Coal-to-Liquids in the United States Status and Roadmap



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Interest Drivers for CTL

- 35% of world energy consumption is from oil ²
- 96% of all world oil used for transportation
- World vehicle population at 700 million; double by 2030 to 1.5 billion; – developing countries to triple
- World oil consumption is 84 MMBPD 20% higher than 1995 – expect 120 MMBPD by 2030
- World oil supplies could peak between 2016 and 2037 ³
- Increasing competition with China, India, and other growing nations for oil resources
- Oil resources not equitably distributed globally; coal more wide spread



Interest Drivers for CTL in the U.S.

- "Addicted to oil" State of the Union address 2006
- US has 27% of world coal supply, but only 2% of world petroleum supply and 3% of world natural gas supply
- In 2006, US petroleum imports (crude and refined products) exceeded 12 MMBPD
 - US is the largest oil importer in the world
 - Imports = approximately 60% of total supplied products
 - Import Cost ~\$265 BILLION (\$2006) ¹
 - US refining capacity not meeting increasing demands for finished products

¹Ref: AEO2008 "Early Release" March 2008



NETL Studies and Systems Analyses

- NETL Report "Baseline Technical and Economic Assessment of a Fischer-Tropsch Liquids Facility
- Small Scale 10,000 bpd facility;
 Stand-alone and Co-sited with IGCC system
- Commercial 50,000 bpd facility; Baseline
- Incremental Impact of CO₂ Compression (in final draft)





Profile of a Coal-to-Liquids (CTL) Plant

- Capacity: 50,000 bpd (~650 million gallons per year, assume 85% availability)
 - Naphtha: 22,000 bpd (44%)
 - Diesel: 28,000 bpd (56%)
- Capital cost: \$ 3.65 billion (June 2006)
- Coal consumption: 24,500 tpd (7.6 MM tpy)
- NPV of \$1.5 billion @ 12% discount rate
- ROE of 19.8% with World Oil Price of \$61/bbl
- Land area: nominal 500 acres
- CO₂ recovery: 13,000 tpd (90%)
- CTL is technically and economically viable under present conditions of world oil price



Ref: NETL Report "Baseline Technical and Economic Assessment of a Commercial Scale Fischer-Tropsch Liquids Facility (April 2007)



U.S. CTL Plant Projections



U.S. Air Force Approach to Alternative Fuels

- In fiscal year 2006, USAF consumed 2.6 billion gallons of aviation fuel at a cost of over \$5.7 billion
- Air Force Synthetic Fuel Initiative:
 - By early 2011, certify the entire fleet to use 50/50 synthetic fuel blend
 - By 2016, be prepared to obtain 50% of contiguous United States aviation fuels from domestic sources capturing and reusing CO₂
 - Boeing B-52 bomber certified in August 2007
 - Boeing C-17 airlifter certified in December 2007
- Engine Ground tests
 - GE F101 done B-1B
 - GE CFM56 ongoing KC-135R
 - P&W F119 planned F-22 Raptor
 - GE F110 planned F-16 Falcon
- B-1B Lancer flight tests
- Tanker flight tests in late spring/early summer 2008
- Possible CTL plant at Malmstrom AFB (Montana)





Barriers to Creation of U.S. CTL Industry

Economic Risk

World oil price volatility - single greatest factor impeding deployment

Petroleum industry capital drawn to higher profit crude oil E&P

Technical Uncertainty

Plant components operated at commercial scale but Integration poses significant risk

Needed Incremental Investment in Infrastructure \checkmark Large quantities of coal needed will drive significant expansion of U.S. coal mining Current railroads/railcars and barge capacity inadequate Mine mouth coal-fuel plants will need pipeline connects

Ready Availability of Critical Materials, Resources \checkmark and Skills

Multiple plants built concurrently worldwide will compete for critical equipment, engineering, labor and materials

Environmental Concerns \checkmark

CTL CO₂ emissions ~2 x petroleum w/o sequestration, equal to petroleum w/sequestration

Water issues: (1) availability and (2) environmental impact





United States: CTL Challenges

Western vs. Eastern Coals

Water content of PRB/lignite
excludes slurry fed gasification.
PRB/lignite must be dried
before feeding to gasifier,
lowering efficiency and increasing
CO₂ emissions

– Due to decreased carbon

content, the amount of PRB/Lignite coal needed per

FT barrel produced is higher.

