2012 saw our continued efforts in technological innovation, focusing on solutions to key technical bottlenecks constraining the development of our core businesses. With boosted capacity in independent innovation and technical competitiveness, we achieved sound growth in oil and gas operations.

**Oil and Gas Exploration:** We innovated seismic data acquisition technology featuring high-density wide-azimuth observation and pre-stack depth migration, and made breakthroughs in boosting drilling speed in ultra-deep and complex formations in mountainous areas. All of these have effectively guided natural gas exploration in the Tarim Basin.

**Improved understanding of reservoir-forming theory for deltas in inland lake basins** helped us identify a number of new oil and gas fields in western China, further consolidating our resource base.

Progress was made in molecular geochemical tracing and identifying of complex oil/gas reservoir forming, providing technical support to some major discoveries in deep, marine-facies carbonates and unconventional formations.

**Oil/Gas Field Development:** Matching technologies for potential release and EOR by chemical flooding in the ultra-high-water-cut period delivered remarkable results in field tests and applications, helping Daqing to maintain stable production.
Technical packages for the development of ultra-low permeability reservoirs have been improved and major breakthroughs were made in horizontal well drilling, completion and staged fracturing, resulting in much higher output per individual well in Changqing Oilfield.

Supporting technologies for tapping ultra heavy oil in Xinjiang’s Fengcheng Field were improved and saw favorable field test results, enabling large-scale development of this hard-to-tap resource.

In Jilin Oilfield, years of study and tests have resulted in a series of matching technologies for CO₂, gas field development, carbon emission reduction, EOR by CO₂, flooding and underground storage of CO₂.

**Refining and Chemicals:** We made new progress in the R&D of inferior heavy oil processing techniques and saw their profitable application at our petrochemical companies in Liaohe, Karamay and Guangdong.

A breakthrough was achieved in cracking catalysts development, the hydrocracking catalysts were successfully put into industrial application for the first time, and a major step forward was made in the R&D of a family of refining catalysts, significantly facilitating the upgrading of our oil products. We successfully developed a technical package for 10Mt/a atmospheric-vacuum distillation units and put it into use at Sichuan Petrochemical. The technical package for 600kt/a ethylene units was successfully applied in the 1.2Mt/a upgrade/expansion ethylene project at Daqing Petrochemical. We also developed China’s first all-in-one technical solution for 450kt/a synthetic ammonia and 800kt/a urea production with natural gas as feedstock and applied it at the fertilizer plant of Ningxia Petrochemical.

**Oilfield Services and Equipment Manufacturing:** We achieved continued progress in the design and manufacturing of offshore drilling rigs, as demonstrated by the launching of the construction of our first 400-feet jack-up rig. Technology for boosting drilling speed saw remarkable performance in Kuqa mountain front in the Tarim Basin. By using precise PCD (pressure controlled drilling) technology, the penetration rate was dramatically increased in drilling the fractured carbonate strata in Tazhong Oilfield.

Our matching technologies for multi-stage fracturing with coiled tubing in horizontal wells supported the development of unconventional hydrocarbons. The 15000-channel G3i seismograph and the remote detecting acoustic reflection imaging logging unit were developed and widely used.

To improve identification of sweet spots, large-area joint pre-stack time migration and 3D seismic data acquisition and processing in ultra-large complex surface areas were adopted, resulting in the establishment of an integrated high-precision, full-3D digital Qikou sag. This has helped expand our reserve base.

Key equipment was developed for natural gas pipelines and X80 large deformation-resistant welded pipes. Technical know-how and equipment for natural gas liquefaction became available domestically, and was applied at LNG projects at Ansai City in Shaanxi Province and Tai’an City in Shandong Province.

**HSE and Energy Conservation:** A boiler technology has been developed in which wastewater from thermal recovery of heavy oil can be recycled without the need to remove SiO₂, thereby chemical costs and sludge generation can be reduced greatly. The promotion of energy system optimization technologies in the refining sector resulted in significant energy saving. Four series of technologies for the treatment of oil-containing sludge took shape, namely, fuel conversion and incineration of heavy oil sludge, tempering and centrifugal dewatering of chemical flooding sludge; chemical washing of ground oily sludge; and pyrolysis and carbonization of refining-generated waste. We also developed technologies for sludge-to-solid fuel and co-firing with coal, which have been applied in Liaohe Oilfield and greatly facilitated the bio-safety disposal of sludge and its recycling use.

