

SUSTAINABILITY, ENVIRONMENTAL DEGENERATION AND CHINA'S EXPANDING ENERGY NEED: DO VARIOUS RENEWABLE ENERGY SOURCES OFFER AN ALTERNATIVE APPROACH TO CHINA'S COAL BASED ENERGY GENERATION?¹

China's energy needs and its coal based energy generation carries fundamental political, economic and social implications for China's future development and its ability to sustain its impressive economic growth. China is already a major polluter with significant social and economic implications and the economic growth focus of its government carry the potential to worsen the situation further. In addition, China also witnesses an increasing process of urbanization and lifestyle change of its urban population, which also increase the energy demand significantly. In addressing specific environmental issues, it is of critical importance to identify the historical trajectories of social inspired environmental challenges and putting them in the contemporary context. Environmental degeneration is neither a solely political, social, economic or technical issues but represent a combination of them. Hence, in China's case, addressing the increasing energy demands of its growing economy and emerging middle class representing critical political, economic and social issues for the government as does the question how best to address China's environmental challenges. As China's energy demands will further increase and the negative implications of its coal based energy generation process are already identifiable in various ways, the issue to what extent renewable energy sources could replace not only present but equal important, future coal based generated energy, becomes an increasing critical topic. Substituting coal based energy generation with renewable energy sources would not only help to address China's greenhouse gas emissions but also adding to the improvement of various local environmental situations by reducing air pollution. The paper will focus on the questions to what extent could wind power and solar photovoltaic-based renewable energy resources could help to address the actual energy demand, but in addition would also offer a response to future energy demands.

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INTRODUCTION

China's energy need and its coal based energy generation carries fundamental political, economic and social implications for China's future development and its ability to sustain its impressive economic growth. China is already a major polluter, which carries significant social and economic implications and the economic growth focus of its government, as well as the increase in urban energy consumption will only worsen the situation further. As environmental degeneration is a multi-faced issue, representing a combination of economic, developmental, technical, social and political factors, addressing the environmental challenges thus required both a multi-faced approach and the identification of its historical trajectories. Among the related issues of environmental degeneration, we can identify are: its close link with development, the inherent political-social implications and challenges faced when addressing issues of environmental degeneration; a technical-economic nexus, as well as the international dimensions of various environmental issues. In this context, identifying the historical and social origins of specific environmental challenges are of crucial importance for developing a comprehensive understanding into the challenges environmental degeneration represent highlighting the complexity of the challenges faced when addressing environmental degeneration and climate change. Consequently, addressing specific environmental challenges will not only require economic-technical solutions but also requires addressing the underlining social-political dimensions as well. Hence, in China's case, addressing the increasing energy demands of its growing economy and of its emerging middle class represent critical political, economic and social issues for the government. Overall, the government's growth strategy has the potential to exacerbate the negative environmental impact further. In addition, the variety of environmental issues China is facing increases the underling complexity of how best to respond and to address these challenges. It is crucial to recognize that China's multidimensional environmental challenges also carry critical implications of its international standing.

As China's energy demands will certainly increase further and the negative implications of its coal based energy generation process are already identifiable in various ways, the issue to what extent renewable energy sources could replace not only present but equal important, future coal based generated energy demands, becomes an increasing serious topic. A shift towards renewable sources for generating energy would not only assist China to address its raising greenhouse gas emissions but also adding to the improvement of various local envi-

ronmental situations by reducing serious pollution issues. In addition, improving the energy efficiency certainly will help to address and reduce both air pollution issues and China's contribution to the process of climate change. The paper will focus on the questions to what extent could wind power and solar photovoltaic based renewable energy resources address not only the actual energy demand China's had to deal with, but in addition would also offer a response to future increasing energy demand. Yet, it will also be argued, that renewable energy sources also play an important role in the wider context of development and in attempting to counterbalance future increases in energy consumption, especially in urban energy consumption. Again, the political-social dimension is as critical as the technical-economic context.

CHINA'S ENVIRONMENTAL CHALLENGES

It is beyond question that China faces a critical and complex environmental challenge, characterized by a range of specific issues. Among them, we can identify: land degradation; water scarcity; water and air pollution; frequent and high intense environmental accidents; and various forms of climate change impacts. The seriousness of China's multifaceted environmental issues are recognized in the 11th Five-Year-Plan (FYP) for Environmental Protection by stating: 'the improvement of environmental quality represents an important component for the implementation of the scientific outlook on development and development of socialist harmonious society'.² In many cases, issues of water and air pollutions representing the pressing environmental challenges China's population are confronted with. Even as the pollution issue signifies a critical environmental issue, this should not negate the increasingly negative impact climate change has on China's environment and its population. The challenges climate change inherent for China's environment and its people are addressed in various government reports and White Papers³ thereby clearly indicating the government's awareness of the vulnerability and urgency regarding the negative implications of climate change as well as the environmental challenges China face. The White Paper on Policies and Actions for addressing Climate Change also highlights specific areas of concern, by identifying a number of key is-

² The National Eleventh FYP for Environmental Protection 2006-2010, http://english.mep.gov.cn/Plans_Reports/11th_five_year_plan/200803/t20080305_119001.htm

³ For example: China's Energy Conditions and Policies; Environmental Protection in China; China's Policies and Action for addressing Climate change; Environmental Protection in China (1996-2005)

sues and by emphasizing that adverse effects are already identifiable especially within agriculture, with regard to the availability of water resources and an accelerating trend of sea level rise⁴. In addressing the challenge environmental degeneration pose, the 11th FYP for Environmental Protection highlights the connection between development and environmental issues, by stating: ‘The contradiction between socio-economic development and resources and environment constraint becomes increasingly evident’⁵. Consequently, promoting sustainable-development represents a crucial goal in addressing climate change and environmental issues. Yet, it is the economic success of the reform period, the energy need of an emerging middle class, and the rapid urbanization process, which significantly increased the pressure on the environment. Here again, we are reminded that environmental degeneration occurs within a specific historical and political-social context and not only within a specific economic-technical context. There exist an additional and equal critical aspect which long-time implications, the issue of lock-in developments. This refers to the issue that the selection of a specific development process, the focus on a specific energy source will generate its own impact on further development, hence impeding a shift towards an alternative strategy at a later stage. Therefore, critical decisions regarding which specific development path a country will follow, which energy sources it will focus on, are inherent political and taken within an economic and social historical context. As shown in Figure 1, coal provides the principal source for generating energy. This dependence on coal in producing sufficient energy largely contributes to China becoming one of the leading CO₂ emitting nations and its increasing contribution the increasing process of Global Warming. CO₂ also represents a critical issue for urban air quality in many Chinese cities. A comparison of the GDP growth rate with the energy production growth rate (Figure 2) signifies that China has managed to disconnect economic growth and the growth in energy production, which certainly represents an important and progressive step, albeit the relationship is not characterized by a singular but a dynamic process between the growth rate of energy production and the growth rate of the GDP. The 2003 to 2005 period present a clear indication of this. Although the following years have indicated a return to the former trend, it needs to be seen whether this will be an indication for the years to come.

