

CLEAN  
CLEAN  
ENERGY

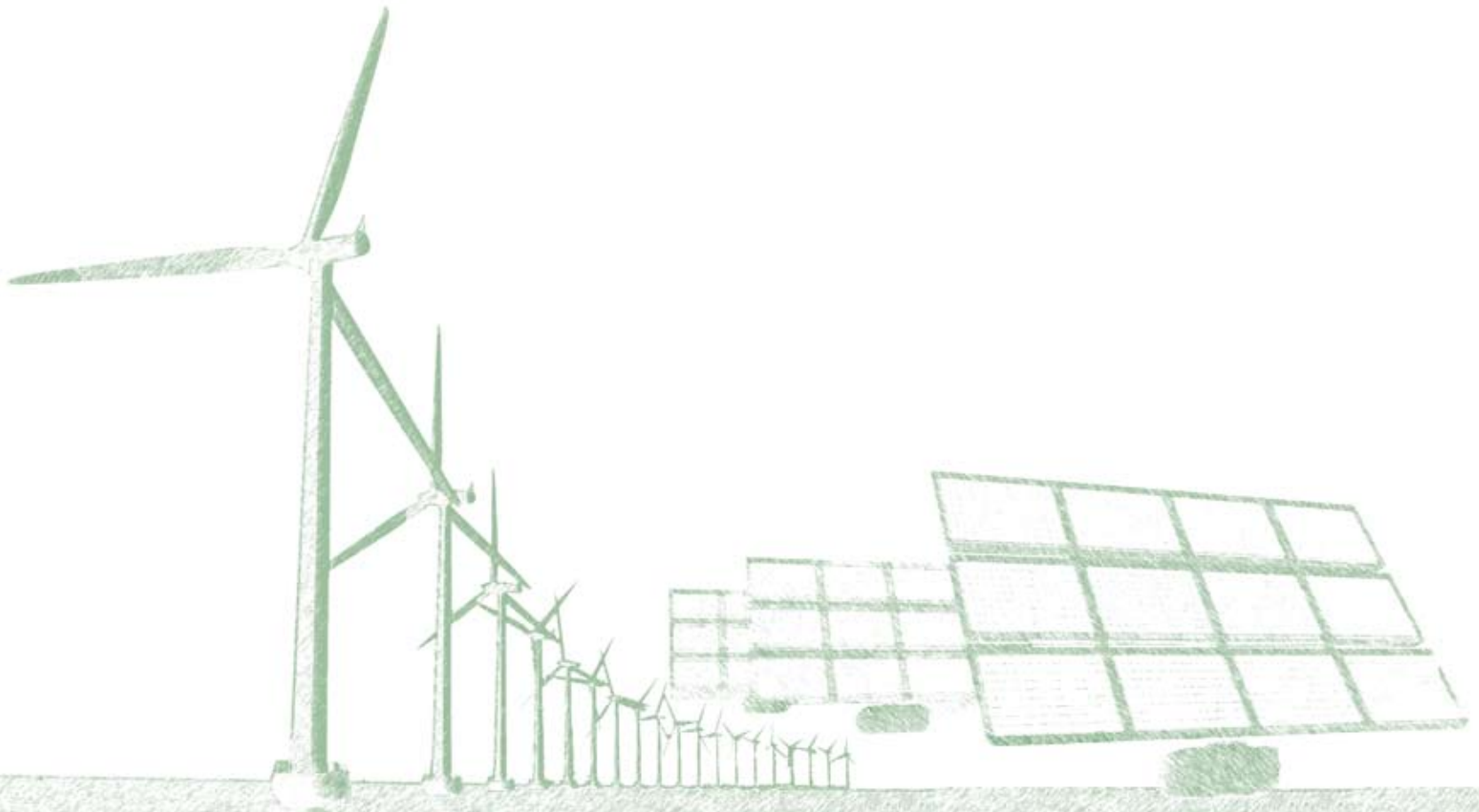
CHINA-2010

**CHINA'S CLEAN ENERGY IN PROGRESS**

发展中的清洁能源科技

Ministry of Science and Technology of P.R.China

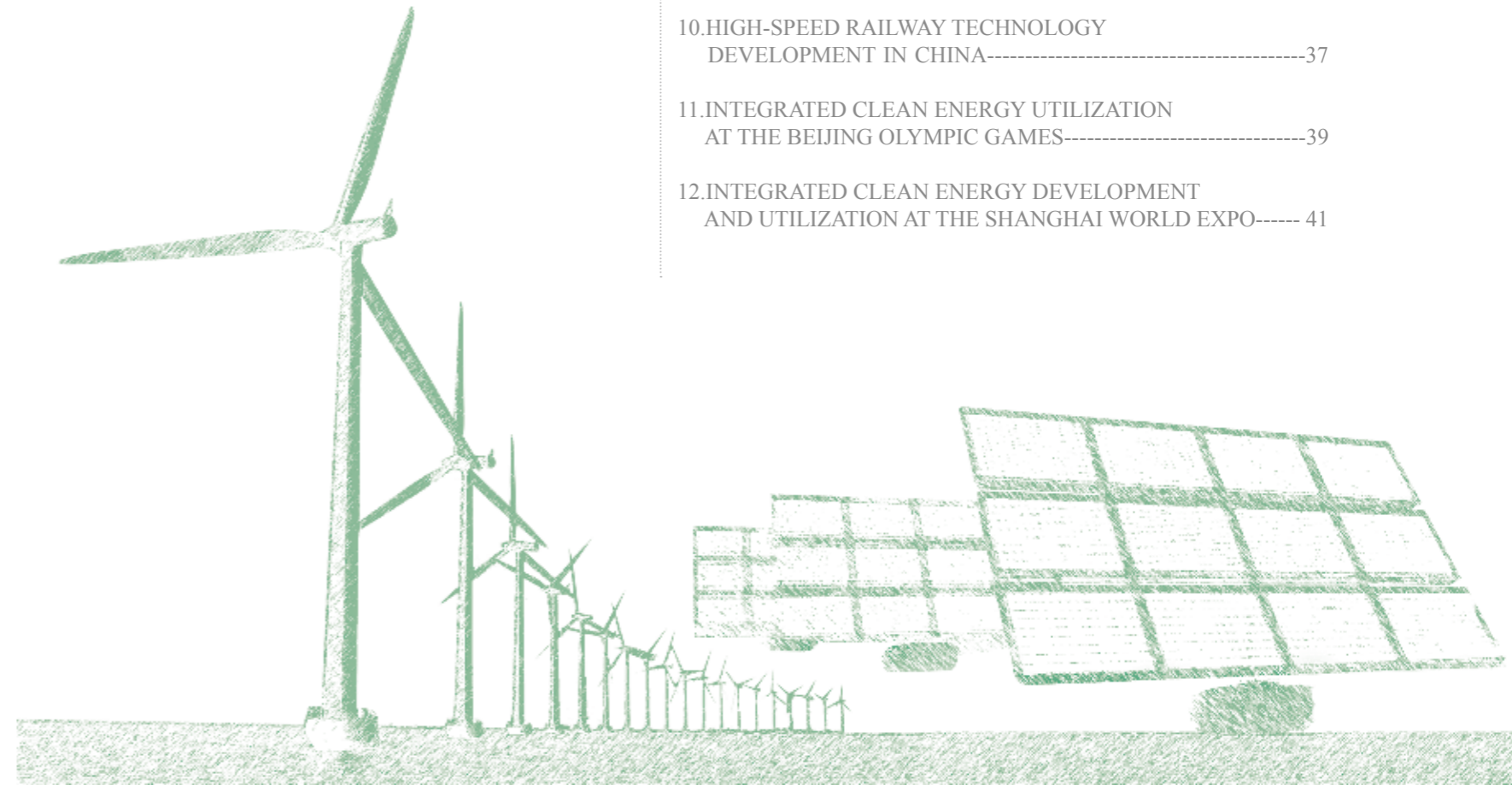
中华人民共和国科学技术部



# CONTENTS

## PREFACE

1.SOLAR ENERGY DEVELOPMENT AND UTILIZATION-----	1
2.WIND POWER DEVELOPMENT AND UTILIZATION-----	5
3.BIOMASS ENERGY DEVELOPMENT AND UTILIZATION-----	7
4.CLEAN COAL DEVELOPMENT AND UTILIZATION-----	15
5.NUCLEAR ENERGY DEVELOPMENT AND UTILIZATION----	24
6.SMART GRID-----	27
7.GEOTHERMAL ENERGY UTILIZATION-----	29
8.SURFACE WATER SOURCE HEATPUMP UTILIZATION-----	21
9.NEW ENERGY VEHICLES-----	32
10.HIGH-SPEED RAILWAY TECHNOLOGY DEVELOPMENT IN CHINA-----	37
11.INTEGRATED CLEAN ENERGY UTILIZATION AT THE BEIJING OLYMPIC GAMES-----	39
12.INTEGRATED CLEAN ENERGY DEVELOPMENT AND UTILIZATION AT THE SHANGHAI WORLD EXPO-----	41



# Preface

**The** 21<sup>st</sup> century ushers into an era of clean energy. The issues of energy, environment and development have prompted us to explore a road of harmonious development with optimized energy mix, green environment and sustainability. Today, China is applying science and technology to the utilization of clean energy and the enhancement of energy efficiency, bringing bright prospects for clean energy.

