



Technology and Innovation

In light of its business development program, the company has deepened R&D reforms and stepped up talent development in a bid to foster innovation on all fronts and create a new engine for growth.

Technological innovation is the key driver for our high-quality growth on the way to build a world-leading integrated international energy company. In 2020, in line with the principle of “Support current business and lead future development”, we continued to unleash the power of innovation by increasing R&D spending, optimizing allocation of R&D resources, beefing up R&D efforts on core technologies and deepening integration of digital technology into the oil and gas value chain. A number of technological advances were achieved in “stuck-point” areas, applied fundamental research, and advanced technology reserve.

Construction of Technological Innovation System

We continue to push ahead with the construction of our technological innovation system featuring multi-tier and multi-direction, to support the growth of our business units. With on-going investment, improved management and stronger team building, our technological supporting system becomes fledged gradually.

In 2020, we continued to optimize the institutional framework for innovation governance to bolster the strategic role of R&D in business growth. We emphasized the leading role of expert committee in decision-making and approval procedures, set up cross-sectoral, cross-disciplinary R&D teams and pushed ahead with the deployment of overseas R&D centers, and kept improving conditions and platforms for conducting R&D work.

Project-based Management was widely adopted. Expert positions were identified and appointed for key R&D projects; a category-based evaluation system was introduced; dividend incentives were piloted at some R&D projects. The management reform for core R&D projects advanced steadily; project managers were selected openly company-wide; the most competent team leaders were appointed to be in charge of the R&D efforts for “stuck-point” technologies.

The construction of a number of R&D platforms was completed, including the National Energy R&D Center (Laboratory) for Long-distance Pipeline Technology & Equipment, National Energy R&D Center for LNG Technology, National Engineering Laboratory for Oil & Gas Pipeline Transportation Safety, CNPC Key Laboratory of Heavy Oil Processing, CNPC Key Laboratory of Oil and Gas Business Chain Optimization, and CNPC Key Laboratory of Market Simulation and Price Forecasting.

As of the end of 2020, we had 84 research institutes, 54 key laboratories and testing centers, and 21 national R&D platforms covering upstream, midstream and downstream activities. We had 30,013 scientists and researchers, including 23 academicians of CAS and CAE, 185 senior technical experts and 468 technical experts.



Research institutes

84



Key laboratories and testing centers

54

Top 10 technological advances in 2020

- Innovations in risk exploration and evaluation technologies led to strategic breakthroughs in oil and gas discoveries
- Large-area high-abundance shale gas enrichment theory guided the building up of a trillion-cubic-meter-reserve gas province in southern Sichuan
- Nano oil displacement technology helped unlock potential, reduce costs and stabilize production in mature oilfields with low/ultra-low permeability
- The eSeis nodal land seismic acquisition system reached the world-leading level and realized industrialization
- Successful development of 3D induction imaging logging tool led to breakthroughs in anisotropic reservoir evaluation
- Automatic cementing technology and equipment improved operating quality and efficiency
- 3D big-platform horizontal well drilling facilitated the scale development of shale oil
- Automated construction and digital pipeline technology supported the construction of the East-Route of Russia-China Gas Pipeline
- R&D and industrial application of aviation biofuel production technology
- World's first diesel adsorption and separation technology and equipment put into industrial application

Improve quality and efficiency through technological innovation

The company has given a massive boost to technological innovation, commercialization and deployment. In 2020, a total of 60 new techniques were rolled out in E&P, geophysical prospecting, well logging, well drilling and completion, oil production and reservoir stimulation etc.; new techniques and new products were widely deployed and licensing of catalyst solutions was implemented in the refining and chemicals sector.

Major R&D Achievements

In 2020, targeting technological frontiers and bottlenecks, we launched a number of R&D projects to explore solutions for “stuck-point” issues, key technologies, key field tests and fundamental research areas and reached major technological milestones in E&P, engineering & equipment, shale gas, tight oil (shale oil) and new energies etc.

E&P: R&D efforts were focused on enhancing efficiency and profitability. New understandings were obtained on shale oil reservoir forming theories and ultra-deep oil and gas reservoir forming theories. New advances were made in developing EOR techniques for ultra-low permeability reservoirs, new polymers and numerical simulation software etc. These achievements supported exploration breakthroughs and discoveries in the Tarim, Junggar, Ordos, and Sichuan basins to ensure growth in oil and gas outputs.

