.us-cap.org.
[27] David Hawkins, Testimony on S. 731 and S. 962: Carbon Capture and Sequestration before the Senate Energy and Natural Resources Committee, April 16th, 2007. http://docs.nrdc.org/globalwarming/glo_07041601A.pdf

Appendix 1. Basis for Figure 1.

Figure 1 compares the well-to-wheels (or full fuel cycle) emissions from alternative transportation fuels in pounds of CO_2-equivalent per gallon of gasoline energy content equivalent. The basis for each bar is described briefly below:

Liquid Coal (no CCD): Fischer-Tropsch fuel produced from coal without carbon dioxide capture and disposal (CCD). Based on a stand-alone plant (R. Williams, Princeton University).

Tar Sands: Gasoline made from synthetic petroleum produced from Canadian tar sands. (Based on Oil Sands Fever, Pembina Institute, November 2005)

Ethanol (Corn, Coal): Ethanol produced from corn using coal for process energy at the ethanol plant. (Based GREET 1.7 beta as modified by Turner et al.)

Liquid Coal (CCD): Fischer-Tropsch fuel produced from coal with carbon dioxide capture and disposal (CCD) from the production plant and assuming a stand-alone plant. (R. Williams, Princeton University).

Gasoline: Conventional gasoline, including upstream emissions. (Based on GREET 1.7 beta)

Ethanol (Corn, Coal, CHP): Ethanol produced from corn using coal for process energy in a combined heat and power system at a new dry mill ethanol plant. (Based GREET 1.7 beta as modified by Turner et al.)

Ethanol (Corn Average): Estimate of the national average emissions rate from the current mix of fuel used for ethanol production and the current mix of dry and wet mills. (Based on GREET 1.7 beta as presented in Wang et al., "Life-Cycle Energy and Greenhouse Gas Emissions Impacts of Different Corn Ethanol Plant Types," presentation to 16th International Symposium on Alcohol Fuels, November 2006.)

Ethanol (Corn, NG): Ethanol produced from corn using natural gas for process energy at a dry mill ethanol plant. (Based GREET 1.7 beta as modified by Turner et al.)

Ethanol (Corn, NG, CHP): Ethanol produced from corn using natural gas for process energy in a combined heat and power system at a new dry mill ethanol plant. (Based on GREET 1.7 beta as presented in Wang et al., "Life-Cycle Energy and Greenhouse Gas Emissions Impacts of Different Corn Ethanol Plant Types," presentation to 16th International Symposium on Alcohol Fuels, November 2006.)

Ethanol (Wet Grains): Same as “Corn, NG,” except that plant sells wet distiller grains as a coproduct, saving the energy of drying the grains. (Based GREET 1.7 beta as modified by Turner et al.)

Biodiesel: Biodiesel derived from soy oil through fatty-acid methol-esterfication estimate including upstream emissions. (Based on GREET 1.7 beta)

Ethanol (Corn, Biomass): Same as Corn No Till, except that biomass is used for process energy. (Based GREET 1.7 beta as modified by Turner et al.)

Ethanol (Corn, Biomass, CCD): Ethanol produced from corn using biomass for process energy at a dry mill ethanol plant with capture and disposal of the CO_2 produced from the fermentation process. Corn is grown with no-till practices and plant sells wet grains. (Based GREET 1.7 beta as modified by Turner et al. subtracting fermentation CO_2 of 6.6 pounds of CO_2 per gallon of ethanol per http://www.kgs.ku.edu/PRS/Poster/2002/2002-6/P2-05.html.)

Ethanol (Switchgrass): Ethanol produced from the cellulose in switchgrass using the lignin for process energy. (Based GREET 1.7 beta as modified by Turner et al.)

Ethanol (Switchgrass, CCD): Ethanol produced from the cellulose in switchgrass using the lignin for process energy with capture and disposal of the CO_2 produced from the fermentation process. (Based GREET 1.7 beta as modified by Turner et al. subtracting fermentation CO_2 of 6.6 pounds of CO_2 per gallon of ethanol per http://www.kgs.ku.edu/PRS/Poster/2002/2002-6/P2-05.html.)

Sources:

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model, GREET 1, Version 1.7, developed by the UChicago Argonne, LLC as Operator of Argonne National Laboratory under Contract No. DE-AC02-06CH11357 with the Department of Energy (DOE).

Turner et al., “Creating Markets for Green Biofuels, Measuring and Improving Environmental Performance,” UC Berkeley Transportation Sustainability Research Center, publication pending.