

## Technology and Innovation

Focusing on self-reliance in top-notch technologies, we embrace innovation as the key driving force for development and promote comprehensive innovation centered on technological advances. The Company has deployed the innovation chain throughout the industrial chain, leveraged the innovation chain to improve the value chain, built up innovative capacity on all fronts, created the new growth engine and strived for high-quality development.



## Technological Innovation System

In 2021, the Company continued to deepen the reform of its framework for innovation governance and improved the technological innovation decision-making system. Progress was made in technological commercialization and breakthroughs were achieved in the integrated reform of “demonstration enterprises in R&D reform”. As of the end of 2021, the Company has set up a total of 93 research institutes, 55 key laboratories and testing centers, and 21 national R&D platforms. We have 29,803 researchers, including 24 CAS and CAE academicians.

### Capacity building on Independent Innovation

Our independent innovation capacity was further boosted. Innovation is a top priority for the Company. We have identified the directions and key areas of our R&D activities on core businesses, aiming to build up our own innovative capacity. A number of landmark innovations in theory and technology, core technologies, and equipment and software products have been achieved, highlighting our leading position in China’s oil and gas innovation system.

The R&D team enjoys a stronger momentum. The Company has made headway in building world-class research institutes and a world-class innovative enterprise in an all-round way and improving our opening-up, collaboration and sharing mechanism, the mechanism to train & groom, attract & pool, appraise & motivate, and use & develop talents, R&D talents evaluation system, as well as R&D incentives to create a stronger innovation momentum for R&D personnel.

### Progress in Technology Platforms and Innovation

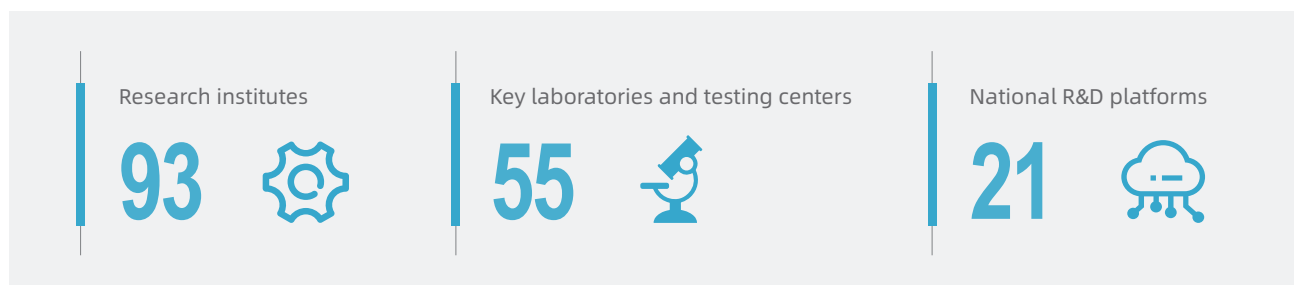
We saw overall progress in technology platforms. The Big Data Security Research Center of Petroleum and Petrochemical Industry, as part of the National Engineering Big Data Security Lab, was set



Researchers tackling technical problems

up in CNPC. The Laboratory of Internet of Things was approved by the Ministry of Industry and Information Technology as a major large-scale intelligent instrumentation maintenance platform for oil and gas production. The Natural Gas Quality Control & Energy Measurement Laboratory and the Oil Pipeline & Equipment Quality and Safety Laboratory were approved to be key laboratories for state market regulation. The construction of the national key laboratory on EOR was making headway. A number of key platforms in new energies and new areas, e.g. hydrogen energy, carbon neutrality etc., have kicked off. A demonstration base was fully launched and approved as one of the third batch of China’s “Mass Entrepreneurship and Innovation” Demonstration Bases.

We have taken energy and chemicals innovation to new heights. On December 28, CNPC Dubai Research Institute, Shenzhen New Energies Research Institute and Shanghai New Materials Research Institute were established, marking an important step in the new journey of building a national strategic technological force and a high ground of energy and chemicals innovation.



## Three New Research Institutes

The three research institutes were inaugurated in 2021 to provide strong support for the Company's international operation and new energies and new materials business.

### CNPC Dubai Research Institute

Middle East-based with an exposure to Africa and other regions, the institute provides optimized solutions for overseas upstream businesses.

### CNPC Shenzhen New Energies Research Institute Co., Ltd.

As an independent new energies innovation center, the institute provides a platform for strategic and decision-making support, technology incubation and commercialization, talent introduction and training, and international exchange and cooperation, in a bid to take the new energies innovation to new heights.

