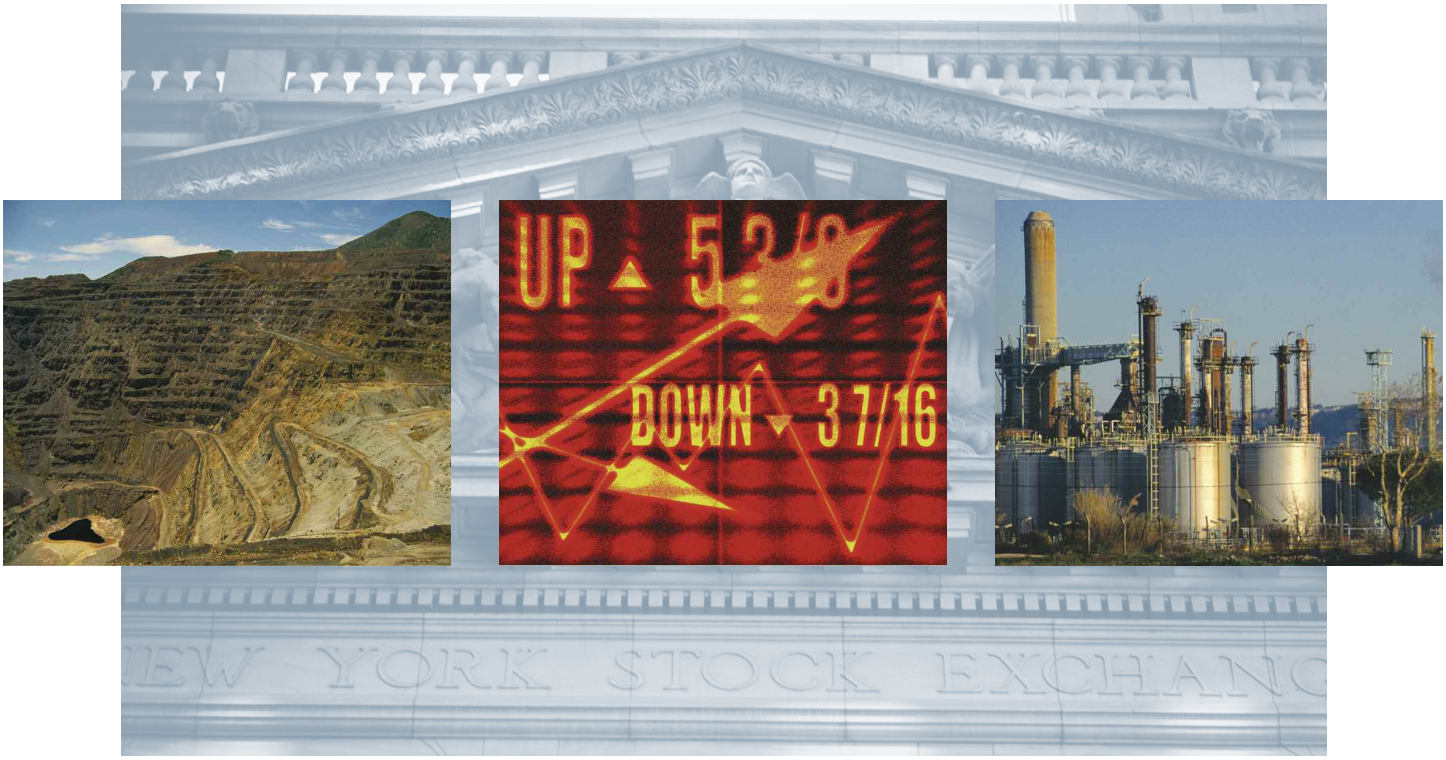
INVESTOR RISKS FROM DEVELOPMENT OF OIL SHALE AND COAL-TO-LIQUIDS



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David Gardiner & Associates (DGA) helps solve the energy and climate challenges facing today's companies, foundations, and non-profit organizations. Informed by the latest in policy, technology, and finance, the firm assists its clients in researching, building, and implementing climate change and energy strategies. DGA's strength lies in our deep understanding of the complexities of the climate and energy field; setting DGA apart is our tailored approach to meeting the needs of our clients and the depth of real-world expertise that DGA staff and consultants bring to each unique project. Dave Grossman, Senior Consultant to DGA, was the primary author of this report. For more information about DGA, visit www.dgardiner.com.

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Ceres is a national coalition of investors, environmental groups and other public interest organizations working with companies to address sustainability challenges such as global climate change. Ceres directs the Investor Network on Climate Risk, a group of more than 90 institutional investors from the US and Europe managing approximately $9 trillion in assets.

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EXECUTIVE SUMMARY

As the United States pursues the goal of increased energy security, discussions about unconventional fossil fuel sources, such as oil shale and coal-to-liquids (CTL), have re-emerged. With technologically recoverable reserves estimated at about 800 billion barrels in the U.S.—three times the size of Saudi Arabia's proved reserves—oil shale offers vast development potential.

Investors considering investment in the development of these carbon- and water-intensive fuel sources are advised, however, to obtain a comprehensive understanding of the range of risks that these undertakings could present. Investors' potential exposure is significant, as companies are spending hundreds of millions of dollars on testing, preparation and R&D, and dozens of projects are under development.

More than 25 companies are involved in some aspect of oil shale development, including oil majors like ExxonMobil, Chevron, and Shell. While an industry-wide figure for investments is not available, Shell's recent agreement to develop oil shale in Jordan illustrates the potential cost of these projects. That venture is projected to cost $20 billion over the next two decades.

At least a dozen CTL projects are under development in the United States, at a projected cost ranging from $2 billion to $7 billion per plant. Combined, these plants would produce approximately 170 million barrels of liquid fuels per year. The EIA, however, projects that CTL production in the U.S. will rise from virtually no production today to about 250,000 barrels per day, or more than 91 million barrels per year, by 2035. Major companies involved in CTL development include Shell, Rentech, Baard and DKRW.

Neither oil shale nor CTL are new energy resources. Oil shale production, which involves immature petroleum in shale deposits found mostly in the western U.S., has been recognized as a potential U.S. energy resource since the mid-1800s. CTL processes, which involve converting coal into liquid fuels such as synthetic diesel fuel, have been utilized worldwide for nearly 100 years. However, oil shale technology is still in the early stages of development, as are efforts to combine various CTL technologies into a commercially viable U.S. plant.

Investments and market formation for these technologies will be influenced by a range of factors, including resource availability, oil prices, carbon prices, technological readiness and development, market and stakeholder reactions, and regulatory directives. More specifically, key risks regarding oil shale and CTL include:

- ***Water constraints:*** Oil shale and CTL development may be constrained by each technology's need for large amounts of water. This is an especially big concern for oil shale production in water-stressed states such as Colorado and Utah. Water needs for oil shale may be anywhere from 1.5 to 5 barrels of water for every barrel of product produced. For CTL, the ratio is generally around 5:1 to 7:1.
- ***Regulatory risks:*** Current and potential regulations seeking to address climate change and limit carbon dioxide (CO_2) emissions, such as low carbon fuel standards and lifecycle emissions requirements, pose potentially serious risks to oil shale and CTL, both of which are highly carbon-intensive.

