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SPECIAL REPORT: GTL, CTL finding roles in global energy supply

Interest in Fischer-Tropsch (F-T) chemistry and associated technologies such as gas-to-liquids (GTL) and coal-to-liquids (CTL) continues to grow worldwide. Within the last few years one new world-scale unit came on line, three others are in construction, and many more are planned, while other approaches and synergies, such as biomass-to-liquids (BTL) and integrated coal gasification-combined cycle (IGCC), are under evaluation.

During this period, commercial products have been tested, certified, shipped, and used. However, concerns such as CTL's carbon dioxide (CO_2) manufacture have come to the center stage. Technology development and demonstration, economics of construction and operation, and regulatory directions in various jurisdictions continue to be in flux. This article reviews recent GTL and CTL activities and discusses the likely directions and commercial impact of this technology.

Background

A general arrangement diagram of F-T-based processes is shown in Fig. 1.

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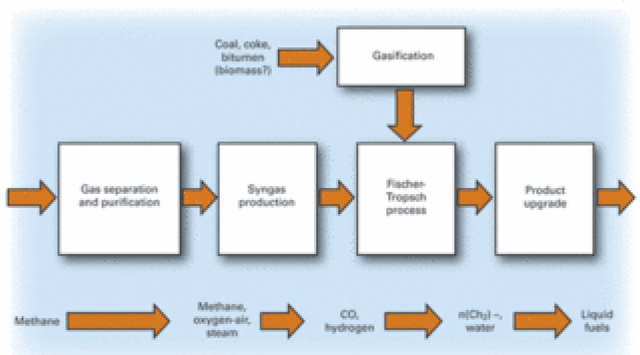

FISCHER-TROPSCH-BASED PROCESSES DIAGRAM Fig. 1

Commercial F-T chemistry uses cobalt or iron-based catalysts in fixed, fluidized, or slurry-phase reactors to convert synthesis gas (syngas) to large-molecular-weight hydrocarbons, such as naphtha, diesel, lube, and wax range material.

The syngas stream, primarily carbon monoxide (CO) and H_2, can originate from different sources, such as natural gas methane partial-oxidation or steam reforming, coal or coke gasification, or the gasification of biomass (not yet commercially demonstrated). The source of the syngas affects F-T chemistry both in terms of potential impurities—such as sulfur and various metals from coal-derived syngas—that need removal and in terms of the syngas CO/H_2 composition.

Aside from the feed and its properties, F-T reactor product composition depends on factors that include reactor type and design and operating conditions such as temperature. One can modulate the mix to produce primarily waxes or diesel, for example. Most often, in low-temperature operation much waxy and lube-range material is produced, which is then mild-hydrocracked to high-quality diesel having near-zero sulfur and a cetane number of 70-75.

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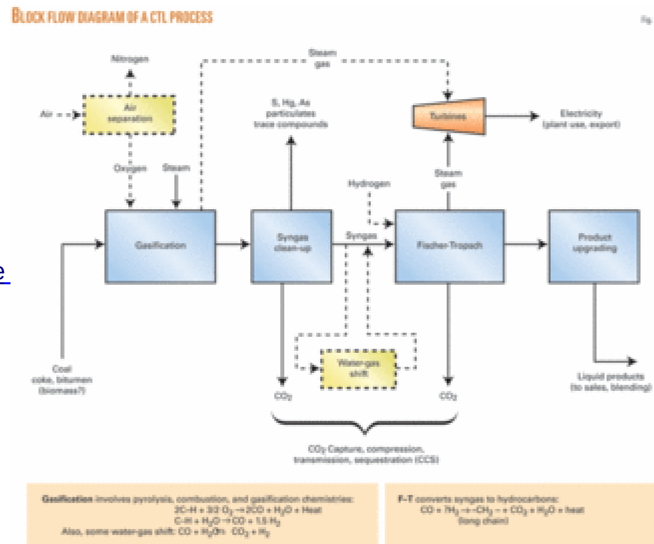

Many variations can be considered in terms of how the key elements are combined and which products are made. Fig. 2, for example, shows the use of coal or other higher-carbon sources as feedstock while potentially generating power, CO_2, or liquid hydrocarbons such as diesel, naphtha, lubes, and waxes. In addition, aside from hydrocracking the lubes-wax stream, the naphtha or light ends could be steam-cracked to syngas and recycled back to the F-T reactor to increase production of high quality diesel.

