TALLINN UNIVERSITY OF TECHNOLOGY

Faculty of Social Sciences

Ragnar Nurkse School of Innovation and Governance

Di Lu

Analysing the Chinese Entrepreneurial State:

The Development of Chinese state-owned enterprises in the energy sector.

Master´s thesis

Supervisor: Professor Dr. Rainer Kattel

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Author’s declaration

I hereby declare that I am the sole author

of this master's thesis and it has not been

presented to any other university for examination.

All works, major viewpoints and data of the other

authors used in this thesis have been referenced.

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The master's thesis meets the established requirements

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Abstract

This paper analysis the Chinese entrepreneurial state based on energy sector, also discusses the role of Chinese state owned enterprises (SOEs) in energy innovation system. The paper chooses Chinese energy sector as main analysis object, presenting two cases of clean energy industry and oil industry to show how Chinese entrepreneurial state has developed and the potential role of Chinese SOEs play in energy sector. Within the theoretical framework of this paper, the existing theories about Entrepreneurial State (ES), innovation, SOEs and green industrial revolution will be analysed.

Key words: State owned enterprises, Innovation, Development policy, China, Energy technologies, Entrepreneurial State

List of acronyms

CCP	China Central Committee
CNOOC	China National Offshore Oil Corporation
CNPC	China Petrochemical Corporation
ES	Entrepreneurial State
GDP	Gross Domestic Product
GW	Gigawatt
ICT	Information and Communication Technology
NDRC	National Development and Reform Commission
R&D	Research and Development
SASAC	State-owned Assets Supervision and Administration Commission
SINOPEC	China Petroleum & Chemical Corporation
SOE	State-owned Enterprise
SOEs	State-owned Enterprises

1. Introduction

Due to the climate change and environmental pollution, countries around the world are looking for a new way to lead the economic growth, and hoping that this kind of growth is also more sustainable (European Commission, 2010; Mazzucato, 2015). Today, trying to make innovative technology and policy to push the economy into the sustainable model which is a green development has become a necessary plan and task for every country. In the process of national innovation and development, the government plays an important role. Also states and governments have realized the importance of innovation in the national economic growth and national development. As Mazzucato argues that the role of the state is not just taking charge of interventions into the macro economy: "the state is also seen as entrepreneur, risk taker and market creator" (Mazzucato, 2015).

Facing challenges like international oil prices decline and climate change, energy companies have gone into action to maintain profits by new technology and innovative policy. On the other hand, these challenges have created a new standard for innovation and growth policy that make growth more smart, inclusive and sustainable (Mazzucato, 2015). So how to realize the new industrialization with high technology content, favourable economic benefits, low resources consumption, few environmental pollution, and taking full advantages of human resource by new technologies have become the focus to energy industry. For example, oil companies are using new information technology to monitor oil exploration and drilling operations. The aim is to use real-time data to make better decisions and improve efficiency, increase safety (Accenture, 2015).

In order to achieve sustainable development in energy industries, Chinese government and state owned enterprises of energy sector has made great efforts on it. Also, under the new development and economy situation in China, the new development plan Chinese 13th "Five-Year Plan" was just issued (Scott K. & Chritopher k. J., 2016).

The paper will choose Chinese energy sector as main analysis object, and present two cases of clean energy industry and oil industry to show how Chinese entrepreneurial state has developed and what potential role of Chinese SOEs play in energy sector. The case of Chinese clean energy industry is very meaningful for analysing Chinese entrepreneurial state as China has built a renewable energy system that is the largest in the world now (Mathews, 2015). It would be very interesting to take a look how Chinese government has made efforts on clean energy industry development. China National Petroleum Corporation as a specific case of Chinese oil industry will be discussed. Because CNPC is the largest oil and gas producer and supplier in China, as well as one of the world's major oilfield service providers, furthermore, as one of the biggest state-owned enterprises (SOEs) in energy sector, CNPC has long been committed to researching and developing sophisticated and practical technologies and solutions in oil and gas exploration and development operations (China National Petroleum Corporation, 2016). It would be very interesting to see how such a large-scale state owned enterprise has developed and effected energy innovation system in China. Also, it is very interesting to take a look at how the 13th Five-Year Plan policy effect on the Chinese SOEs and Chinese economy.

This thesis aims to find answers to the following research questions:

- How is Chinese entrepreneurial state conceptualized and implemented in the energy sector?
- What roles do state-owned enterprises play in energy innovation systems in China?

The paper consists of five chapters: This first chapter is an Introduction of main study subject, the Chinese entrepreneurial state (ES)-The Development of Chinese state-owned enterprise and its current status, reasons for choosing the topic and overview of this paper. The second chapter will focus on the theoretical framework which is based on Schumpeter-Keynes-Minsky analytical framework, Mariana Mazzucato's "Entrepreneurial State" theory, and John A. Mathews's "Greening of

Capitalism" concept, moreover, it will introduce theoretical background of the issue – how scientists and thinkers have seen the Entrepreneurial state framework and the role of innovation in economy growth, and the potential role of SOEs in innovation systems, it is about theoretical analysis. The third chapter will take a look at how Chinese state-owned enterprises have developed, plus an introduction on energy sector, the recent industrial and innovation policy in China. Then the chapter will concentrate on the main research topic and case study. The case study is about theoretical analysis and empirical research - the data gathering and theoretical foundation will be made through statistical and document research. Analyses and discussion will be presented in the fourth chapter. Conclusions of this paper will be made in the final chapter.

2. Theoretical Framework

Before starting the main discussion, it is necessary and useful to state some major theoretical and empirical basis which is related to Entrepreneurial State, innovation, SOEs and green revolution. This section will show how scientists and thinkers have seen the Entrepreneurial State framework and the potential role of state-owned enterprises in national economy and innovation systems.

2.1 The Entrepreneurial State

The main purpose of the paper is analyzing the Chinese entrepreneurial state, so first of all, it is necessary to take a look at how scientists and thinkers have seen the Entrepreneurial State framework.

Mazzucato brought out in her book called "*The Entrepreneurial State: debunking public vs. private sector myths*" that " an entrepreneurial state must welcome, rather than fear, the high risk and uncertainty across the entire innovation chain" (Mazzucato, 2015). This means that State should be as entrepreneur that has ambition to make investment into such areas which are uncertain and high risk. This is one of necessary responsibilities for entrepreneurial state (Mazzucato, 2015). Also, the State should make more investment in innovative technology. The entire society is facing numerous challenges like climate change, youth unemployment, as a result, governments urgently need to make changes to their development strategies which can make economic growth more sustainable. In addition, the state should realize the importance of innovation in economic growth to make new innovation policy for current national conditions (Gros, D., & Roth, F, 2012; Mazzucato, 2013). Above all, an entrepreneurial state has to be ambitious (Mazzucato, 2013).

Moreover, Mazzucato argues that Entrepreneurial State should be courageous and strategic (Mazzucato, 2011). It means that States should not only focus on business and producing goods, but also need to be more confident in exploring smart policies

according to the current trend and finding new ways to make sustainable growth. To be a good Entrepreneurial State also required that State should make early, high-risk, and capital-intensive investment (Mazzucato, 2013). Mazzucato also argues that the key role of government is about actively creating the market for the new technologies (Mazzucato, 2011). It means that Entrepreneurial State requires government to be an active driver in making long-term investment and innovative technologies (Mazzucato, 2011). Besides, it requires State and government to be a leading role in building a highly innovative economy model and making a sustainable development.

Speaking of Entrepreneurial State, Schumpeter's theoretical approach is significantly worthy of introducing. Burlamaqui stated an extension of Schumpeter's theoretical approach that "the state is, more often than not, an entrepreneur and should be at the center of a theory of economic development. An institution that combines the functions of macro-strategist; venture capitalist in chief and creative destruction management clearly "qualifies" as entrepreneurial" (Burlamaqui, 2016). It highlighted the importance of entrepreneur in economic development that the government should support innovation area and make investment in research and development, labor skills and direct and indirect support for technologies (Mazzucato, 2015; Burlamaqui, 2016). It also highlighted that making investment into industrial, innovation and technology policies is a major responsibility that venture capitalist should do. Schumpeter's theoretical approach is very important for analyzing Chinese entrepreneurial state, because it also figured out that Socialism can work (Schumpeter, 1942). It means that Schumpeter's theoretical approach is fit for discussing the situation of Chinese entrepreneurial state. Schumpeter's definition of socialism focuses on socialization. It involves modes of interaction between the private and public spheres (Burlamaqui, 2016; Schumpeter, 1942). In this definition, Schumpeter figured out the characterization of socialism that public sector plays crucial role in economic development, rather than private sector. More importantly, this definition highlights that the control by the central authority (Burlamaqui, 2016; Schumpeter, 1942). For Chinese situation based on one-party rule, Communist Party's Politburo

Standing Committee is a good example to explain the case of control by the central authority (Burlamaqui, 2016). In addition, Schumpeter believed that in the absence of innovation, the economy cannot create a qualitative leap of economic development (Schumpeter, 1942; Mazzucato, 2015).

2.2 Technology, Innovation and Growth

Innovation can be defined in many ways. It can be narrowly defined as the creation of technology that is new to the world (Chunlin., Douglas., William, James, 2009). It can also be defined broadly, "to encompass the processes by which firms master and get into practice product designs and manufacturing processes that are new to them, if not to the universe or even to the nation" (Nelson and Rosenberg, 1993).

In addition, it is necessary to mention the Schumpeter's innovation theory. The famous Austrian economist Joseph Schumpeter popularized the term "creative destruction" in economics. He argues that there are five situations can be called "innovation" (Schumpeter, 1934):

1) Creating new products.
2) Adopting new production method.
3) Creating a new market.
4) Getting a new source of supply.
5) Creating a new form of organization to break the original organization form of monopoly (Schumpeter, 1934).

Innovation is not just a purely technical or technological invention, but a constantly running operation of the mechanism. Schumpeter's innovation theory mainly has the following basic ideas (Schumpeter, 1934):

1) Innovation is endogenous in the process of production
2) Innovation is a revolutionary change
3) Innovation means the destruction at the same time
4) Innovation must be able to create new value

5) Innovation is the essence of economic development
6) Entrepreneur is the propellant of innovation activities; entrepreneur is the major subject of innovation activities (Schumpeter, 1934).

Overall, Schumpeter believed that the innovation and technological change of a nation come from the entrepreneurs, or wild spirits.

Furthermore, Mazzucato argues that government should be ambitious on innovation technology. It is not just about throwing taxpayer money at various activities, but also need government to play an important role in national economic growth (Mazzucato, 2015). It requires States and government to be a leading role in building a highly innovative economy and making a sustainable development. To be more detailed, Mazzucato pointed out that government should guide a right direction for technological change and economic development, and then making investment into innovation areas which is following that right direction (Mazzucato, 2015). Also, the responsibility of government is not only about fixing market failure, but also creating new markets. It means that allowing public organization to experiment, learn and even fail. (Mazzucato, 2014) Therefore, it can be seen that the role of government and public sector is significant in making innovation and pushing economic growth.

Keynes believed that state intervention is the core element for the economy stability. He argued that government should adjust the propensity to consume and investment stimulation (Mazzucato, 2015). Also he believed that the stability of capitalism was dependent on business investment, government investment, consumption spending and net exports (Keynes,1936). According to Keynes's theory, government should not focus too much on increasing consumption, but on investment. Also, he highlighted the importance of investment of government activities. Monetary policy and fiscal policy can be used to stimulate consumption and investment. Keynes argued that it is difficult for government to adjust economy stability only by monetary policy. The main part should rely on fiscal policy (Keynes,1936). Moreover, Keynes argued that government should be more creative in finding and creating something new. In other

words, the government should create the market for the new technologies, making early, high-risk investment which the private sector cannot do (John M. Keynes, The End of Laissez Faire, 1926). In short, Keynes's theory focused on the stability of capitalism. He also pointed out that using government spending to boost demand and stabilize the economy is very important (Mazzucato, 2014). The reason this paper discusses the Keynes theory approach in analyzing Entrepreneurial State framework is that Entrepreneurial state requires government to be an active player in making long-term investment into innovation areas and long-term financial stability of the economy and sustainable development. As Mazzucato pointed out that government should guide a right direction for technological change and economic development, and then making investment into innovation areas which is following that right direction (Mazzucato, 2015).

In addition, the Schumpeter brought out that innovation and "creative destruction" can be seen as important keys to dynamic capitalism that the state is absolutely central to creating a dynamic, innovative and environmentally sustainable economy (Andrew, 2013). Schumpeter identified innovation as the critical dimension of economic change. He argued that economic change revolves around innovation, entrepreneurial activities, and market power. Schumpeter figured out that the momentum of economic development is not changes in consumer demand which claimed by equilibrium theory, but it is the reorganization of present production factors which made by producers in new ways. Economic development is the process of "creative destruction" that breaks new balance and promotes new ways. Innovation includes five typical forms of product innovation, process innovation, market innovation, supply chain innovation and production organization innovation (Mazzucato, 2015). Moreover, Schumpeter argued that the innovation and technological change of a nation comes from the entrepreneurs and wild spirits. Schumpeter's theory emphasized the importance of entrepreneurs' spirits in making innovation activities and national economic development. Schumpeter also believed that in the absence of innovation, the economy cannot create a qualitative leap of economic development (Schumpeter,

1942).

Schumpeter also made a strict distinction between “invention” and “innovation.” Schumpeter pointed out that the activities could be seen as innovation only when the invention of commercialization could be achieved successfully (Schumpeter, 1934). It can be seen that Schumpeter's innovation theory attaches great importance to the fundamental role of the market mechanism in the allocation of innovative elements. Moreover, He highlighted the financial support for innovation. It is not enough for Entrepreneurs to support innovation with desire, but also requiring Entrepreneurs to have innovation behavior and action (Schumpeter, 1934). However, the innovation is based on the discovery and invention, but they are uncertain to cause innovation. It can be seen that innovation is a key to economic development when it realizes business success in the process of development. Therefore, it is meaningless to talk about economic development and growth without a financial system that matches the entrepreneurial innovation. Schumpeter emphasized that the economic profits derived from innovation technology, and also the innovation is the motive power of the economy development and growth.

As mentioned above, many economists have seen that technology innovation plays a crucial role in the economic growth. Economic growth has always been a worldwide problem, especially for developing countries. Along with state economy development and society's progress, economic growth is always the goal of the State, related the entire economy and social development. Technological innovation is the driving force of economic growth and economic development; enterprises are the carrier of economic growth and economic development. Both technological level and innovation capability of enterprises, not only directly determine the competitiveness of enterprises, but also plays a crucial role in the entire industry and economic development. In modern economic growth, science and technology have gradually united to become the primary productive forces in development.

