Conditions Analysis for Development & Deployment of Low-carbon Innovations in China

Selected technologies

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Chinese Renewable Energy Society
Beijing JKD Renewable Energy Development Center

Supported by WWF China

Executive Summary

Climate change has been a worldwide topic and the world economy with low-carbon produced is the trend. The article *Energy technology outlook: the Scenarios and strategies toward the year of 2050* issued by IEA shows that if the current technologies can be widely adopted, the total emission volume of the whole global greenhouse gases will be reduced by 35 billion tons from the current level, with the new technology contributing to 30%.

In order to meet the new challenge of the climate change, China puts forth the policy to transform the mode of economic development and gradually achieves the shift to low-carbon economy; while low-carbon technology innovation certainly is the key. Therefore, it is necessary to conduct the researches on the questions such as what the current situation is for low-carbon technology innovation system in China; what problems and obstacles stay in front of low-carbon technology innovation; how to improve the development of the new low-carbon technology and so on.

Under the support from WWF, this program focuses on one part of the low-carbon technology: wind power, solar energy (PV, thermal power), biomass energy (liquid fuel), hydrogen energy (production, transport and storage), fuel cell, new energy automobile and LED technologies. (Explain that the study looks at the innovation system both from a systems perspective (top down) and ground perspective (bottom up). Visits and researches have been made to the representative enterprises and relevant service supporting institutions in above new energy technologies and their application field, which are under the recommendation of experts. Through the face-to-face talk with the responder, the first-hand material, such as the difficulties and obstacles China's low-carbon new technology development facing have been obtained.

Based on the research and survey, with other relevant information, the expert group deeply analyzes the content and structure of current new energy innovation system of China, get the in-depth knowledge on whole process of China's new energy low-carbon innovation system, including production enterprises, research institutes, intermediary body (service support institutes), finance & investment institutes and government policies. Through the in-depth analysis and research, the panels conclude the problems for China low-carbon new energy innovation are mainly as follow: insufficiency investment in technology R&D development and innovation capacities, lack of in-depth awareness of low-carbon energy technology, absent of corresponding criteria, regulations, monitoring verification and public R&D service platform, in sufficiency of the government's incentive policy and guide toward the low-carbon new energy technology innovation and its market develop and so on.

Then what are the factors that lead to these problems and their existence? The report analyzes the reason in three levels: current government policy, enterprises and history factor. Although complicated and diversified reasons lead to the difficulties and obstacles for China's low-carbon new energy technology innovation, the solutions to overcome the difficulties and eliminate the obstacles, including build up innovative enterprise, industry technology innovation unions, as well as public service platforms etc.

In order to safeguard the innovative development of Chinese low-carbon new energy technology, the report proposed the specific safeguard suggestions which include planning special development program, creating policy environment helpful to the development of innovative enterprises,

improving the organization structure, strengthening coordination and management, carrying out a number of national new energy industrial technology research consortium, and establishing and improving the national scientific research and development center.

Also the Exec Summary could include a few words on:

- How to create market demand domestically
- Stimulate and facilitate international sales of Chinese developed and produced solutions.
- The need for attracting foreign partners and facilitate fruitful int'l collaboration = i.e. the challenges of technology cooperation, technology access.
- The need for financing for Low Carbon Technology (LCT) innovators and entrepreneurs, both regarding public funding and how the companies experience the situation/access to private capital.

General comments about the document:

- Sources and references need to included, as foot notes or end notes. This goes for any kind of number, statement or claim in the report, in order to make it clear to the reader what facts this report is building on, and what is the opinion of the research team.
- Fine tuning of the English translation needed
- Better structure to guide the reader, e.g. in terms of headlines, font sizes, using bold or italic text, bullets, quotes, boxes etc.

Contents

Abbreviation table

WWF	World Wide Fund For Nature
GDP	Gross Domestic Product
Carbon productivity	GDP produced per ton of carbon emissions
Carbon intensity	Unit of GDP of carbon dioxide emissions
CCS	Carbon Capture and Storage technology
ECU	European Currency Unit
IEA	International Energy Agency
IPCC	The United Nations Intergovernmental Panel on Climate Change
GHG	Greenhouse gases
IGCC	Integrated Gasification Combined Cycle technology
TRT	Blast Furnace Top Gas Pressure Power Generation Technology
LED	Semiconductor Lighting
CdTe	Cadmium telluride
GaAs	Gallium Arsenide
CIGS	Copper indium gallium selenium
BEV	Pure electric vehicles (including solar car)
FCEV	Fuel Cell Electric Vehicle
UNFCCC	United Nations Framework Convention on Climate Change
SME	Small & Medium scale Enterprises
Sci-tech	Science Technology
R&D	Research & Development

Chapter 1 Project Background

Include an introduction to the report, e.g.purpose and objective for the study:

- Mapping the landscape, establish better understanding
- Ground + systems analysis
- Provide the basis for recommendations and actions for relevant stakeholders including WWF.

The issues like rapid population growth, excessive consumption of resources, climate variability, environmental pollution and ecological destruction and others are threatening human survival and development. With the supports from WWF, the project team conducted this research. This research mainly studied the following issues:

1. To survey and identify the varied kinds of existing and potential low-carbon innovation technologies and their development status and future potentials;

2. To survey and identify the obstacles and bottlenecks which restrict the large-scale, commercialization and sustainable development in low-carbon innovation markets in China, e.g. lack of technology standard and rules, limited access to financing, lack of powerful incentives policies, etc.

3. To propose the policy suggestion and opinions to policy makers and stakeholders aiming the above difficulties and obstacles so as to accelerate the low-carbon innovation technology development in China.

The analysis will be performed at two levels which are both important for the understanding of how different parts of the Chinese innovation system works:

1. On the ground analysis, profiling climate innovations and entrepreneurs in China i.e. the day-to-day reality and available resources for climate entrepreneurs work in the country.
2. Systems analysis, i.e. an aggregated profile with key indicators for the national innovation system (mapping the Chinese innovation system)

1.1 The aim of low-carbon technology innovation

Global climate change will transform the economic and social development towards a low-carbon model worldwide The core content is to develop low-carbon energy technologies, establish low-carbon economic growth patterns and consumption patterns of low-carbon society. Many countries and enterprises begin to take these measures as a fundamental way to harmonize the relationship between economic development and climate protection.

In the future, low-carbon energy technologies will represent a country's core technology competitiveness, and also it is the strategic focus that major countries in the world response to climate change. Clean and low-carbon technologies will stimulate new economic growth point, and it will reshape the world economic pattern, as the information technology did before. China's clean low-carbon energy technology is facing serious challenges, but there also exists leap-forward development opportunities.

The "Energy Technology Outlook: Scenarios and Strategies for 2050" published by International Energy Agency shows that if existing technology can be widely used, by 2050, global GHG emissions will be cut by 35 billion tons based on the current level, among which the contribution of new technology is about 30%.

1.1.1 Promote China's transition to a low carbon economy

Substantial increase of carbon productivity is the key to complete the transition to a low carbon economy, also is the key measure to response climate change in the framework of sustainable development. Technological innovation is the one of the fundamental means to achieve higher growth rate of carbon productivity. During the period 1990-2005, annual growth rate of China's carbon productivity is 4.6%, while the Annex 1 in "United Nations Framework Convention on Climate Change" shows that a country's annual growth rate of carbon productivity is 2.0%. During the same period, China's improvement of energy efficiency's contribution to annual growth rate of carbon productivity is about 1/3[1]. It shows that in the past 15 years, the improvement of energy efficiency brought by technological innovation has supported China's efforts to increase the growth rate of carbon productivity.

Yet, China's current carbon productivity increases faster, the current unit GDP of carbon intensity still lags behind the developed countries, and one of the key factors is that technical level and energy efficiency is still relatively low. Therefore, it is necessary to speed up technology, especially low-carbon technology innovation to improve China's carbon productivity and promote China's transition to a low carbon economy.

1.1.2 China's strong driving force to achieve voluntary emission reduction targets by 2020

During UNFCCC COP 15 in Copenhagen at the end of 2009, the Chinese government announced action target to control GHG emissions that by 2020, China's per unit GDP of carbon intensity will fall 40%-45% than that in 2005; non-fossil energy share of total primary energy consumption will be about 15%. These targets will be included into China's medium and long-term planning of national economic and social development as binding targets.

Some research has shown that, there are three main ways for China to achieve the established target of decreasing the unit GDP of carbon emission intensity. Namely, by energy conservation, improve energy efficiency on the contribution to decreased carbon intensity is about 26%-30%; develop the nuclear energy, renewable energy and other non-fossil energy sources on the contribution to decreased carbon intensity is about 8%-10%; clean utilization of fossil energy on the contribution to decreased carbon emissions intensity is about 6%-7%[2].

Therefore, the research, development and deployment of low-carbon innovation technology in energy conservation and energy efficiency, non-fossil energy sources and fossil energy cleaning utilization and other fields will play a strong role to achieve China's carbon target of voluntary reducing emission intensity by 2020.

1.1.3 Competitiveness of the country and enterprises

Global response to climate change will be accompanied by intense technological competition, and adjust international trade patterns. Environmental standards of imported products may be raised and carbon tariffs may be imposed directly on products to protect competitiveness of the domestic enterprises. This is a new challenge to high energy embedded and low value added, but it also can be a driving force to promote the upgrading of Chinese industries and optimize the structures.

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[1] <Development of Low-carbon> Zhang Shenmin, Pan Jiahua, Cui Dapeng China Environmental Science Press Oct. 2009, Beijing

[2] Du Xiangwan <Climate Change> The National Climate Committee, China Meteorological Administration 5th volume 2010 Feb. 2010 2010

In these situations of low-carbon technology innovation, the competitiveness of enterprises will face new challenges. The transformation of low-carbon economy will affect the costs of operations, and change the prices, demand and production structure. To react and respond to this low-carbon transition will affect enterprises' own existence and prosperity in a few years.

Large companies in developed countries are increasingly aware of the importance and seriousness of responding climate change, and they're trying to develop long-term sustainability strategies, and take action to gain competitive advantage. Siemens is committed to increasing energy efficiency of its global business 20% during 2006-2011; GE launched "Ecomagination Program" regarding the concept of environmental protection as research and development axis, and its sales in 2010 will exceed 200 billion U.S. dollars, double that in 2005; Toyota Motor plans to reduce each vehicle's CO_2 emissions 30% by 2010 lower than that in 1990[3]. The motivation of these companies in developed countries is to follow the world trend of technological change, aiming at focusing on the potential market during low-carbon economic transition, and maintain leadership.

In the process of China's transition to a low carbon economy, initial policy guidance will bring new opportunities for domestic demand and the development of low-carbon technologies; the global cooperation creating a low-carbon economic development model will provide a good international environment and opportunities of international technical cooperation for China's low-carbon technology innovation. Therefore, as long as we actively deal with the challenges, develop and enact low-carbon technology innovation incentive policies to promote its development, the national and enterprises' competitiveness will undoubtedly be improved rapidly.

1.1.4 Open up new areas of economic growth to increase employment

China has a large population and is facing a severe employment situation. Research[4] shows that compared with fossil energy, new energy and renewable energy industry could provide more employment opportunities. American scholars believe that the employment opportunities created by investing in energy efficiency and solar technologies is double of that in oil and natural gas. According to the estimation of several EU new energy and renewable energy professional committees, once the capacity of wind power reaches about 40GW, PV 3GW, biomass power generation 100GM and solar collector 100Mm^2 in Europe, 1.54 million-1.67 million employment opportunities will be provided by then, and this does not include the potential 0.35 million jobs created by 17 billion ECU commercial export per year. Currently, a considerable number of workforces have been formed in Europe in renewable industry, such as the Danish wind power industry is providing tens of thousands of jobs for the Denmark, and the components of the wind turbines are supplied worldwide, which also created a large number of jobs.

China has also confirmed the renewable industry's contribution to employment. At present, there are more than 2,100 solar energy enterprises, wind energy enterprises, and biomass energy enterprises, with more than 3 million employees across the country; there are over 3,000 semiconductor lighting enterprises, with more than 800 thousand employees; there are more than 20,000 small hydropower enterprises, with 520 thousand employees, which has made tremendous contributions to arranging the rural surplus labor force across the country. Clearly, with the advancement of science and technology, and the development of new energy and renewable energy industry, more employment opportunities will be created for the society. Especially in those regions with renewable energy resources and technological advantages, low-carbon technology's development will not only help increase employment opportunities for the community to ease the employment pressure, but also help local economy to take off by making use of these advantages. +

[3] <Development of Low-carbon> Zhang Shenmin, Pan Jiahua, Cui Dapeng China Environmental Science Press Oct. 2009, Beijing

[4] <Analysis on Renewable Energy Development and Potential Employment Opportunities> Wang Qi, Li Guihua, Sun Yang, Liu Yaoxin, Yang Tianhua, Wei Lihong

provide energy access, secure energy access, enable China to reach climate and environmental goals?

1.2 Content of low-carbon technologies

1.2.1 Definitions and concepts

Involving a wide range, at present, there is not a uniform concept and definition for low-carbon technology. Generally speaking, the technology characterized by reducing GHG emissions can be called low-carbon technology. According to the field of application of low-carbon technologies, they can be divided into three categories, namely carbon reduction technology, carbon-free technology and carbon elimination technology.

Carbon reduction technology: Clean use of coal, oil and gas resources and coal bed methane exploration and other technologies.

Carbon-free technology: solar, wind, nuclearand other renewable energy technologies.

Carbon elimination technology: CCS is an emerging technology, with large-scale emission reduction potential, and fossil energy use is expected to achieve near-zero emissions of CO_2. The technology captures CO_2 produced in industrial processes and safely store CO_2 in the specific geological structure, reducing emissions into the atmosphere to reduce GHG accumulation in the atmosphere, thereby slowing the global climate change. In addition, the GHG can be used for resource utilization, and enhance oil recovery. At present, there have been more than 300 CCS projects, 260of which are actively promoted. China's first CCS power plant will be completed by 2016, and the country's largest base of flue gas purification experiments has been settled in Hechuan, Chongqing, namely the Shuanghuai plant.

1.2.2 Framework and content of low-carbon Technology

The major conclusion of the report in “Energy Technology Perspectives: Scenarios for 2050 and strategies” published by IEA is: if appropriate measures cannot be taken, by 2050, the global energy demand and CO_2 emissions will be at least doubled. Much of the increased energy demand and CO_2 emissions is mainly from developing countries. Technology development can lead the global energy sector into a more sustainable track. Five technology developing scenarios show that with the existing or emerging technologies, CO_2 emissions from global energy field may return to current level by 2050. Compared with the baseline scenario, the enormous difference among these five scenarios is caused by: energy efficiency in transportation, industrial and construction sectors; conversion of the primary energy to carbon-free nuclear energy and renewable energy generation; gas and coal-fired power station using CCS technology leading to significant decarburization of power industry and so on.

IPCC Fourth Assessment Report estimated that the key emission reduction technologies which could be commercialized before 2030 are mainly distributing in the industry, transportation and construction and other terminal sectors.

The results of a study on 80 items emission reduction research in the field of construction suggest that on the cost-effectiveness and potential energy conservation, energy-efficient lighting technology is one of the most promising measures in almost all of the building GHG reduction around the world. By 2020, applying the lowest life-cycle cost lighting system can reduce emissions about 760MtCO_2, with the average cost of -160 U.S. dollars/ton CO_2.

The report “China's green revolution” published by McKinsey focused on China’s potential to

increase energy efficiency and reduce GHG emissions from the baseline scenario. Fully exploiting the maximum potential of all technologies not only can greatly improve China's energy security, but also can control the GHG emissions by 2030 at about 80 million tons (mitigation scenario), which is only about 10% higher than that in 2005. The report "China's low-carbon development path in 2050: Energy Demand and Carbon Emission Scenario Analysis" published by National Energy Research Institute of National Development & Reform Commission shows that with technological progress and energy efficiency, terminal energy demand in low-carbon scenario is lower 17.6% than that in energy saving scenario in 2050; energy demand in enhanced low-carbon scenario is lower 8.4% than that in low-carbon scenario.

From the above all, we can learn that low-carbon technology is a very complex and huge project, which involves all aspects of economic and social development. According to the concept and definition of low-carbon technology and China's strategic goal of achieving transition to low carbon economy, and priority areas of China's future carbon mitigation, we initially built the framework of China's low-carbon technology system, see Table 1.