In 2012, we continued to improve our S&T foundation platforms. The Key Lab of Underground Oil and Gas Storage and other projects under construction were promoted as planned. The platform for CO₂ flooding & underground storage and well logging outfits were listed as China’s Energy Innovation Development Projects. The Pilot Test Base for Development of High-Sulfur-Content Gas Reservoirs was elevated to a state-level R&D (test) center. By the end of 2012, CNPC had 15 state-level key labs/research centers.

We actively promoted S&T communication and cooperation with research institutes and universities at home and abroad, and national and international oil companies in the domains of oil and gas exploration and development, refining and chemicals, and oilfield services. We also participated in activities organized by NOC, IEF, IGU, AAPG, SEG, and SPE to provide us with more opportunities for scientific and technological cooperation.

In 2012, we applied for 4,011 patents (including 1,605 invention patents) and were granted 2,998 (692 of which were invention patents). In addition, 123 Know-how were recognized and 47 software copyrights were registered. Five of our scientific and technological achievements won the National Science and Technology Advancement Award, of which "Key technologies for multi-stage fracturing and stimulation in horizontal wells and their industrial application" won the first prize, and "Major discovery in metamorphic rocks and the efficient development technologies", "Development and industrial application of high-end internal combustion engine oil compounds", "Technologies and industrial application of ultra-high-temperature drilling fluids", and "Technologies of tower plates featuring high-flux and efficient 3D mass transfer and their application for energy conservation in chemical production" won second prizes.
Molecular geochemical tracing of complex oil/gas reservoir forming

This technology developed by CNPC Research Institute of Petroleum Exploration and Development (RIPED) addresses the difficulty in predicting hydrocarbon properties and understanding their enrichment levels and distribution laws in the key exploration areas of China, such as deep and ultra-deep, and carbonate and unconventional reservoirs. It has provided a theoretical basis for quantitative evaluation of the potential of multi-source hydrocarbon accumulation, dynamic tracing of hydrocarbon generation-migration-accumulation processes and related secondary changes, and effective prediction of the properties of major formations and hydrocarbon fluids. It involves four technology series, i.e. using monomers and isotopes of hopanes and steranes as indicators, tracing of nitrogen compounds, dating of monomers and inclusions, and using adamantanes to indicate secondary changes in the accumulation process. The corresponding system of evaluation parameters that is created enables the identification of accumulation factors such as kerogen degradation on the high-/post-mature stage, gas from oil and residual bitumen cracking, and the period of complex hydrocarbon migration, accumulation, and forming.

It has played an important role in theoretical studies on multi-stage hydrocarbon accumulation and late-stage transformation in marine, karst and reef reservoirs, large-scale gas generation, migration and accumulation mechanism in the late-stage deep reservoirs of the Kuqa depression, abundance, near-source charging and continuous accumulation of unconventional resources including shale gas and tight oil/gas, as well as in discoveries in the exploration of deep and ultra-deep, carbonates and unconventional resources.

Theories and technologies for marine carbonates exploration

We have established hydrocarbon accumulating theories focusing on large scale gas generation in the high and post-mature stage due to liquid hydrocarbon retention in source rocks, bedding/inter-bed karstification mechanisms, and assemblage patterns. Meanwhile, exploration technologies based on quantitative description of fracture-cave reservoirs and identification of reservoirs and fluids have been developed, expanding the resource potential of carbonates and improving the accuracy of reservoir prediction and the success rate of exploration wells.

These theories and technologies have facilitated exploration activities in the Tazhong, Halahatang, Gucheng, Anyue, Longgang, and West Jingbian areas, resulting in breakthrough discoveries and a significant increase in reserves in the exploration of marine carbonates.

Exploration and development technologies for low-pressure and ultra-low permeability reservoirs

Changqing Oilfield Company developed a series of exploration and development theories and techniques for low-pressure and ultra-low permeability reservoirs and identified new sedimentation models such as outflowing shallow delta and deepwater sandy debris flow, to help discover large oilfields including Jiyuan and Huaqing, despite the widely held view that it was unlikely to find large oilfields in the central part of inland lake basins.

