RENEWABLE ENERGY OPTIONS IN IMPROVING THE LIFE OF WESTERN RURAL POOR POPULATION IN CHINA

(Final Report)

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TABLE OF CONTENTS

List of Tables and Figures

Acronyms

CD	Capacity Development
CDM	Clean Development Mechanism
CHP	Combined heat and power
CREIA	China Renewable Energy Industrial Association
CRESP	China Renewable Energy Scale-up Program
ERI	Energy Research Institute, of NDRC
FIL	Feed in Law
FYP	Five Year Plan
GDP	Gross Domestic Product
GEF	Global Environment Facility
GW	Gigawatt
GWH	Gigawatt hours
HRC	Hangzhou Regional Centre for Small Hydro Power
IEA	International energy Agency
IGCC	Integrated Gasification Combined Cycle
KJ	Kilojoule
KW	Kilowatte
Mm^2	10^6 m^2
MMS	Mandated Market Share
MoA	Ministry of Agriculture
MoF	Ministry of Forestry
MoST	Ministry of Science and Technology
MoWR	Ministry of Water Resources
MSW	Municipal Solid Waste
Mt	Mega tons
Mtce	Mega tons of coal equivalence
MW	Megawatt
NDRC	National Development and Reform Commission
NPC	National People's Congress
NTEP	National Township Electrification Program
O&M	Operation and Maintenance
PBF	Public Benefit Fund
PV	Photovoltaic
R&D	Research and Development
RE	Renewable Energy
REDP	China Renewable Energy Development Project
RETs	Renewable Energy Technologies
RPS	Renewable Portfolio Standard
SDPC	State Development and Planning Commission
SETC	State Economic and Trade Commission
SHP	Small hydropower
SWH	Solar water heater
TCE	Tonne of coal equivalence
TOE	Tonne of oil equivalence
UNDP	United Nations Development Program
UNF	United Nations Foundation
VAT	Value added tax
WB	World Bank
W_p	Watt peak
WTO	World Trade Organization

Executive summary

As a developing country with both large area and tremendous population, although China's economy is growing rapidly, there are still large quantities of population in poverty, the majority of who are dispersed in the remote western part of China. The western provinces enjoy the best renewable resources in China. The harnessing of RE resources to serve the rural residents, particularly the poor in remote areas is the requirement of building a well-off society. Furthermore, RE resource utilization will help the ecology protection that is becoming significant. More specific, it is the government's obligations to find solutions to supply the unelectrified population clean energies. This paper is trying to provide a justification in harnessing the RE resources to reduce the poverty from the energy supply point of view. An overall initial assessment will be presented regarding the poverty situation in China, RE resources, RE technologies, as well as motivations and barriers in developing RE resources. Barriers analysis will be drawn from some selected case studies. At last, the paper attempts to show the policy outlines to address these problems.

Different technologies in harnessing the RE resources are able to generate different categories energies in rural China, such as electricity, gas and heat. It can be simply categorized as centralized and decentralized types in terms of their targets and project scale. Various technologies are different according to their maturity. Though the biogas, solar stove are relatively cheap, they are still too large a burden for the poor in their normal life. Some other technologies with high cost, such as PV, biomass gasification, are far beyond the affordability for the poor. In this paper it is found that one simple technology in harnessing the RE resources are not realistic to fully satisfy all of the requirements. There is a need to make deep analysis to choose the most desirable RE technology to serve the poor based on the ultimate demands, some of which is actually not from the energy supply at all, according to the local situation. The initiatives taken by China's government in harnessing the rural RE resources, as well as the support to reduce the poverty are all based on such considerations.

Biogas is a mature technology with successful demonstrations in the rural regions. By the end of 2002, the biogas digesters accumulated to 11.2 million. Biogas is popular because it is a significant link among the sound rural ecosystem, including the livestock breeding, plantation, residential energy demand and even the productive activities. Government finance support is also one contribution to its extensive spread. In northern and southern China, "four in one" model (plantation, livestock breeding, biogas, solar greenhouse), and "three in one" model (plantation, livestock breeding, biogas) have achieved remarkable success respectively. Furthermore, biogas has proved useful in aquatic product cultivation, seed preservation etc productive activities. Biogas is limited in arid and cold regions. It is noted biogas is weak in energy supply compared with other RE technologies. Energy supply is only one output from the ecosystem cycle, and that biogas cannot meet all of the energy demand. Government support on the biogas focuses more on the construction process rather than on its operation in some cases.

NTEP aims to electrify the remained 1061 unelectrified townships, taking advantage of the local abundant solar energy, wind energy and hydro resources to provide stable and reliable electricity for the local government venue. Started from year 2002, NTEP is expected to end in year 2005. Its total fund comes from the government, including the system design, device procurement, construction, installation and operation. NTEP achieved the "Frog-Leap" for the local residents, which enable them to benefit from the most advanced technology in the world. It is noted that the

ownerships of these PV stand-alone stations still have not been identified. The repair and components replacement work require stable fund, however the tariff has not set yet which will influence their sustainable operation. A critical problem is the after-sale service for the remote areas.

SHP is one technology that has been utilized for long history since the establishment of new China. Its extensive promotion attributes to its flexibility in the rural areas, particularly in those remote areas with mountainous terrain. Rural hydro-based Electrification County Construction program makes it possible to electrify those residents. SHP is also adopted in NTEP and “Replacing fuel-wood with SHP” program. The current barrier for SHP is more an institutional one, especially for the relationship with the larger grid, than the technical one given the adequate subsidy for the initial cost to serve the poor.

Despite different RE technologies are facing different barriers in its spread, there can be drawn some common features for them. High cost and high price are the top barriers to hinder for the poor benefiting from the poor. Inadequate fund to help the poor is a practical difficulty in introducing RE productions. The previous macro policies or laws focus more on the concepts and generic significances, without concrete and operable measures. There are no unified favorable policies as well as unified leadership in the RE development. Generally, the RE industries are not strong as a whole, and market-support infrastructures for RE products are still underdeveloped. A limited R&D input on these areas contributes to this situation, which contributes to the high cost and prices. As a result, the RE market is small and its commercialization process is slow. The poor always dwell in the remote areas with poor natural condition and transportation. Their education experiences are also rare. All of these contribute to their poverty status, and weak their affordability as well as the ability to use the RE productions. With respect to most of the national programs, the designer or administrative agencies have paid enough attentions on the construction process, whereas few on the follow up management, operation, and daily maintenance work.

In order to solve these identified barriers, some policy outlines are put forward. An external consultation process contributed to this summary.

- Decrease the cost, especially initial cost of RE system. There is a need to strengthen the R&D on RE system specifically tailored to diverse local conditions.
- Promote sufficient as well as diversified financial support.
- Strengthen the coordination and complete the RE promotion law.
- Promote the RE industry, especially in poor rural area and increase local capacity
- Create opportunities for productive and particularly business use of RET to increase income
- Improve the design and organization of national RE initiatives

At last, the future suggestions are raised to give more detailed focus as well as case studies on the national programs experiences summary.

1 Background

There are still about 30 million poor populations, most of whom dispersed in the west of China, without access to the electricity. These places are far away from the end of the grid. Without high quality, clean energy access, the population in poverty in the remote areas always make use of the resources in a conventional way, e.g. the straw and stalk, animal wastes etc for heat and cooking purposes, or candle, kerosene for light, and kerosene as fuels for small devices manufacturing. The energy deficiency limits their development, and the energy utilization approaches are also a great threaten to the environment and ecosystem around them. The natural environment protection is becoming a great challenge. Without an appropriate approach to increase their income, these populations without access to electricity are also basically the poor population in China. Finding a feasible way to address those people's energy utilization has become an important task to speed the western development, also a crucial precondition for the poverty alleviation.

The western part of China is distributed with all kinds of plenty renewable energy resources, including the solar energy, wind, hydro, biomass energies etc. As a practical and economical approach to develop the western provinces, harnessing the local renewable energies so as to get rid of the poverty is also the requirements for the ecosystem protection and sustainable development.

As a large developing country whose energy depends on coal, there is a great need to increase its clean and sustainable alternative energy types. Although various renewable energy technologies have already been adopted decade years ago, its actual penetration degree in the rural areas, especially in the poor regions is still very limited. There are barriers from various in the practical Renewable energy technology promotion.

In this context, this study will focus on the RE utilization perspective in addressing the rural poverty alleviation issues. Before giving an overall policy recommendation, the paper will formulate an initial assessment of the situation and potential of the renewable energy satisfying the rural energy demands. The research will analyze the demand side from various sides first. Then the current situation of the renewable energy in China will be presented in detail. The barriers and the learned experiences will be provided as the basis for the concrete policy guidance.

2 Rationale

- Selection of western China

As a developing country, by the end of 2002, 608 townships, 9300 villages, and about 4.58 million households have yet no access to the electricity (China Electric Power Yearbook, 2003). Some residents have no reliable household energy supply. Most of these populations are dispersed in the remote western part of China. Substantial unbalances exist between Western and Eastern China. Eastern China is facing the Pacific Ocean, and is the earliest places that are open to the world since early 1980. Therefore, the economy is developing much faster than the west. More seriously, the gap of poverty and wealth between the east and west is growing larger. Currently, a distinct comparison is that more population are shifting from the western part to the eastern part. See the following table for the economy and poverty comparison. However, compared with the economy, western China is featured by more abundant resources and larger area. A harmony development is critical for a country. In this regard, this paper focuses on the western regions rather than the entire country.

Table 2-1 Main indicators of the western provinces in Year 2001

	Total population (Million)	GDP (Billion US$)	GDP per capita (US$)
National	1276.27	1293	913
Western	364.47	221	610
Chongqing	30.97	21	684
Sichuan	86.4	54	620
Guizhou	37.99	13	346
Yunnan	42.87	25	586
Tibet	2.63	2	639
Guangxi	47.88	27	564
Shaanxi	36.59	22	610
Gansu	25.75	13	504
Qinghai	5.23	4	697
Ningxia	5.63	4	642
Xinjiang	18.76	18	959
Inner Mongolia	23.77	19	787

Source: China Statistic Yearbook (2002).

Currency exchange rate: 1US$=8.26 Chinese Yuan.

Table 2-2 Main indicators of the western provinces in year 2002

	Rural population (Million)	Rural households (Million)	Net income (US$)
National	933.829	244.322	286
Western	280.951	71.53	212
Chongqing	24.388	7.24	239
Sichuan	69.259	19.74	241
Guizhou	31.606	7.96	171
Yunnan	34.637	8.38	186
Tibet	2.186	0.38	170
Guangxi	40.348	8.77	235
Shannxi	27.713	7.05	180
Gansu	20.395	4.54	183
Qinghai	3.395	0.71	189
Ningxia	3.975	0.96	221
Xinjiang	9.32	2.2	207
Inner Mongolia	13.729	3.62	239

Source: China Statistic Yearbook (2003).

Table 2-3 Key poverty assistance counties in western provinces

Region	Key poverty assisted counties	Region	Key poverty assisted counties
National	592	Tibet	-
Western part	375	Guangxi	28
Chongqing	14	Shannxi	50
Sichuan	36	Gansu	43
Guizhou	50	Qinghai	15
Yunnan	73	Ningxia	8
Xinjiang	31		

Source: Poverty monitoring report of rural China (2003).

- Selection of rural regions

It should be highlighted that there also exists poor in the urban areas. Since year 1990, government of China initiated several major structural reforms including the key restructuring on the large state-owned enterprises, mineral plants etc, which were symbols of the shift from the planning mechanism to the market-oriented economy. A lot of labour-off workers emerged in almost every large and medium cities, particularly for those heavy industry cities. Unemployment became a serious problem since then. Without a normal income source as before, most workers were at the edge of low-income poor situation. However, the poverty is attributed to the macro-economic adjustments from the government, which is temporary and not similar as those poor populations in remote rural regions. Along with the issue of many re-employment policies, as well as the strengthening of the social insurance regulations from various communities, a large portion has already found their new jobs and get rid of the poverty. Furthermore, almost all of the people in the level of county and above, irrespective the poor or non-poor have the access to the electricity[1]. Therefore, this paper will not take consideration of the poverty in the urban area.

3 Initial assessments

3.1 Characterization of population

The poverty line in China (Poverty Monitoring Report of Rural China, 2003) is much lower compared with the international standard of 1US$/day made by World Bank for the poor identification. In line with the rural residential expenditure price indexes fluctuation, the rural "extreme poverty" (critical poverty) criteria has been adjusted from 630 Chinese Yuan [2](76.27US$) during year 2001 to 627 Chinese Yuan (75.9US$) in year 2002, while the "low-income standard" was adjusted from 872 Yuan (105.57US$) to 869 Yuan (105.2US$). (Note: Those populations with net income per year lower than the national poverty line belong to "extreme poor population", while those both above the poverty line and below the low income line belong to "low income population"). This standard consists of two parts, one is the minimum line to buy food equivalent to 2100 calories per day for the rural poor, and another one is the minimum non-food line.

3.1.1 Distribution

With respect to the geographical distribution of the poor population in China, the features are evident. In the year 2002, 83.5% of the extreme poor population locate in the western and middle China, meanwhile the extreme poor population within the twelve western provinces [3] accumulated to 17.42 million, taking up to 61.8% of the whole nation. The total situation comparison of the respective parts within China is shown in Table 3-1. The aggregate number of the poor in western part is far more than the middle and the eastern part. It can also be seen in Table 3-2 that all of the top five provinces with the least rural household income per capita in year 2001 come from western part.

Table 3-1 Poor population distributions in China (Million)

Type	Eastern	Middle	Western	Twelve western [2]	Total
Year 2001	12.55	28.67	49.08	55.35	90.30
Year 2002	15.36	27.27	43.82	50.27	86.45
Growth rate	22.45%	-4.91%	-10.71%	-9.18%	-4.26%

1 Include both the extreme poor population and low-income population
2 Source: Poverty monitoring report of rural China (2003)

Table 3-2 Top five provinces with the least rural household income in year 2001 (US$)

	National average	Tibet	GuiZhou	GanSu	YunNan	QinHai

[1] The only three counties that have no access to electricity in China are distributed in Tibet, i.e. Saga, Zhongba, Zada County.
[2] The currency rate is 1US$=8.26 Chinese Yuan.
[3] Twelve western provinces (Autonomous Regions) includes the traditional western provinces and Inner Mongolia, Guangxi provinces that have been covered in the West Explorer Program, i.e. Inner Mongolia, GuangXi, ChongQing, SiChuan, GuiZhou, YunNan, Tibet, ShaanXi, GanSu, QingHai, NingXia, XinJiang.

Annual income Per capita	286.4	170.0	170.8	182.6	185.6	188.5
Annual residential expenditure per capita		136.0	132.9	136.4	161.7	161.0

Source: China Statistic Yearbook. 2002

3.1.2 Poverty status

In China, the rural poverty and low-income population are always linked with the worse living environment and quality, limited educated personnel resource, lower income and wealth. The majority of the residents have limited knowledge, information and disposable resources. In addition to that, 50.4% of the extreme poor and 46.8% of the low-income poor are dwelling in the mountainous regions (Poverty monitoring report of rural China, 2003), whereas the proportion for other rural residents is only 23%. With respect to the grain production, the respective average output per Chinese Mu (1 Mu=0.166 acre) for the extreme poor and the low-income poor is 217 kg and 224 kg, only 70% of the other rural residents. Generally, the family size of poor is larger, and they have few chances to get educated due to the affordability, transportation etc, which is a high restriction for their life improvement.

Table 3-3 Some comparison information about China's poor population in year 2002

Items	Category		
	Extreme poor	Low income	Others
Household size (person)	5.3	4.8	4.1
Net income (US$/ capita/year)	64.6	99.0	337.6
Located within mountains (%)	50.4	46.8	23
Village Electrification Level (%)	95.1	97.5	99.3
Residential electrification level (%)	85.1	90.8	94.2

Source: Poverty monitoring report of rural China (2003)

3.1.3 Energy access for the poor

It should be noted that there is close relationship between poverty and energy access difficulty. Contents in Table 3-3 show that only 85.1% of the poor rural residents and 90.8% of the low-income rural residents have access to the household electricity, while for other rural group 94.2% is able to use the electricity. It can also reflect the gap when checking Table 3-2 and Table 3-4 that the five poorest provinces take four of the top five provinces with the highest uneletrification level (all of which are located in Western China).

Table 3-4 Top five provinces of the highest unelectrification level in year 2002 (%)

	Provinces	Household	Village	Township
1	Tibet	86.43	77.07	58.89
2	QingHai	13.14	17.87	20.42
3	GuiZhou	7.16	2.39	0
4	XinJiang	4.99	2.87	2.72
5	GanSu	4.99	2.94	0
	National average	1.52	**1.29**	**1.46**

1. Source: China Electricity Power Yearbook. 2003.
2. in the sequence of least unelectrification level.

Considering the clean energy access-electricity, by the end of 2002, there are still 608 townships, 9300 villages, and about 4.58 million households have no access to the electricity. These townships, natural villages and households are principally found in remote areas of China’s Western Provinces (see Appendix 1, 2), far away from power grids. For these people in poverty, their residential energy demands basically depend on the biomass energy resources in a conventional way, such as the agriculture residuals and dry manure of animals. These approaches are not only low efficiency but also may bring large pollutions to the environment, which is not sustainable. Some villages can use diesel mini grids to provide electricity for a couple of hours at night or in case of emergency. Unelectrified populations have to rely on candles and kerosene for lighting and batteries for small-scale applications.

It is estimated by authorities (Ma shenghong, 2003) that 80% of the households and villages will not be possible to access the electricity through power grid extension in the coming 20 years. They have to continue on harnessing the agricultural residuals and dry animal manure in the conventional way unless more efforts have to be carried out. It is therefore a great challenge and large responsibility for government to find ways for clean and sustainable energy alternatives.

3.2 Energy demand analysis

3.2.1 Generic demand

Generally speaking, there are two features for the energy consumption in the western rural areas. The residential energy consumption takes a much larger portion in the whole energy consumption. Another one is that the rural western energy seriously relies on the conventional firewood and stalk. See the following table for the information of the western rural energy consumption. It is indicated in the table that the western *residential* utilization proportion in the aggregate energy consumption, i.e. 63%, is much higher than that of the national average level, i.e. 57%.

Table 3-5 Rural energy consumption conditions in western provinces in year 2001

	Rural population	Energy consumption (million TCE)			Residential energy per capita
	Million	Total	Productive	Residential	TCE
National average	933.83	726.03	311.75 (43%)	414.27 (57%)	0.444
Western average	280.95	189.48	70.14 (37%)	119.33 (63%)	0.425

Source: Ministry of Agriculture of China (2001).

The last column shows the western average residential energy per capita is 5% less than the national average. Meanwhile, the commercial energy portion is far limited. Regarding the residential energy category in western provinces, the commercial energy consumption accumulated to 55.9 million TCE, taking up to no more than *47*%, while the other 53% comes from non-commercial energy options, such as the stalk and straw, firewood and biogas. As a result, there are about 50 million households mainly relying on the traditional stalk and firewood for the residential fuel requirements.

It is therefore expected to change such a situation. First the commercial proportion in residential sector is too low for the western population. There are various reasons contributed to this situation. Meanwhile, the undeveloped economy is the most significant one. With the acceleration of the national urbanization steps and life quality improvement, the high growth of the commercial energy consumption, as well as the aggregate residential energy consumption is inevitable. Secondly, the productive energy consumption is also anticipated to increase. Economical growth requires stable energy supply. Life quality improvement is a great pull for energy demand.

3.2.2 Well-off society construction

In the year 2003, China's government put forward the new target of the entire well-off society's building by year 2020. The targeted society should improve the entire citizen's living standard as well as achieve the stable energy supply for the populations. In case of China, the key targets and difficulties for the well-off society construction are all in the rural regions, which are determined by the basic national situation. Currently, farmers in some of the rural areas, especially in the western countryside, are still leading a very difficult life. Due to the poor historical, natural or geographical situation, their incomes that basically depend on the agriculture and no other sources are too low. Undeveloped economy, low educated population and limited information resources are all the factors that restrict their development. Therefore, their energy consumption type is also lagged behind. In addition, in line with the future society construction, the central government is paying special attention to the "San Nong" (Rural, Agriculture, Farmers) issues. As a result, more focuses will be attached on the western rural areas. Among the development issues, energy supply is one basic thing that should be taken into account. A comprehensive energy strategy should be adopted. It should not only be sufficient for energy supply, economical for local condition, but also environmentally sound, and sustainable for future development.

3.2.3 Ecology environment protection

The ecological environment situation in western part is getting worse and worse. Residential activities, as well as some other excess exploration actions substantially contribute to this serious situation. China is one of the countries that threatened by the desertification in the world. Currently, the desertified area in China is 26.2 million km^2, about 27% of the whole nation (State Council, 2003). 95 percent are located in the western China. In addition, the area with of erosion water and soil loss in China accumulates to 36.7 million km^2, about 38% of the total area, and western provinces occupy 80 percent of the areas. The forestry coverage rate in the West is only 10.28%, 6.27 percent lower than the national average level, particularly in northwest the rate is only 5.9%. In order to stop the deteriorating trend of the environment, the central government has issued several ecology programs, such as "returning arable land to forest", "returning arable land to grass" , "natural forest protection" etc.

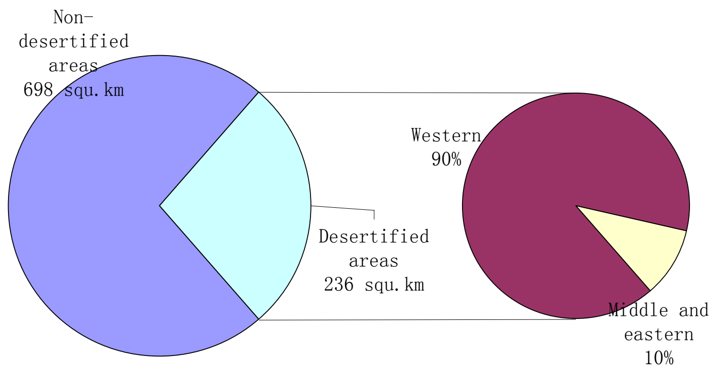

Figure 3-1 Desertification areas in China

The situation of high ratio consumption on non-commercial energy such as firewood is tremendously serious, which is a major threat to those protection programs. In year 2001, the firewood quantity burnt by the western farmers reached 228 million m^3, far exceeding the quota of 64 million m^3 that is set by the State Council for the farmers' firewood consumption (Hangzhou Regional Center for Small Hydropower, 2004). Poverty closely links with high proportion biomass utilization, and hence having large influences on the ecology environment. The activities of over felling on the forestry or depasturing aggravates the serious natural disasters, e.g. the erosion of water and soil, barren land, sand storm and desert expansion in most of the western places. It is therefore necessary to find various alternative energy resources for the residents so as to stop them from destroying the forestry or plantation, as well as construct solid foundation to implement the aforementioned ecology environment protection programs. In this regard, China has formulated a national western rural energy plan, which focuses on the local condition and takes the advantage of local sources, e.g. encourage small hydropower (SHP), biogas, biomass gasification etc for residential purposes.

3.2.4 Unelectrified residents demand

Although the proportion of population without access to electricity has been greatly reduced, taking consideration of the large population in China, the total amount, more than 4.58 million households, over 20 million populations are still a very large number. Their basic household energy demands are satisfied by biomass through traditional way, i.e. straw and stalk, firewood or animal manure etc. The above text has already elaborated the electricity access issue for the poor. The urgent demands for the population without access to the electricity, or to the clean energy sources, are basically limited in household purposes, such as cooking, lighting, warming etc. Particularly for some ecological environment protection programs, e.g. "Replacing fuel with SHP", should supply alternative energy methods for the local residents.

In a summary, there are various aspects that should be taken into account when analyzing the energy demands from the western poor residents. The targets of "well-off society" building, "ecological environment protection", and "Energy access for unelectrified population" give different focuses, and will cover different areas. For most of the western poor regions, the three targets are overlapped covered as has been explained from the above descriptions. It is certain to be given the priority to be considered. Although some regions are not in the poverty status, the ecological situation is rather serious. Their energy issues should also be taken into consideration in the overall energy solutions framework. For this similar reason, although this research work focuses on the poor population, when talking about the application of renewable energies and their roles that can play in the western China, its integrated significances should be mentioned as well.

