Written Testimony of
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Introduction

Mr. Chairman and members of the Committee, I am Dr. Ted Barna, Assistant Deputy Under Secretary of Defense, Advanced Systems and Concepts. I am honored and delighted to have the chance to appear today to discuss opportunities to produce superior fuels for the Department of Defense (DoD).

DoD's Concerns

Supply vulnerabilities: As you are well aware, the US currently imports over 56% percent of its oil and the Energy Information Agency estimates that it will increase to 68% by 2025.

Refining concerns: We are also increasingly dependent on foreign refined fuels, estimated to increase to four million barrels a day of finished product by 2025.

EPA Exemptions: The military currently has EPA national security exemptions to use jet fuels in our tactical equipment that in some cases exceed local EPA requirements. As President Bush stated "America must have an energy policy that plans for the future, but meets the needs of today. I believe we can develop our natural resources and protect the environment."

Reduce the number of fuels: If economic alternatives can be founds, a reduction in the number of fuels DoD currently uses would generate a tremendous operational and logistic benefit. Therefore, a significant goal of our ongoing program is geared to eventually having one battlefield fuel which can be used in the air, on ground, or at sea. Since this fuel would be suitable for the intended function (fit for use) the source of the fuel (synthetic, shale, biomass, petroleum) would be immaterial to the ultimate consumer.

Sources of energy: A quick estimate of total energy resources (shale, coal, oil, and other resources such as biomass and petcoke) comes to approximately 2.3 trillion barrels (bbl) potentially available in the US. (This total estimate includes: 1.4 trillion bbl of shale; 800 billion bbl coal; 60 billion bbl of petroleum, including enhanced oil recovery using CO2; plus renewables, which are not yet quantified). This compares with an estimated 700+ billion barrels total proved reserves (producible at today's prices) in the entire Middle East.) Please note, ("resource" is a technical term that indicates supplies of energy that may be in the ground, but are not economically producible at today's prices).

Note: EIA estimates U.S. proved oil reserves at 24.0 billion barrels as of the beginning of 2003. For technically recoverable oil resources, EIA uses estimates from the U.S. Geological Survey and Mineral Management Services, to arrive at an estimate of 142.8 billion barrels as of the beginning of 2003. The 800 billion bbl estimate for coal represents recoverable reserves only, not total resources. DOE estimates oil shale resources at more than 2 trillion barrels, although the economics of the recoverability of this resource is not considered.

In sum, if economic, the development of the vast national energy resources we have in this country could provide a dispersed, diverse, less vulnerable supply of fuels for the military such that it can meet its national security objectives in the near and far term.

DoD Involvement

Starting in 2003, before the current run up in prices, I was asked to manage a program designed to investigate alternative fuels. This ongoing study, sponsored by Senator Inhofe and Congressmen Sullivan and Cole, all of Oklahoma, researched fuels produced via the Fischer Tropsch (FT) process from natural gas. To accomplish this task I initiated a joint program, led

by the Army National Automotive Research Center (NAC) in Warren, Michigan, to investigate the military utility of these fuels and to evaluate the potential of producing and using a new generation of clean fuels for the military. The NAC in turn formed a joint collaborative program with the Air Force Research Laboratory at Wright-Patterson AFB, Ohio, the Naval Air Systems Command located at Patuxent River, Maryland, the Department of Energy National Technology Laboratory in Pittsburgh, Pennsylvania, and the Southwest Research Institute, San Antonio, Texas. They were joined by the University of Dayton Research Institute in Dayton, Ohio, and Syntroleum Corporation, Tulsa, Oklahoma (which supplied the fuel) to conduct a preliminary evaluation of the technological potential of these fuels for use in aircraft, tactical vehicles and ships.

The team has concluded a preliminary assessment of the chemical properties, storage stability, thermal stability, low temperature characteristics and emissions in diesel and jet engines. It found that neat (100%) FT fuel will require modification for use in legacy (older) military equipment, but these modifications can be made with existing technologies. For example, since the fuel is highly processed, it has a lower lubricity than normal petroleum derived fuels and could lead to premature pump failures. The research team has determined that conventional lubricity additives or blends with petroleum derived fuels could easily remedy this problem. Also, since these fuels are very good solvents, they can cause the elastomers (seals and o'rings) found in legacy systems to shrink and potentially cause leaks. Continuing research to solve this problem includes novel additives, aromatic blends, and blends with conventional petroleum derived fuels.

Bottom line is these are fuels that meet or exceed military and EPA standards. Use of pure synthetic fuels pose some difficulties in the areas of lubricity and seal swell, especially in legacy (older) equipment, but the problems can be solved at some cost, initially by using blends and ultimately by the addition of additives. They also bring us more in line with EPA and EU regulations. Testing and characterization now pro-actively identifies and could significantly ease future difficulties.

It is important to note this effort did not address the economics of using clean fuels for the military, nor whether or not it is ever likely that commercial scale production by the private sector will occur.

The results of this initial look indicated FT fuels, using updated processes and procedures, have the strong potential to produce lower pollutant emissions in diesel engines, reduce particulate emissions in jet engines, have superior high temperature and low temperature characteristics, and provide improved storage characteristics. Even the use of clean fuel blends, designed to counter problems of lubricity and seal-swell, provide significant (~50%) reductions in tailpipe emissions.

Based on these finding, in 2004 I expanded this initial effort to include a wider variety of resources for the production of clean fuels, notably: oil shale, oil sands, coal, biomass and petroleum coke. Although this OSD Clean Fuel Initiative looks at the total energy picture, today I'll concentrate on only two of these resources: coal (briefly) and shale (in more detail).

