CHINA

Population: 1,324,655,000 (2007)
Source: Demographic Yearbook 2008,
Table 5 Estimates of mid-year population: 1999-2008
http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm

Carbon emissions per country: 2007: 6 538 367
Source: (CDIAC) Carbon dioxide emissions (CO_2), thousand metric tons of CO_2
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=749&crid=

Carbon emissions per capita: 2007, China: 4,9194
Source: (CDIAC) Carbon dioxide emissions (CO_2), metric tons of CO_2 per capita
http://unstats.un.org/unsd/mdg/SeriesDetail.aspx?srid=751&crid=

Population below $1 (PPP) per day, percentage: 2005: 15,9 %
Source: http://unstats.un.org/unsd/mdg/Data.aspx

GDP per capita: China $ 7,400 (2010 est.)
Source: https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html

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CHINA

This section on China constitutes to a large extent an extract and analysis of the WWF-commissioned national review titled "Analysis of Conditions for Development & Deployment of Innovations for a Low-carbon Economy in China", produced by Chinese Renewable Energy Society and Beijing JKD Renewable Energy Development Center in 2010. More elaborate description and analysis of China's national climate innovation system can be found in the full report at www.climatesolver.org.

The devastating effects of climate change on people and communities in China are becoming more tangible every year. With the risk that this negative trend continues and worsens in the future, China needs to achieve a fast and smooth transition towards a low-carbon economy. A key factor determining the level of success in this endeavour is the extent to which China will be able to adopt low-carbon technology innovation as part of the national climate innovations system.

In 2009, China passed the U.S. as the world's largest energy consumer[106], and the economy is in the process of speeding up urbanization and industrialization, both of which are characterized by resource-intensive mining and rapid consumption. Identifying innovative solutions to manage limited energy resources is crucial in order to maintain the sustainability of economic growth. Statistical data[107] shows that since 2000, due to the pull of market demand, the average annual growth of China's output of major products in high energy-consuming industries is more than 10%, and this industry's share of China's total energy consumption is more than 55%. The amount of energy used for each unit of GDP is exponentially higher for China compared to Japan, Europe, and the United States and other developed countries. At present, CO2 emissions from energy consumption in China and the United States accounts for 42% of the total emissions of the world.

A vast range of innovations are available for low-carbon energy generation in China. For the purpose of WWF's report on climate innovation systems, the conditions for wind power, solar energy (PV, thermal power generation), biomass energy (liquid fuel), hydrogen energy (production, transportation and storage), fuel cells, new energy vehicles, and LED were analysed, as they dominate the clean energy market in China today.

The Climate Innovation System in China

The role of the government

In order to promote the development of China's renewable energy, the government has worked out a Medium and Long-Term Development Plan for Renewable Energy in China (1996-2010). This national plan states the following overall goal: "to improve conversion efficiency, reduce production cost and increase its proportion in the energy mix." The Renewable Energy Law, which was adopted in 2001, constitutes the cornerstone of and provides legal protection for the development of new energy industries. It explicitly defines the responsibilities and obligations of the government and society in the development and utilization of renewable energy. Furthermore, the Act establishes a series of systems and measures, including long-term funding targets and development planning, and sets up a special financial fund for renewable energy.

106 IEA (2010 B).
107 Zongyu (2010).

Hong Kong – one of many rapidly growing cities in China.

Through the National Science and Technology Program, the Chinese government channels support towards science and technology R&D. This program, centered on economic development, has made strategic efforts to promote the upgrading of industrial technology and enhancing sustainable technological innovation. The government also works actively with taxation incentives in order to stimulate investments in innovative low-carbon solutions in many different ways.

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." This welcome alliance will help fulfill the demand for technology innovation of national strategic industries and regional industries, aiming at forming industries and new competitiveness among enterprises.

One of the first pilot test programs within this alliance is trying to work out a credit, responsibility, and interest mechanism for production, study and research, with an aim to jointly develop common key technologies through integration of resources and innovation of industrial technologies. As a leader in industrial technology innovation, it is expected that the alliance will play an irreplaceable role in technology innovation, industrial development, cooperation among the Mainland, Taiwan, and Hong Kong, as well as increasing international communication and intellectual property rights management.

Knowledge institutions

China has made substantial progress in science and technology since its reform and opening to the outside world. The transformation of the tech-research-oriented enterprises as well as the technical organizational restructure of non-profit research

Biogas production in rural China.

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institutions have made great advances. Today it seems that the research-oriented enterprises have become the main bodies of R&D activities in China.