- ***Uncertainty about and costs for carbon capture & sequestration (CCS):*** Given their carbon intensity, oil shale and CTL will both be very dependent on CCS if they are to survive and thrive as carbon-reducing regulations take stronger hold. CCS, however, still faces great uncertainty, including about commercial viability, public opposition, enabling policies, carbon price levels, public financing levels, and constraints on markets for captured CO_2. CCS is also very expensive, adding to the costs for CTL and oil shale fuels.
- ***Core technological uncertainty:*** Both of these fuels, particularly oil shale, rely on uncertain technological development and commercialization that is core to their processes. Oil shale technology is still in the early stages of development, particularly processes that involve heating the oil shale in place and then extracting it from the ground (*in situ* processes). CTL technologies are much further along, but combining the various CTL technologies into a commercially viable U.S. plant still faces several operational and technical challenges (see case study on page 18).
- ***Market risks:*** The economic competitiveness of oil shale and CTL is contingent on high oil prices. Estimates vary with respect to the oil price range in which these fuels are competitive, assuming the numerous technological and regulatory uncertainties are addressed. Some studies show that CTL fuel is viable when the price of oil exceeds $40-55 per barrel. Oil shale may not be profitable unless oil prices are in the $70-95 per barrel range, though *in situ* oil shale (if technically viable) may be competitive at much lower prices. These estimates do not take into account potential CCS costs or carbon prices, which would raise the price-per-barrel competitiveness level. In addition, oil shale and CTL competitiveness is affected by a range of other market risks associated with building and operating facilities, including coal price volatility, payback horizons, reliance on government intervention, and reliance on private and public investment in supporting infrastructure.
- ***Risks from public opposition:*** CCS projects in places such as Ohio, New York, and Germany have faced public protests that complicated or derailed the projects. Public opposition to development of oil shale and CTL operations – based on their actual or perceived environmental impacts – could similarly derail, delay, or increase the costs of such development.

Each of these factors, as well as others, may carry considerable independent weight in any risk/reward investment decision. Cumulatively, the factors may give pause to many investors.

Given these wide-ranging risks, investors should:

- Engage with relevant companies (e.g., oil and gas companies, CTL developers, end users such as airlines and fleet operators) in which they are shareholders, to further understand the risks that companies are assuming and how they are mitigating those risks.
- Evaluate the potential risks in their fixed income portfolios from state and municipal bonds, to the extent those bonds are used to support development of these fuels.
- Advocate for public policies that address the risks and provide long-term investment certainty, such as a national carbon price and low-carbon fuel standard.

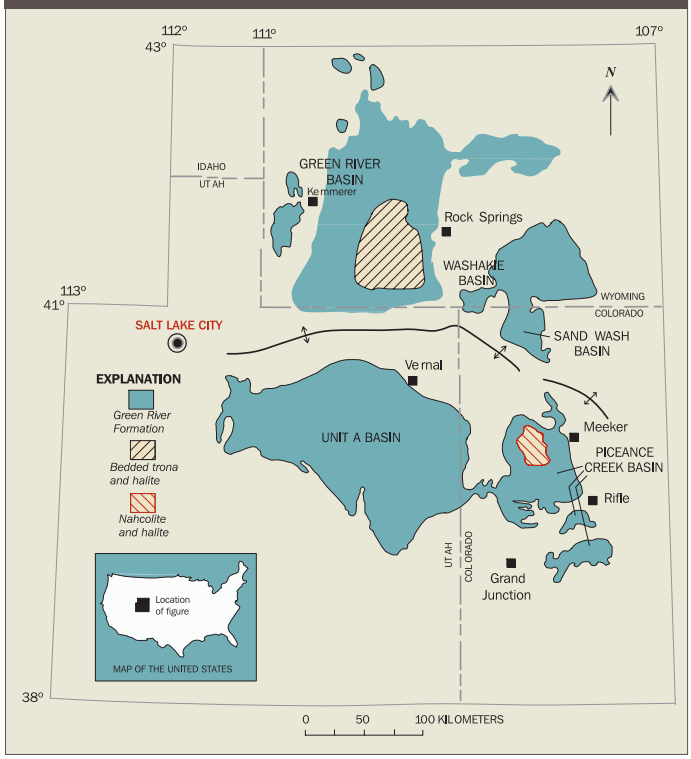
INTRODUCTION TO OIL SHALE & COAL-TO-LIQUIDS

This section provides a brief overview of oil shale and coal-to-liquids (CTL).

Oil Shale

Oil shale is essentially immature petroleum. Due to its relatively shallow depth, the kerogen in the shale has not been subjected to enough heat to mature it to the point that it has fully converted into petroleum hydrocarbons.[1] The kerogen therefore contains a narrower range of hydrocarbons, and distillates from oil shale tend to be kerosene, jet fuel, and diesel fuel, though they can be processed into gasoline.[2] The majority of the largest oil shale reserves in the United States are in the Green River Formation underlying Colorado, Wyoming, and Utah (see Figure 1). Estimates of the technologically recoverable oil there range from about 0.5 to 1.1 trillion barrels; to put that in context, the midpoint in that range (800 billion barrels) is more than triple the proved oil reserves of Saudi Arabia.[3] (Oil shale should not be confused with "shale oil", which involves typical crude oil that is trapped in relatively non-permeable shale rock, such as the Bakken Shale in North Dakota.[4])

Figure 1: Green River Formation Oil Shale Deposits



Source: Dyni, USGS, 2006

Oil shale technology is still in the early stages of development, even though it has been recognized as a potential U.S. energy resource since the mid-1800s. Sporadic attempts to commercialize oil shale during periods of high oil prices or high concern about oil supplies repeatedly failed once oil prices fell again.[5] As oil prices and concerns about conventional reserves have risen again recently, there has been renewed interest in oil shale. In 2005, the Bureau of Land Management (BLM) initiated a Research, Development, and Demonstration (RD&D) program for oil shale and solicited bids from companies; 20 companies applied for oil shale leases, and six were authorized in 2006 and 2007.[6] A second round of oil shale RD&D leases was announced in 2009, with additional environmental safeguards and smaller parcels for potential conversion to commercial use; only three companies applied. In October, BLM announced that it was advancing the three applications to the next phase of the review process, which may take from 4 to 18 months to complete.[7]

Deriving oil from oil shale is referred to as "retorting." There are two basic ways of retorting: surface methods involve mining and crushing the shale and heating it above ground in a manner similar to conventional refining, while *in situ* methods involve heating the shale in the ground and extracting the resulting hydrocarbons through wells.[8]

More than 25 companies are working to develop oil shale in the United States, including oil majors like ExxonMobil, Chevron, and Shell, as well as more focused companies like American Shale Oil LLC (AMSO) and Oil Shale Exploration Company (OSEC).[9] Table 1 (page 6) lists companies actively working on oil shale projects on private or leased land.

