Strategy 4:

Develop a Coal-to-Liquids (CTL) Industry in Kentucky to Replace Petroleum-Based Liquids

GOAL **Kentucky will develop a CTL industry that will use 50 million tons of coal per year to produce four billion gallons of liquid fuel per year by 2025.**

The goal for *Strategy 4* is part of Kentucky's Alternative Transportation Fuels Standard (ATFS), which states that Kentucky can displace 60 percent of its reliance on foreign petroleum by utilizing fuels such as those derived from biomass and coal, plug-in hybrid vehicles, and compressed natural gas.

INTRODUCTION

With its vast coal resources, proven support from elected officials, and dedicated research and development program, Kentucky is uniquely positioned to develop a coal-to-liquid fuels industry that can serve as an engine for economic growth, while helping to reduce our dependence on foreign oil.

Transportation in Kentucky, like transportation in the rest of the United States, is primarily dependent on liquid fuels, and most of these fuels are derived from petroleum. Other products such as lubricants, liquid propane gas, and chemicals for the plastics industry are also made from crude oil, but by far the largest percentage is processed into liquid transportation fuels. Any analysis that concludes that an alternative to petroleum-based fuels is economically viable is equally valid for other products made from crude oil.

The price of crude oil has about doubled in the past year (Energy Information Administration, 2008). While price increases of this nature have happened in the past, crude prices have always come back down after a peak. Is what is happening now a similar spike which will subside, or is it likely that oil prices will remain high indefinitely? Some analysts point to such influences as speculation and fear of supply disruptions as feeding high crude oil prices, and predict that crude oil prices will once again retreat (Williams, 2007). While speculative and emotional factors may be influencing current prices, the overall market situation indicates that high crude oil prices are here to stay.

Peak Oil

The term "peak oil" is frequently seen in articles about energy supply, and is frequently blamed for increasing crude oil prices. In simplest terms, peak oil is the point at which world-wide oil production will peak, or has already peaked, depending on who is doing the calculation (Deffeyes, 2003). Peak oil is reached when the rate of discovery and production from new fields plus production from existing fields declines because there are not enough new fields being discovered and exploited to compensate for the decline in production from existing wells that are currently being depleted. Some experts such as Houston-based energy analyst Martin Simmons also make the argument that Saudi Arabia (and in some cases, other countries) may be overstating their reserves and that the problem of declining oil reserves is more imminent and desperate than we realize.

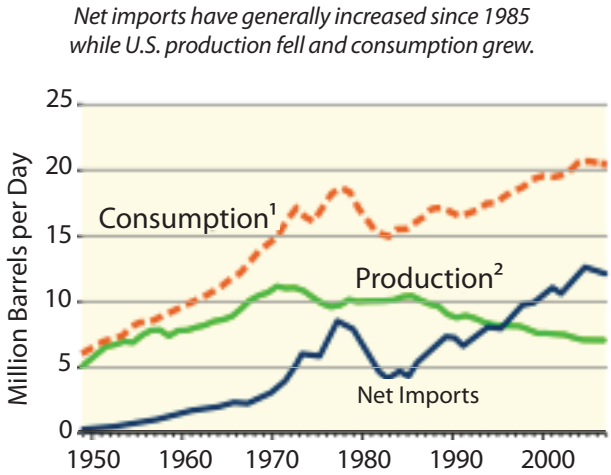
Others believe there are vast reserves of oil available to be recovered. The problem is not the amount of oil, but rather the amount of oil available that can be easily (and relatively inexpensively) extracted and processed. If the trillions of barrels of oil equivalent available in oil shales and tar

sands are accounted for, there is no shortage of oil (DOE, 2004). The cost of recovering this oil, or oil from deep ocean deposits or other remote, harsh extraction environments like the Arctic, is much higher than traditional oil extraction. Furthermore, the number of refineries that can process these non-traditional oils is not sufficient to supply world demand for liquid fuels.

The cost of oil extraction, which for years was constantly declining because of improved extraction techniques and productivity improvements, is now on the upswing with no reversal of the trend in sight.

