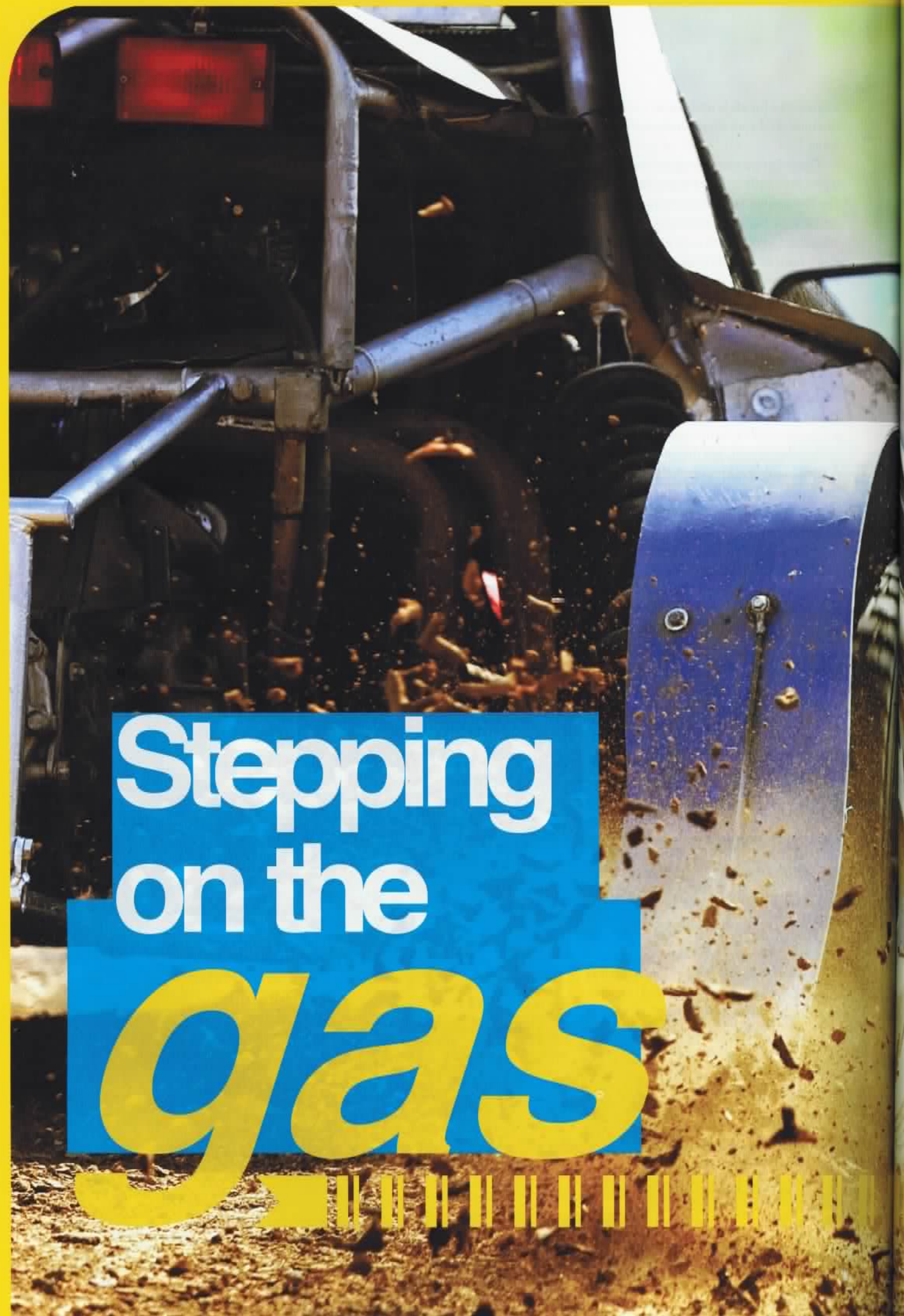

Stepping on the gas

Dr John Winter, Synthesis Energy Systems, US, discusses the potential provided by the company's gasification technology for utilising low-quality coal reserves.

Gasification technologies are widely used to convert coal, biomass and other carbonaceous feeds into a synthesis gas (syngas) comprising a mixture of mostly hydrogen and carbon monoxide. The syngas can then be converted to a wide variety of end-use products, such as basic industrial chemicals, transportation fuels, synthetic natural gas (SNG) and natural gas substitutes, fertilisers, reduced iron and power. Gasification's main advantage is that it allows these many end-use products to be made from the lowest cost feedstock available in a particular region.

