

1. Background

Private oil companies in Korea such as GS Caltex, S-Oil and Hyundai Oilbank have recently announced plans to invest in petrochemical production facilities and have begun entering the chemical market in earnest. These investments include building a Naphtha Crack-

boost demand for plants. Since 2016, global crude oil prices have risen, leading to improved financial conditions at major oil producers and a reduced cost burden for the construction of petrochemical production facilities. As a result, the demand for petrochemical plant orders is expected to increase. In fact, the Downstream Capital Cost Index (DCCI), which tracks cap-

Impact on the Plant Industry in Korea Caused by Oil Companies' Entry into the Petrochemical Market

ing Center (NCC) where naphtha, a product made at existing refining facilities, is used as a raw material to produce ethylene products. As private oil companies have started entering the petrochemical market in Korea, both the supply of petrochemical products and the demand for increased production capacity are expected to rise.

Forward integration of chemical businesses led by refineries is a common sight not only in the domestic but also in the global petrochemical market. This trend is attributed to a decline in profit margins at traditional oil companies, along with a rise in demand for upstream petrochemical products due to the global economic recovery. In addition, Saudi Arabia and the United Arab Emirates have shifted their energy development policy from existing refineries to vertical integration, covering the petrochemical businesses. It is believed that this will

ital expenses for the construction of refining facilities and petrochemical production facilities, was most recently at 182, reflecting a drop from 2004 to 2005 levels, when plant orders surged.

As oil companies have started entering the global petrochemical market, the demand for plants has increased. This is a new opportunity for the Korean plant industry. Therefore, it is timely to analyze the causes and types of oil companies' entry into the chemical market and identify the impact on and opportunities for the Korean plant industry. This study aims to predict the impact on the demand for petrochemical plants caused by global oil companies' strategies to invest in the vertical integration. It is hoped that this study is used as a basic guide for the domestic plant industry to come up with measures to respond in the future.

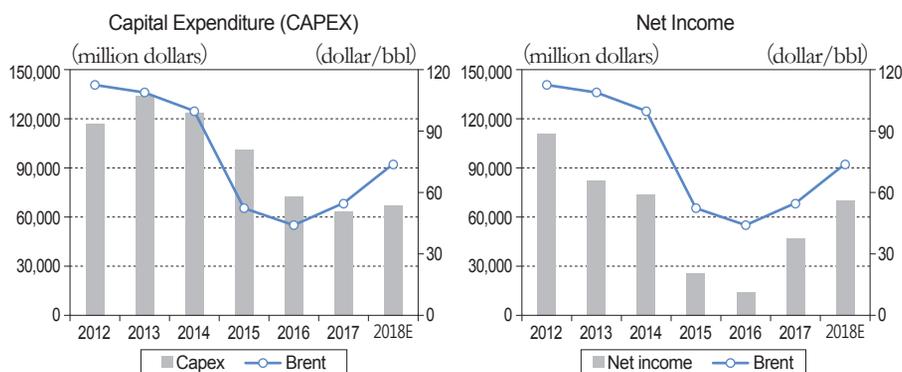
2. Causes and Types of Oil Companies' Entry into the Petrochemical Market

The global petrochemical industry has recently seen an increase in the cases of oil companies entering into the upstream market of the petrochemical industry, where intermediate products such as base oil and intermediate materials are produced. These products are critical to manufacturing final products. The trend is believed to be happening due to growing volatility in corporate revenues in the global petrochemical market. Some research institutes predict that the crude oil prices are unlikely to maintain over 100 dollars per barrel although the global oil prices have steadily recovered since the second half of 2014 when the crude oil price plummeted, mainly because oil producers — especially Organization of the Petroleum Exporting Countries (OPEC) producers — set a strategy to control the oil supply. Refineries were not able to secure profits

in deep-water oil drilling and shale gas projects which were intensively launched by refineries before the year of 2014. Figure 1 shows that capital expenditure (CAPEX) and net profit of oil companies declined significantly from 2015 to 2016 as the global crude oil price dropped. Since 2017, the global oil price has started to rise slightly and the net profit of oil companies has recovered to 2014-levels, before lower oil prices took root. However, facility investment costs have increased at a modest pace despite rising oil prices.