Please see the Appendix 3 for the energy demands and relevant RE technologies.

3.3 RE resources

There are large potential of multiple RE resources, specially the wind, hydro, solar and biomass energies in China (See Appendix 5 of the wind and solar distribution map, and Appendix 4 for the others). In line with the report theme, this paper will focus on those resources with poverty reduction potentials.

3.3.1 SHP

In China, hydropower stations with installed capacity under 50 MW are generally classified as SHP. Particularly, those capacities under 500KW belong to rural small hydro or micro-hydro. A notable difference between SHP and micro-hydro is the population coverage. SHP is able to form a local grid and connected to a larger grid, which will cover more population. The micro-hydro station with limited capacity is generally an isolated home or natural village station.

The theoretical potential in China is 170GW, while the exploitable resources of SHP in China amounts to 120 GW according to the latest statistics, representing 31% of the total hydropower potential in the country, and ranks top one in the world. By the end of 2003, the accumulated capacity is 30.2GW and the exploited level is only 22.9% (Ministry of Water Resources, 2003). There is still very large potential.

The exploitable SHP resources are distributed in 30 provinces, basically in the western part, whose exploitable amount is 81.78GW, taking up to 65.6% of the total resources. The main features of the SHP in China are large potential and uneven distribution. Among the 2300 counties, there are 1104 counties with exploitable SHP potential over 10 MW, (470 counties each has 10~30MW, 500 counties 30~100MW, 134 counties over 100MW). Therefore, in terms of hydropower resources, nearly half of the counties in China could rely on SHP for primary rural electrification. Regarding the uneven distribution, SHP is mainly scattered in the hilly, minority areas or the old revolutionary regions, which are vast and sparsely populated with scattered demand, and where it is hard and uneconomic for the state grid to reach. Thus, SHP plays a vital role in such areas for forming local grids and supplying.

Although the five western provinces, i.e. Tibet, Sichuang, Xijiang, YunNan and QingHai are the top five richest provinces in China, each of which has the exploitable capacity more than 8GW. However, the exploited level is very low. See the appendix 3 and 4 for the resource and exploitation condition in China.

3.3.2 Wind

The rich wind resources are located mainly along the eastern coastlines, its adjacent islands, and the THREE NORTH (Northeast, northwest, north China). Besides, the off-shore wind resource is also very rich (SDPC, 1999).

(1) THREE NORTH rich wind resource band. This region is about 200km broad covering Inner Mongolia, Gansu, Qinghai, Tibet and Xinjiang etc western provinces, and the three north eastern provinces, as well as Hebei province in north China. The wind energy density is over 200~300 W/m^2, while some individual places exceeding 500 W/m^2. It is therefore estimated that the exploitable wind potential with 10m above the ground is 201 GW, about 79% of the entire national wind potential. Wind resource is one of the most abundant sources for western China.

(2) Coastal lines and its adjacent islands. Surrounding the vast territory, China has a border of more than 20,000 km with 18,000km coast line and more than 5,000 islands in the marginal sea. The coastal lines within the rich wind region is around 10km broad, whose annual effective wind capacity exceeding $200W/m^2$, particularly over $500W/m^2$ for its adjacent islands. This region has the potential of 11.2GW, accounting 4% of the entire national potential.

(3) Tremendous off-shore wind resources and several inland rich wind resource spots. The wind utilization within the sea is still blank in China. Due to special topographic impacts, e.g. lakes or high mountains, some places are also feasible for the small wind farm construction.

The total exploitable wind energy accumulates to 1000 GW (ten meters above the ground), 253 GW from on-shore and 750 GW from off-shore respectively. The installed wind capacity is 567MW in China (ERI, 2004). As the most promising on-grid renewable technology, wind farms are emerging rapidly in China. For the poor population in the western part, off-grid wind turbines can readily serve for household purposes.

3.3.3 Solar energy

The richness of the resource is normally indicated with the annual solar radiation and the annual sunshine time. China is one of the richest countries in solar energy resource with the total radiation of 3.3×10^3~8.4×10^6kJ/m^2/year (SDPC, 1999). Two thirds of the total area of China has the sunshine time exceeding 2000 hours/y. *Tibet, Qinghai, Xinjiang, Gansu, Ningxia and Inner Mongolia*, which are all in the *Western provinces*, enjoy the highest annual solar radiation and sunshine hours. They are also the rich areas for solar energy in the world. See the Appendix 4 and 5 for the resource classification.

The solar radiation inland in China is about 50×10^8KJ, equivalent to 170 billion TCE. The best places in harnessing the solar energy are those western provinces, as well as the north-western regions.

3.3.4 Biomass

Biomass energy is a kind of chemical energy stored in biomass and converted from solar energy through the effect of chlorophyll of green plants. Biomass energy includes the following aspects: 1) wood and forest industry residues; 2) agricultural residues; 3) hydrophyte; 4) oil crops; 5) municipal and industrial organic waste; 6) animal manure. As a renewable energy, biomass has multiple advantages, such as easy to combust, low pollution and few ashes. It also has definite disadvantages, which are low caloric value and heating efficiency, large volume and inconvenient for transportation.

In China, the municipal and industrial organic waste treatment is more urgent in urban environment protection than in energy supply. There are also demonstrations as well as research in getting the ethanol and bio-diesel from the sweet sorghum and cassava and oil crops in order to replace some petroleum production. Nevertheless, expensive commercial fuel, including the coal, oil and gas are beyond the current situation to serve the poor. There are severe limitations in their distribution into the rural regions in terms of the affordability, infrastructure, and resource distribution. Introduction of the gas etc commercial energies into the rural regions is inevitable in the process of the urbanization, however basically for wealthy regions. Currently, it is not feasible to take into account the population in poverty.

The basic biomass resources that can satisfy energy demands in rural China are basically agricultural and forestry residues and household wastes. The annul stalk output that can be used for energy purpose is estimated to 300 million TCE. Produced from agricultural and animal residues, the theoretical biogas output is approximately 80 billion m^3 per year. And the forestry wastes are equivalent to 200 million TCE. It is noted that bagasse and rice husk cogeneration are well demonstrated in southern developed provinces with the capacity of 1.7GW (ERI, 2004).

1) Forestry resources. Forest energy is a kind of biomass energy produced during the growth of forest and the process of forestry production, including fuel-wood and

residues from forest industry. Forestry energy plays an important role in rural energy supply: the forest energy consumption in China's rural areas in 1980 or so reached about 100Mtce, accounting for 30% of the total rural energy consumption. In hilly, mountainous and forest areas, forest energy took up over 50% of residential energy consumption. Fuel-wood covers branches from the disbranching of trees, residue materials from wood processing and fuel-wood supplied by fuel-wood forest.

2) Crop stalks. Crop stalks, the by-products of agricultural production, is the conventional fuel in China's rural areas. Stalk energy has close relationship with agriculture, especially planting industry. According to the statistics in 1995, crop stalks output in China reached 604 million tons, 15% of which was returned to the fields as fertilizer or lost during stalks collection. The available 513.4 million tons of stalks were mostly used for cooking and heating in rural households besides for forage and industrial raw materials. Currently, stalk energy consumption in China's rural areas is about 286.2 million tons, most of which is burnt directly in stoves at a low conversion efficiency of 10%-20%.

Along with the rural economic development and farmers' income increase, regional difference is enlarged and the proportion of commercial energy, e.g. coal and LPG etc, in rural residential energy consumption is increasing at a high speed. Actually in wealthy areas or areas close to the commercial energy source, commercial energy has become the primary cooking energy. The conventional approach of stalk utilization is readily replaced. As a result, a large amount of stalks abandoned in fields is increasing annually. In many regions, the abandoned stalks have accounted for over 60% of the total amount, which results in not only environmental pollution but also the energy waste. However, in terms of the utilization approach for the poor, the traditional biomass is still the basic fuel sources for cooking and warming. The access to the commercial energies, i.e. coal, LPG, gas etc, is greatly restricted by the affordability, source distribution and the transportation capability.

3) Animal manure. Animal manure is also an important biomass energy resource, mainly used as raw materials for biogas production in addition to directly used as fuel in pasturing areas. Chickens, pigs and cattle are the main livestock in rural China. According to the statistics, the current animal manure resource in China is approximately 850 million tons (equal to over 78.4Mtce), with 578 million tons (equal to 48.9Mtce), 259 million tons (equal to 22.3Mtce) and 14 million tons (equal to 71.7Mtce) for the cattle, pig, chicken respectively. Animal manure in large and medium-sized farms is more convenient for centralized collection and large-scale utilization. For pasturing areas such as the Tibet and Inner Mongolia, dry manures are the primary cooking fuel for residential life. In some desirable regions with abundant water resources and suitable climate condition, livestock breeding custom will make it possible to build household biogas digester. In Northwest and Southwest rural China, different biogas utilization approaches have been extensively promoted when combined with fruit, vegetable plantation etc.

4) Residential refuse. With the expansion of cities and accelerated urbanization, urban refuse production and accumulation is increasing year by year. In 1991 and 1995, the production of industrial solid waste was 588 and 645 million tons respectively. Residential refuse in the same period was increased by 10% annually. In 1995, 107.5 million tons of residential refuse was cleared from 640 cities of China. The caloric value of urban refuse in China is roughly 4.18 MJ/kg (1000kcal/kg).

3.3.5 Geothermal

Geological survey proves that China enjoys abundant and widely distributed geothermal energy resources and the potential of basin type geothermal energy resources can reach above 200,000 Mtce (SDPC, 1999). China has discovered 3200 geothermal areas and over 2000 geothermal wells have been explored, including 255 areas that have the high temperature potential for power generation with the total capacity of 5800MW. More than 2900 places can be used for direct thermal utilization including the reserves of basin type geothermal energy resources of 200,000Mtce, mainly distributed in North-eastern China, some mountainous basins in north China and southeast coastal areas. Although at present the exploited quantity has not reached 1/1000 of the available resources, the poor populations are only possible to benefit from the geothermal in very limited area regarding tourism, warm water supply, aquatic productions etc.

According to the formation causes, the geothermal energy resources in China can be divided into the several types showing in the appendix.

3.4 RE technology

In terms of the energy supply, there are basically four types, i.e. electricity, gas, heat and liquid fuel. The relevant technologies are listed as following:

- Power generation: Small hydropower, wind power, PV, biomass generation (bagasse, agricultural and forestry residues, biogas, municipal solid wastes combustion, landfill gas), and geothermal;
- Gas supply: Household biogas, large and medium livestock farms biogas, industrial and urban waste water biogas, stalk and straw gasification;
- Heat supply: Solar water heater (SWH), solar stove, geothermal (space heater, hot water supply);
- Liquid fuel: ethanol for transportation, bio-fuel.

In addition, some technologies, such as wind energy can also supply mechanical power for irrigation or grind uses. Each energy technology has its own technique features, resource distribution and economic benefit indicators, which determines its practical application (ERI, 2005). The paper specially focuses those technologies that can contribute to the poverty alleviation.

3.4.1 Biogas

Household biogas can be produced through the process of fermentation from the digester in appropriate temperature and humidity as well as in the atmosphere of micro-organism. The general material resources are the human and animal manures, as well as stalk and grass etc organics. Biogas is basically made up of methane. As one kind of combustible gases, its heat value is around 5000Kcal/m^3.

The appropriate temperature for the biogas production is above 10℃, the higher the gas production rate is better. Generally speaking, a family with one cattle or 3 pigs is able to construct one 8m^3 digester. The gas-generated process requires a certain degree of water so as to maintain the concentrated digested effluent. Therefore, biogas is suitable for those regions with relatively high temperature and humidity, and the residents have the customs to raise livestock. In the majority of the southwest China (except Tibet, northwest YunNan and western plateau of Sichuan), northwest plain regions, it is available to produce biogas in all the seasons. Some other places in northwest, biogas is possible to serve in summer and autumn, however, due to low temperature, biogas cannot be generated under natural condition. Furthermore, some dry northwest regions with few rains are also difficult to produce biogas due to the water resource deficiency. The mode of “Three-in-one” (Fruit plantation, biogas digester plus pigs breeding) in Southern China, and the “Four-in-one” (Plantation, biogas digester, livestock breeding plus solar energy greenhouse) in northern China has been greatly introduced and currently very popular in the rural households. With the technique improvement, it is also possible to maintain the temperature and collect the rainwater, and the biogas technology can serve in larger scope in the northern regions, even in higher altitude (some in 2000m) plateau.

By the end of 2002, there are more than 11.2 million households who are using the technologies of integrated biogas, digested sludge and effluent to increase income (China Biogas Association, 2003). The biogas will supply residential fuel for cooking and hot water, while the sludge and effluent can benefits the plantation and the livestock breeding, as well as for the seeds and tea reservation etc productive activities. It is expected to build 18 million home biogas digesters in the rural areas before year 2010.

3.4.2 SHP

SHP can supply electricity for the electrical cooker, electrical fry cooker, microwave oven, and fan, electrical blanket etc household instruments. Also, it is one of the main resources for the rural productive energy. SHP is simpler than large and medium hydro stations, but it is not simply a “miniature” of large hydropower technology. SHP has its own features. After decades of practice, rich experiences in SHP technology has been gained, practices and proven repeatedly. Co-sponsored by the United Nations Development Program and the Chinese government, Hangzhou Regional Center for Small Hydro Power (HRC) was established in year 1981. The mission of HRC is to promote development of SHP by conducting training, R&D, consultation, design and information dissemination etc for the developing countries. In year 2003, another International SHP base in Chenzhou, Hunan province, was constructed through contraction with HRC for the normal international conferences, and the training work.

In additional to the abundant resources and wide distribution, SHP technology in China has become mature during the 50 years development. A complete industrial system from R&D, design, construction, manufacture, assembling and maintenance are already mature. Furthermore, SHP can be exploited in a decentralized way, forming its own grids to supply energy for households, villages, townships and counties with high adaptability, and thus can play significant role in the well-off society construction processes. It is also highlighted that SHP development in poverty-stricken areas is more economically and technically feasible than that of medium and large hydro or thermal power. In comparison with wind power and solar power, SHP technology is proven and commercialized, with low construction and operation cost. The energy production cost ranges from 5 to 0.61~1.21 US$/MWh, which is much lower than that of diesel power, small thermal power and other RE power technologies. See the production cost of SHP with some other power technologies in the following tables.

Table 3-6 Cost comparison of various power generation technologies

Generation type	Investment/kW	Fuel cost	Energy production cost
	(US$/kW)	(US$/MWh)	(US$/MWh)
SHP*	600~950		0.6~1.2
Diesel power	300~420	2.4~4.2	4.2~6
Small thermal power	350~550	1.8~3.0	3~4.2

1. Source: Rural hydropower and electrification in China. 2003
2. * Excluding the micro-hydro.

Table 3-7 Micro-hydro construction cost breakdown in Guzhang County (US$)

Type	Total cost	Turbines and transportation	Water diversion	Machine room,Forebay tank	Outdoor Transformation	Indoor equipment	Water diversion &storage	Total Households
300W	1846	121	57	636	161	145	726	5
500W	4357	1429	931	872	611	387	73	16
5KW	18467	1550	1554	1223	630	1404	12107	58

1. Source: China Energy Research Association. 2004.
2. They are practical expenses in Guzhang county of Hunan province built from year 2001 to 2002.
3. The micro-hydro costs may vary a lot according to local topography and civil work expenses.

As SHP can provide on-grid power, it is one of the main sources in remote rural China that productive activities relying on power can survive. However, sometimes there are poor transformation condition and serious line loss, which make the retail tariff in the end-user much higher than the consumer's affordability.

In terms of the technology, there are no critical issues that hamper the SHP development. Currently, SHP generally is built on Run-off River and has not storage capabilities. Its output therefore heavily depends on the seasonal fluctuations. In drought seasons, there is a need to import electricity from the larger grids to enable stable power supply. Some small grids are restricted in playing its role without the connection to the larger grids. On the other hand, currently, considerable SHP grids are local grids, built and owned by the SHP owners. Under the spirit of the latest power sector reform, it is required to separate the power generators and the grids. There are debates in the SHP institutional administration, which will impact its healthy development.

3.4.3 Stalk gasification

The agricultural and forestry residues, e.g. stalk and wooden residue, can be transformed to combustible gases through gasification stove. Those gases can be harnessed as cooking fuel, or gas sources in small-scale productive purpose. There are two supply types, i.e. centralized and household gasification stove (Yao XJ, 2004).

1) Centralized stalk gasification station. The thermal heat value of the produced gas from the centralized gasification stove is around 1200kcal/m^3.Its gasification efficiency can be 70%. Multiplied by the stove efficiency of 55%, the energy utilization efficiency can reach 38%. Currently, a relatively mature gasification station in the village level can stably produce gas 600m^3/h and supply gas for 250 households within 1km. It is better to construct the gasification station in those places with abundant stalk and straw resources, as well as in relative denser inhabitation areas and high-income regions. The administration and maintenance ability should also be considered in advance.

Currently, this kind of technology is still not commercialized in the rural China. The total investment for one centralized gas supply station for 250 households is estimated at 55k US$. There exist about 700 village centralized gas station in China, all of which basically relying on the central and local government subsidies, and no investment payback is considered. Therefore, the commercialization process is very slow. The acceptable gas tariff by the farmers is 1.8 US cent/m^3. The farmers are also allowed to exchange the gas by collecting stalk etc. Normally the daily gas consumption is around 4m^3, basically for cooking, heating water etc. The expenses on the gas annually accumulate to 25US$ per household. The centralized gas stations exist in some rural areas with better economic situation, such as Beijing, Shandong etc. There are rare demonstrated stations in western China.

2) Household gasification stove. The burning of agricultural and forestry residues can produce combustible gases in the gasification stove under the condition of inadequate air. Generally the gas production can be 2~3m^3, with the heat value equivalent to 1200kcal/m^3 and gasification efficiency 65%. The terminal heat efficiency can be 36% for cooking, which is 5~7 times of the traditional direct combustion models, and 50% higher than the improved cook-stove. The household gasification stove is featured by its flexibility, and appropriate for dispersed residents in mountainous and remote regions. The structure of the household stove is relatively simple. Many domestic enterprises are able to manufacture. The household gas stove is mainly used for the residential cooking and water heating etc. In addition, it could also supply energy for other productive activities. Its energy utilization efficiency in the tobacco bake is 5~6 times than the traditional firewood stove. It is also popular in frying tea. Since there are no specific requirements for its deployment, it has large potential to be introduced in the western rural areas.

However, the largest barrier is the high cost. Now the price for the gasification stove is estimated at 100~125US$/set (including the stove, cooking instruments and the assembling cost). It is difficult for the poor farmers to buy such a device to replace their free traditional ones.

3.4.4 Solar energy technologies

- Solar stove

The solar stove can form one focus with extremely high temperature from the parabolic sunshine-concentrator, which is desirable for cooking and water heating. The solar stove requires favourable solar energy resources and suitable weather condition. Normally the annual sunshine should be more than 3000h, and the annual radiation exceeds 1430kcal/cm^2. Accordingly, the most suitable regions are Tibet plateau, Xinjiang, Gansu and Ningxia provinces. It is also appropriate in Western Sichuan, north-western Yunnan. All of the regions are in Western China.

The stove can be made by iron, special cement, general cement, and glass steel etc. The prices differ according to the materials, e.g. general cement stove (1.8m^2) is around 12US$, while iron and glass steel is abound 25US$ (ERI, 2003). The reflex membrane quality has large influences on the stove price. A stove with imported membrane is around 60US$. Generally speaking, various solar stoves are mature in terms of the scale-production, sale network, and after-sale service. Therefore it is relative affordable for rural residents. One disadvantage is that the solar stove cannot satisfy all of the cooking demand. In case of cloudy weather, floating dust condition, low outdoor temperature and nights, the radiation energy is not easy to be harnessed. On the other hand, solar stove is able to serve for steaming, boiling food or for water heating or steaming milk tea in pastoral regions at sunshine days. There must be some other supplementary instruments for frying or stewing etc.

- Solar PV systems

Decentralized PV technology is the only approach for the remote farmers and herders in western provinces as Tibet, Inner Mongolia and QingHai to get access to electricity. PV generation system has dynamic components, and can be manufactured or assembled by modules, thus are flexible for distribution. As a clean energy, its operation is reliable, and the maintenance is also very simple. In case of China, there are three types of PV generation systems with regard to electrification in the rural areas (Li Junfeng, 2001): small-scale stand-alone PV generation stations, household PV generation systems, and PV water-pumped systems. The installed capacity of the small-scale stand-alone PV stations range from 8KW to 100KW, and it can supply centralized electricity for the daily work, medical treatment and educational activities in addition to the illumination purpose. There are also PV pump systems currently piloted in plateau, grassland and mountainous regions where there are water resources with abundant solar radiation. A PV water pumped system uses electricity generated by PV cells to drive a motor and pump sets. This system consists of a PV cell array, a DC/AC converter with maximum power point tracker, and a diving or floating pump. There are great potential for the PV pump systems to provide irrigation and drinking water for residents and animals in these places.

The largest barrier for PV's extensive utilization is its high cost (Wang C.G, 2003). The average cost for a PV station system is estimated at 9US$/$W_p$. The selling price of a PV water-pumping system is approximately 8.5US$/$W_p$, among which a PV module and its components are 5.5US$/$W_p$, and the water pump, DC/AC converter and underwater cable are around 3US$/ W_p. Home PV systems range from 10W to 50W, and its cost has decreased from 9.5US$/$W_p$ to 6US$/$W_p$ in these years due to the improvement of the indigenous manufacturer's ability. Despite of this, the overall cost of over 200 US$ for one set falls out of the poor's affordability. At the current stage, most of the home PV consumers depend on the government's subsidy. The small production scale and low technology contribute to the high cost. The PV industry in China is very weak. By the end of year 2002, there are only 10 PV cell manufacturers with annual PV cell modules productions estimated to 10MW. Not only the transformation efficiency, but also the sale price is fairly lagged behind. PV industry heavily relies on the national electrification programs, so still far away from the commercial purposes.

Table 3-8 Features of PV cell/module in China

Item	Production (MW)	Transformation efficiency	Capacity (W_p)	Price (US$/Wp)
Cry-si	8			4.00~4.84
Mono-si		11%~14%	35~70	
Poly-si		10％~13％	35~70	
Amor-si	2	4％~6％	11~12	2.90~3.15

Source: Wang changgui, Wang Chun. 2004.

- Solar water heater

SWH is totally mature in its technology, and achieved the well commercialization in China. SWH even is popular in the eastern rural regions with relatively high economic development. The annual SWH productions and accumulated SWH areas reached 12 million and 50 million m^2 in year 2003 respectively (ERI, 2004). However, SWH can't satisfy all of the residential energy demand. Furthermore, in some western regions SWH can't serve as there are not enough and convenient water resources. SWH is more expensive than solar stove too. SWH is more advantageous in order to achieve a higher life quality in some wealthy rural regions, or in the process of urbanization, rather than necessary in rural poor regions.

3.4.5 Small wind devices

It is available to install small wind turbines in regions with average wind velocity over 3~3.5m/s. The small turbines cover 100W~10KW etc 11 types that are stand-by operated for household consumption equipped with storage cells. The most common turbines are 100W, 200W and 300W, mainly for the lighting, stereo and TV sets. Currently, the domestic manufacturers are able to produce 30,000 small wind turbines annually with better performance. Some productions are even imported to other countries. See the following table for the cost of the respective components.

Table 3-9 Cost breakdown for the small wind systems (US$)

Type	System price	Turbine	Controller/Converter	Battery
100W	195	120	40	25
200W	265	160	60	35
300W	455	280	110	70
500W	850	580	180	75
1000W	1600	1030	280	145

Source: China Energy research Association. 2004.