2.3 State-owned enterprise Rationales and Innovation

SOEs are known by many names – government corporations, government business enterprises, government-linked companies, public enterprises, public sector units or enterprises and so on (Jan, Nick & Sarah, 2015). Generally, a state-owned enterprise (SOE) is a legal entity that undertakes commercial activities on behalf of the state, its owner. SOEs can be fully owned or partially owned by government.

Talking about the role of SOEs play in innovation system is very complex and diverse. Every country has different situation about the role of SOEs in innovation system and economy growth. For example, In the US, SOEs are seen as an extension of the government and its agencies rather than businesses that serve national objectives. However, sometimes they act similarly to venture capital funds (Weiss, 2014; Tõnurist, 2014). In China, there is a different case. SOEs hold an important position in innovation and economy. The main aim of SOEs is to keep control over strategic industries, build them up and direct capital for investment (Chan and Rosen bloom, 2010; Tõnurist, 2014). In Finland and Sweden, the governments have taken a perspective of value creation and positive ownership of State-owned enterprises based on strong strategic choices (Clifton et al. 2006; Tõnurist and Karo., 2016). In the positive way, SOEs could be considered as the prospective drivers of economyic development and innovation. However, SOEs' disadvantages of technological innovation should not be neglected (Tõnurist, 2014). The possible 'public good' nature of R&D of SOEs has been figured out in some studies (Molas-Galart and Tang 2006). In the following sections of this chapter, the discussion will follow this way to see how thinkers and recent researches have seen the importance of SOEs in innovation system.

As stated by Tonurist and Karo that "SOEs could be perceived both as actors and instruments of innovation policy depending on the goals of the policy" (Tonurist and Karo, 2016). In their studies, it has figured out the importance of SOEs in innovation system that SOEs could act as the instruments in innovation policy system. In addition, this study showed that a new approach for analyzing the role of SOEs playing in innovation system that "SOEs can also be rationalized as instruments of innovation

policy, both as independent innovation actors and as potential coordinating change agents within broader innovation systems" (Tonurist and Karo, 2016). It means that SOEs is not only playing potential roles in economic development, but also playing very important role in innovation and making innovation policies. Therefore, the state and the state-owned enterprises could be considered as driver of technological innovation and development.

Some researchers have seen that State-owned enterprises are mainly as independent innovators (Belloc, 2014; Bernier, 2014). Furthermore, Tonurist and Karo figured out SOEs can be taken as a driver in making long-term investment about innovation technology; also, SOEs could act as cooperator between the public sector and private firms (Tonurist and Karo, 2012). So SOEs can coordinate activities and interactions for innovation. The important thing is that SOEs can be seen as innovation policy tools for investment and coordination of R&D, market making and social development (Tonurist and Karo, 2012). Therefore, Tonurist and Karo provided a very important approach and theory for analyzing the role of SOEs in innovation system.

Overall, based on the above theory and research, a positive and wide rationale about the role of SOEs in innovation policy has been introduced. It indicates important information concerning both micro and macro dimensions of governance of SOEs. Commonly, in terms of innovation policy and system it is evident that SOEs activities have become more significant and efficient. However, the disadvantages of SOEs in the innovation system should still be noticed.

2.4 The Green Industrial revolution

Stepping into the 21st century, the global society is facing multiple challenges such as the global energy resource crisis, environmental pollution, and climate change. These are difficult problems to be handled by every single country as well as government. In today's world, green development has become an important trend to every country. For example, like China and Germany, are making a huge effort into clean technology

and innovation sectors. Specifically, in 2015, China invested more than $ 102.9 billion into clean energy and technology. This is the largest investment than any other country in the world (UNEP, Bloomberg New Energy Finance, 2016). It can be seen that green industrial revolution is a necessary change for any countries to walk on a sustainable development path. In this section, it will show theories about green industrial revolution from Mazzucato and John A. Mathews to show how state and government made efforts on it. The reason of talking about green industrial revolution by using theories and approaches from Mazzucato and Mathews in this paper is that both of them take explicitly Schumpeterian view on green economy development research. Mazzucato figured out that Schumpeterian understanding of innovation is very important for analyzing the importance of giving a direction to the potential (Mazzucato, 2014). So the green development direction is reasonable case to demonstrate it. Plus, Mathews highlighted the importance of Schumpeterian creative destruction view on the latest green shift that surge of investment in renewable energies and low-carbon technologies (Mathews, 2015).

Thus, it is necessary to figure out the definition and meaning about green industrial revolution. Actually, there are many conceptions to be talked about. But the basic point of "green industrial revolution" as stated by Mazzucato is that "the current energy sector and industrial system have to be entirely and quickly transformed into a new status that is environmentally sustainable." (Mazzucato, 2015). In addition, Mathews figured out in his book "Greening of Capitalism" that the climate change and environmental pollution have become global problems, these are very severe issues. In this case, it is necessary for the state and government to take decisive action to make a change that is driving the system onto a new one which has new rules and standards. To be specific, the state and government should make new rules for the transition to a new green growth capitalism which has to effect directly on energy, resource, environment and finance, replacing the current and existing way to walk on sustainable and renewable pathways (Mathews, 2015). Also, green development could be seen as the big technological and market opportunity, stimulating private and

public investment (Mazzucato, 2014). However, this kind of investment is uncertain, high-risk and long term. In order to achieve green development, it is necessary for creating the smart governance to implement the effective innovation and development polices which can direct the investment into right direction (Mazzucato, 2014). Mazzucato argued that "without smart government at the organizational level, innovation-led growth is impossible" (Mazzucato, 2014). Moreover, as mentioned "State Entrepreneurial" framework above, an active government to deal with the problems of climate change and environmental pollution by innovative technologies in current situation is very much needed (Mazzucato, 2014). Furthermore, the national development banks play a significant role in this green transformation. Mazzucato said that "high risk and long-term investments are exemplified by confident national development banks that are directing lending to new uncertain areas that private banks and venture capitalists fear" (Mazzucato, 2015). States and governments can act as a force for innovation and change, leading the way which can guide a clear and courageous direction (Mazzucato, 2015). All in all, the main point is that the state and government have to be the driver and leader in this revolution which needs innovation-led to direct the development. To deal with those problems can be seen as a high uncertain, long term investment which the private business sector fears but public sector can do (Mazzucato, 2014).

Although the green industrial revolution is still on the early stage, governments all over the world have already taken actions to support the clean technologies, to make sustainable development policies for green growth and renewable energy, such as wind and solar power. When it comes to this framework, it is also necessary to mention the role of national development bank in these projects that support the sustainable development and clean energy and etc.

As stated by Mazzucato that the role of development banks are not just financing and supporting projects. Actually, development banks have multiple roles in national development, such as supporting of long term and technological development projects, as well as renewable energy, manufacturing and even start-ups, additionally financing

societal challenge projects. These projects have some common futures that of high social value, risky loans which the private sector fears (Mazzucato, 2014). It can be seen that the role of government and public sector is very important in national development and risk investment. Also, it can be figured out that talking about green industrial revolution is very meaningful for analyzing Entrepreneurial State.

In addition, John A. Mathews also figured out in his research "Greening Development: The Role and Experience of Development Banks" that national development banks have already proven to be very important institutions in development challenges, also, they play a significant role as mobilizers of direct financing of investment and green industrial revolution (Mathews, 2014). The good example to show and explain that is China development bank (Mathews, 2014; Mazzucato, 2014; Burlamaqui, 2016). In China, investments by China development bank are a key source of its success in green energy industry (Mazzucato, 2015), such as solar power and wind power. China development bank have heavily invested in green energy projects since 2007. Between 2007 and 2012, China development bank invested more than $78 billion to clean energy industry (Mazzucato, 2015). The rapid development of wind turbine and solar PV panels manufacturing firms made possible by public finance has built Chinese solar and wind technology manufacturers as leader in international market (Mazzucato, 2015). Moreover, China Development Bank is also a crucial factor for Chinese SOEs to make overseas expansion. Chinese clean energy firms and state-owned oil companies are using financing from Chinese Development Bank in order to make overseas cooperative projects with many countries (Buijs, B., 2012). These projects have many advantages for technical communication, technology research and development, and export trade. Therefore, as all talking above it can be seen that national development banks are playing significant role in the development and public investment. This role is not just about making financial support in large projects, but also about supporting in sustainable development and innovation technologies.

Put simply, this chapter is trying to make a basic theoretical framework based on

existing researches for the paper to take a look at how scientists and thinkers have seen the Entrepreneurial state and the potential role of state-owned enterprises in national economy and innovation systems. Schumpeter's theoretical approach is important when analyzing Chinese entrepreneurial state, because it also figured out that Socialism can work (Schumpeter, 1942). It means that Schumpeter's theoretical approach is fit for discussing the situation of Chinese entrepreneurial state. (Burlamaqui, 2016). Schumpeter argued that public sector plays crucial role in economic development, rather than private sector. More importantly, his Socialism definition highlights central authority control (Burlamaqui, 2016). For Chinese situation based on one-party rule, Communist Party's Politburo Standing Committee is a good example to explain the case of control by the central authority (Burlamaqui, 2016). John Maynard Keynes believed that state intervention is the core element for the economy stability. He argued that government should adjust the propensity to consume and investment stimulation. The reason of discussing the Keynes theory approach in analyzing Entrepreneurial State framework is that Entrepreneurial state requires government to be an active player in making long-term investment into innovation areas and making a long-term financial stability of the economy and sustainable development. The reason why talking about green industrial revolution by using theories and approaches from Mazzucato and Mathews in this paper, because both of them take explicitly Schumpeterian view on green economy development research. Mazzucato figured out that Schumpeterian understanding of innovation is very important for analyzing the importance of giving a direction to the potential (Mazzucato, 2014). So the green development direction is a good case to show it. Also, Mathews highlighted the importance of Schumpeterian creative destruction view on the latest green shift that surge of investment in renewable energies and low-carbon technologies (Mathews, 2015). For SOEs rationales, in China, SOEs hold an important position in innovation and economy. The main aim of SOEs is to keep control over strategic industries direct capital for investment (Chan and Rosen bloom, 2010; Kroll and Liefner, 2008). So talking about Chinese Entrepreneurial State by using SOEs which is one of the means to implement entrepreneurial state is

appropriate. Also, China could be seen as a developed Entrepreneurial State (Burlamaqui, 2016).

Hence, as mentioned above, theoretical approaches about the role of state and SOEs in economic development and innovation system have been described. In addition, the potential role of innovation and governance in economic growth has been mentioned as well. In the next section, this paper will take a look at overview about the development of Chinese SOEs of energy sector. And an interesting case study about Chinese energy sector will be discussed, which can help us to deeply understand the theory framework.

3. The Development and Innovation of Chinese state-owned enterprise of energy sector and China's development policy

In this section, the paper will introduce basic information about Chinese state-owned enterprise of energy sector, also, will try to make a good overiew of the recent innovation policies in China. In order to introduce the innovation of whole energy sector, the paper chooses Chinese energy sector as main analysis object, presenting two cases of clean energy industry and oil industry to show how Chinese Entrepreneurial State have developed and the potential role of Chinese SOEs play in energy sector. In addtion, the paper will take China National Petroleum Corporation as a specific case to intoduce the innovation of oil energy sector.

3.1 Overview of the Development of SOEs in China

Each country has its own SOE system and history. Also, the SOEs play different roles in different countries. First of all, the paper will introduce the background of Chinese SOEs.

In China, the classification and definition of SOE has a little difference from other countries. There are three main kinds of enterprises that can be called as SOE. First, wholly state-owned enterprise. Second, state-holding enterprise, whose majority share belongs to the government. Third, joint-operation company or joint-stock company. Thus, in China, state-owned enterprises also include enterprises which are controlled by local government investment (OECD, 2009; Zou, D., & Ouyang, R., 2008).

With the development of Chinese economy that enters the "new normal" condition, economic growth is facing different pressures. There are three main features of the "new normal" in Chinese economy. First, the Chinese economy has shifted gear from the previous high speed to a medium-to-high speed growth. Second, the Chinese economic structure is being constantly improved and upgraded. Third, the Chinese economy is increasingly driven by innovation instead of input and investment (Liu Wei, & Su Jian., 2014). In other words, Chinese economy is facing new opportunities

and challenges. Also, State-owned enterprise reforms in China have walked on a long and uneven road for many years. Generally speaking, the Chinese State-owned enterprise reforms began in 1978, divided into three different stages. The reform of Chinese state-owned enterprises is a process of continuous exploration. It could be seen as a process of interactive development between central government policies and practices (Zou, D., & Ouyang, R., 2008). The government plays a significant role in every reform. Also, the main goals of each reform could make SOEs more efficient than in the past (Mazzucato, 2014). According to the Blue Book of Chinese Development and Reform, there are three important stages for Chinese SOEs reform in the development (Zou, D., & Ouyang, R., 2008).

The first stage (1978-1992): The tentative exploration of SOEs reform. The main content in this stage was that helping SOEs to expand power and reduce tax, gave them more management rights for operation. The number of reported State-owned enterprises grew dramatically in this period. In 1978, SOEs accounted for 78% of China's gross industrial output (Gary H. Jefferson., 2016). In this stage, the state accumulated abundant experiences about SOEs reform (Zou, D., & Ouyang, R., 2008).

The second stage (1993-2003): The exploration about system innovation of the SOEs reform. In this stage, many small SOEs were entirely privatized. For the small SOEs, the result was that ownership of small SOEs was transferred to managers or private investors. For the larger SOEs, incipient forms of mixed ownership evolved in which the state retained majority ownership and control (Andrew & Cole, 2011; Gary H. Jefferson., 2016). The number of SOEs declined gradually. The goal of the economic system reform in China is to establish the socialist market economy system. This stage could be seen as a beginning of exploration of mixed ownership in China. Due to the explicit relation between plans and markets, reform of state-owned enterprises has entered the phase of system innovation from policy adjustment stage (Zou, D., & Ouyang, R., 2008).

The third stage (2004-2015): Restructuring of SOEs. In this recent stage, restructuring the large SOEs was an important plan. It required that the state-owned and state-controlled enterprises have to consolidate into a limited number. SOEs would be dominated and controlled by State-owned Assets Supervision and Administration Commission of the State Council (Gary H., 2016). The main goals of this stage were that to maintain and increase the value of state assets, and to improve the competitiveness of State-owned enterprises and their operational efficiency. In addition, the construction of modern SOEs system, the change of state-owned assets management mode and the reform capital market were three primary missions in this stage (Zou, D., & Ouyang, R., 2008).

These three stages of SOEs reform are very important to the Chinese SOEs development. It not only effected on the scale, ownership and character of SOEs, but also on the system and structure of SOEs (Zou, D., & Ouyang, R., 2008). After effective reconfiguration and destruction reform, the newest structure of relationships among SOEs, State Council, State-owned Assets Supervision and Administration Commission of the State Council (SASAC) and Government will be shown on the figure 1 below.

