

# **Monetizing Stranded, Waste or Unconventional Resources through Small-Scale Production of Fuels and Chemicals: Technical and Commercial Advances**

## **Multi-Client Study Proposal**

February 2019



# Monetizing Stranded, Waste or Unconventional Resources through Small-Scale Production of Fuels and Chemicals: Technical and Commercial Advances

## ABSTRACT

The Catalyst Group Resources' (TCGR's) newest multi-client study will address the latest commercial and technological progress related to the small-scale, distributed production of hydrocarbon liquids and industrial chemicals. Whether you are a producer or a consumer of liquid fuels, specialty chemicals, ammonia, or hydrogen, or have access to potential feedstocks like stranded gas, biogas or plastic waste, you will want to use our in-depth analysis contained in this study to inform you of the latest in the state-of-the-art as well as guide you for further investment opportunities. Our study will give an understanding of the market drivers for small-scale or distributed production of fuels and chemicals and the resulting competitive and strategic implications.

Critical topics this study will address include:

- Raw material sources, quantities, and potential process routes for each
- Technology advances and drivers
- Key players in development and commercialization of new technologies
- Commercial opportunities for small-scale produced chemicals
- Regional outlooks based on market opportunities and regulatory drivers
- Strategies for implementation of small-scale production

With an outlook covering the next 5 years (2019-2024), TCGR will consider commercial and technological developments that will provide the report's subscribers with expert information for current business operation and future business planning. By focusing on emerging technologies, TCGR will detail how changes occurring now and expected in the future will impact the chemicals market of tomorrow. **A key need/justification for this study, and one that TCGR is uniquely capable of delivering, is a comprehensive market assessment of the commercial implications of increased production of chemicals through distributed and/or small-scale production methods, and its effect on refiners, catalyst producers, and various integrated petrochemicals suppliers in such a way that shapes their future plant enhancements.** This study will document the commercial opportunities and competitive threats because of technology changes – it is a “must have” for future success in chemicals production.

## I. BACKGROUND

One of the largest sources of potential feedstock for chemical production is the vast amount of **stranded gas** from the production of oil. It is estimated that nearly 150 bcf of natural gas is flared or vented annually, contributing over 300 million metric tons of CO<sub>2</sub> worth of global warming potential. In response to this, thirty-six oil companies have signed onto the World Bank's Zero Routine Flaring initiative, whose goal is to end routine flaring by 2030. In addition, nine of those oil companies plus four others have joined in a public-private initiative with the World Bank called the Global Gas Flaring Reduction Partnership (GGFR), which works to increase use of natural gas associated with oil production. As flaring is often used in places where transport of gas is limited, small-scale production (defined as less than 2,000 bpd) of

fuels and chemicals allows for the transformation of that gas into more easily transported liquid products. The GGFR has been active over the past few years in promoting the use of small-scale production to help alleviate this issue.

Natural gas associated with oil production is not the only available feedstock. The European Commission has called on its Member States to develop national strategies on the role of **biogas and biomethane** to meet future renewable energy and climate goals, in cooperation with other stakeholders. It has also called for the creation of a long-term policy framework for the development and support of the biogas sector and related areas, with the goal of more than doubling biogas production by 2030, so clearly biogas holds some potential for production of fuels and chemicals.

Estimates also show that only 5-10% of **plastics** are recycled each year, the rest contributing to a growing unease about its environmental fate, especially regarding oceanic pollution. While more and more producers and consumers of polymers have committed to contribute to a circular economy, there remain technical barriers to the reuse and recycling of waste to fuels or chemical feedstocks, although these are rapidly being addressed by various companies, such as by Plastic Energy Ltd., who is working with SABIC to produce feedstock for naphtha cracking in Europe, or Recenso, who has partnered with BASF for the circular production of plastics from waste.

