

Focus on the Development of Shale Gas Industrial Clusters in China - Based on SWOT Analysis

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Abstract: The worldwide energies' price continues to rise again. More countries pay more attention to unconventional energies. Shale gas is one of the significant unconventional energy sources. With the successful development of shale gas in the United States, more and more countries and corporations focus on the shale gas exploitation. The large recoverable reserves of shale gas will ensure China's energy security and diversified energy supply, and it is also an effective way for China to transform into the clean energy economy mode. However, Chinese shale gas development still has a long way to go. By using the SWOT analysis method, this paper studies the internal and external development environment of establishing shale gas industrial clusters in China, and then explores development status of shale gas industrial clusters from four dimensions including strengths, weaknesses, opportunities and threats. Finally, according to the combinations of SWOT matrix analysis, the paper formulates four kinds of different development strategies to provide certain references to the development of shale gas industrial clusters in China.

Keywords: China, industrial clusters, shale gas, SWOT analysis.

1. INTRODUCTION

In the recent years, unconventional natural gas resources have attracted more and more attention. Compared with conventional natural gas resources, unconventional natural gas resources have larger reserves and longer extraction cycle. They have considerable prospects and are valuable to develop. Actually shale gas is an important unconventional natural gas. As an energy power, China has paid great attention to the development of unconventional natural gas resources with the huge energy demand. However, because of the late start and uncompleted technology, China shale gas industry could not make a breakthrough. In this paper, we used SWOT analysis method to analyze the feasibility of developing shale gas industrial clusters in China. At the same time, we look forward to providing reference for the study of developing a model of shale gas industry.

In today's world, natural gas is widely used because of its clean and low-carbon characteristics. However, with a large number of conventional natural gas resources that are mined, reserves of natural gas are gradually reducing. Thus, the difficulty of exploitation and mining costs are gradually increasing [1]. As a result, unconventional oil and gas resources such as shale gas that began revealing the value of development, originally remain idle due to the high cost. In the late century, the United States began to develop shale gas, and successfully achieved the industrialization of domestic shale gas, which greatly eased the energy shortage. At the same time, it also attracted many countries to follow setting off a shale gas boom.

Through the analysis, we can find that success factors in shale gas development of U.S. are policy supports, liberal market environment and the high participation of SMEs (small and medium enterprises) in promoting technological progress. The government of China has already introduced policies to support the development of shale gas industries. But due to the limited strength, Chinese small and medium enterprises lack the ability to develop shale gas independently, and the development of shale gas is still focused on three major oil companies in China. Exactly, industrial cluster development model is focused on this point, which concentrates the power of the set number of SMEs. Industrial cluster can jointly develop shale gas industry to increase the participation of SMEs, help to achieve technological breakthroughs and clear obstacles of shale gas development.

2. THE CURRENT STATUS OF CHINESE SHALE GAS INDUSTRY DEVELOPMENT

The current Chinese shale gas development has been widely appreciated and supported. But China shale gas industry has two major problems, that is poor foundation and the lack of core technology; it faces both opportunities and challenges.

2.1. Resource Situation

Shale gas resource in China has a very considerable developmental prospect. According to research, Chinese shale gas resource is up to 100 trillion cubic meters, and the recoverable reserves are about 36 trillion cubic meters, equivalent to twice the reserves of the conventional natural gas [2]. Meanwhile, shale gas also has some benefits such as a long life cycle and good environmental benefits, making the development of shale gas more valuable. Chinese government is also introducing preferential policies actively to promote the development process of shale gas. However, due to Chi-

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nese basic national conditions different from the United States, the shale gas industry is still in the initial stage. There are still some issues existing to be resolved such as the lack of funds and lack of core technology as well as the mining process may cause environmental pollution. And because of the high difficulty of exploitation of shale gas and high cost, most SMEs are unable to participate in the development of shale gas. Therefore, Chinese shale gas development is more difficult than that in the U.S., and we can't copy the U.S. model of development due to difference in situation.

2.2. Development Status

At present, shale gas in China is developed mainly by China National Petroleum (CNPC), China Petroleum & Chemical Corporation (Sinopec Group), China National Offshore Oil Corporation (CNOOC) and other large energy companies. In recent years, the petroleum enterprises' shale gas explorations mainly concentrated on Sichuan Basin, Ordos Basin, Eastern Depression of Liao He River and other regions. Through these years of painstaking efforts, China has made some achievements. However, some important factors hindering the progress of China's development are the weak foundation, the lack of core technology and other issues. With the global wave of shale gas development arising and the deepening of international exchanges, the development of shale gas will meet a new opportunity.