• Water Usage





Coal with Biomass As A Carbon Control Strategy

Coal/Biomass-to-Liquids (CBTL)

• DOE-DOD joint feasibility study; jet fuel with 20% less CO₂ emissions than conventional petroleum refinery (Aug 2007)

• Concluded: System to reach 20% below conventional petroleum is technically and economically feasible

• Timetable to reach 100,000 bbl/day of jet fuel by 2016 has problems:

-Availability/Timing of multiple CBTL projects

-Legal Framework for CCS





Greenhouse Gas Emission Rates for Fuel Production and Use





Coal / Biomass-to-Liquids May Beat Ethanol on CO₂ Emissions

CTL Tec Americas 2008 / Daniel Cicero / U.S. DOE-NETL / June 2008

Professor Robert Williams (Princeton), presentation to LERDWG meeting, April 18, 2007 Robert Williams Presentation to 5th Annual Conference on CCS, DOE/NETL, May 8–11, 2006

Biomass Required to Make 1 GJ of Liquid Fuel



Domestic Zero CO₂ Liquid Fuel with Less Land-Use Biomass Issues

CTL Tec Americas 2008 / Daniel Cicero / U.S. DOE-NETL / June 2008

Professor Robert Williams (Princeton), presentation to LERDWG meeting, April 18, 2007 Coal use in CBTL bars = (total coal use for plant) - (coal for making electricity in IGCC with CCS)

Purpose of NETL 2008 CBTL Study

Comprehensive Strategic study

Commercialization envelope – short, medium, longterm production; parametric study of coalsbiomasses, plant scale, and locations

– Feasibility Study to Better Understand Potential of CBTL Systems

- -Bituminous and Sub-Bituminous Coal
- -Five Biomass Feed stocks
- -Variations from 100% coal to 100% biomass
- Variety of GHG emissions levels from "standard petroleum" to net zero and beyond
- -28 different systems under consideration
- -Final Report Scheduled for Publication Summer 2008



NETL CBTL Research Initiatives

• On-site NETL Research

- -Construction of a bench scale coal-biomass gasifier
- Continued development of improved catalyst for the conversion of coal/biomass derived syngas to liquid fuels

Funding Opportunity Announcement

- -Requested proposals May 2008
- -Focus on emissions and technical

barriers

- Feeding Coal/Biomass Mixtures Across a Pressure Gradient
- Characterization of the Products from Gasifying Coal/Biomass Mixtures
- Optimization of the Fischer-Tropsch (FT) and Water-Gas-Shift (WGS) Processes





A Possible Path Forward...

- Build and Operate a few Pioneer Plants
 - Subsidize the completion of 3 to 5 front-end engineering design studies
 - Facilitate "Early Commercial Learning Experience"
 - Identify barriers to process improvement and cost reduction
 - Develop a greater understanding of the issues surrounding carbon capture, transport, sequestration, monitoring and verification of permanent storage

• Initiate a Program of Targeted Research

 Build a comprehensive R&D plan built on barriers derived from actual operation of pre-commercial sized plants

Investigate Financial Incentives

- Tax Credits (EPACT 2005 Section 1307)
- Loan Guarantees
- Guaranteed Price Floors
- Formulate and test F-T fuels for early commercial markets
 - DOD, Clean Cities, Northeast Home Heating Oil Reserve

Involve, Coordinate, and Exchange Information with Interested Foreign
 NETLGovernments

Coal-Biomass to Liquids Program

DOE Schedule by Fiscal Year



- S.154 "Coal-to-Liquid Fuel Promotion Act of 2007"
 - DOE provide loan guarantees for CTL plants
 - DoD to purchase, test, and integrate fuels into SPR and military
 - Status: Senate Energy and Natural Resources Committee (Jan 4, 2007)
- S.155 "Coal-to-Liquid Fuel Promotion Act"
 - S. 154 + expand investment tax credits;
 extend Fuel Excise Tax credit, and expand credit
 for CCS equipment
 - Status: Senate Finance Committee (Jan 4, 2007)
- H.R.370 "Coal-to-Liquid Fuel Promotion Act"
 - House version of S.155

Status: House Armed Services Committee (Feb 1, 2007)





