# Green Development Approaches to the Chinese Petroleum Industry

**CNPC Research Institute of Safety &Environment Technology**

**Qin Guojun**

**Oct. 19, 2011**

# Introduction

- **Energy is the material basis for the survival and development of human society, thus, energy sustainability is critical to the national economy and the people's livelihood. As a response to climate change, an energy revolution focused on green and low-carbon technologies has begun around the world.**
- **Petroleum industry is the pillar of China's national economy. However, its exploitation and utilization inevitably leads to negative environmental impacts. The dilemma of how to realize a coordinated and balanced development pattern between exploitation and utilization of crude oil and environmental protection has become a common concern across the international petroleum industry. The promotion of green development is not only a strategic mission for the industrial sustainable development, but also a whole new set of social responsibilities for enterprises.**

- **To accelerate the transformation of existing economic development patterns, China has advocated the construction of a resource-conserving and environmentally friendly society, emphasized green and low-carbon development concepts, vigorously promoted cleaner production and the establishment of a "circular economy," accelerated efforts towards energy conservation and emissions reduction, and made contributions towards a more "ecological civilization."**
- **It is crucial to carve out a basis for strategic decision-making on sustainability in the petroleum industry by correctly analyzing and judging the current status of relevant green developments, proposing a main direction for development, and clearly defining key tasks for green development by aiming at resource conservation and environmental protection.**

# Table of Contents


è 1 Green Developments in the Petroleum Industry: Present Situation Overview

2 Green Developments in the Petroleum Industry: Challenges

3 Green Developments in the Petroleum Industry: Direction and Key Tasks

# 1 Status of Petroleum Industry Green Development

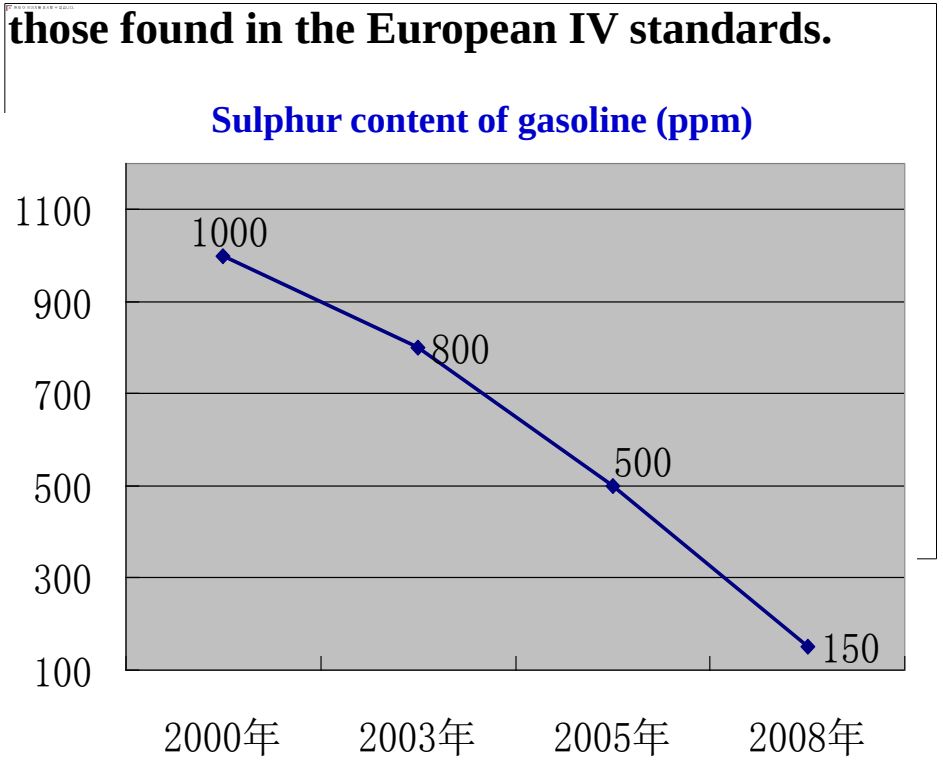
China's petroleum industry attaches great importance to sustainable development, an area where it has made remarkable contributions, working vigorously towards cleaner production, developing the "circular economy," and actively promoting resource conservation and emissions reductions.

