

Challenge and Opportunity of Low-carbon Development for Petroleum and Petrochemical Enterprises

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Abstract: From three aspects of oil and natural gas industry, the paper briefly analyzed the carbon footprint of China's petroleum and petrochemical enterprises, combining the characteristics of petroleum and petrochemical industry as well as current domestic and international situation, the challenge and opportunity of low-carbon economy for Petroleum and petrochemical enterprises were discussed. Finally, some views and recommendations on low-carbon economy development for Petroleum and petrochemical enterprises were proposed.

Key words: Low-carbon economy; Petroleum and petrochemical industry; Challenge; Opportunity

1 Introduction

It has become an indisputable fact that the use of fossil fuel and the emission of greenhouse gas have caused global warming, which prompts low-carbon economy to step onto the onstage. Low-carbon economy is an economic development pattern which, under the guidance of the concept of sustainable development, minimizes the consumption of coal, oil and other high-carbon energy and reduces the emission of greenhouse gas so as to achieve economic and social development and ecological environment protection win-win by means of technological innovation, system innovation, industrial transformation and new energy development. Developing low-carbon economy is a global revolution involving production mode, life style, values and national interests, is a strong complement of ecological civilization, and is an important performance of scientific development view.

In recent years, scholars carried out a lot of positive in-depth research on the definition of low-carbon economy and made some academic achievements. Johnston (2005) and Treffers(2005) think that Low-carbon economy is green eco –economy, and also is the general name of economic forms likes low-carbon industries, low-carbon technologies, low-carbon life and low-carbon development. The substance of Low-carbon economy is to raise the efficient use of energy, implement the regional clean development, promote R&D of low-carbon product, and maintain global ecological balance^{[1][2]}. Kawase and Matsucka (2006) pointed out that low-carbon economy is the economy that carbon emissions of economic development, environmental and socio-economic cost is the lowest, is a way to improve the Earth's ecosystem and is the economy that can improve self-adjustment ability of Earth's ecosystems and has strong sustainability^[3]. Zuang Guiyang (2005), He Jiankun (2009)and Fu yun (2008) hold that the core of Low-carbon economy is energy technology innovation and system innovation, without affecting the economic and social development context, through technology innovation and system innovation, can be as much as possible to minimize greenhouse gas emissions to slow global climate change, and realize clean and sustainable development of economic and social development^{[4]-[6]}.

The adjustment of energy structure is a long process. It is estimated that solar, wind energy, hydropower, nuclear energy, biomass energy, geothermal energy, tidal energy and other new energy sources won't replace the dominant position of fossil energy until 2030. Therefore, China must pay attention to the low-carbon of coal and oil industry to develop low-carbon economy. Low-carbon economy originates in energy problem, but can't leave the reform of energy industry. To solve the coordination of carbon emissions and economic and social development, we must rely on energy technology innovation. Petroleum and petrochemical enterprises in China have taken actions and achieved initial achievements.

2 Carbon Footprints of Petroleum and Petrochemical Enterprises

Petrochemical industries are both energy producers and large families of energy consumption and greenhouse gas emission. Greenhouse gases are mainly produced in the process of petroleum natural gas exploration, refining and chemical, oil and gas storage and transportation. According to a statistics of greenhouse gas from a large composite oil enterprise in 2003, the emission of greenhouse gas per year (carbon dioxide equivalent) is 108.383 million tons, of which the emission of carbon dioxide is 102 million tons (the emission of fuel combustion accounts for 98.12% and the

emission of process exhaust accounts for 1.88%) and the emission of methane is 287.5 thousand tons (the emission of fuel combustion accounts for 1.91%, the emission of crude oil production accounts for 2.82%, the emission of natural gas depletion accounts for 95.27%). It is estimated that the emission of methane from oil and natural gas industry is 47 million tons, which accounts for 20% methane emission in global biosphere. The emission will increase to 78 million tons, which is mainly caused by the increasing production of natural gas and the long-distance pipeline transportation. In China, 39% methane emission from oil and gas production comes from crude oil production, 35% comes from natural gas production and 16% comes from natural gas transportation. In 2005, Chinese oil and gas consumption is higher, of which the natural gas emission mainly from western oil field is 1 billion m³/a.

