Renewable Energy Policy in Remote Rural Areas of Western China: Implementation and Socio-economic Benefits

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ABSTRACT

Electricity is essential for rural development. In 2005, 1.6 billion people, around a quarter of the world's population, living mostly in rural areas of developing countries, had no access to electricity. In general, remote rural areas in developing countries have little prospect of having access to grid-based electricity, which usually only extends to densely populated urban areas, where a large customer base justifies heavy expenditure for electricity infrastructure. One option for electrification in remote rural areas is to decentralize electricity systems based on renewable energy sources. However, such an option is not universally agreed upon. This dissertation examines a renewable energy-based rural electrification program, the 'Township Electrification Program', launched by the Chinese government in 2002. The Program was implemented in 1013 non-electrified townships in remote rural areas of 11 western provinces, providing electricity for 300,000 households and 1.3 million people. And at the time of research, the Program was known as the world's largest renewable energy-based rural electrification program in terms of investment volume ever carried out by a country.

Two townships, Saierlong Township in Qinghai Province and Namcuo Township in Tibet Autonomous Region, were selected as cases for an in-depth examination of rural electrification practices in remote rural areas of western China. Both qualitative (interviews, observations, mapping, and transition walk) and quantitative (household survey) methods were applied in the field to collect data.

The main findings of the study are summarized as follows: First, political leaders' concern over the unequal economic development of eastern and western China, as well as rural and urban areas, was the main factor triggering inclusion of the policy issue, electricity access in remote rural areas of western China, in the government's policy agenda. Second, like other energy policies, the formulation and adoption of the 'Township Electrification Program' followed a 'centralized and closed top-down' approach within China's communist political framework conditions, which ultimately resulted in pursuing political leaders' conceptions instead of the energy needs of local people. Third, the implementation of the Program possessed a technical orientation (e.g. construction of stations, installation of systems), and underestimated the financial implications (e.g. electricity tariff, households' ability to pay electricity fee, financial management) as well as human resources available (e.g. training for operators, household participation) and institutional capacity building (e.g. good governance, regulatory framework) at the local level.

Fourth, there was a change of households' energy use pattern from traditional energy sources (such as candles and dry cell batteries) to electricity from solar PV power stations in the two investigated townships. But traditional energy sources were not totally substituted by electricity. This is due to the fact that the current electricity supply was not sufficient for households' needs and electricity was not provided daily on a regular basis. Households still had to rely on traditional energy sources. Fifth, the impacts of the Program on the improvement of socio-economic benefits for households, the improvement of township development, and the reduction of negative environmental impacts were limited. Lastly, based on these findings, this study suggests policy recommendations for the Chinese government as well as policy implications for developing countries.

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Isaiah 40: 28-31

28 The LORD is the everlasting God,
the Creator of the ends of the earth.
He does not faint or grow weary;
his understanding is unsearchable.
29 He gives power to the faint,
and strengthens the powerless.
30 Even youths will faint and be weary,
and the young will fall exhausted;
31 but those who wait for the LORD shall renew their strength,
they shall mount up with wings like eagles,
they shall run and not be weary,
they shall walk and not faint.

Psalm 23

1 The LORD is my shepherd, I shall not want.
2 He makes me lie down in green pastures;
he leads me beside still waters;
3 he restores my soul.
He leads me in right paths for his name's sake.
4 Even though I walk through the darkest valley,
I fear no evil; for you are with me;
your rod and your staff — they comfort me.
5 You prepare a table before me in the presence of my enemies;
you anoint my head with oil; my cup overflows.
6 Surely goodness and mercy shall follow me all the days of my life,
and I shall dwell in the house of the LORD my whole life long.
(Bible, New Revised Standard Version)

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LIST OF ABBREVIATIONS

A	Ampere
AC	alternating current
ADB	Asian Development Bank
Ah	Ampere-hour
APC	African, Caribbean, and Pacific States
AR	Autonomous Region
BCC	Beijing Corona Corporation
BMZ	Federal Ministry for Economic Cooperation and Development (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung)
CAS	Chinese Academy of Sciences
CASS	Chinese Academy of Social Sciences
CDIAC	Carbon Dioxide Information Analysis Center
CO2	Carbon dioxide
CPC	Communist Party of China
DC	direct current
df	degree of freedom
DFID	Department for International Development
ESMAP	Energy Sector Management Assistance Program
EU	European Union
FASID	Foundation for Advanced Studies on International Development
GDP	Gross Domestic Product
GDRC	Global Development Research Center
Gtce	gigatones of carbon equivalent
GTZ	German Agency for Technical Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit)
GW	gigawatt (1 Watt x 109)
HDI	Human Development Index