Table 1 Frame of Chinese low-carbon technology system

Industry	**Key low-carbon technology (which are the technologies should be developed in China)**
Energy production and supply	**Highly Efficient fossil energy conversion technologies:** advanced steam cycle power generation technology; fluidized bed combustion technology; integrated gasification combined cycle technology (IGCC); combined heat and power technologies; natural gas power generation technologies; ultra-supercritical power generation technology; distributed generation systems. **Advanced carbon capture and storage (CCS) technology:** separation after combustion; combustion before the separation; oxygen combustion technology. **Nuclear power technology:** Third generation nuclear power technology; Fourth generation nuclear power technology. **Renewable energy technologies:** wind power (land and sea); solar power (photovoltaic power generation; concentrating solar power); **biomass power generation technology** (direct combustion power generation technologies; hybrid combustion power generation technologies; landfill gas power generation technology); hydrogen technologies; ocean energy technology; geothermal energy technology. **Water conservation power technology:** Big water power; Small water power. **Vehicle fuel technology:** Fuel ethanol; biodiesel; Cellulose ethanol; biomass butyl alcohol; F-T biodiesel; biomass methyl alcohol; biomass diethyl ether; biomass hydrogen; Coal methyl alcohol technology, etc. **Smart grid**
Manufacture process	**Iron and steel industry:** blast furnace top gas differential pressure power generation technology (TRT); blast furnace pulverized coal injection technology; advanced dry quenching technology; advanced converter (oxygen, suction, converter gas recovery); new heating furnace and External refining process and technology; blast furnace gas and converter gas recovery

	technology; combined cycle generation technology; direct reduction and smelting reduction technology; CO_2 capture and storage technology. **Cement profession:** Highly effective pure low-temperature afterheat power technology; the highly effective cage-type powder separator, circulating pre-grinding, the raw mill roller mill applications, etc. comprehensive technical measures; advanced dry precalcining technology; combustible waste in cement industry application technology; motor drive system frequency conversion, speed regulation, energy-saving and alteration technologies; cement industry CO_2 capture and storage technology (CCS). **Other professions:** Highly effective terminal use electrical equipment; cogeneration of heat and power technology; Raw material recycling use and substitution; Control the non- CO_2 gas emissions; Enhance the energy efficiency technology; The technology of catches and seals the carbon; The noble electrode is used in aluminum production, etc.
Transportation	**Highway traffic automobile technology:** Highly effective gasoline engine, diesel engine technology; Highly effective truck and engine technology; cars and light vehicle's dieselized technology; vehicle lightweight technology; Isotropic compression ignition engine technology; Non-internal-combustion reciprocating engine technology; Advanced highly effective power transmission technology; Machine oil chemical additive and fuel oil chemical additive technology, etc. **New energy vehicle:** Substitute fuel automobile: hybrid automobile; pure electric automobile; fuel cell and hydrogen fuel automobile, etc. **Urban track transportation technology.** **Railway transportation:** fuel-efficient internal combustion engine technology and railway electrification technology **Water and land transportation:** improve channel conditions; achieve ships' large-scaled and standardized; promote the use of standardized ships; reduce ship resistance, improve propulsive efficiency and power plant efficiency, etc. **Air transportation:** promote construction of fuel-efficient incentive mechanisms, promote advanced fuel-saving technologies; etc.
Building	Semiconductor lighting (Light-emitting diode LED) and the solar lighting; energy-saving white household appliance and heating, refrigerating equipment; improve cooking stoves, energy-saving building; sun control window; solar powered heating and cooling design; replaceable refrigerated liquid, recovery and utilization of Freon gas ; intelligent building.
Agriculture	Improve crop land and grazing land management, and increase soil carbon storage; resume cultivation of peat soils and degraded lands; improved rice cultivation techniques and livestock and manure management to reduce CH_4 emissions; improve nitrogen fertilizer applying technology to reduce N_2O emissions;

	dedicate biomass crops to replace fossil fuel; improve energy efficiency; increase crop yields.
Forestry/forest	Forestation; reforestation; forest management; reducing deforestation; wood product acquisition management; use of forest products for bio energy to replace fossil energy use; improve the species to increase biomass production and carbon curing; improve remote sensing technology for the analysis vegetation / soil carbon sequestration potential.
Waste material	Landfill methane recovery; waste incineration, energy recovery; organic waste composting; controlled sewage treatment; recycling of waste minimization; biological cover and bio-filtration; optimize CH_4 oxidation processes, etc.

1.3 Research Areas and Priorities in this Project

1.3.1 Background Information

As the one of the largest non-governmental organizations in the world, WWF has been committed to mitigating global climate change, and urged all countries to unit and act as soon as possible to take effective solution to climate change. In 2006, WWF launched the "Climate Change Solutions: WWF2050 Outlook", and the report pointed out that: with the known renewable energy resources and existing skill level, if we work together to convert to sustainable energy and technology, there will be over 90% of the possibility that not only can meet the increasing demand for energy in 2050, but also can avoid the catastrophic climate change caused by temperature rising over 2 ℃.

At present, China is the world's second largest energy producer and consumer, and the economy is in the process of speeding up urbanization and industrialization which are characterized by resource-intensive mining and rapid consumption, and the contradictions between limited energy and resources and sustainability of economic growth become more intensifying. Statistical data[5] shows that since 2000, due to the pull of market demand, China's output of major high energy-consuming industries products increase at a speed of more than 10% annually, and their energy consumption accounting for more than 55% of the whole society energy consumption. The unit GDP of energy consumption is exponentially higher than Japan, Europe and the United States and other developed countries. At present, China and the United States' CO2 emissions produced by energy consumption accounted for 42% of the total emissions of the world.

"BP World Energy Statistics 2009" shows that influenced by the global economic situation in 2008, the overall global primary energy consumption has a slight increase of 1.4%, which is the smallest increase since 2001. Among it, about three quarters of growth comes from China. In 2008, China's coal demand accounted for 43% of global coal demand, with consumption growing by 6.8%, accounting for 85% of global coal consumption growth. It is clear that coal still accounts for a large proportion in China's energy structure. Meanwhile, as a big energy consumption country, China's low-carbon economic development's position and pattern will contribute to other countries and regions as a reference and promotion to their low-carbon economic development.

Based on the above background and supported by WWF, the project developed the research subject of Chinese low-carbon new energy technology's innovational and developing conditions

[5] *local finance research*, Wen Zongyu, finance science research center of finance department (2010?).

from Nov. 2009 till now.

1.3.2 Research Areas and Priorities' Determination in the Project

Low-carbon new energy's technology is a wide field. In order to determine the focus of this study, namely the key technologies developing environment in the field of low-carbon new energy in China, the project determined the principles of selecting the key technologies according to the national energy development strategy, national action plan to address climate change, and related planning of new energy and renewable energy. Meanwhile, it is also based on the characteristics of various technology, industry's developing stage, future potential and other factors.

- Core technology which plays a strategic, forward-looking and restrictive role in the national low-carbon development.
- Leading role of science and technology that guide the future, and represent the direction of the development of low carbon technology.
- Enhance the technology's innovation, and improve the economic applicability of low-carbon technologies.
- Included in the national development plan with the support of all key science and technology.

The selected and determined research areas and priorities based on the above principles of this project include wind power, solar energy (PV, thermal power generation), biomass energy (liquid fuel), hydrogen energy (production, transportation and storage), fuel cells, new energy vehicles, LED and other technologies, see Table 2.

Table 2 Developing Situation of Low-Carbon New Energy Technology in China

Technical Field	Core Technology	Current Domestic Developing Level
Wind Power Technology	The manufacture of MW-class wind power generators	At present, the domestic enterprises have **basically** mastered the manufacturing technology of MW-class wind power generators, and they can make the main components on their own, not only the production gradually increases, but also a certain competition pattern has been formed. At present, China has achieved the mass production of 1.5 MW wind power generators. China also has been developing out many kinds of 2-3 MW wind power generators prototypes, and carried out the examination in the field.
	Research on the wind energy technology	**Lacking** of designing, manufacturing technology and ability of the key parts of large wind power generators, we **mainly introduce and digest** the foreign equipment and technology

	Essential data of wind energy, the quality standard for the data	The nationwide detailed survey about the wind resources has **not been carried out**, and the evaluation of the wind farm resources on the sea is still a **blank**.
	The wind farm synchronization technology	The standard for the wind farm synchronization is **under setting**.
Solar Energy Technology	crystalline silicon photovoltaic cells module	10MW-Scale and over 10MW PV cells' packaging technology and auxiliary equipment have become **commercial** industrial equipment.
	PV cells' manufacturing technology	**Lacking** of core technology and patents of manufacturing equipment, some key technology and equipment relying on the introduction, **lacking** of independent innovation capability and sustainable development capacity.
	synchronization technology for PV power generation	Without special batteries for PV systems, and inverter production also remained at low-power levels, there is **distance** from foreign technology on research and development levels of high-power inverters.
	Solar thermal power generation technology	At present, the tower-type system, trough and dish systems are still in technical **development and demonstration** phase. Integration technology of solar thermal power generation is **not yet mature** in China.
Biomass liquid fuel technology	Fuel Ethanol technology	Ethanol, as an alternative liquid fuel, has been **successfully applied** in the automobiles and other means of communication. **Lacking** of continuous processing equipment affects the large-scale production.
	Biodiesel technology	China has set up more than 20 manufacturers whose biodiesel production capacity is 10 thousand-ton. With **lagging** industrial technology, low utilization efficiency of raw material, high consumption of material, water, and energy. **Without** ability to adapt to complete sets of advanced technology and equipment for non-grain plants biofuel production. Lacking of effective raw material supply and training system.

Hydrogen energy technology	Basic research and make use of technology	China is focusing on research and development of hydrogen production, hydrogen storage, transportation of hydrogen, hydrogen safety and the fuel cell technology, **laying the technical foundation** for the development of hydrogen energy.
LED technology	Semiconductor lighting core technology	Having formed a **fairly comprehensive** research and development and industrial system that from the upper material, chip preparation, middle device packaging to lower integrated application, entering the stage of rapid growth.
	Exploratory, advanced material growth and device research technology	Explore and research technical route of 200lm/W new white light. Develop research on the GaN homoepitaxy, DUV LED, OLED, LED and non-polar GaN LED.
	Key technology of industrialization	In 2009, optical efficiency of packaged power-type GaN chip on the enterprise's industrial line achieved 80-100lm/W. Optical efficiency of packaged power-type silicon substrate LED chip achieved 78lm/W, which is at the international advanced level. But the core equipment MOCVD is **highly dependent on** the import, which is hard to support extensive core technology, sustainable innovation of process and large-scale production.

1.3.3 Progress of China's Low-Carbon Energy Technologies

(1) Solar Photovoltaic

In 2008, global photovoltaic installed capacity reached 5500 MW, among which more than 70% concentrated in Spain and Germany. China's solar cell production accounts for 33% of world production in 2008, but domestic photovoltaic installed capacity is only 40 MW, and 98% of products are for export.

China's solar cells are mainly crystalline silicon solar cells. The production of crystalline silicon solar cells accounts for more than 95% of total production in 2008, and the production of thin film solar cells (all are amorphous silicon) is about 50 MW. Currently, there are nearly 50 polycrystalline silicon plants are under construction and planned in China, with the total capacity of more than 0.1 million tons. In 2009, only 16 plants are put into operation, with no one reached the expected production in. China is expected to yield 1.5-2 million tons high-purity polycrystalline silicon in 2009, which is still in short supply. After 2010, the polycrystalline silicon may meet domestic demand.

On thin film solar cells, the amorphous silicon plays a key role currently. Certain progress has made on the research of cadmium telluride (CdTe) and copper indium gallium selenium (CIGS) solar

cells, but it is still difficult to rely on domestic technology to achieve industrialization.

On the balance systems and engineering technology, such as inverter, automatic tracking, monitoring station, there is little gap between China and foreign countries, it can totally rely on domestic technology to achieve industrialization. In the future, China's photovoltaic market will focus on synchronization.

(2) Solar Thermal Electric Power Generation

A number of China's thermal power stations are conducting feasibility studies and establishing pilot power stations. By January 2010, the proposed solar thermal power generation projects have been up to 2000MW. Some large power companies have invested research and development strength and launched large power station's site selection. Xi'an Aviation Power Company has completed raising the stock market of the 1MW-dish solar thermal power project, which is the first solar thermal power project operated through the capital market.

Over the past decade, China has studied solar tower-type power supplied heliostat, refectoscope, heat absorber, high-temperature heat storage and heat transfer, etc., and has formed a group of core technologies and approved products. On Trough solar thermal power generation, China has owned proprietary intellectual property rights of high-temperature vacuum tube, which has broken through the technical bottleneck of trough power generation but has not been commercialized.

(3) Wind Power Generation

China is rich in wind energy. Referring to the evaluation of Wind and Solar Energy Resource Assessment Center, China Meteorological Administration, the potential wind energy in China is near to 1 billion kWh In recent years, China's wind power generation is developing rapidly, and the wind power installed capacity is almost doubled for three consecutive years. In 2008, the new additional wind power installed capacity is 6.25 million kW, which is more than the cumulative amount of the past 22 years, with the additional installed capacity growth rate of 89%. And the cumulative wind power installed capacity of 12.15 million kW, accounts for 1.5% of the 790 million kW, which is the total installed capacity of China. Its' cumulative installed capacity growth rate is 106%. In 2009, the national wind power installed capacity is about 9.08 million kilowatts, with the cumulative wind power installed capacity of 21.23 million kW.

(4) Biomass Liquid Fuel

Fuel ethanol is one of the biomass liquid fuels with largest scale and most sophisticated technology in the world. In 2008, the top five countries (or groups) of fuel ethanol production in the world include America, 9 billion gallons; Brazil, 6.47 billion gallons; European Community (EC), 73 million gallons; China, 50 million gallons; and Canada, 24 million gallons. As the contradiction that there exists a conflict between fuel ethanol production and food supply, all the countries in the world dedicated to the development and utilization of technology to produce fuel ethanol from energy crops or cellulose raw material.

Global production of biodiesel has achieved a certain scale. In 2004, global production is about 3.4 million tons, among which the European Union (EU) is about 2.5 million tons. EU plans to produce 10 million tons by 2010. By 2010, America's biodiesel production will be more than the sum of EU countries, reaching 12 million tons. China has basically formed the biodiesel industry, with the annual production capacity of 1 million tons. However, limited by lack of supply of raw material and policies, industry environment has not been established, a serious insufficient of capacity utilization, the annual output is less than 0.1 million tons.

(5) Hydrogen Energy

China's hydrogen production capacity is 8 million tons. China has ranked with the internationally advanced countries in terms of hydrogen production. But most of the hydrogen (about

84%) was used as chemical raw material. At present, in China, the hydrogen made from fossil fuels accounts for about 97%, and the hydrogen made from water electrolysis accounts for about 3%.

High-pressure gaseous hydrogen storage is a common method of hydrogen storage, and it is now considered to be one of more economical and practical options. Cool the hydrogen to -253 ℃, which was liquid, and then store it in a high vacuum thermally insulated container. This is liquid hydrogen storage. On solid hydrogen storage, applying the AB5-type rare-earth hydrogen storage alloy and AB and AB2-type titanium-based material into hydrogen storage devices achieves the large-scale preparation of these materials, and form the serialization products of hydrogen storage devices, with a hydrogen storage capacity of 15-12 thousand liters. At present, small lot (more than 500 sets) of metal hydride hydrogen storage devices have been exported to Japan, America and European countries.

China has independently developed a number of fuel cell buses and fuel cell cars, which respectively have been running more than 20 000 km / vehicle totally. China has broken through the preparative technique of perfluorosulfonic acid proton exchange resin. Thus China has formed a thousand-ton production capacity of perfluorosulfonic acid proton exchange resin.

(6) Fuel cells & New Energy vehicles

Fuel cell technology, as the core technology, has made substantial breakthroughs and will change the world pattern of energy and power in the next 5 to 10 years. China's fuel cells power system technology has made a great progress. Several 1-5 kW level of low temperature fuel cells portable power model has been performing demonstration running, and high temperature fuel cell power system has also been in the course of research and development.

Chinese fuel cells automobile regards the research and development of power system technology platform as the core to drive the production-teaching-research model of critical components' development and vehicle integration. Over the years, it evolved from key technologies' research and development, components' development, system integration, vehicle development, demonstration assessment to carrying passengers' demonstration running, etc. and a series of processes. Therefore, Chinese fuel cell automobile has met the condition of small-lot industrialization and had competitiveness to enter the international market. By the end of 2008, China's fuel cell loading has reached the scale of 10 passenger buses and 53 cars.

The new energy vehicles include hybrid automobiles, pure electric automobiles (BEV, including solar automobiles), fuel cell electric automobiles (FCEV), hydrogen engine automobiles and other new energy automobiles (such as efficient power accumulator, diethyl ether), etc. Among them, hybrid automobiles, pure electric automobiles and fuel cell automobiles belong to the electric automobiles.

China's new energy automobile industry has already formed the research and development layout that regarding power platform as the core to drive the breakthrough in components' technology; and established several technical research and development platforms for new energy automobiles' dynamic system. The key components' (vehicle power battery, driving motor, fuel cell engine, etc.) technology, electronic control technology and system integration technology have made a great progress. The whole new energy automobile has achieved a small lot production and withstood the test of the market.

It is estimated that in 2012, 10 thousand-scale new energy automobiles will be applied, which may reduce about one million tons of traditional gasoline and diesel and nearly 3 million tons of carbon dioxide emissions. If it is calculated by the vehicle's life cycle, these automobiles may reduce about 10 million tons of gasoline and diesel and nearly 30 million tons of carbon dioxide emissions.

(7) LED (Light Emitting Diode)

With continuous breakthroughs in technology and decline of cost, semiconductor lighting's application fields have expanded increasingly. At present, its technology in instruction, display and

landscape illumination domains has become fundamentally mature, giving full play to LED's advantages of high brightness, long life, rich colors, save electricity, etc. The market demands for the traffic light, indoor-outdoor large screen display, decorative lighting, etc. have increased significantly. And LED backlighting has been widely applied in small-medium size screens of laptop, cell phone, digital camera, MP4, etc. And its applied technology in large-size liquid crystal TV has become mature gradually, with an explosive growth of market share. Although its technology in functional lighting areas such as the road, industrial and mining establishments, commercial buildings, family, etc. has just started and in the demonstration pilot phase, they will be the biggest markets of semiconductor lighting in the future. In addition, semiconductor lighting technology in special areas such as the automotive, medical care, agriculture, etc. is unfolding and has great potential space to develop.