Inelastic Demand

A second indication that high crude oil prices are here to stay is that the overall demand for oil is relatively inelastic; in other words, people will pay the price for the fuel, seemingly no matter how high the price per barrel goes. As stated above, the supply of inexpensive oil is dwindling. Overall demand for oil, though, is increasing worldwide. For instance, consumption in developing nations in Asia, the Middle East, and Latin America is expected to rise 3.7 percent per year between 2008 and 2013, more than offsetting a slight decline in demand in developed nations (International Energy Agency, 2008). So even if high oil prices do depress demand in the short run, in the long run, demand will continue to trend upward.



1 Petroleum products supplied is used as an approximation for consumption.
2 Crude oil and natural gas plant liquids production.
Source: Energy Information Administration, Annual Energy Review 2007-Table 5.1. (June 2008)

Source: Energy Information Administration, June 2008 Import Highlights: August 13, 2008

Figure 17: Consumption, Production and Import Trends for Petroleum (1950-2007)

Availability of Substitute Fuels

A third factor that will tend to support continued high oil prices is the lack of available, acceptable substitutes for petroleum-based fuels. There have been other oil price spikes in the past (for instance, in the early 1980s), and other times when adequate supplies of oil have been unavailable (World War II and the OPEC oil embargo in the 1970s) and have created activity in pursuing alternate sources of liquid fuels, primarily from coal. The threat to demand for petroleum that coal presented has always helped push crude oil prices back to a level where coal fuels could not compete economically, and governments and private industries that had initiated coal fuels projects ceased supporting those efforts.

One notable example where pursuit of a substitute source of transportation fuels did not succumb to retreating oil prices was in South Africa. Because of their policy of apartheid (which triggered numerous calls for international trade boycotts of the country) and their lack of domestic oil reserves, South Africa made the strategic decision to develop their own internal coal-to-liquids industry to ensure that they would not be hostage to imported oil for their liquid fuels. SASOL, the name for what started as the South Africa Coal Oil and Gas Corporation, started producing automotive fuel in 1955 and now produces about 40 percent of South Africa's liquid fuel demands

from coal. Because of skyrocketing crude oil prices, SASOL intends to build a fourth CTL facility producing 80,000 barrels per day at an estimated cost of $5-$7 billion. In the last year profits at SASOL have risen 20 percent, and the share price of the company has more than tripled in the last three years (Schutze, 2008).

Impediments to Developing a Coal-to-Liquid Fuel Industry

In a market economy, availability of substitutes tends to keep the price of more or less interchangeable commodities on a par with each other, or at least at a stable ratio. So why is demand not shifting from fuels made from crude oil to liquid fuels made from coal?

There are three primary reasons. The first two are ones that have tended to stifle the industry before: Uncertainty over whether or not oil prices will remain high enough to make CTL facilities economically viable, and the high cost (in both dollars and time) of building the plants. The third reason is a new one which has begun to influence the development of CTL within the last ten years: carbon footprint.

Facility planners and the financial institutions that underwrite their projects do not use spot prices of oil as the basis for predicting the economic feasibility of CTL projects; they use predictive formulae. Until recently their predictions have not supported CTL plant development, but the number of projects now being considered both in the United States and worldwide indicate that those predictions are changing and should no longer present an impediment to CTL development. Numerous studies predict CTL projects will be profitable when crude oil is above $50 - $60 per barrel (Dapice, 2004; Schmetz, 2005; Bartis, 2007; Berg, 2007). There is no reason to believe that long-term prices of crude oil will drop and remain below that level.

High cost is still a factor due to congestion in the equipment manufacturing and construction sectors and escalating prices for construction materials. In 2006, the International Energy Agency (IEA) estimated capital costs of a one billion gallon per year CTL plant would be about $5 billion; however, more recent estimates have been up to 30 percent higher (Taylor, 2007; Zhihong, 2007; Schutze, 2008). All major industrial and manufacturing enterprises are facing the same cost escalations and time delays.