IEA	International Energy Agency
Inwent	Capacity Building International, Germany (Internationale Weiterbildung und Entwicklung gGmbH)
KfW	Kreditanstalt für Wiederaufbau
km	kilometer
km2	square kilometer
KMT	Kuomintang (Chinese Nationalist Party)
kW	kilowatt
kWh	kilowatt-hour
kWp	kilowatt peak
LPG	liquefied petroleum gas
MDGs	Millennium Development Goals
Mtce	million tones of coal equivalent
MW	megawatt (1 Watt x 106)
MWp	megawatt peak
NBSC	National Bureau of Statistics of China
NCCPC	National Congress of Communist Party of China
NDRC	National Development and Reform Commission
NGOs	Non-governmental organizations
NOX	mono-nitrogen oxides
NPC	National People’s Congress
NREL	National Renewable Energy Laboratory
OECD	Organization for Economic Co-operation and Development
PDRC	Provincial Development and Reform Commission
PPP	Purchasing Power Parity
PR China	People’s Republic of China
PV	Photovoltaic
QNEC	Qinghai New Energy Corporation

RMB	Renminbi (CNY, Chinese Yuan)
ROI	Return of Investment
SAR	Special Administrative Region
SCORES	State Council Office for Restructuring the Economic System
SDPC	State Development Planning Commission
SETC	State Economic and Trade Commission
SO2	Sulfur dioxide
SPC	State Planning Commission
SSTC	State Science and Technology Commission
TW	terawatt (1 Watt x 1012)
TWh	Terawatt-hour
UKDFID	UK Department for International Development
UN	United Nations
UNDESAR	United Nations Development of Economic and Social Affairs
UNDP	United Nations Development Programme
UNESC	United Nations Economic and Social Commission
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
V	Voltage (Volt)
VAC	Volts of alternating current
W	Watt
WEC	World Energy Council
Wp	Watt peak

DEUTSCHE ZUSAMMENFASSUNG

Die Politik erneuerbarer Energien in entlegenen, ländlichen Gebieten Westchinas: Implementierung und sozio-ökonomische Vorteile

Hintergrund

Im Jahr 2005 hatten 1,6 Milliarden Menschen auf der Welt keinen Zugang zu Elektrizität. Dies entsprach etwa einem Viertel der Weltbevölkerung, von dem die meisten Menschen aus ländlichen Gebieten in Entwicklungsländern stammten. Elektrizität dient als Grundlage für die Befriedigung grundlegender menschlicher Bedürfnisse wie beispielsweise die Zubereitung von Nahrung, die Wasserversorgung und die Gewährleistung ausreichender Angebote im Bildungs- oder Gesundheitsbereich. Zugang zu Strom ist auch in vielerlei Hinsicht ein direkter und indirekter Einflussfaktor hinsichtlich der Erreichung mehrerer Millennium Development Goals (MDGs) der Vereinten Nationen.

Die meisten Regierungen von Entwicklungsländern räumen der ländlichen Elektrifizierung für die Erfüllung ihrer wirtschaftlichen, sozialen, politischen und regionalen Entwicklungsziele eine hohe Priorität ein. Allerdings besteht in abgelegenen, ländlichen Gebieten in Entwicklungsländern wenig Aussicht auf Zugang zu Strom aus der Steckdose. Elektrifizierung mit Hilfe von Übertragungsnetzen lohnt sich in der Regel nur in dicht besiedelten, städtischen Gebieten, in denen eine große Kundenbasis die erheblichen Ausgaben für die Netzinfrastruktur rechtfertigt. Eine alternative Möglichkeit zur Elektrifizierung in abgelegenen, ländlichen Gebieten stellen dezentrale Stromsysteme auf der Basis erneuerbarer Energieträger dar. Eine derartige Lösung stößt allerdings bis heute noch nicht überall auf breite Akzeptanz. Tatsächlich ist zu diskutieren, ob eine auf erneuerbaren Energien basierende ländliche Elektrifizierung einfacher durchführbar, billiger und weniger problematisch ist als herkömmliche Lösungen der zentralen Energieerzeugung aus fossilen Brennstoffen, Wasserkraft oder Atomkraft und der anschließenden Stromverteilung über eine Netzinfrastruktur.