Chapter 2 Cases studies of the low-carbon new energy technology innovation.

2.1 Methods

2.1.1 Expert Panel

According to the design of the project proposal and the specific requirements of the project implementation, this project has gathered domestic authoritative experts specialized in the research of the new and renewable sources of energy, macro policies of the energy saving industry and fund management. Members of the expert panel specialized in the study of different aspects of the renewable sources of energy and the power-saving technology: wind power generation, PV, solar thermal power generation, bio-energy generation, hydrogen energy generation, fuel cell, electric vehicles, LED, etc. They enjoy high reputation in their respective professional field, with rich practice experience, and a good grasp of the professional development and the trend of their field. During the implementation process, those experts worked through the research, analysis, evaluation and reporting processes.

2.1.2 Investigation referring to Delphi survey method.

The Delphi method was first appeared in the science and technology field, and has been gradually applied in various fields. Unlike common research method, it's known for its anonymity, feedback, astringency and statistical generalization.

Using the reference of international research project and our own experience, this project applied literature review and on-site research with the reference of Delphi.

In accordance with the Delphi method, two sets of questionnaires, respectively targeted at the "ground analysis" and the "system analysis", were made by the project, modified by the experts from different field and then form the final version of the questionnaires. The ground analysis includes the basic information of the enterprises, their products and technology, management and development, policy-making etc. The system analysis contains the basic information of the target group, their opinions, experiences, suggestions and their attitude, and other matters about ongoing work or preparation of the low-carbon technology innovation development.

2.1.3 Selection of the interviewees

Name list of investigation

Research team identified a list of potential interviewees consisted of representative enterprises and institutes from the seven potential interviewees regions selected according to the selection

criteria, which including new energy and renewable energy technology, potential R&D institute, business incubator, financing institutes, and policy makers (government branch) .

On-site investigation target groups

By taken into consideration of factors such as scale, growth stage, place in the industrial chain, research time and cost as well as interviewees', the research team finally choose 24 of them as their field research objects.

In order to enlarge the sample size, the project team also hands out questionnaires to the enterprises that were not chosen as on-site investigation targets.

Gathering the information of both the field research and the questionnaire, the technologies distribution of the interviewees, both the "ground analysis" and the "system analysis", were shown as follows:

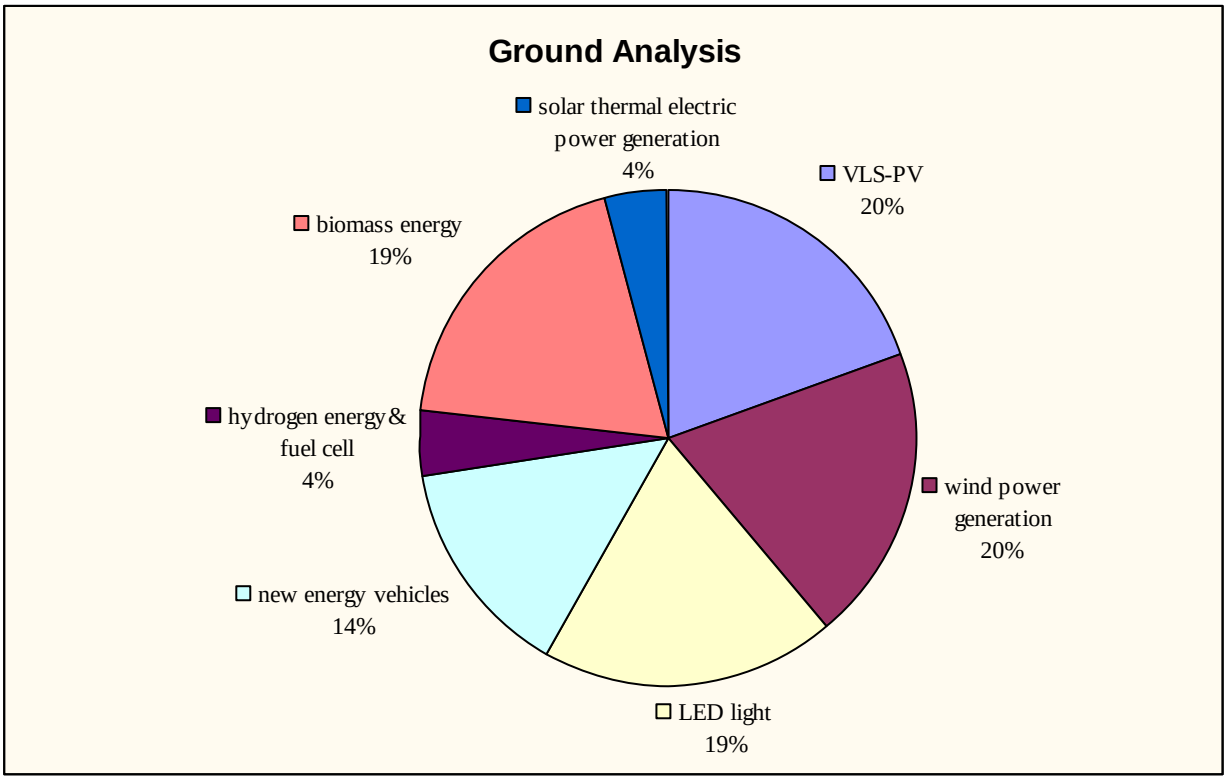

Chart 1 Distribution of targets of Ground Analysis investigation

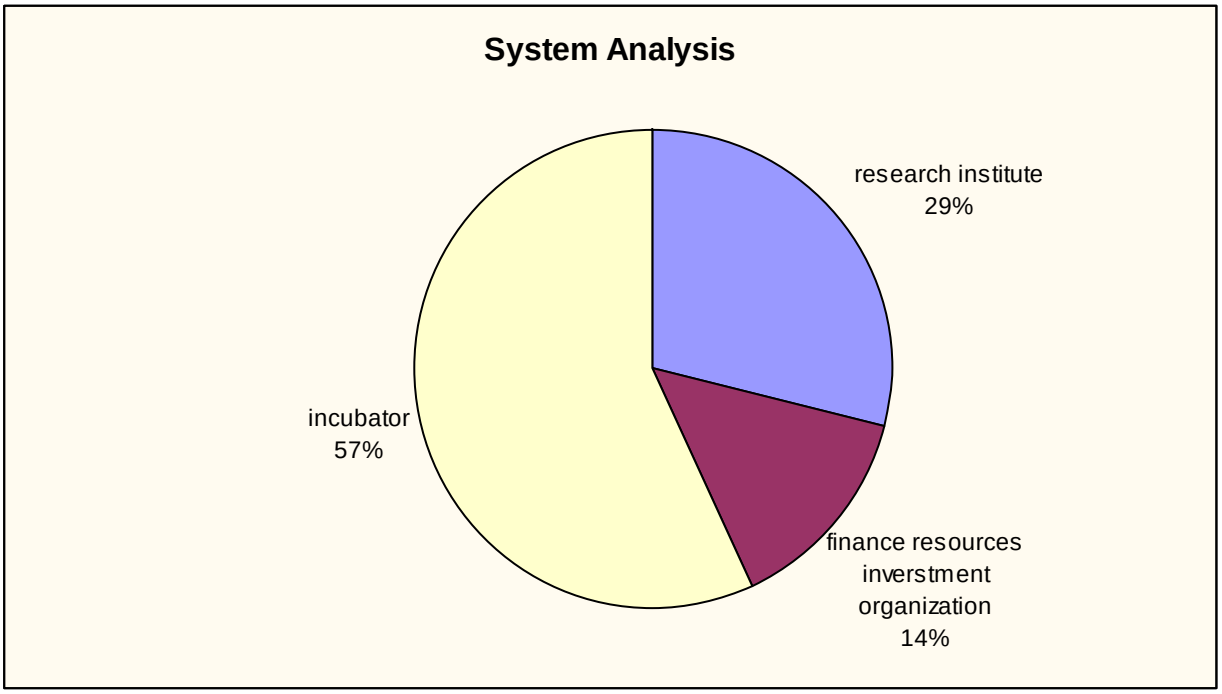

Chart 2 **Distribution of targets of System Analysis investigation**

Selection of the research object and descriptions of work situation, please refer to the Annex 1, the investigation report.

2.3 Conclusion

2.3.1 Ground Analysis

A total of 7 technological fields took part in the research, covering the following technical fields in terms of wind energy, solar energy, biomass energy, new energy vehicles, hydrogen and fuel cells, and LED. This research is carried out in a combined manner of on-site research and paper research.

(1) The Contribution and Role of the Technologies Studied in a Low-Carbon Society

1) Photovoltaic Power Generation

A total of four enterprises participate in the research of the solar photovoltaic power generation, and respectively engage in raw material, key components, balance of plant components and systems integration of the industrial chain. Photovoltaic products are very important for CO2 emission reduction. Take Jiangsu Zhongneng Polysilicon Technology Development Co., Ltd as an example, in 2009, its production capacity is 7,500 tons of polysilicon, enough to produce 1GW of photovoltaic components, which can reduce 1.6 million tons of CO2 emissions.

Baoding Yingli Co., Ltd, the only one in China with the whole industrial chain, its businesses covering a wide range of silicon raw material, crystal silicon ingot, silicon flake, cells, component, control-inverter, photovoltaic systematical project and the research, manufacturing, sales and services of photovoltaic applicant products. At present, such prospect as Yingli that has a complete set of photovoltaic industrial chain would be the trend of development in this field. At present, the conversion rate of Yingli's battery can reach 16.2%. Yingli is devoted to research on a new battery with a conversion rate of 17%, which would be a milestone in this field.

2) Solar Thermal Power

Solar thermal power stays at a breakthrough stage of critical technologies and hasn't achieved industrialization in our country yet. After an all life cycle analysis of solar thermal power station, it is found that its carbon dioxide emission is about 13g/kWh, far lower than the 738g / kWh of thermal power generation stations[6].

Institute of Electrical Engineering's solar thermal power generation technology research group is the first unit engaged in this field as well as the most important research force in China. It is now doing research on building the first demonstrative grid-connected solar thermal power generation station in Asia.

3) Wind Power Generation

Four enterprises in all took part in the research of this field, i.e., R&D, manufacturing, selling and systems integration of wind turbines and their key components. According to statistics, the installation of 100 thousand set of wind turbine each with capacity of 1.5MW can reduce 300 million tons of carbon dioxide emissions.

4) Biomass Energy

Four enterprises participated in the research of this field and were engaged in biomass liquid fuels and biogas projects.

COFCO, for example, has built ethanol production base with an annual output of 800,000 tons in Anhui, Jilin, Guangxi to replace gasoline fossil fuels and reduce GHG emissions of the burning of fossil raw material, and it turns out that it saves nearly 2.8 million tons of oil and reduces 6,300,000 tons of carbon dioxide emissions[7].

Biogas engineering technology reduces pollution emissions and promotes the rational use of agricultural residue resources, thus the establishment of biogas power generation projects is in line with low-carbon economic and technical characteristics. Hangzhou Energy & Environmental Engineering Co., Ltd., for example, recently completed the representative projects, as the 1MW biogas power generation project in Inner Mongolia Mengniu Hoya pasture, the 2MW chicken manure biogas power generation project in Beijing Deqingyuan Ecological Garden, and the 3MW biogas power generation project in Shandong Minhe Animal Husbandry Co., Ltd... The three projects altogether lead to an annual CO2 emission reduction of 0.2 million tons[8].

5) LED Lighting

The upper, middle and downstream of the LED industry chain are processing of epitaxial material and wafers, packaging of industrial components and modules, and application of displaying and lighting respectively. The four enterprises participating in this research were engaged in the three levels of the industrial chain.

According to *Opinions of the Development of Semiconductor Lighting Energy-saving Industry*, by 2015, the Semiconductor Lighting Energy-saving Industry will achieve annual energy saving of 100 billion kWh, equivalent to outputs of 21 power station with a capacity of 1 million kWh.

6) Hydrogen and Fuel Cells

One enterprise took part in the research of this field. Hydrogen fuel cell products, taking advantage of the chemical reaction between hydrogen and air with a small amount of water and no pollution, are used in car engines, bus engines, power stations, standby power, tour buses, and forklifts and so on.

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[6] Source: solar energy industrial guideline catalogue and economic incentive policy research, 2009, CRESP

[7] Source: on-site research record national grain academy

[8] Source: on site research record.

7) New Energy Vehicles

Three enterprises took part in the research of this field. Due to its great proportion in transport energy consumption as well as its rapid expansion, new energy vehicle industry occupies a prominent position in the development road map of energy-saving and environmental protection, and how to cope with its great energy consumption and carbon dioxide emissions becomes the first important problem that we have to face in the development of low-carbon technologies.

Qirui cars are manufacturing environmental friendly products with the concept of safer, more energy saving, and more environmental-friendly.
In 2007, this company worked out the technology of BSG/ ISG and put it into practice during the 2008 Olympic Games, thus becoming the company with earliest operation.

At present, the main products in the new energy field of this company includes: A5BSG、

A5ISG series of cars and S11EV、S18EV、A5EV、S18bEV series of cars. As known, four

models of cars would be manufactured in quantity by the end of 2010. The invention of A5 car means that Qirui technology is moving forward shoulder with shoulder with the world.

(2) Difficulties, Problems and Obstacles Confronting the Enterprise Researched

Summing up from the interviews conducted with the above companies, following difficulties are found in terms of the low-carbon technology innovation and commercialization process:

- Insufficient government's specific **incentive policy and funding**. 86% of the manufactures been investigated hold the opinion that, in the current technical restriction and commercialization conditions, new energies, as an emerging industry, the return of investment is relatively long At the initial stage of development, low-carbon industry, to a large extent, depends on incentive policies and subsidies.. As to the enterprises concerned, they have to bear heavy financial burden as well as great market risks. Without tax break or other incentives, they may suspend or even give up R&D in the case of financial market downturn.

- Insufficient **talents** and **skilled labor** who don't have the capacity and master core technologies, making it difficult to support technological progress and industrial development. 57% of the company been researched face the problem of lack of talented workforce.

- Lack of industrial **technical specifications**, standards and testing certification system, leading to endless disordered competitions in the market, which causes a serious waste of public resources. 33% of the companies consider this as a setback. Without common technology platform, public experimental and testing platform, similar universal technologies could be developed by different institutions. In addition, without the public platform and strong research team support, it is difficult to organize some inter-disciplinary and cross-sector R&D projects and programs which can lead the future trends rather than act only as a follower in this field.

- Lack of **original spirit** of the low-carbon innovation, which is the problem pointed out by the CEO of Yingli. Many of the national innovation evaluation system and standard hold back the spirit of innovation. Sometimes it takes companies a long period to apply for intellectual property.

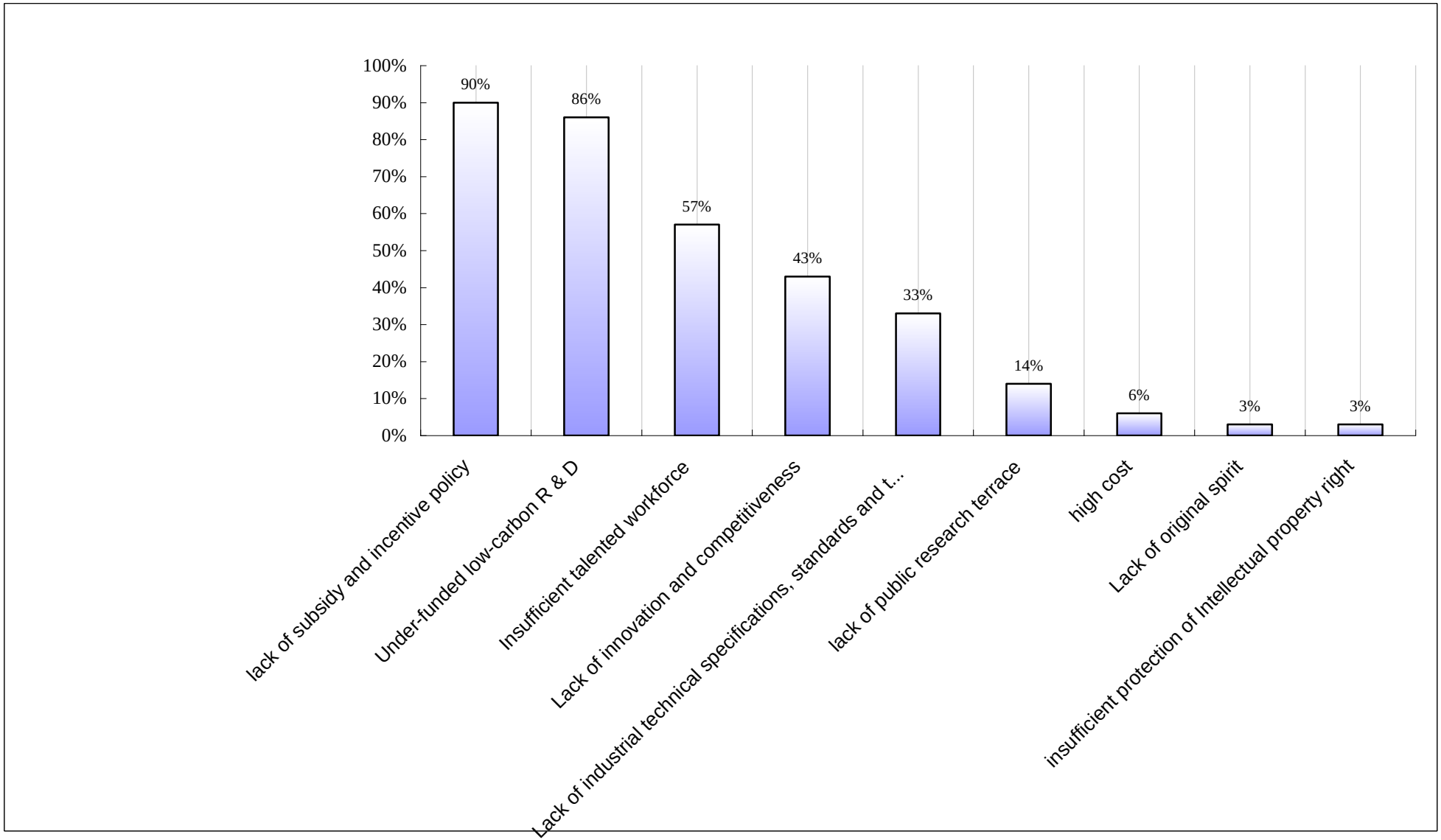


Chart 3 Problems faced by the interviewees and concerning degree of each problem

This chart shows the extent to which each problem is concerned about.