There are numerous steps that can be taken to improve the borrowing climate for the debt financed portion of a CTL project. Some of these measures include:

- A state guarantee to purchase some or all of the off-take from a facility, with or without a price floor to help ensure profitability of the plant.
- Cost-control of the facility's raw material through long-term guaranteed contracts with suppliers.
- Guarantees regarding timing of the permitting process.
- Assistance with direct payment for some of the preliminary design requirements. For example, a rule of thumb is that the cost of the front-end engineering design (FEED) is about one percent of the project cost, so on a $7 billion project the FEED would cost about $70 million. The state could help defray that cost.
- Project cost share, possibly awarded competitively to the most attractive projects.
- Investment tax credits.
- Statutory exemption from standard rules that grant a given electric utility a monopoly on providing retail electricity in a certain geographic area (e.g., allow a gasification project to "wheel" any electricity generated from waste heat directly to a user at rates more favorable than the gasification project would get from the local utility).

- Provision of bond funding, or bond guarantees.
- Regulatory changes to ease right-of-way acquisition through eminent domain actions.
- Preferential funding for infrastructure requirements (such as local road improvements) that will facilitate operations at the proposed plant site.

Numerous studies have been done that attempt to rank order options such as those listed above for their ultimate impact on a project. For instance, in a 2007 study, the U.S. DOE analyzed three of these possible actions: Fischer Tropsch (F – T) subsidies, loan guarantees, and investment tax credits, and found that loan guarantees had the greatest impact of the three, with F – T subsidies falling in the middle. As expected given the impact of risk on the cost of debt financing, that rank order (loan guarantees, F – T subsidies, investment tax credits) is also the order of possible financial loss for the state. However, in addition to actual financial assistance, a strongly supportive environment provided by a state also has an appreciable positive impact on the financing environment.

Given the limitations on available capital that Kentucky faces as a relatively small state and the dollar size of the CTL industry that is envisioned, viable options for Kentucky would include: a guarantee of off-take purchase assistance with a long-term coal contract from a supplier; permitting; investment tax credits; regulatory exemption to allow CTL facilities to "wheel" power; eased right-of-way acquisition; and preference on infrastructure project funding.

It is the third issue, carbon footprint, that provides additional uncertainty regarding development of a CTL fuels industry. Unless some form of carbon management is included in the facility design, it is estimated that a CTL fuel plant will approximately double the amount of carbon dioxide emitted by a petroleum-based refinery, per unit of output (Adam, 2008; Natural Resources Defense Council, 2007).

One of the most promising carbon dioxide management techniques includes capture, compression, and underground sequestration (CCS). This is addressed in detail in *Strategy 6*. But even CCS has serious obstacles to successful large-scale deployment. Any extensive CCS network will increase the cost (estimates range from between 50 percent and over 100 percent) of existing coal-fired electricity production (DOE, 2007; Klara, 2007). There are also serious legal obstacles to large-scale CCS such as the difficulty of obtaining right-of-ways for required pipelines and questions regarding who owns the pore space that the carbon dioxide would be injected into and who would be liable for accidental discharges or leakage at injection sites.

Potential Adverse Impacts of Developing a CTL Industry

If the impediments to developing a CTL fuels industry are overcome, there are other unintended consequences that require mitigation. In recent years the coal industry has enjoyed substantial growth. Starting a new industry based on coal will, in the short run, result in tighter supplies and higher prices. This in turn will raise the cost of electricity generation as well as the cost of industrial and commercial activities which depend on steam generated by burning coal. A CTL industry will also compete with other industries for limited resources such as rail transport and water. The environmental and societal costs traditionally associated with coal mining will increase with increased mining if steps are not taken to minimize their impacts.

Economic Conclusions

Based on the above, it is legitimate to conclude that the current and future market for crude oil makes CTL fuels production economically viable, as long as steps are taken to ensure that carbon management legislation does not punish the manufacture of CTL fuels excessively. So the question is: Does Kentucky want to actively support development of a CTL fuels industry, and if so, what steps must be taken to ensure its success?

Assessment

Kentucky is a "coal state". Coal supports Kentucky's economy in three ways: First is the benefit in direct and indirect employment in the coal industry and the economic and tax revenues generated by the industry. Second, over 90 percent of Kentucky's electricity is generated using coal. Coal-fired power plants provide the cheapest electricity generation available; therefore each Kentucky citizen receives an economic benefit from having one of the lowest electricity costs in the nation. Third, those same low electricity rates make Kentucky attractive to electricity-intensive industries like steel, aluminum, and automotive. Employment and revenues in those and many other industries are a direct result of low-cost electricity.

