Universidade de Aveiro Secção Autónoma de Ciências Sociais, Jurídicas e Políticas
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Renato Miguel Ascenso Roldão

O Uso da Energia Renovável no Noroeste da China: Pontes para um Futuro Sustentável

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The use of Renewable Energy in Northwest China: Bridges for a Sustainable Future

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Estudos Chineses – Negócios e Relações Internacionais, realizada sob a orientação científica do Professor Jacques deLisle, Professor Catedrático da Law School, University of Pennsylvania.

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agradecimentos

The current dissertation would not have been possible to complete without the cooperation of several entities and persons, to whom I would like to address my gratitude for their support and encouragement to go through this study.

To Professor Jacques DeLisle, University of Pennsylvania, who supervised this dissertation, patiently read it and offered me his valuable remarks for its improvement, and guided me in terms of methodology research. He was always very supportive since the very beginning when I choose the topic.

To Professor Serrano Pinto, University of Aveiro, Director of the Masters on Chinese Studies – Business and International Relations.

To Professor Wang Suoying, University of Aveiro, for teach me the first Chinese characters that were extremely useful during my stay in China.

To all my teachers during the MA Programme at the University of Aveiro.

To Ana, my girlfriend, for supporting me in every second of my research even when I was thousands of kilometres away from her. Thanks for listening me all the time about the subject and for reading it carefully.

To my parents, sister that were apart from me in the last two years.

To Mr Ramin Nadimi, Silk Road Project Manager from Shell China Limited at Shell Solar Urumqi Office, Xinjiang for its interest and support in my research project since the very beginning.

To Professor Andrews-Speed at Durham University for his availability to share with me his valuable knowledge about the Chinese Energy Sector.

To Professor *Huang* and other Chinese professors at Beijing Language and Culture University

To all friends that I met during my stay in Beijing.

To the city and the University of Aberystwyth where I spent 10 months of my life researching and writing this dissertation and the Irish Sea for its inspiration.

To all these people, Thank You Very Much!

Resumo

A presente dissertação pretende analisar o desenvolvimento do uso das Energias Renováveis (exclusivamente a energia solar e a energia eólica) nas remotas áreas rurais do noroeste da China, particularmente nas Regiões Autónomas de Xinjiang e Inner Mongólia. Desde o início dos anos 90 até à actualidade diversos acontecimentos tiveram lugar tanto ao nível internacional como ao nível da política interna chinesa influenciando decisivamente a implementação de Energias Renováveis como alternativa aos actuais padrões de consumo energético chineses onde o carvão e outros combustíveis fósseis continuam a marcar uma posição central. O sector energético é um sector estratégico para o futuro desenvolvimento sustentável da República Popular da China. Embora as recentes opções políticas e estratégicas Chinesas para o desenvolvimento das Energias Renováveis sejam animadoras a China não pode enfrentar esse desafio sozinha e necessita de procurar ajuda externa. Assim, o uso das Energias Renováveis no noroeste da China tende a ganhar visibilidade no contexto global, na medida em que se pode relacionar com três questões que vêm ganhando peso na Agenda internacional: a segurança energética, as alterações climáticas e a erradicação da pobreza. Pretende-se, portanto, com este estudo alertar para o potencial de negócio que existe no mercado das Energias Renováveis chinesas, mas principalmente em que medida o desenvolvimento das Energias Renováveis poderá constituir a curto, médio e longo prazo, um meio viável para a China atingir um desenvolvimento sustentável. Finalmente, e em consequência da progressiva abertura Chinesa à comunidade internacional o presente estudo pretende determinar de que forma o uso das Energias Renováveis pode ser compreendido enquanto uma questão de Política Ambiental Internacional. Este enquadramento teórico do uso das Energias Renováveis no âmbito da Política Ambiental Internacional ajuda a compreender a existente cooperação internacional para o desenvolvimento das Energias Renováveis na China e inter-relaciona os crescentes esforços de cooperação neste sector com a integração da China nos Regimes Ambientais Internacionais.

Abstract

The energy sector is a strategic one for the Chinese sustainable development future. The present dissertation analyses the developments in the use of Renewable Energy (exclusively Solar and Wind energy) in the remote rural areas of northwest China, particularly in both Xinjiang and Inner Mongolia Autonomous Regions. Since the beginning of 1990s until now several Chinese and international events influenced decisively the deployment of Renewables as an alternative to the present Chinese pattern of energy consumption which is heavily dependent on fossil fuels. Despite the recent political and strategic Chinese options for the deployment of Renewables the country cannot face this challenging task without external support. In this context, the use of Renewable Energy in northwest China is gaining international visibility mainly due to the existing links with three international Agenda issues: energy security, Climate Change and poverty alleviation. Actually this study emphasises the existing business potential of the Chinese Renewable Energy market but mainly the extent of the Renewables contribution as a mean to achieve the Chinese sustainable development. Finally and as a consequence of the Chinese openness to international community the present study consider the use of Renewables as an international environmental political issue. Within this theoretical framework the existing international cooperation for the deployment of Renewables in China and the Chinese integration the international environmental regimes are studied and inter-connected.

List of Abbreviations, Acronyms

ACCA21 – The Administrative Centre of China's Agenda 21
ADB – Asian Development Bank
Btu – British Units
CDM – Clean Development Mechanism
CRED – Centre for Renewable Energy Development
EUREC -
FDI – Foreign Direct Investment
FYP – Five-Year Plan
GDP – Gross Domestic Product
GEF – Global Environmental Facility
GHG – Green House Gases
GONGO – Government non-governmental organizations
IEA – International Energy Agency
IEP – International Environmental Politics
IR – International Relations
IMAR – Inner Mongolia Autonomous Region
KP – Kyoto Protocol
MOST – Ministry of Science and Technology
Mtce – Million Tonnes of Coal Equivalent
NAS – National Academy of Sciences
NEPA – National Environmental Protection Agency, predecessor of SEPA
NGO – Non-Governmental Organization
NPC – National Peoples Congress
NW - Northwest
OECD – Organization for Economic Cooperation and Development
O&M – Operations and Maintenance
PRC – Peoples Republic of China
PV – Photovoltaic
RET – Renewable Energies Technologies
RE –Renewable Energy
R&D – Research and Development
RMB – *Renminbi* Chinese Currency (*yuan*)
SDPC – State Development Planning Commission
SEI – Stockholm Environmental Institute
SEPA – State Environmental Protection Administration
SETC – State Economic and Trade Commission
SPC – State Planning Commission, predecessor of SDPC
SSTC – State Science and Technology Commission
UN – United Nations
UNCED – United Nations Conference on Environment and Development
UNDP – United Nations Development Programme
UNEP – United Nations Environmental Programme
UNFCCC – United Nations Framework Convention on Climate Change
Wp – Watt Peak
WB – World Bank
WBG – World Bank Group
WEC – World Energy Council
WTG – Wind Turbine Generators

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INTRODUCTION

Recognizing that the energy sector is of strategic importance to China's future social, economic and environmental development, this thesis recommends the use of Renewable Energy[1] (RE) as an alternative to fossil fuels and to other traditional Chinese patterns of energy consumption in order to achieve the most basic energy needs among rural populations of northwest China. In addition, the use of RE in China is becoming an issue of great interest to anyone who is concerned about the Chinese energy sector or the country's sustainable future.

This dissertation focuses primarily on two areas of Northwest (NW) China[2]: Inner Mongolia Autonomous Region (IMAR) and Xinjiang. The study is limited to rural areas of NW because China is a huge and diverse country, even in terms of the potential use of Renewables, mainly Solar and Wind energy. It will evaluate to what extent the rural areas of Xinjiang and Inner Mongolia, China and the International Society could benefit in environmental, social, economic and even political terms from the promotion of the efficient and extensive use of RE.

This work focuses on just two RE sources: the sun (Solar Energy) and the wind (Wind Energy). Why these RE sources? This choice is based on two main criteria: the availability of both in Xinjiang and Inner Mongolia, where they are the more common RE sources, and the non production of harmful impacts on the environment. Furthermore, solar photovoltaics and wind power are the fastest-growing renewables and have the greatest potential for helping rural areas of NW China to achieve a sustainable development future.

Moreover, both wind and solar energy considered as environmental issues are easily articulated with the International Environmental Politics (IEP) approach. One of the most

[1] For the purposes of this dissertation RE refers primarily to energy from wind (both small-scale wind turbines and large wind farms for electricity production but not water pumping systems) and sun (PV Systems for electricity production but not water or other heating systems). This Master thesis will not be focusing in any other Renewable Energy sources. Sometimes wind and solar energy are referred in this dissertation as "new renewable energies".

[2] See Annex 1 with Maps of the studied regions

innovative aspects of this dissertation, is that it discusses the role of RE in NW China from the perspective of IEP in order to high-light business opportunities for the RE Market while concentrating mainly on the critical role that the use of RE could play in fuelling China's fast-growing economy.

The complexity of the nexus of China's development and of the country's energy structure along with its consequences to the Chinese and global sustainable future will shape the way the RE issue in NW China is treated in this dissertation.

Problem Statement

China's economic development has presented a sustainable pattern for the last two decades. The eyes of the entire world are looking deep into the country to see for how long this "uninterrupted" development is going to last and to see if there is any danger of "over-heating". The Peoples Republic of China (PRC) firmly made its first step into the twenty-first century with "favourable timing, terrain, and unit of people", as the old Chinese saying goes, with the country's economy growing at over 8 per cent in 2003. However, China's existing energy structure is based on non-renewable fossil fuels and cannot be sustained indefinitely.

China's energy mix is heavily dependent on coal and at the moment the country is striving to guarantee important oil fields abroad or to make strategic deals to build pipelines and assure the necessary amounts of natural gas to satisfy increasing domestic demand. Nuclear energy is a very controversial form of energy and hydroelectric projects, mainly huge projects like the Three Gorges Dam risk damage to the sustainability of the country. In this context, and in order to minimize Chinese energy dependence, i.e. Chinese energy security and consequent vulnerability the increasing use of RE could be a feasible option to solve NW China's energy constraints.

Since 1949, China's development has always been of concern to global stability, but at present PRC is willing to play an even central role in the international arena. In the twenty-first century, it is not just China's economic development that matters to global

stability: without Chinese social and environmental development that follows its economic progress, the future of the country and of the entire world, without being overdramatic, could be compromised. In this context, the RE sector could be a strategic means for China's pursuit of a sustainable development particularly in its poorest and backward areas.

If the twin goals of lifting the world's poorest population to a decent quality of life while saving and restoring the natural environment represent the bottom rung of global sustainability (Wilson, 2000:35), we can strongly affirm that the rural areas of NW China are yet on the bottom rungs of global sustainability and if no actions are taken to move China from its current pattern of energy consumption any further economic, social and environmental development might be hypothecated.

The Chinese people are also looking deep into their own country trying to see beyond the visible economic development. Using RE, it is hoped that Chinese living standards will increase and that the material needs will be satisfied in parallel with environmental development.

Why do we look at the Chinese energy problem from the perspective of RE instead of using the traditional "fossil fuels and oil lenses"? We believe that the Chinese energy problem needs to be seen through the RE lenses. The aim of this dissertation is to demonstrate how to widely incorporate throughout China this kind of "green" and environment-friendly energy that has thus far been excluded. The rapid deployment of RE in China is a complex problem. The solutions to boost RE depend essentially on Chinese and International social and economic changes started a decade ago but also on technological innovation. It seems that today, within the favourable framework of both Chinese and international politics, we have a "window of opportunity" for effective international cooperation in this field with multiple advantages for all parts involved.

Content and organization of this study

The following section presents a "road map" of this dissertation, highlighting the stages and the shape of the arguments that are going to be developed. The dissertation is structured as follows.

The first chapter provides a frame of reference for the Chinese energy sector as a whole and particularly in the rural areas of NW China; it also discusses how the present energy structure, heavily dependent on fossil fuels is threatening the country's development future. The existing disparities within the Chinese energy sector will be referred to in this context. Assessing critically the Energy structure of rural areas of both Xinjiang and Inner Mongolia it will identify some bottlenecks that could threaten the Chinese and the global green Agenda if they are not going to be solved on time.

The second chapter demonstrates why and how the use of new RE (solar and wind energy) could be a feasible solution to solve the Energy Problem in NW China. The use of RE in NW China is going to play a key role in the pursuit of the Chinese Sustainable Energy Strategy. In the first part of this chapter the concept of Sustainable Energy development is addressed in order to arrive at a programme for "Sustainable Development with Chinese Characteristics". In a second section, are presented some technical features of wind and solar energy systems with emphasis on their advantages or disadvantages. Finally, some RE projects that are under way in Xinjiang and Inner Mongolia will be described.

The third chapter puts emphasis on China's RE Agenda for rural areas of NW China. It describes the recent evolution of China's RE policies and practices. Despite China's political will to promote the use of RE the country presents some limitations to the deployment of RE on its own. Moreover, the use of RE is becoming increasingly related with energy security, climate change and the poverty alleviation concerns of the Chinese State and, consequently, Chinese RE domestic issues are gaining international visibility.

The fourth chapter considers the use of RE in NW China as an IEP issue and integrates Chinese RE issues into International Environmental Regimes. This IEP approach helps to understand the existing international cooperation around the Chinese RE sector. In addition, explanations will be made of the extent to which Chinese participation in key international events is helping the deployment of RE in NW China.

Literature Review

Research for this thesis was done using printed sources such as books, articles, government/official publications and Non-Governmental Organizations (NGOs) publications; technical/industry specific sources in the form of reports; electronic sources and personal communications. A data "triangulation" was done in order to check if different data sources lead to different conclusions. Conceptual Literature, i.e., opinions, ideas, theories and experiences related to RE and the international approaches applied to this "case study" as well as Research Literature, i.e., all the noteworthy studies that give accounts or results of research which has been undertaken to solve the Energy Problems in the rural areas of NW China were analysed. A comprehensive review of the literature was undertaken.

Drawing on a broad set of literature in English, Chinese and other foreign languages this dissertation aims to make the necessary synthesis of what is currently being said, written or researched about the use of RE in NW China in order to move on further and suggest its use as a viable alternative for the sustainable development of Chinese rural areas and for China's future development.

While there is a substantial body of literature on the Chinese energy sector as whole and in the use of Solar and Wind Energy worldwide very little analysis has been focused on the Chinese RE sector and even less with respect to the specific area of NW China. Worldwide there have been a variety of long-term energy scenarios and projections of the future energy supply and demand such as those of Jefferson, World Energy Council (WEC) *Global Energy Perspectives to 2050 and Beyond*, the International Energy Agency (IEA) and Shell. All of them put emphasis in the future key role that RE sources

are going to play during the first and the second quarter of this century. A growing consensus is forming around this idea.

In addition, the IEA *Renewables Information 2002 and Renewables Information 2003* are two comprehensive publications providing world RE statistics and giving to RE the importance they deserve. Usually the RE resources are briefly referred to in the middle of publications that mainly analyse statistical data of the traditional fossil fuels. However, this publication focuses particularly on Organisation for Economic Cooperation and Development (OECD) countries and consequently Chinese RE statistics are not included in these volumes. The IEA also analyses *China's Quest for Worldwide Energy Security,* an issue which is referred to in the third chapter of this dissertation as a reason to give international visibility to Chinese RE issues.

As stated before, there is a growing consensus that RE will play a significant role particularly in future rural area development programs and mainly in developing countries like China. This consensus has grown out of some reports such as the United Nations Development Programme's "Energy after Rio", Royal Dutch Shell's "Energy for Development" and "A Renewable Energy Future? Challenges and Opportunities?", Sawin's "Charting a New Energy Future" and the World Bank's (WB) recent papers on "Fuel for Thought" and "Rural Energy and Development".

When the RE issue is addressed, at a global level, as an alternative way to energize developing countries or as a key element in both the present and the future world's energy mix, José Goldemberg and Thomas B. Johansson emerge as some of the most prominent authors.

Buckley's recent publication *Beyond Petroleum - Renewable Energy Revolution* not address the Chinese RE sector in particular, but is fundamental to an understanding of the global benefits and the structural impacts that a future growing use of RE will generate.

At the moment, news about RE appears quite often both in the Chinese media and academic journals. From *People's Daily* to *Foreign Affairs*, there are articles about the

urgency to move as soon as possible from the traditional patterns of energy consumption which are heavy dependent on fossil fuels and proposals for RE as an increasing economic alternative mainly to developed countries but already in certain areas, i.e., the "niche markets" of developing countries like the rural areas of NW China that are studied in this dissertation. One of the most up to date examples of the increasing academic interest in the Chinese Energy Sector and particularly RE is the recently published McNair Paper *"Oil for the Lamps of China" – Beijing's 21st Century Search for Energy*.

Until now, most of the research on the use of RE in NW China has been conducted by the Chinese Government, few International Organizations and some US Institutes. Most of this literature recognises the enormous potential for the use of renewables and the growing Chinese RE market, mainly in the long-term because it is necessary to overcome certain barriers before it will become fully cost-effective all over China. Almost all the existent studies and publications underline the rich amount of both wind and solar resources that are available in NW China and the potential of its use at local and national levels.

The National Renewable Energy Laboratory (NREL) studies on the use of RE in NW China and its potential have been following a business approach. The study of the American National Academy of Sciences (NAS) refers to Sino-American cooperation in the energy sector as a whole.

At this point it is important to mention that Philip Andrews-Speed from Durham University, one of the top researchers into China's Energy sector, addresses the Chinese Energy Security issue in one of his publication although he does not study the RE sector in particular. The Harvard University book *Energising China – Reconciling Environmental Protection and Economic Growth* is also a reference book about the present situation of China's energy sector but with little information about Renewables.

The *China Human Development Report 2002 – Making Green Development a Choice* is another key book in this dissertation because it makes an up to date assessment of China's Human Development where questions of environmental, social and economic

development are mentioned with a reference to the importance of a better energy management in order to achieve a sustainable path.

Furthermore, during the last decade, at the University of Delaware, John Byrne and his colleagues addressed specifically the topic of this dissertation, i.e. the use of RE in NW China. In their studies they assess wind, solar and hybrid off-grid systems for the electrification of rural areas of NW China. According to another scholar, Debra Lew, who also addresses the use of RE in NW China there is a great market in China for Wind Power Systems and Hybrid Wind/Photovoltaic systems are presented as the most feasible solution for households' electrification in Inner Mongolia. These authors mentioned above provide an updated account on how Renewables could enable rural areas of NW China to deal with their energy demand problem, without compromising either their increasing economic growth or their sustainable development.

Two other studies promoted by the WB and coordinated by Anil Cabraal in 1996 evaluate the potential of Renewables for Chinese electrification (World Bank Report No. 15592-CHA), particularly photovoltaics for household electrification in China (World Bank Technical Paper Number 324). The World Bank, the United Nations Environment Programme (UNEP), the United Nations Development Programme (UNDP) and some other international organizations and private actors, mainly current or potential foreign investors have lately reported on the great potential of RE worldwide and particularly in China.

Although there are few studies and authors who consider that, due to certain constrains that will be referred later in this dissertation, we cannot look for the development of RE market as a certainty in the short or even in the mid-term. There are some of them that completely deny the potential of RE solutions as the best mean to implement the Chinese Sustainable Energy Strategy preferring Natural Gas or Clean Coal solutions in order to pursuit that strategy.

Chow and Economy address China's "West Development Strategy"[3], the "political strategy" that is being implemented in the two studied Autonomous Regions and which, in the context of this dissertation will be considered as one justification for the increasing attention that has been paid lately to the NW China RE issues.

During the research period of this dissertation I read several publications about technical features of Renewable Energy Technologies (RET) that are briefly addressed during the second chapter of this dissertation. The European Renewable Energy Centres Agency (EUREC) *Future for Renewable Energy 2* and some the publications of Center for Alternative Technologies (CAT) that address both household solar and wind systems are valuable sources which illustrate what kind of RET is being or can be used in the rural areas of NW China.

Studies and articles on IEP are used in this dissertation in order to explain the existing cooperation between the Chinese Government and other International Relations (IR) actors in the deployment of RE and the existing links between the Chinese and International Agenda in terms of Climate Change, Poverty Alleviation and Energy Security. However, there is relatively little secondary literature on China's IEP. Among the written sources used in the fourth chapter I would like to mention the Brenton's book *The Greening of Machievelli – The Evolution of International Environmental Politics* and the Imber's "The Environment and the United Nations" as they state that environmental issues are moving from the periphery to the centre of the International Political Agenda. A different opinion is defended by Steve Smith in "Environment on the Periphery of International Relations: An Explanation" where he argues that environmental issues will remain marginal international issues. Taking the use of RE in NW China as an example, we will try to demonstrate how the environmental issues are moving quickly from the periphery to the centre of the International Agenda.

In PRC there is a growing consensus that RE will play a significant role in future development programs of rural areas, mainly in the western part of the country. This

[3] See Annex 2 with the Complete Map of the Chinese areas where the "West Development Strategy" is going to be implemented.

consensus has grown out of *China's Agenda 21*, *1999 White Book on China New & Renewable Energy*, the 9th and 10th Five-Year Plans, *The National Energy Futures Analysis and Energy Security Perspectives in China – Strategic Thinking on Energy Issue in the 10th Five-Year Plan* presented by Ni Weidou at Tsinghua University, and *The Program of New an Renewable Energy Development from 1996 to 2010*. In spite of this acceptance, surprisingly few academic studies have been made on emerging RE markets in the rural areas of NW China. The political will of the Chinese government to deploy RE in rural areas of NW China might be connected with environmental and poverty alleviation concerns that were officially expressed in the *White Paper on Environmental Protection in China* and *White Paper on Poverty Reduction in Rural China* respectively.

This dissertation follows a multidisciplinary approach, tries to combine several important areas of research and provides a broad perspective of the RE situation in NW China. It presents RE as a feasible alternative, explains why China is concerned about the energy situation in NW China and why the international community is worried about China's energy problem by examining the complex and interconnected web of international actors involved in cooperation in the RE field. Following a coherent line of thinking it articulates three levels of analysis: local, regional/national and international.

Research Methodology

The use of RE in NW China is a "Case Study" to evaluate the benefits of its use for China's energy problem in particular and for the international system as a whole.

Some interviews were conducted in person or by telephone and several emails were exchanged with energy researchers, academics and business-men connected to the Chinese energy sector and RE in particular but this is just a tiny part of the present study[4]. Mainly this research was conducted through readings of both secondary scholarly and journalistic sources, re-analysing objective facts and figures from Chinese and foreign institutions as well as libraries and databases. I had access to several personal

[4] Interviews to Kang Wu from East-West Center, Philip Andrews-Speed from Durham University and Ramin Nadimi Silk Road Project Manager from Shell China Limited at Shell Solar Urumqi Office, Xinjiang.

communications about the use of RE in China that were presented at different conferences held in China and abroad.

Theoretical framework

This dissertation applies the theoretical concept of sustainable development to NW China and proposes an alternative way to achieve it in China through the use of RE. The fourth chapter will follow an IEP approach to explain the existent international cooperation between Chinese government and other IR actors in the RE sector supporting the Chinese option for RE. I have followed an "evaluation research" and a "bottom-up" approach, i.e., from the local to global level, to deal with this complex issue.

Data analysis

> *"Availability and reliability of data is a key challenge for everyone who has been assigned the task of describing China"* (SEI and UNDP; 2002: v.)

The Chinese government statistical systems are characterised by serious quality and systematic errors. Data about RE in NW China are scarce and few studies have been done in the area as the RE market is considered an emergent market. Consequently, any quantitative and statistical analysis of the Chinese RE market faces consequently the problem of obtaining statistics. Information from Xinjiang and Inner Mongolia Autonomous Region (IMAR) were even more difficult to gather. Also, due in part to data limitations, the few studies on RE in NW China consists of analysis of case studies, mainly description of pilot projects.

The statistics and other quantitative data presented in this dissertation come and were adapted from the following sources: World Bank, United Nations (UN), Asian Development Bank (ADB), International Energy Agency and other international organizations that produce updated data related to Renewables in China. A comparison between these data and those from the Chinese Sources such as the governmental publications was established.

The China Business Handbook 2002 and The China Business Handbook 2003 were both useful sources from which to gather data about the RE energy projects that are currently being implemented both in Xinjiang and in IMAR.

1. IS THE ENERGY PROBLEM IN RURAL AREAS OF NORTHWEST CHINA THREATENING THE COUNTRY'S DEVELOPMENT FUTURE?

1.0 Introduction

China is an energy superpower and the world's largest potential market for energy. (IEA, 2000) This chapter aims to draw the picture of the current situation of China's energy sector according to the strategic role it plays at the international, national and local levels. First, an overall idea of China's Energy Mix[5] will be given, emphasising the contribution of each energy resource to the Chinese energy structure including China's heavy dependence on coal and other fossil fuels. Second, in order to better understand the particularities of the Chinese energy sector, two internal gaps will be underlined: one between China's Coastal and NW areas and other between rural and urban areas. The second section of this chapter will characterize the two Chinese Autonomous Regions that will be studied in this dissertation: Xinjiang and Inner Mongolia first in terms of their Sustainable Development Indicators and second in terms of the present situation of the energy sector. Finally, some lines will be drawn about the urgency to change the current utilization patterns of energy and to diversify the energy supply both in China as a whole and in the two mentioned regions in order to put China on a sustainable path without compromising its future economic, social and environmental development.

1.1 Present situation of China's Energy Sector

An analysis of the levels of China's Energy must take into account the gap between energy demand, projected by the IEA to reach 98.3 quadrillion of British Units[6] (Btu) by 2020, and its supply. Economic reforms have led to a remarkable growth in the Chinese demand for energy. In fact, the economic reform itself is a very positive sign that China has been opening itself up to the international community. However, these economic

[5] Energy Mix means the energy structure or the energy portfolio, i.e. all the different sources of energy, renewables or non-renewables that contribute to the total energy supply of a country, a region or a city. The weight of a determined source is measured by the percentage it shares in the whole structure.

[6] The British thermal unit (Btu) is a precise measure of energy required to raise the temperature of one pound of water 1 degree Fahrenheit when the water is near 39.2 degrees Fahrenheit. For an explanation of conversions see http://www.eia.doe.gov/kids/units.html

reforms have caused an uncontrolled and non-sustainable development in the energy sector compared with other sectors, bringing much more stress to energy resources. In other words, as the country develops, the demand for energy grows and consequently an additional and negative pressure is put on energy resources. While China presents a low per capita energy consumption, the energy intensity[7] of PRC's economy has been and remains high by international standards (SEI and UNDP, 2002:55). Electricity consumption in China grew by 10 percent in the year 2000, raising new questions about how the country will power its factories, businesses, and homes over the coming decades. (Lew, 2001) Moreover, electrification rates[8] in China are still low but are expected to increase in the next 15 years. (Fesharaki, 1995:2) At the moment, China is the world's second largest consumer of energy after the United States which illustrates the high consumption levels of the country.

On the other hand, and as a consequence of the same economic reforms China's energy resources are no longer capable of "feeding" mounting consumption habits. Consequently, since 1993, when the country started importing oil to satisfy its domestic demand, China has become a net importer of energy. This increasing dependence on the outside world for energy has led the country to set policies to achieve the necessary energy security[9] while its vulnerability to international energy markets grows. Moreover, according to the *White Book on China New and Renewable Energy* the existing gap between energy demand and supply is going to increase:

> *We still have a big gap that needs to be made up by imports. The gap between demand and supply will become larger. We will still have an 8 per cent shortfall in energy in 2010 which will increase to 24 per cent in 2050. The problem of energy security also requires an urgent solution. It is predicted that the 3rd world petroleum crises might occur around 2015.* (SDPC; 1999:4)

Energy is of strategic importance to the development of China, but the present Chinese Energy structure will not be able to satisfy the increasing Chinese domestic demand

[7] Energy Intensity is the amount of energy that is necessary to realise a certain activity. If someone uses more energy than necessary, it is considered that the energy use is inefficient.
[8] See Annex 3
[9] In this dissertation Energy Security refers to the interest of each State in reduce vulnerability towards outside world in secure affordable supplies of energy, i.e. strategic reserves of energy for economic, social and environmental development.

sometime in the future. Therefore, the Chinese development might be hypothecated if the present energy structure is not changed. According to Chinese officials, the harmonious development of the economy, energy resources and the environment is an important pre-requisite to the realization of the four modernizations[10]. In addition, the energy industry is vital to the national economy and of critical importance to the socio-economic development and the improvement of people's living standards. (SSTC, 1994:124) China's energy industry is confronted with triple pressures: economic, environmental and social. If the country is going to run out of energy for one reason or another, the future economic, environmental and social development will certainly be compromised. Although China has achieved many successes in its transformation to a market economy, its energy structure still contains structural deficiencies which need to be addressed in any future energy policy. (McElroy, 1998:69)

In order to prevent any disruption of energy caused by the "predicted" oil crises, it is time for China to step ahead and look further for other forms of energy in order to diversify its energy structure. Moreover, by diversifying its energy sources, i.e., moving away from excessive dependence on fossil fuels, China will be able to preserve its environment.

But what does the present energy structure look like? To understand what should change within China's energy sector and why, it is important to state what the contribution of the different sources of energy is and how it has evolved in recent years. The following paragraphs will refer to different energy resources according to their importance to China's energy market: coal, oil, natural gas, nuclear and other alternative sources of energy like hydroelectric and renewable energies.

China has access to all the energy resources known to humankind. (SEI and UNDP, 2002:55) According to the *White Book on China New and Renewable Energy*, China's energy structure in 1999 was as follows: Coal 75 per cent (64 per cent at the present),

[10] The four modernizations policy were started by Deng Xiaoping in the end of the 1970s. Deng's approach of modernization focused on four key areas: industry, agriculture, science & technology and national defence.

Petroleum 17 per cent, Natural Gas 2 per cent (3 per cent at present[11]) and Hydro and Nuclear together 6 per cent.

Coal will continue to provide over half of China's energy – the country is now the largest coal user and producer in the world. China is trying to introduce and develop clean coal technologies all over the country in an attempt to reduce the hazardous effects of this "dirty" fuel on both public health and the environment in general. As we mentioned above, China is the second largest energy consumer in the world and accounts for 13 percent of global energy-related carbon emissions (NAS, 2000:x), many of which are generated from the burning of dirty coal.

> *For power generation it is the large-scale, inefficient utilisation of poor quality and poorly prepared coal that leads to large emissions of pollutants.* (SEI and UNDP, 2002:27)

Coal is expected to retain its importance in China's energy production mix, with its share rising to 77.4 percent of the total by 2015. (Byrne, 1999) Nevertheless if current plans work out, much of this new capacity will be in cleaner burning plants. (May, 1997:17)

"Black Gold" has been the cause of several conflicts between nations in the last century mainly because of its strategic importance for world "development". With the world's oil reserves coming to an end, violent conflicts might increase as a result. So, every country is trying to gain access to oil in order to guarantee its strategic reserves. China is no exception. A decade ago, in 1993, as mentioned before, China became for the first time in its long history a net oil importer abandoning its traditional goal of self-sufficiency.

> *For decades, China, inspired by "the heroic spirit" of the workers in its great oil field at Daqing, in Manchuria, was committed to self-sufficiency. For that was the year that China – no matter how heroic the spirit – simply could not do it on its own any more not with an economy that was growing 8 per cent a year. It became a net importer. And its imports have continued to grow.* (Yergin, 2003)

This was a very significant year in oil terms for Chinese history. In spite of its rich oil reserves, available resources were not enough to satisfy domestic demand. According to

[11] The updated data for coal and natural gas share in China's energy mix come from the Energy Information Administration (EIA) of the US Department of Energy's recent China Country Analysis Brief available online at http://www.eia.doc.gov/emeu/cabs/china.html.

Kang Wu, a fellow researcher at East-West Center, "for its domestic economy, China is concerned about its growing dependence on sea bound oil imports, particularly imports from the Middle East"[12].

A decade from now the world will probably consume 20 per cent more oil than today. This means that today's worldwide consumption of 77 million barrels a day will be over 90 million barrels per day by 2013. The increased demand will come mainly from the developing world and, in particular, from China. PRC is the third largest oil consumer after Japan, and will soon overtake Japan to become the second largest oil consumer in the world. As China continues on its remarkable course of economic growth, so its oil consumption continues to increase. Today it uses twice as much oil as it did a decade ago. The facts mentioned above illustrate how fast the energy sector is changing in China and worldwide.

In an era of "The War against Terrorism", defence analysts have warned that nuclear power plants remain a key – and a vulnerable – terrorist target. The bombing of this kind of power plant would have unpredictable consequences. Furthermore, the expansion of nuclear energy, one of the most expensive means of generating electricity, is under suspicion due to the double use that can be made of nuclear and radioactive materials. While the share of nuclear power in the world energy supply is going to fall, some predict that nuclear will become increasingly important in China if the country is to pursue its ambitious plans to develop its nuclear strategy, to compensate for declines in petroleum supplies.

Natural gas has received much attention lately as an alternative to coal and oil. China possesses significant reserves of natural gas, but an important part of China's future natural gas needs will come from abroad. China's natural gas reserves are smaller than oil reserves and China is projected to begin importing natural gas around 2005. By 2020 it is expected that 30 per cent of the natural gas consumed will be imported[13]. Once China

[12] Email received on 17th January 2002
[13] According to Cambridge Energy Research Associates, see http://www.cera.com/home/.

needs to transport this energy resource in pipelines through international borders, the use of natural gas will intensify Chinese energy security problems and concerns.

In this context, RE brings some comparative advantages relatively to coal, oil, nuclear and natural gas.[14] RE can be installed rapidly and in dispersed small or large scale applications getting power quickly to areas where it is urgently needed, delaying investment in expensive new electric plants and power lines, and reducing investment risk. (Sawin, 2003:89) Using RE to replace coal will minimized the environmental damage and reduces significantly the energy pollution produced from the coal burning. In addition, RE sources such as wind and solar are also gaining favour with the big advantages of being "indigenous resources" and consequently not requiring transboundary transportation which "theoretically" minimizes the risk of energy disruptions in China and contributes to a reduction in dependency on imported fossil fuels. The use of oil and natural gas considered as "transnational resources"[15] makes China more vulnerable so it is clearly valuable to support indigenous capabilities. (McElroy, 1998: 53)

> *Oil and natural gas are no longer sources of international political influence for Beijing, but rather a source of vulnerability that could subject China to unwanted foreign pressures.* (Downs, 2000:12)
>
> *The fossil fuels are unlikely to be free from economic, technological and environmental challenges. Rising import dependency, and lengthening supply lines for natural gas and oil, are likely to provoke challenges to supply and price stability.* (Jefferson, 2000)

Moreover, both oil and natural gas can be transported by pipelines which increase the risk of "sabotage" of energy distribution. Recently, China used energy "sabotage" as part of its negotiation for diplomatic purposes[16]. Later on, someone may be interested in the use

[14] See the Annexes 4 and 5 with the Chinese Maps of Oil, Natural Gas projects.