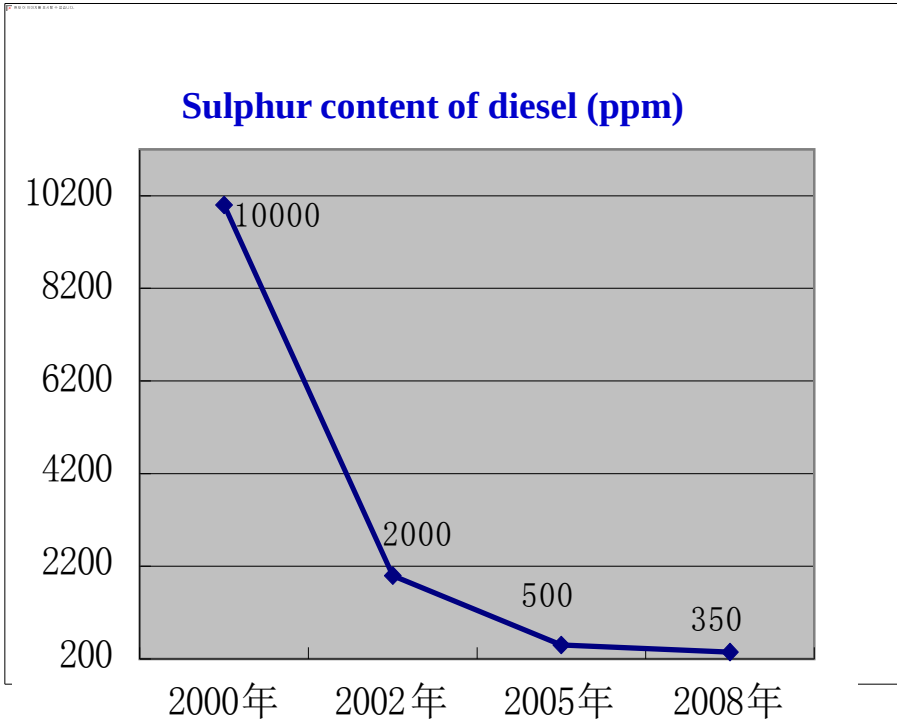

By reaching obligatory targets of "during the 11th Five-Year Plan period , energy consumption per unit GDP is to be be reduced by 20%, the further target is a 10% reduction in total emission of major pollutants ";greenhouse gases emissions are now under control.

# (1) Active Promotion of Energy Structure Adjustment

- **Use of natural gas is rapidly expanding. Compared with 2005, the percentage of gas consumption as primary energy has increased by 2.4% in 2010, which contributes considerably to emissions reductions of $CO_2$,$SO_2$, $NO_x$ etc.**
- **The stable development of coalbed methane (CBM) is under way; fuel ethanol is beginning to take shape; biodiesel is poised for take-off.**

- **The speed of quality upgrades for refined oil products has increased markedly, and the country has responded by intensively issuing relevant standards. From 2000 - 2008, the limit of sulphur content in motor gasoline and diesel saw four sizable cuts; large cities such as Beijing, Shanghai, and Guangzhou promptly published stricter local standards equal to those found in the European IV standards.**




**Effectively mitigating the pollution arising from rapid growth in motor vehicle**

# (2) Active Promotion of Industrial Structure Adjustment

- **Pay attention to refinery and petrochemical plant integration, base construction, large-scale plants gradually appeared, as well as movement toward improved concentration in processing. From 2000 - 2010, the number of refineries processing 10 million tons or more increased from 4 to 17, and a refinery and petrochemical industrial belt (or circle) took shape, which contributed considerably to the realization of overall resource allocation, utility integration and optimization, improvement in resources utilization and energy efficiency, and reduction of pollutant discharge and energy consumption per unit of output.**
- **Hydrogenation capacity developed rapidly. The wide application of combined processes, i.e.: "oil hydrogenation - gas desulphurization – acidic water stripping – sulphur recovery", as well as cleaning processes and equipment such as the circulating fluidized bed boiler (CFBD), made cleaner production and circular economy a reality, not only providing clean refining oil products for society, but also recovering sulphur and ammonia and comprehensively reducing the generation and emission of the infamous "three wastes."**
- **During the development period, a large amount of heavy pollution, high material-consuming and high-energy intensity technologies, equipments and products were eliminated , and a large number of small-scale refinery and chemical plants were forced to shut down.**

# (3) Active Advocacy of Environmental Protection, Energy Conservation and Technological Innovation

**According to national policies, regulations and standards, upholding the concept of main business drivers, arranged a considerable amount of scientific research conducted in four steps – "dissemination and application, field tests, technological breakthrough and reserve" to provide effective scientific and technological support for promoting business in environmental protection and energy conservation.**

