

Cooperation of the Refining and Petrochemical Industries between China and the Belt and Road Countries

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Abstract: This study introduces the market demand of the Belt and Road countries and investigates the prospects of cooperation between China and countries along the route based on the supply capacity of China's refining and petrochemical industries. It also proposes cooperation opportunities concerning resources and markets, among other areas. This study also comprehensively analyzes the resources, markets, support policies, and investment environment concerning both China and the Belt and Road countries. Based on this, the key cooperation countries and tasks during cooperation in refining and petrochemical investment, technology trade, engineering services, and equipment export are selected by using an analytic hierarchy process. Lastly, it also proposes several policy recommendations, including coordinated promotion of the entire industry chain, increased publicity, standards integration, fiscal and tax incentives, and risk control.

Keywords: Belt and Road; refining industry; petrochemical industry; cooperation

The population of 64 Belt and Road countries (here and in other similar references, China is excluded) accounts for approximately 44% of the world's population; however, the average GDP of these countries accounts for only 16% of the global GDP. Therefore, there is vast potential for economic development and market development. It is of great practical significance to investigate the development status and market environment of the refining and petrochemical industry along the Belt and Road and to explore the opportunities for cooperation between China and the Belt and Road countries in the refining and petrochemical industries.

1 Development status of the refining and petrochemical industries in Belt and Road countries

1.1 Refining industry

In 2017, the refining capacity of Belt and Road countries was 1.51×10^9 t/a. This is expected to increase to 1.65×10^9 t/a by 2020. This means that these countries' share of the world's refining capacity will increase from 31.9% in 2017 to 33.5% in 2020. The refining capacity growth in the countries and regions along the Belt and Road from 2000 to 2017 and the forecast results for 2020 and 2025 are shown in Table 1.

Compared with 2017, it is estimated that by 2025, the Belt and Road countries will have increased their refining capacity by approximately 1.6×10^8 t/a, mainly referring to Kuwait, Iraq, Saudi Arabia, and Malaysia.

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Table 1. Refining capacity of countries or regions along the Belt and Road from 2000 to 2025 ($\times 10^8$ t/a).

Region	2000	2010	2017	2020	2025
Southeast Asia	2.02	2.17	2.19	2.54	2.56
South Asia	1.33	2.25	2.87	2.89	2.89
Central Asia	0.42	0.42	0.48	0.50	0.50
Russia/Mongolia	2.58	2.79	3.14	3.26	3.26
West Asia/Middle East	3.74	4.36	4.91	5.80	5.94
Central and Eastern Europe	1.90	1.59	1.47	1.49	1.49
Total capacity	11.99	13.58	15.06	16.48	16.64
Global capacity	41.37	45.38	47.28	49.21	50.85

Source: PIRA database.

1.2 Petrochemical industry

Belt and Road countries make full use of their resources or market advantage to vigorously develop their petrochemical industries. The production capacity of multiple petrochemical products—represented by ethylene, para-xylene (PX) and three major synthetic materials—is growing rapidly. It is predicted that the growth trend will be maintained in 2025, as shown in Table 2.

Table 2. Petrochemical production capacity of countries or regions along the Belt and Road from 2000 to 2025 ($\times 10^4$ t/a).

Variety	2000	2010	2017	2020	2025
Synthetic resin	2694	5481	7592	8388	9416
Synthetic rubber	220	250	439	505	505
Synthetic fiber	744	1023	1318	1454	1454
Three major synthetic materials	3658	6754	9349	10 347	11 375
Ethylene	1800	4338	5842	6213	7142
PX	513	1093	1508	1921	2058

Source: IHS database.

In 2017, the production capacity of the three major synthetic materials along the Belt and Road was 9.349×10^7 t/a. This is expected to increase to 1.1375×10^8 t/a by 2025, and the ratio of the production capacity of the Belt and Road countries to global production capacity will increase from 24.1% in 2017 to 25.3% in 2025. This production capacity growth is mainly ascribable to India, Malaysia, Iran, Russia, Vietnam, and a few other countries.