(3) Expected Policy Proposals by the industry

Based on the above researches, the policy recommendations or comments expected by the industry in the low-carbon technology innovation and industrialization process are as follows:

In the aspect of the governmental policies:

- The government departments concerned should encourage, pay attention to and support non-consensus theory, test and verify simple and original inventions and unusual but wonderful thinking from the private sector and civilians through empirical validation so as to promote originality of low carbon innovative technologies
- Established government-funded low carbon technology innovation and R&D platform, which can reduce the cost of technological innovation of research institutes and enterprises, expanding the exchange of information at all levels, increase the source of information on technological innovation, also it can reduce the blindness of technological innovation, repeatability and hence improve the validity of market. It is necessary to build a testing and evaluation system of the low-carbon innovative product performance so as to strict the access threshold to low-carbon technology industry, strengthen testing certification system. Improve related laws, regulations, standards and testing certification system.
- Under the guidance of national policies, it is important to assist institutions of higher education with the continuous expansion and creation of related disciplines according to the market demand, and build a technical personnel and talent reserve for the low-carbon industry.
- For low-carbon innovation patent, on the existing basis, it is necessary to further simplify and shorten the approval time for patent applications and to help enterprises convert a patent into productive forces in a relatively short period of time. At the same time, constantly improve and strengthen patent protection.

In the aspect of industry development plan:

- In the low-carbon core technology research and development support, it is urgent for the state, while continue to formulate and improve relevant policies, to fully integrate national R&D funding and technical resources, promptly adjust and optimize the core technology R&D deployments according to international and domestic market demand and technological development, effectively increase its support to critical core technologies and key enterprises so as to occupy commanding ground of technologies.

In the aspect of finance and investment:

- In the low-carbon technology innovation and industrialization, it is imperative to build and improve incentive preferential policies and financing channels, strengthen supervision and management while actively offering supports so as to ensure that low-carbon enterprises at the stage of development enjoy preferential policies and subsidies in terms of loans, taxes, selling prices, etc.

In the aspect of public awareness promotion:

- To raise public awareness of low-carbon society. The whole society should actively promote low-carbon

lifestyle, the application of low-carbon technologies in life and enhance the people's awareness of energy-saving and emission reduction by means of public information, the media, school education, etc.

- In the end market of low-carbon innovative technologies, the government need to fully display its role in guiding, leading and supervising, introduce at the very first time loans and deed tax preferential policies to the end-users of innovative low-carbon technologies, continually improve and expand a healthy end-user market and attract more users to spontaneously join the ranks of the use of low-carbon innovative technologies, thus creating a benign development track where an increasing number of low-carbon innovation and technology has been developed and an increasing number of these innovations and technologies is being used, and in turn stimulate the development and use of more.

2.3.2 System Analysis

Those who participated the investigation including Zhangjiang Star Business Incubator in Shanghai, High-Tech Undertaking Service Center in Baoding, Beijing Green-Tec Science Incubator, Beijing LED Promoting Center, Tongji University in Shanghai, Dalian Institute of Chemical Physics (a branch of Chinese Academy of Science) and Tsinghua Unisplendour Venture Capital, Inc.

The results show that all the institutions or companies take the development of renewable energy seriously enough and their efforts have yielded results.

Business Incubators

The business incubator of Renewable energy industry serves as a cradle for start-up companies. By providing innovative service ideas and measures; it does a great job in accelerating scientific and technological innovative, especially for small and mid-size companies.

Take **Zhangjiang Star Business Incubator** for an example, the service system includes supportive policies, professional incubation, Angel Investment and entrepreneur’s mentor.

Companies that anticipate in the incubator can enjoy supportive policies given by both central and local governments, such as a large proportion of the rent subsidies, tax break, supportive funds and so on. These preferential can help them to cut down the running costs and improve their competitiveness.

The “Angel Investment” platform has prepared equity investment for start-up enterprises that have potentials and ensure that the enterprise grew along with the incubator. Meanwhile, the incubator needs to explore the opportunities for venture capital investments, thus providing multi-channeled investment and financing services for the enterprises. A special fund from the incubator that add to venture capital and angel investments is dedicated to support new energy innovation and entrepreneurship. The incubator also actively helps the enterprises to get various funds from the government, including innovation funds, “Xiaojuren” (it is the name of the fund) funds and other incubation funds. They provide financial services that can get loans for the enterprises; and supply preferential interest payments on loans.

The incubator also provides a helpful hand during the course of their developments to the enterprises, with the professional opinions from the venture mentors and experts database.

The action done by **Baoding hi-tech new-business service center** also proved that the business incubator plays an important role in low-carbon new energy innovation. Hi-tech zone takes effective actions to support the innovation of large and medium scale corporations, to encourage them to set up research centers, resulting in a new-energy research system of four different units, including corporations, higher education institutions, specialized research centers and innovative incubator zone. The hi-tech zone helps corporations applying various kinds of governmental funding support. The establishment of the hi-tech supportive fund urges the corporations to transform research results into productivity.

This research shows that industrial incubators and innovative service centers with its specialty could be of great support and help those starters in these fields. Industrial incubators with its familiarity with the governmental policies could help corporations find their own position in this field and help them get financed, which is crucial to starters in the low-carbon new energy business. Meanwhile, service centers' guidance to innovative corporations is helpful in the aspect of capacity building.

As one of the first batch of pilot test programs, Semiconductor Lighting Industrial Technology Innovation Alliance is trying to work out a credit, responsibility and interest mechanism for the alliance of production, study and research with an aim to solve common key technologies through resources integration and industrial technology innovation platform. As a leader in industrial technology innovation, it will play an irreplaceable role in technology innovation and breakthrough, industrial development, cooperation among the Mainland, Taiwan and Hong Kong, international communication and intellectual property rights management.

R&D Institutions

R&D institutions have outstanding conditions for doing researches, which the individual enterprise may not be equipped with. Due to the fact that research institutions are not for profit and funded partly by the government, they willingly take more social and environmental responsibilities than enterprises. These institutions put more efforts in developing low-carbon technologies and examining how it might affect the energy consumption structure and the efficiency of energy utilization.

Clean Energy Automotive Engineering Center of Tongji University (CEAEC) is devoted to promote the industrialization of hydrogen and fuel cell vehicle. The Hydrogen Power Technology Institute of CEAEC focuses its attention mainly on the development and utilization of fuel cell and hydrogen technology with the purpose of reducing the cell's producing costs and improving its durability, thus promoting the hydrogen energy infrastructure and related key technologies.

Dalian Institute of Chemical Physics (a branch of Chinese Academy of Science) focuses on finding new energy, renewable energy and non-fossil energy and cooperating with enterprises for the purpose of promoting low-carbon economy.

Investment and Financing Institutions

A large quantity of money is needed in the process of building a low-carbon economy, opening the low-carbon market to the attention of financing department.

Tsinghua Unisplendour Venture Capital Inc. was well aware of the importance of low-carbon technology in mitigating the impact of climate change. Improving ecological environment and coping with climate changes are their first priorities. The companies follows closely the latest news about new energy, energy-saving and emission reduction.

Currently, the corporation is managing a investment funds focusing on investing low-carbon economy. It plans to invest 1 billion RMB on companies on CCS, solid waste recycling, disposal and utilization, integrated utilization of crop waste and so on.

Meanwhile, the corporation will continue to look into related policy and the technology itself, take references from capital markets domestic and abroad, and come out with potential industries and companies related to low-carbon economy. According to their plan, in the next five years, they will finance 10 to 20 institutions and assist another 5 to 8 institutions to complete the IPO.

As reported[6], the development of low-carbon economy not only broadens the scope of loan products and financial services in commercial banks, but also bringing them new areas of financial innovation and financial innovation pressure. "Green Finance" is in fact the low-carbon finance. It aims at serving those financial institutional arrangements and financial transactions that reduce GHG emissions. Financial institutions should provide financial support such as preference credit and insurance to those R&D institutions or companies that are engaged in environmental protection, ecological protection, utilizing new energy, circular economy, green manufacturing and eco-agriculture. Since 2007, the State Environmental Protection Administration and the financial industry have jointly launched three environmental protection policies – "green credit", "green insurance" and "green securities".

In this context, commercial banks should give major support to low-carbon economy. Meanwhile, they should improve the management system of granting loans in order to meet the needs of low-carbon economy development. Since 2006, Industrial Bank has open a green channel to grant loans to enterprises engaged in energy-saving, emission reduction, which was the first in domestic financing business. The bank offers seven kinds of financing models to different kinds of customers and projects. Until June this year, the bank has issued of about 4.2 billion Yuan as “energy-saving, emission reduction project loans” to 100 projects in 17 provinces. At present the overdue rate of these loans is zero.

Difficulties and barriers

According to the information collected, the major difficulties and obstacles faced by China's current low-carbon technologies are summarized as follows:

- Lack of funds and relatively backward research infrastructures are the two common problems in the process of China’s low-carbon technology development and innovation.
- Lack of professional and technical personnel in the field of new energy technologies.
- Lack of a general guideline that can direct the industry to grow in a healthy and orderly way.

Besides, as researched, when inventing these incubators, financing institutes met many practical problems including:

[6] Financial Thoughts on the Development of Low-carbon Economy, Han Fuling, Financial Bond Academy from Central Financial University

- Lack of loan or financing channels for small and medium sized corporations. This problem was closely related to the features of low-carbon energy industry. The input for the early stage which will be returned in a long run, are large…all these factors caused the lack of loan or financing channels.
- Lack of adequate business entrepreneurship training mentors. The current numbers of training mentors cannot meet the needs of the market.
- The difficulty in popularizing low-carbon life is due to people's living habits and the high costs of utilizing low-carbon technologies.

Advises and recommendations?

The team has also collected advices from the interviewees about the development of China's low-carbon technology from the investigating objects. They are as follows:

For the government:

- Continue the research in innovative system in order to provide qualified services such as planning, management and performance appraisals.
- Establish a national clean energy laboratory that can make more breakthroughs in key technologies about new energy, renewable energy and non-fossil energy; actively cooperate with enterprises or institutions to promote new products application; encourage private organizations to carry out researches on the innovation system (will be supported by the government by the means of funds).

For the financing institutions:

- The state owned financial sectors should establish and improve preferential policies and financing channels for the application and industrialization of new energy technology. They should show special preference to enterprises of small and medium scale. Moreover, they should improve their tax policy in this respect. The government should assume the guiding and supervising role, introducing loans tailored for end-users of new energy technology and tax breaks, thus healthily expanding the end-users' market.

For the industrial incubator:

- Inviting more professional and technical personnel to take part in the process.
- Providing various services for enterprises engaging in new energy technology, e.g. putting emphasis on the incubators capacity building; establishing a platform of information exchange in order to strengthen communication and cooperation of information, intelligence and resources across fields, thus realizing optimal use of resources and promoting innovation activities.




Chart 4 On-site and face to face investigations

Chapter 3 the current status analysis of the low-carbon new technology innovation

3.1 The content of innovation system

Developing low-carbon energy is closely related to China's present construction of innovative nation. This on-going project indicates that China is moving from a traditional industrialization economic towards to a new pattern of development focusing on knowledge, talents and information; it also indicates that China's the pattern of transformation from energy-consuming to low-carbon society

The National Innovation System generally refers to the social network system consisting of all the elements of innovation integrated in China. This system not only marks a new stage of innovation oriented development, but also reflecting the relationship between science technology and economic development. Based on the basic ideas about innovation and the formation of an innovating system, the National Innovation System with the market's impetus and the government's impulse could be built. The main elements in the National Innovation System involve the manufacturing enterprises, research institutions, agencies (including industrial associations, financial institutes and enterprise incubators, etc.) and the government. In china, financial institutes are usually discussed in the category of intermediary institutions. Private investment & finance organization is not the mainstream financial institutes in China. The relations between all the elements are shown as follows, chart 1:

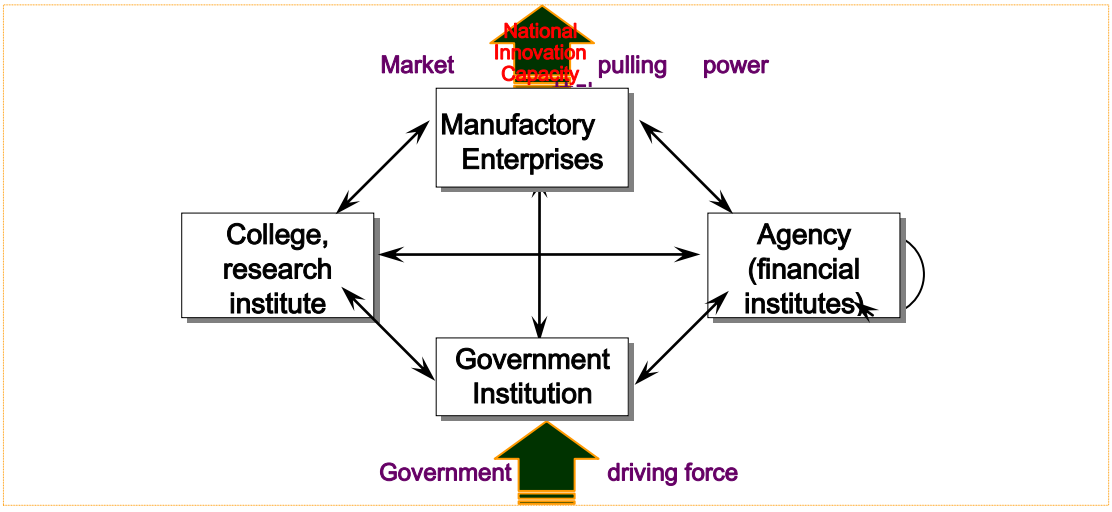


Chart 5 Relationship between key factors of innovation system

This chart is the basic framework of the National Innovation System; it is in accordance with the *Report of the National Innovation System*[7] issued by the OECD in 1997. Innovation is the result of communications among the various entities and organizations. The core of the National Innovation System is the enterprises. This system is the channel through which the enterprises organize their production/innovation, and acquire the external knowledge. The main sources of the external knowledge are the other enterprises, the various research institutions and the intermediary

[7] OECD, Research Group of National Innovation System, Internet Working Papers, 1997.

institutions. The government mainly formulates the national industrial development strategies and guides the public policy. All the departments in the government should work in cooperation and integrate optimistically.

The integral innovation capacity of is the original driver for a country to act on international stage. But on the other hand this capacity comes from the country, that is to say the innovation capacity can be constructed and developed by national-level acts (strategies, policies, and plans etc.) This is of the reason and purpose of analyzing the Nations Innovation System. We are going to place emphasis on the innovating policy and measures of the low-carbon techs from the relevant bodies in of the China's government.

The system-generated methods of studying innovation also include some related terms and frameworks. The policies are applied to integrating the interaction and the mutual effect among these factors, which would further improve the performance and competitive position of the whole system. The current common method to study a national innovation system is to categorize the entities by various levels such as national level, area level and industrial level, or by different types of participants.

3.2 The condition of the innovation system

With longer-innovating-cycle, heavy-investment, and strongly-infrastructural, the new energy industry development depends more on the commitment to and inputs of the energy R&D technology. China's energy-tech innovation system is a part of the National Innovation System and it categorize the entities on sectors, so it is natural for the system to include all the enterprises, research institutions, intermediary institutions/agencies (including the financial institutes) and the relevant bodies in the government. The main low-carbon energy tech we've chosen is the most active modern tech in the technology innovation of energy industry.

3.2.1 Manufacturing enterprises

Observing across the world, we can find that most of the technological innovations take place mainly in the enterprises which have their own R&D centers. The institutionalizing of industrial research and development started from the late 19th century and it is a very important transformation for the enterprises' competitive capacity and technological innovation. For the industrialized countries, the real organized R&D phase began after the Second World War. Here are some reasons that the research and development institutions, when talking about the technology innovation, are more important than the laboratory in colleges and the governmental research laboratories: first, the enterprises are in great demand of technology, which is quite the opposite from the ones can supply technologies, it is usually the enterprises that apply the new techs to production, and it is impossible to innovate the techs without the demands and inclinations of the enterprises; second, in order to benefit from the tech innovation, the enterprises should coordinate the whole process of R&D, the production and the sale. **That's why we consider the enterprises as the main body of the innovation system and why we take the enterprises as our first objective when studying the low-carbon energy technologies.**

At present there are approximately more than 100 manufacturers producing small wind turbines. The year 2008 has seen the total production of 78784 air blowers, reaching to 400 million RMB. 38957 sets were exported, which was 50% of the annual total of the year 2008. This indicates that China's production technology and quality has been greatly improved and developed in producing small wind turbines.