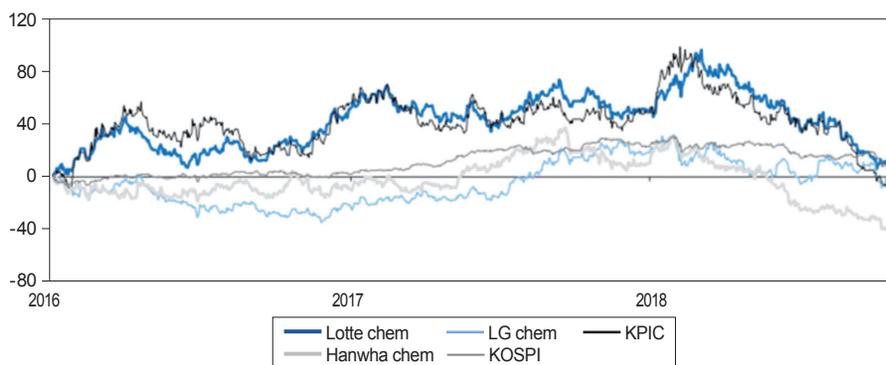
Meanwhile, the global petrochemical market has seen that the demand for general-purpose petrochemical products is steadily increasing in emerging countries and the demand for high-value added chemical products is growing in the advanced countries. The demand for petrochemical ingredients such as naphtha and Liquefied Petroleum Gas (LPG) is believed to maintain this growth. Petrochemical products are thought to replace natural materials in

Figure 1. Trends in Global Oil Prices and Financial Indexes



Source: Meritz Securities co, LTD. (2018), Meritz 2019 Forecasting Series; Refinery and Chemical Soft-Landing, Meritz Securities co, LTD. Research Center.

Figure 2. Comparison of Stock Prices of Korean Major Petrochemical Companies



Source: Meritz Securities co, LTD. (2018), Meritz 2019 Forecasting Series; Refinery and Chemical Soft-Landing, Meritz Securities co, LTD. Research Center.

emerging countries, raising demand for petrochemical products to a level similar to the GDP growth rate of each country. That is the main reason behind refineries' new investments in the petrochemical markets to secure profits at a stable level. The Korea Petrochemical Industry Corporation (KPIC) and Lotte Chemical are the major ethylene producers in Korea with share prices higher than the KOSPI index average. This indicates that their businesses are in a good position compared to the overall domestic economic conditions (See Figure 2).

The oil companies entering the market can be categorized in three types based on chemicals sales. First, there are the oil companies with less than five percent of sales accounted for by chemicals. These companies focus on oil refining, producing parts of aromatic compounds. Major oil producing countries such as the Middle East, Russia, and South America tend to center their investment strategies on oil refining. The second type of company is one

with less than 15 percent of sales in chemicals. These companies are equipped with both existing refining facilities and dismantling facilities to break down raw materials. This strategy is to diversify businesses by securing facilities to produce the primary derivative coming from naphtha produced at a refining facility. This strategy is mainly notable at global leading companies such as British Petroleum (BP), Total, Shell and producers in Asian countries including South Korea, the ASEAN nations and India. The third type of company is one with over 15 percent of sales accounted for by chemicals, referred to as vertical integration in the chemical businesses. These companies feature forward integration of chemical businesses led by refineries having secured facilities to produce derivatives. Only a few companies take this strategy, such as the South Korea-based SK and companies in Taiwan.

Total, which falls into the second type of oil company, has shifted its business strategy.

