COAL-TO-LIQUIDS (CTL)

Misplaced solution for oil starved world

By

Sunita Dubey
groundWork-USA
c/o SADF
555 Amory Street
Boston 02130
Tel- 1-617-273-0349

INTRODUCTION

Limited resources, soaring oil prices, and an increasing concern for energy security have generated a renewed interest worldwide in CTL and in companies like Sasol. Such myopic vision is now responsible for countries like United States, China and India ignoring the past environmental record of coal-to-liquids technology and companies like Sasol. This South African company pioneered the art of making liquid fuels from coal during the apartheid era because of international sanctions imposed on its government. Highly subsidized by the South African government and reaping benefits from its oppressive policies, Sasol flourished under the apartheid regime. Sasol has used the Fischer-Tropsch technology for years and is now working with companies in western China. Syntroleum, a company that originated as an R&D group through the US Department of Energy, based in Tulsa, Oklahoma, is working with a company in Brisbane, Australia. Shell GTL, an oil company that has a gas-to-liquids (GLT) plant in Malaysia is working with companies in China with CTL. In early 2006 Bumi, Indonesia's largest private energy company, announced its plans to build an 80,000bbl/d CTL facility in South Sumatra. In Germany, a pre-feasibility study is being undertaken for a 3000bbl/d facility at Spreetal. The project is seeking financial support from the Saxony State Government and, is currently eligible for a €100 million ($128 million) grant.

Despite Coal-to-Liquids past record and its assault on environment and poor black communities in South Africa, the governments of major coal producing countries are more than eager to join hands with Sasol and other companies, in the name of energy security. China and the United States are actively developing CTL technology. China is building a multi-billion dollar CTL plant in Inner Mongolia, while the U.S. Department of Defense is looking at CTL technology as a means to reduce dependence on foreign oil. The National Coal Council, an American pressure group is asking the government for subsidies that would help the domestic coal industry generate enough liquid fuel to satisfy 10 percent of America's expected oil demand in 2025. Many Senators in the US support CTL and while Senator Barack Obama of Illinois and Jim Bunning of Kentucky have introduced a bill calling for tax incentives for coal-to-liquid fuel conversion plants.

> *However, the prospect of coal-to-oil conversion will add further to the already surging demand for coal, which now accounts for nearly 80 percent of electricity generation in China -- up from 71 percent in 1990 -- and 68 percent in India -- up from 65 percent in 1990 -- according to the World Bank.*

A large percentage of the world's coal reserves are found in three of the larger, higher-growth economies: India, China and the US. All three countries are engaged in discussions with Sasol with a view to developing CTL plants that will lessen their dependence on oil imports.[i] In the United States, where coal-fired power plants account for about 31 percent of the country's carbon dioxide emissions, coal is the source for nearly 40 percent of electricity.[ii]

CTL – A BRIEF HISTORY

At the start of the Second World War, both Germany and the UK had

operational coal liquefaction plant. By the end of the war, in Germany nine indirect and 18 direct liquefaction plants were producing almost 4 million tones/year of gasoline, 90% of German consumption. Synthetic oil produced from coal was used by Nazi Germany to fuel their war machine. Following the war the liquefaction plant in Germany and elsewhere were generally closed down. Although there was some further process development in the USA in the early and mid-1950s, the price of oil was falling relative to coal and the economics of liquefaction became increasingly unattractive.[iii]

After World War II, the vast oil fields of Arabia made it uneconomic for most nations to pursue the coal-to-liquids (CTL) technology. However, with the institutionalization of apartheid in 1948, South Africa picked up the technology where Nazi Germany left off. In the 1950s, after unsuccessfully looking for oil, South African government started exploring the possibility of turning coal into liquid fuels and established the South African Coal, Oil and Gas Corporation Limited, which later became Sasol Ltd. The company started synthetic fuel production in 1955 through a process first developed in the 1920s by two German chemists: Franz Fischer and Hans Tropsch. This so-called 'Fischer-Tropsch' process converts solid coal into a gas, which then combined with hydrogen under high pressure and temperature produces synthetic crude oil that can then be refined.

Sasol started its first plant in 1955 in Sasolburg (a whole town was created for this company), benefiting from cheap land, labor and government incentives. The township called Zamdela was created to house workers drawn to the growing industrial area. This black township was located downwind from the industries, and it became the twin to the white Sasolburg as per the apartheid planning.[iv] As was common under the apartheid regime, the white population (13% of total) consumed most of the oil, whereas black community was bearing the impacts of its production.