3. SWOT ANALYSIS METHOD

SWOT analysis method is an analysis method concerning competitive situation, largely used for strategic analysis process. In other words, it is an effective strategy development tool. "SWOT" is the abbreviation for the capital word of Strength, Weakness, Opportunities and Threat, in which "S" and "W" are internal factors while "O" and "T" are external factors [3]. It is commonly accepted that an industry's strengths and weaknesses demonstrate the industry's internal characteristics and are controllable; and industry's opportunities and threats are determined by external factors on which the industry has no direct control but can react to its own advantage. SWOT analysis is a methodology allowing an industry to understand and plan to use their strengths to exploit opportunities, to recognize and repair or avoid their weaknesses, and to defend against or sidestep any threats. The method has been widely used as a strategic planning tool and was found effective.

In the paper, S, W, O and T factors involved in the shale gas industry in China are proposed and analyzed with qualitative methods in the next part. We rank these factors according to their influence on the development of China's shale gas and put the factors that are significant as well as direct prior while the factors that are indirect later. Data used in the analysis stem from multiple sources including literature review, statistical reports, government regulations and policies. These findings would provide a valuable reference to assess and evaluate the shale gas industry in China.

4. SWOT ANALYSIS OF SHALE GAS INDUSTRIAL CLUSTER IN CHINA

By means of SWOT analysis method, we analyze the development model of shale gas industrial cluster from four

aspects, namely strengths, weaknesses, opportunities and threats. Then, we combine all factors and try proposing feasible suggestions.

4.1. Strengths

4.1.1. Abundant Resource Reserves

According to the Energy Information Administration (EIA), the mineable resource amount is nearly $187 \times 10^{12} \text{ m}^3$. The resource potential of shale gas is shown in the Table 1. And China has a mineable resource potential amount about $36 \times 10^{12} \text{ m}^3$ (20%), ranking first and followed by the USA (13%) [4], Argentina, Mexico and South Africa. The report from Ministry of Land and Resources shows that the resource reserves of China reach 134.42 trillion cubic meters (excluding Qinghai and Tibetan areas), and 25.08 trillion cubic meters is mineable [5]. It's obvious that the minable amount of unconventional natural gas resource is no less than conventional natural gas. With the support of abundant resource reserve, the industrial clusters would have great development potential. Fig. (1) shows the comparison between the minable resource of natural gas and the minable resource of shale gas.

Table 1. Assessment result about shale gas of EIA (Trillions of cubic meters).

Country	Minable Resource of Natural Gas	Minable Resource of Shale Gas	Percentage
China	30281	360825	19.25%
America	77118	223946	11.95%
Argentina	3792	219042	11.69%
Mexico	3396	192723	10.28%
South Africa		137255	7.32%
Other Area	168695	740235	39.50%
Total	283282	1874026	100.00%

4.1.2. Lower Cost and Stronger Competitive Power

The shale gas industry has a complete industry chain including processes such as exploration, mining, storage and transport and refining. If a shale gas industrial cluster is founded, there would be more specialized division of labor, more effective communication of information and more co-operation. It's expected that the cost of shale gas would be reduced and the productive efficiency would be increased. The co-operation among the companies of clusters would lead to a reduction of the cost of transaction, transportation and pollution abatement, which helps to increase the competitive power.

4.1.3. Benefit to Local Economy

It's expected that the foundation of shale gas industry cluster would be beneficial to local economy. And the

