

NEAR ZERO EMISSION COAL BASED POWER GENERATION IN CHINA GREENGEN PROJECT

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ABSTRACT

As China's power industry mainly relies on coal-based power generation, opening up a new industrialized road of comprehensive, coordinative and sustainable development is a major consideration for us. The main factors impacting sustainable development of coal-based power generation is high pollutant emission and low generation efficiency. Viewing from the sustainable development of the Chinese electric power industry, existing clean coal generation technology is still unable to meet the demand of future society on pollutant emission and generation efficiency of coal-based power generation. Therefore, China Huaneng Group puts forward a GreenGen plan, which is to research and develop integrated coal gasification hydrogen production, hydrogen power generation and CO₂ sequestration system in order to realize great coal-based generation efficiency and near zero pollutant emission. This paper briefly describes China Huaneng Group's strategic vision and practical scheme on the development of GreenGen.

Keywords: green coal-based power generation, electricity, sustainable development

In order to keep up with the rapid development of economy, the power industry has to grow at quicker speed in a substantially long period. As China's power industry mainly relies on coal-based power generation, opening up a new road of comprehensive, coordinative and sustainable development for coal-based power generation is a major consideration for the Chinese electric power enterprises. Viewing from the future sustainable development of the Chinese electric power industry, present clean coal generation technology is still unable to meet the demand of future "Green Coal-Based Power Generation (GreenGen)" in respects of pollutant emission and generation efficiency. Therefore, China Huaneng Group (CHNG) puts forward and puts in practice a GreenGen plan to develop high efficiency and near zero emission coal-based power generation technology.

1. STATUS OF CHINA'S POWER INDUSTRY AND CHALLENGES

In the past 20 years, China's power industry has made great achievements. In 2004, the installed capacity was 440GW, ranking the second in the world both in installed capacity and electric power generation. It is predicted that the country's installed capacity will amount to 600GW in 2010 and 950GW in 2020. In China's prime energy structure, thermal power accounts for about 75% and over 95% thermal power comes from coal-based power generation.

In 2004, the proportion of coal-based units in the country's installed capacity was about 70%. It is predicted that up to 2020 the proportion will be still about 60%. In CHNG, the coal-based power accounted for about 92.5% installed capacity in 2004, which takes the predominant position at present and will still be so in the future. The efficiency of energy utilization in China is far lower than that in the western developed countries. In 2004, the country's average coal consumption for power supply was 379g/kWh, which is about 50-60g/kWh higher than the international advanced level. The CHNG's average coal consumption is 337g/kWh, which is lower than China's average but is still 17g/kWh higher than the international level. Consequently, one of the major tasks for Chinese enterprises is to increase the generation efficiency of coal-based generating units and reduce coal consumption for power supply.

Nowadays the mankind is confronted with four major environmental problems: atmospheric smoke, acid rain, greenhouse effect and ozonosphere destruction. The pollutant emission of thermal power

備えた超々臨界石炭発電システムは、中国の近い将来における増大する電力需要の要求を満たすことができる。しかし、長期的には真のグリーン石炭発電テクノロジーは、石炭ガス化水素製造、水素発電、CO₂隔離貯留のシステム統合となる。

CHNG のグリーンジェン・プロジェクト開発は中国石炭電力の将来にわたる持続可能な開発のため、必要となるテクノロジー開発とエンジニアリング実証を行なうものである。当システムとその主要テクノロジーは、国際的なエネルギー研究開発の注目の的であり、困難を伴う分野でもあり、国際社会の関心が強く、研究開発の焦点となっている。国家発展改革委員会と科学技術省のリーダーシップの下、CHNG は国内知的所有権によるグリーンジェン・テクノロジーの開発と、中国の石炭電力産業の持続可能な開発に新たな道を開くことに邁進する所存である。

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plants is closely related to the above environmental problems and it is one of the most social concerns in the future.

In conventional coal-based power generation, large amounts of pollutants, including gas (SO_x, NO_x, etc.), solid (clinker, dust, heavy metal, etc.) and liquid (industrial waste water etc.), results in serious environment pollution. The statistics shows that SO₂ emitted by power plants accounts for over 40% of the total of the country's industrial enterprises. The primary requirement of future society on coal-based generation technology is to control the major pollution, particularly discharge of SO₂, NO_x, fine ash (PM₁₀, PM_{2.5}) and heavy metal (Hg, etc.). Global climate warming up due to greenhouse gases is the hotspot and difficulty mostly concerned in the present and future energy and environment issues. The total CO₂ emission in China is just next to the United States, ranking the second in the world, and will keep on increasing. If pollutant and CO₂ emission are required to be controlled at the present level while power demand keeps on increasing, China's power industry has to adopt efficient and clean GreenGen technology.

By optimizing the power source structure and increasing the proportion of clean energy power generation, renewable energy power generation and nuclear power generation, the contradiction of electric power development and environment protection can be relieved to a certain extent. However, for China's power industry with coal-based generation as its main prop, the most important and urgent task is to reduce pollutant emission of the existing thermal units and adopt efficient and clean GreenGen technology for the newly installed units.

