Statement of
Richard D. Boardman, Ph.D.
Energy and Environmental Science and Technology Division
Idaho National Laboratory

before the

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Mr. Chairman and Members of the Subcommittee, I am honored to be invited to contribute to the discussion about the benefits and challenges of converting coal into liquid transportation fuels by gasification followed by catalytic transformation of the resulting syngas into synthetic diesel and other petroleum-like substitutes. This method of converting coal into synthetic fuels is often referred to as the Fischer-Tropsch process.

INTRODUCTION & BACKGROUND

By way of introduction, I am a senior consulting research and development lead for the Idaho National Laboratory (INL) where I have worked for the past 17 years. My project assignments have covered a spectrum of fundamental and applied research projects in nuclear fuel reprocessing, radioactive waste cleanup, pollutant emissions control, clean coal technology development, and gasification-based technology assessment, development, and process design. Over the past six years, my research efforts have primarily focused on integrated gasification and combined cycle power generation, and process modeling of Fischer-Tropsch synthetic fuels plants. I am currently working with other scientists and engineers at the INL, regional universities, and private companies to develop gasification technology and associated process understanding to efficiently convert hydrogen deficient materials (i.e., coal, coke, resid, biomass, and other opportunity fuels) into clean fuels, substitute natural gas, electrical power, and chemicals such as ammonia. I am also the Lead for the INL Energy Security Initiative, aimed at increasing the Laboratory's capabilities and missions in developing **CLEAN**, **SECURE**, **ECONOMICAL**, and **SUSTAINABLE** energy solutions including the integration of the next generation of nuclear reactors to assist in the extraction and conversion of oil shale, oil sands, and coal to liquids.

I have served as an adjunct professor at the University of Idaho and Brigham Young University, providing course instruction and student advise in combustion processes, air pollutant control, and nuclear chemical engineering. I support Wyoming State government's interest to better understand clean coal conversions options, as well as private industry project development through DOE approved Work for Others and Cooperative Research and Development Agreements with the INL. I am an officer for the Idaho Academy of Sciences (IAS), just having completed a customary one-year term as the IAS President. I organized the IAS 49th Annual Conference held this past April with the theme <u>Energy for the Future: Environmental and Ecological Considerations</u>.

I provide this personal background to establish a perspective for the views that follow. While all of us here today and others across the nation will claim an interest in protecting our environment; most will also concur that we have come to appreciate a sustained quality of life living at a comfortable temperature in modest dwellings with adequate mobility to reach our work location and other destinations in a safe, orderly, and efficient manner. We also have come to depend on an uninterrupted and diverse supply of fresh food and basic consumer commodities. The fact is that the basis for our present quality of life is realized from the development of at least three indispensable energy-related commodities: First) ammonia based fertilizers; Second) electrical power; and Third) transportation fuels, which today is primarily derived form petroleum-derived gasoline and diesel. Global demographics and the quality of life are directly correlated to these three commodities, including, but not limited to mass production and distribution of food, operation of machinery that enables mass production, and transit of these products to consumers. Remove any one of these commodities, and life as it is appreciated today, both here and in developing nations will be dramatically halted. Add all of these commodities to stable developing nations, and the standard of living will eventually approach that of the United States. Thus, we should all be concerned about the potential escalation of environmental and political consequences of increased energy demand and production around the globe.

All of us present here today are concerned with the compelling statistics regarding the imminent peaking of oil production (estimated by most to occur within 5-10 years). Adding to this concern, there is a simultaneous increasing demand for energy and transportation fuels by China, India, and many other nations. Projected population in India and China alone may increase from around 2.3 billion persons (estimated population in 2003) to over 2.8 billion in 2015. The per capita oil consumption in these two nations in 2003 was only 0.74 and 1.4 barrels per year, respectively. In comparison, the per capita consumption in the United States was 25.6 barrels per year, while it was 19.5, 15.2, and 5.3 bbl/yr in Canada, Japan, and Mexico, respectively. It is possible then, and many credible sources predict, that the global energy demand through 2050 will exceed ten times the equivalent oil reserves of the concentrated oil triangle in the Middle East, where roughly 60 percent of the remaining oil reserves are located. These combined facts underscore two potentially significant terrestrial events that are relevant to national security and global climate detriment. Clearly, I am referring to the increasing scarcity of oil and an escalation of green house gases attributed to unmitigated release of carbon dioxide. These two problems should not overshadow the ongoing loss of industry in the United States, including fertilizer, glass, steel, and chemical production to foreign nations, and the impact on national security and economic prosperity when U.S. manufacturing and production further decline.