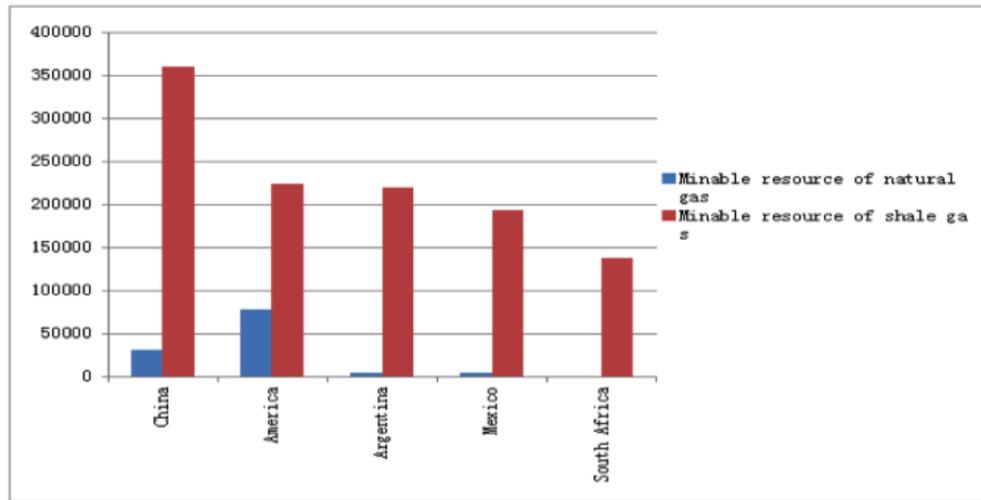


Fig. (1). The comparison between the minable resource of natural gas and the minable resource of shale gas.

economic progress will be helpful to the industry cluster, too. It's obvious that the shale gas industry cluster has multiple advantages.

4.2. Weaknesses

4.2.1. Lack of Fund

As a kind of unconventional natural gas, shale gas has gained a lot of attention in recent years. As a result, the technology and facilities of shale gas industry have not been completed yet. Especially, there are a lot of limitations in the transportation of shale gas. It's necessary to equip the industry with facilities, which require a large amount of fund [6]. This is the very reason why many middle and small-sized enterprises have difficulties in developing shale gas industry. And the cost of exploiting is still high since the technology is incomplete. What's more, it's also a burden to purchase the land to build industry clusters. Even for industry clusters, the lack of fund is still a limitation.

4.2.2. Lack of Core Technology

The development of shale gas industry in China is at a primary stage. There is not an important breakthrough in horizontal well technology and hydraulic fracturing technology, which has influenced the progress of the development of shale gas industry. Thus, the cost of mining is still high. And it may also have a negative effect on development prospect. According to some reports, burying depth of shale gas in America ranges from 200 meters to 2000 meters, whereas that in China ranges from 1500 meters to 4000 meters. And part of shale gas in China is buried in areas where there is a large population and where disasters occur frequently, making it harder to mine the shale gas. Table 2 shows the distribution of the minable resource potential. To achieve the industrialization of shale gas, it's necessary to make breakthroughs in core technology.

4.2.3. Lack of Common Standard of Exploitation

Although China has abundant shale gas resource, the elementary task of developing shale gas is still weak. And what we know about the storage condition of shale gas re-

source is not enough and there is no systematic methods to evaluate shale gas resource. These factors have a negative influence on the reliability of shale gas resource evaluation and exploitation of shale gas. Thus, China has difficulty in exploiting shale gas with great resource. On the other hand, it is difficult to choose the location for industry clusters if we can't evaluate the exploitation condition of shale gas.

4.2.4. Environmental Pollution

Hydrofracture is widely used in exploiting shale gas now. However, a lot of waste water would generate, resulting in serious environmental pollution [7]. Though waste water would be dealt with together, it is possible that the difficult of pollution abatement would increase as the production of shale gas increases.

4.2.5. Some Problems of Industry Clusters in China

Shale gas industry cluster is a kind of resource-based industrial clusters which have some problems. As discussed above, shale gas resource is a kind of unconventional natural gas resource and the main problems of developing shale gas are the great difficulty of exploitation and the high exploitation cost. Since there is a complete production model of conventional natural gas, the main job of shale gas industry cluster is to exploit shale gas. It's possible that there would be excessive competition among clusters. In addition, many clusters consist of middle and small-sized enterprises but technological innovation often means much input and great risk. As a result, a lack of innovation ability and innovation motivation is expectable, which would also affect the development of shale gas.

4.3. Opportunities

4.3.1. Government Policies to Guide and Support

With the strong support of our state and government, the development of the shale gas industry has been promoted well, which provides conditions for the development of shale gas industry cluster. During the 12th Five-Year-Plan period, the state will focus on shale gas as a key energy and mineral resource to strategically investigate, explore, develop, and

Table 2. Real distribution of China’s minable shale gas resource potential.

Area	Resource potential (Trillions of Cubic Meters)	Percentage (%)
Upper Yangtze and DianQian-Gui Area	9.94	39.63
North and Northeast China	6.7	26.7
Mid-lower Yangtze and	4.64	18.49
Northwest China	3.81	15.19

Table 3. Chinese shale gas industrial policy list.