In many areas within China, there are strong wind resources but weak solar radiations in winter; while in summer the situation is just on the opposite. Due to the features of seasonal fluctuations, the complementary use of the two energy sources could efficiently meet the consumers' power demand. Currently the AC PV/wind hybrid systems include 35W PV/100 W wind, 70W PV/200 W wind, and 140W PV/300W wind system.

Although there are few operation expenses for these home systems, and the wind resources are desirable to install the small turbines, or hybrid systems, these technologies are still too expensive for these unelectrified residents to afford. This is particularly the situation in Tibet, Xinjiang, Inner Mongolia, Qinghai within the national "Brightness program". The ongoing program will have to allocate considerable money to subsidize the consumers.

3.4.6 Other Biomass utilization

At present, great majority of biomass energy resources in China are utilized basically through conventional combustion technologies. Biomass gasification, biomass ethanol and bio-diesel transformation, and biomass power generation technologies, however, are gradually being developed. Some technologies are piloted successfully in limited regions basically for gas supply, such as the stalk gasification in the northern rural villages. Biomass power generation in China, with an installed capacity of almost 2GW (ERI, 2004), are mainly combined heat and power (CHP) in sugar mills and power generation using rice husks. Other types of biomass power generation, such as the biomass gasification or blended fuel technologies, as well as biofuel, have not yet reached significant scale in China. Even the CHP and the rice husk generation are not able to operate in commercial approaches in large scale yet in China.

In terms of the electrification options for the poor, none of the various biomass power generation technologies are appropriate for the poor population. First of all, the resource collection in large area is not viable for centralized utilization. Secondly, most of the new biomass technologies are high–technology, and highly qualified staffs are required for the safe operation while it is not possible for the local poor farmers with few education. Thirdly, the electricity produced by the biomass is too expensive for the poor to afford. As the biomass resource potential is very large everywhere, it is an important task to carry out the research on the further dissemination of biomass generation. From the development trend point of view, the Municipal Solid Wastes (MSW) generation, stalk (including the forestry residues) generation (including gasification generation) and the biogas generation will be the most promising technologies.

To sum up the aforementioned technologies, see the features in the following table from the side of supply.

Table 3-10 Summaries for various potential technologies in western rural regions

	Types	Features	Resource requirements	Main purpose	Potential zones
Heating purposes	**Decentralized model**				
	Biogas	Household (output $8m^3$)	2-3 pigs, high humidity and temperature	Cooking, water heating, lighting	South Qinling mountain except some high altitude and cold regions such as Tibet; Heat preservation measures needed in other regions
	Solar stove	Solar energy transformed to heat	Annual sunshine hours over 3000h, moderate temperature	Basically water heating, steam food	Western Yunnan, Sichuan, Tibet, Gansu, Qinghai, Ningxia, Inner Mongolia, Xinjiang
	Household gasification stove	High combustion efficiency	Relatively dry regions	Cooking, water heating	Majority western regions
	Centralized model				
	Centralized stalk gasification	High combustion efficiency	Abundant stalk resource regions	Cooking, water heating	Southwestern, northwestern plains and grain production regions
Power supply	**Centralized model**				
	SHP	Consumer tariff under 0.2 Yuan/kwh	Annual hours over 3000, average household capacity 0.5w	Basically cooking, water heating, some for warming	Yangtze river, Zhu river etc in the southwestern and middle China; Domestic river in Xinjiang and some international river
	PV station	Centralized electricity supply	Abundant sunshine hours	Office facilities, health, school	Tibet, Inner Mongolia, QinHai, Gansu , Xinjiang
	Decentralized model				
	Home PV	Decentralized electricity supply	Abundant sunshine hours	Lighting, stereo, TV	Tibet, Inner Mongolia, QinHai, Gansu, Xinjiang
	PV water pump	Solar energy transformed to mechanical power	Abundant sunshine hours	Lifting water for irrigation, drinking water supply	Inner Mongolia, QinHai, Gansu, Xinjiang, Grassland, desert areas and sea islands
	Home wind turbine	Wind energy transformed to electricity	Average wind velocity over 3~3.5m/s	Lighting, TV, stereo	Northeast, northwest, northwest, North Tibet plateau, coastal islands

Note: 1 Chinese Mu=1/6 acre.
Source: Compiled by the author.

From the demand side, the renewable energy technologies are categorized as the following table.

Table3-11 Renewable energy technologies

Sector/Subsector	Requirements	Technology
Residential/commercial gas	*Fuel for cooking, water heating, space warming*	*Agri. residue gasification* *Household biogas* *Large and medium biogas (livestock farms; industrial*

		and urban wastewater) Landfill gas
Residential off-grid electricity	*Cooking, electric fans, lighting, TV etc.*	*Off-grid wind, mini-hydro, SHP, PV, biomass generation*
Residential/commercial heat	*Boiling water (drinking, bathing), cooking*	*Solar water heater, solar stove, geothermal*
On-grid electricity	*Power supply for various appliances*	*SHP, wind, biomass generation from bagasse, agri. & forestry residue, and gasification generation*

Source: Compiled by the author.

Different technologies are in different development phase. Some of the technologies are already mature in terms of the commercialization, such as the SHP (including mini-hydro, household biogas, household gasification stove, solar stove, small wind turbines. There is no need to bring incentives to encourage normal commercial development. However, there are different difficulties in their serving for the poverty as mentioned above. For some other technologies, e.g. PV productions, biomass generation technologies, stalk gasification technology, still require special incentives in expanding their use in commercial approach, let alone for the population in poverty. See the following table for the general information about the R&D etc capability of various RE technologies according to practical situation.

3.5 Case studies

As a large country, renewable energy has already greatly been developed, especially in the western China where enjoy the plenty of RE resources. China has, in the three sequential "Five Year Plan", conducted the *Rural Electrification County Construction* in totally 600 counties, basically adopting the small hydropower technology. In order to slowdown the natural environment worsening in western and middle regions, such as erosion of water and soil, barren land, sand storm and desert expansion, the Program of *REPLACEING FUEL WITH SMALL HYDROPOWR* serves to supply power, together with other heat supplying options to prevent the farmers from excessively cutting the forests, grass etc. for traditional biomass purpose. In the year 2000, the government initiated the *Brightness Program*, which is proposed to introduce the *three small power* technologies, namely micro-hydropower, small wind power, small PV, and hybrid of these technologies, for the remained 30 million populations who have no access to electricity. In addition, another government action, large scale of *National Township Electrification Program* (NTEP) was started in year 2002, and aimed to supply power for the public and social energy purposes at the township level in all of the 1065 remained unelectrified townships, using PV and small hydropower respectively.

Therefore, it is not so easy in limited papers to describe details of the RE utilization in China. In this regard, this paper is aiming to give clear introductions about three types in the case studies:

1) Selection of one technology- Biogas
2) Selection of one national program- *National Township Electrification Program*
3) Selection of one popular technology- SHP in Minority County

3.5.1 Case study 1: Biogas technology

Since reform and opening-up adopted in China from 1979, the government has attached large attention on the technical research of biogas technology and come up with policies and guidelines for the technical development and many kinds of technical standards. After that, biogas technology has been continuously advanced. The utilization of biogas, digested sludge and effluent is greatly extended everywhere.

At that stage, the biogas is expected to solve the energy deficiency in rural regions. In the early of 1990, biogas was closely linked with the agriculture motivated by the farmers' participation and innovation. A representative energy ecology model in South China, i.e. Pig-Biogas-Fruit model (referring the livestock, energy and plantation), simplified as "Three-in-one", and the model in Northern China, i.e. solar energy, biogas technology, livestock and plantation, simplified as "Four-in-One", was emerging in the rural economy market. After the middle of 1990, with the importance of resource, ecology and environment issues, biogas construction enters the ecology protection fields. The biogas is booming in playing ligament role in the energy supply, agricultural residues treatment, comprehensive utilization of resources and economy development.

Northern biogas ecological agriculture is a highly efficient production model that integrates solar energy, biogas technology, livestock and plantation as a whole with biogas technology as the ligament. The model aims to achieve multiple use of energy and well life-circle of materials. In such a system, the pigs grow well in winter season; the excrement can be used as green other than chemical fertilizer after fermentation in the digester. Various profit-making hazard-free vegetable, fresh fruits, flower and herbal medicine are planted in the greenhouse. This is a pioneering work of renewable energy utilization.

Southern biogas ecological agriculture model takes livestock feeding as the focus, using biogas as one ligament to connect grain and fruit planting (or sugarcane, fishery, vegetable and tobacco), makes full use of biogas and its fermented residue, thus forming a sustainable agriculture with recycle use of materials and energy. This model has become a new growth pole in rural economy.

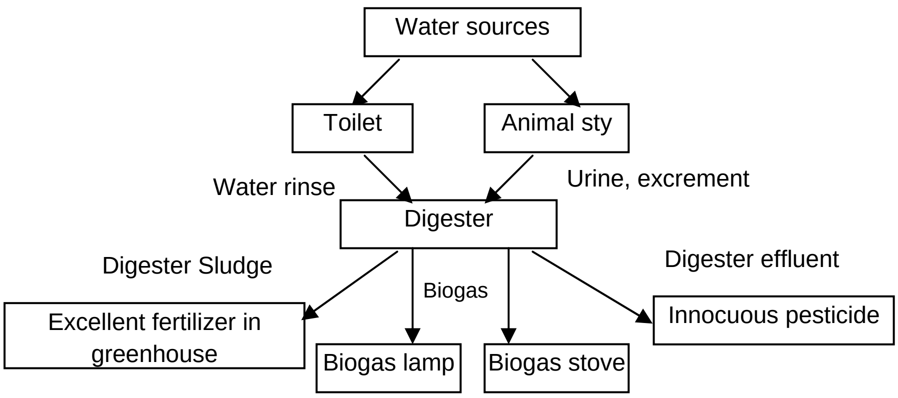

Figure 3-2 Four-in-one of biogas ecology model in Northern China

The reason for choosing biogas is that it is one technology that can be extensively popularized in China, no matter in the north or south places or in the developing west or relatively developed east regions. Once the temperature and humidity degree is suitable, it is possible to built biogas digesters. Furthermore, biogas construction is more a comprehensive energy ecology development model than a single energy supply approach. Besides the fuel supply-biogas, which can be used for cooking and lighting, biogas can also be used in grain storage or for fruits store. Its digester sludge is one better fertilizer for plantation. It has proved successful in Southern places making use biogas for mushroom and silkworm cultivation. Digester effluent is also one harmless pesticide. Fishery, livestock feed, rice cultivation all benefits from the effluent. It should also be noted that biogas introduction will help the farmers to operate some other economical business other than the agriculture. Hence it is one solution for the poor to increase their income by themselves when closely combine the energy use. Find the roles that biogas can play in the rural development in the following table.

Table 3-12 Biogas roles in the rural well-off society building

Category	Field	Importance*	Role	Inter-links
Productive	Agri. And rural economic development	1	Impel the agr. Structure adjustment, promote the farmer's income increase	Important connections between agri. And livestock breeding
	Ensure agri. production quality	1	Innoxious agri. Production, increase the quality	Digester effluent and sludge displace the pesticide and fertilizer
Residential	Rural residential utilization	1	Develop high-quality and clean energy to change the traditional lifestyle	Human-being and livestock manure fermented in the digester, generating energy, and replacing coal, firewood, stalk
	Rural public sanitation environment	1	Extinguish dissemination medium of infectious diseases	Restructure the sty, toilet, kitchen, thus annihilate the bacteria and insect eggs, tackle the sanitation issue
Ecosystem	Ecology development	2	Decrease the biomass consumption, protect the achievements of the ecology program	Address the rural residential energy deficiency issue, ensure the vegetation coverage rate to prevent land degrading and oil loss
	Environment protection	3	Rural wastes comprehensive utilization, decrease the pollution	Anaerobic fermentation make use of the wastes environmentally sound

*1: One of the important measures, 2. One of the basic measures, imperative matching programs in large-scale ecology development, 3: Necessary technical measures
Source: Compiled by the author.

Therefore, the central government initiated the rural biogas development project in year 2002 (China Biogas Association, 2003) financed by the national debt. In year 2003, 1 billion Yuan (120 million US$) was arranged to subsidy the farmers to build the biogas digesters. Particularly for the western residents, each household may be subsidized by 120~140US$, compared with the subsidy of 100US$ on the eastern and middle rural households. The majority of the projects are located in the western region. The entire biogas digesters accumulated to 11.2 million Yuan by the end of year 2002. See the following figure for the biogas increase trend.

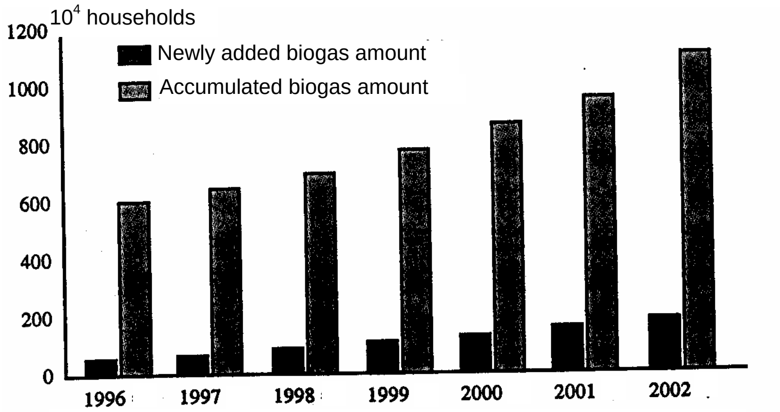

Figure 3-3 Newly added biogas and the accumulated biogas amount

However, as has been indicated, biogas technology can only be introduced in regions with appropriated condition. Temperature and climate will determine its desirable deployment and expected output.

Moreover, despite the various benefits, from the energy supply point of view, the biogas is not able to satisfy all the residential energy requirements at all. It can only serve for part of them. In southern places, the annual gas output is around 300 m^3, which can satisfy 70% of the residential energy demands of one family. However, in north regions with relative low temperature, the space-warming energy ratio is relatively higher. Therefore, a normal biogas digester is able to produce roughly 260 m^3 annually, which can only meet 40% of the household energy requirements. Biogas utilization is limited in the cooking, water boiling and lighting etc. It cannot serve for space warming and fodder heating, or for the electrical instruments. Hence, biogas consumers have to find some other energy resources for supplementation. It is common in biogas families to continue using the traditional biomass. Some wealthy houses are able to buy coal for emergency, particularly in northern cold rural regions.

At the initial phase, some families are selected for demonstration as the biogas can only survive when rural households have the custom to combine their energy consumption custom with the livestock raising tradition. A new innovative energy utilization model has to be encouraged before its successful introduction. Otherwise, the rural residents will not accept such a new custom. Currently, under the government support, it is to be spread in large scale. Therefore, complicated technical service and management on infrastructure emerge as a critical issue. Great majority of the biogas digesters are located within the yard. The farmers have to carry out the management and service activities by themselves. However, the maintenance work actually can't be totally burdened either by the farmers themselves or by the government. The after-sale service and management belong to public affairs in a certain degree, and require the corresponding public affair service, which also means finance support. Currently, the focus of the fund support from the government is on the construction of the digesters. Once the civil work is done, the support is ceased too. There is no agenda on the follow-up management at all.

According to the previous experiences, if a demonstration biogas digester is totally financed by the government, the consumers will generally not give enough care in its normal operation and maintenance. It proves not successful without consumers' own participation. However, one household biogas digester (volume 6~8m^3) plus simple facilities, is estimated as 180US$ in southwest, and 360US$ in northwest (China Biogas Association, 2003), which remains large burden for the local farmers. Currently, the rural residents are encouraged to build biogas with considerable subsidy from the national debt, as well as the "rural small-scale commonwealth fund" from the treasury, as mentioned above. Lack of finance is therefore a large barrier for further development. There is a need to find some new finance sources to promote the biogas's extension.

In the spread process of the biogas digester construction, there is also some organization work that should be improved. Particularly for technical training before the project inception, some technicians start to work under the training course, which cause serious quality issues. Some of the biogas digesters are not built within the most appropriate seasons. There will be quality issues in the winter time. Nevertheless, these technical issues are easy to address once given enough attentions.

3.5.2 Case study 2: National Township Electrification Program

- Background

The administration levels in China are, in the sequence from the high to the low level, province (or autonomous region, or municipality), city (or autonomous state), county (or autonomous county), township, administrative village, natural village and household. By year 2001, there were still 1061 townships without access to electricity, most of which are in the western provinces. The following table give the information on the province with the most serious unelectrification issue.

Table 3-13 First 10 provinces with least unelectrified households

No	Province	Total rural households	Unelectrified households	%	Total No. of village	Unelectrified Villages	%
1	Tibet	367,000	289,300	78.83	7,306	5,254	71.91
2	Gui Zhou	7,087,000	1,294,000	18.26	25,847	3,377	13.07
3	Xinjiang	1,872,600	316,200	16.89	8,934	563	6.3
4	Hainan	999,000	160,300	16.05	2,633	253	9.61
5	Qinghai	671,000	101,000	15.05	4,054	774	19.09
6	Yunnan	8,064,000	1,003,800	12.45	13,423	528	3.93
7	Gansu	4,403,000	488,700	11.1	17,803	1,045	5.87
8	Ningxia	810,000	64,000	7.9	15,616	1,306	8.36
9	Inner Mongolia	3,477,000	249,590	7.18	13,993	2,360	16.87
10	Guangxi	8,779,000	388,600	4.43	14,816	700	4.72

Source: China Electricity Year book. 2002.

Majority of these townships are in the remote areas in western China, where it is sparsely populated. It is obvious that grid extension is not economically viable to provide electricity to these people. In addition to that, the mountainous landscape makes it extremely difficult to build the power transmission line. But western China enjoys very rich renewable energy resources, such as solar and small hydro and wind. Therefore renewable energy becomes one of the important technical choices to generate electricity and serve for the local residence.

- Objective and scope

In 2002, the former State Development and Planning Commission (SDPC), currently as National Development and Reform Commission (NDRC) initiated the *National Township Electrification Program*. Its objective is to supply reliable and continuous power to those unelectrified township locations where is not feasible to be electrified by grid extension in the Western provinces, with desirable RE technologies (PV, wind, small hydro or hybrids) according to the local condition by year 2005. The expected energy requirements are the community and residential energy category, such as the daily office demands, community hospital, schools, post, and household electricity demands. There are altogether 1,061 townships included in the *Township Electrification Program*, which are spread across the 12 western provinces (or provincial level municipalities), e.g. Inner Mongolia, Qinghai, Gansu, Sichuan, Tibet and Shaanxi etc.

This program is very ambitious as well as unique in providing the power to the poor as it is totally initiated and financed by the government. The China government provide 240 million US$ to subsidize the capital cost of the overall expenses. The investment on the hardware is estimated at 240 million US$ financed by the central government, and the local government will provide 100 million US$ matching fund to be responsible for the training and institutional development. There are 378 SHP stations to be constructed with the aggregate capacity of 200MW, and 666 PV stations with the capacity of 20MW during the program. It is estimated that about 1 million residents will benefit from this program.

Table 3-14 Distribution of power systems in the National Township Electrification Program

Type	Number of Systems	MW
Small Hydro	378	200
Solar Power	666	20
Solar/Wind Hybrid	17	0.8*
	1061	

*Power of wind turbine generators in the projects
Source: Ma Shenghong, 2003.

A township generally covers several counties with a total population range from 5,000 to 100,000 populations. The government office venue is always located in the centre of the township. There is a centralized population around the centre. Compared with the other remote areas within the township, there is better road condition and transportation is convenient. Therefore, business is always developed in these regions. More activities other than the residential categories are required in its adjacent areas. Besides the consumption for the normal office maintenance and households purposes, there are also energy demands from public facilities, such as the hospital, post, bookstore, schools etc. Business shops, hotels, entertainment places and local processing factory may also the energy demand resources.

The principles in selecting the targeted locations are:
1) None of the villages has been electrified in the township;
2) Not feasible to extent grid;
3) Only for the village where local government is located;
4) Small hydro-power shall be the first choice, otherwise, PV or PV/wind hybrid shall be considered;
5) Capacity shall at least meet the residential needs;
6) Mini-grid shall be established in the meanwhile.

- Implementation Status

The Provincial Planning Commission issued tenders for NTEP: one for systems integrators to design, procure and install systems, and one service-company for operate and maintenance work. Since the initiation of the project, progress has been smooth in all areas of work. By the end of 2003, 87% of the PV power stations, viz. 601, are now in operation and able to provide electricity. The remained stations are still being constructed. In terms of the SHP, 26 stations have been finished, and the other 135 is being constructed. All of the projects are expected to be completed by the end of 2005.

In this program, a bidding procedure was adopted in selecting the contractors. The selected contractors will be responsible for the power station design, equipment procurement, site construction, and three years' operation. All the selected contractors are research institutes or enterprises in the areas of PV power station design, construction, and management, with plenty of experiences in PV power station building and enjoying advanced skills, which are important to ensure the quality of the projects and controlling the investment of the projects.

To secure the quality of the projects in NTEP program and its stable and sustainable operation, NDRC issued "NTEP Projects Management Requirements and Construction Procedure" and "Regulations on NTEP projects acceptance and operation and maintenance", which identify clear requirements on the construction, check, operation, and maintenance of the projects. At the same time, training materials were prepared for the operators, in which, all the knowledge and skills necessary for operating the projects were incorporated. This establishes a profound base for the sustainable operation of the power station.

- Experience and challenges

This NTEP is some kind of "leap frog" for the local residents, as they get power from the most advanced technologies in the world that otherwise is impossible. The implementation of the program brings brightness to roughly one million people in over 1000 townships. It is possible for them to access the TV, which will significantly increase the living standards of the local residence, promote the sustainable development of the local economy and society. It is one of the largest RE-based rural electrification programs in the world. The substantial input for this program makes it possible to create a robust and sustainable RE infrastructure in rural China, particularly for PV. NTEP has, to a large extent, stimulated the rapid development of China's PV industry, which is evidenced by the fact that China's capacity for production of PV modules has increased by ten times in the past three years. Rather than demonstration, this program has achieved a shift from lab experiments in harnessing stand-alone renewable energy power systems to truly satisfying rural power demands through actual projects and implementation. Accordingly, a great number of technicians have been trained, and some rural energy service companies have been organized to provide service for sustainable operation of the power stations. Meanwhile a series of policies, standards, and regulations will be developed, which will benefit the follow up projects. As the NTEP is only the first step in addressing the electrification issue. Chinese governments are obligated to electrify the remained 20 thousand villages that are not foreseen to be connected through grid extension. This program will then accumulate valuable experiences for the next programs started from year 2005, i.e. Village Electrification Program etc.

But from long run, there are still many challenges in operating the installed power stations in a sustainable way. First of all, it is still not determined who should be the owner of these stations so as to collect fund for its maintenance. Although service companies are established for its operation and maintenance, they are only responsible for the first three years. System integrators aim only at the design, and installation of the systems. In addition, tariffs have not yet been set for the NTEP, and the ambiguous ownership contributes to the barrier in the tariff collection. Therefore, the expenses of the O&M and repair of the system can't be recovered in a sustainable approach. Particularly when the components i.e. cells for the PV stations should be replaced, the negative consequences will inevitably emerge. This is an urgent problem, which reflects a neglecting in the program design process. The government should address the ownership issue as quick as possible, since some of the PV stations are already able to work for the local residents.

The tenders indicated how much PV should be provided to each township. While other local resources, such as wind or diesel, were not carefully considered, even if they provided better reliability at lower cost. There has been very limited time to carry out detailed feasibility study in each province. This will, of course, contribute to reduce some bureaucratic activities, however, also readily to ignore some indispensable preparation steps. For instance, most of the unelectrified populations are highly dispersed in very remote regions, where historical renewable resource data is frequently nonexistent, especially for localized wind resources. As a consequence, many installations of hybrid village power systems are based on poor resource information that can result in poor performance and higher costs than necessary.

Frequently, system problems arise from the lack of knowledge and experience of the users. Failures can arise from malfunctions in the systems, but many problems attributes to the users. For example, wrong polarity connections, short circuit, and improper loads or improper use of the system. Most residents of un-electrified townships in China are herdsmen or farmers with few experience of education. Training and a well functioning service program are essential to keep systems operating.