- The techniques support single-well production appraisal and waterflooding dynamic predication in ultra-low permeability reservoirs, with the prediction accuracy increasing from 70% to 90%.
- A quick productivity prediction/appraisal system based on log data is developed for ultra-low permeability reservoirs, with the coincidence rate increasing by more than 15%.
- Innovative techniques such as fine description of fractured ultra-low permeability reservoirs, separate layer advanced water injection, and integrated profile control have contributed to an increase of 7% in water drive swept volume, 1.5% in recovery efficiency and 10% in waterflood producing reserves.
- A series of technologies have come into being, including screening of abundance zones and well-siting in tight and heterogeneous gas reservoirs, designing of horizontal development well pattern and trajectory, and dynamic tracking and prediction in ultra-low permeability reservoirs, effective and massive development of reservoirs by horizontal wells, and multi-cluster, multi-stage and multi-fracture fracturing of horizontal wells in ultra-low permeability reservoirs. In addition, innovative surface processing and standard construction procedures have been introduced.

Development technologies for ultra-deep and ultra-high pressure condensate gas reservoirs

Tarim Oilfield Company achieved a breakthrough in tapping ultra-deep, ultra-high pressure condensate gas fields, delivering a range of techniques, including integrated fracture evaluation and prediction; precise modeling for fractured, low porosity and ultra-low permeability reservoirs with a sparse well pattern; bottomhole pressure calculation, digital well testing and productivity appraisal for fractured, stress-sensitive condensate gas reservoirs; well drilling and completion for low-permeability, fractured and ultra-high pressure condensate gas reservoirs; and cable-based testing for ultra-deep, ultra-high pressure condensate gas reservoirs.

The concept of double-barrel perforation gun was introduced for the first time in China to develop Ø127mm high temperature, ultra-high pressure, full-bore perforator and matching tools. In addition, a high-temperature acidification inhibitor for super 13Cr tubing was designed and manufactured and the standard processing flow for high pressure condensate gas was developed.
This series of techniques enables the efficient development of Dina-2 gas field and facilitates the development and building of ultra-deep, ultra-high pressure gas fields such as Dabei and Keshen.

**High-density wide-azimuth seismic techniques for complex mountainous areas**

These techniques developed by BGP and Qinghai Oilfield Company adopt a "field + indoor" noise suppression approach, and are in line with three basic rules, i.e. first-arrival time error less than a quarter of the valid signal period, non-aliasing line interval, and cut-off frequency attenuation of a valid signal less than 3 dB. They lead to high precision geographic data-based irregular 3D seismic acquisition in complex mountainous areas, efficient implementation in mountainous areas, marker-based integrated static correction in shallow layers, and 3D seismic data processing focusing on pre-stack noise suppression.

High-quality migrated image data has been obtained, using a wide-azimuth surveying system with 468 folds (max), high source line density, 24 receiver lines, and an aspect ratio of 0.7 or higher. This data helped identify Yingdong-1 Structure and technically supported the discovery of the 100-million-ton Yingdong Oilfield.

**Technologies and equipment for ultra-deep well drilling**

CNPC Drilling Research Institute, Bohai Drilling Engineering Company and Tarim Oilfield Company developed a series of mission-critical technologies and equipment for ultra-deep well drilling.

- A streamlined and optimized casing program solves difficulties caused by the coexistence of multi longitudinal pressure strata series, mass gravel layers and high-pressure saline layers in ultra-deep well drilling, resulting in a higher target encounter rate.

- Innovative organic salts, temperature-tolerant drilling fluids and new oil-based mud help tackle challenges such as long-section mudstone necking and salt-gypsum bed creepage occurring in ultra-deep wells, significantly reducing accidents caused by complex downhole conditions.

- Automatic vertical drilling prevents deviation and ensures fast drilling in high-steep structures.

- Gas-based underbalanced drilling techniques remarkably boost drilling efficiency in the upper strata and increase the discovery rate in deep strata in ultra-deep wells.

- High-efficiency rock breaking techniques allow for a faster penetration rate in deeper strata, thus reducing the drilling period of ultra-deep wells.