With this background in mind, I turn your attention to the purpose of my testimony today. It is my intention to address the importance of providing immediate incentives to advance coal and biomass conversion to liquid transportation fuels in an environmentally acceptable manner. I will address solutions that are being proposed and developed by the Idaho National Laboratory and industrial CRADA partners to reduce both the projected life cycle release of greenhouse causing gases and the potential demand on water resources. This testimony will hopefully convey an understanding that the technology basis and environmental solutions for CTL plants are equally applicable to production of synthetic natural gas, ammonia, chemicals, hydrogen, and electrical power from coal and biomass resources. A holistic and balanced approach to resource utilization to achieve the optimum use of our natural resources will therefore be suggested. This discussion will lead recommendations on the role of Federal research in achieving these goals.

GREENHOUSE GAS EMISSIONS PROJECTIONS

I will begin my technical remarks by sharing the results of a recent technical study completed by the Idaho National Laboratory under a Cooperative Research and Development Agreement with

Baard Energy, through its project company Ohio River Clean Fuels, L.L.C. (ORCF), is developing a coal gasification Fischer-Tropsch synthetic fuels plant in Wellsville, Ohio. The ORCF project is a nominal 50,000 barrel per day plant using a dry-feed, entrained-flow gasification process. A process model for the project has been developed by the Idaho National Laboratory to assist Baard Energy with design and permitting activities. The model has been used to determine operating conditions to capture and sequester byproduct carbon dioxide and to study the benefits of blending biomass with coal to reduce greenhouse gas (GHG) emissions. A life cycle GHG emissions assessment based on the model results for the ORCF plant, and apportioned to the product mix of liquefied petroleum gas, naphtha, diesel fuel, and power, indicates that a 30% reduction in GHG emissions compared to life-cycle GHG emissions for transportation fuels produced from Arabian Crude for the synthetic diesel fuel is achievable when biomass fuel is blended with the coal feeding the process and when concentrated CO_2 is separated from the syngas feed to the Fischer-Tropsch reactors and used or sequestered. When credit is also given for the sale of surplus electrical power generated by the plant (compared to the GHG emissions of the average electrical U.S. power mix), the ORCF plant will further reduce GHG emissions approaching 50% of the emissions from ultra-low sulfur diesels derived from crude oil. Additionally, other plant products, specifically the synthetic naphtha liquid produced by the Fischer-Tropsch process, which may be used to produce additional transportation fuels or chemical feedstock such as ethylene, can also reduce GHG emissions compared to similar petroleum-derived products.

The results of the Baard Energy study are being presented in eight days at the 24^{th} Annual International Pittsburgh Coal Conference being held on the doormat of the Sasol Secunda

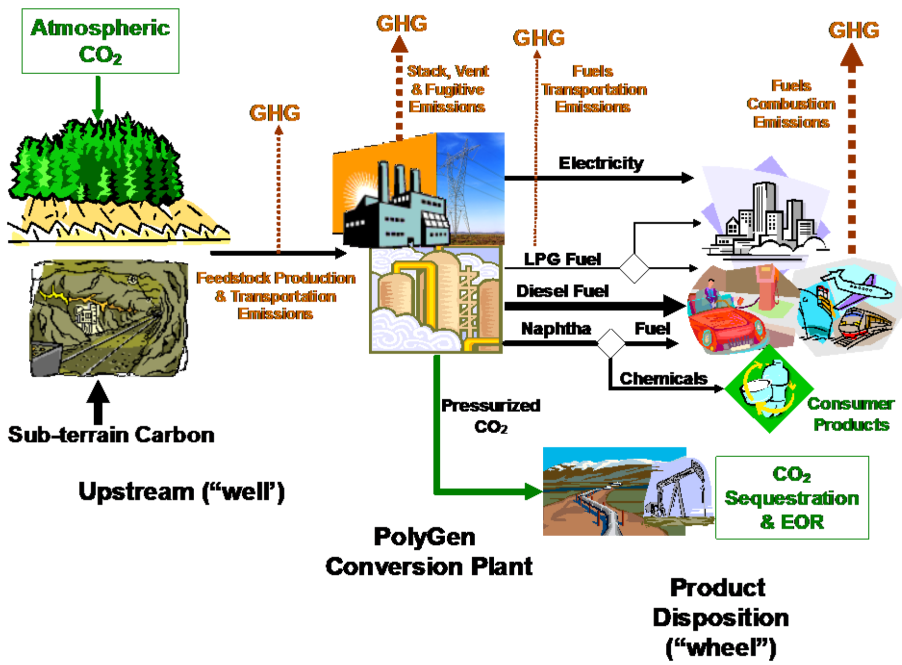
CTL complex in Johannesburg, South Africa. While some key findings of the INL-Baard study are provided here today, I encourage you to review this technical paper after it has been released with the Conference Proceedings.