In terms of the O&M, most un-electrified townships in China are located in very remote areas, such as Inner Mongolia, Yunnan, especially Tibet, Xinjiang, and Qinghai. The road conditions are very poor. A single round trip for a routine maintenance job may require a three-day drive in a four-wheel drive vehicle. System integrators in general are reluctant to absorb such service costs.

There are also some lessons that can be drawn:

1) Tariffs should be rational to cover the O&M, components replacement etc. Moreover, it should be identified as soon as possible;
2) There is a need to provide quality manuals and certifications for qualified technicians, trainers and operators;
3) It is better to integrate the design companies and operate system companies, so as to minimize the installation problems and the future O&M difficulties.
4) New conflicts emerged between the low design capacity and the growing load due to the more and more appliances purchased by the residents.

3.5.3 Case study 3: SHP development in Minority County

Ronshui Miao Minority Autonomous County (Hangzhou Regional Center for Small hydropower, 2003), a western mountainous area of north GuangXi Zhuang Minority Autonomous Region in south of Yun-Gui plateau, is particularly rich in water resources with advantageous conditions for building SHP, tanks to the flourishing forests, abundant rainfalls, steep mountains. The potential hydro resource is estimated at 318MW, of which the exploitable installed capacity account for 243MW with an annual generation output of 712 GWh.

Among the 21 towns and townships in the count, 17 are situated in hilly mountainous areas. There are more than 460 thousand residents in this county, of which the ethnic minorities including Miao, Yao and Tong account for 71%. The county covers an area of 4600 m^2 with 85.5% of hilly region. Due to the bad natural conditions, the disadvantageous landform, the awful climate and inconvenient transportation, the county was heavily stricken by poverty, and was among the 300 poor counties that were specially given financial support by the central government.

Under the favourable policies from the government, e.g. “3-self” (self-construction, self-management, self-consumption), and “SHP should have its own supply area”, and “Those who construct an SHP station should manage it and get benefits from it”, all the townships and villages were fully engaged in investing in SHP, with the technical assistance of the County Bureau of Hydropower, who will focus on the key projects at the county or township levels. So far, 1814 SHP stations have been set up, with an annual power generation output of 38 GWh and an installed 15MW capacity. Presently, 100% of the townships and 94% of the villages, that is 193 of the aggregate 205 villages, have access to electricity. As a result, 71% of the area in the county has access to the power supply. The installed capacities of the stations range from several kW to 1600 kW, and are equipped with 35kV and 10kV transmission lines and transformers.

SHP development in Ronshui County has scored many achievements after continuous efforts, with a progression from nothing to something, from small to large and from simple type to advanced type. The main experiences gained are described below:

- Governments at all levels paid great attention to SHP, and huge technical or financial support was received from the administrative authorities or the financial sectors concerned, in particular, a large amount of loans were given to SHP construction.
- Local residents participated with great enthusiasm and tremendous spirit in building their own “bridge” to modern civilization.
- Great importance was attached to the training of professionals.
- Preferential investment policies were formulated, focusing on multi-level, multi-channel and multi-mode financing, encouraging both individual and collective investment in SHP construction, which greatly promoted rural electrification.
- Supervision and management of SHP was reinforced. For instance, one of the deputy directors of the County Bureau of Hydropower and concerned administrative authority are in charge of the power management, and they often give supervision and guidance to all the stations in the country. Moreover, one or two training courses are regularly held each year for improving the skills of the operators.

However, as the favourable policies on the SHP were basically issued during the Planning economy periods, SHP is facing some challenges in current market operation, and thus restrains it from serving the poor. There are internal factors that accompanied with SHP: small scale production which results in higher unit cost of investment, consistent increase of capital investment, high seasonal variation, and low plant factors due to lack of reservoir capacity etc. Some external issues also exist. Local SHP-based grids can’t deliver power to the larger grids due to their different affiliation, which is both a power waste and therefore profit loss for SHP station. No evaluation on the external environment impact has been taken into account in determining the tariff for other fossil fuel-fired power. It is unfair for SHP to compete in the market. As aforementioned, the on-going power sector reform requires the separation of the grid and generation assets, the SHP station is impossible to survive without its own supply area in some cases. The conflicts between the larger and local hydro-based grids emerge within the reform process. The instinct intermittent power output aggravates this status. With respect to serving the poor, the acceptable tariff should not exceed 1.2-1.8 US cent/kWh, which requires both a considerable subsidy on the investment capital from the government and a self-strengthening of its ability in management.

Last, a case study selection matrix can be summarized as:

Table 3-15 Case Study selection matrix

Potential Case Studies **Criteria**	Case Study 1 (Biogas technology)	Case Study 2 (Township Electrification Program)	Case Study 3 (Local SHP construction)
Representativeness Replicability Potential population benefited	 High 80 million (southwest) 15 million (northwest)	 High 1065 unelectrified townships	 High 300 thousand
Complexity	Medium	High	Medium

Source: Compiled by the author.

3.6 Assessment of capacity

Renewable energy can play an indispensable role in the rural development, especially for the western China. However, to achieve the targets of clean energy supply, ecological environment protection, well-off society building as well as the sustainable development, various chains should be studied comprehensively before any action is to be initiated. It is those chains that become the bottleneck weakening practical poverty alleviation when adopting RE technologies, unless awareness is raised, capacity is increased and measures are strengthened.

3.6.1 Legislative authorities

There is a need to enact a comprehensive RE law, which will also pay attention to the responsibility of central and local government, citizen's obligation, financial channels, knowledge outreach networks, training ability etc for the decentralized RE utilization. China is now working on this Renewable Energy Law, which has been approved by the National People's Congress in early this year.

China Environment Resource Commission under the top legislative authority- National People's Congress (NPC), cooperated with NDRC, is responsible for the drafting of RE promotion law. NDRC supply the background information of RE status in China. There maybe difficulties with respect to the other government authorities, such as Ministry of Treasure, General Bureau of Tax in approving the law in some of the subsidy and tax favourable policies for the poor.

3.6.2 Government macroeconomic and development planners

NDRC is the only central government body in macroeconomic and development planning. It merged the former SDPC and State Economic and Trade Commission (SETC) in year 2003, and become the powerful macroeconomic plan body. Currently, the Energy Bureau under NDRC is the only central government sector in the energy strategy planning and major projects approval. Therefore, the national policies related to the energy sector and the other economic sectors are easier to be coordinated.

3.6.3 Government energy authority

With regard to the development of RE, government awareness is the priority factor that should be considered. All of the following factors can be addressed once the government can incorporate RE in its national energy strategy. For a long time, the administrations of various RE technology in China were dispersed in various government sectors, e.g. Ministry of Water Resources, Ministry of Agriculture, Ministry of Science and Technology, former State Economy and Trade Commission, former SDPC (now NDRC). There is no unified plan, let alone an integrated strategy development. Furthermore, RE development in long term was regarded as one of the complementary energy supply approaches within the framework of rural energy. Therefore, as the RE development is not indispensable and RE technologies are much expensive compared with the traditional biomass, large-scale RE development, particularly from the point view of environment protection and the sustainable development, has never been actually realized. Therefore, various aspects, e.g. R&D, manufacturing, O&M, mature market are all comparatively weak. It is for this reason that many RE technologies have been used for many years, however are always in a small application scale.

The Department of Renewable Energy and Rural energy under Energy Bureau is the only administration and planning government authority related to the rural RE development. It is responsible for the national RE strategy formulation. For the first time, a national energy strategy, incorporating the RE has been issued. Particularly, the rural RE development, as well as its role in poverty alleviation has been identified. RE is able to play its unique role in the national economy development from now on.

However, there still not exists a comprehensive policy which is sustainable for the entire national RE development, though in some areas, government had set a few legal polices, e.g. the on-grid wind mechanism, the tax policies in the SHP, landfill gas generation. Particularly with respect to the decentralized rural RE development, there is no sound institution that can help the rural poor to utilize the RE resources. In addition, there are no corresponding provincial RE planning division yet. RE and rural energy planning body still exists in the provincial agriculture authority.

3.6.4 Energy regulatory bodies

China is shifting from the planning-based to the market-oriented mechanism. Various regulatory bodies have been established, such as the finance, securities, insurance regulatory commission. State Electricity Regulatory Commission is the only regulatory body related to the energy sector.

The RE development is still in the initial stage and far from the commercial operation, there are no specific regulatory body. In establishing some RE projects, particularly subsidized or co-financed by the government, NDRC will be responsible for its monitoring, oversight, check and acceptance. The situation of regulation and compliance in the RE will be improved once the Promotion law is approved.

3.6.5 Market coordination agencies

The Chinese Renewable Energy Industries Association (CREIA) was established in 2000 with the support of the United Nations Development Programme (UNDP), the Global Environment Facility (GEF) and the former SETC. The mission of CREIA is to promote the adoption of advanced technologies among renewable energy enterprises in China and actively develops capacity for the rapid industrialization of the Chinese renewable energy sector. CREIA can also supply information exchange and consultation service in investment process. Its limited role can be extended when the market grows.

3.6.6 Non-energy governmental authority

As has been indicated, there are various RE technologies that can be harnessed for centralized and decentralized applications. In practice, there are several government bodies related to the RE deployments. The SHP is always under the administration in Ministry of Water Resources (MoWR). Ministry of Agriculture (MoA), together with the Ministry of Forestry, make the biomass development on the biogas, agriculture residues, biofuel etc. Since wind turbines, PV modules and some of the biomass generation projects belong to the high-technology, Ministry of Science and Technology (MoST) is responsible for the R&D, as well some demonstration projects.

Energy supply for the poor is one important solution for the poverty alleviation. The State Council Leading Group Office on Poverty Reduction is responsible for the sustainable plans targeted on the poor, among which some energy infrastructures are incorporated such as education, drinking water, community assistance. There should be more coordination between various sectors in the RE initiatives. Moreover, attentions on the poverty reduction should be highlighted.

3.6.7 R&D

As a developing country, R&D is a particularly urgent issue in China, not only in the energy sector which can be shown below, but also in many areas that related to the high technology.

Table 3-16 Ratio of Energy R&D Expense to GDP in 1997

Country	Energy R&D expense to GDP **(%)**	Energy R&D expense to gross R&D expense **(%)**
China	0.0013	0.20
U.S.A.	0.032	1.27
Japan	0.092	3.09
Germany	0.015	0.66
France	0.039	1.69

Source: Energy resource Institute (2003).

Since 1980s', China has carried out many kinds of favourable policies to promote the RE development. However, comparing with foreign countries, renewable energy investment is still small. Up to now, RE construction projects haven't been officially incorporated into any level of the local government's financial budget plan. Due to the limited investment and lack of enough capital for R&D, plenty of key equipments have to rely on import, which result in low level of industrialization and commercialization, and thus form a limited market and slow development speed. This is the particularly the situation for the PV industry and some biomass generation technologies. During the development process, innovation and "leap-frog" development should be stressed.

3.6.8 Manufacturer, O&M and service industry

Different technologies have totally different maturity in terms of the market. Despite most of the RE systems located in eastern China, the situation of manufacturing, O&M, as well as service industry in China is significant to the practical effects for the western poor. Originated from the rural energy construction, China has formed a group of capable personnel in the some mature fields, such as SHP, solar stove, SWH, household biogas and small wind applications etc. There are experienced manufacturers in the equipment supply and civil construction. Due to the large penetration, there are also skilled group for the O&M services available in rural regions. Positive competition has been formed within the rural market, which could ensure the production and service qualities.

However, at the current stage, most of the enterprises come from developed eastern provinces or large cities, and the skilled personnel are also distributed within these places. As a result, the O&M and after-sale services in west poor regions sometimes become a critical issue in the practical situation. This situation is worse regarding a large portion of consumers in the remote areas with poor transportation.

With respect to the high technologies such as centralized PV stations, PV pumps and biomass gasification etc, the capabilities in China are still weak. Hence, a series of

PV productions prices are beyond the affordability of the western poor. The O&M infrastructure and capability for the PV or hybrid systems are also large barriers for sustainable development. Therefore, there is a great need to focus on the training etc capacity building not only on the local consumers, but also to the companies that supply the services and management.

Generally speaking, the renewable energy development in rural regions is becoming a profit and employment making industry. According to the statistic of China Rural Energy Industry Association, in year 2002, there are around 7000 enterprises that are engaging in the rural field of SWH, biogas, biogas, SHP, household wind turbines, different photovoltaic system components. The engaging staffs accumulate to more than 200,000. The aggregate achieved GDP is estimated to 2.05 billion US$. Particularly, CREIA was established under the financing from UNDP which can offer a wide range of services and support, including web-based services, networking, training events, and study tours for industry, as well as policy support for Government.

It is forecasted that (ERI, 2004) in 2020 renewable energy industry will provide more than 2 millions employment opportunities for the rural region, and create GDP for 100 billions Yuan. Meanwhile, during the development of renewable energy, agriculture will be restructured, and the income of peasants will be increased through energy industry development, for instance, plant of energy crop, deep process of energy productions, and energy ecology economy based on energy technology etc.

3.6.9 Financing institutions

In China case, government subsidy is generally the finance source for the rural RE development. Most of the government initiatives are supplying different degree of subsidy to the practical implementation. Besides the central government preferential policies on the RE utilization, each province has its own incentives in the area of RE support. For example, half of the finance on NTEP comes from the central government; another half comes from the local government. Even the high level of penetration technology-biogas, in some poor regions, 10%-30% subsidy is required to encourage the farmers to take care of the biogas system. There are also economic incentives, such as the half VAT for SHP, and discount loans for the wind promotion.

The subsidy or economic incentives are able to promote the local RE development in the context of poverty alleviation. However, there are no definite financing systems, such as Public Benefit Fund (PBF) or Cost Sharing for the use of clean energies, which are sustainable and economic sound for the Poor's development. Ministry of Agriculture do have some regulations in providing subsidy for the farmers, such as through "Rural small-scale public infrastructure subsidy program", while it is not a sustainable approach in addressing the Poor's demands. Compared with the on-grid wind, SHP etc, the rural dispersed demands on the local RE energy is more easily ignored.

Some international projects are trying to find appropriate ways to address these issues. Other international sources, such as Clean Development Mechanism (CDM) relative to the global GHG reduction are also welcome to supply opportunities for the poor.

More emphasis also needs to be placed on generating investment financing for renewable energy deployment. Since government funds will always be limited, wherever possible, the government should leverage its grant funds with private sector investment funds by a heavy factor.

3.6.10 Academic and research organizations

There are many universities engaging in the energy research work. e.g Tsinghua University. Many research institutions from Academy of science, e.g. the electrical research institution, Guangzhou Energy Research Institute. All of the MoA, MoWR, MoST have affiliated research agencies, for instance, Rural Energy Research Center from the branch of Ministry of Agriculture. Nevertheless, these research works always stay at the level of policy research, R&D research. They should be strengthened in sharing the information, large scale in education scope, technical training etc.

3.6.11 Media

There are no continuous or strategic attentions on RE from the media's side. The relationship between RE with high technologies, and RE with rural energy attract few interests in the past. There should be mechanism to create the involvement of the media in assisting the poor's access to the RE resource.

3.7 Identification of niches

China is too large for detailed research on which region is suitable for some RE technology. As previously mentioned, each technology has its utilization limitations. It is related to many aspects, *i.e.* natural resource, technology, topography, climate, fund *etc*. The above case studies does not attempt to give a full description of the overall technologies but to provide a typical model from different view of points which may be valuable for the other workgroups.

For instance, the biogas is a very mature technology in rural China. However, it can't satisfy all of the requirements from the household purposes. There is a need for them to find other energy solutions for the space heating, or driving the TV instruments, etc. Despite the evidenced deficiencies, biogas is the only type of RE that can provide residents with more opportunities to increase income other than simply for energy. A comprehensive rural energy model is currently very popular in rural China. Therefore, the priority in adopting biogas is not only to provide residents energy. It is more an integrated solution to create better living style, which can increase the income. This is important for poverty alleviation.

There are strict requirements for the biogas utilization. The technology is mature, which can be easily replicated everywhere given the appropriate condition. However, biogas differs a lot in Northern and Southern China. The common features for the biogas are the temperature and water sources requirements. Besides, the livestock custom is also needed. Restricted by the water sources, biogas can only work in some of the north places. It is for this reason that the amount of planned digesters of the Three-in-one type in south-western China is much larger than the Four-in-one model in northern China. It is concluded that a most suitable model is selected according to the local condition.

Affordability is the most practical aspect in the biogas construction. Although compared with the other expensive technologies, biogas will be readily affordable for the rural residents. It is still a large burden for them to accept such a new living model. The higher subsidy on the poor in introducing the biogas is a common approach in spreading some other comparatively mature technologies, such as solar stove, small wind turbines. The consumers are required to pay for another portion of payment to be allowed to use them. A total subsidy on these mature technologies will be difficult to secure a well maintenance.

The NTEP is selected as it can be served as reference for the other GNESD. It is the latest national initiative to address the common unelectrification issue. The basic idea of this program is to electrify all the remained 1061 townships with stand-alone PV stations, or off-grid SHP supported by the national debt and local government's finance. It is highly noted that these township is located far away from the power grids. A SHP/PV station is easier and more economical to construct than the grid extension solution. The run-off disadvantage of SHP can be offset due to the small load in those remote areas. In addition, small grids can connect with each other so as to form a local grid without a need to connect large grid in places with abundant hydro potential. It is one economical solution for a relatively centralized residents group in the remote areas. PV stations are also more efficient in providing electricity directly to those remote residents. Different from SHP, there are still large gap for PV to achieve a scale-up market. Together with the high initial cost, PV is beyond the consumer's affordability. For these expensive technologies, a Frog-Leap method for the poor is taken. The government design, procure, construct the PV/SHP stations without charging the consumers. Otherwise, the poor in poverty are not possible to access the electricity. This is to be replicated for the next phase "Village electrification program". However, a sustainable maintenance and operation mechanism should be established before further replication.

SHP is widely distributed in China with abundant resources. It is particularly concentrated in the western China where the majority poor populations locate. SHP can be exploited in a decentralized way, forming its own grids to supply energy. In terms of capacity, SHP can range from a few kW to tens, hundreds, or even tens of thousands of kW. It can supply energy to households, villages, townships and counties, with high adaptability and "radiation" effect. Since the exploitation technology is mature, the operation and maintenance costs are also low. At the establishment of new China, the SHP has been promoted rapidly in China.

See Appendix 9 for a description of the identified niches.

3.8 Assessment of other experiences

The Chinese Government has undertaken a series of national activities and programs in order to promote the development and utilization of renewable energy in the largest extent. See appendices for the detailed analysis of its role and achievements.

Comprehensive Rural Energy Planning and Construction Program: From the 1980s, the Chinese Government has begun rural energy construction work that focused on renewable energy and rural energy efficiency (China Rural Energy Association, 2000). The main areas of work were in promoting improved cooking stoves, rural biogas digesters, firewood forests plantation, and solar stove. The results of the improved cooking stove and rural biogas digester components were particularly outstanding. At present, the coverage rate of improved cooking stoves in China's rural areas is over 65%. Biogas work has moved forward from merely resolving energy needs to become a key component in the development of ecological agriculture and rural sanitation. The program does not focus on the poor. As a result, some lessons can be drawn. 1) These technologies are generally in demonstration, which can only benefit a limited household. 2) Productive energy is ignored. Most of the adopted technologies can satisfy multiple dimensions of the residential energy requirements other than productive energy. 3) This program is not sustainable due to inadequate fund. Demonstration gave weak impacts on the society for large-scale spread without a sustainable fund.

Rural Hydro-based Electrification Program: Of all of the national electrification programs, Rural Hydro-based Electrification Program basically relying on the SHP is the earliest, widest and most economical approach. This program is in charge by the Ministry of Water Resources. SHP station construction is closely linked with the agriculture development at the early age when new China was built. Through successively constructing the three batches of hydropower-based primary rural electrification counties during the '7th-Five Year Plan(FYP)', '8th FYP', '9th FYP' periods (1985~2000), many achievements have been made, as well as remarkable economic, social and ecological benefits (MoWR, 2003). These three batches of 653 hydro-based primary rural electrification counties cover a population of 252 million, and an area of 2.71 million km^2, with more than 82% distributed in central and western regions, and more than 80% are in the former revolutionary, ethnic, remote or poor areas. Each year, the Chinese Government invests 36 million US$ in the development of SHP, attracting additional investments from local governments, enterprises, and individuals. It is highlighted that 17.7 GW of the newly installed 20.2 GW power capacity come from SHP. The total installed capacity of small hydropower in China is now 30 GW.

As one of the comprehensive alternatives to slowdown the natural environmental deterioration in western and middle regions, such as erosion of water and soil, barren land, sand storm and desertification, the Program of *REPLACING FUEL WITH SMALL HYDROPOWER* serves as the only way to supply power, other than heat supplying options to prevent the farmers from excessive cutting the forests, grass etc. for traditional biomass energy purpose. From Dec. 2003, this program commenced in five pilot western provinces (China Rural Hydro and Electrification Website).

SHP is the only technology that can provide cheap electricity to the rural residents other than grid extension. During the past 15 years, up to 120 million people have gained or improved the access to electricity. The electrification level growth greatly promotes the restructuring of the local economy. The proportion of industrial output value in the typically agricultural counties ascended from 36.6% in year 1985 to 77.5% in 2000. Improved by the comprehensive utilization of the water resources, the electrification counties achieved a net increase in irrigated area of 1,686,700 hectares, and an increase in grain yield of 30 billion kg, and more than 6.4 million populations can get clean water for drinking. The SHP has become one important pillar in the economy development in hilly areas. It is also the important source of a county's fiscal revenues, the significant way to reduce poverty and set out a road to prosperity. The hydropower enterprises in the 653 primary electrification counties achieved about 600 million US$ of taxes and profits annually, and the collected taxes accounted for 8.8% of the fiscal revenues of the county. During the period the third batch (1995~2000), the GDP of the targeted counties increased by 18% every year, twice as fast as the national growth rate. In terms of the income growth, for instance, it quadrupled for the farmers and herdsman during the 15 years in all of the 10 hydro-based primary rural electrification counties in Qinghai province. As one important solution to prohibit the local residents to fell down the trees, the forest courage rate in those counties increased at an annual average rate of 9.88% since 1985, which is 5.4% quicker than that of the whole country.

The experience from the Rural Hydro-based Electrification can be drawn. 1) The active policy supports from the central government are significant. For example, there are policies like "3-self" (self-construction, self-management, self-consumption), “SHP should have its own supply area” and “half VAT for SHP companies”, which give flexible atmosphere for SHP’s development. Particularly, the MoWR is in charge of the program, which is a solid foundation for successful implementation. 2) Rural electrification is closely in accordance with China’s conditions, as well as the existing national economy development level. 3) SHP can’t survive without closely combined with the local situation. 4) In terms of electrifying the poor with SHP, it is cheap in harnessing the local resources compared with the other options besides the irrigation, drinking water diversion etc other comprehensive benefits. 5) In some case, SHP is required to strengthen its own management ability in order to decrease the O&M cost as well as the tariff for the poor, so as to overcome the disadvantage of integration of generation and T&D functions.

Brightness Program: In 2000, China’s former State Planning Commission put forward plans the *Brightness Program*. The aim of the program was to use PV modules and wind power systems to provide residential power to the remained 23 million unelectrified populations in China (Ma ShengHong, 2003). Meanwhile the energy demand from frontier stations, relay stations, road service stations, maintenance stations of oil pipe line, signal stations of railway in the remote areas shall also be satisfied. The program planned to provide these populations with an average capacity of 100 watts per capita by year 2010, which is equivalent to one third of China’s national average capacity per capital. The targeted unelectrified populations are dispersed within over nearly half of China’s total area. A substantial proportion of them suffer from poverty. Thus, the *Brightness Program* is a large-scale project that addresses poverty alleviation. It is estimated that in order to achieve the goals the total investment in equipment and services is about 1.2 billion US$. This project focuses on the provinces in Western China, with special support given to Xinjiang, Inner Mongolia, Gansu, Qinghai, and Tibet. At present, four provinces have established *Brightness Program* project companies to develop projects associated with the program. At the same time, the *Brightness Program* has attracted the attentions from the outside world. The Government of Holland is supporting the “Silk Road” *Brightness Program* in Xinjiang. The German Government has given technical and financial support for the *Brightness Program* in Yunnan, Qinghai, Inner Mongolia, and other areas.