- Cementing techniques in huge temperature differences effectively improve the long-section cementing quality of deep wells, leading to prolonged wellbore life.

- Pressure controlled drilling (PCD) techniques solve the problem caused by the narrow density window in ultra-deep wells.

- The ZJ-5850 8000-meter rig was developed, reducing drilling costs while safeguarding production.

**Imaging logging tools**

The imaging logging tools independently developed by CNPC Logging includes micro-resistivity scanning series and array induction series. These tools are used in combination with precise image processing and interpretation techniques.

With technological breakthroughs in self-adaptive plates and in a dynamic resistivity measurement range as wide as 10,000 ohm-meters, micro-resistivity scanners feature a working temperature/pressure of 175°C/140 MPa at maximum, and have been successfully used in 7,000m-deep wells at Tarim Oilfield.

Array induction tools with a highly reliable coil system and fast synthetic focusing capabilities have replaced dual induction logging devices, and perform well in quantitative saturation evaluation of low porosity, low permeability reservoirs. With innovative mechanical and software combined focusing and monitoring in addition to multi-frequency nanovolt-scale measurements, the array lateral logging unit provides information about lateral formation resistivity with a vertical resolution of 0.3m.

Through a unified high-speed transmission interface, quick integration of array induction tools with conventional tools, or micro-resistivity scanners with array acoustic instruments is possible, to achieve much more efficient logging and cost-saving exploration and development.

By the end of 2012, 240 imaging logging units had been used more than 6,800 well-times at more than a dozen oilfields including Changqing, Qinghai and Tarim, resulting in an average 5% increase in reservoir identification accuracy.
Technologies and equipment for high-grade steel, high-pressure, large diameter and long distance pipelines

We made breakthroughs in the R&D of technologies and equipment for high-grade steel, high-pressure, large diameter and long-distance pipelines. The fracture control approach for X80 steel pipes has been worked out, marking an important technological advance in China’s long distance, large diameter gas pipelines in three aspects, i.e. material science, transportation and construction. A series of engineering techniques for X80 steel long-distance pipelines with a working pressure of 12 MPa have been developed. X80 steel pipes have been made for the first time in China. The first two 20-megawatt electric compressor units have been developed for industrial application testing; the first 30-megawatt fuel-driven compressor unit was developed; and the first 30 40”/48” high pressure, large diameter fully welded ball valves (600lb and 900lb) have been developed. These products have been used in the Second and the Third West-East Gas Pipelines and greatly reduced construction costs.

Hydrocracking catalysts

Hydrocracking is the process whereby distillates are converted into China V clean-burning diesel and 3# jet fuel with a sulfur content of less than 10μg/g. Its tail oil is a high-quality feedstock for ethylene cracking and the production of lube base oil.

CNPC Petrochemical Research Institute has enabled the modification of DAY zeolites through organic coordination, DQ-35 zeolite synthesis in concentrated systems, composition of carrier materials, and preparation of hydrocracking catalysts. With these key technologies, challenges faced in the coordination between hydrotreating and cracking have been addressed. Hydrocracking catalyst PHC-03 which has been developed boasts stable activity, a wide choice of medium oil, and excellent isomerization. A test for industrial application was conducted in the 1.2Mt/a hydrocracker at Daqing Petrochemical in 2012. The test delivered satisfactory products, with a yield rate approximately 3% higher for diesel and jet fuel, a 5°C+ decrease in the condensation point of diesel, and a drop in BMCI value of tail oil by 2.

Package of technologies for large ethylene plants

After years of research, China Huanqiu Contracting & Engineering Corp independently developed an industrial solution for large-scale ethylene units. The solution addresses a number of technical issues, including expression of a large amount of unidentified petroleum distillates in the quench system, calculation of stress in relation to pyrolysis gas in the cracking furnace and thermal expansion of ultra-high pressure steam piping, and binary interaction parameters of quantum gases such as hydrogen. Models were created for C₂ hydrogenation and C₃ hydrogenation and major breakthroughs were made in cracking, dielectric and cold box technologies. In 2012, the solution was applied to a newly built 600kt/a ethylene unit at Daqing Petrochemical and the unit yielded qualified products.
Ethylene unit at Daqing Petrochemical