The Future of Gasification

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Gasification technology has experienced periods of both high and low growth, driven by energy and chemical markets and geopolitical forces, since introduced into commercial-scale operation several decades ago. The first large-scale commercial application of coal gasification was in South Africa in 1955 for the production of coal-to-liquids. During the 1970s development of coal gasification was propelled in the U.S. by the energy crisis, which created a political climate for the country to be less reliant on foreign oil by converting domestic coal into alternative energy options. Further growth of commercial-scale coal gasification began in the early 1980s in the U.S., Europe, Japan, and China in the coal-to-chemicals market. The technology quickly transitioned into an alternative cleaner energy platform with the first coal-to-natural-gas project completed in the U.S. in North Dakota and the first integrated gasification combined-cycle (IGCC) project demonstration at Cool Water, California. In the 1990s the completion of the Polk and Wabash cleaner coal commercial IGCC power projects further advanced the technology. As energy prices continued to trend ever higher, the development of cleaner energy projects using coal gasification accelerated rapidly in the early 2000s.

In the U.S., this dynamic quickly changed with the ensuing drop in natural gas prices associated with the emergence of hydraulic fracturing of shale for natural gas extraction. Development of coal gasification projects in the U.S. then slowed significantly, with the exception of a few that were far enough along in development to avoid being cancelled. However, during this time period and on into the early 2010s, China continued to build a large number of coal-to-chemicals projects, beginning first with ammonia, and then moving on to methanol, olefins, and a variety of other products. China’s use of coal gasification technology today is by far the largest of any country. China rapidly grew its use of coal gasification technology to feed its industrialization-driven demand for chemicals. However, as China’s GDP growth has slowed, the world’s largest and most consistent market for coal gasification technology has begun to slow new builds.

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Recently, growth in the coal gasification industry in general has slowed as the global energy price landscape has shifted significantly. If the gasification industry continues to think about coal gasification as it has been historically defined (i.e., large projects focused on conversion of high-quality coal into mainly chemicals), I believe the future will continue to look challenging. But, if historical conventional thinking about the

Successful gasification projects demonstrate that viable markets exist.
role of coal gasification is left behind, and market trends are carefully evaluated, I believe market and geopolitical forces are aligning to allow for a new wave of significant growth in coal gasification.

NATURAL GAS PRICES

The main competitors to coal gasification are oil- and natural gas-based energy and products and natural gas prices are the single most important indicator for the viability of coal gasification projects. When natural gas is inexpensive and plentiful, coal gasification projects are unlikely to be built. Figure 1 shows projections for liquefied natural gas (LNG) prices in Japan, natural gas prices in Europe, and natural gas prices in the U.S. Figure 2 shows the landed LNG prices around the world in early 2016.

Looking at the information provided in these two charts, several key conclusions can be drawn:

- With the exception of the U.S., natural gas prices around the world are expected to remain elevated well into the future.
- While projected to be stable, natural gas is still subject to high volatility.
Although landed LNG prices shown are under $6/MMBtu, LNG regasification and pipeline transportation add additional cost before the fuel becomes available to the end user. For example, over the past year, I have seen natural gas prices in China ranging from 2.5 to 3.5 RMB/Nm³ ($10–15/MMBtu).

The bottom line is that natural gas prices in the areas of the world anticipated to have the highest growth (China, India, Indonesia, Brazil, Africa) are expected to remain high for the extended future. This sets the stage for an emerging large opportunity for lower cost alternatives to expensive natural gas and LNG, such as clean syngas from coal gasification, to enter the markets.

ENERGY DEMAND

Canada and the U.S. are by far the highest users of energy on a per capita basis, although these numbers have decreased recently (see Figure 3). The European countries shown in Figure 3, while highly developed, have a lower energy utilization per capita. It is reasonable to assume that as developing countries continue to grow, they could eventually approach the energy utilization per capita of the EU.

China, for example, has already seen major increases in its per capita energy consumption over the last few decades, and additional growth is likely. With China’s population of about 1.35 billion people, increasing the energy per capita from the 2012 level to 5000 kWh (slightly lower than all the EU countries in 2012) would require about 250 GW of additional power generation capacity. For India, with a population of about 1.25 billion people, more than 600 GW of additional capacity would be required to achieve this level. These numbers do not take into consideration the additional power capacity required, due to further increases in population which are likely to occur in these countries. Additional electricity and fuel capacity will be necessary to meet the energy demand of these growing populations (see Figures 4 and 5).

Figure 4 shows both a historical perspective and a future projection. Notably, the rate of growth in energy consumption for non-OECD countries mirrors the shape of the coal consumption curve shown in Figure 5. In fact, most of the growth in electricity capacity will be in the non-OECD countries, and these countries will use coal. Gasification can play a big role in this growth by providing low-cost, low-emissions clean energy from locally sourced coal with superior carbon capture retrofit capabilities, compared to traditional coal-based technologies.

POTENTIAL FOR COAL GASIFICATION FOR NEW POWER ADDITIONS

As power providers and governments make decisions about new power generation options, several key factors must be considered. First, a decision needs to be made regarding the fuel that will be consumed. Often, the most important selection factor is the cost of the fuel. In addition, considerations will be made regarding the long-term availability of the fuel, and the domestic energy security impacts of imported fuel versus domestic fuel. Finally, the emissions will increasingly be scrutinized as evidenced by the Paris Agreement resulting from COP21.
In parts of the world with a large discrepancy in the cost between natural gas and coal, it is highly likely that coal will still be selected, as it is economical and locally available. While developed markets will likely attempt to offset the carbon emissions from coal plants by building more expensive renewable technologies, such as wind and solar, the large emerging markets need economical and reliable new power capacity at large scale immediately. This dynamic has driven, and will likely continue to drive, large increases in the demand for coal-based power projects. Coal gasification can play a significant role because of its ability to generate economic, reliable power with very low levels of criteria emissions.