[15] The introduction of the concepts of "transnational resources" and "indigenous resources" is important in this part of the dissertation as both concepts are related with the energy security issues. At the moment, it is important to clarify that the "transnational resources" are all the energy resources that are transported from one country in order to energize another country (both energy imports and exports). In contrast, "localized resources" are used for energy production in the country of origin. International transportation is not necessary. The more dependent China will be on "transnational resources" the more vulnerable the country will be in terms of Energy Security. The "transnational resources" are frequently associated with "Resources Wars" while "localized resources" could be able to avoid the same wars.

[16] In the sequence of the Development of Nuclear Weapons Programs in North Korea, China cut off oil supplies to North Korea for three days to punish its oldest ally for the nuclear standoff with the United

of the same means against China. All these facts show serious long-term problems in the supply of oil and gas in China. (McElroy, 1998:85)

Finally, RE presents also advantages when compared to nuclear energy. Renewable resources are generally domestic, pose no fuel or transport hazards, and are much less vulnerable to terrorist attack than nuclear power plants. Competitive renewable resources could reduce incentives to build a large world infrastructure in support of nuclear energy, thus avoiding major increases in the production, transportation, and storage of plutonium and other nuclear materials that could be diverted to nuclear weapons production. (Johansson, et al., 1993)

Renewables are already bringing electricity - and therefore lighting and power - to many villages in developing countries. A move towards renewables is an integral part of the changes that are needed to create a cleaner and fairer China, but also a cleaner and fairer world, with sustainability covering not only energy use but quality of life - and reducing the risk of "resource wars". Unlike fossil fuels, the energy from solar radiation and wind power is available in every country. (Buckley, 2003:15)

Due to fossil fuels, environmental pollution remains a major problem and a challenge for China's energy industry (Chandler, 1997, 255) but:

> *The origin of China's environmental challenge is far more complex than these immediate causes. It lies in the broader trends and forces, which shape people and society, such as population growth, economic reform, and globalisation.* (SEI and UNDP, 2002:39)

China's existing energy structure is based on non-renewable fossil fuels. This approach can no longer be sustained[17] as the production and use of traditional energy fossil fuels

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States. In a hypothetical scenario, similar situations could happen in the future East-West pipeline, for instance the transport of natural gas from Kazakhstan that will go from the NW border in Xinjiang to Shanghai on the Southeast coast of China. PRC is not free from any kind of "attack" both from inside (for example separatist Islamic groups in Xinjiang) and outside the country (any political problems with any of the Central Asian Countries). The consequences of an energy disruption in a city like Shanghai would be hard to calculate.

[17] In China, the environmental and health costs of air pollution, due mainly to coal burning, totalled approximately 7 per cent of GDP in 1995 and by 2020 the World Bank estimates that under business as usual, these costs could rise to 13 per cent of China's GDP. (Sawin, 2003:87)

harms the social, economic and environmental development at all levels – local, regional and global.

Renewables introduce a new way of thinking about energy supply, a mean to escape the 19th century imposition of the fossil fuel infrastructure. With China's coal use forecast to triple by 2020, the expansion of RET is urgently needed for local, regional and global environmental sustainability. (Taylor, 1998:iv)

Demand for renewable sources of energy is projected to increase, but those sources will likely remain a tiny fraction[18] of primary energy consumption because of financial and technological constraints. (Downs, 2000:6) Nevertheless China's desire to develop its indigenous renewable resources can also be a driver for promoting good governance of the energy sector.

PRC has achieved remarkable progress in RET development and utilization even if it is from a very low base. Although RET have failed to emerge as a prominent component of China's energy mix in the past two decades, the development of RE is expected to reach expectations of 87.50 Mtce[19], 4.2 per cent in 2015's energy mix of China. (Gu and Liu, 2000:1) China must find new and additional ways to develop sustainable energy resources like Wind and Solar Energy. The country possesses abundant RE resources, and is gaining the technical foundations to develop and utilize RE resources on a large scale. (Gu and Liu, 2000:3) RET are being developed and applied alongside "traditional" fossil fuels technologies. (McElroy, 1998:94)

At the moment, hydroelectric energy[20] is the RE resource that takes the most significant proportion in China's energy mix (20 per cent in 1997[21]) and will also become increasingly important. Apart from being a RE, the use of this resource is far from

[18] Demand for renewable sources of energy is projected to grow at an average annual rate of 3.2 per cent from 1996 to 2020, and that share of primary energy consumption is expected to remain around 5 per cent.
[19] Mtce means that the amount of energy produced is equivalent to a certain amount, in millions of tons, of coal that would necessary to produce the same energy.
[20] Hydro energy likely to be exploited is 378 million kilowatts, of which, more than 11 per cent has been developed according to *the Outline for Development of the New and RE in China*.
[21] One-quarter of China's energy is presently [2002] supplied by renewable resources and the major contribution is from electricity from large hydropower projects (SEI and UNDP, 2002:56).

consensual, mainly due to its harmful impact on the environment. The hydroelectric energy plant that invites the greatest amount of polemic in China is the Three Gorges Dam Project with a capacity of 18GW, which is claimed to be the biggest hydroelectric project ever built worldwide. The inundation areas that will result from the Dam and its consequences in the surrounding ecosystem are incalculable.

Generally speaking, the intensity of solar energy in the western part of China is higher than that in the eastern part. (McElroy, 1998:96) On 6 million square kilometres of China territory, two thirds of China's vast territory, annual sunshine is over 600 000 joules per square centimetre or a solar radiation energy density of more than 130 kilocalories per square centimetre (kcal/cm2). (McElroy, 1998:75) Solar Energy[22] is currently used mainly in solar water heaters, solar stoves and passive solar houses. Solar cells are also being popularised for electricity production mainly in household systems in backward rural areas with no access to other commercial forms of energy and with no access to the national electric grid.

Wind Power resources are estimated[23] at 1600000 GW, 10 per cent of which is exploitable[24]. (SSTC and SPC, 1994; Byrne, et al, 1996a:5; McElroy, 1998:76) *The Outline for Development of the New and RE in China* has pointed out that the installed capacity of wind power generation in China will reach 1 million kilowatts by 2010. In June 2000, the installed[25] capacity of wind power was only 240MW, a very small proportion of exploitable resources. In the next decade or more, wind power in China will increase by over 20 per cent annually. The development targets of installed capacity of wind turbines will be 3000, 4900 and 7000 MW respectively in 2005, 2010, and 2015. (Gu and Liu, 2000:7) Growth of wind energy in China has been very slow, if one takes

[22] See Annex 6
[23] In this dissertation the term "estimated resources" refers to the amount of a particular energy resource that is known to exist in its natural form in nature.
[24] In this dissertation the term "exploited resources" refers to the amount of resources that could effectively be used in power or energy production.
[25] In this dissertation the terms "installed power" or "installed capacity" refer to the amount of energy or power that is possible to generate with the technology available at a certain point. It is usually expressed in terms of the addition of the rated power of each single technology device like a solar panel or a wind turbine (for example the total installed capacity of a Wind Farm with 10 Wind turbines able to generate 650Kw each is 6500Kw).

into consideration their immense energy needs, their vast wind energy potential and the urgency of the country's air pollution problems.

However, the different energy resources, both renewable and non-renewable, that contribute to the Chinese energy structure are not equally available all over the Chinese territory. RE geographic distribution complements China's fossil fuels. Despite being, as a whole, a rich country in terms of energy resources, China is, in fact, an unbalanced country when we talk about where the energy resources come from or where and to what extent they are consumed. In addition, if we divide the energy resources available for China's high population we are confronted with a low availability of energy resources per capita:

> *The combination of high and increasing population pressure on already scarce resources, an already critical environmental situation, and a bold push for economic growth – all these aspects add up to an uniquely incompatible situation.* (SEI and UNDP, 2002:11)

INTERNAL GAP BETWEEN SOUTHEAST COASTAL AREAS AND THE NORTHERN AREAS

China's energy situation varies tremendously across the vast country. There is an internal gap in terms of availability of energy resources (supply) and its consumption (demand) between the northern areas of China and its southeast coastal ones. Although the rich Chinese energy resources like coal, oil or natural gas are concentrated in the poorest, but geographically large northern areas of the country[26], these resources or the electricity and the energy that they produce are mainly consumed in the geographically small but rich southeast coast of China, the major energy demand centres.

> *Energy resources in China are quite diverse and complete in variety, rich deposits, but uneven in distribution.* (McElroy, 1998:73)

The less developed areas are contributing to further development in the southeast, enlarging the already existent economic, social and environmental gap between these two parts of the country. Indeed the way the energy sector is being developed in China is promoting these asymmetries. The fact that Xinjiang and Inner Mongolia are important

[26] The major oil fields in eastern China are already in decline.

energy providers to Shanghai and Beijing respectively illustrates the existing asymmetries of China's energy sector.

China's Agenda 21 agrees that the distribution of China's energy resources does not correspond to the distribution of economic activities, since nearly 80 per cent of energy resources are located in the western and northern parts of the country, while 60 per cent of energy output is consumed by the economically advanced south eastern part of the country. (SSTC, 1994:125)

Besides the internal gap between the costal areas and northern areas mentioned above there is another gap in China's energy sector that cannot be omitted: the internal gap between urban and rural areas.

INTERNAL GAP BETWEEN URBAN AND RURAL AREAS[27]

It is important to note that each zone of China includes industrial and agricultural areas; modern cities and "backward" communities; and developed and undeveloped areas. Even within each rural area of each Chinese Province or each Chinese Autonomous Region it is difficult to discover a common pattern for the analysis of the energy sector at rural levels due to, among other causes, the vast cultural and territorial dimensions of China, just to put it simply. This study will focus mainly on the remote and rural areas of Xinjiang and the Inner Mongolia Autonomous Region and not on urban energy problems or any of the problems of other Chinese Provinces or Autonomous Regions.

Within the PRC, not all regions have benefited equally from the exceptionally rapid Chinese economic growth during the last two decades. Poverty is highest in the interior provinces, especially in the western region of the country. Most of the remote and rural areas of Xinjiang and Inner Mongolia have no access at all to commercial forms of energy. Some of these rural areas are not connected to the national grid because they do

[27] Three quarters of the Chinese population live in rural areas, 40 per cent of the country's rural households (90 per cent in the country's western provinces) still do not have access to the Chinese power grid. (Byrne, et al, 1999:5)

not satisfy the economic requirements that prevail over the social and environmental ones. In other words, the remote and rural areas of Xinjiang and Inner Mongolia are not economically attractive because the costs to connect them to the national grid are too high in proportion to the widely distributed and low number of people who would benefit from the energy through the grid. When compared with the Chinese urban areas, the rural ones present a much more dispersed population, generally speaking, which in terms of business opportunities for grid-extension is officially seen as "few customers per square meter" to be worth any investment. It is generally accepted that the supply cost of conventional grids is higher than the installation of off-grid systems. Once again the wind and solar power are seen as feasible alternatives to the *status quo* of China's energy structure, providing energy supplies for rural areas.

> *The extent of China's rural areas, the large rural population and the lack of infrastructures make the provision of commercial energy extremely difficult.* (McElroy, 1998:101)

However, we are not talking about poor areas in terms of availability of energy resources. For example, the most abundant wind power resources are found in Xinjiang and Inner Mongolia. We are talking about poor areas in terms of access to commercial energy resources, in terms of social indicators like living standards or average incomes and in terms of environmental indicators. We must note that poverty, particularly energy poverty,[28] and inequity, is a driving factor in the creation of environmental degradation. Energy resources like coal, oil, natural gas are widely available in the rural areas of studied Autonomous Regions. However, as a consequence of the low social levels, i.e., extreme poverty, most of the population cannot afford them. In other words, the estimated energy resources are available in the rural areas to be exploited, but the installed capacity (infrastructures) for energy production from traditional sources and for connection to the grid are nonexistent as they are not economically viable.

[28] In this dissertation Energy Poverty is considered the lack of access to commercial sources of energy and the low social, economic and environmental conditions that are linked with this lack of energy. See map of Energy Poverty in Southeast Asia in Annex 7.

On the other hand, and as a consequence of the lack of infrastructure, the use of non-commercial energy resources[29] by the rural populations is often inappropriate and inefficient and so contributes to a certain extent, at the micro level, to environmental pollution. They burn "dirty" coal, charcoal, animal dung, wood and other locally produced energy sources that are commonly found in the less-developed world. They also extensively use candles and kerosene. The big gap between energy supply and demand in Chinese rural areas led to resources over-exploitation and the deterioration of the ecological environment. (SDPC, 1999:9)

Nowadays, rural energy consumption in China is spreading from household to industry, and is leading to nationwide energy shortages (Yang, 1997:326) which means that even though the highest energy consumption rates are registered in the southeast coastal areas and in the Chinese urban areas, we should not neglect the increasing importance of the rural areas of NW China and the urgent need to solve their own energy problems. Chinese rural inhabitants should be able in the near future to have access to commercial forms of energy for their own, for China's and for the world's benefit. By satisfying basic energy needs in a sustainable way, Chinese rural areas will be contributing to social, economic and environmental amelioration.

1.2 Rural Areas of NW China

> *Given the diversity and the size of China, any attempt to describe and analyse its energy situation begins by reducing the country into a manageable set of homogeneous zones and regions.* (SEI and UNDP, 2002:4)

This section aims to characterize each of the two Autonomous Regions[30] of NW China, Xinjiang and Inner Mongolia, which will be analysed in this dissertation according to

[29] These non-commercial energy resources are energy resources like "dirty" coal, charcoal, animal dung or wood that are not properly measured or accounted for in official statistical terms because they are not commercialised. Nevertheless, they make their "small" contribution to environmental pollution at local levels. The end user collects these "non-commercial" resources directly from the nature.

[30] This administrative designation means that a significant share of the population is of non-Han nationality. There are five Autonomous Regions in China: *Neimengu* (Inner Mongolia); *Guanxi Zhuang*; *Xizang* (Tibet); *Ningxia Hui* and *Xinjiang Uygur*. But only Xinjiang and Inner Mongolia will be analysed in this dissertation.

their Sustainable Development Indicators[31] and the present situation of the energy sectors. Later in this section, the reasons for choosing these two regions will be presented.

The Peoples' Republic of China faces the enormous challenge of balancing the growing energy demand of its increasing population with continuous economic growth without compromising the living standards of future generations, as was described in the first part of this chapter. Although, it is beyond the scope of this dissertation to address the Chinese energy problem as whole, the construction of energy infrastructures in rural areas is an important measure for protecting and improving the rural and ecological environment. Indeed, this paper focuses on the Energy problems faced by rural and remote areas of NW China, analysing the energy situation both in Xinjiang Autonomous Region and the Inner Mongolia Autonomous Region. In order to understand the present energy situation in both Autonomous Regions it is important to describe each of them.

After a quick look at any map of China everyone can understand the degree of isolation enjoyed by NW China where Xinjiang and Inner Mongolia are located. This is a very remote area that finds itself imprisoned in the centre of the "Middle-Kingdom".

> *A particular effect of China's geomorphology is the locking of its Northwestern half into an interior drainage basin that has no connection to the sea and corresponding roughly to the area that receives less than 400 mm precipitation per year. The combination of lack of sea drainage and very low precipitation adds to the fragility of ecosystems and societies in China's western areas.* (SEI and UNDP, 2002:4)

The NW Interior Region comprises a continuous territorial barrier that has served throughout Chinese history to separate and protect mainland China from its northern and western "hostile" neighbours. Apart from the massive mountains ranges and vast deserts, the rest of the NW Interior Region consists of more or less fertile plateaus with grasslands and steppes.

[31] See Annexes 8 and 9 for more detailed and complementary data related with the socio-economic indicators of the inhabitants of rural areas of Xinjiang and Inner Mongolia according to China's Statistical Yearbook 2000 and UNDP.

The harsh weather conditions also contribute to Western China isolation and backwardness even within China. Summers are hot and the mean temperatures in July reach above 25ºC, particularly in the deserts. Winters are very cold and the average temperatures in January go below -12ºC for most of the territory with vast areas reaching below -20ºC.

To describe solar and wind power energy in remote areas of NW China[32] in economic terms, annual wind speed is above 5m/s, annual sunshine above 2500 hours and distance from grid over 25km (SDPC, 1999:98). This availability of resources makes both kinds of renewable viable economic alternatives[33] to traditional fossil fuels in order to energize this so far overlooked niche of the market in the rural areas of NW China. In addition, the distance from the national grid makes renewables an even more attractive option.

XINJIANG AUTONOMOUS REGION[34]

a) Sustainable Development Indicators[35]

Xinjiang is China's largest region with an area of 1.6m sq km. It is sparsely populated and contains only a tiny percentage of the total Chinese population. The Xinjiang population was 18.8 millions in 2001 but is growing by about 300,000 people a year. This might put some pressure on energy resources in the near future or compromise the region's development. However, in 2001 the central government announced family-planning targets that are aimed to limit its population to 21.8 millions by 2011 in order to facilitate a more balanced development of the region. NW arid China is an area with

[32] For further information please see Annexes 10 and 11.
[33] The use of RE is a viable resource in order to bring energy to rural areas of the NW region. This will be analysed in more detail in the following chapters.
[34] See detailed map of Xinjiang Autonomous Region in Annex 1.
[35] The Sustainable Development Indicators are measures that establish the extent to which development is following a sustainable path. (Markandya, 2002:172) Inside sustainable development indicators is important to distinguish between social, economic and environmental indicator. Social indicators include poverty, population demographics, education, health, and human settlement. Economic aspects include GDP, consumption patterns, measures of aid received, debt servicing. Environmental indicators include measures of water, land, atmosphere or natural resources use (where we include energy resources) as well as waste generation that results from the use of those elements. The source of data presented in this section is the *China Business Handbook 2003.*

harsh living conditions and the impact of human activity has been limited, mainly due to the pressure from the population. Xinjiang is predominantly a farming area.

Urumqi is the regional capital and is a commercial and transportation centre for north-western China. It enjoys similar preferential policies to those accorded to the coastal open cities. It is Xinjiang's largest industrial production centre, accounting for 60 per cent of its GDP.

In 2001, the annual GDP per capita in Xinjiang was Yn 7,470, around Yn 20 per day but more than 1.3m farmers and herdsmen live with less than Yn 6 per day. Poverty is the rule in rural areas of Xinjiang, not the exception. China has sought to address this problem through its national poverty alleviation programme, which it claims has raised the per capita annual income of farmers and herdsmen to Yn 1,138 since 1994, when the average was Yn 600.

> *The traditional livelihood, particularly among the indigenous populations such as Uygurs, has been herding – cattle, sheep, horses, goats, donkeys, and camels – rather than agriculture.* (SEI and UNDP, 2002:6)

The existing poverty might be a barrier to the deployment of RE technology in rural areas of Xinjiang as most of the potential users are also poorly educated and technically backward while the technology to be adopted is new and advanced.

Recently, there has been an increasing interest in Xinjiang and its problems, both from China and from abroad, in order to promote the development of the region, mainly because of the existent natural resources located there.

> *Up to now, the region has had limited economic importance, but recent evidence of the wealth of natural resources, has sparked bold development plans.* (SEI and UNDP, 2002:6)

This attention can be partially explained by the West Development Strategy[36] that was launched by the Chinese Government in order to develop the west both in social and economic terms and to catch up with the wealthier regions in the southeast. According to the Chinese government the West Development Strategy is simultaneously a poverty-alleviating, widely-dispersing, high-investment, environmentally-friendly and sustainable project.

In 2000, contracted Foreign Direct Investment (FDI) increased to US$92m and utilised FDI increased to US$19m. Hong Kong, Taiwan and Macao accounted for 63 per cent of this investment. The utilised FDI in the Xinjiang Autonomous Region was US$20m in 2001. Most foreign capital has been invested in traditional fossil fuels such as oil and gas exploitation.

b) Present Situation of the Energy Sector

The government is worried about the lack of economic development in west China, particularly Xinjiang, and the resulting and enlarging regional balance. In 2001, Xinjiang was China's third largest crude oil production base with an output of more than 19m tonnes. The Karamay[37] basin is the largest single producer, and since the first oil field discovery in 1955, dozens of oilfields have been developed.

Between 1999 and 2001, four large and medium-sized oil and gas fields and 13 oil-bearing formations were discovered in the Tarim Basin, with proven reserves totalling 346m tonnes. These fields, particularly the Kara-2 gas field, are under development by China National Petroleum Corporation (CNPC) and Sinopec plans to invest more than Yn1bn annually in oil and gas exploration in the region over the next few years. In order to better illustrate the oil industry situation we can also add that in 2001 another oilfield,

[36] In 2000 the region announced the introduction of 15 new preferential policies for foreign investors. These include free land use, tax exemptions and a simplified approval process. Government authorities are responsible for the examining and approving foreign investment projects must now respond within five days of receiving an application from an investor. For further information see map in Annex 2.
[37] In the Uygur language "Karamay" means "black oil".

the Luliang oilfield, operated by the Xinjiang Oilfield Co, produced 420,000 tones of crude oil.

CNPC has opened a 476km pipeline stretching from Korla city, on the edge of the Tarim Basin, to Lanzhou in neighbouring Gansu for refining. In 2002, the corporation entered talks to assess the feasibility of building pipelines to transport crude oil and gas from Kazakhstan to Xinjiang. Eventually, these might link up with the 4,200 km gas pipeline that CNPC is building between the Tarim Basin and Shanghai. This west-to-east pipeline will cost US$17bn to build and will allow gas to be transmitted to China's coastal provinces when the project is completed in 2005.

PetroChina is building a 182km-long pipeline to deliver 150m cubic meters of natural gas annually from the southwest Tarim Basin to Hotian. The gas will be used for power generation.

Xinjiang announced in June 2002 that it would build a liquefied natural gas plant in Hami County, at an estimated cost of Yn8bn, to process natural gas from PetroChina's Turpan-Hami gas field. The gas will be transported to the coastal province of Fujian to ease energy shortages there.

Within eight years, Xinjiang is set to become China's largest petroleum and gas producer, surpassing Heilongjiang's Daqing oilfield. Twenty-three oil and gas fields have opened in the past decade.

In spite of the tight restrictions on foreign involvement in China's onshore oil sector, foreign oil companies have been active in Tarim Basin, starting with Exxon in 1993. However, this company withdrawn from exploration projects, having failed to find significant oil or gas deposits. Only the Japan National Oil Corp is still actively exploring in the area.

> *Renforcée par l'existence de ressources naturelles – pétrole, gaz naturel et charbon -, cette position stratégique fait du Xinjiang une zone d'une importance capitale pour Pékin. Au sudest, à côté du lac Lop Nor, se trouvent également les zones utilisées par l'armée chinoise pour ses tests nucléaires.* (Sala, 2002)

As stated above, Xinjiang's energy structure like the national Chinese one that was described in the first section of this chapter is heavily dependent on fossil fuels particularly oil. Xinjiang's dependence on oil and cotton has given rise to the term "black and white" to characterise its economy. Despite being an important reserve of oil and natural gas these resources are mainly consumed outside the region. In other words we can say that fossil fuels are being "stolen" from Xinjiang instead of being used to promote the "development" (not sustainable) of the region.

In view of the impending demise of the supply of fossil fuels, it makes little sense to try to promote sustainability anywhere through the intensive use of fossil fuels. So the region urgently needs to discover and develop alternatives to diversify its energy portfolio and satisfy the increasing demand of its growing population. Despite its oil reserves, "the poorest of the poor" that live in rural areas have no access to any commercial forms of energy and have no access to electricity. In ten years time, all China will probably be connected to the national grid[38] and by that time, an eventually less sparsely distributed population might create additional attractive business opportunities.

Soon or later, RE appears to be the way to go. This can help to develop the Xinjiang economy and, if someone is willing to invest, the Xinjiang inhabitants and the Chinese government would be more than happy to accept.

Alternative energy resources, such as wind and sunlight, are all being investigated. The most promising RE source is wind power. Xinjiang already has one of the largest installed wind power bases in China. According to China's *White Book on New and Renewable Energy* the exploitable wind power resource of the Autonomous Region is around 34 000 MW. Installed capacity reached 240 MW in 2000, accounting for 21 per cent of the national total. Some of the generating units in the region are made domestically. Solar energy, using Photovoltaics (PV) to electrify the remote and rural areas of Xinjiang, is also a promising energy source. The southern and western counties

[38] According to interview with Dr. Philip Andrews-Speed on 11th July 2003.

of Xinjiang Autonomous Region have good and excellent solar radiation levels and offer real opportunities for development of solar PV home systems and community PV generation. (Byrne, 2001:39) For Xinjiang, stand-alone PV systems should receive highest priority from policy makers, the business community and international organizations. (Byrne, 2001:40) The solar and wind projects that are being implemented in rural areas of Xinjiang will be presented in detail in the next chapter.

INNER MONGOLIA AUTONOMOUS REGION (IMAR)[39]

a) Sustainable Development Indicators[40]

The Inner Mongolia Autonomous Region (IMAR) forms much of the central part of China's northern frontier, sharing a 4,200km border with Russia and the Republic of Mongolia, also known in China as Outer Mongolia. The capital city of IMAR is Hohhot. Occupying 12 per cent of the Chinese mainland area with its 1.2m sq km, IMAR is China's third largest administrative region after Xinjiang and Tibet. However, its population is sparse at only 23.8m out of the total Chinese population of 1,290m. A significant proportion of Inner Mongolia's inhabitants are herders. The original Mongol population has been diluted by Han Chinese migrants to a much greater extent than the Uygurs in Xinjiang. In 2001, GDP per capita in Inner Mongolia was Yn 5,872. In the same year, Inner Mongolia received US$107m out of the total US$51,469m FDI utilised in China.

b) Present Situation of the Energy Sector

Its proven coal reserves of 225bn tonnes are the second largest in the country after the reserves of Shanxi province. Shenhua Group has invested Yn2bn in coal liquefaction projects. The conversion project is intended to facilitate the shortage of oil in the region by converting low-cost coal to gasoline and diesel oil. First-phase construction is

[39] See map of IMAR in Annex 1.
[40] See Annex 8.

scheduled for completion by 2004, with production due start in 2006. The facility will have an annual capacity of 2.5m tonnes of oil products.

Inner Mongolia is also a major supplier of power to Beijing, providing 20 percent of the capital's energy requirements in 2000. To meet rising demand, Beijing International Power Development Corp and the Inner Mongolia Power Group signed an agreement in 2001 to build in Inner Mongolia a Yn4.8bn power plant with an installed generating capacity of 2,400 MW.

The region invested Yn13bn in power construction in 2001, bringing its installed capacity to 5,100 MW. In 2002, it launched a 497km gas transmission project, which will run from Changqing to Hohhot.

Inner Mongolia is one of the regions with the greatest commercial development potential for wind power[41] in China. (Byrne, 2001:7) Much of the region stands more than 1,000 meters above sea level which in terms of wind energy availability means it is a good quality resource. The region is now China's biggest producer, accounting for 26 per cent of the national total. According to the *White Book* the total exploitable wind power resources in IMAR correspond to 62 GW. Wind energy in this region reaches 1.01 billion kilowatts, according to the Inner Mongolia General Company.

> *Starting in1996, the government of Inner Mongolia Autonomous Region stepped up efforts to bring light to remote grasslands through using wind-driven generators.* (China Daily; 2000)

In May 2002, China's State Development Planning Commission (SDPC) granted approval for six wind power projects in Inner Mongolia. The projects, which will be operational by 2008, are supported by US$92m in loans from the Netherlands, the US, Spain and Denmark. Wind generators have been imported from Germany, Denmark, the US and the Netherlands in recent years. The regions waiting for this new source of RE

[41] For further information related with Renewables potential in NW China see Annexes 12 where its potential is compared with Solar potential; 13 which compares the availability of both solar and wind resources in Xinjiang and Inner Mongolia; 13A with Annually installed Grid-Connected Wind turbines and 14 which gives the dimension of RE market in Xinjiang and Inner Mongolia.

are mostly remote and poverty-stricken areas. This kind of projects are of very remarkable social benefit but bring low economic benefits, therefore encouragement and support from the central government and local governments seems even more essential. (SDPC, 1999:7)

Solar resources in the IMAR are some of the richest in China, but they are seasonal being more available during the summer than during the winter time. Consequently, apart from wind farms there are some hybrid systems projects being implemented that combine both the use of sun and wind.

IMAR presents some of the same problems identified in China as whole and also in Xinjiang. Like all China, IMAR is heavily dependent on coal. On one hand, the region is a very important coal reserve to China. On the other hand, the energy that is generated from that coal is not enough to satisfy the region's energy demands. This means that like Xinjiang, IMAR needs urgently to find alternatives to fossil fuels in its energy structure. The investments in energy infrastructures are reaching neither the entire region nor all the energy resources in an equitable way. It is necessary to correct this pattern of IMAR's energy sector. Like in Xinjiang, considerable parts of IMAR's rural areas are not electrified and have no access to the national grid. This energy poverty is like a vicious circle that at the same time generates and is generated by extremely poor social, economic and environmental conditions.

WHY NW CHINA?

Now that the two autonomous regions have been briefly characterized in terms of their sustainable development indicators and the present situation of their energy sector it is time to understand the reasons why this dissertation is going to focus in these two particular Chinese regions. This is designed to be a "bottom-up" study of the complex Chinese energy sector going simultaneously to identify the root of the energy problems and to understand the grassroots of the most remote areas of China.

In this context, the rural areas of Xinjiang and Inner Mongolia seem the ideal units of analysis. They represent at simultaneously a challenge and a "window of opportunity". The rural areas in these two Autonomous Regions have less chance of gaining access to national grid in the near future. Therefore, the challenge is to provide commercial alternative forms of energy at an economically feasible price to the poorest areas of China and where the greatest constraints to access to energy are experienced. Ensuring equitable access to commercial forms of electricity, and facilitating strategic foreign investment and trade in environmentally-friendly energy commodities must be the challenge of the Chinese government.

The "window of opportunity" is being open partially by the so-called "West Development Strategy[42]". Through the implementation of this strategy, the rural areas of NW China are gaining increasing visibility, i.e., national and international attention, and have the opportunity to make rational use of their own rich energy resources, like wind or solar energy for their own benefit and for their own development.

> *With the beginning of the new century, China is launching a major development effort in the west. Given the high sensitivity of the ecosystems and the current state of the environment, caution flags have been raised at the heated western development strategy, calling for careful planning with attention of the people and the region.* (SEI and UNDP, 2002:37)

The development of Xinjiang and Inner Mongolia is now one of the most fundamental development objectives of the Chinese government.

> *The Great Western Development Strategy is a central development activity that takes a market-oriented approach to developing the poorer western provinces. The strategy offers obvious opportunities for merging growth and environmental protection. The west is rich in RE resources, and these, rather than fossil fuels, could be put at the centre of development. And cleaner sector activities can be stimulated to provide much of the employment and economic growth.* (SEI and UNDP, 2002:44)

Realising the importance of narrowing the gap between the Eastern and Western parts of the country, the Chinese government has made the development of the West a top

[42] China has access to a wide selection of energy, with considerable potential for renewables, not least in the more than half of the country that is included in the *Great Western Development Strategy* (SEI and UNDP, 2002:58)

priority. The target is to put an end to the backwardness of western regions, to develop the regional economy, to foster a newly educated generation and to improve the living standards of local people. However, to rely only on exports of natural resources is not the way to achieve the aim. (Ni, et al, 2000:19) These western regions should rely also on domestic resources as an alternative.

The former Chinese President Jiang Zemin declared that Western Development was crucial to the maintenance of China's stability and the Communist Party's hold on power, as well as to the "revitalization" of the Chinese People. Under the "Go West"[43] policy of President Hu Jintao the government is pouring money into the region in unprecedented amounts to try to close the gap between China's prosperous coastal regions and its economically backward inland areas. (Watts, 2003) Hu wants the local people to push local social and economic development to a new height. Their, i.e., the Chinese leadership ambition to make the "Wild West" a Chinese California[44] reached its fulfilment in the "Great Western Development Plan" launched by President Jiang Zemin on 17 June 1999 in Xian, ancient capital of inner China.[45] (Tyler, 2003:201)

> *"Xinjiang is like California before 1849. We must start work immediately in Xinjiang to save this vast province for, like a piece of natural jade, once polished and shown to the world, it will prove our most valuable possession" said the Mandarin Aitchen Wu in the 1930s.* (Tyler, 2003:203)

Beijing's triple tactic in Xinjiang, therefore, is to exploit the land and the natural resources on which the Uighurs live for the benefit of huge population transfers; to overwhelm the Uighurs numerically by means of huge population transfers and to pacify them and win their loyalty with a better standard of living. (Tyler, 2003:208)

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[43] Another designation for West Development Strategy

[44] There are same similarities between California and Xinjiang; both are located in the Western parts of US and China respectively. And if the Chinese people want to follow the Californian example of development in terms of the use of RE, this could be very advantageous to the Chinese Autonomous Region. The biggest PV power plant is located in California that is at the forefront in the development of this technology worldwide. From Xinjiang and Inner Mongolia to California leaders in government, business and international organizations are calling for a transition to a RE economy.

[45] See Map in annex 2 with the Chinese regions where the "West Development Strategy" will be implemented.

To the Uighurs, "the Great Leap to the West"[46] looks not so much like the promise of a better future but an artificial boom in support of a Han takeover which will break up their communities and destroy their traditional way of life. (Tyler, 2003:221) There is however a positive note: the promise of financial compensation at a "certain level" for areas which supply natural resources and contribute to the country's "ecological equilibrium". (Tyler, 2003:208)

This plan is expected to include the construction of 35,000kms of roads and 4,000 kilometres of railways over the next decade, as well as the construction of the US$14 billion, 4,000-km gas pipeline linking Xinjiang to Shanghai. To the critics, the Shanghai pipeline illustrates everything that is wrong with the strategy. Xinjiang's wealth will be consumed again on the eastern seaboard; there is no "development" for the Uighurs contained within it, only "exploitation" (Tyler, 2003:213) in order to create markets in which to sell products from the east coast. The Western environment is fragile, and large transportation projects such as gas pipelines, railroads and roads could have a direct, negative impact on it. (SEI and UNDP, 2002:59)

1.3 Conclusions of the Chapter

Energy is essential for the world's development and particularly in rural areas of developing countries like China where there are no commercial forms of energy at all. As this chapter showed, the current Chinese energy structure presents three great weaknesses. First, the excessive dependence on fossil fuels which has to be partially fulfilled by imports. Second, the unbalanced distribution between demand and supply energy centres. Third, the non-electrification of rural areas, particularly in NW China. Therefore, the structure needs urgently to be modified. Taking into account the key importance of the energy sector, China needs quickly to find an alternative energy strategy. In spite of the present energy poverty, both Xinjiang and Inner Mongolia rural areas are rich in RE resources that can satisfy their basic energy needs. At the same time, they can promote the development of the regions[47] without endanger the future

[46] This is an analogy with "the Great Leap Forward" 1958-1960.
[47] See the Annex 15 about the "Productive Uses" of Renewable Energy in Rural Areas.

development of China. This is the great challenge that China faces and which the second chapter will develop.