While global hydrocarbon resources continue to grow, there is also a growing demand for better economic and environmental utilization of these resources. The abundance of low-cost natural gas in many regions coupled with relatively high oil prices presents an opportunity in terms of raw material cost advantages to **gas-to-liquids (GTL) and other chemicals**. Stranded gas and associated gas represent two potential sources of low-cost feedstock but transporting those feedstocks to a production facility remains a roadblock. **Distributed production has been well known in the process gas industry for localized production of oxygen or nitrogen at the users' locations through smaller-scale production facilities, and this model could easily be adapted to production of chemicals using natural gas, biomass, or other local feedstocks.**

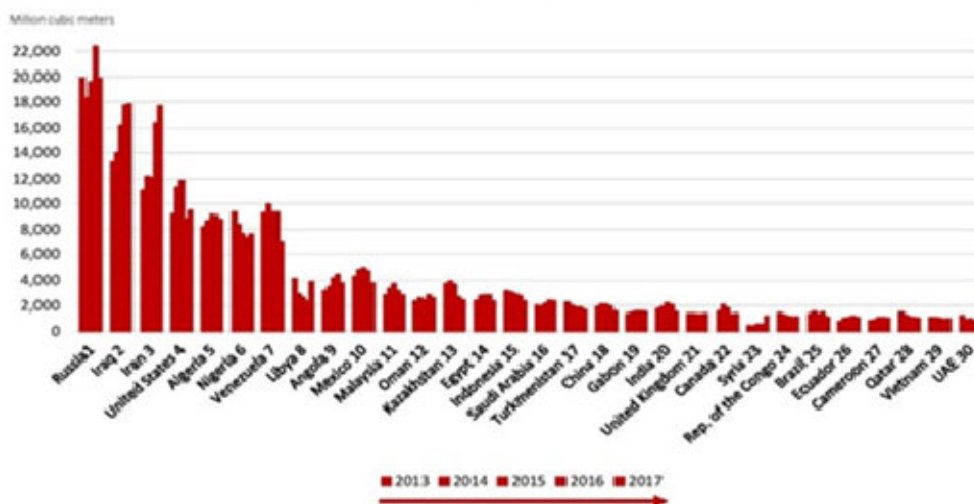
Distributed production could allow for utilization of those resources by localizing production to a more value-added finished form which is easier to bring to market. In addition, for other chemicals that are either costly to distribute (such as hydrogen gas) or present safety concerns while transporting or storing (e.g., ammonia, ethylene oxide), distributed production can provide a solution. In general, when the distribution cost is greater than the production cost, distributed production presents an economically beneficial solution.

TCGR's 2012 report, ***"GTL/XTL: An Assessment of the Technologies, Business, and Competitive Landscape, 2010 to 2020,"*** first introduced small-scale production of Fischer-Tropsch and methanol-to-gasoline to its subscribers. Since that time, this approach has been applied using different technologies to an increasing amount of chemicals, like ammonia, aromatics, olefins, to name a few. **This report will present the latest technological, commercial, and environmental trends in small-scale production of these and other chemicals, with a focus on advances at the pilot and commercial phases.**

## II. INTRODUCTION

The World Bank estimates that 140 bcf of natural gas is flared or released each year, with half coming from just 7 countries (Figure 1). This represents enough energy to meet half of the African continent's annual electricity needs, and billions of dollars in lost opportunity. Biomass, biogas, and municipal waste represent additional untapped potential as feedstocks, through either direct conversion to fuels and chemicals, or by indirect conversion, first to either methane or CO<sub>2</sub> to feed biological reactors.

Figure 1. The new ranking – top 30 flaring countries (2013-17) Ranked by 2017 flaring volume