China boasts of considerable potentials for clean energy development. Currently, coal accounts for 70% of China's primary energy consumption, which promises great prospects for clean coal utilization. Wind power resources in China amount to 700-1,200 million KW, while the convertible energy potential of biomass resources stands at 720 million tons, equivalent to 330 million tons of standard coal. Each year, ground-absorbed solar energy in China is approximately 1.7 trillion tons of standard coal, which could heat 2 billion m<sup>2</sup> of water, generate 2.2 billion KW of electricity, and replace some 320 million tons of standard coal. Exploitable geothermal resources in China stand at around 3.3 billion tons of standard coal.

The Chinese government has attached high importance to clean energy development. In 1994, it approved and implemented China's Agenda 21. It also formulated a series of laws to promote the development of green energy in China. These include the Environmental Protection Law (1989), the Electric Power Law (1995), the Coal Law (1996), the Renewable Energy Law (2006), the Law on the Promotion of Circular Economy (2008) and the Energy Conservation Law (2008).

Through science and technology, China is now embarking on large-scale development and utilization of clean energy. The Green Coal-Fired Power Program will greatly upgrade coal-fired power plants and reduce carbon dioxide and pollutant emissions. By 2015, coal-fired power plants with near-zero emissions will be built. These plants can improve efficiency by 1/3 over the currently most advanced thermal power generation plants and achieve near-zero emissions of carbon dioxide and pollutants. In the meantime, utilization of solar, wind, biomass, nuclear, geothermal and other clean energies is developing fast. And the application of smart grids, surface water heat pumps, new energy vehicles and high-speed trains has achieved remarkable effects. We firmly believe that, with powerful technological support, clean energy will surely become one of the leading energy sources in China. We also believe that clean energy will inject a new driving force for the growth within China and in the world. ■



# ●●● Solar energy development and utilization

## Solar photovoltaic power generation >>>

Two-thirds of China's land territory has annual sunshine hours of over 2,200h, with a total annual solar radiation over 5,000 MJ/m<sup>2</sup>. China now has the largest solar cell output in the world. In the next 2 years, the Golden Sun Demonstration Project will support at least 640 MW photovoltaic systems and promote grid connection. By 2020, China's total installed photovoltaic generating capacity is expected to reach 20,000 MW. China is now implementing various projects, including 50 MW grid-connected photovoltaic power plants, research and demonstration of 2 MW photovoltaic micro-grid power generation, and thin-film solar cells.

### Case 1: Yiwu Grid-Connected Photovoltaic System in Zhejiang Province

In 2008, the Yiwu Trade City 1,295 KW Grid-Connected Photovoltaic System in Zhejiang Province was completed. As the largest building photovoltaic system in China at that time, the system has played an important demonstrative role in promoting large-scale photovoltaic power generation across China.

● Yiwu Trade City 1,295KW Grid-Connected Photovoltaic System in Zhejiang Province



## Case 2: Dye-sensitized Solar Cell

Currently, China has developed dye-sensitized solar cells with efficiency of 5.9% on  $15 \times 20 \text{cm}^2$  modules. In 2004, a small-scale 500W demonstration system was built, offering key references of stable performance and 12,000 hours of aging data. Currently, pilot production lines for dye-sensitized solar cells are under construction.

● 500W Dye-Sensitized Solar Cells in Hefei, Anhui Province



● Multiple Photovoltaic Automatic Tracking System in Yangbajing in Tibet



## Case 3: Yangbajing High-Voltage Grid-Connected Photovoltaic Power Plant in Tibet

The Yangbajing 100KW Grid-Connected Photovoltaic Power Plant in Tibet was completed in 2005. Being China's first photovoltaic power plant connected with the high voltage power grid, it will be expanded to 10 MW while carrying out the research and demonstration of 500KW photovoltaic grid-connected inverter system. The power plant plays an important role in developing key technologies and equipment for large-scale photovoltaic power plant and promoting their wide application in plateau areas.

● Yangbajing High Voltage Grid-Connected Photovoltaic Power Plant in Tibet



## <<< Solar photothermal technology

Solar photothermal technologies have been developing rapidly in China. The total output of solar water heaters in the country has reached 140 million  $\text{m}^2$ . Centering on solar vacuum tube technology, China has made much advancement in such technologies as solar selective absorbing coating, solar heating of buildings, solar air conditioning, solar water heater, solar drying and solar seawater desalination. With regard to concentrated solar power, China has made major progress in heliostats, high-temperature vacuum tubes, high-temperature heat-storage materials and design of solar thermal power plants. Capable of producing core equipments for solar thermal power generation, China will soon build its first solar thermal power plant and national experimental base for solar thermal power generation in Beijing.

● MW-level Tower-Type Solar Thermal Power Plant in Beijing



## Case 1: Concentrating Solar Thermal Power Generation Technology (Beijing)

China has built its first MW-level tower-type solar thermal power plant in Beijing. With this, the country will not only fully grasp the technologies for solar concentrating, high-temperature heat storage, high-temperature light and heat conversion, and system integration, but also gradually establish its own system of specifications and standards. As for core equipment, China's fourth-generation heliostat can withstand winds of force 6 and offer such advantages as low cost and convenient installation.

## ●●● Wind power development and utilization

China has taken wind power generation as one of the main alternative energy sources in adjusting its energy mix and coping with climate change. As of the end of 2009, China's installed wind power generating capacity had topped 25,000MW, achieving a growth of 100% for five consecutive years. The figure is expected to reach 120,000-150,000MW by 2020. Currently, China's own 1.5MW wind power generating units have been industrialized and widely used in wind farms. The 3MW wind power generating units have entered grid operations. At the next step, China will focus on designing >5MW offshore wind power generating unit, manufacturing its key parts, and making breakthroughs in operation and maintenance of large-scale wind farms.

### Case 1: MW-level Double-fed Variable Speed and Constant Frequency Wind Power Generating Units

In 2005, China developed its first MW-level double-fed variable speed and constant frequency wind power generation system (WPGS). So far, China has a series of WPGS from 1MW to 3MW, which have been commercialized.

● Assembly Site of SUT-3000 3MW Double-Fed Variable Speed and Constant Frequency Wind Power Generation System



● Modular Heliostat Matrix Concentrating Thermal System in Shanghai

### Case 2: Concentrating Solar Thermal Power Generation Technology (Shanghai)

The Modular Heliostat Matrix Concentrating Thermal System built in Shanghai achieves a light and heat conversion ratio of 70-80% and a working temperature of 350-400°C. Energy cost for large-scale power plants is expected to stand at RMB 0.5/kWh. The system, if combined with heat storage technology, can achieve an operational coefficient similar to that of coal-fired power plants, thus able to offer stable and continuous power supply. This solar power plant can also be combined with wind power, to form an ideal integrated system of renewable energy.

## Case 2: 1.5MW Direct Drive and Permanent Magnet Wind Power Generating Units

The 1.5MW direct drive and permanent magnet wind power generating units developed by Xinjiang Goldwind Science and Technology Co., Ltd. entered into batch production in 2008. For Beijing Green Olympics Project, thirty-three 1.5MW wind power generating units were installed, providing clean power to the Games. Currently, China has installed more than 1,000 such units and achieved an annual production capacity over 1,500 sets. The 3MW half-direct drive and permanent magnet wind power generating units have also been put into trial operation.