2. COULD THE USE OF RE BE A FEASIBLE SOLUTION TO SOLVE THE ENERGY PROBLEM IN NW CHINA?

2.0 Introduction

Despite of some Chinese commentators still advocate the use of clean coal technologies rather than renewable energy (RE) sources to guarantee the success of China's Sustainable Energy Strategy and the importance of fossil fuel lobbies,

> *We should admit that clean coal is the "future energy" and that developing clean coal technologies is an important strategy.* (Zhou, 1997: 371)

This chapter suggests that the use of RE could be not the only solution but a feasible one and probably the best to solve energy problems in NW China. RE's use needs to be seen in this dissertation as part of a sustainable energy strategy. A clear understanding of the interconnections between RE and a sustainable energy strategy will support the proposal of a sustainable development approach in order to face China's New Challenges in NW China. In the first section of this chapter we will present the concept of Sustainable Energy Development and its strategic importance in the face of new challenges in NW China to achieve what will be called "Sustainable Development with Chinese Characteristics". At the same time these challenges will be identified. Admitting that RE are a key element of any Sustainable Energy strategy and of the Chinese sustainable energy strategy in particular, in the second part we will underline the increasing role of RE in Energy Portfolios, both in China and worldwide. The main technical features of Solar and Wind Energy for electricity production in NW China will also be analysed in order to better understand what kind of technology we are describing and the main advantages or disadvantages of these REs will be pointed out. Finally, some solar and wind projects in Xinjiang and IMAR will be briefly described.

2.1 Sustainable Energy Strategy to Face New Challenges in NW China

Before analysing the sustainable energy strategy and its meaning according to Chinese idiosyncrasies, it seems better to clarify the new challenges that this paper refers to and

which the country is facing in its NW regions. Thus the challenges are to ensure a secure energy supply for the NW region or at least the ability to satisfy its basic energy needs without compromising the environment while simultaneously guaranteeing the improvement of the social and economic conditions of its population in order to reduce its wealth gap with the most developed Chinese regions.

A key challenge is how to provide essential energy services without incurring unacceptable damage to human health and to the environment. (SEI and UNDP, 2002: 55) The supply of fossil fuels is not at risk for the foreseeable future but this provides time for China, at present heavily dependent on coal and oil imports, to start tracking a new way to diversify its Energy-mix. On the other hand, China is not short of indigenous energy sources. On the contrary, the country possesses some of the best RE resources in the world like the sun and wind. Consequently, one of the challenges that China is going to face is to find a strategy to increase the use of RE resources. Such a sustainable future would rely increasingly on solar energy resources with contributions from other RE sources. (Jefferson, 2000:278; Byrne, 1999:6) Chinese government and business leaders have changed their thinking about sustainable energy strategy since the mid-1980s. Currently the Chinese State encourages and supports power generation with new and RE. (SDPC, 1999:15)The emerging interest in developing RE options by the Chinese government offers more chances for the Chinese energy strategy to succeed.

These challenges will be analysed in detail with reference to the Northwestern Autonomous Regions of Xinjiang and Inner Mongolia but China faces these challenges at local, national and international levels. However, this is a "bottom-up" study that first proposes solutions at local level followed by an osmotic spread of these solutions nationwide and worldwide.

As emphasised in the previous chapter, a major change in Chinese Energy Systems development is required to meet the social, economic and environmental goals of NW China, which is summed up as sustainable development[48]. These challenges can be met if

[48] Sustainable Development (SD) is the broad concept behind the concept of Sustainable Energy Strategy. The term sustainable development is often used synonymously with sustainability. However, while

principles of sustainable development inform the nation's economic, energy and environmental policy, and if international support is mobilized to meet its needs. (Byrne, 1996a:7) The necessity to shift the development paradigm in order to find the path towards a sustainable future is absolutely urgent. China can decline towards environmental catastrophe, or it can become a leading environmental model. (SEI and UNDP, 2002:2) This major change will require major choices. Although real opportunities exist for stopping and even reversing environmental degradation in China, unleashing those opportunities requires firm choices to be made now. (SEI and UNDP, 2002:1)

The Chinese Government is making its decisions. A new approach to energy needs to be developed and implemented is a "sustainable energy approach". (Zhang, 1999:50)

> *The twin goals of lifting a stabilized world population to a decent quality of life while saving and restoring the natural environment is the bottom line of global sustainability.*(Wilson, 2000:35)

China must develop market rules for Sustainable Energy Development identifying and analysing important new technologies for sustainable energy but also proposing demonstration projects for the new technologies' deployment.

Worldwide, the demand for energy is increasing as a consequence of socio-economic development and this is particularly true in Asian developing countries like China. Over the long-term, development of large-scale RE supply is strategically important for local, regional and global environmental sustainability. (Taylor, 1998:1) Adequate supplies of energy at reasonable cost are essential for long-term economic prosperity and social development, and to correct past environmental problems as well as to prevent new ones.

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sustainability implies that well-being can be at least maintained over time, sustainable development implies in addition that the factors which determine quality of life, such as literacy and education in general, health, human rights and so on, improve over time. Thus, the term "sustainable" implies that the capital stocks that generate human well-being should not be depleted over time. The use of the term "development" in conjunction with sustainability requires that the issues crucial to human development must be taken into account. In the context of this dissertation, the Chinese Sustainable Energy Strategy aims to deploy energy resources and develop energy structures to improve the social, economic and environmental conditions of the inhabitants of rural areas of Xinjiang and Inner Mongolia. These impoverished populations need do more than "just" maintain their well-being.

(NAS, 2000: ix) Environmental degradation has increased alongside the economic growth, mainly due to growing and inefficient energy consumption. One way for developing countries like China to avoid environmental and economic stress is to leapfrog the technologies used by industrialized countries in the past. This means incorporating energy-efficient technologies in the development process. (Goldemberg, 1997:337) By following a sustainable development approach China will be able to succeed and face the new challenges. This choice would increase the chances that China will achieve its future goals without sacrificing already constrained natural resources and a deteriorating environment, and without threatening the survival and development of future generations. (SEI and UNDP, 2002:11)

There is no doubt that Chinese people desire a sustainable future but it is of critical importance to change end-consumers' attitudes[49] towards energy if sustainable development goals are to be reached in the rural areas of NW China and in China as a whole.

> *Through demand-side measures and, early in the next century [this century], with the new RE supply systems, the regions could achieve a healthier, more prosperous future.* (Chandler, 1997:267)

Following an energy-supply approach for China's Sustainable Energy strategy the present energy production patterns must change, diversifying energy resources and the structure of power production, and establishing an energy structure that is less or not at all harmful to the environment. The three major elements in the Sustainable Energy Approach are:

i. the efficient use of energy especially at the point of the end use;
ii. increased utilization of RE sources;
iii. development and implementation of a new generation of cleaner fossil-fuel using technologies.

[49] Energy-demand approach should be pursued in order change the patterns of energy consumption in NW China. They should switch from fossil fuels to more environmentally-friendly energy resources. It might be easier to change the energy demand patterns of this population than in the most developed areas because usually the consumers tend to use the energy resource that is mostly available even if it produces hazardous effects in the environment and in this case they do not have access to any commercial forms of energy.

The Chinese objectives are to achieve Sustainable Development in the Energy industry, and simultaneously meet the needs of socio-economic development through the following means:

i. strengthening the planning and the management of the Energy System;
ii. formulating and implementing policy and regulatory systems appropriate for the market economy;
iii. developing and popularising advanced environmentally-sound energy production and utilization technologies;
iv. increasing efficiency;
v. reducing environmental pollution. (SSTC, 1994:124)

Chen Jiagui, vice-president of the Chinese Academy of Social Sciences affirmed that:

> *Having sufficient energies is a key factor ensuring China's sustainable development and it appears that there is increasing pressure on China to put in more effort to develop new and RE resources.* (People's Daily Online, 2001)

SUSTAINABLE DEVELOPMENT WITH CHINESE CHARACTERISTICS

The basic idea of Sustainable Development was outlined in the Brundtland Commission as "development which meets the needs of the current generation without jeopardising the needs of future generations" (Brundtland, 1987). In the Brundtland report, *Our Common Future*, it was stated that "a safe sustainable energy path is crucial to sustainable development. RE sources should form the foundation of the global energy structure during the 21st Century". Using global energy strategies, often seen as western concept or energy development strategies, to change the face of rural areas of NW China, promoting sustainable development and satisfying the region's basic energy needs, requires these strategies to be thoughtfully interpreted to meet local conditions and priorities of both Xinjiang and Inner Mongolia. This new drive for the sustainable development of the rural areas of Xinjiang and Inner Mongolia should be rooted in the growing recognition of the strong links between energy use, environment and development.

According to Dr. Ausilio Bauen cited in the SEI Newsletter:

The role of energy in sustainable development is to provide the services that allow for a development that is economically efficient, environmentally sound and that contributes to social equity, which in sum are three essential pillars of sustainable development. Energy on its own is not a priority but a means to achieving social priorities. RE potential remains largely unexploited around the world. It is urgent to develop this further. Little progress has been made in the world's poor countries, a basic requirement for their economic development.

For energy resources to be evaluated in terms of their contribution to the sustainable development of rural areas of NW China, their energy performance has to be evaluated in such a way that the electricity generated would replace the conventional burning of wood and fossil fuels that have adverse environmental effects and which use technologies that have failed to secure the aims of social equity. If RE options can meet the basic energy needs of the poor people in NW China and promote their economic and social development without threatening human health or environmental sustainability, they would be evaluated positively in comparison to conventional energy options. (Byrne, 2001:25)

The pursuit of a Sustainable Energy Strategy might put both Xinjiang and IMAR on to the alternative development path[50]. A sustainable energy strategy as opposed to the traditional Chinese energy strategy that relies heavily on fossil fuels and does not bring enough commercial variety or development to NW China is vital for the macroeconomic stability of China and its two Autonomous Regions. These fragile areas require economic development enabled by reliable and cost-effective electrical power. Widespread recognition of the full environmental lifecycle cost of nuclear and fossil fuels, coupled with depletion of natural resources, is making RE an increasingly attractive option. In remote rural areas renewables (even with the full life cycle costing) might offer the optimal solution to the challenges of rural poverty. (WEC, 2003:3) Technical and economic viability analysis make the conclusion obvious: under current circumstances adopting wind and/or solar energy to solve the power supply problem in remote areas of China is feasible and conforms to the State policy of sustainable development; it is also

[50]This path represents an equitable alternative to the paths typically being experienced by developing countries. As a consequence of the utilization of RE these two regions could increase their incomes, reducing the internal gap between the backward NW part of the country and the developed coastal areas. Such a development process has many environmental implications. An alternative development path is consistent with conservation rather than with a degradation and loss of diverse natural resources.

evidently superior in cost-effectiveness and social terms to the grid extension or the diesel-based power generation. (SDPC, 1999:99) RE could be the least-cost option for China to address its growing needs, especially in rural areas. (Byrne, 1999:7) RE helps alleviate fuel price risks. As the costs of using it continue to fall, RE is expected to overtake fossil fuels as the lowest cost, least-risk investment over the next several decades (GEF, 2002:58) In rural areas of NW China with inadequate supplies of electricity, RE could provide an alternative to expensive extensions of the national grid to sparsely populated rural areas.

> *RE can provide a cost-effective alternative for decentralised electricity generation when project costs are examined over the full design of the generating system. After all, the cost of the energy itself is zero.* (Allen, 1998:3)

In Social and Economic development terms the production of RE can provide economic development and employment opportunities in rural areas of NW China that otherwise have limited opportunities for economic growth. RE can thus help to reduce poverty in these Chinese rural areas.

> *Using renewables stimulates local economies by attracting investment and tourist money and by creating employment. RE provides more jobs per unit of capacity or output and per dollar spent than conventional energies do. (Sawin, 2003:89) Many of the components if not the entire systems for solar homes, wind farms, and other renewable technologies are now manufactured or assembled in developing countries, creating local jobs, reducing costs, and keeping capital investments at home. China developed a domestic wind turbine industry and is now the world's largest producer.* (Sawin, 2003:90)

Investment in renewables in rural areas of NW China will demonstrate that it is an energy-rich part of the country that can leapfrog over dirty technologies relied on earlier in industrial countries as well as in the most developed parts of southeast China and can develop its economy with clean, domestic, secure sources of energy to avoid long-term and costly imports. Simultaneously, the development of the RE industry will bring many social benefits, among which the most obvious are that 1 million jobs all over China are estimated to be newly created so that the problem of power supply for about 25 million farming or husbandry will be solved by 2015[51]. (Gu and Liu, 2000:10) Some of these

[51] Worldwide, 100,000 people are now employed in the wind industry worldwide. (Sawin, 2003:92)

benefits are already being experienced in rural areas of NW China and could be amplified in the mid or long-term.

> *In Inner Mongolia, thousands of people now have access to education, information, and other benefits for the first time thanks to the use of televisions and radios powered by small wind and solar systems.* (Sawin, 2003:90)

As a result, IMAR inhabitants have become more productive and have increased their monthly household incomes by as much as $150. (The average per capita annual net income in Inner Mongolia ranges from about $120 to $240)

Additional benefits may include economic and social developments coming from access to electricity, health benefits from access to clean energy for cooking and heating, income generation for local communities, capacity building, local employment and expertise. These renewable resources will produce overall effects like improvements to the quality of life, a rise of living standards, increased productivity, and a reduced potential for economic and political instability. One main objective of the industrial development of wind power generation is to improve domestic production capacity for wind generation equipment and realize the localization of wind turbine manufacture, so as to meet domestic demand caused by the high-speed increases of wind farm construction. There should also be an aim to export domestic wind turbines.

Environment becomes one of the core themes in the Chinese future energy sector development, planning and implementation. Environmental considerations have a real influence over the development of policy and all energy programmes. The Chinese government in particular the SDPC and SETC are mapping out China's energy future with the promotion of renewables. In environmental terms RET present virtually[52] no hazardous emissions that contribute to air pollution. RE does not produce carbon dioxide and other greenhouse emissions that contribute to global warming. By the year 2015, the power created annually by the new and renewable energies in China is expected to be

[52] In fact, a small amount of pollution is generated during PV panels' manufacture including many of the chemicals and heavy metals used in the semi-conductor electronics industry.

equivalent to that produced by some 43 million tons[53] of coal every year. (People's Daily Online, 2001)

Around the world, the transition to RE systems has already begun. IEA scenarios are looking three decades into the future. In 1999, the IEA noted that "the world is in the early stages of an inevitable transition to a sustainable energy system that will be largely dependent on renewable resources". (Sawin, 2003:86). The *Alternative Policy Scenario* developed by the IEA in 2002 highlights the potential impact of the new energy and environment policies which are today under consideration in many countries. A transition to RE is inevitable not because fossil fuel supplies will run out, but because the costs and risks of using these supplies will continue to increase relative to RE. (GEF, 2002:58) Moreover, meeting a transition to a renewable-intensive energy economy would provide environmental and other benefits not measured in standard economic accounts. Because RE is expected to be competitive with conventional energy, such benefits could be achieved at no additional costs (Johansson, 1997:233). The sooner China initiates this transition to RE, the lower the impacts and the associated costs.

2.2 RE as a Cornerstone of Chinese Sustainable Energy Strategy

> *Renewables have gained market share very fast in recent years and attracted large-scale industrial investments, including among some of the oil multinationals. The effort must continue, and every cent spent on renewables R&D and deployment today is certain to pay dividends in the shape of a more sustainable energy future for the generations to come.* (Hague, 2002)

RET have the potential to meet world energy demand many times over, could theoretically provide a nearly unlimited supply of relatively clean and mostly local energy and are now ready for use on a large scale. Renewable energies have considerable potential and wind and solar powers are the fastest-growing energy sources in the world. By some estimates, "new renewables" (which exclude large-scale hydropower and traditional biomass) already account for more than 100,000 megawatts (MW) of grid-connected world electric capacity. (Sawin, 2003: 85) Yet the momentum for change has

[53] Note that other sources refer to different expected data for 2015.

been building. Wind power installations are growing at 30 percent a year – a phenomenal rate of growth. (Buckley, 2003 and WEC, 2003:2)

A founder of the World Council for RE emphasises the business opportunities presented by renewables stating that they are like petroleum in the last century, which had only 2% of the market in 1902 but quickly became the energy of choice around the world, or the expansion of mobile phones more recently and he believes that the renewables can experience the same exponential grow.

There is no doubt that RE – energy derived from the sun and the wind – is the energy source of the future. (Allen, 1998:2) The flow of RE to the Earth land surface is thousands of times greater than mankind's present rate of total energy use. Utilizing only a small fraction of this resource would provide humanity with an alternative and environmentally sound path towards meeting future energy needs (Johansson, 1997:232).

THE INCREASING ROLE OF RE IN ENERGY PORTFOLIOS

RE development has the potential to make a difference to China's energy future. (Taylor, 1998:4) Exploring new and renewable sources of energy as local conditions allow is part of China's strategy and policy for the improvement of its energy structure and environmental protection. Renewables can contribute substantially to national economic and environmental objectives because, in quantity, renewables can add new value to the energy portfolio. (Haug, 2002)

Electric power from RE sources is often envisioned as the long-term goal of a nation's energy development, though the time frame in which such a transition can occur remains unclear. (NAS, 2000:42)

Chinese wind power has the greatest potential for large-scale western investment. In 1998, China has at least eleven commercial wind farm installations and as many as 140,000 small household wind turbines supplying power in remote regions. Most of the

large wind turbines are imported[54] from Denmark, Sweden, and the US, though turbines as large as 55 kW are manufactured domestically. (McElroy, 1998:50)

> *The Chinese government should give priority to the development of RE resources in the Natural Energy Development Strategy.* (SSTC, 1994:134) *Developing the abundant wind energy and solar energy is the only way to realize sustainable development* (SDPC, 1999:1)

In the last 20 years, great progress has been made in China in the development and utilization of the new and RE. During the 1980s China introduced a solar-cell production capacity and in 1996, 1.5 MW solar panels were already produced. In the same year, 7 MW PV panels began to be installed in China. Renewable energies have played and will continue to play an important role in the development of national economy and meeting the demand of the living standard in rural and remote areas.

> *China's unserved rural regions may be ideal for proving next-generation renewable distributed power systems such as solar* (NAS, 2000: x)

Rural electrification is now and will remain in the mid and long-term an essential element for Chinese rural development and the development and utilization of RE is becoming one important, strategic option to realize the rural electrification of NW China.

Moreover, Renewables continue to face a "credibility gap"[55] (Sawin, 2003:108) and this lack of credibility is also visible in the Chinese market. A report on the current energy situation, and the Program for RE Development in China was presented by Prof. Zhou Fengqi stating that "while the potential contribution of RE in China is recognized to be large, the cost per unit of installed capacity still high relative to current conventional energy systems". (Zhou, 1997 and 1999)

[54] See Annex 16 for further information on the origin of Wind Turbine Generators.
[55] Many people remain unconvinced that renewables could one day be harnessed on a scale that would meet most of the world's energy needs. But those assumptions are outdated.

MAIN TECHNICAL FEATURES OF SOLAR AND WIND ENERGY FOR ELECTRICITY PRODUCTION IN NW CHINA

Retailers have been very active selling RE systems in the north-western provinces of China, both wind and photovoltaic. Based on reports from photovoltaic companies, an estimated 45,000 photovoltaic systems were sold in 1997. None of the photovoltaic system retailers and distributors serving these areas conducted any type of formal survey to determine the size of the market for RE systems. (Vorovate, et al, 1999:1)

As a type of new and high technology, RET have features of new-tech products and are at a different stage of development. Most renewable products do not have a mature, normative market and price system in China. Only a few technologies are basically mature. However, these technologies need to further reduce costs so as to compete with conventional energy. Currently, there are some products with a certain scale of production such as solar PV systems, grid-connected wind farms, and off-grid wind generation systems. (Gu and Liu, 2000:3) Solar and Wind are now developing at a very high speed which will increase in the future so that they will be responsible by 50% of the national energy supply by the year 2060. (SDPC, 1999:5)

Recent developments in energy conversion technologies will reduce the cost of RE to competitive levels, thus permitting large reductions in fossil and nuclear energy use over the coming decades (Chandler, 1997:257)

a) Photovoltaics (PV)

Solar Energy is considered the most important basic energy among various RE. The Sun delivers to Earth more than 10,000 times the energy that humans currently use. (Sawin, 2003:93) Photovoltaic Solar electric technology is simply the conversion of solar radiation, i.e. sunlight into electricity. Solar energy is used in two main ways: to make electricity (photovoltaics) and to heat water (solar thermal). The photovoltaic (PV) application is the more widespread of the two and data is also more readily available.

There are four primary applications for PV power systems[56]: Off-grid domestic; off-grid non-domestic; Grid-connected distributed and Grid-connected centralized. This dissertation is going to analyse the off-grid domestic systems and at certain point refer to the Grid-connected distributed applications of PV in NW China.

Solar cells convert sunlight directly into electricity. They are made of semiconducting materials similar to those used in computer chips. The best known example of such a material is silicon – a cheap abundant mineral. (Buckley, 2003:6) In the short term, the development of photovoltaic cells/devices will be stressed by the Chinese Government, so as to improve conservation rates and reduce costs. There are growing markets and manufacturing bases in China for the production of solar cells. (Sawin, 2003:93)

Over the long term, Chinese officials propose to establish large-scale solar power stations. (SSTC, 1994:134) Large PV systems can be integrated into buildings to generate electricity or can produce electricity to be exported into the Chinese national grid.

Solar PVs that produce energy in the middle of hot summer days are likely to see dramatic cost reductions. (Sawin, 2003:93) According to the US National RE Laboratory (NREL), PVs have the potential to become one of the world's most important industries. The PV industry generates business worth more than $2 billion annually and provides tens of thousands of jobs. (Sawin, 2003:93) Each second, at least three solar cells leave a factory production line somewhere in the world. (EUREC, 2002a:26) China might be a destination country.

Photovoltaic (PV) technology for the conversion of sunlight into electricity is already a cost-effective method for many applications worldwide include the rural areas of NW China.

A typical photovoltaic system is made up of a photovoltaic panel and the balance-of-system (BOS) components such as a battery, DC/AC Inverter to convert direct current

[56] See IEA Photovoltaic Power Systems Programme at http://www.oja-services.nl/iea-pvps/isr/index.htm for additional information about each kind of PV application.

(DC) to alternating current (AC) and a charge or load controller to prevent overcharge of the battery. Photovoltaic panel manufacturers describe their products in terms of their rated output. Watt peak (Wp) refers to the maximum power output. They will only produce this when the sun is at its peak and the sky is clear. (Allen, 1998: 8) The traditional view has been that households would not want systems below 50 Wp, because they would not supply sufficient power. (Vorovate, et al, 1999:9) However, this is not the case in rural areas of Xinjiang and IMAR where the most common systems used are 10, 20 or 50 Wp photovoltaic systems. In China, the panel and the other components are usually packaged in two self-contained wooden boxes. The user only needs to set the panel in place and connect the battery to the panel in order to be ready for it to start operating. (Vorovate, et al, 1999:14)

The largest cost-effective application today is the provision of electricity to rural communities in the developing world and emerging countries. (EUREC, 2002a:31) This is the principal niche market for PVs. In other areas, some projects are already technically but not yet economically feasible. At present costs, PVs are economically competitive with the traditional alternatives: kerosene lamps, candles, primary batteries, small gasoline generators, and extending the grid for small demand levels. (EUREC, 2002c:195) And in the long-term, if the projected cost reductions are achieved, PVs could become a significant option in countries with severe shortages such as China.

In 1998 PV Solar cells production provided 2.1 MW, about 1.3% of the world total production. To date we have altogether 4 monocrystaline silicon cell and component factories and two monocrystaline silicon factories in China. (SDPC, 1999:3)

The international Solar Energy Photovoltaic Technology market has increased 15 percent every year in the last 15 years. Large companies around the world are setting up and carrying out production expansion plans. (SDPC; 1999:23) The world's top solar cell producers are Sharp (whose PV output reached 123 MW in 2002), BP Solar (66.8), Kyocera (60 MW) and Shell (55.5 MW) (Buckley, 2003:7)

PV can make an important contribution to help meet basic needs and increase productive use activities. It is uniquely suited to provide small amounts of electricity (for lighting in particular) for household systems where there are weak grids. PV systems are technically proven, and are competitive at present prices in certain niche markets like the rural areas of NW China. An emerging market for photovoltaic systems is developing in the Northwestern provinces of China. At present, this market is at an early stage of development, as commercial retailers have only begun to service these provinces during the last three years. There is a need to increase both the awareness and availability of photovoltaic systems. Solar cells are already the most affordable option for getting modern energy services to hundreds of millions of people in developing countries. (Sawin, 2003:107)

Millions of people around the world would like to heat their homes with and run household appliances with solar power. But the cost of doing so puts it beyond their reach. The cells convert only 10-15% of the radiation from the sun into energy and the PV material used is a form of silicon that has to be made under high-vacuum conditions and heated in special kilns to 1,400◦C. That makes photovoltaic solar cells horrendously expensive. (The Economist, 2003)

b) Wind Turbines

When wind projects were discussed 20 years ago, "you could safely say that they were science projects" said Steve Zwolinski, president of GE Wind Energy[57]. "They've come of age now, and they're really viable technology," he added, believing that RE will be an integral part of the world energy mix throughout the 21st century.

Wind energy, the kinetic energy of moving air is no longer the preserve of "green" enthusiasts. It has become a serious global industry. (Buckley, 2003:4) Wind energy capacity installations worldwide have surged from under 2,000 MW in 1990 to the present level of approximately 13,400 MW at the end of 1999, representing a more than six and a half–fold increase during that time period. In recent years, the wind energy

[57] See http://www.gepower.com/dhtml/wind/en_us/index.jsp for company details.

market has been growing at 20-30% a year, reaching about $7bn in 2002. With this dramatic growth rate, wind energy seems to retain its position as the fastest growing energy technology in the world. By that year, some wind farms were producing electricity at less than 5 cents per KWh, making wind energy competitive with traditional sources. Wind power is leading the way in many nations generating more than 20 percent of the electricity needs in some regions and countries, and is cost-competitive with many conventional energy technologies.

Wind turbines are 15 times more efficient than they were in the 1980s. According to Philipp Andres, a vice president for business development at Vestas[58] American Wind Technology, a subsidiary of the Danish Vestas, the world's largest manufacturer of wind turbine, "The efficiency of the turbines has gone up about 5 percent every year". By 2003 wind power source had become a $7 billion industry worldwide and is forecast to reach $25 bn by 2010. However, unlike solar cells, wind energy depends on mechanical devices which need maintenance and suffer from occasional breakdowns. A drawback is that wind energy cannot provide continuous power without separate electricity storage or back-up facilities. Yet wind power seems likely to be an important part of the energy mix. (Buckley, 2003:5)

Today's windmills – often called wind turbines – are quieter and more reliable than ten years ago, and they generate more power at a lower cost. They are outfitted with dozens of sensors and connected to a network that allows them to be monitored remotely, from a PC or a laptop. (Kirsner, 2003) Today's wind turbines rely on an "electronic nervous system" that allows them to predict the force and direction of the wind up to 24 hours in advance, and adjust the orientation of the rotor and even the pitch of each individual blade in order to wring the maximum energy out of a passing breeze.

The wind blows hard enough to turn a windmill almost anywhere in the world. But consistency and strength vary enormously. Wind speeds increase with elevation and over

[58] See www.vestas.dk for more details about the world's largest manufacturer of Wind Turbines. **Vestas - International Wind Technology A/S** is the branch of the group responsible for the introduction of wind energy turbines in China. While I was doing my research I was in touch with the company by email and learnt that they do not have any kind of business in China.

water. Where wind speeds are consistently above 5m/s the installation of wind farms could be a good option. Site location is the key to economical power generation. Power output is related to the cube of wind speed. Germany is the world's leading user of wind energy. Danish manufacturers, helped by various government incentives, have become world leaders in wind technology production. Wind farms have started to gain ground in the United States, in United Kingdom in Denmark or in Spain.

Worldwide, installed wind power generation capacity has increased more then ten-fold over the last decade. For the last three years, wind power capacity additions have significantly exceeded those of nuclear power. Michael O'Sullivan, a senior vice president at FPL Energy[59], the US leader on Wind Energy producer, said that 2003 will probably be the second-biggest year in the industry's history, in terms of adding capacity exceeded only by 2001. Wind is emerging as a mainstream energy source. (BP, 2002)

Wind is already being used in countries with sharply increasing demand for electricity and wind power could play an important role in China's electricity sector, but key barriers must be addressed before this clean energy source meets its entire potential. (Lew, 2001) China is the sleeping giant of wind energy. (AWEA, 1999) In 1999, China ranked fifth worldwide in new added wind turbine installed generation capacity while US ranked second[60] China is expected to be one of the most significant markets. Wind Turbines are the key to bring light to remote Inner Mongolia and Xinjiang Autonomous regions. (China Daily, 2000)

The "annual mean windspeed" for the site will determine how much power we can get from the wind turbine. The average wind speed for open land without cover and for farmland windbreaks over 20 meters above the sea level - which is the case in the majority of the vast rural and backward areas of Xinjiang and Inner Mongolia - is 6.2m/s and 5.5m/s respectively. The biggest new turbines have towers and rotor blade diameters exceeding 100 meters. Most of the world's installed wind turbines are in now in the 600-700 kW range.

[59] See http://www.fplenergy.com for additional details.
[60] See www.mpsutility.com/delegates.jpg

Wind power is due to grow even faster in the future in terms of both RE market share in China and the Chinese Energy mix. The wind turbines will continue to get bigger too, but there are theoretical limits to their increase beyond around 8MW. The largest to date is 3MW. Multi-megawatt turbines are now made by companies such as the American companies ENERCON, NORDEX and GE (Buckley, 2003:4) In China, wind turbines have also been growing in size. The 55-150kW wind turbines were the most commercialised in the 1980s. In the early 1990s these were superseded by 200-300kW turbines. In the mid-1990s 500-600kW turbines were put into the market and their mass production was started. (SDPC; 1999:11)

In China, despite the Government's aim of 1000 MW of installed wind power by 2000 (and 3000 MW by 2010) only 25 MW capacity was added during 1999, bringing the end-year figure to 253 MW. Twelve provincial and autonomous power corporations are engaged in developing wind power and 19 wind farms with 525 wind turbines and 223.6 MW of total capacity have been established in the two high-wind Chinese zones or Wind-belts. One of the wind belts is located in the NW and the other in the costal areas of southeast. The 64 MW Xinjiang Dabancheng Wind Farm[61] is China's largest.

In addition to large wind power plants (typically 20-100 MW) for connection to the national grid, the Chinese government planned to install clusters of small wind turbines (10-100kW) in townships and villages for rural electrification and also on a very small scale (0.5-10 kW) in individual homes to provide electricity for domestic uses.

Wind turbines have an undeserved reputation for being noisy. However, the design of turbines has improved dramatically over the last decade. If there is a very low level of background noise then the wind turbine is more likely to be heard. When we look at wind turbines they appear large and visible producing a certain visual impact even if some of the wind energy enthusiastic insists to call them "White Angels". This is particularly true in the studied areas of Xinjiang and Inner Mongolia where there are no other visible structures for energy supply.

[61] For further information on Dabancheng Wind Farm please see Annex 17.

The independence afforded by wind power in terms of energy supply is only partial because a backup system is required. Wind is not predictable so other forms of power must be available to make up any shortfall.

But the real benefits of the use of wind power in NW China should not be underestimated. Wind power is a huge renewable resource: pollution-free; with no land inundation; with less land occupation than traditional fossil fuels power plants or hydroelectric power plants; that requires a short construction period, flexible investment and few operation and management staff.

The pollution mitigation potential of wind power is significant. If China develops even one-half of its conservatively-estimated wind resources, it could generate about 275 billion kilowatt-hours of power each year – about one-fifth the country's current demand – displacing emissions of 125 millions tons of sulphur dioxide and 65 million tons of carbon. (Lew, 2001) The environmental considerations should be the main attraction even when the economic costs of any RE system are high in the short-term.

Wind turbines and PV cells can produce electricity in NW China without harmful emissions, installation costs are low and the fuel is free. Moreover, power can be generated wherever it is needed, creating a distributed energy system which is less vulnerable to monopoly control or an eventual terrorist attack – "democratising" energy supply amongst the poorest areas of China. Their modularity makes them suitable for decentralized generation; they are extremely reliable and compatible with human activity.

OFF-GRID AND GRID-CONNECTED SYSTEMS

China's rural energy development efforts can be divided into two classes: off-grid (or household) and grid-connected.

a) Off-Grid Systems

Off-grid wind and PV technologies are feasible to be used in the regions of Xinjiang and Inner Mongolia. Years of practise has proved that off-grid wind power and solar PV technologies are applicable in Inner Mongolia and Xinjiang. (SDPC; 1999:97) Despite the remoteness of these areas, retailers have recently dramatically stepped up sales of RE systems – particularly wind (starting in the early 1980s) and photovoltaic home systems since 1995. (Vorovate, et al, 1999:8)

China has been very successful in developing small-scale RE. In fact, a significant number of installed household systems and a mature industry for small-scale RE are already in place. Virtually unknown in 1992, solar home systems, also know as PV off-grid systems using photovoltaic technology now provide power to more than 1 million rural households. And at least 30 major firms have committed themselves to investing $10 to $15 billion in RE over the next five years. Between $500 million and $1.5 billion have been earmarked for RE projects in developing countries each year, a market with an annual growth of 5 to 10 percent. (GEF, 2002:xii) At the moment, there are approximately 200,000 solar home systems already installed all over China for rural electrification.

These systems provide electricity to households and villages that are not connected to the utility grid. They provide electricity for lighting, refrigeration and other low loads and have been installed worldwide, particularly in developing countries, where they are often the most appropriate technology to meet the energy demands of off-grid communities. Off-grid domestic systems generally offer an economic alternative to extending the electricity distribution grid at distances of more than 1 or 2 km from existing power lines. PRC is the world's largest manufacturer and user of small turbines with its 155,000 to 170,000 small wind turbines. (Qin, 2001:93), totalling 42 megawatts of capacity. Small-sized wind generation technology has become very mature.

China is able to manufacture over 10 types of wind generation units with a range of capacity from 100W to 10W. Compared with similar foreign wind generators, Chinese

products have features such as low start-up speed, high generation in low wind speed, reliability at limited speed and stable operations. More importantly, they have a much lower production cost and sale price. However, there are still some gaps in turbine appearance and blade power quality. The difference between units with a capacity of tens of kilowatts is also apparent.