Refining and Chemicals: The transformation and upgrading in refining and chemicals sector picked up pace; R&D efforts for value-added products were beefed up; Big Refining/Big Ethylene technologies were developed and applied; refineries saw a shift in production from fuels to chemicals; raw materials were becoming low-cost and diversified while refined products were more targeted to high-end and specialized applications. A 400kt/a adsorption and separation unit for diesel was designed and completed.

Oilfield Services: Our service capabilities were bolstered with new breakthroughs in high-end equipment, tools, software and materials, including the GeoEast system, 3D induction logging tool, 7000HP electric fracturing skid and high-performance dissolvable bridge plug etc. We pressed ahead with technological upgrading and further improved efficiency-enhancing solutions for key reserves and production areas.

Frontier Technology: R&D efforts were focused on exploration, cost-efficient development, clean fuels production and high-end equipment manufacturing. Significant progress was made in applied fundamental research, generic/core technologies and advanced technology reserve study. Remarkable results were achieved in E&P, refining and chemicals, oilfield services, natural gas, new materials, energy conservation and environmental protection.

New Energy/New Business Areas: R&D plans were made to promote new energies/new business areas such as geothermal, hydrogen energy, biomass energy, underground coal gasification; R&D efforts in CO₂ flooding, carbon capture and storage were beefed up; significant progress was achieved in related industrial tests to facilitate green development.

Digital Transformation and Intelligent Operation

The company has been actively promoting digital transformation and intelligent operation and used digital technologies such as cloud computing, Internet of Things, 5G, big data and artificial intelligence to facilitate business restructuring, management mode reform and business model innovation, improve core competences, promote business transition and create value.

In 2020, Kunlun Digital Technology Company was set up to create an open, knowledge sharing and innovation ecosystem supporting digital-intelligence transformation, and bolster our services capabilities in the process of digital industrialization and industrial digitalization. "Dream Cloud", the first independently developed shared cloud platform in China's oil industry, has been upgraded and deployed to enable important changes in upstream decision-making, productivity improvement and cost reduction, reserves and production growth, efficiency enhancement and shift on production organization model. Information technology has been further integrated into business operation to build smart oil/gas fields, intelligent refineries, smart marketing and intelligent engineering.

Technological Cooperation

We continue to deepen strategic partnership and carry out technological exchange and cooperation with IOCs, NOCs, international academic bodies, industrial organizations and research institutes from home and abroad to jointly promote theoretical innovation and technological advance in the oil industry and facilitate the "going out" of CNPC technologies.

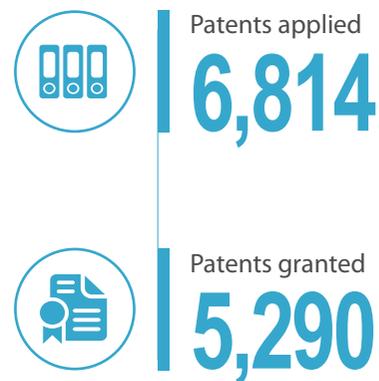
In 2020, CNPC and Saudi Aramco launched a range of technical exchanges in key areas such as refining techniques, molecule management and smart refinery and reached consensus on a number of issues. Despite COVID-19 impact, we held video conferences and webinars with international peers, including Total, Equinor, Rosneft, and Gazprom to promote the two-way flow and openness of technical resources, facilitate exchanges and cooperation in EOR, produced fluid treatment and recycling, coalbed methane E&P and catalytic cracking catalysts.

We have been partnering with domestic research institutes and universities to carry out technical research and personnel training in the field of oil and gas. In 2020, CNPC and Southwest Petroleum University set up an "innovation combo", a platform for further consolidating production, academy, research and commercialization resources, tackling bottlenecks in E&P activities and providing theoretical and technical support in meeting the needs of key E&P areas. We also made headway in strategic cooperation with the Chinese Academy of Sciences and China University of Petroleum, with a focus on frontier E&P technologies, new materials and new energies etc.

S&T Awards and Intellectual Property Rights

The company's review system for S&T awards is fully aligned with the national review system. In 2020, the 4Mt/a Indirect Coal Liquefaction Technological Package and its Commercialization received the First Prize of the State Science and Technology Progress Award. We also received two second prizes of the State Science and Technology Progress Award and one second prize of the State Technological Invention Award. At CNPC, we stress the importance of the protection and enforcement of intellectual property rights. In 2020, the company filed 6,814 patent applications (including 4,664 patents for inventions) and was granted 5,290 patents (including 1,577 patents for inventions). An open platform for R&D resources has been in place to promote sharing of research results, laboratory data and facilities.