Table 1. Types of Oil Companies' Entry Strategies into the Petrochemical Market

Types	Refinery based	Partial entry	Vertical integration
Business structure	Refinery only Refinery + BTX	Refinery + Cracking center	Refinery + Cracking center + PX
Share of chemical business	Less than 5%	From 5% to 15%	More than 15%
Examples	Refinery companies of oil producing countries	BP, Total, Shell Korea, ASEAN, India	SK (KOR) Formosa (TWN)

Source: Im (2018), "How will the global oil companies expand their investment to petrochemical business?", LG Economic Research Institute.

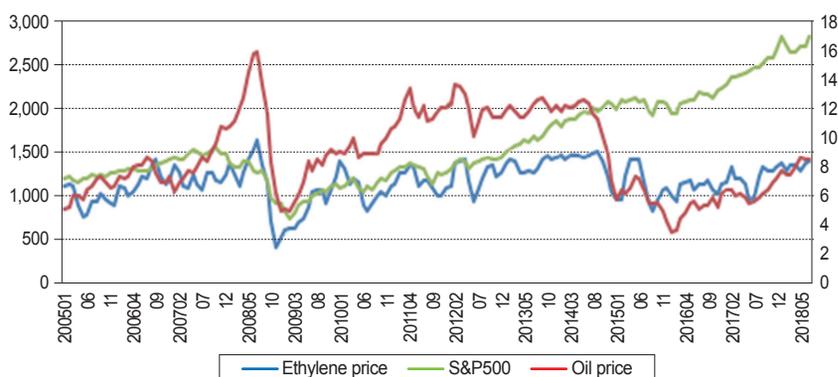
Where it once focused on specialty chemicals, it now manufactures general-purpose products including base oil and polyolefin products. Total has a newly-built Ethane Cracker Center (ECC) in the United States and Saudi Arabia, where materials such as ethane and natural gas are used, and it has improved and expanded its facilities in Korea and Europe to ensure a flexible supply of raw materials by using natural gas, condensate (in Korea), and imported ethane (in Europe) as raw materials in its existing NCC. Total pursues a business strategy that stabilizes profits by securing cost competitiveness and utilizes the general-purpose petrochemical products as a future growth engine.

3. The Outlook of the Domestic and Global Petrochemical Market

The domestic ethylene market has seen growing demand for and supply of ethylene products. Even as China, the world's largest importer of chemical products, has gradually raised its self-sufficiency in the base oil sector of the petrochemical industry, the production

and exports of Korean ethylene products have increased continuously. Naphtha, which is highly linked to the international crude oil price, is the main ingredient in ethylene. The cost of naphtha accounts for more than 70 percent of the production cost of ethylene. The price of ethylene products tends to follow a change in the international crude oil price. In the second half of 2015, the international crude oil price plummeted. Since then, product margins, which are the price gap between the product and the international crude oil price, have widened, leading to an increase in operating profits for ethylene producers, resulting in increased operation of production facilities and facility investment. The price of ethylene moves in a similar direction to that of global crude oil. On the other hand, there is no statistically significant correlation with changes in the S&P 500 Index that reflects the global economic conditions. Since the 2010s, when output of non-naphtha products grew due to the development of shale gas and coal chemistry technology, decoupling has been expected to occur between the prices of global crude oil and ethylene. However, the supply

Figure 3. Trend of Ethylene Price and Other Indexes



Source: Ethylene price data from the Korea Petrochemical Industry Association (KPIA). Oil price data from Petronet (<http://www.petronet.co.kr>). S&P 500 data from Yahoo Finance.

of non-naphtha products has not increased as quickly as expected, and the price of the two products is still linked.