● 1.5MW Direct Drive and Permanent Magnet Wind Power Generating Units Provided Clean Power to the Beijing Olympic Games



● 3MW Wind Power Generating Units Built by Gold Wind Science and Technology Company Ltd. at Daban, Xinjiang Uygur Autonomous Region



## ●●● Biomass energy development and utilization

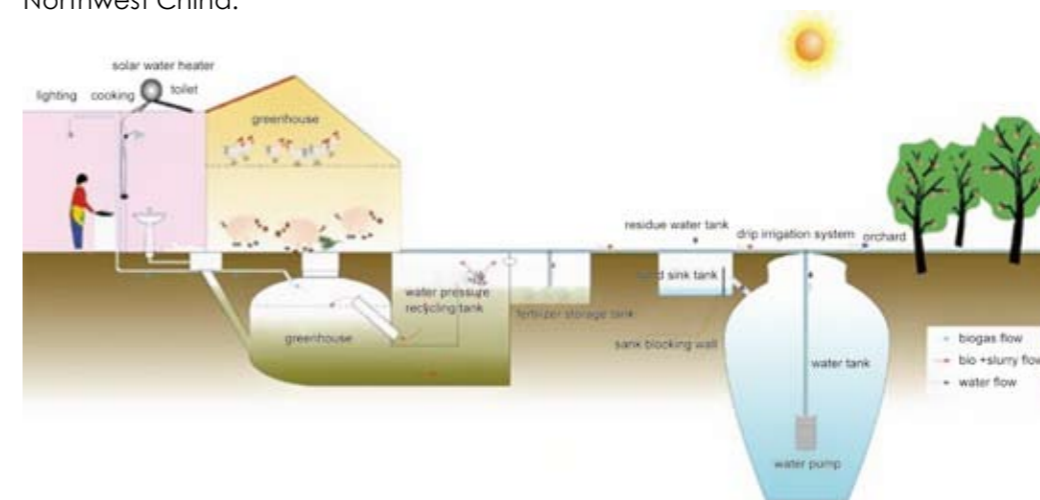
**B**iomass is organic matter symphonized by living organisms through photosynthesis. It includes all kinds of organic wastes and energy plants, thus becoming the only renewable resource that can directly generate gas, liquid and solid energies. Currently, the biomass resources available for energy use in China each year amounts to some 720 million tons, equivalent to 330 million tons of standard coal. With socio-economic progress and the plantation of energy crops on marginal land, the output of biomass energy in China could reach 700-1,000 million tons of standard coal. By 2020, China's biomass energy development will reach the following goals. The total installed biomass power generating capacity in China will reach 30,000MW, with the annual consumption of solid biomass briquettes amounting to 50 million tons, biogas 44 billion m<sup>3</sup>, ethanol 10 million tons and biodiesel 2 million tons.

### <<< Biomass gas

Biomass gas is a typical low carbon fuel. Using organic wastes as the raw material to produce biomass gas can eliminate organic pollution, control greenhouse gas emissions and substitute fossil fuels. Currently, China has the potentials to produce 200 billion m<sup>3</sup> of equivalent biogas, convertible to some 120 billion m<sup>3</sup> of equivalent natural gas. By the end of 2008, the country has developed 2,761 large-scale biogas projects, including 1,192 new projects in 2008. As agricultural plantation and breeding in China become more intensive, concentrated biomass gas projects will offer tremendous potential and has become an emerging industry with strategic importance in the area of new energy.

### Case 1: Rural Household-Use Biogas Project

Statistics show that as of 2008, there were 30.48 million biogas-using households in China, with an annual biogas output of 11.4 billion m<sup>3</sup>. Household-use biogas models in China mainly include the ecological agricultural model of "biogas pits, pigpens, toilets and vegetable greenhouses" in North China, and the model "biogas pits, orchards, warming sheds, water storage pits and watch rooms" in Northwest China.



● Rural Household-Use Biogas Project in China (Model of "Biogas Pits, Orchards, Warming Sheds, Water Storage Pits and Watch Rooms")

## Case 2: 2MW “Gas-Heat-Electricity-Fertilizer” Biomass Gas Project

The Project is located at the laying hen bred farm of DQY Agricultural Technology Co., Ltd. in Yanqing County, Beijing. With a standing stock of 3 million egg-laying hens and an annual output of 500 million eggs, the company uses 77,400 tons of chicken excrement and 200,000 tons of sewage as raw materials to build a centralized biogas plant in line with the ecological recycling model of “gas-electricity-heat-fertilizer”. The project consists of 4 primary fermentation tanks each with a volume of 3,000 m<sup>3</sup> and a 5,000 m<sup>3</sup> level-2 fermentation tank, which could generate 7 million m<sup>3</sup> of biogas, 14 million KWh of electricity, and some 180,000 tons of biogas slurry and residue fertilizers per year. Each day, the project could supply 2,000 m<sup>3</sup> of biogas as domestic fuels to nearby villages.

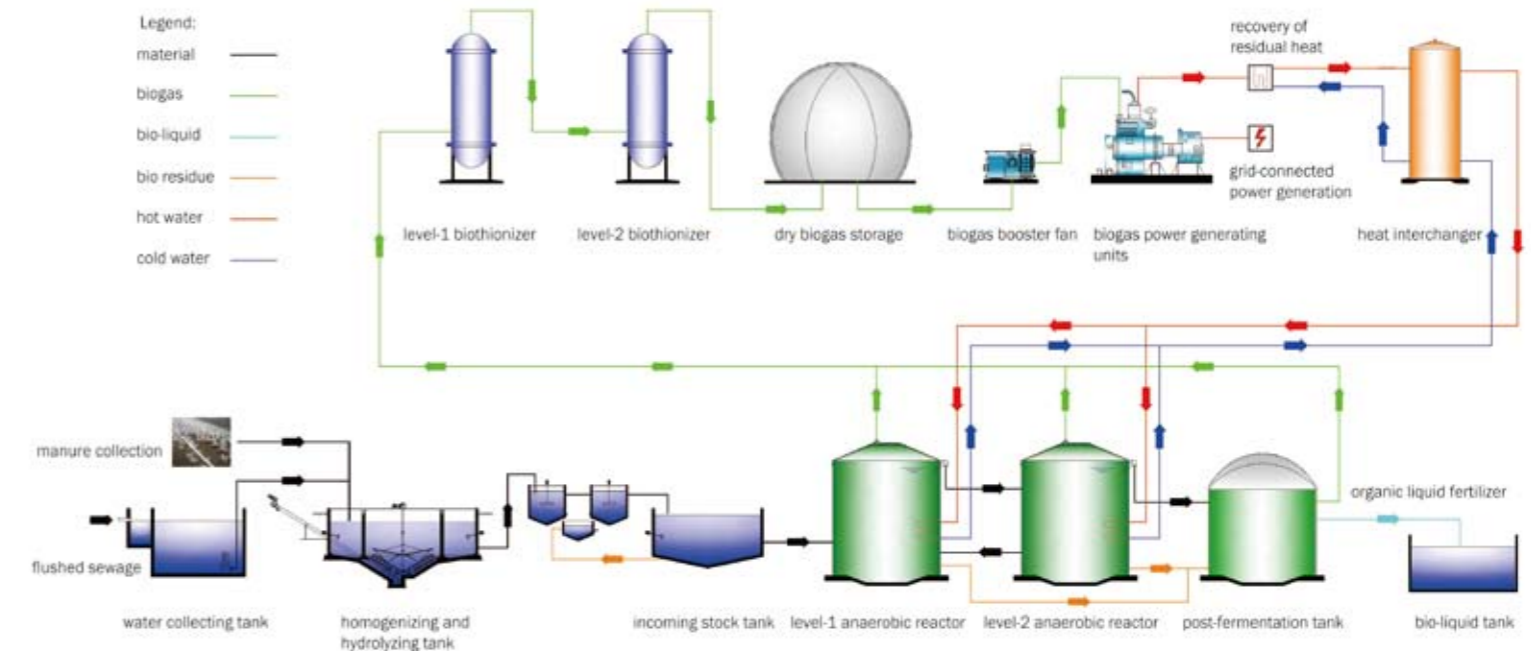
Each year, the Project can reduce carbon dioxide emissions by 84,000 tons and is one of the largest agricultural CDM projects in China. The buyer is International Financial Corporation of the World Bank Group, and the selling price is 9 Euros/ton. The first-phase purchase contract of the Project will last to 2012.

The Project is also the first breeding farm biogas project which generates grid-connected power in China. In 2006, it obtained grid connection permit from North China Grid Company. Currently, grid connection lines have been laid and the power generated by the Project has been fed into the North China Grid. Residual heat from power generation is recovered and supplied as the heat energy for preserving the temperature of fermentation tanks and for heating up materials.

● Yanqing 2 MW Biomass Gas Project Site in Beijing



● Process Flow Chart of Biomass Gas Project



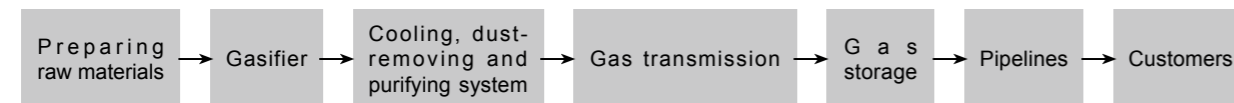
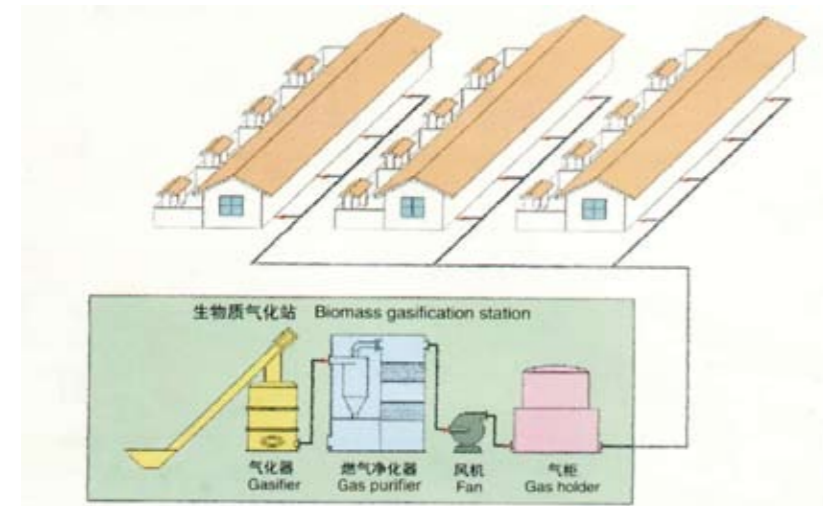


### Case 3: Straw Gasification and Centralized Gas Supply

Straw gasification and centralized gas supply is a new technology adopted to support rural energy supply in China. Abundant straws and stalks in rural regions provide raw materials to generate inflammable gas after pyrolysis and reduction reactions, which then transmitted through pipelines to rural households for cooking and heating purposes.