The table below summarizes the life-cycle emissions of greenhouse gases for CTL transportation fuels on the basis of the mileage attained by a standard U.S. utility sports vehicle achieving 24.4 miles per gallon of fuel.

Case or Reference Data	**GHG emissions* (grams equivalent CO_2 per mile driven)**
Arabian Crude Fuel Product	~ 510
NETL CTL Plant Estimation	~ 938
INL-Baard Case 1. 100 wt.% Bit. Coal, no carbon capture	1050
INL-Baard Case 2. 100% Coal with CO_2 capture and sequestration	610
INL-Baard Case 3. 70 wt.% Bit. Coal, 30 wt.% biomass	801
INL-Baard Case 4. 70 wt.% Bit. Coal, 30 wt.% biomass with CO_2 Sequestration	358 (30% reduction compared to crude)
INL-Baard Case 4 with credit for carbon emissions trading for surplus electrical power sold to the utilities market	285 (46% reduction compared to crude)

*GHG emissions include CH_4 and N_2O converted to equivalent CO_2 concentrations

The INL-Baard study takes into account all green house gas emissions associated with fuels and feedstock input production and transportation to the CTL plant. The study includes cases where woody biomass produced in the United States is blended with the coal in the same manner that already has been proven technically feasible in Europe at the Puertollano, Spain and the Buggenum, Holland integrated gasification, combined cycle (IGCC) power plants. The study accounts for all greenhouse gas emissions associated with conversion of the fuels into syngas and subsequent cleanup and conversion of the syngas into liquid fuels using the Fischer-Tropsch reaction process and associated product upgrading and refining. Next, the study takes into account the greenhouse gas emissions associated with delivery of the fuel to consumers and finally the consumption of the fuel in a standard transportation vehicle. This study emulates the work performed by the DOE National Energy Technology Laboratory (NETL), and investigations by other federal, university and private organizations to assess "well-to-wheel" greenhouse gas emissions associated with various transportation fuels. While such studies invoke specific assumptions, it should be noted that the majority of the greenhouse gas emissions are attributed to the CTL plant and end-state combustion as illustrated in the Figure that follows.



This INL-Baard life-cycle greenhouse gas study corroborates the findings of other organizations, but varies to the extent that the design of the CTL plant differs from the other studies. It is important to understand there can be significant variation in the CTL plant emissions depending on unit operation choices, the options selected for the integration of heat and material recycle, and the decision to co-produce electricity or other chemical products. I herby state without reservation that greenhouse gas emissions for coal-derived transportation fuels can be reduced by at least 20% relative to petroleum fuels. The INL-Baard study shows that a 30% reduction may be possible before credit is taken for the clean power produced by the plant. When apportioned credit is taken for the green power co-produced by the plant, the GHG emissions reduction is estimate to be 46% as previously indicated by Baard Energy in a press conference just last May. It is also important to state that these reduced levels of GHG emissions can be accomplished by using existing technologies to concentrate and remove the CO_2 produced by the process, and by blending biomass with the coal feedstock.

Some important observations of the study include the following:

1. Almost 50% of the carbon fed to the CTL plant can be readily captured and sequestered in an appropriate geological sink or it may be used for enhanced oil recovery.
2. Approximately 30% of the carbon is incorporated in the liquid and gaseous fuels produced by the plant.
3. Approximately 15% of the carbon is converted to electrical power that is used for the auxiliary load requirements in the plant while also producing much needed clean electrical power.
4. Sequestration of the bulk CO_2 produced and process efficiency improvements can easily reduce life cycle GHG emissions from CTL transportation fuels to a level comparable to fuels derived from crude oil.
5. Use of 30% biomass by weight, achieves an apportioned reduction percentage of approximately 20-25%, depending on the choice of biomass utilized and the relative carbon content and moisture levels in the biomass.
6. The surplus electrical power produced by a CTL plant is neutral with respect to GHG emissions when 30 weight percent biomass is used in combination with CO_2 sequestration (please refer to the Pittsburgh International Coal Conference paper for a detailed explanation).