References 1-3 give more detail on the F-T chemistry and GTL-CTL processes, products, and qualities.

Drivers and issues

Many factors that originally aroused interest in GTL and associated processes during the past decade remain valid:

- A steady increase in global energy demand. F-T-based processes along with a number of other approaches are being developed to meet this growing need, much of which is muscled by emerging economies. China has an annual 8-11% historical and projected growth in diesel requirement, and energy demand is projected to remain strong in India and Brazil. Barring major upsets, the industrial economies will develop at a low single-digit pace. Escalation of energy use to 2030 for Organization for Economic Cooperation and Development (OECD) and non-OECD countries is projected to average 0.8 and 2.9%/year respectively, with a global average of 1.8%/year.[4 5]
- Large volumes of stranded gas in several global areas having little access to the market.[6 7 8] In addition to GTL, other options such as LNG and gas-to-chemicals (GTC) facilities are either operational or in various stages of progress.
- Tightening quality specifications such as those for sulfur in hydrocarbon products, particularly diesel and gasoline, in many jurisdictions. These requirements are being met largely through improved hydrocracking, hydrotreating, and other refining processes, although F-T-based synthetic products are excellent blendstocks due to their low sulfur and high cetane.
- The need to reduce gas flaring for economic, environmental, and legal reasons in countries such as Nigeria, which flares 2.5 bcfd.[9]

At the same time, certain factors have gained in importance during the past years:

- The increase in the market value of crude oil. An oil price that has crossed the psychological $100/bbl mark multiple times with little expectation of retreating to pre-2004 levels has improved the economics of many technologies, including CTL and GTL.[63 64]
- Worldwide resource security concerns, given the current global political climate. Of great interest in this arena are gas—only about 40% of the proved reserves are in the Middle East—and coal, of which the US has the largest reserves in the world.
- Concern about the possibility of global climate change and the potential impact of CO_2 release. This has led to the exploration of a number of approaches ranging from technology improvements for increased efficiency to CO_2 capture, compression, and sequestration (CCS).[10] Additionally, topics such as BTL conversion are seriously on the table, although many technological as well as economic and strategic issues remain to be resolved.[11]

GTL projects

A list of existing GTL-CTL plants and those under construction is shown in Fig. 3. There has been a flurry of activity in this area, the most important being the construction, start-up, and operation of the first GTL plant in 15 years.

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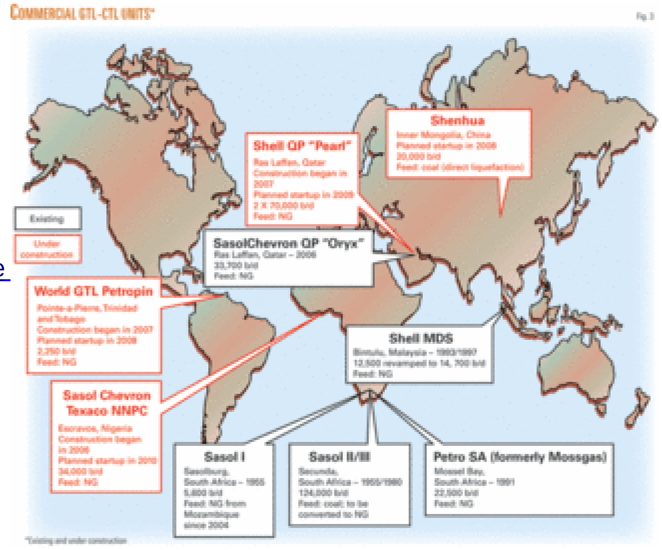

General contractor Foster Wheeler began construction of the Sasol Chevron and Qatar Petroleum Oryx GTL facility in Ras Laffan, Qatar, in 2003 and completed it in mid-2006. It has a design capacity of 34,000 b/d and will use 300 MMscf of gas from North field. Slurry reactors start-up took about 6 months—2 months longer than expected—and production began in earnest in December 2006.[12]

Sasol claimed the plant was completed within budget, originally stated at $950 million. The first product shipment from the plant was announced in May 2007.