2.1 Petroleum and natural gas exploration

The main emission sources of oil and gas exploration are the venting and combustion of torches, the emission of associated gases, the volatilization of tanks, the methane from flash, equipment leakage, the natural gas desulfurization and dehydration process, the emission of fuel combustion, inorganization dissipation, and the indirect emission caused by the energy consumption in exploration. At present, most oil fields are in the afternoon of development life in China. The energy saving pressure in exploration is high because of the expanding scale of land construction and the soaring proportion of high-energy production

2.2 Refining and chemical industry

The greenhouse gases from refining and chemical industry include carbon dioxide, methane and nitrous oxide, of which carbon dioxide include the combustion emission of furnace, boiler and hot working device, the combustion emission of coke catalytic and cracking, the combustion emission of torches, the emission of hydrogen production, the emission of process exhaust of catalytic and cracking, chemical fertilizer, ethylene glycol, polyvinyl alcohol, hydrogen production, coking and synthetic ammonia, of which methane include the emission of fuel combustion and crude oil production, of which nitrous oxide mainly comes from oxalic acid and nitric acid units. The energy dissipation of refining process is 4%~10% energy of processing material. Since the scale of production expands, the quality of crude oil becomes poorer and the demands for oil quality increase, it's difficult to cut the emission intensity of carbon dioxide.

2.3 Oil and gas storage and transportation

The main emission sources of greenhouse gas in oil and gas storage and transportation are the energy dissipation of pipeline transportation, the emission of natural gas pipeline maintenance and emergency process, compressor emptying, pipeline leakage, crude oil heating, the pressure adjustment of LNG and CNG. We must point out that natural gas is clean energy, that gas on behalf of the oil and gas on behalf of coal will decrease the emission of greenhouse gas.

3 Challenges of Low-carbon Development that Petroleum and Petrochemical Enterprises Are Facing

3.1 Pressure brought from products' high carbon properties

Most scientists think it is using so much fossil fuel, such as the coal and petroleum, which makes high emission of carbon dioxide and leads to global warm. With in-depth of action responding to climate change, petroleum and petrochemical enterprises will face not only more pressure from environment protection, carbon dioxide emission reduction and much higher fuel quality standard, but also from market to promote new energy and renewable energy. In the long term, human try hard to find alternative energy so that usage of fossil fuel will be limited more and more. Chinese petroleum and petrochemical enterprises must be preparing to vigorously develop low-carbon energy and low-carbon economy, energetically promote green oilfield, and green chemical engineering, benefiting from low-carbon economical development, which is the only way on sustainable development.

3.2 Action and pressure of energy saving and emission reduction

During the eleventh five-year plan, we have gotten great achievements on energy saving and emission reduction. In Nov., 2009, our government publishes operational objectives of controlling greenhouse gas emission. That is, to 2020, carbon dioxide emission gets down from 40 percents to 45 percents than that in 2005 per unit of gross domestic product. To obtain this goal, a large number of effective measures should be adopted. It is estimated that during the twelfth five-year plan, China will still continue to propose indicators of energy saving and emission reduction, and link it to greenhouse gas. And that will lead to increasing pressure of carbon emission reduction for enterprises. With characteristics of high energy consumption, petroleum and petrochemical industry will face pressure

from energy saving and emission reduction in the long term. With in-depth of energy saving and emission reduction, difficulties of related work will continue to increase significantly. Vigorously developing low-carbon economy, strengthening clean production, and reducing usage of own energy means to increase energy supply for society, and also reduce greenhouse gas emission. This is a win-win option.

3.3 Pressure of restraining fossil energy consumption policy

With continuous in-depth of every country's action responding to climate change, various restraining fossil energy consumption policies have been published. Many promoting and preferential policies of new energy have been put, and development of renewable cars have been paid high attention, such as hybrid electric vehicle, fuel cell vehicle, and electric vehicle and so on. When America discusses to adjust the levying of border tax, developed countries have implemented. Sweden, Denmark, Italy, France and some province of Canada have levied carbon taxes to Japan step by step. Chinese environmental and tax authorities are also researching carbon taxes policies. This kind of policies has a significant inhibition of fossil energy consumption. Petroleum and petrochemical enterprises should view this kind of energy positively. At the same time, they should be prepared for such as intensifying exploiting low-carbon energy.

