Technology and Innovation

Focusing on self-reliance in state-of-the-art technologies and taking innovation as the key driving force for development, we improve the technological innovation framework, accelerate the commercialization of scientific and technological achievements, develop new quality productive forces, and promote high-quality development.

Technological Innovation System

At CNPC, we deepen the reform of the framework for innovation governance by strengthening top-level design and overall planning. We continue to improve our innovation capabilities, create high-level innovation platforms and promote the deep integration of the "innovation chain" and the "industrial chain." The National Technology Innovation Center for Geophysical Exploration was approved for construction, making it the first national technology innovation center in the oil and gas field. As of the end of 2024, the company had 29 national technological innovation platforms and more than 60,000 R&D personnel.

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Reform of Innovation Governance Framework

- Continue to improve the three-tiered system for technological innovation management
- Continue to introduce and improve the "organized research" mechanism
- Continue to diversify types of incentives in R&D

Daqing Oilfield: research personnel in lab

Major R&D Achievements

At CNPC, we actively implement an innovation-driven strategy, focusing on major bottlenecks in key areas. We strengthen the debottlenecking in core technologies and forward-looking, basic and strategic research, and accelerate the commercialization of new technologies for productivity gains, with fruitful results in E&P, refining, chemicals and new materials, as well as low-carbon new energies.

Top 10 Technological Achievements in 2024

Significant progress in deep earth drilling exceeding 10,000 meters

Faced with challenges such as ultra-high temperatures, ultra-high pressures, and complex pressure systems in 10,000-meter ultra-deep wells, the Company has developed the core technology and equipment solutions, including 12,000-meter automated drilling rig, high-temperature-resistant wellbore working fluids and 10,000-meter-deep coring toolkit, which combined with the 10,000-meter drilling process, and enabled the drilling of Shenditake 1 Well to surpass the 10,000-meter depth at a record-setting speed in comparison to onshore drilling operations worldwide. In this process, CNPC obtained core sample data as valuable as "lunar soil", and reported oil and gas shows for the first time in formations deeper than 10,000 meters. Shenditake 1 Well as a national major project has set a new world record for the shortest time taken to drill a 10,000-meter onshore well, making it the first well in Asia and the second well globally to exceed 10,000 meters in vertical depth and marking a milestone in China's drilling engineering history.

Industrial application of independently developed metallocene catalysts

Metallocene polyethylene (mPE) exhibits excellent performance, and the mPE technology is a significant indicator to measure the development level of a nation's polyolefin industry. Metallocene catalysts, known as the "chip" for producing mPE, have long been relying on imports, which severely curb the development of high-end polyolefin operations. Focusing on key scientific and technical challenges in relation to the structure and performance of metallocene catalysts, CNPC has independently developed high-performance metallocene polyethylene catalysts and produced over 10,000 tons of mPE products based on large-scale commercialization.

Launch of 70-billion-parameter Kunlun Large Model

CNPC has created the Kunlun Large Model covering all upstream, midstream, and downstream operations to promote AI-powered new industrialization. The Kunlun Large Model is the first industry large model that is open to the entire energy and chemical sector and is available for public use. In November 2024, it was selected as one of the exemplary cases for "AI-powered new industrialization" organized by the Ministry of Industry and Information Technology, demonstrating an industry-leading influence. The Company will watch closely the trend in large models, develop first-class large model applications, and ramp up efforts in building an innovative application ecosystem.

Domestic substitution and industrial application of large geological engineering integrated fracturing software system

Breakthroughs have been made in 11 key technologies, including non-planar 3D fracture simulation, complex artificial fracture simulation and 4D geo-stress simulation, and the first domestic geological engineering integrated fracturing design software platform (FrSmart) has been developed and widely used in CNPC's oil and gas fields

The first set of mobile "NMR-Laser-CT" integrated equipment for well-site rock sample measuring

The high-fidelity near-in-situ measurement of the core in the first instance at the well site is the key to overcome the errors caused by oil and gas loss, stress and structural changes, and to accurately determine the reservoir physical properties and oil and gas bearing properties. CNPC has successfully developed the world's first mobile "NMR-Laser-CT" integrated measurement equipment, marking a major breakthrough in measuring well-site rock samples.

A 3000-m oSeis OBN for oil and gas exploration in ultra-deep water

CNPC has overcome challenges like ultra-high static pressure sealing and long-term timekeeping and developed China's first set of 3000-m oSeis OBN with state-of-the-art performance to ensure technological self-reliance in ultra-deep water seismic data acquisition.

