NextGen Energy Council

The Critical Role for Western States In Reducing U.S. Dependency on Foreign Oil Imports through Advanced Coal-to-Liquids Projects

The federal government, Southern States Energy Board, Western Governors' Association (WGA), and others have recognized the importance of developing domestic sources of alternative transportation fuels to reduce the United States growing dependence on foreign oil while protecting the economy from the volatile world oil market. This brief summarizes the potential role and benefits of the western states (those within the WGA) in helping the U.S. gain domestic energy security through the production of alternative transportation fuels from western coal reserves.[1]

Figure 1. Western States Ready for CTL and CBTL Projects

Advantages	Market Position
Liquid Fuels Experience	• 90% of U.S. crude oil production (2006) • 72% of U.S. imports of crude oil (2006)
Coal Mining Experience	• 57% of U.S. coal production (2006) • Excellent Mine Safety Record (2006)
Available Coal Reserves	• 234 years of coal reserves at 2006 production levels • 5.5 trillion tons of hypothetical coal reserves estimated by USGS for Alaska (USGS 2004)
Low Feedstock Costs	• $9 to $23 per short ton (minemouth price, 2006) • 50+% lower cost than Appalachian coals (2006)
Low Carbon Footprint Design Options	• Enhanced Oil Recovery (EOR) with captured CO_2 • Carbon capture, compression, and sequestration (CCS) • Co-gasification of coal and biomass resources for liquids production • Enhanced Coal-bed Methane Recovery with captured CO_2
EOR Opportunities	• Extensive operational experience with EOR operations • Existing and planned CO_2 pipeline infrastructure

In 2005 and 2006, the United States imported over 60% of its liquid fuels supply to meet current demand. According to the Department of Energy's Energy Information Agency (EIA), the U.S will continue to rely on imported crude oil and finished petroleum products for 60% of liquid fuels in 2030, as demand is estimated to increase from 21 to 27 million barrels per day (MM BPD) in the next 22 years. World oil prices continue to rise from a market high of $60 (per barrel) in 2005, to $71 in 2006, and $90+ in 2007 (EIA 2007a), market analysts continue to predict a rising trend in both world oil prices and demand for liquid transportation fuels. Figure 1 summarizes the key advantages of the western states in developing a coal-to-liquids (CTL) and coal/biomass-to-liquids (CBTL) industry to reduce the United States dependency on foreign oil.

[1] Western resources for producing alternative transportation fuels include a wide range of both renewable and nonrenewable energy resources. This brief highlights the importance of coal-to-liquids production, which has the largest resource potential, while recognizing the importance of a diversified resource strategy.

The process of converting coal-to-liquids is a “mature” technology with over 50 years of industry experience in South Africa (Sasol 2007), and to a lesser extent, other countries around the world. The United States has operated various pilot-scale and demonstration facilities in the past 30 years. However, a CTL industry never developed in the United States due to the historically low price of world crude oil ($20 to $30 per barrel range) which prevented the technology from being considered economically viable. Co-feeding biomass with coal to produce liquids has been demonstrated to reduce life cycle greenhouse gas (GHG) emissions well below current petroleum-based fuels. The advantage of CBTL plants is the ability to utilize both renewable and fossil energy resources while significantly reducing GHG emissions below current standards. In today’s market, CTL/CBTL production of alternative transportation fuels is considered economically viable with a world oil market price above $60 per barrel (NETL/AF 2007, SSEB 2006), which is below EIA’s imported crude oil price projection for the next 20 years.

The role of WGA states in catalyzing and sustaining a CTL/CBTL based industry is important to future domestic energy security. Environmentally acceptable CTL/CBTL plant design options will be necessary to reduce GHG emissions below conventional petroleum-based transportation fuels while minimizing water consumption in areas with limited supplies. The following sections summarize the western states’ capabilities to develop a CTL/CBTL industry to obtain domestic energy security with environmentally acceptable plant design options.