However, many knowledge institutions are seen as having outstanding conditions for doing research, enjoying access to high-quality equipment as well as powerful research forces – a level of capacity individual enterprises can never dream to have. Research institutions are often non-profit organizations funded to a large extent by the government. As a possible consequence, these knowledge institutions tend to focus a lot of their attention on social responsibility, and care more about the environment than profit-making enterprises. The institutions put great effort in developing low-carbon technologies and examining how such technologies might affect social and economic aspects of society - such as energy-consumption patterns and efficient energy utilization, as well as people's general living conditions. As an example, Clean Energy Automotive Engineering Center of Tongji University (CEAEC) is devoted to promoting the industrialization of hydrogen and fuel cell vehicles. The nations' dependence on fossil fuels would be significantly reduced if vehicles in the future could be fuelled by clean energy, thus reducing CO_2 emissions and helping to build a low-carbon society. Another example is the Hydrogen Power Technology Institute of CEAEC, which mainly focuses its attention on the development and utilization of fuel cells and hydrogen technology. The aim of this research is to reduce the cell's production costs and improve its durability, thus promoting the hydrogen energy infrastructure and related key technologies.

The vast number of national knowledge institutions includes 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. In 1984, the Chinese government put in place a special plan to build many national laboratories. Today there are impressive 156 national key laboratories running all over the country. These research hubs have put many highly-qualified researchers together, and the government has provided the necessary financing for advanced instruments and equipment. With a relatively independent managing capacity, these labs carry out important work in producing, gathering, analyzing, and disseminating research information in the field of clean energy and innovation.

Studies of the R&D sector of renewable energy electricity generation (hydropower excluded) suggests that compared to the whole energy industry in China, the renewable energy sector is involved in technical collaboration with foreign knowledge institutions to a much larger extent. Through these cooperation modalities Chinese knowledge institutions and enterprises are able to access new research fields and markets, and can capitalise on foreign low-carbon energy technologies as well as critical know-how.

Entrepreneurs and the private sector

China has a very large number of enterprises engaged in the renewable energy industry. At present, there are more than 20,000 small hydropower enterprises, with 520,000 employees. There are more than 2,100 solar, wind, and biomass energy enterprises with more than 3 million employees across the country. In addition, over 3,000 semiconductor lighting enterprises employ more than 800,000 people across the country.

Observations from around the world suggest that the enterprises with their own R&D centers also have the strongest capacity to generate and apply new technological innovations. Therefore, it is of high interest to study the various support mechanisms of Chinese business that aim to provide such R&D capacities for small and medium enterprises (SMEs). These institutions are described further in the next section.

Intermediaries and incubators

There's an extensive support service system for technology innovation in China. It includes institutions that could be called intermediaries, such as industry associations, productivity promotion centers, technology development zones, scientific parks and incubators, etc. The main function of these actors is to provide a bridge between the government and enterprises and between technology provider and users, as well as providing a technology and information platform.

Currently, more than 1,000 of China's Productivity Promotion Centers can be found throughout the country. The main function of these centers is to support Chinese businesses in an array of issues, including providing training, consultations on policies and regulations, business diagnosis, investment & financing consultation, as well as intellectual property right protection. Another supporting structure is the existence of Industry Alliances in China. Through the integration of enterprise-college-research and the industry upstream and downstream chain, the aim is to establish a platform for communication and cooperation. On the basis of the enterprises' demand for development and the common interest of all parties, the alliances aim to upgrade the technological creative ability of industries, and form an integrated, technologically innovative, and cooperative organization which can share interests and risks – and can complement the different players' comparative advantages.

Furthermore, China has for several years promoted additional development opportunities for the country's many businesses through technological development zones, science parks, and incubators. Through technological development zones the government is able to promote research and application of high-tech innovative solutions for enterprises, concentrated on specified regional zones. Science parks provide infrastructure and supporting services to Chinese businesses, such as building cooperation with local development institutions as well as universities and research institutions. The science parks also provide critical management support and technology transfer services for small-and-medium-sized enterprises.

The business incubators for small- and medium-sized enterprises in the renewable energy industry provide physical space and infrastructure for these businesses. The

incubators offer a range of support services to reduce risks and entrepreneurial start-up costs, with the ultimate aim to foster successful businesses and entrepreneurs. Taking the Zhangjiang Star Business Incubator as an example, the service system includes the following five categories of support: (1) Providing financial means to grow: Companies that engage in the incubator enjoy supportive policies provided by both central and local governments, such as a large rent subsidies, tax relief, investment funds, etc. (2) Establishment of an "Angel Investment Platform": The platform provides - in advance - prepared equity investments for start-up enterprises that are assessed to have great potential. The platform works to make sure that the enterprises grow along with the incubator. (3) A special fund for new energy start-ups: A special fund that can contribute towards many private ventures and angel investments is dedicated to supporting new energy innovation and entrepreneurship. (4) Improving the investment and financing system: The incubator actively helps enterprises receive various sources of financial support from the government, including venture capital funds and innovation funds, as well as profitable loans. (5) Strategic guidance: With the professional guidance from venture mentors, counselors, and liaison teams, new enterprises receive a helpful hand during their first years of development.