In 2008, the foreign manufacturers shared 24.4% in the market of the large scale grid-connected

wind turbines' manufacture. Now Chinese companies have gotten the whole set of production techs through **paying fees for technology transfer**. Taking the forms of **joint venture**, **cooperation in designing** and **doing self-researches**; China have acquired 750kW to 3MW technical specifications. Jinfeng Co. Ltd., Huarui Co. Ltd., and Oriental steamer Manufacturer covers 57.43% of the new installed capacity in 2008, which become a good foundation for Chinese wind power industry scale-up.

By 2008, there have been 62 manufacturers capable of producing solar battery in China. They produced 2000MW, forming 3000MW production capacity which is one third of the global output. This resulted in an accumulated capacity of solar energy power of 140MW, and the new installed capacity in 2008 was up to 40MW.

3.2.2 Scientific research institution

China has made an enormous progress in science and technology since the reform in [1978] and opening to the outside world. The reform of science system structure which is mainly including the transformation of the **tech-research-oriented enterprises** and the **technical organizational restructure of non-profit research institutions** has made great advance, which causes that the enterprises has become the main bodies of R&D activities.

Besides the enterprises, academic departments (including colleges, universities and research institutions) play a vital role in R&D. Concerning the funding resources, government is still the main supporter.

National-level institutes include national key laboratories, national engineering research centers, national engineering technological research centers, research institutions managed by Chinese Academy of Sciences and some distinguished research institutions in many colleges and universities.

1. The National key laboratories

In 1984, the Chinese government practiced a special plan to build many national key laboratories. These key laboratories are set in some universities and institutions, focusing on the advanced research fields at home. They have gathered the keen-witted and capable talents and sponsored by the government to buy instrument and equipment. With a relatively independent managing capacity, these labs carry out the operating mechanism of opening, circulating, uniting and competing, and they are under the management of the commissioned unit and under the regular inspection from the government.

Now we have 156 running national key laboratories at home, generally covers most of the subjects in the Chinese fundamental researches. This group of labs has put many highly qualified researchers together, possessed a number of advanced instrument and equipment and undertaken a large number of national major research projects. They have become the core strength of the national fundamental researches.

Table 3 The national key laboraories studing on energy technology

Field of technology	The national key laboratories	The supporting institutions	Location
Coal	coal burning Clean coal combustion technologies Coal conversion	Huazhong University of Science and Technology; Tsinghua University; Shanxi	Wuhan; Beijing;

		Coal-chemistry Institution, (under Chinese Academy of Sciences)	Taiyuan
Oil gas	Oil/Gas Reservoir Geology and Exploitation	Southwest Petroleum University; Chengdu University of Technology	Nanchong/ Chengdu
Electrical power	security control & simulation of power systems and large scale generation equipments; Electrical Insulation for Power Equipments	Tsinghua University; Xi'an Jiaotong University	Beijing; Xi’an
Energy saving	Automobile safety and fuel conservation	Tsinghua University	Beijing
Impetus	Multiphase Flow in Power Engineering; Engine Combustion; Turbulence research department of mechanics	Xi'an Jiaotong University; Tianjin University; Peking University	Xi’an; Tianjin; Beijing

2. National engineering research centers

In the beginning of the 1990s, the State Planning Commission (now called the National Development and Reform Committee) put forward a plan. In the spirit of transforming the scientific and technological achievements, industrialization and adopting of the market principle for the developing orientation, relying on the institutes, colleges and enterprises which are strongly capable in doing researches, this plan has put forward the establishment of nearly 100 national engineering research centers. By now 70% of these research centers have been transformed into limited liability companies and joint-stock companies. Here listed as follows are several national engineering research centers concerning with energy technology. Please refer to the following table 4:

Table 4 National engineering research centers concerning with energy science technology

Field of technology	National engineering research centers	The supporting institutions	Location
coal	coal-water slurry gasification and coal chemical industry; Cleaning and combustion equipment of Pulverized coal fired	Yankuang Southern Shandong Chemical Fertilizer Plant; Thermal power Research Institute; Tsinghua University;	Tengzhou, Shandong; Xi’an;

	power boiler; Cleaning and combustion equipment of industrial boiler; Safe Mining Techniques in the Coalmine	Chongqing Branch of Chinese Coal Scientific Research Institutions	Beijing; Chongqing
Oil gas	Software study of oil-gas exploration; Refining process and activator; gas conversion process	Bureau Of GeophysicalSical Prospecting, CNPC Scientific Research Institute of Petroleum under Chinese Petrochemical General Company Chengdu Organic-chemistry Research Center, Chinese Academy of Sciences	Zhuozhou, Hbei; Beijing; Chengdu
Electrical power	Power transmission and distribution projects and Electricity-saving Technology; Electrical system controls and economical operation; current-mode power supply; power electronics; Power-electronics application; Vibrations of Large Thermal Power Generator Networks	Electric Power Research Institute of China; Nanjing Power Automation Technical Research Institute; Ministry of Information Industry, No.18 Institution; Xi'an Power & Electronic Institute; Zhejiang University; Southeast China University	Beijing; Nanjing; Tianjin; Xi'an; Hangzhou; Nanjing

3. National engineering technological research centers

Since the 8th Five-Year Plan for national economic and social development, the former State Scientific and Technological Commission (now it is called the Department of Science and Technology) has began to set up many national engineering technological research centers. Relying on the industries, key research institutions with strong researching capacity and scientific and technological enterprises/colleges, national engineering technological research centers have a comprehensive level of researching conditions. These research centers can provide comprehensive services and have become the developmental entities closely related to the relevant enterprises. This group of research centers aims at exploring the new ways combining science and economy together, enforcing the central link of transforming scientific and technical payoffs into production capacity; meanwhile, facing the actual need of production scale, they should also improve the maturity,

overcoat ability and engineering level; help renew the productions and support the enterprises to introduce, assimilate and absorb the advanced techs from abroad. Here listed as follows are several national engineering technological research centers. Please refer to the following table 5:

Table 5 National technological engineering research centers concerning with energy science technology

Field of technology	National technological engineering research centers	The supporting institutes
coal	Coal burning of power stations	Liaoning Combustion Engineering Technology Center
	water-coal-slurry	Coal Science Research Institute
renewable resources	New energy	Beijing Solar Energy Research Institute
	photovoltaic	Jiangxi Saiwei 3d2 Solar Energy Company
	wind power generation	Xinjiang Jinfeng Technology Co. Ltd.
	biomass energy	Guangxi Academy of Sciences
power generation	Hydropower generation	Electronic Engineering Institution of Harbin Industrial University
	Thermal power generation	North China Electric Power University

4. Research institutions managed by Chinese Academy of Sciences

Among the research institutions managed by Chinese Academy of Sciences, there are many very important R&D institutions in the field of energy, such as CAS Electrical Engineering Research Institute (Beijing); CAS Electrical Engineering Research Institute (Beijing); Institute of Semiconductors, CAS (Beijing); Technical Institute of Physics and Chemistry, CAS; Institute of Physics, Chinese Academy of Sciences; Guangzhou Institute of Energy Conversion, CAS (Guangzhou); Shanxi Institute of Coal Chemistry, Chinese Academy of Sciences (Taiyuan); Dalian Institute of Chemical Physics, Chinese Academy of Sciences(Dalian); Institute of Plasma Physics, CAS (Hefei) and Chinese University of Science and Technology.

5. Some distinguished research institutions in many colleges and universities

Many colleges and universities have established departments and research institutions studying energy. For example, Department of Thermal Engineering in Tsinghua University, Institute of Nuclear and New-energy Technology in Tsinghua University, Department of Energy and Power Engineering in Shanghai Jiaotong University, Institute for Thermal Power Engineering of Shanghai Jiaotong University, Department of Energy and Power Engineering in Xi'an Jiaotong University, Department of Mechanical and Energy Engineering in Zhejiang University, Energy Source Engineering Institution of Zhejiang University, Mineral & Energy Resources Engineering of China University of Mining & Technology, Power Engineering Department of Southeast China University, Sources and Environment Engineering Department of East China University of Science &

Technology, Mineral & Energy Resources Engineering Department of Huazhong University of Science and Technology, and so on. They are not only the main force of carrying on the energy-researching plans, but also the basic power to explore the new energy techs for the market.

All the above institutions, including the national key laboratories, national engineering research centers, national engineering technological research centers, research institutions managed by Chinese Academy of Sciences and some distinguished research institutions in many colleges and universities, are engaged in the researching and exploring the low-carbon energy technologies. They are currently the main force to explore new techs for energy in China, and they make up a platform for China to research and develop the low-carbon energy techs.

Here are some representative R&D institutions working in the field of new energy and renewable energy technologies:

- Institute of Electrical Engineering, Chinese Academy of Science
- Fuel cell Engineering Department, Dalian Institute of Chemical Physics, Chinese Academy of Sciences
- Beijing Solar Energy Research Institute
- Institution of Nuclear & New Energy, Tsinghua University
- Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences
- Institution of Wind Energy Technology, Shenyang University of Technology
- New Energy Engineering Research Institute, China University of Geosciences

The investigation on the R&D institutions shows that, **insufficient funding and a severe shortage of talents are the main difficulties in the way of innovation. The outcome is similar with the investigation on the enterprises.**

The reform of R&D institutes carried out by our nation has greatly advanced the steps of innovation. **The transformation/joining of the R&D institutions into research-oriented enterprises is a very effective way to improve the manufacturers' research capacity. It also helps the outputs to be commercialized and industrialized. By now, almost all the national engineering research centers and part of the national engineering technological research centers have been transformed.**

3.2.3 Intermediaries Agencies

The intermediaries we mentioned here refer to the **whole support service system for the country's technology innovition.** It includes industry association, productivity promotion center, technology development zone, scientific park and incubator, etc. The main function is to provide a bridge for the government and enterprises, technology provider and users; and also to provide a technology and information platform.

Industry Association

In the field of China's energy technology, there are many industry associations which are related to low-carbon energy technology, such as China Energy Research Society, China Renewable Energy Society, China Energy Conservation Association, China Electro-technical Society, China Mechanical Engineering Society, China Light Industry Association, Society of Automotive Engineers of China and China Technology Venture Association, etc.

Productivity Promotion Center

China's Productivity Promotion Center is a new socialize technology service organization, began to build in 1992 under the promotion of the former State Science and Technology Commission,

using the experiences of other countries for reference. Currently, China's Productivity Promotion Centers can be found all over the country, with the total number of more than one thousand.

The main function of the Productivity Promotion Center is to integrate the social resources, and to provide policy-making consultation, technological policy information, business diagnosis consultation, investment& financing consultation; and promote the technical achievements, training, intellectual property right protection and other services to the government, enterprises, scientific research institutions and professional service institutions.

Industry Alliance

Industry Alliance is a creative organization form. Through the integration of enterprise-college-research and the upstream and downstream of the industry chain, the aim is to set up a platform for communication and cooperation. The industry alliance could provide finance support to its members, also could get funds from government and other organizations and provide it to its members. On the basis of the enterprises' demand for development and the common interest of all parties, it aims to upgrade the technological creative ability and form an integrate technological innovative and cooperative organization which can share interests and risks and can also complement each other's advantages on the basis of laws. For example, the state semiconductor project R&D and Industry Alliance which based on Beijing Semiconductor Lighting Technology Promotion Center has set up an enterprise-college-research platform through organizing the cooperation of enterprise-college-research between upstream and downstream of the semiconductor lighting industry chain since 2004, so that it can realize the transformation of the scientific and technological achievements; organize the Olympics and other major demonstration projects; hold the innovation contest and set up the patent pools, etc. It has built an enterprise-college-research platform and increased efficiency for innovation and also promoted the national implementation of major projects such as 863 Project.

Technological Development Zone, Science Park and Incubator

Technological Development Zone is a regional type which enjoys special economic policies and participates in some kind of economic activities. It is also an efficient way to promote the economic development.

Since 1980s, China began to set up special economic zones and different kinds of development zones have rapidly developed. Currently, the new Hi-Tech industry development zones whose aim is to promote the formation and development of the new technology and its industry have become the main form of China's development zones. Among them, there are hundreds of state-level development zones which have been approved by the State Council (including the economic and technological development zone, the high and new technology industry development zone, free trade zone, export processing zone, the frontier economic zone and other types of development zone, etc).

For example, Baoding Hi-Tech Industrial Development Zone is the country's new energy and energy equipment industry base; in Jiuquan Windows& PV powering equipment manufacturing industrial park (which is belonged to the local government), the Wind & PV power productivity promotion center and Wind & PV power Application Engineering Research Center are under construction, so that these can provide a public technology service platform for scene electricity.

Science Park has been set up for hatching and helping the innovative scientific enterprises with high growth. The park will provide a series of infrastructure and supporting services such as building

up cooperative relationship with local development institutions; building up formal and daily connections with universities and research institutions; providing management support and technology transfer services for small-and-medium sized enterprises. In 2009, the country certificated some university science parks, such as State University Science Park of Daqing Petroleum Institution, State University Science Park of Suzhou University, State University Science Park of Huazhong University of Science and Technology, State University Science Park of Kunming University of Science and Technology, State University Science Park of Lanzhou University of Science and Technology, etc. Among them, the State Council has certified to build up a national level independent innovation demonstration zone in Zhongguancun Science and Technology Park in March, 2009. Until the end of 2009, there were more than hundreds of scientific parks of various kinds in China.

Business incubator is a service institution to cultivate and support the new technology-based SMEs (Small & Medium scale enterprises). It provides physical space and infrastructure for them and also provides a range of support services, thus to reduce the risk and the entrepreneurial start-up costs, to improve the success rate of entrepreneurship, to promote scientific and technological achievements and also to foster successful businesses and entrepreneurs.

At present, there are 7 kinds of incubators in China's science businesses: a high-tech innovation service center-based integrated business incubators, specialized technology-based business incubators, university science parks, software technology park, overseas students pioneer park, state-owned business incubators and international business incubators, etc. In 2008, the number of China's new state-level incubators was up to 71, such as Beijing Kang Huaweiye Co., Ltd., Beijing Shenzhou Space Technology Incubator Co., Ltd., Beijing Zhongguancun Science and Technology Development Co., Ltd., etc.

The issues for the intermediary agencies were mainly **lack of talents in establishing a business, professional services and training**, so they may not able to meet the demand from the scientific and technological SME which are starting their businesses.

The establishment of a wide range of intermediary agencies meets the country's urgent needs. There were no such things under the planned economy before the Reform and Opening.

The science parks and incubators developed rapidly and have gone in a healthy and standardized way under the promotion of the central and local governments.

The industry associations such as coal and petroleum were set up after the government withdrew. Because the ownership kept changing (now belong to State Assets Administration Committee), **there were no bridges or links formed between the enterprises and the government, the technical services and guidance were not in place.** The industry associations will advocate investing more to protectthe intellectual property rights andputting more emphasis on the public network in the industry. Governments, enterprises and research institutions should understand more about the important role of industry association.

3.2.4 Investment and Financing Institutions

There are many types of investment and financing institutions, including venture capital, private equity funds, commercial banks, investment banks, trust institutions, guarantee agencies, financial leasing, mortgage and various types of investment companies, etc. China's investment and financing institutions mainly involved in venture capital institutions, science and technology innovation funds for technology-based SMEs.

1. Venture Capital for enterprises in establishment stage

By the end of 2008, there were 464 venture capital institutuins in China, an increasement of 21.1% compared to 2007 and the venture capital investment management has incresed 0.8%. The state-owned institutions and the government made large contribution, together accounting for 35.8%. At present, most technology SMEs who engaged in low-carbon energy technologies are in the early stages of enterprise development, yet have strong competitiveness in the market, the firm size is limited, the core technology is relatively deficient and the environmental and financing conditions are relatively poor. In this respect, the involvement of venture capital will provide a good financial support for the development of China's low-carbon energy technologies.

2. Technology Innovation Funds for Technology-based SMEs

In 1999, Small Technology Innovation Fund was approved by the State Council , and it was in charged by the Ministry of Science and Technology, supervised by the Department of Finance. Through grants, loan interest subsidy and capital investment, etc. to support and guide innovation activities of the technology-based SMEs. From 1999—2008, the central government allocated the budget of 7.65 billion yuan and has supported 14000 projects. **Among them, there are 755 projects in new energy and energy saving areas, nearly 450 million yuan subsidy, the size of its planned funding has gradually increased every year.** Innovation Fund has been included in the revised "*Law for Science and Technology Progress*."

3. Venture Capital

China's venture capital institutions and technology innovation fund have been set up only recent years, and China's growth enterprises market was just started. Therefore, to reinforce the integration of science and capital market, and promote the development of capital markets is a relatively weak link in our nation's innovation system. In July, 2009, Ministry of Science and other six departments jointly issued "the Overall Implementation of National Technology Innovation Program," pointed out: increasing the financial support of technological innovation will help the launching of low-carbon technology innovation.