To support the development of the production of the three major synthetic materials, the basic chemical materials industries—such as that of ethylene and PX—in Belt and Road countries developed rapidly. The ethylene production capacity of Belt and Road countries in 2017 was 5.842×10^7 t/a and is expected to increase to 7.142×10^7 t/a by 2025. The increased production capacity can be ascribed mainly to Malaysia, India, Iran, Russia, and a few other countries. At the end of 2017, the PX production capacity of the Belt and Road countries was 1.508×10^7 t/a and is expected to increase to 2.058×10^7 t/a by 2025. The increased production capacity can be ascribed mainly to Saudi Arabia, Brunei, Vietnam, India, Iran, Russia, and a few other countries.

1.3 Technology level of refining and petrochemical industries

1.3.1 Technology and operation level of refining and petrochemical industries

Most Belt and Road countries have small-scale refining and petrochemical industries and their technology bases are insubstantial. Moreover, their independent abilities concerning research and development of refining and petrochemical technology are weak. Most countries with refining and petrochemical industries use European and American technologies, while a few countries—such as Sudan, Iran, Uzbekistan, and Azerbaijan—use China's refining and petrochemical technology. Countries in the Middle East are attempting to adjust their economic

structures—which are dominated by oil and natural gas production—and intensify efforts to develop the refining and petrochemical industries by introducing advanced refining and petrochemical technology. The development levels of the refining and petrochemical industries in Southeast Asia is uneven and many countries are still in their infancy in this regard.

1.3.2 Service level of refining and petrochemical engineering design and construction

The refining and petrochemical engineering capacity of Belt and Road countries is weak and the service level limited. Approximately 125 of the world's 250 largest international engineering contractors operate in petroleum and petrochemicals; however, only 14 of these contractors are in countries along the Belt and Road: 11 in Turkey, two in India, and one in Thailand. Among these, there are a few dominant contractors, but the design and construction gap is large between most of these companies and their international counterparts.

1.3.3 The level of refining and petrochemical equipment

The refineries in some of the Belt and Road countries were built in the middle and late 20th century. The equipment is therefore outdated, the deep processing capacity insufficient, and the comprehensive processing capacity weak. These refineries are in urgent need of an upgrade. In some countries, the refining equipment manufacturing industry is also weak. Even Russia—that has a relatively developed manufacturing industry—only has a domestic capacity to manufacture certain static equipment. For large rotating equipment and pumps, Russia still relies on imports. Moreover, electronic instruments and controls are manufactured locally by large international multinational companies. For example, for the recent largest refining project in Russia (new refining capacity 8×10^6 t/a), the imported tower in the crude unit accounts for approximately half of the total construction cost, the imported heat exchanger accounts for about 70%, and only 40% of the static equipment of the catalytic cracking unit was made locally. All of the large units were imported.

2 The development status of China's refining and petrochemical industries

2.1 The scale of development of the refining and petrochemical industries in China

China has become a major global refining and petrochemical power and its production capacity in most areas ranks among the highest in the world. According to the SINOPEC Economics & Development Research Institute, in 2017, China's refining capacity reached 8.16×10^8 t/a, 17.3% of the total global capacity. Moreover, its ethylene production capacity was 2.416×10^7 t/a in 2017, approximately 14.2% of the global capacity and ranking second in the world. China's major petrochemical products—such as the three major synthetic materials—accounts for a large portion of global production, among which polyester, refined terephthalic acid (PTA), and polyethylene terephthalate (PET) account for more than 50% of the respective global production capacities.

Due to renovation and expansion, the number of refineries with 10 million-t refinery capacity in China has continued to increase, reaching 29 at the end of 2017. The average capacity of refineries increased from 1.95×10^6 t/a in 2000 to 4.3×10^6 t/a in 2017; furthermore, the average capacity of ethylene plants increased from 2.2×10^5 t/a in 2000 to 7.7×10^5 t/a (petroleum base) in 2017. There are currently eight individual million-t ethylene enterprises, which have formed three refining and petrochemical industry clusters in the Yangtze river delta, the Pearl river delta, and the Circum-Bohai-Sea region.