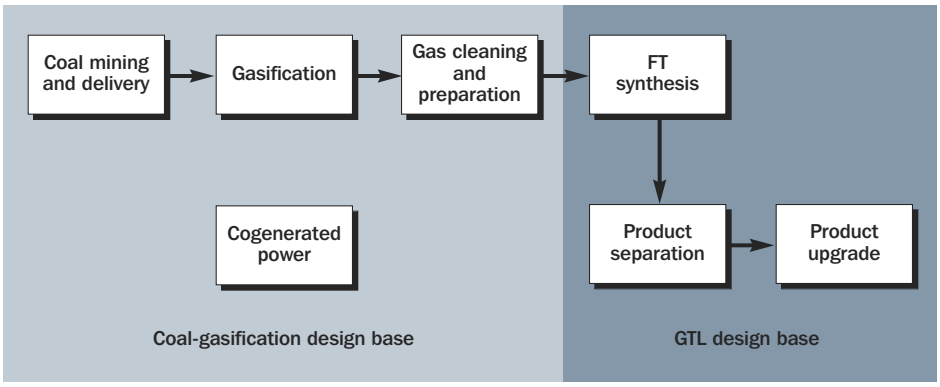
TABLE 1: Select Oil Shale Projects in the United States[10]		
Company	**State**	**Lease Type**
American Shale Oil LLC (AMSO)	CO	BLM 1st Round
AuraSource, Inc.	UT	Applied for BLM 2nd Round
Chevron	CO	BLM 1st Round
Eco-Shale/Red Leaf Resources, Inc.	UT	Private
EnShale, Inc.	UT	State
Exxon Mobil	CO	Private & Applied for BLM 2nd Round
Great Western Energy, LLC	UT	State
Independent Energy Partners	CO	Private
Millennium Synfuels, LLC	UT	State
Mountain West Energy	UT	State
Natural Soda Inc.	CO	Applied for BLM 2nd Round
Oil Shale Exploration Company (OSEC)	UT	BLM 1st Round
Shell Exploration and Production Co.	CO	Private & BLM 1st Round (3)

Coal-to-Liquids

CTL, as the name suggests, involves converting coal into liquid fuels. CTL production processes have been around for nearly 100 years. CTL use in Germany peaked in the 1940s, South Africa has been using the technology since the 1950s, and China has begun ramping up the use of CTL. In the U.S., the government promoted the development of CTL in the 1970s, shelved the projects when the price of oil fell in the 1980s, and has resurrected its interest in CTL technology over the past few years.[11]

The "indirect liquefaction" CTL process involves gasifying the coal at elevated temperatures and pressures to produce syngas and carbon dioxide, removing sulfur compounds and mercury from the syngas, releasing or capturing the CO_2, reacting the syngas with catalysts in a Fischer-Tropsch (FT) reactor to form a range of hydrocarbons, removing additional CO_2, and then upgrading and refining the hydrocarbons to produce synthetic diesel fuel and naptha.[12] (see Figure 2) An alternative indirect process is the Methanol to Gasoline (MTG) approach, in which the coal is gasified to produce syngas, the syngas is converted to methanol, and the methanol is made into gasoline.[13] Other carbon-containing feedstocks, such as biomass, can be used in addition to coal in either process.[14] (China has been pursuing a direct liquefaction approach that requires a high-temperature chemical reaction, hydrogen gas, and a catalyst to produce low-quality liquid fuels that would be expensive to make compliant with U.S. purity standards.[15])

Figure 2: Simplified Fischer-Tropsch CTL Process Schematic



Source: Bartis et al, RAND, 2008

At least a dozen CTL projects have been proposed or are under development in the United States (see Table 2), with projected costs per plant ranging from $2 billion to $7 billion. If all these projects come to fruition, the amount of liquid fuels produced would total approximately 170 million barrels per year; the EIA, however, projects that CTL production in the U.S. will rise from virtually no production today to only about 250,000 barrels per day (more than 91 million barrels per year) in 2035.[16]

TABLE 2: Select Coal-to-Liquid Projects in the United States

Company	Project	State	Location	Size/Output	Cost	Investment
Alaska Natural Resources-to-Liquids[20]	Beluga Plant	AK	Cook Inlet	80,000 barrels/day	$5 billion	Company: $1.5 million
American Clean Coal Fuels[21]	Illinois Clean Fuels	IL	near Oakland	400 million gallons/yr		
American Lignite Energy[22]	American Lignite Energy	ND	Western N.D.	460 million gallons/yr	$4 billion	State: $10 million
Australian-American Energy/Crow Nation[23]	Many Stars CTL	MT	Crow Reservation	50,000–125,000 barrels/day	$7 billion	
Baard Energy[24]	Ohio River Clean Fuels	OH	Wellsville	52,000 barrels/day	$6 billion	Investors: $5 million
Clean Coal Power Operations[25]	Clean Coal Power Operations CTL Plant	KY	Paducah	40,000 barrels/day	$7.6 billion	State: $550 million
Drummond Coal[26]	Drummond CTL Plant	IL	Montgomery Cty	48,000 barrels/day	$3.6 billion	
Fairbanks Economic Development Corporation[27]	Fairbanks Economic Development Corporation CTL	AK	Fairbanks	20-40,000 barrels/day	$2-6 billion	FEDC: $550,000
Medicine Bow Fuel & Power (DKRW)[28]	Medicine Bow Plant	WY	Medicine Bow	21,000 barrels/day	$2.7 billion	
Nuclear Solutions/Kentucky Fuel Associates[29]	Fuel Frontiers Plant	KY	Muhlenberg Cty	72 million gallons/yr		County: $625 million
Rentech Inc.[30]	Natchez CTL	MS	Natchez	30,000 barrels/day		State: $2.75 billion
TransGas Development Systems[31]	TGDS CTL plant	WV	Mingo Cty	6.5 million barrels/yr	$3 billion	

Major companies involved in CTL development, in addition to some of the oil majors like Shell, include: Rentech, which has a proprietary FT technology ("the Rentech process") and is building or planning several CTL facilities, including the Natchez Project in Mississippi;[17] Baard, which is developing a CTL facility in Ohio;[18] and DKRW, which is developing a CTL facility in Wyoming.[19]

KEY INVESTOR RISKS FROM DIRTY FUELS

Investors face risks from oil shale exposure through their public equity investments in the major oil companies and their holdings in other related companies. They may also face risks through private equity and other forms of development capital. For CTL, investors are similarly engaged via public equity holdings and some private equity investment; the financing picture may also include some fixed income investments (to the extent bonds are involved).