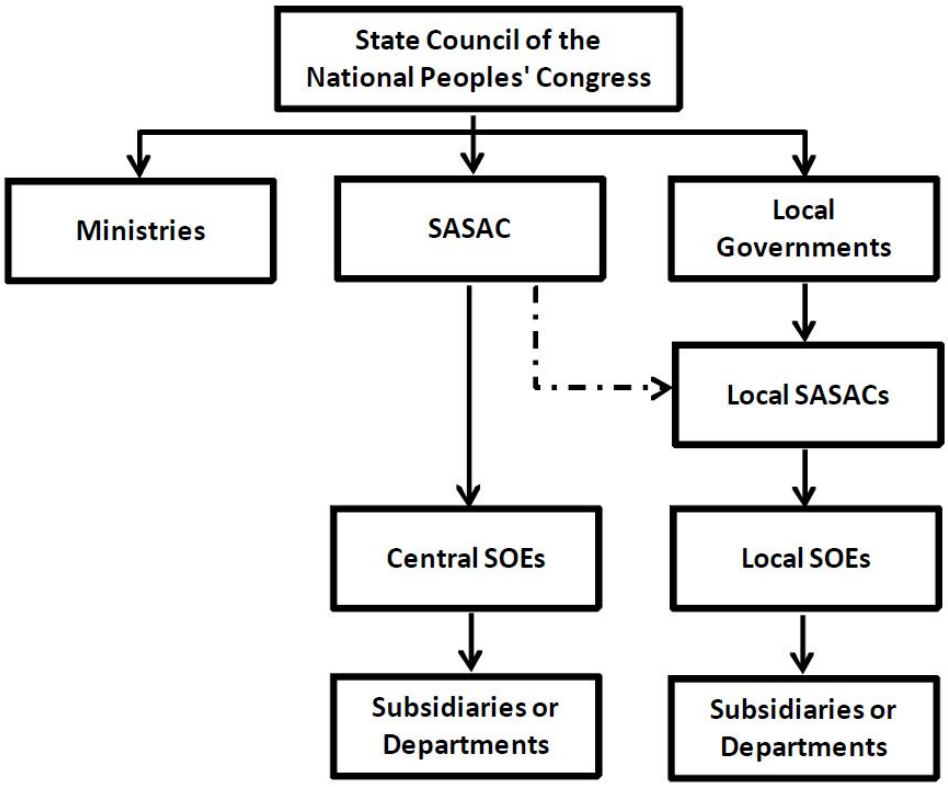

Figure.1. Structure of relationships among SOEs, SASACs and central and local governments (Andrew & Cole, 2011)

The Chinese government defines SOEs as enterprises in which all assets are owned by the state. SOEs are either centrally owned by local governments. However, Central SOEs are controlled and managed by State-owned Assets Supervision and Administration Commission (SASAC), such as China National Petroleum Corporation (CNPC), China Petrochemical Corporation (SINOPEC); (Andrew & Cole, 2011).

According to the statistical data, in 2015, there were 106 Chinese companies on the list of top 500 Global Companies. It can be seen that China is second only to the U.S., which has 128 companies on the list. And comparing this 2015 data with the past, China's progress is very breathtaking. China had just 46 companies appearing on the list in 2010 and only 10 in 2000 (Gary H., 2016). Among 106 Chinese companies 88 companies are SOEs (Fortune, 2015). It is observed that SOEs have very important position in China.

Although the process of Chinese SOEs development is long and uneven, all reforms of SOEs have many significant meanings for the Chinese development and economy (Gary H. Jefferson, 2016). First, it enhanced the vitality of the state-owned enterprises and improved the control force of national economy. Second, the national economy was promoted to go forward along the way of sustainable, rapid and healthy development. Third, it improved the competitive ability of the state-owned economy. Fourth, the reform improved the efficiency of the state-owned capital allocation and optimized the layout of state-owned economy, playing the role of market mechanism fully (Zou, D., & Ouyang, R., 2008). The purpose is to explore the mixed ownership economy development, also, to establish and perfect market economy system (Gary H., 2016). However, the reform of SOEs is a very controversial problem in China (Sujian, H., 2014). Due to the important role of SOEs in the China's development, even its large scale of assets controlled by the state, so that the reform of Chinese SOEs is evolving difficultly (Michal, 2016). In addition, Chinese SOEs reform and the effects of development policy on SOEs will be discussed further in next chapter.

3.2 The innovation of energy sector in China

Big changes have taken place in China's energy sector over the past decade. These changes have effected on energy consumption, trade, production and regulatory policies in China. Facing the challenges such as climate change, environmental pollution, fierce international competition, and China's energy sector has to make a change to meet all sorts of challenges (Wu Y, 2003). Due to the irreplaceable role of energy to various fields of the national economy and people's livelihood, so energy sector is always seen as the focus of the reform. For now, after several reforms, the newest regulatory structure of the China's energy sector is brief and efficient. The institutional innovation is also one important part of innovation plans in energy sector. The following figure 2 will show the newest structure.

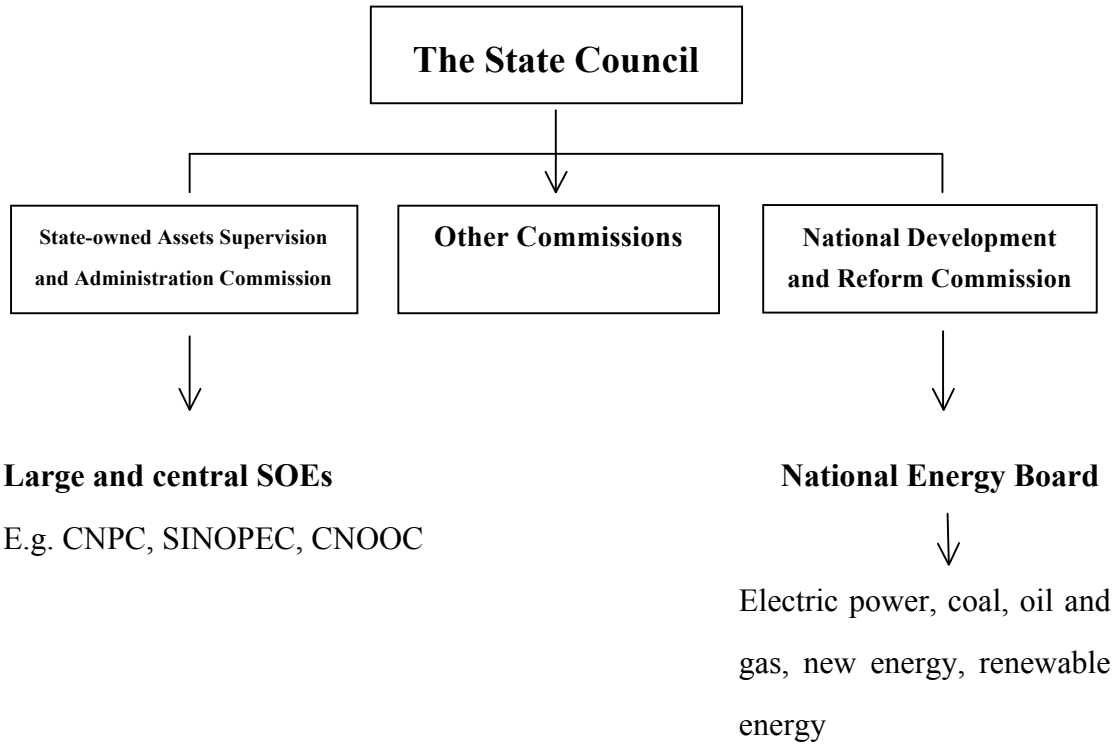

Figure.2. Regulatory structure of China's energy sector. (The State Council, 2016)

From Figure2 we can clearly see that natural energy resources such as coal, oil and gas are totally owned and controlled by National Energy Board, even new energy and renewable as well. National Energy Board is one of sectors managed by National Development and Reform Commission (NDRC). But large central energy SOEs are managed by State-owned Assets Supervision and Administration Commission (SASAC), such as China National Petroleum Corporation (CNPC), China Petrochemical Corporation (SINOPEC).

In the process of development, China relied on oil and coal to generate the power it needs to drive its economic growth, which like the development of Britain, US and Germany in 19th century (Peter. F, 2009). Recently, climate change and environment pollution have become a serious problem to any countries around the world. Thus, to achieve green development which required policymaker to make innovation policy making industrial development more sustainable has become an important trend to every country.

In fact, the Chinese government has invested heavily in clean energy technology for a long time, even it can be seen as the leader in this "green shift development" around the world (Mazzucato, 2015). For example, in 2015, China invested more than $ 102.9 billion into clean energy and technology. This is the largest investment than any country (UNEP, Bloomberg New Energy Finance, 2016).

As mentioned above, According to the Fortune top 500 global companies ranking, in 2015, there were 106 Chinese companies on the list of top 500 Global Companies, 88 of them are State-owned enterprises. And energy companies accounted for a very large proportion around one-third. (Fortune, 2015). The Figure 3 will show it below.

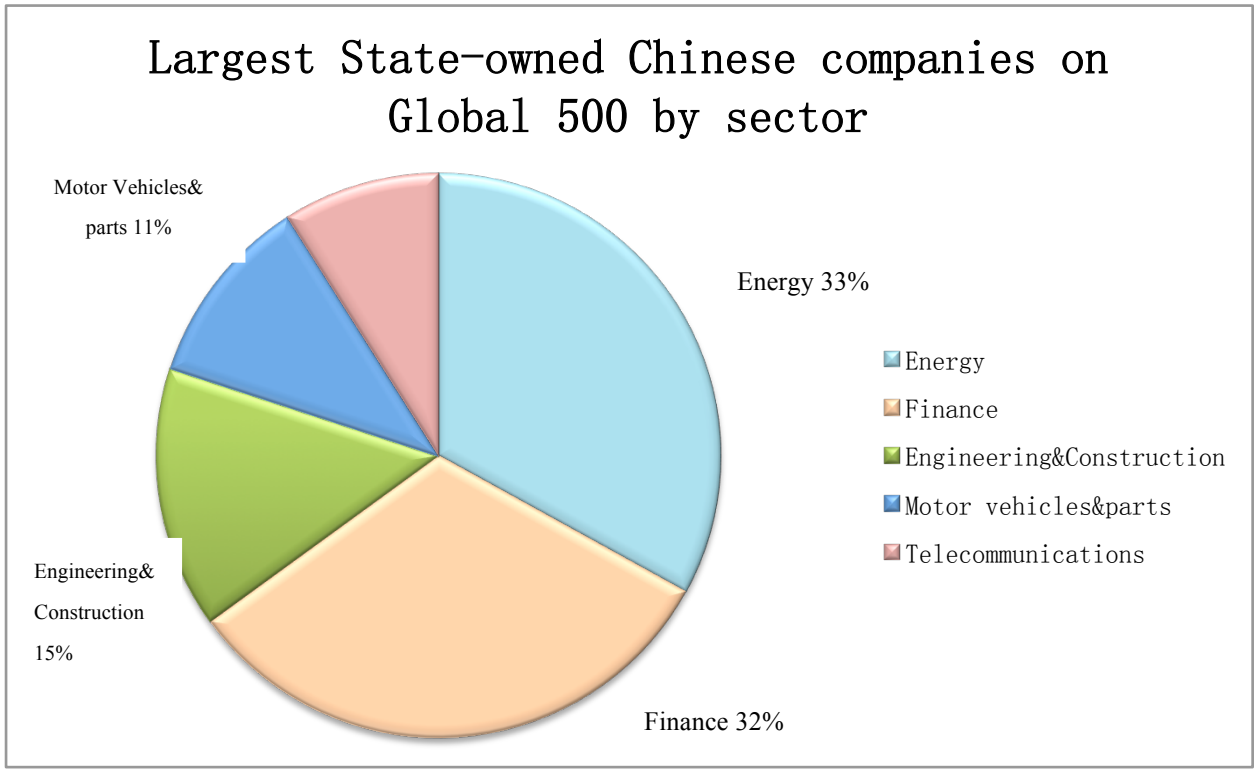

Figure.3. Key Sectors of China's largest state-Owned Enterprises on Global 500 (Gary H. Jefferson, 2016; Fortune, 2015)

In the rest part of this section, it will take a look at how Chinese government is making efforts on innovation in energy sector to achieve two goals. The first one is to provide economic growth. The second one is to mitigate pollution and climate change.

3.2.1 Innovation in the Clean Energy Industry

With China's high speed growth of development, the country's energy demand entered a new phase. As a result, China's energy sector has to be confronted with a series of challenges associated with transiting to a new growth pattern which is sustainable and smart (Bo, Weibin, Aiming, & Wei, 2015). After years of efforts, China has built a renewable energy system that is the largest in the world now (Mathews, 2015). Since 2015, China has gotten 12% of its total primary energy from non-fossil sources per year (ChinaFAQs., 2016). Moreover, many Chinese stated-owned electric power companies and local governments invested into to clean energy research and development or established their joint ventures of new energy to seek the new economic increase point and widen the service fields by new technologies. The paper will make different figures by the real data to show how big changes have happened in Chinese energy sector.

- Investment: Figure 4 shows that global new investment in clean energy by region in 2015. It is clear see that China is the number one investor in renewable energy in 2015 with $102.9 billion, accounting for over a third of global investment, even more than the summation of the US and all Europe. In fact, China has been the number one investor in renewable energy from 2012 to 2015 (UNEP, Bloomberg New Energy Finance, 2016). From Figure 5, it can be seen that solar power and wind power are two largest parts of clean energy investment in China, counting for 46% and 43% respectively. Moreover, Chinese government and clean energy enterprises have invested heavily into equipment research and development, material innovation, clean technology technologies, and technological innovation to make advanced and high quality equipment of clean energy which is based on independent research and development.