Any kind of tax on carbon emissions or any cap-and-trade program requiring reductions in carbon emissions will raise the price of coal-fired electricity disproportionately compared to other forms such as nuclear, wind, or hydroelectric. To illustrate, if the cost of coal-fired generation doubles while other sources stay the same, then a state where 50 percent of the electricity is generated using coal will, on the average, have a 50 percent increase in electricity costs. In a state like Kentucky where practically all of the electricity is provided by coal, rates could almost double. This would place an immediate burden on Kentucky consumers and eliminate one of Kentucky's big advantages in attracting new industry or keeping industry already located here, and in the long run stifle demand for coal, putting downward pressure on coal prices and reducing the amount mined.

Because of the fundamental technology used to make CTL fuels, CCS costs would constitute a considerably smaller percentage of overall operating costs than they would with electricity generation (see Berg, DOE, and Oakley et al., 2007). These analyses demonstrate that even with the expected increase in costs of adding CCS to a CTL fuels facility, such a facility will still be economically viable when crude petroleum costs are in the $50-$60 per barrel range.

Developing a CTL fuels industry in Kentucky not only provides a whole new high technology industry potentially providing thousands of high paying jobs, it also supports the coal industry by providing a market for Kentucky coal. In 2006 Kentucky produced approximately 126 million tons of coal. If all of that coal were made into liquid fuels, it would make approximately 10 billion gallons of diesel fuel. In 2006 demand for diesel fuel in the United States was over 40 billion gallons. In other words, developing a CTL fuels industry would boost Kentucky's economy by providing a use for coal other than electricity generation and by providing jobs in Kentucky to produce the coal-based liquids.

The direct impact on Kentucky's economy of a strong CTL program will be substantial. Estimates of construction jobs, permanent jobs and projected tax revenues indicate that a plan as aggressive as the one proposed for Kentucky would provide a huge economic stimulus.

One of the more detailed analyses available for a sizeable CTL project has been presented by

Rickard, 2006. In that paper Rickard uses the Minnesota Implan Group's Implan 2.0 economic impact assessment software system to predict the total economic and fiscal impacts of the proposed Bull Mountain energy project in Musselshell County, Montana. That study predicts that an 11,000 barrel-per-day project would create approximately 3,950 jobs during the construction phase, and that operation of the facility would create approximately 3,575 direct and indirect jobs. Rickard's study further predicts that labor income from the facility would be approximately $233 million per year, and that the facility would generate about $20 million in state, county, and city tax revenue per year. Extrapolation to Kentucky's proposed 260,000 barrel-per-day plan would suggest substantial impact on job growth and economic benefits. Rickard's analysis seems quite optimistic, and more conservative estimates (CAER, 2007) would place direct employment around 3,500.

But there are other benefits that would accrue not only to Kentucky but also to the nation as a whole. By developing a CTL fuels industry, Kentucky can position itself as a national leader in two essential areas. First, national security will be enhanced. Currently, foreign countries provide about 60 percent of the crude oil consumed by the United States. The top 15 countries that supply that crude oil include Nigeria (#5), Angola (#7), Algeria (#8), Columbia (#11), and Ecuador (#12), all of which suffer from periodic political turmoil and all of which are subject to supply disruptions. The top 15 exporters to the United States also include Venezuela (#4) whose leader is openly hostile to America (EIA, 2008). Finally, while Iran does not export oil to the United States, it is the fourth largest oil producer in the world (EIA, 2007). Since oil supplies are tight worldwide, disruption in any of the major oil exporting countries would cause shortages and price spikes that would eventually have a negative ripple effect on the United States. By developing a robust CTL fuels industry, Kentucky would take a large step toward helping ensure America's energy independence and security.

Secondly, a strong CTL fuels industry would benefit the United States as a new industry in and of itself, but more importantly, would provide a dependable supply of liquid fuels at a predictable price and thus help make U.S. manufacturing more competitive.