The business incubators play an important role in facilitating low-carbon energy innovation development in China. Hi-tech zones provide effective actions to support the innovation of large- and medium-scale corporations. As an illustration of the crucial role of these national supporting structures, one could turn to the statistics from Baoding hi-tech technology zone. The *Baoding hi-tech new-business service center* has achieved a growth rate of over 50% for three consecutive years.

Challenges and Recommended strategies

Strengthening systems for knowledge development and information-sharing

In order to further enhance use of low-carbon innovations in China, there is a need to raise public awareness of the opportunities and benefits that come with a low-carbon lifestyle. Efforts to strengthen dissemination should be carried out through, for example, public information campaigns, the media, and school education. However, the difficulty in popularizing low-carbon lifestyles is due to people's living habits, and the high costs of utilizing low-carbon technologies. Therefore, further research on innovative systems for reducing costs of low-carbon energy use is needed. A strategy to increase the use of low-carbon innovations in China may include the development of planning services, management and performance appraisals, and financial instruments to stimulate demand.

Analysing research reports on energy systems in China in the 1990's reveals little mention of renewable energy innovation. This suggests that today's research on low-carbon systems is fairly new and a number of opportunities exist for expanding knowledge and innovation systems in China. One way of seizing this momentum is by establishing a national clean energy laboratory that could focus on enabling breakthroughs in key low-carbon technologies and renewable energy. Such a national hub for high-standard knowledge in this field is necessary to actively cooperate with enterprises and other institutions to popularize new products and encourage private organizations to increase research on innovation systems.

A challenge in the field of research is the perceived scattered approach to knowledge development on clean technology. This makes it difficult to initiate much needed trans-disciplinary and cross-sector R&D projects and programs, which have the

potential to guide China in the path towards a more sustainable low-carbon energy system. Therefore, the government should explore the possibility of establishing a government-funded, low-carbon technology innovation and R & D platform, which can reduce the cost of technological innovation of research institutes and enterprises, and expand the exchange of information at all levels.

Building capacities and increasing resources

Figure 20: Challenges for entrepreneurs in the Chinese innovation system.

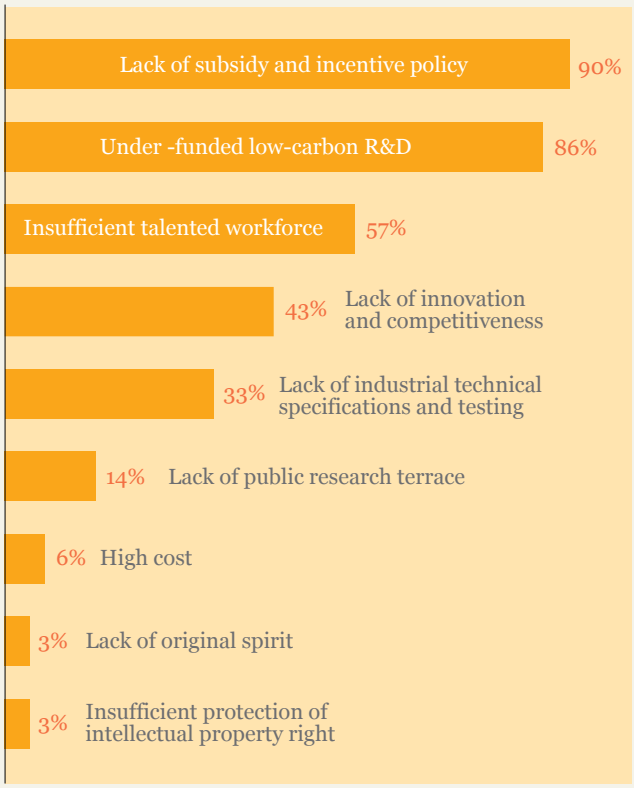

Figure 20 presents existing challenges in the Chinese climate innovation system identified by enterprises interviewed for this study. Turning these challenges into opportunities will determine the success of China's – and the world's! – transition to a low-carbon economy.

Close to 9 out of 10 entrepreneurs interviewed for this WWF research hold the opinion that with current market conditions, investments in low-carbon energy technology do not generate sufficient return in the short term. This results in a heavy financial burden as well as great market risks for individual small- and medium-sized enterprises. Lack of loans and other financing mechanisms, coupled with relatively backward research infrastructures, are the two common problems in the progress of China's low-carbon technology development and innovation. It is clear that there is a great challenge to increase investments in R&D of low-carbon energy technologies in China. Relevant literature in this field[1088] shows that in the year 2000, energy R&D investments in China amounted to about 6.34% of total R&D investment, accounting for 0.064% of the country's GDP. Government investments were 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 amounts invested, China is lagging behind the developed countries even more. In short, China faces a great challenge in stimulating increased investments in energy R&D, as current low levels are the fundamental reason for the lack of energy mainstream technology, along with independent intellectual property rights, and the slow development and high cost of low-carbon energy technologies.