The economic reforms have certainly transformed China and had a fundamental positive im-

⁴ China’s Policies and Action for addressing Climate Change, http://www.china.org.cn/government/whitepaper/2008-10/29/content_16682687.htm

⁵ The National Eleventh FYP for Environmental Protection 2006-2010, http://english.mep.gov.cn/Plans_Reports/11th_five_year_plan/200803/t20080305_119001.htm

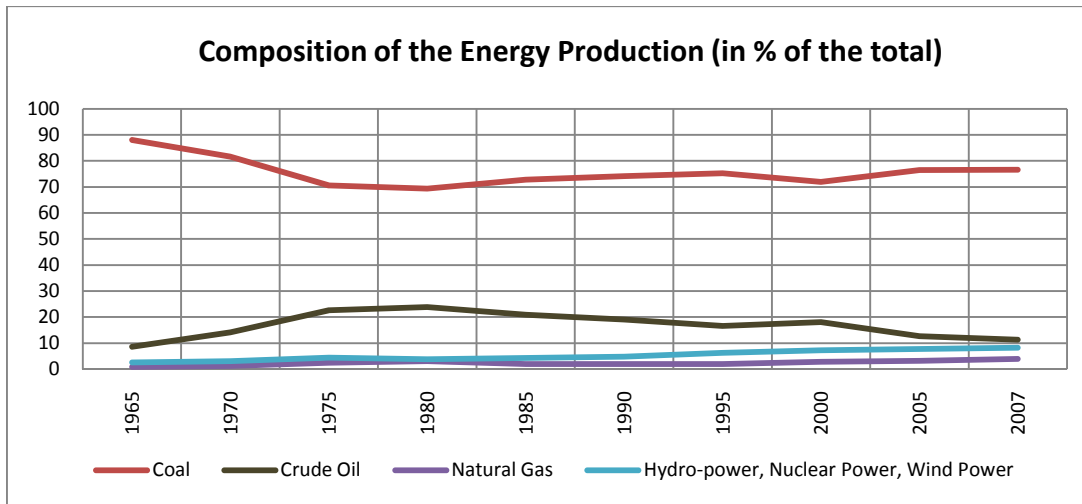


Figure 1 – Composition of the Energy Production; Source: Various editions of the Chinese Statistical Yearbook

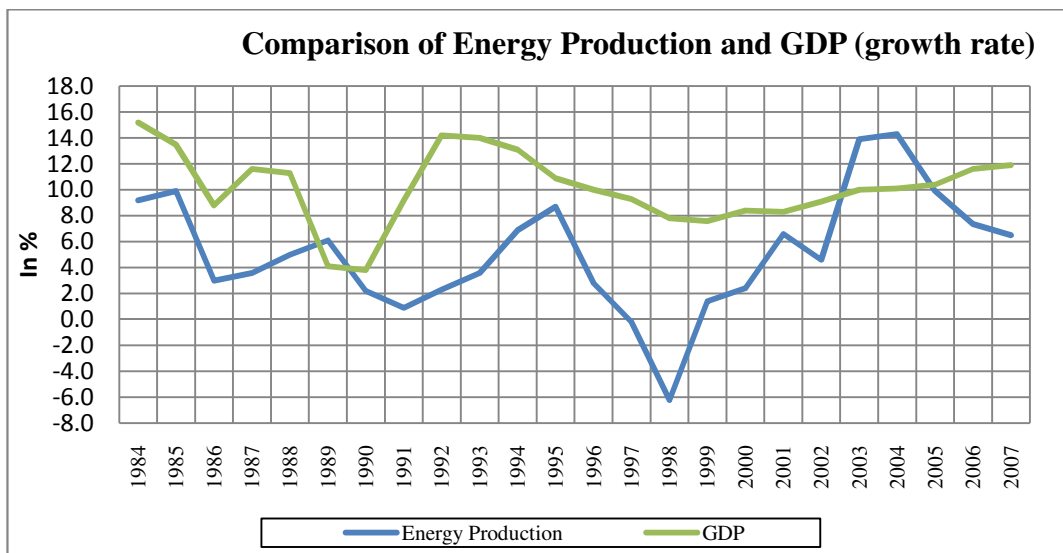


Figure 2 - Comparison of Energy Production and GDP growth; Source: Various editions of the Chinese Statistical Yearbook

pact on million Chinese people by lifting them out of absolute poverty. Yet, this success came at a significant cost and the increasing environmental stress China’s population has to endure is one prominent feature. Critically, as the challenge environmental degeneration represents for China’s future development has to be understood in a wider political and developmental context, the following section will focus on this wider and complex relationships.

DEVELOPMENT AND ENVIRONMENTAL ISSUES: A MULTIFACETED RELATIONSHIP WITHIN A SPECIFIC HISTORICAL AND SOCIAL CONTEXT

In analyzing the complex relationship between development, politics and environment it is critical to recognize that this relationship exists within a specific historical and social setting and to remember that guaranteeing economic development and prosperity is a fundamental aim of all governments, and contribute to their political legitimacy. The economic imperative becomes especially visible when faced with economic backwardness and economic underperformance. Environmental considerations often sidelined, as there exist a perception regarding a goal conflict between environmental protection and economic growth and prosperity. Hence, albeit accepting the crucial importance of economic development for political legitimacy, an economic growth strategy can also incorporate the goal of protecting the environment, thereby limiting the potential negative implications. Critically, which strategy a country selects – cleaning up while growing or cleaning up after successful economic growth – is a fundamental political decision, which is made within a specific historical and social-political structural environment. Regarding the situation in China, there are strong indications that its leadership has become increasingly aware of the multifaceted, and especially social-political, challenges environmental degeneration represent for China's future development and its population. The National Eleventh Five-Year-Plan for Environmental Protection (2006-2010) emphasizes that the existing focus on economic growth should be replaced with an equal emphasis on both, economic and environmental goals⁶. An similar position can be identified in the China Human Development Report 2009/10 by stating that human development should be not only the ultimate objective but to measures human development in economic growth figures alone would be misleading, instead development requires a holistic approach.⁷ Nevertheless, generating economic growth still figures prominently within the Chinese leadership's considerations, and not without justification as generating economic growth provides a crucial part of the political legitimacy the Chinese Communist Party (CCP) enjoys.⁸ Nevertheless,