Coal

The U.S. has the necessary recoverable reserves of coal in Appalachia, the western United States, and Alaska (approximately equivalent to 800 billion barrels) to produce clean military fuels via the above mentioned Fischer-Tropsch process or through direct liquefaction. In either case, since the coal is gasified to carbon monoxide and hydrogen, then recombined over a catalyst, these processes remove most if not all pollutants, including sulfur and mercury. When coupled with carbon strategies, such as CO_2-sequestration, while more costly than alternatives, the entire process is certainly more environmentally friendly. In addition to producing military fuels, this coal gasification process can be used technically to generate electricity, hydrogen, fertilizers, and chemicals.

Oil Shale

America's Western Oil Shale is the largest unexploited hydrocarbon resource on earth. It's estimated that deposits in Colorado, Utah and Wyoming contain approximately 1 trillion barrels of recoverable oil (equivalent) that are well suited for producing premium quality diesel and jet fuels for the military. For example, Shell Oil is currently conducting a shale oil conversion pilot project which will convert kerogen to oil and gas via thermal cracking and in situ hydrogenation. Eastern Oil Shale could provide 400 billion of barrels of oil based on estimates in the 1990's, (Dr. Ari Geertsema, Center for Energy Institute, University of Kentucky). These eastern oil shale deposits are not as concentrated as western shale It is of interest that, while not as concentrated a Western Shale, Eastern Shales are low in carbonate content and retorting will not cause decomposition and the production of large amounts of CO_2. Greater than 90% of the near-surface mineable resources are in Kentucky, Ohio, Indiana and Tennessee.

DoD demonstrated in the early 1980's that shale oil derived from kerogen, when properly hydrogenated, has properties similar to crude oil. Since no shale fuels have been produced lately because of the cost of production, our evaluation relies on interpreting archival data. The technical literature reports early laboratory work on producing quality jet fuels from shale oil as early as 1951. Understandably, DoD interest increased dramatically in 1973 following the Arab Oil Embargo.

The initial large scale evaluations of petroleum refined from shale oil were sponsored by the Navy and the Naval Petroleum

and Oil Shale Reserves Office. These investigations looked at gasoline, JP-4 (Air Force standard jet fuel during this period), JP-5 (Navy aircraft fuel), diesel fuel marine (DFM) and a heavy fuel oil. Eventually, quality fuels were produced under these contracts and the Navy and DOE conducted extensive tests in military and commercial equipment. The initial focus of the testing was on the DFM product for naval shipboard use and included evaluating the fuel in fuel pumps and fuel distribution equipment to assure compatibility with Navy fuel system materials. After a complete evaluation, the Navy conducted hardware tests in diesel engines, Navy boilers, marine gas turbine engines, and conducted a shipboard test on the USS Scott. The Navy reports showed that DFM produced from shale oil was suitable for shipboard use.

The Navy also conducted tests of a shale derived JP-5 fuel in aircraft engines. The Navy report of the period states that a reasonable quality JP-5 could be produced (although the fuel was somewhat more corrosive than some petroleum derived fuels) and required the addition of lubricity additives for fuel pump durability. Engine tests were conducted by Allison on the T63-A-51 and T56-A-14 engines; General Electric on the TF34-GE-400 engine; and Pratt and Whitney TF30-P-414 engine. The shale derived JP-5 fuel performed satisfactory in all tests.

At the same time, the Air Force investigated shale derived JP-4 fuels. The fuel was tested in combustion rig tests conducted by Pratt and Whitney and General Electric and the fuel found to be suitable for testing in full scale engines and aircraft. Accelerated durability testing was also conducted by United Technologies on shale derived JP-4 in the TF30 and F100 fighter engines. Performance was found to be satisfactory in these engines tests, although the reports recommended additional research on fuel lubricity additives. Based on these positive results from the engine tests, a plan was developed to use the fuel at Air Force Bases in Utah (Hill AFB) and Idaho (Mountain Home AFB). The program was abruptly brought to an end by the announcement by Exxon of the closure of the Colony Project signaling the end of this phase of oil shale development.

Therefore, our conclusion is that shale oil can technically be processed using conventional refining techniques into high quality clean fuels, which are suitable for general use, to include use in tactical military equipment.

Notwithstanding these favorable results, a fresh look at shale derived fuels will be required by the military since the main jet turbine fuel is now JP-8, a version of commercial jet fuel Jet-A1, which replaces the JP-4 (gasoline/kerosene fuel blend) used by the Air Force and diesel fuel used by the Army. This fresh look includes developing new specifications designed to yield fuels that produce less tailpipe emissions (SOx and particulates), have improved low temperature characteristics, and allow use in all military tactical vehicles such as Army tanks, Navy ships, and Air Force and Navy aircraft.

Looking to the future, economic shale derived fuels produced to clean fuels specifications could also be used in fuel cells and advanced propulsions systems required for hypersonics.

Therefore, based on our experience from the 1980's, plus new specifications and application of modern extraction and refining techniques, there is no reason to expect that shale oil can not technically be processed into high quality clean fuels, which are suitable for use in tactical and non-tactical military equipment.

Conclusion

If economic, a reduced number of fuels would have significant operational and logistics consequences, and supply chain vulnerability would be reduced by having more, dispersed refineries. Cleaner fuels would bring DoD more in line with current, and evolving EPA regulations, reduce the possibility of limits on potential deployment (i.e. EU) locations, and contribute to technology advancements, (for example hydrogen vehicles, fuel cells, and scram jets).

Mr. Chairman, I look forward to working with you and the members of the Committee as we pursue our mission of providing DoD energy security.

I would be pleased to answer any questions.