Im Jahr 2002 startete die chinesische Regierung das „Township Electrification Programm“. Durch dieses Programm wurde überhaupt erst anerkannt, dass weiterhin

12,9 Millionen Menschen meist in abgelegenen, ländlichen Gebieten Chinas ohne Zugang zu Stromnetzen leben. Dem Investitionsvolumen nach zu urteilen handelt es sich bei diesem Programm um das weltweit größte Projekt ländlicher Elektrifizierung mit Hilfe erneuerbarer Energien. Insgesamt wurden für 1013 bisher nicht elektrifizierte Gemeinden in 11 westlichen chinesischen Provinzen der Zugang zu Strom für 300.000 Haushalte, insgesamt 1,3 Millionen Menschen, geschaffen.

Über die Durchführung des ehrgeizigen Projektes in den ländlichen Gebieten gab es bisher nur begrenzte Informationen, insbesondere aber mangelt es an Studien hinsichtlich der Auswirkungen des Programms auf das Leben der ländlichen Bevölkerung. Es ist Ziel dieser Arbeit, diese Wissenslücke zu füllen und die Umsetzung, Ergebnisse und Auswirkungen des ‚Township Electrification Programms' zu analysieren. Die Ergebnisse dieser Studie liefern dabei Erkenntnisse hinsichtlich der generellen Machbarkeit, der Kosten und der Praktikabilität einer Elektrifizierung des ländlichen Raums in Entwicklungsländern mit Hilfe dezentraler Stromerzeugung durch erneuerbare Energieträger. Die geschilderten Erfahrungen bieten darüber hinaus konkrete Anregungen für die erfolgreiche Gestaltung weiterer derartiger Programme in China und anderen Entwicklungsländern.

Forschungsziele

Die Ziele dieser Studie lauten wie folgt:

1) Analyse der politischen Hintergründe zur Konzeption und Erarbeitung des Township Electrification Programms in der Volksrepublik China;
2) Analyse der Umsetzung des „Township Electrification Programms" in abgelegenen ländlichen Gebieten Westchinas;
3) Analyse der konkreten Nachfrage nach Strom durch die lokale Bevölkerung sowie die empfundenen Vorteile und Probleme des Township Electrification Programms durch diese;
4) Analyse der Auswirkungen des Township Electrification Programms auf die örtliche Bevölkerung, deren Gemeinden und die Umwelt;
5) Ausarbeitung von Empfehlungen für die chinesische Regierung auf Grundlage der gewonnenen wissenschaftlichen Erkenntnisse;

6) Diskussion der Implikationen der Erfahrungen mit dem chinesischen Township Electrification Programm für andere Entwicklungsländer.

Fragestellungen

Diese Studie zielt darauf ab, die folgenden Forschungsfragen zu beantworten:

1) Wann und aus welchen Gründen gewann der Zugang zu Strom in den ländlichen Regionen Westchinas die Aufmerksamkeit der chinesischen Politik? Welche Gründe spielten eine Rolle dabei, dass die chinesische Regierung auf eine Elektrifizierung mit Hilfe dezentraler, erneuerbarer Energien, nicht aber auf eine Energieerzeugung mit fossilen Brennstoffen und einem Ausbau des Übertragungsnetzes setzte? Aus welchen Gründen startete die chinesische Regierung im Jahr 2002 zur Lösung der Elektrifizierungsfrage das Township Electrification Programm?
2) Wie geschah die Formulierung und Verabschiedung des Township Electrification Programms innerhalb des politischen Rahmens der VR China? Was sind die Vor- und Nachteile einer solchen "zentralisierten Initiative des öffentlichen Sektors“?
3) Welche Resultate und Probleme sind mit der Umsetzung des Township Electrification Programms verbunden? Was sind die Faktoren, die die Nachhaltigkeit des Programms beeinflussen?
4) Was sind die „Outputs“ (Leistungen und Erträge) des Township Electrification Programms?
5) Was sind die „Outcomes“ (Resultate) des Township Electrification Programms? Inwieweit hat das Programm die Energieverbrauchsmuster in den Haushalten von traditionellen Energiequellen hin zur Stromerzeugung durch Solar-Photovoltaik (PV)-Anlagen verändert?
6) Was sind die „Impacts“ (Auswirkungen) des Township Electrification Programms? In welchem Umfang hat das Programm auf lokaler Ebene zu sozio-ökonomischen Vorteilen für die privaten Haushalte, Entwicklung in den Gemeinden und nachhaltigem Umweltschutz beigetragen?
7) In welchem Umfang hat das Township Electrification Programm das Kriterium der nachhaltigen Energieversorgung in abgelegenen, ländlichen Gebieten Westchinas erfüllt?

