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Turning Coal Into Liquid Gold: Alchemy? No, Polygeneration

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Transforming coal into a variety of superclean, value-added energy products may sound like the result of some futuristic technology. But even though most people outside the energy business have never heard of "polygeneration," the process of taking coal and turning it into synthetic natural gas, gasoline, diesel and jet fuel, and many other refined products was actually developed in Germany after World War I and has been in use in South Africa since the 1970s.

Now, amid today's concern about climate change, some participants in the energy debate in the U.S. are looking at coal-to-liquids (CTL) and coal-to-gas (CTG) technologies as potential solutions for bridging the gap between long-term environmental objectives and real-world economic and political considerations. Polygeneration technology proponents say CTL and CTG could create a wide variety of cleaner energy sources using abundant domestic coal supplies as a feedstock while still relying on existing railway and natural gas pipeline infrastructure. Polygeneration could also decouple strategic industries from their dependence on increasingly volatile imported oil.

Commercializing this technology on a large scale, however, has its challenges. Standard & Poor's Ratings Services believes lenders will need to consider several critical items for any proposed debt financing of CTL and CTG projects.

Ratings Implications

We don't expect to assign credit ratings to many CTG or CTL projects in the near future, given the significant additional development that will be required to obtain regulatory approvals, negotiate sales (or "offtake") agreements, and improve initial cost estimates. Nonetheless, we do expect that CTG will likely be at the forefront of polygeneration development in the U.S. because it's a relatively more certain technology. CTL plants with true polygeneration capability are probably still several years away from seeking broader access to credit markets. Initial projects in these areas will not likely have investment-grade characteristics during construction and the initial years of commercial operation. But after such plants establish a reasonable commercial operating record, investment-grade ratings could be possible if long-term, price-certain contracts with creditworthy counterparties (or government entities) are in place.