An innovative whole petroleum system theory for discovering insource reserves in Fengcheng Formation, Northwest China's Junggar

The Fengcheng Formation in the Junggar Basin has a great potential for unconventional oil and gas exploration potential due to its fine-grained carbonate deposits in a saline lacustrine basin. However, unclear reservoir control factors and hydrocarbon accumulation mechanisms have hindered the exploration process. CNPC's multidisciplinary research team has developed an innovative whole petroleum system theory and supporting exploration technologies, leading to the discovery of 1-billion-ton insource unconventional resources in the Fengcheng Formation.

Major breakthrough in nylon 66 complete technology using benzene as a single raw material

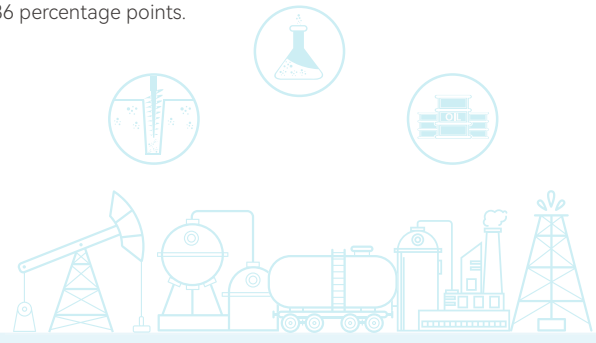
CNPC has independently developed a complete nylon 66 technology using benzene as a single raw material, leveraging benzene resources and creating an independent and controllable industrial chain. The first nylon 66 technical package using benzene as a single raw material has supported the construction of the Company's industry-leading nylon facility to produce adiponitrile at 50,000 t/a, hexamethylenediamine at 50,000 t/a, and nylon 66 at 100,000 t/a.

Development and commercialization of gas-phase polyolefin elastomer (POE) technology

CNPC has pioneered the development of POE technology in China by overcoming bottlenecks in high-content low-carbon α-olefin copolymerization, catalyst system, thermodynamic balance reconstruction etc. to support a gas-phase process that is shorter, more cost-effective, and more scalable than solution-phase processes, and enable technological self-reliance in key materials needed for the development of new energies.

1-MW downhole electrical heating-assisted steam dryness enhancement technology for effective recovery of deep heavy oil

Aiming to address sub-standard steam dryness in kilometer-deep heavy oil recovery, high energy consumption and high carbon emission of steam injection and the lack of a revolutionary alternative technology, CNPC has developed the first 1-MW downhole electrical heating-assisted steam dryness enhancement technology, based on innovative solutions for multi-umbilical structure, insulation main material, outer armor material and prefabrication process and technical breakthroughs in 38 mm outer diameter, 4 kV high-voltage insulation, 450°C high temperature and 5 kW/m high power density. A pilot-scale deployment of this technology in Liaohe Oilfield has successfully increased steam dryness by 36 percentage points.

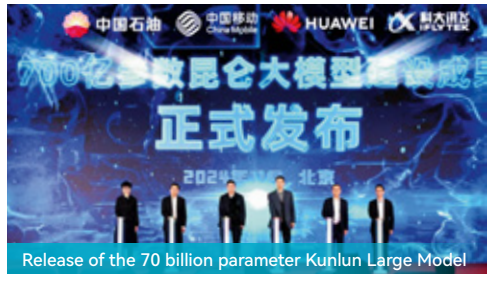


Digital and Intelligent Empowerment

The Company has established "Digital and Intelligent CNPC" as its fifth major strategic initiative and released the overall plan. CNPC (Beijing) Digital Intelligence Research Institute Co., Ltd. was established to promote IT Reinforcement, Digital Empowerment and Intelligent Operation. Significant achievements were made in the construction and application of the Service Station 3.0 Program, the Unified Office Platform, and the Engineering Intelligence Support Center etc. The Kunlun Large Model made two achievement releases; the pilot projects of digital transformation were burgeoning; the Yunmengze Smart Platform was up and running; network security and new infrastructure support capabilities were further enhanced. All these demonstrate significant progress in the transition to a Digital and Intelligent CNPC with a digital ecosystem for the intelligent energy and chemical operations, providing strong support to the Company's efforts in deepening reforms and building into a world-class enterprise.

Launch of 70-billion-parameter Kunlun Large Model

In 2024, the Company launched the 70-billion-parameter Kunlun Large Model, presenting 43 professional and general-purpose application scenarios designed for the petroleum industry. The Kunlun Large Model has passed the national registration for generative AI services, making it the first large model in China's energy and chemical industry to achieve this milestone. The Kunlun Large Model is jointly developed by CNPC, China Mobile, Huawei, and iFLYTEK, featuring the training of 8 large models, 18 application scenarios, extensive industry and specialized datasets, a customized AI mid-office, and an intelligent computing environment. This has led to the preliminary formulation of a methodology for implementing large models in major enterprises.