Gasification is a diverse industry. In parts of Asia, coal gasification is frequently used to make chemicals, fertilisers, fuel gas and SNG. In the US, Europe and the Middle East, many feedstocks are used to make power, chemicals and transportation fuels. Figures 1 and 2 show the publicly reported feedstock and product distribution for the global gasification market, according to the US National Energy Technology Laboratory (NETL) report, "2010 Worldwide Gasification Database".

Although gasification is a mature process and industry, it is experiencing rapid growth (Figure 3). Much of the industry is in high growth economies, such as China and India. The price and availability of hydrocarbons in much of Asia make coal gasification the only economic route for domestic production of many chemicals, fuels and nitrogen fertilisers. As the gap between oil supplies and demand can only grow, there will be continued displacement of production of industrial chemicals and plastics from oil-derived feedstocks to coal and renewable feedstocks.

In the US and the Middle East, some production will be shifted to natural gas, but natural gas will be increasingly driven towards preferred use as a fuel – as has already happened by dictat in China. Eventually, demand increases and resource depletion will drive even more gasification applications to use more plentiful coal, perhaps with carbon capture and storage, or renewables.

Low costs enable many new opportunities

Gasification is typically used to lower feedstock costs to produce high-value end-use products. When comparing technologies, investors in these facilities will look at relative capital cost, feedstock cost (the principal differentiator in total operating cost) and proven reliability / availability.

The vast majority of installed gasification capacity worldwide is based on technologies described as high temperature, entrained flow and low temperature, moving or fixed bed. SES gasification technology differs from these by using a low-temperature fluid bed that has several inherent advantages over other technologies.[1] In the past, fluid bed gasification

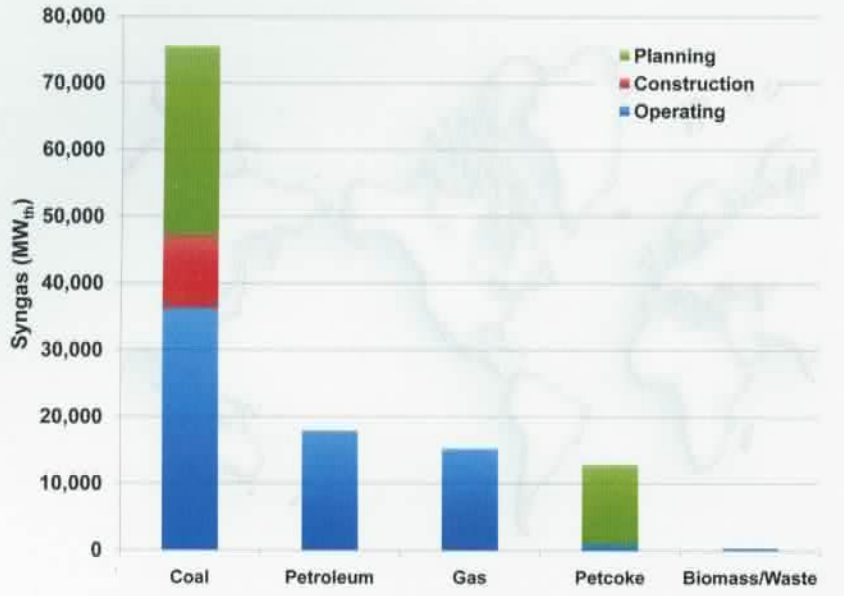

Figure 1. World gasification capacity and planned growth by feedstock.