The project objective in the First Phase is to electrify about 8 million people, 2,000 villages, 100 boarder stations and 100 microwave stations. In additions it is necessary to establish a solid foundation for the further development of the program. In principle, the fund should basically come from the beneficiaries and the government will give necessary subsidy and will also assist in collecting money from various resources. The following achievements have been made so far:

- About 4000 Wind/PV hybrid home systems, 1 Wind/Diesel/Battery village system will be installed in Inner Mongolia till 2002
- 12000 PV home systems were installed in Gansu till 2002
- 6 PV village systems around 6 kW were installed in Tibet till 2001

The brightness program has made a solid foundation and accumulated valuable experiences for the follow-up NTEP. As funds for this program are basically from the consumers, the government subsidy for the poor is especially important in its implementation. However, the current project has made few preliminary researches regarding the affordability of these beneficiaries. The subsidy on them are unified irrespective their different income, thus lack of flexibility. Actually, different farmers have different incomes and therefore different affordability. Some households can’t maintain the systems without proper subsidy. The required local matching fund can hardly be achieved, as the targeted western provinces are always poor in economy.

It is difficult for them to allocate more funds to subsidize the project. There have been few attentions put on fund-raising to form a sustainable model for this project. Therefore, there are gaps in the involvement of finance sector.

Township Electrification Program: It has been elaborated in previous pages. At current stage, experiences are drawn from this program. It will serve for the initiation of the National Village Electrification Program shortly.

International assistance projects

During this 10th Five-Year-Plan (2000~2005), especially with the establishment of some international cooperation projects, the local capacities were strengthened gradually (ERI, 2004).

Efforts to promote renewable energy in China have intensified in recent years, with several domestically and internationally supported initiatives, but the widespread commercialization and adoption of associated technologies is impeded by many challenges in capacity, financing, policy, technology, and information. The international cooperation project Capacity Building for the Rapid Commercialization of Renewable Energy, launched in year 1999 and to be closed in year 2005, is meant to strategically address a number of these challenges, with an emphasis on spurring forward a group of technologies on the brink of commercialization. The project is supported by the Government of China and the Global Environment Facility (GEF) through partnership with the United Nations Development Programme (UNDP) and with co-financing from Australia's AusAID and the Government of the Netherlands. The project's overall budget is US $25.8 million, including funding from UNDP-GEF ($8.8 million), Australia ($3 million), the Netherlands ($2.53 million), and the Government of China ($11.5 million).

China Renewable Energy Development Project (REDP), established in 2001, aims to build sustainable markets for wind and PV technologies in order to: (1) supply electricity in an environmentally sustainable way; and (2) increase access of isolated rural populations and institutions to electricity services. The World Bank and the Global Environment Facility (GEF) propose to provide 27 million US$ grant to this project. Currently, it has established a "smart grant" mechanism for supporting the development of market-driven sales and after-sales service systems for solar home systems through strengthening the capabilities of 25 PV companies in Western China. It is a sound trend for the sustainable development.

The project, "Expansion and Improvement of Solar Water Heating Technology in China", is financed by United Nations Foundation (UNF) and NDRC. It aims to widen the use of solar water heaters in residential buildings, promote the design and spread of high quality, expand the market, and raise the awareness through carrying out dissemination activities. The previously mentioned UNDP/GEF Project "Capacity Building for the Rapid Commercialization of Renewable Energy in China" also supported the establishment of the National Solar Water Heating Testing and Certification Program in China, including a national testing center system, updating national standards for product testing, and establishing a product certification and labelling program.

China Renewable Energy Scale-up Program (CRESP, 2003) was set up by the Government of China in cooperation with the World Bank and the Global Environment Facility (GEF). The program aims to assess renewable energy resources in China, learn from the experiences of developed countries in developing renewable energy, take research and formulate policies for the development of renewable energy in China, so as to gradually achieve scale-up development of renewable energy power. The proposed budget for this program is 141 million US$ from GEF grant, 100 million loan from WB and 125 million US$ from government fund. The Project Office has been established for 3 years, and this project is expected to last for 10-12 years.

There are also other rural electrification programs supported by GTZ, KFW that aims to supply village electricity in western China, the same for Shell Solar program in Xinjiang. RE development in China have multiple motivations. Meanwhile the RE utilization in poverty alleviation is only one of them. Those projects share the common feature in that focus is put on the capacity building and advantageous equipment import from developing countries rather than the subsidy on the poor. The increase of government awareness, industry ability, sale and service groups and consumers' knowledge is significant to develop the RE industry and foster market, which will indirectly help to serve the poor. This progress, however, is sometimes too slow to keep up with the poverty generation. Furthermore, unless enterprises are involved, the non-profit projects on the poor will not attract any attentions, and the domestic matching fund will also become one painful target to achieve.

3.9 Overall assessment and Identification of problems

Although the economy is growing rapidly, China as a developing country with both large area and tremendous population still has large quantities of populations in poverty. Most of these poor populations, particularly those without access to electricity, are dispersed in the remote western part of China. In comparison, the western China enjoys richest RE resources within China, such as hydro, solar, wind and biomass energy. In order to build a well-off society and reduce the poverty that exists in the rural areas, it is necessary to make better use of these resources. Thus, poverty alleviation through RE resource comprehensive utilization in the rural areas is one of the urgent impetus in the national effort on RE development. Various technologies that can be adopted to harness these resources are showing different maturity in the market. Some are able to work in the market without special government support, while some others can't survive in practice due to the high cost. However, with respect to serving the poor, all of them need to be given more supports according to the local condition. This part gives a systematic analysis on the barriers that drawn from the above sections.

3.9.1 High cost and low affordability

Great progress has been made and the cost and price has decreased significantly for RE equipments and productions in the past decades. The systems have also been improved and became more reliable and convenient to operators and users. Despite those improvements, the cost and price for RE equipments and products, especially in China, are still rather high. Due to the critical poverty and traditional lifestyle, it also happened that the people in western China can't afford and get used to modern RE technologies.

- High initial investment

Generally, the initial investment, especially that of unit capacity, for RE generation systems, including PV module, SHP etc, represent a very large initial expense, which are absolutely beyond the affordability of the rural poor population. For typical household with disposable income of around 100US$ per capital per year in western poor area, the required investment of a set of RE system is closely equal to the total income of the family and thus the installation of RE system means a difficult decision. Though a solar stove or a biogas digester is only no more than 150 US$, it is still a major expenditure for a family. The poor have to depend on the subsidy to buy the systems, or get loans from the credit companies, all of which restrain them from freely choosing these convenient and high-efficiency productions.

- Relatively high cost and prices of RE equipments and products

So far, most of the renewable energy technologies generally feature relatively high cost and high price, especially when compared with biomass energy traditionally used in rural area that are totally free. Take the technology of power generation as an example, assuming the cost of coal-based power as 1, then for SHP it is 1.2, for wind power 1.7 and for PV 11 to 18 (Peter Meier, 2002; ERI, 2004). That is to say, SHP is the only form that has become cost effective in quite a lot of remote villages in western China. Although the government has kept in mind the affordability of the poor in rural remote area and provided subsidies to the RET projects, the retail price of RE product are still too high for the users. In some cases the tariff for SHP is too high due to the poor transformation condition and serious line loss. Consequently, the poor in remote rural area often give up the purchase or turn to traditional biomass consumption. Therefore, both residents and government are very careful when selecting RE as the solutions to meet the energy needs in poor area and determining the scope and scale of RE programs and systems. High cost and prices constitutes the largest obstacle for wide use of RET in the rural poor regions.

3.9.2 Finance barrier

Generally speaking, there are not enough funds to help the poor despite the large amount subsidies in the national initiatives elaborated in the previous sections. The quantity of the population in poverty is too large. They lived in several provinces, covering two thirds of the country area with different natural, historical, geographical features. There are multiple reasons that contribute poverty, while energy supply can only address one part of their poor life. The limited fund allocated the large quantity of poor have to overcome the high initial barrier in the RE technology disseminations, which become more difficult. Therefore, most of the solar products have to be demonstrated before large scale expanded. Despite its maturity of technology, SHP can only be built in the mountainous regions with sufficient finance.

Basically, there are three major financing sources for RE projects in rural poor area: central government subsidy, local government matching finance and collected money from local beneficiary. The central government will cover all of the expenses of the NTEP before its completion; however is not always the case. The principle for the Brightness Programs is that the consumers should act as the main financing source and be partly complemented by the central and local government public financing. The other rural energy construction plans share the same rule in implementation due to the limited fund. Actually, this kind of method is effective in leading a sustainable development. In practice, the poor would rather give up the subsidy than take their money out of pocket to buy the RE systems because of their low income. Similarly, the matching fund from the local government is also limited, and even sometimes cannot be fulfilled. It is therefore necessary to develop other diversified financing sources. International fund and the rural credit institution have potentials to contribute to this goal.

It is indispensable for the government to subsidize the poor in harnessing RE resources. Many programs envisage the problems of what subsidy quantity or proportion is desirable to the poor. Sometimes, there are not adequate research on the affordability and attractive level of subsidies before the initiation. It is not flexible to adopt a unified subsidy when facing different condition, despite equity is achieved in a sense. The actual program is however to realize the poverty reduction, thus a subsidy principle instead of a quantity is better in these programs.

3.9.3 Institution and policy issue

It is clear that China's central government has paid great attention to the development and utilization of renewable energy, poverty reduction in western China, as well as the underlying relationship of the two issues. Many efforts have been made to combine the renewable energy initiatives and poverty reduction in the form of government planning, national program, government financing, etc. Accordingly, millions of western poor have benefited from these actions in getting access to clean energies including electricity. However, compared with the industrialized countries' definite laws adopting Renewable Portfolio Standards (RPS), Feed-in-law (FIL), and competitive tendering (CRESP, 2003), etc, the existing favourable polices in China are too general and lack concrete measures, therefore not powerful enough. For instance, the State Council issued the "*Ten options for the environment development*" in 1992, and "*China's 21st Century Development Agenda*", which emphasized the "development of renewable energy such as solar, wind, and biomass energy according to the local conditions", and "place the RE in a priority within the national energy development strategy". These macro policies cannot be implemented due to lack of concrete matching measures. There are also legislative identifications on the rural RE development. The *ELECTRICITY LAW*, issued on Feb. 1995, definitely announce that the government encourages and supports the use of RE and clean energies, particularly in Chapter 6, "rural electricity construction and agricultural power", which stresses that the use of solar energy, wind, geothermal, and biomass energies in the rural power construction will be supported and encouraged by the central government. This was reaffirmed in the new *ENERGY CONSERVATION LAW* issued in 1997. The practical effects are also weak without enough operable measures.

Accordingly, the responsibility of various government authorities and the citizen's obligation in utilizing the RE are not identified. It is not favourable to develop RE in places with plenty of RE resources where the poor always dwell. In many places, the resource has not been assessed at all, and therefore not possible to be fully explored. The overall RE industry, technology and market can hardly make it feasible for the RE to serve the poor without a whole-society response, as most of the REs are expensive and go beyond the poor's affordability. The gap in the unified policy or law readily makes the public ignore RE's importance. Furthermore, it is only possible to construct one fund-raising principle for the poor in the law, such as a special electricity fund.

For a long time the administrations of various RE technology in China were dispersed among various government bodies including MoWR, MoA, MoST, former SETC, former SDPC (now NDRC) etc. There is no unified plan, let alone an integrated strategy development. Various government authorities would carry out their own initiatives instead of a unified design and planning. They made few preliminary researches in cooperation before their actions. This results in small scope beneficiaries. Particularly, the Leading Group Office on Poverty Alleviation's role in providing the energy options to the poor is too limited. There is a need to make more cooperation among the different sectors in the future.

With respect to most of the national initiatives, the designer or administrative agencies have paid enough attentions to the construction process due to the public welfare property, whereas the daily operation and maintenance as well as repair work are not well designed. Although there are actually difficulties in these activities, there should be a detailed plan for the after-sale management and repair. Some of the projects with national debt support for the biogas construction and NTEP are facing such embarrassment. The result is the “achievements have been made, however, households can’t actually benefit”. Hopefully, the trend toward development of National Action Plans for industry and technology development and multi-year program planning frameworks, is likely to help with government coordination. The analyses at the provincial level are as well needed to identify or develop a comprehensive renewable energy development plan for the province as a whole. This kind of responsibility should come into mind of the provincial authorities.

3.9.4 Underdeveloped industry and technical aspect

Originated from the rural energy construction, China has formed a group of capable personnel in the fields of SHP, solar water heater, biogas, and small wind turbines. There are experienced enterprises in the equipment supply and civil construction. Due to the large penetration in the rural regions, there are also skilled groups for the O&M services in rural regions. Positive competition has been formed within the rural market, which could help secure the production and service qualities.

However, with respect to the high technologies such as PV stations, PV pumps and biomass generation etc, the capabilities in China are still weak. Generally, the industries are not strong as a whole, and market-support infrastructures for RE products are still underdeveloped. The undeveloped industry, as well as the small market, greatly contributes to the high production cost and difficult O&M service. PV modules is one example because its relatively popular dissemination and huge initial costs.

The total input for the industry is not enough either. Compared with those in foreign countries, renewable energy R&D investment is still very small. Up to now, RE construction projects haven’t been officially incorporated into any level of the local government’s financial budget plan yet. Thus, plenty of key equipments have to rely on import, which result in low industrialization and commercialization level, and accordingly form a limited market and slow development growth.

At current stage, most of the enterprises come from developed eastern provinces or large cities, and the skilled personnel are also distributed within these places. As a result, the O&M and after-sale services in west poor regions sometimes become a critical issue in the practical situation. What is somewhat inspiring, however, is that a few companies involved in the Brightness Program and NTEP program have developed basically competent expertise and skills, representing a good starting point for quick industry development in the future.

3.9.5 Local poor condition

The poor populations are generally dwelling in a close region. There are few opportunities for them to make profit from productive activities and thus increase income. Particularly, great majority of un-electrified townships in China are located in very remote areas, such as Inner Mongolia, Tibet, Xinjiang, and Qinghai. They are either on mountainous regions, or high altitude plateau, or remote grassland. The road conditions are very poor. A single round trip may take a three-day drive for a four-wheel drive vehicle from a centralized town. It is a most practical barrier for the difficult after-sale service.

Accompanied with the worse natural condition, the consumers generally have few education experiences. This in addition contributes to the gap in the expertise/know-how/skills required to operate and maintain the systems. Frequently, system problems arise from the lack of knowledge and experience of the users. Failures can arise from malfunctions in the systems. Training and a well functioning service program are essential to keep systems operating.

3.9.6 Program Organization

With respect to most of the national programs, the designer or administrative agencies have paid enough attentions on the construction process since they are public welfare property. Whereas the follow up management, operation, daily maintenance as well as repair work are generally ignored. Therefore, the arrangement of design, installation, operation and maintenance may be inappropriate, which will result in weak technical service and support. Some projects have not taken enough consideration of the sustainable O&M for the RE systems. For instance, tariffs have not yet been set to fund the necessary O&M and components replacement expenses. The result is the "achievements have been made, however, households can't actually benefit after the project is over". Some of the projects within national debt support for the biogas construction and NTEP are possible to face such embarrassment.

Sometimes, detailed preliminary feasibility study are also absent. Currently in China, system design heavily relies on one set system configuration, without consideration of the integration of local resources or unique requirements of a specific village. Hybrid systems were not carefully considered, even if they provided better reliability at lower cost.

4 Policy Outlines

4.1 General Objectives

It has been shown that poverty is usually related to lack of access to basic modern and clean energy, lagging behind social and economical development, fragile local natural and ecological system. Modern RETs have proved and is expected to play an active role in addressing these issues. Experiences of China and foreign countries have proved that relevant external supports, especially those by government, are essential to achieve this goal. However, the future action for the development and utilization of RE should be carefully taken so that the outcomes are expected. The following general objectives or principles, therefore, should be kept in mind and followed when considering RETs for the purpose of poverty reduction. On the other hand, these principles are also the motivations for developing RETs.

- Secure energy supply for basic residential life and social service
People in poor area usually have difficult access to modern and clean energy for daily life, and suffer from heavy work of firewood collection, tedious night without light, and ignorance of rapid progress in modern world. China's government paid very attention to and eager to address the energy needs of daily life and key public service, such as lighting, TV, and communication and other basic social services in rural area so as to improve the population quality and life standards.

- Promote economic development
Economic development is the essential approach for poverty reduction. Modern and clean energy is an important input to economic activities. RETs should play a key role in supplying the productive activities and business with affordable and sufficient clean energy and even create new business opportunities.

- Ensure compatibility and consistency with Sustainable Development
Traditional biomass consumption imposes threats on natural resource and ecological system, and will eventually threaten the sustainable development. Chinese people and government are more and more concerned about the ecological system protection and sustainable issue. The development and utilization of renewable energy should be conducted in a way compatible and consistent with environmentally sound development. Negative impacts should be minimised.

- Promote the self-support of RE development and utilization action in the long term
At present stage, external financial, human resource and technological assistance to the poor area is necessary to develop and utilize renewable energy in poor rural area. In the long term, the initiative should enhance the capability of self-support so that reliance on external support could be reduced.

- Increase the efficiency and effectiveness of the external support
During the past decades and especially in recent years, a lot of initiatives have been taken. A great deal of money and human resources have been put into the effort to develop renewable energy in rural China. The past efforts have created a foundation upon which to build, despite the progress was far from being satisfactory and inspiring. The future plan, action and initiatives, especially those taken by government with public finance, can be implemented in an more efficient and effective way if the past projects can serve as models or guidance, and can be carefully studied to see what made them work.

4.2 External consultation

To better understand China's poverty situation and RETs potential to reduce poverty, this study completed the consultation process on the policy outlines before making conclusive result. ERI organized one workshop on January 31, 2005 in Beijing, which was also one of the GNESD activities facilitated by UNDP. In addition to the dissemination work on the GNESD and its theme work, this workshop aimed to generate extensive discussion in the areas of energy issue and poverty reduction. *Twenty* stakeholders (officials/experts) coming from government sectors, research institutions, and industrial sectors participated this workshop. Being experts in the areas, they show great interests in the topics. Discussion focused on the RE needs for the poor, the barriers for RETs expansion, and the desirable solutions for RETs in poor regions. Table 4-1 gave the meeting agenda for reference.

Table 4-1 Agenda for the external consultation workshop

13.30-14.00	*Registration*
14.00-14.05	*Chaired and Welcome*
	By Mr. Wang Zhong Ying,
	Director, Center for Renewable Energy Development (CRED) of ERI
14.05-14.20	*Introduction on GNESD and the UNDP facilitated work*
	By Mr. Wang Zhong Ying
	Director, Center for Renewable Energy Development (CRED) of ERI

14.20-14.40	*Presentation on GNESD theme work: Synthesis Report and Energy Access Issue in China* *By Dr. Gao Hu, CRED of ERI*
14.40-15.00	*Presentation on GNESD theme work: Renewable Energy Technology Potential in Poverty Alleviation in China* *By Zhao Yong Qiang, CRED of ERI*
15.00-15.20	*Tea Break*
15.20-16.50	*Theme Discussion*
16.50-17.00	*Conclusion*
17.00-18.00	*Dinner*

The initial assessment research and policy outlines outcomes are distributed to the participants in advance to ensure an effective discussion. Despite the strong support for RETs' development and the urgent call for poverty alleviation from the stakeholders, participants in the external consultation workshop brought some valuable advises and show some concerns on RETs development and poverty reduction. Some highlighted conclusions from the discussions are drawn as follows:

1. Poverty currently in China is tremendously complicated. RETs themselves are not able to solve all energy issues. There are barriers for their development respectively which may not be overcome in practice. Energy and RET are one piece of an integrated approach to poverty. It is therefore not so easy to conclude exactly at what level RETs' can play a role in reducing poverty. However, it is definite that RET contribute to poverty reduction, and it remains large challenge for poverty reduction work through RETs penetration currently for China.

2. Electricity access issue is indispensable for poverty reduction. The research had paid substantial focus on the relationship between the poverty and electricity access. Nevertheless, there is a need to find whether electricity is adequate enough for reducing poverty, which means whether one poor household can reduce poverty once they get electricity. In some places, the electricity is not the priority issue to be developed. For instance, the road bridging the poor populations with outside is more important than electricity access in some places. To a large extent, electricity may actually be the facilitating agent, the necessary precursor to the real issue; e.g. power to an appliance that increases income, a water purification system, an x-ray machine in a health clinic, etc. It is better to discuss RETs for poverty alleviation in context with poverty alleviation systems; for example, a modular health clinic design; an education package for schools that includes the RET power source combined with teaching aides, small enterprise kits that combine the power source with an income producing system (water pumping, machine shop, etc.), etc.

3. Representatives from government and research institution organization show great interests in basic data about the poverty situations and electrification achievements. There are gaps between the policy making process and the practical situation, which is a large barrier for policy making. Participants in the external consultation called for some field investigations to acquire the basic information about the poverty and RETs penetration. This proposal was confirmed to be urgent by the energy policy makers in the workshop. It is also suggested that the reports of field case studies should be submitted to high-level government sectors for policy making reference. Also, it is desirable to take advantage of the experience of agencies working directly in the field; e.g. the Tibet Poverty Alleviation Fund in Lhasa.

4. In terms of the energy utilization in rural regions, the best option should be based on the four principles drawn from the previous experiences, which absolutely apply to poor areas: develop in line with the local condition; focus on the practical effects; make supplementary contributions based on various energy types; and comprehensive utilization of resources. The study should take into account all forms of energy in addition to electricity in line with the local integrated situations, that is to say there could be a fifth principle, which is to provide integrated solutions – address all of the issues bearing on a particular problem, not just the one component of energy. The proved experiences will sure be applicable currently.

5. The rural renewable energies, such as the SHP, biogas, highly-efficient stove, had made great contributions in reducing the poverty in the past. In terms of the coverage area, SHP-based electrification program proved to be one effective solution to electrify scale-up populations. However, the decentralized RET options are most effective for the isolated populations.

6. There have been several national programs targeting on the poor populations. However, the poverty reduction effects are different. Some are successful while some are not. Benefits diversified in regions depending on local situations. This means that a better pre-feasibility study is required before programs initiation. Furthermore, a unified model is not applicable as well as reasonable for such a large country. Flexibility is needed in line with the local situation. Thirdly, some national programs should enhance the management and training work. This would help secure the sustainable operation for the RETs. Generally, in the national programs, the central government need not only address the financing issue to compensate the costs of village power RET hardware, but also finance a national training program to support the operation, establish standards and regulations not only for designing and installing the hardware, but also for operating and managing it, establish regulations for ownership and tariffs, set up a fund for ongoing maintenance and equipment replacement. The Renewable Energy Law is expected to address some of these issues.

4.3 Classifying problems and barriers according to priority

Section 3.9 has indicated the problems of and barriers to the development and utilization of renewable energy through modern technology in China's poor rural area. It is obviously that these problems and barriers restrain the success of using RET to reduce poverty in various ways and to different extent. These problems and barriers are restructured and classified as follows in light of (1) the extent to which they are directly related to and hinder the application of RETs in poor rural area for poverty reduction purpose, and (2) based on the external consultation process, the possibility and feasibility for the stakeholders to take corresponding actions and measures in near future within China's specific context.

- High cost, especially initial cost of RE system

It is quite clear that high cost of RE system act as the greatest barrier to their extensive installation and successful use in a large scale. Thus the access to modern and clean energy for the poor in western rural area is not likely to be achieved unless the following circumstances could happen.