⁶ The National Eleventh FYP for Environmental Protection 2006-2010, http://english.mep.gov.cn/Plans_Reports/11th_five_year_plan/200803/t20080305_119001.htm

⁷ China Human Development Report. 2009/10: China and a Sustainable Future: Towards a Low Carbon Economy and Society: English, Compiled by United Nations Development Program, (2010), p. 1

⁸ Highlighting the critical relevance of economic development and performance in providing the CCP with political legitimacy Deng Xiaoping himself acknowledged in the spring of 1992: "Anyone who attempted to change the line, principles and policies adopted since the Third Plenary Session of the Eleventh Central Committee would not be countenanced by the people, he would be toppled." Adding that "[h]ad it not been for the

addressing environmental degeneration constitutes a complex challenge for China's government as sustaining its economic growth strategy not only requires the use of more resources in the future, but in addition, rising living standards and lifestyle changes, increasing and rapid urbanizations as well as rising industrialization will add pressure in generating enough energy. This in turn will increase the negative impact on the environment. Furthermore, China's enormous dimensions, regarding the size of its economy and the size of its population represents an additional and crucial factor that fundamentally contributes to the negative dynamic China development has on climate change and on environmental issues.

Nonetheless, assessing China's global environmental impact is not as straightforward as it may appear. Take for example the issue of CO₂ emissions, where China overtook the USA in 2006 as the leading global emitter. The country level data presented in Figure 7 clearly indicates that we can identify from the late 1980s onwards first an accelerating and then from 2000 onwards a dramatic increase of China's CO₂ emissions. The challenge this poses for the global climate system seems obvious and clearly identifiable. However, we will reach a rather different assessment, when taking into consideration the data provided in Figure 8, which compare China's CO₂ emission with leading industrialized countries on a per capita basis. Here the ranking order changes dramatically, with the United States far in the lead, followed by other highly industrialized countries and China ranking far below them, albeit one also can identify China's upward trend, but this trend is less dramatic when compared to the data in Figure 7. Making a comparison on a per capita basis is essential when considering that leading industrial countries not only highlighting their economic growth and consumption based strategies but also encourage other countries to follow their model. Yet, one has to take into consideration the dramatic environmental impact this would generate if other developing countries and of course China would follow the example of the leading industrial nations. Hence, as indicated before, it is critical to acknowledge, that increasing environmental damage should not be accepted as an unavoidable element of economic growth, instead it rather reflects a specific political choice.

achievements of the reform and the open policy, we could not have weathered June 4th." (Selected Words of Deng Xiaoping, Volume III 1982-1992). <http://english.peopledaily.com.cn/dengxp/vol3/text/d1200.html>

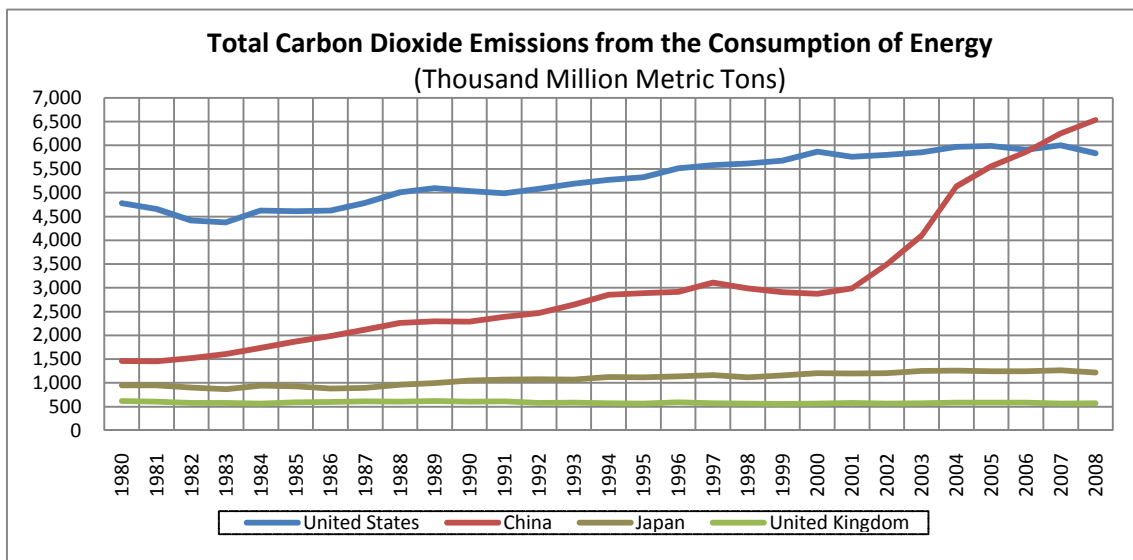


Figure 7 - Data from: Energy Information Administration – Official Energy Statistics from the US Government; <http://www.eia.doe.gov/environment.html>