Domestic Energy Security

Over 90% of the crude oil extracted in the United States for liquid transportation fuels comes from WGA states (EIA 2007b). Texas, Alaska, and California are the nation’s top three states for on-shore production of crude oil.[2] Analysis of 2006 U.S. imports by Petroleum Administration Defense Districts (PADD) concludes that WGA states account for 72% of total U.S. imports.[3] Liquid fuels experience and infrastructure are two key advantages for the Western states in lowering the initial development costs of a future coal-to-liquids industry. The WGA 2006 “Transportation Fuels for the Future” resolution placed a priority on reducing foreign imports through alternative resources within the Western states. Coal-to-liquids, among others, was identified as a critical resource for off-setting the need for imported crude oil.

WGA states also accounted for 57.4% of the total U.S. coal production in 2006 and contain 59.2% of the remaining 264 billion short tons of recoverable reserves in the United States; see

Figure 2. WGA State Crude Oil and Coal Statistics

WGA State	Domestic Production		Reserves
	Crude Oil[1] (M BBLS)	Coal[2] (M Tons)	Recoverable Coal[3] (MM Tons)
AK	368,230	1,425	2,832
AZ	55	8,216	--
CA	238,526	--	--
CO	23,390	36,322	9,727
HI	--	--	--
ID	--	--	2
KS	35,651	426	680
MT	36,262	41,823	74,901
ND	39,911	30,411	6,877
NE	2,313	--	--
NM	59,818	25,913	6,965
NV	426	--	--
OK	62,841	1,998	798
OR	--	--	9
SD	1,394	--	277
TX	397,677	45,548	9,490
UT	17,910	26,018	2,700
WA	--	2,580	681
WY	52,904	446,742	40,144
WGA Total	1,337,308	667,422	156,083
US Total	1,483,069	1,162,750	263,781
WGA/US	90.2%	57.4%	59.2%

Unit Abbreviations:
M = Thousand, MM = Million

Source:
1. EIA, Petroleum Supply Annual (2006 Production Data)
2. EIA, Annual Coal Report 2007 (Table 2)
3. EIA, Annual Coal Report 2007 (Table 15)

Note:
Data includes both state on-shore and off-shore produciton (Federal off-shore production excluded).

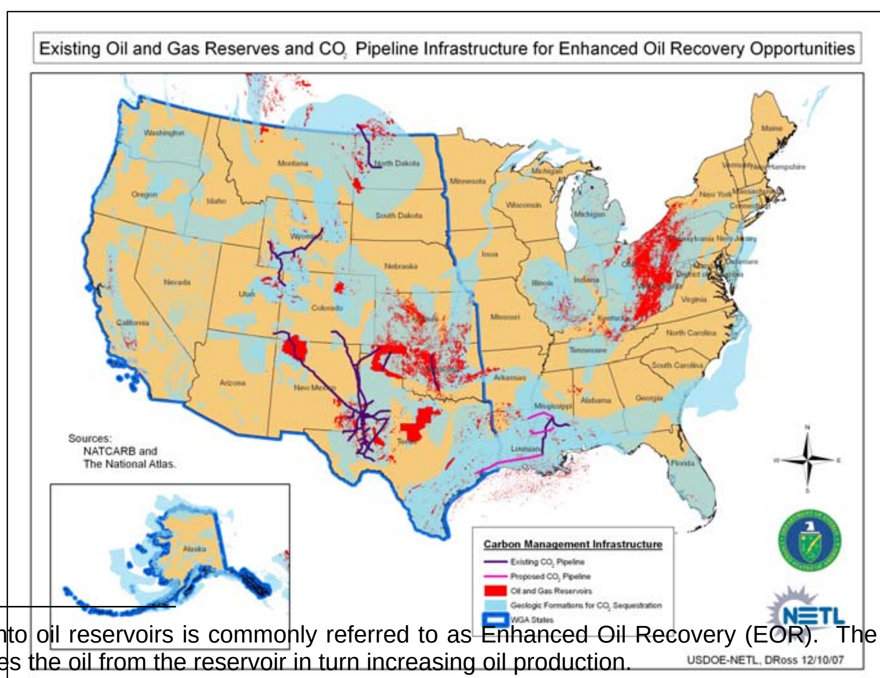
[2] Federal off-shore production in the Gulf of Mexico is the largest domestic source of crude oil in the United States [illegible] 474,000 MM BPD in 2006 (EIA 2007b).
[3] EIA data for 2006 U.S. imports of crude oil were allocated t[illegible] PADD II – 85%, PADD III – 80%, PADD IV – 100%, and PAD[illegible]

Figure 2 (EIA 2007c). The estimated recoverable reserves in the WGA states are sufficient to support 234 years of production at the 2006 production rate. The addition of a CTL industry operating for 20 years would only utilize 2% of the total estimated recoverable reserves in the WGA states.