- Lack of diversified, sufficient and sustainable financial support

High cost and price of RET at present and great population of the poor in western rural area require substantial financial input if RE system are to be widely and effectively used to meet their basic energy demand and facilitate poverty reduction. So far, the existing and future possible financial support and input only from government and the local poor are far from being able to meet this challenge.

- Lack of coordination of RE policy, policy and program and concentration of authority on RE among the government bodies

Due to lack of coordination of program and concentration of authority on RE among the government bodies, the efficiency and effectiveness of the RE initiatives have been adversely affected to a considerable extent.

- Deficiency in the design and organization of national program in a large scale

Although the government has launched some initiatives and programs, the inadequate design of the activities mode and organization often result in efficiency loss and unnecessary expense and even failure.

- Immatureness of RE industry, especially in poor rural area and deficiency of local related capacity

In the present stage, immatureness of RE industry cause lack of perfect after-sale service and technical support. In the long term, mature RE industry, especially in western China is the essential and most effective solution to the development and utilization of RE in western rural area.

- Lack of opportunity for productive and particularly business use of RET to increase income

Due to disadvantage in the aspect of natural resource and economic and social development, the lack of opportunities for productive and business use of RETs remains a big obstacle for poverty reduction.

4.4 Policy and Action Objectives

According to the problems and barriers listed in section 4.2, the future policy and actions should be made to achieve the following objectives:

- Decrease the cost, especially initial cost, of RE system
- Promote diversified as well as sufficient financial support
- Strengthen the coordination and complete the RE promotion law
- Promote the RE industry, especially in poor rural area and increase local capacity
- Create opportunities for productive and particularly business use of RET to increase income
- Improve the design and organization of national RE initiatives

4.5 Policy and action outlines

This section raised a series of policy suggestions based on various objectives listed above. Taking into account the complicated correlation issues, it is not surprising to note that **some policy and action suggestions also contribute to some other objectives under which they are not placed**.

4.5.1 Decrease the cost, especially initial cost of RE system

1) Strengthen the R&D on RE system specifically tailored to diverse local conditions

More efforts should be made to research, design and produce RE system in light of specific local conditions, such as with government encouragement and support, and the engagement of local people. Increase input in the R&D from the government, or favourable policies in encouraging the investment, and capacity building of industry stakeholders will all contribute to decrease the cost. Of course, some of the measures are entangled in the following suggestions.

2) **Take into consideration all possible RE sources and RETs at the national level, emphasize on flexible and feasible RE sources and RETs**

Since China is a very large country with diverse and unbalanced RE resources and social and economic development, no single solution would prevail at national level but should not be excluded either. The selection should be based not only on scientific investigation and study, but also on comprehensive consultation with local people so as to make the solution both technically and socially desirable. As relatively mature and less costly technologies, biogas, solar stove and SHP could play more roles in a wide range. Anyway, the damage on the natural resource and ecological system, which were quite popular in the effort to gain rapid economic growth during the past years, should be prevented.

3) Introduce and promote the successful ecological pattern

Integrated biogas use with ecological pattern such as "pig-biogas-fruit" has become popular in extensive area. But it could also been noted that such successful experience have not yet been effectively introduced to the extreme poor western area. Therefore, a lot of efforts in western rural area can be made to lower the incremental cost of biogas system by benefiting from other productive activities and outputs.

4) Increase capacity of institutions and industry

Increase the capacity of research institutions and the industry to develop technology to promote cost reduction, develop advanced technologies, increase the efficiency and reliability of renewable energy systems and components, improve the management and manufacturing skills of domestic industry, and develop the capacity of financial institutions to evaluate and make investment decisions for renewable energy projects.

4.5.2 Promote sufficient as well as diversified financial support

1) Attract private and foreign involvement through mechanism innovation

The existing subsidies have been promoting the local RE development in the context of poverty alleviation. Preferential financial policies are also needed to attract the investment flow and the enterprise, such as loan, tax policies etc. Fund will never be adequate unless active involvement of private sector and definite and continuous financing systems, such as Public Benefit Fund (PBF), which are sustainable and economic sound for the Poor’s development. Policies encouraging the participation of private sector are more desirable. Other international sources, such as CDM relative to the global GHG reduction are also opportunities for financing the poor. The drafted law proposed to share the cost through inter-grids balance that burdened by all of the citizens. It is ambitious as well as significant for sustainable operation.

2) Strengthen the research on the payment capacity of users and improve the design of governmental subsidy

More efficient subsidy method and different subsidy objects should be studied to ensure that the poor population could actually get the final subsidies. Different consumers have different payback abilities. The government subsidy should be flexible to solve the actual difficulties of the poor population.

3) Establish and improve tariff system for centralized RE system

Charging for centralized RE system would discourage unnecessary consumption, particularly in the public welfare programs such as NETP. The collected fund is indispensable for operation, maintenance and repair of the RE systems. The most effective tariffs would be based on analysis of several factors: ability to pay, willingness to pay, current energy payments, cost recovery of the O&M and repair of the system, future outlays for expansion of the system, and cost recovery of the system. Regulations related to compliance monitoring, penalties etc are desirable to be established.

4) Improve the efficiency for allocation of subsidy funds

Typically for poverty alleviation programs, subsidies go direct to consumers or to systems integration companies for hardware support, with little consideration for software support. Such “software support” includes funding that could be used to strengthen the infrastructure for development of rural energy systems, such as training programs, resource assessment, project development grants, monitoring and evaluation programs, and funds that can be used to promote village enterprise and business development. The government should allocate some of its subsidy funds for these issues as well as to provide hardware buy-downs.

4.5.3 Strengthen the coordination and complete the law

1) Approval and completion of the promotion law

The on-going law pay special attentions on the rural and remote poor residents’ energy demands. It also tries to formulate the mechanism to share the isolated incremental cost of RE power technologies from the utility due to the clean energy consumption. This mechanism will solve the fund raising issue, which is the most difficult practical barrier in extending the RE in the poor.

2) Define responsibility of related governmental bodies through RE law

The drafted law identify the respective responsibilities and obligations of various bodies. It will make clarifications what kind of activities should be burdened by the central and local government, and what kind of cooperation is required to be established.

3) Deliberative and comprehensive RE plan by single authoritative government body

Energy authority should not only distinctly describe the development direction and tendency, but also specify the quantity and policy instruments explicitly. These plans should based on the actual resources and technological potential, take into account of the national plans in the energy and electricity sectors and analyse the relationship between new/renewable energy and the whole energy sector. Secondly, the responsibility of executing these plans should be assumed to a specific department. The national plan should be supported by the plans of every province, every relevant industry, and even every technology in order to avoid the situation that these plans are put aside on the shelf. Thirdly, there should be a well-known timetable to specify the target, the execution scheme and monitoring methods in each stage. The plans should also be comprehensive representing a complete integrated response to rural energy planning that includes all aspects of developing sustainable renewable energy rural programs. Therefore, the plans should also incorporate such issues as training, tariff regulations, insurance programs, etc.

4.5.4 Promote the RE industry, especially in poor rural area and increase local capacity

1) Create RE market through renewable energy law approval

Market could be used as critical driving force for the development of RE industry. Market scale and cost could be influenced positively. This has already been taken into consideration by China's government and researchers. The draft China's Renewable Energy Utilization and Promotion Law states that government places priority on the renewable energy and is to formulate overall quantitative objectives and corresponding measures to promote the establishment and development of RE market. And the interests of diversified investors are to be protected. Special articles are written for the rural poor's utilization of RE resources too. Potentially, the Renewable Energy Law could also directly address some issues impacting industry development in rural areas; for example, tax relief, financing issues (e.g., short term loans for the purpose of meeting seasonal cash flow problems), business training to improve management capacity, etc.

2) Strengthen the awareness and pattern of RE technology transfer to poor rural area

Technology transfer is not simply about the supply and shipment of hardware between different nations or regions, as the present case in China. It is also about the complex process of sharing knowledge and adapting technology to meet local conditions and strengthens human and technological capacity. The national initiatives and programs should organize in a way that is consistent with and supportive for technology transfer to western poor area.

3) Encourage the CREIA's attention to the development of RE industry in western rural area to

As a result of the growing attention to the development of renewable industry, the Chinese Renewable Energy Industries Association (CREIA) was established in 2000 with the support of the UNDP, the GEF and the former SETC. CREIA could play an essential role in promote the development of RE industry in western rural area. Furthermore, it could make the bridge for the capacity building.

4.5.5 Create opportunities for productive and particularly business use of RET to increase income

1) Improve local policy environment and infrastructure

Opportunities for productive use and particularly business use depend on the local natural resource, economic development stage, structure and environment, life style and social custom, etc. Although some factors are unlikely to be changed, the economic environment, including economic policies and regulations on land, water, etc, and lifestyle can be, if desirable, adjusted and basic infrastructure provided to create more productive and business opportunities. These efforts will greatly contribute the poverty reduction.

2) Direct support of business and enterprise development

Frequently, there is little support in rural areas for small scale business development or village enterprise. For poverty regions, there is also a need but lack of financing available to individual households and villages to pursue new enterprises. Some experience in China with micro-credit and micro-finance funds demonstrate that it is feasible to achieve high payback rates on small loans to support business development and income generation in the agricultural sector and for village enterprises. This type of support is not generally available from the government or local banks.

3) Raise awareness of the desirability of modern RE technologies among the poor

At last, there is a need to make good use of all kinds of medias to introduce the critical roles of new/renewable energy in improving the ecologic environments and living quality as well as the sustainable development. Moreover, the newest development of technology and related information in this field by means of newspapers and websites. By this way more and more decision-makers and investors may support or invest in this field. More and more people will support the development of new/renewable energy.

4.5.6 Improve the design and organization of national RE initiatives

1) Improve and innovate organization pattern of governmental RE program

To increase the effectiveness and efficiency, the governmental program could be organized and implemented stage by stage in sequential three years with different aim and activities: technical training and pilot/demonstration project construction for the first year, wide spreading for the second year and checking and improvement for the third year. In this way, the progress could be closely monitored and quality guaranteed. Although there are actually difficulties in these activities in some cases, there should be a detailed design on the after-sale management and repair. Furthermore, China's government may encourage and invite experienced international and multilateral organizations, such as UNDP, UNEP, ADB, to directly participate in the design and implementation of national RE initiatives and program in rural area, so as to take advantage of their expertise and experiences on organization of the activities

2) Change the role of government and let the market and enterprise determine appropriate selection and design of RE system

It should be kept in mind that it is the energy services, such as the lighting or refrigeration or TV, that the end-users urgently require, not the PV panels or wind turbines. Renewable energy solutions to rural electrification should be resource, cost and need driven, rather than based on a specific technology/application. The available renewable resources, the economics of alternatives, the village electrical load demand, villagers' willingness and ability to pay for electrical service should determine the appropriate solutions to provide power to the communities. Therefore, the most effective role for government would be to simply issue requests and payment for provision of energy services, and allow the companies to decide whether a hybrid PV/diesel, a biomass gasification station or a hybrid PV/wind system would supply the given load with a specified reliability at lower cost.

3) Restructure the process of determination of designer, builder and maintainer

In order to encourage a reliable, robust, high-quality system with good components, a single tender for bids to design, install, own, operate and maintain systems could be implemented as adopted in NTEP. The bids can still be selected based on lowest cost-per-kWh and other considerations (such as quality and service). In this case, a system integrator company can partner with a service company to bid, or one company with expertise in both areas can bid. This will ensure that the service division of the company is able to maintain and repair the system and have a supply of spare parts. Another option is to issue the tender for the service companies first, and then the selected service companies can issue a tender for turnkey system integrators, with guidance from the provincial authorities.

4) Establish and innovate arrangement pattern for operation, maintenance and repair of central RE system

If the designer and/or constructor are not responsible for the O&M of RE system, just as the present case, the following three solutions could be considered for selection: public service based on local governmental finance; self service by trained residents/users at the community/village level; and market-oriented service provided by private sector. Business motivations could also be used to support partial commercialization in this sector. For example, a small business could be developed to operate and maintain clusters of village power systems on a fee basis. Renewable energy service company models could be used to support this approach. The NTEP program is amenable to this solution, since in some areas in western China the density of village power systems is sufficient that a critical mass can be achieved for business development.

4.6 Stakeholders Reactions

In addition to the external consultation workshop, the above policy outlines have also benefited from many previous meetings in relation to the RETs development and poverty reduction.

There have been many workshops on the RE situation summary in China, barrier analysis and policy recommendation in recent years, particularly after the establishment of previously indicated project offices financed by WB, GEF and UNDP *etc*. For instance, there are discussions on wind industry (basically on-grid wind) development, the viable model of Mandated Market Share (MMS, selected options from RPS, FIL or competitive tendering) for RE development, and special topics on SHP, rural home biogas, solar energy industry etc. As a large project, NTEP also required a couple of conferences for initiation. In most cases, a variety of sectors, including governmental divisions, researchers, industrial representatives, power companies *etc*, were invited to participate and represent their views and comments. Particularly, the on-going China RE Utilization and Promotion Law called almost all of the stakeholders in a two-day international conference to discuss the RE-related articles in the drafted law. Various groups from them have also been involved in the drafting, consultation and revise work. At this moment, the drafted law has been reviewed in the Standing Committee of National People's Congress for its approval.

The general ideas from different stakeholders are summarized from the valuable consultation workshop as well as the various meetings indicated above. In this sense, though some of the policies are hard to predict their effects and potential reactions from stakeholders, a sound analysis can still be drawn. Their attitudes towards the RETs development with poverty reduction are simply summarized as following.

- Government

- NDRC (Energy Bureau): Energy Bureau is the drafter of the RE utilization and promotion law. Therefore give more focus on the legislative initiatives and show support for RETs outreach in poor regions. Division of Renewable Energy and Rural Energy under Energy Bureau was established to be responsible for concrete plans and programs, which was good news for RETs large penetration.
- NDRC (Economy division etc): Coordinated with Energy Bureau and give support.
- Ministry of Agriculture: Actively getting involved and appeal for more attention on the capability of biogas and small-wind, small-hydro, small-PV electrification in reducing poverty.
- Ministry of Treasure: Emphasis on local matching fund for RETs penetration
- State Administration of Tax: Positive support for RETs utilization, however opposition in tax discount.
- Ministry of Water Resources: Emphasis the importance of SHP and its proved role in electrifying the poor and accordingly reducing poverty. Indicate the SHP should be given priority to be supported and developed in despite of its mature technology.
- State Environment Protection Administration: Strong support
- Local government: Strong support for RE development; difficult in matching expenditure
- Legislative representative: National Environment and Resource Commission is one of the RE promotion law drafters, and therefore give indispensable support for the RETs further development in poor regions.

- Research institutions

- CREIA: Willing to play more roles in the market expansion and knowledge dissemination
- Rural Energy Association: Emphasis on the RETs in supplying energy in the past decades in rural regions; more attention on household projects and non-electricity applications
- University: Strong support in promoting RETs in reducing poverty

- RET-related Enterprises

- General ones (potential investor and operator): Be cautious, unless concrete policy support is available
- RE R&D and producer: Strong support, with larger input given more favourable policies
- Power utility (integrated transmission and distribution functions): Conditioned support due to the national-ownership, objective in burdening some RE incremental costs that placed on them and the risk of intermittent energy supply from RE resources
- Power company: Strong interests in developing large hydro, on-grid wind power, other than the rest

- NGO

- NGO: The voice from NGO is not very loud. Despite of this, their influences are becoming larger and larger in recent workshops. Their special supports focus on environment and natural resources protection, which always link with the poor population's life.

- Finance

- Multilateral banking: Belong to its priority areas, strong interests with cautious involvement
- Policy banking: Acceptance since no previous cases yet

5 Key findings and recommendations

5.1 Key findings

As a developing country with both large area and tremendous population, although China's economy is growing rapidly, there is serious unbalance in the economy level and growth rate. There are still large quantities of population in poverty. By the end of 2002, 608 townships, 9300 villages, and about 4.58 million households have yet no access to the electricity, and according far away from the civilization. In terms of the regional distribution, the poor basically locates in the rural regions. The gaps between rural and urban regions are getting enlarged. It is noted that the rural population exceeds 900 million in China, roughly 75% of the aggregate population. Residents in poverty exist in urban regions too. However, they are generally labours-off due to the economy restructuring. Many of them have found new jobs and thus get rid of poverty. Furthermore, the poor in rural areas is top priority to be considered in terms of the energy access issue. On the other hand, from the view of point of geographic distribution, the economy in western provinces is obviously lagged behind the eastern ones. Populations without access to electricity basically concentrate in the twelve western provinces. Poor population is generally distributed in the western and some middle provinces adjacent to the western part. Most of these populations are dispersed in the remote western part of China. There are substantial unbalance between Western and Eastern China. In this regard, this paper focuses on the western regions rather than the entire country.

There are plenty of renewable resources in China, including SHP, biomass, solar and wind energy etc. They are very abundant in the rural regions where poor populations dwell, particularly the various biomass resource, e.g. stalk, rice husk etc agricultural and forestry residues, human being and animal manures. Generally speaking, the unbalance resource distribution exists in China too. The western regions enjoy the best hydro, wind and solar energy in China. For instance, 60% of the hydro resource is in southwest, meanwhile Xinjiang, Tibet and Qinghai, which are the three provinces with the largest quantity of unelectrified populations, are the best provinces in the solar energy radiation. It is environmentally sound, economical as well as sustainable in harnessing these resources according to the local conditions to provide residential, productive and community energy requirements for the residents.

There are several motivations for China in harnessing the RE resources to serve the rural residents, particularly the poor in remote areas. First, it is the requirement to build a well-off society. The unbalanced situation is not expected in the coming future. Clean energy supply for the poor is a fundamental factor for their development. Secondly, the ecology system in rural areas particularly in western provinces is getting worse and worse. Traditional biomass still dominates in the local household energy consumption, which is a great contribution to the aggravation of ecology disasters, such as the on-going desertification, land erosion and oil loss. The harness of RE resource will help to protect the ecology. Thirdly, more specific, there are still large quantities of unelectrified population in a substantial region. It is obligated to find solutions to address this issue.

Different technologies in harnessing the RE resources are able to generate different categories energies. For example household biogas, centralized stalk gasification stations can provide residential fuels to satisfy the cooking, heating water etc. It is even possible to make use of biogas for lighting. Solar stove can convert the solar energy to heat to meet the cooking, heating water demand. SHP, PV modules, wind turbines, biogas generation stations are able to generate electricity to drive the household appliances such as electrical bulb, electrical fans, electric cooker, and meet the needs of school, hospital, shops, manufacturing activities. PV pumps and wind pump devices can also change the solar and wind energy into mechanical energies for irrigation, water diversion.

It can be simply categorized as centralized and decentralized types in adopting these technologies. The targets of the household biogas, solar stove, small wind turbines, and household PV systems are each single family with small scope. However, it is efficient for consumers with economical and reasonable inputs. For instance, the small wind turbines and the biogas are already considerably mature in the technique. Therefore the prices for the devices are relatively affordable. It is also convenient for the users to conduct operation and maintenance activities. PV and small wind turbines are more desirable for the herders with frequent liquidity. SHP, PV stand-alone station may create stable, reliable electricity for relatively centralized consumers, e.g. a natural village with a hundred households, or venue of local government and the market centre with centralized public facilities, as well as some regions with large loads due to the processing and manufacturing activities. Stalk and straw gasification stations will make use of the agricultural residues to provide fuel for village or township level consumers. The difference of centralized and isolated utilization approaches determines the diversity of project scale, reliability, and O&M issues.

The market-based commercialization ability differs quite a lot depending on the technology maturity. In practice, different measures may be chosen accordingly because some are mature with lower cost and a certain degree of market, while others are high in the production cost and small scale. For the former one, their introduction to the poor residents should accompany with subsidy or favourable credit support. Though the biogas, solar stove are relatively cheap, they are still too large a burden for the poor in their normal life. The higher subsidy, or discount loans from the Rural Credit Company can secure the affordability for the poor. Some other technologies with high cost, such as PV, biomass gasification, are far beyond the affordability for the poor. It is required to take economic measures to compensate such a high gap. Increase input in R&D, discount loans, tax reduction etc may contribute to reduce the production cost. However, normal poor residents still neither afford such a high investment, nor can they grasp the complicated techniques to operate such a system. The government is responsible to supply fund to provide the devices, to organize construction, management, and training work etc. For the poor consumers, both the household PV and the PV stand-alone station are too expensive for the market to disseminate. NTEP is one example in showing this feature. Obviously, the high initial investment for one SHP is also beyond the affordability for the poor despite SHP's mature technology. It is also required to offer large finance in the initial stage to make the SHP project to move forward before it can serve residents. It also requires large sums of money to operate and maintain these systems, without which, the danger constantly exists that the systems will fail. On the other hand, the use of these centralized systems increases the ability to generate income using productive applications, which generally require more electricity than small household systems are able to produce.

There are multiple dimensions of energy demands, such as basic residential energy, productive energy, community and public energy etc. Gas, electricity, and mechanical energy are possible to be required in different demand categories. Depending on the serving targets, there are also different requirements on energy supply quality and quantity. In this paper it is found within the poverty alleviation and sustainable development framework that one simple technology in harnessing the RE resources are not realistic to fully satisfy all of the requirements. There is a need to make deep analysis to choose the most desirable RE technology to serve the poor based on the ultimate demands, some of which is actually not from the energy supply at all, according to the local situation. It must be resource available, economically viable, as well as environmentally sound solutions. The hybrid system of PV/SHP/Wind turbines is one example in showing the compensation in both resource and technology features to enable stable electricity. The initiatives taken by China's government in harnessing the rural RE resources, as well as the support to reduce the poverty are all based on such considerations.

Solving the energy requirements of the poor is one important measure to help them to get rid of poverty and develop the economy. As aforementioned, the obvious unbalance distribution of resource and wealth determines that there are diversified options in addressing the problems. RE can be adopted as one kind of solutions to satisfy the rural energy demands so as to improve the living condition, make comprehensive use of the resources, reduce the excess consumption on the wood and protect the ecology environment etc. It is heavily motivated by the objective of well-off society building. Within these activities, the poor is targeted as the key to be supported. The government will allocate relatively higher subsidy to ensure that the poor can afford the cost, and also to secure the success of the projects. Generally, the adopted RE technologies are mature in the market. Thus the price is not very high. For example, the poor will benefit from constructing the biogas digesters with part cost shared by the government. Another model is a direct poverty alleviation as well as public welfare project, such as the NTEP. The targeted population of this kind of project either belong to "extreme poor" residents, or those having no hope to access the clean electricity in the coming 20 years. In addition to the former method, the modern devices are direct introduced to these residents. The result is the poor population can access the off-grid electricity in a Frog-Leap type. They are able to benefit from the TV, radio etc modern civilization in this approach, otherwise is impossible at all. The case studies selected in this paper are based on such an analysis, which is expected to give a clear overview on the ideas to reduce poverty in China.

Biogas is a mature technology with successful demonstrations in the rural regions. However, the quantity of consumers has been growing very slowly until these years. The annual increase of household digesters in rural regions reaches 1 million. By the end of 2002, the biogas digesters accumulated to 11.2 million. The government promotion is an important contribution to its booming. A total 120 million US$ from the national debt is allocated to subsidize the households in building the biogas digesters. In addition to this, biogas is popular because it is a significant link among the sound rural ecosystem, including the livestock breeding, plantation, residential energy demand and even the productive activities. In northern and southern China, "four in one" model (plantation, livestock breeding, biogas, solar greenhouse), and "three in one" model (plantation, livestock breeding, biogas) have achieved remarkable success respectively. Biogas is produced from the fermentation of animal wastes, which can serve the residential fuel. The environment in cooking room is improved accordingly. Biogas effluent and sludge can benefit the plantation. Residents can increase their income through the livestock breeding. Furthermore, biogas has proved useful in aquatic product cultivation, seed preservation etc productive activities.

