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Circular Economy Strategies of oil and Gas exploitation in China

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Abstract

With the strategy of sustainable development is generally accepted, developed countries are harmonious developing oil and gas and ecological environment by developing circular economy and building cyclic ecological society. Circular economy has a successful practice in the oil and gas industry in some developed countries and has formed the varied and practicable development modes. In this paper, circular economy strategies of oil and gas exploitation in China have been analyzed. The author believes that would be helpful to "low extraction, high use and low emissions".

Keywords: circular economy; strategy; oil and gas exploitation

1. Introduction

The industrial structure of oil companies in China includes oil and gas exploration, oil refining, pipeline transportation, sales of oil and gas refined products, oil field and engineering services, petroleum equipment production, oil trade, etc. Forthmore, their oil production and consumption has a long chain which related to a wide range such as drinking water sources and ecologically sensitive areas. Meanwhile, the explosive refining devices are mostly located near rivers, lakes or residents concentrated area. Thus, due to its character of high risk, oil companies in China take measures to implement total circular economic strategies in its upstream, downstream and links in the production chain. According to

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successful experience of multinational oil companies and requirements of circular economy, our oil companies need to establish recycling economic model and implement alternative energy strategies.

This article is organized as analyzing circular economy strategies of oil and gas exploitation in China, which is, industry chain strategy of the resource extraction, technical progress and innovation, optimizing resource exploitation, improving resource efficiency and supporting system of circular economy.

2. Circular Economy Strategies of oil and Gas exploitation in China

2.1. Improve industry chain strategy of the resource extraction

Value of resources (or intermediate products) in recycling economic industry chain can be divided to two parts, explicit value and potential value. The former could reflect by traditional industry chain, meanwhile, the later exists in recycling economic ones. Potential value can be achieved only through some mechanism, technology innovation and management optimization. oil companies in China should establish its own recycling economic model through extending oil industry chain. Therefore, the target of circular economy of oil companies in China is to show potential value of oil resources. The process of externalization means implement of internal circular economy in several of links such as oil exploration, exploitation, transportation, oil production, oil consumption, etc. Also, this process needs to expand range and scale of oil engineering service. With this process, we can extend oil and gas resources industry to form saving industry chain, improve the efficiency of resource extraction, reduce the cost of exploration, promote development of non-contact exploration technology, reduce environment damage of exploration areas and actively promote R&D process to increase value-added products. Besides, we can maximize the transform and utilization of active ingredient of coal such as carbon, hydrogen, oxygen etc. Meanwhile, we can realize the optimization and upgrade of oil fields and petrochemical industry. In this process of industry chain extension, oil companies in China can achieve its new economic growth points including environmental protection, clean production, rational use of waste resources, as well as promoting the development and utilization of green energy and environment-friendly product.

2.2. Enforce technical progress and innovation strategies

Modern oil industry is aggregation of technology-intensive industries, and its pace and quality of future development does not depend on natural resources, hardware technology or capital amount, but on innovation, form and utilization of software resources such as knowledge and techniques. In order to catch the development opportunities bring by knowledge economy, Oil companies in west take measures to adjust industrial structure regarding knowledge and high tech. In term of technology environment of oil companies in China, most theories and frontier technologies are followed foreign countries and lack of innovation and competitive advantages. In contract to abroad, there is distance in our main industry of oil exploration, exploitation and refining. Our oil and gas exploration industry must fully depend on science and technology to get rid of quantitative expansion with low technology level, and raise our utilization efficiency of mineral resources and reduce consumption level caused by economic development.

In terms of oil and gas resources exploration, the types of technology innovation are as follows:

(1) New technologies for identification of minerals, oil, gas and water. This type includes: ① Remote sensing, aerial surveys or other geophysical and geochemical methods; ② Establishing criteria for query in spatial database with help of economic and environmental model, in order to identify various of natural resources(including subterranean ones) and potential environmental disasters; ③ Establishing neural networks and decision support systems to do integration and analysis of multi-data sets with standardized database; ④ New methods to determine organic matters of natural substance which are high efficiency

with low cost and for both exploration and environmental industry(comparable with those methods which are increasingly applied for determination of inorganic); ⑤ New methods applied for situ analysis of organic and inorganic minerals or chemicals; ⑥ Researches on comparative evaluation of Ecology or Economics; ⑦ Innovative drilling technologies; ⑧ Improved three-dimensional simulation and analysis technologies based on advanced computer software, which are for identifying all kinds of resources including deposits and finding out ways of sustainable mining.