3.2.5 Government Policies

Government policies can be classified as follows: the top-level state law and regulations, relevant development planning and policies, including R&D policies for technology supply and demand market-driven policies. (Specific categories can be found in table-6)

Table 6 Policy tool category

Law, regulation, development planning and policies	
R&D policies (for technology supplier)	**Market-driven policies (for demand)**
• R&D input from the government • Taxation policies encouraging R&D input • research institute cooperation with academia and industries	• Relevant laws and rules (management rules) • Government procurement • Credit, taxes • Subsidies • Information exchange

• Incubator	

1. State Law, regulations, planning and policies

- **Renewable Energy Law** (Took effects since January 1st, 2001)

Renewable Energy Law is cornerstone of and provides legal protection for the development of new energy industry. It explicitly defines the responsibilities and obligations of the government and society in the development and utilization of renewable energy, establishes a series of systems and measures, including long-term goal about total amount and development planning, supports grid connection system of renewable energy, preferential on-grid power tariff and cost-sharing system and sets up special financial fund for renewable energy.

Under the current grim situation facing China's energy and environment, this law will guide and encourage economic parties home and abroad to participate the development and utilization of renewable energy, help its long-term development, enhance its proportion in the energy mix and reduce environmental issues caused by the burning of fossil energy, coal in particular to promote sustainable development.

- **Renewable Energy Law Amendments** (Took effects since April 1st, 2010)

Renewable Energy Law Amendment of the PRC, aiming to promoting China's renewable energy industry, stipulates that China shall set up renewable energy development fund, the state shall purchase all power produced by renewable energy sources and make overall plan for the development of various renewable energy, which plays an important role in promoting the development of renewable energy and energy mix adjustment in China.

- **Policy Outline of China Energy Conservation Technology** (Compiled by the State Planning Commission, State Trade and Economic Commission, State Science Commission (Took effects since May, 13rd, 1996)

In article 6 "New Energy and Energy Substitute Technology" of the Policy Outline of China Energy Conservation Technology, it explicitly puts forward the relevant policies of developing and utilizing "solar, wind, geothermal, tidal, ocean, biomass and other new energy and renewable energy and supporting scientific research, promoting industrialization, substituting and complementing the conventional energy.

- **State High-Tech Product Catalog** (Complied by the State Science Commission on August 4th, 1997)

In item 501 "New Energy" of article 5 "New Energy, High Efficiency and Energy Conservation" of the National High-Tech Product Catalog, it writes the development of high-tech products such as "highly efficient solar collector and power generation equipment, solar cells and application system, medium and large wind turbines, new liquefied gas storage devices, new hydrogen production and storage devices, new high-energy batteries, geothermal, ocean energy application devices and other new highly efficient power generation equipment"

- **Current Catalogue of Key Industries, Products and Technologies, the Development of Which is Encouraged by the State** (Compiled by National Planning Commission on December 31st, 1997)

Since the issue of Current Catalogue of Key Industries, Products and Technologies, the Development of Which is Encouraged by the State, it has been modified many times as time goes by, but in the part about electricity, renewable energy like "solar, geothermal, ocean, biomass and wind power" is still unmoved.

- **Current Priority Areas of Focus of High-tech Industrialization Guide**

As of now, Guide has been issued four times, namely, “Guide 1999”, “Guide 2001”, “Guide 2004”, “Guide 2007”, all of which include the renewable energy.

- **Medium and Long-Term Development Plan for Renewable Energy in China (1996-2010)**

In order to promote the development of China’s renewable energy, the previous State Science Commission, National Planning Commission, State Trade and Economic Commission jointly worked out Medium and Long-Term Development Plan for Renewable Energy in China (1996-2010) as well as “Priorities in the Development of New Energy and Renewable energy” in 1996. Since the issue of Medium and Long-Term Development Plan for Renewable Energy in China (1996-2010), the general goal for the development of China’s renewable energy in 15 years has been confirmed, which is “to improving conversion efficiency, reduce production cost and increase its proportion in energy mix”. Based on this plan, the previous National Planning Commission also worked out "the Ninth-Five Year Plan of Energy Conservation and the Development of New Energy and the 2010 Development Plan," and the previous State Trade and Economic Commission formulated “*Development Plan for the Industrialization of New Energy and Renewable Energy in the Ninth-Five Year Period”*

Though there are so many policies to renewable energy technology and industry, the principal position of enterprises in innovation still un-clarified; the innovation awareness is still week and their understanding to innovation is insufficient; the communication between government, enterprises, research institutes and service organizations is insufficient; finance inputs to R&D is insufficient and its efficiency low, all of these factors led to the week innovation ability.

2. Government R&D Policies

- **R&D Input from the Government**

National Science and Technology Program is an important medium for the Chinese government to support science and technology R&D. This program, centered on economic development, has made strategic deployment in promoting the upgrading of industrial technology and enhancing sustainable technological innovation. It follows a system of “3+2”, namely, 3 body plans: National High-tech R&D Program (863 Program), National Key Technologies R&D Program, National Basic Research Program of China (973 Program) , and **2 developing condition programs: For R&D and its industrialization**

In 2006, China issued the National Outlines for Medium and Long-term Planning for Scientific and Technological Development (2006-2020), which requires that the proportion of the nation’s input on R&D to GDP shall gradually grow and is expected to “rise to 2.5% or above of the gross domestic product(GDP) by 2020”

- **Taxation Policies Encouraging R&D Input**

In the supporting polices and enforcement regulations of the National Outlines for Medium and Long-term Planning for Scientific and Technological Development (2006-2020), the “taxation incentives” cover the following items:

To increase income tax deduction for enterprises making input into independent innovation; Enterprises are allowed to offset the taxable income tax of the current year according to 150% of the cost of technology development actually incurred in the current year. The deficit part in this regard may be carried over for settlement within 5 years according to relevant provisions. The expenditure of enterprises for the purchase of domestic or foreign patent technology may be included in the cost in one lump sum or in installments. If the expenditure drawn by enterprises for education of the workers and staff is within 2.5% of the taxable total wages, it may be deducted from the before-tax income of the enterprises; to work out taxation systems that can promote the cooperation in production, study and research.

To allow the enterprises involved to accelerate the depreciation of the R&D instruments and equipment. The instruments and equipment used by enterprises for research and development, with

unit prices under 300,000 Yuan, may be included in the management fee in one lump sum or in installments, among which those reaching the standards of fixed assets shall be independently managed, but depreciation shall not be deducted. Where the unit price is above 300,000 Yuan, the required years of depreciation for fixed assets may be appropriately shortened or the depreciation be expedited.

Improve the taxation system that supports the development of new and high-tech enterprises and promote VAT reform for new and high-tech enterprises. For those new and high-tech enterprises in development zone that meet the prescribed conditions, the corporate income tax may be exempted within two years after the year of profit making, and the corporate income tax shall be levied at the tax rate of 15% after two years. Improve taxation system that encourages the export of new and high-tech products and taxable wages tax deduction policy for new and high-tech enterprises.

Expedite the development of investment in risk ventures for starting business. Venture capitals which mainly invest in small and medium-size new and high-tech enterprises will enjoy preferential policies like investment income tax deduction or be allowed to offset income tax according to the proportion of investment in their income.

Enhance the function of the innovation carriers. Business tax, income tax, house tax and town/township land use tax may be exempted for the incubators of scientific and technological type enterprises and national scientific and technological parks for universities that meet the conditions. Technological consultation and services shall be provided to other scientific and technological agencies that meet the standards and necessary supporting tax system shall be worked out

Besides, other preferential tax policies have been issued, such as "Preferential Income Tax Policy on Technological Innovation for Enterprises" (Taxation [2006] No.88), "Interim Provisions on the Exemption of Import Tax on the Articles Used for Scientific and Technological Development" (No. 44 of the Ministry of Finance 2007)、"The Interim Provisions on the Exemption of Import Duties from the Articles Used for Scientific Research and Teaching" (No. 45 of the Ministry of Finance 2007), "Notice of State Administration of Taxation of the Ministry of Finance on Taxation Policies Promoting the Development of Venture Capitals (Taxation [2007] No.31), "Notice of State Administration of Taxation of the Ministry of Finance on Taxation Policies about National University Science Park" (Taxation [2007] No.120), "Notice on Taxation Policies about the Science and Technology Incubation Enterprises" (Taxation [2007] No.11).

- **Alliance of Production, Study and Research**

In 2008, the Ministry of Science and Technology together with other Ministries put forward guidance on "Promoting the Setup of Industrial Technology Innovation Strategic Alliance":

It will be set up to fulfill the demand for technology innovation of national strategic industries and regional industries, aiming at forming industries and new competitiveness with enterprises as the mainstay and industrial technology innovation as the focus in virtue of market mechanism to converge innovation resources and combine enterprises, universities and research institutes to jointly break through the technological bottleneck.

Setup of the relevant industrial alliances for renewable energy and new energy automobiles and other technological fields is currently under the pipeline.

3. Market incentives

● Government rules

There are laws such as the *Environmental Protection Law* (December 26, 1989), the *Electric Power Law* (December 28, 1995) and so on.

● Government Procurement

Government procurement policies are made under the guidance of the *Outline of the National Long- and Medium-Term Program for Scientific and Technological Development (2006-2020)*.

Supporting policies and enforcement regulations are also formulated in accordance with the *Government Procurement Law* as following:

<Measures for the Administration of Accreditation of National Independent Innovation Products (for Trial Implementation) > (Ministry of Science and Technology, 2006), *Administrative Measures for Government Procurement Budget of Independent Innovation Products* (Ministry of Finance, 2007), *Assessment Method for Government Procurement of Independent Innovation Products* (Ministry of Finance, 2007), *Administrative Measures for Government Procurement Contracts of Independent Innovation Products* (Ministry of Finance, 2007), *Administrative Measures for Government Procurement of Imported Products* (Ministry of Finance, 2007), *Administrative Measures for Government Initial Purchase and Order of Independent Innovation Products* (Ministry of Finance, 2007) and so on. All these measures listed are to promote the country's independent innovation.

● Credit and taxation

Policies for promoting low carbon energy technologies regarding credit and taxation are as following:

Circular of People's Bank of China on the Implementation of Credit Policies and Strengthening of Environment Protection (People's Bank of China, 1995), *Circular on Taxation Policies of Application Promotion of Scientific and Technological Achievements* (Ministry of Finance, State Administration of Taxation, 1999), *Circular on Tax Issues Related to the Implementation of the Decision of the CPC Central Committee and State Council on Strengthening Technical Innovation, Development of High-tech and Realization of Its Industrialization* (Ministry of Finance, State Administration of Taxation, 1999), *Circular on Import Tax Issues Related to the Implementation of Suggestions of the State Council on Speeding Up the Revitalization of the Equipment Manufacturing Industry* (Ministry of Finance, the National Development and Reform Commission, General Administration of Customs, State Administration of Taxation, 2007) and so on.

● Subsidies

There are electricity price subsidies for electricity from renewable energy power, for example: *Tentative Administrative Measures for Prices and Expenses Allocation for Generating Electricity by Renewable Energy* (Development and Reform Commission, 2006), *Interim Measures on Readjustment of Additional Electricity Revenue by Renewable Energy* (Development and Reform Commission, State Electricity Regulatory Commission, 2007), *Circular on Price Subsidies and Quota Trading Scheme in Renewable Energy from July to December 2008* (Price of the Development and Reform Commission〔2009〕No.: 1581), and so on.

● Information exchange

There are documents such as *Several Suggestions on Improving the Capabilities of Information Application and Service of Intellectual Property Rights, and on Promoting the Establishment of Information Service Platform of Intellectual Property Rights* (Ministry of Science and Technology, 2006), *The Catalog of China's Key Technologies and Major Products with Independent Intellectual Property Rights in the Information Industry* (Ministry of Information Industry, Ministry of Science and Technology, National Development and Reform Commission, December 25, 2006) and etc., which provide technical supports for communication and information exchange between the innovation subjects, and thereby accelerate the development of innovative technologies.

Since the *Outline of the National Long- and Medium-Term Program for Scientific and*

Technological Development (2006-2020) was issued, government organizations such as the Ministry of Science and Technology, the National Development and Reform Commission, the Ministry of Finance and etc, have made a series of enforcement regulations and supporting policies. Although they are not specific and practical enough in some areas, it is very important currently for enterprises, research institutions, intermediaries and financial institutions to learn these regulations and policies and get thorough understanding of them, so as to raise questions and suggestions from practice, and summarize, refine and improve them to reach the object of improving the efficiency of the nation's innovation system.

The government organizations also need to make sure the science and technology programs are with no duplications and overlaps, to integrate the programs well with the industry development, so as to save administrative costs and resources.

At the same time, real work should be done in systematic surveys, monitoring and evaluation of government policies, so as to adjust, refine and improve government policies and regulations formulated.

3.3 Summary

After collecting, summarizing and analyzing the feedbacks of surveys and with literature researches and discussion meetings, five major problems are concluded.

1. Insufficient investment in R&D of low carbon energy technologies

Low investment in R&D of low carbon energy technologies is a reflection of the investment situation of energy R&D in China. It is showed in the literature[8] that in 2000 energy R&D investment in China was about 6.34% of the total R&D investment, accounting for 0.064% of the country's GDP. Government investment was 10.65% of the total energy R&D investment, accounting for 0.068% of the country's GDP, which was much lower than that of most developed countries in the same period. In terms of absolute quality, it was much more lagging behind the developed countries. For example, it was only 1.8% of the amount in Japan. In another literature[9], it is calculated that in 2004 energy R&D investment in China was about 4.10% of the total R&D investment, accounting for 0.058% of the country's GDP. Government investment was 5.74% of the total energy R&D investment, accounting for 0.034% of the country's GDP, which was much lower, comparing with 2000 (*Research of Energy R&D Investment in China*). Lack of investment in energy R&D is the fundamental reason for China's being in short of energy mainstream technology with independent intellectual property rights, and is also a very import reason for the slow development and high product cost of low carbon energy technologies.

2. Insufficiently recognized strategic significance of low carbon energy technologies, another important reason for the slow development of new energy and renewable energy in China.

In *China's Energy Research and Development (R&D) Policy Study* (National Research Center for Science and Technology Promotion and Development) completed in 2004, it is suggested that "the CCS technology should be made one of the 21st Century Energy Technology R&D Major Research Subjects. If CO_2 can be isolated and be disposed and utilized properly, it will be possible to achieve sustainable development even with coal and other fossil fuels as the main source of energy."

[8] A study on Chinese Energy R&D Input, Ma Chi, National Oil Economy, March 2003.

[9] A Research Report on the Role of the Government of Energy Technology Innovation, Dong Shuli, Chinese Science & Technology Development Research Center, Jan. 2007.

This reflects that national science and technology programs began to attach great importance to low carbon energy technologies. However, national environment protection policies have not been sufficient for promoting the development of new energy and renewable energy, which means there are still problems in cognition and positioning on the level of national macro-strategy.

3. Short for product quality standards, technical specifications, monitoring, certification system, platform of public R&D, and service.

There are various products of new energy, renewable energy and other alternative energies and they are developing rapidly. So, there is an urgent need to make quality and safety standards, so as to avoid wasting the precious resources, to protect interests of users, and to safeguard market expansion and development. With the establishment of standardization, serialization and authentication systems of products, and the expansion of the consumer market, product cost of low carbon energy technologies will be reduced gradually.

The public R&D and service platform will be helpful in saving public resources and labor power, avoiding reconstruction and wastes in research and development, and will make it easy for enterprises, research institutions and universities to share information, which is helpful for the promotion of production-study-research cooperation.

4. A relatively common R&D model in the area of low carbon technologies of renewable energy and new energy: bring in the technology, digest and absorb it, and then come up to re-innovation.

In the literature of *Government Function in China's Energy Technology Innovation*, it is showed that R&D projects of renewable energy electricity generation (hydropower excluded) collaborated with foreign institutions account for 7.13% of the total projects that are in different ways of technical cooperation (such as with universities, research institutions, enterprises, etc.), which is well above the average of 3.39% in the energy industry. It is indicated that foreign partners are more welcomed in R&D cooperation of renewable energy electricity generation; on the basis of bringing in low carbon energy technologies, innovation cooperative R&D with foreign enterprises or research institutions, and active introduction of foreign talents due to the lack of professional and technical talents are all important things that worth special attention and study.

5. Insufficient market incentives from the government in the area of low carbon energy technologies.

Market incentives include aspects of taxation, credit and subsidies. And subsidies mainly include value-added tax refund, income tax relief and local financial subsidies, which largely determines the performance of those enterprises in the fields of environment protection and public utilities.

Subsidies are necessary to support enterprises of low carbon energy technologies, to help them in development and growth, and to make them more competitive against the traditional fossil energy industry, so that the enterprises of new energy and new technology can enjoy greater growth and stronger strength. It is an important national policy that is indispensable for a country to address the problems brought by global warming.

It is also reflected in the researches that the intensity of tax incentives is not strong enough. This is also because many relative rules and regulations are too broad, too brief and too principled; and the terms are too general with flexibility and lack maneuverability. Of course, it is true that many of the rules and policies have just been formulated and need test in practice. So, it is quite necessary to track, research, monitor and evaluate the government regulations and policies.

Chapter 4 Policy Proposals to Promote China's Low-Carbon and New Energy Technological Innovation and Development

4.1 Cause Analysis of the Existing Problems

The above chapters analyzed the situation and existing problems of China's low-carbon and new energy technological innovation from different perspectives. By and large, China's low-carbon and new energy technological innovation still remains at the initial stage with sound momentums. It still faces a great deal of difficulties and obstacles in some aspects due to various factors of the entire innovation system.

And the reason from companies is about the innovation spirit and impetus. Compared with European and American companies, few of domestic enterprises view low-carbon and new energy technology innovation and application from a strategic perspective. A great number of enterprises holding the innovation flags as a marketing scheme. All these are derived from the comprehension of technology innovation.