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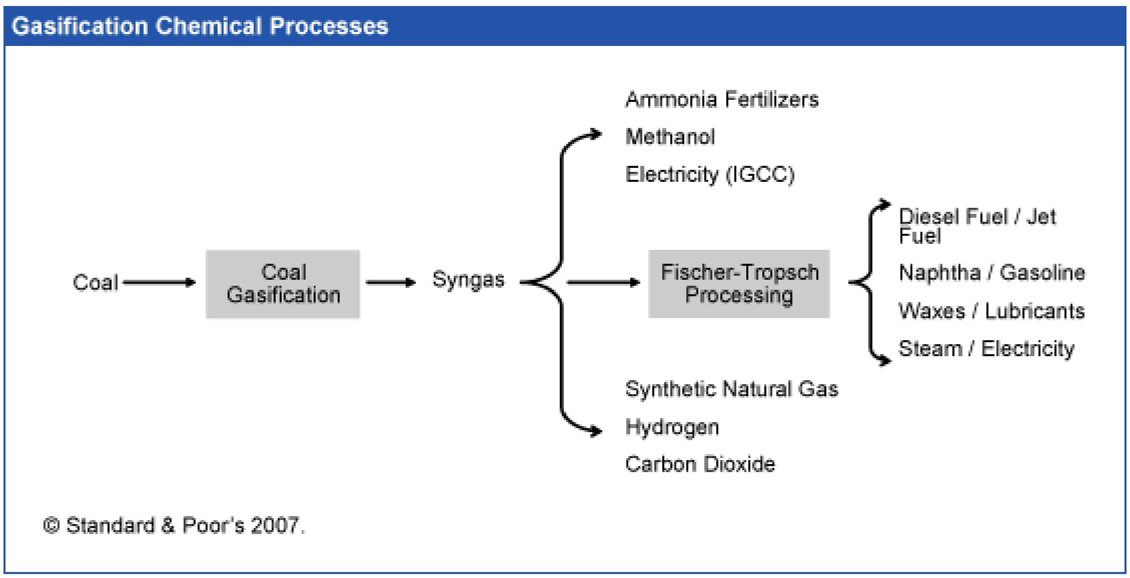
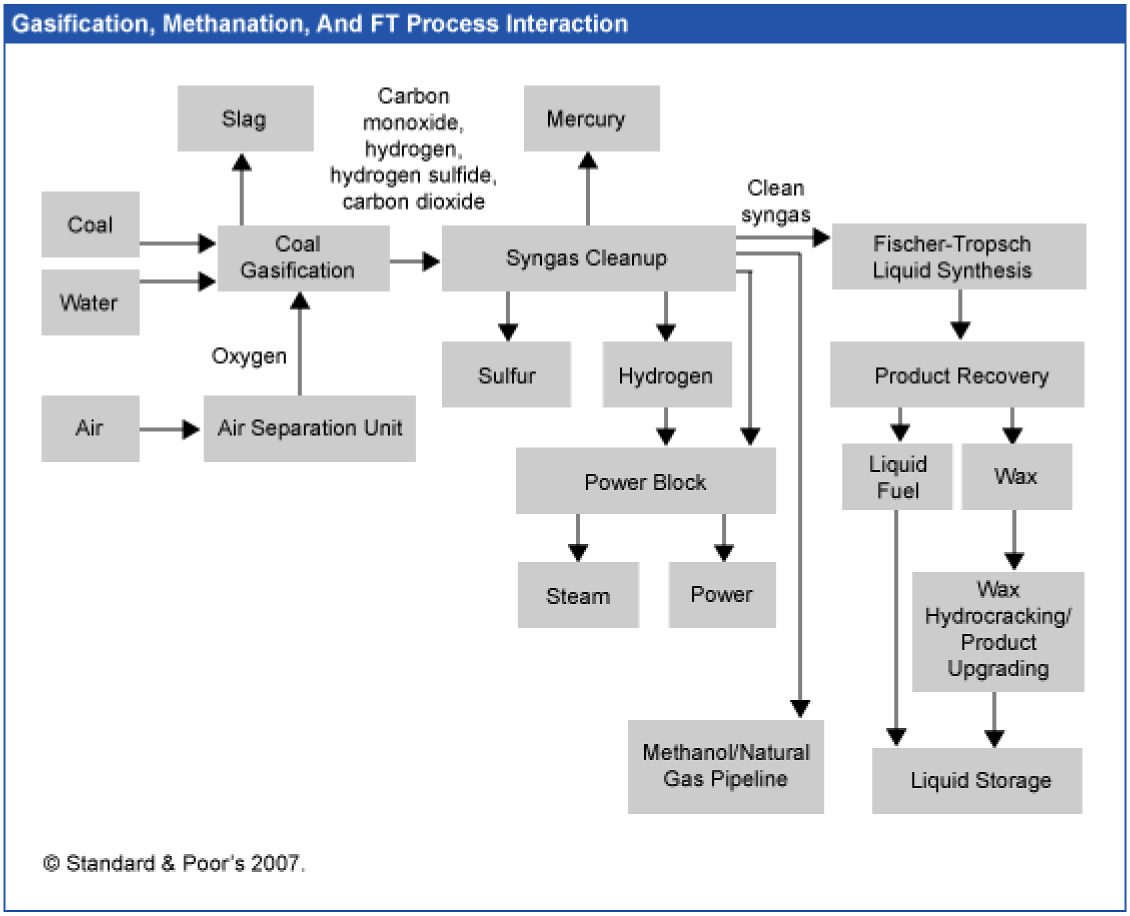
How Polygeneration Works

Polygeneration refers to using coal as the primary feedstock to produce a wide range of energy resources that include synthetic natural gas, methanol, diesel fuel, naptha, steam, and electricity. These projects are also referred to as "independent fuel producers," as opposed to "independent power producers." For the purposes of this article, we will discuss primarily the challenges and opportunities for this technology to convert coal to either natural gas or fuel liquids, such as naptha or diesel, although a polygeneration facility can make many other refined products.