In the case of coal-fueled projects, a choice must be made between traditional pulverized coal-fired boilers and coal gasification-derived power. Key considerations will be the time required to build the plant, the capital cost of the plant, and the availability of low-cost financing. Another important decision will be the capacity of the plant. Traditional large-scale coal power generation plants capable of generating 600 MW and larger may not always be desirable, due to lack of centralized load demand and adequate long-range transmission capability. In these cases, smaller-scale power generation in the 50–300 MW range will be more desirable, due to the more distributed nature of load demands.

Criteria and greenhouse gas emissions are also important considerations. Coal gasification-derived power is capable of producing power with far lower criteria pollutant emissions, such as SO\textsubscript{x}, NO\textsubscript{x}, and particulate matter, compared to traditional pulverized coal. In addition, as CO\textsubscript{2} utilization technologies are developed and demonstrated, existing coal gasification facilities will offer significantly less expensive and commercially demonstrated methods to retrofit for the capture of carbon.

Coal gasification-derived power cannot only compete in the electricity market, but can quickly grow into a leader for coal-based power in these markets. However, there are a couple of key requirements. First, the gasification technology must be able to economically gasify low-cost, low-rank coal (such as lignite, brown coal, or high-ash coal), and coal wastes. The power plants must generate electricity with criteria pollutants much lower than historical coal power production. And finally, coal gasification providers need to continue to educate and drive the message regarding the superior retrofit capability of carbon capture of gasification. While the coal gasification power plants being built in the near term may not include capture, the ability to retrofit operating plants to drastically reduce CO\textsubscript{2} emissions at a low cost has significant value and hedges the investment risk in a carbon-constrained world.

Coal gasification technologies exist that can fill the needs of the power market. For example, Synthesis Energy Systems (SES) has developed a small-scale, coal-fed power generation product. This new product, iGAS, combines the superior low-rank coal capability of SES Gasification Technology (SGT) with small-scale gas turbines for the production of low-cost, low-emissions power on a distributed power platform.

**OTHER ENERGY DEMANDS**

In addition to the production of electricity, coal gasification can be used to generate other forms of energy. Two emerging markets are the production of substitute natural gas (SNG) and the production of syngas to replace natural gas or other fuels in industrial applications. Gasification for the production of SNG can be profitable, if the price of the coal is low and the price of alternative natural gas is high. However, this will still likely be more of a niche opportunity, with plants built at the coal source with access to existing natural gas pipeline infrastructure.
A new and emerging market for gasification is the use of low-priced coal to generate clean syngas that can be used directly as a fuel in an industrial setting, such as in the production of ceramics, glass, or aluminum. SES’s initial three such projects—licensed by its China Joint Venture, Tianwo-SES Clean Energy Technologies Company—were announced in December of 2014. The first of these projects started up in July 2015, and is estimated to save the Aluminum Corporation of China (the facility owner) more than $50,000/day in fuel costs for its aluminum products. Syngas can also be used to replace natural gas in the production of direct reduced iron in the steel industry.

THE CHANGING FACE OF GASIFICATION

What does the coal gasification industry need to do to capture a share of this large potential energy market? First, it needs to change focus from producing chemicals to producing clean energy. Chemical production projects will still be built, but I believe the real growth opportunity is in clean energy. Second, the industry needs to readjust its geographic focus. Historically, the location for coal gasification projects has been centered in eastern China and the U.S. China will still dominate as a major market for coal gasification, but next-generation markets will expand to include all of Asia, including countries such as India, Indonesia, Mongolia, Pakistan, and Vietnam. In the longer term, there will also be demand for this technology in other developing markets such as Brazil and Africa.

Finally, it is likely that many of the next-generation gasification projects will not be built by large-scale companies and government-owned entities with ready access to capital and financing. Coal gasification technology providers will need to expand beyond the traditional role of supplying license and equipment, to being able to provide turn-key gasification islands and become more involved in assisting the project developers in securing equity and financing to help these projects get started. With the favorable economics of these clean energy projects, equity investment by the technology providers themselves can also be a very lucrative opportunity.

KEY CONCLUSIONS

In summary, several key conclusions can be taken away from this analysis:

- Market forces in high-growth regions are more aligned than ever with the capabilities of gasification technology.
- Coal gasification technology providers have a great opportunity in large, high-growth mega-markets of energy.
- Gasification is a clean energy technology.
- Coal will be utilized heavily to fuel much of the global growth.
- Gasification is the best option for coal in a CO2-constrained world.
- Project decisions will be driven by (1) speed, (2) low CAPEX, (3) economics, and (4) environmental performance related to criteria emissions, capability for CO2 capture retrofit, and water consumption.

Coal gasification technology providers that have aligned their focus to take advantage of this unique combination of market dynamics and changing customer requirements will be successful. At SES, we believe our technology has the ability to meet the energy needs of the future and continue to utilize coal, the world’s largest energy resource, to provide clean energy to those who need it most.

REFERENCES