In addition to these conclusions, other environmental benefits of the combination of coal and biomass conversion to synthetic fuels using the gasification / Fischer-Tropsch process include significantly reduced emissions of sulfur and other acid rain and ozone pollutant precursors and complete control of mercury and other toxic metal emissions. Additionally, it can be shown that this manner of converting biomass to liquid fuels, specifically woody biomass as well as most herbaceous materials, is a much more efficient method of converting and utilizing the chemical potential of biomass. The GHG emissions associated with indirect conversion of biomass to liquid fuels are significantly less than ethanol fuels derived from the popular fermentation process.

Auto manufacturers in Europe and Japan are now producing hybrid cars that will operate on diesel fuel and will attain higher fuel mileage than their gasoline-electric driven counterparts. Therefore, it is not difficult to conclude that diesel fuels produced in the manner outlined in the INL-Baard study will further reduce greenhouse gases emitted from a hybrid vehicle. In other words, the greenhouse gas emissions are mainly due to the production of the fuels, and are not a strong function of type of fuel used in the hybrid vehicle.

FEASIBILITY OF GASIFYING BIOMASS WITH COAL

Regarding the technical feasibility of incorporating biomass with the coal feed in a coal-to-liquids plant, coal gasification plants in Europe have demonstrated the viability of operating commercial, high-pressure, entrained-flow gasifiers with blends of biomass for sustained periods of operation. While the Baard ORCF project is based on gasifier technology that has successfully operated on significant biomass and coal blends, there are other options that can be used to incorporate biomass gasification into a CTL plant. One alternative is to independently inject the biomass into the gasifer while simultaneously feeding coal through a separate nozzle. A second option would be to locate a set of gasifiers designed specifically to gasify biomass along with the battery of conventional entrained-flow gasifiers used for pulverized coal. Both high-pressure fluidized-bed and fixed-bed biomass gasifiers are commercially proven and available. This option opens the possibility of using the high temperature of an entrained-flow coal gasifiers to destroy tars and oils produced at lower operating temperatures in the fluid-bed or fixed-bed biomass gasifiers.

An important technical point to make is that biomass by itself can be difficult to gasify due to its high moisture content and other physical and chemical properties. Biomass gasifiers inherently produce tars and oils that are troublesome to convert into syngas in conventional biomass gasifiers. Another problem can be the low melting point of the ash which can be difficult to manage. Hence, significant attention continues to be directed to developing efficient and reliable biomass gasifiers. However, when the biomass is blended with coal and gasified in a high temperature slagging gasifier, the issue of tar formation is eliminated. The slag produced by the biomass is readily incorporated into the higher mass of slag produced by the coal. These facts underscore the benefits of gasifying biomass with coal. It is technical the best method of converting the biomass to syngas and subsequently to synthetic fuels. Additional arguments in favor of co-gasifying biomass with coal are beyond the scope of this testimony, but can be provided by any expert in gasification and thermal conversion processes.

Biomass gasification should not be considered a barrier to current project planning that is aimed at reducing greenhouse gas emissions and other environmental impacts. However, commercialization and testing of proven and emerging biomass gasifiers, in connection with testing by DOE and industry of dry feed pumps and advance syngas cleanup technology should continue. Improvement of biomass feedstock collection, preparation, and delivery technology and infrastructure should also be supported. This work will expand the possible uses of a wider variety of biomass, and will increase our current understanding of the benefits and potential impacts of biomass gasification on refractory life and syngas cleanup requirements, for example. In conclusion, the feasibility of using biomass with coal can be resolved with engineering, ingenuity, and the will to do so.

The fact that biomass itself can be converted to liquid fuels begs an answer to the supposition that the U.S. need not develop its coal resources to produce liquid transportation fuels. The short explanation is that resource availability and economics do not support this assumption. In order to match the current U.S. consumption of over 20 million barrels of oil per day, two-thirds of which is converted to transportation fuels, a formidable amount of biomass would be required. However, a ratio of 30 % biomass and 70 % coal for synthetic fuels is much more plausible. For additional information, I refer you to the 2005 "Hirsch Report" that discusses peaking of world oil production and its impacts and mitigation alternatives.[1]

The INL-Baard study of a notional 50,000 barrels per day synthetic liquids plant would use approximately 8,000 to 9,000 tons per day of woody biomass at 15% moisture content (harvested wood typically contains about 30-40 % moisture). This material will need to be collected, dried, and ground to specifications meeting the gasifier feed system