Statistics show that as of the end of 2008 there had been 856 straw gasification and gas supply projects in China, with 179 new ones. These projects can generate 20 million m<sup>3</sup> of biogas per year.

• Straw Gasification and Centralized Gas Supply Diagram



• Straw Gasification and Centralized Gas Supply Process

### Bio-liquid fuels >>>

Bio-liquid fuels are important oil substitute, mainly consisting of fuel ethanol and bio-diesel. Based on its land resources and agricultural production characteristics, China in recent years has decided not to increase its food-based fuel production capacity, but to rationally use non-food biomass raw materials to produce bio-liquid fuels. The focus is placed on developing fuel ethanol with cassava, sweet potato and sweet sorghum as the raw materials; producing bio-diesel with Jatsr Dapha Curcax R, Chinese pistache, Tung oil tree, cottonseed crops and waste oil from catering as the raw materials; and producing liquid fuels, like making cellulosic ethanol through hydrolysis and the preparation of light fuel oil through catalytic cracking.

### Case 1: 200,000 t/a Cassava Fuel Ethanol Project

Guangxi COFCO Bio-Energy Co., Ltd. started construction on December 24, 2006 and put the Project into trial production on December 22, 2007. The Project adopts a production model of “clean production, recycling economy” and aims to achieve energy conservation and emissions reduction. The main technologies adopted include cassava slicing and fresh cassava grinding technology, medium temperature spray liquefaction of the dual enzyme method, simultaneous saccharification and gravity fermentation technology, coupled with differential thermal multi-effect distillation technology and direct-fired drum drying technology. By establishing a new model of agricultural industrialization and commercial cooperation among the government, enterprises, research institutions, financial institutions and rural households, the Project ensures the supply of 600,000 t/a of dry cassava slices and an annual fuel ethanol output of 200,000 tons.

• Beihai 200,000 t/a Cassava Fuel Ethanol Project in Guangxi



## Case 2: 50,000-100,000 t/a Bio-diesel Project

Longyan Zhuoyue New Energy Development Co. Ltd. uses waste animal and plant oil and fat to make esterification and transesterification reactions with methanol to generate fatty acid methyl ester under the action of certain catalysts and fixed-bed devices, and produce bio-diesel through purification. The production process is efficient, clean and energy-saving. The 70,000 t/a Bio-diesel Project in Longyan and the 50,000 t/a Bio-diesel Project in Xiamen have both been completed, while the 100,000 t/a Project is still under construction. Through technological innovations and project implementation, 120,000 tons of waste animal and plant oil is consumed each year for bio-diesel output, equivalent to 150,000 tons of standard coal. The Project has reduced large amounts of carbon and sulfur gas emissions and played a good demonstrative role in the development of recycling economy and low carbon industries in China.

• Site of 70,000 t/a Bio-diesel Project in Longyan City, Fujian Province



• Site of 50,000 t/a Bio-diesel Project in Xiamen City, Fujian Province



## <<< Concentrated utilization of urban and industrial biomass wastes

Currently, there are some 156 million tons of household garbage and some 200 million tons of biomass wastes of industrial origin, which are recyclable in China. Through adoption of anaerobic digestion technology, household garbage can generate 7.8 billion m<sup>3</sup> of biomass gas a year. Calculated at 100 liters of fuel consumption per bus per day, such amount can power 240,000 buses annually, or cover the total bus fuel consumption of 10 mega-cities (such as Beijing). 70% of the biomass wastes of industrial origin can be degraded through anaerobic digestion and pyrolysis gasification technologies, with 12 billion m<sup>3</sup> of biomass gas generated a year.

Large-scale urban biomass gas projects play a role in absorbing household garbage and industrial solid wastes, reducing greenhouse gas emissions and complementing fossil energies. They can reduce solid wastes by 250 million tons, equivalent to 25 million tons of COD, and cut CO<sub>2</sub> emissions by 264 million tons, thus cutting emissions of both solid wastes and greenhouse gases.

## Case : Anaerobic Biomass Gas Project

Zhoukou City in Henan Province has established a mixed anaerobic digestion-based biomass gas project with urban catering wastes and livestock wastes as the raw materials. The Project consists of 10 primary fermentation tanks, each with a volume of 2,500m<sup>3</sup>, yielding an annual biomass fuel gas output of 35 million m<sup>3</sup>, a power output of 70 million KWH, and a waste residue fertilizer output of some 900,000 tons. Each day, it provides 5,000m<sup>3</sup> of natural gas to nearby vehicle-use gas stations. The Project can reduce carbon dioxide emissions by 420,000 tons a year.

• Zhoukou Vehicle-Use Fuel Gas Project in Henan Province



## ●●● Clean coal development and utilization

### Microalgae biomass energy development and utilization>>>

Microalgae bio-energy is a third-generation bio-energy technology, which takes advantage of microalgae's high light conversion efficiency, fast proliferation, high oil content, strong carbon sequestration capacity and occupancy of no arable land. By 2020, China can breed microalgae on 5% of its waste sandy land (64,000km<sup>2</sup>), sequester 1.6 billion tons of carbon dioxide and produce some 1 billion tons of bio-diesel. ENN Group has developed "microalgae carbon-absorbing technology". In 2008, the whole microalgae bio-energy process workflows were integrated and put into pilot operation. Design work is now underway for industrialization demonstration in Da Baner in Inner Mongolia.

#### Case: ENN Group's "Microalgae Bio-Energy Pilot System", Hebei Province

ENN Group has established a "microalgae bio-energy pilot system" for microalgae to absorb carbon dioxide emitted from coal chemical production. This pilot system includes the-whole-process equipment for capturing carbon dioxide emitted from coal chemical industry, microalgae breeding, reactor design and manufacturing, microalgae collection, oil and fat extraction and bio-diesel preparation. With a scale of 20,000 m<sup>3</sup>, the pilot system can absorb 110 tons of carbon dioxide and produce 20 tons of bio-diesel and 5 tons of proteins a year. Meanwhile, ENN Group has set up a platform for microalgae natural screening, mutation breeding and gene breeding and an industrial algae species bank with 1,000 varieties.



The Chinese government has attached high importance to clean coal development and utilization. China has undertaken considerable R&D and achieved notable results in technologies for efficient power generation from clean coal, CO<sub>2</sub> capture and sequestration, underground coal gasification, coal-to-natural gas, coal-to-oil and coal-to-olefin.

### <<< Underground coal gasification technology

Underground coal gasification technology integrates 3 major technologies of well building, coal extraction and ground coal gasification, and changes traditional physical coal extraction to chemical coal extraction, which helps raise the efficiency of coal utilization and becomes a main direction of clean coal technologies in China. The country has now completed industrial tests in underground coal gasification research and laid a solid foundation for its industrialization and demonstration.

#### Case 1: R&D of Stable Control Technology for Underground Coal Gasification

China has conducted systematic research on stable control technologies for underground coal gasification and built a pit-type underground coal gasification experimental base in Ezhuang Coalmine, Xinwen, Shandong Province. This experimental base has completed oxygen-rich gasification experiments and achieved a daily coal gas output of over 50,000m<sup>3</sup>. The calorific value and output fluctuation range of the effective ingredients in the coal gas has been controlled within 20%. The generated gas is supplied to local boilers and industrial stoves.

● Oxygen Making and Coal Gas Purification System at Ezhuang Gasification Station in Shandong Province



## Case 2: No-pit-type Underground Coal Gasification Technology

At the Meiguaying Coalmine in Ulanqab City, Inner Mongolia, a no-pit-type underground coal gasification technology experiment, research and production system has been built. It has completed experimentation for air continuous gasification and oxygen-rich continuous gasification, and conducted research on gasifier stove ignition, burning area detection and control, and pollutant monitoring and control, bringing about major breakthroughs in the core technologies of no-pit-type underground coal gasification. The Ulanqab Gasification Station, in continuous operation for 2 years, has been using coal gas for power generation through internal combustion engines. Currently, an industrialization demonstration project combining “underground coal gasification methane, methanol and power generation” is underway.

● The Ulanqab Gasification Station in Inner Mongolia



## Integrated gasification combined cycle (IGCC) <<<power generation technology

In 2009, Huaneng's Green Coal-Fired Power Tianjin 250MW IGCC Demonstration Project has been approved by the State Energy Administration to become the first large-scale IGCC power plant ever built in China.