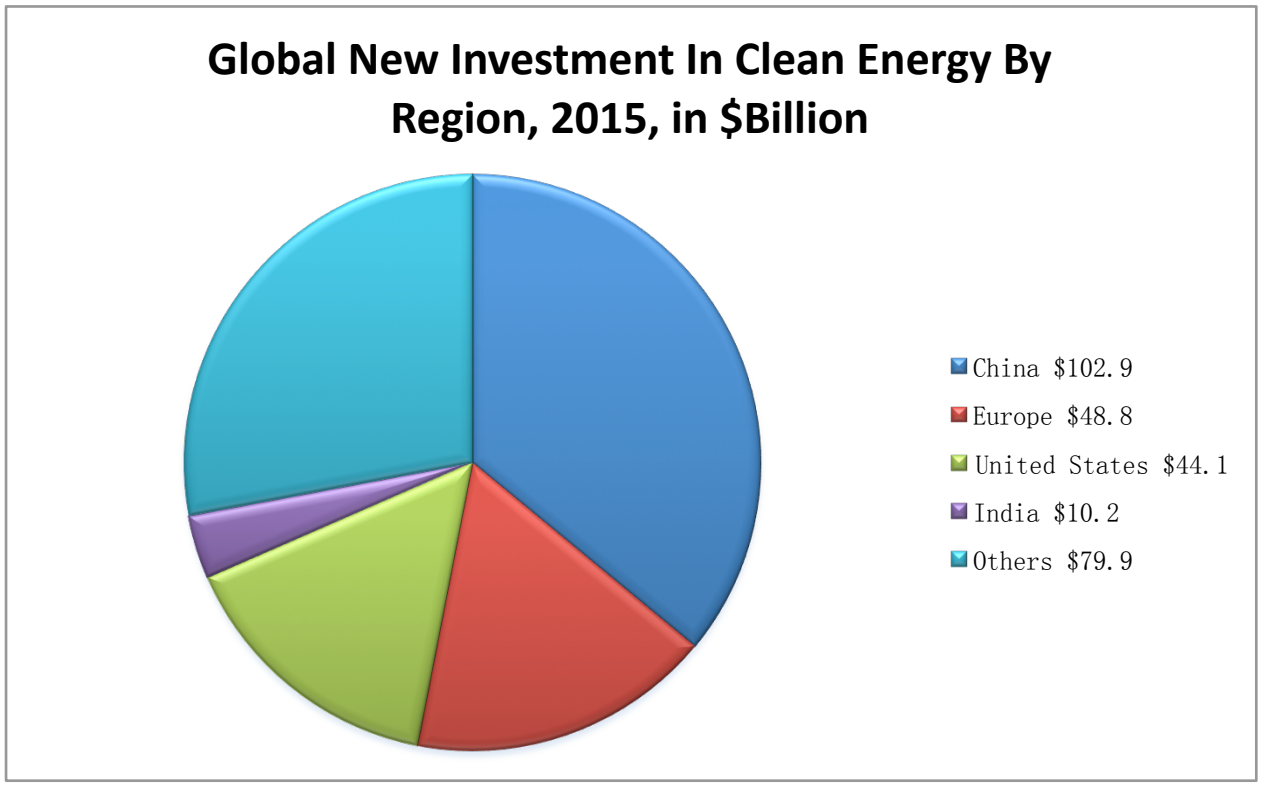

Figure. 4. Global New Investment in Clean Energy by Region, 2015 (UNEP, Bloomberg New Energy Finance, 2016)

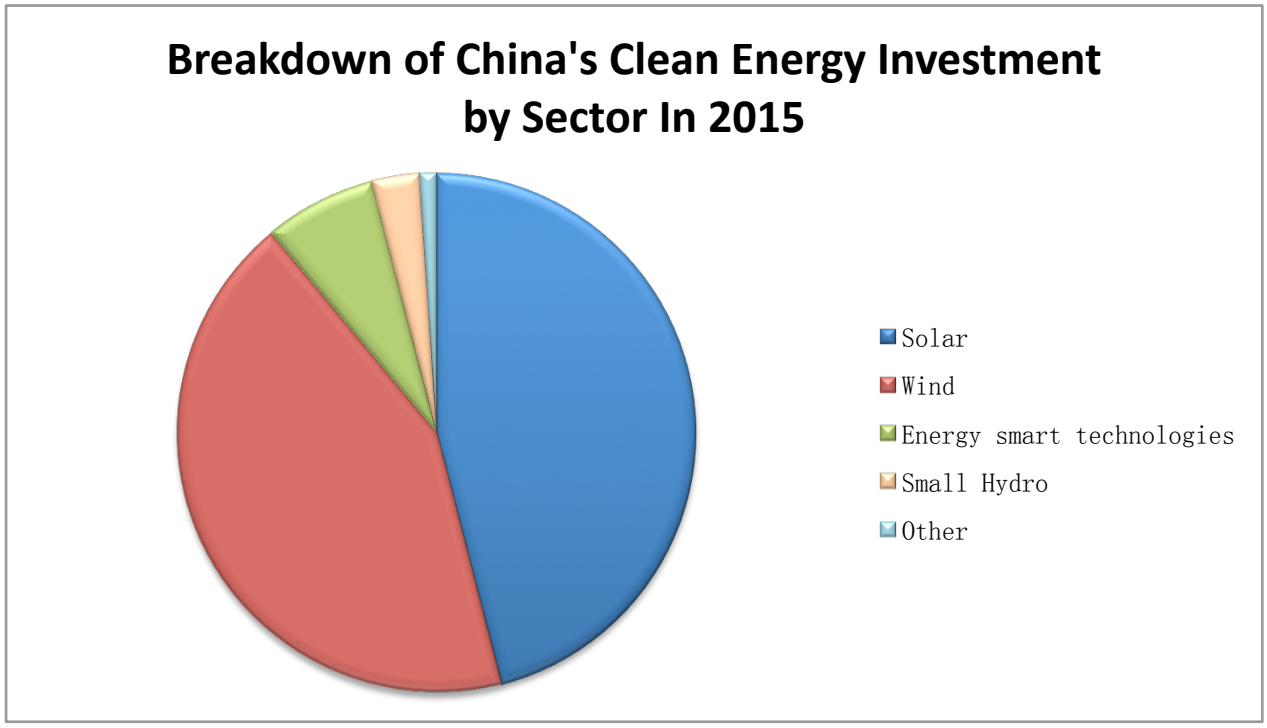

Figure. 5. Breakdown of China's Clean Energy Investment by sector in 2015 (UNEP, Bloomberg New Energy Finance, 2016)

➢ Wind Power:

Taking wind power, wind energy is the largest and most mature of the 'new' non−hydro renewable energy sources and has experienced dramatic growth in the past decade. From Figure 6, it can be seen that China ranks first in the world in installed wind power capacity, with 139 GW by the end of 2015. It is also clear see that China has dramatically increased on installed wind capacity since 2008. According to existing research papers that China takes the lead in wind power production (ChinaFAQs., 2016). Also, China has become the largest growth market in terms of installed capacity (Matthews, J. A., & Tan, H. 2014).

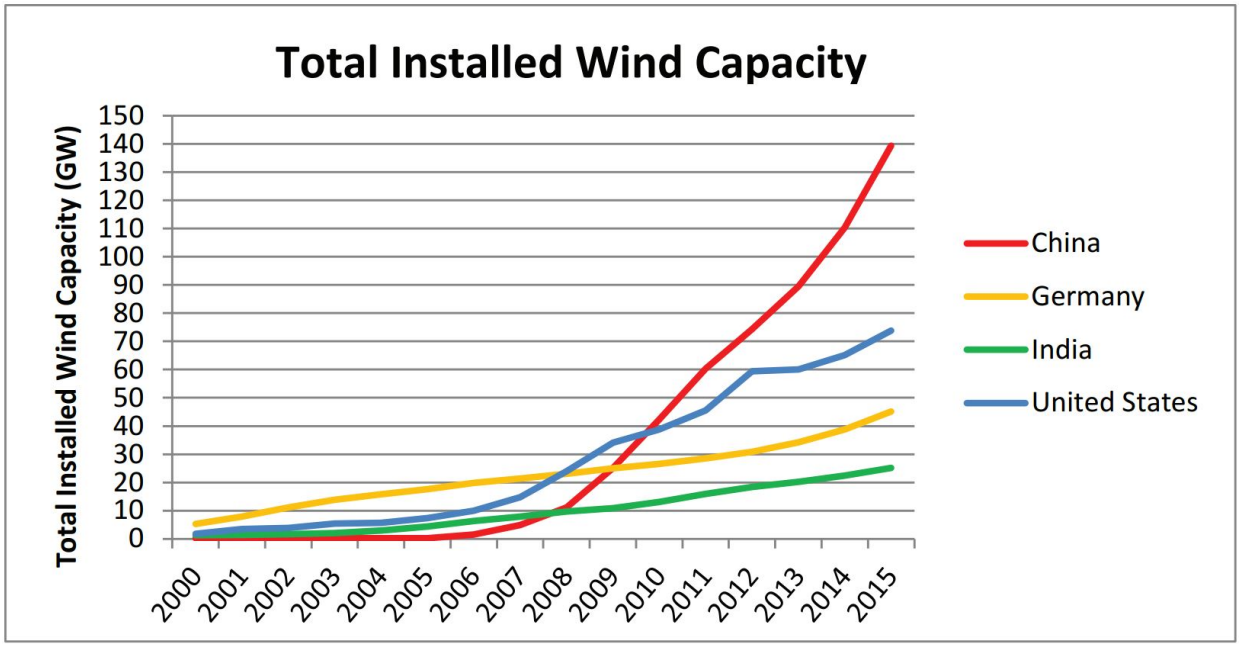

Figure.6. Total Installed Wind Capacity of Top 4 countries from 2000 to 2015 (UNEP, Bloomberg New Energy Finance, 2016)

➢ Solar Power

Taking solar power, solar energy is another non−hydro renewable energy technology. It has attracted a lot of attention and experienced exponential growth in the past decade. China has invested massive funds in solar power technology for many years with new techniques being used for the photovoltaic material, cells and panels which

can reduce costs and improve efficiency as well as for processing and manufacturing methods (Buijs, B., 2012). At the beginning, installed capacity was concentrated in Europe. In recent years, China has gained a preponderant share in the production of solar panels. From figure 7, it is clear see that China has dramatically increased on installed solar PV capacity since 2012. Even China has surpassed Germany to become the world leader in installed solar power, with 50 GW of solar capacity installed by the end of 2015 (ChinaFAQs., 2016).

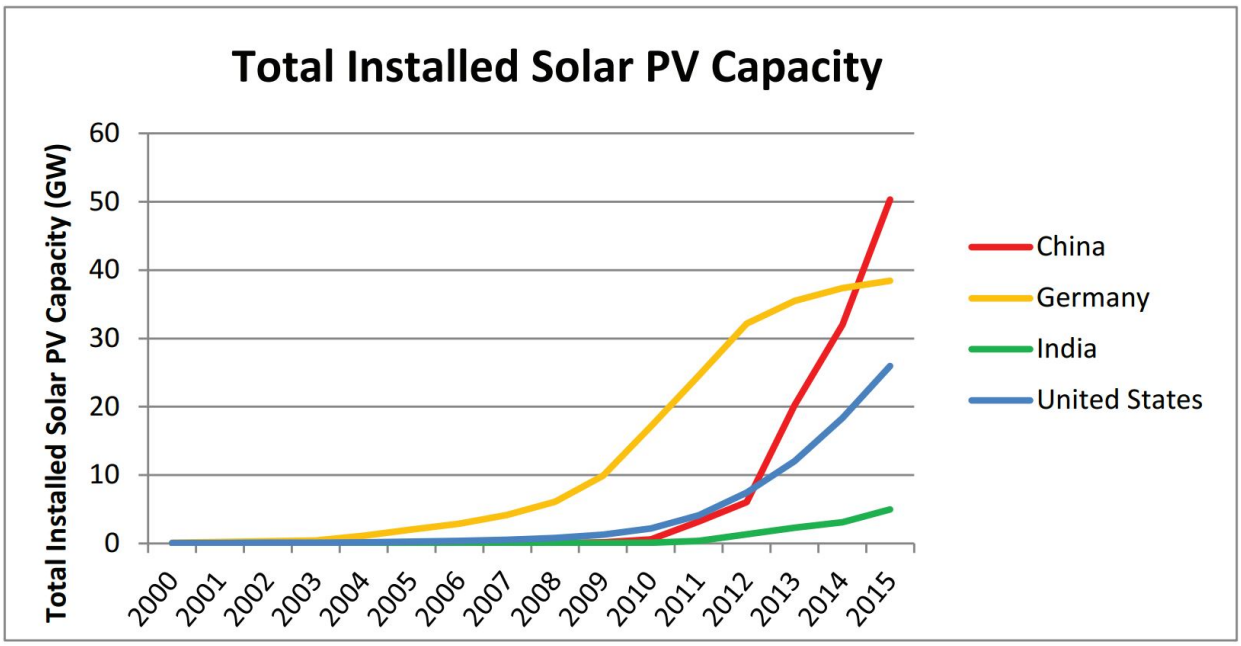

Figure.7. Total Installed Solar PV Capacity of Top 4 countries from 2000 to 2015 (UNEP, Bloomberg New Energy Finance, 2016)

As stated above, it can be seen that Chinese government has made great efforts on new clean energy technologies. China can be seen as a good example which is making a big push on clean technology to provide a green, sustainable economic growth and mitigate climate change (Mazzucato, 2014). Figure 8 shows that the growth of global new investment in renewable energy by top regions from 2005 to 2015. Although China is not the country which made early investment in clean technology, it has already been the leader in green technology with largest investment since 2012. In Europe area, Germany is the first driver in clean energy technology investment. Also, The US invested in green technologies very early with large investment, it also plays

very important role in green economic development. Since 2015, China has gotten 12% of its total primary energy from non-fossil sources per year (ChinaFAQs., 2016). According to China's 13th Five Year Plan, it aims to increase the share of primary energy from non-fossil sources to 15% in 2020 (ChinaFAQs., 2016). Also, Chinese government made a decision to the Paris Agreement, it committed to increase the non-fossil share to 20% by 2030 (ChinaFAQs., 2016). Therefore, China has ambition to walk on a road of low-carbon economic growth by improving energy efficiency and promoting clean energy industry development (National Development and Reform Commission, 2015).