A CTL industry in the Western U.S. has the ability to capture, compress, and transport CO_2 from the plant to near-by oil reserves for enhanced oil recovery (EOR). This presents a two-fold opportunity to reduce imported crude oil: (1) direct off-sets from low-sulfur naphtha and diesel fuel produced from the CTL plants and (2) increased domestic crude oil production from injection of CO_2 into oil reservoirs.[4]

The leading transporter and marketer of CO_2 for EOR in the United States, Kinder Morgan, estimates that it takes between 6 and 15 thousand cubic feet (MCF) of CO_2 to produce a barrel of oil (Kinder Morgan 2007). CO_2 consumption estimates by Westport Oil and Gas range from 7 to 8 MCF per barrel of oil (Nelms and Burke 2004). Therefore applying a conservative factor of 10 MCF of CO_2 will produce one addition barrel of oil (equivalent to 1.7 barrels of oil per ton of CO_2), the total increase in domestic crude oil production from CO_2 captured from CTL plants is approximately 1.2 additional barrels of oil from EOR operations per barrel of CTL product produced.[5] Increased domestic crude oil production through EOR from CTL industry CO_2 has the potential to further reduce imports by almost doubling the domestic energy security benefits. Enhanced oil recovery using CO_2 is currently employed within several Western states. A network of CO_2 pipelines run from Texas, New Mexico, Colorado, Utah, and Wyoming. Additional CO_2 pipelines are proposed for construction in the near future as illustrated in Figure 3. WGA states have a proven track record of experience and industry support for EOR operations and interstate pipeline transport of CO_2 .

Figure 3. Overview of Existing and Proposed CO_2 Pipelines in the United States



[4] Injection of CO_2 into oil reservoirs is commonly referred to as Enhanced Oil Recovery (EOR). The CO_2 acts as a solvent and displaces the oil from the reservoir in turn increasing oil production.

[5] 100% of the CO_2 captured from the CTL plants is assumed to be used for EOR. According to NETL, a 50,000 BPD CTL plant equipped with CCS produces 32,481 TPD of CO_2 (NETL 2007) available for pipeline transport to an oil reservoir or a geological formation suitable for carbon sequestration.

Environmentally Acceptable Design Options for CTL Plants

Environmental acceptability of CTL and CBTL projects in the United States are determined by two primary factors: (1) the total release of greenhouse gases (GHG) compared to conventional petroleum-based transportation fuels [reported in terms of global warming potential (GWP) as carbon dioxide equivalents (CO_2E)], and (2) the volume of water required to produce a barrel of CTL product. Both factors are of significant importance to the WGA states and the nation. Other environmental factors such as criteria air pollutant emissions, releases of toxic water pollutants, and solid waste generation are currently managed by Federal and/or State regulations unlike GHG emissions and water use[6]; therefore, they currently attract less public attention in discussions regarding the environmental acceptability of CTL projects today.

It is a fact that CTL facilities designed without carbon, capture, and storage (CCS) emit more GHGs than conventional petroleum-based fuels production on a life cycle basis.[7] Various studies have reported a range of 100% to 143% increase in CO_2E compared to petroleum-based diesel (NETL 2001, EPA 2007, UC Davis 2007).