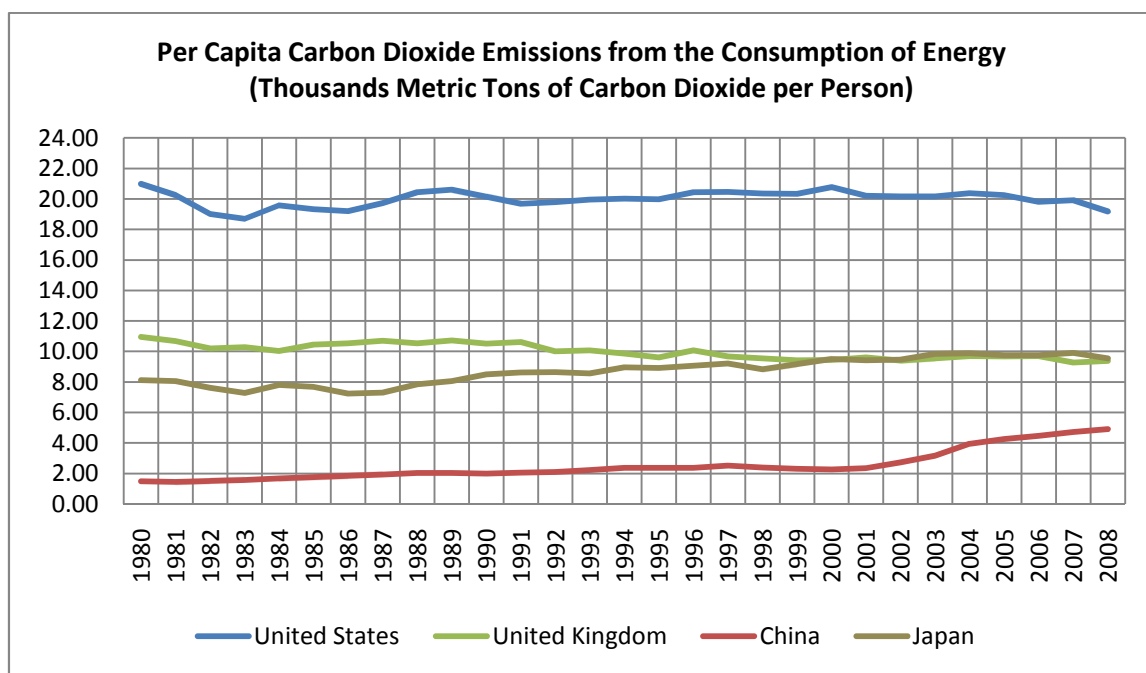


Figure 8 - Data from: Energy Information Administration – Official Energy Statistics from the US Government; <http://www.eia.doe.gov/environment.html>

Environmental concerns already became a critical subject at various National Peoples Congresses and figured as a topic in Hu Jintao’s report at the 17th National Party Congress, held in

October 2007. Sustainable development and an environmental-friendly society were mentioned as a significant goal for further development.⁹ Equally, the 11th FYP also offers a renewed commitment in addressing pressing environmental issues and a potential change in the development strategy, by emphasizing the development of a ‘resource-efficient and environmentally-friendly society’ and a change towards a ‘more environmental friendly’ energy mix by increasing the contribution of renewable energy sources¹⁰. Again, and in a rather stronger way, the Chinese Human Development Report also emphasizes addressing the environmental implications of China’s economic modernization requires a shift in it’s the development strategy towards a low carbon economy. Adding, that such a shift no longer represents an option, but instead an essential requirement. It is further emphasized, that a low carbon economy provides major opportunities for promoting technological innovations, transforming production processes and consumption pattern, as well as sustaining economic development.¹¹ However, environmental protection and addressing climate change are not seen an independent goal, but in the context of securing national development in general which is also emphasized throughout the Chinese Human Development Report. Emphasizing that mitigating the impacts of climate change and environmental degeneration, increasing energy efficiency and adapting renewable energy technologies also enhances China’s energy security.¹² In addition, fostering the adaption and dissemination of renewable energy technologies will provide critical access to energy for rural and remote areas as well, thereby addressing another critical issue in China’s development.

Being successful in delivering these goals, will certainly increase the legitimacy of the government and the Communist Party, thereby highlighting the critical political implications a specific development strategy carries. In addition, we are also reminded on the ‘human security’ dimension, which underlines the concern of environmental degeneration.

⁹ The environmental issue was addressed in Hu Jintao’s report to the 17th Party Congress, on October 15th 2007. The environmental issue was mostly addressed in the context of resource scarcity and its potential negative impact on further developments of the environment and the negative impact on the quality of life as a result of the economic development. Hu Jintao further acknowledged that China’s economic growth is realized at costs of resources and the environment, <http://english.cpc.people.com.cn/66102/6290205.html>

¹⁰ The National Eleventh FYP for Environmental Protection 2006-2010, http://english.mep.gov.cn/Plans_Reports/11th_five_year_plan/200803/t20080305_119001.htm

¹¹ China Human Development Report 2009/10, p. 16

¹² China Human Development Report 2009/10, p. 17

RENEWABLE ENERGY SOURCES AND THEIR POTENTIAL IN ADDRESSING CHINA'S ENVIRONMENTAL ISSUES AND ENERGY DEMAND

In evaluation the prospect and impact renewable energy resources, in the context of this paper, wind and solar energy, will have in addressing China's huge and increasing energy needs as well as in mitigating the effect of environmental degeneration and climate change within China, we have to take into considerations a variety of aspects. Among them, we can identify: issues of development and modernization; the energy needs of China's industry; the accelerated process of urbanization and life-style changes of China's rapidly growing middle-class. In addition to these demand-side pressures, further challenges are identifiable, as for example technological issues and geographical factors as the potential locations of renewable energy sources are not always matching with the location where the energy demand is at highest. There are also manifestations of ongoing political conflicts between the centre and various provinces over the implementation of various economic decisions, especially related to the closure of energy and polluting intensive industrial units. This again highlights the complexity when addressing China's increasing energy demand and the related environmental degeneration and climate change issues, and the requirement of understanding the wider political-social-economic context. The main characteristics within the contemporary political-social-economic setting we can identify in China are an emerging consume-oriented middle-class, an almost dramatic process of urbanization, an impressive economic development and a fundamental reliance on coal (because of its domestic abundance) for generating the energy required. Yet, it is this overreliance on coal, which also represents the source of critical pollution issues and which drives China's contribution to climate change, hence, replacing fossil fuel energy, especially coal, with energy generated from renewable sources represents an critical issue in addressing China's environmental issues. Yet, to ensure that such a shift will be successful, the future development of renewable energy sources is of crucial importance.

This section focus on the development and potentials wind power and solar power offer in addressing China's increasing energy demand, and in their contribution of lessen the negative impact on its environment by reducing pollution issues as well as in reducing China's contribution to the process of climate change.