3.4 Transformation pressure brought from new technology development

When the whole globe pay general attention to the same question, it always means that a new era comes, predicting the huge changes of society and economy. Science and technology innovation, especially energy technology innovation, is one of core forces to accomplish low-carbon economy development. Energy technology innovation forces energy enterprises to embark on a transformation way, researching new direction to adapt to new circumstance. Enterprises should continuously exploit lower carbon energy, increase technological investments, support more plentiful energy products, adopt to more flexible operating mode, and fulfill energy demand that new technology needs. Shell, BP, and Exxon Mobil, these international energy giant enterprises start business on bio-energy, solar energy, wind energy, carbon trade and gas generation, and so on. All of them are even involved in nuclear power project.

3.5 Competition pressure brought from international petroleum enterprises

Under strict requirements of low-carbon rules, such as environmental protection and energy saving, and restrain of greenhouse gas emission reduction indicator, with in-depth development of low-carbon technology, developed countries grasp a large number of key technologies. With in-depth of our entering WTO, petrochemical and sales market gradually open so that international competitors owning more technology and experience on new energy and low-carbon energy will gradually enter our market. It brings competition pressure to development of petroleum and petrochemical. At the same time, Chinese petroleum and petrochemical enterprises are speeding up the strategy of going out to face supervision from foreigner government with international indicator and opponents' competition^{[7][8]}.

4 Low-carbon Development Opportunities that Petroleum and Petrochemical Enterprises Are Facing

4.1 Strategic opportunity period of low-carbon

From a strategic view, Bush Administration strives large number of time for America to do research on energy saving, substitution and greenhouse gas emission reduction controlling, and exploration on associated technology industrialization. Many developed countries utilize the first commitment period in Tokyo Protocol to promote low-carbon technology and market development rapidly. Our petroleum and petrochemical enterprises also should grasp the strategic opportunity brought from the mutual but significant principle that our country always insists, and develop economy positively.

As fossil energy will keep quite a long time as the main energy, the opening of the petrochemical market in our country is progressing steadily, which also provides China's petrochemical enterprise with period of strategic opportunities to develop low-carbon economy. Petroleum and petrochemical enterprises have abundant equipments, talents and economic strength, and have the ability to lead the development of low-carbon economy. In addition our country's foundation is weak, which also provides China's petrochemical enterprise with a broad space to develop low-carbon economy. To be sure, our country's petroleum and petrochemical enterprises have reinforced the development of low-carbon economy, for example China Petrochemical has strengthened the supplies of clean oil, The China National Petroleum strives to develop the business of natural gas and coal seam, starts to develop oil and gas business unconventional, diversify their supply, actively participate in social green public activity

and develop to low-carbon energy company, China National Offshore Oil Corporation develops renewable energy and implement the action of reduce emission through the projects of coal gas and offshore wind energy.

4.2 Good opportunities of natural gas and new energy business

Coal is the main fuel in our country's primary energy and the proportion of oil and natural gas is not high so that the carbon emission intensity of unit energy is high and the structure of the energy is not reasonable. According to estimates, burning 1 ton coal will produce 4.12 ton carbon dioxide gas, which is 30% and 70% more than oil and natural gas respectively. In the preliminary stage of low-carbon economy, the use of low-carbon energy is the effective way to reduce the emission of greenhouse gases and that the utilization ratio of the oil and natural gas is improved in the percentage of primary energy will greatly alleviate the pressure of emission of greenhouse gas produced in the rapid economic development^[9].

The low-carbon economy provides a great opportunity for exploitation and utilization of new energy and clean energy, such as natural gas, coal bed gas, shale gas, bio-fuel, methane hydrate and so on. There is a common international idea that the production and consumption of natural gas in the future will grow at the higher rate so that the production of natural gas in the world will likely surpass the production of coal and oil after 2020 and natural gas will become the most important energy in the world, moreover natural gas is also known as low-carbon "transition fuel" in the future. The supply of the natural gas should have better reserves conditions and the development of the low-carbon economy will certainly leads to increasing domestic demand of natural gas. So China's petroleum and petrochemical enterprises should actively arrange the world's natural gas market and speed up the construction of natural gas pipeline network^[10].

4.3 Opportunity of enhancing enterprises' competitiveness and level of management

In the process of the rapid development, there are large amounts of problems existing in our country's oil industry, such as relative extensive management, the low degree of intensive development, the larger proportion of low-and-middle product and the low level of environmental protection. The low-carbon economy requires the enterprises to continuously improve the level of clean production, energy conservation and environmental protection, pay great attention to the details of the production and the operation of the system, continuously improve informatization level of the production, which inevitably encourage enterprises to improve level of management in objective, reduce the gap with the international advanced level, even surpass the international advanced level in some areas.