Petrochemical products, produced from ethylene products, are the core material in demand industries such as automobiles, electronics, construction, civil engineering, and household goods industries. According to the Ministry of Economy, Trade and Industry (METI) in Japan, the global ethylene market is expected

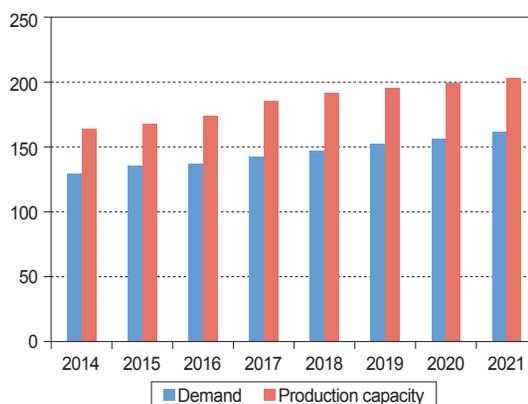
to expand at an annual average growth rate of three percent by 2021, mostly driven by the Asian market. China and India are expected to post remarkable growth in their ethylene markets, having large domestic markets. The ethylene market is sensitive to the economy and is subject to the 10-year economic cycle (since the 2000s). As the demand industry maintains steady growth, ethylene demand should grow continuously. Emerging countries centering on

Table 2. Ethylene Demand Forecast by Region

	2015	2021	CAGR
World	135.8	161.8	3.0
Asia	63	80.3	4.1
-S. Korea	4.5	4.7	0.4
-China	36.8	49.9	5.2
-ASEAN	7.6	9.2	3.4
-India	7	9.1	4.5
-Japan	4.7	4.8	0.4
Europe	21.1	22.1	0.8
N.America	34.2	37.7	1.6
Middle East	9.4	11.5	3.3

Source: METI (2017), Demand and supply forecast of the global petrochemical market.

Figure 4. Demand and Supply Forecast of the Global Ethylene Market



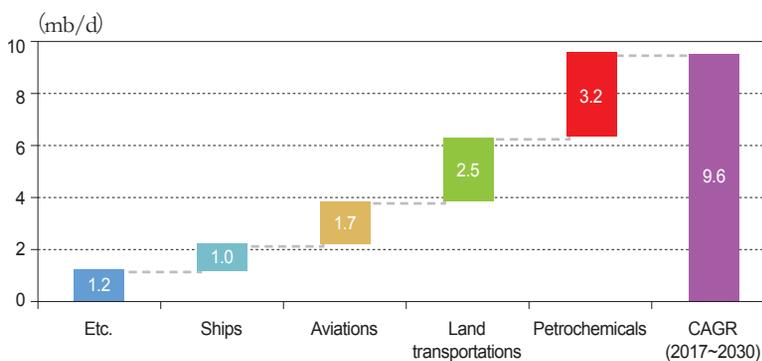
India and China have attracted foreign capital and expanded production facilities to promote their own domestic petrochemical industries, leading to an increasing production capacity at a faster pace than the demand growth. It indicates that the global ethylene market may face an oversupply issue in the future.

A study published by the International Energy Agency (IEA) predicted that the oil demand for petrochemical products would take up the largest share by 2030. The study divided the oil demand into five parts: ships, aviation, ground transportation, petrochemicals, and others. The growth of the oil demand for petrochemicals was the highest at 3.2 percent followed by that of the demand for ground transportation and aviation. Until now, the oil demand for ground transportation accounted for the majority of demand. Oil demand growth is predicted to slow down due to improved energy efficiency, the development of public transportation and alternative transportation such as alternative

and electric vehicles. The oil demand for petrochemicals is expected to expand in the United States and China in the short term and in Asia and the Middle East in the medium and long term. The IEA predicts that India and South-east Asian countries will lead the oil demand growth by intensively investing in petrochemical production facilities. At the same time, the demand for replacing natural products with chemical products is thought to grow due to a steady global economic growth, population growth and technology development. The IEA also predicts that advanced countries including the European Union, Japan and Korea will strengthen their recycling policies to keep a sustainable environment, leading to a boost in the demand for chemical products.

