Testimony of Dr. Robert Freerks
Director, Product Development
Rentech, Inc.

Before the Subcommittee on Energy and Environment
Committee on Science and Technology
U.S. House of Representatives

September 5, 2007

The Benefits and Challenges of Producing Liquid Fuel from Coal: The Role of Federal Research

Honorable members of the House of Representatives Committee on Science and Technology, Subcommittee on Energy and Environment, thank you for the opportunity to testify today on the benefits and challenges of producing fuels from coal. I am Dr. Robert Freerks, Director of Product Development for Rentech, Inc. For the past 8 years I have been working on processes for the production of synthetic jet and diesel fuels from alternative resources utilizing the Fischer-Tropsch (F-T) process. My educational background is in synthetic organic chemistry and I have 26 years experience in fuels and related technologies.

Rentech is one of the world's leading developers of Fischer-Tropsch technologies. As such, it is the company's vision to develop technology and projects to transform underutilized hydrocarbon resources such as coal, petroleum coke, remote or stranded natural gas and biomass and municipal waste into valuable clean fuels and chemicals that will help accommodate our nation's growing energy needs. Our company has been in the business of developing alternative and renewable energy technologies for more than 25 years, having been initially affiliated with the Solar Energy Research Institute which became the National Renewable Energy Laboratory in Golden, Colorado. Rentech's focus is on the technology for converting synthesis gas, carbon monoxide and hydrogen, into ultra clean synthetic diesel and jet fuels via the Fischer-Tropsch process followed by hydroprocessing.

The goal of our efforts is to demonstrate the viability of this technology for diverse alternative feedstock materials into fungible transportation fuels in volumes great enough to reduce importation of crude oil and refined fuel products. Currently the United States imports approximately 65% of our crude oil and fuel products. Conversion of biomass into first generation biofuels is estimated by EIA to provide only 11.2 billion gallons in 2012 per year or 458,000 barrels of oil equivalent per day, which would account for about 2.3% of today's consumption of 20 million barrels per day. The largest plants will have a capacity of no more than about 7,000 barrels per day. Rentech's first plant will produce 30,000 barrels each day or 460 million gallons per year, and it will be scalable to more than 80,000 barrels per day.

Rentech is well aware of the dual energy problems facing America: The need for independence from imported crude oil; and the need to reduce the greenhouse gas (GHG) footprint of these fuels. First I'd like to briefly address energy security. As a company we believe that the U.S. cannot achieve energy independence without utilization of its many diverse natural resources, including both renewable and fossil fuels. Given the current level of our dependence upon imported oil we must consider all realistic options in solving this problem. But achieving this goal will take guidance and support from the federal government to protect investors from the consequences market manipulation by the oil cartel. We must remember that the oil markets are not free markets and it is not unreasonable to believe that if we begin to succeed in ending our addiction to foreign oil, the nations that produce it will try to undermine our efforts at energy independence by cutting prices. Relying on affordable, abundant domestic coal helps to mitigate strategic concerns, but does not eliminate the risk of a price cut intended sustain our addiction to imported oil.

The benefits to the U.S. in terms of energy security, balance of payments, and the establishment of the new CTL technology base with an associated increase in jobs will be substantial and obvious. Projects that Rentech is developing are located in economically challenged areas such as our proposed plant in Natchez, Mississippi, and our conversion of a fertilizer plant in East Dubuque, Illinois. Our hope is that Washington will make a long-term commitment to a broad suite of alternative energy solutions; including those utilizing our abundant coal reserves, but that encourages cooperative efforts across segments of the alternative fuels industry.

Second, Rentech is committed to developing and deploying technologies and processes that reduce the GHG emissions associated with both the production and use of our fuels. We have assembled a Carbon Leadership Team to address the overall carbon footprint of fuels production using Rentech's F-T technology. This team which includes all senior executives, staff scientists and engineers has committed the company to being a leader in reduction of carbon dioxide emissions from our projects. A CO2 solution is a key decision criterion in advancing a project. The Rentech plant design already incorporates carbon capture as an integral part of the process, the only obstacle to significant carbon emissions reductions is sequestration of the captured carbon dioxide.