- H.R.2208 "Coal Liquid Fuel Act"
 - DOE 6 coal liquefaction projects to establish a federal price guarantee. Required to certify fuel has life cycle CO₂ emissions of at or below levels of comparable petroleum based facility
 - Status: House Energy and Commerce Committee, (May 8, 2007)
 House Science and Technology Committee (May 15, 2007)
- H.R.3300 "Coal-to-Liquid Fuel Marketing Act of 2007"
 - Provide new risk management tool to shield CTL producers from dramatic oil market volatility
 - Status: House Energy and Commerce Committee, Subcommittee on Energy and Air Quality (Aug 1, 2007)
- S.1443 "Clean, Affordable, and Domestic Fuels for Energy Security Act of 2007"

- Mandate regs & emission standards for coal fuels;

provide loan guarantees for coal fuel facilities, and establish R&D centers

Status: Senate Energy & Natural Resources Committee (May 21, 2007)

Congressional Activities - 110th Congress (cont.)

- S.2149 "Coal Fuels and Industrial Gasification Act"
 - Implement 2-phase development of a limited number of CTL and industrial gasification facilities
 - Status: Senate Finance Committee (Oct 4, 2007)



• H.R. 6 "Energy Independence and Security Act"

- Section 526: Prohibits Agencies from entering into contracts for procurement of alternative or synthetic fuels, including nonconventional petroleum sources unless lifecycle GHG emissions are less than or equal to fuel produced by conventional petroleum products
- Status: Became Public Law No. 110-140 (Dec 19, 2007). Air Force initiating study to determine if CTL could be included under Section 526.



- H.R.5437 "American-Made Energy Act of 2008"
 - Extends AFC for coal fuels, expands advanced coal project investment credit

 Status: Currently referred to House Energy and Commerce Committee; House Oversight & Government Reform Committee, House Armed Services Committee; House Agricultural Committee, House Natural Resources Committee, and House Ways and Means Committee (Feb 14, 2008)

- H.R.2419 "Farm, Nutrition, and Bioenergy Act"
 - Farm Bill: Extends the AFC for coal-derived fuels
 - Status: Currently in consideration by appointed conferees for modification and amendment (Apr 14, 2008).



• S. 2827 Inhofe and Hensarling introduced bills for a simple repeal of Section 526. (April 7, 2008)

S.2958 "Oil Drilling, Alternate Fuel Development including CTL"

- Mandates 3 B gallons clean coal-derived fuels over the next decade and 6 B gallons over the next 14 years with life-cycle GHG emissions no greater than conventional gasoline. Allows for the long-term procurement of synthetic fuels by DoD and repeals Section 526
- H.R. 6001 Main Street U.S.A. Energy Security Act of 2008 (May 8, 2008)
 - SEC. 201 DOE to support development of CTL manufacturing facilities including CCS at military installations.
 - Air Force authorized \$10 M for RDT&E of assured domestic fuels and procure synthetic fuels developed from coal for aviation jet use.

 SEC. 203 DOD enter into long-term contracts to develop & operate CTL plants on/near installations for up to 25 years.



- S. 2972 Aviation Investment and Modernization Act of 2008 to reauthorize & modernize the FAA (May 2, 2008)
 - SEC. 603 Production of Clean Coal Fuel technology for Civilian Aircraft
 - (a) ESTABLISH RESEARCH PROGRAM: DOT establish research program to develop jet fuel from clean coal; include educational & research institutions with existing facilities and experience in processing coal to aviation fuel.
 - (b) DESIGNATION CENTER OF EXCELLENCE- Within 6 months FAA designate a Center of Excellence for Coal-to-Jet-Fuel Research
- H.R.5658 Fiscal 2009 Defense Authorization (May 22, 2008)
 - Amendment clarifies Section 526 to allow for oil sands sources.
 - Creates "director of operational energy plans and programs"



S.3036 Lieberman-Warner Climate Security Act of 2008

 substitute amendment (June 4, 2008)

- H.6170 Clean Coal-Derived Fuels for Energy Security Act of 2008 (June 5, 2008)
 - To require the inclusion of coal-derived fuel at certain volumes in aviation fuel, motor vehicle fuel, home heating oil, and boiler fuel.





Reduce Gasoline Usage 20% in 10 Years



"Let us build on the work we've done and reduce gasoline usage in the United States by 20 percent in the next 10 years. When we do that we will have cut our total imports by the equivalent of threequarters of all the oil we now import from the Middle East."

> President George W. Bush, 2007 State of the Union Address



Alternative Fuels (CTL/CBTL) Fills Gap



For Additional Information

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