In 2014, CNPC continued to improve its technological innovation system and enhanced its research work and field tests. R&D progress in exploration and development, refining and chemicals, oilfield services, storage and transportation, operational safety, environmental friendliness and cutting-edge technologies strongly supported the growth of our oil and gas businesses.

Construction of Technological Innovation System

In 2014, CNPC further improved its technological research system to reallocate and leverage the innovation resources at its affiliated research institutes, technology centers and regional companies. We also accelerated the construction of technology enablement platforms, resulting in enhanced lab/testing capabilities. A total of 16 platforms were selected as state-level infrastructural enablement platforms. With an improved system and supporting environment for innovation-driven development, CNPC has become a more dominant innovator of China’s petroleum technologies.

Major R&D Advancements

Exploration and Development

Improved geological theories and technologies for gas accumulation in deep paleo-marine carbonates guided the rapid identification of China’s largest monomer uncompartmentalized gas reservoir at Longwangmiao Formation of Moxi Block in Anyue Gas Field.

Innovative geological modeling of salt-related structures and understanding of the formation of deep gas reservoirs resulted in major breakthroughs in exploration depth and engineering technologies of extremely-thick salt layers, supporting the construction of Keshen Gas Field with a reserve of more than one trillion cubic meters.

Our world-leading ASP flooding technologies consisting of six packages, including the R&D and production of surfactant series, had been most widely used by our company. These packages cover the entire development process of oilfields and enable the tapping of high-water-cut and high-recovery-degree oilfields that would otherwise be impossible using conventional technologies. In fact, they have improved recovery efficiency by more than 20% over waterflooding.

Our innovative horizontal well and reservoir stimulation technologies for the development of ultra-low-permeability or tight oil and gas reservoirs helped Changqing Oilfield continue to increase its oil and gas output, which exceeded 55 million tons in 2014.

Refining and Chemicals

We successfully developed hydrorefining catalyst series and technical package for the production of ultra-low sulfur content diesel, which meet the demand for upgrading CNPC’s automobile diesel to the National IV/National V standard.

We developed the capacity of independent engineering design for 10Mt/a refineries and rolled out desulfurization and denitrification technologies for catalytic cracking flue gas.

Delayed coking was used and worked excellently at seven 1Mt/a coking units, marking major progress in the development and application of the technological package for the processing of inferior heavy oil.

A unit enabled by China’s first package of technologies for large-scale industrial ethylene units with independent intellectual property rights has operated for a long period of time. CNPC has become one of the six patent holders of such packages in the world.

Oilfield Services

Regarding geophysical prospecting, GeoEast Software V3.0 became world leading in terms of functionality and performance and boasted much a higher forecasting precision and utilization rate. With more octaves of excitation signals, our low-frequency seismic technologies improved the capacity of lithology and fluid identification.

In logging, our 15-meter one-string logging devices precisely collected all conventional log curves in a single down-hole pass, shortening the time by more than 30%. A multi-frequency MRI logging unit was added to our family of domestically manufactured imaging logging devices that played important roles in the identification and assessment of complex and unconventional oil and gas reservoirs.

In terms of drilling, a 9,000m quadruple-stand AC VFD drilling rig enhanced comprehensive ROP by approximately 15% in field tests. The 12V175 high-performance diesel engine and an automated drill string handling system were developed. We also completed testing of 21MPa/35MPa snubbing operation equipment for gas wells, which can meet the operational demand of 60% of our gas wells.
Oil & Gas Storage and Transportation

Trial production of 1,219mm X90 and 1,422mm X80 steel plate rolls, sheets, welding pipes and associated fittings, was completed, technically enabling the 1,422mm pipes to be used on the eastern route of the Russia-China Gas Pipeline.

Regarding equipment manufacturing, we completed industrial testing of a 20MW electric compressor unit, developed a 30MW gas-driven compressor unit and SCADA software V1.0, and finished ex-factory verification of domestically manufactured heavy-duty oil transport pumps, mission-critical valves and actuators, and flow meters.

We independently developed a double-circulation mixed-refrigerant process and a circulated multi-stage single-component-refrigerant process for gas liquefaction, and developed the capability to manufacture key equipment, including refrigerant compressors, cold boxes, and low-temperature valves, and build 3.5Mt/a gas liquefaction facilities.