(2) Mineral mining and processing technologies including: ① Technologies of automating resources exploitation. For example, a kind of technology applies pumping system to optimize allocation and design to reach the goal of lowest energy consumption, which is based on principles of saving energy, functional complementing, reducing cost and increasing comprehensive benefits; ② Key technologies for resources conservation. Which include comprehensive utilization of resources, efficient water injection while producing oil and gas, advanced treatment and comprehensive utilization of oilfield produced water and sewage; ③ Organizing and implement significant demonstration projects in conservations, with purpose to improve the evaluation system for screening technologies and promote application of mature technique, such as optimal selection in matching pumping system and portfolio of parameters to realize best energy cost; ④ New mining technologies. In oil fields whose oil with characteristics of heavy or super heavy, we need to research and develop comprehensive technology for improve the efficiency of the boiler gas injection, insulation technology for pipelines with high-pressure or high-temperature, wastewater treatment and reuse technology of heavy oil, water supply technology for boiler with thermal recovery to gas injection. We also need to improve oil engineering, establish systematic and mature supporting technologies, and enhance technology research and transfer for energy development; ⑤ Find out methods to increase yields and recovery ratio of oil fields.

(3) New technologies for recycling waste stream and by-product production, including: ① Producing value-added products with "trash" such as waste and residues; ② Basic methods to get useful materials from emissions in waste steam which are based on physical, chemical and biological leaching technology; ③ Methods to increase yields of by-products; ④ Methods used for by-products in process of oil gas treatment(such as cuttings contaminated with oil), in order to make those by-products fit the standards for reuse or discharge(including discharge to marine environment); ⑤ Methods to inject SO^2 and hazardous fluid products into mined oil and gas reservoirs etc.

(4) Land remediation and maintenance afterwards, including: ① Botany technology, microbiology techniques, fungal technology and biological treatment technology based on Genetics including bio-extraction technologies; ② Methods to recycle compounds based on biological and chemical leaching; ③ Ways to protect and treat current water sources and isolate contaminated mud; ④ Real-time systems to monitor management and control of contaminated land; ⑤ Application of resource utilization and environmental management system.

2.3. Best strategy for optimizing resource exploitation

For the oil and gas resources which are non-renewable energy resources, we assume that the consumer exploring a certain amount of on-renewable energy resources in a period. Let k_t denote the quantity of non-renewable energy resources at the time of t; suppose $k_0 = 1$; c_t is the quantity of on-renewable energy resources in the period of t; the utility that consumers gained from non-renewable energy resources translate to the effectiveness of beginning is $\beta^t \ln c_t$. Optimal exploitation of non-renewable energy resources in the period of T is given by Eq(1) [1]:

$$\max \sum_{t=0}^{T} \beta^t \ln c_t \tag{1}$$

Be bound to Eq(2) :

$$\begin{cases} k_1 \le k_0 - c_0 \\ \cdots \\ k_t \le k_{t-1} - c_{t-1} \\ k_{t+1} \le k_t - c_t \\ \cdots \\ k_{T+1} \le k_T - c_T \end{cases} \tag{2}$$

Because there can be no unexploited non-renewable energy resources at the end of energy, we assume $k_{T+1} \ge 0$.

Lagrange function is defined by Eq(3):

$$L = \sum_{t=0}^{T} \beta^t \ln c_t + \beta^0 \lambda_0 (k_0 - c_0 - k_1) + \cdots + \beta^{t-1} \lambda_{t-1} (k_{t-1} - c_{t-1} - k_t) + \beta^t \lambda_t (k_t - c_t - k_{t+1})$$
$$+ \cdots + \beta^T \lambda_T (k_T - c_T - k_{T+1}) + \mu k_{T+1} \tag{3}$$

Then we get first-order conditions, is given by Eq(4):

$$\begin{cases} \dfrac{\partial L}{\partial c_t} = \beta^t [1/c_t - \lambda_t] = 0, \ t=0,\,1,\,2,\,\cdots,\,T \\[2mm] \dfrac{\partial L}{\partial k_t} = \beta^{-1t} [\beta \lambda_t - \lambda_{t-1}] = 0, \ t=0,\,1,\,2,\,\cdots,\,T \\[2mm] \dfrac{\partial L}{\partial k_{T+1}} = \mu - \beta^T \lambda_T = 0 \end{cases} \tag{4}$$

We also get relaxation conditions, is given by Eq(5):

$$\begin{cases} \lambda_0 \ge 0, \ \lambda_0 (k_1 - k_0 + c_0) = 0 \\ \lambda_{t-1} \ge 0, \ \lambda_{t-1} (k_t - k_{t-1} + c_{t-1}) = 0 \\ \lambda_T \ge 0, \ \lambda_T (k_{T+1} - k_T + c_T) = 0 \\ \mu \ge 0, \ \mu k_{T+1} = 0 \end{cases} \tag{5}$$

According to the optimal conditions, we can get $\lambda_t \succ 0$, with the relaxation conditions, we can get:

$$k_t - c_t - k_{t+1} = 0, \quad t=0,\,1,\,2,\,\cdots,\,T \tag{6}$$

At the same time, we can get $\mu \succ 0$, then $k_{T+1} = 0$. Thus, according to utility maximization, we can get:

$$c_t = \beta c_{t-1}, \qquad t=1,2,\ldots,T \tag{7}$$

The amount of optimal exploitation of oil and gas resources in each period is given by Eq(8):

$$c_t = \beta^t [\frac{1-\beta}{1-\beta^{T+1}}] \qquad (8)$$

2.4. Establish the strategy for improving resource efficiency

In response to the practical features of gas and oil exploration, oil companies in China have to build production and consumption patterns with saving and recycling-type step by step, realizing the transformation of resources use way from single linear process of "resources-products-waste" into feedback cycle process of "resources-products-waste-renewable".

