TESTIMONY

Opportunities for Alternative Fuels Production

JAMES T. BARTIS

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1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
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James T. Bartis[1]
The RAND Corporation

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Subcommittee on Energy and Power
United States House of Representatives

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Chairman and distinguished Members: Thank you for inviting me to speak on the opportunities for the greater production and use of alternative fuels for transportation. I am a Senior Policy Researcher at the RAND Corporation with over 30 years of experience in analyzing and assessing energy technology and policy issues. At RAND, I have been actively involved in research directed at understanding the costs and benefits associated with the use of domestically abundant resources, such as coal, oil shale and biomass, to lessen our nation's dependence on imported petroleum. The findings that I will discuss today are drawn from studies sponsored and funded by the National Energy Technology Laboratory (NETL) of the U.S. Department of Energy, the United States Air Force, the Federal Aviation Administration, the National Commission on Energy Policy, the U.S. Chamber of Commerce, and the Defense Logistics Agency.

Today, I will discuss the strategic importance of alternative fuels, our assessment of the most promising candidates for near-term production, the barriers impeding alternative fuel production, and potential measures that Congress could pursue to promote a commercially-competitive subsidy-free domestic alternative fuels industry. My key conclusions are as follows. First, successfully developing a competitive alternative fuels industry in the United States would bring significant economic and national security benefits. But achieving those benefits requires an industry capable of producing millions of barrels per day. Second, the Fischer-Tropsch method, which is a thermochemical conversion method, is the only near-term approach capable of producing large amounts of alternative fuels beyond the level currently supplied by corn-derived alcohol fuels. Other near-term approaches, such as seed and waste oils and animal fats have extremely limited production potential. Third, alternative fuels production is being impeded by continuing uncertainties regarding world oil prices, uncertain production costs for first-of-a-kind facilities, and an uncertain regulatory environment, especially regarding the management of

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greenhouse gas emissions. Finally, a federal program directed at reducing these uncertainties and obtaining early, but limited, commercial experience in alternative fuels with a high production potential appears to offer the greatest strategic benefits. Federal policies that favor renewable fuels irrespective of energy security or environmental benefits should be reexamined.

The Importance and Value of Alternative Fuels

The United States' consumption of liquid fuels is about 19 million barrels per day (bpd). Meeting this demand requires importing about 10 million bpd of petroleum, mostly in the form of crude oil. In a world that consumes about 85 million bpd of petroleum products, the United States holds first place in total consumption and the magnitude of its imports. Currently the average price of crude oil imports is over $105 per barrel. At these prices, oil imports would cost U.S. oil consumers nearly $400 billion per year. Considering both direct and indirect expenditures on energy, each $10 increase in the price of world oil costs the average U.S. household over $550 per year.

The national security consequences of the dependence of the United States, and its allies and trading partners, on imported oil are well-documented.[3] All oil consumers are vulnerable to increased payments for oil when oil exporters are able to reduce supplies on the world oil market. Most serious would be the economic impact of a large and extended disruption in global oil supplies as a result of conflict or natural disaster.

The governing regimes of some oil exporting nations, such as Libya, Venezuela and Iran, pursue policies that run counter to the national security interests of the United States and its allies. When oil prices are high, these nations have more funds to invest in purchasing armaments and building their own industrial bases for manufacturing munitions. High oil prices also provide more funds that may eventually find their way to large terrorist organizations such as Hamas and Hizballah.

Alternative fuels are already being produced in many countries. Examples include corn-derived ethanol in the United States and sugar-derived ethanol in Brazil, synthetic crude from oil sands in Canada, coal-to-liquids production in South Africa, natural gas-to-liquids production in Qatar and Malaysia, and small amounts of biodiesel production in the United States and Europe. Expanding alternative fuels production beyond these initial efforts would offer economic and national security benefits to the United States. Because it provides a substitute for products refined from crude oil, increased production of alternative fuels will reduce demand for crude oil, resulting in lower world

[3] *Imported Oil and U.S. National Security*, Crane et al., Santa Monica, Calif.: RAND Corporation, MG-838-USCC, 2009.

oil prices to the direct benefit of all oil consumers. Lower world oil prices and greater supply diversity also mitigate the adverse national security impacts of imported oil.