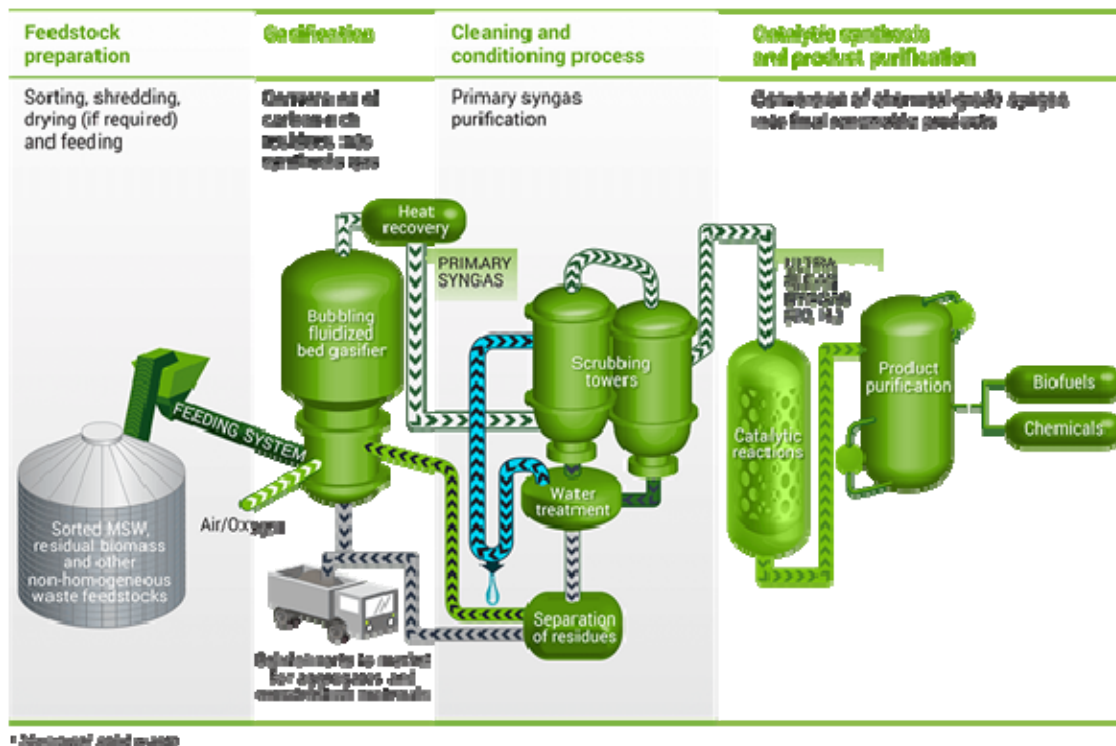
As methane represents one of the key feedstocks in the chemical industry, there have been years of research into better utilization of it for syngas production, and the first such program to reduce gas flaring through small-scale conversion to chemicals appears to be CompactGTL's partnership with Petrobras, which is operating a demonstration plant feeding 200k sfcd of associated gas to produce syncrude (shown at right). This plant has been operating for nine years, and the goal of the project is ultimately to integrate the technology into an FPSO vessel to reduce offshore flaring.

Demo Plant: Associated Gas to Syncrude



On other fronts, many new approaches to syngas and its downstream products have been proposed, depending primarily on the choice of feedstock. For example, Enerkem (Figure 2) has developed and built a plant based on biomass or municipal solid waste (MSW) input to produce biofuels and chemicals.