### Case: Green Coal-Fired 250 MW IGCC Demonstration Project

Huaneng Group's Green Coal-Fired 250MW IGCC Demonstration Project is the first IGCC power generation project approved in China, which is located in Binhai High-tech Industrial Development Area, Tianjin. It adopts a two-segment dry powder pressure gasification technology and can process 2,000 tons of coal a day.

● Coal Gasification System at Tianjin IGCC Power Plant



## CO<sub>2</sub> capture and sequestration technology for coal-fired power plants>>>

In recent years, China has made major progress in developing CO<sub>2</sub> capture and sequestration technologies for coal-fired power plants. Since 2006, 3 sets of demonstration installations have been built in the country. At the end of 2009, Huaneng Group built, at a Shanghai coal-fired power plant, a CO<sub>2</sub> capture system, which can capture 120,000 tons of CO<sub>2</sub> a year.

### Case: Coal-Fired Power Plant Flue Gas CO<sub>2</sub> Capture Experimental Demonstration Project

At its Huaneng Beijing Thermal Power Plant, the Huaneng Group has built a flue gas capture experimental demonstration system with an annual recovery capacity of 3,000 tons of CO<sub>2</sub>. The system, by capturing CO<sub>2</sub> with a concentration of over 99% from flue gases with a CO<sub>2</sub> concentration of 13%, then going through a refined system, can produce food-level CO<sub>2</sub> products. In operation for over one year, the system has been running stably and reliably, and met with the designed technical and economic standards. CO<sub>2</sub> recovery rate has topped 85%, while CO<sub>2</sub> purity has reached 99.997%, higher than the purity requirements for food-level CO<sub>2</sub> products. An accumulated total of 4,000 tons of CO<sub>2</sub> has been recovered and fully utilized. The Project has opened a new way for the traditional coal-fired power technologies to achieve sustainable development while effectively lowering carbon emissions per unit of GDP.

On this basis, Huaneng Group has built the world's largest coal-fired power plant CO<sub>2</sub> capture project at the Shidongkou No.2 Power Plant in Shanghai. The Project was completed and put into operation at the end of 2009. Each year, it can capture 120,000 tons of high purity CO<sub>2</sub> for the production of CO<sub>2</sub> products for sale.



● 3,000 t/a Coal-Fired Power Plant's CO<sub>2</sub> Capture Project in Beijing



● 120,000 t/a CO<sub>2</sub> Capture Project in Shanghai

## Coal-to-olefin technology >>>

Coal-to-olefin technology is a core technology for developing new coal chemical industry, while methanol-to-olefin technology is its key technology. Since the early 1980s, China has conducted research and development on methanol-to-olefin technology and built 10,000t-level industrial experimental installations. Now three sets of large-scale industrial demonstration installations are under construction.

### Case: Methanol-to-olefin Technology -- R&D and Demonstration

China has built a 10,000t-level methanol-to-low carbon olefin industrialization experimental installation in Shaanxi Province. This technology has been successfully used in Shenhua Group's ongoing 600,000 t/a coal-to-olefin (MTO) industrial installation. Being the first of its kind in the world, the installation will be put into operation in 2010.

- 10,000t-Level Low-Carbon Methanol-To-Olefin Industrialization Experimental Installation



- 600,000 t/a Coal-To-Olefin (MTO) Industrial Installation



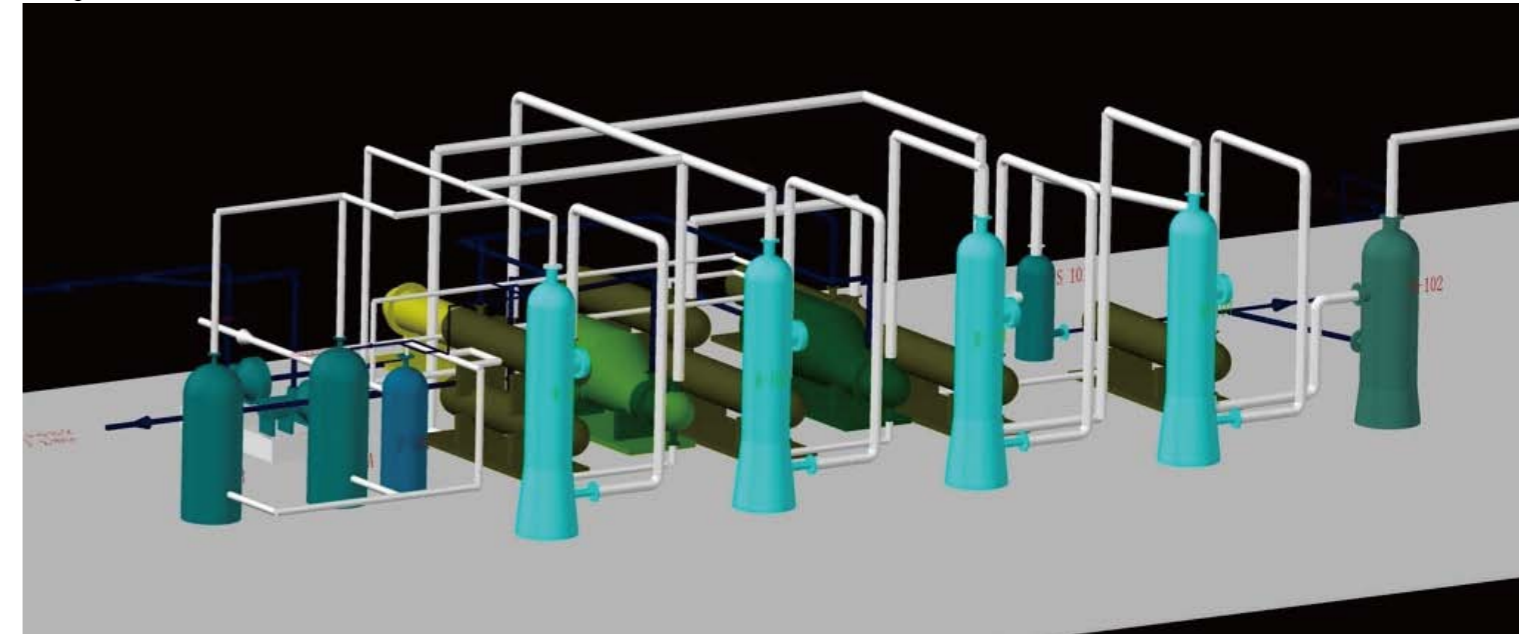
## Coal-to-natural gas technology >>>

Currently, China Datang Corporation is building 3 coal-to-natural gas demonstration projects in China, including Ke Banner 4 billion m<sup>3</sup>/a coal-to-natural gas (SNG) project in Inner Mongolia, Fuxing 4 billion m<sup>3</sup>/a coal-to-natural gas (SNG) project in Liaoning Province and Huineng 1.6 billion m<sup>3</sup>/a coal-to-natural gas (SNG) project in Xinjiang Uygur Autonomous Region.

### Case: Key Coal Gasification and Methanation Technology Development and Coal-To-Natural Gas Demonstration Project

In recent years, China Shenhua Group, China Datang Corporation and Hebei ENN Group have conducted research on the key technologies for medium and high temperature synthetic catalytic gasification and methanation, waste water treatment, the pipe transmission, liquefaction and vehicle use of synthetic natural gas, bringing forth China's core coal-to-gas technologies and related standards. This has laid a solid foundation for the industrialization of coal-to-gas technologies in China.

- Diagram of Coal Gasification and Methanation Demonstration Installations



## Coal-to-oil technology >>>

The diversified development of coal-to-oil technologies and industries in China has provided an effective way for the clean and efficient utilization of the relatively rich coal resources and the implementation of a fuel oil strategy in the country.

### Case 1: Direct Coal Liquefaction Technology -- R&D and Demonstration

Shenhua Group has developed direct coal liquefaction technologies and set up a pilot base with comprehensive facilities. It has built and put into successful operation a million t/a-level direct coal liquefaction industrial demonstration installations in December 2008.

• Shenhua Group's Million Ton-Level Direct Coal Liquefaction Industrial Installation



• MTG Industrial Installation at Jincheng Anthracite Mining Group in Shanxi Province



### Case 2: Methanol-to-gasoline R&D and Demonstration

Shanxi Jincheng Anthracite Mining Group has built a 100,000 t/a fixed bed methanol-to-gasoline (MTG) installation, which was successfully put into operation in 2009. ICC, CAS made studies on MTG processes and developed one-step fixed-bed and heat-insulation reacting technology. It is now building a 100,000 t/a gasoline industrial installation.