2.2 The development level of refining and petrochemical engineering technology in China

2.2.1 Technology and operation level of refining and petrochemical industries

China owns the entire technology process of modernized refinery technology and has realized the construction of a single series of 10 million-t refineries with advanced international-level processing technology by relying on their own technology. The country has also successfully developed a series of refining technologies, such as fixed bed residue hydrotreating, catalytic cracking, hydrocracking, catalytic reforming, and super deep desulfurization of gasoline and diesel. These techniques are on an advanced technological level comparable to the global standard and produce automotive gasoline and diesel that conform to the China 5 and China 6 emission standards. In addition, the catalytic cracking catalysts and hydrogenation catalyst has successfully entered the international market.

China has had breakthroughs in the large-scale complete technology area of large organic raw materials (such as large ethylene, large aromatic hydrocarbons and ethylbenzene, styrene, acrylonitrile, and PTA) and three major synthetic materials (such as polypropylene [loop tube method], high density polyethylene, PET, butadiene rubber, and styrene butadiene rubber). China also has the ability to build equipment for the production of ethylene and

aromatics on a large scale by using their own technology. The core equipment of the million-t ethylene plant—such as the three compressors and the cold box—was manufactured locally.

2.2.2 Service capabilities of refining and petrochemical engineering

China's refining and petrochemical engineering service enterprises focus on improving engineering design, construction technology level, and international operation ability. These enterprises have great advantages, such as the project construction cost and construction progress of international refining and petrochemical engineering projects. Some refining and petrochemical engineering service enterprises have accumulated vast experience in the international market, established a good brand image, and have the ability to provide whole process project services to businesses. The engineering contracting model is also transforming into a comprehensive, high value-added engineering integrated service that includes factors such as technology, capital, management, standards, and services.

2.2.3 Manufacturing service level of refining and petrochemical equipment

China has mastered the special equipment manufacturing technology for both the refining and petrochemical industries and has a lot of experience. The country has the ability to manufacture major equipment for large-scale refining, ethylene, and aromatics. At present, China's refining equipment manufacturing level has largely reached a first-class level internationally.

With advanced technology, good quality, and excellent service, China's equipment manufacturing enterprises have achieved full recognition from their clients and have grown into a unique equipment manufacturing enterprise. The manufacturing enterprises include China First Heavy Industries Co., Ltd. (production of large-scale high-pressure heat exchangers, 1400-t hydrogenation reactor, and 2000-t coal liquefaction reactor), Shenyang Blower Works Group Co., Ltd. (production of large turbo compressors, large natural gas booster compressor for natural gas long-distance pipeline, and large centrifugal pump for 125 t large thrust reciprocating compressor), Hangzhou Oxygen Generator Group Co., Ltd. (production of large-scale air separation equipment, large-scale ethylene cold box, vacuum storage tank, and centrifugal cryogenic liquid pump), Chemical Machinery Factory of Nanjing Chemical Industry Co., Ltd. (Sinopec Group Co., Ltd.) (production of large reactor for PTA plant, PET plant, and ethylene glycol plant), and Sinopec Engineering Group Co., Ltd. (production of super large fractionation tower and integral large heating furnace).

3 Cooperation opportunities between China and Belt and Road countries in the refining and petrochemical industries

3.1 Highly complementary

China has the productive advantages of China Design, Made in China, Built in China, and the economic strength of China savings, China investment, and China reserve pool. China's refining and petrochemical companies are able to provide the entire service process, from technology licensing and process package design to start-up and trial operation for large-scale projects, such as 10 million t of refining and 1 million t of ethylene/aromatics. The Belt and Road countries have obvious resource and market advantages. These countries are aiming to transform these advantages into industrial advantages and actively extend the refining and petrochemical industry chains. Consequently, it is possible to create a win-win community of interests through cooperation. This can be accomplished by combining China's production advantages in refining and petrochemical technology, equipment manufacturing and engineering construction with the Belt and Road countries' resources, or by combining China's financial advantages with the resource development and market cultivation of the Belt and Road countries.