A smoky view of Sasol's Secunda plant

The oil crisis in 70s led to company's big expansion project in Secunda near Johannesburg. Sasol's second plant was also a greenfields development near what was then the black town of Driefontein. The town was renamed Secunda after the plant, and rezoned as a white town. The black residents were relocated to eMbalenhle, downwind of the plant, surrounded by Sasol's coalmines and the Harmony gold mine, and adjacent to the town dump.

The oil price shock in 1970's drove countries like the USA, the UK and Japan to pursue significant coal liquefaction research and development. Due to the fall of oil prices in 1980's these developments were largely put on hold.

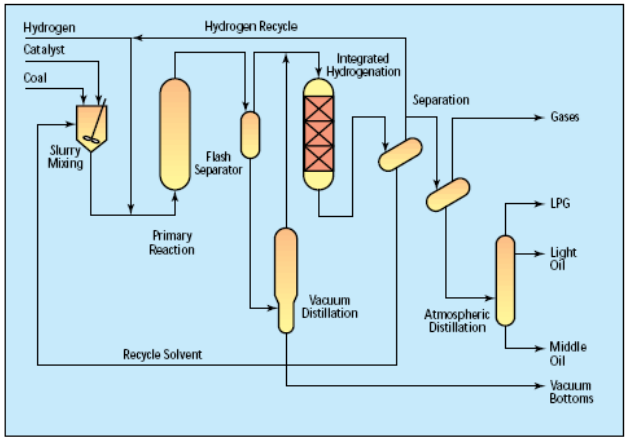
CTL TECNOLOGY *(sourced from Technology Status Report by DTI, UK)*

The CTL's development was mostly pursued in the early 1900s and two distinct technology approaches were followed. The earliest process route involved high temperature and high-

pressure dissolution of coal in a solvent to produce high boiling point liquids. No hydrogen or catalyst was used at this time. This approach, known as direct liquefaction, was patented by Bergius in 1913 and commercialized in the early 1920s; it also became known as either the Pott-Broche or I G Farben process.[v] In 1925, Fischer and Tropsch patented an alternative process known as indirect liquefaction. This involved the gasification of coal to produce a synthesis gas containing H2 and carbon monoxide (CO). These were then reacted over a cobalt catalyst to produce liquids. The process was commercialized in the 1930s, initially for the production of chemical feedstocks rather than liquid fuels.

Direct Liquefaction

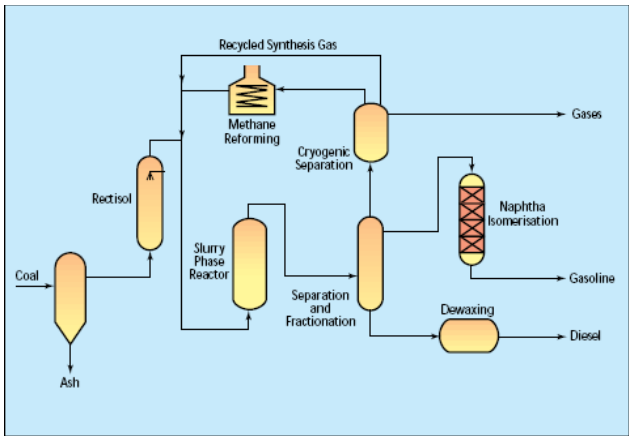
Direct liquefaction processes aim to add hydrogen to the organic structure of the coal, breaking it down only as far as is necessary to produce distillable liquids . Many different processes have been developed, but most are closely related in terms of underlying reaction chemistry. Common features are the



dissolution of a high proportion of coal in a solvent at elevated temperature and pressure, followed by the hydro cracking of the dissolved coal with H2 and a catalyst. Direct liquefaction is the most efficient route currently available. Liquid yields in excess of 70% by weight of the dry, mineral matter-free coal feed have been demonstrated for some processes in favorable circumstances. Overall thermal efficiencies for modern processes are generally in the range 60-70% if allowance is made for generating losses and other non-coal energy imports.

Indirect Liquefaction

Indirect liquefaction involves, as a first step, the complete breakdown of the coal structure by gasification with steam. The composition of the gasification products is then adjusted to give the required mixture of H2 and CO, and to remove



sulphur containing catalyst poisons. The resulting 'synthesis gas' is reacted over a catalyst at relatively low pressure and temperature. The products may be paraffins, olefinic hydrocarbons or alcohols (particularly methanol), depending on the catalyst selected and the reaction conditions used.