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[1] Robert L. Hirsch, et al., Peaking of World Oil Production: Impacts, Mitigation & Risk Management, February 2005, available at: http://www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf

requirements. I cite with permission an example of a U.S. project currently under construction near Selma, Alabama that will produce dry wood pellets containing about 7% moisture. This project, referred to as the Dixie Pellet project, will use biomass gasifiers to produce hot gas and substitute natural gas to produce pellets with minimum use of fossil-based energy. The exception will be the electricity used in the plant which will be purchased from a local utility provider. This plant, when operated at capacity, will produce upwards of 1500 tons/day of dry wood pellets that could be readily shipped to a coal-to-liquids project. Hence, indications are that 5 to 6 comparable plants will support the biomass required for one 50,000 barrels per day CTL plant using 30 wt.% biomass with 70 wt.% coal. Whether the CTL plants purchase biomass collected and assembled by plants such as the Dixie Pellet Plant, or whether they implement in-line feed stock preparation is a matter of plant design choice and will depend on the region where the plant is located and the choices of biomass available. Biomass derived from switch grass, animal waste, and woody sources can all be gasified with an appropriate choice of gasification technology.

Obviously, it will not be economically viable for all plants, especially plants located in the high deserts of the upper Rocky Mountain States, to collect or transport biomass from high growth regions of the United States. Some have suggested that the overgrowth of western forests would be a reasonable source of biomass for western plants. It is likely that logistics, economics, and environmental impacts of collecting dead or diseased timber for synthetic fuels production will rule out using this potential source of biomass for these synthetic fuels projects. However projects in western states (as well as other states), may take advantage of any of the following recommendations.

1. Begin with a plant design that maximizes the concentration, separation, and capture of CO_2. Approximately 50% carbon capture is readily attainable.
2. Implement energy saving technology, including, but not limited to heat recovery cycles that can utilize the low grade and intermediate grade steam that is produced by the Fischer-Tropsh reactors and integrated unit operations.
3. Consider Co-locating the CTL plant with other renewable energy providers such as wind power turbines to offset the GHG emissions resulting from the plant. In this manner, higher ratios of product recycle would be incorporated

into the plant while using a significant portion of "green" power for the plant auxiliary loads.

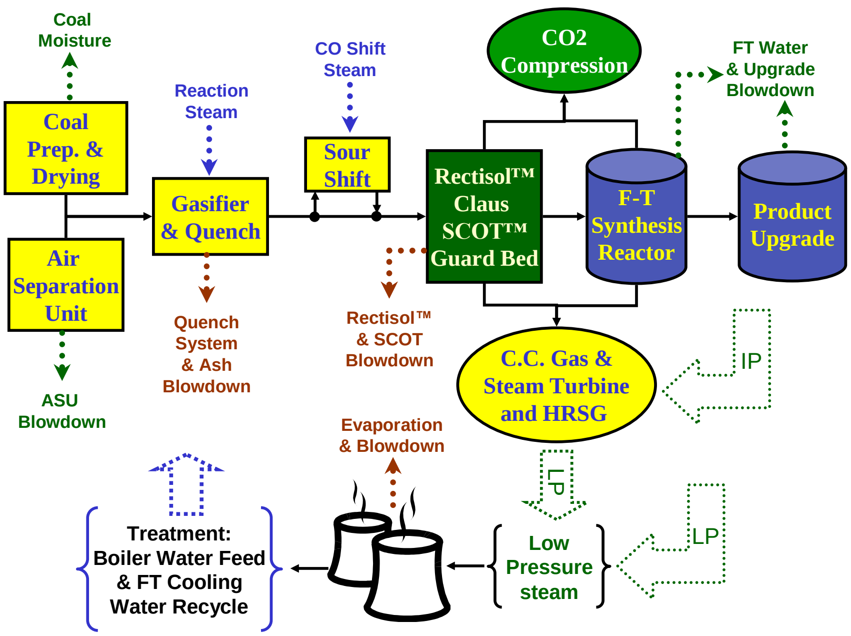
4. Locate the CTL plant near the mine mouth, and where possible in proximity of existing refinery industry to minimize the greenhouse gas emissions associated with transportation of the feedstock and plant products.
5. Select coal resources that are near the surface to minimize greenhouse gases associated with coal-bed methane releases and resource production. Western coal mines typically release significantly less CH_4 and CO_2 greenhouse gases than eastern coal mines.
6. Consider biomass transportation costs and logistics when trains moving coal to energy importing states in the East and Southeast return with biomass from high growth biomass regions.