The companies encountered a number of technical problems, including issues with the utility section and with catalyst-slurry separation, the latter resulting in the contamination of intermediate waxy streams with particulates and fines to some downstream units.[13] Consequently, the plant has been operated at levels below 10,000 b/d during 2007-08 while solutions are devised. Sasol announced late in 2007 that the facility will begin operating at full capacity by July 2008.[14] It more recently said the facility is unlikely to reach full capacity for some time.

Construction of the other large GTL facility in Qatar—the 140,000 b/d Shell-Qatar Petroleum Pearl plant—continues apace, although with major cost overruns. Construction began in February 2007 on the plant, which will have two 70,000 b/d trains and fixed-bed reactors and is due to start up in 2009.[15] Projected construction cost, originally $6 billion in 2004, increased rapidly to $12-18 billion and then to $20 billion.[16 17 18] Factors causing the overruns include the large amount of engineering and construction activity globally, especially in the Middle East, with the rising price of crude and petroleum products.[19]

In part resulting from such cost escalations, a number of GTL projects in Qatar were cancelled or placed on hold until at least 2009.[16 20 21] Particularly noticeable is the cancellation of the ExxonMobil and QP Palm GTL plant having a planned capacity of 154,000 b/d, which leaves much of the burden of "proving" GTL's economic and technical feasibility in Qatar on the shoulder of Oryx. The other facilities put on hold include plants planned with ConocoPhillips and Marathon-Petro-Canada as Qatar assesses North field reserves.

Another major project, the Escravos GTL plant in Nigeria, has a design capacity of 34,000 b/d and would use more than 300 MMcfd of gas and contain slurry-bed reactors. Chevron Nigeria Ltd. and Nigerian National Petroleum Co., however, say they expect the capacity to be expanded to 120,000 b/d within 10 years.[22] The engineering, procurement, and construction contract for this $3 billion project was awarded in 2005, and construction started in mid-2006.[23] Despite some delays, first production is set for 2010.[24]

Also being constructed is the 2,250 b/d World GTL plant in Trinidad and Tobago (see cover). This facility, to use about 21 MMscfd of gas and contain two fixed-bed reactors, is a rather late-comer, with $100 million financing obtained in 2007.[25] World GTL is relocating mothballed equipment, such as a reactor from a Delaware methanol plant and a hydrocracker from Guatemala.[26] It has an aggressive construction plan, with start-up set for March or April.

Along with these, a large number of other projects are at various stages of study, planning, and design around the world, including plants in Australia, Egypt, Thailand, and Papua New Guinea, among others.

Product demonstrations

Although commercial GTL units in South Africa and Malaysia and CTL units in South Africa have been operating for decades, their products' utility and performance, including emission characteristics, were further demonstrated in several ways during the past few years.

A number of fleet tests of GTL diesel blends were or are being performed. For example, in 2007 Chevron and a northern California transit district initiated 6-month-long test evaluations involving 60 buses using GTL diesel and biodiesel.[27]

The US Air Force Synthetic Fuel Initiative, meanwhile, has successfully performed a number of tests using 50:50 blends of F-T and JP-8 jet fuels to certify all of its aircraft by 2011—and 50% synfuel use in the US by 2016.[28] These tests include flight testing of B-52s and subsequent certification of the F-T blend, ground testing of the engine that powers the C-17 and Boeing 757, and a transcontinental flight-test of the C-17 in October 2007.[29 30 31]

Last month Airbus A380 became the first commercial aircraft to complete a flight using GTL jet fuel blend. Parties to the flight test included Shell, Qatar Airways, and Rolls Royce, the engine manufacturer.