Wind Energy Resources

It is now widely accepted that China possesses rich sources of wind energy, but they still need to be developed. Yet, these potential sources of wind power are not evenly distributed within China, instead they are located in specific areas as in the northeast and north-west of China as well as along its southeastern shoreline. Hence, various localities are more able to profit from the abundance of potential wind power as an alternative energy resource than other and do not necessarily correspond with the locations, where the energy demand is strongest. This is especially critical in the context of the China's less developed grid network, which hamper the distribution of this energy source towards the urban and industrial centre where it would be needed most, thus weakening its potential in providing a renewably sources for energy generation. However, another notable aspect, as mentioned in the 'China Wind Power Report 2007', is that wind power resources complement seasonal variations of hydro power resources, offsetting periods when hydro power is lesser available. Yet, again, the issue of location also undermines to some extent this positive offset. Independent of these challenges, the development of grid-connected wind power farms goes back to the 1980s, and was characterized by a rapid and continues development of installed wind power capacities with growth rates of almost 40 percent during the 2000 to 2006 period and a growth rate of 105 percent in 2006 alone.¹³ Despite this impressive increase in the installed wind-power capacities, the character of the earlier mentioned regional distribution did not changed. In the 'China Wind Power Report 2007' is also mentioned that a long-term target is not only to make wind power competitive with conventional power technology by 2020, but in addition that wind power should became the third major source for electricity generating, after fossil fuels and hydro power.¹⁴ In 2008, China ranked fourth within the top ten global nations regarding added and existing wind power capacities.¹⁵ In 2009, China not only kept its global second position regarding the total wind power capacity installed worldwide, China also became the global leading nation for installing new wind power capacity, more than doubling the amount of installed wind power from 2008.¹⁶ Equally, the 2009 Renewable Global Statues Report also highlight the gains made by China, pointing out that China strongly contributed to the strong

¹³ See 'China Wind Power Report-2007, Lead Authors: Li Junfeng Gao Hu Shi Pengfei Shi Jingli Ma Lingjuan Qin Haiyan Song Yanqin, p. 4-5

¹⁴ 'China Wind Power Report 2007', p. 49

¹⁵ 'Renewables Global Status Report 2009 updates', p. 23

¹⁶ Wind Energy Barometer, EurObserv'ER March 2010, p. 44

global wind power market growth in 2008. China ranked second in adding new wind power capacity, and doubled its total wind power for the fifth year in a row.¹⁷ The data in Figure 9, total installed capacity of Wind Power, clearly demonstrate these positive developments and highlight the strong progress made since 2006.

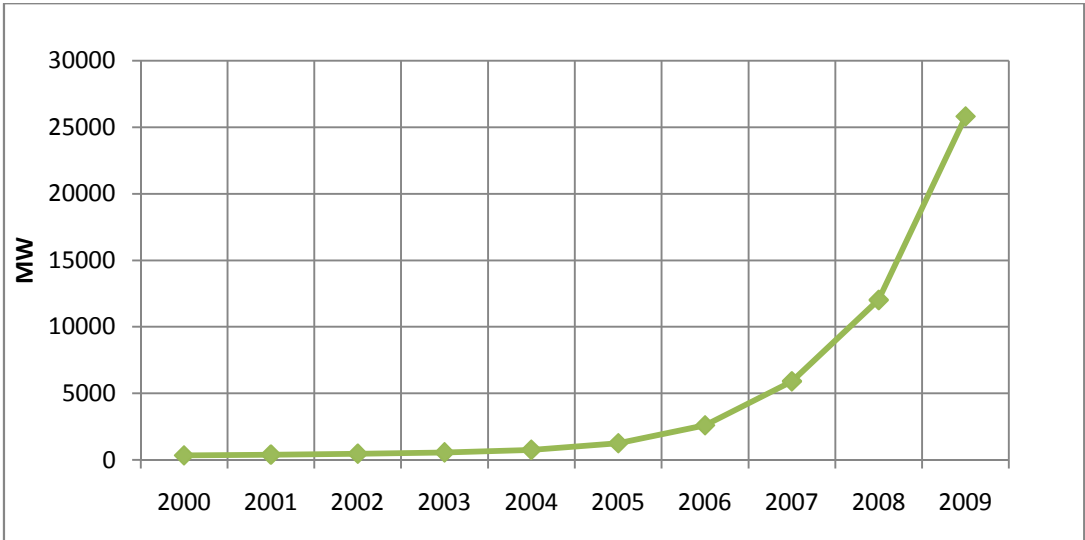


Figure 9 - Total Installed Capacity Wind Power (MW); Source: GWEC Global Wind 2009 Report, page 27

By 2008, China was the world’s second largest wind market by newly installed capacity and the fourth largest by overall installed capacity.¹⁸ The gains made did not come on its own, and the second report on China’s Clean Revolution, clearly stated that various government policies did facilitate the domestic growth of the wind power industry, by various supportive measures among them industrial, fiscal and taxation policies, and a mandatory feed-in wind power quota. Another measurement was that the government insisted that 70 % of the equipment needed for wind-power plants must be made domestically.¹⁹ Independent of the dramatic success wind-power had, several critical issues remain, among them: accurate wind resource assessments; increasing the innovation capacity of the wind power industry; grid construction and management did not keep pace with the development of wind power; improving

¹⁷ ‘Renewables Global Status Report 2009 updates’, p. 11
¹⁸ Global Trends in sustainable Energy Investment 2009: Analysis of Trends in and Issues in the Financing of Renewable energy and Energy Efficiency, United Nations Environment Program and New Energy Finance, 2009, p. 48
¹⁹ China’s Clean Revolution II: opportunities for a low carbon future, The Climate Group, 2009, p. 28-29

the pricing system; and the improvement of the standard and certification system for wind power.²⁰

Turning to solar energy as another renewable energy source with a critical potential, it shares some characteristics and challenges with wind power as a viable source of renewable energy and for offsetting the coal based energy generation.

Solar energy resources

As in the case of wind power, China also has rich abundance on solar energy resources, and this richness is a bit equally distributed all over China, albeit lesser developed regions in western China are in a rather more advance position regarding their access to potential solar energy resources. Alike the above case of wind power, the solar energy market saw a dramatic development over recent years in China, albeit one can identify, as emphasized in the 2007 Chinese Solar PV Report, a specific focus on: rural electrification, communication and industrial purposes, road signs as well as for lighting.²¹ Nonetheless, we can identify various projects within Chinas urban areas as well, including Beijng's 'Lightning-up Program', which emphasized the use of solar streetlights in the constructing of new urban development. In addition, another project in rural areas of Beijing, 'Solar Lighting in 100 Villages', lead to the installation of nearly 40.000 lights. In yet another project, 'China Brightness Program', several western provinces were the focus of PV applications,²² less surprising then, that an increasing number of companies identified PV manufacturing as an interesting industrial segment for their activities. The amount of annual installed solar PV kwp²³ in China (Figure 10) is not

²⁰ 'China Wind Power Report 2007', p. 50

²¹ 'China Solar PV Report 2007', Lead Authors: Li Junfeng, Wang Sicheng, Zhang Minji, Ma Lingjuan, p. 15

²² 'China Solar PV Report 2007', p. 21

²³ Die Größe einer Photovoltaik-Anlage wird nach der Leistung des Solargenerators in kW_{peak} (kWp) angegeben.