Adding to the challenge mentioned above, 57% of the companies included in this study face the problem of lack of a technologically-talented workforce. There is a need to enhance the number of professional and technical personnel who have innovative capacity and can master core technologies that support technological progress and industrial development. It is therefore important to assist institutions of higher education with the continuous expansion and creation of related disciplines according to market demand, and to create a reserve of high-skilled entrepreneurs and personnel for the low-carbon industry. To that end, there is a similar need to address the lack of adequate business entrepreneurship training mentors, which are deemed to be too few to meet the needs of today's market.

1088 A study on Chinese Energy R&D Input, Ma Chi, National Oil Economy, March 2003; Cleantech Group, "10 Predictions for 2010" (2009).

Finally, close to half of the interviewed enterprises (43%) identified the lack of innovation and lack of competitiveness of low-carbon core technology, due to insufficient software and hardware for such research.

Establishing an enabling institutional framework

Despite the positive trend of increasing attention on renewable energy and environment as critical areas of concern in today's Chinese society, the economic inefficiency and high costs have forced the government to revaluate promoting a low-carbon economy. This has resulted in a slow-down of its large-scale industrialization process, and has impaired its international competitiveness. Also, while most institutions for renewable energy research are fall under the management of local governments, institutions for fossil energy are usually attached to the central government. These circumstances all hinder much-needed efforts to promote low-carbon energy innovations in China.

Notwithstanding impressive government efforts to enable development of low-carbon climate innovation systems in China during recent years, there are still challenges in the establishment of industrial technical specifications, standards, and certification systems. Limited access to such frameworks leads to cost-inefficient overlaps and disorderly competition in the market, which causes waste of public resources. So, there is an urgent need to develop quality and safety standards, so as to avoid wasting scarce resources, to protect interests of users, and to safeguard market expansion and development. With the establishment of standardization, serialization, and authentication systems for low-carbon technology and products, the costs could gradually be reduced and the technology could become more available in national and international markets.

Given that the low-carbon industry in China is relatively new and undeveloped it is critical that small- and medium-sized enterprises initiating investments in this market receive support. At the initial stage of business development in the low-carbon industry, enterprises are to a large extent dependent on incentive policies and subsidies, including loans, taxes, selling prices, etc. To meet the needs of such enterprises with high potential, the government should establish and strengthen favorable policies and financing channels for the application and industrialization of new energy technology. Direct support for low-carbon energy technologies is necessary in order to create a level playing field in competition with the continued massive subsidies for the conventional fossil-based energy industry. It is also reflected in research that the intensity of tax incentives is not sufficiently effective in China. This is partly because many rules and regulations are broad, brief, and too principled, without much-needed manoeuvrability. It is important to recognize, however, that many of the rules and policies in this area have just been formulated and adopted, and need to be tested in practice. For this reason it will be necessary to put national frameworks in place that make it possible to regularly track, research, monitor and evaluate government regulations and policies.

Last but not least, many enterprises stress the challenge of long application periods for intellectual property rights. In the low-carbon innovation patent process, it is necessary to: further simplify and shorten the approval time for patent applications; help enterprises convert a patent into productive force in a relatively short period of time; and, at the same time, constantly improve and strengthen patent protection.

Establishing a national platform for coordination and information exchange

The sections above have emphasised the need for increased national efforts to establish a series of industrial alliances and scientific centers to enhance coordinated

Wind power production site for one of China's 2,100 renewable energy enterprises.

and effective supporting services for low-carbon innovations. These platforms could facilitate useful connections between stakeholders in the innovation system, and ensure access to professional and technical personnel to take part in key processes and services.

The role of incubators in these efforts is of great importance. In order to seize opportunities for increased climate-sensitive investments, the following steps could be taken in the respective fields of renewable energy production:

1. Set up an alliance of solar energy power generation at the Yangtze River Delta, to gather the strengths of relevant corporations, research institutions, universities, etc. The alliance would focus on development and production of photovoltaic cells and generating systems with high efficiency and low cost.
2. Build a new energy alliance along the Bohai Sea in Tientsin that brings together rim corporations, research institutions, and universities mainly to develop and produce thin-film solar cells.
3. Set up a wind power generating alliance along the Southeast coast that gathers climate innovation stakeholders to practice autonomous designs and constructions of wind farms and maritime wind farms.
4. Construct bio-fuels alliance that could mainly take part in the development and production of ethanol, diethyl ether, and synthetic fuel with the association of related corporations, research institutions, and other key stakeholders.
5. Using the same model as proposed above, build up hydrogen energy and fuel cell alliances.