Figure 2. Enerkem: Biomass or MSW to Biofuels or Biochemicals

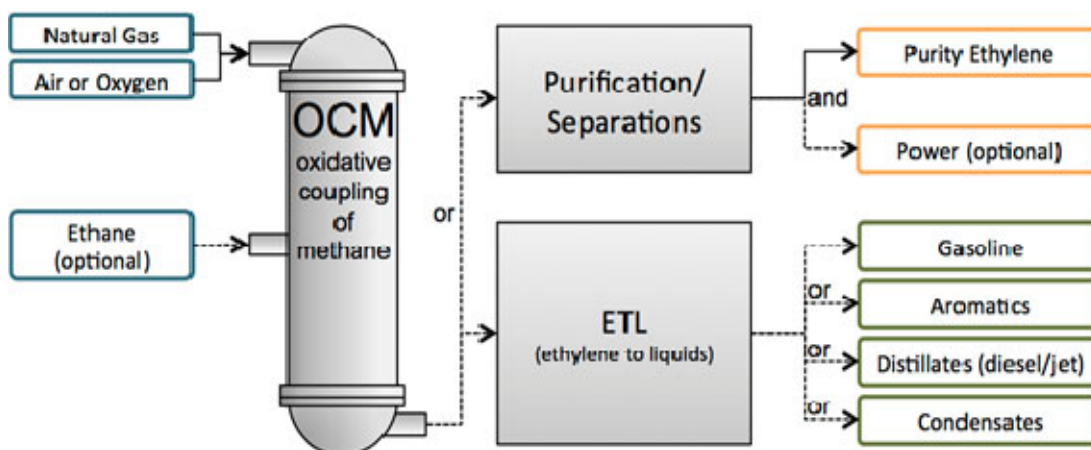


\* Minimum feed mass

Source: Enerkem website

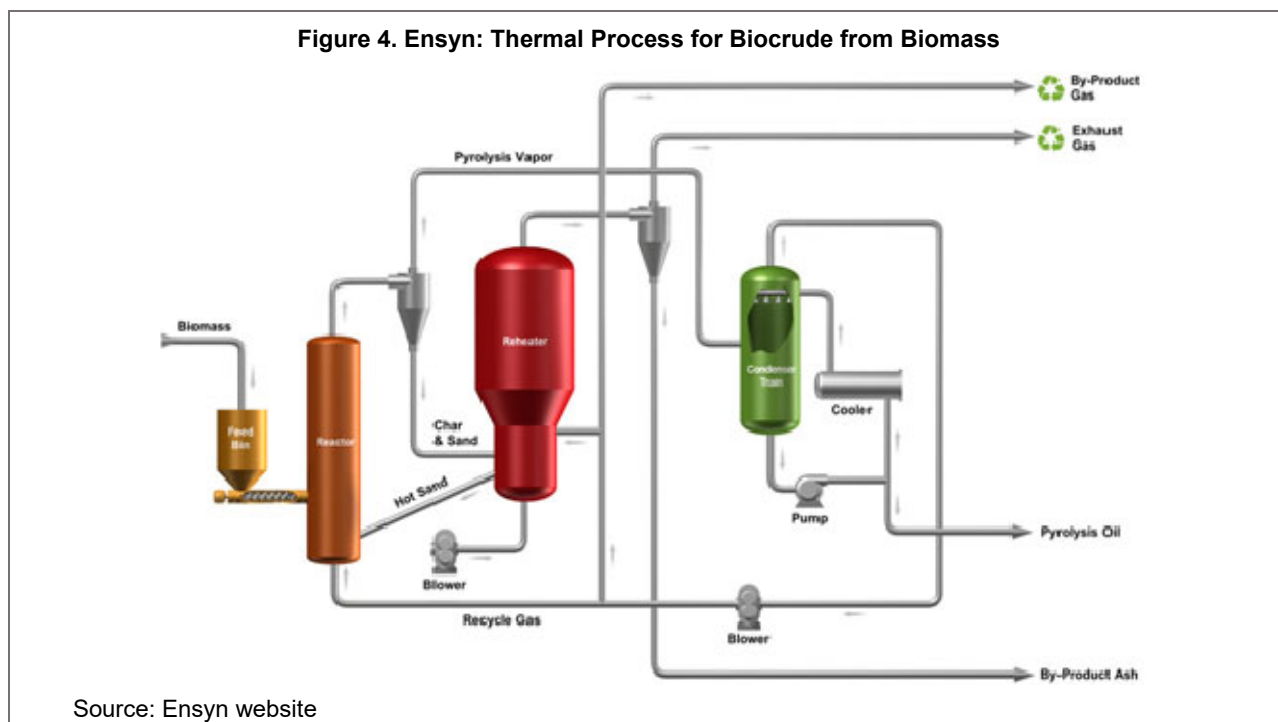
Siluria, in partnership with Linde, proposes oxidative coupling of methane (OCM) to produce ethylene, which can then be sold or converted to heavier hydrocarbons in its ethylene to liquids process (Figure 3). Raw materials for this process can come from stranded gas, biogas, or refinery off-gases.