General Principle		Industry Supervising		Demonstration Build		Industry Technological Policy		Market and Transportation		Support Policy	
NO.4 Speed up the development of shale gas, encourage enterprises (include private enterprises)to invest into the shale gas industry.	NO.8 Build up proper supervise mechanism to supervise the development of shale gas.	NO.9 Encourage co-operation with foreign enterprises with advanced technologies and introduction of foreign technology and experience.	NO.11 Encourage to build up demonstration area. Encourage several enterprises to build up demonstration area together.	NO.13 Accelerate the use of land in demonstration area, support the build demonstration area.	NO.19 To promote the development of shale gas, National Energy Administration will make standard specification about shale gas development.	NO.21 The ex-factory price of shale gas is market-set prices.	NO.22 Encourage shale gas industries to use the piping system nearby.	NO.30 Shale gas industry will be brought into strategic industry of China. Give more financial support to shale gas development.	NO.31 Give financial support to shale gas enterprises including the production.	NO.33 Give a lot of tax incentives to shale gas enterprises.	NO.34 Shale gas project can import equipments and technologies which can't be made in China without tariff.

increase channels of the investment and financing. The implementation of national policy will promote technological innovation and industrial upgrading of shale gas hence providing impetus for the rapid development of the shale gas industry clusters. At the same time, under the guidance of national policy, local governments also invest in infrastructure construction and introduce preferential policies to promote the development of shale gas industry. At present, in domestic areas rich in shale gas, the government has guided to set up several shale gas industrial parks, such as the plan to build the port area of 3750.5 acres of shale gas industrial heavy equipment park in Chongqing. It is estimated that after the completion of park, output will reach 30 billion Yuan. In October 2013, "Shale gas industrial policy" has been published to promote the development of shale gas. Table 3 shows some of these policies.

4.3.2. Huge Potential Market

China is a big country in terms of oil consumption. China’s natural gas production in 2011 was 102.5×10^9 m³, while consumption is 130.7×10^9 m³. The gap between supply and demand is almost 28.2×10^9 m³ [8]. And at present, the supply pressure of domestic oil and other energy is becoming much heavier, which make domestic energy in short supply and natural gas price on the rise as a whole While the natural gas prices in the U.S. market continue to fall due to the significant increase in the amount of shale gas exploration. Price of domestic gas is 50% higher than that of the United States over the same period, which provides the

opportunity for the development of shale gas industry in China. Meanwhile, domestic energy structure is not reasonable. For example, clean energy, only accounting for 4% of the total energy consumption, is 20% lower than the world average. In order to reduce air pollution and alleviate the pressure of oil and other energy supply, China will focus on developing clean energy in the future, which must lead to growing demand for clean energies. Shale gas has great market potential as a kind of efficient and clean energy.

4.3.3. The Deepening of International Communication and Cooperation

Government of China is encouraging domestic enterprises to strengthen exchanges with foreign countries. For example, domestic enterprises getting the right to exploitation of shale gas can carry out international cooperation and joint development. Up to now, many domestic companies have established cooperative relationships with the US. For example, CNOOC has set up R & D center in Houston. The deepening of international communication and cooperation and learning the commercial operation pattern from the developed countries such as the United States, Canada brought opportunities for the development of China's shale gas industry model.

4.3.4. The Accumulation of Related Experience in the Domestic Oil and Gas Industries

Oil and natural gas industries in China have accumulated valuable experience not only on the conventional oil and gas

but also on industrial cluster models. The accumulation of related experience in domestic oil and natural gas industry cluster will provide reference for orderly development of shale gas industry cluster.

4.4. Threats

4.4.1. *The Uncertainty of Resources*

According to preliminary estimates, the shale gas resource of China has considerable development potential. But up to now, the investigation and evaluation of shale gas resources in China's overall system have not been completed. Under the condition that potential resource and distribution of shale gas are still not clear, there is great uncertainty in the development of shale gas. The United States has done a large amount of resource evaluation and basic research work in the early stage, which greatly promote the development of shale gas industry. Compared to shale gas resources in the United States, shale gas resources are generally buried deeper in our country, therefore the strategic investigation and evaluation work of shale gas resources becomes more important. But at present our country's basic research significantly lags behind in identifying the actual needs for shale gas development, and the lack of a comprehensive survey and evaluation work, to a certain extent, would restrict the development of shale gas industry.

4.4.2. *Dependence on Foreign Technology and Fierce Competition*

The success of the American commercial shale gas industry led to the global development of shale gas industry. Its key to the successful development of the shale gas lies in the mastery of the horizontal well technology, multistage fracturing technology, hydraulic fracturing and a series of core technologies. Shale gas industry belongs to high-tech industries, which requires high cluster innovation ability. The exploration and development of shale gas in China is still in the exploring stage. High dependence on foreign technology and weak innovation ability make the sustainable development of the cluster lacking with core power.