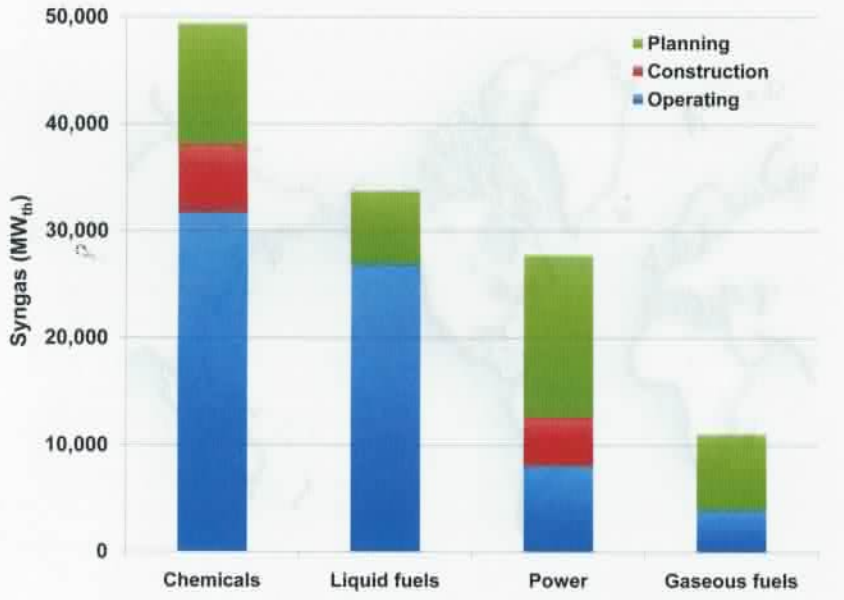

Figure 2. World gasification capacity and planned growth by product.

technologies had one drawback: lower conversion of the feed carbon to syngas, which lowered the yield of end product per unit of feedstock. SES technology includes patented technology and extensive expertise for a proprietary jet modified fluid bed gasifier, which achieves both high conversion and high yield.

Coal ash has melting temperatures that vary greatly among different deposits. The ash melting temperature plays a key role in the design and operation of gasifiers. In gasification technology descriptions, high temperature is used to mean gasifiers operating above the melting point of the ash, typically above 1300°C, while low temperature is used to describe those operating below the melting point of the ash, typically below 1050°C. These different temperature regimes have fundamentally different designs, performance characteristics and syngas product impurities, due to ash properties (a viscous fluid or a dry solid), the kinetics of the gasification reactions and other factors.

SES' technology was first deployed at its ZaoZhuang (ZZ) plant in Shandong Province, China. This plant is a joint venture (97% SES owned) in partnership with a local coke and methanol producer. The plant has two SES gasifiers that operated at 3 bar pressure and with a capacity of up to 400 tpd of coal-based feed for each gasifier. Syngas from this joint venture is used by the local coke producer to supplement methanol production from its coke oven gas.[2] The plant is designed to run on local coal washing wastes, but also ran on a variety of local coals and coal wastes. In addition, SES conducted extended runs on a variety of high ash coals, sub-bituminous coals and lignites in the ZZ plant.

Some of the gasification milestones achieved at ZZ were the demonstration of cold gas efficiencies (the fraction of the feed coal heating value in the heating value of the syngas) above 82%; carbon conversions above 98%; online switching of coal feeds between coals of widely varying properties; and achievement of reliability above 98% and syngas availability above 95%.

SES launched a second joint venture (25% SES owned) with Yima Coal Industry Group for a coal-to-methanol plant in Henan Province. The current Phase I capacity is 300,000 t/year methanol using nominally 2400 tpd of Yima coal, which has 38 to 45 wt% ash. Two additional phases of development are planned for this site for an eventual capacity of 1200 tpd methanol equivalent (other products are being considered for future phases). The plant is in early commercial operation ramping up production. Much of the infrastructure for the future phases is already in place at this facility. The gasifier operating pressure for this project is 10 bar.

SES gasification technology is on track to show reliability and flexibility and is differentiated by its ability to handle an extremely broad variety of feedstocks, which allows for selection of low-cost feedstocks (Figure 4). This important design feature ensures low life cycle feedstock cost, since coal feedstocks and feedstock suppliers can be changed after the plant is running without modification to the plant. The technology is robust with respect to operating and design margins

and parameters, which lowers capital costs and makes the plants safe and reliable. The company's operating experience is that the technology is simple to operate and maintain, which contributes to low operating costs.

Syngas cost

Competing gasification technologies are compared on syngas cost and reliability and availability. Syngas cost is dominated by feedstock cost, capital cost recovery and, to a lesser extent, electricity cost. Feedstock cost can be 60% or more of syngas cost. Particularly for those economies, such as China, where coal gasification is widely used due to high oil and gas prices, syngas cost is dominated by the cost of the coal feedstock.