Although no commercial plants yet exist, Shenhua Group's first CTL facility is under construction in China using direct liquefaction technology. The less efficient, but commercially proven, indirect liquefaction process relies on the gasification of coal to produce synthesis gas (a mixture of carbon monoxide and hydrogen) which is then reacted over a catalyst at temperature and pressure to produce the desired liquid products. It is

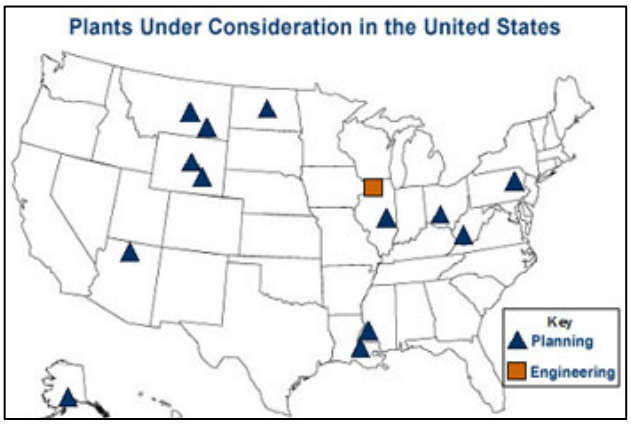
this indirect process, using well-established Fischer-Tropsch synthesis, which has been commercialized by Sasol in South Africa and will be used in several new projects proposed in China. [vi]

STATUS OF CTL IN THE UNITED STATES

The US interest in the coal-to-liquids technology was sparked when German scientists and technical documents were captured in the latter stages of the WW II. One of the reasons for this was massive quantities of coal available in the US and because of this; the Federal Government began investigating possible coal-based synthetic alternatives in scenario of decline of America's natural oil supplies. Passage of the Synthetic Liquid Fuels Act of 1944 began the first concentrated effort to study future ways to use the Nation's abundant coal supplies.[vii] Although companies like Rentech and Syntroleum have been doing technology research but no large-scale commercial plant has been built in the US.

In fact, the United States experimented with CTL in 1979 by creating a Synthetic Fuels corporation (SFC), assuming high oil prices in the 1980s. Although SFC invested in six CTL projects, all its products became unviable due to a sustained drop in oil prices in 80's, and SFC was terminated

However, in the recent times, coal to liquids lobby and its proponent have found fresh vigor to promote and push this technology at the Capitol Hill. At least nine coal-to-liquids facilities are now in the planning stages, including one each in Illinois, Pennsylvania, and Wyoming that already have significant funding lined up and are slated to begin production by 2009, according to the



According to the U.S. Department of Energy, companies, local governments and American Indian tribes have announced plans to build the nation's first 16 coal-to-oil plants. Map courtesy of DOE.

National Energy Technology Laboratory. There are currently a number of projects undergoing feasibility studies, including the Medicine Bow Project in Wyoming, the Waste Management and Processors Inc (WMPI) project in Pennsylvania and the Rentech project in Illinois. There are also projects proposed in Arizona, Montana, and North Dakota. DKRW Energy's CTL project in Medicine Bow, Wyoming is being designed to produce 11,000bbl/d of various fuels – primarily diesel. DKRW Energy has long-term plans to expand the capacity of the facility to produce as much as 40,000bbl/d of fuels. The Medicine Bow project will also include the construction of an integrated gasification combined cycle (IGCC) unit to produce electricity on the site using the syngas and steam produced in the CTL process. During the first phase, an estimated 45MW of power will be generated. As reported by National Coal Council to Department of Energy, if federal tax incentives and state subsidies is provided to kick-start the industry, coal-based fuel production could soar to 40 billion gallons a year by 2025 – or about 10 percent of forecast oil demand that year.

The Energy Policy Act of 2005 also encourages the development of these technologies in a number of ways, including a new loan guarantee program for innovative technologies that does not require the appropriation of any taxpayer funds.[viii] On March 30, 2006, DOE awarded funding of about $4.3 million for a $5.4 million project that would further develop Syntroleum technology to produce either hydrogen or high hydrogen-content. The funding was part of a broader award of $62.4 million for 32 U.S. clean coal research projects.[ix] The USA's proposed Foreign Oil Displacement Act seeks to provide financial tax incentives for CTL projects. Specifically, the bill would provide a 28% Investment Tax Credit and exemption from the Fuels Excise Tax for CTL fuels.