Figure 3. Siluria: OCM to Ethylene

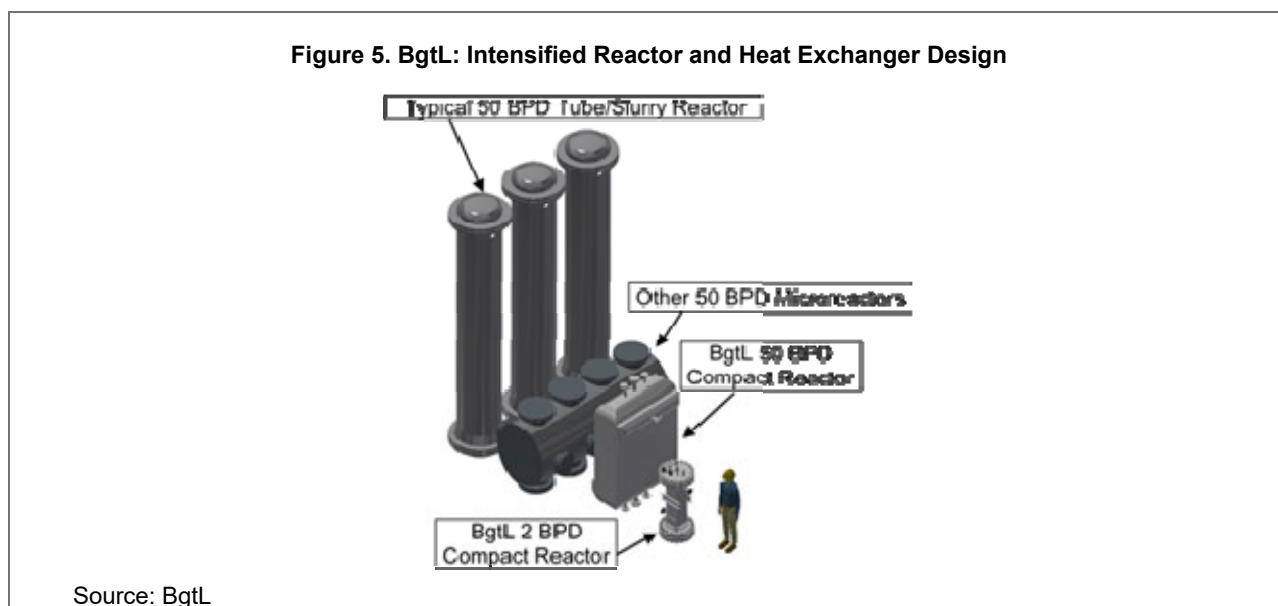


Source: Siluria website

Ensyn has been producing biocrude from biomass since 2005 at various facilities and has entered into partnership with Honeywell to license and commercial the technology. The thermal processing technology (Figure 4) does not use a catalyst and is designed to recover excess heat to minimize emissions.



BgtL Inc. promotes the use of intensified reactor and heat exchanger design to efficiently produce liquids (fuels, alcohols, or ethers) from feedstocks such as biomass, flare gas, and landfill gas. Using efficient design, they claim to be cost-effective at scales as low as 20 bpd (Figure 5). Due to the small size, these micro-reactors can be skid-mounted and transported from site-to-site as the feedstock needs require.



These are just a few of the innovations that have surfaced since our 2012 report. Clearly, the design choices are as varied as the feedstock sources and end products that can be made, and many firms have risen to take on the opportunities that have presented themselves over the past few years. This report will detail the players, the technologies, and the challenges that are faced in bringing small-scale production to market.

**Furthermore, as the technology for small-scale production has rapidly advanced over the past few years, smaller sources of raw material which were previously uneconomical to exploit have now become viable. New, low-cost sources of abundant natural gas, expected to be sustained for the foreseeable future, coupled with crude prices that have a floor set by North American shale and tar sands production costs, have created an opportunity for those in position to take advantage of these sources to produce more valuable finished products based on the spread between alternative feedstock costs and finished product price.** As companies are pushed to increase their returns while becoming greener, there are increasing opportunities for small-scale production utilizing resources that would otherwise be wasted or sold at a low price.