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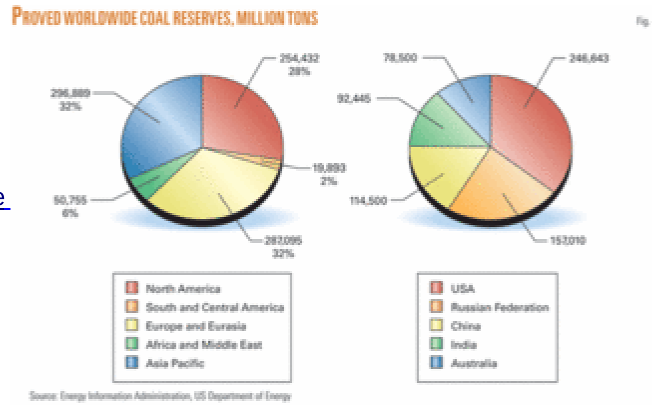

There have been flashy demonstrations. Ten Audis used in the 2007 World Economic Forum annual meeting at Davos, Switzerland, were run on Shell GTL fuel.[32 33] In April to June 2006, Sasol Chevron ran a 6,500-km "GTL challenge" where five cars, including one on pure GTL diesel, were raced from Sasolburg, South Africa, to Doha, Qatar.[34] In both 2006 and 2007 the entries using fuel formulated to include Shell Bintulu GTL diesel raced in and won the 24-hr Le Mans competition.[35]

Coal-to-liquids

Lately, CTL has gained a relatively high profile in the US—witness a 60 Minutes segment as well as multiple New York Times editorials and articles—as the country leads a small group of countries with substantial proved coal reserves, including Russia, China, India, and Australia (Fig.4).[36-39] Within the US, coal reserves are distributed in several states, including Montana and Wyoming in the West, Illinois and West Virginia in the Midwest and East, and Louisiana and Mississippi in the South. The quality of the coal varies in different US and global regions with respect to water, sulfur, and energy content, but based on current levels of usage—primarily in power generation—it is expected to last two to four times as long as world oil or gas reserves (Table 1).

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GLOBAL PRIMARY ENERGY RESERVES

Table 1

Resource	Proved reserves	Energy, quadrillion btu	Million tons of oil equivalent	Years remaining at current production
Oil*	1,372 x 10^9 bbl 191 x 10^9 tons	7600	191,000	41
Natural gas	6,405 tcf	6,600	165,000	63
Coal	479 X 10^9 tons	8,500	213,000	147

* Includes Canadian oil sands.
Source: BP Statistical Review of World Energy, 2007

In the US, many stakeholders are involved in improving the technology, evaluating implementation feasibility, and affecting policy. Parties include:

- Private industry, which includes coal companies such as Peabody; technology suppliers such as Chevron, ConocoPhillips, Sasol, Rentech, Syntroleum, and GE; and industry advocacy groups such as the National Coal Council, American Coal Foundation, and Coal-to-Liquid Coalition.
- Environmental stakeholders having concerns regarding CO_2 generation and water usage. These include the Natural Resources Defense Council and Groundwork USA.
- Government entities, including the departments of Defense and Energy, which are active in technology evaluation and development; and state and federal governments and agencies involved in policy development and project funding.
- The general public having dual interests in the development of cost-effective and secure energy resources and good shepherding of the environment.

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OVERALL CTL BALANCE Table 2

Total liquid product capacity	11,000 b/d[1]	50,000 b/d[2]
Coal (Illinois #6, bituminous), tons/day	4,891	24,533
Other feeds: air, water,...		
Diesel, b/d	7,500	27,819
Naphtha, b/d	3,509	22,173
Co_2, tons/d	6,035	32,481
Net Power, Mw	9.7	124.3
Other products: S, slag, fuel gas, ...		
Bbl liquid/Ton coal	2.25	2.04
Ton CO_2/Ton coal (carbon /carbon)	0.53	0.57
Ton CO_2/Ton coal	1.23	1.32
Overall thermal efficiency, % HHV	[3]51	[3]47

[1]NETL study for DOD/Air Force Apr. 9, 2007. [2]NETL/DOE study Aug. 24, 2007. [3]Not verified. Does not include all energy recovered in process.
Sources: NETL/DOD feasibility study, DOE/NETL feasibility study.

A number of recent technical and economic feasibility studies provide information on CTL and its prospects.[40 41] Table 2 provides overall mass balance from two works in which many design and strategic factors are examined.[42 43] Note especially the production of 1.3 tons of CO_2/ton of coal (0.65 tons/bbl of liquid product).

CTL projects

Currently, only one commercial CTL unit—in South Africa—is operating, with even this likely to be converted to GTL gas feed during the next few years (Fig. 3). However, CTL has a long commercial history, with multiple units operational for as long as 5 decades. Many projects are at various stages of progress globally, including the US (Table 3).