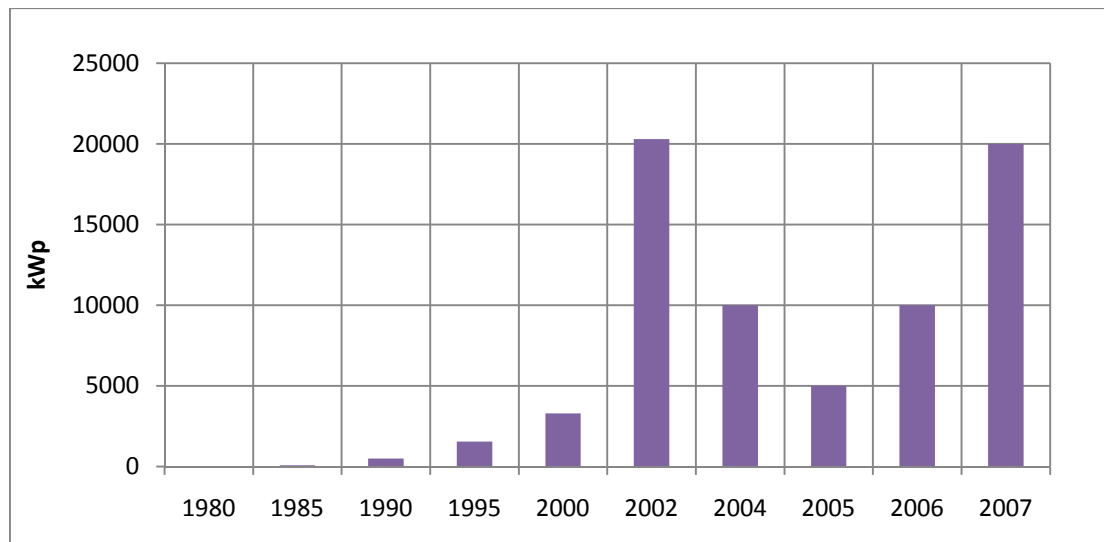


Figure 10 - Annual Installation of Solar PV in China; Sources: China's Clean Revolution II: opportunities for a low carbon future, August 2009, p. 25

only impressive, but also adds to the economic viability of solar generated renewable energy sources. Nonetheless, as emphasized in the 2007 China solar PV Report, on-grid solar system technology is still at an early stage in China, albeit there are projections that this will undergo changes in the near future. Some cities are already at the forefront of this development, as for example Shenzhen, which already completed the largest grid-connected solar PV system in Asia. Other Chinese cities are following its example.²⁴ Yet, China's geographic characteristics open it to another, and potential critical application of solar PV, large-scale desert power plants, albeit the grid connection issue is as important as it is in the case of wind power. Again, issues of sufficient capacity, to transmit the power as well as the geographic location of power demand are vital issues as well. The 2007 China Solar PV Reports highlight that large-scale PV desert power plants should be within 50 km of the main grid system and neither more than 100 km away from potential power demand centers to reduce transmission loss.²⁵ Yet, there is another example of the success in the application of solar generated energy, albeit it may be less impressive from a technological angle. China's solar water heater market is growing at 20 percent annually and not only contributes in addressing the increasing energy demands in China's cities, but also help addressing the serious urban air pollution sit-

²⁴ 'China Solar PV Report 2007', p. 26

²⁵ 'China Solar PV Report 2007', p. 27

uation as well.²⁶ In 2008, China also succeeded in becoming the leading nation in the PV cell production on the global level, certainly adding to the economic access of the industry.

Further prospect of development of renewable energy sources

The 2002 Township Electrification Program relied on photovoltaic as well as small-scale wind electricity generators to solve the power supply problem in more than 700 townships in seven provinces in western China, and by 2005, 721 sets of wind-solar PV power stations had been completed. By providing electricity to 300.000 households, this makes it the world's largest rural electrification project.²⁷ The Renewable Energy Law, enacted in January 1st, 2006, provided additional contribution to the dynamic of the renewable energy sector, by stipulating various critical aspects. Among them, we can identify a strong commitment to the development and facilitation of renewable energy sources and the renewable energy market (Article 1 /4). In addition, the law also stipulates that central state organs are responsible for organising and coordinating the survey of national renewable energy resources (Article 6) as well as setting out middle and long-term targets regarding the utilisation of renewable energy resources at the national level (Article 7). Article 8 also stipulates that the province level authorities and authorities of autonomous regions and municipalities should set targets for their respective area, in accordance with the set targets of the national middle and long-term developments targets. In addition, the scientific research into the technical and industrial application of renewable energy source is identified as a priority by the government (Article 12). There are specific references made to the issue of grid-connected renewable power sources and that grid enterprises are required to build and update their grid system to enable the transmitting renewable generated energy. However, the related cost shall be shared (Article 13 /14 / 21). The Renewable Law also stipulates the establishment of specific technological standards especially in relation to the solar energy utilization in construction and the design of buildings. This also includes the setting of efficiency standards (Article 17).²⁸ Another crucial step provided the 'Medium and Long-Term Development Plan for Renewable Energy in China' prepared by the National Development and Reform Commission, which also stipulated the further developed of the renewable energy sector by providing a policy framework. Emphasizing various strategies: adopting a renewable energy development strategy as a key

²⁶ 'China's Clean Revolution', The Climate Group, (2008), p. 19

²⁷ 'China Solar PV Report 2007', p. 25

²⁸ 'The Renewable Energy Law', www.renewableenergyworld.com/assets/download/China_RE_Law_05.doc

strategy for achieving China's goal of a sustainable development; increasing the market competitiveness of the renewable energy sector as well as increasing its share in the overall energy consumption mix, are fundamental and guiding principles. The overall objectives regarding the development of the renewable energy market for the next 15 years identified as increasing the proportion of renewable energy in the total energy consumption, resolving the problem of power shortage in remote, off-grid, areas.²⁹

