SYNGAS PRODUCTION AND CONVERSION TO PRODUCTS – TECHNOLOGY AND COMMERCIAL UPDATE 2011

MULTI-CLIENT STUDY PRESENTATION

May 2011
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I. BACKGROUND

In 2007, The Catalyst Group Resources (TCGR) completed a two-part multi-client study entitled “Syngas Production and Conversion to Products – A Strategic Assessment of the Technologies, Markets and Competitive Landscape.” It was the first integrated value chain analysis from feedstock to enduses conducted to our knowledge at that time, and this has held true today-2011. It provided a key benchmarking review and detailed business analysis, with an R&D pipeline examination, “for the industry, by the industry.”

TCGR used very experienced industry talent to assist us in documenting the situation in gasification and reforming (i.e., ex-Shell; ex-Texaco/Chevron; ex AEP Power and ex-UOP executives participated). More details on the 2007 effort can be found at: www.catalystgrp.com/php/articledetail.php?syngas2007-28.

It has been four (4) years since completing the original report and some important conclusions and new developments have taken place which warrant revisiting. TCGR has updated the report in a single volume study. These include the following topics:

As a result, this newly updated report covers some very important areas which executives and technologists will find invaluable in business planning and decision-making over the next few years. The topics examined include:

- Progress on processes in commercial and R&D development: (1) TRIG, ex-KBR; (2) GTI UGAS: and (3) P&W Rocketdyne, - to name a few. Western EPCs and gasification licensors have reduced CAPEX of gasification and increased flexibility of feedstocks for coal and biomass advanced gasification.

- Improvements in CAPEX or OPEX since March, 2007; e.g. larger capacity gasification units by GE (Texaco), larger compressors, improved refractories, etc. The industry’s constraints still appear to be the same, i.e., the cost of gasification plants/licenses prohibit the commercialization of most projects, e.g., Eastman recently cancelled two gasification projects.

- A more in-depth review of IGCC. Duke Energy’s Edwardsport IGCC unit, to be commercial by 2012, but has run into major cost overruns. A closer examination of this project and the reasons for its difficulties provide valuable lessons in understanding the hurdles and challenges facing future projects. A second “case study,” on Noun’s second gasification unit in The Netherlands, demonstrates a different approach to IGCC units in avoiding such substantial issues.
• An assessment of the status of Chinese gasification and IGCC including developments in intellectual property (IP) and licensing. Valuable insights from the U.S.-Chinese cooperative development program through the National Institute of Clean and Low Carbon Energy (NICE) in the PRC provide more up-to-date perspectives on where commercialization is headed. Sinopec’s “Olefin Catalytic Cracking (OCC) Process is highlighted for its significance over thermal steam cracking over the next ten (10) years.

• An update on the advances in membranes (e.g., ion transport membrane, ITM) along with a comparison of the improved cost/performance of ASU’s and what has changed in the dynamics of pipeline oxygen and hydrogen vs. stand-alone units. A look into how operating efficiencies have improved and capital costs have been lowered in ASUs.

• Documentation of the financial incentives and benefits for using MSW as a feedstock for various processes including gasification and production of electricity, fuels and chemicals from syngas. An explanation of how co-fired coal/biomass’s popularity is drawn from IEA Coal, U.K., including the effect on CAPEX of coal/biomass pre-treatment methods.

• An understanding of the drivers, business strategies and cost/performance changes affecting the demand for syngas in producing downstream derivatives such as hydrogen, ammonia, methanol/DME, etc. These are expected to be among the highest growth chemical segments during the next five years.

These are the core reasons and drivers that justify updating TCGR's 2007 report and to obtain a clearer development perspective to 2015/20.

II. THE NEED FOR THE STUDY

Syngas production, whether by reforming, catalytic partial oxidation (COPox) or through gasification, is a “hot topic” for a number of key reasons. First, it is of tremendous commercial importance! The high growth in demand for new plants to produce hydrogen, now approaching 600 billion Nm³/year (over 50 million mt/yr) and growing at 4-5%/year, are needed to quench it’s increasing use in refining to meet new environmental fuel standards. Coming into fruition in the next few years will be the upcoming desulfurization of marine bunker fuels. This is coupled with the expansion of chemicals and fuels production in the Middle East, China and India, with higher environmental standards for transportation fuels. These very large projects, including IGCC power projects from coal and new residue/pet coke gasification/reforming units in refineries and Canadian tar sands expansions, means process licensors, construction services and catalyst companies will need to be prepared to serve these expanding markets.
This study update, “Syngas Production and Conversion to Products – Technology and Commercial Update 2011” compliments an ongoing portfolio of similarly well-received studies that The Catalyst Group Resources (TCGR) has delivered to clients over recent years. This growing experience demonstrates TCGR’s unique capability, resources and expertise to deliver exceptional insight. Past multi-client studies and current membership-directed programs include:

- **Carbon Dioxide Capture & Conversion (CO₂CC) Program** (ongoing membership-driven program initiated January 2010)

- **The Integration of Biofuels ‘Inside the Refinery Gate:’ Implementation, Logistics and Strategies** (completed February 2009)

- **Biomass Conversion to Biofuels and Biochemicals - A Critical Assessment of the State of the Technology: Feedstocks, Conversion Pathways, Products and Risks** (completed December 2006)

- **Alternative Energy and Fuels Technology**
  - *Volume 1 – Nonrenewables* (completed August 2005)
  - *Volume 2 – Renewables* (completed September 2005)

- **Gas-to-Liquids (GTL) – A Strategic Assessment of the Technologies, Markets and Competitive Landscape** (completed October 2004)

The value of TCGR’s insights comes from almost 30 years of active participation with leaders in trying to elaborate and define the “key issues for success” based on industrial investment, perspectives and in benchmarking developments. We continue to assist our clients through timely information resources. Clients anticipate that when TCG/TCGR offers a study, there is a technology/business opportunity contained therein!