Small-wind generators, often called stand-alone systems, continue to have their niche market for remote power supplies. The main disadvantage of these systems is that if there is no wind there is no electric. So, a storage system is required.

Some regions in China, notably Inner Mongolia, already have well-developed rural wind programs that play an important role in improving the quality of life for hundreds of thousands of Chinese living in remote areas. While off-grid wind power provides clean, relatively cheap power to herders, farmers, and villagers, the impact of these units on China's energy sector is small compared with the impact that grid-connected wind farms could achieve in terms of share in China's Energy Mix.

b) Grid-Connected Systems

Within Grid-connected systems we should distinguish between centralized and distributed ones. The centralized systems have been installed for two main reasons: as an alternative to conventional centralized power generation or to strengthen the utility distribution system. These systems, still in a demonstration phase and with some feasibility and reliability studies yet to be done, have been manufactured in Germany, Italy, Japan, Switzerland and the USA. On the other hand, we have the distributed PV systems that are currently being developed in NW China. This is a relatively recent application where a PV system is installed to supply power to a building or other load that is also connected to the utility grid. These systems are increasingly integrated into the built environment and are likely to become commonplace. The systems typically feed electricity back into the utility grid when the on-site generation exceeds the building loads. Compared to an off-grid installation, systems costs are lower as energy storage is

not generally required which improves system efficiency and decreases the environmental impact.

Wind Farms or Grid-Connected Systems enable the export of electricity produced through wind energy to the grid without the necessity for additional storage systems. These systems are being more and more used, compared with stand-alone systems. The grid-connected systems will be the more environmentally friendly solution when compared with stand-alone systems, because of the use of connected inverter (that will enable energy export to the grid) instead of batteries. However, the grid-connected systems present higher economic costs to rural areas.

At the moment, grid-connected RE is not as successful in China as the off-grid options. Lately, the Chinese authorities have concentrated their efforts on the development of large-scale, grid-connected RET, but research conducted by the Center for Energy and Environmental Policy of the University of Delaware shows that, at present, China would gain more social, economic, energy and environmental benefits by increasingly developing decentralized, off-grid RET, especially in the country's rural areas. (Byrne, et al, 1996b and 1999)

During the period of 1990-1998, grid-connected wind power generation increased by over 60% per year. Because almost all large-sized wind generation turbines were imported from abroad at high prices, this resulted in extremely high investment and generation costs to PRC. Current international capital costs for 750-kilowatt turbine units are about $1,000 per kilowatt. In the next few years, when China will be capable of manufacture domestically large wind turbines, capital costs could fall to below $700 per kilowatt. Levelized costs under this scenario would drop about 30 percent, faster than any other policy scenario. Most Chinese and international experts believe wind will generate power economically in remote, off-grid regions in the Chinese countryside, but they doubt its ability to supply base-load electricity at competitive prices during the coming decades. (Hausker, 1999:x) A single 750kw wind turbine – typical of the thousands installed worldwide – can save the emission of 5000 tonnes of carbon dioxide a year.

After distinguishing the present situation of both off-grid and grid-connected systems for electricity production in China it is important to clarify that the grid connection and the small decentralised systems should not be viewed as mutually exclusive options for the electrification of rural areas of NW China. The development of private, community, or cooperative distribution companies may be one way to make energy supply more responsive to demand in off-grid areas. (SEI, 2002)

PROJECTS IN XINJIANG AND INNER MONGOLIA

In this final section of the second chapter some of the existing projects of solar and wind energy that were or are being implemented in Xinjiang and Inner Mongolia, will be described.

a) Xinjiang

- Increasing of the wind energy installed capacity in Dabancheng Wind Farm

A project to increase the wind energy installed capacity production was implemented in Dabancheng Wind Farm. In 1999, Dabancheng Wind Farm II in Xinjiang was selected by the Tang Energy Group, an American company, and the Xinjiang Wind Power Corp for an investment of Yn200m in order to increase the output of that wind power facility, from 12MW to 23MW. As a consequence of the wind power output improvement in Dabancheng, the Dutch company NedWind supplied 51 wind turbines to the region, with a total generating capacity of more than 25MW of electricity.

- "The Silk Route Project" Shell Solar supplies power to remote areas in China[62]

[62] See http://www.shell.com/home/Framework?siteId=shellsolar&FC1=&FC2=%2FLeftHandNav%3FLeftNavState%3D3&FC3=%2Fshellsolar%2Fhtml%2Fiwgen%2Fabout_shell%2Fcase_studies%2Fchinacase_0912_1521.html&FC4=&FC5 for further details about this case study.

In July 2001, the Dutch government funded a the project with [63]€20 million to support the project to provide home solar power systems to more than 70,000 rural homes in Chinese remote areas. This project is being implemented by Shell and is part of a project to provide electricity in Xinjiang Western China. The involvement in structure set-up is very important in rural community projects. It is important to train local people to make the best use of the wind-driven or solar generators said L. Chao, China Programme Communication Officer of World Wide Fund for Nature (China Daily, 2000) The Xinjiang Brightness Project feasibility study was approved by SDPC. In January 2002 the grant agreement was signed. A working contract was signed between Shell Solar International and the Xinjiang Investment Company. (Xu and Ma, 1997:16)

Furthermore, there appears to be a market for photovoltaic system expansion in rural areas of Xinjiang, beyond the initial purchase of smaller, more affordable systems. Overall, the market for photovoltaic is likely to expand quickly. There is the development of related markets and industries like TV sets and other electrical appliances.

Households with access to some form of electricity for lighting, including photovoltaic systems, small wind systems, photovoltaic-wind hybrid systems, small generators, and community-village grids, are happier with their lighting source compared to those without electricity. (Vorovate, et al, 1999:31) Having electricity may reduce the feeling of isolation among those who live in very remote areas of the country.

b) Inner Mongolia

A high percentage, around 57 percent, (Vorovate, et al, 1999:24) of households in the Inner Mongolia area are getting light from electricity produced by RE sources. There are more wind turbines installed in Inner Mongolia, than in any other region of the world. These 140,000 wind turbines provide electricity to about one-third of the non-grid connected households in this region. (Lew, et al, 1997) A project proposal of Brightness Project in Inner Mongolia was approved by SDPC.

[63] See transcript of the interview to Shell Solar project manager Ramin Nadimi in Annex 18 and photos of the project Annex 18 A.

Inner Mongolia Hybrid Household Project – The University of Delaware and DOE/NREL completed case studies on household and village power systems, including technical performance and economic analyses of 41 households and three villages in 1997. Subsequently, in a pilot project between DOE/NREL and the Inner Mongolia New Energy Office, 96 household PV/wind (450-500 watt) systems were installed initially, with an additional 125 systems installed in 1999, and 120 in the year 2000. The US is providing US PV modules for this project. As a result of this activity, local officials in Dongwu County have completed a feasibility study and plan for 4,000 hybrid systems to be installed over the next five years. (DOE and MOST, 1999:3)

Given the intermittent nature of electricity produced from sun and wind, which is a low density and random energy (SDPC, 1999:14), the possibility of developing small and inexpensive hybrid systems using both resources is being explored and should be reinforced in the future. (Vorovate, et al, 1999:4) A recent study conducted by the Center for Energy and Environmental Policy of the University of Delaware on the economic viability of household and community scale PV, wind and PV-wind hybrid systems in Inner Mongolia, based on the Inner Mongolia Hybrid Household Project mentioned above indicates that stand-alone RE systems can provide a year-round electricity service to remote rural areas at a lower cost than conventional diesel or gasoline generator-sets and grid extension to supply power. Wind and Solar energy systems are complementary generating systems. In many areas of China, there is strong wind but little solar radiation in winter, while during the summer the situation is just the opposite[64]. Because of the seasonal distribution characteristic the complementary use of the two energy sources could efficiently meet the users' power demand. With the implementation of hybrid systems both resources could be effectively utilized. The wind power or the solar power cannot be turned on and off as needed, must have backup power for generation every day. Intermittency will be overcome by hybrid systems or grid connected systems.

2.3 Conclusions of the Chapter

[64] See Annex 20 with world solar radiation data during the winter and during the summer.

At the dawn of the 21st century, China is wrapped up in the midst of rapid and fundamental societal, economic, and even political transition. At the same time China is searching its soul. The visions of the future shine bright and prosperous, but the path that should lead the Chinese civilisation there is not clear (SEI and UNDP, 2002:11). If China wants to put the rural areas of Xinjiang and Inner Mongolia on a path to sustainable development with Chinese characteristics, the country should pursue a sustainable energy strategy in order to guarantee the basic energy needs of those rural populations without compromising their environmental and promoting simultaneously the social and economic development. The use of RE seems to be a good alternative to the present energy pattern.

There are certain operational questions and economic challenges that need to be met for the deployment of renewable energies in rural areas of NW China. The renewable resources are available in NW China and are getting general acceptance in terms of the strategic role that they are able to play. However in terms of the generalised accessibility of local people to renewables there is a long way to go to achieve the necessary cost-effectiveness.

RE has come of age. After more than a decade of double-digit growth, RE is a multibillion-dollar global business. At the moment, PV Solar Systems and Wind Turbines seem the most mature RET to be used in China.

Each energy revolution initiated a new development for world civilization. Developed countries are devoted to developing RE and seeking future energy. The new RE revolution is underway and China has a key opportunity to be in the forefront of this revolution. China should pursue its own Energy Revolution in line with the old Chinese revolutionary tradition as a mean to achieve societal development. The country transition from a State-Planned economy to a Market economy needs to be accompanied by a transition to renewable-intensive energy economy[65]. If PRC is able to make the right

[65] In order to have an overall idea of what China is doing in order to move forward to a renewable-intensive energy economy see map with Renewable Energy projects that were being implemented during the year 2000 in Annex 21.

choices in the right time this RE revolution will be peaceful and with benefits for all at local, national and global level. The extent of Chinese Political Support to RE is going to be presented in the next chapter.

3. CHINA'S RE AGENDA FOR THE RURAL AREAS OF NW CHINA

3.0 Introduction

Following an argument that the present patterns of energy consumption in the context of the Chinese Energy structure as a whole and of Xinjiang and Inner Mongolia in particular are unsustainable and need to change as quickly as possible in order not to compromise both the overall economic and social development of China and particularly of the rural areas of NW China, an alternative path for the Chinese energy sector was proposed. In the second chapter it was recommended that China should follow a sustainable energy strategy for the development of rural areas of NW China where RE would play a key and increasing role. In this third chapter we will discuss whether the Chinese government has the necessary capacity to promote the sustainable energy development strategy in NW China. To address this broad question the third chapter will first present the China's RE Agenda for the rural areas of NW. Secondly, it will be explained why a self-reliant China is not able to improve the use of RE by itself. Latter in this chapter it will be explained how is the use of RE in NW China gaining international visibility and being influenced by the international Agenda.

3.1 The Chinese Political will for RE deployment

What role has the Chinese government taken and what have been the effects of China's Policy in the development of Renewable Energies in NW China and in the implementation of the proposed Sustainable Energy Strategy? Chinese leadership has stepped up their intentions and policies with regard to the energy problems of rural areas. But have these responses been sufficient?

> *The energy constraints in NW China, the problem of environmental pollution and sustainable development are all arduous and long-term tasks.* (SDPC, 1999:1)

China has recently strengthened its RE policies emphasising its role in new development plans. (Andrews-Speed, 2002:18) Sustainable development and RE deployment must be taken into serious consideration while formulating the different Chinese State Five-Year Development Plans that still make up the major decision-making instruments of the Chinese, despite the growing influence of market-economy mechanisms. Market mechanisms may be appropriate in a liberalized energy market, but a regulatory approach is needed where the energy sector remains controlled by the government. The macro-politics of the Chinese Government are stated in the Plans.

If it is accepted that the energy market is conditioned by government decisions, then this same principle should work when we move on to sustainable development or to sustainable energy strategies. Whether we like it or not, a "Sustainable Society" cannot be brought about without national government intervention to complement and connect market forces. (Spligiotti, 1997: 39) In this particular context of the deployment of renewable energies in NW China, the "political will" of the Chinese Government has been of extreme importance in order to complement and connect all the market forces involved.

According to China's Agenda 21:

> *the Chinese Government should coordinate programs at international, national and regional levels, it should also make great efforts to expand rural electrification and integrate energy development at the county level by establishing demonstration sites in order to achieve the sustainable, coordinated development of the rural economy and the environment. The Chinese authorities should diffuse the use of wind and solar power technologies.* (SSTC, 1994:127)

RE has depended heavily on government incentives to get itself off the ground. (Buckley, 2003:14) Consequently, the Chinese Government should be expected to promote research and development; demonstration projects; information-dissemination and education programs. In other words, the Chinese Government should stimulate all the cost-reduction efforts to introduce and use environmentally desirable technologies whenever there are substantial benefits. (Zhang, 1999:63)

China's RE sector is poorly coordinated within the government. Responsibilities for power-related energy development are widely dispersed among various agencies[66]. If China is to meet its energy needs for sustainable development in the future, it needs to create a transparent organizational foundation (Byrne, 1999) to coordinate all policies to be implemented.

Reforms have come later and slower to the energy sector, but they appear to be gaining momentum. Indeed, the government is already seriously engaged in policies of poverty alleviation and it is concerned about the scarcity of electricity without hypothecating the environment. In addition, Sustainable Development has matured into a key national development policy that enjoys strong backing from the political leadership. (SEI and UNDP, 2002:77) The Chinese government has come up with a series of laws, regulations, official documents and political intentions. The Chinese government has also drawn up certain incentive policies to support RE sources for rural and remote areas.

The Chinese Government has been playing an important role in the development of RE, such as supporting the research and development of relevant technology, providing grants for renewable projects, and instituting preferential policies toward RE development. (Gallagher, 2001:25)

Like other countries, China is also proposing domestic targets for RE that range from 5 to 15 percent of the new electricity supply within 10 to 20 years (GEF, 2002:58) The Chinese government has been addressing the challenges of RE to varying degrees for years now. The Chinese leadership set its own domestic targets for increased use of RE, accompanied by policies to promote market penetration by renewable systems. National and regional targets for RE may help reach certain strategic goals or obligations and they can be highly effective if used to guide policies.

More than most developing countries, China has made significant and relatively successful efforts to promote RE use, particularly as an adjunct to the overall

[66] See table with all the Chinese governmental Ministries, departments or Agencies that are involved in the electrification issues of Xinjiang and Inner Mongolia in Annex 22.

programmes for rural development and electrification. (SEI and UNDP, 2002:56) A key factor in China's successful rural areas electrification programme through the use of RE was the central government's determination and its ability to mobilise contributions at the local level. China has developed several blueprints to help guide the development of the economy and protect the environment. (Hausker, 1999:14)

It is within the Chinese government plans, to expand, as appropriate to natural conditions, the scope of the utilization of wind power to provide electric power in the remote area; in the short term, to emphasize research and the development of large wind power generating units and the reduction of costs; over the long term, to emphasize the development of large wind power generating stations. (SSTC, 1994:134)[67]

The new and renewable energies were listed in the Sixth (1981-1985), Seventh (1986-1990) and Eighth[68] (1991-1995) Five-Year Plans (FYP). The main objectives of the 8th FYP included a total capacity from 14 wind farms of 60,000 kW of electricity. But the major political achievements in order to promote the use of renewables came to the light of the day later on with the Ninth[69] (1996-2000) and Tenth Five-Year (2001-2005) Plans.

During the period of the 9th FYP, a coherent strategy governing the project of new and RE was pursued. Within the 9th FYP framework, the Chinese government planed its policies for RE deployment in accordance with available local resources and economic conditions; multi-energy complementary supply; integrated energy use and concern of commercial and economic viability. The government tried to implement measures in order to develop new and RE technology to address global environmental concerns.

In order to develop both Wind and Solar energy during the ninth Five-Year Plan period, the State Planning Commission worked out special measures and development programs

[67] Annex 23 fully illustrates Chinese Political Will to promote Renewables.
[68] During the period of the Eighth Five-Year Plan China developed the 55-kilowatt and 200 kilowatt wind power generators and introduced the technology of 250 kilowatts wind power generator.
[69] The Ninth Five-Year Plan established targets to accomplish the manufacture of commercially viable sample machines of the 200-300 kilowatt wind power generating sets, and to upgrade their rate of nationalization. During the period of implementation covered by the Ninth Five-Year Plan other specific programs were set up in order to achieve the targets mentioned in referred plan.

to effect their implementation step by step: the "Ride the Wind Program" to implement steps to construct wind farms and to find substitutes for the imports of wind turbines, and the "Brightness Program" to solve the problems of non-electrified areas by developing abundant wind and solar energy. With the support of relevant governmental departments both programmes are under implementation and a new and dynamic atmosphere has emerged in various fields of work, bringing about measurable social and international results. (SDPC, 1999:2)

- "Ride the Wind Program" (also known as *Chenfeng*)

The 9th FYP put forward the objectives that at the end of this period, the total installed capacity for wind energy will approach 400,000kW, which will highlight the urgent requirement to localize the large scale wind power in the country, i.e. to accelerate the equipment localization process. When, in March 1996, SDPC formulated the "Ride the wind Program", the aim was also to establish Sino-foreign joint ventures by means of combining technologies and teaching to introduce, digest and assimilate advanced technologies. (SDPC, 1999:12)

The Implementation steps[70] of "Ride the Wind Program" were: to analyse the development status of large scale wind generators and then define the main type of wind generator which could be produced on a large scale in China; to ask for bids from the local machinery industry, and to review two assembly plants and the plants of the suppliers of key components; to organize the mainstream technologies in different industries which would help the enterprises take up the core technologies for manufacturing large-scale wind generators; to set up joint-ventures between foreign companies and the wind farm clients together with the designated assembly plants, taking the order form of the government loan project as the bargaining counter to require the foreign companies to transfer their wind generation manufacturing technologies and parts of the design technologies. The main objective of the "Ride the Wind Program" was to

[70] See http://news.energy-china.com/en/policy/nr/1773/20030214/23410.html for further details about "Ride the Wind Program.

start from assembling the wind generator and gradually raise their localization in China, so as to own the ability to produce part of the key components.

In 1996, the State Planning Commission asked for bids for the local assembly enterprises to manufacture wind generators of 600kW capacity, and then confirmed the Xian Airplane Motor Company and the China Luoyang No.1 Truck Group as the two successful bidders. Together, two joint venture wind manufacturing plants were established. One joint venture was formed by Xian Airplane Group with Nordex Company and the other joint venture created by the China Luoyang No1 Truck Group with MADE Company. Each manufacture plant used its single design. Right now, these two plants continue to operate and have already produced a prototype generator.

In order to illustrate the enormous potential of the Chinese domestic wind market, at the end of 1999, the State Planning Commission distributed an appropriate loan of about 7.5 million Yuan in a bid contract to build a demonstration wind farm where local wind generators were installed. These 7.5 million Yuan were also used in monitoring the quality of the system and 6.5 million of the 7.5 million were spent in compensations for the demonstration wind farm which clearly showed that in commercial terms this kind of project was not profitable.

- “Brightness Program”

The “Brightness Project” draft in 1996 which was only put forward in the year 2000, aims to provide electricity from solar PV technologies and wind energy in a number of remote Chinese areas until the year 2010. It utilizes new RE to solve the non-electrification problems of those non-electrified areas. The program was projected as a result of the World Solar Energy Summit held in 1996 where participants agreed to implement “Brightness Programs” worldwide.

Special preferential support was given to the NW China provinces such as Xinjiang and Inner Mongolia in the implementation of the “Brightness Program”. It is important to note that this program also acts as an incentive to the ongoing poverty-alleviation

"Village Television Project" in China, strengthening ethnic unity and territorial frontiers. (SDPC, 1999:101).

The "Brightness Program" is different from other construction projects because it targets a population scattered over a vast area comprising about half the total area of China. In many cases the population density is less than one person/km^2. More than 6 million households accommodate about 23 million people, around 2.65% of China's rural population, in more than 10 counties, 442 townships, and 120,000 villages. (Xu and Ma, 1997:8) This high investment and big scale Program is a sustainable development project which aims to alleviate poverty by supplying electricity in an environmentally friendly way.

The Chinese government has been slowly improving the legal framework for the development of the energy policies that promote the Chinese efficiency and conservancy and on November 1st, 1997 the People's Congress adopted the Energy Conservation Law[71].

The thinking behind this strategic development related to energy is reinforced in the 10th Five-Year Plan. One of the SEPA's key environmental Goals for the 10th FYP is the promotion of clean energy sources like renewables. RE is analysed in this plan and some important institutional problems with its deployment should be solved during this period, problems such as the introduction of competitive mechanisms for wind farm construction and the elimination of the monopoly of state and local power sectors. This plan suggests the construction of a transmission line from wind power-abundant areas to load centres. In the 10th FYP, a leap-frogging program for the rapid development of the photovoltaic industry, targeted at the most advanced photovoltaic technology should be conducted in order to accomplish a breakthrough within a few years by the concerted efforts of different research institutes and enterprises.

[71] Full document available at http://eande.lbl.gov/EA/partnership/China/chinaeelaw.htm

During the 10th FYP the grid connected RE projects must be supported. In addition, during that period market driven mechanisms should be applied to promote the deployment of RE such as the Renewable Portfolio Standard (RPS) and the concession approach to wind power development. (Ni, et al, 2000) The 10th FYP calls for almost a five-fold increase in China's wind capacity by 2005 to 1.5 gigawatts. Given proper incentives, however, China could easily surpass this target. (Lew, 2001)

The formulation of the 10th FYP creates a timely opportunity to develop an integrated strategy for the poorer western regions by setting up energy infrastructures to promote socio-economic development. The 10th FYP will promote more environment-friendly power generation in the western region. Under the 10th FYP, the Government has set a 5 percent target of RE-based electricity by the end of 2005 to reduce the high pollutant generation rate per unit delivered to consumers.

> *The Chinese government's draft 10th FYP proposes a 5.8% renewable portfolio standard for the country.* (Gallagher, 2001:14)

Besides the several Chinese Five-Year Plans mentioned above it is important to point out other key political tools that have been used by the Chinese leadership in order to promote RE all over China and in particular in its NW rural areas. One such tool is China's Agenda 21.

The development of RE is incorporated into Chinese government programmes but it was not until after the Rio Conference of 1992 that the Government drew up China's Agenda 21, concentrating on renewable resources. China's Agenda 21 defined a strategy to lead the country on a sustainable development path in the 21st century and readjust the regional structure of the allocation of state poverty relief funds. Within China's Agenda 21 there are preferential policies to resource development in the western region.

One section of Agenda 21 deals with RE issues under the heading of "Sustainable Energy Production and Consumption". This part of the document observes that:

> *RE resources can be replenished after depletion and produce very little or no pollutants, thus providing the basis for China's energy structure of the future.* (Item 13.53)

In addition, this section provides detailed resource estimates and deals with specific development objectives and with the activities required to achieve them.

In the report of China's Agenda 21 emphasis is placed on the development of new and RE by distribution of the higher cost of wind energy beyond the normal price of energy over the whole grid and by giving favourable import customs duties to wind energy and solar energy products.

The Administrative Centre of China's Agenda 21 (ACCA21) was set up by the SDPC and the MOST for handling day-to-day work with regard to Agenda 21 implementation. China's Agenda 21 work during the 1990s was characterised by a top-down approach, but with experiences from a number of experimental community-based projects, the aim now is to localise future Agenda 21 activities and bring in citizens and NGOs to the work at the community level. All government departments and all provinces are expected to take part in the implementation of this key policy for China's Sustainable Development path. (SEI and UNDP, 2002:77) Perhaps under the influence of China's Agenda 21, the concept of environmental governance has become part of the national discourse to encourage information disclosure and public participation. (SEI and UNDP, 2002:11)

According to China's Agenda 21 and in order to continue the preparatory work for the study of China's 2050 energy strategy, the country should:

> *... be involved in extensive international cooperation and exchange; learn about comprehensive planning and management techniques from advanced foreign experience; conduct research into comprehensive planning methods, management practices, and policy instruments appropriate to China's actual conditions; use various channels to introduce advanced foreign technologies and processes to improve technological levels for the domestic energy production and utilization; strive to acquire bilateral or multilateral international assistance.* (SSTC, 1994:128)

No energy source was ever established without political support. Policy support for the initiation of RE is a matter of market fairness for abolishing the existing bias.

The National Program on New and RE Development from 1996 to 2010 has been another political instrument used by the Chinese government to develop its domestic RE's market. Among other things this document states that new and RE should be extensively exploited according to local conditions, in particular the conversion into cost-effective electricity power for light, TV sets and pumps for those remote areas, so as to facilitate their development and bring economy and ecology in line.

In 1995 the State Development Planning Commission (SDPC), the State Economic and Trade Commission (SETC) and the Ministry of Science and Technology (MOST) or State Science and Technology Commission (SSTC) formulated a "Program on New and RE from 1996-2010". According to this Program the targets for installed wind and solar energy will be respectively 1,000,000 and 1,500,000 kW equivalent to 1.5 million tons of standard coal by the end of 2010. Despite the ambitiousness of the targets fixed by this program, China intends with this program to overcome technical and institutional barriers with timely and targeted international assistance.

> *China's New and RE Development Outline from 1996 to 2010 requires that commercial RE consumption increase from the current levels of less than 2 Mtce to about 120 Mtce by 2020.* (NAS, 2000:42)

Finally, in terms of Chinese political intentions that are being demonstrated by the Chinese government in order to support the use of RE, it is important to refer to the *White Book on China New & Renewable Energy* that was published in 1999 and is considered by its authors as a valuable reference information tool for RE researchers at home and abroad.

3.2 Would a self-reliant China be able to improve the use of RE by itself?

Technical, commercial, and regulatory barriers restrain the large scale expansion of solar and wind power in China. In a broad sense we can divide the Chinese limitations into two big groups: financial limitations and technological limitations.

> *Wind-generated electricity is still relatively expensive and technical problems need to be solved before wind can contribute more significantly to China's power mix* (Lew, 2001).

> *China's efforts to tap its large wind power potential are limited by its lack of widespread technical and financial know-how.* (NAS, 2000:55)

First, we should distinguish between two main constraints that affect financial limitations for China's market development of RE. One is the artificially low pricing system applied to traditional fossil fuels, the other is the unavailability of huge amounts of money to invest in order to help the Renewable Energies market gain the necessary dimension.

> *As part of the legacy of the planned economy, China's energy is priced far below the environmental costs of using these resources, and even below the production costs.* (SEI and UNDP, 2002:83)

Scarcity and environmental externalities have not been added to the prices of energy. In addition, economic subsidies to traditional fossil fuels continue to distort the prices of energy. However, China's pricing system has been transformed by the introduction of markets, decentralization and price adjustment. In addition to price reforms and ownership changes, the Chinese Government has also initiated policies to promote energy efficiency directly (Chandler, 1997:256)

Due to lower incomes a significant number of rural households cannot afford the prices of basic energy services provided by RE. Consequently temporary "lifeline" consumer subsidies for high cost renewables might be justified provided they are targeted, transparent and temporary. (WEC, 2003:4) These subsidies should be phased out in time.

> *Richer farmers and herdsmen now buy the generators on their own, while those who cannot afford them said that they would buy the equipment if they could get governmental subsidies* (China Daily, 2000)

Certain families in NW China are not able to purchase solar home systems (SHS) with cash. If suitable financing (micro credit) can be provided as an additional instrument to make the RE more affordable, there are strong indications that sales could increase dramatically.

To meet surging Chinese demand for electricity, a large amount of financing will be necessary. As the Chinese government is not able to provide all the financing for RE projects by itself it becomes necessary to adopt financial incentives and create certain market mechanisms.

> *It's impossible for local government to help all residents buy wind-driven generators. Regional governments should help farmers obtain loans to buy wind-driven generators said a senior engineer of Beijing Jikedian Renewable Energy Development Centre* (China Daily, 2000)

Investments in the energy system make up a significant fraction of total investments in any rapidly growing economy like the Chinese one. Traditional sources of finance are not likely to be able to meet increasing demands of capital. Only private financial markets, domestic and foreign, will be able to contribute to the major parts of the needed capital in the future. FDI has been an important new and rapidly growing source of capital in China in recent years. The capital must flow to investments that are compatible with sustainable development in a broad sense. (Zhang, 1999:51)

The environmental and the capital crises are related, because the industrialised countries are pressuring the developing countries to cut their emissions and adopt environmental measures as a *quid pro quo* for capital. This link between capital and the environmental aspects of the energy crises may be unfair, but it is *Real Politick*. (Reddy, 1997: 352)

China assumes that 20 percent of its power sector capital requirement can be provided by foreign funds. This amounts to an annual flow of $4.2 billion investment funds from foreign sources between 2000 and 2015. (Byrne, 1999) In order to face their financial limitations the Chinese government needs to go out and look for international financial aid or assistance both in bilateral or multilateral forms which will be explained in more detail in the next chapter.

Second, concerning the Chinese technological limitations and technology transfer, it is important to mention both Chinese dependence on imports of Renewable Energy Technology (RET) and the lack of Research & Development (R&D) for RE technology which is reflected in the relatively low localization of the RE industry in China.

> *The widespread and integrated utilization of RE resources requires future technological development and cost reduction.* (SSTC, 1994:133)

China remains a developing country hugely reliant on the import of US technology and expertise. Chinese reliance on Western technology is precluding the development of an indigenous technological base while export-led growth strategies make China vulnerable to global economic slow-downs and the vagaries of globalisation. It also renders China structurally reliant on the US and the West in relation to the development of its economic infrastructures. (Roden, 2003:197)

> *In order to develop the wind power sector, it is imperative to be innovative in approach to realize the industrial production in China on the basis of the digestion and absorption of the introduced technology.* (GIEC, 2001)

Assuming that the RE industry is commercially oriented and thus more likely to develop technologies that have commercial applications, there is a danger that Chinese R&D will not lead to the development of applicable technologies.

> *The more China can shape its own technological future, the more the technology will be appropriate to Chinese conditions and the less expensive it will be to upgrade.* (SEI and UNDP, 2002:50)

A report from China Classification Society said that society is working to establish China's first certification systems for wind generators to help the industry develop under related international technical standards.

> *The wind turbine generator is an environmentally friendly method of generating electricity, which could erase the pollution that comes from traditional electricity generators.* (Peoples Daily Online, 2001a)

said Li Kejun, president of the non-official China Classification Society.

The extensive manufacture of large, high-quality turbines in China could lower costs compared to the units it currently imports. Most imported wind turbines currently rely on concessionary financing, but these subsidies may actually slow the progress of the sustainable development of a market for wind power. New financial and regulatory

incentives, such as tax breaks and competitive bidding for planned projects, could accelerate the development of a market for wind power in China (Lew, 2001). Assimilation of foreign technologies through reduced input duties and expanded joint ventures to increase the scale of development is considered critical for making the commercial windpower industry competitive in China. (McElroy, 1998:50)

World Bank and Japanese loans have helped the Chinese government to create joint ventures with the local assembly plants to effectively transfer all kind of technologies including design technologies to China. The local plants were asked to follow the rhythm of development of foreign technology in order to absorb all the innovations and acquire the capabilities of exploring future technologies by themselves and to manufacture the key parts of the systems such as gear boxes or blades. It is estimated that the foreign investments are likely to bring about lower levels of pollution than would prevail if the anticipated increases in Chinese electricity generating capacity were supplied exclusively by domestic Chinese capital and technology. (McElroy, 1998:640)

Among China's priorities within the energy sector are the new and RET, large wind turbines and solar photovoltaic technologies (SEI and UNDP, 2002:57) but there is a lack of investment in R&D into the RE market from SDPC. Quite a lot of key equipment like large and medium scale wind turbines has to be imported with government loans from other countries. (SDPC, 1999:8)

> *At the moment, the environmental protection-related product market and technology in China is dominated by foreign companies. The government has connected environmental protection with the country's overall economic development and as the use of renewable energies is being encouraged, the country should promote research and development.* (People's Daily Online, 2002)

Energy planners in China are pushing for more reforms to promote economic and energy efficiency and environmental protection. Technical assistance can help China implement these reforms by supporting Chinese energy experts and by promoting joint ventures and foreign investment in energy efficiency technologies and services. (Chandler, 1997:257)

To face the Chinese technological limitations in the RE field, it is necessary to implement technology transfer projects (which will be discussed in more detail in the last chapter of this dissertation) but simultaneously and gradually to increase the amount of RE R&D and the RE local industry units. International cooperation in this programme area will include the use of foreign capital and technologies to conduct research on and build demonstration projects for the development and utilization of the new and RE resources. (SSTC, 1994:135)

3.3 How is the use of RE in NW China gaining international visibility?

To what extent have the use of RE in NW China and the PRC's energy and environmental constraints become issues for non-Chinese? There has been some change in the visibility of the issues related with the electrification of rural areas of NW China due to increasing foreign involvement. At the moment, the use of RE in NW China can be considered "indirectly" one of the priorities of the International Political Agenda.

The use of Renewable Energies in NW China has turned out to be an international problem because as an Energy issue it is intrinsically connected with global sustainable development, Climate Change and the scarcity of fossil fuels. The creation of strong incentives for switches to alternative energy sources such as renewables is absolutely essential if we are to address Climate Change, Poverty Alleviation and Energy Security in a business-like way. In this context it has become an international environmental and political problem.

The environmental pressure created by the hazardous and inefficient energy consumption patterns of a population of almost 1.3 billion, in combination with continuous economic growth and consequent increasing demand as well as the pressures generated by the limited availability of fossil fuels all over the world, i.e., coal, oil and natural gas reserves, makes China's use of Renewable Energies and diversification of Energy Mix a global concern.

The provision of domestic energy at affordable costs, in a secure and environmentally benign manner could be an alternative that will permit China to succeed both at local, regional and global levels. Reductions in reliance by a huge country like China on fossil fuels means reducing transboundary pollution and its impacts on Climate Change, providing commercial energy and electricity for the first time to rural areas of NW China and balancing the development between the NW and southwest China regions without compromising the future role of China as a major actor in international economic relations.

- Climate Change and the Environmental Problems in NW China

Environmental pollution problems are related to the way energy is supplied and consumed. In the words of the UN Secretary General Kofi Annan:

> *Over the next half-century we could be a world making the transition to RE sources or one still dependent on fossil fuels, and where climate change is destabilizing many nations.* (GEF, 2002:viii)

Renewed attention is now given to the development and utilization of renewable sources of energy, in response to growing concerns about climate change and securing affordable supplies of energy for economic and social development. The threat of climate change could help catalyse further energy resources management in China.