3.2 Certain Belt and Road countries have obvious resource advantages

With the rapid growth of oil demand in the Belt and Road region, the net export amount of crude oil along the Belt and Road route will decline from 1.055×10^9 t in 2017 to 9.99×10^8 t in 2025. However, these areas will still remain the most stable net crude oil exporters in the world. Moreover, the net export amount of Saudi Arabia, Russia, Iraq, the United Arab Emirates, and Kuwait would be more (1×10^8 t) [1].

The net gas export volume of the Belt and Road countries will further expand from 2.88×10^{11} m³ in 2017 to 3.295×10^{11} m³ in 2025. The main exporting countries are Russia, Qatar, Malaysia, and Turkmenistan.

Seven of the Belt and Road countries were among the ten largest crude oil importing countries in 2017. Moreover, three Belt and Road countries ranked in the top five liquefied natural gas importing countries. Concerning China, all the imported natural gas (by pipeline) was from the Belt and Road countries. Lastly, it is of great significance to

safeguard China's energy security by strengthening energy cooperation with these countries.

3.3 Certain Belt and Road countries have extensive market cooperation space

At present, 45 of the Belt and Road countries are net importers of refined oil. Moreover, the net imports for nine of these—in order: Indonesia, Egypt, Vietnam, Iraq, Pakistan, Philippines, Turkey, Ukraine, and Lebanon—were more than 5×10^6 t. Moreover, 23 members of the Belt and Road countries are net importers of synthetic materials and the net imports for four of them—in order: Turkey, Vietnam, India, and Indonesia—exceeded 2×10^6 t.

The per capita consumption of refining and petrochemical products among the Belt and Road countries is low, indicating that there is great potential for refining and petrochemical production capacity in the area. From 2017 to 2025, the new refining capacity, ethylene production capacity, and PX capacity will increase to 1.6×10^8 t/a, 1.3×10^7 t/a, and 5.5×10^6 t/a respectively. Additionally, the investment amount for these industries will be around 80 billion US dollars, 100 billion US dollars, and 45 billion US dollars, respectively. Investment in these industries will promote the development of the local refining and petrochemical industries, create opportunities for refining and petrochemical engineering services, and provide opportunities for China to export technology and equipment for the refining and petrochemical industries.

3.4 The Belt and Road countries have high motivation to develop refining and petrochemical industries

3.4.1 Oil and gas resource countries actively develop their refining and petrochemical industries and extend the downstream industry chain

The oil and gas resources of the Belt and Road countries—such as Saudi Arabia and Iran—point toward the development of a diversified economy, focusing especially on the development of the refining and petrochemical industries, attracting foreign capital and technology, and extending the downstream industry chain to alleviate the national economy's excessive dependence on oil and natural gas exports.

3.4.2 Some Belt and Road countries develop refining and petrochemical industries to meet domestic demand

The more populous Belt and Road countries—such as India, Indonesia, Pakistan, the Philippines, Vietnam, Turkey, and other countries with a population of more than 50 million—are in the process of industrialization. The size of the middle-class population in these countries is expanding constantly. Moreover, the domestic demand for refined oil products and the three major synthetic materials is growing rapidly. To develop their own comparative advantages in manufacturing, these countries urgently need to increase the scale of their refining and petrochemical industries to ensure a domestic supply of refined oil and the three major synthetic materials.

3.4.3 Some Belt and Road countries upgrade their refining and petrochemical industries

Although some Belt and Road countries—such as Saudi Arabia, Thailand, and Malaysia—have a refining and petrochemical industry base, they need to improve the quality of their refined oil, develop high-middle value-added chemicals, optimize the structure of domestic refining and petrochemical product chains, and enhance the overall competitiveness of the refining and petrochemical industries.

