

## Strategic Path of China's Low-carbon Technology Development

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**Abstract**—There are a great deal of discussions and questions on how to establish and develop low-carbon economy, not excepting China. In order to provide suggestions and countermeasure, this paper considers that every country must masters key elements of the low-carbon system so as to promote it in a proper way. All elements in the huge low-carbon economy system are operating cooperatively, however, low-carbon technology is indispensable because it provides strategic sustention for low-carbon economy, especially in developing countries. Proceed from China's actual conditions, by introducing the significance of low-carbon technology, this paper expounds the most key and emergent low-carbon technologies, i.e., clean coal technology and CCS(carbon capture and storage) technology. Furthermore, proposes the strategic path of low-carbon technology system in China, and suggests that related departments of the state should place coal gasification technology or polygeneration in combination with CCS at the heart of China's low-carbon technology strategy.

**Keywords**—low-carbon technology; clean coal technology; CCS(carbon capture and storage); strategic path; combination technology

### I. INTRODUCTION

With the great endeavor of addressing climate change, we have entered a new era of low-carbon economy. It influences all aspects of a country. Therefore, every country must faces low-carbon economy actively, not excepting China. In December 2009, Wu Xiaoqing, vice minister of Ministry of Environmental Protection of China emphasized that low-carbon economy is to lead China's future development. Who is one step ahead, who is the big winner. A new round of low-carbon economy will determines the country's competitiveness.

As the largest developing country, industrialization, urbanization and modernization promote China's economy growth rapidly. However, this growth also result in many serious problems, such as environment pollution, ecological deterioration, energy shortage and continual increase of Greenhouse Gas(GHG) emissions. These environmental problems affect the realization of China's economic development targets, and improvement of people's health and livelihood strongly. Moreover, China's coal based energy system has led to a number of challenges which could jeopardise China's future economic growth.

In fact, environment protection does not contradict the priority of economy grow in China. On the contrary,

environment protection and economy growth are interdependent, mutually promoting. Low-carbon economy is a perfect combination of environment protection and economy growth, which not only ensures the economy growth positively, but also addresses climate change more effectively. Therefore, in 2007, President Hu Jintao stressed that climate change is fundamentally a development issue; so it can only be resolved by means of sustainable development. In 2009, Hu Jintao promised solemnly that China will continues to take strong measures to conserve energy, reduce emissions, build green economy, low-carbon economy and circular economy energetically, research and popularize climate-friendly technology. In 2009, Premier Wen Jiabao pointed that addressing climate change and developing low-carbon economy would serve as the important basis for formulating government medium- and long-term development strategy plan. So, development of low-carbon economy is raised to the national strategy of China.

In recent years, China has made outstanding achievements in economic development and environmental protection by implementing the scientific concept of development, developing the low-carbon economy, building the conservation culture, and adhering to the basic state policy of resources saving, environment protection and sustainable development.

### II. LOW-CARBON TECHNOLOGY IS THE STRATEGIC SUSTENTION OF CHINA'S LOW-CARBON ECONOMY SYSTEM

Low-carbon economy should be viewed as a complex adaptive system(CAS). There are many key elements in this CAS, such as energy basis, public policies, related laws and regulations, and management mechanisms. However, low-carbon technology is indispensable because it provides strategic sustention for low-carbon economy, especially in developing countries.

At present, China has been becoming the world's largest emitter of CO<sub>2</sub>, the significant increase of CO<sub>2</sub> emissions accounts for 57% of the global CO<sub>2</sub> emissions increment from 2000 to 2006. Compared with China, India is 6.03%, US is only 0.22%. Moreover, It can be seen from the table 1, China's carbon productivity is 0.41\$/kg CO<sub>2</sub> in 2006, which higher than that of 2005, but only 30% of the global average value and one-fourth of that of the US value. In other words, China has to release 70% more CO<sub>2</sub> than the global average value and 75% more CO<sub>2</sub> than the US value to produce 1 US

dollar value production(B.Jing, Z.Q. SUN and M.Q.Liu, 2010)<sup>[1]</sup>.

Furthermore, According to the report “Climate Change Solution: Prospect of the Year 2050” of WWF (World-Wide Fund for Nature ), China’s current total energy efficiency is about 33%, which is about 10% lower than that of the developed countries. The average energy consumption in power, steel industry, nonferrous metals industry, petrochemical engineering, building materials, chemical engineering, light duty industry and textile industry is 40% higher than the international advanced level.