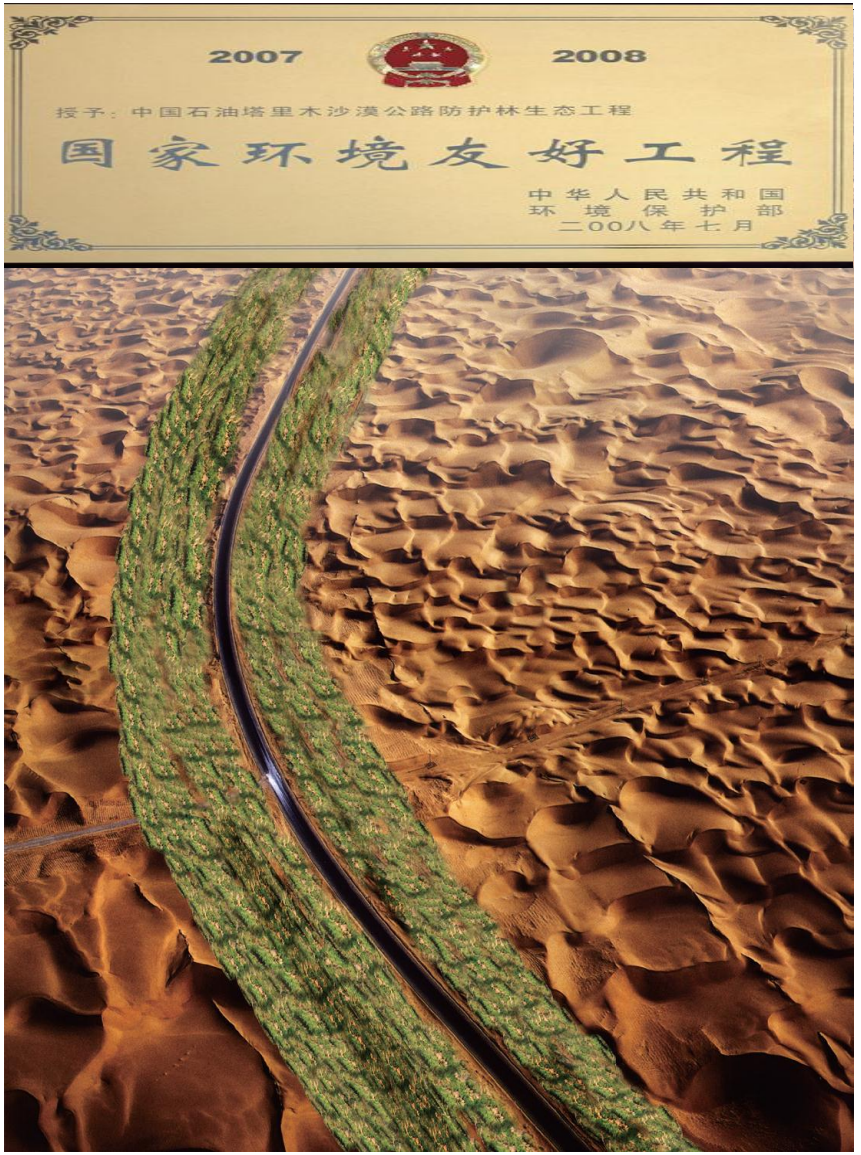
- **The research results of "Heavy Oil Sewage Recovery: Technology and Applications" produced effective heavy oil sewage treatment, a sewage with heat reusing in boiler, thus , fresh water consumption and waste water discharge were reduced; the use of residual heat from sewage reduced boiler fuel consumption and achieved the dual effects of environmental protection and energy conservation. These results were awarded the second-class National Scientific and Technological Progress Award .**
- **Technologies, such as "oily sludge utilization as resource " and "advanced treatment and reuse of refinery and petrochemical sewage" etc., have been recognized as significant breakthroughs and widely promoted and applied.**


稠油污水循环利用处理站


浮选处理单元


过滤与软化处理单元

- The research results of **”Tarim Desert Highway Protective Forest Ecological Engineering Construction Project: Technological Development and Application”** solved technical problems in building comprehensive desert highway protection systems, formed key supporting technologies in constructing a desert highway anti-sand green corridor, and was awarded the second-class National Scientific and Technological Progress Award in 2008. Based on the above technical support, the protective forest ecological engineering project, a 436km-long forest belt running through Taklamakan desert across 3,128 hectares of land improved the ecological conditions of the desert hinterland and was thus awarded the honorary title of “National Environmentally-friendly Project.”