At the same time, because the United States has a experience of commercial operation, we will face intense competition from foreign firms and the impact of the international market in the development of shale gas cluster in China. Although shale gas industry subsidies policy has been issued, yet domestic enterprises do not dare to enter due to its own technology gap, which would not be conducive to the independent development of shale gas independent industrial clusters in China.

4.4.3. *No Perfect Market Service System*

Although the government department in charge of shale gas resources is open-minded, and encouraged non-oil, and gas companies as well as much private capital to enter the shale gas industry, yet overall, the three major oil companies are still the main body of exploration and development and technical engineering services of shale gas. The fact that a competitive market and a sound market system consistent with shale gas industry have not yet fully formed, therefore the role of market mechanism to optimize the allocation of resources is severely affected. This is not conducive to entry

of general capital, and will hinder the formation of the industrial cluster.

4.4.4. *No Formal Specification of Management System*

At present, although investment and financing system of shale gas, as well as the related management system, have been put forward, yet the system that can promote the construction system of the industry is still under discussion. And investment and financing management systems relatively lag behind. Imperfect management system and regulatory policies make the formation of gas industry cluster lacking with power, so that the industrial development of shale gas remains in the exploration stage, which is mainly composed of three major oil companies. And other aspects of progress are also slow, which is not healthy for the formation of an orderly industry cluster. Therefore, the related management system needs to be improved and implemented.

5. DEVELOPMENT STRATEGIES OF CHINA'S SHALE GAS INDUSTRY

5.1. The Analysis of SWOT Strategic Matrix

Through the above systematic analysis about strengths, weaknesses, opportunities and threats of China's shale gas industry, we come to the SWOT strategic matrix of Chinese shale gas, including the strength - opportunity (SO) strategy, weakness - opportunity (WO) strategy, strength - threat (ST) strategy and weakness - threat (WT) strategy. SO represents the strategy that plays industry internal strengths and takes advantage of external opportunities. WO strategy represents the strategy that uses external opportunities to compensate for internal disadvantages. ST represents the strategy that utilizes internal strengths to avoid or reduce the external threats. WT represents the strategy that circumvent external threats while to make up for internal disadvantage. The contents of strategy are displayed in Table 4.

5.2. SWOT Strategy Formulation of China's Shale Gas Industry

5.2.1. *SO Strategy*

First, take the opportunity of the supportive and guiding effect of policies, make full use of the rich resources, low-cost and low-pollution of shale gas to promote developments and make progress of the shale gas industry cluster. Meanwhile, industry cluster pattern promotes the development of the local economy and in turn tilts government policies towards cluster pattern (S1, S2, S3, O1).

Second, take opportunity of the huge market potential of shale gas, exploit the abundant shale gas resources and gradually reduce the development cost. As the surrounding areas benefit from it, they develop side by side through mutual interaction (S1, S2, S3, O2).

Third, absorb advanced technique to reduce production cost with the deepening of international communication and cooperation so that technical progress will be promoted and the size and amount of industry cluster will be increased as well. Furthermore, with reduced shale gas's exploitation cost, industrial competition ability is enhanced, thus effectively attract domestic foreign investment (S2, O3).

Table 4. The SWOT strategic matrix of Chinese shale gas.

Internal	External	
	S (Strengths)	W(Weaknesses)
O (Opportunities)	SO strategy	WO strategy
	P1 Take the opportunity of the supportive and guiding effect of policies, make full use of the rich resources	P1 take the advantage of government policy support
	P2 Make use of the huge market potential of shale gas, exploit the abundant shale gas resources and reduce the development cost.	P2 Attract domestic and foreign investment to promote the progress of core technique
	P3 Bring into advanced technique to reduce production cost	P3 Set a feasible strategy to solve the shortage of capital, the backward technology and the contamination control
	P4 Combine actual situation of shale gas to exploit the resources and seek ways to reduce cost.	P4 Learn experience from other industry cluster to promote the development of shale gas.
T (Threats)	ST strategy	WT strategy
	P1 Guide the exploration and research of shale gas resources	P1 Put more effects to the evaluation work of shale gas resource.
	P2 Learn the successful experience of foreign countries	P2 Publish policies to protect domestic shale gas industry and guarantee the shale gas healthy
	P3 Relax the effect on resource competition and enhance competitive ability.	P3 Improve the market mechanism and create a good market environment for shale gas industry. Encourage small and medium size companies to participate in shale gas development work
		P4 Determine a reasonable management system to effectively manage the industrial cluster

Forth, learn from those successful experiences of cluster pattern, combine actual situation of shale gas to exploit the abundant energy resources and actively seek ways to reduce cost. Thus shale gas could be commercially available and in turn nurturing industrial cluster and region economy (S1, S2, S3, O4).