Chart 1 illustrates the general chemical processes through which coal is first gasified and then further altered to create a synthetic fuel. In turn, that synthetic fuel can be converted to electricity using integrated gasification combined-cycle (IGCC) technology, directly synthesized into pipeline-quality synthetic natural gas (SNG) through a methanation process, or further refined through additional chemical reactions like the Fischer-Tropsch (FT) process to create higher value-added products such as gasoline.



To understand the financial risks and economic benefits of CTG and CTL, it's imperative to understand the coal gasification and FT synthesis components of a polygeneration project. Chart 2 provides a closer look at how the gasification, methanation, and FT processes interact. It's based on technical schematics that industry experts expect will be used in commercial-scale CTL or CTG projects currently under development.



The initial coal-gasification process CTG or CTL projects use is identical to the technology currently under development for IGCC units. Oxygen, coal, and water are combined during gasification in a controlled chemical reaction to create a combination of carbon monoxide and hydrogen called crude syngas. Byproducts from the process include hydrogen sulfide, carbon dioxide (CO2), and slag (i.e., mineral residue from the coal). These must be removed from the syngas before it's suitable for industrial application or power generation.

The first step in the syngas cleanup process is extracting residual mercury compounds through a commercially demonstrated vapor-phase process. Results at an Eastman Gasification Service Co. coal-gasification facility suggest that this technology is effective at removing upward of 94% of the gasified coal's mercury content. Next, a solvent is introduced to the syngas that results in the physical or chemical absorption of sulfur and CO2. Currently, three different technologies exist for this "acid gas removal" procedure, each of which is distinguished by its choice of chemical catalyst, operating temperature, and absorption capability. Two primary technologies (Selexol™ and Rectisol™) appear to have the widest industry acceptance as syngas cleansing technologies, and each has the ability to eliminate more than 99% of residual sulfur and from 50% to over 90% of the carbon in the original coal feedstock. As with the mercury removal, acid gas removal has shown to be highly reliable based on operating experience at a large number of petrochemical units worldwide.

After most impurities are removed, syngas may be processed in a methanation plant to create synthetic natural gas or methanol. Synthetic gas created through these techniques is of high quality and meets purity standards for interstate pipelines. Alternatively, the syngas can be synthesized into refined chemicals and diesel fuels using FT processes. FT synthesis involves subjecting the syngas to a high-pressure environment, adding a catalyst such as iron or cobalt, and modifying the reaction temperature to either directly produce a liquid fuel or produce an intermediate-stage wax hydrocarbon that's further catalyzed (or "cracked") into an end product.

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What Are The Benefits Of CTG And CTL?

There are three main benefits for CTG and CTL--fewer carbon emissions, more fuel diversity, and better energy security for the U.S.

Low carbon emissions

CTG and CTL proponents cite a number of environmental, economic, and strategic benefits from large-scale commercialization of these technologies. Environmentally, the syngas cleaning process automatically transforms about 50% to 70% of the coal's total carbon content into CO_2 that's ready for compression and sequestration. To the extent that hydrogen would form the ultimate end product of a CTG plant, additional carbon capture of up to 90% is possible.

Although CTL and CTG plants' environmental benefits are reasonably attainable with available technology, it's important to note carbon-capture benefits aren't automatic. They depend on an additional investment in compression and sequestration infrastructure that's outside the scope of gasification and FT technologies themselves. A recent Massachusetts Institute of Technology (MIT) study suggests that without a method of compressing and storing a polygeneration plant's CO_2 byproducts, FT processing can actually increase CO_2 emissions by 150% compared with directly refining petroleum-based fuel products.(1) The MIT study further suggests that CO_2 emissions from the gasified coal would be up to 175% higher for SNG created without carbon capture versus regular natural gas. The higher emissions are due to the relative inefficiency of gasification and FT technology, which requires more coal to be processed and increases the absolute amount of carbon byproduct. Fortunately, because the CO_2 created through gasification and FT synthesis is a relatively pure byproduct, industry experts estimate that the incremental cost of carbon-capture technology is almost one-third less than for the closely related IGCC technology.(2)