The Energy Information Agency projects that the US will get 1.7 million barrels of transportation fuel per day from coal by 2030. This is nearly half of the expected worldwide coal-to-liquids (CTL) production. A new report prepared by the National Coal Council suggests CTL technologies could produce 2.6 million barrels per day, including gasoline, diesel and jet fuel.

High capital costs – $1 billion to $6 billion for a single facility – and the unknown cost of carbon sequestration could make such projects unappetizing for investors to swallow without federal incentives.

According to Wall Street Analysts, the $800 million project, which would make 5,000 barrels of CTL fuel a day in Gilberton, Pa., is part of an industry push where CO2 capture costs are not considered into the bottom line of the business plan.

Ongoing Lobbying Efforts

The National Mining Association has ramped up Capitol Hill lobbying by creating a new coalition and website "futurecoalfuels.org". Many in Washington are warming to the idea of CTL. The bills promoting CTL in the House of Representatives and the Senate have received strong bipartisan backing and supporters of the bill range from Sen. Barack Obama (D) of Illinois to President Bush. In his State of the Union speech Jan. 23, President Bush called for the United States to produce 35 billion gallons of "alternative fuel" by 2017.

A "Coal to Liquids Coalition" is a network of companies and organizations trying to promote CTL in the US, which includes companies like Sasol, Rentech, Syntroleum, and National Mining Association etc. This coalition was launched on March 28, 2007 and several US Congress members from coal-producing states attended the launch.

Sasol North America, a division of the company that produces CTL fuel in South Africa, paid the Livingston Group $320,000 last year to lobby Congress to support building CTL plants in the United States. With congressional members and the White House promising to promote alternative fuels, a number of other alternative-fuel companies have joined Sasol in hiring firms to lobby for tax breaks and other incentives to ease their entrance into the market dominated by oil companies.[x] Sasol wants to build coal-to-liquid (CTL) plants in three US states as part of its global expansion program. The three states - Montana, Illinois and Wyoming - hold about 56 percent of total US coal reserves, or 267.3 billion tons combined.

Glitches in the CTL

The price estimates cited by CTL industry proponents assume facilities are going to be uncontrolled for CO2 emissions. However, the judgment by the US Supreme Court on April 2, 2007 on global warming categorized CO2 as an air pollutant under the Clean Air Act and well within the jurisdiction of EPA. Given the current debate in the Congress and public concern on global warming, investors should be careful of increasing likelihood that the US could establish emissions controls, so that "any large investment in CTL would need significant subsidies to offset environmental costs.

> In a DOE environmental impact filing in December 2006, it reported that a leading CTL development had no near-term plan to capture any of the 2.3 million tons of CO2 it would produce annually.

A key question is whether CTL plants will have carbon sequestration as an integral part of their operations. If they do not, then these plants will emit millions of tons of CO2 into the atmosphere annually. Even if gases were pumped underground, CTL fuel, when burned in an engine, would still emit about 8 percent more CO2 than a gallon of gasoline, According to Princeton University study in 2003.[xi]

INDIA'S INTEREST IN CTL

With a rapidly growing economy, India's thirst for oil is increasing dramatically—in 2005-06 it consumed 120 million tones, with a nearly 6% increase in consumption from 2004-05. This increase in consumption was the outcome of the growth of personal motorized transport and the rise in share of road haulage.[xii] Furthermore, given that nearly 72% of its crude oil requirement is currently imported, India is looking for technological solutions that can reduce these imports, while still meeting the increasing demand.

Coal-to-liquids technology is considered particularly attractive, as India has significant coal resources. In 2000, a delegation from Coal Ministry visited Sasol, appraised its CTL technology and submitted a report to the Ministry. The team recommended setting up of a task force of experts to look into the feasibility of converting coal into oil and to initiate a dialogue with Sasol for technical help. The task force was never formed but with increasing oil prices, the CTL technology has now gained a new interest among policymakers.[xiii] Sasol has also showed interest in bringing their technology to India and it is willing to invest around $6 billion in an Indian coal liquefaction project. CTL also got a major impetus when the three-member Investment Commission, set up by the Ministry of Finance recommended CTL as a feasible technology for India in Jan 2007.[xiv]

Based on their recommendation, the Prime Minister has directed the Planning Commission to set up an Inter-Ministerial Group to further examine the proposal and recommend a time bound action plan. Riding on the euphoria generated during the meeting with the Investment Commission, Finance Minister Chidambaram promised that India would consider creating "a fulltime job for an officer to handle the [Sasol] investment and see it through". He also praised Sasol's coal-to-liquids fuel technology and said India would "have to give [Sasol] identified coal blocks" to allow it to begin doing business in India. Sasol currently has an office in Mumbai.