Release of the 70 billion parameter Kunlun Large Model

Pilot Launch of the Yunmengze Smart Platform

On September 30, 2024, the pilot version of Yunmengze Smart Platform, CNPC's first e-commerce service platform for the energy and chemical industry was launched. This platform aims to streamline all aspects of the industrial chain, including production, trading, and distribution. Employing an "Agile + Waterfall" implementation strategy, it leverages CNPC's existing digital infrastructure to rapidly integrate across systems, providing comprehensive ecosystem-based services such as trading, logistics, finance, data, and technology to the energy and chemical industry chain. As of December 31, 2024, the pilot phase included 743 functionalities, covering three core operations, i.e., chemical sales, logistics, and finance. The platform has been opened to internal and external users through a unified enterprise portal and App, demonstrating a leading role in bolstering the online, standardized, and digital transformation of CNPC's trading operations.

As of December 31, 2024

The pilot phase included

743 functionalities

Chemical sales

Logistics

Finance

Progress in Digital Transformation and Intelligent Development

Main Line	Target	Annual Progress
Business Development	Collaborative Optimization in the Oil and Gas Business Chain With the goal of maximizing the overall profitability and shareholder value of the upstream and downstream operations, CNPC actively pushed forward optimized resource allocation, integrated operational efficiency management, and coordinated emergency response.	◎ The Company made steady headway in building its production and operation platform. Engineering Intelligent Support Center (EISC) introduced an engineering management model, featuring "Headquarters EISC for coordinated remote support, regional center for full-process management, and direct instructions for on-site operations". New functionalities such as intelligent fracture risk identification and real-time oil testing monitoring were added, achieving comprehensive coverage of geophysical exploration, drilling, logging, well logging, fracturing, and oil testing operations. New features of intelligent production safety management were added, including safety management scenarios for well sites, stations, oil depots, and refineries and petrochemical facilities etc. The safety management interface expanded to cover production sites, significantly enhancing the capability to prevent disruptive risks. ◎ The Service Station 3.0 was fully launched, which innovatively introduced the industry's first pay-by-palm scenario Innovative scenarios of e-fueling, one-click shift closing, volume-based performance, and intelligent risk control, were deeply applied. Single-customer service time was significantly reduced. ◎ The intelligent operation system was further streamlined by incorporating key data monitoring for natural gas uploading, new energy power generation, and all drilling rig operations. The scope of production and operation monitoring further expanded to enable daily tracking of CNPC's full-chain production and operation plan execution and improve resource allocation capabilities in support of natural gas supply scheduling. ◎ The industrial vision system was fully deployed, substantially enhancing visual insights in production processes and emergency control capabilities. The centralized carbon asset management platform was launched and running, effectively facilitating the transition to facility-level carbon emission accounting.
	Transformation and Upgrading of Core Operations Technologies such as the Internet of Things (IoT), big data, and artificial intelligence (AI) were integrated into CNPC's core operations to support industrial transformation and upgrading.	◎ Intelligent Oil and Gas Fields: A new model designed to facilitate the transformation of our domestic oil and gas fields was introduced, featuring unmanned operation of key production sites, real-time sensing of equipment status, integrated exploration and development collaboration, intelligent connectivity and automatic optimization of the entire production process for wells, stations, plants, and equipment on the production site; and streamlined organizational and personnel structures. For overseas operations, a digital management and control mechanism for capacity construction and ground engineering was introduced; the pilot projects of unmanned operation rapidly advanced; and the management efficiency of oil and gas well production operations was further improved. Changqing Oilfield passed the Level 4 Maturity Evaluation for Digital Transformation, and Tarim Oilfield was included in SASAC's List of Digital Transformation Pilot Projects in State-owned Enterprises. ◎ Intelligent Refining & Chemicals: The next-generation production and operation models were taking shape to support comprehensive sensing, real-time monitoring, predictive warning, intelligent response, collaborative optimization, and precise execution. Dushanzi Petrochemical and Guangdong Petrochemical passed the Level 4 Maturity Evaluation for Intelligent Manufacturing, and Lanzhou Petrochemical was included in SASAC's List of Digital Transformation Pilot Projects in State-owned Enterprises. ◎ Intelligent Sales & Marketing: Based on a platform-enabled and ecosystem-driven approach, the Service Station 3.0 Program and the uSmile Mall Program supported CNPC's sales and marketing operations. The comprehensive management system of crude oil production and marketing was upgraded to support the unified management of crude oil by-product sales. The Sales & Marketing IoT achieved the full-coverage monitoring of all national-level key oil depots. ◎ Intelligent Natural Gas Sales & Marketing: New achievements included an integrated model for online and offline sales, an omni-channel intelligent customer service system, an efficient response mechanism, and intelligent stations with 24-hour monitoring.
Management Reform	CNPC enhanced decision support, operational management, collaborative office, collaborative R&D, and shared services through digital transformation to promote the modernization of the Company's governance system and governance capabilities.	◎ High-quality progress has been made in key projects for IT Infrastructure Revamping. In line with the four major goals of integrating logistics, capital flow, information flow, and workflow; integrating business and finance; coordinating production and operation; and coordinating upstream and downstream operations, the Company completed the blueprint design, centralized system implementation, and integrated testing with high quality with a focus on data, process and standardization. The full-chain verification of the first participating units achieved overall success with desired results. ◎ The Unified Office Platform was launched and running, providing a collaborative and personalized workbench based on the "platform + application" approach. It enables "one-click login and unified to-do list" and solving the problem of users logging into multiple systems, to promote the shift of work mode from "people-driven" to "task-driven." ◎ The global shared service system continued to expand, featuring a comprehensive quality management system with "risk management, regulatory compliance, standardization, and customer satisfaction" for shared financial services and the visualization of talent management and in-depth talent mining for shared HR services.