Expanding on the second recommendation on this list, I am personally aware of, and have technically reviewed one closed-loop heat recovery technology that is capable of recovering and converting 95% of the energy contained in the copious amount of low-grade and intermediate-grade steam produced by a Fischer-Tropsch plant into electrical power. These developing concepts take advantage of low boiling point fluids that can condense the steam, thus eliminating the cooling tower loads while increasing electrical power production by as much as 15 – 20%. This is an example of how impetus to improve the efficiency of a CTL plant will spur creative engineering aimed at designing more efficient and cleaner plants.

WATER RESOURCE REQUIREMENTS

Let us now turn attention to water consumption concerns associated with synthetic fuels plants. In a recent workshop sponsored by the Gasification Technologies Council, I presented data that indicated the consumption of water in a coal-to-liquids plant could approach 15 barrels of water per barrel of liquids fuels product for low moisture bituminous coal, and 12.5 barrels of water per barrel of liquid fuels for high moisture sub-bituminous coal. The basic problem is two-fold; first, coal does not containe the amount of hydrogen that is required for synthetic fuels production, and second, process cooling water and cooling tower evaporation rates in CTL plants are significant.

Approximately five times the atomic ratio of carbon to hydrogen in coal is needed to produce synthetic natural gas (CH_4) while approximately 2.5 times this ratio is needed to produce liquid fuels. Water (as steam) is used to make up the hydrogen requirements. This is currently accomplished by shifting CO and water (H_2O) to hydrogen (H_2) and CO_2. The Fischer-Tropsch process converts a portion of the syngas to water (in the form of intermediate pressure stream) while producing the liquid hydrocarbon products. The general plant water use and rejection locations and discharges are illustrated in the figure below.



In summary, process makeup water, cooling tower evaporation, and dirty process water discharges (i.e., blowdown) can be significant. The water demand is especially significant in arid locations.

A custom-design heat recovery system for combined-cycle power generation and process water recovery, treatment, and recycle can reduce the water consumption for bituminous coal-to-liquids plants from 15 to 10.5 barrels of water per barrel of liquid hydrocarbon product. Combined use of moist biomass with coal can further reduce the process water requirement by one-half (½) barrel of water per barrel of liquid product. In this case, the plant water use is approximately apportioned among the following sinks:

- 1.75 barrels of water per barrel of liquid fuels for process requirements

- 6.0 barrels of water per barrel of liquid fuels for cooling tower evaporation losses and blowdown
- 2.25 barrels of water for cooling tower evaporation losses and blowdown associated with surplus power generation

These relative figures hopefully contribute to the understanding of the water requirements for a CTL plant. Studies regarding water requirements vary widely, but are generally consistent with the plant design and reporting basis. The most important point to capture is that cooling tower losses and waste water blowdown constitute the majority of water required for a CTL plant (8.25 of 10 barrels for the INL case study). In order to reduce the water duty, gas-to-gas heat exchangers could for used for steam cooling. Alternatively, a closed-loop heat recovery system, such as that referred to previously in my testimony, would eliminate the cooling tower and water evaporation losses, while also increasing electrical power generation by 15-20 percent. This process improvement is comparable to a modern natural gas furnace that achieves higher efficiency by condensing the steam in the exhaust gas before it vented to the atmosphere. Incorporation of a closed-loop heat recovery system would provide the joint benefit of reducing water use while reducing greenhouse gas emissions. Thus, the water requirement can be reduced to as little as 3-5 barrels of water per barrel of synthetic liquid product.

Another point to consider is the opportunity for CTL plants located near the coal mine to use coal-bed methane (CBM) produced water, or oil field water. For example, the Wyoming Coal Gas Commission estimates the potential water production from nearly 24,000 wells in existence in the Powder River Basin could yield upwards of 15 billion barrels of water over approximately 30 years. The water quality of a large portion of the PRB basin CBM water is adequate for direct use in a CTL plant. The salinity or hardness of the remainder of the water can be reduced with minimal water treatment, possibly comparable to the current cleanup requirements for much of the surface or well-produced waters used in power plants throughout the United States.

If two-thirds of the estimated CBM produced water in Wyoming were used for CTL plants in conjunction with advance steam cooling technology, then there would be sufficient water to produce 4 million barrels of synthetic fuels per year over a 50 year period.[2] This is equivalent approximately 25-30% of the transportation fuels currently consumed in the United States.

