Research Brief

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Alternative Fossil-Based Transportation Fuels: Economic Benefits and Environmental Concerns

Abstract

Dependence on oil creates significant economic, energy-security, and environmental concerns for the United States. RAND researchers compared alternative fuels derived from oil sands and coal liquefaction to conventional petroleum–based fuels on the basis of future production levels, cost, and greenhouse-gas emissions. They found that both alternatives have the potential to diversify fuel supplies at a competitive price, but neither moves the country toward the significant carbon dioxide–emission reductions needed to arrest climate change over the longer term.

Petroleum products derived from conventional crude oil account for more than 95 percent of all energy used in the U.S. transportation sector. Currently, the nation imports about 60 percent of its oil. When prices are high, this dependence results in a large transfer of wealth to foreign oil producers. It also makes the nation susceptible to the adverse effects of unpredictable jumps in oil prices.

Climate change from rising global emissions of carbon dioxide (CO_2) and other greenhouse gases is also a major concern. The United States emits slightly less than one-quarter of global CO_2 emissions from the combustion of fossil fuels, and one-third of U.S. emissions are from transportation-fuel use. The Energy Information Administration projects that U.S. emissions from transportation will increase by about 10 percent between 2007 and 2030.

Two Alternative Transportation-Fuel Options

Among the transportation fuels that might be commercially available in the next 10–20 years are renewable fuels, such as ethanol and biodiesel, and unconventional, fossil-based liquid fuels derived from heavy oils, oil sands, oil shale, and coal. The National Commission on Energy Policy, a bipartisan nongovernmental body of energy experts, asked RAND to compare the economic and environmental attributes of unconventional fossil fuels with those of fuels from conventional petroleum and to determine their potential contributions to the nation's motor-fuel supplies by 2025.

RAND researchers focused on synthetic crude oil (SCO) produced from deposits of oil sands in Canada and fuels produced by coal liquefaction. The research team assessed the potential future production capacity and costs for these fuels, environmental concerns, and potential for capturing CO_2 during the production process and storing it in geological formations. The team then compared the two alternative fuel sources to conventional-petroleum fuels to determine how cost-competitive they might be under different assumptions about future production costs, world oil prices, and potential regulatory constraints on CO_2 emissions.

Cost-Competitiveness of SCO Versus Conventional Petroleum

Oil sands are deposits of bitumen, a thick, tarlike mixture of hydrocarbons and other substances contained in sand or porous rock. Bitumen can be extracted and converted into a crude-oil substitute. Existing refineries can then convert this SCO into a wide range of petroleum products, including gasoline, diesel fuel, and jet fuel.

Canada's bitumen reserves—estimated to be equivalent to 173 billion barrels of oil—place that country behind only Saudi Arabia in oil reserves. Currently, more than 1 million barrels per day of SCO are produced in Canada, and

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production levels may increase to several million barrels per day in the next 10 to 15 years.

There are, however, several potential environmental and natural-resource constraints on further large-scale extraction efforts. Canada's oil sands lie within the boreal forest, the second-largest forest system in the world and a major freshwater resource and wildlife habitat. Extracting bitumen causes significant disruptions to the local environment, and the ability of land protection and reclamation methods to ensure the long-term health of the boreal forest is uncertain. Bitumen extraction and upgrading to SCO also require significant quantities of water. Finally, because more energy is required to produce SCO than to produce conventional crude oil, the life-cycle emissions of CO_2 for fuels refined from SCO are 10–30 percent higher than for fuels from conventional petroleum.

Despite these challenges, production of SCO from oil sands is likely to be very cost-competitive with crude oil across a wide range of future oil prices, even if future regulation imposes significant costs on CO_2 emissions. Consequently, there may be little economic incentive to invest in capturing and storing CO_2 emissions from SCO production.

Cost-Competitive Conversion of Coal-to-Liquid Fuels: Feasible but Challenging

A modern coal-to-liquids (CTL) plant would draw on recent commercial experience in key parts of the process, and several new U.S. facilities are in various stages of initial engineering design.[1] While producing significant quantities of CTL would require major increases in coal use, vast U.S. coal reserves appear to be adequate for many decades to come.

The RAND research team concluded that, while its economic advantages are not as strong as for SCO, CTL should be competitive with conventional-petroleum fuels across a considerable range of future oil prices, assuming that CTL production costs will decline as the technology matures. The greater potential challenge to CTL's competitiveness is posed by its high level of CO_2 emissions, which are roughly twice those of conventional-petroleum fuels. Future regulation of greenhouse gas–emission levels thus could add considerably to the delivered cost of CTL.

During the CTL production process, up to 90 percent of plant-site CO_2 emissions are separated from other gases. It is relatively easy and inexpensive to compress and transport this CO_2 via pipeline for underground storage where appropriate geological formations are available. But while it appears to be promising, geological storage has not yet been demonstrated to be technically and economically viable on a large scale.

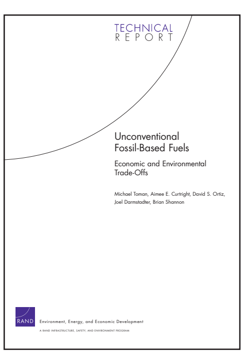
It is also possible to design and construct facilities that accept a mixture of coal and biomass as feedstock, with the biomass directly offsetting CO_2 emissions. Co-firing biomass with coal may achieve economies of scale not possible in biomass-only plants. Either capturing and storing CO_2 or co-firing biomass with coal will result in life-cycle greenhouse-gas emissions for CTL fuels that are comparable to those of conventional fuels.

Policy Implications

Both of the alternative fuels examined in this study offer opportunities to mitigate concerns about energy security due to high and unpredictable oil prices. Their increased availability would help moderate oil prices in the world market and reduce the fraction of supply from potentially unstable suppliers. On the other hand, neither alternative can move the country toward the significant emission reductions that will be needed in the longer term as part of a global effort to limit CO_2 concentrations in the atmosphere.

This creates a dilemma for policymakers concerned about both energy security and climate change because major expansions in the production of unconventional fuels would require large capital expenditures that could become uneconomic once tougher CO_2 limits are introduced. Additional investments are needed to advance biomass and other renewable-fuel options as well as to improve fuel efficiency. Steps also must be taken to reduce uncertainty about the technical and economic viability of large-scale CO_2 storage. ■

[1] Older CTL facilities continue to operate in South Africa, but key parts of their technology are considered obsolete today.



This research brief describes work done for RAND Infrastructure, Safety, and Environment documented in *Unconventional Fossil-Based Fuels: Economic and Environmental Trade-Offs*, by Michael Toman, Aimee E. Curtright, David S. Ortiz, Joel Darmstadter, and Brian Shannon, TR-580-NCEP (available at http://www.rand.org/pubs/technical_reports/TR580/), 2008, 96 pp., $37.50, ISBN: 978-0-8330-4564-5. This research brief was written by Judy Larson. The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors. RAND® is a registered trademark.

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