4.4 Opportunity of international cooperation

All countries in the world have announced that they will strengthen the international cooperation that they cope with the climate change and the low-carbon economy areas together, for example the clean energy cooperation between China and America in the recent two years. Our government constantly promotes the level of the technique input in the process of coping with the climate change and hopes that advanced countries can share the technology of energy saving and emission reduction while simultaneously providing funds. China petroleum and petrochemical enterprises have stronger international influence, many international collaborative activities, good economic, technological and talent base, the better opportunity in the region of low-carbon international cooperation, especially the introduction of clean energy and low-carbon technology.

5 Strategy of China's Petroleum and Petrochemical Enterprises Develop Low-carbon Economy

Developing low-carbon economy and coping with climate changes is the important content of petroleum and petrochemical enterprises actively fulfilling their social responsibilities. In allusion to current situation of China's low-carbon economy, several following key problems should be taken into consideration in the present situation that petroleum and petrochemical enterprises develop low-carbon economy.

5.1 Perfecting corresponding system

We should perfect the corresponding system and implement overall planning about the low-carbon economy. Firstly, we should strengthen the leadership of the low-carbon economy and perfect the low-carbon system. The headquarter of China National Petroleum should establish the low-carbon development committee, strengthen the leadership of the low-carbon economy and perfect the low-carbon system such as low-carbon decision-making coordination system, action system and so on; Secondly, we should finish establishing the overall planning of adjusting to low-carbon development as

soon as possible. The key of oil adjusting to developing low-carbon economy under the condition of the high carbon energy, speeding up establishment of the executing solution of low-carbon economy of China National Petroleum” and action route plan, setting up the statistical evaluation index system of low-carbon economy, bringing the concept, we should insist taking a new road to industrialization, develop low-carbon economy under the condition of the high carbon energy, speed up establishing of “the executing solution of low-carbon economy of China National Petroleum” and action route plan, establish the statistical evaluation index system of low-carbon economy, bring the context of promoting the development of low-carbon economy into “the twelfth five-year plan” and special plan which is required to implement step by step and push forward coordinately; Thirdly, we should strengthen the propaganda of the low-carbon economy and foster low-carbon culture. We should strengthen the propaganda, set up the consciousness of the low-carbon consumption, and bring the core contents of adapting to the development of low-carbon economy into the system of China National Petroleum’s social responsibility^[11].

5.2 Restructuring Energy production structure

Energy production structure should be restructured and enhanced; High-quality and high-effect clean energy should be provided more. The first is that the production and using of natural gas are internationalization. Petro China is the biggest oil and gas producer and provider in our country, it should sustainably accelerate the exploration of natural gas and import foreign pipeline gas, foster Industrial Cluster which use natural gas, and protect the safety of gas supply under the network; Secondly, the production and using of coal bed methane and shale gas should be scaled. Petro china ought to regard exploration of coal bed methane and shale gas as one of their business strategies, widen exploration area, increase coal bed methane production capacity, early put on the market, let production satisfy China’s demand of low-carbon energy; The third is industrialization of bioenergy ought to be developed and used. Petro china positively intervene, participate and organize the development and using of new energy and renewable matriculate, make production and using scale quickly. scientific research and text of bioenergy must be organized, the industrialization of bioenergy should be advanced.

5.3 Developing circular economy

Circular economy must be developed, energy consumption structure ought to be restructured and enhanced, and efficiency of energy using should be advanced. First is the develop of circular economy, key point is to do a good job of industrial energy saving and emission reduction. Conserving enterprise should be established, energy saving and emission reduction must be advanced. It need to put energy efficiency management into practice, improve energy efficiency and, reduce carbon emissions. Low-carbon diggings and base installation must be found, improving energy efficiency; Second is fostering industrial cluster which use natural gas, increase clean energy efficiency. With the using of natural gas, promoting the development of building materials industry, electronics ,IT and other high and new technology industries, or establishing low-carbon industrial park, forming industrial cluster. The effect of natural gas for founding low-carbon city must be strengthened. The proportion of natural gas used automobiles will be enhanced. Policy regulation should be strengthened, infrastructure construction of CNG ought to be improved, actively cultivating CNG vehicle market; Third is expressing the potential of Carbon Sink, constructing national ecological barrier, realizing industry chain ecological cycle. In energy development, ecological engineering construction should be implemented to expand green space in multi-channel, increase the forest coverage and carbon sink ability; and make a contribution for the construction of national or regional ecological barrier.