HSE and Energy Conservation

Our special low-carbon R&D led to the development of digital oil pumping units which have been extensively deployed in Changqing Oilfield. We originated recycling of wastewater from heavy oil thermal recovery without removing silicon, resulting in savings in terms of capital investment and operating costs. Important progress was made in heating furnace efficiency. Methods were created to forecast energy conservation potential and assess energy and water conservation in oil and gas fields, and technologies were in place to optimize heat supply systems in our staff communities.

HSE development included technologies for the blowout response of oil and gas wells and disaster-prevention evaluation of large-scale petroleum storage, in addition to two lightning-proof products for external float-roof tanks and six absorbent materials for river oil spills.

Cutting-edge Technology Research

CNPC pays great attention to basic research and advanced research of the industry’s cutting-edge technologies in order to ensure future oil and gas supply. In 2014, we made remarkable progress in the research of unconventional hydrocarbon exploration and development technologies and state-of-the-art refining and petrochemical techniques.

Our basic and proactive research on unconventional and deep oil and gas enriched the geological theories of hydrocarbon generation, drainage, migration, and accumulation mechanisms, improved the parameter system and standards for a new round of resource assessment, and made major progress in lab simulation technologies. We independently developed new technology for the lab testing of three-phase relative permeability. Helping us precisely describe the complex seepage patterns of underground crude oil, the technology will provide a new core approach and theoretical guide for optimizing the development of oil and gas fields. We researched molecule-scale-management-based refining technologies. With a set of methods for the analysis and description of the composition, structure and properties of heavy oil, we drove heavy-oil chemistry towards molecule-scale methodology, and became a world leader in the basic theoretical study of heavy oil processing.

Technological Cooperation

We communicated and worked with IOCs, NOCs, high-end manufacturers, and high-tech players in EOR, unconventional oil and gas development, treatment and recycling of oil-containing sludge, and new engineering technologies. Progress was made in R&D projects, skills training, and technical exchanges. A number of outcomes from our joint R&D efforts have been put into commercial application. We set up a high-level alliance with the Chinese Academy of Sciences (CAS) in line with China’s innovation-driven development strategy, and focused on six prioritized research projects including “R&D and application of elastic wave seismic imaging technologies” for synergistic innovation among industries, colleges, research institutes and enterprises. We also participated in the communication activities of international and industrial organizations to advance our scientific and technological cooperation.

We applied for 5,095 patents, including 2,358 invention patents, both at home and abroad, and were granted 4,049 patents, including 914 invention patents. Nine of our major achievements won China’s national science and technology awards. In particular, “Key Technologies for the Construction and Operation of China’s Strategic Oil and Gas Channels” was awarded the First-class National Scientific and Technological Advancement Award.
Technical Packages for Alkaline-surfactant-polymer (ASP) Flooding Put into Industrial Application

Research on ASP flooding technologies and large-scale field tests have been carried out in Daqing Oilfield with good application results. The technical packages and standard specification system of ASP flooding for EOR were formed. Daqing has thereby become the only oilfield in the world that realized the commercial application of ASP flooding.

Six innovative technical packages have been developed for ASP flooding: (1) A package of diversified technologies for the R&D and production of surfactant series; (2) Technologies for the design of the reservoir engineering program. The reservoir engineering program design method was developed for the first time and put into large-scale application; (3) Technologies for whole process tracing and control. The principle of staged control and implementation standards of main measures were established; (4) Preparation and injection techniques featuring “centralized preparation and dispersed injection” were developed, reducing the occupied area by 50% and costs by 30% compared with the original techniques; (5) Anti-scale lifting technologies. The mechanisms and characteristics of scale forming in oil wells were figured out, and an expert real-time diagnostic system was developed; and (6) Technologies for produced liquid treatment. Difficulties in produced liquid treatment were revealed, with dewatering equipment and treating agents optimized, treatment effects improved, and processing costs reduced.

Oil production by ASP flooding in Daqing Oilfield exceeded 2 million tons in 2014, with recovery efficiency improving by more than 20% on the basis of waterflooding. ASP flooding has become one of the major EOR technologies for Daqing Oilfield, which can help boost oil production to 25 million tons during the 13th Five-Year Plan period and can be applied at similar oilfields at home and abroad.