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PARTIAL LIST OF US CTL PROJECTS Table 3

Project lead	Project partners	Location	Feedstock	Status	Capacity, b/d	Cost, $ billion
American Clean Coal Fuels	None cited	Oakland, Ill.	Bituminous, biomass	Feasibility	25,000	—
Synfuels Inc.	GE, Haldor Topsoe, NACC, ExxonMobil	Ascension Parish, La.	Lignite	Feasibility	—	5
DKRW Advanced Fuels	Rentech, GE	Medicine Bow, Wyo.	Bituminous	Design (2011)	15,000-20,000	1.4 (?)
DKRW Advanced Fuels	Rentech, GE, Bull Mountain Land Co.	Roundup, Mont.	Sub-bituminous, lignite	Feasibility	22,000	1-5
AIDEA	ANTRL, CPC	Cook Inlet, Alas.	Sub-bituminous	Feasibility	80,000	5-8
Mingo County	Rentech	WV	Bituminous	Planning	25,000	2 (?)
WMPI	Sasol, Shell, DOE	Gilberton, Pa.	Anthracite culm	Design	5,000	0.612
Rentech/Peabody	N/A	Montana	Sub-bituminous, lignite	Feasibility	10,000-30,000	—
Rentech/Peabody	N/A	Illinois, SW Indiana, Kentucky	Bituminous	Feasibility	10,000-30,000	—
Rentech		Natchez, Miss.	Coal, petcoke, biomass	Planning	1,600 (Ph. I)	—
Baard Energy	AMEC Paragon	Wellsville, Ohio	Sub-bituminous, lignite	Feasibility	35,000	4

Although all of the US CTL projects are in the early stages, at least one project in China is under construction and slated for start-up this year. The Shenhua Inner Mongolia facility has a capacity of 20,000 b/d of liquid products using direct liquefaction technology as opposed to classical CTL routed through the manufacture of syngas.[4 44 45]

This technology historically has not been favored, as the chemistry is considered to be more difficult, requiring better controls for good operational reliability. In light of its large coal resources and growing energy demand, China has made a strong commitment to CTL, with several projects in the works and various entities stressing the importance of CTL to the country's energy policy.[46]

At the same time, the Chinese leaders have expressed concern for environmental quality issues and are particularly mindful of the large amounts of water required in CTL as many parts of the country are arid.[47 48] Given these issues and the high capital cost of CTL, there are reports that China might cancel some projects.[49]

Other non-US CTL undertakings at various stages of study, planning, and design include projects in Lu'an and Yankuang and joint ventures with Sasol and Shell in China and projects by Alon Resources PLC in Australia, Pertamina in Indonesia, Tata Group and Sasol in India, Sasol in South Africa, CIC Energy in Botswana, and L&M Group in New Zealand.

US policy action

A number of entities are involved in influencing, evaluating, and developing policy at the US state or federal levels and, over the years, various elements have been put in place:

- A 50¢/gal subsidy on F-T naphtha and diesel in the 2005 Federal Transportation Bill. This was extended to 2010 in the 2007 Farm Bill, although a requirement for recovery and sequestration of at least 50% of CO_2 was also included—and up to 75%, if technologically possible.
- Loan guarantees for gasification projects with less than 65% electricity output as mandated in the Energy Policy Act of 2005.
- A 20% investment tax credit applied to the first $650 million during the first year of operation, also included in the Energy Policy Act of 2005.
- Over $2.2 billion funding for CCS R&D, demonstration, and assessment in Title VII of the Energy Independence and Security Act (EISA) of 2007 that President George W. Bush signed into law last December. This includes provisions for at least seven large-scale CO_2 sequestration tests as well as carbon capture demonstrations.

In addition to these, there are numerous regulations and incentives related to plant emissions and fuel usage as well as regulations on fuel quality and specifications. In Europe, an emissions trading scheme is in place, while in the US voluntary emissions trading markets, such as the Chicago Climate Exchange, exist, and California and some northeastern states have their own initiatives in the works.[50, 51]

Is a cap-and-trade regime coming? What about a carbon tax? Noting the great uncertainty and flux in the policy area, particularly as related to CO_2 emissions, many players, particularly in the US, are awaiting more visibility in this area before committing large resources to actual commercial CTL implementation.