Based on the above analyses, no matter low carbon productivity or high emissions, they are closely related to the low-carbon technology, so the latter is imperative to the development of low-carbon economy. Therefore, it is high time that governments and enterprises put considerable emphasis on the low-carbon economy and implement it as soon as possible.

“Low-carbon technology will become an important sign of a country’s core competitiveness. Who wields low-carbon core technology, who would has the initiative of development and competition. The key to building of low-carbon economy in China is development and mastery of low-carbon core technologies.” said Xie Heping, an academician of the Chinese Academy of Engineering, president of Sichuan University.

### III. THE MOST KEY AND EMERGENT LOW-CARBON TECHNOLOGIES FOR CHINA ARE CLEAN COAL TECHNOLOGY AND CCS TECHNOLOGY

Low-carbon technology, general speaking, is all the technologies that can reduce carbon emissions of human activities. These technologies can be divided into two areas: non-carbon or decrease-carbon technology, carbon capture and storage (CCS) . The former includes three aspects: the first is green energy technology, such as wind power, biomass power, hydrogen energy, ocean energy, solar energy, geothermal energy, and tidal energy, and nuclear power. The second is conserving energy and reducing emissions technologies of the traditional fossil energy, that is, more efficient, cleaner, comprehensive exploitation and utilization of coal, oil and natural gas. The third is conserving energy and reducing emissions technology of other industrial processes, such as energy conservation of manufacture industry, construction industry and transportation.

Proceed from China’s actual conditions, the most key and emergent low-carbon technologies are clean coal technology and CCS technology.

#### A. Clean Coal Technology

China has been committing to the development and application of clean coal technology for many years. As early as in the period of sixth five-year plan, China has proposed the clean coal technology. In 1997, the state council ratified “The ninth five-year plan of the clean coal technology and the development plan in 2010. In 2005, the state council issued “A certain number of opinions on promoting coal industry a sound development” , it suggested that the National Development and Reform Commission(NDRC)

formulated plans, organize the construction of demonstration projects, and give financial support so as to promote clean coal technology to realize industrialization. In 2009, propelling industrialization of the clean coal technology and clean energy such as nuclear electricity, wind power, solar energy etc., are served as importing tasks that were placed in the Government Work Report. The Ministry of Environmental Protection, NDRC and Ministry of Science and Technology are responsible for implementing these programs.

Under the China’s current situation, in view of the existing pattern of energy relies on the coal, electric power relies on the coal-fired power continuing will continues to exist for a long period, development of the cost-effective, advanced and clean coal comprehensive application technology is a significant requirement of energy sustainable development, ecological environment protection and conserving energy and reducing emissions. Therefore, clean coal technology is defined as strategic emerging industries in the development plan of emerging energy industry. To be specific, clean coal technology mainly includes following technologies.

#### 1) Flue Gas Desulphurization Technology (FGD)

In China, 90% of SO<sub>2</sub> is caused by coal combustion, now results in acid rain falling on more than 30% of China’s total land. Cutting of SO<sub>2</sub> emission has been put on the main agenda, China first put forward the target of reduction 10% of SO<sub>2</sub> emissions by 2010. For achieving the target under coal-fired factors account for 90% of national SO<sub>2</sub> total emissions, China must develop FGD energetically.

The Chinese government has adopted a series of policies to develop FGD, such as new coal-fired units must be equipped with FGD facility, provide power price subsidy for desulfurized power plants, levy in the Two Control Zones, etc.. As a result, newly installed desulphurization capacity in 2006 was more than the combined total over the past 10 years, accounting for 30% of the total installed thermal (mostly coal-fired) capacity. This helped to slow down the growth rate of SO<sub>2</sub> emissions significantly in 2006, which was 11.3% less than that in 2005. By 2007, the coal-fired units installed with FGD increased to 266 GW from 53GW in 2005. Generation units with FGD further rose to 379GW in 2008. Accordingly, the portion of coal-fired units with FGD rose to 51% in 2007 and 66% in 2008 of the total installed thermal capacity from 13.5% in 2005(Zhang, 2010)<sup>[2]</sup>.

To further expand and consolidate these achievements, governments must enforce the monitoring and appraisal mechanisms so as to ensure FGD will be widely employed in applications. Meanwhile, can encourage enterprises to utilize FGD actively through project supporting, finance subsidy, FGD R&D and talents training, and so on.