But our commitment to CO2 management does not stop at the fence. Rentech has already established relationships with companies that transport and sequester CO2 using existing Enhanced Oil Recovery (EOR) technologies that have been proven for over 20 years. EOR in conjunction with F-T fuels production will increase available energy by approximately one barrel of crude for every barrel of F-T fuel produced, increasing oil production from existing North American fields and further improving our nation's energy security. Pipelines already exist for the transportation of CO2 in several areas of the country and plans are being formulated to extend pipeline capabilities to cover significant areas of the central and eastern U.S. Rentech has partnered with Denbury Resources to supply CO2 to several locations for EOR sequestration. One sequestration site is the Gulf Coast Stacked Storage project in Cranfield, Mississippi, part of the Southeast Regional Carbon Sequestration Partnership (SECARB), a public-private

partnership dedicated to the development and deployment of carbon sequestration solutions.

But the benefits of Rentech's fuels are not limited to CO2. Rentech fuels will be the cleanest liquid transportation fuels available. F-T diesel and jet fuel are pure paraffinic hydrocarbons. This means that they inherently contain essentially no sulfur and aromatics, two fuel components that have long been the focus of federal and state environmental protection policies. The fuels are clear, non-toxic, biodegradable and completely fungible with current fuels and fuel transportation infrastructure. This means that no changes are needed to fuel distribution pipelines or engines to use F-T diesel and jet fuel. *(A comparison of the lifecycle CO2 emissions from diesel fuels produced from coal to diesel fuels produced from several different qualities of crude oil is shown below as Figure 1.)*

The Department of Defense has been a leader in advancing the development of a U.S.-based Fischer-Tropsch fuels industry. As part of several conjoined programs, the Department is seeking to encourage the development of a domestic alternative fuels industry that can provide a reliable source of fuel for their aircraft, tanks, ships and other vehicles while reducing emissions. For the sake of simplifying logistics, these initiatives also aim to reduce the multiple types of fuels that our military must carry to the battlefield - approximately 9. This new fuel also must be capable of being stored, transported and distributed using existing infrastructure. Only fuels produced using the Fischer-Tropsch process are able to meet all of these requirements.

Through the Assured Fuels Initiative the Air Force has tested F-T jet fuel in multiple applications from a diesel engine powered HMMWV (Hummer) to a B-52 bomber. Last month, the Air Force certified its entire B-52 fleet to fly on a 50/50 blend of F-T jet fuel and conventional jet fuel, and is progressing on extending that certification to all its aircraft by 2011. *(See Figure 2 below for a comparison of particulate emissions from a turbine engine using blends of conventional and synthetic Fischer-Tropsch jet fuels. Figure 3 illustrates the DOD view of the future use of F-T jet fuel in a multitude of applications.)*

Commercial aviation is also progressing towards full acceptance of F-T jet fuel in general aviation aircraft. The Federal Aviation Administration is supporting the Commercial Aviation Alternative Fuels Initiative (CAAFI) which will oversee the efforts to approve the use of blends of F-T fuel with conventional jet fuel. This fuel is already in use in South Africa and all planes flying out of Johannesburg International Airport have been using a blend of F-T jet fuel and conventional jet fuel for 7 years, including Delta Air Lines that recently initiated service from Atlanta.

F-T fuels offer numerous benefits for aviation users. The first is an immediate reduction in particulate emissions. F-T jet fuel has been shown in laboratory combustors and engines to reduce PM emissions by 96% at idle and 78% under cruise operation. Validation of the reduction in other turbine engine emissions is still under way. Concurrent to the PM reductions is an immediate reduction in CO2 emissions from F-T fuel. F-T fuels inherently reduce CO2 emissions because they have higher energy

content per carbon content of the fuel, and the fuel is less dense than conventional jet fuel allowing aircraft to fly further on the same load of fuel.

The fuel also offers increased turbine engine life through lowered peak combustion temperature. This reduces stress on hot components in the turbine engine thereby increasing the life of those components. Fuels that burn cooler may also help to reduce the heat signature of aircraft, making them less vulnerable to infrared missile attacks. *(Figure 3 shows some of the many applications for F-T jet fuel in military equipment ranging from tanks to fuel cells to spacecraft.)* Also critical to meeting the needs of aviation, F-T fuels are truly "drop-in replacements" for their petroleum-based counterparts, requiring no new pipelines, storage facilities, or engine modifications, barriers that have stalled other alternative aviation fuels programs.