Does it make sense for India?

When the whole world is talking about less dependence on fossil fuel, India is planning to invest its money and resources in a technology, which is not only capital intensive but also highly polluting. The environmental and social costs associated with CTL cannot be seen in isolation from coal mining. India's total coal production in 2005 was approximately 360 million tones coming from 560 operational mines and this is increasing every year.

CTL technology in India will come with enormous economical, social and environmental costs. Given Sasol's poor environmental and social record in South Africa, one can only wonder what will happen in India. The poor record for enforcing pollution control for 'big, important' projects in India will mean that Sasol's profit will once again get subsidized by poor communities living around the proposed mines and plants, if this project comes through.

With India's ambitious plan to turn coal into liquid, the devastation by coal mining itself will be of major concern, in addition to the pollutants from CTL.

Furthermore, there are also serious economic issues to consider. The CEO of Sasol has stated that the company "needs a tax regime in India that will give incentives to them". After enjoying tax incentives in the apartheid South Africa, Sasol is demanding the same in India. While considering the provision of incentives, it is important to recognize that CTL is only economically viable in a world of high oil prices.

STATUS OF CTL IN CHINA

China began developing coal-to-liquid fuel technologies in the 1980s. The coal liquefaction project was given strategic significance in the mid 1990s, as China became a net oil importer in 1993. In 1999, China launched its first coal-to-liquid project in Pingdingshan, Central China's Henan Province. However, the project, with a 500,000-ton annual capacity was closed end, because the type of coal proved unfit for coal liquefaction.

However, China in 2004 signed an agreement with Sasol of South Africa to build two coal-to-liquid fuel plants in Ning Xia and Shaan Xi provinces.. These plants, costing $3 billion each will jointly produce 60 million tons of liquid fuel (440 million barrels) a year. The company claims that the raw material and capital costs of a barrel of fuel would fall under $10 and other costs would not bring total costs over $15.[xv]

In 2005, Shenhua – one of China's largest energy companies – started construction of the largest CTL plant in China with a capacity of 50,000bbl/d. The first stage of this plant is expected to begin production in late 2007 with gasoline, jet fuel and diesel fuels being the primary products. Shenhua plans to build further CTL plants, worth in the region of $10bn, including a number of joint ventures with Sasol and Shell. These plants will make the equivalent of 10 million tones of crude oil by 2010. Shenhua hopes to lift this production to 30 million tones by 2020, equal to about 16% of China's present crude oil output of 180 million ones [China Daily 2006]. A number of other energy companies have embarked on a similar course.

According to a report by Credit Suisse, there are at least 30 large-scale CTL projects in the detailed planning, permitting, or feasibility stage.

Problems with CTL in China

China possesses one of the world's most extensive coal mining industries, although this happens to be one of the most dangerous and lethal occupations. According to the *Los Angeles Times,* well over 5,000 people per year perish in Chinese coal mines, a mortality of over 100 deaths per week. Nevertheless, despite the lethality of the effort involved, the Chinese coal industry is experiencing skyrocketing demand amid generally rising oil and energy prices.[xvi]

> Even in China, project developers Shenhua are seeking guarantees from the Chinese government to provide a floor price for the fuel they will produce. This means that the return on investment is ensured for the developer while the government assumes the oil price risk.[1]

In November, the International Energy Agency projected that the China will become the world's largest source of carbon dioxide emissions in 2009, overtaking the United States nearly a decade earlier than previously anticipated. Coal is expected to be responsible for three-quarters of that carbon dioxide. In addition, the CTL planners have calculated that coal prices will remain stable over the next 10-15 years. Nevertheless, if coal prices go up, the cost of CTL production will also go up. Furthermore, the feasibility of massive CTL production assumes an abundant supply of coal. The extra demand for coal by massive CTL production will inevitably cost more human lives unless a huge investment is made to improve safety facilities, which, again, would increase mining costs. Moreover, China now is one of the world's most energy-inefficient countries. Consequently, efforts to improve energy efficiency will also help ease China's current oil thirst and reduce pollution. This should be less costly than the ambitious CTL program.[xvii]

CONCLUSION

Although CTL might very well be an important technology for enhancing energy security, the question remains as to whether the governments have fully considered all its other impacts. South Africa, which was used as a testing ground for this technology at a commercial level, is a burning example of pollution and health effects caused by Sasol's CTL plants in Sasolburg and Secunda**.**

Effects of pollution from Sasol's CTL operations are not borne by the company, but are rather externalized onto the mostly poor black communities who pay with their health. Under the apartheid regime, Sasol worked with minimal pollution regulations, especially when the pollution primarily affected its black population. Sasol's own reports in 2001 noted that annual emissions from its Sasolburg plant alone amount to over 42,000 tons of volatile organic compounds (VOCs), 22,000 tons of hydrogen sulphide and 26,000 tons of sulphur dioxide.