Innovation still remains in the stage of absorption and digestion of technology imported and the re-innovation in the real sense has not utterly embodied yet. Take wind power and photovoltaic generation for example. China has now become a country with the fastest growing on installed capacity of wind power. The production of solar cell had surpassed Japan, becoming the No.1 in the world. But all these had been realized by the contribution of capital and market, while the core technology remains in other people's hands.

The reasons from the governmental level side are more in number and more important, thus they have an even greater impact.
First, it lacks explicit development objective and planning, so it can not be used to effectively guide the development and innovation of low-carbon technology in various industries.
Second, it lacks relevant supporting measures.
Third, the low-carbon and new energy technology hasn't caused enough attention. It is an undisputable fact that China's low-carbon and new energy technology has been ignored for too long or even been marginalized. The situation had not been changed until the promulgation of the Renewable Energy Law of the People's Republic of China in 2005.
Fourth, not sufficient support is given, especially to the R&D and innovation of the core technology of low-carbon and new energy, the introduction and absorption of high-end technology talents and the establishment of national project R&D centers and public service platforms as well as the formulation of national technical standards and foundation of national testing and certification centers. The financial and policy support to the abovementioned aspects are far too weak. It has become a common aspiration of the business circle and technology circle to change the status quo as soon as possible.
Fifth, the publicity is so poor that people can rarely see or hear any coverage on the technology development of science and business circles especially the low-carbon and new energy circles as well as innovative personalities and their outstanding achievements.

4.2 Ways to Promote Innovation

Facts and research have proved that **fostering innovative enterprises, setting up industry**

alliance and establishing public service system are three key paths to achieve sci-tech innovation, and one of the best practice in improving competitive edge and great economic leap.

4.2.1 Nurture and Development of Innovative Enterprise

China enterprises, especially those related to low-carbon and new energy industry, are weak in innovation capacity generally, because of a lack of support in innovation and a deficient system incorporated by production, education, research and use. Those shortcomings have become the bottle neck in turning China into an innovative country. Therefore, nurturing and developing innovative enterprises and giving enterprises a full play in technical innovation are not only an urgent need to enhance competitive edge of enterprises, but also a must in building a well-off society and an innovative country.

Building innovative enterprises calls for certain conditions. It should make innovation in terms of technology, brand, institution, management, philosophy and culture. To be specific, first, the enterprise should boast core technology with IPR and take the lead in the industry. Second, the enterprise should have sustainable innovative capacity; put R&D investment (including private investment) into place; focus on the introduction and training of technicians and talents, so as to exert their intelligence. Third, create self-own brand and put the management and innovation of the brand high on the agenda, in order to make it well-known. Fourth, it is also important to have profitability and strong management ability, and establish a sound intellectual property management system and quality assurance system. Fifth, the enterprise should focus on the management and development of strategy innovation, develop a corporate culture of innovation, and take technological innovation and self-brand innovation as a major part in management and development strategy. There is still a big gap in innovation capacity between China low-carbon industry and the foreign counterpart. Great effort should be made to catch up with the innovation trend in China.

The success of nurture and development of innovative enterprise lies in support and guidance from the government. So does the technology in low-carbon technology. This is because such enterprises are latecomers with weak basics and competitiveness. Without government support and guidance, their technological innovation capacity can hardly been improved. Even survival can be a problem.

4.2.2 Establishing Industry Alliance

Members of the alliance, with large-and-medium sized enterprises and flagship enterprises as the core, are linked by generic technologies and key standards. An industry alliance means a long-term strategic alliance featuring “production, education and research” in certain key fields. The improvement of industrial alliance is conducive to the enterprises through the integration of innovative factors such as resource, technology, human resources, management etc. It further helps the enterprises to make best use of the advantages and bypass the disadvantages , share complementary advantages, join forces and make breakthrough, so as to promote the technology innovation and achieve low carbon technology.

Currently, China is meeting a bottleneck in integration of “production, education and research” in low carbon energy. The system needs further improvement; enterprises should grip its dominance; enterprises, universities, and research institutions fail to reach the same goal due to unclear responsibility, a lack of financial support, policy and benefit protection mechanism, and driving force of cooperation. Therefore, it is imperative to make more effort in long-term cooperation mechanism of “production, education and research” by establishing a sound credit mechanism, responsibility system and benefit protection system, improving the environment, so as to achieve a positive interaction among the three parties.

4.2.3 Establishing Technology Platform for Public Service

Public service platform is a key for enterprise innovation and a must for its development in market oriented economics. In recent years, with the support of the government, a series of national engineering centers and laboratories have been established, such as the new energy technology center,

wind power engineering center, biomass center, solar power laboratory, wind power laboratory and so on. Some universities have set up energy major for personnel training. However, these centers have not performed as well as what is expected, due to a lack of sustainable financial support.

It is necessary to take measures to draw resources of public services so as to provide support for enterprise innovation. On one hand, measures should be taken to help the enterprises have better access to national labs, universities, research institutions, engineering centers, and testing centers. On the other hand, universities and research institutions are encouraged to have better cooperation with enterprises. Besides, draw upon experiences and build up the technology intermediary system by scaling up support to technology market, productivity promotion center, technology business incubator, technology consulting company and venture capital services, so as to provide innovation service to the enterprises and build up its innovation capacity.

4.3 Related development suggestions and supporting measures.

Research and formulation on special development plans

According to China's long-term goal on energy development and basic requirement of *National medium and long term scientific research and technique development planning outlines(2006-2020)*, China should formulate short and medium-term special innovation plans or development paths for different technologies. The direction and focus, as well as developing conditions for innovation companies in 10 years should be identified.

Create supportive policy environment for the development of entrepreneurial firms.

Strengthen the implementation of and continuously improve all existing policies and regulations in ***National medium and long term sci-tech development planning outlines (2006-2020)***.

Increase the amount of funding and investment in innovation and raise the subsidies for the core technical.

Establish a governmental new energy industry development fund. According to the low carbon innovation technologies development scheme, funds will be financed to provide support for the **technology application, absorption and re-innovation, key technical equipment and the R&D for key technologies annually**. To develop the diversified finance input form to the technology research.The enterprises should also be encouraged to increase the fund input for technology development. The capacity of independent innovation should be increased and core competitiveness of industries should be strengthened through autonomous research and the mastery of core technology with proprietary intellectual property rights.

To explore and diversify the forms of fund investment into the industrial technology, Perfect investment and financing system for the technical innovation projects, and initiatively promote stock right stimulation projects. It is suggested to introduce market operation mechanism, make best use of social capital and overseas capital to diversify the investment subjects and form the pattern of "Government instructs, Enterprise acts, Society participates, market operates".

Improve the policy on price and revenue. Pricing mechanism, which is propitious to the development and innovation of new energy technique, should be established. Certain regulations for revenue stimulation that stated in the *National medium and long term scientific research and technique development planning outlines (2006-2020)* (details are on page 46), the reduction of customs duties, preference on income imposition that stipulated by the China Ministry of Finance should be realized, and revenue preference range that relate to creative development of new energy technology should

be enlarged.

Promote the new stimulation mechanism with great efforts. In order to stimulate the enthusiasm of scientists and engineers, advance scientific research development and transformation of scientific research achievements, improve the autonomous innovation ability of colleges and universities, research institutions and enterprises, Zhongguancun Science and Technology Park is now actively develop stock rights stimulation and seven stimulation methods have been put forward. They are the buying in of scientific and technological achievements, equity rewards, equity carve out, stock option, dividend rights, and gain sharing of scientific and technological achievements. Currently, 202 units belong to Zhongguancun Science and Technology Park has taken part in the stimulation experiment and has shown successful results in the trial operation. For the sake of accelerating the development and innovation speed on low-carbon new energy, the experiment on this technology, which is hosted by the government and guided by the former experiences, should be actively and systematically put in to effect.

Consummate organizations and strengthen coordination and operation.

Due to the duplication in the low- carbon new energy administrative setup, un-uniform management, and divided policies from various sources, it is suggested that the coordination function of the National Energy Administration Committee should be strengthened; led by the National Energy Bureau to enhance the energy institutional construction; strengthen the coordination, communication and cooperation between all the administrations; systematically deal with the problems of decision making and capital allocation during the process of the new energy development and innovation; enhance guidance and supervision to ensure the smooth and sound development of new energy technology.

Strengthen science development , human resources capacity building and improve the inner motivation of autonomous innovaton.

Set up new energy special technology fund, support digestion and absorption of implanted technology, give prominence to re-innovation, and support manufacture of crucial technique equipment and development of key technique in major industries. By autonomous research and mastery of core technology with proprietary intellectual property rights, the capacity of independent innovation should be increased and core competitiveness of industries should be strengthened. And addition to that, we should also increase the financial imputes on base construction for new energy talents, adopt the method of Industry-University-Research Institution innovation network to form a real effect mechanism that bases on the method.

Organize a series of national new energy industrial technology alliances and scientific research centers

According to the practical requirements of the current development of low-carbon energy technology, the following industrial technology alliances will play a very high improtance on the technology innovation.

First, set up an alliance of solar energy power generating at the Yangtze River Delta. This alliance relays mainly on Suntech Power Holdings Co. Ltd.(STP), and associate with the related corporations, research institutions, universities, est., to form the first power generating alliance, which is with crystalline silicon solar cell remaining predominant, in China. The alliance mainly develops and produces photovoltaic cells and generating system with high efficiency and low cost.

Second, build new energy alliance along the Bohai Sea in Tientsin. This alliance relays mainly on Xinao Group, and associates with the related and rim corporations, research institutions, and universities to mainly develop and produce thin film solar cells.

Third, set up wind power generating alliance along the Southeast coast. This alliance relays mainly on Jinfeng and Huarui Group, and associates with other related corporations, research institutions, universities to practice of autonomous designs and constructions of wind farms with power no less than 2.5MW and maritime wind farms.

Fourth, construct bio-fuels alliance which mainly relay on COFCO Group and Tianguan Group. This alliance will mainly take part in the development and production of ethanol, diethyl ether, and synthetic fuel with the association of related corporations, research institutions, and universities.

Fifth, build up hydrogen energy and fuel cell alliances with Shanghai Shenli Group as their main body. This alliance mainly develops and produces hydrogen energy and fuel cells with the related corporations, research institutions, and universities.

Strengthen the dissemination of low-carbon nenergy to the public

Strengthen dissemination, increase and extend the publicity and report on low-carbon new energy technology, and improve the whole nation’s low-carbon and energy conservation initiative to create a harmonious environment for the development of low-carbon energy.

Based on this project implementation and research progress, in order to make a more deep research on the innovation system and the obstacles faced by it, it is suggested that a series of researches could be conducted. Several typical innovation products or technologies should be selected, and the research should following the whole life cycle of each technology or products. Problems and obstacles faced by the typical renewable energy technologies innovation process will be researched in deep and propose suggestions accordingly. It is believed that the research results will be more targeted and practicable.

Annex 1 On-site survey report

1. Methods

(1) Expert composition

According to the design of the project proposals and the specific requirements of the project implementation, this project brings the pundits on domestic new energy and renewable energy and the experts on the macro-policy management of energy saving industry and the fund management together. Here are the compositions of the experts and the fields that they are specialized in.

Name	Unit	Domain
Hu Xiulian	The energy conservation center of the National Development and Reform Commission Research Institution	Expert on energy conservation
Zhang Zhengmin	The Energy Institution of National Development and Reform Commission	Expert on renewable energy
Ding Xuewei	SME Technology Innovation Fund Management Center of the Ministry of Science and Technology	Innovation fund management
Sun Dejiang	SME Technology Innovation Fund Management Center of the Ministry of Science and Technology	Science and Technology project management(new material)
Wang Yangdong	SME Technology Innovation Fund Management Center of the Ministry of Science and Technology	Science and Technology project management(new material, resource environment, new energy and hi-tech service domain)
Ma Chi	Strategic Research Institute of Ministry of	Renewable energy

	Science and Technology	strategic programming
Wei Dongyuan	Strategic Research Institute of Ministry of Science and Technology	Renewable energy strategic programming
Wu Ling	Beijing Semiconductor Lighting Technology Promotion Centre	Experts on semiconductor lighting technology
Yuan Jun	Beijing Semiconductor Lighting Technology Promotion Centre	Experts on semiconductor lighting technology
Xu Honghua	The Institute of Electrical Engineering of Chinese Academy of Social Sciences	Expert on photovoltaic power
Chen Zhenbin	The Institute of Electrical Engineering of Chinese Academy of Social Sciences	Expert on wind power
E Chunliang	The Institute of Electrical Engineering of Chinese Academy of Social Sciences	Expert on wind power
Wang Zhifeng	The Institute of Electrical Engineering of Chinese Academy of Social Sciences	Expert on solar thermal power
Zhu Xinjian	Shanghai Jiaotong University	Expert on hydrogen power and fuel cell
Yuan Zhenhong	Guangzhou Energy Research Institute of Chinese Academy of Social Sciences	Technologist on biomass energy
Wang Cheng	The major project of	Expert on new energy

	863 energy saving and new energy vehicles	vehicles
Ren Dongming	The Energy Institute of National Development and Reform Commission	Expert on renewable energy
Li Baoshan	China's Renewable Energy Academy	Team leader
Lv Fang	Beijing Jikedian Center	Team member
Xu Yunsong	China's Renewable Energy Academy	Team member
Ma Liyun	Beijing Jikedian Center	Team member
Wang Jielu	Beijing Jikedian Center	Team member

From the above table, we can see the panel members coming from the domain of renewable energy and energy conservation technology innovation, such as wind power, photovoltaic power, solar thermal power, biomass energy utilization, hydrogen energy utilization, fuel cells, electric vehicles and LED etc. They enjoy the prestige in their own domains; have tons of experience and a good understanding of the development and trend of their own filed. During the project implementation, the experts are involved in the project research, analysis, evaluation and report writing, etc.

(2) Referring to Delphi Method to organize the survey

Delphi Method firstly derived from science and technology, and was increasing applied into various areas. Compared with the traditional survey, the main features of Delphi Method are its anonymity, feedback, convergence and statistics.

By drowning on the experience of international research projects and our past experience, this project began to carry out its written survey and field research by referring Delphi Method

Delphi questionnaire is different from the traditional questionnaire, usually the traditional questionnaire raised questions to the respondents and asked them to answer them, while Delphi questionnaire not only raised questions, but also took the responsibility to provide information to

According to the Delphi Method, the project group specifically designs questionnaires for the target groups of Ground analysis and System analysis, the questionnaires will be revised by the experts and the final questionnaires will be made on the basis of the experts' suggestions. The questionnaires of the Ground analysis cover the basic information, the products and technology, the operation and development and the policy of the surveyed enterprises; while questionnaires of the System analysis cover the basic information, the attitude and views toward low carbon innovation technology, and the work done or being done in the aspects of the low carbon innovation technology of the surveyed enterprises.

(3) The selection of the surveyed objects

(1) Specify and identify the low-carbon innovation areas within the research of the project.

Based on the implementation cycle and support of this project, currently the project regards the areas of new energy and renewable energy as its focus and starting point.

At the opening meeting, the panel together discussed the selection standards of the technology and industry type for the new energy and renewable energy, they chose the following technology and industry type as their major research objects at this stage based on the standards, they are solar photovoltaic power, wind power, semiconductor lighting, new energy vehicles, biomass energy, hydrogen energy, fuel cell and solar thermal power. In addition, the project also chose a representative R&D institution, investment and financing institutions and policy makers, that is government departments, which will do the survey according to the requirements of the project.

(2) Delineation of the research objects list

Based on the selection criteria of the surveyed objects, the experts recommended 44 representative enterprises and agencies in the 7 selected major research categories, among which are the technology of the new energy and renewable energy, potential R&D institutions, industry incubator, investment and financing institutions and policy makers, which are the government sectors. The following are the 44 enterprises and agencies.

Number	Domain	Unit
1	Photovoltaic power	Wuxi Shangde Solar Power Co., Ltd
2		Baoding Yingli Group Co., Ltd
3		Fujian Junshi Energy Co., Ltd
4		Jiangsu Zhongneng Polysilicon Technology Development Co.,Ltd
5		Sichuan Xinguang Silicon Limited liability Company
6		Institution of Electrical Engineering Chinese Academy of Science
7		Hefei Sungrow Power Spply Co., Ltd
8	Wind power	Zhejiang Yunda Wind Power engineering Co., Ltd
9		Baoding Tian Wei Feng Dian Technology Co., Ltd
10		Goldwind Science and Technology Stock Co., Ltd
11		Beijing Corona Science and Technology Stock Co., Ltd
12		Sino-wind Energy Co., Ltd
13	New energy vehicles	Chery Motor Stock Co., Ltd
14		Faw-volkswagen Motor Co., Ltd
15		Chongqing Changan Motor Co., Ltd
16		Saic Motor Group Stock Co., Ltd
17	Hydrogen power and fuel cell	Dalian Institute of Chemical Physics Fuel Cell Engineering Center of Chinese Academy of Social Science
18		Shanghai Shenli High Tech Co., Ltd
19		Hydrogen Energy Institute of School of Automobile Engineering of Tongji University
20	Biomass energy	Fujian Zhuoyue New Energy Co., Ltd
21		Hangzhou Energy and Environmental Engineering Co., Ltd
22		Hefei Tianyan Co., Ltd

23		Institute of COFCO
24		Beijing Ebankon Energy Technology Development Co., Ltd
25		Changsha Tiandi Green Energy Technology Institute
26	Solar thermal energy	Solar Thermal Power Group of Institute of Electrical Engineering, Chinese Academy of Sciences
27	Semiconductor lighting	Xiamen Sanan Optoelectronics Technology Co., Ltd
28		Shanghai Rainbow Optoelectronic Material Co.,Ltd
29		Fushan Nation Star Technology Co., Ltd
30		Shenzhen Diguang Electronics Co., Ltd
31		Tongxiang Shenghui Lighting Electronic Co., Ltd
32		Dongguan Qin Optoelectronics Stock Co., Ltd
33		State Semiconductor Lighting R &D and Industry Alliance(Beijing Semiconductor Lighting Technology Promotion Center)
34	Investment and financing institutions	China Energy Conservation Investment Corporation
35		Qinghua Ziguang Investment Advising Corporation
36		Xinshengdai Asset Management Co., Ltd
37		China Development Bank Investment Service Bureau
38		China Power Economic Research Center
39	incubator	Wuxi Productivity Promotion Center
40		Baoding National High-Tech Industrial Development Zone Productivity Promotion Center
41		Energy and New Technology Incubator of Xian High-tech Zone
42		Shanghai New Energy Incubator
43		Beijing Greentec Environmental Group
44		Xian Base of National 863 Software Incubator

(3) Delineation of the on-site surveyed objects

Based on the outline of the project, the team takes the overall consideration of the scale of the object, growing phase, industry stage, projection time, economic cost, geographical location and other factors and select 24 units as their on-site research objects. The 24 units are divided in to two parts under Ground analysis and System analysis respectively according to their different natures. Here are the details for their implementation.