GTL, CTL projections

Many studies and analyses during the first half of the decade projected 400,000-800,000 b/d of worldwide GTL liquid products for the medium term (2015-20).[1] However, the 2007 EIA projections suggest that much of the F-T liquid products might be the result of added CTL units rather than GTL.[4]

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Global CTL, GTL liquid fuels production — Table 4

	1992	2004	2005	2010	2015	2020	2025	2030
				1,000 b/d				
GTL liquid products								
High case	—	—	—	20	60	100	110	140
Low case	—	—	—	20	30	40	50	60
Reference case	—	—	—	20	50	90	100	120
CTL liquid products								
High case	100	100	100	300	600	1,800	3,000	3,900
Low case	100	100	100	300	300	500	800	900
Reference case	100	100	100	300	600	1,200	1,700	2,400

Source: Energy Information Administration, International Energy Outlook 2007

Evaluating cases ranging from projected low to high oil prices, they project global CTL liquid fuels of 0.9-3.9 million b/d by 2030 while, for GTL, they show a more modest production of 60,000-140,000 b/d (Table 4). In their scenarios, China will account for nearly 60% and Qatar 80% of the added global CTL and GTL capacity by 2030. Assuming growth of 1.8%/year in the global consumption of middle distillates, CTL and GTL would contribute modestly though meaningfully in meeting the expected demands— as much as 9% of the 2030 demand under the high GTL and CTL implementation scenario (Fig. 5).

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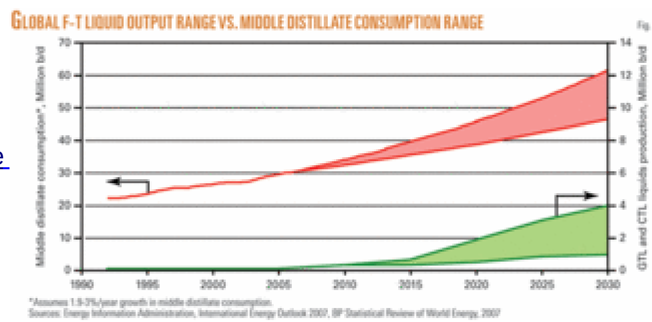

The EIA's CTL projections for the US shown in Fig. 6 suggest that by 2030 as much as 6% (2007 projection) to 9% (2008 projection) of the US middle distillate demand can be met through CTL.[4, 52] As expected, given the value of natural gas in the US, no GTL units, except demonstration units, are likely to be built in the US.

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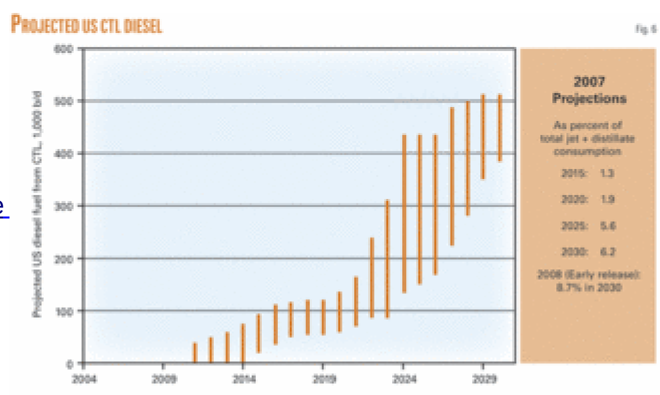

There are other projections for CTL and GTL growth. International Energy Agency expects 180,000 b/d of CTL in China by 2015 and 750,000 by 2030 while none in India during the same time period, a surprise given India's large reserves of coal.[5] These numbers are decidedly modest when compared with EIA's projections. Another analysis suggested a global GTL capacity of about 400,000 b/d during the next decade.[53]

Projections also vary quite a bit with respect to the US. Depending on government policy decisions, the Federal Task Force on Strategic Unconventional Fuels forecasts US CTL capacity ranging from 400,000 to 2.6 million b/d by 2035.[54] The National Coal Council similarly projects 2.6 million b/d of CTL liquids by 2025, while the Southern States Energy Board calls for a very aggressive growth of CTL to 5.6 million b/d by 2030.[56] More reasonably, a Baker and O'Brien study suggests 250,000 bbl of CTL middle distillates from four to six large-scale CTL plants by around 2020.[41]