The company continues to build up its standardization system and participate in the standard-setting activities in frontier technologies and areas where we enjoy strength. In 2020, we led the formulation of one international standard, i.e. *Natural gas - Upstream area - Determination of Composition by Laser Raman Spectroscopy*, and participated in the revision of six international standards. We were granted the organizer prize of the China Standard Innovation Contribution Award and four project prizes jointly granted by State Administration for Market Regulation and Standardization Administration. In addition, we have been playing an active role in forming the Group Standardization Committee of the China Petroleum Society to work with industrial peers in promoting progress in group standardization for the oil and gas industry.



Drive high-quality growth through digital transformation

The digital economy is opening up an era of significant transition. Deep integration of information technology into industrial technology is reshaping our production organization and operation mode, leading to industrial revolution and transformation with mushrooming new industries, new business forms and new models. At CNPC, we underscore digital transformation as a strategic step to modernize our corporate governance system and capabilities by promoting integration of Internet, big data and artificial intelligence into oil and gas operations, in a bid to foster new growth, create new momentum and drive high-quality development.

Over the past two decades, we have created and applied 80 IT integrated systems covering production management, operation management, general management, infrastructure components and network security, marking two milestones in the company's IT capabilities, i.e. from distributed to centralized, and from centralized to integrated.



Routing inspection by drones at Changqing

Digital Transformation Goals

Digital CNPC will be achieved by the end of the 14th Five-Year Plan period by leveraging real-time operational data acquisition based on automated sensing, access to internal and external data based on full connectivity, and optimization of execution and operation efficiency based on digital technology. A closed-loop system integrating the physical form of CNPC with its digital twin will be developed to promote two-way connectivity between the tangible business operations and the digital world. A mechanism for linking internal and external activities, information sharing and collaboration will be created to facilitate cost reduction, efficiency improvement, collaboration and sharing, ongoing innovation, risk mitigation and smart decision-making and enable continuous improvement in per-capita productivity and asset profitability.

Digital Transformation Trends

Digital technology will be integrated into products, services and processes of the oil and gas value chain to drive changes in the company's development concept, working pattern, operation management, R&D and institutional framework etc. and build new capabilities in smart production, network-based collaboration and individualized services, in a bid to usher in new business models, production forms and industrial ecosystems driven by users, data and innovation.

Digital Transformation Framework

Based on a value-oriented, strategy-led, innovation-driven and platform-supported principle, the company's digital transformation plan will be focused on business development, management change and technology empowerment. An industrial internet system and an applied ecosystem centered on cloud computing will be established, in a bid to create a "Two-in-One" strategic digital transformation framework.

Further integration of information technology into business operation

	Aim	Application
 <p>Smart oil and gas field</p>	<p>Based on perception, interconnection and data fusion, achieving a new oilfield business model of "Real-time Monitoring, Smart Diagnosis, Automatic Handling and Smart Optimization" in the production process.</p>	<p>All-encompassing information systems, including an IoT-based production system and the Collaborative Research Environment, were launched at Xinjiang Oilfield to monitor real-time production dynamics and facilitate business activities. Intelligent analysis was promoted in the decision-making process.</p>
 <p>Intelligent refinery</p>	<p>Improving the ability of perception, analysis and optimization, prediction and coordination of refineries to build a new smart refining model featuring efficient supply chain, lean operation, safe work control and interconnected operation and maintenance.</p>	<p>An information system covering management, production execution and operating control was in place at Changqing Petrochemical to enable automated operation, lean management and coordination in production, equipment, HSE and other business areas.</p>
 <p>Smart marketing</p>	<p>Based on IoTs, big data, and artificial intelligence, building the digital system of people, vehicles and life, and achieving the goal of "smart marketing, digital operations and integrated management".</p>	<p>Shanghai Marketing is trying to create a digital ecosystem and realized targeted retailing with technologies such as big data and artificial intelligence.</p>
 <p>Intelligent engineering</p>	<ul style="list-style-type: none"> ■ Building an intelligent support platform for drilling engineering lifecycle to improve risk control, operating quality and efficiency ■ Implementing intelligent wellbore techniques to enable real-time, visualized and remote surface/downhole monitoring in the process of drilling and completion ■ Building smart operation sites, including smart drilling and digital seismic crews 	<p>Leveraging CNPC's engineering intelligent support system, the digital transformation and intelligent development of our engineering services has shown positive results. As of the end of 2020, the data platform had covered 1,124 wells and solved 4,300 on-site problems remotely, with a 47.93% speed boost in complex troubleshooting.</p>