There are 16 research subjects under Ground analysis, namely:

Number	**Name of the Unit**	**Remark One （result）**	**Remark Two （mode）**
1	Baoding Yingli Group Co., Ltd	Y	On-site
2	Jiangsu Zhongneng Polysilicon	Y	On-site

	Technology Development Co.,Ltd		
3	Hefei Sungrow Power Supply Co., Ltd	Y	On-site
4	Zhejiang Yunda Wind Power engineering Co., Ltd	Y	On-site
5	Baoding Tian Wei Feng Dian Technology Co., Ltd	Y	On-site
6	Beijing Corona Science and Technology Stock Co., Ltd（wind）	Y	On-site
7	Xiamen Sanan Optoelectronics Technology Co., Ltd	Y	On-site
8	Tongxiang Shenghui Lighting Electronic Co., Ltd	Y	On-site
9	Chery Motor Stock Co., Ltd	Y	On-site
10	Shanghai Shenli High Tech Co., Ltd	Y	On-site
11	Fujian Zhuoyue New Energy Co., Ltd	Y	On-site
12	Hangzhou Energy and Environmental Engineering Co., Ltd	Y	On-site
13	Beijing Ebankon Energy Technology Development Co., Ltd	Y	On-site
14	Solar Thermal Power Group of Institute of Electrical Engineering, Chinese Academy of Sciences	Y	On-site
15	Beijing Corona Science and Technology Stock Co., Ltd(light)	Y	On-site
16	Institute of COFCO	Y	On-site

There are 8 research subjects under Ground analysis, namely:

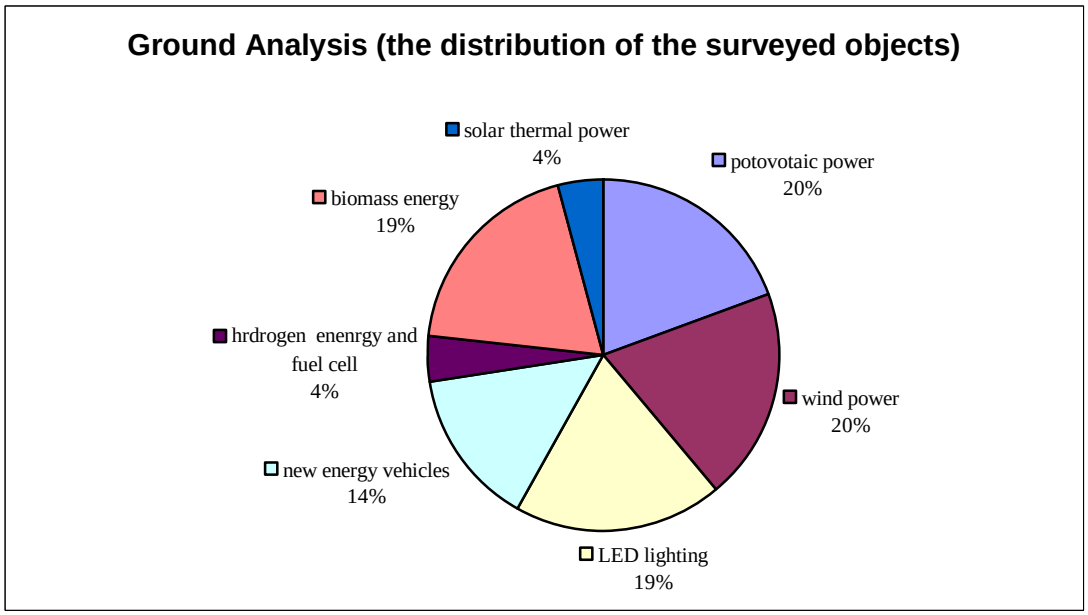
Number	**Name of the Unit**	**Remark One（result）**	**Remark Two（mode）**
1	Hydrogen Energy Institute of School of Automobile Engineering of Tongji University	Y	On-site
2	State Semiconductor Lighting R &D and Industry Alliance(Beijing Semiconductor Lighting Technology Promotion Center)	Y	On-site
3	China Energy Conservation Investment Corporation	N	The respondent said the questionnaire was only

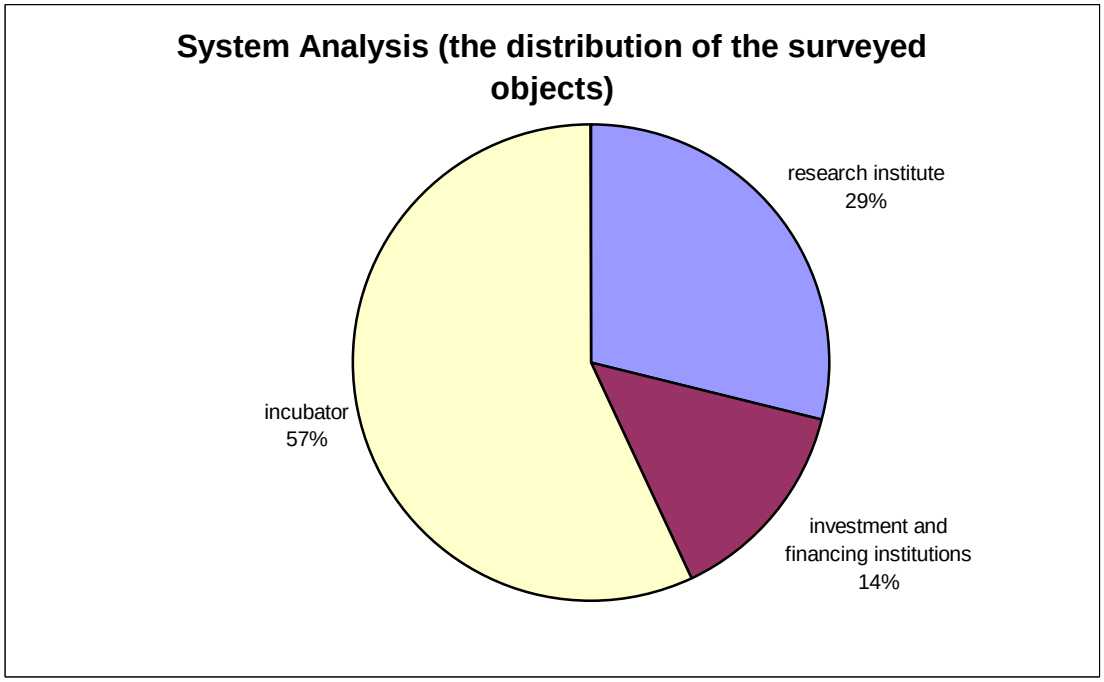
			personal views and asked not to be included in the report
4	Qinghua Ziguang Investment Advisory Corporation	Y	On-site
5	China Development Bank Investment Service Bureau	N	On-site
6	Baoding National High-Tech Industrial Development Zone Productivity Promotion Center（Baoding High-tech Business service center）	Y	On-site
7	Shanghai New Energy Incubator （Zhangjiang Star Business Incubator）	Y	On-site
8	Beijing Greentec Environmental Group	Y	On-site

While at the same time, in order to expand the scope of the survey samples, the team also handed out the written questionnaires to the units which were not selected as the on-site objects for gathering information; while totally 20 questionnaires were handed out, only 6 feedback questionnaires were returned, namely:

Category	**Number**	**Name of the Unit**	**Remark One （result）**	**Remark Two （mode）**
Ground	1	Gold Wind Science & Technology Co., Ltd.	Y	written
	2	Fushan Nation Star Technology Co., Ltd	Y	written
	3	Dongguan Qin Optoelectronics Stock Co., Ltd	Y	written
	4	Chongqing Changan Motor Co., Ltd	Y	written
	5	Shanghai Motor Group Stock Co., Ltd	Y	written
System	6	Dalian Institute of Chemical Physics of Chinese Academy of Social Science	Y	written

According to the on-site survey and written questionnaires, the distribution in terms of the technology and application areas of the two-type surveys under Ground analysis and System analysis is as following:





2. The process

The project research can be divided in to on-site research and the research through handing out written questionnaires. In order to collect the data from more resources, the team did the written survey by sending an email to the 20 objects which were recommended by the experts, in addition to the 24 units which were chosen as the units of doing on-site survey.

- Research route

With the rational combination of the efficient time, cost-effective, non-circuitous route and technology as a premise and by comparing several plans, we decided to do the survey in the following 4 routs:

Route	Provinces and cities	Technological areas	Surveyed enterprises or agencies

Route One	Beijing	Photovoltaic power	Institution of Electrical Engineering Chinese Academy of Science
		Solar thermal power	
		Wind power	Beijing Corona Science and Technology Stock Co., Ltd
		Biomass energy	Institute of COFCO
			Beijing Ebankon Energy Technology Development Co., Ltd
		Investment and financing institutions	China Energy Conservation Investment Corporation
			Qinghua Ziguang Investment Advisory Corporation
			China Development Bank Investment Service Bureau
		Semiconductor lighting	State Semiconductor Lighting R &D and Industry Alliance(Beijing Semiconductor Lighting Technology Promotion Center)
		incubator	Beijing Greentec Environmental Group
	Baoding	Photovoltaic power	Baoding Yingli Group Co., Ltd
		Wind power	Baoding Tian Wei Feng Dian Technology Co., Ltd
		incubator	Baoding National High-Tech Industrial Development Zone Productivity Promotion Center
Route Two	Jiangsu	Photovoltaic power	Jiangsu Zhongneng Polysilicon Technology Development Co.,Ltd
	Anhui		Hefei Sungrow Power Supply Co., Ltd
		New energy vehicles	Chery Motor Stock Co., Ltd
Route Three	Zhejiang	Areas of wind power	Zhejiang Yunda Wind Power engineering Co., Ltd
		Biomass energy	Hangzhou Energy and Environmental Engineering Co., Ltd
		Semiconductor lighting	Tongxiang Shenghui Lighting Electronic Co., Ltd
	Fujian		Xiamen Sanan Optoelectronics Technology Co., Ltd
		Biomass energy	Fujian Zhuoyue New Energy Co., Ltd
Route	Shanghai	Hydrogen energy	Shanghai Shenli High Tech Co., Ltd

Four		and fuel cell	Hydrogen Energy Institute of School of Automobile Engineering of Tongji University
		incubator	Shanghai New Energy Incubator

- The composition of the research team

The research is conducted by the combination of the members and the experts in various fields.

- Research time

Taking the time and places into consideration, the project team together with the experts began their survey from the distant provinces and cities. They were divided into 3 groups and conducted the research at the same time, starting from 16th, DEC. 2009, under the route One, route Two, route Three respectively and finished their work on 22ed, DEC. 2009.

As the route One covered extensive areas and is more concentrated in geography, the team asked the experts to conduct the survey under 4 routes respectively, starting from 28th, DEC.2009. One investment and financing institution, namely the National Development Bank Investment Services Bureau, said they were not involved in the research temporarily because of its nature although the team made a great effort to communicate with it. In addition to this, all the research work was completed before 30th, DEC.2009.

Annex 2 Information of the interviewed

PV

No.	Organization	Location	Interviewed
1	Baoding Yingli Group Co., Ltd	3055#, Fuxing Mid Road, National High Technology Zon, Baoding	Ma Xuelu
2	Jiangsu Zhongneng Polysilicon Technology Development Co., Ltd	66#, Yangshan Road, Xuzhou Economic Development Zone, Jiangsu Province	Zhong Zhenwu
3	Beijing Corona Science & Technology Co., Ltd	23F, Block B, Tsinghua Tongfang Hi-tech Plaza, No.1, Wangzhuang Road, Haidian Dist., Beijing	Jiang Yanxing
4	Hefei Sungrow Power Power Supply Co., Ltd	2#,Tianhu Road, Hefei Hi-tech Zone, Anhui Province	Zhang Youquan

Wind power

No.	Organization	Location	Interviewed
1	Zhejiang Yunda Wind Power Engineering Co., Ltd	A Block, 22F, Xihu International Plaza,391# Wen-erWest Road, Hangzhou	Pan Donghao
2	Baoding Tianwei Wind Power TechnologyCo., Ltd	3666#, Xiangyang North Road, Baoding, Hebei Province	Lu Zhiping
3	Beijing Corona Science & Technology Co., Ltd	23F, Block B, Tsinghua Tongfang Hi-tech Plaza, No.1, Wangzhuang Road, Haidian Dist., Beijing	E Chunliang
4	Xinjiang Goldwind Technology Co., Ltd	19#, Kangding Road, Beijing Economicand Technology Development Zone	Yan Xufei

LED

No.	Organization	Location	Interviewed
1	Xiamen San'an Optoelectronics Technology Co.,Ltd	1721#, Lvling Road, Xiamen	Ke Yongrui
2	Foshan Guoxing Optoelectronics Technology Co.,Ltd	18#, Huabao South Road, Cha cheng Dirt., Foshan, Guagndong	Wang Yaohao
3	Zhejiang Shenghui Lighting Co.,Ltd	Jiachuang South Road, Jiaxing XiuzhouIndustry Zone, Zhejing	Shen Jinxiang
4	Dognguan Qinshang Optoelectronics Co.,Ltd	Hengjiangsha Management Zone, Chngping Town, Donggua , Guangdong	Li Xuliang
5	State Semiconductor Lighting Technolog Alliance (Beijing Semiconductor Lighting Technology	702/1002C , B Block, Shuma Plaza, Zhongguancun South Road, Haidian	Ruan Jun

	Promotion Center)	Dist., Beijing	

New energy vehicle

No.	Organization	Location	Interviewed
1	Chery Motor Stock Co., Ltd	8#, Changchun Road, Wuhu Economic &Technology Development Zone, Anhui	Fagn Yunzhou
3	Chongqing Chang'an Motor Co., Ltd	260#, Jianxin East Road, Jiangbei Dist.,Chongqing	Ren Yong
4	Shanghai Motor Group Co., Ltd	489#, Weihai Road, Shanghai	

Hydrogen and fuel cells

No.	Organization	Location	Interviewed
1	Dalian Insititute of Chemical PhysicsFuel Cell Engineering Center of Chinese Academy of Social Science	457#, Zhongshan Rode, Dalian	Sun Gongquan
2	Shanghai Shenli High Tech Co., Ltd	2# Block, Longyang Industy Zone, Fengxian, Shanghai	Hu Liqing
3	Hydrogen Energy Institute of Tongji University Automobile Engineering College	4800#, Can'an Rode, Jiading, Shanghai	Lv Hong

Biomass enrgy

No.	Organization	Location	Interviewed
1	Fujian Longyan Zhuoyue New Energy Co., Ltd	Pinglin Development Zone, Tieshan Town, Xinluo Dist., Longyan, Fujian	Ye Huodong
2	Hangzhou Energy and Environment Engineering Co., Ltd	118#, Fegnqi East Road, Hangzhou	Cai Changda
4	Institute of COFCO	8#, Chaoyangmen South Road, Beijing	Lin Hailong
5	Beijing Taitiandi Energy Technology Development Co., Ltd	41#, Maizidian Street, Chaoyang Dist.,Beijing	Wang Mengjie

Solar thermal power

No.	Organization	Location	Interviewed
1	Solar Thermal Power Technology Research Group, Chinese Academy of Sciences	6#, Bei-er-tiao, Zhongguancun, Haidian, Beijing	Wang Zhifeng

Finance and investment

No.	Organization	Location	Interviewed
1	Tsinghua Ziguang Investment Adivising	2203#, Fangxinyuan, Nanbahe South	Li Xingyu

	Corporation	Road, Chaoyang Dist., Beijing	

Incubator

No.	Organization	Location	Interviewed
1	Baoding High-tech Enterprises ServiceCenter	118#, Fuxing Road, Baoding	Liu Dongyue
2	Shagnhai Zhangjiang Chuangxingyuan Garden	88#, Da-er-wen Road, Zhagnjjiang, Pudong,, Shanghai	Huang Xia
3	Beijing Lvchuang Environmental Group Incubator	28#, Zhenxing Road, Changping Dist.,Beijing	Meng Fanying