Investor exposure can be significant, although due to limited disclosure, it can be difficult to assess. To give some sense of some of the figures in play:

- ExxonMobil spent $1 billion on failed oil shale development efforts in the 1970s,[32] and Shell's recent agreement to develop oil shale in Jordan is projected to cost $20 billion or more over that project's first two decades.[33]
- Rentech's Natchez CTL Project in Mississippi was approved for up to $2.75 billion in bonds in 2007,[34] and that same year the company sold stock to raise about $55 million to fund long lead-time expenditures and site-preparation costs to convert its East Dubuque, Ill., fertilizer plant to a coal-to-liquid fuels refinery – a conversion process that could ultimately cost at least $1 billion.[35]

Given potential investor exposure to oil shale and CTL endeavors, it is important for investors to understand some of the risks they face from their investments in companies developing these resources. These risks stem from uncertainties about resource availability, technological readiness, market and stakeholder reactions, and regulatory directives.

Water Constraints

Oil shale and CTL processes both generally require a great deal of water – a resource that can be in limited supply in critical areas such as the relatively arid western states and that can therefore be a constraint on development.

Oil shale

"[W]ater availability was and continues to be viewed as a major constraint on large-scale oil shale development in the Green River Formation."

- RAND study

Oil shale extraction and processing generally require several barrels of water to produce a single barrel of oil.[36] According to Shell Oil, the *in situ* retorting process involves a 3-to-1 water-to-oil ratio, while surface retorting involves a 5-to-1 ratio, although those ratios may improve by the time oil shale production achieves commercial viability in 10-15 years.[37] The National Oil Shale Association argues that the figures are closer to 2-to-1 for surface retorting and 1.7-to-1 for *in situ* retorting (with a great deal of uncertainty surrounding the actual water needs of particular technologies and operations),[38] and ExxonMobil believes it can make its *in situ* process work with about a 1.5-to-1 ratio.[39] Nevertheless, as stated in a 2005 RAND study, "water availability was and continues to be viewed as a major constraint on large-scale oil shale development in the Green River Formation."[40] The U.S. Government Accountability Office similarly recently suggested that the size of the oil shale industry in Colorado and Utah may be limited by water availability.[41]

Even if there is enough water to satisfy the needs of oil shale processing, the general scarcity of water in the regions where the shale deposits are located can lead to significant public opposition to oil shale development plans, potentially leading to delays or other hurdles.[42] As the U.S. Department of Energy's National Energy Technology Laboratory explained in 2006:

> *The vast oil shale resources of Colorado, Utah, and Wyoming will undoubtedly be the initial target for industry development. These resources lie within the Upper Colorado River Basin where several years of drought have raised public awareness regarding the river's ability to sustain long-term regional development and meet rising water demands. Water availability and water quality concerns influenced past oil shale development in the 1970s and 1980s and are likely to do so again as industry proceeds with renewed development plans in the Western United States. … The Colorado River and its tributaries are critical resources in the semiarid region.*[43]

Water rights in the region are based on the doctrine of prior appropriation (first in time, first in right), with rights apportioned to particular parties for a specified amount of water for a specified use, and with a hierarchy of usage in times of shortage. Many potential developers of oil shale already have water rights that were acquired directly through the prior appropriations system or that were bought from agricultural users, although determining the extent of developers' water rights is challenging because the information is considered proprietary.[44] Western Resource Advocates estimates that oil shale developers have established conditional water rights associated with more than 200 separate structures (pipelines, reservoirs, etc.) in the Colorado and White River Basins that collectively would enable diversion of more than 10,000 cubic feet per second of water and storage of more than 1.7 million acre-feet.[45]

Rising populations in the region have led to increasing water demand for electric power, recreational use, and ecosystem restoration, while extended droughts have reduced river flows, suggesting that "[s]ignificant water withdrawals to supply an oil shale industry may conflict with other uses downstream and exacerbate current water supply problems."[46]

For instance, in February 2010, Shell announced it was abandoning its effort to obtain a 15-billion-gallon water right from Colorado's Yampa River – the state's last river with unclaimed water – citing project delays due to the economic downturn.[47] Potentially also playing a role was the fact that Shell's bid had generated opposition letters from 25 federal, state, and local agencies, as well as businesses and environmental groups; applications for water rights usually generate seven or fewer letters.[48]

Coal-to-liquids

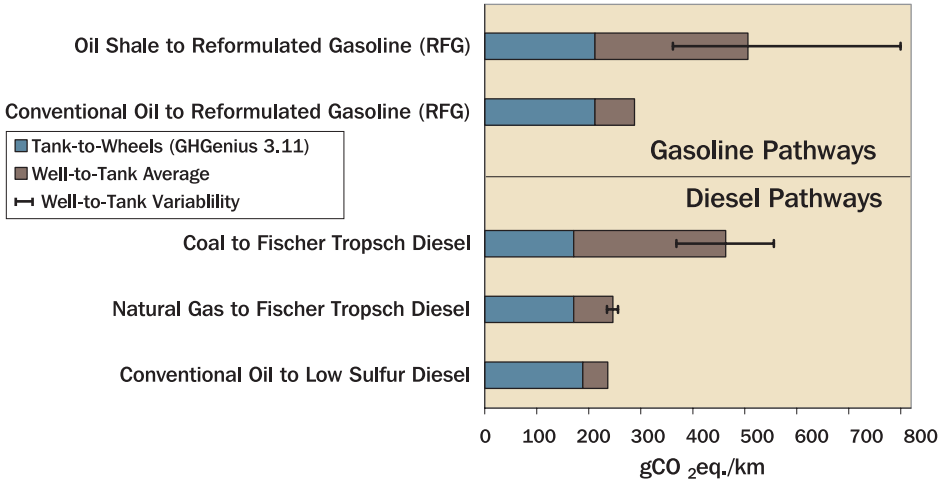
Coal liquefaction can similarly require significant volumes of water, with the exact amount depending on variables such as the facility's design, the type of gasifier used, the properties of the coal used, and the average ambient temperature and humidity. Estimates of water requirements for coal liquefaction range from a 5-to-1 ratio to more than 7-to-1.[49] Water used for cooling that is lost through evaporation tends to be the largest source of water consumption;[50] use of air cooling instead of water cooling can potentially reduce water requirements to less than 1 barrel of water per barrel of Fischer-Tropsch product.[51]

Water usage issues for CTL can include region-specific considerations. As with oil shale, withdrawals of surface or groundwater in semiarid Western states will compete with agricultural and ranching uses. In the Midwest (Illinois Basin) and Eastern (Pennsylvania / West Virginia) states, competition for water comes from electric power generation and public supply for consumption, although the absence of established water rights somewhat lessens the risks for developers in these regions.[52]

Regulatory Risks

Both oil shale and CTL face significant risks from current and potential regulations. The most apparent risks to these highly carbon-intensive fuels stem from regulations that seek to address climate change and to limit carbon dioxide emissions.