Another advantage to F-T fuels is the maturity of the technology. Rentech's plant designs are a relatively straight forward application of existing, proven commercial components that can provide reliable production of liquid hydrocarbon fuel and chemical products. The process first takes a carbon source such as coal, gasifies it to carbon monoxide and hydrogen (known as synthesis gas or syngas), removes contaminants from this syngas including carbon dioxide, and captures energy from that process for electricity production. The purified syngas is then fed to a Fischer-Tropsch reactor where the carbon monoxide and hydrogen are converted to hydrocarbons. At this stage, additional carbon dioxide is captured from the recycle stream and prepared for sequestration. The raw F-T products are further processed into chemical feedstocks, diesel, jet fuel and naphtha using conventional refining and distillation technologies. *(See Figure 4 for a simplified process flow diagram.)*

Today, the barriers to building large scale commercial F-T facilities that can cut into the volume of imported oil are purely financial. The history of the energy business, particularly the oil industry, is marked by volatility. Investors have long memories and, as has been said before, "capital is cowardly." Many who are interested in investing in alternative energy production are looking to Washington to provide some level of certainty. The cost of a 30,000 to 40,000 barrel per day F-T plant is estimated in the $3 to $6 billion range, numbers that are often associated with large traditional refineries or power plants, not alternative energy production.

Federal policies and programs that can help to provide the needed certainty can take several forms. The first, and most natural, would be for the Department of Defense to enter into long term supply contracts with F-T fuel producers. There are several bi-partisan proposals to enable this, including extension of the Department's contracting authority from its current 5 year limit to 25 years. Next would be the establishment of a program similar to that proposed by Representatives Boucher and Shimkus to create a "price collar" program which would protect producers from a dramatic drop in oil prices and taxpayers through a revenue sharing mechanism when prices exceed a certain level.

Extending the extending the existing alternative fuels excise tax credit, which covers F-T fuels and is set to expire in the fall of 2009, to 2020 would also provide a level of

protection for investors from potential OPEC price manipulation intended to undermine U.S. alternative energy programs.

The next area that the federal government can assist in is providing regulatory certainty with respect to CO2 sequestration. The DOE should encourage the exploration of options for managing industrial CO2 and the federal government should assume responsibility for geologically sequestered CO2.

As our nation enters into a regulatory regime for managing CO2 emissions, it will also be critical that the system that is established to account for manmade CO2 is beyond reproach. This Committee should take a leadership role in forcing the development of a modern, comprehensive and universal model for assessing the lifecycle greenhouse gas emissions for all fuels. Such a lifecycle analysis should consider the latest production technologies and processes, the energy inputs throughout production of the raw material through fuel distribution to the point of sale, including those of imported oil and other fuels, and the emissions associated with its use. This model should be applicable across all fuel types and not tailored to consider only the emissions of a few.

With the exception of improving lifecycle analysis science, all of the incentives that I have listed are to advance deployment of F-T technology rather than to advance the state of it. To repeat, our current hurdles are financial much more than technical. But as I described above, the first step in our process is the gasification of a feedstock, either coal or petroleum coke, to produce synthetic natural gas for use in our F-T reactor. While coal and pet coke are the feedstock of choice today that does not forever have to be the case. As a company we are agnostic on what feedstock we use, as long as it works. Rentech is in the early stages of developing the next generation of our process – biomass-to-liquids. Unlike CTL, which has been utilized commercially for decades, commercialization of BTL faces near-term hurdles. Current gasification technology manufacturers and operators have limited or no experience with biomass gasification on a commercial scale. Some are just now investigating their ability to feed biomass along with coal and there is no estimate yet available for how much biomass could be fed without upsetting the design of the gasifier.

Advancing new biomass gasification technologies could be greatly expedited with federal support to attract investment. Biomass gasification works and it is our objective, moving forward, to prove technologies and processes that allow for an increasing percentage of our feedstock to come from biomass. Congress can help advance the technology of BTL through the establishment of loan or grant programs expressly to allow commercial operators to acquire gasifiers that can be dedicated to testing various forms of biomass over extended periods and growing seasons. Coupled with carbon sequestration this holds great potential to help move fuels production from a process that emits CO2 to one that absorbs CO2. But for a company such as Rentech, or any of the other U.S. based F-T fuels developers and their investors, such risks are not financeable at this time.