4 Analysis of the key cooperation points of the refining and petrochemical industries between China and the Belt and Road countries

4.1 Investment in refining and petrochemical industries

A comprehensive hierarchical analysis of oil and gas resources, market demand, and investment environments along the Belt and Road route showed that some countries—such as Russia, Saudi Arabia, Qatar, and Arabia—have superior resources and investment environments. Moreover, other countries—such as Indonesia, Turkey, the Philippines, Malaysia, and Vietnam—are considered to have superior market and investment environments.

To facilitate export-oriented refining and petrochemical projects in countries with obvious resource advantages, we should improve joint venture cooperation with national oil companies and build export-oriented refining and petrochemical projects in countries rich in oil and gas resources. The joint venture cooperation between countries will provide stable oil and gas resources as well as investment returns.

Next, we address building refining and petrochemical projects to meet domestic demand in countries with obvious market potential. Through tripartite joint venture cooperation with the national oil companies of the resource countries and the national oil companies of the project location, large-scale refining and petrochemical production plants will be built to meet the market demand of the project host countries.

4.2 Refining and petrochemical technology trade

The key countries for developing refining and petrochemical technology trade can be divided into two categories. In the first category are countries with relatively weak refining and petrochemical technology but with more newly-built or expanded refining and petrochemical capacity. In the other category are countries with relatively weak refining and petrochemical technology, whose refining and petrochemical equipment is in urgent need of transformation. Through selection and analysis, these key countries in both categories were determined to include Russia, Vietnam, Malaysia, Saudi Arabia, Iraq, and Egypt.

To provide differentiated services, it is necessary to analyze the characteristics of the main contenders and clarify the advantages and disadvantages of utilizing China's refining and petrochemical technology. In the process of competition, we should highlight the unique advantages of integration and emphasize the advantages of R&D, design, material and equipment, construction, and operation to provide customers with personalized and differentiated technical services. Moreover, we should meet the unique demands of different countries and formulate differentiated technology marketing strategies. For countries who actively invest, we should give full play on the relative advantages of investment and financing. For countries with a good foundation of refining and petrochemical industries, we should make full use of the advantages of integration, price, and service. Concerning countries with relatively weak refining technology, we can provide full system solutions.

4.3 Engineering services and equipment export of refining and petrochemical industries

The key cooperative countries for developing refining and petrochemical engineering services and equipment export can be divided into two categories. Countries in the first category are those with large refining and petrochemical capacity, weak manufacturing competitiveness, and weak engineering capability. In the second category are countries with large refining and petrochemical production capacity that are in urgent need of plant renovation to enhance the competitiveness of their manufacturing industry. Through selection and analysis, these key countries were shown to include Saudi Arabia, Malaysia, Vietnam, Kuwait, Russia, Malaysia, and Turkey.

To accomplish our goal, we should build a community of interests and concentrate on developing international markets, utilizing engineering projects as the carriers and the engineering companies as the main body. This can be accomplished by giving full play to important role players as a bridge between engineering companies and by encouraging refinery and petrochemical enterprises, engineering companies, and manufacturing enterprises to "go global in groups." Moreover, we should improve the management level of international projects and the competitiveness of engineering, procurement, and construction (EPC) by summarizing the experience of international project contracting. We should also create a competitive advantage in EPC general contracting by strengthening engineering and technical cooperation and by improving the ability to acquire and implement PMC and EPC high-end contracting projects. Lastly, we need to improve the brand and reputation of China's refining and petrochemical engineering technology services in the international market through the exemplary role of China's refining and petrochemical engineering services along the Belt and Road.

5 Policy suggestions

5.1 Establishing the cooperative promotion mechanism of the whole industry chain

The industry chain of refining and petrochemical investment, engineering construction services, and equipment technology trade along the Belt and Road as a whole could have a synergistic effect of upstream, midstream, and downstream integration. This leads to the provision of comprehensive services for customers while striving for the best overall benefits. First, we suggest establishing a coordination mechanism to support the investment, the "going global" of technology and equipment, and an appropriate supporting policy. Second, we need to comprehensively evaluate the overall benefits of investment projects by coordinating resources and market factors. Third, we must enhance China's influence in the international market through investment in petroleum and petrochemical projects, integration of operation management, and trade and marketing "go global" to give full play to their comparative advantages, form the best strategic plan, and gradually enhance the brand image of equipment and technology in China's refining and petrochemical industries.

