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Economic analysis of unconventional liquid fuel sources

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ABSTRACT

In this study, the potential of the alternative liquid fuel sources to enter into the liquid fuel market is analyzed based on the cost structures of these sources. Firstly, the current unconventional sources are classified as syncrude, synthetic fuels and biofuels and some basic information including production methods and current production amounts about these alternative sources is explained. Secondly, the production costs are examined to calculate the market entrance prices and shut-down prices for the technologies used to produce liquid fuels from the unconventional sources. Lastly, the structure of the liquid fuel market and the potential of alternative fuels in the market are discussed. Based on the analysis, it is concluded that the liquid fuel market can be characterized as a competitive market in which three factors play important role on determining the entrance into the market. These factors are (1) the corresponding oil prices for entrance and shut-down prices, (2) total capital cost of the project (the level of sunk cost), and (3) the capital cost per daily barrel of capacity. The evaluation of these factors together shows that biofuels are the most preferable option followed by gas-to-liquids. In terms of market entrance price, syncrude is the most advantageous option, but its high capital cost increases the risk. On the other hand, coal-to-liquids is the most risky one with high market entrance price, large initial capital cost and high margin between entrance and shut-down prices.

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1. Introduction

Liquid fuels like gasoline and diesel have been produced from conventional oil for more than a hundred years. Mankind has also used other natural sources like coal, biomass, and natural gas to get liquid fuels. However, none of these materials has become dominant in the fuel market, except some special cases like the ones in Germany, and South Africa. Germany produced liquid fuels from coal in 1940s as a substitution to the fuels originated from petroleum during the World War 2. In this period, 9 indirect and 18 direct liquefaction plants were constructed to produce 4 million tones of gasoline, 90% of total consumption [1]. After the war, the liquefaction plants were closed down, because lots of cheap oil was available around the world [2]. Regarding South Africa, the reason was the trade boycott held in 1950s because of the apartheid policies. As a response to the trade boycott, she started to use large coal reserves to produce liquid fuels to meet the fuel demand [3]. In 1980s, the share of coal based liquids was 60%, but in the following years this ratio has been decreased. Currently, around 30% of the country's gasoline and diesel needs are produced from indigenous coal [1]. In addition to these two extensive usages, several attempts have been carried out mainly in the developed countries, but only few of them have reached the commercial phase. Several technologies have been developed, but the final products have never succeeded to be competitive in terms of costs compared to oil based liquid fuels. These attempts especially were abundant in the high-oil-price periods, but the decline of oil prices always prevented the extensive production of unconventional based liquid fuels.

The interest to unconventional sources has been revived recently thanks to the increase in oil price which has leaded some countries to produce liquid fuels from alternative sources. In addition, many other countries are taking several projects into their agendas, especially the ones having competitive advantages in terms of source. Taking into account the current and forecasted production amount of unconventional based liquid fuels, it is expected that the market share will increase from 3% to 10–18% by 2035 (Fig. 1) [4] based on the level of crude oil price. If oil prices keep increasing, much more liquid fuel would be produced from unconventional sources and the market share will rise to 18% by 2035. However, if price decreases, the market share of unconventional sources reaches only to 10% by 2035 from 3% in 2007. This expectation shows that there are also some other reasons other than oil price that facilitate the entrance of alternative sources into the market. Among these reasons security of supply, diversification of supply, and sustainable development concerns can be mentioned.

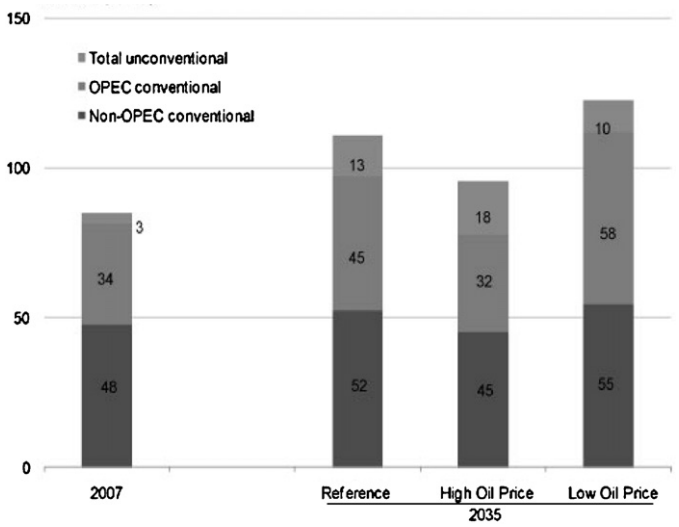

Fig. 1. Unconventional liquid fuel supply in three cases in 2030 (millions bbl/day).

In this paper, the structure of the liquid fuel market is analyzed to understand how and under which circumstances these unconventional sources increase their shares in the market. In the second section, some basic information including technology, reserves, current production, and some applications about these sources is given. Then, in the third section, costs of liquid fuel production from the unconventional sources are discussed. In the fourth section, first the structure of liquid fuel market is evaluated in terms of the competition and then, the entrance of other sources into the market is analyzed by focusing on the entrance prices and shut-down prices.

2. Unconventional liquid fuel sources

The term "unconventional liquids" applies to three different product types: syncrude, derived from the bitumen in oil sands, or from extra-heavy oil, or from oil shales; synthetic fuels, created from coal, or natural gas, or biomass feedstock; and renewable fuels – primarily, ethanol and biodiesel – produced from a variety of renewable feedstocks [5]. Generally, these resources are economically competitive only when oil prices reach relatively high levels. In this section, we will give some basic information about these unconventional sources.

2.1. Syncrude

Syncrude is produced from low quality or immature oil in the forms of oil sands, extra-heavy oil sands and shale oil. These sources are discussed in this section.

2.1.1. Oil sands (bitumen)

Bitumen has some negative properties from crude oil: (1) it has low API gravity that is less than 10; (2) bitumen is composed of carbon-rich, hydrogen poor long-chain molecules; (3) its viscosity is very high compared to crude oil; (4) it generally contains lots of heavy metals and sulfur. Therefore, in the past, the explored bitumen reservoirs had been abandoned undeveloped. Nevertheless, the difficulty of finding new big crude oil reservoir, the increase in oil price, and the development of technology have fostered the production of liquid fuels from oil sands.

Currently, two methods are used to get bitumen from oil sands: open-pit mining and in situ method. If the layer over the oil sand reservoir is thin, open-pit mining becomes less costly option. It is extracted with the physical separation. Then, it is coked, distillated, catalytically converted, and hydro treated to produce syncrude with 86% efficiency on average. Unlike open-pit mining method, in situ process is preferred for reservoirs that are deeper than 225 feet [5]. In in situ process two wells are drilled one of which is used to inject steam or gas to heat and lower the viscosity of bitumen and the other is used to gather the bitumen. Once bitumen is extracted, the remaining process is the same.

The explored oil sand sources are not dispersed thoroughly around the world. Canada solely has 81% of all explored oil sands with 2.5 trillion barrels of bitumen [6]. However, only 321 billion barrels of this resource can be processed under the current economic and technological conditions [7]. If crude oil price remains high, this amount, most probably, will increase in the following years.

2.1.2. Extra-heavy oil

Extra-heavy oil is, in fact, a kind of crude oil whose API gravity is less than 10 and viscosity is higher than regular. As a result it flows slowly in reservoir compared to conventional crude oil. To extract extra heavy oil, steam or gas injected to well, in order to decrease its viscosity.