There is also a role for the federal government in assessing the regional availability of various biomass supplies. It is currently not known how much biomass will be available in any given location without disrupting the ecology of that area or impacting food

supply. It is always assumed that biomass is readily available, but few studies exist to show that supplying biomass to a major fuels production facility can be accomplished on a sound economic basis and that this supply can be sustained for an extended time period. Congress should study of the availability and cost of biomass in several areas of the U.S. where CTL plants could be located. The sustainable availability of biomass at some level is needed if biomass is to be used to reduce the overall carbon footprint of a CTL facility. There have been assertions that specific levels of biomass co-feeds are possible. These will remain academic theories until these questions are answered.

Once biomass has been proven as a viable commercial feedstock for F-T plants and plants are connected to carbon sequestration opportunities such as EOR, as is our Natchez plant, then it is entirely realistic to envision a process that extracts CO2 from the atmosphere and stores it underground. This would move transportation fuels from being a contributor to global warming to being part of the solution. We view this as a "game changer" not only for Rentech but for our nation.

Thank you very much for the opportunity to address the Subcommittee today and I look forward to answering any questions you may have for me.

Figures

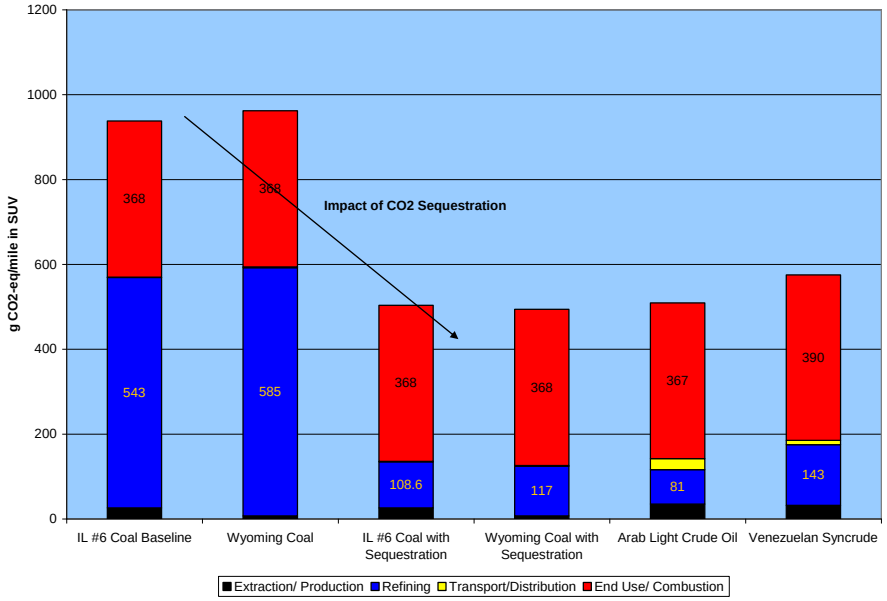

Figure 1. Full lifecycle GHG emissions for CTL F-T fuels without and with sequestration compared to conventional Arabian Light and Venezuelan Crude derived diesel based on NETL analysis by Marano/Ciferno, 2001