5.2 Strengthening the promotion of China's technology and equipment

To promote the "going global" of the technology and equipment in China's refining and petrochemical industries,

China's technology and equipment should be introduced in Belt and Road countries, making them an important business card for China. First, China's technology and equipment should be introduced through major diplomatic activities and arrangements should be made for relevant personnel to visit scientific research groups or inspect large-scale refining and petrochemical enterprises. This will demonstrate China's achievements in technology development and engineering technology.

Second, the restrictions on personnel going abroad—such as investment, engineering technology, and science and technology professionals—should be relaxed. On-site service for international refining and petrochemical engineering projects should also be offered to make technology exchange and promotion more convenient. We should also support market developers and scientific and technological personnel that participate in international conferences to carry out technical exchanges and promote technology and equipment development.

Third, to promote China's refining and petrochemical technology and equipment and to understand the developments and trends of international technology in refining and petrochemical industries, we could support state-owned enterprises that participate in international exhibitions in related industries. Last but not least, we should make full use of the Belt and Road initiative's preferential finance policies and take advantage of the international market layout and rich international experience of international engineering companies. This will realize complementary advantages, mutual benefit (a win-win situation), and encourage the joint development of overseas technology markets by increasing the technical cooperation with large foreign engineering companies.

5.3 Establishing international standards for technology and quality

The equipment manufacturing capabilities of China's refining and petrochemical equipment manufacturing enterprises have improved rapidly; however, a lot of equipment lacks independent intellectual property rights, which is a major obstacle to equipment "going global." Enterprises should be encouraged to innovate independently and to establish their independent intellectual property rights as soon as possible. First, we should organize domestic scientific research teams to study and analyze foreign technical inspection, testing, packaging, and transportation standards for major refining and petrochemical equipment. Then, we can formulate a corresponding standard system to reach the international level as soon as possible.

Second, enterprise standards should be self-contained, complete in content, highly internationalized, and conforming to international standards in form and content. This facilitates the evaluation and adoption of international standards by international users. To attain the internationalization of standards and promote the "going global" of national standards and industry standards by using enterprise standards as a guide, it is necessary to give full play to the strong engineering capabilities of leading enterprises of domestic refining and petrochemical engineering companies. This will promote the "going global" of equipment in China by conforming to international standards [2].

5.4 Increasing financial and taxation support for "going global" technology and equipment in the refining and petrochemical industries

We suggest that the Chinese government establish a Belt and Road investment fund for refining and petrochemical projects. First, it can provide low interest and discount long-term loans for refining and petrochemical project in the Belt and Road countries, with Chinese enterprises to provide technical, engineering design, construction and equipment. Second, it can support domestic enterprises to undertake investment or joint venture to participate in the refining and petrochemical projects of the Belt and Road countries, with an added clause that technical, engineering design, construction and equipment should be provided by Chinese enterprises.

Next, we suggest that preferential tax policies should be implemented for engineering enterprises that undertake refining and petrochemical projects. First, income tax can be collected on the international income of the enterprises that undertake multiple projects in many countries or undertake multiple projects in one country. Second, the international income tax rate could be treated in a similar way to that of the high-speed rail and nuclear power projects. Third, the transfer of refining and petrochemical technology is exempt from income tax to support technological innovation and R&D.

5.5 Avoiding risks and improving risk control ability

First, the government should establish a risk-sharing mechanism by setting up a risk fund to share the investment risks of enterprises. Second, embassies abroad should actively provide relevant enterprises with information on

national conditions and laws and regulations, as well as possible political and legal risk consultation when undertaking projects. Third, decision-making in line with the decision-making process of enterprises should not be investigated for personal responsibility if losses are caused by unforeseen reasons. Finally, it is necessary to address China's refining and petrochemical technology comprehensively, clarify the state of technology intellectual property rights, compile and publish a catalog of technology licenses in advance, and attempt to eliminate risks concerning property rights [3,4].

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