Here we can identify key government strategies, which helped the renewable sector in its commercial development and facilitated a process that saw China becoming an important place for low carbon investment on the global level. Government policies underlines these developments and as stated in the second report on China's Clean Revolution, Chinese decision-maker are adjusting their national development strategies for providing a greater focus on the low carbon economy, by placing a stronger emphasis on energy conservation, emission reduction, the development of renewable forms and low emissions vehicles.³⁰ Albeit it would be misleading to contribute the renewable energy sectors success solely to government initiatives, albeit, set at the right time, government initiatives do can have crucial impact in stipulating a specific market segment. For example, government support was needed (development of wind-power and its related industry) and came in the form the Renewable Energy Law, introduced in 2006. However, additional measurement as a specific pricing policy and a requirement for grid companies to purchase renewable electricity as well as a policy of cost distribution (over the whole network).³¹ Yet, over time, both domestic demand and government policy facilitated that China now become one of the few mass-producing countries of wind turbines.³² That such a development provides additional input for generating further contributions into China's wind-power industries and in installing additional wind-power capacities is rather apparent. Such development also provides a good example for another critical issue, that the renewable energy sector provides not only a dynamic growth potential but also offers employment opportunities. This observation applies for both, wind and solar power industries. Government support for solar power also included pilot projects, building Solar Cities, as well as specific research schemes to facilitate related technological development

²⁹'Medium and Long-Term Development Plan for Renewable Energy in China', 2007, page 4, 5, www.chinaenvironmentallaw.com/wp-content/uploads/2008/04/medium-and-long-term-development-plan-for-renewable-energy.pdf

³⁰ China's Clean Revolution II: opportunities for a low carbon future, The Climate Group, 2009, p. 8-9

³¹ 'China Wind Power Report 2007', p. 5

³² 'China Wind Power Report 2007', p. 15

which may over time become commercial viable as well. Overall, facilitating the commercial use of both wind and solar power represent a critical issue and will certainly be instrumental in reaching ambitions targets like that mentioned in the 2007 China Solar PV Report in 2050 thirty percent of China's electrical power capacity shall be generated by renewable energy resources.³³ In addition, as emphasized in the 2008 report 'China's Clean Revolution', economic factors are the major short-term reasons which restrict the use of renewable energy sources in China, hence government intervention will be a critical issue for advancing its commercial use.³⁴ As it is already the case, China's renewable energy power generating market not only expanded by 75 percent between 2004 to 2008 but this also contributed towards China's success of becoming the leading nation in this market³⁵ Renewable energy is clean and sustainable, and is especially successful in offsetting the negative implications of fossil fuels use for energy generating as it reduce the carbon dioxide emissions. In addition, renewable energy sources are sustainable as well and will improve China's energy security situation as well, as the sources of renewable energy are local.

³³ 'China Solar PV Report 2007', p. 43

³⁴ 'China's Clean Revolution', 2008, p. 8

³⁵ 'Renewables Global Status Report' 2009 update' (REN21), (2009), p. 12

RENEWABLE ENERGY SOURCES AND THE ISSUES OF LOCK-IN DEVELOPMENT AND THE CHALLENGE OF COMMERCIALIZATION

A fundamental and critical question is, to what extent diverse sources of renewable energy could provide an alternative source for China's coal based energy production and equally critically the ability of generating enough energy to keep up with the increasing demand. Albeit the success of renewable energy sources in providing energy for China's economic development and its almost dramatic process of urbanization, wind and solar power will not be able to replace coal generated energy production in the near future. The above mentioned aim that renewable energy sources will provide 30 percent of the national energy mix by 2050 is still an ambitious target. Nonetheless, it would be misleading to conclude that renewable energy, especially wind and solar power, are not offering an alternative route of development in addressing China's future energy needs and the environmental degeneration it faces. A critical issue relates to the crucial question of how long the 'window of opportunity' for alternative routes of economic development will exist as economic investment in specific industries will create specific incentives and embedded interests which may forestall a future shift in a country's development strategy. China Sustainability Development Report (2009) recognizes such implications for further developments, by emphasizing that China faces a critical strategic situation as it could surpass the traditional heavy-chemical industrialization stage in its national development and could instead focus on a strategy towards a low carbon economic transition.³⁶ Regarding this process of lock-in, Ruth points towards a process of co-evolving of a specific institutional setting for particular industries by citing the example of centralized fossil-fuel based power plants which led to the generation of public/private research facilities for addressing related issues. This generates additional vested interests and facilitating a process of development which consequently forestall a shift in strategy at a later stage.³⁷ One may recall the dominant position heavy industry enjoyed in pre-reform China and the political power of the related ministries, to appreciate the implications the selection of a specific economic developmental strategy has. Overall, the dominance of the heavy industry was based on political decisions made by the leadership indicating their conviction that the development of heavy industry was a pre-requisite for national development and national strength. In this

³⁶ Yi Wang, China Sustainable Development Strategy Report 2009 – China's Approach towards a Low Carbon Future, Executive Summary, 2009, p. 8

³⁷ Mathias Ruth, 'Future socioeconomic and Political Challenges of global Climate Change', in Dennis Pirages and Ken Cousins (eds) Resource Scarcity to Ecological Security, (2005), p.162

context it is worth noting that the Chinese government designated the automotive industry as a pillar industry of the national economy in 1994, thereby not only following other major industrial countries but also providing important signals for a specific industrial development as well as generating specific economic incentives and interests with critical long term implications. It is worth noting that, adapting and fostering the development of renewable energy resources represents as much a political-economic issue as it presents a technological challenge.

Yet, there is an additional dimension regarding the process of the 'lock-in' dynamic, which is especially relevant to China: the issue of urbanization and urban energy consumption. China does experience a strong urbanization process highlighted by the increase in its urbanization rate from 17,9 % in 1978 to an expected 47% by the end of 2010 and of 60% around 2030.³⁸ A further potential increase in urban energy consumption certainly can be expected, especially if China would follow urban consumption behavior of developed countries and would reach contemporary consumption levels similar to those in the United States, Japan, or of European countries. Such a development would not only exert a strong negative impact on China's own environment but would also dramatically increase China's contribution to the process of global climate change. Addressing urban energy consumption is not solely a technological issue, as the reduction of energy use per unit of output does not play such a dominant role as in manufacturing. Indeed, reducing urban energy consumption will largely depend on lifestyle choices, better city management, increasing the efficiency of urban energy consumption, and influencing the individual energy consumption behavior of the urban population. Consequently, the emphasis is on reducing the total amount of energy consumption in urban areas, and what is described as an 'evidence-based approach' (actual energy consumption of buildings, transport activities and changes in it) in the 2009 CCICED report, should be at the focus of investigation.³⁹ Hence, addressing urban energy consumption and its further increase does require a long-term strategic view, including a specific focus on city planning and the way renewable energy sources could be integrated to deal with some of the increasing energy demands. Various programs, are already in place, among the solar based city lighting and hot