Fuel diversification

Beyond purely environmental considerations, economic interest in CTL is growing in the airline and transportation sectors, both of which have suffered from increasing oil and natural gas price volatility in recent years. Naptha, gasoline, and diesel fuel created from FT processes have the potential to provide transportation companies with a fuel source less correlated to global oil price volatility. Furthermore, these industries may be able to better hedge their exposure to changing fuel costs through longer term supply contracts with CTL refiners when these producers' operational characteristics become better understood.

Improved national energy security

Finally, many participants in the coal and defense industries think CTL and CTG technologies can have strategic and political benefits for U.S. energy security. The Energy Information Administration (EIA) estimates that net imports of liquid fuels in 2005 accounted for about 60% of total domestic consumption.(3) Furthermore, imports should remain at these levels through 2030, as increasing domestic oil production isn't likely to significantly offset projected consumption growth. Some worry that reliance on global markets to meet most of U.S. energy needs exposes the economy to supply disruptions from politically unstable regions. Even absent geopolitical turmoil, some observers predict an inevitable slowdown of U.S. economic growth as increasing oil demand from emerging economies like China, India, and Brazil causes future commodity prices to rise.

CTL and CTG supporters suggest that the U.S. can curtail its import dependence by as much as 5% annually by exploiting domestic coal reserves, which in 2006 were estimated to be about 267 billion short tons.(4) This suggests a 240-year domestic reserve life at 2006 consumption rates. The addition of coal-based technologies provides a much larger array of domestic resources on which to base economic growth. Also, the location of U.S. coal reserves--across 26 different states--would diversify fuel production away from the Gulf Coast, with its weather-related supply interruptions and limited domestic refining capacity.

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Key Risks For Polygeneration

Although CTL and CTG projects are probably several years and a few pilot projects away from finding wide acceptance in the financial markets, project sponsors and potential lenders will need to consider a number of risks and credit issues in the near term when evaluating the risk profile and commercial viability of any investment opportunities. Standard & Poor's believes lenders should consider several key items as the dialogue surrounding this technology continues to expand.

Technology risk

In the 1920s, German scientists pioneered the FT process that lies at the heart of the polygeneration concept to bridge the gap between that country's inability to finance petroleum imports and the need to rebuild its economy after World War I. The Nazis later expanded FT technology to achieve energy independence during World War II, when total synthetic fuel production peaked at 124,000 barrels per day (bpd) across 25 plants.(5) Second-generation development of FT technology occurred in the 1970s and 1980s at Sasol, a South African company that has to date developed the world's only fully operational CTL plants. Although privately owned Sasol has not publicly disclosed any operating statistics or technological specifics of its Sasol II and Sasol III plants, their long-term operating performance has been sufficiently reliable to provide between 30% and 40% of South Africa's fuel requirements over the past 20 years.(6) Likewise, the methanation process used to convert syngas into synthetic natural gas is a commercially proven technology widely used in the chemical industry.

As previously mentioned, Eastman Gasification has successfully demonstrated that CTG units can be reliably operated for 20 years. Since 1984, Eastman's CTG facility has posted an average forced outage rate of less than 2% and has had single unit reliability of up to 90%. Even higher reliability has been achieved by using redundant gasifier units during planned and unplanned maintenance. Moreover, most planned CTL/CTG facilities will use five or six small gasifiers. This results in gasifier availability of more than 90% and is an important distinguishing factor from IGCC, where the plants are usually designed to have two large gasifiers, with resultant lower overall reliability. A solid operating track record for the gasification components is good news for potential lenders to these projects because the gasifiers contribute an estimated 25% to 30% of the hard project costs of CTL and CTG facilities.