5.4 Strengthening independent innovation ability

Independent innovation capability must be strengthened to form low-carbon technology system. Technology innovation is a key factor for Promoting a low-carbon economy development and, realizing the energy conservation and emission reduction. Petroleum and petrochemical enterprises, as a comprehensive energy company, need to enforce low-carbon technology innovation strategy, pay attention to the development and introducing of low-carbon talents. Independent innovation capability must be strengthened to form low-carbon technology system of Petro china, such as High-efficient exploitation and utilization of new technology for oil and natural gas, CBM resources distribution, security development technology, the development technology of biodiesel, ethanol, and other new and renewable energy, improving energy efficiency and energy saving of the key technology and so on .

5.5 Strengthening international exchanges and cooperation

To strengthen international exchanges and cooperation, adapt to a low-carbon economy development. We should learn foreign oil and gas company’s system and experience in promoting the development of low-carbon, and response to climate change together. international low-carbon

technology exchanges and cooperation ought to be strengthened, especially we must strengthen low-carbon cooperation with the European Union, the United States and international oil and gas companies, introduce and digest advanced low-carbon technology, highly energy-efficient technology and renewable energy technology. We should fully and effectively use developed countries' technology transfer, promoting China's oil to adapt to a low-carbon economy development.

5.6 Establishing policy and financial security platform

A policy and financial security platform which adapts to low-carbon economy development should be established. Petroleum and petrochemical enterprises need to actively plan, strive for carbon exchanges. It ought to enlarge fund investment, improve the implementation of safeguards ability for low-carbon development policy measures. Petroleum and petrochemical enterprises must do well in a low-carbon economy pilot and base construction, positively create Petroleum and petrochemical enterprises "low-carbon economy development demonstration area", "Low-carbon industry park demonstration area", Promoting low-carbon economy development^[12].

5.7 Strengthening the reserves and application of CCS and CCU

Petroleum and petrochemical enterprises should strengthen the reserves and application of CCS and CCU. For Petroleum and petrochemical industry, although the scale of development and commercial using of CCS and CCU still have a long way to go, we can't stop and wait. Hence, we should continue to strengthen ability construction, strengthen the carbon storage research, analysis and assessment of CCS technology route, regard CCS as frontier strategic technology reserves. Stronger development in east China have appear some dry gas block, they can be used as CO₂ reservoir libraries after reforming, at the same time, we can seek the sustainable development of dry oil and gas fields. Second, we should pay attention to CO₂ oil displacement technology, develop and application of CO₂ chemical technology. Moreover, oil companies should broaden sources of funds, strive for national and international institutional support and deepen international cooperation, track on international progress in the field of CCS, strengthen technical exchanges, introduction, digestion and innovation.

5.8 Paying attention to personnel training

Petroleum and petrochemical enterprises should strengthen the management of emission reduction and cultivate talents. Firm ought to strengthen energy conservation and emission reduction in the system construction and the basic work, make energy conservation and emission reduction through all of the process of the exploration, development and production, refining, transportation and so on. Reducing CO₂ emissions need to be regarded as important production, technology and management variables, considering overall efficiency. We should use the information technology to improve the management level of energy saving and emission reduction. Firm should improve all the staffs' consciousness for emission reduction, to create a good enterprise effective reduction cultural atmosphere. Through all kinds of ways, Petroleum and petrochemical enterprises strengthen the low-carbon technical talents and management personnel of the reserves and training, and enhance development in the future.

6 Conclusion

China's Petroleum and petrochemical enterprises must recognize the nature and connotation of low-carbon economy, combine low-carbon economy with the development of company together, catch the opportunity, through the introduction of technology and research, by strengthening the management and planning, construct advanced energy technology research and development and promotion system, strengthen the low-carbon development ability, try to offer more clean and lower carbon energy sources for our country, diversify their supply, promote China petrochemical enterprise to transform to be a kind of low-carbon energy company type, advance our country's low-carbon economy vigorously development and the greenhouse gas controlling index could be completed

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