Main Line	Target	Annual Progress
Technological Empowerment	A leading industrial Internet system in the energy and chemicals sector was taking shape to empower CNPC's digital transformation.	◎ The Kunlun Large Model made two achievement releases, forming an industry large model with 70 billion parameters for language, 300 million parameters for vision, and 16 billion parameters for multi-modal processing. As the first nationally registered large model in China's energy and chemical industry, the Kunlun Large Model is selected as one of the exemplary cases by the Ministry of Industry and Information Technology. ◎ Based on its four data centers, CNPC continued to improve the complementary and integrated network and strengthen the IT infrastructure support capabilities. ◎ The Three-Year Data Governance Action Plan was completed, effectively improving data standards, consolidating the unified control foundation of data resources, and ensuring the integrity, efficiency and security of data transmission. The data catalog of CNPC was created, achieving "data retrieving on demand" across all data domains. The standardization of public data made progress, significantly improving the quality of operational management data.

Technological Exchange and Cooperation

At CNPC, we continue to deepen innovation cooperation, consolidate innovation resources to enhance innovation capabilities, and work closely with energy companies, associations and research institutes at home and abroad. We advocate for industry technology alliances and innovation consortia and strive to create an innovation ecosystem with in-depth integration of the industrial chain and the innovation chain.

Domestically

CNPC led the establishment of CCUS Innovation Consortium of Central SOEs jointly with China Huaneng Group, and participated in innovation consortia in high-end metal materials, basic components, building information modeling (BIM), production, storage and transportation of hydrogen energy, energy storage solutions and electronic specialty gases. Meanwhile, the Company made headway in strategic cooperation and R&D projects with Peking University, Beijing University of Chemical Technology, and Southwest Petroleum University etc. Under the "Technology + Finance" initiative, the Company invested in Fusion Technology (Anhui) and participated in technical research and construction of Burning plasma Experimental superconducting Tokamak (BEST) to tap into the supporting sectors in the nuclear fusion industry chain.

Internationally

CNPC bolstered scientific and technological cooperation within the framework of overseas strategic partnerships, with significant progress in technological exchanges and cooperation projects with companies like TotalEnergies. The Company actively participated in major international industry events such as the Abu Dhabi International Petroleum Exhibition and Conference (ADIPEC), the Society of Petroleum Engineers (SPE) Annual Technical Conference, the Asian Offshore Technology Conference (OTC Asia), the International Petroleum Technology Conference (IPTC), and the International Gas Research Conference (IGRC). The Company recommended its experts to serve as committee members and speakers at some industrial conferences to enhance its influence.

S&T Awards and Intellectual Properties

CNPC continued to improve its standardization system and enhance standardization capabilities to support high-quality development. In 2024, the Company led the development and revision of 11 international standards and advanced foreign standards.

Throughout the year, the Company filed 11,381 patent applications and was granted 3,850 patents. By the end of 2024, the Company had 37,871 vaild patents both at home and abroad. The independently developed "Key Technologies and Equipment for Onshore Wideband Wide-Azimuth High-density Seismic Exploration" won the first prize of the State Technological Invention Award.

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CNPC wins the first prize of the State Technological Invention Award

On June 24, 2024, the 2023 National Science and Technology Awards were announced in Beijing. BGP's proprietary "Key Technologies and Equipment for Onshore Wideband Wide-Azimuth High-density Seismic Exploration" won the first prize of the State Technological Invention Award. It is CNPC's first prize for the first time.

To implement the national deep-earth development strategy and explore deeper and more complex oil and gas reservoirs, BGP's R&D efforts have been focused on original innovation in concepts, methods, high-end equipment and industrial software over the past 15 years, leading to the proprietary next-generation onshore seismic prospecting techniques. The world's first "broad band, wide azimuth and high density" onshore seismic prospecting techniques and equipment helped ensure comprehensive measurement, fast data acquisition and accurate prospecting in deep-earth exploration exceeding 10,000 meters.