It is likely that some of the projections, particularly for CTL, are too aggressive, as several elements could moderate the pace of CTL implementation:

- The fate of CO_2 and the CCS option will be slow to resolve because studies such as finding and certifying suitable geologic formations for sequestration will take years to give results. At the same time, policy actions in a democracy such as the US will be slow to develop and decidedly conservative in implementation.
- CTL units cost $70,000-100,000/bbl-capacity. This high capital cost will require multiple partners and several sources of financing as well as higher return potential, all of which result in slower analysis and approval for such projects (Table 5).

TYPICAL CTL CAPITAL COST FOR NOMINAL 50,000 B/D UNIT Table 5

Capital cost, $ million[1]		
Coal and slurry prep	425	67%
Gasification	1,150	
Air separation unit	425	
Syngas clean-up	850	
WGS + F.T	510	12%
Product upgrading	210	5%
Power generation	255	16%
Other	425	
TIC	4,250	
~$85,000/bbl installed capacity		

[1]Excludes CO_2 compression, transportation, sequestration costs.

Overall, the global progress of CTL will likely be at the lower end of the EIA projections and may reach 0.5-1 million b/d of capacity by 2030.

On the other hand, GTL capacity might grow a bit faster than expected, as it has lower capital costs—assuming the cost escalation at Qatar's Pearl is an aberration—and fewer environmental concerns compared with CTL. As such, growth in the upper range of the EIA estimates—150,000-250,000 b/d—by 2030 seems reasonable.

Potential impact

Given the understandably great variation on projections and the many assumptions involved, including potential policy action, few elements can be predicted with authority. However, the following are likely:

- A handful of projects are operational or are being built. Given the high capital cost for these technologies and other uncertainties, such as CO_2 regulation and cost, many parties will suspend or slow projects for the next few years until results of the existing projects from technical, economic, and strategic points of view become known.
- In light of the very large regional reserves of stranded gas and coal, demands by existing and new GTL, CTL, and related technologies such as GTC will not overly tax these reserves. At the same time, some additional coal mining will be needed, especially in the US.[57]
- The impact of GTL and CTL products such as diesel and naphtha on the markets will be generally modest in helping meet the increasing demand. At the same time, the products can have a major impact on meeting demand in certain regions. One analysis suggests that as much as 15% of the near-to-medium-term European diesel deficit can be met by the commercial F-T units currently under construction.[53] F-T diesel will be an excellent blendstock in Europe although not fully valued for its low sulfur and high cetane, as the European refineries have implemented a large number of hydroprocessing units to satisfy sulfur restrictions. In Asia and other jurisdictions with evolving specifications, however, the F-T diesel could have additional value as it blends to help meet the new specifications.
- F-T naphtha, due to its paraffinicity and linearity, is best used as petrochemical feedstock. However, it can be processed in the refinery using isomerization (light-end) and reforming (heavy-end) units for improved octane, although these might need

to be dedicated or run at different conditions.[65]

- F-T units will produce only a small amount of lubes and waxes, as these streams will be hydrocracked down to diesel and naphtha to avoid overwhelming the global lubes and wax markets—about 1 million and 100,000 b/d, respectively. The quality of the F-T lubes and waxes is high, and even the small amount added to the market will help retire the less efficient lube refineries, which generally produce lower viscosity index products.

CO_2 and CCS

About 28 billion tons of CO_2 was emitted globally into the atmosphere in 2005, the US share of which was about 6 billion tons.[4] About half of this came from large stationary sources, primarily coal-fired power plants, from which CO_2 is considered to be captureable (Table 6).