2. TECHNOLOGY SELECTION OF "GREEN COAL-BASED GENERATION"

The supercritical and ultra supercritical generation technology (SC/USC), circulating fluidized bed combustion generation technology (CFBC), integrated gasification combined-cycle generation technology (IGCC) and pressurized circulating fluidized bed combustion combined-cycle generation technology (PFBC-CC) are all clean and large capacity generation technologies available for selection. However, viewing from the point of the future power sustainable development, the existing clean coal-based generation technologies cannot meet the demand of future society. If lower pollutant emission and higher generation efficiency are required at the same time, these technologies, namely supercritical and ultra supercritical generation technology (SC/USC), circulating fluidized bed combustion generation technology (CFBC), integrated gasification combined-cycle generation technology (IGCC) and pressurized circulating fluidized bed combustion combined-cycle generation technology (PFBC-CC), will encounter many technological difficulties, especially on CO₂ separation and sequestration. Though IGCC technology has the advantages of low pollutant and high efficiency, it give no consideration of CO₂ separation.

GreenGen technology is the integrated coal gasification hydrogen production, hydrogen power generation and CO₂ sequestration system. There is no NO_x in coal gasification and hydrogen production process, and other pollutants such as sulfur can also be deprived. Hydrogen combustion creates only clean H₂O. Therefore, green coal-based power generation technology can realize near zero emission of all pollutants including CO₂. With fuel cell and hydrogen turbine combined cycle generation technologies, coal-based generation efficiency of the system can be greatly increased. The high efficiency and near zero emission can meet the demand of coal-based generation for the sustainable development.

Compared with the existing coal-based generation technologies, coal gasification hydrogen production and hydrogen power generation technology can realize higher efficiency (50%–60%) and near zero emission of various pollutants including CO₂, which is unreachable for existing coal-based generation technologies. With the increasing demand of future society for generation efficiency and environment protection and with the progress in science and technology, especially when the future international society imposes increasingly strict regulation on CO₂ emission, the coal-based power generation technology by means of coal gasification hydrogen production and hydrogen power generation is a coal-based power generation technology which has more

advantages over other clean coal power generation technologies. It will realize near zero discharge of coal-based energy transformation system and higher utilization efficiency at acceptable price.

3. GREENGEN PLAN OF CHINA HUANENG GROUP

3.1 Strategic Consideration of GreenGen

CHNG is the largest independent power generation corporation in China, which had an installed capacity of 33560MW in 2004. It is planned that its installed capacity will be up to 60000MW by 2010 and 120000MW by 2020. The coal electricity for CHNG takes the predominant position at present and in the future.

CHNG attaches great attention to application and development of new technology for coal-based power generation. It takes the lead at home in adopting supercritical generating unit and is the independent power generation corporation that owns the largest number of supercritical generating units in China. 2×600MW supercritical generating units of CHNG in Qinbei, Henan were put into operation in 2004. Presently, its first 1000MW ultra supercritical generating unit is being installed in Yuhuan, Zhejiang, which is also the demonstration project of the first domestic-made ultra supercritical generating unit in China. Implementation of these projects has great significance in promotion of China's supercritical and ultra supercritical generation technology.

Facing the future, CHNG is responsible for making contributions to sustainable development of China's power industry. CHNG will pay more attention to developing "green energy" technology, and become a "green" corporation laying stress on science and technology, protecting environment and promoting sustainable development. Meanwhile, developing "Green Coal-Based Generation" is the essential strategic selection for CHNG to realize sustainable development and that is also long term wish of electricity power engineers to ultimately solve the pollution of GreenGen. CHNG is ready to concentrate all of its resources (technology, experts, funds, experimental base, etc), in cooperation with domestic enterprises and with introduction of foreign technologies, to complete in ten years the "Green Coal-Based Generation" demonstration project that will meet the requirements of the Chinese concrete conditions.

3.2 Total Object of "Green Coal-Based Generation"

CHNG's object for GreenGen is: to research and develop and demonstrate (RD&D) the integrated coal gasification hydrogen production, hydrogen power generation and CO₂ sequestration system; to greatly increase coal-based generation efficiency; to make coal-based generation reach near zero emission of all pollutant including CO₂ and to realize sustainable development of coal-based power generation. The brief flow sheet of green coal-based power generation is shown in figure 1 (See Appendix).

3.3 The Development Plan and Goals in Stages

Stage One: During the "11th-five-year plan", CHNG will research and develop the 1000-2000t/d grade gasification technology, gas purification technology, low heating value gas burning technology and the system integration. A 250MW IGCC demonstration plant will be built in Tianjin or Suzhou. With full Chinese property right, the demonstration project will be also used to verify and test coal gas hydrogen production, fuel cell power generation and CO₂ separation.

Stage Two: During "the 12th-five-year plan", CHNG will accomplish the research, scale-up and system integration of 3000t/d grade large-scale dry pulverized coal pressurized coal gasification technology, gas purification technology and low heating value gas burning technology that have the Chinese property right. In the meantime, a 300-400MW coal gasification combined cycle generation system will be demonstrated. And an industry-scale verification will be conducted for 100MW grade new type coal gas hydrogen production, fuel cell power generation technology and

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CO₂ separation.