NEXUS OF CTL WITH NUCLEAR ENERGY

It is also worth noting to the possible nexus of coal and unconventional fuels production with nuclear energy. With the electricity produced from a nuclear reactor it is possible to produce oxygen for a coal/biomass gasifier while concurrently producing hydrogen for the Fischer-Tropsch reactor. Future class nuclear reactors will also have the capability of boosting the pressure of the low-grade and intermediate grade steam to levels amenable for electric power generation by a steam-driven electrical power turbine-generator set. Consider also the possibility of co-electrolyzing CO_2 with water inside a fuel-cell operated with power and heat produced by a nuclear reactor. In this application, the CO_2 and water would be converted to CO, H_2, and O_2 - all essential inputs to coal and biomass gasification and Fischer-Tropsch synthetic fuels production. Thus, the amount of carbon incorporated in the fuel could theoretically exceed 95%. Other studies funded by AREVA using Powder River Basin coal as the feed and an advanced generation nuclear power plant showed that greater than 96% of the carbon in coal could be converted to liquid fuels.

BENEFITS OF A HOLISTIC APPROACH

The preceding discussion supports the argument for a holistic approach to energy and transportation fuel development that is protective of the environment, while giving adequate attention to sustainable and secure energy for the nation’s future. The urgency for clean energy need not come at the expense of national security. As the nation moves forward using biomass and other renewable energy resources, and eventually with nuclear power and heat, it will be to again produce ammonia for fertilizer, chemical feedstock for consumer products, industrial gas for gas and steel production plants, and clean hydrogen for electrical power production (as known as FutureGen), hydrogen for sour crude and unconventional fossil fuel upgrading, and last, but not least, secure

[2] (1,000,000,000 bbl-water) / (5 bbl water per bbl-fuel produced) / (50 years) = 4,000,000 bbls fuel/yr for 50 years

transportation fuels for the next century and beyond. This can be done while reducing green house gas emissions. Failure to take on this leadership will only transfer this responsibility to future generations or foreign nations that will continue to produce the products demanded without probable control of greenhouse gas emissions. Failure to assume this leadership will also result in economic decline and increased national security risk. On the other hand, willingness of project developers and environmental protection organizations to accept coal conversion with biomass blending and carbon management will enable the U.S. to provide solutions to our global commons, while assuring secure, clean, efficient, and sustainable domestic energy for the future.

Other system approaches could consider the use of high pressure CO_2 slurries to transport western coal and CO_2 to CTL plants and carbon sequestration sites in the East, with a return line bringing water from the East to the arid West as practical. The reality is that the U.S. is not short on viable solutions to build a clean, and secure CTL industry. Such ideas abound within the nation's research academic institutions and national laboratories. The key for currently developing projects is to implement proven technology with a goal of reducing green house gases and minimizing water use. This recommendation is consistent with other technical experts who have previously testified before congressional committees. It is consistent with DOE and Department of Defense objectives to establish a secure domestic supply of transportation fuels while simultaneously mitigating global climate impact concerns.

I personally support efforts to convince the U.S. to conserve energy, while moving to a new fleet of hybrid cars and electrically-driven commuter cars. I support accelerated development of wind and solar energy, as well "smart" deployment of nuclear electrical power generation. I support a movement to develop biomass as a national resource, and the associated deployment of a system to improve yield, collection, preparation, and transportation of this resource to points of efficient conversion into energy and transportation fuels. However, I also believe the pending peaking of oil production, as well as diminishing domestic reserves of natural gas, in parallel with global energy demand projections and the acute need to address climate change point to the urgency for the United States to begin unprecedented efforts to begin building plants for transportation fuels from the nations abundant supply of coal with biomass. It is both in the interest of national security as well as global environmental protection. The example established by the United States can serve as a model for other countries to follow. This task cannot be left purely to the market place, since it is not presently the lowest cost method to produce electricity, natural gas, ammonia, chemicals, and transportation fuels. It is for these reasons that "big oil" is not currently investing in the development and construction of CTL plants in the United States. Therefore, Federal incentives to move to a synthetic fuels industry are necessary for timely market entry- in a manner that is protective of the environment. Establishing necessary greenhouse gas reduction targets will impact the economics and risk of the first U.S. plants; hence, assistance in the form of loan guarantees and tax advantages will help establish this vital industry ahead of significant economic incentives.