About 45 percent of the operating refinery capacity of the United States is located in the hurricane-prone states of Texas, Louisiana, and Mississippi. Because alternative fuel production would likely occur in diverse locations throughout the United States, a domestic alternative fuels industry would improve the resiliency of the petroleum supply chain, especially against natural disasters. Increasing the geographical diversity of fuels production implies that a smaller fraction of supplies would be affected by any natural disaster. As such, we anticipate less economic disruption as the remaining supplies are allocated to users.

But if alternative fuels are to achieve these economic and security benefits, combined global and domestic production of alternative fuels must be an appreciable fraction of global and domestic demand for liquid fuels. Specifically, the need is for an alternative fuel portfolio that can competitively produce millions of barrels per day in the United States. Alternative fuel advocates often use gallons per year when describing production potential. For perspective, one million barrels per day is 15.3 billion gallons per year.

An important finding from our research in alternative fuels centers on the vastness of the resource base for alternative fuels in the United States. The largest deposits of oil shale resources in the world are located primarily in western Colorado and eastern Utah. The potential yield is about triple the oil reserves of Saudi Arabia. Our coal resource base is also the world's largest. Dedicating only 15 percent of recoverable coal reserves to coal-to-liquid production would yield roughly 100 billion barrels of liquid transportation fuels, enough to sustain production of three million barrels per day for more than 90 years. Our biomass resource base is also appreciable, offering to yield over two million barrels per day of liquid fuels. And over the longer term, advanced research in photosynthetic approaches for alternative fuels production offers the prospect of even greater levels of sustainable production.

Assessment of Alternative Fuels

The Duncan Hunter National Defense Authorization Act for Fiscal Year 2009 contained a provision calling for the Secretary of Defense to select a federally funded research and development center (FFRDC) to conduct a study of the use of alternative fuels in military vehicles and aircraft. Responding to Congress, the Department of Defense asked the RAND National Defense Research Institute, an FFRDC, to conduct an examination of alternative fuels for military applications. Our report on this study was published and delivered to the Secretary of Defense

and Congress in January 2011.[4] As part of that study, RAND researchers examined the opportunities to produce alternative fuels in a way that reduces lifecycle greenhouse gas emissions relative to emissions from the production and use of the petroleum products that they would replace.

Because this Congressionally-mandated study was directed at military applications, we focused our attention on alternative fuels that could substitute for jet fuel, diesel fuel, and marine distillate fuel, since these are the major liquid fuels consumed by military aircraft, ships, ground vehicles, and associated combat support systems. These fuels are often referred to as distillate fuels to distinguish them from the more volatile and more easily ignited gasoline used in spark-ignition automobiles.

As a group, distillate fuels account for over 95 percent of military fuel purchases, which are currently averaging about 340,000 barrels per day. Distillate fuels are also important in the civilian sector, fueling commercial transport and serving as an important home heating fuel in some parts of the United States. Current consumption of distillate fuels in the United States is about 5 million bpd. For comparison, recent gasoline demand is running at slightly below 9 million bpd.

While the emphasis of our assessment of alternative fuels was on military applications, our results also apply to alternative fuels that could displace petroleum-derived distillate fuels that are used in civilian application. Please note, however, that as part of this Congressionally-mandated study, we did not examine options for producing alternative fuels that can substitute for gasoline, such as alcohol fuels. For safety and operational reasons, these more volatile fuels are not appropriate for military applications. Since RAND has not conducted an in-depth examination of alcohol fuels, my remarks today will not cover this family of fuels.