³⁸ Energy Efficiency and Urban Development (the building sector and the transport sector) CCICED policy Research Report 2009, CCICED 2009 Annual General Meeting, November 11-13, 2009. <http://www.cciced.net/enciced/policyr/Taskforces/phase4/tfeerd/200911/P020091124520301826967.pdf>, pp 9-10

³⁹ Energy Efficiency and Urban Development (the building sector and the transport sector) CCICED policy Research Report 2009, p. 27, 32

water generation, and the increasing use of solar technology to produce electricity are steps in the right directions. What's more, renewable energy resources, as emphasized by Cook and Boes, are particularly successful in offsetting greenhouse gas emissions, albeit the specific level of offsetting depends primarily on the type of energy production they replace.⁴⁰

Hence, replacing China's overwhelmingly coal based energy production with renewable energy resources would certainly have a fundamental impact in the reduction of greenhouse gas emissions with positive implications not only for the domestic environmental situation but for the global climate change process as well. Yet, we should be aware, that renewable energy sources will not be able to completely replace coal as a source for energy in China in the foreseeable future, however, increasing the percentage of renewable energy in the energy mix, still will provide a fundamental positive impact and equally important, positive long-time impacts by reducing the sole reliance on coal based energy generation. There may also, as emphasized by Cook and Boes, be future serious gains made in both new developments as well as in increasing the economic viability of an existing technology. They note for example, that advances made in photovoltaic technology over the last twenty years make the equivalent technology of the 1980s appear limited and primitive. In addition, improved manufacturing technologies were also instrumental in reducing the costs associated with today's photovoltaic technology and consequently increased its competitiveness.⁴¹ Albeit there are encouraging signs, we may be rather cautious when overly anticipating future research discoveries, as there is no guarantee that new discoveries will be achieved. Yet, as indicated in the 2007 Global Status Report on Renewables and its 2009 updated version, the investment in renewable energy capacity, manufacturing plants, and research and development continues to increase dramatically, reaching a fourfold annual investment as compared to 2004 in 2008.⁴² If these trends continue, then it is rather likely that the manufacturing cost will decline further, and thereby making these technologies more attractive, as well as increasing the dynamic of replacing traditional and more environmentally damaging energy production. The accelerating replacement of pollution sources of energy generation with sustainable sources would also lessen the negative impact consumption has on the environment. Nonetheless, clean coal technology and increasing energy efficiency are other, fundamental and critical topics without

⁴⁰ Garry Cook and Eldon Boes, 'Renewable-Energy Technologies', in Dennis Pirages and Ken Cousins (eds) *Resource Scarcity to Ecological Security*, (2005), p.142

⁴¹ Cook and Boes, 'Renewable-Energy Technologies', p. 136, 139

⁴² Renewable 2007 Global Status Report' (REN21) (2008), p. 6

neither China's energy demand nor the related negative environmental implications will be addressed successful. Increasing energy efficiency may provide another good example for the link between domestic and international environmental issues, as this will not only help to reduce the domestic energy demand, but as pointed out in the second report on China's Clean Revolution, China as a major place for global manufacturing, will not only gain in its competitiveness but also will help to reduce the global CO2 emissions.⁴³

It is crucial to be aware that the timing matters, particularly when selecting an appropriate development strategy, as opportunities do not exist permanently and decisions made at one point in time have strategic implications not only for future developments but equally, for the range of opportunities available. Opportunities not only exist within China's domestic market, but as emphasized in the 2009 Renewables Global Status Report, the global renewable market grow extraordinarily in 2008, with wind power in the lead, and worldwide investment in renewable energy in 2008 double the investment made in 2006.⁴⁴ This trend, indicates that renewable energy resources will provide interesting and increasing economic opportunities in the years to come. Nevertheless, and as noted previously, politics takes a central role in the selection and amendment of a specific development strategy and in taking advance of specific domestic and international trends.

CONCLUSION

This paper addresses the complexity involved when addressing China's energy needs and the potential and opportunities renewable energy sources like wind and solar power may offer as an alternative to China's overwhelmingly coal based energy generation. This emphasis on coal based energy generation is also responsible for an extensive part of China's environmental degeneration and China's contribution to the process of global warming. Hence replacing China's coal based energy generation through renewably sources would to a considerable extent decrease the negative environmental impact China's economic success, its rapid urbanization process and the equally rapid developing energy consumption patterns of its middle-class has. Albeit there are various, and strong indications, political and economically, that

⁴³ China's Clean Revolution II: opportunities for a low carbon future, The Climate Group, 2009, p. 17

⁴⁴ Renewable 2009 Global Status Report' (REN21), p. 12, 14,

renewable energy sources will play a more prominent part in China's future energy mix, and thus lessen the negative environmental impact, it would be wrong to identify renewable energy sources as the definite answers to China's energy needs and China's environmental problems. For that, the importance of coal as abundant source of energy will not be replaced by renewable energy sources soon. Having made this point, there exist strong incentives for facilitating a continuous shift towards renewable energy sources, especially wind and solar power as their use will lessen the negative environment impact and may hold the potential to offset some future energy needs as well. In addition, there also exist strong incentives of acting now to avoiding a further lock-in of fossil fuel technology and hence providing an alternative route of development in the energy sector. This last aspect is of critical importance, as decisions made now will have fundamental consequences in the years and decades to come. Another essential issue is, as indicated by the strong renewable market development in China as well as globally, that renewable energy technology will provide increasing employment opportunities within China as well as economic growth. An equally, crucial role for renewable energy sources can be identified in their ability of addressing fundamental development issues in providing non-grid energy sources for remote and rural communities throughout China.

It is equal important to recognize that when addressing specific environmental issues, to identify the historical trajectories of social inspired environmental challenges and putting them in the contemporary context. Environmental degeneration is neither a solely political, social, economic or technical issues but represent a combination of them. China is no exception to this, overall, which development strategy a country follows – a 'growth first and clean up later' or 'cleaning up while growing' – represents a conscious political decision, with potential far-reaching implications. Equally, the specific energy demand, and related pollution and environmental issues are also related to specific social-economic processes within a specific historical context. China's rapid urbanization, its growing middle-class and the willingness and ability of this middle class to consume are critical issue, which drives the demand side of China's energy issue. This is not to deny, that the governments growth strategy also increases the pressure for providing enough energy. For all that reasons, renewable energy sources, especially wind and solar power, do have an important role in China's future energy scenarios. Renewable energy sources also play a fundamental role in providing electricity and power to remote and rural communities throughout China and thereby facilitating the development of these communities.