## (4) Vigorous Promotion of Cleaner Production and Circular Economy Development

- **Strive to strictly cleaner production audit aiming at heavy pollution, and high-energy consumption plants or facilities. Implement free, low-cost, and high-cost improvement solutions, and form a group of pilot enterprises, plants or facilities.**
- **Experiments on building green oil field and petrochemical eco-industrial parks have seen steady progress.**

# (5) Effective Implementation of Energy Conservation, Emissions Reduction, and Delicacy Management


Clear rights and liabilities, strong supervision, and distinct awards and penalties

Energy conservation and emission reductions

Evaluation system

Sound, standardized, and well-equipped

Energy conservation and emissions reductions

Monitoring system

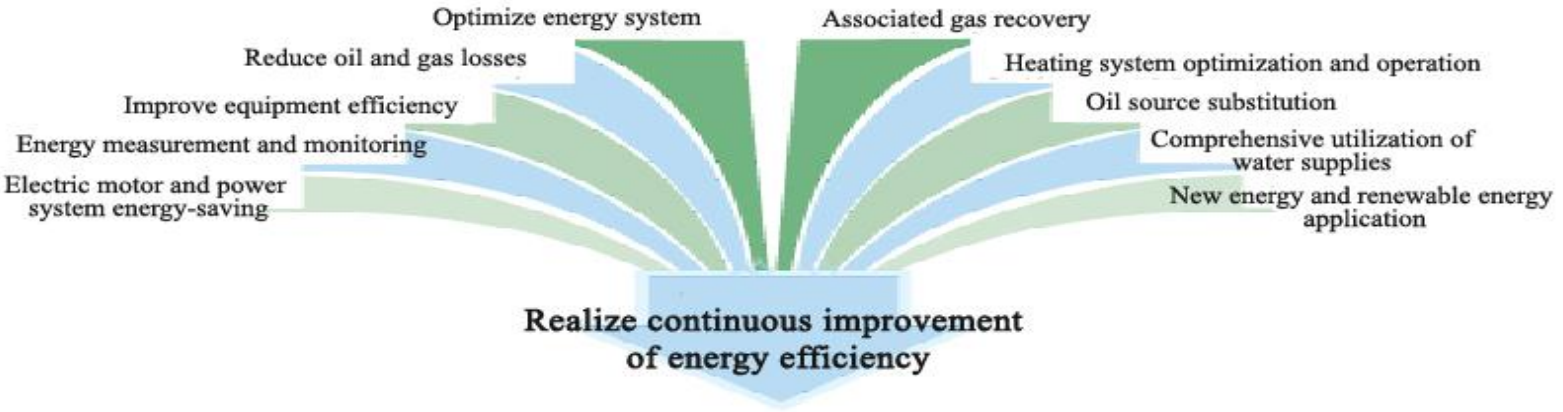
Comprehensive indicators, scientific methods, and accurate data

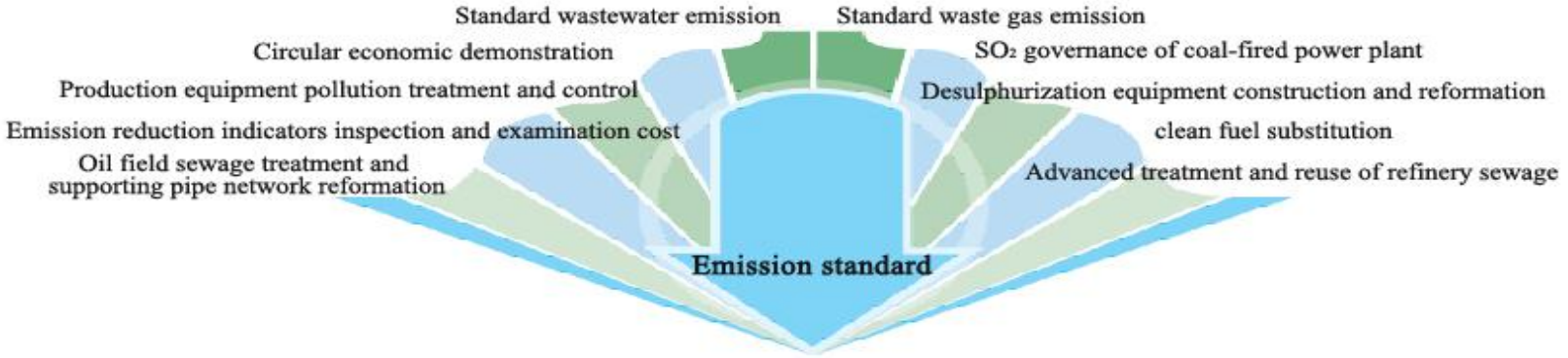
Energy conservation and emissions reductions