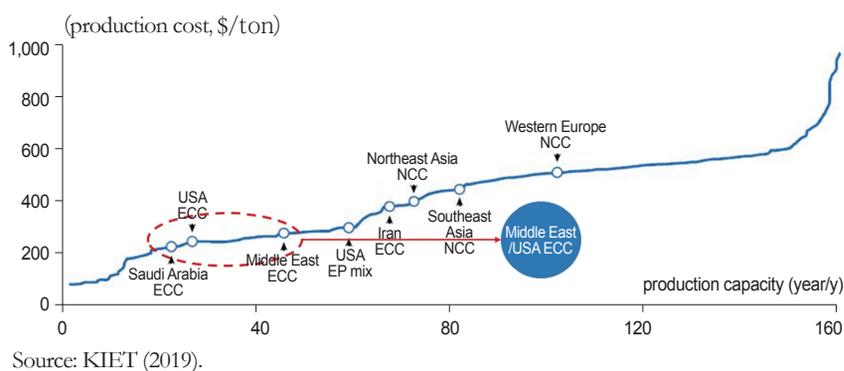
Since the 2010s, oil companies in the United States and the Middle East have been making aggressive investments in petroleum to chemical integration facilities and entering the upstream market of the petrochemical indus-

Figure 5. Forecast for Petroleum Demand Growth Rate by Sectors



Source: International Energy Agency (2018), *The Future of Petrochemicals; Towards more sustainable plastics and fertilizers*.

Figure 6. Effect on Oil Companies Entry into Petrochemical Market



try. As production facilities in the United States and the Middle East use ethane as the main raw material, increasing production capacity of these facilities helps the oil companies achieve economies of scale and gain an advantage in price competition with existing NCC in Western Europe and Northeast Asia. As a result, the market shares of products made in the United States and the Middle East will increase because cost competitiveness plays a key role in the market for general-purpose petrochemical products. If oil supply outpaces demand due to overheated investment in petrochemical production facilities, suppliers would inevitably face a drop in prices and profits caused by oversupply.

4. Impact on the Plant Industry Caused by Refineries' Entry into the Petrochemical Market

Engineering companies in Korea such as Samsung Engineering, Daelim Industrial and

GS Engineering and Construction entered into overseas markets based on their previous experience and performance. In 1991, Daelim Industrial became the first Korean company to win an overseas contract for an ethylene plant project placed by TOC of Thailand. In 1992, Samsung Engineering obtained an order for an ethylene production project to produce 0.3 tons of ethylene annually from Jilin Chemical Industrial Company. Since 2005, the number of ethylene project orders have surged and Korean Engineering, Procurement and Construction (EPC) companies have started winning orders. In Iran, Hyundai Engineering and Construction won eleven project orders to produce one million tons of ethylene annually, working as part of a consortium with Linde plc. In 2017, Hyundai E&C obtained an order to build an ethylene plant with annual production capacity of one million tons under financing conditions. Daelim Industrial won an ethylene plant order from Sadara Chemical Company in Saudi Arabia in the biggest deal yet, for a plant

was capable of producing 1.5 million tons of ethylene per year.

GS Engineering and Construction formed a consortium with KBR and won an order to build the Ustyurt Gas Chemical Complex (UGCC) in Uzbekistan. In the first quarter of 2018, Samsung Engineering and SK E&C obtained ethylene project orders in Thailand and Vietnam, respectively. Samsung Engineering has built production facilities in Asia and the Middle East, capable of producing 5.6 million tons of ethylene in total. Hyundai Engineer-

ing, Hyundai E&C and SK E&C have been fighting with overseas companies to win an ethylene plant project order. Since 2014, crude oil prices have remained relatively stable and ethylene demand is expected to rise. There will be fierce competition to place and win an order across the world.