Integration risk

The relatively long history of polygeneration's component processes suggests that pure technology risk may be less of an issue for new projects. Scale-up risk, however, is likely to be a significant concern for CTL and CTG facilities. Currently, the Sasol plants in South Africa produce 80,000 barrels of diesel fuels per day. The company's familiarity with the technology and extensive experience have enabled this level of output. In the U.S., no local operators or project developers have direct experience with CTL units, so demonstration projects under development are much smaller than Sasol's units and can produce only 5,000 to 10,000 bpd. Most project sponsors agree that commercial-scale plants would require 30,000 to 40,000 bpd output to remain economical.

Sasol doesn't make operating data for FT liquefaction reliability publicly available, and therefore reliability represents a more significant technical risk for CTL lenders than for CTG facilities that don't employ the FT. In most project financings, integration risk is typically addressed through engineering, procurement, and construction (EPC) contracts that provide cost certainty to lenders. These are backstopped by substantial performance guarantees that ensure that the plant's design achieves a minimum operating level.

Based on discussions with project developers, Standard & Poor's believes that traditional turnkey, EPC-style contracts will not be available for CTL projects, given that FT units' operating performance isn't well understood outside of Sasol. Engineering firms like General Electric and Eastman may be able to provide performance guarantees on gasification units they supply, but these guarantees are unlikely to apply to FT liquefaction units. And they're likely to have liquidated damage provisions less than the 20% to 30% of total contract cost that's normally associated with investment-grade projects. Furthermore, FT providers in the U.S. are smaller, more entrepreneurial companies whose balance sheets do not support significant performance guarantees for their technologies. CTG units also appear unlikely to attract turnkey EPC contracts given the lack of a single vendor owning all available technologies.

Notably, although integration risk is one of the main concerns for lenders, it may be more manageable in a CTG or CTL plant compared with IGCC because the production process is fairly linear, with fewer feedback loops for steam, gas, and other process elements. Reliability issues in an IGCC facility often result from these integrations aimed at improving process efficiency. However, this advantage will ultimately need to be tested under operating conditions.

Capital cost versus commodity exposure

Obtaining good cost estimates for a CTG or CTL project is difficult. Project sponsors indicate that a polygeneration plant's operating cost structure will be very site-specific and could vary considerably due to differences in plant configuration, access to coal supplies, and local infrastructure. Industry participants Standard & Poor's interviewed estimate that to build a viable commercial-scale CTL facility it would need to be able to produce 30,000 to 60,000 bpd, with construction costs of about $100,000 to $120,000 per barrel (in 2007 dollars). Preliminary cost estimates are about one-half as much for a CTG facility with a 30 billion to 50 billion cubic feet per year output capability. This puts the range for CTL hard capital costs between $3 billion and $3.6 billion, and from about $1.5 billion to $1.8 billion for a CTG plant. Recovering these large amounts will require lenders and equity sponsors to have a long-term view toward the project's success, as well as some price certainty surrounding the plant's output.

In general, CTL pilot plants are likely to produce either naptha or diesel fuel as their primary product. Naptha is preferred due to the significant pricing premium it commands on the open market as a higher value-added refined product. In addition to the market conditions for the final end product, the competitiveness of a CTL refined product will depend on prevailing oil prices, the facility's operating and financing costs, and the period of time that both equity- and debtholders should reasonably expect to recover capital costs. Therefore, estimates concerning the price at which CTL projects will become economical vary widely and are extremely sensitive to the operating and financing assumptions specific to the project. In general, project sponsors and academic research estimate that CTL products are likely to become competitive on a production cost basis when oil prices are around $55 to $65 per barrel, whereas CTG plants are likely to become competitive with natural gas at prices between $6.50 and $8.00 per thousand cubic feet.