Statistic system

# （6）Vigorous Implementation of the Energy Conservation and Emission Reduction Project

**Top ten energy conservation and emissions reduction projects – taking CNPC as an example**



# 1 Status of Petroleum Industry Green Development

## Please note:

**Comparatively speaking, the production scale of China's oil and gas exploration, development, as well as refinery and petrochemical plants, are quite considerable, in terms of energy conservation , emission reduction and low-carbon options, we are faced with considerable challenges. Through we've carried out much arduous work in recent years and made remarkable steps forward, there is still a great disparity with the international level. Therefore, it is critical to learn from advanced international experience, complete each task effectively, and work step by step to make green development a reality.**

1 Green Developments in the Petroleum Industry: Present Situation Overview

è 2 Green Developments in the Petroleum Industry: Challenges

3 Green Developments in the Petroleum Industry: Direction and Key Tasks

# 2 Green Developments in the Petroleum Industry: Challenges

--Internal Environment Analysis

**Currently, China is still facing a shortage of oil and gas resources and petrochemical products, which has caused energy consumption to climb, and waste water, waste gas and solid wastes to increase accompanying with building larger scale production capacity, adding to treatment challenges and bringing about exceptional problems in standard pollutant emission, energy conservation, emissions reductions, greenhouse gas controls, and relevant ecological system maintenance. We must shoulder heavy responsibilities for green development.**

# (1) Oil and Gas Exploration and Production

- **With old onshore oil fields entering their medium or late development period in succession, more and more oil wells are classified as “stripper well” and “low-efficiency well.” The proportional increase of water content causes stark rises in the quantity of liquid and produced water . But restricted by reservoir conditions, produced water reinjection is limited, causing discharges increases;**
- **Increases in low-yield, hypotonic, heavy oil, high sulfur natural gas**
- **The scale of tertiary oil recovery is continuously expanding; exploitation techniques such as SAGD are being applied more widely;**
- **Usually, hydrocarbon gases are emitted during oil and gas exploitation and from gathering system; whereas $CO_2$ is generated by fossil fuel-burning equipment, especially coal-fired boilers used for thermal heavy oil exploitation.**

# (2) Refining and petrochemical

- **With the shrinking domestic share in light crude oil processing and the increase of heavy oil, large amounts of crude oil imports are coming into China. This processed crude oil is heavy and contains high amounts of sulfur and acids;**
- **The energy structure should be adjusted to make full use of oil and gas, and the substitution of coal, petroleum coke and deasphalted oil for oil and gas is a continuing trend. But the treatment and use of inferior oil is an important issue;**
- **As integration in the refining & chemical industry continues to develop and base construction and products quality upgrade implementation accelerate, enterprise scale is expanding, the processing depth is increased, the industrial chain is expanding, and plants for heavy pollution and high energy consumption such as catalytic cracking, delay coking, hydrogenation etc., are used on a wider basis.**
- **Forced by pressures to water conservation, enterprises have implemented large-scale efforts for sewage recovery and high concentration pollutants in concentrated water (chloride and chemical oxygen demand) were discharged ,which means higher treatment costs .**
- **Usually, hydrocarbon gases are emitted from refining & chemical production or from storage and transportation systems; $CO_2$ is generated by fossil fuel burning equipment, especially coal-fired or petroleum coke-fired boilers. Refining& chemical processes, especially advanced hydrogenation process required during cleaning fuel production, may produce a large amounts of $CO_2$.**

# (3) Oil and Gas Storage and Transportation

**Considering China's vast territory, domestic oil and gas resources and their consumption are extremely unevenly distributed. This implies there is a great development space for pipeline transportation , however, which necessarily involves a number of environmentally sensitive areas, such as nature reserves, drinking water source protection areas, scenic areas and densely populated residential area .**