Also included here is a brief statement regarding the oil shale resources located in the Green River Formation of Colorado, Utah, and Wyoming. Here our findings derive from the RAND 2005 examination of oil shale and our continuing monitoring of progress in this area.[5]

Fischer-Tropsch fuels are the most promising near-term options for producing middle distillate fuels cleanly and affordably. The Fischer-Tropsch (FT) method was invented in Germany in the 1920s. It can produce alternative liquid fuels that can substitute for petroleum-derived civilian and military fuels, including civilian and military jet fuels, marine fuels, and

[4] Alternative Fuels for Military Applications, Bartis and Van Bibber, Santa Monica, Calif.: RAND Corporation, MG969-OSD, 2011.
[5] Oil Shale Development in the United States: Prospects and Policy Issues, Bartis et al., Santa Monica, Calif.: RAND Corporation, MG 414-NETL, 2005.

automotive diesel fuel, and home heating oil. Generally, gasoline is produced as a co-product in FT facilities, and one commercially proven variant can be configured to produce only gasoline. The method accepts a variety of feedstocks. For example, a commercial facility operating in South Africa uses coal, one operating in Qatar uses natural gas, and forest product firms in the United States are examining the viability of small facilities that would use biomass. Blends of up to 50 percent FT-derived jet fuel and petroleum-derived jet fuel have been certified for use in commercial aircraft. Ongoing work by the services strongly suggests that appropriately formulated FT fuel blends can be safely used in tactical military systems as well.

Both coal and biomass are abundant in the United States. Together, they are sufficient to support a multimillion-barrel-per-day alternative fuel industry based on FT fuels. But if FT fuel production is to occur without compromising national goals to control greenhouse gas emissions, the following must hold:

- For **biomass-derived FT fuels**, the biomass feedstock must be produced in a sustainable manner; specifically, its production should not be based on practices that lead to sizable emissions due to direct or indirect changes in land use. If this is achieved, lifecycle greenhouse gas emissions can be near zero.
- For **coal-derived FT fuels**, carbon dioxide emissions at the FT fuel production facility must be captured and sequestered. If this is achieved, lifecycle emissions can be in line with those of petroleum-derived fuels.
- For **FT fuels derived from a mixture of coal and biomass**, carbon dioxide capture and sequestration must be implemented. The biomass must also be produced in a sustainable manner. If this is achieved, lifecycle emissions can be less than half those of petroleum-derived fuels. In particular, a feedstock consisting of a 60/40 coal/biomass blend (by energy) should yield alternative fuels with lifecycle greenhouse gas emissions that are close to zero.

The above approaches can result in FT fuels with lifecycle greenhouse gas emissions that are less than or equal to those of their petroleum-derived counterparts and thereby fuels that are eligible for government purchase per the provisions of Section 526 of the Energy Independence and Security Act of 2007.

Considering economics, technical readiness, greenhouse gas emissions, and general environmental concerns, FT fuels derived from a mixture of coal and biomass represent the most promising approach to producing amounts of alternative fuels that can meet military, as well as appreciable levels of civilian, needs by 2030. But whether this technology will reach its potential depends crucially on gaining early production experience—including production with carbon

capture and sequestration—in the United States. To our knowledge, no agency of the U.S. government has announced plans to promote early commercial use of FT fuels derived from a mixture of coal and biomass.

It is highly uncertain whether appreciable amounts of hydrotreated renewable oils can be affordably and cleanly produced within the United States or abroad. Hydrotreated renewable oils are produced by processing animal fats or vegetable oils (from seed-bearing plants such as soybeans, jatropha, or camelina) with hydrogen. Various types of algae have high oil content and are another possible source of oil for hydrotreatment. Fifty-fifty blends of hydrotreated oils have already been successfully demonstrated in flight tests sponsored by the commercial aviation industry. Laboratory analyses and testing strongly suggest that hydrotreated renewable oils can also be formulated for use in the Department of Defense's tactical weapon systems. Technical viability is not an issue.

The problem lies in uncertainties regarding production potential and commercial viability, especially affordability and lifecycle greenhouse gas emissions. Animal fats and other waste oils may offer an affordable low-greenhouse-gas route to hydrotreated renewable oils. But these fats and waste oils are also traditionally used in other nonfuel applications, including animal feed additives and the manufacture of soaps, household cleaners, resins, and plastics. Because the supply of these feedstocks is limited, substitutes would need to be found for use in these other applications. These substitutes may cause additional greenhouse gas emissions. Production potential is also a clear issue with animal fats and waste oils: The available supply of these feedstocks will likely limit production to no more than 30,000 barrels per day.