### CNPC (Shanghai) New Materials Research Institute Co., Ltd.

Taking the high ground of new materials innovation, the institute is a center for R&D in new technologies, technology commercialization, talent gathering and international exchange and cooperation.

## Major R&D Achievements

The Company implements actively an innovation-driven strategy focusing on major bottlenecks in key areas. Debottlenecking in core technologies and forward-looking, basic and strategic research were further strengthened and commercialization of new technologies for productivity gains was accelerated to achieve fruitful results in E&P, refining and petrochemicals, oilfield services and new energies etc.

### Top 10 Technological Innovation Achievements of CNPC

- ◆ Geological theories and E&P technologies for continental shale oil
- ◆ 1Mt/a ethane-to-ethylene technology set
- ◆ CG STEER rotary geosteering drilling system
- ◆ One-click interactive 7,000-meter automated drilling rig
- ◆ EV56 high-precision broadband vibroseis
- ◆ Multifunctional integrated reservoir numerical simulation software (HiSim4.0)
- ◆ AnyCem automatic cementing technology and equipment
- ◆ CPLog multidimensional and high-precision imaging logging system
- ◆ 4<sup>th</sup>-generation fine zonal water injection technology
- ◆ Technology set on 1-butene/1-hexene production with flexible mutual conversion

**E&P:** The Company focused its ongoing R&D efforts on high-efficiency E&P and cost-effective production, innovative geological theories for carbonate reservoir forming, development and improvement of key technologies used in comprehensive geological evaluation for marine-facies deep shale gas, composite flooding in conglomerate reservoirs, and chemical flooding-based EOR in oilfields, so as to facilitate deep/ultra-deep strategic substitution, large-scale shale gas production and production stabilization/expansion in mature oilfields. These efforts provided technical support in achieving a record-high newly-added proven reserves of oil and gas equivalent and a steady production growth in 2021.

**Refining and Chemicals:** The Company continued to optimize its refining and chemical product mix, and facilitate coordinated progress in six key R&D projects (Big Refining, Big Ethylene, Big Aromatic Hydrocarbon, Refining and Chemical Transformation & Upgrading, New Polyolefin Products, New Chemical Materials for Oilfields), and implemented 27 field test projects, e.g. CBB capacitor, and ultra-high melt flow rate metallocene based polypropylene, etc. The CCOC catalytic cracking process for further reduction of olefins in gasoline and the zonal DCP process for heavy diesel were developed and commercialized. 1Mt/a ethane-to-ethylene unit, 1.5Mt/a liquid feedstock-to-ethylene unit, catalysts set for ethylene units and other core supporting technologies were developed and deployed to enhance the competitiveness of the Company's ethylene products.

**Oilfield Services:** R&D achievements regarding core technologies and equipment included open platform-based new-generation

ultra-large seismic processing and interpretation software, multi-dimensional high-precision imaging logging system, rotary geosteering drilling system, and one-click interactive 7,000-meter automated drilling rig. The Company is basically able to produce the entire spectrum of upstream equipment on its own, indicating a remarkable improvement in technical service capabilities and international competitiveness.

**New Energies and Green & Low-Carbon:** Geothermal technologies for the conversion of disposed wells into geothermal wells and thermal reservoir fracturing were making important progress; advances were made in building a pre-emptive technical reserve, e.g. natural gas hydrates, in-site conversion of shale oil and underground coal gasification etc. The carbon dioxide capture, utilization and storage (CCUS) source-sink pairing and potential evaluation methodology was developed; CCUS industrial tests were accelerated in main oil producing areas, with new progress in the debottlenecking and application of supporting technologies to provide strong support for improving oil recovery and facilitating the Company's green growth.

**Frontier Technology:** The Company has been developing new theories, methods and technologies in line with strategic development needs of the future and international technological development trends. Breakthroughs in understanding the mechanism of deep/ultra-deep oil and gas accumulation, and research on new geophysical evaluation technologies were achieved to provide support for deep E&P and EOR activities; geological theories on the accumulation and enrichment of continental shale oil were developed to guide and propel the continental "shale oil revolution"; theoretical understanding and core technology in nano-flooding, carbon dioxide flooding, and smart injection and production made important headway to improve effectively the recovery and producibility of low-permeability oilfields and high-water-cut oilfields. R&D efforts were organized to debottleneck technologies under study regarding new-generation high-value-added synthetic materials and products, and natural gas-based high-value-added chemicals, and to deploy a pre-emptive technical reserve for new chemical materials; major breakthroughs were made in high-end polyolefin materials for medical applications.