# 2 Green Developments in the Petroleum Industry: Challenges

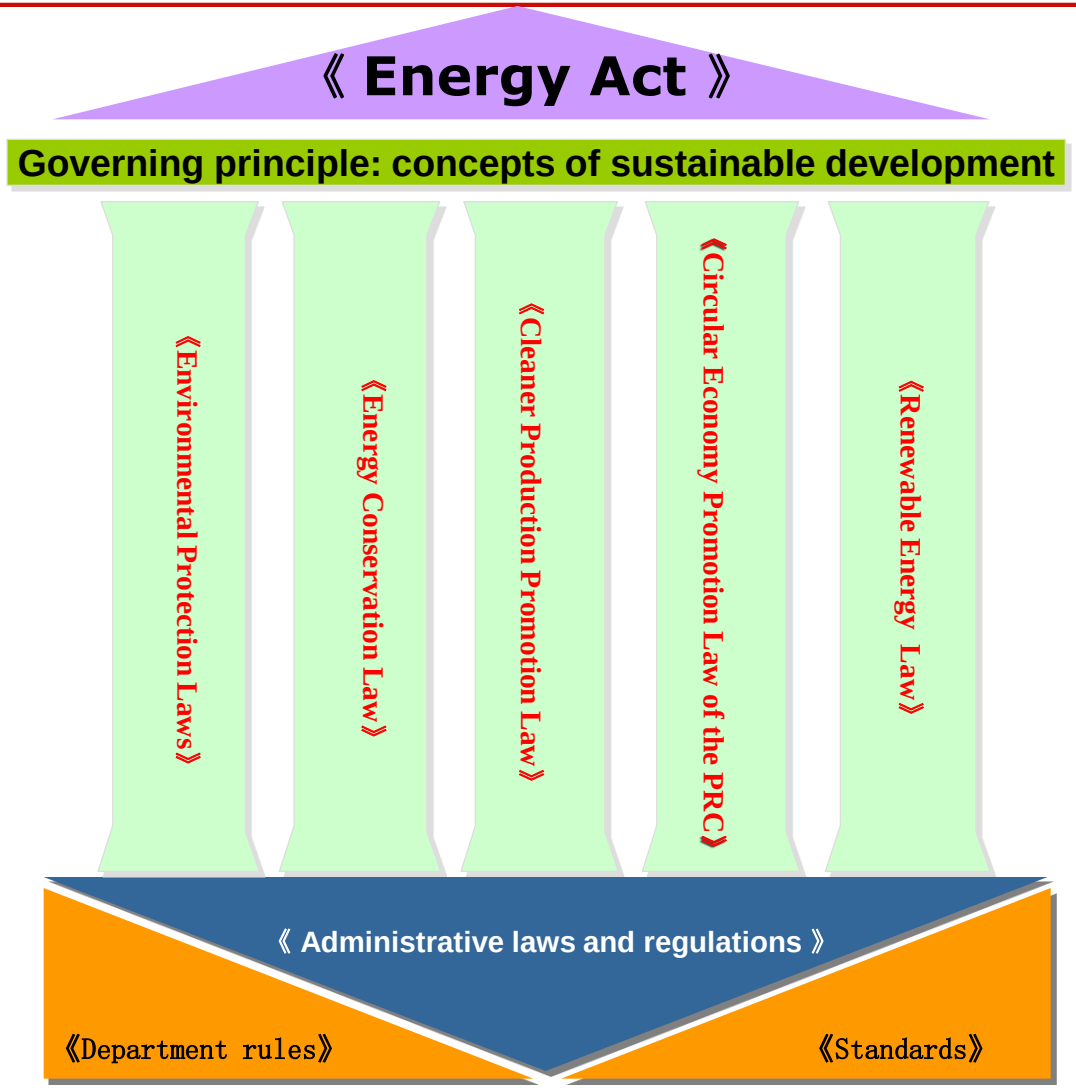
--External Environment Analysis

- In recent years, addressing climate change has become an urgent and long-term undertaking, and low-carbon development is seen as a common strategic measure against climate change across the international community.
- China duly issued the National Climate Change Program in 2007, which combined efforts to address climate change with sustainable development strategies, listing energy generation and conversion, efficiency improvements and energy conservation, industrial production controls, etc. among other key measures to slow down greenhouse gas emissions, and vigorously promoted energy-saving technological development and application in the petroleum and petrochemical field.
- In 2008 China issued the "Policies and Actions for Addressing Climate Change" and made a solemn commitment at Copenhagen Climate Change Summit in 2009, namely to, "cut $CO_2$ emissions per unit of GDP by 40% -45% in 2020 compared with the 2005," which has been incorporated as a mandatory target into the medium and long-term plans for the national economy and social development. The government is also expected to issue strict greenhouse gas emission standards and set obligatory emission targets for enterprises.

- **China has incorporated energy conservation and emissions reduction targets into the medium and long-term plans of the national economy and social development as mandatory targets, and has continuously set strict regulations for local government and enterprises.**
- **The attainment of energy conservation and emission reduction targets has been incorporated into local comprehensive economic and social development evaluation systems, which is the main tool for evaluating the performance of comprehensive governmental leaders and executives. Implementing this strict accountability system includes: implementing administrative penalties, regional planning restrictions or enterprise restrictions etc. to local governments and companies who fail to meet the targets.**
- **Implementing environmental impact assessment and energy conservation evaluation on fixed investments projects ,which has been the necessary element for project examination and approval .**

# Continuous Improvement of China's Legal System on Energy-Saving and Environmental Protection

China is making every effort to complete and implement a specified multi-layer energy-saving and environmentally-friendly legal system for the energy industry which will be led by Energy Act, governed by the concepts of sustainable development, represented by the Energy Conservation Law, the Cleaner production Promotion Law, the Circular Economy Promotion Law and the Renewable Energy Law, supported by administrative laws and regulations, department rules and other laws.