Figure 3: Well-to-Wheels Greenhouse Gas Emissions of Fuels



Adapted from: McKellar et al 2009

Oil shale and CTL both have high greenhouse gas (GHG) emissions associated with their production and use, which could present a risk to their marketability in a carbon-constrained economy (see Figure 3). Estimates of the carbon burden of these fuels vary. The Task Force on Strategic Unconventional Fuels estimates that about 670 pounds of carbon (2,450 pounds of CO_2) would be emitted for every barrel of Fischer-Tropsch liquid product produced, compared to approximately 250 pounds of carbon (900 pounds of CO_2) per barrel of petroleum fuels.[53] Some studies have found that CTL fuels have higher lifecycle emissions even with carbon sequestration, while others have found no difference or that CTL with sequestration results in lower emissions.[54] Lifecycle emissions for oil shale using an *in situ* process have been estimated at 21 to 47 percent greater than for conventional petroleum fuels, while the estimate for a typical surface retort was 150 to 500 percent greater.[55] One study comparing numerous lifecycle analyses demonstrated that surface retorting of oil shale was 2 to almost 8 times more GHG intensive and CTL was 4 to almost 8 times more GHG intensive than conventional fuels.[56]

Assuming the estimates of elevated GHG emissions for oil shale and CTL are reaffirmed and verified, then development of these fuels could face risks from regulations such as:

- ***Lifecycle emissions requirements:*** Section 526 of the Energy Independence and Security Act of 2007 forbids any federal agency (including the Department of Defense) from entering into a contract to procure "alternative or synthetic fuel" unless the lifecycle greenhouse gas emissions of the fuel are less than or equal to conventional fuels.[57] Attempts have been made to repeal or modify this provision, including in May 2010, when the House of Representatives adopted an amendment that would allow federal agencies to buy commercial fuel if less than half of it comes from alternative fuels with lifecycle greenhouse gas emissions that exceed conventional fuels.[58] Nevertheless, unless the section is actually repealed, section 526 could limit the market for oil shale and CTL developers.

- ***Low-carbon fuel standards:*** Low-carbon fuel standards aim to regulate and reduce the lifecycle carbon intensity of transportation fuels. In 2009, the California Air Resources Board adopted an LCFS to reduce the average carbon intensity of transportation fuels used in the state by 10 percent by 2020.[59] Other states are exploring following California's lead. For example, in December 2009, the Northeastern and Mid-Atlantic states agreed to develop a regional LCFS to be finalized by 2011.[60] The Midwest and Western states are also exploring low-carbon fuel standards.[61] As with section 526, these requirements could significantly limit the market for oil shale and CTL developers.
- ***Comprehensive climate and energy legislation:*** A comprehensive climate and energy bill passed the House in June 2009 but stalled in the Senate in August 2010. Though it is very unlikely that legislation that puts a price on carbon emissions will be approved in the near term, many analysts believe that carbon-limiting legislation is inevitable in the longer term. Although it is unclear how such legislation would apply to the transportation sector, it is clear that such legislation could increase the cost of producing fuels from oil shale and CTL.[62]

Carbon-related regulations are, of course, not the only ones that pose risks to CTL and oil shale development, as other environmental safeguards and rules about the level of royalty rates could also constrain commercialization and development.[63]

CCS Uncertainty and Costs

Oil shale and CTL will both be very dependent on carbon capture and sequestration (CCS) if they are to survive and thrive in a carbon-constrained economy. But CCS technologies still carry great uncertainty, as well as high costs.

- ***Technological and process uncertainty:*** Capturing and sequestering huge volumes of CO_2 is theoretically possible but has not yet been established as commercially viable. (For CTL, capturing CO_2 is an inherent part of the process, but questions remain about transport and storage.)[64] Further testing on a large scale is necessary to resolve both technical and policy questions.[65]
- ***Risks of public opposition:*** Public reaction to carbon storage sites has been mixed, with some storage projects (particularly those in coal-friendly regions) receiving strong support but others facing protests that have complicated or derailed them, including storage projects in Ohio, New York, and Germany.[66]
- ***Increased fuel costs:*** CCS requirements will likely raise the costs of the fuels. CCS could increase the cost of fuel from oil shale by about 15 percent,[67] and just sequestering the captured CO_2 could add $5 a barrel to the price of the CTL-derived fuel.[68]
- ***Uncertainty about international politics, carbon prices, and public financing:*** According to a recent International Energy Agency report, the commercial viability of CCS is reliant on investment of another $5-6.5 billion each year for the next decade by G-8 governments, international agreement on a mechanism to price carbon, and a higher CO_2 price than the $15-35 per ton range that currently exists in the EU.[69] (At CO_2 prices in that range, "a sneeze in world oil prices could derail a CCS project."[70]) Such achievements are by no means a given.

- ***Constraints on markets for captured CO_2:*** There are likely to be market constraints on the CO_2 that is captured. As RAND noted, new CTL facilities with CCS may initially be able to use their captured CO_2 to satisfy the market for CO_2 use in enhanced oil recovery (EOR), but "it seems likely that, at a production level of several million barrels of CTL fuels per day, the EOR market would be saturated, and additional CO_2 emissions would entail bearing either the added costs of CO_2 storage or the costs of other CO_2-mitigation and -offset measures."[71]

Core Technological Uncertainty

Apart from the issue of capturing and storing carbon dioxide, both oil shale and CTL (although particularly oil shale) rely on uncertain technological development and commercialization that is core to their processes.

Oil Shale

As noted earlier, oil shale technology is still in the early stages of development, even though it has been recognized as a potential U.S. energy resource since the mid-1800s. Surface retorting technology has not been applied successfully in the U.S. at a commercially viable level, and although the technology has been in development for several years, further development and testing is required.[72] According to a draft report from the National Energy Technology Laboratory:

> *While the technologies associated with mining oil shale (either underground or open pit) are generally considered to be commercially proven, there remains some uncertainty about the commercial-scale viability of the various surface retorting technologies for converting the organic material (kerogen) of oil shale into "oil" suitable for refining. The major technical challenges (not environmental) to commercial development include relatively low process energy efficiency (net energy balance) and relatively high net water requirements as compared to conventional oil production. The technologies being developed for* in situ *recovery of oil from oil shale (either underground or open pit) are technically and commercially unproven, and face the same energy efficiency challenges. In addition,* in situ *technologies face very process-specific challenges. For example, Shell has been working to perfect a reliable downhole heater for its ICP process. In addition, Shell has been working to prove its freeze wall system for isolating the* in situ *retort to prevent groundwater contamination.*[73]