> *The present path of energy development worldwide is not sustainable from an environmental point of view, nor is it compatible with the social, economic and environmental goals of China as spelled out for example in China's Agenda 21.* (Zhang, 1999:50)

There is no doubt that China's behaviour in the short term matters critically not only to its own citizens – who account for one-fifth of the world's population – but to the world at large. (IEA, 2000) If China and other countries in the developing world were to adopt the extravagant energy habits of North America and Europe, the stresses on the planet would become unbearable. It has become clear that a shift to clean, RE is not only highly desirable but is vital for the future development of human civilisation. Most governments now accept the desirability of clean energy. (Buckley, 2003:14)

China's energy path will have strong implications for global climate change. One of the biggest concerns regarding energy consumption in China is that of carbon emissions and the threat of increasing global warming. China puts half as much carbon into the atmosphere as the United States does, but its contribution is growing faster than America's. The problem with China is that it is big and increasingly more powerful. (May, 1997:16) According to the US Department of Energy, China's carbon emissions are expected to increase 4 percent annually until 2015, driven by rapid economic growth and a rapid increase in coal use. The country's total carbon emissions are likely to exceed 2 billion metric tons after 2015. China is set to overtake the US as the biggest producer of green house gases by 2025. More than 70% of China's energy production is from burning coal, and acid rain is widespread. In terms of Climate Change, the risks posed by the current approach to energy are at best problematic and at worst catastrophic. (GEF, 2002:58) From this perspective, the local use of energy by rural people in NW China becomes part of an International Problem. The potential to generate and solve problems related with Climate Change exist at all levels: local, regional and global.

Furthermore long-term security is threatened by a problem at least as dangerous as chemical, nuclear or biological weapons of mass destruction, or indeed international terrorism: human-induced Climate Change. (Houghton, 2003) Like terrorism this weapon, i.e. human-induced Climate Change, knows no boundaries. In the words of the British Prime Minister Tony Blair "There can be no genuine security if the planet is ravaged by Climate Change". But words are not enough. They have to be matched with adequate action.

Should Global Warming prove to be a serious problem, it will have to be dealt with using tomorrow's technology (Churchill, 1997, 312) which in other words could mean the use of high RE technology also in China. Shell chairman Sir Philip Watts called for global warming sceptics to get off the fence and accept that action needs to be taken "*...before it is too late....We can't wait to answer all questions on global warning beyond reasonable doubts ... there is compelling evidence that climate change is a threat.*"

Although the foremost objective of RE targets is to reduce greenhouse gas (GHG) emissions, other ways of achieving the same goals should also be considered. (WEC, 2003:1) Some "renewable-sceptics" state that investing in clean fossil fuel technology such as Clean Coal Technologies can often lead to much greater environmental benefits than supporting some currently immature RET, particularly in markets with over-capacity.

- Poverty Alleviation and the Social Problems in NW China

> *The transition from energy poverty to relative prosperity is a complex process with no regular pattern discernible from one family, rural area or country to another.* (Hague, 2002)

So, what about the role played by renewables in this transition process? How can they play a role in alleviating energy poverty, and poverty in general, in rural areas of NW China?[72]

In rural areas of NW China RET, such as solar and wind, are likely to get the most uptake for specific off-grid applications. These RET are tailor-made for niche markets in rural areas of NW China, as experience has shown. RE applications should be perhaps regarded as the option for the less poor among the poor, or for those who have access to development assistance funding.

Look around the world today, and it has to be said the quality of leadership on sustainable development elsewhere falls a little short of inspirational, especially in some of the world's most powerful nations. The speech on 24th of February 2003 was billed as the Blair vision for a sustainable developing world, in which he took into account the need for equality in world trade, eradication of poverty and debt, and the prevention of environmental degradation. The British Prime-Minister said that:

> *"There can be no lasting peace while there is appalling injustice and poverty. We need to combine greater economic development with better environmental impact, bringing the environment, economic development and social justice together."*

[72] These two pertinent questions were originally address at a global level by the Director of Energy Efficiency, Technology and R & D of IEA (Hague, 2002). In this dissertation I am going to make use of the same questions and address them to the particular case of rural areas of NW China.

1.6 billion People in the world do not have access to modern, commercial energy of any sort and 80% of them are in South Asia. Most of these people live in developing countries, many in rural areas or isolated communities. Energy poverty is a primary reason for their poor living conditions and low prospects. Indeed, this situation poses a social challenge with huge implications for world peace, (WEC, 2003:2) prosperity and progress and several millions of Chinese people living in the rural areas of NW China are facing this problem.

Access to electricity and modern energy sources can be a major step in helping the economically vulnerable, like the inhabitants of rural areas of Xinjiang and Inner Mongolia, to escape the vicious circle of poverty. Renewables have a special role to play in providing the vital electric power. This was reflected in several energy initiative voluntary partnerships involving renewables formed at the Summit between UN agencies, governments, industry, intergovernmental and non-governmental organisations. In China we expect to see significant improvements, in pace with increasing prosperity between now and 2030. (Haug, 2002)

- Energy Security and Economic Problems in NW China

Until recently there was too much reliance on the Chinese state to address the energy scarcity problems in NW provinces, but responses in some cases have been too reactive, with focus on expensive measures to clean up fossil fuels like coal rather than effective utilization of RE resources.

> *To address problems of energy security or access, especially in developing countries with inadequate capacity, it is vital to consider that renewables, being primarily domestic fuels, should be treated on a case-by-case basis because their feasibility and true costs depend on local circumstances.* (WEC, 2003:1)

China's Energy Security policy is currently dominated by a limited range of strategic measures.

All of the items suggested above, Climate Change, Poverty Alleviation and Energy Security will, in the next fifty years, have to be confronted in the new context.

3.3 Conclusions of the Chapter

The China's sustainable energy strategy for the deployment of RE has been launched. The Chinese Government is doing a great effort to promote the sustainable energy strategy in NW China mainly through the last two Chinese Five-Year Plans; "the Ride the Wind Program" and "the Brightness Program"; the *Chinese Agenda 21* and "the Outline for New and Renewable Energy in NW China". Despite the evident Chinese political will to improve the use of REs by itself, the country is facing financial and technological limitations that can only be overcome with help of entities external to the Chinese Government. Moreover, the use of RE in NW China is "indirectly" linked with three priorities of the International Political Agenda: Climate Change, Poverty Alleviation and Energy Security which explains the increasing international visibility that a local issue in one of the poorest areas of the world is gaining. The complex web of international actors that are cooperating with Chinese government in the deployment of RE in NW China will be analysed through IR theories in the next and last chapter of this dissertation.

4. THE USE OF RE IN NW CHINA AS AN INTERNATIONAL ENVIRONMENTAL POLITICS ISSUE: THE OTHER IR ACTORS AND CHINA'S INTEGRATION INTO INTERNATIONAL ENVIRONMENT REGIMES

4.0 Introduction

After describing and analysing China's energy structure and the use of RE in NW China, its implications for China's Energy Development Strategy and the scope of China's RE Agenda and its limitations, the following chapter, while taking the risk of applying the "assumed universalism" of the International Relations (IR) theories to this particular Chinese case, will draw on one of the IR theories or subfields, the International Environmental Politics (IEP), to justify the actions that have been taken at local, national and international level in order to develop RE in NW China. If scholars of IEP are to contribute to global environmental management, we must begin developing contingent knowledge that identifies how the choices of IR actors promote environmental protection and RE deployment. (Mitchell, 2003:512) Moreover, if the discipline of IR is able to influence the way international practice is carried out because it has a legitimating effect (Dickson, 1997:10) the application of this theoretical framework to this empirical question can be a challenging and innovative approach to the study of RE in China. Connecting theory to evidence not only sharpens the understanding of theory, it also creates common ground across the boundaries established by disciplines, sub-disciplines and intellectual communities. (Herrmann, 2003:119)

In order to better understand the application of IEP theory, it is important to take into account the empirical facts to which it will be applied. So, the first part of this chapter analyses the existing international cooperation for the promotion of RE deployment in NW China and the complex web of IR actors involved in these cooperative actions. The second part presents the international environmental political framework, i.e. the key international events that decisively marked China's integration into environmental regimes in the last decade and the extent to which they are able to influence the increasing use of renewable energies in NW China. This chapter assumes the use of RE as part of a sustainable development strategy which is being implemented in China and that will not be fully implemented without cooperation between China and other

international actors. The use of RE cannot be assumed to be a localized or an exclusive Chinese national problem, unless it is possible to isolate the country completely from the international system, and to understand its economic, political and social system without reference to the global environment. Moreover, the use of RE in NW China is linked with the idea of Chinese sustainable development which can only be understood and pursued in the new global context. (Muller-Kraenner, 2002)

There is no reason why the unit of analysis of Chinese sustainable development and environmental thinking must be exclusively the Chinese state. At the moment, the transnational and pluralist approach that has been implemented in NW China points to new types of actors and activities from local communities to the whole world and is changing the nature of Chinese IR. The interplay between these actors would be important and fruitful. Sustainable Development in IR would therefore focus on different societies, at different stages of development, as they attempted to improve their individual or collective position in the global political economy. (Dickson, 1997:22) The link between the Chinese environment and sustainable development has thus become one of international political significance. (Dickson, 1997:68)

According to the Chairman of Global Environmental Facility (GEF) Mohamed T. El-Ashry, pursuing a path of sustainable development while protecting the global environment and eradicating poverty the way the Chinese government pretends to do in rural areas of NW China is a complex undertaking that will require unprecedented levels of effort, knowledge, and international cooperation. The Chinese RE Agenda is truly global.

4.1 The Chinese environmental and sustainable development issues in the IR context

Traditionally the “low politics” of environment and sustainable development were largely ignored by IR. Applying IEP theory to this particular Chinese case proves that the environmental issues are moving from the periphery to the centre within the practise of IR.

The study of international environmental issues only gained recognition among International Relations scholars in the late 1980s. Until that moment, IEP articles, in major IR journals, were infrequent. (Mitchell, 2003:501) After the 1992 Rio Summit there has been a massive expansion of academic interest in environmental politics within the discipline of IR. The period of emergence of IEP as an IR issue was at the same time the period of growing importance of RE both in China and worldwide. The theory and the empirical facts to which it will be applied have developed simultaneously. Research on IEP can identify new ways of achieving RE targets and meeting the sustainable development needs of the rural areas of NW China.

In the past, China had rarely been exposed to IEP theory. Like most elements of China's foreign policy, Chinese IEP is a severely understudied area. (McElroy, 1998:586) The use of renewable energies in NW China must, in the context of this dissertation, be understood at the international level as well as in terms of the complex interconnections between the IR actors. This requires going beyond the domestic and local level of analysis and taking into account the role of IEP theory.

At the moment, the Chinese leadership is using IEP as a vehicle for increasing its international status, preserving a favourable international image as a responsible major power and satisfying its desire to acquire foreign green technology. Green technology and RE resources, such as wind and solar power are gaining increasing attention in the field of IR particularly in its subfield of IEP due mainly their interconnection with such issues that are gaining momentum in the international Agenda such as Climate Change, Poverty Alleviation and Energy Security.

Wind and solar power both offer clear commercial opportunities and real environmental benefits. Foreign governments, multilateral assistance agencies and private investors are building clean new energies around the world - and in China. A deeper appreciation of this economic and environmental international interdependence that lies behind the growing support for Renewables as an alternative source of energy is essential to tackling both the Chinese and the globe's environmental problems. (GEF, 2002:xi)

4.2 International Cooperation to Promote RE in NW China – the complex web of IR actors

The problems in developing countries tend to gain attention only when people in Agenda-Setting states become concerned. Governments, the scientific and academic community, NGOs and foreign private companies can, at the moment, link environmental impacts and concerns caused by present Chinese patterns of consumption to broader political agendas. (Mitchell, 2003:502) Japan, US and some states of the European Union that are considered Agenda-Setting states are concerned with the Chinese energy patterns of consumption and with the potential benefits that the use of Chinese rich renewable resources could give to the present situation and this might be one of the reasons why the RE issue in NW China is gaining increasing attention. Maybe the real power to put the RE policies forward lies with the other actors in IR mentioned above.

The G8 is considered one of the IR actors with more influence in the international Agenda setting and at the 2000 G-8 Summit[73] in Okinawa, Japan, assembled ministers for the first time publicly recognized the importance of RE and linked it to the world sustainable development, saying:

> *We call on all stakeholders to identify the barriers and the solutions to elevating the level of RE supply and distribution in developing countries.* (GEF, 2002:58).*though there will be a higher costs in the first decades, measured solely in terms of the costs so far reflected in the market, successfully promoting renewables over the period to 2030 will prove less expensive than taking a 'business as usual' approach within any realistic range of discount rates. Renewables are key elements of sustainable development, providing clean, affordable, and reliable energy, a valuable resource in the World's energy portfolio.*

As stated above, the G8 is pushing the RE issues to the international Agenda. Now is up to China to take the lead in this strategic process for its own and world future benefit. The rapid deployment of RE in NW China argues for cooperative solutions. The role of RE and the role of international technology collaboration is crucial for the development of rural areas of NW China. Promulgating good policy requires understanding from the

[73] G8 is the group the eight most industrialized countries which includes Canada, France, Germany, Italy, Japan, UK, US and Russia. The full text of the Okinawa Communiqué can be found at www.g8kyushu-okinawa.go.jp/e/documents/commu.html or at http://www.mofa.go.jp/policy/economy/summit/2000/communique.html

Chinese Government and other IR actors about which policies are most likely to be implemented in ways that RE use will produce desired behavioural changes and environmental benefits. (Mitchell, 2003:508) Furthermore, the Chinese Government and some IR actors are committed to work together in the promotion of RE in NW China.

In every area of IEP and, in this particular case, in Sustainable Energy Development Strategy for RE promotion in NW China, economic and political issues are totally interconnected.

> *China continues to play an active role in the globalisation process, and puts environmental protection at the centre of its strategies. Trade and investment policies have environmental considerations. The government continues to utilise FDI and development assistance in support of domestic policy objectives and as drivers of environmental improvements.* (SEI and UNDP, 2002:96)

Unfortunately, in certain cases, the RE cooperation is not a goal in itself to achieve sustainable development, but it is just a mean to achieve economic and commercial benefits. It is urgent that all IR actors involved in the promotion of RE are able to fulfil their responsibilities to give to the present and succeeding generations of the rural areas of NW China a chance to live with dignity and hope for the future. (GEF, 2002:ix)

The most effective cooperative strategy would focus on "aggressive" measures to help the PRC move as far away as possible from a traditional energy development path. (McElroy, 1998:6)

> *Development co-operation has been a major catalyst of change in China, providing not only financing but, even more so, a channel to the international community leading to imports of new technology.* (SEI and UNDP, 2002:64)

The development co-operation has also been influential in paving the way for changes that have met resistance, such as the deployment of RE. The Chinese government uses development co-operation to obtain new RET, ideas and expertise, examples of lessons learned from other countries, and for experimenting with policies, techniques, and skills.

China is making concerted efforts to seek international cooperation in the field of RE. China enjoys rich natural resources and it is a huge market, with a vast range of prospects for developing RE. The country hopes to strengthen international technical exchange and economic cooperation and accelerate the global development of RE. The Chinese government is increasingly opening the RE market[74] to international financial organizations and various energy and environmental protection foundations to deeper participation in the Chinese projects and increase of the loan amounts.

According to "The Wind Power Development Planning" the national SDPC should:

> *…promote the rapid development of the wind power industry; reform and open wind energy markets; strengthen international cooperation; introduce foreign advanced technology and equipment; utilize foreign capital; broaden capital financing channels; apply for loans from foreign governments and international financial organizations as well as international commercial credit organizations. In addition, Foreign Investors are welcome by means of Direct Investment; Joint Ventures; Cooperative Enterprises and Balance of Transfers.* (SDPC; 1999:15)

Energy efficiency technology transfer is often cited as a high priority in international development cooperation programmes for China (Chandler, 1997:248) PRC is rapidly becoming one of the most vital actors on the global environmental scene. China is interesting because it produces an important part of global energy-related carbon dioxide emissions and simultaneously it is undergoing rapid changes of energy and economic policy.

In the development-oriented Poverty Reduction Program for Rural China – *White Paper on Poverty Reduction in Rural China* the Chinese government tried to promote international cooperation in the field of environmental protection, actively expanding exchanges and cooperation concerning the environment and development with other countries and international organizations, earnestly implementing international environmental conventions, and seeking scope for China's role in global environmental affairs. (IOSC, 1996)

[74] China has opened its electricity market to foreign investors since 1990s.

International Assistance in RE will enlarge the dimension of the market for the development of the nations' exports; reduce global carbon emissions; minimize energy-related pollution in China; and accelerate social progress and the development of the market economy in China. (Chandler, 1997:257) Facilitating joint ventures in the RE markets simultaneously helps developed nations' firms to get into the country and promotes economic development and environmental protection in China (Chandler, 1997: 266) Facilitating demonstration projects in areas of foreign expertise is another good way to promote joint ventures (Chandler, 1997: 267)

The PRC has demanded, and obtained, bilateral donor support and cooperation for most of the RE projects that are in place at the moment. Because of this, projects tend to remain small. The slow deployment of wind turbines has been in part due to the Chinese insistence on bilateral donor support or cooperation for projects instead of multilateral ones. It will require entirely commercial developments to reach the level of growth that the country needs.

a) Foreign Governments

Nations like China are learning that there is a comparative advantage to working together on the problems they share with others. (GEF, 2002:xii) Foreign countries with advanced high technology construct demonstration projects and conduct direct technical exchanges, or cooperate with Chinese experts in software study, or the establishment of joint ventures to manufacture RE equipment and to do business fairly in the Chinese marketplace. China hopes that the foreign countries that establish bilateral government loan relations will increase the amount and proportion of their loans for the development of new and RE, to strengthen the alliance, make plans for and to participate in the ongoing "Ride the Wind Program" and "Brightness Program" in China.

Within the cooperation between China and foreign states in the RE sector it is important to refer the Sino-American cooperation because the energy futures of China and the United States are intimately linked: both countries draw on the same international sources for imported oil and are affected by changes in its price and availability. (NAS, 2000:ix)

In addition, both China and United States will play an important role in the world's energy future.

There has been a remarkable amount of activity in the renewables sector since 1995 when the US Department of Energy (DOE) signed a protocol for "Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization" with the State Science and Technology Commission (SSTC) in China. Furthermore, this agreement has some annexes on wind energy and rural energy development. For example the Annex II to the Protocol was signed in late-1996 with the objective of promoting the sustainable, large-scale deployment of wind energy systems for both grid-connected and off-grid village power applications in China. Despite this protocol there has been very little US FDI into RE in China.

The Sino-European cooperation in RE sector is also gaining increasing importance at both bilateral and multilateral level. The former Chinese Prime Minister Zhu Rongi urged efforts to strength hi-tech cooperation and to carry joint research projects in renewable energies between China and EU. (People's Daily Online, 2002b)

In 1998 the Spanish government offered US$300million specifically for the development of RE in China. The Danish and Dutch governments also offered loans for RE development in PRC. In addition, China is also receiving bilateral assistance in RET from Germany and Australia. The total foreign capital from 1999 to 2002 reached over US$2billion according to the *1999 White Book on China's New & Renewable Energy*.

b) Local and Regional Governments within China[75]

One of the most successful means for disseminating household-scale RET in rural China has been through local public-private bodies that offer such services as technical support, materials sales, subsidies, and government loans for locally manufactured technology. These bodies frequently provide revolving credit with repayment linked to the timing of a household's income stream – for example, payments become due after crops have been

[75] For additional information see Xinjiang and IMAR governments' web sites and statistical yearbooks.

harvested. As a result of this program more than 140,000 small wind turbines, producing power for more than a half-million people, have been installed in Inner-Mongolia – the greatest number of household-scale wind plants operating anywhere in the world. (Sawin, 2003:103) Eighty percent of the counties in China now have a rural energy office, which plays an important role in marketing and popularising the new RET.

The Shell Solar project manager Ramin Nadimi talking about the vital importance of local governments said[76]:

> *"We [the Shell Solar Project] have been very lucky with this project as we have been able to negotiate and receive subsidies from the Provincial Government in Urumqi. These subsides are being very helpful. The subsidies are negotiated on a case by case basis. Sometimes we can get a 300rmb subsidy other times we can get subsidies up to 600rmb."*

c) "Private" Companies

This section refers to both Chinese and foreign companies involved in the Chinese RE sector. According to China's *White Book on New & Renewable Energy* in 1999 there was just few cases of the private sector participating in the RE field. By that time SDPC was studying the feasibility of international enterprises investment and its specific implementation methods. (SDPC, 2000:110) However, the RE energy sector is changing quickly and at the moment both large and small-scale turbine manufacturers are setting up joint ventures to prepare for even rapid growth in the future. It is expected that strong wind energy development in China is going to take place during the next decade.

The private sector is playing an increasingly constructive role in China's RE sector, at the same time acknowledging that preserving the environment is both good business and a moral obligation. Companies are working to reduce their companies' negative impact on climate change and to increase the options for cleaner energy in NW China. Private investors are shifting their attention and investment shares to RE.

[76] For further information please see transcript of the phone interview with Mr. Ramin Nadimi in Annex 18.

Realistically, an influx of large-scale foreign investment and technology assistance to alter China's energy path must serve not just the country's economic priorities but the interests of foreign and Chinese firms. The prospects of participating in the development of an efficient and modern energy system in the world's fastest growing major economy could garner powerful private sector support for greater engagement with the PRC. (McElroy, 1998:8) As the Chinese market approach becomes more widespread, and the people, industry and government think increasingly in terms of market forces, many new opportunities for RE deployment and environmental protection will unfold. Market-based instruments provide incentives to the private sector to finance environmental protection. (SEI and UNDP, 2002:44)

China's exploration of RE is still at a low level, which is an appealing investment area for foreign partners. China has placed solar power and wind power on the top of the list for inviting foreign capital. RET in NW China are now attracting the funds of venture capitalists and multinational corporations alike. As a result of such investments, the use of RE is expanding rapidly. If current growth rates continue, economies of scale and additional private investments in R&D and manufacturing capability will achieve further dramatic cost reductions, making RE affordable even in the poorest areas of NW China. The presence of private companies in China's RE market may increase the probability of price reforms in the sector.

Major corporations are entering the Chinese renewables marketplace including Royal Dutch/Shell. Shell has been keen over the past couple of years to be seen as progressive on green issues while ExxonMobil has been labelled a fossil fuel dinosaur by environmentalists. Shell has been pushing ahead with its own investments in wind, solar and other renewable fuel sources but still believes that hydrocarbons will not become scarce at least until 2025 – and probably quite long after that. Sustainable expansion of RE will only start after developments in energy storage around the same period of 2025. It will be only by the middle of this century that renewables will take a serious grip of energy supply, possibly providing a third of the world's needs by 2050. (Macalister, 2003)

US firms have been among the most active foreign companies in China's energy development. Alpha Solarco signed a contract for solar PV and another for FloWind wind projects during 1990s. Zond Systems Inc. (later acquired by Enron Renewable Energy Corp.) signed a wind energy contract with the China Electric Power Technology Import and Export Corp. with help from the US Ex-Im Bank in 1996.

Whether foreign private companies will be able to succeed or not in the Chinese RE market depends on how they face all the challenges and difficulties to take advantage of all the commercial opportunities that such a huge market offers. An innovative approach is needed, one which develops the RE market and consequently the rural economy of the NW China, one which is able to produce locally some of the technology related with RE so as to take the advantage of the existing indigenous resources.

International companies' investments are often competitive and local politicians and companies in NW China can learn from these investments. However, at the moment, private companies are unlikely to make the necessary investments to develop RET because the benefits are distant and not easily captured by individual firms. (Johansson, 1997:244).

Walk into the headquarters in Beijing of any of China's three national oil companies and you will see how China is responding. In the lobbies of PetroChina[77], Sinopec[78], and CNOOC[79] – three companies created to reform, make more efficient and partially privatise China's oil industry – there are flashing screens showing the current world stock markets' activities. This is not exactly what we would expect to see in what used to be known as a centrally planned economy. These scenes vividly capture the shift from state control to markets. Breaking up the old state monopoly and subjecting the newly born oil companies to the discipline of capital markets is one of the most important ways that China has sought to cope with the country's growing oil demand. (Yergin, 2003)

[77] See http://www.petrochina.com.cn/english/ for more information about the company.
[78] See www.sinopec.com.cn/ for more information about the company.
[79] See http://www.cnooc.com.cn/english/default.asp for more information about the company.

d) International Organizations

At the international level, the GEF[80] has allocated $650 million to RE projects in developing countries since 1992. However, this is but a small fraction of global investments in carbon-intensive energy projects through international financial institutions like the World Bank and taxpayer-funded export credit agencies. (Sawin, 2003:106)

Although there were no renewable projects financed by Multilateral Development Banks (MDBs) in China before 1997, there are now some underway. The GEF is a prominent driver of this activity. GEF has made a difference bringing RE to people in developing countries, many of whom live far from existing grids like the inhabitants of rural areas of Xinjiang and Inner Mongolia.

Ongoing efforts at the multilateral and international organization level to promote the use of RE in China are as follows: World Bank/GEF demonstration of wind[81] of approximately 290 MW and solar power systems, underway since 1996 and funded at over $400 million dollars; UNDP/ GEF RE project of over $25 million with some funding for technical assistance, pilot projects and wind and solar resources assessment; China-WB/GEF Renewable Energy Scale Up Program[82]; the Asia Development Bank's (ADB) funding pre-feasibility studies and an assessment of wind energy.

In 1999 the World Bank Group (WBG) strategic partnership with the GEF in the development of renewable energies, PRC was the first trial country proposed for strategic partnership. This strategic partnership was established to expand the scale, speed and efficiency of world supplies of RE by increasing the amount of capital; to develop technologies and markets; and to simplify the approval procedures at according to the particular characteristics of each country. In 1999, The World Bank approved a loan and

[80] GEF began as a pilot project in 1990 and has been accepted as a major funding organizer and technical adviser on issues such as Climate Change. It is a World Bank instrument but is moving more into the UN orbit. NGOs have been invited to participate as observers at GEF meetings.
[81] See more information about this project in the Annex 24.
[82] See details about this Program in Annex 25.

the GEF gave a grant to China for the RE Development Project (LN 4488-CHA, 1999) which includes a large photovoltaic component. This component will provide assistance to photovoltaic system companies to market, sell, and maintain an estimate of 300,000 to 400,000 systems in the remote areas of China's northwestern provinces (Vorovate, et al, 1999:2) The WB Beijing representation office established a long-term cooperation with SDPC to carry out the "Trial Program for the WBG-GEF strategic partnership in the development of RE".

Also notable in this sector is the joint GEF/World Bank RE development project in wind and solar energy, which is designed to prevent contamination from 12.9 million tons of carbon dioxide and add 200 MW of RE capacity, mostly in the form of grid-connected wind farms. The availability of GEF grants apparently influenced China's willingness to pursue RE projects with the World Bank. It should be noted that the World Bank has no independent renewable projects, which means that GEF appears to possess leverage in all of the World Bank's renewable investment. (Gallagher, 2001:33)

According to Kofi Annan,

> *a strategic alliance of the UNDP, UNEP and the WB, the GEF is a unique and innovative source of funding mandated to make the connection between local and global environmental challenges, and between the national and the international efforts.* (GEF, 2002:ix)

The ADB plans for 2000 and beyond seem to indicate a significant shift towards renewables[83], especially with its $230 million investment for RE and Eco-Development in Rural Areas. ADB will identify more RE projects related with wind and solar power and has extended loans for the use of solar energy in China[84].

[83] According to the email from the Deputy Country Director of Asian Development Bank Resident Mission in PRC, Mr. Edgar A. Cua received on 9th December 2002 ADB "still have limited involvement in RE in China, although we are actively exploring and developing new projects in this field. I believe there is an informal donor roundtable on RE headed by the Dutch Embassy."
[84] See two ADB projects in Annexes 26 and 27.

From the presentation of this RE projects in China we can conclude that there is institutional support to RE deployment from the multilateral organizations[85] such as the World Bank, the GEF; the United Nations Development Program (UNDP), the European Union and the ADB to clarify the institutional basis for cooperation with China in the transfer of RET. Technology transfer is one of the targets of international and multilateral development assistance[86].

In addition, WTO accession will directly influence residential energy consumption and indirectly the demand for RE. There is not yet any consensus about whether WTO membership will be an incentive or a barrier but almost everyone agrees that it will have certain impacts. It will mainly affect rural residents. There is a limit to the availability of agricultural products that China can produce so the country will start to import huge amounts of agricultural goods and the rural households of remote and backward areas of NW China will be losers in the short-term, because their disposable income will be reduced as they do not have the means to put their products on the market at competitive prices. Most of the population from Xinjiang and Inner Mongolia have incomes that are dependent on agriculture. Two forces drive the final residential energy use demands: one is the price of energy products, which was pointed out before, and the other is the disposable household income.

The World Trade Organization (WTO) meetings in Seattle in 1999 were pivotal in showing that there has been a profound move away from the classic treatment of the environment and development issues to more confrontational discussions over economic globalization. (Muller-Kraenner; 2002) The WTO has started to develop an environmental conscience. The organization is in fact developing constructive principles for accommodating both trade and environmental concerns. (Weinstein, 2001:147)

[85] The institutional support is made through loans to the country or financing/ co-financing programs to which international companies can apply to start producing, for example, renewable technology in China

[86] Among the projects promoted by International Organisations in order to provide sources of capital to the International Companies that are able to invest in the transfer of RE technology to China it is important to refer to: Energy Sector Management Assistance Program (ESMAP); Small Grants Programme; Asia Alternative Energy Program (ASTAE); Multilateral Investment Guarantee Agency (MIGA); Renewable Energy and Energy Efficiency Fund (REEF); Solar Development Corporation (SDC); Solar Century, Sunlight Power International Holdings, Inc.; E & Co and Environmental Enterprises Assistance Fund (EEAF).

Pressuring countries to adopt clean technologies would be another effective measure. This step would require China, now a full member of WTO, to reduce tariffs and remove needless regulations that impede imports of pollution-control equipment and other environmental technologies and services.

e) Non-Governmental Organizations (NGOs)

China's legal framework does not promote the creation of NGOs in the Western sense, since the government associates these types of groups with political dissidents (SEI and UNDP, 2002:88) as NGOs have the potential to represent views and wishes of project beneficiaries and to contribute to project formulation. Local NGOs in the PRC are not well developed in the traditional sense. Neither are International NGOs in the PRC active on a large scale. International NGOs, particularly in the environmental sector, in which renewable energies can be included, have a lot to offer China that traditional development co-operation financing cannot.

Within China's Government Organized Nongovernmental Organizations (GONGO) sector, environmental GONGOs are among the most active in forming transnational advocacy across China's borders. (Wu, 2002:49) Environmental Chinese GONGOs are quasi-governmental units. The Chinese Renewable Energy Industry Association (CREIA)[87] is a GONGO affiliated with State Economic Trade Commission (SETC), SEPA and UNEP and was established in 1999 to implement the five-year *Capacity Building for the Rapid Commercialisation of Renewable Energy in China Project.* This project was initiated by SETC, SEPA, and UNDP, and co-funded by UNDP, UNEP, GEF, and the Australian and Dutch governments. CREIA was created to explore market opportunities for Chinese RE enterprises and introduce foreign technical and financial measures. (Wu, 2002:51) CREIA has become more independent in decision-making and project implementation, partially because external forces were involved in this organization from the beginning. (Wu, 2002:52) CREIA defines its role as a bridge between regulatory authorities and industry professionals, bringing together national and international project developers and investors. (Qin, 2001:95)

[87] See www.creia.net/uk/about/about.hml to learn more about the Chinese RE Industries Association.

The state's original idea behind the establishment of CREIA was: to take advantage of international capital to move quickly to the development of RE industries; to promote the market for RE products; and encourage more cooperation to join this market. CREIA's activities, however, have been expanded to include advising national and provincial RE policies, and building cooperative networks with GEF, the World Bank, the Packard Foundation, and other international donors. With its leading role in setting professional standards and norms, and its networks with domestic industries and international actors, it is very possible CREIA will play a crucial role in the self-regulation and monitoring of the RE sector. In a way, CREIA is creating a new interest group in society, rather than solely representing the government's views. (Wu, 2002:53) CREIA's successes are creating the investment opportunity facility thus attracting international investment. GONGOs with strong professional expertise, such as CREIA, will find it more effective to be independent as China's free-market and legal reforms progress.

f) Academic and Research Institutes

Slowly, Academic research institutes and think-tanks are gaining capacity and ability to influence China's RE policy at certain levels. It is important to distinguish between the foreign and the Chinese institutes, many of which have gained a status something akin to NGOs.

Environmental and energy policy research tends to be conducted by these government-affiliated research institutions, but also by institutes concerned with capacity development, training, education and outreach. (SEI and UNDP, 2002:88) Research collaboration between Chinese and western experts can itself elevate local environmental and energy concerns to national and international policy agendas.

Under bilateral agreements between the US department of Energy and the Chinese Ministry of Science and Technology (the US-China Energy and Renewable Energy Protocol), the National Renewable Energy Laboratory (NREL) and the Center for Energy and Environmental Policy (CEEP) research project was conducted at the University of

Delaware examining off-grid RE options for rural electrification in western China. (Byrne, 2001:i) The Rural Renewable Energy Analysis and Design Tool (RREAD), was created to evaluate the energy and economic performance of off-grid RET including PV and wind systems. (Byrne, 2001:ii) NREL helped to develop and support the implementation of China's largest rural electrification program, "The Brightness Program".

Through the work of the NREL in Colorado, hundreds of US manufactured wind and solar modules have been installed in rural areas of China in recent years. A project for solar and wind household systems is underway in Inner Mongolia. As a result of these demonstration projects, the Chinese government intends to deploy tens of thousands more modules to electrify rural areas of China. NREL and United Nations Environment Protection Agency (EPA) have also completed a wind mapping and resource assessment project in China.

The prestigious Energy Research Institute (ERI) under the SDPC umbrella is an example of a think-tank that has had a lot of influence over China's future energy policies, including its dynamic Centre for Renewable Energy Development. ERI and Centre for Renewable Energy Development (CRED) work mainly on a consultancy basis, partly for government, partly for international donors, and partly for the private sector. (SEI and UNDP, 2002:88)

It is this complex interdependence which both prevents domination of the international environmental agenda by any single group, including large multinational corporations, and which dictates the necessity for compromise and collaboration (Broadhurst; 1998:17) and the IR actors mentioned above are definitely key actors in the future deployment of RE in NW China.

> *Due to double pressure from energy and the environment, the World Bank's and International Companies' interest and enthusiasm in developing China's PV Market which will definitely promote and catalyse the development of Solar PV industry in China is increasing.* (SDPC; 1999:26)

In fact, the existing cooperation in the RE sector between China and the other IR actor will definitely promote and catalyse not just the development of Solar PV industry in China but also the development of Wind power projects both in scale and quality.

4.3 From Rio to Johannesburg: China integration in Environmental Regimes

Since the 1990s the UN has held a series of Summit meetings attended by top leaders of all the countries to discuss and formulate the "World Solar Energy Strategic Plan" among which we should underline the "International Solar Energy Convention" and the "International Solar Energy Fund". Work continues, with UNDP funding, to develop the institutional framework for Wind Resources.