- **China is continuously promoting cleaner production, the development of the "circular economy," requiring enterprises to be "low-input, low-consumption, low-emission and high-efficiency", and implement waste "reduction, recycling and reuse" according to relevant laws.**
- **Pipe-end treatment alone is incapable of bearing the newer and heavier environmental burdens arising on a daily basis. It is thus necessary to implement systematic integration of cleaner production, circular economy, energy conservation and emissions reduction, and to propel the construction of petrochemical eco-industrial parks and green oil fields, and implement process controls, which would be the preferential economic development strategy, for it is the key tool of achieving stable pollutant standards, as well as radical energy conservation and emissions reduction.**

# In Terms of Industrial Policy:

- **Actively promote structural adjustment and vigorously weed out obsolete techniques;**
- **In order to change the energy structure that heavy dependence on coal, low-carbon clean energy development is encouraged, such as natural gas, shale gas, coalbed gas, renewable energy, biomass fuel etc.;**
- **Quality is being continuously upgraded and updated; refined oil products should follow IV standards nationwide;**
- **Set clear requirements for construction projects, energy conservation and emissions reductions; strictly implement the policies for access .**

1 Green Developments in the Petroleum Industry: Present Situation Overview

2 Green Developments in the Petroleum Industry: Challenges

è 3 Green Developments in the Petroleum Industry: Direction and Key Tasks

# 3 Direction and Key Tasks of Petroleum Industry Green Development

**Green development indicators are generally composed of the following:**

**(1) Decline in the rate of energy consumption per unit GDP;**

**(2) Decline in the rate of $CO_2$ emissions per unit GDP;**

**(3) Rate of decrease in major pollutants and greenhouse gases emissions;**

**(4) The clean energy consumption ratio growth rate.**

**Focusing on the above green development indicators and the current situation on the ground, China's petroleum industry has learned from the green development experience of major international oil companies and decided to take a diversified approach to work toward green development. Key tasks ahead include the following nine:**

# (1) Developing Clean Energy

**Focusing on developing clean energy for the purpose of improving energy structure and reducing pollutant emission, like $CO_2$ and $SO_2$ is highly advised.**

- **Natural gas and nonconventional natural gas resources, such as shale gas and coalbed gas, are the clean energy sources with potential for rapid development in the following stage. Consequently, pushing for their development and improving their share of overall pipe-end energy consumption is advised, which would be an effective measure to improve the energy structure, reduce $CO_2$ emissions, and mitigate environmental pollution.**
- **Based on the principle of "neither fighting the people for food nor fighting the plants for land," scientifically develop biomass fuel , including bio-fuel ethanol, biodiesel etc.;**
- **Continuously improve the quality of refined oil products , and further reduce sulphur, aromatic hydrocarbon and olefins content.**

# (2) Optimizing Industrial Distribution

- **Rationally allocate crude oil resources and ensure resource flow coordinates with refining & chemical industrial distribution;**
- **Optimize enterprise distribution and production scale based on the distribution of the main consumer market, local resources and environmental capacity;**
- **To reduce energy losses and materal losses sustained during loading and unloading during long-distance transport, one available option is strengthening the integration of upstream, middlestream and downstream petroleum industry, and base construction, as well as further improving concentration in the processing sector, and encouraging the construction of coastal crude oil importing and processing bases.**

# (3) Adjusting Industrial Structure

**Emphasize cleaner production and circular economic development**

- **Oil and gas fields should abide by "overall verification and exploration" instead of "rolling verification and exploration," implement comprehensive planning and systematic design for the purpose of reducing ground engineering losses, the emission of associated gas and negative ecological impacts;**
- **Pay attention to the integration of the refining & chemical industry, base construction, and the growth of plants scale;**
- **Centering on large-scale base construction, conduct logistics and energy optimization and take measures for step utilization, shape the raw materials, by-products and mutual energy sources among enterprises, and improve comprehensive utilization of energy based on the concept of the "circular economy";**
- **Vigorously develop the refinery with high capacity in hydrogenation and decrease the output of high-sulphur petroleum coke in order to make efficient use of crude oil resources;**
- **Eliminate obsolete processes, equipment and products which create heavy-pollution or consume large amounts of materials and/or energy, shut down small refineries, and discard small-scale chemical plants;**
- **Continue to implement strict cleaner production audit and achieve continuous improvements according to relevant standards.**