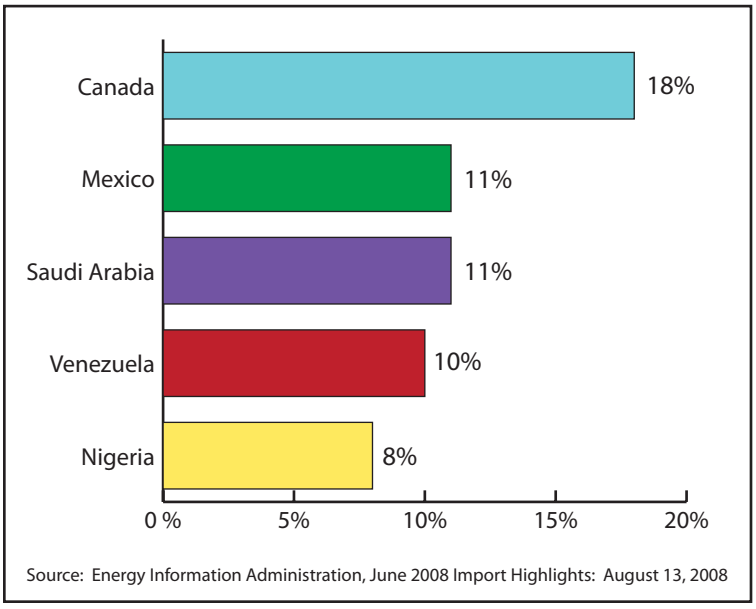


Figure 18: Top Suppliers of Crude Oil and Petroleum Products to the United States (2007)

The potential benefits described above overwhelmingly support development of a CTL fuels industry in Kentucky.

Kentucky is promoting CTL development. Through fiscal year 2009, the EEC has funded initial site assessments and feasibility studies at seven properties across the state. The EEC has also developed a "site bank" of 41 properties that have been initially screened for CTL development potential. These sites were nominated by local officials seeking to promote CTL development in their area.

The state, through the EEC, has also devoted significant grant funding for construction of a demonstration-scale F - T refinery at the CAER, and has also funded critical research needed to develop F - T catalysts.

ACHIEVING THE GOAL

Kentucky will develop a CTL industry that will use 50 million tons of coal per year to produce four billion gallons of liquid fuel per year by 2025.

This would ensure that there is a market for Kentucky's coal, provide a source of high-technology, high-paying jobs for Kentucky citizens, and put Kentucky in a leadership role in reducing the United States' dependence on imported oil.

In 2006 Kentucky used annually approximately 2.26 billion gallons of gasoline, approximately 1.3 billion gallons of diesel and approximately 298 million gallons of jet fuel, for a total of almost four billion gallons of liquid fuels. It is assumed here that the producers of the liquid fuels will determine the correct mix of exact products to manufacture. Therefore, for planning purposes, the generic term 'CTL fuels' will be used without identifying or differentiating between the exact products. Also for planning purposes, it is assumed that the transportation fuels usage in 2025 will be the same as in 2006 (approximately four billion gallons). While in normal circumstances growth would be expected, the impact of federal fuel economy legislation and the move to plug-in hybrid electric automobiles will absorb some of the growth in liquid fuels demand.

Near-Term Actions (1-3 years)

1. Work with vocational training institutes in Kentucky to ensure that trained personnel are available to work in the coal industry required for CTL industry development. For two CTL fuels facilities to come on line in 2013, trained personnel must be available to meet possible production levels of 138 million tons per year in 2013, 150 million tons per year in 2014, 163 million tons per year in 2015, and 175 million tons per year in 2016. While it is expected that federal carbon management legislation will reduce these levels in later years (due to reduced exports to other states), it would be an unacceptable risk to the planned CTL and coal-to-gas (CTG) industries not to have an adequate supply of trained personnel. To achieve the required employment levels, increased training capability must be available within the next three years.
2. The all-time high production level that the Kentucky coal industry achieved was 179.4 million tons in 1990. Since this level has been reached in the past, it should be achievable in the near term as long as trained personnel are available for the mines. In order for the electric generating industry in Kentucky to transition from coal, the first four CTL plants (a total of 25 million tons of coal per year) should be fed with existing production capacity; i.e., production above the 125 million ton level that was achieved during 2006. In the near term, Kentucky must evaluate its current coal mining capabilities and ensure that it can readily reach 175 million tons per year as it has in the past, if in fact that should prove necessary.
3. Kentucky already has economic incentives in place to encourage the CTL industry. However, state legislation will be necessary to remove the risk barriers which may prevent CTL development. There are undeniable advantages to being a leading state supporting the industry; companies that pursue production of CTL fuels will be more likely to locate in Kentucky if the state has an advantage over other states in available support. By acting quickly and decisively, Kentucky can ensure that CTL facilities are built here.