> ***"I don't know when we'll see commercial development on public lands. It's an industry that is not ready for prime time."***
>
> *- DOI senior legal advisor*

Similarly, Shell's government affairs manager said last year that its *in situ* extraction technology is still being developed and explained that: "We're still in the research stages, and there are some things we won't have final answers on for some number of years."[74] Shell also indicated in 2008 that "the earliest a commercial decision would be made is in the middle of this decade and possibly later depending on … the outcome of research activities."[75] ExxonMobil has similarly said that it does not foresee production from oil shale for another 10 to 24 years.[76] And a Department of the Interior legal advisor told an energy conference earlier this year that "I don't know when we'll see commercial development on public lands. It's an industry that is not ready for prime time."[77]

The uncertainties about and continued testing and development of new technologies and processes for producing oil from oil shale leaves a great deal still unknown – the amount of the resource that is recoverable, the efficiencies and costs of various methods, and the effects of various technologies on the costs of final products (and

thus the competitiveness of oil shale).[78] And this uncertainty creates risk for investors. As the Task Force on Strategic Unconventional Fuels put it, "[d]emonstration of first-generation technologies will be required at a commercially-representative scale before significant private investment will lead to commercial production."[79] The Task Force further explained that "[t]echnology uncertainty is the largest single risk factor associated with oil shale development. This uncertainty remains even after 50 years of government and industry research to develop a commercially viable retorting technology."[80]

Coal-to-liquids

CTL technologies are much further along than is the case with oil shale, leading one report from the National Energy Technology Laboratory to suggest that CTL technology "is commercial and ready for deployment now."[81] However, while many of the underlying technologies are proven, combining them into a commercially viable CTL plant in the U.S. is not.[82]

A RAND analysis points out that "[m]any new U.S. CTL plants will be pioneer process plants because they will use new configurations of existing technologies drawn from the IGCC [integrated gasification combined cycle] and GTL [gas to liquid] technology bases" and that challenges have emerged in the evolution of these underlying technological bases that provide insight into the challenges a new CTL plant might face. For example, Sasol experienced unexpected complications and performance shortfalls in starting up a Fischer-Tropsch GTL plant in Qatar, which extended the startup period to more than a year and a half and led to much higher start-up costs. The RAND analysis notes that "FT CTL plants built in the United States will be as technically complex and challenging with similar performance risks."[83] The National Petroleum Council similarly observes: "Given that modern CTL plants will likely have significantly new systems and processes from the previous generation plants built in South Africa and Germany, it is reasonable to expect that the first new generation CTL plants will be encumbered with unanticipated technical and operational problems."[84]

> ***"Given that modern CTL plants will likely have significantly new systems and processes from the previous generation plants built in South Africa and Germany, it is reasonable to expect that the first new generation CTL plants will be encumbered with unanticipated technical and operational problems."***
>
> *- The National Petroleum Council*

Similarly, the Task Force on Strategic Unconventional Fuels observes that "[t]he integration of advanced coal gasification technologies and advanced FT synthesis technologies that have been developed over the past twenty years has not been attempted. This poses significant technical risks that may be considered unacceptable by potential process developers and investors."[85]

Market Risks

The economic competitiveness of oil shale and CTL depends principally on the global price of oil and on the costs associated with building and operating facilities.

- ***Oil prices:*** For both fuels, the key variable in competitiveness is the price of oil. As noted earlier, sporadic attempts at commercial oil shale efforts during periods of high oil prices or high concern about oil supplies repeatedly failed once oil prices fell again.[86] During the early to mid 1980s, the U.S. government sponsored a Synthetic Fuels Corporation to stimulate production of shale oil and coal-derived fuels, but the price of oil plummeted in the mid-1980s, and the government closed SFC in 1986. Reviewing the history of the SFC, a RAND analysis notes that "the fact that oil prices did not trend inexorably higher (as expected) offers an important caution in current assessments of unconventional-fuel potential."[87] High oil prices have not proven to be sustainable, as they put a drag on economic growth and spur investment in energy efficiency and alternative fuels, which reduces demand.[88]

"World oil price volatility poses a significant market risk to the deployment of CTL facilities."

- Task Force on Strategic Unconventional Fuels

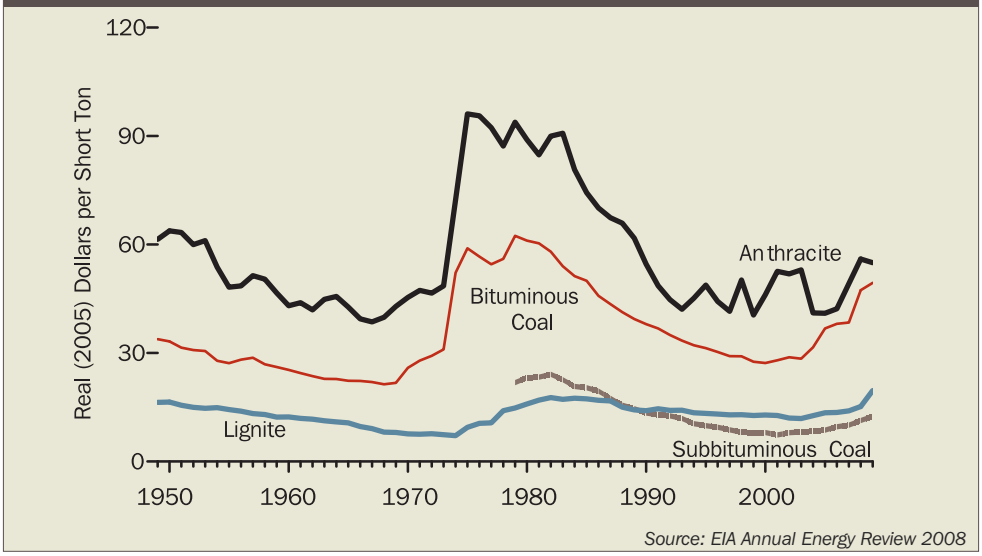
In general, oil shale and CTL are not competitive in an economic environment of low oil prices. The Energy Information Administration's 2010 *International Energy Outlook* projects that in a Low Oil Price scenario, shale oil is virtually non-existent through 2035 and CTL grows only from 0.2 million barrels per day in 2008 to 0.3 in 2035; in the Reference case, shale oil slowly grows to 0.4 and CTL to 1.4 million barrels per day by 2035, while in the High Oil Price scenario, shale oil again grows to 0.4 but CTL grows to 3.3 million barrels per day.[89] The trajectory of world oil prices therefore strongly determines the economic competitiveness of CTL and oil shale fuels; as the Task Force on Strategic Unconventional Fuels observes, "[w]orld oil price volatility poses a significant market risk to the deployment of CTL facilities."[90] Estimates vary with respect to the oil price range in which these fuels are competitive, assuming the technological and regulatory uncertainties described earlier are addressed. Some studies show that CTL fuel becomes viable when the price of oil exceeds $40-55 per barrel.[91] Oil shale from surface retorting may not be profitable unless oil prices are in the $70-95 per barrel range, though *in situ* oil shale (if technically viable) may be competitive at much lower prices.[92] (These competitiveness estimates do not take into account potential CCS costs or carbon prices, which would raise the price-per-barrel competitiveness level.[93])