Meanwhile, the amount of local companies' overseas plant orders steadily increased until 2014. Even during the financial crisis in 2008, the total amount of orders grew despite a decline in the number of orders for other in-

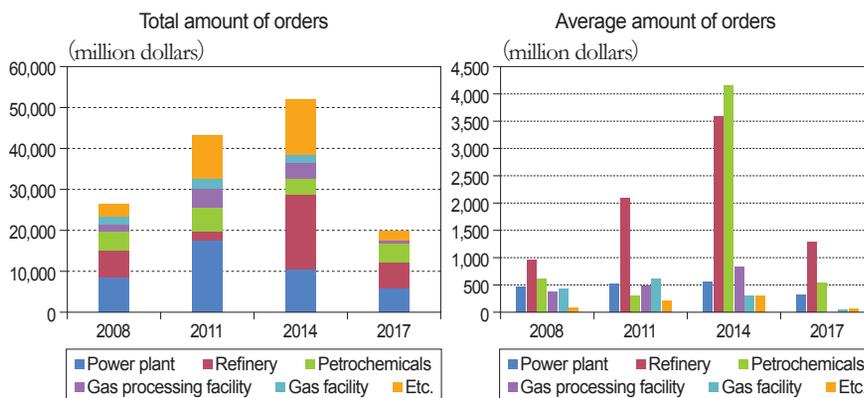
Table 3. Global Ethylene Plant Construction Schedule of Korean EPC Companies

Company	Project	Production capacity (thousand ton/year)	Completion year
Samsung	(CHN) Jilin	300	1994
	(THA) TPI Phase 1	350	1997
	(THA) TPI Phase 2	700	1999
	(MYS) Petronas Olefin	600	2001
	(SAU) Tasnee	1,200	2010
	(THA) MOC	900	2010
	(IND) Opal Dahej Ethylene	1,100	2015
	(THA) PTTGC Olefin Retrofit	500	2020
	Subtotal	5,650	
Daelim	(THA) TOC Rayong	385	1995
	(PHI) JG Summit	320	2014
	(SAU) Sadara	1,500	2015
	Subtotal	2,205	
Hyundai	(IRN) Olefin 11	1,000	2011
	(IRN) South Pars 12	1,000	2021
	Subtotal	2,000	
GS	(UZB) UGCC	400	2015
	(MYS) Lotte Titan	92	2017
	Subtotal	492	
SK	(VNM) Long Son	1,000	2022
Total		11,347	

Source: Cho (2018). "Global ethylene plant construction project trends", FOCUS, KPIA.

Note: Shaded are current projects.

Figure 7. Global Plant Orders Conducted the Korean EPC by Sector



Source: International Contractors Association of Korea (ICAK) (2018), Statistics Database.

dustrial facilities such as power plants, chemical plants and gas processing facilities. Since 2014, however, orders from power plants and refineries have decreased remarkably due to enhanced regulations across the world and environmental changes including declining oil prices, an increasing demand for electric vehicles and reduced oil demand.

Investment in chemical facilities is expected to rise due to the global economic recovery, growing demand and stabilized corporate margins in the petrochemical industry compared to the refining industry. Based on overseas orders for chemical plants by 2017, the amount of orders is estimated to go down in the short term, but to go up in the long run thanks to stable demand.¹⁾

Amid the recent trend of declining orders for other industrial facilities, overseas orders for

chemical plants seem to have remained steady or increased slightly. This is because international refineries have expanded their investments in petrochemical facilities due to decreasing oil demand and thinning corporate margins caused by growing risks of oil exploration and development, enhanced environmental regulations and the development of alternative energy sources. Investment in chemical facilities is expected to rise because of global economic recovery, growing demand and stabilized corporate margins in the petrochemical industry compared to the refining industry. Based on overseas orders for chemical plants by 2017, the amount of orders is estimated to go down in the short term, but to go up in the long run thanks to stable demand. These results are based on previous orders that Korean plant companies won from 1990 to 2017. It is highly

¹⁾ In this paper, a time-series analysis is conducted by using global chemical plant orders data from 1990 to 2017 which made by the ICAK. Based on the analytical results, I forecast the chemical plant orders until 2025. It shows that chemical plant orders will slightly decrease until 2021 before recovering gradually.