ROLE OF FEDERAL RESEARCH

In my opinion, the role for Federal research is to press forward with its existing programs to promote commercial development of clean and efficient coal-to-liquids plants. Efforts that support the characterization of sites for CO_2 sequestration should be accelerated in order to provide technically acceptable options for the first CTL plants. In addition, efforts to advance biomass gasification, particularly with coal blends, will help expand the current set of commercially available options. Ongoing efforts to improve and expand biomass feedstock collection and preparation options, as well as high-pressure injection technology, are encouraged. Additionally, federal research aimed at demonstrating emerging heat recovery options is advised. Concepts that recovery the heat from low grade stream to help reduce water consumption while improving overall plant efficiency (thus further reducing greenhouse gas emissions) should continue to be validated through appropriate technology demonstrations supported by federal research funding.

Process modeling of integrated CTL plants should also continue. These studies may include investigation of the technical feasibility of emerging heat recovery options. Process modeling can be complemented with academic research aimed at developing a deeper understanding of the fundamentals of Fischer-Tropsch reactor hydrodynamics and reaction processes. The benefit will be improved reactor designs for future plants and computational tools to help optimize operating conditions in first-of-kind CTL plants in the U.S.

A study that addresses the feasibility of collecting, treating, and using coal-bed methane produced water would have significant ramifications on the impact of establishing CTL plants in some western states. This potential benefit may also apply in eastern and southern states. Such a survey and assessment will help balance CTL water requirements. The study may also consider the use of this limited water resource for biomass growth.

Development of a national basis for estimating green-house gas life cycle emissions, inclusive of potential credits for co-generation of electrical power and other consumer products derived from a CTL plant is advisable. An acceptable arbiter of carbon emissions and credits for all possible energy platforms and co-generation plants will require careful and factual consideration of system interactions with the environment. The comparative INL-Baard life-cycle emissions studies are considered accurate, but leave open the possibility of calculating other greenhouse gas emissions benefits associated with the non-transportation products from a CTL plant. This merely points to the interdependence of energy with other consumer products and not strictly the transportation sector. Similar consistent calculation methods should be developed for other energy conversion platforms.

Federal research covering infrastructure needs, including the capability of manufacturing and transporting gasifier and Fischer-Tropsch reactor vessel to CTL projects locations is advised. One of the most significant cost and schedule impediments to establishing the CTL industry in the U.S. is the lack of heavy vessel manufacturing capability throughout the world. In order to establish greater independence from foreign controls, the U.S. may need to re-establish this capability. A social-economic study on the buildup requirements and logistics of this critical infrastructure component is recommended.

A holistic approach to deployment of CTL plants with biomass and water resources, and nuclear assisted energy should be pursued as an out-reaching goal. Although this should not impede the first generation of CTL plants, such an outlook will help ensure optimal use of our nation's resources and environmental protection for future generations. As the nation expands this industry beyond the first generation of CTL plants, it will become increasingly important to consider overall system performance.

CLOSING REMARKS

I recommend a balanced federal focus on renewable energy and development of the nation's coal. Mass deployment of "smart" hybrid and electrically powered cars should be pursued in conjunction with the development of synthetic fuels from coal. These two objectives are complementary and mutually compatible. In this manner, the U.S. can establish greater energy independence, while assuring there is a proper fuel choice for aircraft, shipping vessels, trains, heavy vehicles, and machinery that currently consume a high percentage of the petroleum-derived fuels in the U.S. - namely diesel and jet fuels. The aims of environmental protection advocacy groups and the coal industry should not be viewed as being exclusive. A balanced portfolio of clean energy is needed, inclusive of coal utilization and conversion to electricity, chemicals, and transportation fuels. I believe it is possible to reverse greenhouse gas emissions when considering methods to reduce the greenhouse gas emitted from coal-derived fuels and chemicals. Incentives to encourage clean CTL projects are therefore both important and necessary.

Federal and State governments can help build the supporting infrastructure necessary to propagate the synthetic fuels industry ahead of any imminent global energy crises. Absent from my testimony today, but of significance, is substantive argument to establish domestic capability to supply the steel, manufacture the vessels, and erect these plants before they become vitally necessary in a relative short time frame. The Federal government can focus attention on rebuilding these capabilities by working with industry and equipment fabrication shops in various regions where coal-to-liquids plants will be constructed. There is a need to continue to build liquid product and CO_2 pipelines, while providing practical and acceptable solutions for carbon management.

In conclusion, moving forward with a set of clean CTL plants today, and the research roles identified earlier, responsible infrastructure can be established to help ensure our nation’s energy and political security. Workforces can be trained and engaged and economic prosperity sustained by industrial construction and plant operations on home soil. The U.S. can provide technical leadership to other nations poised to utilize coal to meet their increasing energy demands.