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The potential of gas-to-liquid technology in the energy market: The case of Qatar

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Abstract

This paper presents a comprehensive methodology for evaluating the economic attractiveness of gas-to-liquid (GTL) technology in a gas rich country like Qatar. The Qatari gas volume needed to fully satisfy the projected long-term market demand of GTL products (mainly diesel oil) in the Asia-Pacific region is evaluated. Based on the state-of-the-art GTL technology, the number, size and the commissioning dates of GTL plants required for that purpose are determined along with the associated investment and running costs. The economic attractiveness of GTL investment is evaluated based on the internal rate of return, and the impact of adopting large-scale GTL projects on Qatar oil refining industry is assessed. Sensitivity analyses are conducted using several scenarios to account for variations in GTL premium, capital cost, operation and maintenance cost and cost of gas feedstock.

Keywords: Gas-to-liquid technology; Clean fuel; Market analyses

1. Introduction

The gas-to-liquid (GTL) process is concerned with the conversion of natural gas (NG) into liquid fuels of excellent technical and environmental qualities which supersede those obtained from ordinary refinery products. Key GTL products include diesel, liquefied petroleum gas (LPG), lube base-stocks and waxes, and petrochemicals such as naphtha and stream cracking. The products are of generally high quality with near zero sulfur and high cetane for the diesel (Rahmim, 2005). In recent years, several factors have resulted in the increased interest in GTL and its variations. These include (Ghaemmaghami, 2001; Rahmim, 2003, 2005):

- Stricter environmental regulations through tighter fuel specifications.
- Need to develop additional energy resources.
- Tendency to monetize flare gas and large reserves of stranded gas.
- Diversification of supply.

The US Department of Energy (DOE) (International Energy Outlook, 2005) suggests that GTL can only be economic if oil prices over the coming years are above US$20/B and gas is available at prices of the order of US$0.50/MMBtu. Recent forecasts suggest that oil prices may remain at US$40/B or higher, but the availability of gas feedstock at very low price is not straightforward. The important gas sources for GTL industry are likely to be those that are remote or stranded, flared or re-injected (Gas to Liquids Technology Worldwide, 2002).

The GTL concept has been introduced by several authors who reported on the progress achieved and the potential of this emerging technology. In a comprehensive report (Rahmim, 2005), Rahmim compared GTL with liquefied natural gas (LNG) in terms of NG consumption. He concluded that the LNG and GTL facilities available worldwide consume only 0.12% of proven gas reserves and about 8% of global annual gas consumption. Rahmim

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reported that GTL is virtually sulfur free and primarily paraffinic and therefore it can be considered as an important blending element in satisfying environmental and auto emission requirements. Ogawa et al. (2000) analyzed the long-term forecast of oil demand in Asia and its characteristics, investigated the current trends of environmental measures being taken by Asian developing countries and studied the marketability of GTL and its needs. A GTL taskforce (GTL Task Force, 2001) prepared a GTL industry development discussion paper to promote Australian GTL industry. A life cycle assessment (LCA) study (Five Winds International, 2004) presented the environmental attributes of GTL fuel. The study compared GTL technologies to conventional refinery based technologies and provided a holistic view of the technologies' impact on the environment by measuring the impacts caused by producing, transporting and using the fuels.

The objective of this paper is to assess the potential of GTL industry in Qatar by addressing the following issues:

- The extent to which Qatar's undeveloped gas reserves could support a world-scale GTL industry.
- The potential market opportunities for Qatar GTL industry.
- The impact of Qatar GTL industry on the oil refining industry.

2. Research methodology

This paper focuses on GTL diesel only because of all GTL projects representing a total liquid product capacity of 1.5–2 million B/d; Qatar alone is considering a liquid product capacity of 696,000–900,000 B/d by 2012–2015 with 70% are likely to be premium diesel for automotive industry (Rahmim, 2005; EIA Country Analysis Brief). Hence, this paper will evaluate the gas volume needed to fully satisfy the Asia-Pacific market in GTL (diesel oil) and determine the number, size and the commissioning dates of GTL plants required for that purpose together with the associated investment and running costs. The impact of GTL projects on Qatar's oil refining industry will also be assessed, and sensitivity analyses will be conducted using several scenarios to account for variations in GTL premium, capital cost, O&M cost and in the cost of gas feedstock. The flow chart shown in Fig. 1 summarizes the methodology followed in this paper.

3. Qatar's energy overview

3.1. Qatar's natural gas (EIA Country Analysis Brief; Hayward, 2005)

Qatar has proven gas reserves of 910 Tcf, making it third in size after Russia and Iran. Most of the gas in Qatar is located in the North Field, which contains 380 Tcf of gas in-place and 239 Tcf of recoverable reserves. In addition, the Dukhan field contains around 5 Tcf of associated and 0.5 Tcf of non-associated gas along with other smaller associated gas reserves in Id al-Shargi, Maydan Mahzam, Bul Hanine, and al-Rayyan oil fields.

3.2. GTL projects in Qatar (EIA Country Analysis Brief, ; Five Winds International, 2004; GTL Task Force, 2001; Ogawa et al., 2000)

GTL projects are planned and proposed in Qatar to capitalize on the extensive NG reserves, which together with Iran's reserve constitute 74% of the Middle East's NG. Of the projected worldwide GTL capacity amounting to 1,916,440 B/d by the year 2011 (Worldwide GTL Projects, 2001), Qatar alone has planned to contribute to a capacity of 696,000 B/d (36% out of the total). Other important planned contributions are expected to happen in Alaska (250,000 B/d), Australia (220,000 B/d), Iran (110,000 B/d) and South Africa (157,000 B/d) (Worldwide GTL Projects, 2001). A key factor to motivate GTL production is the availability of large stranded gas fields. In this respect, Qatar has such large fields (around 1300 Tcf of recoverable reserves are available in large fields of size greater than 30 Tcf), but in the Asia-Pacific region, the availability of large stranded gas fields is limited (only around 100Tcf of recoverable reserves are available in large fields of size greater than 30 Tcf) (Ogawa et al., 2000).

Table 1 shows GTL plants in Qatar that are either under construction, in the design phase or under discussion.

3.3. GTL demand estimation

As was mentioned earlier in this paper, the GTL diesel oil demand in Asia will be considered as the GTL market for Qatar. The forecast of diesel/gas oil demand for the period 2000–2010 suggests that Asia has both the highest annual average growth rate (4–5%) and the highest demand (around 300 million tons during 2000) compared with the annual growth rate in North America (1–2%), South America (4–4.2%), Eastern Europe (3%) and the Middle East (2%) (Refining and Petrochemicals, 2004).

The stringent environmental constraints concerning emissions in Asia are pushing the Asian countries to find alternatives or cleaner resources at a faster rate than Europe and North America. Hence, full-fledged introduction of desulfurization and dearomatization facilities will be necessary for that purpose. Alternatively, GTL can be a promising option to compete with refinery expansion as will be shown in Section 7.

In fact, the world demand for diesel fuel for transport is estimated to grow at 2% per year over the next 5–10 years, with China and India having the highest growth rates. According to Ogawa et al. (2000), Rahmim (2005) and Worldwide GTL Projects (2001) the GTL demand was 500,000 B/d in 2005, and is likely to increase sharply to 4.94 million B/d in 2020 at a supply price of US$25/B. At supply