#### 2) Integrated Gasification Combined cycle (IGCC)

IGCC is the clean coal power technology that owns the most attractive, the greatest development potential and on behalf of the world’s advanced technology direction in the 21st century. It is the super clean and high efficiency power generation technology that integrated with coal gasification and gas turbine combined cycle. As the most actual,

economical coal-fired power generation technology, IGCC is advancing toward the target of approaching zero emissions of CO<sub>2</sub>.

IGCC brings together the high power generation efficiency and environment protection, not only makes up the weaknesses of single coal application technology is difficult to meet the various demands simultaneously, such as efficiency, cost and environment, but also is compatible with the long-term sustainable development targets of hydrogen energy application, CO<sub>2</sub> emissions decrease. So, it is the most effective way of realizing the clean coal technology.

IGCC can take on the mission of “application of high technology, join more industries and open new road”, achieves combinative production of energies and material productions such as power, clean fuel, hydrogen, chemical, steel and so on, and promotes integration of various industries in the course of conserving energy and reducing emissions, optimizes and upgrades power, steel, chemical industry and coal industries so as to form sustainable competitiveness. The efficiency of power generation those are using the IGCC technology is 6%~8% higher than the same scale coal-fired plants, pollutants is only one-tenth, saving water more than 50%. The 11th five-year plan proposed clearly to develop the IGCC power stations. The first demonstration project that will be finished in 2011 is Huaneng IGCC green coal-fired plant in Tianjin, its efficiency will increase one-third compared with the most advanced coal-fired technology now, power generation is as high as 1.2 billion kwh each year and approach zero emission of CO<sub>2</sub> and pollutants<sup>[3]</sup>.

In addition, Coal gasification, Supercritical (SC) and Ultra-supercritical (USC) and are also the important low-carbon technologies.

### B. Carbon Capture and Storage(CCS)

CCS is a fundamental measure and the important opportunity for occupying the commanding height of low-carbon technology. At present, neither renewable energy can help world's economy accomplish low carbon transformation, nor can meet the demands of economic and social development, 80% of world's energy consumption is resulted from fossil energy. In this critical transformation moment, CCS is to become the breakthrough point in the effort to solve the dilemma completely (Seymour, 2010)<sup>[4]</sup>.

CCS refers to separate CO<sub>2</sub> that result from industry and related energy industries by means of carbon capture technology, transport and seal to the insulation place where is totally isolated from atmosphere, such as seafloor or underground. CCS is not only a critical technology, but also a fundamental measure to reduce CO<sub>2</sub> concentration in the atmosphere and truly realize approach zero emissions. Based on the statistic estimate of International Energy Agency(IEA), the contribution of CCS reducing emissions will accounts for 3% of the total inducing emissions in 2020, and reaches as high as 10% in 2030 and 19% in 2050, it becomes the individual technology that owns the largest share of emissions cutting.

America has made a huge investment in the field of CCS. Up till now, Department of Energy has invested \$4 billion on CCS demonstration projects. These investments will lay a solid foundation for the CCS deployment widely in the next ten years in America.

CCS may be the important chance of China occupies the low-carbon technology highland and Chinese enterprises march into the international market. In recent years, China has made great efforts to the CCS R&D, Furthermore, Chinese government has been attending the CCS leader forum since 2003. National key projects including the “863 project” and “973 project” all carry out the research on CCS.

In partnership with Australia and Xi'an Thermal Power Research Institute, the Huaneng Group commissioned a post combustion carbon capture pilot facility at the Gaobeidian power plant in Beijing in July 2008. Designed and developed by Xi'an Thermal Power Research Institute, with all of its equipments made in China, this pilot project is capable of recovering more than 85% CO<sub>2</sub> with a purity of 99.99% from the power plant flue gases and can trap 3000 ton of CO<sub>2</sub> a year<sup>[5]</sup>. In August 2010, Shenhua group starts building the China's first whole process CCS project in Erdos, Inner Mongolia, it is expected to capture and storage 100,000 ton of CO<sub>2</sub> each year, to be equivalent to increase annually 4150 acres forest. This is the first development of the same type project in Asia, as well is the largest program in Asia(Z.Lai, J.Liu, 2010)<sup>[5]</sup>.

Based on the above analyses, for developing low-carbon technology in China, the concerned departments should integrate related technologies so as to expand the application field and obtain factual achievements. The key sustainable technologies are shown by the Fig.1.