Methodik

Die Studie basiert auf der Kombination von einer Analyse bestehender Datenquellen sowie eigener Feld- und Marktforschung. Für die Sammlung der notwendigen Informationen und die Erhebung der Daten wurden dabei sowohl qualitative (Interviews, Beobachtungen, Kartierungen und Begehungen) als auch quantitative (Haushaltsbefragung) Methoden angewendet. Zwei Gemeinden, Saierlong in der Provinz Qinghai und Namcuo in der Autonomen Region Tibet (Tibet AR), wurden für diese Studie als Fälle ausgewählt, um die ländliche Elektrifizierung in entlegenen, ländlichen Gebieten Westchinas im Detail zu analysieren.

Forschungsrahmen

Die Analyse des Township Electrification Programms basiert konzeptionell auf dem „Policy Process-Modell“ (Dye, 1998; Dunn, 1994; Anderson, 1975). Der „Policy Process“ (Politikprozess) besteht in der Definition dieser Studie aus folgenden Phasen: Erkennung des Problems durch die Politik, Politische Programmformulierung und Verabschiedung, Programmumsetzung und Politikbewertung dieser (sowie ihrer „Outputs“, „Outcomes“ und „Impacts“).

Die Ergebnisse der Forschung

Die Ergebnisse dieser Studie sind im Folgenden analog zu den oben aufgeführten Forschungsfragen erläutert.

1) Die Erkennung des Problems durch die Politik

Stromzugang für abgelegene, ländliche Gebiete in Westchina rückte im Jahr 2000 in die Aufmerksamkeit der chinesischen Regierung. Die Politiker zeigten sich damals besonders besorgt über die ungleiche wirtschaftliche Entwicklung zwischen Ost- und Westchina sowie zwischen ländlichen und städtischen Gebieten und das darin vorhandene Potential für soziale Instabilität, eine Gefahr für die Herrschaft der Kommunistischen Partei Chinas. In dem Bestreben, dieser existierenden

Entwicklungskluft entgegenzuwirken sowie ihren nationalen Entwicklungsplan zur Förderung erneuerbarer Energiequellen zu erfüllen, entschied sich die chinesische Regierung für die Elektrifizierung der ländlichen Regionen mittels erneuerbarer Energiequellen und dezentraler Lösungen.

Seit 2000 wurden von der chinesischen Regierung zur Lösung des Problems des Stromzugangs in ländlichen Gebieten mehrere Initiativen, beispielsweise das „Brightness Programm“, und Projekte der internationalen Zusammenarbeit ins Leben gerufen. Diese nur auf bestimmte Bereiche und Regionen begrenzten Initiativen waren allerdings nicht in der Lage, das im 10. Nationalen Fünfjahresplan (2001-2005) eingestellte Ziel von Stromzugang für eine Million Haushalte in abgelegenen, ländlichen Gebieten zu erreichen. Aus diesem Grund hat im Jahr 2002 die chinesische Regierung das Township Electrification Programm aufgesetzt, mit dem Haushalte in abgelegenen, ländlichen Gebieten der elf westlichen Provinzen Stromzugang auf Basis von erneuerbaren Energien ermöglicht wurde. Gemessen am Investitionsvolumen handelt es sich bei diesem Programm zur ländlichen Elektrifizierung um das weltweit größte, das auf erneuerbaren Energien basiert.

2) Politische Programmformulierung und Verabschiedung

Die kommunistische Partei Chinas hat einen erheblichen Einfluss auf den Prozess der Formulierung und Verabschiedung politischer Strategien in China, und auch in der Energiewirtschaft spielt die chinesische Regierung eine dominante Rolle. Wie die restliche Energiepolitik folgte daher auch die Formulierung und Verabschiedung des Township Electrification Programms einem zentralisierten top-down Ansatz. Da demokratische Mechanismen für die Beteiligung der Öffentlichkeit an der Formulierung und der Verabschiedung der Politik im kommunistischen China fehlen, sind in den Township Electrification Programmen die Bedürfnisse der lokalen Bevölkerung und anderer Akteure der ländlichen Gebiete im westlichen China nur geringfügig berücksichtigt. Das Programm wurde von der Nationalen Entwicklungs- und Reformkommission (National Development and Reform Commission, NDRC) des Staatsrats (State Council) entworfen und vom Staatsrat angenommen.