However, biogas construction has strict requirements in the climate and temperature. Therefore, its spread is limited in arid and cold regions. Without an animal breeding custom it is not possible to make use of biogas either. It is noted biogas is weak in energy supply compared with other RE technologies. Energy supply is only one output from the ecosystem cycle, and that biogas cannot meet all of the energy demand. A normal biogas digester is able to produce roughly 260 m^3 annually, which can only meet 40% of the household energy requirements. Biogas utilization is limited in the cooking, water boiling and lighting etc. It cannot serve for space warming and fodder heating, or for the electrical instruments. Hence, biogas consumers have to find some other energy resources for supplementation. However, it is this 'link' feature in the ecosystem that can help the poor in a sustainable way. According to the previous experience, though the biogas is already very mature, and its total price is not very high, the rural residents are not willing to build it unless the government offers subsidy. The subsidy on poor households is higher than other ones. In practice, the benefited scope is still small due to the large subsidy and limited fund resource. Furthermore, the local maintenance and repair work lack of fund too. There is a need to create new finance resource, to enable the role of Rural Credit Company, regional and international development bank, as well as introducing some mechanism related to the GHG emission reduction.

NTEP is one public welfare project. Its targets are those 1061 townships without access to electricity. These townships locate in remote areas far from the power grid with difficult transport situation, and are impossible to get electricity through grid extension in the near 20 years. NTEP aims to electrify these townships according to the local conditions, harnessing the abundant solar energy, wind energy and hydro resources to provide stable and reliable electricity for the local government venue. Started from year 2002, NTEP is expected to end in year 2005. Its total fund comes from the government, including the system design, device procurement, construction, installation and operation. NTEP achieved the "Frog-Leap" for the local residents, which enable them to benefit from the most advanced technology in the world. It is noted that some problems remain unresolved for NTEP. The ownerships of these PV stand-alone stations still have not been identified. The repair and components replacement work require stable fund, however the tariff has not set yet which will influence their sustainable operation. A critical problem is the after-sale service for the remote areas. The transport is difficult, while the local residents are hardly educated to be able to maintain the devices. Many RE technologies face the same problem in serving the remote poor residents.

SHP is one technology that has been utilized for long history since the establishment of new China. Its extensively promotion attributes to its flexibility in the rural areas, particularly in those remote areas with mountainous terrain. Rural hydro-based electrification county construction makes it possible to electrify large-scale residents. SHP is also adopted in NTEP and "Replacing fuel-wood with SHP" program. The current barrier for SHP is more an institutional one, especially for the relationship with the larger grid, than the technical one given the adequate subsidy for the initial cost to serve the poor. Under the power sector reform plan, local small hydro-based grids always have conflicts with larger grids in the supply region, and affiliation issues, as it is required to separate the utility and generation assets in this wave of reform.

Despite different RE technologies are facing different barriers in its spread, there can be drawn some common features for them:

- So far, majority renewable energy technologies have the features of high cost and high price particularly in comparison with traditional energy that are totally free. Moreover, the RE equipments, productions and O&M expenses are generally too high for the poor. This is the top aspect that hinder for the poor benefiting from the poor.
- The quantity of the population in poverty is too large. Therefore, there are not enough funds to help the poor despite the large amount subsidies in the national demonstration projects. Taking the high cost of RE technology and the low affordability of the poor into consideration, the limited fund is a practical difficulty in introducing RE service to the poor.
- There are no unified favorable policies as well as unified leadership in the RE development, let alone their application in poverty alleviation. Despite the various macro policies or laws in ensuring the rural RE's role, they focus more on the concepts and generic significances. The actual RE development and application can hardly benefit from them without concrete and operable measures.
- Generally, the RE industries are not strong as a whole, and market-support infrastructures for RE products are still underdeveloped. A limited R&D input on these areas contributes to this situation, which contributes to the high cost and prices. As a result, the RE market is small and its commercialization process is slow.
- The poor always dwell in the remote areas with poor natural condition and transportation. Their education experiences are also rare. All of these contribute to their poverty status, and weak their affordability as well as the ability to use the RE productions.
- With respect to most of the national programs, the designer or administrative agencies have paid enough attentions on the construction process, whereas less on the follow up management, operation, daily maintenance work. Sometimes, detailed preliminary feasibility study are also absent. There is also very little current emphasis on the longer term evaluation of projects, surveys to assess impacts and performance, and long term monitoring procedures.

5.2 Recommendations

China has made sound foundation to promote the RE development in multiple dimensions. It is good opportunity to take steps to go ahead. A significant idea should be kept in mind that RE technologies can't satisfy all of the demands at all. A practical method should be taken based on the local conditions. Sometimes, it is desirable to implement in phases other than beyond the current status.

Accordingly some measures are raised in relationship to the above-identified barriers.

- It is urgent to decrease the cost, especially initial cost of RE system. There is a need to strengthen the R&D on RE system specifically tailored to diverse local conditions.
- Promote sufficient as well as diversified financial support and experiment with different approaches to financial support to identify the most effective approaches
- Strengthen the coordination and complete the RE promotion law; concrete measures towards poor populations are desirable
- Promote the RE industry, especially in poor rural area and increase local capacity

- Create opportunities for productive and particularly business use of RET to increase income
- Improve the design and organization of national RE initiatives, particularly training for the local residents proves to be significant with respect to the program success

Supplementary Note:

In February, 2005, The Standing Committee of National People's Congress of China, the top legislation agency, approved the China Renewable Law (See Appendix 11), bringing new and concrete policy support for the development and utilization of renewable energy resource and technologies.

According to the law, the government branch at various level is obliged to formulated specific plan and measures, state science and technology and industry development program will be launched for and finance support will be given to push forward the development of the promising renewable energy technologies and industry, the off-grid renewable energy power systems will be established or subsidized with central government support or through special fund, etc.

As a result of China renewable Law, various group of stakeholders are excited and more optimistic about the future of RE industry and its contribution to the economic and social development in rural area.

China Renewable Law will come into effect on Jan. 1st ,2006. Its practical impact will depend on the detailed rules and measures of implementation that are to be released shortly.

6 Suggestions for future activities

Representatives from government and research institution organization show great interests in basic data about the poverty situations. There are gaps between the policy making process and the practical situation, which is a large barrier to the policy outline. Participants in the external consultation called for some field investigations to acquire the basic information about the poverty and RETs penetration. This proposal was confirmed to be urgent by the energy policy makers in the workshop.

Specially, since China has already carried out various national electrification programs, there is a need to do some detailed case studies to conclude some valuable experiences in sharing with the other developing countries. Most of these programs had been initiated in the near five years. There are still no detailed statistics to track the actual changes. Detailed case studies are particularly desirable.

Moreover, there are also some other bilateral or multilateral poverty reduction programs in the western China. It is also a good opportunity to draw some conclusions in the comparison, so as to acquire more reasonable results. Such a communication will facilitate each other's work.

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Appendix 1: Unelectrification levels of each province in China

	Provinces	**Household** (%)	**Village** (%)	**Township** (%)
	National average	**1.52**	**1.29**	**1.46**
1	Tibet	86.43	77.07	58.89
2	QinHai	13.14	17.87	20.42
3	GuiZhou	7.16	2.39	0
4	YunNan	6.11	1.2	0
5	GanSu	4.99	2.94	0
6	XinJiang	4.99	2.87	2.72
7	SiChuan	3.82	1.67	1.41
8	Inner Mongolia	3.52	3.98	0
9	GuangXi	2.22	0.84	0
10	NingXia	1.94	0	0
11	HaiNan	1.73	0.29	0
12	ShannXi	1.2	0.06	0
13	HeNan	0.8	0	0
14	ChongQing	0.69	0.14	0
15	JiangXi	0.63	0.28	0
16	HuNan	0.61	0.31	0
17	ShanXi	0.59	0.97	0
18	HuBei	0.21	0	0
19	FuJian	0.15	0	0
20	AnHui	0.13	0	0
21	HeiLongJiang	0.1	0.13	0.1
22	GuangDong	0.1	0	0
23	LiaoNing	0.02	0	0
24	ZheJiang	0.02	0	0
25	JiangSu	0.01	0	0
26	BeiJing	0	0	0
27	TianJing	0	0	0
28	HeBei	0	0	0
29	JiLin	0	0	0
30	ShangHai	0	0	0
31	ShanDong	0	0	0

Source: China Electricity Power Yearbook. 2003.

Appendix 2: Map of China

Appendix 3: Energy technologies and requirements

Category	Requirements	Renewable Technologies	Compatibility with users (*)	Competing non-RE or traditional
Residential	*Cooking*	*Solar stove* *Biogas*	*H* *H*	*Firewood;* *Agri. and animal residues*
	Space warming	*Solar house;*	*H*	*Coal stove* *Kerosene stove* *Charcoal* *Agri. and animal residues*
	Water heating for drinking or bathing	*Solar stove;* *Solar water heater*	*H* *H*	*Electric heating* *Firewood heating*
	Lighting for reading	*Wind* *SHP*	*H* *H*	*Kerosene, candles*
	Cooling fan	*Small hydropower*	*M*	*Power grid*
	Leisure appliance (stereo, TV etc.)	*Small hydropower* *PV*	*M*	*Power grid*
Productive	*Water pumping for crop irrigation*	*Wind* *PV*	*H* *M*	*Power grid*
	Drying	*Solar energy*		
Social/Community Services	*Public light, small electric devices*	*SHP, PV*	*M*	*Diesel, Power grid*

(*) H = high; M = medium; L = low

Souce: Compiled by the author.

Appendix 4: RE resources

Table 1 China small hydro resources

	Exploitable potential (GW)	Output potential (TWh/y)	Percentage
Western part	81.79	269.9	65.6
Middle part	22.34	73.72	17.9
Eastern part	20.49	67.61	16.5
Total	124.62	411.24	100

1. Source: Ministry of Water Resources.
2. The operational hours for SHP are estimated as 3300h according to statistics.

Table 2 Provinces with total SHP installed capacity over 800MW.

No	Province	Capacity (MW)	No	Province	Capacity (MW)
1	Guangdong	3576	7	Zhejiang	1872
2	Sichuan	3526	8	Hubei	1465
3	Fujian	3057	9	Guangxi	1407
4	Yunnan	2250	10	Jiangxi	1180
5	Xinjiang	2114	11	Guizhou	958
6	Hunan	2033	12	Chongqing	839

Source: Rural hydropower and electrification in china.

Table 3 China wind areas and percentage in whole inland area

Index	Unit	Abundant area	Comparatively abundant area	Utilization area	Shortage area
Annual effective wind energy density	W/m^2	>200	200~150	<150~50	<50
Annual cumulative hours above 3m/s	h	>5000	5000~4000	<4000~2000	<2000
Annual cumulative hours above 3m/s	h	>2200	2200~1500	<1500~350	<350
Percentage in total inland area	%	8	18	50	24

Source: White Book of China New and Renewable Energy. 1999

Table 4 Solar energy resource distribution in China

Category	Area	Annual sunshine (Hours)	Annual radiation ($kcal/cm^2$ • y)
1	West Tibet, Southeast Xinjiang, West Qinghai, West Gansu	2800~3300	160~220
2	Southeast Tibet, South Xinjiang, East Qinhai, South Ningxia, Mid Gansu, Inner Mongolia, North Shanxi, Northwest hebei	3000~3200	140~160
3	North Xinjiang, Southeast Gansu, South Shanxi, Nroth Shaanxi, Southeast Hebei, Henan, Jilin, Liaoning, Yuanan, South Guangdong, South Fujian, North Jiangsu, North Anhui	2200~3000	120~140
4	Hunan, Guangxi, Jiangxi, Zhejiang, Hubei, North Fujian, North Guangdong, South Jiangsu, South Anhui, Heilongjiang	1400~2200	100~120
5	Sichuan, Guizhou	1000~1400	80~100

Source: White Book of China New and Renewable Energy. 1999

Table 5 Types of geothermal geo-fields

Type	Heat reserve temperature	Representative geofields
Modern/neoteric volcano type	High	Datum, 293 ℃ high temperature fluid (Taiwan), Tengchong (Yunnan*)
Magma type	High	Yangbajing, embedded 6-10km under the earth's surface, 329℃ at 1.5-2km; Yangyi (Tibet*)
Rupture type	Moderate	Dengwu and Dongshan Lake (Guangdong) Fuzhou and Zhangzhou (Fujian), Huitang (Hunan)
Fault-subsidence basin type	Low-moderate	Beijing, Tianjin, Hebei
Sunken basin type	Low-moderate	Sichuan*, Guizhou*

Source: White Book of China New and Renewable Energy. 1999

* Western provinces

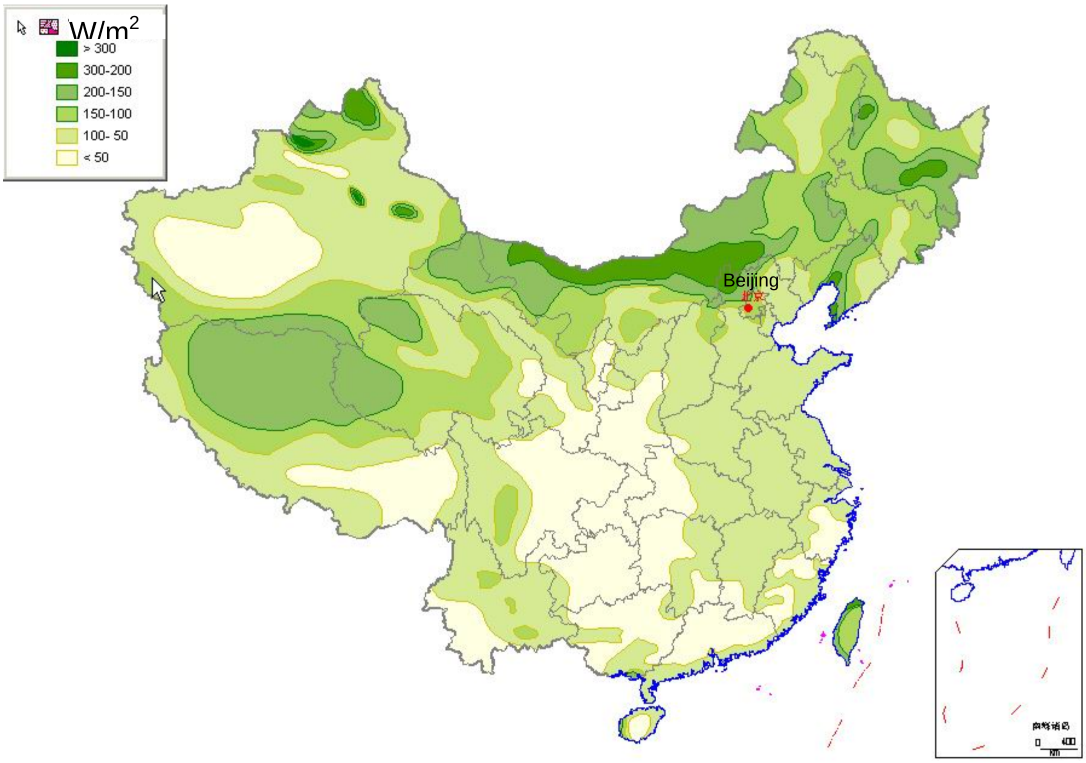
Table 6 Geothermal temperature category

Temperature category		Temperature limit	Main purpose
High temperature		t>150	Electricity generating, drying
Medium temperature		90<t<150	Industrial use, drying, power generation and cooling
Low temperature	Hot water	60<t<90	Heating, technological process
	Moderately hot water	40<t<60	Medical treatment, bathing, green house
	Warm water	25<t<40	Agricultural irrigation, aquaculture, soil processing

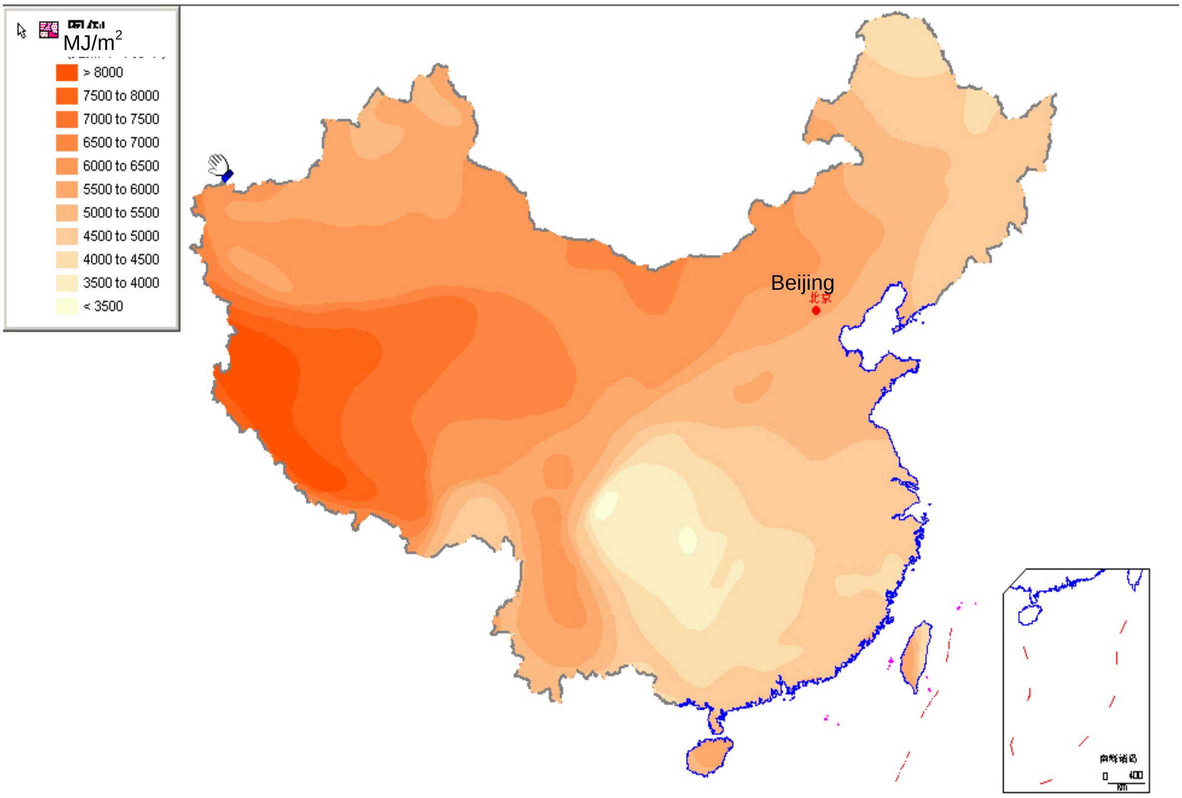
Source: White Book of China New and Renewable Energy. 1999

Appendix 5: Wind and Solar energy resource distribution map of China

1) Wind resource



2) Solar energy resource



Appendix 6: R&D Capacity of various RE technologies in China

Technologies	Capacity Category	Capacity Status	Capacity Development needs	Application prospect for the poor
Mini-hydro	Commercial model etc	*Very mature*	*Not critical*	*High*
SHP	Commercial model etc	*Very mature*	*Not critical*	*High*
Household Biogas	Commercial model etc	*Very mature*	*Not critical*	*High*
Centralized stalk gasification	Commercial model O&M infrastructure Human resources Installed industrial capacity	*Demonstration* *Medium* *High* *Medium*	*Significant* *Significant* *Not critical* *Not critical*	*Medium*
Household gasification stove	Commercial model O&M infrastructure Human resources Installed industrial capacity	*Medium* *Medium* *High* *Mature*	*High* *High* *Not critical* *Not critical*	*High*
Solar stove	Commercial model O&M infrastructure Human resources Installed industrial capacity	*Medium* *High* *High* *Mature*	*High* *Medium* *Medium* *Not critical*	*High*
PV station	Commercial model O&M infrastructure Human resources Installed industrial capacity	*Demonstration* *Medium* *High* *Medium*	*Significant* *Significant* *Not critical* *Not critical*	*High*
Home PV	Commercial model O&M infrastructure Human resources Installed industrial capacity	*Demonstration* *Medium* *High* *High*	*Significant* *Significant* *Not critical* *Not critical*	*High*
PV water pump	Commercial model O&M infrastructure Human resources Installed industrial capacity	*Demonstration* *Medium* *Medium* *Low*	*Significant* *Significant* *High* *High*	*High*
Small wind turbine	Commercial model O&M infrastructure Human resources Installed industrial capacity	*Mature* *High* *High* *High*	*Not critical* *Not critical* *Not critical* *Not critical*	*High*
Biomass generation	Basic research Applied research Commercial model Technology transfer O&M infrastructure Human resources Installed industrial capacity	*Medium* *Demonstration* *Low* *Low* *Medium* *Medium* *Medium*	*Significant* *Significant* *Not critical* *High* *Medium* *Medium* *Medium*	*Low*

Souce: Compiled by the author.

Appendix 7: Case studies

Case studies characteristics are listed with the following table.

Table 1. Data Case Study1-biogas					
Category	**Requirement**	**Energy req.**	**Technology**	**% Covered with RETs**	**Target population**
Residential	*Lighting, cooking*	5400kJ/day per household	*Biogas*	60% (northern), 70% (southern)	*40% farmers in the southwestern provinces, 30% farmers in the northwestern provinces*

Souce: Compiled by the author.

Table 2. Data Case Study2-Township Electrification Program					
Category	**Requirement**	**Energy req.**	**Technology**	**% covered with RETs**	**Target population**
Residential	*Cooking, lighting, stereo, TV*	20-30 kWh/month per household	*SHP/PV*	*50%*	*Disperse 310,000 rural residents within the scope the unelectrified townships*
Productive	Irrigation		SHP	100%	

Souce: Compiled by the author.

Table 3. Data Case Study3-SHP development in minority county					
Category	**Requirement**	**Energy req.**	**Technology**	**% covered with RETs**	**Target population**
Residential	*Lighting*	4 kWh/month per household	SHP	*100% (100% penetration)*	71% of the 460 thousand populations
	Stereo, TV, VCD, refrigerator, washer machine	8 kwh/month per household equipped with	*SHP*	*100% (40-50% of penetration)*	
Public facility	Lighting for government office; school; hospital; post; board defense	2 kwh/day per place	SHP	100%	
Productive	Irrigation, manufacturing	5 kwh/day per place	SHP	100%	

Souce: Compiled by the author.