However, there are many technologic and managing problems should be resolved in the CCS field. In November 2009, Ma Yanhe, the director of Social Development Department of Ministry of Science and Technology pointed out that many problems remain unresolved on CCS technology, and its large quantity of energy consumption is very worrying, moreover, lacking reliable means to assess its long-term environmental impact. These problems are as follows: the first is the huge investment and high cost. The cost of power generation resulted from the CCS application is estimated to increase \$0.01~0.05 kwh, and consume more than 20% of the energy. The second is the CCS exerts great uncertainty to the geological structure, sea ecosystem, human health and the earth cycle system, has great influence on living environment of humanity. Meanwhile, the certain risks of CCS exist in the course of its application, for example the related risks of pipe transportation, leakage of geologic storage, sea acidification caused by injecting CO<sub>2</sub> into the sea. Third, there is a lack of understanding and preparation for the CCS, risk evaluation and monitoring mechanism etc., moreover, for the time being at least, there is no suitable legal framework to promote the implementation of the geologic storage, and no consideration of the relevant long-term liability.

In view of these problems, the aspects that are in great need of improvement as follows: firstly, enhancement of CCS maturity and security, such as Pre-combustion capture,

transportation and seal technology, stratigraphy injection, plume flow transportation; secondly, improving related laws and regulations on securely application of CCS, enhancing the security and reliability of geologic storage, resolving the patterns and sites for CO<sub>2</sub> storage, assessing the storage ability throughout the country so as to master the datas and parameters of transportation, storage and seepage. According to a study published by Natural Resources Defence Council of America.China has an unique advantage in storage ability and owns the basis of carrying out large-scale storage. China has the storage potentiality of 3,066 billion tons of gas in the underground and seafloor, to be equivalent over 400 years of current emissions amount. Moreover, more than 90% of mainly produce center of CO<sub>2</sub> is not more than 160 kilometers distant from the large storage base[10]; the last but not the least, it is high time that governments should establish the effective international cooperation mechanisms actively, propel the progress of demonstration projects, explore the suitable conditions and development rules of commercial and industrial application of CCS in China, so as to popularize and apply the achievements of CCS technology.

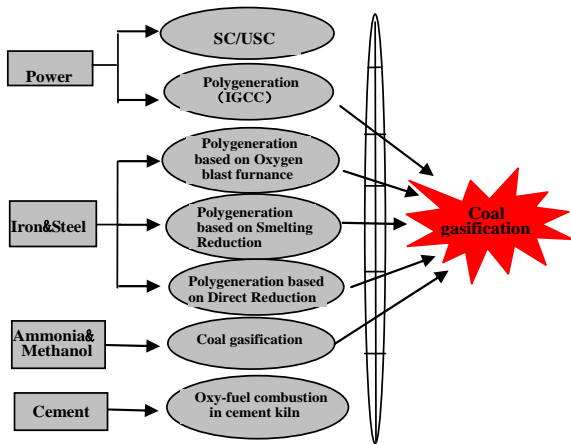


Figure 1. Summary of critical CCS-enabling technologies( Sources: [1])

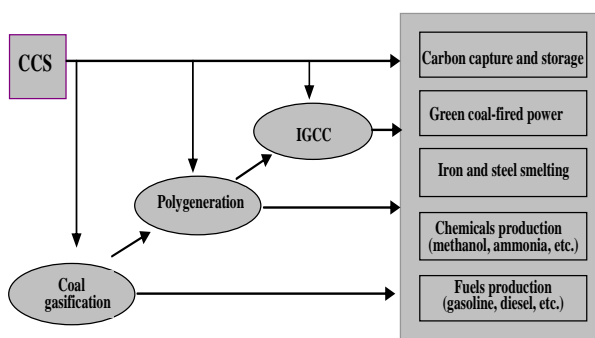


Figure 2. Strategic path of low-carbon technology for China.

#### IV. CONCLUSION

On the whole, various technologies form the low carbon technology system and it will produce powerful economic and social benefits through cooperative application and nonlinear action of all kinds of elements. From what has been discussed above, we may construct the strategic path of

low-carbon technology system in China. As is shown by the Fig. 2, various essential elements with different effects in the technology system provide China's low carbon economy with sustentation. It is obvious that coal gasification is the generic and basic technology for most of the CCS-enabling technologies, the concerned government departments should place coal gasification technology or polygeneration in combination with CCS at the heart of China's low-carbon technology strategy(Liu and Gallagher, 2010)<sup>[6]</sup>. This strategic combination is not only a perfect way of reducing CO<sub>2</sub> emissions, but also have an unique opportunity to contribute high efficient and clean power generation, iron and steel smelting, and chemical production, such as methanol, ammonia. So, it is the sound strategic path of low-carbon technology for China.

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