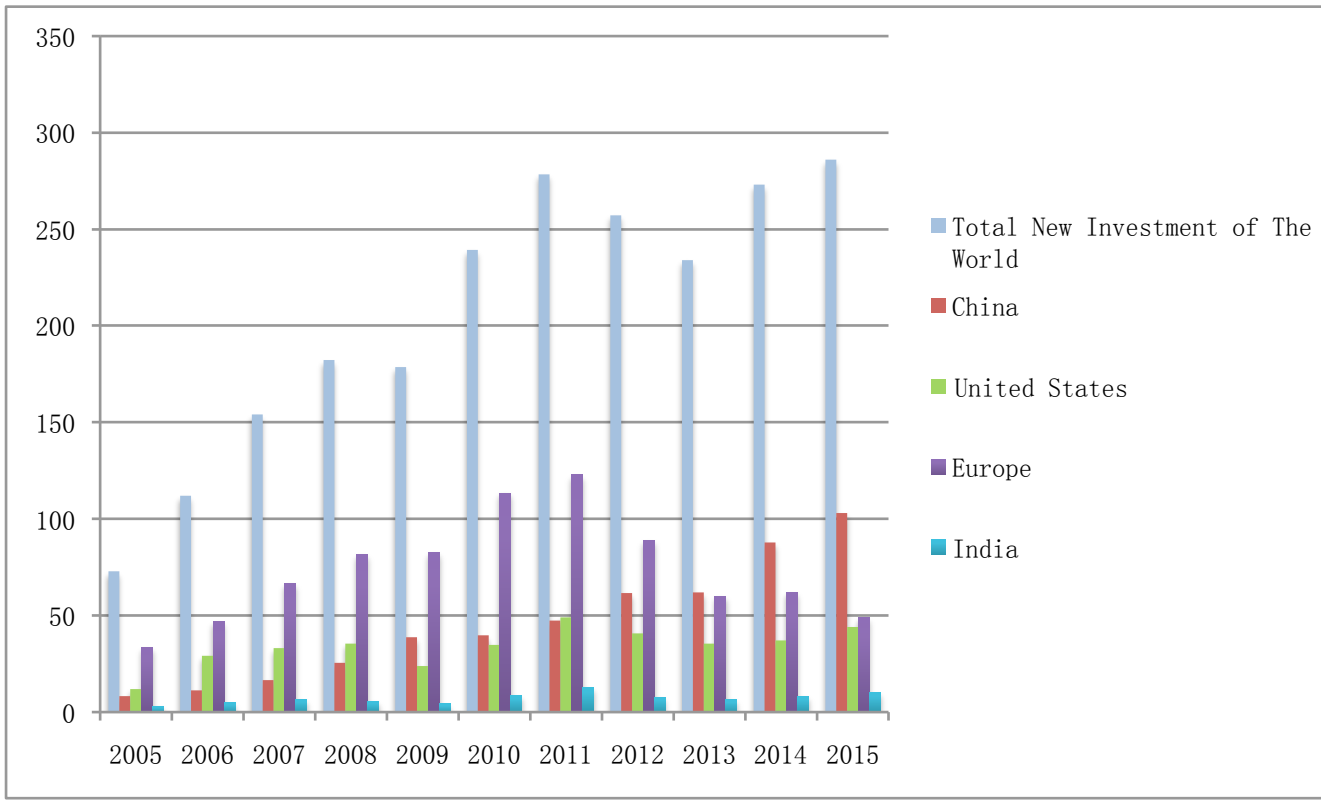

Figure.8. The Growth of Global New Investment in Renewable Energy by Top Regions from 2005 to 2015, in $Billion (UNEP, Bloomberg New Energy Finance, 2016).

China is not only making a heavy investment into innovative technology of clean energy in the domestic market, it also has made a trade with export of advanced new energy equipment in global market, such as wind turbine and solar PV panels. Even more exports are coming up in the future. For example, one of the largest Chinese

wind turbine firms Goldwind science and technology company has signed big trade deals with US, Australia, Pakistan, Brazil, Romania, Chile and Turkey for exporting turbines since 2010. The expectation of global market trade could expand further in future (Buijs, B., 2012). Goldwind Science and Technology Company is a joint-stock company that two biggest shareholders are State-owned enterprises. In this case, Chinese SOEs could act as the director for guiding the direction of capital investment. In addition, China Development Bank is also a crucial factor for Chinese SOEs to make overseas expansion. Chinese clean energy firms and state-owned oil companies are using financing from China Development Bank in order to make overseas cooperative projects with many countries (Buijs, B., 2012). These kinds of projects have many advantages for technical communication, technology research and development, and export trade.

3.2.2 Innovation in the Oil and Gas Industry

The oil industry is an important part of the world economy. Firstly, oil is the basic energy for the world. Secondly, the oil industry chain is very complex, involving many economic and industrial areas. Therefore, the role of oil industry in the world economy cannot be replaced by other industries so far. According to the statistics, at present, China is the world's largest oil consumer and importer. In 2013, even China was the world's fourth largest oil producer. In this case, China plays an important role and position in global oil market. Facing the Challenges such as climate change, the drop in oil prices and the growth of oil demand in China, Chinese state-owned oil enterprises have to make some changes by new technology.

China's oil sector has been dominated by three large state-owned oil enterprises (the fourth one is YANCHANG Petroleum which has a small oil market share; it is also a state-owned company) for a long time. They are China National Petroleum Corporation (CNPC), China Petroleum & Chemical Corporation (SINOPEC), and China National Offshore Oil Corporation (CNOOC). These enterprises have made a huge achievement in China's oil industry, also they have been developing the country's domestic reserves, building and operating pipelines, and filling Chinese

strategic petroleum reserves. There are millions of workers working in these three enterprises (Michal, 2016). Also, they have played the role of major investors in the global upstream and established a presence in global refining and oil trading for a long time. According to the Fortune, all of them are in the top ten global oil companies (Fortune, 2016). Figure 9 and Figure 10 show that the China's domestic oil and gas production in 2015 by CNPC, SINOPEC, CNOOC, YANCHANG. It is clear see that China's domestic oil industry is controlled by these oil enterprises, and CNPC plays a dominant role of oil and gas producer in China's oil and gas industry. This section will take CNPC as an example to show the performance of innovation of oil and gas industry in energy sector. The case of China National Petroleum Corporation (CNPC) is very intriguing as CNPC is the largest oil and gas producer and supplier in China, as well as one of the world's major oilfield service providers. As one of the biggest state-owned enterprises (SOEs) in energy sector, CNPC has long been committed to researching and developing sophisticated and practical technologies and solutions in oil and gas exploration and development operations (China National Petroleum Corporation, 2016).Also, CNPC has built up its innovation capabilities for a long time with complex innovation network. On the other hand, Due to Chinese CNPC has become a key player in international oil industry, it has realized the importance of innovation technologies that could improve the operation efficiency and create additional economic value and income. So CNPC has paid more attention to the innovation and research and development of new technologies.

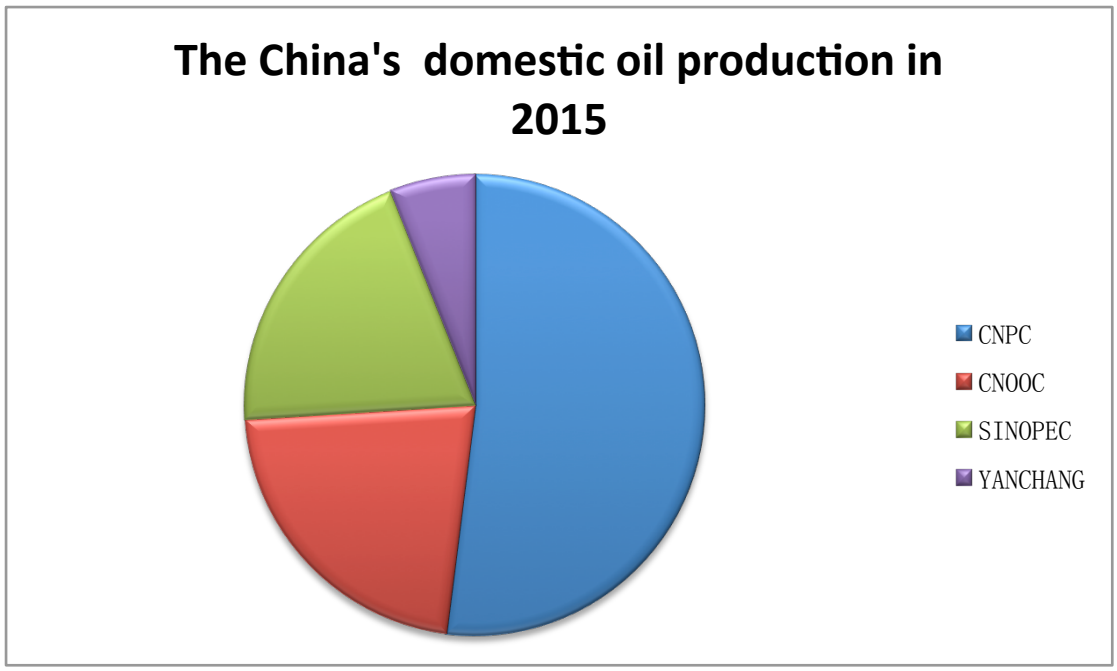

Figure.9. The China's domestic oil and gas production in 2015 (Michal, 2016).

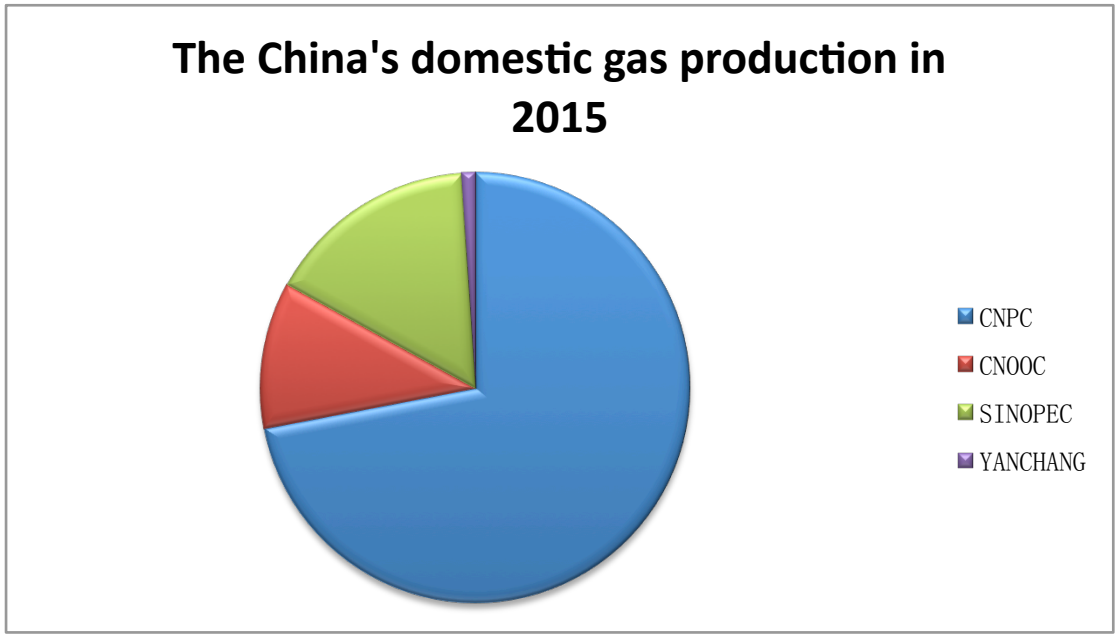

Figure.10. The China's domestic gas production in 2015 (Michal, 2016).

The Table 1 shows the general operation of CNPC from 2013 to 2015. Based on complex and difficult Internet oil market background, it can be seen that the Operating income of CNPC slowly declined from 2013 to 2015, but it still keep a positive financial status. In 2015, CNPC got operating income of RMB 2,016.8 billion and total profit of RMB 82.5 billion with RMB 338.1 tax paid. The CNPC is still a big contributor of national revenue. Although the total profit declined, the total oil and

gas production achieved a slow growth from 2013 to 2015, especially in overseas projects. In 2015, CNPC positively optimized production process and actively implemented the "Independent Innovation" strategy and "Made in China 2025" plan to offer oil production and equipment with high quality in domestic and overseas markets.

	2013	2014	2015
Financial Index			
Operating income (billion RMB yuan)	2759.3	2730.0	2016.8
Total profit (billion RMB yuan)	188.0	173.4	82.5
Net profit (billion RMB yuan)	140.8	123.8	56.2
Tax paid (billion RMB yuan)	407.8	407.0	338.1
Oil and Gas Production			
Oil production (mmt)	159.81	164.17	166.57
Domestic	112.60	113.67	111.43
Overseas (CNPC's share)	47.21	50.50	55.15
Gas production (bcm)	103.89	113.92	116.67
Domestic	88.84	95.46	95.48
Overseas (CNPC's share)	15.05	18.45	21.19
Refining, Chemicals and Sales			
Crude runs (mmt)	188.55	196.98	195.24
Domestic	146.02	150.16	151.32
Overseas	42.53	46.82	43.92
Domestic refined products output (mmt)	97.90	101.4	103.69
Domestic lube oil output (mmt)	1.89	1.58	1.21
Domestic ethylene output (mmt)	3.98	4.98	5.03
Domestic refined products sales (mmt)	118.33	117.02	116.25

Table.1. The general operation of CNPC from 2013 to 2015 (China National Petroleum Corporation, 2016)

- Independent innovation and policies supporting

Based on supporting from state's policies such as China's Five -Year Plan, scientific and technological innovation has become a powerful driving force and priority in CNPC. In addition, CNPC made internal innovation plan for its innovation system to perfect its innovation system. For example, during the period of 12th Five-Year Plan (2011-2015), CNPC issued and implemented CNPC's opinions on promoting the application of major technology and equipment with independent innovation in equipment manufacturing sector to promote the innovation development on the quality of oil equipment manufacturing (China National Petroleum Corporation, 2016). Additionally, CNPC positively responses national policy on 'Independent Innovation', implemented high enterprise standard to develop its own major research projects and key technologies (China National Petroleum Corporation, 2016). Therefore, the number of CNPC's original patents is growing gradually year by year. Figure 11 and Figure 12 show it below.