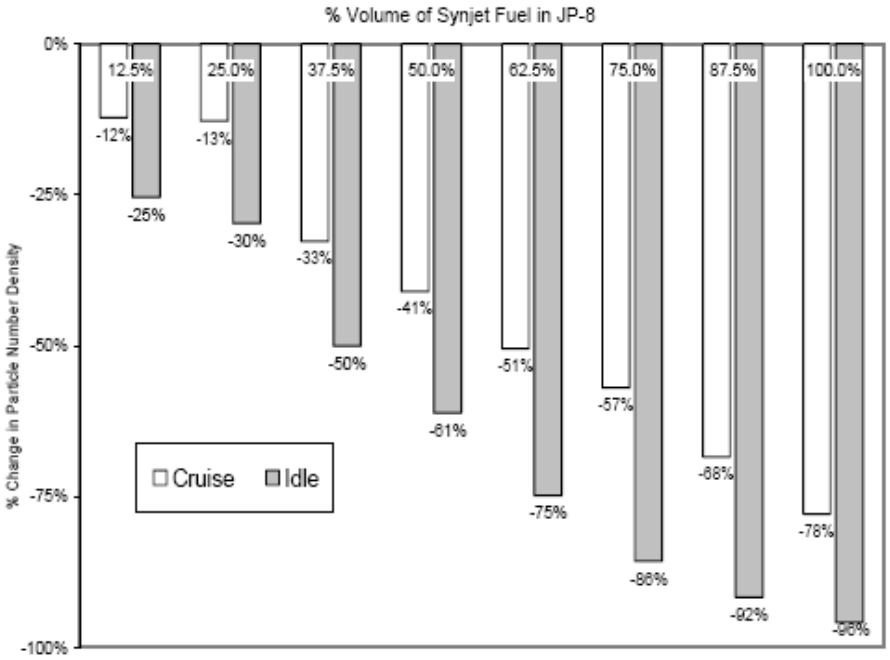

Figure 2. Reductions in particle number density emissions from T63 engine as a function of synthetic fuel in JP-8

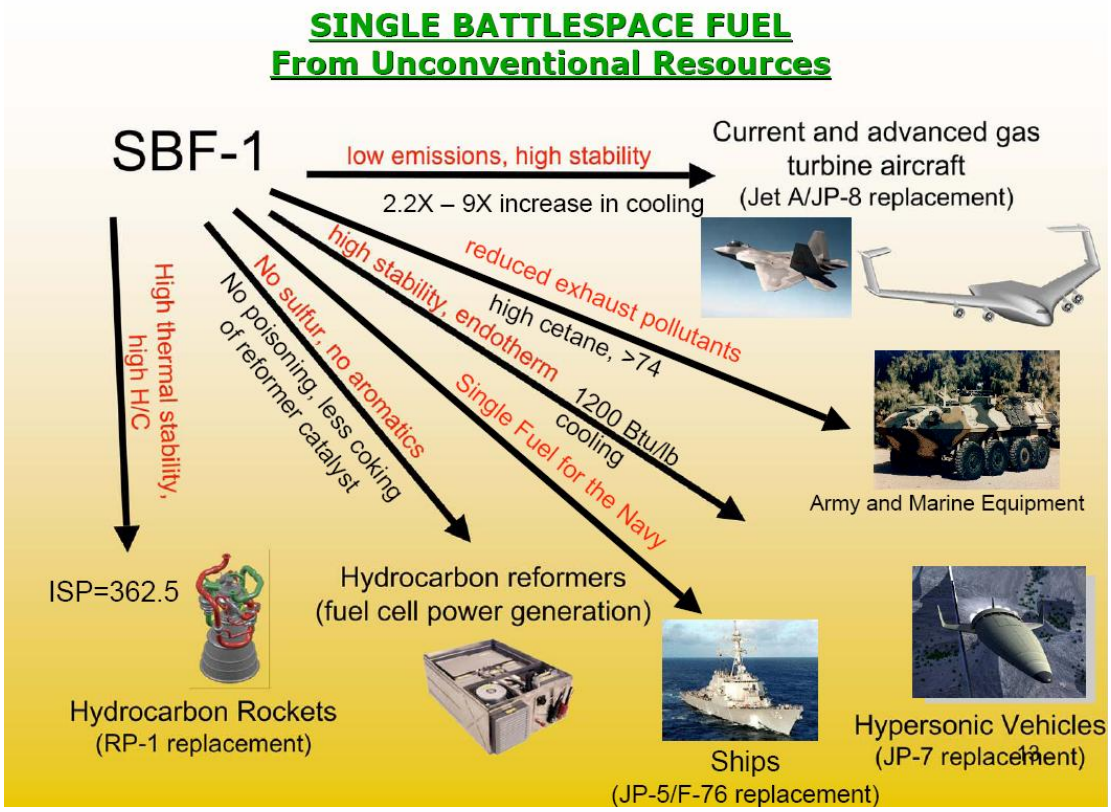

Figure 3. DOD Single Battlefield Fuel concept for Fischer-Tropsch jet fuel.