• Low Temperature Slurry Bed 5,000 Ton F-T Installation at Yanzhou Coal Mining Group in Shandong Province

### Case 3: Indirect Liquefaction Technology -- R&D and Demonstration

The Institute of Coal Chemistry of the Chinese Academy of Sciences (ICC, CAS) and Synfuels China have conducted research on Fischer-Tropsch synthetic industrial technologies and developed 10 million-ton pilot installations. Their technologies have been used on 3 sets of 160,000-180,000 t/a indirect coal liquefaction industrial demonstration installations with stable operation, all of which were put into successful operation in 2009. Shandong Yanzhou Coal Mining Group has carried out research on Fischer-Tropsch synthetic industrial technologies with different processes, and successfully developed iron-based catalyst, low temperature slurry reactor Fischer-Tropsch synthesis and high temperature fixed-bed Fischer-Tropsch synthesis technologies. The Group has built 2 sets of indirect liquefaction pilot installations.

## Nuclear energy development and utilization ●●●

China, starting its nuclear fusion energy research in the early 1960s, has made steady progress in recent years, conducted considerable research and achieved certain results in the physical experiment field. By around 2020, China is expected to attain the ability to independently design and build experimental fusion reactors that can demonstrate large-scale fusion power generation. Currently, China is building the world's first AP1000 nuclear power plant. A series of experiments have been conducted on high temperature gas-cooled reactors and major research progress has been made in helium turbine technology. The Key Special Project on High Temperature Gas-Cooled Reactor Power Plant has kicked off. In the meantime, China has also achieved leapfrog development in LMFBR technologies. And an experimental fast reactor will be soon completed.

### Case 1: Full Superconducting Tokamak Fusion Experimental Device

The Institute of Plasma Physics of the Chinese Academy of Sciences has developed a full superconducting Tokamak nuclear fusion experimental device (EAST) with large-scale non-circular cross sections. EAST's objectives are: to build a magnetic confinement fusion experimental system with the full superconducting non-circular cross section Tokamak as the core part, to conduct exploratory experimental research on frontier engineering physics problems relating to future fusion reactors, and to make important contributions to laying a physical and engineering technological foundation for the future stable, safe, efficient and advanced commercial reactors. In the next decade, EAST will provide a plasma experimental platform for ITER and support the ITER Project and nuclear fusion energy development.

● Experimental Advanced Superconducting Tokamak (EAST)



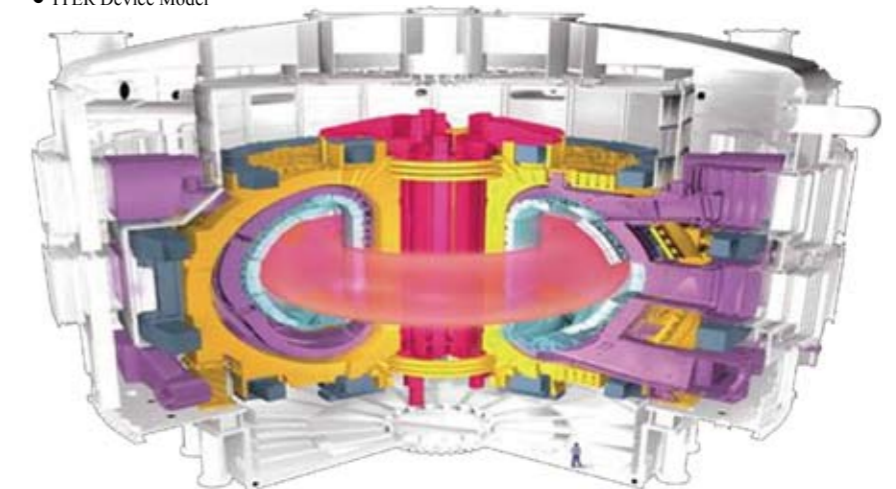
### Case 2: International Thermonuclear Experimental Reactor (ITER) Program

ITER is not only one of the largest international mega-science projects, but also the biggest international science and technology collaboration project, which China has ever participated in. Its goal is to verify the science and engineering feasibility of magnetic confinement fusion for power generation through setting up and running an ITER device in France. The 33 participating countries of ITER Project include China, the EU, India, Japan, South Korea, Russia and the United States.

The Project is to be implemented in 4 stages: a 10-year construction period, a 20-year commissioning period, a 5-year decommissioning period, and the final handing over to the hosting country, France, for retirement. With a total cost of some 10 billion Euros, the successful implementation of the Project will lay a foundation for all participating parties to build demonstration reactors at a later stage and for the eventual development of commercial reactors.

In August 2007, the Standing Committee of China's National People's Congress approved of the Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project and the Agreement on the Privileges and Immunities of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project. Since 2008, ITER has entered a stage of device construction, signifying cooperation in full play. China has joined hands with the ITER Organization and the other six parties to push forward the smooth implementation of the ITER Project.

● ITER Device Model





### Case 3: High temperature Gas-cooled Reactor Power Plant

In the mid-1970s, China made exploratory research on high temperature gas-cooled reactors. In June 1995, the country started to build its first 10 MW high temperature gas-cooled reactor (HTR-10). In December 2000, HTR-10 was completed and made its debut success. In January 2003, it made grid connection and generated power, achieving 72 hours of successful operation at full power. Currently, preparatory work for building a high temperature gas-cooled reactor demonstration power plant has been completed. The plant is scheduled for completion around 2013.

● Drawing of High Temperature Gas-Cooled Reactor Demonstration Power Plant



● Drawing of China's Experimental Fast Reactor



### Case 4: Experimental Fast Reactor in China

In the late 1960s, China started fast reactor technology research and carried out considerable preparation on physical, thermal engineering, materials and sodium technologies. In 1995, the country started to build an experimental fast reactor. Preliminary design was completed in 1997 and the construction started in 2000. The reactor will be fully completed in 2010.

Smart grid research in China has focused on large-scale intermittent power grid connection, energy storage, smart power transformation and transmission, distribution and utilization, and scheduling and control. The country has grasped some key technologies for 1000kV UHV AC transmission and  $\pm 800$ kV UHC DC transmission and applied them to the construction of some projects. China has built large-scale power grid safety monitoring, early warning and defense systems, developed and improved integrated power system analysis tools, which can be used to forecast power system stabilities after wind power farms being connected with grids. The country has successfully developed 650Ah sodium sulfur battery monomers and established batch production pilot lines, laying a foundation for large-scale energy storage project applications. Preliminary research has also been conducted on the operational features of various distributed energies in grids and the micro grid theories. China has built electric bus recharging stations for the Beijing Olympic Games and a smart grid demonstration for Shanghai World Expo Park.

### Case 1: Smart Grid Demonstration Project at the Shanghai World Expo Park

The smart grid demonstration project at the Shanghai World Expo Park has integrated distributed power grid connection, energy storage system, smart transformer station, automatic power distribution, trouble call management system (TCM), power quality monitoring, power use information collection system, smart power-use buildings/homes, as well as new energy vehicles charging/discharging and grid access technology.

● Smart Grid Demonstration at Shanghai World Expo



## ●●● Geothermal energy utilization

China is among the countries with rich geothermal resource reserves in the world. Geothermal resources are mainly used for power generation, heating and aquatic breeding. Statistics show that the exploitable geothermal water resources nationwide amount to 6.8 billion m<sup>3</sup> each year, convertible to a heat output of 32.84 million tons of standard coal a year. In 2008, geothermal development in China generated economic benefits of RMB7.092 billion, reducing carbon dioxide emissions by 19.87 million tons. Currently, the geothermal energy development in China features geothermal power generation (represented by Yangbajing, Tibet), geothermal heating (represented by Tianjin and Xi'an) and recuperation and tourism (represented by southeastern coastal regions).

### Case 1: Beiyuan Jiayuan Geothermal Heating Project in Beijing

The Beiyuan Jiayuan No.6 Residential Quarters Geothermal Heating Project Phase I covers a total floor space of 406,000 m<sup>2</sup>, the largest integrated geothermal-heat pump project in China. The Project includes a total of 3 geothermal wells, with an exit water temperature of 69°C. It has achieved stepwise use of geothermal water. In combination with a water spruce heat pump system, it can provide winter heating and summer cooling for the whole residential area, as well as hot water for hot spring bathing. Currently, the system runs well and can substitute over 8,100 tons of fuel coal each year.

● Beiyuan Jiayuan Residential Quarters



### Case 2: Wind and Solar Storage and Transmission Demonstration Project

The Wind and Solar Storage and Transmission Demonstration Project is a clean energy utilization project, which integrates wind power, photovoltaic power, chemical energy storage and transmission. The Project has a total construction scale of 700 MW, among which the installed wind power capacity is 500 MW, the installed photovoltaic power capacity 100 MW and the chemical energy storage cells 70~110 MW. It possesses 5 composite operational modes, i.e. "wind power", "photovoltaic", "wind power + energy storage", "photovoltaic + energy storage" and "wind power + photovoltaic + energy storage". The demonstration project will focus on key technologies for the planning, design, monitoring, control, scheduling, operation and large-scale energy storage of combined wind and solar power generation systems. It will push forward the building of 10-GW wind power plants, and upgrade the technology and industry of wind power, photovoltaic power and energy storage in China.