### **III. THE NEED FOR THIS STUDY**

Due to increasing environmental drivers, the need for such a study has never been timelier. Major producers of crude and natural gas have committed to significant reductions in emissions over the next 10-15 years, and many chemical companies have committed themselves to a circular economy, so choices on technological approaches on how to achieve those goals need to be taken quickly. As demonstrated in the examples above, there are numerous approaches, in scale and technology, being developed by different companies trying to take advantage of low-cost feedstocks to produce higher value products in an economically and ecologically-friendly fashion. **The benefits of aggregating these approaches into one study creates an opportunity to extract and determine which approach or pathway is most beneficial given the local circumstances, providing value to chemical producers and suppliers of alternative feedstocks. For the developers of mini-scale or distributed technologies, this study provides a map of the potential targets, feedstocks, and products as well as the challenges to further adoption, driving R&D and engineering efforts to create further efficiencies, driving down costs and ultimately driving sales.**

Critical topics this study will address include:

- Raw material sources, quantities, and potential process routes for each
- Technology advances and drivers
- Key players in development and commercialization of new technologies
- Commercial opportunities for small-scale produced chemicals
- Regional outlooks based on market opportunities and regulatory drivers
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In our 2012 study referenced earlier, TCGR benchmarked 9 companies developing technologies for small-scale production based on natural gas and another 6 companies developing technologies for alternate feedstocks. This study will update the previous study and include new entrants into the game, providing the reader with the latest in technological and commercial prospects in one reference.

This study also compliments other studies undertaken by The Catalyst Group Resources, demonstrating TCGR's unique capability and resources to deliver exceptional insight. Recent multi-client studies focused on large-scale developments include ***Advances in Syngas Production: Catalyst and Process Developments Update – 2018*** and ***Natural Gas Conversion vs. Syngas Routes: A Future of Convergence (Volumes I & II)***. Studies available to members of our **Catalytic Advances Program** include ***Advances in C<sub>1</sub> Chemistry***, ***Advances in Methanol Conversion to Products***, and ***Catalytic Conversion of Syngas to Chemicals, Volumes I, II, & III***.

#### **IV. SCOPE AND METHODOLOGY**

TCGR's study will document and assess recent developments in small-scale or distributed production of chemicals from natural gas, biogas, municipal solid waste, and biomass with the goal to provide insightful, timely advice in both technical and commercial directions.

Topics included are:

- Regional supply trends for raw material inputs
- Environmental regulations and non-binding commitments
- Technical advances
- Supplier profiles and commercial partnerships
- Strategic analyses and competitive implications

As depicted in the Table of Contents (see pages 9-10), TCGR's study begins by completing an overview of the market opportunities based on the latest regulatory and economic drivers coupled with available regional feedstocks (**Section III**).

**Section IV.** Technical Developments and Commercial Landscape, will highlight emerging technologies and trends and provide an overview of the key technology and equipment providers in this space. Existing plants and plants under construction will be a focus in order to keep the reader abreast of the latest technical and commercial developments.

**Section V.** Products and Local Markets, will provide an overview of the products that can be made via small-scale production methods, as well as an overview of the regional markets for those products.

**Section VI.** Strategic Analyses and Business Recommendations, provides an insightful analysis to the impact of small-scale and distributed production may have to future local producers. The potential timeline of this developing market will be analyzed to understand the implications for technology providers and users.

All TCGR studies are characterized by competitive and strategic insights for industrial and financial companies to evaluate. These include key trends, concerns, and conclusions on the best return on investment (ROI) actions, competitive expectations, and strategic SWOT's on the players. TCGR is noted for its sound strategic advice in over 35 years of experience.

TCGR's unique background and established global Dialog Group® ensures expert capability and skill level in this study area. TCGR will utilize numerous deeply experienced experts in process intensification/integration, syngas and gas-to-liquid processing as well as chemical and fuels marketing to assist us in providing insights beyond what other sources that do not have comparable reach and industrial experience can provide.