> According to a study done by Groundwork, (an environmental justice group working in South Africa) air samples taken in Sasolburg showed very high levels of benzene and hydrogen sulfuide.

Long-term exposure to benzene could result in anaemia and leukaemia, and

hydrogen sulphide is linked to respiratory problems. Statistics from clinics in the area do indicate high rates of anaemia, asthma and other respiratory problems among the local community near Sasolburg.[xviii] Sasol's impact on poor black communities also extends beyond Sasolburg.[xix]

It is only because of ignoring such health and environmental problems that Sasol's fuels are relatively cheap. CTL plants require enormous investments—about $1 billion dollars for a 10,000 barrel/day facility, and up to $6.5 billion or more for a large-scale 80,000 barrel/day plant with a five-seven year lead-time.[xx]

Furthermore, with the looming challenge of mitigating global warming, it is important for Nations not to invest in high carbon emission technologies. According to a recent MIT study, the conversion of coal to synthetic fuels and chemicals requires large energy inputs, which in turn result in greater production of carbon dioxide (CO2). Thus, synthetic fuels derived from coal produces a total of 2.5 to 3.5 times the amount of CO2 produced by burning conventional hydrocarbons.[xxi]

ENDNOTES

[i] http://www.busrep.co.za/index.php?fSectionId=&fArticleId=3764969 Business Report

[ii] http://news.mongabay.com/2006/0816-wsj.html Coal to oil conversion gaining interest in China, U.S. Driven by surging oil prices, but fueling environmental concerns mongabay.com August 17, 2006

[iii] http://www.dti.gov.uk/files/file18326.pdf. Technology Status Report-Coal Liquefaction by Department of Industry

[iv] http://www.groundwork-usa.org/archives/000025.php

[v] Ibid 4

[vi] http://www.iea.org/Textbase/work/2006/ciab_nov/programme.pdf Coal to liquids-An alternative oil supply by International Energy Agency and Coal industry Advisory Board.

[vii] file:///C:/Documents%20and%20Settings/chikkatur/My%20Documents/Sunita%20GW/Sasol/US%20DOE%20History.htm US DOE and its History

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[ix] http://www.fossil.energy.gov/news/techlines/2006/06035-syntroleum_Projects_Show_Progress.html DOE Projects Provide Stepping Stone to America's Hydrogen Economy

[x] http://thehill.com/leading-the-news/its-coal-vs.-oil-as-lobbying-heats-up-hill-2007-03-26.html

[xi] http://www.csmonitor.com/2007/0302/p02s01-ussc.html Coal in cars: great fuel or climate foe?

[xii] Integrated Energy Policy- Report of Expert Committee, Planning Commission of India, August 2006

[xiii] Business Line-Ministry revives coal to oil conversion plan — To review 2001 report on SA's Sasol plant , July 31, 2005

[xiv] The investment commission has Mr. Ratan Tata as a Chairman and Mr. Deepak Parekh (Chairman HDFC) and Dr. Ashok Ganguly (Chairman ICICI) as members. The Investment Commission has been set up to enhance and facilitate investment in India. See: http://www.investmentcommission.in/about_us.htm

[xv] http://yaleglobal.yale.edu/display.article?id=4249 Strategy for an Energy-Starved World: Go Coal!

[xvi] http://www.energybulletin.net/22997.html A new kind of Energy by Bryon W king

[xvii] http://www.atimes.com/atimes/China_Business/HE23Cb06.html Asia Times, "China bets big on coal to liquids projects.

[xviii] http://www.groundwork.org.za/AirQuality/oil%20industry.pdf

[xix] South African People and Environment in the Global Market: 2002, Edited by Mark Butler and David Hallowes.

[xx] http://www.futurecoalfuels.org/faq.asp

[xxi] Furthermore, even if the CO2 emissions from the manufacturing process can be captured and sequestered, combustion of the resulting fuel would still put more CO2 into the atmosphere than conventional fuel would. See: Future of Coal-Options for a Carbon Constrained World, An interdisciplinary MIT Study, pp 152-154 March 2007.