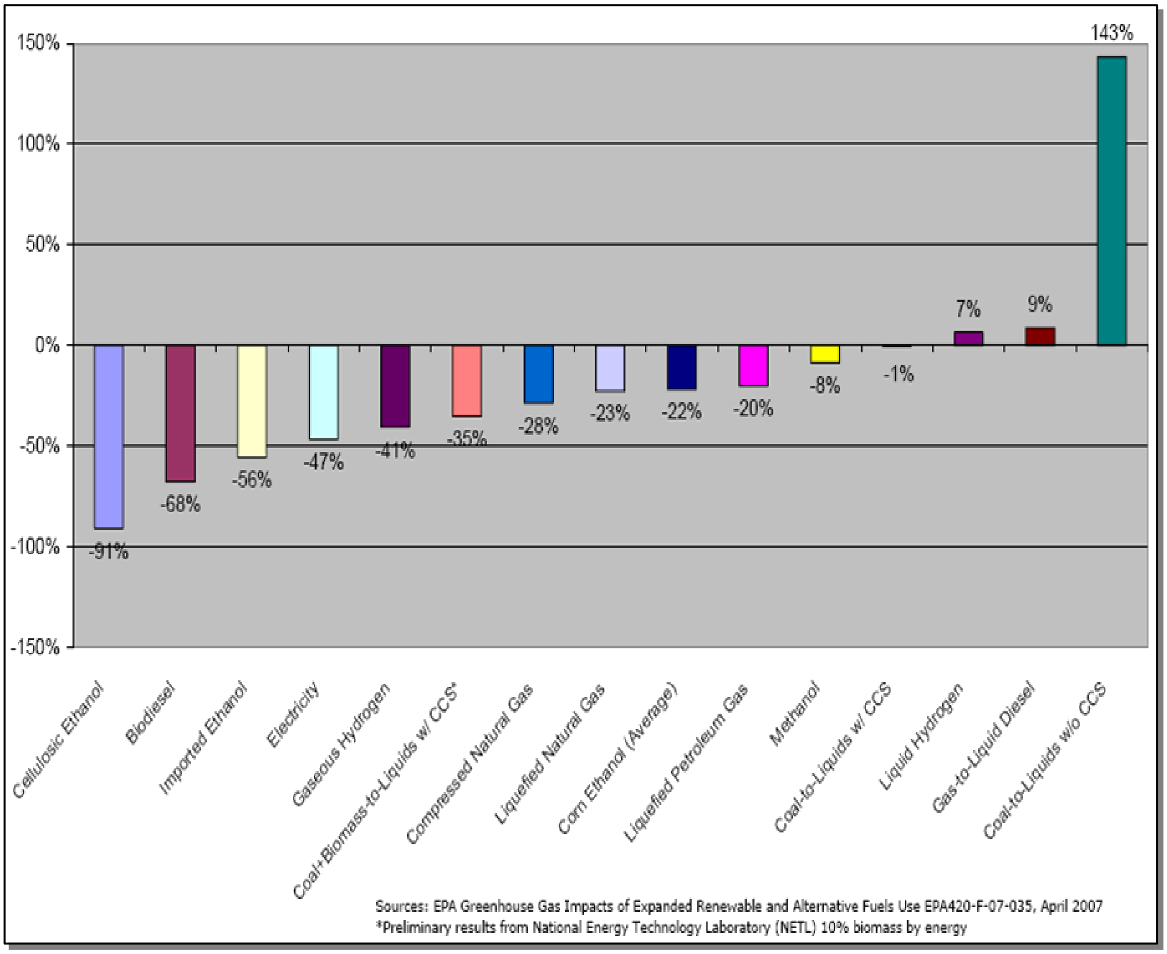
Adding CCS to a CTL plant lowers the life cycle GHG emissions to -1% to -5% *below* conventional petroleum-based fuels (NETL/AF 2007, EPA 2007). The co-conversion of coal and biomass to liquid fuels (CBTL) with CCS further reduces the GHG emissions to below conventional petroleum-based fuels. The biomass amount, by energy content, blended with the coal feedstock determines the magnitude of reduction in GHGs compared to conventional petroleum-based fuels. For example, co-feeding only 10% corn stover, switchgrass, or woody biomass (by energy) results in a 20 to 30% reduction in life cycle GHG emissions on a CO_2E basis (NETL/AF 2007, EPA 2007). Figure 4 compares the percent change in GHG emissions of CTL and CBTL and other alternative transportation fuel options to conventional petroleum-based fuel (i.e., diesel fuel) produced in the United States. The U.S. Environmental Protection Agency (EPA) is currently benchmarking the environmental preferability of alternative transportation fuel options to the global warming potential of conventional diesel fuel on a life cycle basis. This action is part of EPA's Renewable Fuel Standard Program charged with promulgating regulations to reduce the release of GHG emissions from transportation fuels in the United States.