With regard to feedstock vegetable oils, to keep lifecycle greenhouse gas emissions at levels lower than those of petroleum-derived fuels, these oils must be derived from crops that do not compete with food production and that minimize nonbeneficial direct and indirect changes in land use. Jatropha and camelina are often mentioned as ideal plants to meet these requirements, but there exists little evidence to back these claims. Even if low-greenhouse-gas approaches can be established and verified, total fuel production is likely to be limited. Producing just 200,000 barrels per day (about 1 percent of daily U.S. petroleum consumption) would require an area equal to about 10 percent of the croplands currently under cultivation in the United States.

Advanced approaches, such as photosynthetic approaches using algae or other microbes as a feedstock, may yield renewable oils without the limitations and adverse land-use changes associated with seed oils. But all of these advanced approaches are in the early stages of the

development cycle. Large investments in research and development (R&D) will be required before confident estimates can be made regarding production costs and environmental impacts.

Considering (1) the very limited production potential for fuels derived from animal fats and waste oils, (2) the highly uncertain prospects for affordable, low greenhouse-gas fuels derived from seed crops, and (3) the early development status of algae/microbe-based concepts, renewable oils do not constitute a credible, climate friendly option for meeting an appreciable fraction of civilian or military fuel needs over the next decade. Because of limited production potential, fuels derived from animal fats, waste oils, and seed oils will never have a significant role in the larger domestic commercial marketplace. Algae/microbe-derived fuels might, but technology development challenges suggest that algae/microbe-derived fuels will not constitute an important fraction of the commercial fuel market until well beyond the next decade.

The prospects for oil shale development in the United States remain uncertain. With regard to oil shale, most of the high-grade shale is on federal lands. Six years ago, when we published our examination of oil shale, we concluded that the prospects for development were uncertain. They remain so today. The Bureau of Land Management has made available small amounts of acreage so that private firms can perform research and development and demonstrate technology performance before committing to the construction of full-scale commercial plants. It is our understanding that privately-funded research activities are on-going but that no private firm is prepared to commit to commercial production. Meanwhile, the Department of the Interior has announced a review of the commercial rules for the development of oil shale resources on public lands. In part, this review will examine approaches for assuring a fair return for providing access to oil shale lands. This part of the review is consistent with recommendations provided by RAND to the Congress in 2007.[6] The key to progress lies in formulating a land access and incentive policy that rewards those private firms willing to take on the substantial risks associated with investing in pioneer production facilities. It would not be advisable to develop detailed regulations that would pertain to full-blown commercial development until more information is available on process performance and impacts.

Impediments to Alternative Fuel Production

Presently, just about all alternative fuels production in the United States is motivated by a combination of federal subsidies and the Renewable Fuel Standards that are mandated by the Energy Independence and Security Act of 2007. This combination has promoted the production of

[6] "Policy Issues for Oil shale Development," Testimony by James T. Bartis presented before the House Natural Resources Committee, Subcommittee on Energy and Mineral Resources, April 17, 2007. Available for download at http://www.rand.org/pubs/testimonies/CT279.

diesel fuel from seed oils and to a much lesser extent from animal fats. As previously discussed, both of these approaches have extremely limited production potential and may result in lifecycle greenhouse gas emissions that exceed those of conventional petroleum-derived products. In addition, the diversion of croplands to energy production adversely affects food prices. From an energy policy perspective, neither of these two approaches have been productive. The primary impact of the current law promoting diesel fuel production from renewable oils is a transfer of wealth from U.S. oil consumers to the agricultural sector.

Alternative fuels produced via the Fischer-Tropsch method using biomass as a feedstock would qualify under the Renewable Fuel Standards. However, biomass-only FT fuels are expensive to produce, especially when compared to the case when the feedstock is only coal or a combination of coal and biomass. Our best estimate is that unsubsidized production would not be economic unless world oil prices exceeded $130 per barrel. This high cost is due to two factors. First, biomass is generally more expensive to deliver than coal. Second, biomass-only FT plants need to be fairly small (at most, producing 5000 barrels per day of fuel), due to limitations on how much biomass can be harvested within a reasonable distance of the FT fuel production facility. With current technology, such small FT plants are well below the size required to achieve economies of scale.