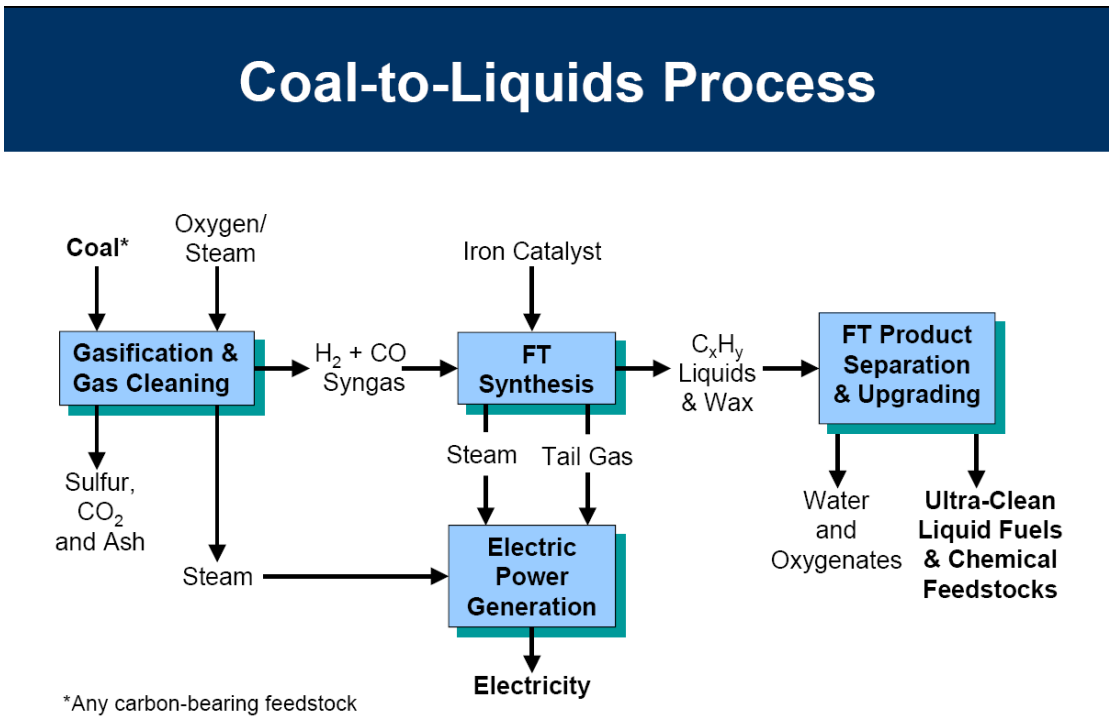

Figure 4. Process Flow Diagram for CTL facility.

Bibliography

(1) Marano, J. J.; Ciferno, J. P. *Life-Cycle Greenhouse-Gas Emissions Inventory For Fischer-Tropsch Fuels*, U.S. Department of Energy, National Energy Technology Laboratory, 2001.

(2) Altman, R. L. In *HOUSE TRANSPORTATION COMMITTEE HEARING ON ENERGY INDEPENDENCE AND CLIMATE CHANGE* Washington, DC, 2007.

(3) Corporan, E.; DeWitt, M. J.; Monroig, O.; Ostdiek, D.; Mortimer, B.; Wagner, M. *American Chemical Society, Fuels Chemistry Division* **2005**, *51*, 338.

(4) Harrison, W.; "The Drivers for Alternative Aviation Fuels" Presentation, OSD: 2006.

(5) "**THE POTENTIAL USE OF ALTERNATIVE FUELS FOR AVIATION**" In *International Civil Aviation Organization* Montréal, Canada, 2007. http://web.mit.edu/aeroastro/partner/reports/caep7/caep7-ip028-altfuels.pdf

(6) Maurice, L. "Alternative Fuels, Aviation and the Environment" *ICAO / Transport Canada Workshop on Aviation Operational Measures for Fuel and Emissions Reductions* Canada, 2006. http://www.icao.int/icao/en/env/WorkshopFuelEmissions/Presentations/Maurice.pdf

(7) Reed, M. E.; Gray, D.; White, C.; Tomlinson, G.; Ackiewicz, M.; Schmetz, E.; Winslow, J. *Increasing Security and Reducing Carbon Emissions of the U.S. Transportation Sector: A Transformational Role for Coal with Biomass*, NETL, 2007.