Furthermore, the central period studied by this dissertation, from 1992 to 2002 is a period framed by the two biggest environmental international events that have taken place during the last, decade: the Rio Conference in 1992 and the Johannesburg Conference in 2002. Between the two events there was the controversial Kyoto Protocol.

> *China's environmental awakening came around 1972. When the Chinese government sent is first delegation to the United Nations Conference on the Human Environment in Stockholm, Sweden, that year, China was still a very much self-enclosed society in the middle of the Cultural Revolution turmoil. Thirty years later, the Chinese government sees the value of employing the market to make environmental protection profitable and motivate a knowledgeable population to control compliance and environmental qualities.* (SEI and UNDP, 2002:10)

The number of international environmental conventions increased and the RE issues were first addressed during the 1980s (Broadhurst and Ledgerwood, 1998). The proliferation of environmental conferences and negotiations with Chinese participation where the discussion of RE deployment has been a key issue has helped to turn our attention to renewables. We can expect environmental problems involving transboundary impacts and large or immediate threats to appear in the international agenda more easily and more frequently than those lacking such traits. (Mitchell, 2003:502) The transboundary impacts and threats of the current pattern of energy use in NW China are not large or immediate but the causes of a future unsustainable situation have already been identified at national and international level so it is time to act.

China should follow various agreements and protocols such as the Rio Conference[88] and the following Rio Declaration, Agenda 21[89]; the Kyoto Protocol[90]; the UN Millennium Declaration[91] or more recently the Declaration of Johannesburg[92].

- Rio Summit 1992 and Agenda 21[93]

Agenda 21 is the global sustainable development agenda set out in the Rio Declaration on Environment and Development, which was established at the Earth Summit in 1992. Agenda 21 consists of 40 chapters, and at its roots there are 27 principles. Four broad sections cover a range of issues: social and economic dimensions; conservation and management of natural resources for development; strengthening the role of major groups; and implementation. Agenda 21 highlights the importance of national strategies with international cooperation. It includes proposals for the integration of the decision and provisions for international institutional arrangements and legal mechanisms. Agenda 21 is an important document which has broad support among nations on all aspects of the environment related to social and economic growth[94]. Agenda 21 as a whole was a voluntary system, with few binding targets. The Peoples Republic of China fully agreed with the purpose of this document and later on created its own. Agenda 21 was an ambitious project for moving towards sustainable development globally. One of the ten major strategies for the environment and development was to improve the energy consumption structure.

The 1992 UN Conference on Environment and Development (UNCED) made international environmental issues both politically and intellectually more salient. Energy issues were referred to during the conference in terms of transboundary polluting

[88] The Earth Summit in 1992 was regarded as a success.
[89] Agenda 21 was implemented to promote sustainable development all over the world and China already prepared its own Agenda 21 as we mentioned before.
[90] It was signed in 1997 after a convention held on climate change and the limitation of greenhouse gas emissions.
[91] Reinforced the previous agreements and was signed in 8 September 2000.
[92] The World Summit on Sustainable Development that was held in September 2002. There is no edited declaration yet, just an unedited text with the plan of implementation.
[93] The text of *Agenda 21* is available online at http://www.un.org/esa/sustdev
[94] This definition of Agenda 21 is according to *Dictionary of Environmental Economics*, p.4, 2002.

emissions. (Sato, 2002:2) After the United Nations Conference on Environment and Development in Rio, 1992, China was the first country to publish a national Agenda 21. (SEI and UNDP, 2002:77)

The Report "Programme for the Further Implementation of Agenda 21", that was published later in 1997 to access the developments after Rio 1992, referred to energy in different terms and noted that:

> *Energy is essential to economic and social development and improved quality of life. It is necessary to ensure international cooperation for promoting the use of RE and research, and the development and dissemination of innovative energy-related technology. There is a need for promoting efforts in research on and development and use of RET at the international and national level.*[95]

- Kyoto Protocol

The Kyoto Protocol is an important step towards achieving the aim of the United Nations framework Convention on Climate Change (UNFCCC).[96] The Kyoto Protocol was the first substantial agreement to set limits on greenhouse gas emissions. Adopted in 1997, the Kyoto Protocol established carbon emission targets for developed countries, with an average target reduction of 5 per cent by 2008-2012. The protocol included a degree of flexibility in meeting targets with the official endorsement of emissions trading, the establishment of joint implementation and the Clean Development Mechanism (CDM). The deployment of RE in China could largely benefit from the CDM of the Kyoto Protocol. Energy efficiency has been improved and greenhouse emissions have shown signs of declining but the Chinese Energy Sector as a whole is still inefficient. Investment in the Chinese power sector could reduce carbon dioxide emissions for a fraction of the cost of achieving similar reductions almost anywhere else in the world. But what is CDM?

The CDM is an instrument to limit emissions by leveraging western private capital into appropriate investments for developing countries. (McElroy, et al, 1998:v)These schemes

[95] Selected extract from the report "Programme for the Further Implementation of Agenda 21" fully available online at http://www.un.org/documents/ga/res/spec/aress19-2.htm.
[96] This definition of Kyoto Protocol is according to *Dictionary of Environmental Economics*, p.123, 2002.

would transfer capital and/or technological resources from the West into the RE sector of NW China, in return for a share of the emission reduction credit needed to meet FCCC obligations of the investor country. For example, the Dutch Government's interest in China's RE sector can be partially explained by this CDM. In order for the CDM to be effective in ensuring additional carbon-emissions reductions, the transfer of cutting-edge climate-friendly technologies like RET is seen as essential. The lower technological baseline in rural areas of NW China would imply that such an investment would result in potential reductions in carbon emissions. RE projects in NW China would get a positive push through CDM because of the fact that CDM projects must assist the region in achieving sustainable development. Furthermore, since the rural development of NW China is considered an intrinsic part of Chinese and global sustainable development and an issue to be dealt with by international environmental politics, the CDM based on RETs could be vital to meet the Xinjiang and IMAR rural energy demand, and thus contribute to local sustainable development.

Countries can, in partnership with enterprises in developing countries, invest in the establishment of state-of-the-art technologies in host developing countries. Wind power appears the strongest candidate for CDM investment, with a medium- to long-term horizon for appreciable national emissions abatement. (McElroy, 1998:50) This process turned out to be a complex web of climate change diplomacy, resulting in a difficult ratification phase.

In the future there is an enormous potential for growing emissions in the industrializing South nations, particularly if coal, oil and gas are the main energy sources as in the case of China. China and its environmental and energy policies will be of crucial importance for the future of the global environment. (Ferguson, 2002)

More and more governments, spurred by the Kyoto accords, public pressure and concern over the security of energy supplies, have introduced programmes to support renewables such as wind and solar PV.

- Millennium Development Goals[97]

The millennium development goals were established during the UN Millennium Conference to gain support for a global pledge to "reduce extreme poverty by half, in every part of the world, before 2015". Sustainability is one of those goals. Pursuing its Sustainable Energy Strategy in NW China and increasing the amount of RE in its Energy Mix the country will be stepping forward to meet both the sustainable development of rural areas of Xinjiang and Inner Mongolia and this millennium development goal.

- The World Summit on Sustainable Development (WSSD) in Johannesburg

In September 2002, the WSSD considered the introduction of a global RE target which proposed an increase in the use of RE to 10% of total primary energy supply by 2010. The framework plan for implementation of the ideas that came out from Johannesburg contains plentiful references to the interdependence of social and economic development, environmental protection or RE and states as follows:

> *Diversify energy supply by developing advanced, cleaner, more efficient, affordable and cost-effective energy technologies, including RET, and their transfer to developing countries on concessional terms as mutually agreed. With a sense of urgency, substantially increase the global share of RE sources with the objective of increasing its contribution to total energy supply, recognizing the role of national and voluntary regional targets as well as initiatives, where they exist, and ensuring that energy policies are supportive to developing countries' efforts to eradicate poverty, and regularly evaluate available data to review progress to this end.*

At the international level, there is an increasing interest in RE resources as an alternative to solve pollution problems, energy scarcity or excessive dependence on oil. Chinese membership of Environmental Regimes, i.e. Chinese full participation in the international events mentioned above gives the country a full-time responsibility for environmental improvement.

During the Johannesburg Summit international leaders pledged to take concerted actions for the achievement of sustainable development and assured a joint responsibility to

[97] For more details on the Millennium Development Goals visit www.undp.org/mdg .

advance and strengthen the three inseparable pillars of the protection of the environment, social, and economic development at the local, national, regional and global levels. Energy was one of the five key areas addressed during the conference.

During the Summit, Chancellor Schroeder announced three initiatives in the massive development of renewable energies. Germany will provide €500 million to promote international cooperation in renewable energies over the next five years.

At the World Summit on Sustainable Development, there was strong opposition to the adoption of specific numerical targets for the use of new RE worldwide from the governments of most oil-producing nations and major fossil fuel users such as China and the United States. (Sawin, 2003:86) Although no agreement was reached at the World Summit on Sustainable Development on numerical targets for RE with specific deadlines, China and other countries around the world are setting their own targets. One achievement of the Summit was a growing acceptance that business does have a role to play in addressing global problems such as environmental and energy ones.

4.4 Conclusions of the Chapter

The importance of the use of RE in China and the country's cooperation and coordinated effort with international actors is clear: although developed countries have at the moment the experience and the know-how related to the deployment of RE resources, the longer-term market for these energy technologies will mainly be in developing countries like China. International assistance in form of grants, loans or technology transfer seem to be a good solution for the development of RE market in China. Together, China and the world community can produce the new ideas and enact the innovative policies that will realize a sustainable future. (Byrne, 1996a:7)

The Chinese Government is not alone in the promotion of RE in China and it is open to the growing international involvement in this particular sector. There has been a growing multilateral but mainly bilateral cooperation in the Chinese RE sector. The future strength of multilateral cooperation would permit the growing in scale of Chinese RE projects.

Foreign governments, local governments within China, private companies, international organizations, non-governmental organizations and academic and research institutes are all committed to help in the deployment of RE in China and give the necessary institutional, financial and technical support to PRC.

All the environmental international events referred in this chapter, i.e. Rio Conference, Kyoto Protocol, Millennium Development Goals and the Johannesburg Summit addressed the RE issues. The Chinese leadership is fully committed to participate in the development of International Environmental Regimes that will give the necessary room for future RE deployment both in China and worldwide.

Inspired on the Agenda 21 that came out from the Rio Conference the Chinese government produced the China's Agenda 21 and the CDM that is referred in the Kyoto protocol might facilitate the foreign investment in RET in the rural areas of NW China. The Chinese aim of sustainable development promotion in rural areas of NW China through the use of RE can be perfectly integrated within the Millennium Development Goals. Finally, during the Johannesburg Summit the international leaders assumed the joint responsibility to achieve sustainable development and they consider the Energy section as one of the key areas to be addressed.

The existing international cooperation around RE issues is strengthening the China's image as an environmental responsible international actor and bringing benefits to everyone who is involved.

Conclusion

Making use of three different levels of analysis, this dissertation demonstrates how local, national and international levels are interconnected with this hard and complex task of promote RE in NW China in order to guarantee a sustainable future.

There is not just one single approach to study Renewables and this is an innovative and interdisciplinary approach to RE in NW China. Consequently, renewables were studied during this work from different perspectives in order to make this issue more attractive. It applies concepts and theories to new cases, i.e., the Chinese case. Some of these theories are emerging within its field of studies. We consider the use of RE as an International Environmental Politics (IEP) issue and IEP is an emerging approach within the International Relations (IR) field. At least, in the Chinese case IEP is moving from the periphery to the center. China itself is an emergent country and economy within the international context. Moreover, the RE market/ sector is also an emergent and a promising one both within China and worldwide. This is just to say that this work is a very single part of what might be, and I believe it will be, a promising sustainable future.

"The world is in the early stages of an inevitable transition to a sustainable energy system that will be largely dependent on renewable resources" (Sawin, 2003:86) We just get into the "Renewables Era", so there is a long to go, probably until the end of the first quarter of this century to find the use of Renewables in China with a comfortable share of its energy mix.

This work does not recall the past, as the past of Renewables in China is a very recent one. Showing this complex web of actors and policies, at different levels, fully committed to promote renewables in China, this dissertation tried to be a starting point for further research and academic interest on the topic.

Energy is essential for world development and as China is considered an energy superpower and the world's largest potential market for energy the study of Chinese energy issues gain additional interest. Saying that we can firmly admit that RE is a particularly interesting issue, essential for rural areas of NW China development.

With the economic development the Chinese consumption is growing and the energy offer is not enough neither in quantity or quality. China should pursuit simultaneously a demand-side approach and a supply-side approach. On one hand, it should change habits of energy consumption of the and-users increasing energy efficiency levels, on the other hand, it should move gradually from traditional fossil fuels and diversify its energy mix.

The Chinese energy structures as well as the energy structures of Xinjiang and Inner Mongolia present certain constrains. All of them need to be reformulated reducing dependence on fossil fuels and minimizing the weight of imports in the energy mix. Furthermore, the major energy production centers in China are not the main centers of energy consumption. The current energy situation benefits the increasing of the gap between the poorest areas of NW China and the richest southeast costal areas.

China should as soon as possible bring, i.e., ensure equitable access to electricity and other commercial forms of energy to remote rural areas of NW China. The People's Republic of China is trying to find alternatives. Following an alternative sustainable energy strategy is the only way of rural areas of NW China to catch up with wealthier regions. As was stated in the Brundtland Report *"a safe sustainable energy path is crucial to Sustainable Development. RE should form the foundation of the global energy structure during the 21st Century"*. In this context, RE presents itself as a promising solution.

China's energy is confronted with triple pressures: economic, environmental and social. Developing renewables China can avoid environmental and economic stress and leapfrog the technologies used in the past by industrialized countries.

RE is a feasible alternative to traditional fossil fuels as it helps to lift poverty and improve social conditions mainly in the rural areas of NW China where it is already cost-effective, but it might produce the same effects, in the long-term, all over China and worldwide. Renewables might create jobs in rural areas of NW China and promote economic development; they give access to information and education lifting local populations

living standards; minimize environmental impacts previously caused by energy production, i.e., from burning "dirty" coal or traditional biomass. Promoting better environmental conditions through the use of RE China reduces transboundary pollution, reduces its greenhouse gases and mitigating its own impacts on Climate Change. Renewable resources are endogenous with no need of transboundary transportation, reducing Chinese vulnerability to the outside world and enhancing China's energy security.

Within the renewable alternatives, the technologies for wind and solar energy production are the fastest growing and more mature ones. In addition, there are good availability of both wind (annual wind speed above 5m/s) and solar (annual sunshine above 2500 hours) resources in the studied areas of Xinjiang and Inner Mongolia. Moreover, large wind turbines and solar photovoltaic technologies are among China's priorities within the energy sector. They are already cost effective in this "niche market". Despite of being the most cost-effective alternative to electrify rural areas of NW China and despite of these resources being available in large scale they are not yet entirely accessible to end-users due mainly to: their low incomes as most inhabitants of rural areas of Xinjiang and Inner Mongolia are farmers or herders; their lack of education to deal with Renewable Energy Technology (RET) high-tech devices, i.e., they still facing energy poverty. And we should remind that energy poverty is a primary reason for their poor living conditions and low prospects. Indeed, this situation poses a social challenge with huge implications for world peace. (WEC, 2003:2)

"China is a sleeping giant of Wind Energy" (AWEA). Xinjiang as one of the largest installed wind power bases in China, mainly grid-connect of which the Dabancheng wind farm is an illustrative example. Inner Mongolia, China's biggest wind producer is the place in the world where there are more small-wind turbines, i.e., over 140.000. This is a good cluster of small wind turbines.

Solar Photovoltaic system (PV) is also a promising energy technology both in Xinjiang and Inner Mongolia. Stand-alone PV systems have been used for rural households and entire communities electrification. At the moment, approximately 200.000 solar home

systems are deployed in China and some of them are being implemented within the Shell's project framework. Both solar and wind resources are seasonal and complementary so hybrid systems using both of them are also being implemented in rural areas of NW China. Comparing a grid-connected system with an off-grid one, in environmental-friendly terms, the first one is better as it does not require any backup system. However, off-grid systems are dealing with environmental challenges through the promotion of recycling programs of old batteries and backup systems. In addition, they are responsible for the "democratization" of the energy access in China.

Renewables share within the Chinese energy portfolio still a tiny fraction despite of have been growing at an impressive rate it was from a very low base. To move further from this study and until the day RE shares in China became noteworthy the Chinese authorities must still working firmly, showing their political will to promote renewables: produce and apply more policies and framework programs (like "Ride de Wind" or "Brightness Program") or other major decision-making instruments to promote the use of renewables; set ambitious RE energy targets (national and regional) during the preparation of the next Five-Year Plans; spend more money on RET R&D; spend more money on training, information-dissemination and education programs; promote in articulation with private companies and investors the local production of complete RE devices or at least some of their components in order create jobs, stimulate local economy and reduce current costs of importing RET; promote demonstration projects; be fully committed with its participation in International Environmental Regimes; promote both bilateral and multilateral international cooperation in order to increase the foreign direct investment for the RE sector or increase the know-how and technology transfer; develop market rules for sustainable energy development; guarantee a "fair" price to be paid for energy without subsidies and which include the environmental and social costs of using fossil fuels; create "micro-credit" lines for RE technology purchase.

While the energy security concerns, climate change and poverty alleviation remain at the top of the international Agenda, China will find enough political room and visibility to accommodate its sustainable energy strategy. At national level, the "West Development Strategy", with its pros and cons, is also making the Chinese Agenda and taking the

attention of Chinese leadership to rural areas of NW China and its patterns of development, which necessarily include the development of renewables.

Despite the Chinese political will the leadership recognizes its own limits, mainly financial and technical, to promote the use of renewables in NW China by itself and considers necessary the development of international cooperation. China is following enthusiastically certain international guidelines for sustainable development promotion and deployment of RE and the concept of environmental governance is becoming part of the national discourse. As an example, China was the first country in the world to publish its own Agenda 21 as a consequence of Rio Conference in 1992.

In terms of business opportunities within the RE markets of NW China, the Chinese government should, recognizing the importance of technology transfer projects, promote joint ventures and facilitate the access of the foreign companies to the Chinese market. In 1999, there was just few cases of the private sector participating in the RE field in China, but after some SDPC feasibility studies of international enterprise investment the presence of foreign companies is getting bigger. Moreover, China as placed solar power and wind power on the top of the list for inviting foreign capital. Major energy companies are already trading into this promising market. In addition, multilateral international banks and Export Credit Agencies are financing renewable energy projects. Some countries are using the Clean Development Mechanism (CDM) from Kyoto protocol to buy credits through investment in RE projects in developing countries. This might be a way of getting into the market.

Finally, the Chinese sustainable energy strategy is in accordance with all major international environmental events that occur during the last decade from Rio Summit to Johannesburg World Summit on Sustainable Development and principles that were discussed inside those *fora*.

To Sum up, there are plenty of opportunities to build solid bridges for China's sustainable future. Now it is time to act before it is too late.

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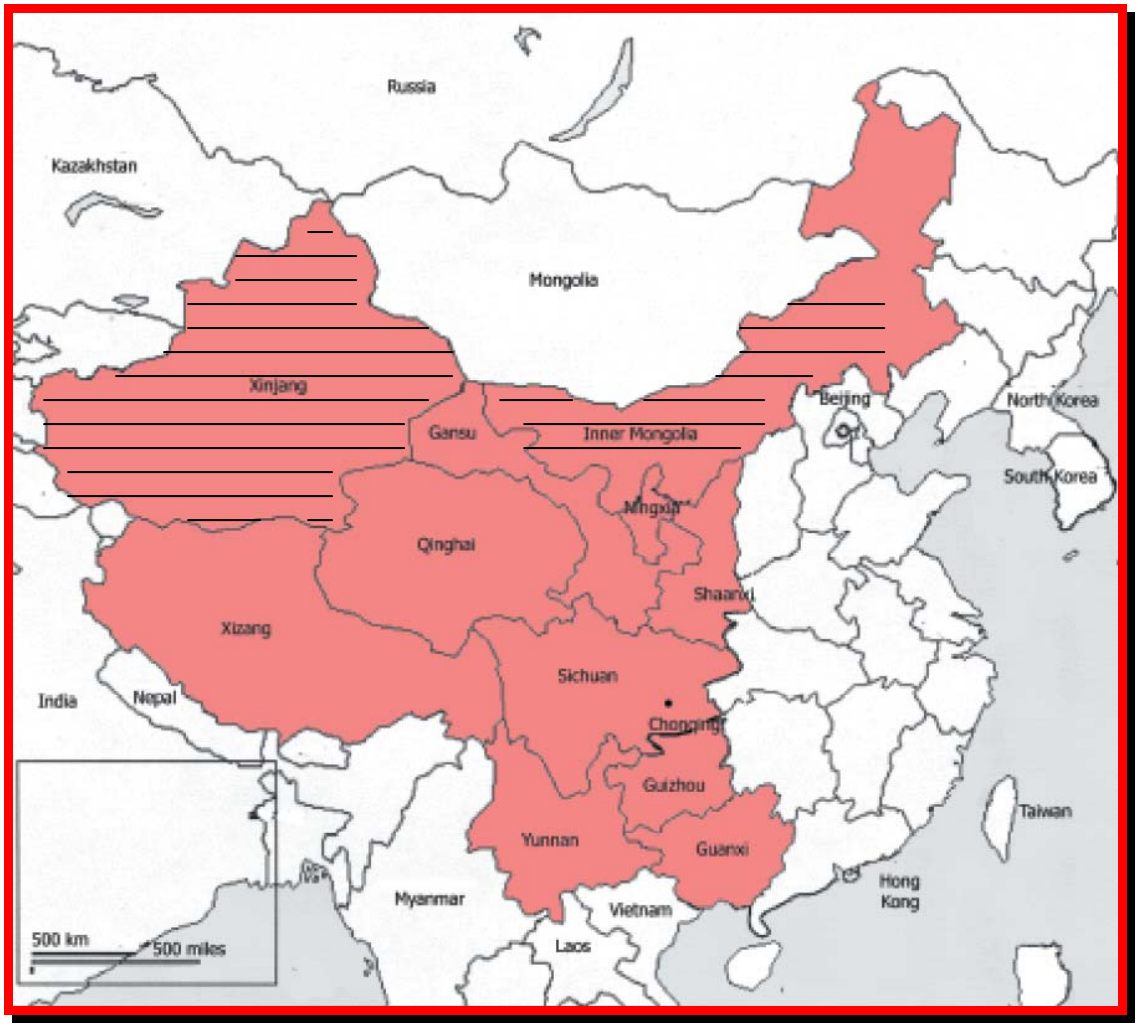
ANNEX 1 - REGIONS STUDIED IN THIS DISSERTATION

Source: Map of Xinjiang adapted from Hong Kong Liaison Office available at www.ihlo.org/item/map_xinjiang.jpg

Source: Map of Inner Mongolia adapted from Hong Kong Liaison Office available at www.ihlo.org/item5/map_innermongolia.jpg

ANNEX 2

CHINESE REGIONS WHERE THE "WEST DEVELOPMENT STRATEGY" IS GOING TO BE IMPLEMENTED



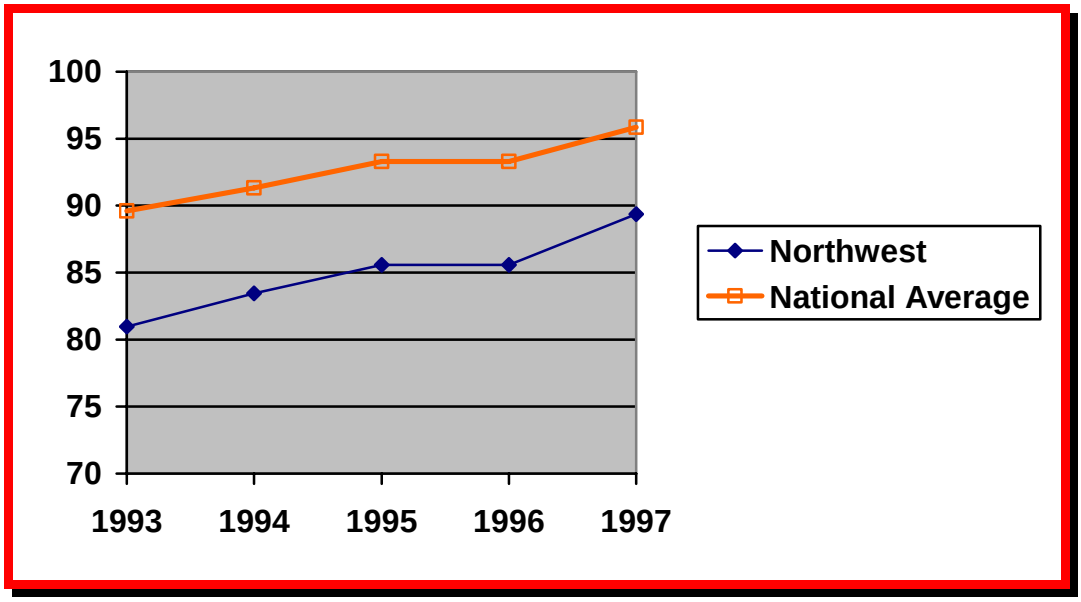
Source: Adapted from *China Environment Series – Issue 5*

Areas studies in this dissertation

ANNEX 3

COVERAGE OF RURAL ELECTRIC GRIDS IN NORTHWEST CHINA

Percentage of Rural Households with Electricity (%)



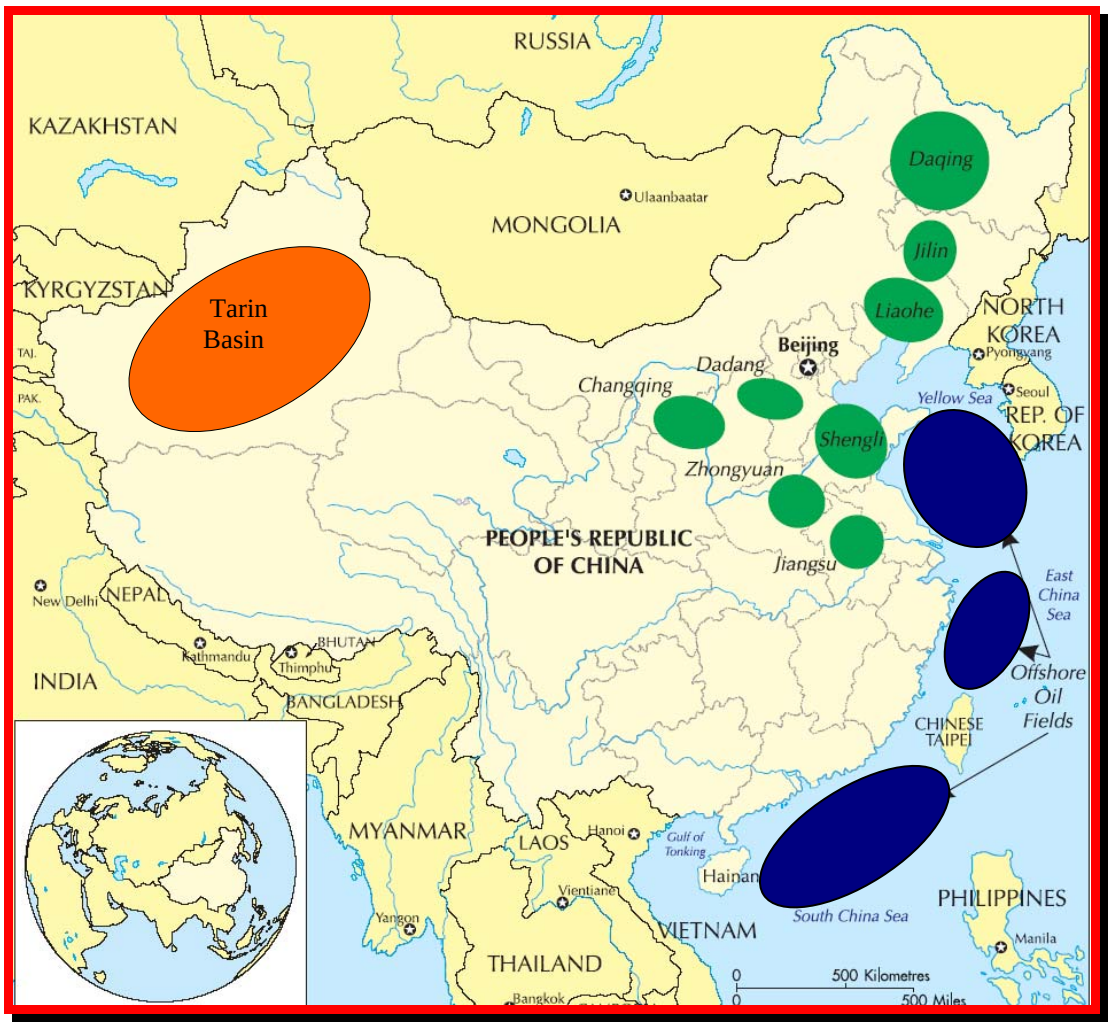
Source: Adapted from China Energy Databook, Lawrence Berkeley National Laboratory, 2001.

ANNEX 4

Sources: Adapted from IEA and Energy in Japan No. 158, July 1999,

ANNEX 5

MAIN OIL AND NATURAL GAS RESERVES IN CHINA



Source: Adapted from China Oil, Gas and Petrochemical, (OGP)

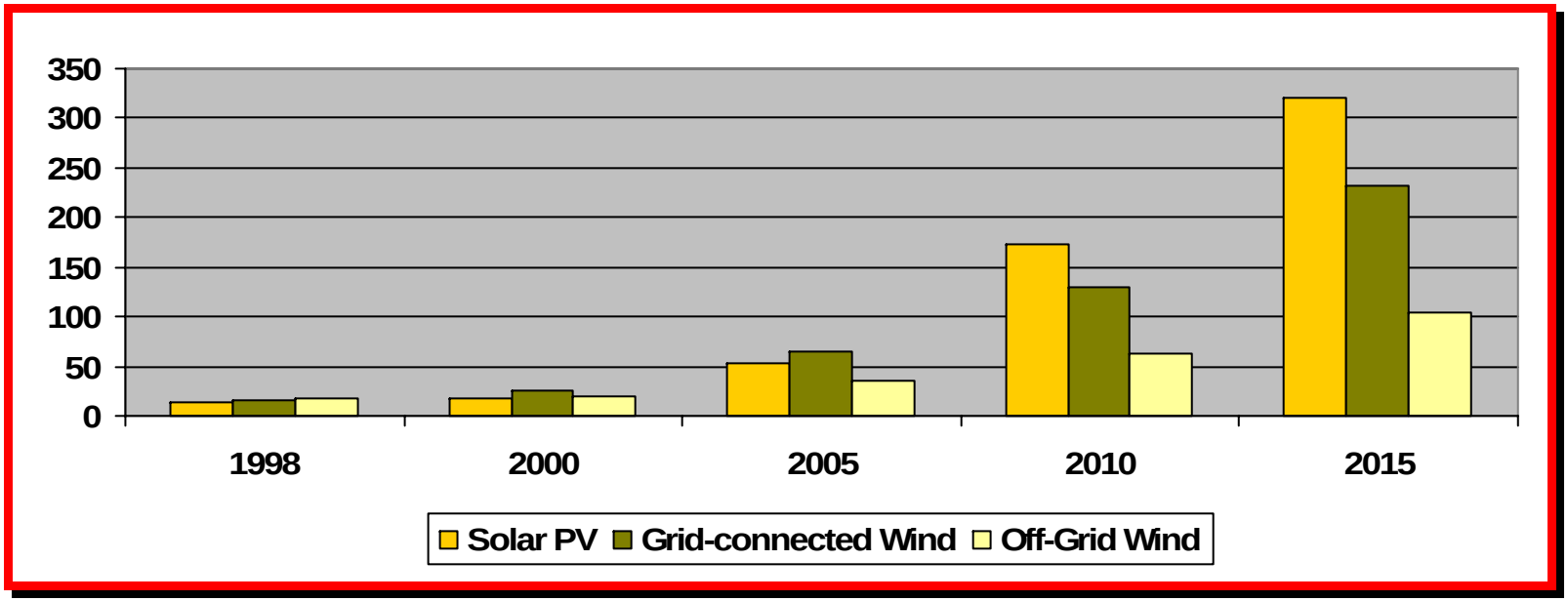
Oil Reserve in Xinjiang

Oil and Natural Gas Reserves in Northeast China

Offshore Oil Fields

ANNEX 6

DEVELOPMENT TARGETS FOR RENEWABLE ENERGY IN CHINA (1998-2015)

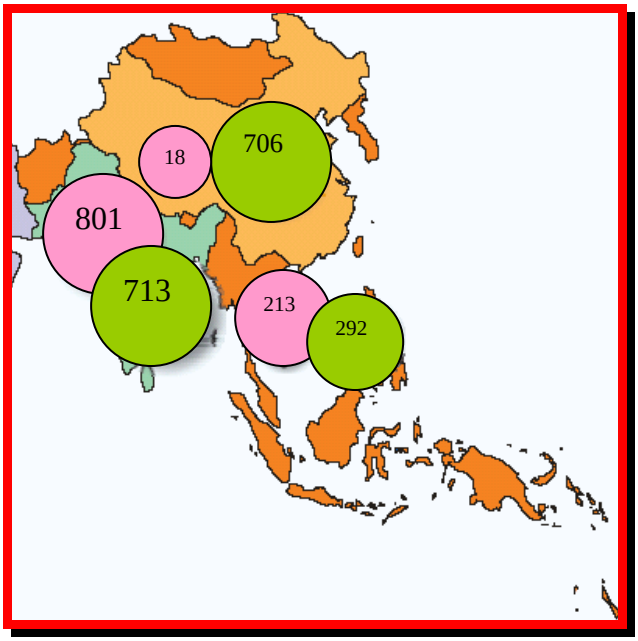


Year	1998	2000	2005	2010	2015
Installed Capacity of Solar PV (MWp)	13	18.5	53	174	320
Installed Capacity of Grid-Connected Wind Turbines (MW)	15	26	64	129	232
Installed Capacity of off-Grid Wind Turbines (MW)	17	20	35	63	105

Source: Adapted from *The Role of Renewable Energy Options in China's Present and Future Energy System.*

Annex 7

Map of Energy Poverty in Southeast Asia



Source: Adapted from IEA available at http://www.oecd.org/dataoecd/48/13/2505498.pdf