- ***Capital and carbon costs:*** Along with oil price volatility, oil shale and CTL facilities also face challenges from their high up-front expenditures. The exact costs for building a commercial-scale CTL plant in the U.S. are unknown, but rough estimates are that a CTL plant producing 10,000 barrels per day (bpd) could cost $600-700 million to build, with the refining process being three to four times more expensive than for oil, while a 50,000 bpd plant could cost $3.5-4.5 billion.[94] A National Petroleum Council paper estimated CTL capital costs to be $60,000 to $130,000 per daily barrel, though it notes that "unanticipated technical and operational problems" in new U.S. first-generation CTL plants "entail[] risks and costs."[95] These high capital costs create considerable investment risk. If CTL ends up costing more than anticipated, it may not be cost-competitive even absent a carbon price; in the presence of a carbon price, CTL will be more competitive if CCS costs turn out to be low and oil prices high.[96] A RAND analysis found that "without CCS, CTL cost-competitiveness is vulnerable to CO_2 prices as well as to oil prices. With lower CTL [production] costs, CTL is more competitive, though a CO_2-emission cost above $30/ton and a return to more moderate longer-term oil prices would still cast a shadow over its competitiveness."[97]

  Production of oil shale is similarly "characterized by high capital investment, high operating costs, and long periods of time between expenditure of capital and the realization of production revenues and return on investment," and the significant uncertainties about the size of capital and operating costs for a first-generation commercial facility (likely in the billions of dollars), combined with oil price vulnerability and other uncertainties, "pose investment risks that make oil shale investment less attractive than other potential uses of capital."[98]

- ***Coal price:*** For CTL projects, coal price volatility and availability create potential risks. Coal price volatility has increased greatly over the past decade, with a 200 percent price spike in 2001 and a 300 percent spike in 2008.[99] (see Figure 4) In addition, economically recoverable American coal resources, while significant, may be markedly smaller than previously believed.[100] Price volatility and potentially smaller reserves suggest that investment analysis of CTL projects may require particular diligence to carefully assess the coal supply – its origins, quality, availability, and long-term price assumptions – and to test developer-generated data against government and various types of market-based information.

Figure 4: Coal Prices 1949-2008



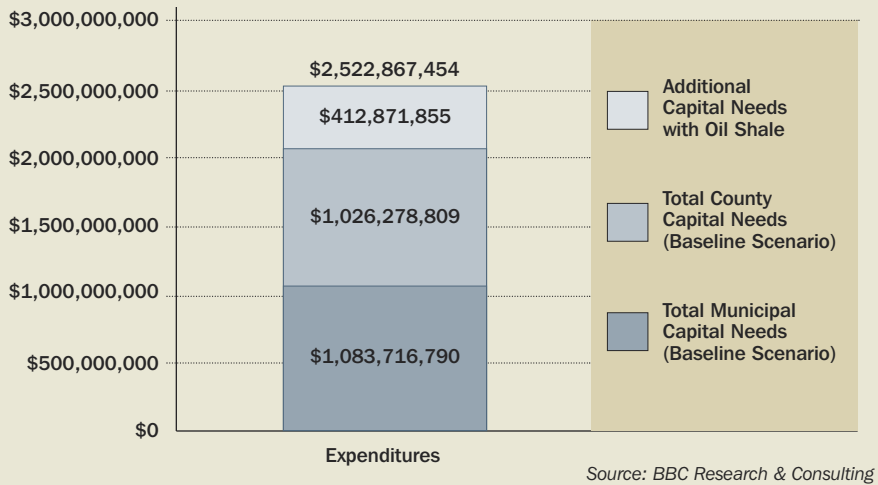
Source: EIA Annual Energy Review 2008

- ***Payback horizons:*** When investments have a long payback period, investors should pay greater attention to the technological, regulatory, market, and other risks presented by the project. Oil shale, in particular, has a long payback period. As noted, production of oil shale is "characterized by high capital investment, high operating costs, and long periods of time between expenditure of capital and the realization of production revenues and return on investment."[101] A 2005 RAND study estimated that oil shale development would not reach the production growth phase for at least 12 years, a production level of 1 million barrels a day for more than 20 years, and a level of 3 million barrels a day for more than 30 years.[102] CTL likely has a shorter payback period – the National Energy Technology Laboratory estimates it at about 5 years.[103]

- ***Reliance on government support:*** Like other relatively nascent energy technologies, CTL and oil shale will be somewhat reliant on government subsidies and involvement to ensure adequate return on investment (ROI). For instance, Section 1703 of the Energy Policy Act of 2005 established loan guarantees for coal gasification projects, up to 80 percent of the project cost, which could lead to an 11 percentage point increase in ROI for CTL projects.[104] The 2008 Emergency Economic Stabilization Act expanded the tax credit for refinery property used to convert oil shale into liquid fuels and contained several tax credits for coal gasification plants and CTL fuels.[105] Given pressures to reduce government spending and to shift to a low-carbon economy, there is a risk that such government support mechanisms may cease.

- ***Reliance on public & private investment in supporting infrastructure:*** The success of investments in CTL and oil shale projects is often contingent on a broader series of public and private investment decisions concerning the infrastructure needed to support these projects. For instance, commercial development of oil shale could increase populations in counties in northwest Colorado by 50,000 people, requiring improvement or expansion of road systems, expanded public services, and other costs and measures that could be 20 percent above baseline needs, that would be difficult for existing towns and local governments to accommodate, and that could overwhelm northwest Colorado's rural public infrastructure. (see Figure 5) Addressing these additional needs would necessitate major financial investments and planning – but the uncertainty inherent in the boom-and-bust fossil fuel extraction business makes public and private decisions to invest in needed infrastructure more challenging.[106]

Figure 5: CO County & Municipal Capital Needs 2008-2035



Source: BBC Research & Consulting 2008

Risks from Public Opposition

As noted earlier, public reactions to some carbon storage projects and attempts to secure water rights have led to protests that have complicated or killed the efforts, and public opposition to development of oil shale and CTL could similarly derail, delay, or increase the costs of such development.