Given commodity prices' volatility in recent years, it's possible that CTL and CTG projects could become more cost-competitive, but lenders to these projects would need significant protection from downturns in the commodity cycle over the 20- to 25-year cost recovery period that appears reasonable for these types of investments. This suggests that CTG or CTL projects without long-term, price-certain offtake contracts, or government tax incentives or price protection are likely to be untenable, at least initially.

Regulation and government support

It seems almost certain that a lot of governmental support will be required to commercialize CTL projects in the U.S., given the high capital costs involved, technology risks, and oil price uncertainties. Standard & Poor's believes that without some federal or state government commitment to commercial-scale pilot projects, the financial risks related to CTL projects are simply too large for traditional fixed-income investors to bear. For example, Sasol would have been unable to successfully complete its South African facilities without loan guarantees and price supports from the South African government. Furthermore, federal, state, and local agencies are well situated to take many of the longer-term risks that the financial community is unable to accept. We believe this is appropriate given that many of the environmental and strategic benefits (i.e., cleaner air, improved energy security, and increased fuel diversification to support strategic industries) are too broad to easily assign costs and benefits to specific groups. The Department of Defense is a much sought-after potential customer for liquid fuels from CTL projects.

CTG projects differ from CTL in two important ways that somewhat lessens the former's reliance on government support. First, methanation technology is better understood than FT. Second, rather than depending on the federal government for fixed-price guarantees, CTG projects maybe able to enter into long-term, fixed-price contracts with creditworthy utilities that would purchase natural gas for their gas-fired power plants. However, state regulatory support that allows investor-owned utilities to pass "out-of-market" costs along to consumers without regulatory disallowances or extensive prudence reviews would remain necessary for these projects to achieve higher ratings.

Such support could take a variety of forms. However, it's important that the support directly addresses the most important issues to potential lenders, such as ensuring a long-term offtake, contributing to price certainty, or protecting against financial losses due to technical failure. Examples of governmental support that would improve a polygeneration facility's credit profile are:

- Federal and local municipalities or agencies could serve as the primary long-term offtaker for CTL or CTG products, or agree to act as a "buyer of last resort" if market prices don't support sales to private market participants.
- Federal loan guarantees could be provided to projects to lower capital costs for investors, though we expect that they're likely to be insufficient in their current form and would require modification. Currently, for many programs, the government guarantees only 80% of the loan amount, effectively leaving the debt rated at the project's intrinsic credit quality.
- Governments could provide a minimum price support if global commodity prices fall below predetermined thresholds that render CTG or CTL products uneconomical.
- Federal and local tax incentives could increase capital returns to investors and lower the cost of capital for project sponsors.

Although polygeneration may appear to be modern-day alchemy, the base technology has been with us for almost 80 years, and now may hold the key to achieving important advances in lessening the effects of climate change. The benefits that polygeneration provides with respect to energy independence and fuel diversity make future CTG and CTL projects likely beneficiaries of both public and private market support for environmentally friendly energy alternatives. Ultimately, however, risk allocation between these constituents will determine how much capital markets can do to support these investments.

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Notes

(1) Massachusetts Institute of Technology. "Coal Based Electricity Generation," The Future of Coal: Opportunities for a Carbon-Contrained World," Massachusettes Institute of Technology (2007).

(2) Ibid.

(3) Table A.11 – Liquid Fuels Supply and Disposition – Reference Case, Annual Energy Outlook 2007, Energy Information Administration (February 2007).

(4) "Coal Reserves Information Sheet," Energy Information Administration (November 2006): http://www.eia.doe.gov/neic/infosheets/coalreserves.html.

(5)"Fischer-Tropsch History." Coal Gasification & Fisher-Tropsch: CCTR Basic Facts File #1. Indiana Center for Coal Technology Research (July 2006).

(6) Geertsema, Arie; "CTL and SNG Production: Issues and Opportunities," GTC Workshop (March 14, 2007).

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