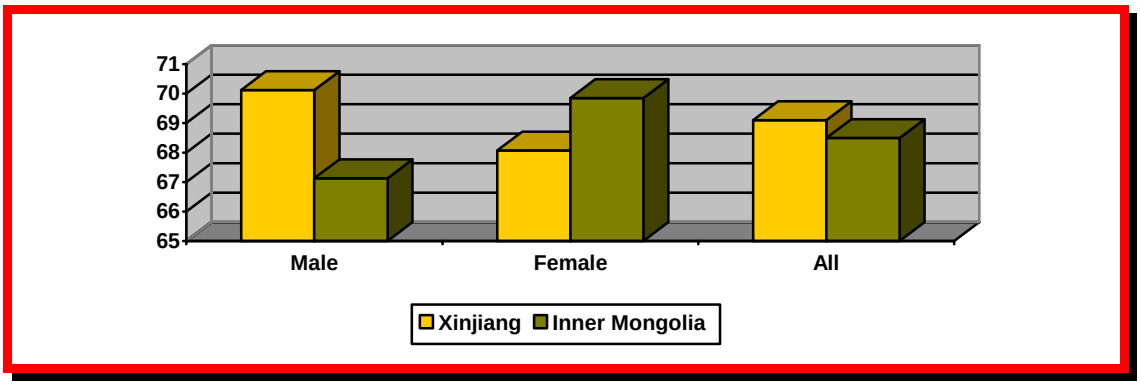
Millions of People without Access to Electricity

Millions of People relying on non-commercial forms of Biomass

ANNEX 8

SUSTAINABLE DEVELOPMENT INDICATORS OF XINJIANG AND INNER MONGOLIA

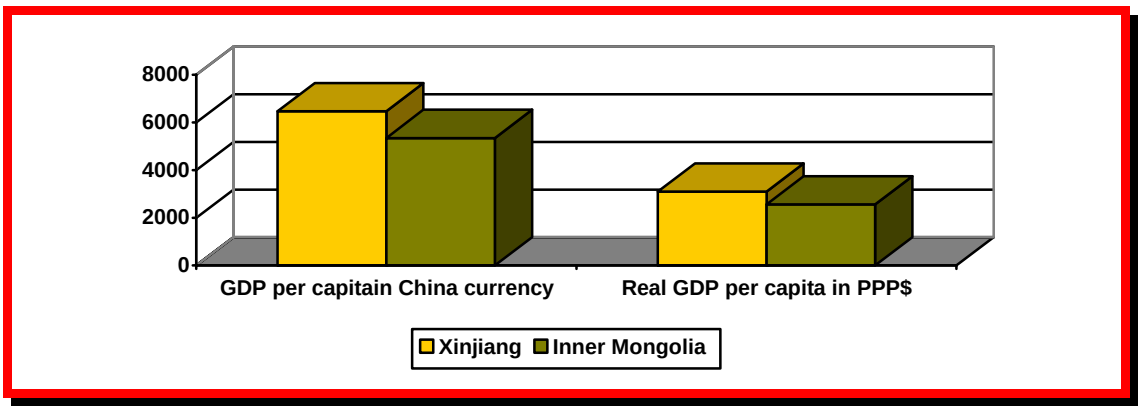
Life Expectancy, 1995



Source: Adapted from UNDP

Autonomous Region	Life expectancy in birth (years) in 1995		
	Male	Female	All
Xinjiang	70.12	68.07	69.10
Inner Mongolia	67.13	69.85	68.49

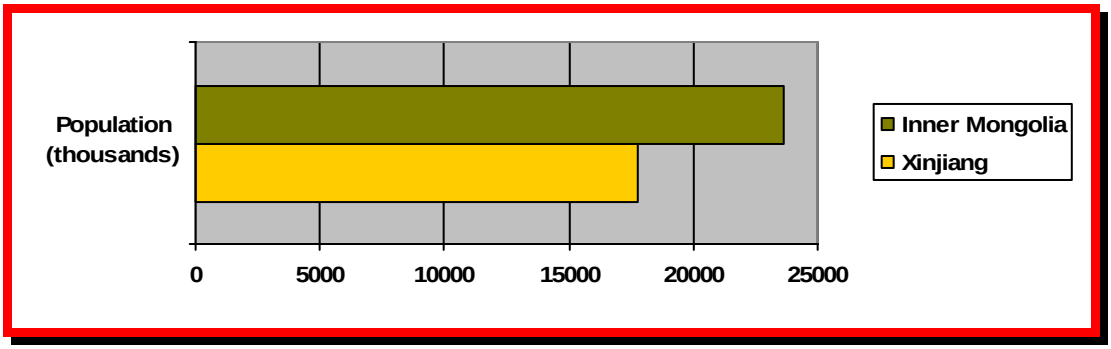
GDP per Capita, 1999



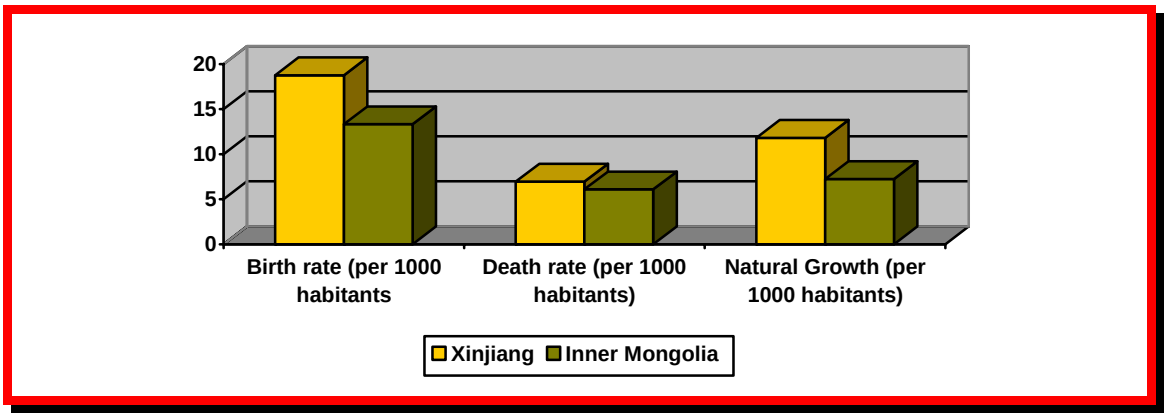
Source: Adapted from China Statistical Yearbook 2000 and UNDP

Autonomous Region	1999	
	GDP per capita in China currency	Real GDP per capita in PPP$
Xinjiang	6470	3099.27
Inner Mongolia	5350	2562.95

Growth of Population, 1999



Source: Adapted from China Statistical Yearbook 2000 and UNDP

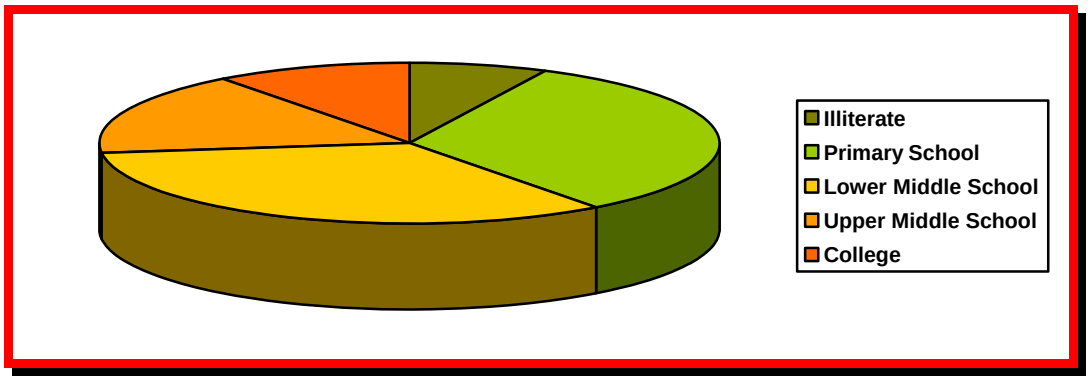


Source: Adapted from China Statistical Yearbook 2000 and UNDP

Autonomous Region	Population (thousands)	Birth rate (per 1000 habitants)	Death rate (per 1000 habitants)	Natural Growth (per 1000 habitants)
Xinjiang	17740	18.76	6.96	11.80
Inner Mongolia	23620	13.32	6.08	7.24

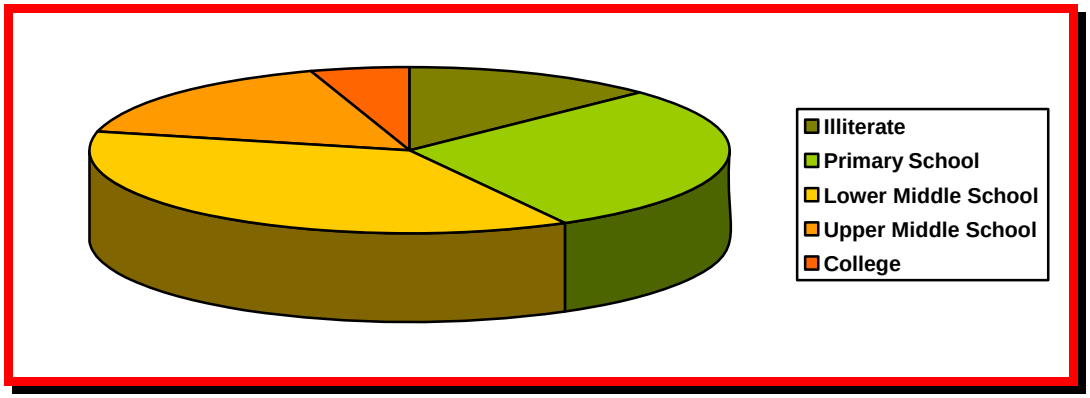
Different Levels of Education (%), 1999

1. Xinjiang



Source: Adapted from China Statistical Yearbook 2000 and UNDP

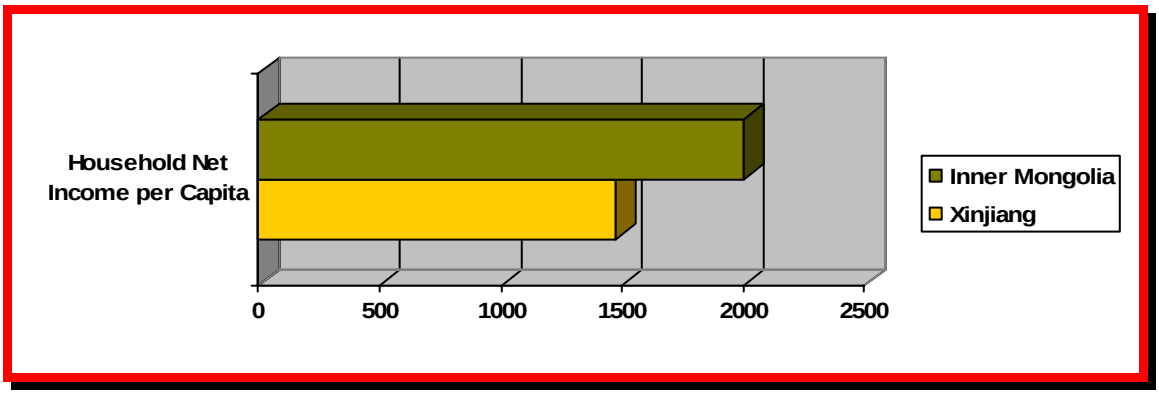
2. Inner Mongolia



Source: Adapted from China Statistical Yearbook 2000 and UNDP

Autonomous Region	Illiterate	Primary School	Lower middle school	Upper middle school	College
Xinjiang	7.2	32.4	33.4	16.6	10.4
Inner Mongolia	12.7	29.2	36.6	16.4	5.1

Rural Household Income per Capita, 1999

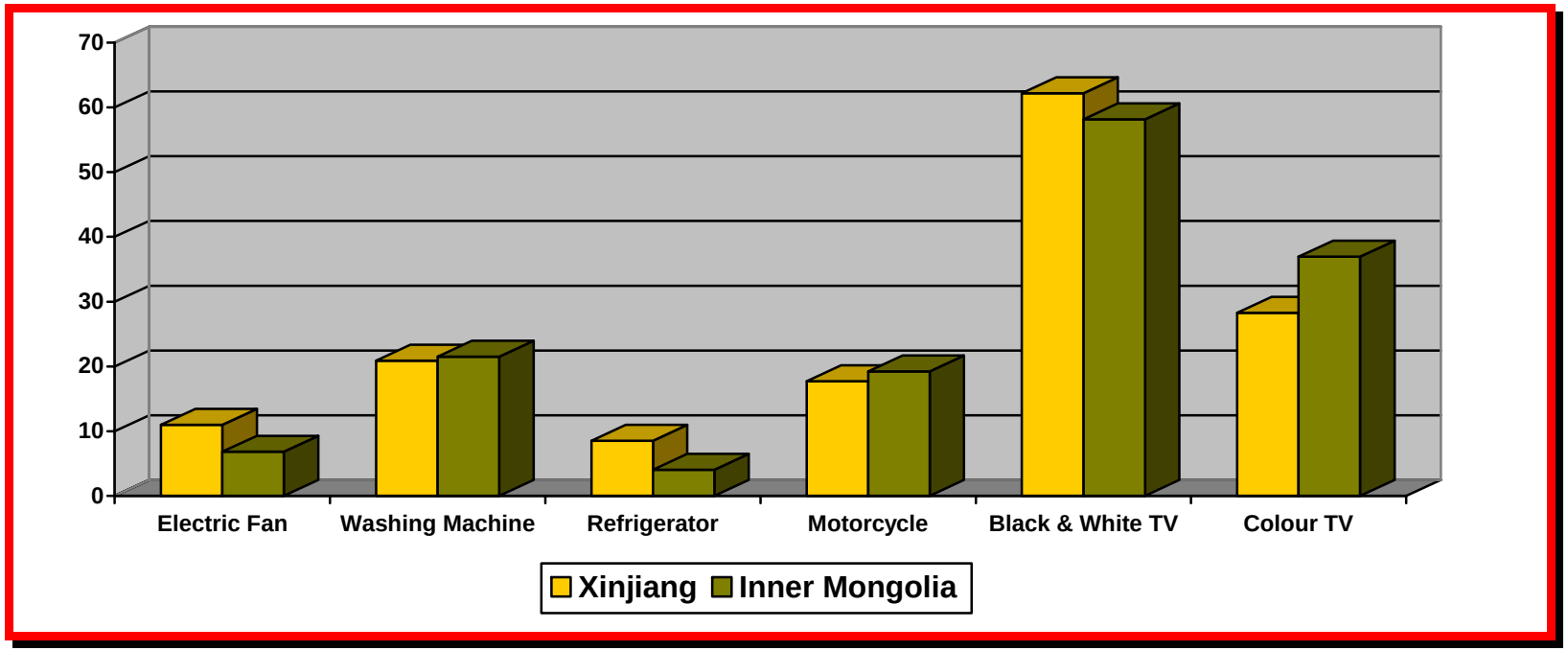


Source: Adapted from China Statistical Yearbook 2000 and UNDP

Autonomous Region	Household Net Income per Capita
Xinjiang	1473.17
Inner Mongolia	2002.93

Annex 9

Number of Selected Durable Goods Owned in Rural Areas (per Household), 1999

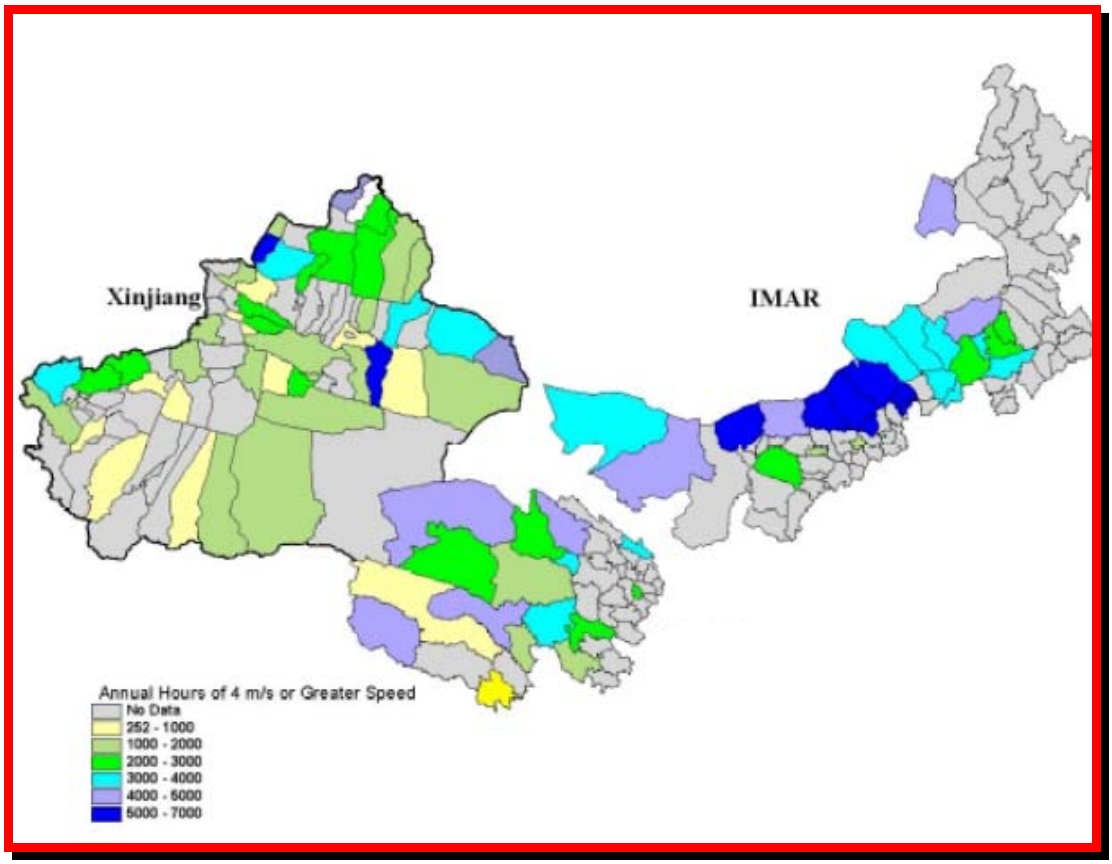


Source: Adapted from China Statistical Yearbook 2000 and UNDP

Autonomous Region	Electric Fan	Washing Machine	Refrigerator	Motorcycle	Black & White TV	Colour TV
Xinjiang	11.00	20.87	8.53	17.73	62.20	28.27
Inner Mongolia	6.84	21.50	4.03	19.22	58.16	36.94

ANNEX 10

WIND RESOURCE DISTRIBUTION IN NORTHWEST CHINA - WIND SPEED OVER 6 METERS/SECOND IN XINJIANG AND INNER MONGOLIA[1]

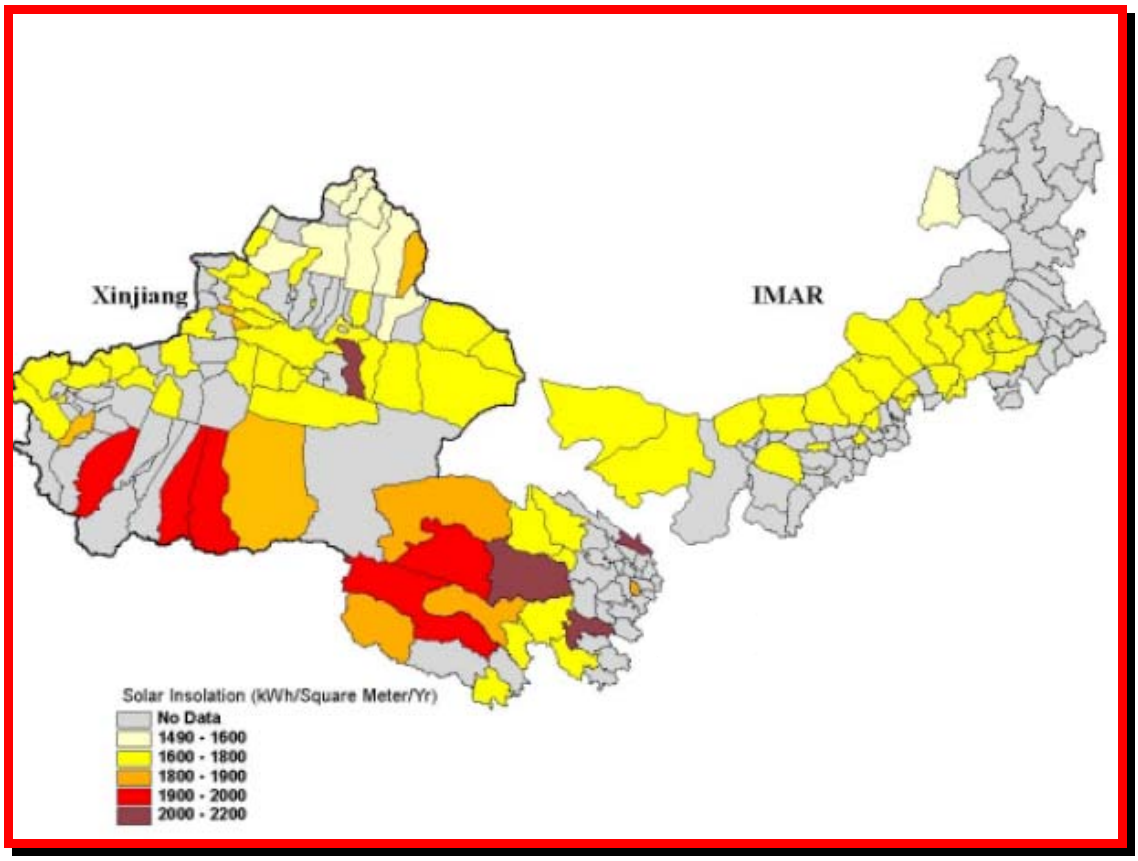


Source: Adapted from *Off-grid Renewable Energy Options for Rural Electrification in Western China*.

[1] This dissertation only focus in Xinjiang and Inner Mongolia Autonomous Region consequently only the data related to these two areas should be taken into attention when analysing this figure.

ANNEX 11

SOLAR RESOURCES DISTRIBUTION IN NORTHWEST CHINA – KWH/SQUARE METER/YEAR IN XINJIANG AND INNER MONGOLIA[1]

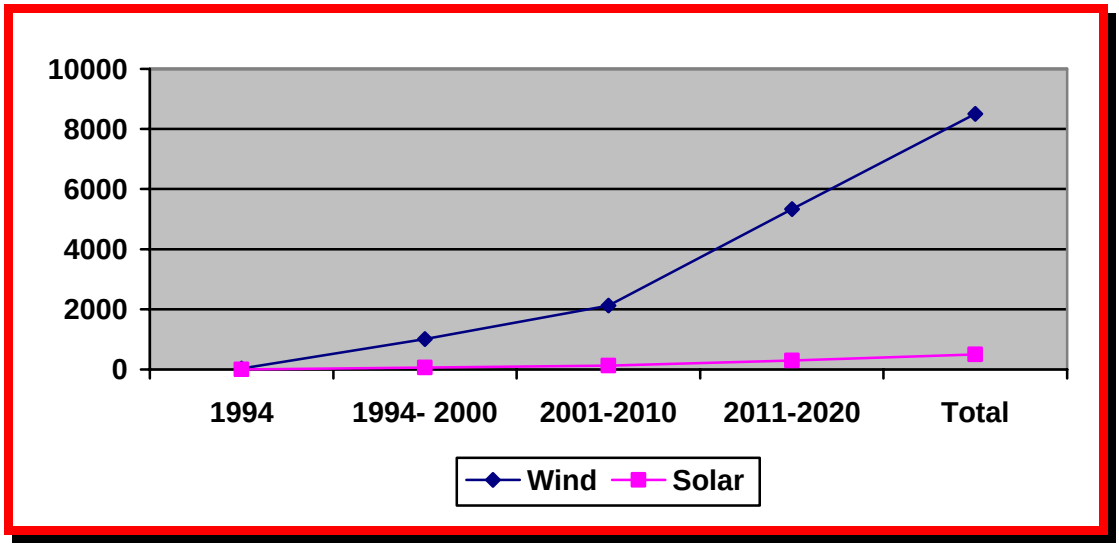


Source: Adapted from *Off-grid Renewable Energy Options for Rural Electrification in Western China*.

[1] This dissertation only focus in Xinjiang and Inner Mongolia Autonomous Region consequently only the data related to these two areas should be taken into attention when analysing this figure.

ANNEX 12

CHINA'S RENEWABLE ENERGY CAPACITY EXPANSION PLANS (MW)

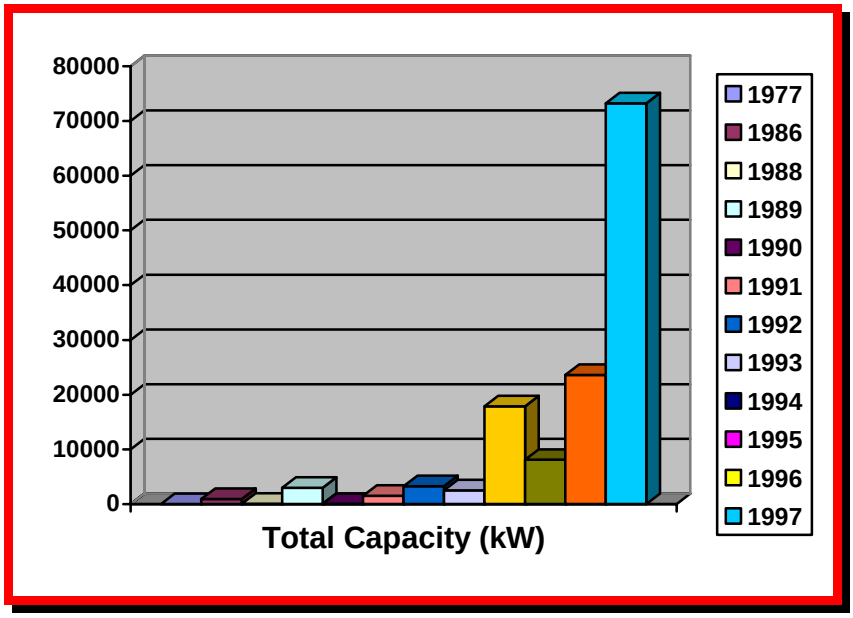


Renewable Resource	Installed Capacity (1994)	1994-2000	2001-2010	2011-2020	Total	National Resources
Wind	30.4	1010	2130	5330	8500	250,000
Solar	3.3	66	130	300	500	450~1200

Source: Adapted from National Renewable Energy Laboratory (NREL)

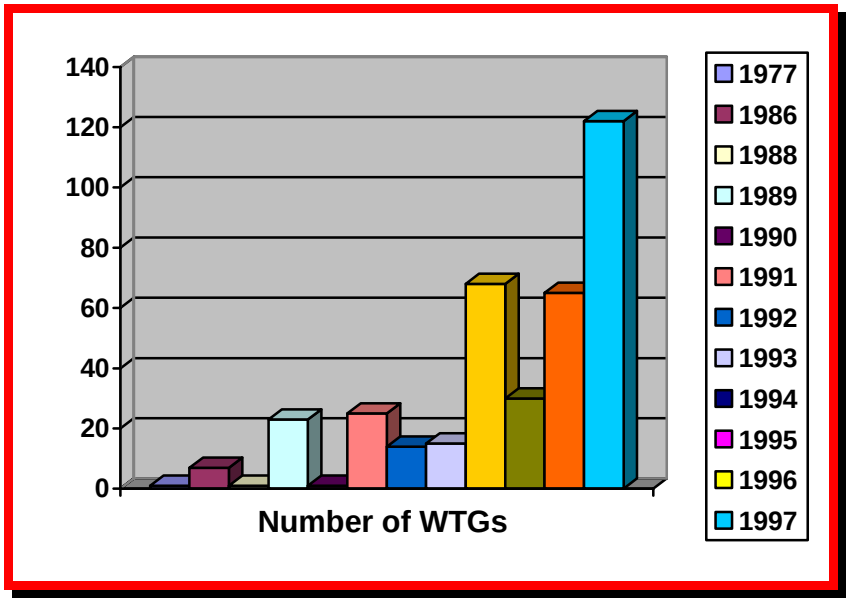
ANNEX 13 A

ANNUALLY INSTALLED GRID CONNECTED WIND TURBINE GENERATORS (WTGS) IN CHINA



Year	Total Capacity (kW)
1977	22
1986	965
1988	55
1989	2995
1990	30
1991	1529
1992	3300
1993	2530
1994	17900
1995	8100
1996	23600
1997	73200

Source: Adapted from China Energy Databook, 2001



Year	Number of WTGs
1977	1
1986	7
1988	1
1989	23
1990	1
1991	25
1992	14
1993	15
1994	68
1995	30
1996	60
1997	122

Source: Adapted from China Energy Databook, 2001

Annex 13

Wind and Solar Energy Resources in Western China

1.Xinjiang

	Wind Energy Density (W/m2)	Hours of Wind Speeds above 3m/s per year	Hours of Wind Speeds above 6m/s per year	Total Solar Insolation per year (kWh/m2)	Hours of Sunshine per year
Xinjiang	-	906-2700	18-876	1708-2006	4406-4704
Qinghe	-	1890	288	1811	4505
Gongliu	-	1562	96	1708	4704
Tuokx	-	2700	876	1865	4473
Qiemo	-	2298	324	2001	4476
Pishan	-	906	18	2006	4406

2.Inner Mongolia

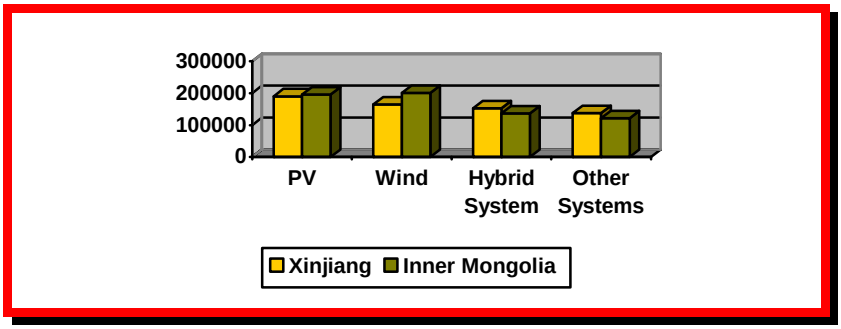
	Wind Energy Density (W/m2)	Hours of Wind Speeds above 3m/s per year	Hours of Wind Speeds above 6m/s per year	Total Solar Insolation per year (kWh/m2)	Hours of Sunshine per year
Inner Mongolia	**100-300**	**4000-7000**	**1000-4000**	**1400-1740**	**2800-3400**
Si Zi Wang	150-200	5000-7000	2000-3000	1610-1700	3100-3300
Su Ni Te You	200-250	6000-7000	3000-3500	1585-1670	3100-3200
A Ba Ga	150	4000-5000	1500-2000	1530-1610	3000-3200
Dong Wu Zhu Mu Qin	100-150	4000-5000	1500-1700	1420-1560	2800-3000

Source: Adapted from Ministry of Agriculture of China

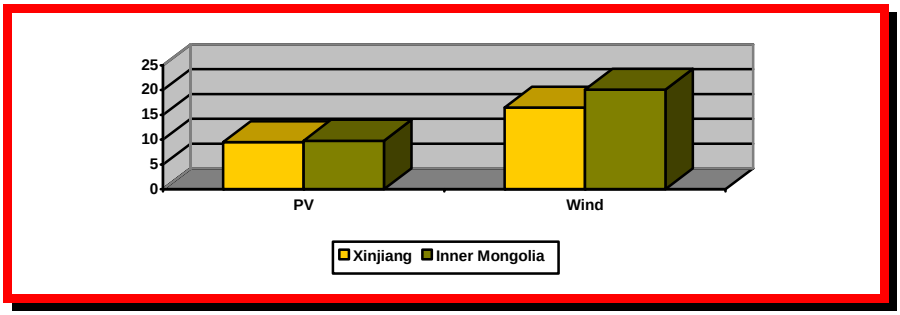
ANNEX 14

MARKET SIZE OF RENEWABLE ENERGY SYSTEM IN XINJIANG AND INNER MONGOLIA

Total Units that Could Be Sold (units)

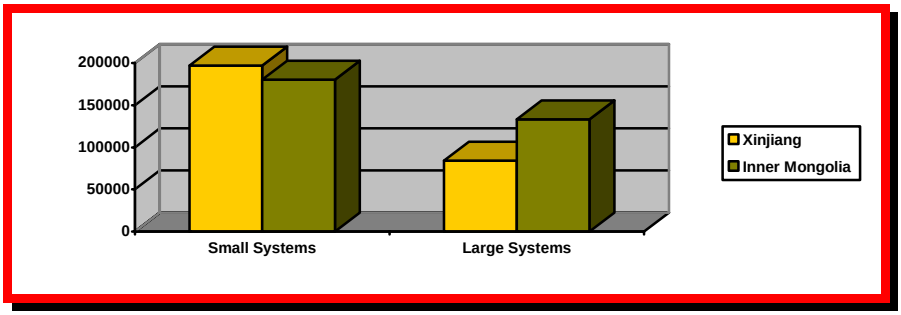


Total Capacity that Could be Sold (MW)



	Total Units that Could be Sold (units)				Total Capacity that Could Be Sold (MW)	
	PV	Wind	Hybrid System	Other Systems	PV	Wind
Xinjiang	189990	164444	152900	137898	9.50	16.44
Inner Mongolia	195793	200867	136234	121202	9.79	20.09

Total Units of PV that Could Be Afford (units)



	Total Units of PV that Could Be Afford	
	Small/ Off Grid Systems	Large/ Grid-Connected Systems
Xinjiang	196991	84421
Inner Mongolia	180186	133348

Source: Adapted from *Assessing Market for Renewable Energy in Rural Areas of Northwest China*, World Bank Report

ANNEX 15

Promote "Productive Uses" of Renewable Energy in Rural Areas

Beyond improving quality of life with lighting and TV, productive uses increase incomes and expand development benefits

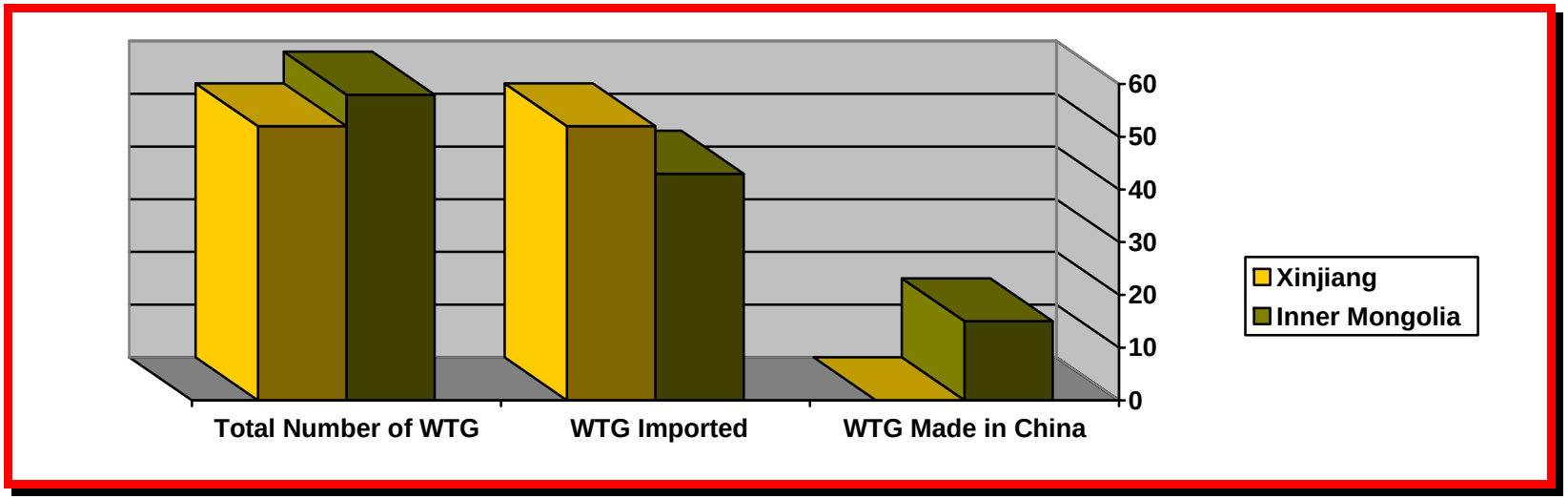
General Categories:

- Agriculture: water pumping, drip irrigation, crop drying, electric livestock fences
- Health: drinking water, "telemedicine", vaccine refrigeration, medical equipment power
- Education: distance education, internet, school lighting, computer training
- Commercial services: telephony, commercial communications, fax, internet, Xerox
- Small industry: craft tools, retail lighting, sewing, grinding, freezing

Source: Adapted from GEF

Annex 16

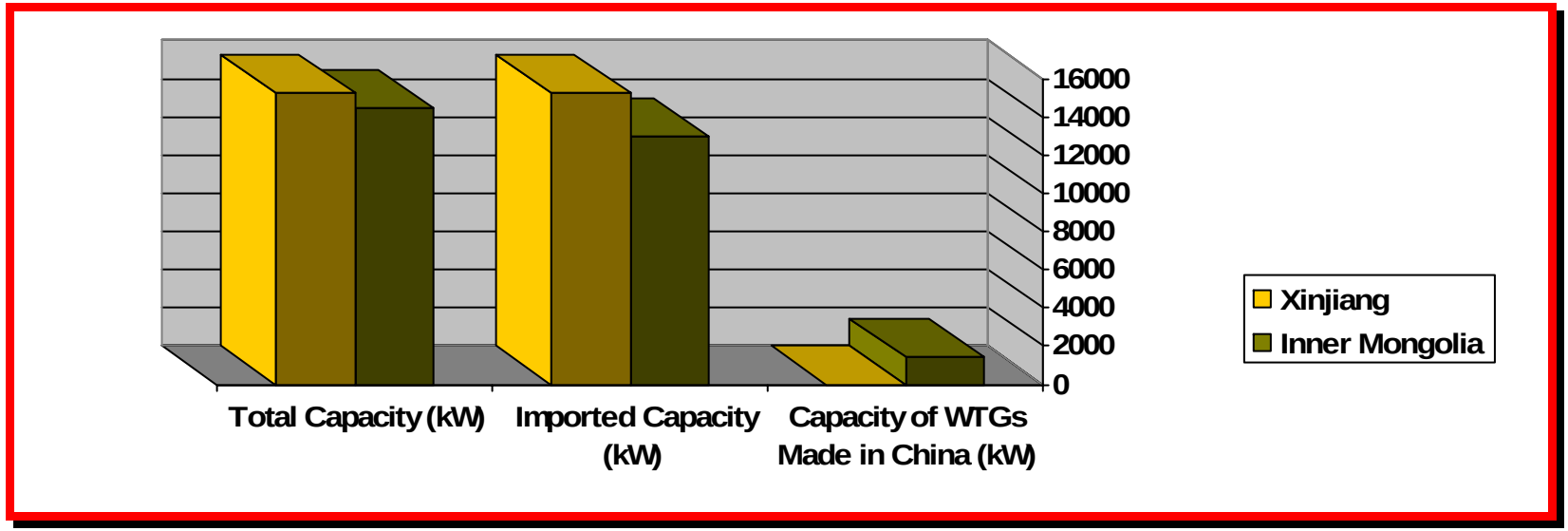
ORIGIN OF WIND TURBINE GENERATORS



Source: Adapted from Electric Power Research Institute, 1996.