Appendix 8: Capacity assessment

Stakeholder	Function/Activities	Capacity Status / Problems	Capacity Development (CD) Measures	Magnitude of CD needs / Priority
1. Legislative authorities, elected officials	Set national political priorities; social, economic, and environmental goals; legal framework conditions.	*China Environment Resource Commission under the Top legislative authority-National People's Congress, cooperated with NDRC, is responsible for the drafting of RE promotion law. NDRC supply the information of RE status in China. There maybe difficulties with respect to the other government authorities, such as Ministry of Treasure, General Bureau of Tax in approving the law.*	*RE Promotion Law specifies the legal responsibility of each level government, for the resource survey, industry guidance, promotion and application of RE. There is a need of coordination between RE promotion law and the existing Electricity Law.*	*Very high*
2. Government macroeconomic and development planners	Define development goals and macro policy; general economic policies; cross-cutting issues; subsidies and trade policy; sustainable development goals, and frameworks.	*Department of RE energy and rural energy under Energy Bureau of NDRC is the administration and planning government authority. RE has been incorporated within the medium and long-term national energy strategy development. NDRC is the only one of the macroeconomic regulation authority in China.*	*There is a need for the decision makers in the provincial and under level on the RE potential and its role. National RE strategy has to be divided for each province to implement.*	*Very high*
3. Government energy authority or ministry	Set sectoral goals; technology priorities; policymaking and Standard-setting functions; legal and regulatory framework; Incentive systems; federal, state, and local level jurisdiction.	*- Energy Bureau under NDRC in the central government. It integrates the functions of former State Development and Planning Commission and the former State Economy and Trade Commission.* *- Lack of respective authority in the provincial level*	- Centre for Renewable Energy Development of Energy Research Institute under NDRC provide concrete policy suggestions and various timely information. - Strengthen the local authority awareness on RE.	*High*
4. Energy regulatory bodies	Have monitoring and oversight functions; implement the regulatory framework; administer fees and incentives.	*- There are various departments of Coal, petroleum, electricity, nuclear, natural gas and comprehensive management under Energy Bureau.* *- Division of Price under NDRC responsible for the price specifying* *- State Electricity Regulation Commission has the regulatory work on electricity.* *- Regulation and compliance will improve once the Promotion law is approved.*	*Electricity reform is ongoing. RE power should be separately specified.*	*Medium*
5. Market coordination agencies	Dispatch entities; have operational coordination functions; Interface with industry investors; information brokers.	*China Renewable Energy Industrial Association (CREIA) can only supply information exchange and consultation in investment.*	*Strengthening of CREIA*	*Medium*
6. Non-energy governmental authorities/ministries	Sector policies; crosscutting issues in relation with energy policies; public sector energy consumers; require energy inputs for social services provision.	*- SHP is under administration of Ministry of water Resources. Small scale wind, mini-hydro are under the scope of Ministry of Agriculture. Ministry of Science and Technology will carry out pilot research on Large wind turbines, PV module, hydrogen research etc. NDRC is enhancing its ability in coordinating the various entities, as it is able to issue comprehensive policies on RE.* *- Other ministries as treasure and tax may reject the promotion law*	*- Enhancing the information exchange between various authorities.* *- Integrate RE technologies development under one strategy*	*High*

Stakeholder	Function/Activities	Capacity Status / Problems	Capacity Development (CD) Measures	Magnitude of CD needs / Priority
7. Energy supply industry	Private companies and public utilities; manage energy supply, electricity generation; fuels management and transport; finance some R&D.	*- Lack of interest in supplying energy in dispersed and remote regions* *- Grid companies object the responsibility of the cost sharing for the Re high cost.*	*Establish the promotion mechanism for not only the on-grid energy, but also for the off-grid energy.*	*Medium*
8. Entrepreneurs and productive industry	Business development; economic value added; employment generation; private sector energy consumers.	*- Some REs, i.e. SHP, biogas, efficient stove are mature in both the industry and the market* *- Other related industries have limited capacity due to limited market and competition*	*Expand the demand and therefore the market*	*Low*
9. Energy equipment and end-use equipment manufacturers	Supply equipment for the energy industry and other industries, including vehicles and appliances; impact energy end-use efficiency; adapt/disseminate technology; finance some R&D.	*- Some REs, i.e. SHP, biogas, efficient stove are mature in both the industry and the market* *- Other related industries have limited capacity due to limited market and competition*	*Expand the demand and therefore the market*	*Low*
10. Energy equipment O&M services	Provide O&M. Feedback on performance and feasibility	*Low level for the local O&M services*	*There is a need for training and CD targeting at the local residents*	*High*
11. Credit institutions	Financing options for large- and small-scale energy generation; capital provision for energy using enterprises; financing options for household energy consumers.	*There are policy banks for RE projects. However, regarding rural disperse program, relative credit institutions are lack.*	*Establish the credit mechanism regarding the household RE systems. Encourage the farmers to get loans from the rural credit community.*	*Medium*
12. Civil society / NGOs	Consumer participation and awareness; oversight and monitoring; environmental and social advocacy; equity considerations	*Not available*	*Encouraging the establishment if necessary*	*Low*
13. Users	Users of renewable energy systems. Providers of feedback and knowledge about resources, cultural traits, technology performance, friendliness and suitability.	*The most popular RE systems are the solar water heater in the urban and SHP throughout the nation. Consumers are always influenced by the cost rather than its benefits to the environment.*	*Encouragement through the economical method and the dissemination.*	*Medium*
14. Energy specialists and consultant firms	Strategic advice, problem definition and analysis; systems development; specialist services delivery; options analysis; information sharing.	*- There are limited amount of specialist dispersed in various research organization or universities.* *- No consultation firms*	*Expect to emerge as the market is large enough.*	*Low*

Stakeholder	Function/Activities	Capacity Status / Problems	Capacity Development (CD) Measures	Magnitude of CD needs / Priority
15. Academia and research organizations	R&D, knowledge generation, and sharing; formal and informal education; technical training; technology adaptation, application, and innovation.	*- There are many universities engaging in the energy research work. e.g Tsinghua University; Many research institutions from Academy of science, e.g. the electrical research institution, Guangzhou Energy Research Institute; Rural energy research from the branch of Ministry of Agriculture.* *- These research work always stay at the level of policy research, R&D research. No close relation to the industry.*	*More education oriented to the poor.*	*High*
16. Media	Awareness raising, advocacy; information sharing; journalistic inquiry, watchdog functions; monitoring, public transparency.	*No continuous or strategic attentions on RE from the media's side*	*Enhance CREIA to be one source for the RE information dissemination.*	*Low*

Souce: Compiled by the author.

Appendix 9: Identified niches

Potential Niches Criteria	Case study 1- Household Biogas	Case study 2- NTEP	Case study 3-SHP development in Minority county
Representativeness			
1. Replicability	*High. It depends on the climate and the livestock custom. Some places are restricted due to the lack of water.*	*High in decentralized remote areas. SHP and PV station will be appropriate for the relatively centralized population regions such as the local townships government venue.*	*High. Abundant distribution in mountainous region, with mature technology and simple O&M requirement.*
2. Potential population benefited	*40% farmers in the southwestern provinces, 30% farmers in the northwestern provinces*	*Disperse 310,000 rural residents in the case study. The entire program is targeting the 0.2 million within the township*	*193 out of 205 villages, that is 300 thousand population*
Complexity			
Suitability/Viability/Sustainability			
3. Affordability	*Medium. A 30%-40% subsidy from the government to encourage is available.*	*Low. National debt and the local government fiscal expenditure. Local affordability remains a potential problem.*	*High. Given hydro-based grids are not far from the consumers. Previously, the government investment is the main body, the poverty reduction effect is large.*
4. Effectiveness	*Medium. Supplemented by other energy types to meet the entire energy demands.*	*High. A quick, economical, environment sound solution for the electrification*	*High. SHP resource is abundant throughout China rural regions.*
5. Risk of obsolescence	*O&M is a problem for the poor without any education.*	*Medium. Management issue is still not clarified. PV station requires battery replacement.*	*SHP stations can be well operated commercially.*
6. Flexibility	*High. Serve for cooking, lighting, and water boiling.*	*Medium. Electricity supply only.*	*High. The station can be designed in line with the local condition to be centralized or isolated.*
7. Technological capability	*High. Very mature throughout rural China. Typical Three-in-one in south western China and Four-in-one model in north western China.*	*Medium. SHP is mature, however PV module depends on import.*	*High. SHP is the most mature RETs in China.*
8. Suitability and urgency	*High. It is one option to increase the household income and comprehensive use of the resources.*	*Medium*	*High.*
9. Resilience			
10.Adaptability	*Typical Three-in-one in south western China and Four-in-one model in north western China.*	*High. Pilot projects prove.*	*High*
11.Environmental impacts	*Positive. Comprehensive utilization of the animal residues*	*Positive. Little GHG emissions. SHP may have negligible impacts on the environment.*	*SHP hardly makes any impacts on the environment. It benefit the indoor environment indirectly through clean electricity suppy.*
12.Social acceptance	*High.*	*High*	*High.*
13.CD requirements	*There is a need for training for the local residents*	*O&M requires training.*	*Training for local residents.*

	particularly for the O&M skills.		
14.Income generation	*High. The digester sludge and effluent are also valuable for economical purposes, therefore a source for income increase.*	*Medium. Supply power productive purposes.*	*SHP can propel the local economy development in providing the power.*

Souce: Compiled by the author.

Appendix 10: Assessment of previous experiences

Experience (E) **Criteria**	E 1: Comprehensive Rural Energy Planning and Construction Program	E 2: Rural Electrification Program	E3: Brightness Program	E4: Township Electrification Program
Description				
Objectives	Rural energy construction work that focused on renewable energy	Take the advantage of the hydro resource to electrify residents	Supply >100W per capita for the unelectrified population	Satisfy the power needs of public utilities and residents of un-electrified townships in remote, border regions of Western China
Goals	Promoting energy efficient stoves, rural biogas digesters, fuel wood forests, and solar energy	Use of small-scale hydropower to achieve 100, 200, 300 counties rural electrification in the sequential five years plan. (1985-2000). Another 400 counties to be electrified within this five year plan.	Adopt PV modules and wind power systems to provide power for residential demands to the population of 23 million in China without access to electricity	Electrify the 1065 townships that remain no access to electricity
Results obtained	High efficient stove and rural biogas digester components were particularly outstanding. At present, the coverage of energy efficient stoves in China's rural areas is over 95%. Biogas work has moved from merely resolving energy needs to being a key component in the development of ecological agriculture and rural sanitation	- Over 600 counties (accounting for 30% of all of China's counties) achieve the electrification mainly on SHP. - The total installed capacity of small hydropower in China is now 30 GW.	Three demonstration pilots in Inner Mongolia, Xinjiang, and Tibet have been complete, and are to be extended to national wide. Four provinces (or provincial level municipalities) have established *Brightness Program* project companies to develop projects associated with the program.	378 SHP stations with the capacity of 200MW, 688 PV stations with the capacity of 20MW, and 20 wind-PV hybrid systems was built. Presently, most of the PV stations of this program are able to work, and the small hydropower projects are being constructed.
Population target	100 counties	600 counties	30 million without access to the electricity	1065 townships
Population benefited	10 million	120 million	Currently 3 pilot projects.	200 thousand
Weak points	No electricity supply. Generally, some complementary energy resources should be added.	- High initial investment - Difficulty connection of SHP based small grids with large grids	- High initial investment, 10 billion Yuan - Subsidy is not sustainable for the poor	- High initial investment, 10 billion Yuan - Management body of these PV stations is not definite yet
Capacity status assessment of the project stakeholders	Medium. The adopted energy technologies are relatively simple, and the cost is not high.	High. Since 1960 until now, China acquired plenty of experiences.	Medium	Medium. First time in China in large-scale for the centralized PV construction
Zones	National wide counties	Eastern, middle, western counties with abundant hydro resources	Western remote regions without access to electricity	12 western provinces except Guangxi, in addition with HuNan Province
Representativeness				

Experience (E) **Criteria**	**E 1: Comprehensive Rural Energy Planning and Construction Program**	**E 2: Rural Electrification Program**	**E3: Brightness Program**	**E4: Township Electrification Program**
Replicability	High. Most of the counties are able to construct the biogas once the temperature and the humidity are appropriate. The stove is easy to be restructured without too much cost. Residents are willing to get involved in the program.	High. Each five-year plan, the government increased the amount of electrified counties. SHP model is to be greatly promoted in larger scale throughout China. China is going to invest 70 billion RMB to build another 400 SHP-based rural electrification counties, 85% of which are in remote and poverty-stricken regions	Medium. Initial investment is too high.	Medium. The electrification for the township level is urgent. PV station and SHP is appropriate in utilization.
Potential population benefited	100 million	320 million	30 million	200 thousand
Suitability/Viability/Sustainability				
Affordability	High. All the technologies are simple and the cost is low together with the subsidy from the government.	Medium. Some regions, SHP price is much lower than the large grid as the O&M cost is low.	Low (90% subsidized). Majority of the targeted population belong the extreme poor.	Low (100% subsidized. National debt plus fiscal subsidy from local government).
Effectiveness	High. Farmers benefit from the firewood saving, and the convenient from the biogas and solar energy.	High. SHP can address the primary electrification issue in less cost than grid extension.	High. The most economical and sustainable solution to the electricity access.	High. All of the townships are electrified currently.
Risk of obsolescence	Medium. Biogas is easy to be malfunctioned unless consumers are willing to continue to use it	Low. SHP can operate more than 50 years.	Medium. There is a need to guarantee O&M and concern about the sustainability in continuous adopting.	Management issue is urgent to be addressed.
Flexibility	Low	Medium. The construction is the only complex stage.	Medium	Medium
Technological capability	Medium	High. China is the leader in the design, construction, manufacturing etc.	Medium	Medium. The SHP is mature, however the PV module depend on the import.
Suitability and urgency	High	High. SHP is the priority China is adopting in the rural electrification program. It is also the largest installed capacity in China among RETs.	High	
Resilience	Low	Low	Low	
Adaptability	High	High	Medium	High. PV and SHP allows to secure the long-term utilization.
Environmental impacts	Positive. Clean the kitchen, save the firewood	Low. Civil construction work will have few impacts on the environment. Clean energy with no GHG emission, no flood damages.	Positive. PV and wind technologies have no GHG emission or environment pollution, or any impacts on the plantation.	Positive. SHP's civil construction work will have few impacts on the environment.

Experience (E) / **Criteria**	**E 1: Comprehensive Rural Energy Planning and Construction Program**	**E 2: Rural Electrification Program**	**E3: Brightness Program**	**E4: Township Electrification Program**
Social acceptance	High	High	High	High
CD requirements	Local capacity building is needed.	Local capacity building is needed.	Local capacity building is needed.	Local capacity building is needed.
Income generation	Medium. Biogas can bring the other economical production chains.	Medium	Medium.	Medium

Souce: Compiled by the author.

Appendix 11: China Renewable Energy Law

Table of Contents

Chapter 1. General

Article 1—In order to promote the development and utilization of renewable energy, improve the energy structure, diversify energy supplies, safeguard energy security, protect the environment, and realize the sustainable development of the economy and society, this Law is hereby prepared.

Article 2—Renewable energy in this law refers to non-fossil energy of wind energy, solar energy, water energy, biomass energy, geothermal energy, and ocean energy, etc.

Application of this Law in hydropower shall be regulated by energy authorities of the State Council and approved by the State Council.
This Law does not apply to the direct burning of straw, firewood and dejecta, etc. on low-efficiency stove.

Article 3—This Law applies to territory and other sea area of the People's Republic of China.

Article 4—The Government lists the development of utilization of renewable energy as the preferential area for energy development and promotes the construction and development of the renewable energy market by establishing total volume for the development of renewable energy and taking corresponding measures.

The Government encourages economic entities of all ownerships to participate in the development and utilization of renewable energy and protects legal rights and interests of the developers and users of renewable energy on the basis of law.

Article 5—Energy authorities of the State Council implement management for the development and utilization of renewable energy at the national level. Relevant departments of the State Council are responsible for the management of relevant development and utilization of renewable energy within their authorities.

Energy authorities of local people's governments above the county level are responsible for the management of the development and utilization of renewable energy within their own jurisdiction. Relevant departments of local people's governments above the county level are responsible for the management of relevant development and utilization of renewable energy within their authorities.

Chapter 2 Resource Survey and Development Plan

Article 6—Energy authorities of the State Council are responsible for organizing and coordinating national surveys and management of renewable energy resources, and work with related departments to establish technical regulations for resource surveys.

Relevant departments of the State Council, within their respective authorities, are responsible for related renewable energy resource surveys. The survey results will be summarized by the energy authorities in the State Council.

The result of the survey of renewable energy shall be released to the public, with the exception of confidential contents as stipulated by the Government.

Article 7—Energy authorities of the State Council sets middle and long-term target of the total volume for the development and utilization of renewable energy at the national level, which shall be implemented and released to the pubic after being approved by the State Council.

Energy authorities of the State Council shall, on the basis of the target of total volume in the previous paragraph, as well as the economic development and actual situation of renewable energy resources of all provinces, autonomous regions and municipalities, cooperate with people's governments of provinces, autonomous regions and municipalities in establishing middle and long-term target and release it to the public.

Article 8—Energy authorities of the State Council shall, on the basis of the middle and long-term total volume target of renewable energy throughout the country, prepare national renewable energy development and utilization plan, which is to be implemented after being approved by the State Council.

Energy authorities of the people's governments at the level of province, autonomous region and municipality shall, on the basis of the middle and long-term target for the development and utilization of renewable energy, cooperate with relevant authorities of the people's governments at their own level in preparing national renewable energy development and utilization plan for their own administrative regions, which shall be implemented after being approved by people's governments at their own level.

The approved plan shall be released to the public, with the exception of confidential content as stipulated by the government.

In case that the approved plan needs to be modified, approval of the original approving authorities shall be obtained.

Article 9—In preparing the plan for the development and utilization of renewable energy, opinions of relevant units, experts and the public shall be solicited and the scientific reasoning shall be done.

Chapter 3 Industry Guidance and Technology Support

Article 10—Energy authorities in the State Council shall, in accordance with the national renewable energy development plan, prepare and promulgate development guidance catalogs for renewable energy industries.

Article 11—Standardization authorities of the State Council shall set and publicize technical standard for renewable energy electric power and the technical standards for relevant renewable technology and products for which technical requirements need to be standardized at the national level.

For those technical requirements not dealt with in the national standard in the previous paragraph, relevant authorities of the State Council may establish relevant industrial standard, which shall be reported to the standardization authorities of the State Council for filing.

Article 12—The government lists scientific and technical research in the development and utilization of, and the industrialized development of, renewable energy, as the preferential area for hi-tech development and hi-tech industrial development in the national program, and allocates funding for the scientific and technical research, application demonstration and industrialized development of the development and utilization of renewable energy so as to promote technical advancement in the development and utilization of renewable energy, reduce the production cost of renewable energy products and improve the quality of products.

Education authorities of the State Council shall incorporate the knowledge and technology on renewable energy into general and occupational education curricula.

Chapter 4 Promotion and Application.

Article 13—The Government encourages and supports various types of grid-connected renewable power generation.

For the construction of renewable energy power generation projects, administrative permits shall be obtained or filing shall be made in accordance with the law and regulations of the State Council.

In the construction of renewable power generation projects, if there is more than one applicant for project license, the licensee shall be determined through a tender.

Article 14—Grid enterprises shall enter into grid connection agreement with renewable power generation enterprises that have legally obtained administrative license or for which filing has been made, and buy the grid-connected power produced with renewable energy within the coverage of their power grid, and provide grid-connection service for the generation of power with renewable energy.

Article 15—The Government supports the construction of independent renewable power systems in areas not covered by the power grid to provide power service for local production and living.

Article 16—The Government encourages clean and efficient development and utilization of biological fuel and encourages the development of energy crops.

If the gas and heat produced with biological resources conform to urban fuel gas pipeline networks and heat pipeline networks, enterprises operating gas pipeline networks and heat pipeline networks shall accept them into the networks.

The Government encourages the production and utilization of biological liquid fuel. Gas-selling enterprises shall, on the basis of the regulations of energy authorities of the State Council or people's government at the provincial level, include biological liquid fuel conforming to the national standard into its fuel-selling system.

Article 17—The Government encourages workplaces and individuals in the installation and use of solar energy utilization systems of solar energy water-heating system, solar energy heating and cooling system and solar photovoltaic system, etc.

Construction authorities of the State Council shall cooperate with relevant authorities of the State Council in establishing technical economic policies and technical standards with regard to the combination of solar energy utilization system and construction.

Real estate development enterprises shall, on the basis of the technical standards in the previous paragraph, provide necessary conditions for the utilization of solar energy in the design and construction of buildings.

For buildings already built, residents may, on the condition that its quality and safety is not affected, install solar energy utilization system that conform to technical stdnards and product standards, unless agreement has been otherwise reached between relevant parties.

Article 18—The Government encourages and supports the development and utilization of renewable energy in rural areas.

Energy authorities of local people's governments above the county level shall, on the basis of local economic and social development, ecological protection and health need, etc., prepare renewable energy development plan for the rural area and promote biomass energy like the marsh gas, etc. conversion, household solar energy, small-scale wind energy and small-scale hydraulic energy, etc.

People's government above the county level shall provide financial support for the renewable energy utilization projects in the rural areas.

Chapter 5 Price Management and Fee Sharing

Article 19—Grid power price of renewable energy power generation projects shall be determined by the price authorities of the State Council in the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable, where timely adjustment shall be made on the basis of the development of technology for the development and utilization of renewable energy. The price for grid-connected power shall be publicized.

For the price of grid-connected power of renewable power generation projects determined through tender as stipulated in the 3rd paragraph of Article 13 hereof, the bid-winning price shall be implemented; however, such a price shall not exceed the level of grid-connected power of similar renewable power generation projects.

Article 20—The excess between the expenses that power grid enterprises purchase renewable power on the basis of the price determined in Article 19 hereof and the expenses incurred in the purchase of average power price generated with conventional energy shall be shared in the selling price. Price authorities of the State Council shall prepare specific methods.

Article 21—Grid connection expenses paid by grid enterprises for the purchase of renewable power and other reasonable expenses may be included into the grid enterprise power transmission cost and retrieved from the selling price.

Article 22—For the selling price of power generated from independent renewable energy power system invested or subsidized by the Government, classified selling price of the same area shall be adopted, and the excess between its reasonable operation, management expenses and the selling price shall be shared on the basis of the method as specified in Article 20 hereof.

Article 23—The price of renewable heat and natural gas that enters the urban pipeline shall be determined on the basis of price management authorities in the principle of being beneficial to the development and utilization of renewable energy and being economic and reasonable.

Chapter 6 Economic Incentives and supervisory measures

Article 24—The Government budget establishes renewable energy development fund to support the following:

1. Scientific and technological research, standard establishment and pilot project for the development and utilization of renewable energy;
2. Construction of renewable energy projects for domestic use in rural and pasturing areas;
3. Construction of independent renewable power systems in remote areas and islands;
4. Surveys, assessments of renewable energy resources, and the construction of relevant information systems;
5. Localized production of the equipment for the development and utilization of renewable energy.

Article 25—Financial institutions may offer preferential loan with financial interest subsidy to renewable energy development and utilization projects that are listed in the national renewable energy industrial development guidance catalogue and conform to the conditions for granting loans.

Article 26—The Government grants tax benefits to projects listed in the renewable energy industrial development guidance catalogue, and specific methods are to be prepared by the State Council.

Article 27—Power enterprises shall authentically and completely record and store relevant materials of renewable energy power generation, and shall accept the inspection and supervision of power supervisory institutions.

Power supervisory institutions shall do the inspection in accordance with stipulated procedures, and shall keep commercial secret and other secret for inspected units.

Chapter 7 Legal Responsibilities

Article 28—If energy authorities of the State Council and the people's governments above the county level as well as other relevant authorities breach this Law and have one of the following, people's government of their own level or relevant authorities of the superior people's governments may order them to make correction, and impose administrative penalty for competent personnel that are liable and other personnel directly liable; in case that such breaches constitute crime, criminal liabilities shall be legally pursued.

1. Failure to make administrative licensing decision in accordance with law;
2. Failure to make an investigation when illegal activities are dicovered;
3. Other acts of not legally performing supervision and management responsibilities.

Article 29—If the power grid enterprises breach Article 14 hereof and fail to purchase renewable power in full, which results in economic loss to the renewable power generation enterprises, such power grid enterprises shall be liable for compensation, and the national power supervisory institutions shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than the economic loss of the renewable power generation enterprises shall be imposed.

Article 30—In case that enterprises of natural gas pipeline network and heat pipeline network breach paragraph 2 of Article 16 hereof and do not permit the connection of natural gas and heat that conform to the grid connection technical standard into the network, which results in economic loss to the gas and heat production enterprises, relevant enterprises shall be liable for compensation, and energy authorities of the people's government at the provincial level shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than said economic loss shall be imposed against them.

Article 31—If gas-selling enterprises breach paragraph 3 of Article 16 hereof and fail to include biological liquid fuel that conforms to the national standard into its fuel-selling system, which results in economic loss to the biological liquid fuel production enterprises, relevant enterprises shall be liable for compensation, and energy authorities of the State Council or people's government at the provincial level shall order them to make correction within a stipulated period of time; in case of refusal to make correction, a fine of less than said economic loss shall be imposed against them.

Chapter 8 Miscellaneous

Article 32—Terms used herein shall have the following meanings:

1. Biomass energy: means energy converted from natural plants, rejecta as well as urban and rural organic waste.
2. Renewable energy independent power system: means independent renewable power system not connected to the power grid.
3. Energy crop: means herbage and wood plants specially planted and used as raw materials of energy.
4. Biological liquid fuels: means methanol, ethanol, bio-diesel and other liquid fuels derived from biomass resources.

Article 33—This Law shall become effective on Jan 1st, 2006.