Table 4. Forecast for Global Chemical Plant Order Conducted by Korean EPC Companies

	2014	2017	2021 (p)	2025 (p)
Total amount of orders	4,172	4,405	3,917	4,489
Average amount of orders	4,172	551	582	670

Units: million dollars

Source: KIET (2019).

Note: The average amount of orders is defined as the total amount of orders divided by the number of orders, and the number of orders of 2014 is one.

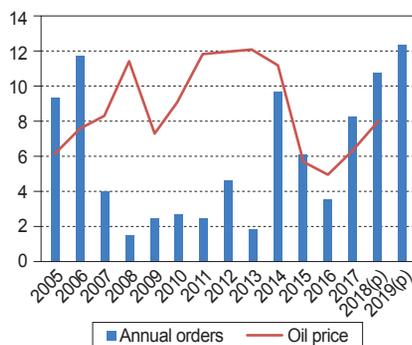
likely that Korean plant companies' performance in winning orders surpasses estimates if the global crude oil price remains stable and oil companies cause plant demand to increase by newly building petrochemical production facilities such as cracking centers.

Ethylene production is heavily influenced by manufacturing costs depending on international oil prices. Therefore, when oil prices stay at a high level, ethylene plant orders tend to be low, but companies tend to make aggressive orders when prices are relatively low. In 2006, there was a boom in the construction of ethylene plants. Ten large ethylene plant projects were ordered in the Middle East and Asia. Af-

ter the boom ended, the ethylene industry has entered a recession due to the global financial crisis and high international oil prices. In this period, changes in market status occurred, including mergers and acquisitions of licensors and EPC companies. Orders for an ethylene plant project were placed in the United States in 2014 and in the U.S., China, Russia, and the Middle East in 2015. In 2016, lower crude oil prices hit construction of ethylene plants hard, with only three projects initiated to build ethylene plants in China, with an annual production capacity is at 3.4 million tons.

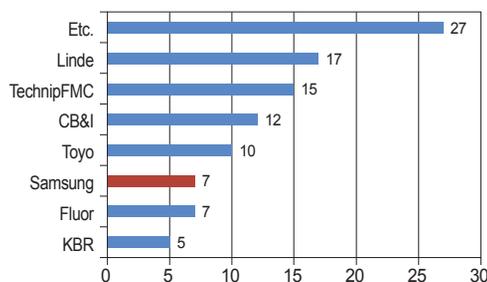
Projects orders have seen rising in the United States, the Middle East and Asia as the

Figure 8. Oil Price and Ethylene Plant Orders



Source: Cho (2018), Global ethylene plant construction project trends, FOCUS, KPIA.

Figure 9. Global EPC Companies



global crude oil price remains relatively stable and the long-run demand for ethylene is expected to increase. The market for petrochemical products has a significant potential to grow because the Asian market including China accounts for 60 percent of the world's population. In particular, China has steadily built ethylene production facilities and increased production capacity in its existing facilities for the past 20 years. Since China is expected to expand ethylene-based petrochemical plants for a while, it is a good opportunity for Korean EPC companies including Samsung Engineering and a consortium of four licensed companies to expand.

The Asian region is notable in forecasting demand for petrochemical plants. The Middle East and China in the 2000s and the United States in the 2010s had seen a plant investment boom. It is highly likely that the next plant investment boom will spark in the ASEAN countries and India. ASEAN countries have strong population growth and economic growth despite their diversity in race and religion. When the significance of the petrochem-

ical industry in economic development is taken into account, we expect that ASEAN countries will see a surge in demand for petrochemical products. An expected forecast of ethylene demand by region shows signs that India, China and ASEAN countries will have increasing demand for petrochemical products.