Mid-Term Actions (3-7 years)

1. Bring on line two new 500 million gallon-per-year (approximately 35,000 barrels per day) CTL facilities in both 2013 and 2014.
2. Prepare for a substantial expansion of the Kentucky coal mining industry above recent production rates (126 million tons per year).

Long-Term Actions (>7 years)

1. Bring on line two additional 438 million gallon-per-year CTL fuel facilities by 2018 and two more by 2025.

ENVIRONMENTAL BENEFITS AND LIMITATIONS

According to the Energy Information Administration (EIA), in 2006 Kentucky used approximately 42 million tons of coal to produce about 91,000 megawatt-hours of electricity from approximately 15,500 megawatts of electricity capacity. Without changes to Kentucky's electricity generation mix, those numbers are expected to grow to 59 million tons of coal producing about 129 thousand megawatt-hours from 20,000 megawatts of electricity generating capacity.

However, existing coal-fired electric generation is poorly suited to carbon management. In particular, capture of carbon dioxide from post-combustion exhaust streams is extremely difficult and expensive. Even new technology coal-fueled electric generation options like integrated gasification combined cycle (IGCC) power plants pay a high price for carbon management. If carbon management legislation is passed, electric utilities will be forced to shift generation capacity to nuclear and/or renewable sources of generation. Developing a CTL fuels industry will protect the Kentucky coal industry as this change in electric generation occurs.

Conventional gasoline and diesel fuel have a well-to-wheel carbon dioxide emission rate of 25.4 pounds per gallon and 26.5 pounds per gallon, respectively (van Vliet, 2007). Assuming a 50/50 mix of gasoline and diesel fuel from the Kentucky CTL fuels industry (since characteristics of jet fuel are more similar to diesel than gasoline), the average carbon dioxide emissions from a gallon of conventional fuel would be 26 pounds per gallon. Applying a two-to-one emission factor for the well-to-wheel emission of a gallon of F - T fuel gives 52

In 2006 Kentucky burned 42 million tons of coal to generate approximately 15,500 megawatts of electricity, so the 50 million tons of coal the fully developed CTL industry would use could produce about 18,500 megawatts. Using a factor of three million tons of carbon dioxide emitted for every 500 megawatts of coal-fired electricity generated (DOE, EPA, EIA, 2000), then 50 million tons of coal per year used to generate electricity would emit 111 million tons of carbon dioxide per year. Therefore, even without using CCS to manage the carbon dioxide generated in the manufacture of CTL fuels, the reduction in carbon dioxide emitted per year by diverting 50 million tons of coal from pulverized coal electricity production to CTL fuel production would be 48 million tons of carbon dioxide per year, a decrease of almost 44 percent. If CCS were used to control 90 percent of the carbon dioxide emitted in the CTL fuels manufacturing process, then the reduction would be over 94 percent.

pounds per gallon. Burning a gallon of gasoline or diesel fuel produces 19.4 and 21.9 pounds of carbon dioxide respectively, so the average emission from a gallon of CTL fuel is 20.7 pounds per gallon and the manufacturing carbon dioxide contribution is 52-20.7=31.3 pounds per gallon. Approximately 80 gallons of fuel are produced from a ton of coal, so the 50 million tons of coal used by the recommended CTL fuels industry would emit 63 million tons of carbon dioxide in the manufacture of the liquid fuels. But because the carbon dioxide is more easily captured in CTL processing than with electricity generation, CCS is much more practical and economical.

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