Our estimates of production costs of FT fuels using either coal or a combination of coal and biomass are more favorable, being competitive when world oil prices exceed $70 and $100 per barrel, respectively. But under current law, such alternative fuels do not qualify for subsidies or meet the requirements of the Renewable Fuel Standards.

Three major uncertainties continue to impede private investment in coal-to-liquid and coal/biomass-to liquid facilities in the United States.

- uncertainty about production costs
- uncertainty regarding how and whether to control greenhouse-gas emissions
- uncertainty regarding the future course of world oil prices.

Of these three factors, the greatest impediment appears to be the uncertainty regarding future world oil prices. If investors would be confident that average long-term crude oil prices would remain consistently above $100 per barrel, no government policy would be required to support the emergence of a coal-to-liquids industry and possibly a coal/biomass-to-liquids industry. But with the possibility that oil prices could fall significantly in the near to medium term, the financial risk surrounding investments in first-in-the-U.S. FT production facilities is appreciable.

Promoting Subsidy-Free Alternative Fuels Production

The current Renewable Fuel Standards are sufficient to promote alternative fuels production from commercially proven methods, including corn-derived ethanol and diesel substitutes from seed and waste oils. The energy security benefits of continuing the current subsidies are highly questionable.

As discussed earlier, the fact that an alternative fuel is "renewable" does not necessarily imply that it has value in terms of reducing oil imports or greenhouse gas emissions. While there is no doubt that additional coal mining raises safety, health, and environmental issues, inappropriate production of biomass can also lead to serious adverse environmental impacts, including loss of biodiversity, diversion of water resources, and water pollution. With regard to worker health and safety, agriculture ranks among the most hazardous industries. For these reasons, we suggest that when framing new energy legislation, Congress refrain from establishing resource-specific goals and instead focus on desired outcomes, such as conventional petroleum displaced and lifecycle greenhouse gas emissions.

The preceding remarks apply to commercially proven technologies. For alternative fuel technologies that are ready for first commercial production in the United States, federal incentives may be appropriate. At present, the strongest candidates for pioneer production facilities are FT plants, especially those that would accept a combination of coal and biomass. In the future, oil shale facilities using in-situ techniques and advanced biomass plants might also be ready for pioneer production.

At RAND, we have examined how the federal government can encourage the early participation of competent and capable companies in alternative fuels production.[7] The answer lies in the creation of incentive packages that cost-effectively transfer a portion of investment risks to the federal government. In particular, we found that a balanced package of a price floor, an investment incentive, and an income-sharing agreement is well suited to do this. The investment incentive, such as a tax credit, is a cost-effective way to raise the private, after-tax internal rate of return. A price floor provides protection in futures in which oil prices are especially low. And an income-sharing agreement compensates the government for its costs and risk assumption by providing payments to the government in futures in which oil prices turn out to be high.

[7] *Producing Liquid Fuels from Coal: Prospects and Policy Issues*, Bartis, Camm and Ortiz, Santa Monica, Calif.: RAND Corporation, MG-754-AF/NETL.

We also found that loan guarantees can strongly encourage private investment. However, they encourage investors to pursue early alternative fuel production experience only by shifting real default risk from private lenders to the government. By their very nature, the more powerful their effect on private participation, the higher the expected cost of these loan guarantees to the government. In addition, loan guarantees encourage private investors to seek higher debt shares that increase the risk of default and thus increase the government's expected cost for providing the guarantee. We strongly recommend that the government should recognize both the costs that such guarantees could impose on taxpayers and the extent to which government oversight of guaranteed loans can be effective in limiting these costs.

Finally, it is important that the Congress not falter in its support on long-range, albeit higher risk, research that offers to provide the foundation for sustainable production of alternative fuels via photosynthetic approaches.

In closing, I commend the Committee for addressing the important topic of alternative fuels. The United States has before it many opportunities—including renewable resources, coal, oil shale, improved energy efficiency, and fiscal and regulatory actions—that can promote greater energy security. But to exploit our national potential, we need laws that are more goal-oriented and less prescriptive about the means of achieving those goals.