(1) Establish saving mode of oil and gas exploration and production

In the oil and gas field construction and development decision-making, we should conduct a comprehensive study of energy use and make rational use of natural and artificial recharge energy in order to develop ability of oil and gas production. when formulating oil and gas exploration plans, we should consider sufficiently recycling of natural gas to improve the recovery of natural gas and reduce gas and oil own use and consumption in the process of production. We also should simplify the process oil and gas processing, use tight process to reduce oil and gas loss, implement project of saving and replacing oil, reduce the crude oil consumption and increase oil and gas production and commodity rate.

(2)Establish a system optimized model of energy efficient use.

Aim at the serious problems of high load system, imbalance regions and high energy consumption in the middle and late period of oil and gas exploration, with optimal adjustment of system base of energy-saving technology transformation of oil field, facilities layout optimization, the replacement of high energy consumption equipment, the number of equipment reduction and new energy-saving technology promotion should be implemented by measures of "off, stop, and, transfer, pumping, replacement, use, management" and so on [2]. Also the fine management and scientific management should be strengthen to achieve organic synthesis of system optimization and comprehensive utilization of energy-saving technology and improve operating efficiency of oil region aphaeresis system, gathering system and water and power system.

(3)Establish circular model of resources utilization

Pay attention to recovery and utilization of Waste heat, residual energy and residual gas in oil and gas exploration and promote heat pump technology which is used to recycle low-temperature heat of oilfield produced water for heating and gathering in oilfield and reduce energy waste and losses; study effective sewage disposal method to improve produced water in oilfield, re-injection rate and the utilization level of domestic wastewater; Strengthen the waste recycling, the implementation of waste oil recovery, recycling of drilling fluid , and multiple utilization of fine coal ash resources.

(4)Establish alternative energy strategy model

Alternative energy is an important strategy to protect national energy security. Multinational energy giant which is Amoco, BP, Chevron, Exxon, Mobil, Shell, Texaco all strengthen the investment of alternative energy. In order to solve long-term energy shortage problem in china, oil companies in China put the development of new alternative energy as one of development strategy. oil companies in China insists on the new energy development-oriented strategies which include oil and gas co-development, natural gas terminal sales, development and utilization of coal bed methane, adjustment of fuel restructure, coal processing and so on. In addition, there are deep mining coal gasification and chemical process, process and comprehensive utilization of oil shale, deep process and comprehensive utilization of coal and biological resources and energy research. oil companies in China makes full use of the advantage of stock and mature oil and gas exploration technology to explore coal bed methane exploration, mine the underground coal gasification, and develop geothermal resources and so on.

2.5. Improve supporting system of circular economy

The supporting system of sustainable material planning for oil and gas resource realizes optimal efficiency with planning on exploration, utilization and protection, including coordination to three kinds of resource structures which are foundation, using hierarchy and market. The coordination is in four aspects including structure, function, region and time. Among four kinds of coordination, the structural one means that intrinsic link of three structures has a little closer organization and higher ordering; the functional one means the elements in the system composed by these three structures should be complementary and simulative, which directly reflects system's states; the regional one means open system of these structures should be in line with development of surrounding areas to avoid regional restriction; time coordination means three structures are different on different socio-economic stages regards to their circumstances.

Therefore, supporting system for circular economy of oil and gas involves: ① Establishing sound mining system.; ② Promoting exploration of commercial mineral; ③ Making full use of two types of resources and two different markets, that is, multinational capital flow; mining, development and utilization of resources overseas; trans-national mergers and cross-listed of mining enterprises and international share of information, knowledge, technology and management; ④ Raising reserves of oil and gas resources;⑤ Speeding up legislating of circular economy; ⑥ Perfecting tax / fee system for protection of ecological environment. In one hand, we should expand the resources compensation tax and increase in fees appropriately; in the other hand, we should comprehensively promote tax / fee system that benefit for environment protection.

3. Conclusion

Generally speaking, the government leads the energy economy operation, and plays a very important role. So this makes the energy economy operation manifests the strategic features on the one hand and reflect institutionalized features on the other hand. Therefore, if we want to vigorously push forward circular economy development mode of China's oil and gas resource mining industry, we need to collaborate with enterprise, society and government. Based on the recycle economy mode of foreign oil and gas exploration, this paper put forward the circular economy strategic framework of our oil and gas resources exploitation: developing oil and gas resources mining industry chain strategy; strengthening resource technology progress and innovation strategy, building the strategy of energy efficiency improvement and completing the support system of circular economy.

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