### III. SCOPE AND METHODOLOGY

TCGR’s study addresses recent advancements in the production of syngas as well as its utilization looking at various feedstocks, production technologies and conversion products. Biomass gasification routes, including necessary pre-treatment, are also examined closely. TCGR’s study documents the recent advancements in syngas production and highlights the developments most likely to achieve significant advances in the next five (5) to fifteen (15) years. The study also reviews syngas production technologies and assess the competitiveness of the players and the impacts of new routes and/or entrants. These analyses and comparisons allow both syngas users and technology providers to fine tune their investment and business development plans. Where warranted, historical perspectives also provide background that has led to the current situation.
Developing processes and emerging technologies of importance are assessed for their impact on the future business environment and the likely timing of their commercialization, industrially. Future R&D from academic and government laboratories, including those in China, are cited as merited.

The study transitions to syngas conversion/utilization, including the ammonia and methanol trains, hydrogen and alternative fuels/power markets. A particular emphasis is placed on the alternative fuel enduses including F-T liquids, methanol (and its conversion to DME and to diesel, via MTO/MTP), etc.

The most significant and meaningful advances in each enduse market, ammonia, methanol, hydrogen, chemicals, alternative fuels and power generation consuming syngas are highlighted. TCGR’s study discusses the evolving competitive landscape for process licensing and, where merited, relative economics (for comparison purposes) have been generated.

In the study’s executive summary, we take a top-down as well as a side view of how different companies have (and can) position themselves to best take advantage of this growing industry. As a result, business leaders will receive valuable competitive intelligence in understanding the business opportunities that can be derived from the rapidly changing dynamics.

For those that understand and appreciate this study undertaking, you will know how important and critically timely this evaluation is! We are standing at a critical crossroads as it pertains to syngas production and conversion to enduse products. The next five years are certain to be telling. Thus, TCGR’s study - a thorough update of its 2007 assessment of this value chain – is warranted.

For details on the study scope, the report’s actual Table of Contents appears on the following pages.
Syngas Production and Conversion to Products – Technology and Commercial Update 2011

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IV. QUALIFICATIONS

The Catalyst Group Resources, a member of The Catalyst Group, works with clients to develop sustainable competitive advantage in technology-driven industries such as chemicals, refining, petrochemicals, polymers, specialty/fine chemicals, biotechnology, pharmaceuticals, and environmental protection. We provide concrete proven solutions based on our understanding of how technology impacts business.

Using our in-depth knowledge of molecular structures, process systems, and commercial applications, we offer a unique combination of business solutions and technology skills through a range of client-focused services. Often working as a member of our clients' planning teams, we combine our knowledge of cutting-edge technology with commercial expertise to:

- Define the business and commercial impacts of leading-edge technologies
- Develop technology strategies that support business objectives.
- Assess technology options through strategy development, including:
  - Independent appraisals and valuations of technology/potential
  - Acquisition consulting, planning and due diligence
- Provide leading-edge financial methodology for shareholder value creation
- Lead and/or manage client-sponsored R&D programs targeted through our opportunity identification process.
- Provide leading information and knowledge through:
  - World-class seminars, conferences and courses
  - Timely technical publications

The client-confidential assignments conducted by The Catalyst Group include projects in:

- Reinventing R&D pipelines
- Technology alliances
- Technology acquisition
- Market strategy

We have built our consulting practice on long-term client relationships, dedication, and integrity. Our philosophy is clear and focused:

We Provide the "Catalysts" for Business Growth by Linking Technology and Leading-Edge Business Practices to Market Opportunities
V. DELIVERABLES & PRICING

This report is timely and strategically important to those industry participants and observers considering investment, as well as to process technology companies evaluating the syngas production and/or conversion markets. TCGR’s report, based on technology evaluations, market assessments and interviews with key players goes beyond public domain information. As a result, subscribers are requested to sign a company secrecy agreement (as part of the “Order Form and Secrecy Agreement” on the following page).

The study, Syngas Production and Conversion to Products – Technology and Commercial Update 2011, was completed in May 2011 and is now available.

Syngas Production and Conversion to Products – Technology and Commercial Update 2011 $18,500

Report in PDF format, in addition to subscription price $1,000

- Notice to Subscribers of TCGR’s 2007 Two-Part Syngas Multi-Client Study Series -

Due to the complementary nature of this study to the 2007 study series, we are offering a discounted price to subscribers of that series. Subscribers are requested to contact John J. Murphy at +1.215.628.4447, or John.J.Murphy@catalystgrp.com for further details. When completing the order form, please make sure to indicate your company’s subscription to the 2007 multi-client series.
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