Changqing Oilfield Digital Command Center

## Digital Transformation and Intelligent Operation

Focusing on intelligent technology and product innovation, the Company has integrated digital technology into its products, services and processes along the oil and gas value chains to restructure the value system and rebalance the production relationship. In this way, we facilitate the shift from capacity-driven growth to innovation-driven growth by leveraging new elements, new growth-drivers and new capabilities to create new businesses, new operations and new business models that are in line with a "Digital CNPC".

The Company has implemented digital transformation in three main areas, i.e. business development, management reform and technological empowerment, and introduced an integrated, two-tier strategic framework by creating the application ecosystem centered on Industrial Internet technology system and cloud platform. The Internet, big data and artificial intelligence have become an integral part of the Company's business operations to facilitate digital transformation and intelligent operation in the form of intelligent oil/gas fields, intelligent refineries and chemical plants, smart marketing, and intelligent engineering.



Drones used in Yumen Oilfield for production site inspection

In 2021, the pilot programs of digital transformation and intelligent operation kicked off, involving 14 member companies in key business areas chosen as the first batch of demonstration bases, in a bid to explore a replicable, practical CNPC model of digital transformation and intelligent operation.

### China's first 5G smart refinery was unveiled at Changqing Petrochemical Complex

On June 10, 2021, China's first smart refinery with 5G dedicated network, 5G-enabled production process, 5G eco-system and all-scenario 5G application was launched at Changqing Petrochemical Complex.

The deployment of 5G dedicated network and mobile edge computing (MEC) platform helped to build a high-speed, large-bandwidth, low-latency, and high-reliability 5G cloud infrastructure that meets the needs of Changqing Petrochemical in terms of network latency and data security etc.

The 5G+ early warning system for mobile devices deployed on the MEC platform can track automatically the status of hundreds of mobile devices on premises through 24-hour real-time calculation and precise sensing, with an accuracy rate of over 95% for its early warning. Such a system enabled a significant drop in the failure rate and maintenance cost of equipment to ensure safety and stability in refining production.

Changqing Petrochemical also has an intelligent inspection route leveraging 5G, digital twin, and visual recognition technologies to improve the control and management of production operations.

### The first Blockchain + Energy company in Asia Pacific was incorporated

During the signing ceremony held for the SOE delegation at the 4th China International Import Expo on November 6, 2021, PetroChina International signed a cooperation agreement on Commodity Blockchain Platform with nine global partners including Sinochem Energy and COSCO Shipping Energy Transportation. As a result, TradeGo Pte. Ltd. was established as a joint venture engaging in blockchain-based commodity trading. This is the first "Blockchain + Energy" company in Asia Pacific.

TradeGo Pte. Ltd. offers a digital platform for blockchain-based commodity trading. This platform will effectively address the pain point problems related to security, authenticity and timeliness of key document delivery in international commodity trading and reduce information asymmetry among the various links of traditional trading processes. It is a ground-breaking solution to improve operating efficiency, lower financial costs and provide a safe, authentic and high-efficiency trading environment for upstream and downstream clients involved in commodity trading as well as the industry regulators.

## Technological Exchange and Cooperation

In the principle of mutual benefit and win-win cooperation, the Company works closely with energy companies, organizations and research institutes at home and abroad to carry out S&T exchange and R&D cooperation, in a bid to jointly promote technological progress and innovation in the industry.

Domestically, the Company's collaboration with Peking University, Tsinghua University and Chinese Academy of Sciences was mainly focused on oil and gas-related frontier technologies, new energies and new materials, with technical seminars to discuss R&D cooperation in multiple areas.

Internationally, the Company worked with its strategic partners, including TotalEnergies, Petronas, Rosneft, Gazprom and ADNOC on waterflooding and polymer flooding-based EOR, fracture design software, molecular management and smart refinery, carbon emission reduction and management etc.

## S&T Awards and Intellectual Property Rights

The Company continued its efforts in standardization in 2021. The platform for standardization made steady headway and the Standardization Committee of the China Petroleum Society was set up. The Company played a leading role in the development and introduction of two international standards, including the ISO 24076:2021 *Plastics - Polypropylene (PP) - Determination of*

*Isotactic Index by Low-resolution Nuclear Magnetic Resonance Spectrometry.*

In 2021, honors and awards received for achievements in R&D projects led or participated by the Company included: one first prize and two second prizes of the State Science and Technology Progress Award, one second prize of the National Award for Technological Invention, one silver prize and five excellence prizes of the 22nd China Patent Award, one first prize and two excellence prizes of the 3rd SOE Shining Star Innovation and Creativity Competition. In 2021, the Company filed 5,016 patent applications (including 4,779 patents for inventions) and was granted 4,277 patents (including 1,728 patents for inventions).

Patents applied

5,016



Patents granted

4,277



Daqing Refinery Control Center