	Total Number of WTG	WTG Imported	WTG Made in China
Xinjiang	52	52	0
Inner Mongolia	58	43	15

Note: Wind turbines made in China include the experimental machines



Source: Adapted from Electric Power Research Institute, 1996.

	Total Capacity (kW)	Imported Capacity (kW)	Capacity of WTGs Made in China (kW)
Xinjiang	15300	15300	0
Inner Mongolia	14475	13000	1475

Note: Wind turbines made in China include the experimental machines

ANNEX 17

WIND FARMS IN XINJIANG

DABANCHENG 1

Type of Wind Turbine	Micon-100	Bonus150	Tacke	Bonus450
Country	Denmark	Denmark	Germany	Denmark
Capacity (kW)	100	150	600	450
Number	1	13	2	3
Start Date	October 1989	October 1989	1996	1996
Note	Bilateral cooperation	Bilateral cooperation	Bilateral cooperation	Bilateral cooperation

DABANCHENG 2

Type of Wind Turbine	Bonus300	NTK300/31	Bonus500	NTK300/31	NTK300/31
Country	Denmark	Denmark	Denmark	Denmark	Denmark
Capacity	300	300	500	300	300
Number	4	4	4	23	2
Start Date	November 1992	December 1992	April 1994	December 1994	December 1995
Note	Bilateral cooperation	Bilateral cooperation	Bilateral cooperation	Bilateral cooperation	Bilateral cooperation

Source: Adapted from Electric Power Research Institute

ANNEX 18 A

PHOTOS FROM SHELL SOLAR PROJECT IN XINJIANG

Source: Adapted from Shell Solar Website

Source: Adapted from Shell Solar Website

Source: Adapted from Shell Solar Website

Aspect of Xinjiang Landscape in the summer

Aspect of nomadic life in Xinjiang

ANNEX 18 - TRANSCRIPT OF THE INTERVIEW WITH MR. RAMIN NADIMI

It is very difficult to deal with the lack of updated statistical data about RE in China. In 1996 we did a feasibility study and we concluded that there was potential for the implementation of this project in Xinjiang. The feasibility study was conducted by State Development and Planning Commission, one Research Centre in the Netherlands and an Agent of Shell in China with years of experience in the country. We used the Xinjiang Statistics Yearbook but in some cases it was to general. We had to go to gather data on the field near the population. This is a bilateral project between the Dutch Government and the Chinese Government. In January 2002, the grant agreement was signed.

This project is closely defined in terms of time. It is a 5 years' project to electrify 70,000 households, i.e., to install 70,000 solar energy systems where there were no other forms of commercial energy before. We have a Chinese partner that works with a local network. They care about the after-sales part of the project. Shell is responsible for the quality standards of the project, technical management and assistance through 6 to 10 local technicians.

New systems were specifically developed to Xinjiang, according to the Xinjiang reality, due mainly to the harsh environmental conditions and the characteristics of the population. It's a sparse and nomadic population. An important part of our costumers are herders. Consequently we needed to develop robust systems both in technical and design terms. On the other hand, this system is an extremely mobile one that is possible to pack up and unpack in just 5 minutes respectively. This is very helpful for those herders that use their camels to move from on place to another. And install these systems near their tents.

The first system that was installed was a Solar Home System 100 (25Wp module).The Charge Control and the module of this system were imported from Shell in the Netherlands, but the Balance of the System (BOS), the storage system, the lights, the wires and the other components were all produced locally.

Until now, 8000 systems were installed and hundreds of families, lets say 1000 families, already bought TV sets, radio sets and other appliances.

The aim of this project is to reach the poorest of the poor in order to fulfil their basic energy needs. We cannot forget that this is the first time that these people are having access to electricity. The lowest module that we are installing is of 25Wp which is enough to fill the basic needs of the majority of our costumers (90% of the costumers). We also sell a limited number of 50Wp modules (10%). Shell is not responsible for systems upgrades this is with our Chinese partner. There has been an increasing demand of Colour TV.

Creating economies of scale is very important and might decrease the costs of Renewable Energy, I do agree with you, but one thing is economies of scale and the other thing is technology improvement. In this particular case, what is really necessary to low down the prices of the systems is to improve the technology that still quite expensive.

Concerning the energy price, in this project, we cannot forget that it is founded by the Dutch Government (20 million euros). On the other hand, we have been very lucky with this project as we have been able to negotiate and receive subsidies from the Provincial Government in Urumqi. These subsides are being very helpful. The subsidies are negotiated on a case by case basis. Sometimes we can get a 300rmb subsidy other times we can get subsidies up to 600rmb.

In terms of access to credit lines it would be a good idea but I don’t have any knowledge about any micro credit line opened by Chinese banks to assist to this kind of projects. It would be very helpful particularly in the South of Xinjiang where the people have low incomes and it is very difficult to afford these systems and buy it by themselves. At the moment, there is a pilot project being develop for the World Bank branch in Beijing about the credit to this kind of projects and I am very interesting to know what comes out from this study. For example, I know that in the Sri Lanka the access to micro credit is the key to the deployment of RE Systems.

We have 6 to 10 people working on the field, going to people's houses to see if the systems are working and give training and our staff is always very welcome by the population. We always have harmful receptions and sometimes they invite us to have food or to stay overnight. They are very happy because they were able to get rid of the former dirty kerosene systems or inefficient candles.

The training is basic: explain how to use a Solar Home system, what kind of appliances can be used with this system, for how long, etc…it is very important to explain for how long they can use the system in order to not run out of energy and provide a stable flow of energy. The charge controller will turn off automatically if the storage system is being over-used. Other important things that are explained to our costumers are the maintenance and cleaning procedures of the system and how to position correctly the system in order to face the sun and avoid the shadow. The systems have to be positioned to face the south.

In environmental terms we set up a recycling program for batteries because at a certain point we might have 70 000 old batteries out there. On the other hand, Solar Energy is a much more clean solution when compared with Kerosene systems or wood burning.

Generalization of Renewables might be a good alternative option but just in the long term. At the moment, this is the best option for niche markets like non-electrified areas of Xinjiang where it is much more expensive to connect to the National Power grid.

Compared with other Asian Countries and as far as I know there is much more government support for the introduction of Renewables in rural areas, especially in the western part, from the Chinese Government. Not in terms of subsidies but in terms of political framework.

The subsidies are good to stimulate the Renewables market but on the other hand we cannot forget how hard it is for companies to compete for subsidies. You need to have good relations with the Government in order to obtain them. This can change the nature of the market.

ANNEX 19 - WIND FARMS IN INNER MONGOLIA

ZHURIHE

Type of Wind Turbine	Model56-100	Model56-100	HSM-250T	HEEK-Bonus-120	NTK300/31
Country	US	US	Germany	Denmark	Denmark
Capacity (kW)	100	100	250	120	300
Number	5	6	4	10	3
Start Date	December 1989	April 1991	September 1993	December 1994	December 1994
Note	Domestic Investment	Domestic Investment	Bilateral cooperation	Domestic production by license	Bilateral cooperation

SHANGDU

Type of Wind Turbine	FD-15-55/11	NTK300/31
Country	China	Denmark
Capacity	55	300
Number	5	12
Start Date	August 1993	December 1994
Note	Experimental Machine	Bilateral cooperation

XILINHAOTE

Type of Wind Turbine	HSM-250T
Country	Germany
Capacity	250
Number	4
Start Date	November 1995
Note	Bilateral Cooperation

HUITENGXILE

Type of Wind Turbine	M1500-600/150
Country	Denmark
Capacity	600
Number	9
Start Date	September 1996
Note	Bilateral Cooperation

LIAONING HENGSHAN

Type of Wind Turbine	HSM – 250 T	M700 – 225/40
Country	Germany	Denmark
Capacity	250	225
Number	4	16
Start Date	July 1993	August 1996
Note	Bilateral Cooperation	Bilateral Cooperation

GUANGDONG NANAO

Type of Wind Turbine	Newind (WP-90)	Newind (Sentic Mark-3)	NTK130	NTK10 XLR	NTK200F	N29/250	N29/250
Country	Sweden	Sweden	Denmark	Denmark	Denmark	Denmark	Denmark
Capacity	90	150	130	150	200	250	250
Number	1	2	3	6	15	16	12
Start Date	June 1989	June 1989	June 1991	July 1992	December 1994	December 1995	1996
Note	Domestic invest.	Domestic invest.	Bilateral Co-op	Bilateral Co-op	Domestic invest.	Bilateral Co-op	Domestic invest.

DONGGANG

Type of Wind Turbine	FD16-55	NTK300/31	NTK500
Country	China	Denmark	Denmark
Capacity (Kw)	55	300	500
Number	1	5	9
Start Date	August 1991	December 1994	November 1996
Note	Experimenta l Machine	Bilateral Cooperation	Bilateral Cooperation

FUJIAN PINGTAN

Type of Wind Turbine	FD16-55	FD32-200	Wind Master-200
Country	China	China	Belgium
Capacity (Kw)	55	200	200
Number	1	1	4
Start Date	December 1989	April 1993	October 1986
Note	Experimental Machine	Experimental Machine	Bilateral Cooperation

ZHEJIANG CHENGSI

Type of Wind Turbine	FD16-22	FD16-22	FD11.2-30	FD16-30	Aeroman 12.5/30
Country	China	China	China	China	Germany
Capacity (kw)	22	22	30	30	30
Number	1	2	1	1	10
Start Date	November 1977	January 1991	March 1990	January 1991	June 1991
Note	Experimental Machine	Experimental Machine	Experimental Machine	Experimental Machine	Experimental Machine

CANGNAN

Type of Wind Turbine	FD16-55	NTK500	FD32-200
Country	China	Denmark	China
Capacity (kw)	55	500	200
Number	1	2	1
Start Date	October 1993	1995	1996
Note	Experimental Machine	Domestic Investment	Domestic Investment

SHANDONG RONGCHENG

Type of Wind Turbine	Vestas 55/11
Country	Denmark
Capacity (kw)	55
Number	3
Start Date	May 1986
Note	Domestic Investment

CHANGDAO

Type of Wind Turbine	FD15-55/11
Country	China
Capacity (kw)	55
Number	2
Start Date	May 1991
Note	Experimental Machine

HAINAN DONGFANG

Type of Wind Turbine	Vestas 55/11	HSM – 250T
Country	Denmark	Germany
Capacity (kw)	55	250
Number	1	6
Start Date	October 1988	1995
Note	Domestic Investment	Bilateral Cooperation

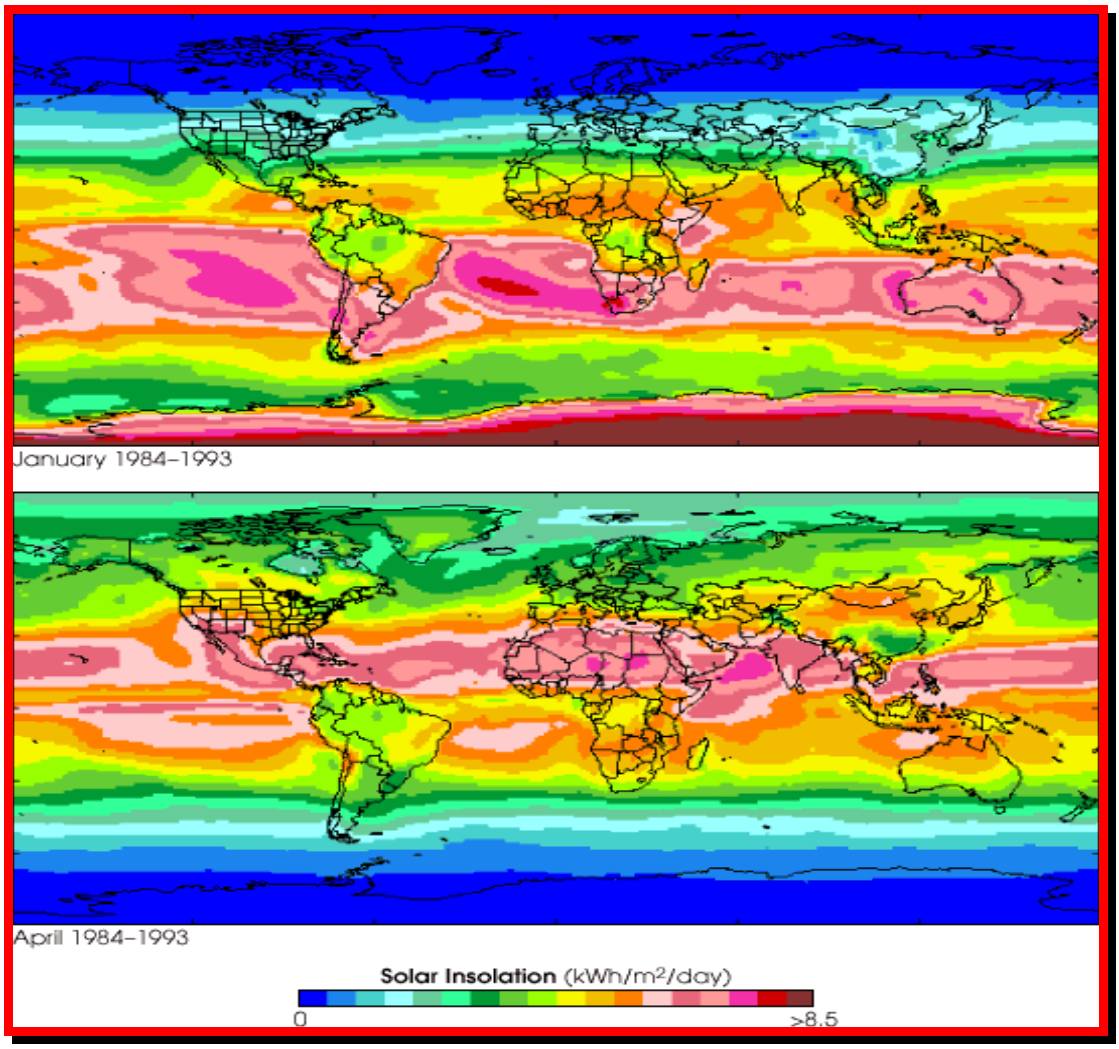
HEBEI ZHANGBEI

Type of Wind Turbine	NTK 300	Tacke
Country	Denmark	Germany
Capacity (kw)	300	300
Number	2	11
Start Date	June 1996	December 1996
Note	Domestic Investment	Bilateral Cooperation

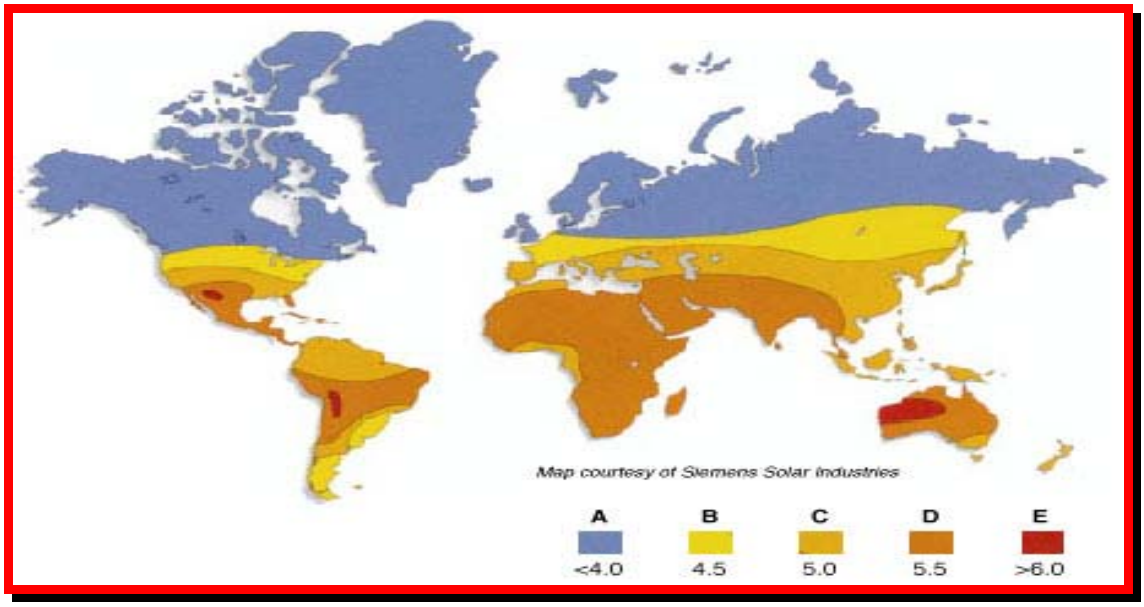
Source: Adapted from Electric Power Research Institute, 1996.

ANNEX 20

SOLAR INSOLATION WORLD MAPS



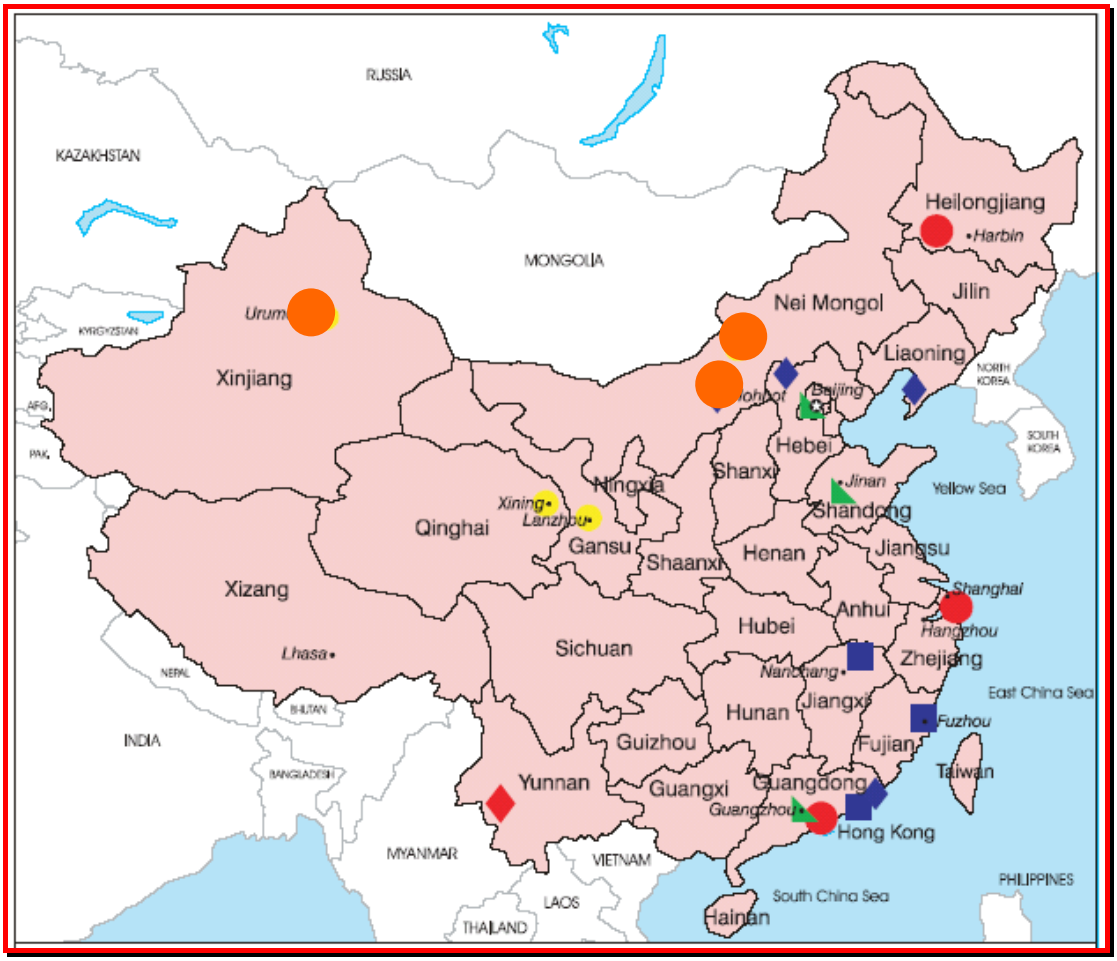
Source: Adapted from Earth Observatory, NASA



Source: Available online at www.solartsonic.com

ANNEX 21

RENEWABLE ENERGY PROJECTS IN CHINA IN THE YEAR 2000

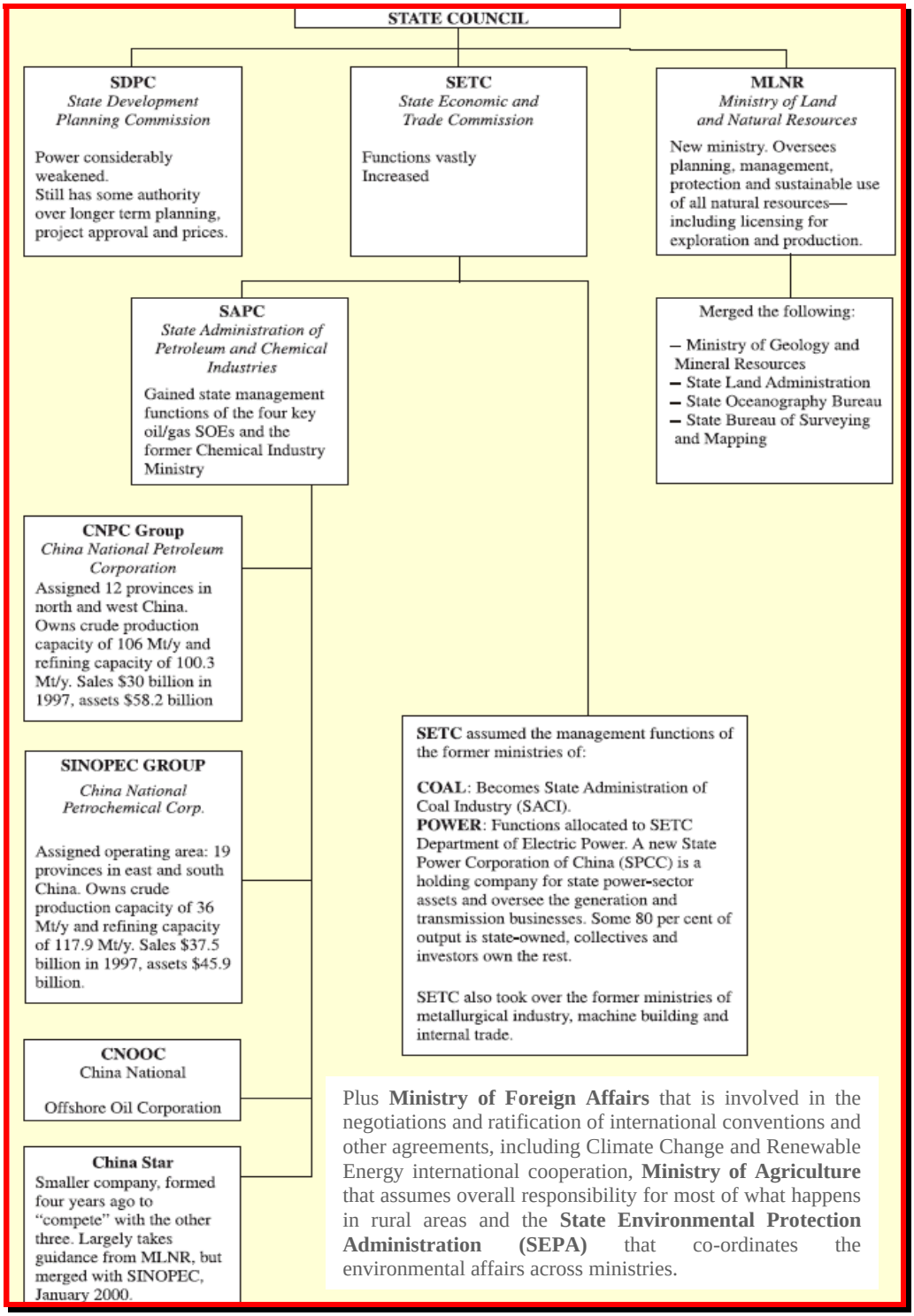


Source: Adapted from the Protocol for Cooperation in the Fields of Energy Efficiency and RE, NREL.

- Electrification projects of Rural Areas of Norwest China studied in this dissertation using Wind and Solar Energy
- Rural Electrification Projects not studied in this dissertation
- Ground Source Heat Pump
- Biomass Projects
- Wind resources Assessment Projects in southeast China wind belt
- Wind Farm Development Projects in southeast China wind belt
- Geothermal Drilling Assistance

ANNEX 22

CHINESE GOVERNMENT MINISTRIES AND AGENCIES WITH RENEWABLE ENERGY AND ENVIRONMENTAL RESPONSIBILITIES



Source: Adapted from UNDP

ANNEX 23

CHINA'S POLITICAL WILL TO ACCELERATE RENEWABLE ENERGY DEPLOYMENT

The Government of China has developed plans to accelerate renewable energy deployment. This is reflected in the China Agenda 21, Guideline of the ninth-five-year plan and 2010 Long-term objectives on economic and social development in China. The State Planning Commission (SDPC), State Science and Technical Commission (MOST) and State Economic and Trade Commission (SETC) jointly formulated a program on renewable energy development in China (1996-2010). However, renewable energy can not yet satisfy the large market demand in China. There are several barriers to the deployment of renewables which include: no state or local level detailed action plans, therefore a lack of a clear guidance from the Government; planning and implementation methodologies are proving unreliable and targets are not being met; lack of commercialisation experience; lack of related legislation and fiscal policies for renewable energy development; complicated and ambiguous procedures for investors in renewable energy projects.

The government of China has started to give attention to developing renewable energy, in order to achieve this they need to give attention to developing policies to support renewables. There is also a need for financial mechanisms to encourage investment into renewable energy. In addition quality and standards need to be addressed and legal and regulatory infrastructure put in palace. The targets and research contents of the renewable energy program include: to study the motivation for renewable energy in the world; to assess barriers to renewable energy development in China; to identify appropriate strategies and policies to encourage renewables; to set development objectives to support the Tenth Five Year Plan; to make an action plan for the development of renewable energy.

The objective is for renewable energy to increase its contribution to China's energy supply so that it contributes between 34.7 and 36.1 million tce by 2005, and 42.3 to 44.6 million tce by 2010, with electricity from renewables contributing 71.6 - 83.4 TWh by 2005 and 100 – 135 TWh by 2010. In order to achieve these increases a number of measures will be implemented. These will include establishing a strong technical capability, taking steps to reduce the costs of producing energy from renewables which is currently perceived as being costly, and opening up markets for electricity and heat. These measures will include implementation of a renewable Portfolio Standard which will ensure that renewable energy maintains or increases its share of the electricity market. Targets will be set nationally and regionally, standards developed, international co-operation encouraged, and a promotional campaign which aims to raise public and official awareness of the environmental benefits of renewable energy. Efforts of various ministries and commissions with a role will be co-ordinated via a nation-wide action plan to ensure that resources are used effectively and that policies are complementary.

Source: Adapted from Centre for Development of Renewable Energy (CRED), China.

ANNEX 24

Wind Power in China (World Bank/GEF)

No way to force utility purchases of expensive wind power

- Four new domestic wind-power companies were to construct 190 MW of wind farms and enter into commercial power-purchase agreements with utilities
- Planned 100 MW wind farm component in Inner Mongolia cancelled because regulatory framework for inter-provincial power purchases doesn't exist and power sector reform has created "true" commercial entities for the first time
- Wind farms constructed by "IPPs" that are owned by utilities: an extended form of utility demonstration?
- Highlights question: who will pay for the additional costs of wind power?
- $90 million technology improvement grant to assist domestic manufacturers to innovate, improve quality, and reduce costs. But experience with technology transfer from other GEF projects in China casts doubt on viability.

Source: Adapted from GEF

ANNEX 25

World Bank/GEF China Renewable Energy Scale-Up Program (CRESP)

A long-term effort to develop policy and regulatory frameworks

- Focus on grid-based power generation from renewables
- 10-year program, $100 million World Bank loans, $140 million GEF grants
- Expected to leverage $10 billion in private investment in renewable energy
- Policy frameworks for renewables portfolio standards (RPS)
- Regulatory frameworks for grid access and sales by independent producers
- Pilot approaches in three provinces first, then expand nationally
- Latest Five Year Plan proposes 5% of new generation from renewables, whic could mean 20,000 MW added by 2010

Source: Adapted from GEF

ANNEX 27

People's Republic of China	PPTA: PRC31163-01
Cost and Financing Plan (in $US)	600,000.00

ADB Wind Power Development Project

Location
Xinjiang Autonomous Region[1], Liaoning and Heilongjiang Provinces

Sector
Energy /Electric Power

Initial Listing
1 May 1998

Most Recent Update
9 December 1998

Executing Agency(ies)
State Power Corporation

Technical Assistance (TA) Fact-Finding Mission Undertaken/Scheduled: 25 May-2 Jun 1998

TA Approval Date	Estimated Completion Date
21 September 1998	30 June 1999

Description
The Project comprises development of commercial grid-connected, wind-based electricity generation by expanding one existing wind farm in the Xinjiang Autonomous Region, and developing new wind farms in Liaoning and Heilongjiang provinces.

Strategic Development Objectives

Primary	*Secondary*
Sound Management of Environment	Not Mentioned

Objectives and Scope
The objective of the technical assistance (TA) is to support the development of commercial grid-connected, wind-based electricity generation by expanding one existing wind farm in the Xinjiang Autonomous Region among other projects. Its scope will include reviewing the Government's strategies and policies for the development of wind energy resources; developing an appropriate institutional and financial framework for increased investments in wind-based electricity generation projects; and determining the technical, economic, and financial feasibility of the project components.

Policy Dialogue
None

Environment Category: B

Environment Impact and Mitigation: Not Mentioned

Social Aspects and Remedies: Not Mentioned

Benefits and Beneficiaries
The TA will result in the establishment of four grid-connected wind farms with a total generating capacity of about 90 MW.

Beneficiary Participation in Formulation: Not Mentioned

Beneficiary Participation in Implementation: Not Mentioned

Consulting Services
About 15 person-months of international consultants with expertise in power engineering, wind power development, institutional analysis and development, procurement, environmental and social analyses, and financial and economic analyses will be required. About 13 person-months of domestic consultants with similar expertise and knowledge of PRC Company Law will also be required.

Source: Adapted from Asian Development Bank (ADB)

[1] This dissertation focus on the Xinjiang Autonomous Region Projects consequently this project to increase the energy capacity production in one of the Xinjiang's Wind Farm helps to illustrate this study.