# (4) Utilizing Cleaner Energy

**Substitute coal, petroleum coke and deasphalted oil for oil and gas and build an public engineering oasis of refineries by adopting the IGCC and CFB, which would provide steam, electricity, hydrogen, nitrogen and clean fuel gas for the whole plant, improve the utilization efficiency of energy and oil and gas resources, result in centralized high-efficiency desulfuration, and effectively rein in the generation of NOx and $CO_2$ emissions.**

# (5) Saving Energy

## Oil and gas exploitation

- Mechanized mining system optimization
- Water injection system optimization
- Lifting system optimization
- gathering system with heat- traced reduction
- Downhole oil-water separation
- Downhole throttling
- Recovery of produced water and residual heat
- Optimum distribution of steam
- Recovery of residual heat from boiler

## Refining and petrochemical

- Overall optimization of the energy system
- Low-temperature residual heat recovery
- Desalination of sea water
- Water system optimization
- High-efficiency recovery of condensed water
- Sewage recovery
- Powered cogeneration promotion

## Oil and gas storage and transportation

- Low-consumption transportation
- Low-temperature storage
- Recovery and usage LNG cold energy
- Recovery of residual heat from Compressor unit

# (6) Pollution Reduction and Waste Resources Utilization

- ✓ **Reduce pre-treatment load of pipe-end sewage**
- ✓ **Advanced reduction in concentration and volume of pollutant**
- ✓ **Strive to obtain "zero emissions" in environmentally sensitive areas**
- ✓ **Desulfuration and denitration of gases generated from boilers or FCC regenerators**
- ✓ **Advanced desulfuration in tail gas from natural gas purification plants**
- ✓ **Acidic water and acidic gas recovery from refining &petrochemical plants and advanced tail gas treatment**
- ✓ **Reclamation and treatment of oily sludge, waste OBM, acidic fracturing water, refined waste residues, etc., strive to improve resources utilization ratio of waste.**

# (7) Greenhouse Gases Control and Utilization

- **Recovery of gases from oil and gas fields, CBM exhaust gases, oil gases of petroleum depots and gas stations, refinery trucks or ships, refined waste gases and flare gases;**
- **Capture and storage , and utilization of $CO_2$ in exhaust gases from fuel-fired and hydrogen-produced plant;**
- **Reduction nitrous oxide emission arising from adipic acid and nitric acid plants;**
- **Implement ecological restoration projects, take measures to control erosion, soil remediation and revegetation of retired well fields and other deserted production sites; enforce mining area "greenification" projects, improve the percentage of vegetation coverage; carry out carbon sink projects and push forward the construction of carbon sequestration forests.**

## (8) Improving the energy-saving and emission reduction management system

- **Take measures to implementing delicacy management and to perfect the three energy-saving and emissions reduction management systems: monitoring, statistics and evaluation;**
- **Establish a supportive benchmarking database and form a complete energy conservation and emission reduction evaluation indicators system for the petroleum industry as well as construction standards for petrochemical eco-industrial parks and green oil fields.**

## (9) Establish Low-carbon Development Strategic Mechanism

- **Research and formulate a low-carbon development strategic mechanism for the petroleum industry**
- **Construct low-carbon development management systems (based on evaluation, examination and technical assessment)**
- **Build a low-carbon development standard system**
- **Formulate supporting policies in terms of carbon finance and emissions trade**

**The establishment of a long-lasting low-carbon mechanism will provide decision-making support and a policy guarantee for the low-carbon development in the petroleum industry.**

# Conclusion

- Currently, China is at a crucial stage of accelerated development towards industrialization and urbanization, which will continue to stimulate oil consumption and exacerbate the conflict between resource and environment bearing capacity and petroleum industry development.
- Though China's oil industry has carried out much arduous work in the area of green development and has made some remarkable achievements, there is still a great disparity compared with advanced international level. With the rising appeal for energy conservation, emissions reduction and addressing climate change, we are faced with unprecedented opportunities and challenges.
- Green development, which will be achieved through a diversified approach – through the pursuit of cleaner production and circular economy across the board, further promotion of energy conservation and emission reduction, and improvements in low-carbon ecological civilization, is a comprehensive strategic action to make sustainable and low-carbon petroleum industry development a reality. China's oil industry should actively work towards green technological innovation and advance, widely strengthen international communication and cooperation, vigorously conduct R&D, and give effective support in the areas of science and technology.

**CNPC is willing to communicate and cooperate with worldwide friends to make a contribution to building a green and harmonious world.**

# Thank you