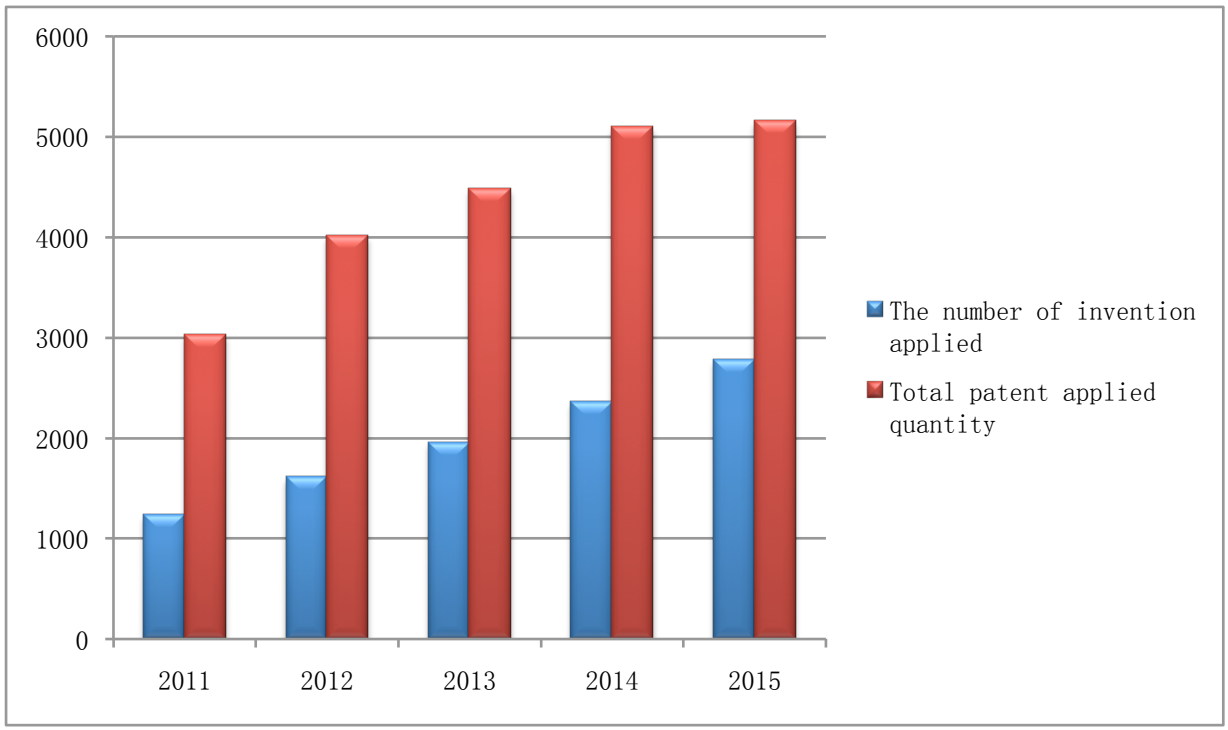

Figure.11. CNPC's the number of patent applied from 2011 to 2015. (China National Petroleum Corporation, 2016)

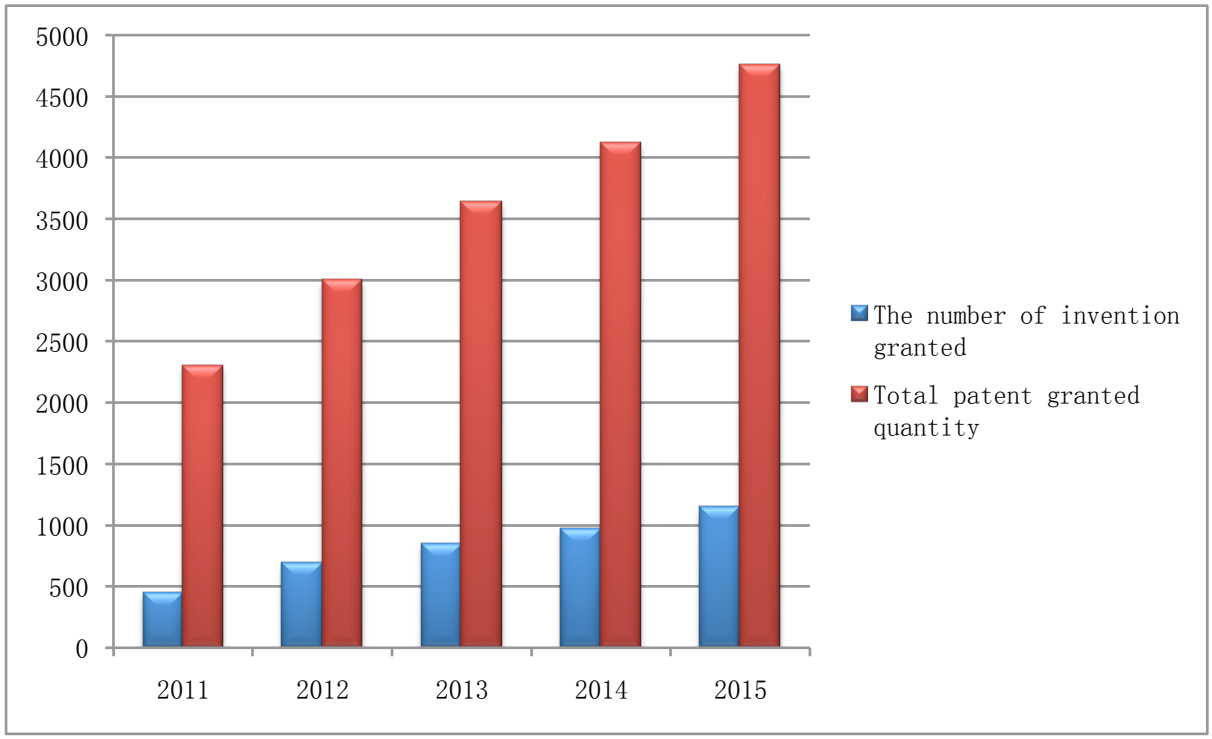

Figure.12. CNPC's the number of patent granted from 2011 to 2015. (China National Petroleum Corporation, 2016)

- Innovation system and research institutes

Talking about innovation system of CNPC is very complex, especially on research institutes. It can be said that CNPC's research institutes comprised many Chinese top research institutes. Also, CNPC has a strong innovation system and complex innovation network. The effective innovation system construction has promoted the development of the company, especially the mechanism of development system, the transformation of scientific and technological achievements organization, innovation dynamic mechanism, talent incentive mechanism, cooperation mechanism (Liu jin., 2014). Figure 13 shows the basic information about CNPC's scientific and technical innovation system. It is made up of Research and Development Organization, Science and Technology Research System, Condition Platform System and Science and Technology Security System. Also, it can be divided to Central Technology Research System and Local Technology Research System. Generally, the research institutes of CNPC are made up of Research University such as China University of Petroleum which is one of the top Universities in China, National Research Institutes and Local

Research Institutes such as Scientific Research Institute of Petroleum Exploration and Development, Research Laboratories, public enterprises, cooperative private Enterprises, cooperative foreign Enterprises and its own R&D department (China National Petroleum Corporation, 2016). In 2015, CNPC worked with Chinese Academy of Sciences and China Aerospace Science & Industry Corporation to push the research about integration between the technology innovation and industrial manufacturing chains helping its development of oil equipment manufacturing (China National Petroleum Corporation, 2016). Also, CNPC has built 18 National Science and Technology Laboratories which played a key role in driving technological innovation development by the end of 2015. Moreover, CNPC is going to build new National Research Centre for oil and gas drilling equipment (China National Petroleum Corporation, 2016).

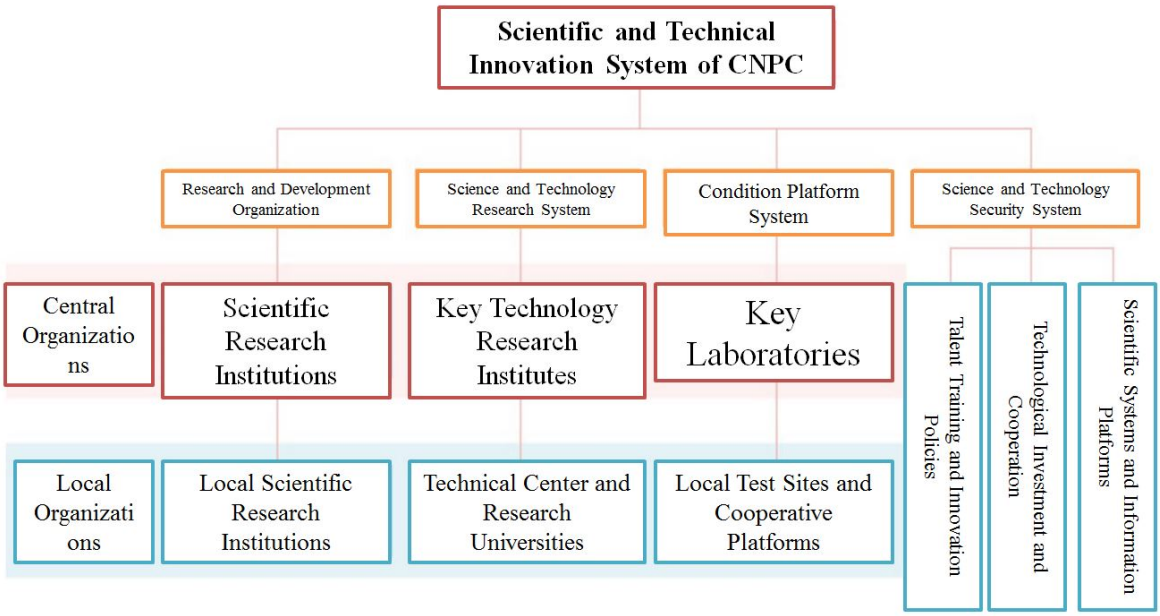

Figure.13. CNPC's scientific and technical innovation system. (China National Petroleum Corporation, 2016)

- Using new technology

With the development of technology, information communication technology has been already widely used in many industry areas and our daily lives. For example, CNPC has developed extensive cooperation with Alibaba Group which is one the largest E-commerce and Internet Company in China to expand new business for cooperation and speed up building smart logistics and smart oil station. This cooperation is called 'Internet+' powers smart project which includes different services such as maintenance, vehicle decoration, insurance agency and inspection (China National Petroleum Corporation, 2016). This project expands services from oil products marketing to vehicle life span care, upgrades the operation mode from traditional service station to a more open and consolidated mode, from entity marketing to big data marketing (China National Petroleum Corporation, 2016). This project does not only can increase the commodity consumption, it also can improve the work efficiency of oil station, reduce cost, realizing the maximization of economic benefits (China National Petroleum Corporation, 2016).

Another example should be introduced is CNPC's Digital Oil fields innovation project. Since 1998, the former U.S. Vice President Al Gore has proposed and described the innovative idea of a "Digital Earth", after that, Wang Quan who is the senior engineer working in Daqing oilfield of CNPC proposed the construction of the "Digital Oilfield" concept, and formulated a technical strategy about the information technology innovation for the Oilfield in 1999 in Daqing oilfield (Wei & Quan & Nanan, 2011). Generally, Digital oilfield is that the use of information technology to manage production, personnel, safety, allowing for reduced costs, increased production, and improved efficiency in the oil and gas industry (Wei & Quan & Nanan, 2011). It is obvious that how to build an intelligent oil field to improve the work efficiency has become a hot project in the global oil industry. In addition, it has been figured out that the use of ICT in petroleum industry can increase productivity, the efficiency of management and economic benefits. CNPC have invested this project heavily not only in petroleum exploration and development, but also in oil

exploitation and petroleum transportation. It means that CNPC are using high-speed communications, and data-mining techniques to monitor and fine-tune remote drilling operations (Accenture, 2015). Also it helps CNPC to use real-time data to make better decisions and predict glitches (Wei & Quan & Nanan, 2011). There are six advantages of digital oilfield project for CNPC: Cost reduction, increased up-time, improved efficiency, increased safety, enhanced recoveries, and increased environmental compliance (Accenture, 2015).

- Cooperation and Go global

Based on China's "One Belt One Road" strategy and "Made in China 2025" plan, CNPC has cooperated with many International oil companies to development the overseas projects. Also, CNPC actively expanded the international market to export its oil equipment. For example, in 2015, CNPC used different measures to ensure the efficient and sustainable development of overseas projects. CNPC shared in overseas crude production and natural gas production 55.15 million tons and 21.19 billion cubic meters, respectively (China National Petroleum Corporation, 2016).

- Petroleum Equipment Manufacturing

Benefited from the China's "Made in China 2025" plan and 12th Five-Year plan, CNPC's petroleum equipment manufacturing business did very well in 2015. CNPC made a great structural adjustment within the company to guarantee product quality with lower cost, high quality, and high standard. Also, the industrial structure of CNPC has been transformed from absolute production to integrated International business which contained product research and development, manufacturing, products sales, and service offering. In order to emphasize new high-end products, CNPC invested heavily in research and development of drilling equipment, recovery equipment, petroleum steel pipes, and power units, thereby increasing the percentage of high value-added products (China National Petroleum Corporation, 2016). In addition, CNPC actively expanded the international market and improved the layout of domestic marketing network to look for more strategic partners by high quality products. So far, its petroleum materials and oil equipment have exported to more

than 81 countries and regions, such as Russia, Kazakhstan, and Turkmenistan (China National Petroleum Corporation, 2016).

- Energy Efficiency

CNPC developed its new type heating furnace and improved production process by new technology and equipment to continue walk on its energy-saving and consumption reduction road. For example, CNPC reduced energy consumption by 1.16 million tons of standard coal and water consumption by 20.61 million cubic meters in 2015 (China National Petroleum Corporation, 2016).

- The recent science and technology achievements

During 12th Five-Year Plan (2011-2015) period, CNPC enhanced its comprehensive strength and international competitiveness, achieved many significant results which contained 40 major innovative achievements, 30 National Science and Technology Reward, 1 exploration and production of US 2015 Special Meritorious Awards for Engineering Innovation. Also, CNPC applied more than 2,100 patents, researched 25 new oil equipment and intelligent software (China National Petroleum Corporation, 2016). In addition, CNPC innovated 15 magnificent theories and core technologies about oil industry, such as "Theoretical and Technological Innovations for the Exploration and Development of Ultra-Low-Permeability Tight Oil and Gas Reservoirs" which got the first-class National Science and Technology Award. Particularly, CNPC created additional economic value by new technology summed up to $20 Billion (China National Petroleum Corporation, 2016). CNPC have made a great contribution to energy innovation system. It has brought about prominent social and significant economic benefits (China National Petroleum Corporation, 2016). Table 2 shows the major science and technology achievements of CNPC from 2011 to 2015.

Under the situation of international oil prices declined and the fierce market competition increased, scientific and technological innovation has become an important support and a strong driving force for the steady development of CNPC.

Project	Quantity
National Science and Technology Reward	30
Major Achievement on Innovation	40
Core Technology and Supporting System	15
New Research on Equipment and Software	25
The number of patent applied	21766
The number of patent granted	17813
Issued International Standard	3
National Research Laboratory	18
Creating additional economic value by new Technology	Over $20 Billion

Table. 2. The major science and technology achievements of CNPC from 2011 to 2015 (China National Petroleum Corporation, 2016)

As mentioned above, it figured out that Chinese government is making efforts on supporting its development into a more innovation-centred way which is focusing on 'indigenous innovation'. Also it is making an increased investment in research and innovative development with the technological level of its economic growth and industrial development. Speaking of innovation of energy sector, it can be seen as a long-term challenge for Chinese government and SOEs of energy sector, especially in clean energy industry and oil industry. Therefore, Chinese government is not only making a large long-term investment into innovation development of energy sector, it also makes long-term supporting to sustainable development through smart national policies. On the other hand, the energy sector is researching new solutions to increase the efficiencies in fossil fuels industries, such as oil and gas industries, meanwhile controlling coal consumption, adjusting and optimizing the traditional industrial structure.

Furthermore, The Chinese Development Bank plays important role within the

development of Chinese SOEs in energy sector. The Chinese Development Bank has specialized in providing long-term credit for Chinese strategic industries for a long time, such as clean energy industry, oil and gas industry and advanced equipment Manufacturing. China development bank has heavily invested in green energy projects since 2007. Between 2007 and 2012, China development bank invested more than $78 billion to clean energy industry (Mazzucato, 2015). The rapid development of wind turbine and solar PV panels manufacturing firms made possible by public finance has built Chinese solar and wind technology manufacturers as leader in international market (Mazzucato, 2015). Moreover, China Development Bank is also a crucial factor for Chinese SOEs to make overseas expansion. The aim is to enable them to withstand fierce international competition (Matthews, J. A., & Janeiro, Rio de., 2014; Mazzucato, 2015). It also operates as the Financial backer funding both China's outreach to develop oil and gas supplies from around the world, as well as providing long credit lines to clean energy companies which have strengthen their rapid rise in international competition (Matthews, J. A., & Janeiro, Rio de., 2014).