Feedstock cost

Feedstock cost per unit of syngas is proportional to the price of the feedstock divided by the yield of syngas per unit of that feedstock. SES technology is considered advantageous here for several reasons. Compared to the class of high temperature gasifiers, SES technology can efficiently use much lower-cost low-quality feedstocks. These include high ash sub-bituminous coals, high moisture lignite coals, coal wastes and biomass. This is critical for the life cycle cost of the end-use products of gasification, because the price premium for higher quality coals, such as bituminous, compared to low quality coals, such as lignite, is rapidly rising as supplies of high quality coals are rapidly depleted in many markets outside the US.

SES' fluid bed technology is able to use different coals in the same gasifier with minor changes in operating parameters and no changes in plant equipment. The company's ZZ plant routinely changed feedstock during continuous operation of the gasifier.

This is a critical cost advantage in a plant, as it frees the plant from being captive to a single or small number of suppliers. SES technology has exceptionally high cold gas efficiencies, particularly compared to high temperature gasification technologies, even when operating with low quality feedstocks. For many gasification applications, this is a decided advantage since it affects both operating and capital cost.

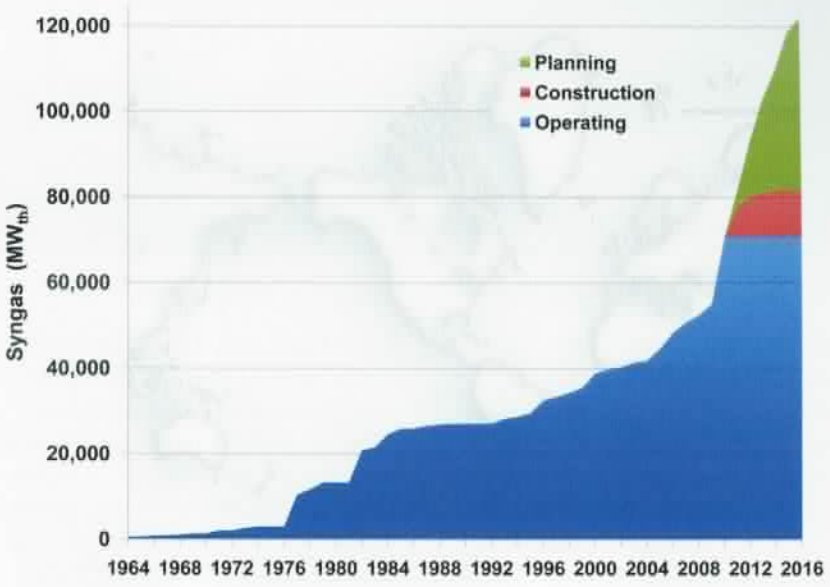

Figure 3. Worldwide gasification capacity and planned growth: cumulative by year.

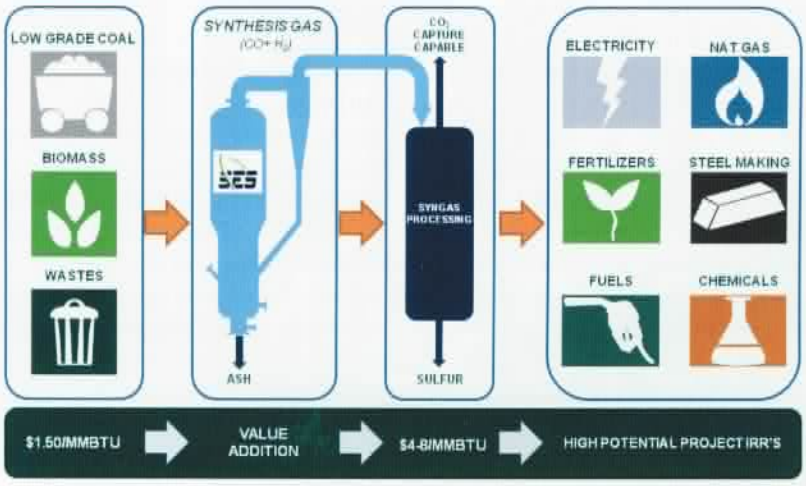

Figure 4. A key competitive advantage of SES gasification technology is the ability to convert low-cost feedstocks to high-value end products.