Stage Three: During “the 13th-five-year plan”, CHNG will complete the technology research and development of 300-400MW grade large-scale coal gas hydrogen production, fuel cell power generation, hydrogen gas turbine combined cycle generation and CO₂ separation, and will build a 300-400MW grade GreenGen demonstration project and have design integration technology of system and key equipments. The system will reach great generation efficiency and near zero emission, so as to lay a good foundation for constructing a commercial green coal-based power generation system.

Technological goals are to complete an industrial demonstration project of 400MW before 2020, with generation efficiency up to 55%-60%; SO₂ and NO_x emission less than 20mg/Nm³; PM_{2.5}, Hg and VOC near zero discharge; over 80% of CO₂ separated and treated; byproducts effectively utilized. And commercial operation of the unit will be gradually realized. Under the same condition of environment protection, the investment and operation cost of the unit will be able to compete with other energy systems.

The key technologies involve high efficiency and large scale gasification technology, gas cleanup technology, hydrogen gas turbine technology, fuel cell power generation technology, membrane separation technology, CO₂ capture and sequestration technology and system integration technology.

4. PRACTICE

The action of CHNG in advocating and practicing GreenGen plan has gained affirmation and support from the Chinese government, which greatly promotes CHNG’s confidence in developing GreenGen. In 2004, CHNG established and approved “The Program of ‘Green Coal-Based Power Generation’ Development”. The stage one of the project of GreenGen has passed the expert appraisal of “The State Key Industrial and Technological Development Project on Key Technologies for Environment Protection” funded by the State Development and Reform Commission. The Ministry of Science and Technology is considering funding the relevant research in *The State Medium and Long Term Program in Science and Technology* and “the 11th-five- year plan”. Domestic experts have also given high evaluation on the GreenGen plan.

CHNG has constituted the *Electricity Product Development Plan and Science Development Plan before 2020*, which will provide financial and engineering conditions for implementation of the GreenGen project. CHNG has established the GreenGen project leading group, working group and research group. The general manager of CHNG serves as the head of the project leading group.

According to the approved *GreenGen Project 2005 Working Plan*, CHNG has started relevant work of GreenGen project. The initial stage research of GreenGen project has been listed into annual working plan of CHNG and has been funded by scientific research funds. The feasibility study of the first step demonstration project has been finished in Sept. 2005, and the demonstration plant will be started to construct in 2007 and put into operation in 2009.

Xi’an Thermal Power Research Institute (TPRI) is the technology center of CHNG, which has advanced technologies and experienced experts. By undertaking IGCC technology research projects from the *State 863 Plan* and the *State Scientific Key Project Plan*, TPRI has basically mastered the IGCC design optimizing technology and has laid a good foundation for many key technologies, such as coal gasification, coal gas purification, combined cycle generation. In addition, TPRI has begun to conduct the research of fuel cell power generation technology, membrane separation technology etc, which has created essential technology conditions for development of CHNG’s GreenGen project.

An international consultant group including EPRI of USA, CRE of UK, TPRI of China have completed the evaluation of IGCC power plant in the world in 1999. TPRI has developed the

software for IGCC in cooperation with EDF by 2006. A type of two stages gasification technology with full Chinese property right has been developed successfully by TPRI in May 2006. The characters of the technology are oxygen entrained flow, 2 stages reaction, dry feed, water cooling wall.

With CHNG technology center being the core, CHNG intends to draw experts from the whole nation to form a powerful expert technology supporting system. An in collaboration with all sides, CHNG will established a key project team that will be a cross-industry and cross-organization body involving experts from research institutions, colleges and universities, enterprises, power industries, manufacturing, etc.

CHNG has set up GreenGen Industrial Alliance, and welcomes the energy companies in the world to participate in GreenGen. GreenGen Ltd., Co. was found by eight groups in Beijing on Dec. 23, 2005. GreenGen manifests the responsibility of state-owned energy giants in addressing energy utilization and environmental issues.

CHNG participated in FutureGen Industry Alliance on Oct. 27, 2005, which includes twelve coal and power corporations from US and other countries. It will provide favorable oversea cooperative environment for the independent development of China's GreenGen technology.

5. CONCLUSION

The development of social economy requires the power industry to adopt more energy-conservative and more environment-friendly green electric power technology. Since China's energy structure takes coal electricity as its main prop, developing green coal-based electricity is the necessary selection for sustainable development of China's power industry. Developing ultra supercritical coal-based power generation system with FGD and SCR can meet the requirements of China's electric power growth in the near future. But for the long-term future, the real green coal-based power generation technologies are the integrated coal gasification hydrogen production, hydrogen power generation and CO₂ sequestration system.

CHNG's development of the GreenGen project is to conduct technology storage and engineering demonstration for future sustainable development of country's coal power generation. Being the hotspots and difficulties of international energy research and development fields, the involved systems and key technologies are the main concerns of international society and the focus of research and development. Under the leadership of the State Development and Reform Commission and the Ministry of Science and Technology, CHNG is confident in the research and development of the domestic property right GreenGen technology and in opening a new road for the sustainable development of China's coal power industry.

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