State-owned enterprises as an important role in the development of the innovation, they have to play backbone and leading role in the implementation of innovation-driven development strategy. Therefore, the innovative capabilities of energy SOEs have highly connected with the domestic innovation system and economy growth, requiring SOEs to seek new profit growth point by innovative technology and new technique. In addition, facing the International fierce competition, it also requires energy SOEs not only to be innovation-oriented entrepreneurs in domestic market, but also to be an active player in the broader innovation system in overseas market (Burlamaqui L, 2016). Figure 14 refers that energy innovation system of Chinese SOEs. It also shows the connection among SOEs, research institutes, government departments and technology agencies. Chinese government and China national development bank as policy guiding and financial support of SOEs have made enormous contribution to the development of innovation system and SOEs in energy sector. In addition, Chinese SOEs of energy sector actively responded to the

National policies in order to improve internal industrial structure, developing core competitiveness by new technology and innovation. They have sufficient funds to invest long-term projects and research. Figure 15 shows top 5 Chinese enterprises about research and development expenditure in 2011. It is clear see that four of them are SOEs. The first is China National Petroleum Cooperation from energy sector, invested 242.86 Billion RMB yuan into technology research and development in 2011 (Bin., 2014).

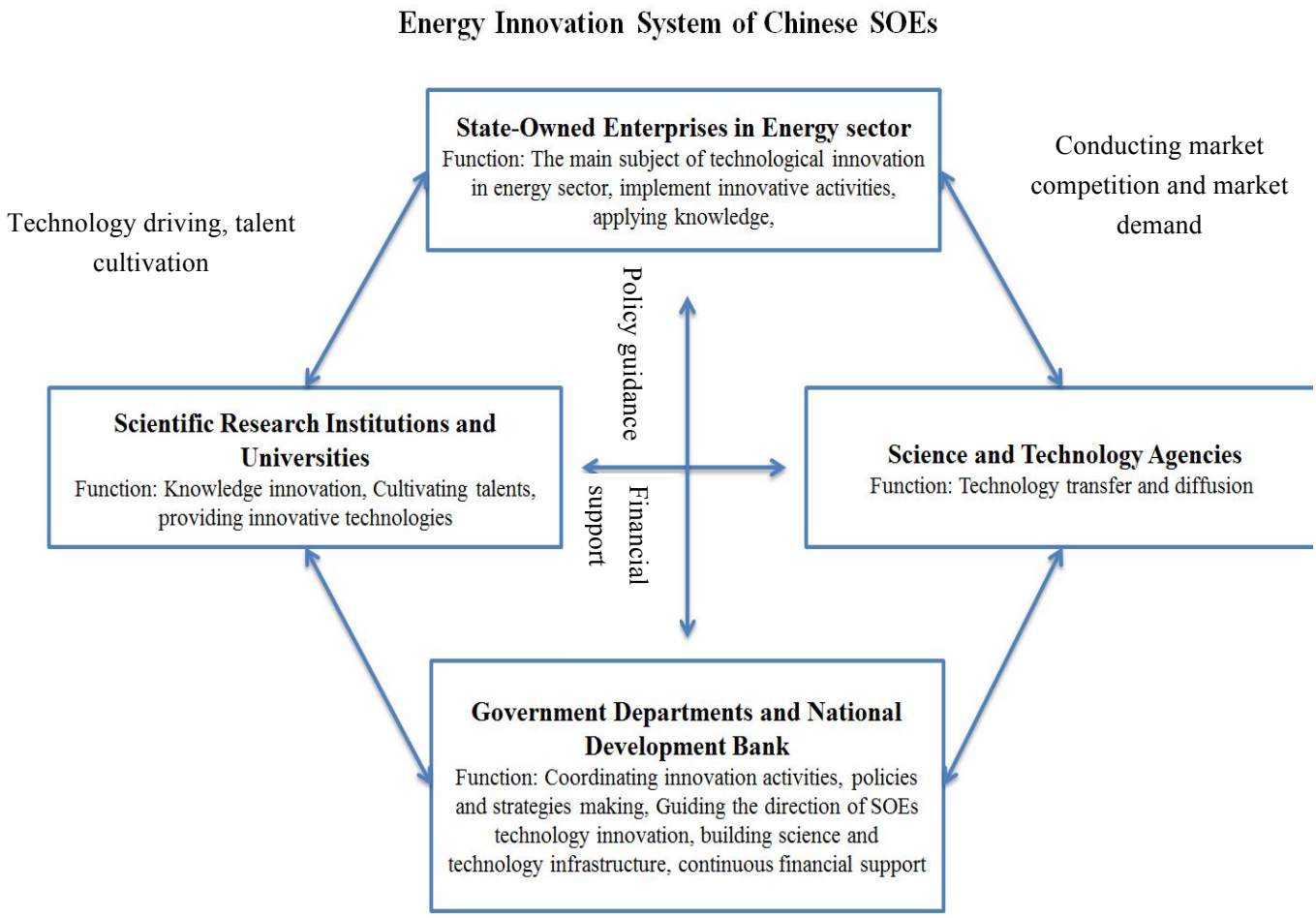

Figure. 14. Energy innovation system of Chinese SOEs (Benye. S & Junjiang. L., 2010)

Ranking	Company Name	R&D expenditures (Billion RMB	Industry	Enterprise Type

1	China National Petroleum Cooperation	242.86	Energy	SOE
2	HuaWei	219.00	Communication Equipment	Private
3	China Aviation Industry Corporation	216.80	Aviation	SOE
4	China Mobile Communications Cooperation	143.51	Communication	SOE
5	China shipbuilding industry corporation	102.15	Shipbuilding	SOE

Figure. 15. Top 5 Chinese enterprises about research and development expenditure in 2011 (Zhou Bin., 2014)

3.3 Innovation and Development Policy: China's Five-Year Plan

For the development of energy sector, supporting of development policy is very important, as well as for Chinese SOEs. Also, for the Chinese government, making an appropriate strategy about development and industry is a necessary mission. Therefore, talking about Chinese SOEs and innovation of energy sector, it is necessary to mention Chinese five-year plan which is a blueprint that details the government's main policy goals and development initiatives for a period of five years.

Five-Year Plan is issued by the Communist Party of China (CCP) Central Committee. Put simply, Five-Year Plan is a blueprint that details the government's main policy goals and development initiatives for a period of five years (Worldwide, A. P. C. O., 2010). In fact, it provides overall objectives and goals which are related to economic growth and social development, industrial plans and technology development. Industrial planning in key sectors or regions is also mentioned in the plans, including which industries and products will be targeted for preferential government support. In fact, the plan can be seen as an economic direction for local and provincial governments, financial industry, industry development, science and technology,

energy industry and state-owned enterprises (Andrew & Cole, 2011).

With the newest 13thFive-Year Plan (2016-2020) just issued in 2016, the new expectations and targets about China's economy have come. How 13th Five-Year plan effects on SOEs and innovation of energy sector? Plus, how was the performance of 12th Five-Year Plan (2011- 2015) in China's economy and energy sector? In this section, it will make a brief introduction and analysis on it.

3.3.1 The 12th Five-Year Plan (2011-2015)

In 12th Five-Year Plan, the document highlighted the following main industries which were being focused: new-generation information technology, energy-saving and environmentally friendly technologies, biotechnology, new-generation information technology, advanced equipment manufacturing, new materials, new energy and hybrids and electric vehicles (Buijs, B., 2012). During 12th Five-Year Plan (2011-2015) period, Chinese government aimed to invest more than $1.5 trillion into those industries (Buijs, B., 2012). The key point of developing those industries is that Chinese government highlighted the sustainability should be placed in first position (Mazzucato, 2014). The mission was not only to build domestic manufacturing industries but also to reinforce capacity for independent innovation (Buijs, B., 2012). Table.3 shows that 12th Five-Year Plan targets and actual performance about main areas. China's 12th Five Year Plan set a goal for research and development spending to rise to 2.2% of GDP by 2015. The government also highlighted that innovation should be as new driving force to economic growth. The actual performance of improving energy efficiency, achieving low-carbon development, and replacing coal energy with low-carbon energy benefited greatly from technological innovation on a large scale. A set of policies had also been emphasized the importance of 'indigenous innovation' with special Chinese characteristics on research and development, new energy industries and advanced equipment manufacturing, such as solar PV panels, wind power equipment, and High-speed rail equipment (Scott. & Chritopher k., 2016). Therefore, Innovation can be seen as a growing priority for China. Taking new energy, as mentioned in the last section, the actual performance was totally successful in

China. Since 2015, China has gotten 12% of its total primary energy from non-fossil sources per year (ChinaFAQs., 2016). In fact, China has been the number one investor in renewable energy from 2012 to 2015 (UNEP, Bloomberg New Energy Finance, 2016). In other areas, it is observed that the actual performance of China's economy was basically achieved the targets of 12th Five-Year Plan by 2015, especially in innovative manufacturing and low-carbon development aspects (Buijs, B., 2012).

		Target		Actual Performance	
		By 2015	Growth*	By 2015	Growth*
The Economy					
GDP (trillion yuan and %)		—	7	67.7	7.8
Services/GDP (%)		47	[4]	50.5	—
Urbanization (%)		51.5	[4]	56.1	—
Science and Technology					
R&D spending/GDP (%)		2.2	[0.45]	2.1	—
Enrollment in high school (%)		87	[4.5]	87	[4.5]
Nine-year compulsory education rate (%)		93	[3.3]	93	[3.3]
Invention patents/10,000 people		3.3	[1.6]	6.3	—
Social Welfare					
Population (billion)		<1.39	<0.72%	1.375	—
Per capita disposable income of urban residents (yuan)		>26,810	>7%	—	7.7%
Per capita net income of rural residents (yuan)		>8,310	>7%	—	9.6%
New urban jobs (million)		—	[45]	—	[64.31]
Registered urban unemployment rate (%)		<5	—	4.05	—
Coverage of urban basic old-age pension (million)		357	[1]	377	—
Coverage of three-point rural medical care system (%)		—	[3]	—	[>3]
Development of affordable housing units (million)		—	[36]	—	[40.13]
Increase in average life expectancy (years)		74.5	[1]	76.34	—
Environment and Resources					
Reduction of major pollutants (%)	Chemical oxygen demand	—	[8]	—	[12.9]
	Sulfur dioxide	—	[8]	—	[18.0]
	Ammonium nitrate	—	[10]	—	[13.0]
	Nitrogen oxide	—	[10]	—	[18.6]
Forest growth	Forest coverage (%)	21.66	[1.3]	21.66	[1.3]
	Forest coverage (billion sq. meters)	14.3	[6]	15.1	—
Reduction of energy consumption/GDP (%)		—	[16]	—	[18.2]
Reduction of water consumption/unit of industrial value-added (%)		—	[30]	—	[35]
Effective use of irrigation water (utilization coefficient)		0.53	[0.03]	0.532	—
Reduction of CO_2 emissions/GDP (%)		—	[17]	—	[20]
Total acreage of cultivated land (billion square meters)		1,212	[0]	1,243	—
Nonfossil fuel/primary energy consumption (%)		11.4	[3.1]	12	—

Table.3. 12th Five-Year Plan key Targets and Actual Performance (Scott. & Chritopher k., 2016)

3.3.2 The 13th Five-Year Plan (2016-2020)

With the newest 13th Five-Year Plan (2016-2020) just issued in 2016, Chinese government is going to move forward (Scott. & Chritopher k., 2016). The key theme of the Plan is to redefine the concept and path of development for China under the 'new normal' during the coming five years and beyond. It means that economic growth rate will change from high-speed to medium-to-high (6.5%), but development is still seen as the top priority. China's development is making a shift from investment-driven to consumption-led growth. (Worldwide, A. P. C. O., 2015). The leading engine of development will be innovation. From Table 4 below, it shows the targets of 13th Five-Year Plan. What's the performance of 13th Five-Year Plan will be, it is hard to predict now. But from the context of 13th Five-Year Plan, it can be seen that China's government is ambitious for the development in future. Moreover, the Chinese government plan to invest more money in its development and innovation technologies. For example, the government has invested more than RMB 500 billion to support the 13th Five-Year plan projects in 2016 (Scott. & Chritopher k., 2016). And an increasingly large financing will be invested by state-controlled banks and other investment funds (Scott. & Chritopher k., 2016).

		Target		Predictive or Mandatory
		By 2020	Growth*	
The Economy				
GDP (trillion yuan and %)		>92.7	>6.5%	Predictive
Services/GDP (%)		56	[5.5]	Predictive
Urbanization (%)	Resident population	60	[3.9]	Predictive
	Registered population	45	[5.1]	Predictive
Labor productivity (yuan/person)		>120,000	>6.6%	Predictive
Innovation				
R&D spending/GDP (%)		2.5	[0.4]	Predictive
Sci-tech progress contribution rate (%)		60	[4.7]	Predictive
Internet penetration (%)	Fixed broadband (households)	70	[30]	Predictive
	Mobile broadband (households)	85	[28]	Predictive
Invention patents/10,000 people		12	[5.7]	Predictive
Social Welfare				
Per capita disposable income (%)		-	>6.5	Predictive
Development of affordable housing in units (million)		-	[20]	Mandatory
New urban jobs (million)		-	[>50]	Predictive
Poverty alleviation in rural areas (million people)		-	[55.75]	Mandatory
Coverage of urban basic old-age pension (%)		90	[8]	Predictive
Average years schooling for working-age population (years)		10.8	[0.57]	Mandatory
Increase in average life expectancy (years)		-	[1]	Predictive
Environment and Resources				
Reduction of major pollutants (%)	Chemical oxygen demand	-	[10]	Mandatory
	Ammonia nitrate	-	[10]	Mandatory
	Sulfur dioxide	-	[15]	Mandatory
	Nitrogen oxide	-	[15]	Mandatory
Forest growth	Forest coverage (%)	23.04	[1.38]	Mandatory
	Forest coverage (billion sq. meters)	16.5	[14]	Mandatory
Recently developed land (billion square meters)		-	[<21.7]	Mandatory
Reduction of energy consumption/GDP (%)		-	[15]	Mandatory
Reduction of water consumption/10,000 yuan GDP (%)		-	[23]	Mandatory
Reduction of CO_2 emissions/GDP (%)		-	[18]	Mandatory
Cultivated land (billion square meters)		1,243	[0]	Mandatory
Nonfossil fuel/primary energy consumption (%)		15	[3]	Mandatory
Air quality (%)	Days of good-moderate air quality in cities at & above prefecture level	76.7	>80	Mandatory
	Decrease in PM2.5 concentration in cities at & above prefecture level	-	[18]	Mandatory
Surface water quality (%)	Equal or better than Grade III water	>70	-	Mandatory
	Grade V water	<5	-	Mandatory

Table.4. 13th Five-Year Plan Targets (Scott. & Critopher k., 2016)

There are four guiding principles of China's development paradigm about economy

and industries that are highlighted in 13th Five-Year plan:

- Innovative development and high technology:

Innovation is the first and the most important principle highlighted in this new plan. The new plan sets a goal for research and development spending to rise to 2.5% of GDP. It means that innovation should be as a driver of economic development to push China's economic structure shift into a higher-quality growth pattern.