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WORLDWIDE LARGE STATIONARY CO_2 SOURCES Table 6

Process	No. of sources	Emissions, Million tons CO_2/year
Power	4,942	10,539
Cement production	1,175	932
Refineries	638	798
Iron and steel Industry	269	646
Petrochemicals industry	470	379
Oil and gas processing	Not available	50
Other fossil fuels	90	33
Bioethanol and bioenergy	303	91
Total	**7,887**	**13,466**

Source: Intergovernmental Panel on Climate Change Special Report, Cambridge University Press, 2005

Given production of a typical 0.65 ton CO_2/bbl of liquid products, a 50,000 b/d CTL plant is expected to produce 11.3 million tons/year of CO_2 (Table 2). In light of CTL growth projections, simple calculations suggest that, without CO_2 CCS, US CTL units might emit as much as 175-230 million tons of CO_2 in 2030, equal to 1.3-1.7% of the 2005 global large stationary source emissions (Table 7). The implementation of CCS can reduce emissions by 80-90%, reducing the projected CTL emissions shown in Table 7 to 0.1-0.3% of that of the global large stationary sources.

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US CTL CO_2 EMISSIONS PROJECTIONS Table 7

Projected emissions from CTL, Million tons CO_2/year	Without CCS	With CCS
2015	10-41	1-8
2020	28-61	3-12
2030	175-230	17-46
2030 CTL emissions as % 2005 Global large stationary sources	1.3-1.7	0.1-0.3

Source: Energy Information Administration, International Energy Outlook 2007

There is disagreement about the efficacy of CCS. Some argue that, even with CCS, CTL diesel manufacture results in higher CO_2 compared with conventional diesel.[58] However, over the past few years, all major parties in the US and other industrial nations have agreed that CCS is critical to the acceptance and implementation of CTL, and therefore great effort is beginning to be expended in this area.

The elements of CCS—CO_2 capture, compression, transmission, sequestration—have been implemented commercially in many contexts over the decades. Currently there are more than 2,500 km of pipelines transporting more than 40 million tons/year of CO_2 in the US, as 30 million tons/year of CO_2 is injected for enhanced oil recovery. And about 1 million tons/year of CO_2 is injected from Sleipner gas field into a saline aquifer under the North Sea.[10]

Given the large volumes of CO_2 that would require sequestration from CTL, coal-fired power plants, and other sources, suitable geologic formations must be found and investigated for capacity, stability, and impact in tests that require several years. Many parties are at work on this in the US and internationally. Major US efforts include:

- The FutureGen Alliance, a nonprofit organization representing some of the world's largest coal and utility companies. It has a budget of $1.7 billion, 74% of which comes from the US government, excluding EISA 2007 funding. The alliance selected a test site at Matton, Ill., in December 2007, but the Department of Energy canceled funding for the project, making its current status uncertain.[59 60]
- Plains CO_2 Reduction Partnership, part of a $300 million program testing three regions in North America. In one, 1 million tons/year of compressed and liquefied CO_2 will be injected into a formation about 10,000 ft below North Dakota.[61]

These parties are joined by others outside the US, such as GreenGen in China, Coal21 in Australia, and the Asia Pacific Partnership.

Meaningful progress

The advancement of F-T-based technologies over the past few years have been measured but meaningful: one commercial unit is on stream, and three others are to start operating by the end of the decade; products have been tested and are used in commercial quantities; and technical problems have been confronted and are being resolved.

Yet important issues remain: capital cost, economics, and potential growth in the near term and the environmental impact of CO_2 emissions during CTL production in the long term.

Nevertheless, excitement exists in these areas fueled by higher global energy demand and rising crude prices. It is likely that, given all this, F-T-based technologies will continue to improve in commercial application and relevance, although they will remain a modest component of the overall search for clean, secure, and cost-effective transportation fuels.

Acknowledgment

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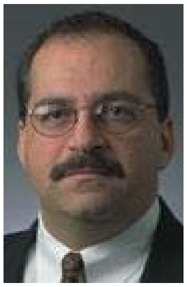
References

1. Rahmim, I. I., "Stranded gas, diesel needs push GTL work," (OGJ, Mar. 14, 2005, p. 18).
2. Rahmim, I. I., "The Promises and Limitations of Gas-to-Liquids Technology," Global Forum on Natural Gas, Galveston, Tex., May 2004.
3. Rahmim, I. I., "Potential Impact of GTL Commercialization on Fuels and Specialty Product Markets," NPRA Annual Meeting, Salt Lake City, Utah, March 2006.

The other references (62) are available from the author upon request.

The author



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