Water is considered a scarce resource in most Western states. This is especially true in states with abundant coal reserves to support a CTL and/or CBTL industry. Effective water conservation strategies are expected to be incorporated into the design of CTL facilities proposed in WGA states. CTL plant designs are dependant on many factors, including the quantity of water available for process and cooling operations. CTL plants can be designed to reduce the water requirement to *less than one barrel of water per barrel of liquid fuel product*; 1 bbl H_2O/1 bbl of FT Liquids (Mitertek 2005).

[6] Water use may be included in facility National Permit Discharge System (NPDES) permits on a site specific basis. However, there are no Federal or State regulations limiting water withdrawal and consumption for specific industries.

[7] The term "life cycle basis" refers to the cumulative releases of GHGs from acquisition of the raw materials from the earth (e.g., coal mine, oil well, growth and harvesting of biomass), transport to a CTL facility or petroleum refinery, production or refining to produce the transportation fuel (e.g., diesel fuel), and transport, storage, and dispensing of the fuel into the vehicle tank. This type of analysis is also commonly referred to as a "well-to-tank" study. Inclusion of the emissions from the consumption of the fuel may or may not be included within the study. If included, the scope of the life cycle may be referred to as a "cradle-to-grave" or "well-to-wheels" study. GHG results discussed in this paper are reported on a well-to-tank life cycle basis.

Figure 4. Percent Change in GHG Emissions Compared to Petroleum-based Transportation Fuels (Basis of Comparison: Life Cycle "Well-to-Tank" GWP, g-CO_2E)



Reference: EPA, Office of Transportation and Air Quality, Paul Argyropoulos, Presentation to Cellulosic Ethanol Summit, October 2007

Water reduction strategies for CTL plant designs include (but not limited to):

- Air Cooling (versus wet cooling) for the Steam Cycle Condenser
- Air Cooling for the Air Separation Unit
- Air Cooling for the Acid Gas Removal System
- Implementation of Maximum Reuse/Recycle of Process Water

Implementation of these water reduction strategies will increase plant capital costs (approximately 3%) and increase plant parasitic power requirements (Mitertek 2005). Designing the CTL plant to utilize a once-through configuration, instead of recycling a portion of the FT tail gas to increase liquid yield, will increase the amount of power produced by the plant to off-set the parasitic power requirements from air cooling equipment. As demonstrated, a low-water CTL plant can be designed for WGA states with minor increases in capital and operating cost.

Proven technology exists today to build an environmentally acceptable CTL industry in the WGA states. Utilizing carbon, capture, and storage or enhanced oil recovery will be necessary to lower the carbon footprint of CTL products to the current petroleum-based fuel life cycle footprint. Unlike petroleum-based fuels, opportunities exist to co-gasify coal with biomass to further reduce the global warming potential of transportation fuels produced from coal and biomass feedstocks. A reliable domestic resource, such as coal, combined with a renewable biomass-based feedstock has the potential to produce an alternative carbon-neutral transportation fuel for the United States. Biomass availability will be a key determining factor in whether CBTL plants operate on 10%, 30%, or greater biomass (by energy) to limit life cycle GHG emissions.

Significant reductions in water consumption can also be achieved at environmentally acceptable levels through plant design options. For example, utilization of air cooling equipment instead of wet cooling towers to dissipate heat can reduce the water requirement to *less than one barrel of water per barrel of liquid fuel product*; 1 bbl H_2O/1 bbl of FT Liquids (Mitertek 2005).

Conclusion

Western states are well positioned with the resources and experience to develop a CTL and/or CBTL industry. Carbon capture and storage will be required to produce a domestic alternative transportation fuel with a lower global warming footprint than conventional petroleum-based fuels. Efficient water conservation strategies will also be required to preserve scarce water resources for other uses. As discussed throughout this brief, environmentally acceptable design options exist today utilizing commercially available technology. Continued research and development strives to further improve the environmental footprint and performance of CTL and CBTL plants.

Extensive domestic resources, both fossil and non-fossil, will be required to achieve a reasonable and balanced alternative transportation fuels strategy in the United States. As demonstrated, the WGA states are positioned with the coal resources, experience, and infrastructure to begin development of an industry today to start on the path towards domestic energy security.

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