Because the SES technology can accept fines generated during normal coal mining and handling, a greater portion of the as-mined coal can be utilised compared to moving or fixed bed technologies that require a minimum feed particle size. The ability of the SES gasification technology to efficiently use coals with ash content above 50 wt% offers additional benefits to the owners of coal resources. Previously unmarketable high ash coals can be economically used in the SES technology, while the mineable reserve and production life of a given mine can be significantly enhanced by the ability to sell higher ash coal and coal wastes.

Capital costs

Capital cost is driven by syngas capacity and cost per gasification system. SES' latest high-pressure gasifier system has capacity to produce more than 100,000 m^3/hour of $CO+H_2+CH_4$ per gasifier system.

SES has built five gasifier systems in China using Chinese domestic equipment manufacturing and materials. The company intends to replicate this low-cost approach for future business in all of its worldwide markets.

Figure 5. Yima joint venture coal-to-methanol project using SES gasification technology.

Electricity costs

Modern gasification technology uses oxygen as a principal reactant. The oxygen is produced from air using electricity, so electricity cost is primarily driven by oxygen consumption per unit of syngas produced. SES gasification technology uses less oxygen per unit of syngas produced from low quality coals than high temperature gasification processes. This further enables SES to cost effectively unlock value in low cost, low quality coal resources.

These SES technology capabilities allow economic production of a variety of high-value products from coal that would otherwise not be cost effective. The proven ability to use low-cost coals and coal wastes with high product yields makes coal-based production competitive in many markets where it previously was not, due to insufficient margins between product prices and the cost for higher quality coals.

Case studies

The SES technology can be readily and easily scaled in both size and pressure. The company's design for future commercial plants would operate between 30 and 50 bar pressure, depending on the syngas pressure requirement. This results in gasifier system syngas capacities of approximately 100,000 – 120,000 m^3/hour of $CO+H_2+CH_4$, depending on the quality of the coal feedstock.

Ammonia and power in India

One key SES product is an integrated design to produce ammonia and power from coal.

The principal markets for this technology are India and China. SES has completed a preliminary design study for a project in India, which produces 2200 tpd of ammonia and exports 50 MW power from 5200 tpd of a 32 wt% ash (dry basis) coal blend. The company projects attractive returns in India for combined fertiliser and power projects, as well as for projects to produce reducing gas for iron production and SNG projects. Coal-based production of these key industrial products appears to be the only viable domestic production route to meet increasing demand in India, so the forward outlook on returns should be favourable.

Distributed power with GE turbines

SES recently announced a joint marketing agreement with GE to co-market a distributed power product using the SES gasification technology and GE LM2500 turbines. This product is projected to produce 70 – 100 MW net power. This distributed power product is attractive in the many world markets with poor power distribution infrastructure and electricity costs above US$ 0.1/kWh. The electricity cost for this product is comparable to more polluting and less fuel flexible coal boiler technologies and significantly cost advantaged compared to power produced from LNG.

Reducing gas for iron production

SES has also completed a preliminary design and cost evaluation for producing coal-based reducing gas for reduced iron production. Reduced iron is used in electric arc furnaces to produce steel and competes with traditional blast furnace technology, which produces steel using coal. Reduced iron production to date has been based on natural gas. Consequently, in those countries, such as India and China, where natural gas prices are high and availability is limited, use of natural gas-based reduced iron technology has been limited. Using a number of proprietary concepts to reduce capital and enhance efficiency, SES technology can use low quality coal to produce syngas for reduced iron at prices that will allow this route to compete with both traditional coal-based blast furnaces and natural gas-based reduced iron production.

Unlocking the value in low quality coal

The ability and flexibility of the SES technology provides many opportunities for countries with low quality coal resources to produce products that are otherwise imported or made from much higher cost natural resources and to extend the recoverable and marketable reserves of their coal resources.

The distributed power product is a good example of this for a wide range of country markets. Small-scale power generation, using coal and other locally produced resources, holds great promise for clean power production in many areas of the world where conventional power plants either cannot be built because of the lack of fuel or high costs. WC

Notes

1. SES owns proprietary advanced fluidised-bed gasification technology. SES holds an exclusive global license for the U-GAS® technology from the Gas Technology Institute in the US and has since developed and demonstrated substantial improvements to this technology through its plants in China and other efforts.
2. The ZZ joint venture plant has been restructured commercially and is currently in the process of being restarted in late 2013 with increases in both efficiency and production.

References

Figure 1, 2 and 3 provided courtesy of the US Department of Energy's National Energy Technology Laboratory (NETL).