In ASEAN countries, state-owned companies lead the projects or attract foreign capital to carry out plant projects to increase ethylene production capacity, reflecting their own circumstances. PETRONAS, a state-owned petrochemical company in Malaysia, is working on a project to build a NCC by 2019 that can produce 1.1 million tons of ethylene a year. Vietnam has a plan to operate an integrated crude oil-to-chemical complex from 2021 after completing the construction of a complex that can produce five million tons of product a year. Thailand's state-owned oil company PTT, Saudi Aramco and the Vietnamese government invested in the project, with stakes of 40 percent, 40 percent and 20 percent, respectively. Vietnam's state-run company PetroVietnam has set a goal to

Table 5. Forecast for Ethylene Production Capacity in the ASEAN Countries

Unit: million tons, %

	2015		2017 (p)		2019 (p)		2021 (p)		CAGR
	Capacity	Share	Capacity	Share	Capacity	Share	Capacity	Share	
ASEAN	19	11.3	22	11.7	22	11.3	26	12.8	5.4
Asia	67	39.9	75	40.5	77	39.3	82	40.0	3.5
World	168	100.0	186	100.0	197	100.0	204	100.0	3.1

Source: METI (2017), Demand and supply forecast of the global petrochemical market.

Note: ASEAN includes Singapore, Thailand, Indonesia, Malaysia, the Philippines, and Vietnam.

build production facilities for the conversion of natural gas to methane-to-olefins and start commercial operation in 2020. Singapore has no plan to expand facilities to produce base oil. However, it has carried out a project with Exxon Mobile to establish facilities to produce derivatives by 2019. Pertamina, a state-owned company in Indonesia, announced its plan to complete the construction of facilities by 2022 that can produce 1 million tons of ethylene a year. Lotte Chemical Titan plans to build an ethylene production facility in Java, Indonesia. ASEAN countries would see an increase in annual ethylene production capacity by 5.4 percent and account for 13 percent of the global petrochemical supply. The growth of ethylene production capacity in ASEAN countries outpaces that of the global supply. Considering the investment plans, ASEAN countries appear poised continue increasing production capacity after 2021.

5. Implications

Despite the growing volatility in global crude oil prices, the international petrochemical market is a good condition with a three percent annual demand growth. On the other hand, oil companies' revenues have been declining due to growing volatility. Against this backdrop, it is reasonable that oil companies set strategies to enter the upstream market of the petrochemical industry by expanding their businesses. Not only oil companies but

also existing petrochemical companies plan to expand production facilities as the industry enters a boom period. Some have expressed concerns about oversupply in the petrochemical market, but many experts and research institutes have an optimistic market outlook. From the perspective of the plant industry, changes in the global petrochemical industry can boost the demand for plants. A study predicts that after 2025, chemical plant orders from overseas would outnumber current levels and plant demand will increase in ASEAN countries followed by the Middle East, China, and the United States.

To cope with demand growth, plant companies in Korea should find ways to improve their capability of winning a contract. They clearly have a competitive edge compared to overseas companies, having won a number of chemical plant orders in ASEAN countries. Therefore, Korean companies should select candidate sites with the demand for chemical plants, conduct market research and carry out feasibility studies in a more efficient manner. Modeling and Simulation (M&S) can reduce costs of feasibility studies to enhance efficiency. For example, based on their experience in ASEAN countries, they may establish a database and conduct a feasibility study on plant design and engineering at a lower cost by using M&S.

Safety and environmental pollution in chemical plants have recently become important issues. From an engineering stage, process and

work safety should be secured by designing an unmanned system to allow Internet-of-Things (IOT) sensor networks to remotely control a plant and enhance workplace safety, and by designing the management system of chemical substances. In addition, Korean companies should introduce processes to reduce energy consumption and negate environmental im-

pacts. It will give Korean companies an advantage in domestic and overseas competition to win chemical plant orders.

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