Such opposition could stem from the environmental impacts of oil shale and CTL – impacts that might cause reputational damage to companies developing these resources. CTL is, of course, reliant on expanded mining of coal – potentially hundreds of millions more tons of coal.[107] The tragic Massey coal mine deaths in West Virginia earlier this year highlight some of the potential safety and reputational risks involved in such a pursuit. Beyond the safety concerns, coal mining also has huge impacts on the water, air, and land that could generate opposition. Oil shale mining and processing can have similar impacts, including land disturbance, air pollution, and water contamination.[108]

Apart from the impacts of mining, public opposition may also be based on concerns about climate change or on perceptions of the risks the CTL and oil shale facilities themselves pose to human health, safety, and the environment (comparable to the increasing public opposition to siting coal-fired power plants).[109]

This public opposition may at times take the form of litigation. For instance, environmental public interest groups have filed lawsuits concerning Baard's Ohio CTL facility, challenging the wetlands fill, air pollution, and water pollution permits; Baard blamed the delays and uncertainties these lawsuits would cause in announcing that it had withdrawn its application for a critical loan guarantee from the Department of Energy.[110] Similarly, environmental public interest groups have filed suits challenging a plan by the federal government to open almost 2 million acres of Western land to oil shale development.[111]

RECOMMENDATIONS FOR INVESTORS

Each of the risks described in this report, as well as others, may carry considerable independent weight in any risk/reward investment decision. Cumulatively, the factors may give pause to many investors.

Given these wide-ranging risks, investors should:

- ***Engage with relevant companies:*** Shareholder engagement with companies can help investors understand the risks that companies are assuming related to oil shale and CTL, as well as the ways in which companies are mitigating those risks. Relevant companies clearly include CTL developers and those in the oil and gas sector, but investors should also engage with companies that are end users of these fuels, such as fleet operators and airlines.
- ***Pay attention to potential risks from state and municipal bonds in their fixed income portfolios:*** Financing for development of these fuels can sometimes come from state and municipal bonds. For example, as noted earlier, the Mississippi Business Finance Corporation approved Rentech's Natchez CTL Project to apply for up to $2.75 billion in bonds in 2007. Investors should examine their fixed income portfolios to assess the extent to which they are exposed to risks from bonds used to support development of these fuels.
- ***Advocate for public policies:*** Some of the risks and uncertainty that oil shale and CTL face could be addressed by a clearer regulatory framework. Investors should advocate for policies that provide long-term investment certainty, such as a national carbon price and low-carbon fuel standard.

CASE STUDY

BAARD'S OHIO CTL PROJECT

Through its affiliate Ohio River Clean Fuels, LLC, Baard Energy began developing in 2003 a $6 billion, 53,000 barrel-per-day, Coal and Biomass-to-Liquids facility in Wellsville, Ohio. Project design calls for 20 percent equity and 80 percent debt, but Baard has had difficulty securing both public and private financing. Throughout the project's seven-year history, the company has announced or disclosed unspecified relationships with financing partners and sought federal and state support for aspects of the project. For instance, in October 2010, Columbiana County development officials announced that Planck LLC would provide money to purchase options on land for a coal refinery prior to the end of 2010; the transaction, valued at an estimated $5 million, would secure land for the Baard project, but no further details are available.[112]

Baard will use both coal and biomass as feedstock for a Fischer-Tropsch (FT) catalytic reactor that will produce low-sulfur diesel fuel, jet fuel, liquid propane gas, and naptha. The company proposes to capture 85 percent of the carbon dioxide produced during the refining process and pump it to nearby oil fields for enhanced oil recovery.[113]

Baard plans to sell up to half of its jet fuel to the Department of Defense; however, the DOD will not be able to do so unless Section 526 of the Energy Independence and Security Act is repealed, or the project's carbon capture technology is proven. Baard is also exploring as yet uncommitted, relationships for the sale of diesel, naptha, and other products.

The Baard Project, like any CTL undertaking, presents investor risks that are both specific to it and illustrative of the broader challenges that face this new investment opportunity. Examples of these risks include:

- ***Technological*** – Baard will pioneer a process combining complicated gasification and gas-to-liquid technologies into one of the United States' first commercially viable CTL plants, and technical and operational problems are expected. Moreover, the project is designed to accommodate a 30 percent biomass flexible fuel and, according to the DOE, there has been limited testing of this burn strategy, and several technical areas "must be addressed."[114]
- ***Uncertain Costs*** – Cost estimates for the Baard Project have fluctuated from $5 billion to $6.8 billion between September 2007 and February 2010. Baard estimated the cost at $6 billion in its February 2010 application to the State of Ohio. DOE's project cost for a similar-sized CTL project in 2007 was $4.5 billion.[115] A changing market for heavy capital construction, the use of new technologies, and uncertain government policy drive the cost uncertainties.

- ***Coal Supply & Cost*** – Baard's business plan is based on a surplus of low-cost Pitt #8 coal, but this type of coal may not be as available, or as cheap, as Baard assumes. The company's February 2010 Project Summary identifies Pitt #8 coal as its preferred fuel source, and its feedstock supply analysis suggests that "the Project will not only have access to significant coal reserves that are currently idled, but it also expects to be able to procure this coal at a discount to coal with lower sulfur content."[116] However, a recent earnings call for a leading coal producer with heavy Pitt #8 reserves, CONSOL Energy, announced significant movement of Pitt #8 coal to China for metallurgical markets for 2010-2011, plans to expand in the Port of Baltimore for greater future tonnage, and a rising price environment.[117]
- ***Government Financing*** – CTL projects rely on government subsidies and involvement to ensure adequate return on investment. In March 2009, however, Baard withdrew its funding application from the U.S. Department of Energy.[118] The Ohio Air Quality Development Authority Board, renewed its pledge in March 2010 to issue up to $4.8 billion in bonds to assist in financing the project.[119] The state is not obligated to pay the debt, however; it would offer the bonds for sale through the private bond market. Investors will need to fully appreciate the workings of multiple levels of government and private-sector negotiation processes, which may add time and cost to the project on the development end and compliance risk to the longer-term transaction.
- ***Environmental Impacts & Public Opposition*** – The Baard Project has faced public opposition and litigation over its air pollution permitting. Environmental groups assert that the air pollution permit granted by the state would let the plant emit more pollution than the federal Clean Air Act allows. Ohio has a heavy concentration of coal plants and already struggles with air pollution compliance.[120] Environmental groups also challenge the project's commitment and technological ability to capture and sequester 85 percent of the carbon from the coal gasification process, as proposed by the company.[121]
- ***Time & Inconsistency*** – Due to its handling of the risks outlined above, Baard has had mixed success at ensuring that the project is built and operational on time and on budget. The company recently asked to delay a hearing on the case challenging the legality of Ohio EPA's air permit approval because it lacked funding to pay experts.[122] Recent disclosure of public documents show the developer has been sued by an engineering firm for failure to pay for services rendered.[123] The difficulty of maintaining consistency and financial commitments to the development team are practical risks encountered by first-generation development projects.

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