5.2.2. ST Strategy

First, on the basis of rich resources reserves, make effective use of the orientation function of market and the pushing effect of industry cluster on regional economy to guide the exploration and research of shale gas resources; for example, a comprehensive evaluation of nationwide shale gas (S1, S2, S3, T1).

Second, on the one hand, use huge resource reserves and indigenous advantage of competitive advantage to compete with foreign competitors. On the other hand, while learning the successful experience of foreign countries, the advantages of cluster, including high internal efficiency and abundant research resources, we should work to promote the progress of core technique (S1, S2, T2).

Third, rich recoverable resource provides some relaxation effect on resource competition. Compared to independent small and medium sized enterprise, clusters have more power and more effective developmental environment is available, enhancing its competitive ability and ensuring the cluster could withstand the competitive market (S1, S2, T3).

5.2.3. WO Strategy

First, take advantage of the government policy support. On the one hand, government will boost relative investment. On the other hand, relevant incentive policies will also attract more foreign investment, making up for the shortage of capital, making access to a breakthrough in core techniques, to provide the sustainable development of shale gas's industrial cluster a solid backing (W1, W2, O1).

Second, on the basis of shale gas's great market potential, attract domestic and foreign investment effectively to promote the progress of core technique, then push the progress of shale gas's resource evaluation and determination of mining standard. Eventually, accelerate the speed of shale gas development progress (W1, W2, W3, O2).

Third, by means of communicating and cooperating with countries which have successfully developed shale gas industry, introduce and absorb international shale gas development advanced techniques. According to the industry conditions, set a feasible strategy to solve present problems such as the shortage of capital, the backward technology and the contamination control (W1, W2, W4, O3).

Forth, many companies have accumulated practical experience from the construction of relevant resources industry clusters, which is very helpful to resolve the problem of lack of funds and vicious competition (W1, W5, O4).

5.2.4. WT Strategy

First, more efforts should be put into the completion of shale gas's resource evaluation work to have a comprehensive view of the status of shale gas resources in China. It will help to attract more investment, determine a unified exploitation standard, push the development of shale gas's follow-up work, and then promote the development of shale gas industry (W1, W3, T1).

Second, increase supportive efforts for shale gas industry and publish preferential policies to protect domestic shale gas industry and guarantee the shale gas healthy and ordered development. Speed up the research of core technology to achieve breakthrough on core technology as soon as possible. Overcome the lack of core technology as soon as possible and disengage from technology dependence on foreign countries (W1, W2, T2).

Third, improve the market mechanism, and create a good market environment for shale gas industry. Encourage small and medium sized companies to participate in shale gas development work to solve the problem of scarce funds and slow paced development so as to achieve new breakthroughs (W1, W2, T3).

Forth, determine a reasonable management system to effectively manage the industrial cluster and effectively control the pollution generated in the development process. Meanwhile, avoid vicious competition in internal cluster, encourage innovation and efficient operation and inject vitality into the shale gas industry development process.

CONCLUSION

The shale gas industry cluster in China is still in the initial stage of exploration. On the one hand we have an advantage, we must grasp the opportunity. On the other hand, we still have disadvantages, and still face threats. Using SWOT method, the developmental mode of industrial cluster in Chinese shale gas was analyzed. At the same time, keeping in the industry cluster development of shale gas, we put forward four kinds of development strategies: strength–opportunity (SO) strategy, weakness–opportunity (WO) strategy, strength–threat (ST) strategy and weakness–threat (WT) strategy. While gaining the advantages of shale gas industrial clusters, we must grasp the external opportunities at the same time. While using external opportunities to make up for self-disadvantages, we can use our own advantages to avoid or reduce the external threat. Finally, we should try to

overcome disadvantages to avoid external environment threats.

As the Five-year Development Program is promulgated and implemented, the proportion of shale gas in the China energy structure will continue to increase. At the same time, China has gained rich experience and good results in the industry cluster development pattern. Therefore, industry cluster development pattern is feasible and worthy of further consideration and research.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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