● Drawing of Wind and Solar Storage and Transmission Demonstration Project



## ●●● Surface water source heat pump utilization

Surface water thermal energy is an important renewable energy, which can be mainly used for heating and cooling buildings through a surface water source heat pump system. The total volume of surface water resources in China stands at 2.7 trillion m<sup>3</sup>. Based on the safe water extraction rate of 1%, it can provide heating and cooling for the floor space of 2.8 trillion m<sup>2</sup> of various buildings, accounting for 1% of the total existing floor space or 14% of the new floor space in China. Correspondingly, it can save 8.40 million tons of standard coal and reduce CO<sub>2</sub> emissions by 32 million tons each year. Preliminary statistics show that surface water source heat pumps occupies 11% of China's total renewable energy in 2007 and this number expanded to 33% in 2009, with 2.4 million m<sup>2</sup> of floor space using surface water source heat pumps. China has undertaken various surface water heat energy demonstrations, including seawater source heat pumps at Xinghai Bay in Dalian and at the Olympic Yachting Site in Qingdao, and freshwater source heat pumps at Chongqing Poly Theatre. On the whole, the surface water source heat energy develops very fast in China.

### Case study: Chongqing Poly Theatre---River Source Heat Pump Heating and Cooling Demonstration Project Phase 1

Adjoining the Yangtze River in the east and Jianling River in the south, Chongqing Poly Theatre is located at the heart of Jiangbeizui CBD, Chongqing. Adopting an energy model of “electric cooling plus river water source heat pump plus ice-cold storage plus hot water generating unit” and having a total installed capacity of 115.65MW (not including ice storage), the project provides heating and refrigeration to buildings with a floor space of 1.60 million m<sup>2</sup>, including Chongqing Poly Theatre. Each year, the Project can help reduce CO<sub>2</sub> emissions by 3048 tons, SO<sub>2</sub> emissions by 24.7 tons and dust emissions by 12.3 tons.

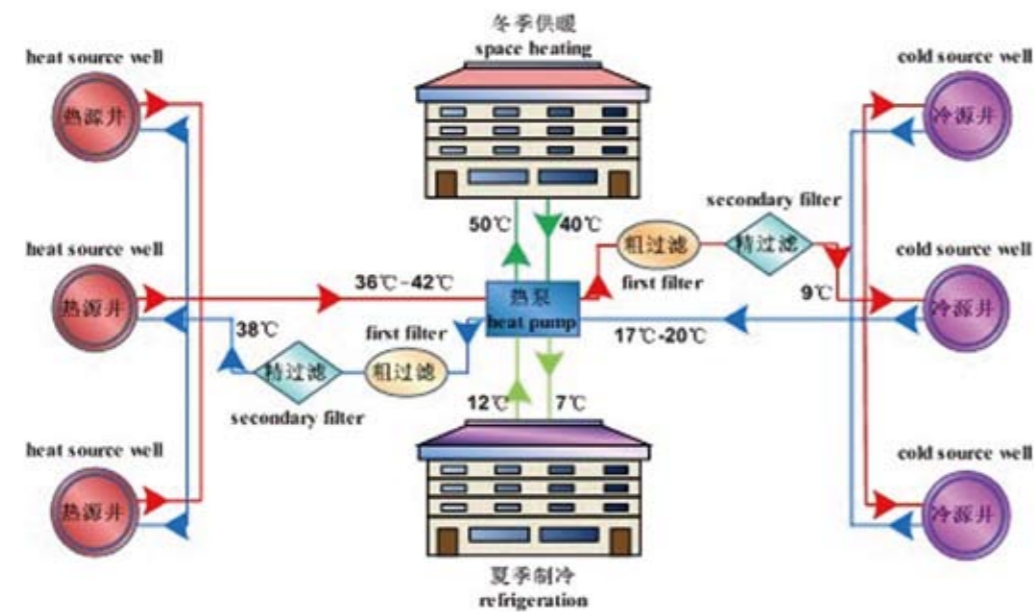
● Chongqing Poly Theatre



### Case 2: Tianjin Historical Cultural Street Geothermal Utilization Project

The Historical Cultural Street in Tianjin is located on the western banks of the Haihe River. Through shallow source extraction-recharging well pairs of aquifers at different depths, the Project uses the temperature differences and heat pump technology to adopt a cycled utilization mode of summer recharging for winter heating and winter recharging for summer cooling to buildings. The operation of heating and cooling periods shows that the cold and hot source wells maintain stable water quality and water level before and after extraction and recharging, with a recharging rate of 100%. The Project has produced impressive effects in protecting the environment, saving energy, maintaining aquifer pressure and improving resources utilization.

● Geothermal Utilization Project at Historic Cultural Street in Tianjin



## New energy vehicles ●●●

Since 2001, a number of universities, research institutions and enterprises in China have been building up a comprehensive R&D framework for new energy vehicles, focusing on the power systems, power battery, drive motor and electronic control systems for hybrid (HEV), pure electric (EV) and fuel cell vehicles (FCV). Thanks to the well-organized, large-scale, high-intensive and on-going R&D efforts, the above-mentioned entities have developed some core technologies, set up technology platforms for power system, formed a pattern of R&D and industrialization for key parts, and conducted in-depth demonstration and technological assessment. At present, over 160 varieties of new energy vehicles have been publicized on China's automobile product bulletins, in addition to 30 state key laboratories and 42 technological standards, paving the way for their industrialization.

The Chinese government is intensifying its efforts to develop new energy vehicle into one of its strategic emerging industries. By the end of 2010, more than 20,000 domestically-made new energy vehicles (like EV, HEV and FCV) will be available in China through the implementation of "New-energy Vehicle Demonstration Program". This will lead to the application of more than 150,000 new energy vehicles at the market, which will rise above 1 million by 2015 and up to 10 million by 2020, indicating the successful fulfillment of strategic technology transformation in China's automobile industry.

### Pure electric vehicles>>>

The new-generation pure electric vehicles widely apply some key technologies like Li-ion batteries, vehicle control, power system matching, smart recharging on-board and fast recharging. A total of over 50 models ranging from mini sedan cars to bus have been developed and publicized in China's new product bulletins. Pure electric passenger cars have achieved an energy consumption rate of 83.8kWh/100km, while braking energy regeneration contributes 18% of pure electric vehicle's driving range, with their power systems withstanding durability tests over an equivalent mileage of 150,000Km. High-speed pure electric cars have been exported in small batches to the European and US markets.



● Chery M1 Pure Electric Car



● BYD E6 Pure Electric Car



● BIT-Jinghua BK6122EV Pure Electric Bus



● Shanghai Sunwin pure electric bus for the World Expo

## New energy vehicle demonstration and promotion >>>

From 2003 to 2008, over 500 new energy vehicles were put into small-scale demonstrative operations in State Grid Corporation and 7 cities around China, including Beijing, Tianjin, Wuhan and Shenzhen, with an operation mileage of over 15 million Km.

During the 2008 Beijing Olympic Games, 600 pure electric, hybrid and fuel cell vehicles jointly developed by FAW, Dongfeng, Chang' an, Chery, Tsinghua University, Shanghai Fuel Cell Vehicle Power Ttrain Corporation and other 13 units were put into operation, running an accumulated total mileage of over 3.70 million Km and transporting passengers of more than 4.40 million person-times, thereby marking the largest demonstrative operation of new energy vehicles in the Olympic history. The demonstration vehicles showed good reliability, and various hybrid electric vehicles achieved a fuel-saving rate of 10%-30%.

In 2009, the first group of 13 cities, participating China's "New Energy Vehicle Demonstration Program", took the lead in using new energy vehicles for public transport, taxi, government service, environmental sanitation, postal services and other public services. By the end of 2009, almost 5,000 new energy vehicles of various models had been demonstrated and promoted across China, with more than 70 new models launched into the market. The demonstration program has significantly boosted private-sector investment in power battery and drive motor. By 2011, a production capacity of 150,000 whole vehicles and key parts will be available in China.

Thanks to concurrent R&D, demonstrative operation and assessment over the past 7 years, all demonstration cities in China have established a diversified demonstration-operation-service system, preliminarily explored new transportation modes with various transport means interacting with one another. Such efforts have continuously improved new energy vehicle technologies, achieved energy efficiency and emission reduction, and accumulated rich experiences of demonstrative operations and technological assessment.



• Taxis at Olympic Hybrid Service Outlets Serve



• Electric Vehicles Serve the Davos Forum in Dalian



• Fuel Cell Sedan Cars Serve Olympic Marathons



• Hybrid Buses Are Ready for Operation

## ●●● High-speed railway technology development in China

### Hybrid electric vehicles >>>

After approximately 10 years of development, hybrid electric vehicles in China now adopt such key technologies as multi-energy power control and braking energy regeneration, which have continuously improved their fuel efficiency and reliability. Depending on different hybrid solutions, these vehicles can achieve an operational fuel-saving rate of 10%-40% on actual road conditions. Hybrid sedan cars can attain a reliability level comparable to that of traditional vehicles. Hybrid bus have seen their average mileage between failures rising from 3,000Km in 2008 to over 4,200Km. To meet the demands of demonstration cities, China has also developed natural gas/ electric hybrid sedan cars and buses, bringing forth more varieties of hybrid electric vehicles in the country. At present, 110 hybrid electric vehicle models have been included in China's new product bulletins, marking the preliminary industrialization.