- Coordinated Development and inclusive growth:

It means that 13th Five-Year Plan focuses on balanced regional growth between urban and rural areas which will improve in rural infrastructure and public services, as well as between coastal and inland provinces in China.

- Openness:

It highlights that China should optimize trade structure, enhance economic cooperation zones and utilize both domestic and global markets to be more active in global governance. It means that China's "One belt One Road" strategy and "Made in China 2025" plan will go further.

- Green Development:

It means that Chinese government will make more efforts on protecting the environment and pursuing environmentally friendly economic growth. Also, China's 13th Five Year Plan aims to increase the share of primary energy from non-fossil sources to 15% in 2020.

3.3.3 The effects of recent Five-Year Plan on SOEs

Five-Year Plan as an important policy of Chinese development guiding all industries, banks, technology to go a way for further developments which conforming to the situation of China. Therefore, talking about the effects of Five-Year Plan on Chinese SOEs is very significant. The review about effects of recent Five-Year Plan on SOEs will be analysed in this part. Generally, there are five major effects:

- Planning for the future direction:

Five-Year Plan is a blueprint that details the government's main policy goals and development direction for next 5 years. Therefore, it contains different guiding opinions, development goals, and growth goals for energy industries, high-speed rail industry and state-controlled banks which are heavily dominated by the Chinese government or state. Therefore, according to the new plans and goals issued by the state, SOEs should take an action and make changes for new challenge and mission.

- Encouraging innovation and planning innovation projects

The recent 12th Five-Year Plan and 13th Five-Year Plan emphasized the vital role of innovation in the development and encouraging domestic firms to invent new technologies. The both plans highlighted that the development of state and enterprises should go into a new phase which is "innovation-driven" development and "independent innovation" to promote the developments. Moreover, 13th Five-Year Plan highlighted that China's position in global value chains should be upgraded and further strengthened by cultivating strengths in technology, standards, brands, equipment quality and service, such as high-speed rail equipment, oil equipment and new materials, new energy equipment. Although the plan does not mention SOEs definitely, those areas are heavily dominated by SOEs in China, such as rail way industry, oil and gas industry.

- Optimizing and updating industry structure

The 13th Five-Year Plan figured out that enterprises should improve production efficiency, product quality and brand reputation to build a smart manufacturing by utilizing new technologies. In addition, developing new strategic industries is also a requirement. In other word, it is needed for SOEs to optimize and update industry structure and process structure to improve operational efficiency, especially for old industrial regions in China. Also, it means that emerging industries such as biotechnology, IT, smart manufacturing, high-tech equipment, and new energy industries should be focused and developed.

- Implementing green development

Implementing green development is a very important effect on SOEs. Due to the

challenge of climate change and environmental pollution, achieving green development can be seen as a necessary mission for all industry areas. The aim is to mitigate climate change achieving sustainable development. Many large manufacturing, industries and even almost all energy sectors were dominated by SOEs in China, so SOEs plays important role in the green development in China. It is not only required SOEs to optimize and update production structure by new technologies, but also to strengthen regulation and supervision and make energy structure transition, pursuing low-carbon development growth.

- Pushing forward the reform of SOEs

The SOEs reform can be seen as the most impact on Chinese SOEs. With the development of the socialist market economy in China, the capital operation has been playing an important role in the SOEs reformation and development. In 13th Five Year Plan period, China will continue to push forward the reform of SOEs through a mixed ownership model (Worldwide, A. P. C. O., 2015). The aim is to enhance the internal governance and competitive environment of SOEs, improving SOEs operating efficiency and encouraging them going forward to invest more of their resources and funds in public services and national security (Worldwide, A. P. C. O., 2015; Scott. & Chritopher k., 2016), also, allowing private sector and firms to make investment into SOEs (Scott. & Chritopher k., 2016). However, this impact is very controversial in developmental process of SOEs in China. So far, there are still more than 150,000 SOEs in China, and their assets are continuing growing. In this circumstance, carrying out reform is a very difficult and long term challenge. Therefore, the result of SOEs reform is difficult to predict right now, but as the blueprint for China's development, the 13th Five-Year Plan will have a deep impact on economic growth and SOEs development (Michal, 2016). And no matter how it turns out, the goals of Chinese government making changes and adjustments on SOEs is to enhance SOEs as national champions in domestic and overseas markets and protect their assets (Scott. & Chritopher k., 2016).

3.4 The potential role of SOEs in innovation system of energy sector

Based on the discussion above, the study has shown the innovation in China's energy sector. And the cases figured out the current innovation situation in clean energy industry and oil industry as well as the main content of China's innovation development policy. Therefore, the main question of the research about the potential role of SOEs in innovation system of energy sector will be answered in this part.

The implementation of innovation-driven development strategy is the inevitable requirements and strategic initiatives which could accelerate the transformation of economic development, improving China's comprehensive national strength and international competitiveness. As the case discussed above, innovative technology plays an important role in the development of state-owned enterprises in China. On the other hand, SOEs also make contribution to the Chinese energy sector innovation system. Chinese energy sector innovation system was basically composed of Enterprises, Government, Scientific Research Institutions, China National Development Bank and Science and Technology Agencies. Government plays significant role in coordinating innovation activities, policies and strategies making, guiding the direction of SOEs technology innovation, building science and technology infrastructure. China Development Bank is vital within the development of Chinese SOEs in energy sector. The Chinese Development Bank has specialized in providing long-term credit for Chinese strategic industries for a long time. It can be seen as continuous financial support to SOEs in energy sector. Moreover, China Development Bank is also a crucial factor for Chinese SOEs to make overseas expansion. The aim is to enable them to withstand fierce international competition. Scientific Research Institutions can provide innovative technologies and talents to SOEs. Based on theoretical framework and Chinese current situation, the role of SOEs in innovation system of energy sector will be summarized in the following.

Firstly, Chinese SOEs play the leading role in innovation system of energy sector. In other words, Chinese SOEs can be seen as independent innovator in energy sector. Chinese SOEs of energy sector has strong strength and innovation capacity on research and development. SOEs are the main subject of technological innovation in

energy sector. They have sufficient funds to invest long-term projects and researches. They have strong innovation systems with advanced experimental facilities. In addition, they have enough professional research institutes for attracting talented people and making new innovation researches, such as Research University, National and Local Research Institutes, Research Laboratories, public enterprises, cooperative private Enterprises, cooperative foreign Enterprises and its own R&D department that include professional researchers and laboratories. The number of technology patent applied by SOEs is increasing every year in energy sector. In addition, since energy sector is heavily dominated by the Chinese state, as a result, the SOEs mastered many key technologies in the field of nuclear energy, oil and gas exploration, hydropower etc. SOEs even control the key strategic industrial in energy sector, directing the capital investment into innovation technology and development projects. Therefore, Chinese SOEs can be seen as the main force of innovation ability in energy sector.

Secondly, Chinese SOEs could act as a driver in technological innovative cooperation in energy sector. State-owned enterprises are an important force for the implementation of open innovation. According to the cases discussed above, it has figured out that many Chinese SOEs played important roles in the international energy market. They are not only exporting high quality equipment and production to the overseas market, but also making much cooperation with international energy firms. In this case, SOEs have strong ability of international operation; besides, they could get more chances of learning new technologies from international energy firms as technical exchange. On top of that, Chinese SOEs can be seen as driver in technological innovation cooperation in its own domestic energy market. Under the base of the background of Chinese industry, many other industries are also heavily dominated by the state such as high-speed rail industry, military industry, aerospace industry, and telecommunication industry. SOEs are the main power of scientific and technological innovation in the industries mentioned above. Many large innovative projects require the integration of the key technologies of these enterprises. Also, the SOEs, as the owner of the key technologies of those industries, running though entire

innovation chain, they connect each SOE on the supply and innovation chain, it functions as a bridge which allows the enterprises cooperate mutually between State-owned enterprises and private enterprises. In this case, SOEs could promote the co-operation between SOEs and form a new business model to seek new profit growth and develop core competitiveness. Therefore, Chinese SOEs could act as a driver and bridge in technological innovation cooperation in energy sector; it is also a main force for enhancing the national innovation ability.

All in all, the innovative capabilities of energy SOEs have highly connected with the innovation system of energy sector in China, requiring SOE to make long-term supporting for sustainable development. In conclusion, Chinese SOEs can be seen as independent innovator in energy sector; Chinese SOEs could act as a driver in technological innovation cooperation in energy sector.

4. Main findings and discussion

The case study of this paper indicates the current development of SOEs in energy sector that are based on clean energy industry and oil industry in China and also presents their impacts of the most important Chinese development policy on SOEs of energy sector. According to the Chinese development, SOEs truly act as the leading role in its energy sector which is heavily controlled by the state. Based on the theoretical framework of entrepreneurial state, the development of China's growth can be seen as a fully developed Entrepreneurial State (Burlamaqui L., 2016). Therefore, this paper showed that how Chinese government has made efforts in the clean energy industry with satisfied and notable results to achieve sustainable development. On the other hand, CNPC is another classic example showed the role of SOEs that played in Chinese energy sector. CNPC as one of the largest Chinese SOEs, it has been playing important roles in Chinese energy sector for a long time. It is not only playing the significant role in innovation system of energy sector in China, but also acting as an active role in the international oil industry. Both clean energy and oil energy cases are potential examples for analysing Chinese Entrepreneurial State. Many studies have figured out that SOEs could as instruments in innovation policy (Tõnurist, P.,2015), also figured out that SOEs can be seen as important instruments for fostering a more pro-active role of the state in innovation (Tõnurist, P., & Karo, E. ,2016). This study goes forward into another way to show SOEs also act as driver of the state energy sector in innovation system in China, furthermore, it figured out that innovation could act as an important role in Chinese microcosmic and macroscopic economy development.

However, some other studies indicated the problems in Chinese SOEs system that their share of output, sales, loans and the number of SOEs have fallen in the last three decades (Lardy, N. R. ,2014), but the total assets of SOEs was continuing to rise with opaque corporate governance and debt problems (Scott. & Chritopher k., 2016). Accordingly, Chinese government issued a series strategies and development policies to make SOEs reform and restructuring as soon as they realized these problems.

Taking Chinese oil industry, as the case which was discussed in chapter 3, Chinese oil sector is completely controlled by the state; the government still maintains important influences in commercial decisions through oil price setting and support investments. And it is heavily dominated by three oil SOEs. More recently, China's 13th Five-Year Plan may change this situation for the oil industry likely to extend pricing reforms and letting the market decide, it is allowing SOEs to receive investments from private firms. Although it is a tentative strategy, the main purpose is to protect the state-owned assets, to increase SOEs' running efficiency, speed up the development of the capital market and improve the competitiveness of the SOEs in both domestic and overseas market. Moreover, improving the core competitive power of the SOEs is a significant externalization of guaranteeing the direction of the socialist market economy. Based on the theory, Mazzucto pointed out that the government has a major role to play in building a highly productive, innovative and sustainable economy to make a smart growth (Mazzucato, 2014). It can be seen that the case of Chinese energy sector is meaningful.

Meanwhile, to fully bring out the potential role of SOEs in energy innovation system, it requires government and energy SOEs to be more effective and smart within the innovation process (Mazzucato, 2014). For the case of Chinese energy sector, SOEs should improve their mechanism of sustainable funding, changing the ways of measuring and judging innovation performance (Mazzucato, 2014). Furthermore, Chinese SOEs should update their cooperative innovation mechanism to make more cooperation with other public related SOEs, private firms and related departments, promoting collaborative innovation and exploring an open cooperative innovation path. Chinese bank system is also heavily dominated by the state, in order to make SOEs more active and effective requires National Development Bank to play an active role of supporting innovation and sustainable development of SOEs in China.

As all discussed above, it can be seen that Chinese entrepreneurial state is implemented through the 12th Five-Year and 13th Five-Year Plans. Five-Year Plan is issued by the Communist Party of China (CCP) Central Committee. Based on the

Schumpeter's view of characterization of socialism discussed in theoretical framework, public sector plays a crucial role in economic development, plus, the central authority is vitally important in socialist society. Therefore, it can be argued that Chinese entrepreneurial state fits well with what Schumpeter argued about socialism. According to the 13th Five-Year Plan, Chinese government has already put the innovation on an important position. In order to achieve innovation-driven growth and sustainable development, Chinese government needs to play a more active role in SOEs reform and making effective development policies with a very clear direction for future investment, research and development, innovation and technology, and SOEs governance.

5. Conclusions

The aim of this paper is to analysis the Entrepreneurial State in China based on Chinese energy sector, also discussed the potential role of Chinese SOEs in energy innovation system. The theoretical framework of this paper was based on Schumpeter-Keynes-Minsky analytical framework, Mazzucato's "Entrepreneurial State" theory, and Mathews's "Greening of Capitalism" concept. The paper chose Chinese energy sector as main analysis object, presented two cases of clean energy industry and oil industry to show how Chinese Entrepreneurial State has developed and what potential role of Chinese SOEs played in energy sector. Moreover, China National Petroleum Corporation was discussed above as a specific case of Chinese oil industry. Both clean industry and oil industry cases are built upon theoretical analysis and empirical research, the data gathering and theoretical foundation were made through statistical and document research. The paper also discussed the impacts of the recent Five-Year Plan on development and innovative technology of Chinese SOEs.

As stated above, there are three main conclusions in this paper. Firstly, Chinese SOEs play the leading role in innovation system of energy sector due to their dominant position. In other words, Chinese SOEs can be seen as independent innovators in energy sector. Secondly, Chinese SOEs could act as drivers in technological innovative cooperation in energy sector. Thirdly, innovation is indeed crucial in the process of economic development. The innovative capabilities of Chinese energy SOEs have highly connected with the domestic innovation system and economy growth, requiring SOEs to seek new profit growth point by innovative technology. In addition, facing the International fierce competition, it requires Chinese SOEs not only to be as innovation-oriented entrepreneurs in domestic market, but also to be active players in overseas market.

From analysis above, Chinese government is not only making a large long-term investment into innovation development, but also supporting to sustainable development by national development policies. In order to achieve innovation-driven

growth and sustainable development goals in China, it still needs Chinese government to play a more active role in SOEs reform and making effective development policies with a very clear direction of future investment, research and development, innovation and technology, and SOEs governance.

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