*As it does in each of its industrially-focused multi-client studies, TCGR will seek input from “charter” subscribers (i.e., those that sign up prior to study launch) to help shape the report's final scope and Table of Contents. This interactive and client-driven methodology ensures that the final report covers and emphasizes the most pertinent content due to the numerous process approaches covering a range of inputs and end-products that might be of interest.*

## **Preliminary Table of Contents\***

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    - a. Haldor Topsoe
    - b. Johnson Matthey
    - c. Toyo
    - d. CompactGTL
    - e. Velocys
    - f. Siluria
    - g. Others (e.g., Standard Alcohol Co., BgtL, Primus Green Energy, Oberon Fuels, Synfuels International, etc.)
  - 2. Plastics
    - a. Plastic Energy Ltd.
    - b. Agilyx
    - c. Recenso
    - d. Others (e.g., RES Polyflow, Vadxx Energy, New Hope Energy, Renewology, Plastic2Oil, etc.)

3. Biomass
  - a. CRI Catalyst (IH<sup>2</sup> Technology)
  - b. BioTfuel (Total, IFPEN, ThyssenKrupp)
  - c. Eni
  - d. Gevo
  - e. Renmatix
  - f. Anellotech
  - g. Enerkem
  - h. Others (e.g., Virent (Tesoro), Ensyn, BioBTX, etc.)
4. Municipal solid waste
  - a. Cogent Energy Systems
  - b. Fulcrum BioEnergy
  - c. AlterNRG
  - d. InEnTec
  - e. Others (e.g., Advanced Plasma Power, Plasco Conversion Technologies, ThermoChem Recovery, Earth Energy Renewables, Sierra Energy, etc.)
5. Other
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  - b. Linde
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  - d. Others (e.g., Coaltec Energy, Tsubame BHB, etc.)

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*As it does in each of its industrially-focused select-client studies, TCGR will seek input from “charter” subscribers (i.e., those who sign up prior to study launch, scheduled on or before March 15, 2019) to help shape the report’s final scope/TofC by delineating areas of particular interest as depicted in Sections III, IV, and V in the preliminary TofC.*

\* \* \* \* \*

## **V. 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***

## VI. DELIVERABLES AND PRICING

This report is timely and strategically important to those industry participants and observers both monitoring and investing in the development and implementation of technologies for the small-scale or distributed production of fuels and/or chemicals. TCGR's report, based on technology evaluations, commercial/ market assessments and interviews with key players will go beyond public domain information. As a result, subscribers are requested to complete and sign the "Order Form and Secrecy Agreement" on the following page.

The study, "***Monetizing Stranded, Waste or Unconventional Resources through Small-Scale Production of Fuels and Chemicals: Technical and Commercial Advances***" is expected to be available in June/July, 2019.

<u>Participation</u>	<u>Deadline</u>	<u>Price</u>
<u>"Charter" subscribers*</u>	<u>before March 15, 2019</u>	\$21,500
<b><i>Monetizing Stranded, Waste or Unconventional Resources through Small-Scale Production of Fuels and Chemicals: Technical and Commercial Advances</i></b>		
<u>Post-launch subscribers</u>	<u>after March 15, 2019</u>	\$23,500
<b><i>Monetizing Stranded, Waste or Unconventional Resources through Small-Scale Production of Fuels and Chemicals: Technical and Commercial Advances</i></b>		
Report in PDF format, in addition to subscription price		\$1,000

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\* \* \* \* \*

## ORDER FORM AND SECRECY AGREEMENT

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Spring House, PA 19477 - USA - website: [www.catalystgrp.com](http://www.catalystgrp.com)

Please enter our order for “**Monetizing Stranded, Waste or Unconventional Resources through Small-Scale Production of Fuels and Chemicals: Technical and Commercial Advances**” to be completed in June/July 2019, as follows:

\_\_\_\_\_ **Monetizing Stranded, Waste or Unconventional Resources through Small-Scale Production of Fuels and Chemicals: Technical and Commercial Advances**, as a “charter” subscriber (i.e., prior to March 15, 2019) for \$21,500 (\$23,500 after study launch).

\_\_\_\_\_ Please enter our order for the study to be delivered in PDF (Adobe Acrobat) format for use across our sites/locations (i.e., site license) for an additional \$1,000.

\_\_\_\_\_ Please send us \_\_\_\_\_ additional printed copies @ \$250 each.

**In signing this order form, our company agrees to hold this report confidential and not make it available to subsidiaries unless a controlling interest (>50%) exists.**

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