● Dongfeng Hybrid Bus

● Chang'an Jiequn Hybrid Sedan Car

### Fuel cell vehicles >>>

Fuel cell vehicles, which adopt two unique hybrid fuel cell power systems: energy hybrid and power hybrid, are now available for small batch industrialization in China and for competition at the world market. Fuel cell buses can fully leverage their braking energy regeneration, with a hydrogen fuel consumption of 7.42kg/100Km under urban road conditions. Fuel cell sedan cars have notably more integrated car power systems, whose DC/DC volume per unit power is reduced by 30%, motor control volume per unit power down by 19%, driving range increased from 230Km to 300Km while the hydrogen consumption rate stands at 1.12 kg/100km. These indicators show that their overall vehicle performance is comparable to that of traditional vehicles.



● Tsinghua University-Beiqi Foton Fuel Cell Bus



● SFCV Fuel Cell Car

High-speed railways are “electric vehicles with tracks”. Since 2004, high-speed railways have entered a golden age in China. Currently, 6,552Km of high-speed railways have been built in the country, and the figure will reach 13,000Km in 2012. These include over 8,000Km of 350Km/h lines and more than 5,000Km of 250Km/h lines. By 2020, high-speed railways in China will have a total operating mileage of over 18,000 Km.

On April 18, 2007, China raised the speed of its high-speed railways for the 6th time, to a maximum operating speed of 250Km/h. On August 1, 2008, Beijing-Tianjin Inter-City High-speed Railway started operation, with a maximum speed of 350Km/h. On February 26, 2009, Wuhan-Guangzhou High-speed Railway was put into operation. With a total operating mileage of 1,068Km, the whole line runs through 226 tunnels and 684 bridges, with a maximum speed of 350Km/h and an average travel speed of 340Km/h.

Around the end of 2011, new-generation high-speed trains will be put into operation on the Beijing-Shanghai High-speed Railway Line. With a total mileage of 1,320Km, the line will have a maximum running speed of 380Km/h and a maximum experimental speed of over 420Km/h.

### Case 1: Wuhan-Guangzhou High-speed Railway

High-speed trains can achieve reliable operations under a one-time operation of over 1000Km, a continuous operation of 350Km/h, crossing 226 tunnels and overcoming climate change and environmental conditions with different temperature and humidity. Punctuality rate can reach 98.6%. Train control system has achieved the speed of 350Km/h for the first time, and GSM-R and two-way wireless transmission-based train control, and minimum operational time interval of 10 min.



## Case 2: New-generation High-speed Train

Higher speed: The maximum operating speed is increased from 350Km to 380Km, and the critical speed from 490Km to 550Km. Better energy conservation performance: with outstanding aerodynamic layout, and train operating resistance can be reduced by 6-8%. Better comfort and personalized passenger interface: low vibration, low noise, comfortable and spacious interior design.



## Case 3: 400Km Integrated Experimental Detection Train

Concurrent detection is done at a maximum operating speed of 400Km/h, featuring the functions of integrated detection of track geometry, contact net, ground signal equipment, infrastructure and signal system. Synchronous data transmission between train and wayside and connection with wayside expert analysis database were available for timely maintenance and overhaul.

## ●●● Integrated clean energy utilization at the Beijing Olympic Games

11

In accordance with the three major concepts of “Green Olympics, Hi-Tech Olympics and People’s Olympics”, a large number of advanced and applicable clean energy technologies were brought into large-scale demonstration and application during the Beijing Olympic Games. These included new energy vehicles, green energy and high-efficiency and energy-saving technologies. These technologies provided advanced, reliable and applicable technical support and technical assurance for the successful staging of the Beijing Olympic Games and helped to achieve the goal of “Green Olympics”. During the Beijing Olympic Games, direct CO<sub>2</sub> emissions amounted to 1.18 million tons. During the preparatory and actual staging periods of the Olympic Games, various “Green Olympics” measures for energy conservation and emissions reduction reduced CO<sub>2</sub> emissions by 1.24-1.51 million tons, achieving a carbon balance for the Beijing Olympic Games.

**Demonstrative operation of new energy vehicles:** During the Beijing Olympics and Paralympics, the largest demonstrative operation of new energy vehicles in Olympic history was organized. A total of 595 energy-saving and new energy vehicles of all kinds were put into Olympic transportation services, with an accumulated operating mileage of 3.714 million Km and transporting passengers of 4.4173 million person-times. “Zero emission” transportation was achieved at the central areas of Olympic Park, while “low emissions” were realized in the vicinities of the Olympic venues and on priority transport routes.

**Large-scale integrated application of landscape semiconductor lighting (LED).** At the Water Cube, LED lights have an installed power of 300-400KW, achieving the largest full color, variable scene LED landscape lighting in the world. Compared with traditional lighting, it saves electricity by 60-67%. At the multi-functional broadcasting tower, a total of over 2,000 sets of 24W LED light fittings are used with a maximum installed power of 60KW. Through computerized control, the operating power is less than 30KW, saving electricity by over 50% compared to traditional light sources.

**Large-scale utilization of solar energy technology.** The Olympic venues in Beijing are the architectural complex that consumes the greatest solar power in the world. Solar photovoltaic grid-connected power generation systems have been used in the National Stadium and other 6 Olympic venues, with a total installed generating capacity of over 600KW and an annual power output of 580MWH, equivalent to saving

170 tons of standard coal and reducing CO<sub>2</sub> emissions by 570 tons. On the roads between the Olympic Village and the various venues, solar semiconductor lights have replaced ordinary road lamps. These lights provide lighting to 90% of the lawn lamps and road lamps in the Olympic venues. At the Olympic Village, the solar energy hot water system is well integrated with the roof gardens, providing services to 16,800 athletes during the Olympic Games, then to 2,000 households in the area after the games.

**Regenerative water source heat pump system:** The regenerative water source heat pump system at the Olympic Village extracted heat from the regenerative water at the Qinghe Sewage Treatment Plant, and provided winter heating and summer refrigeration to the Olympic Village. This could save electric power by 60%. Each year, the heating supply can substitute over 8,000 tons of fuel coal.

**Grid-connected wind power generation system.** Wind power generated at the Guanting Reservoir in Beijing is connected with the local grid. At the first phase of the project, 33 wind power generating units are installed, with a total installed generating capacity of 50,000 KW. Each year, these generating units can provide 100 million KWH of green power, equivalent to a reduction of coal consumption by 50,000 tons or the usage of 20 million m<sup>3</sup> of natural gas, reducing CO<sub>2</sub> emissions by 95,000 tons.



## ●●● Integrated clean energy development and utilization at Shanghai World Expo

To highlight the concepts of green Expo and low carbon and to meet the “green and low carbon” requirements for energy use at the 2010 Shanghai World Expo, research and large-scale demonstration has been organized on new energy vehicles, clean energy technologies and LED technologies. Such work has promoted the application and industrialization of clean energy technologies and will help to achieve “zero emission” for passenger transport means and “low emissions” at Shanghai World Expo Park.

**Demonstrative application of 1,000-plus new energy vehicles.** During the Shanghai World Expo, a total of 1,017 new energy vehicles including 196 FCVs, 321 EVs and 500 HEVs will be put into demonstrative operation at the Expo and surrounding areas. This will be the largest commercial operating demonstration of new energy vehicles in the world.

**Demonstration of integrated LED application.** LED landscape lighting will account for over 80% of all the night lighting at Shanghai World Expo Park, which will be lit up by LED and become the largest concentrated LED demonstration zone ever in the world.

**Integrated demonstration of photovoltaic power, buildings and grid-connected power.** Shanghai World Expo Park will have a total installed solar photovoltaic power generating capacity of 4.5MW, displaying the largest integrated photovoltaic, building and grid-connected power generation system in China and even in Asia.



**Commercial application of offshore wind power.** During the Shanghai World Expo, China's first offshore wind power demonstration project, the thirty-four 3MW wind power generating units at the East China Sea Bridge 100MW Offshore Wind Power Farm in Shanghai will be generating grid power and provide green and clean energy to the Expo.

**Concentrated application of river source heat pump technologies.** Inside the Shanghai World Expo Park, river source heat pump heating/refrigeration supply systems will be used in 5 functional zones. This will reduce the overall energy consumption of the cooling and heating source systems for the central air conditioning and ease the "hot island effects" at Shanghai World Expo Park.

**Showcase integrated clean energy applications.** At the Future Exhibition Hall of the Urban Best Practice Zone, integrated clean energy applications including wind power, solar power and biomass energy will be put on show, centering on the theme of "Low Carbon Cities - World Expo in Practice, Shanghai in Action".