Eine zentralisierte, öffentliche Energieinitiative wie das Township Electification

Programm hat eine Reihe von Vorteilen: Durchgeführt von der chinesischen Regierung, ist das Programm finanziell sehr gut ausgestattet und trägt zur Elektrifizierung der ländlichen Gebiete in Westchina massiv bei. Neben diesen Vorteilen, birgt es jedoch auch einige Nachteile: Aufgrund der staatlichen Monopolstellung entsteht bei der Durchführung keinerlei Wettbewerb. Erfahrungsgemäß führt dies dazu, dass die Stromversorgung dadurch oft ineffizient, intransparent, von schlechter Qualität und daher ressourcenverschwendend ist. Zudem führt ein derartiger Ansatz des Projektes zu Korruptionsrisiken zwischen verschiedenen staatlichen Stellen und den privaten Vertragspartnern bei der Durchführung der Aufgaben. Schließlich fehlt in dem Prozess der politischen Programmformulierung und Verabschiedung eine Partizipation der lokalen Ebene, welche für den Erfolg einer derartigen zentralisierten, öffentlichen Energieinitiative wichtig ist.

3) Programmumsetzung

Bis zum Jahr 2004 wurden im Rahmen des Township Electrification Programms 670 Solar-PV-Anlagen und 51 Solar-PV/Wind-Hybrid-Anlagen gebaut und somit die Stromversorgung von 644 bisher nicht elektrifizierten Gemeinden mit 70.000 Haushalten und 340.000 Einwohnern sichergestellt. Neben dieser Nutzung der Sonnenenergie und Windkraft zur ländlichen Elektrifizierung wurden 146 Kleinwasserkraftwerke in neun westlichen Provinzen gebaut und so die Stromversorgung von weiteren 369 bisher nicht elektrifizierten Gemeinden mit 230.000 Haushalten und 960.000 Einwohnern erreicht.

Bei der Durchführung zeigte sich eine starke technische Ausrichtung des Programms (Bau der Stationen und Installation der Systeme) bei einer gleichzeitigen Unterschätzung der Probleme hinsichtlich der lokalen finanziellen und personellen Ressourcen sowie der lokalen institutionellen Kapazitäten. In den beiden untersuchten Gemeinden Saierlong (Provinz Qinghai) und Namcuo (Tibet AR) wurden verschiedene Probleme hinsichtlich der Finanzen festgestellt. Zu nennen sind z.B. unerschwingliche Strompreise, ungeeignete Erhebungsmethoden der Stromgebühren, fehlende finanzielle Ressourcen und grundsätzliche mangelnde Bereitschaft der privaten Haushalte für den Strom zu zahlen, Mängel in der Administration der gesammelten Stromgebühren sowie zu geringer und unregelmäßiger Lohn für die lokalen Betreiber, hinsichtlich der personellen Kapazitäten eine fehlende Ausbildung der Betreiber und mangelnde Beteiligung der Haushalte und Gemeinden an dem Programm und hinsichtlich dem Aufbau institutioneller Kapazitäten ein Mangel an Good Governance in Bezug auf institutionelle Rahmenbedingungen, den rechtlichen Rahmen und die öffentliche Verwaltungsstruktur. Die drei genannten Faktoren haben erhebliche Auswirkungen auf die Nachhaltigkeit der Elektrizitätsversorgung in beiden untersuchten Gemeinden. Die Nachhaltigkeit des Programms wurde nicht nur durch dessen technische Realisierung beeinflusst, sondern war auch erheblich von den finanziellen und personellen Ressourcen sowie den institutionellen Kapazitäten auf lokaler Ebene abhängig.

4) Politikbewertung – Erträge und Outputs

Grundsätzlich bestehen drei verschiedene Möglichkeiten, die Resultate der Politik zu bewerten: Outputs, Outcome und Impact. Alle drei Ansätze sind in dieser Studie zur Bewertung des Township Electrification Programms herangezogen worden.

Outputs des politischen Programms bewerten Waren, Dienstleistungen oder Ressourcen, welche von den Zielgruppen bzw. Begünstigten erhalten wurden. Zwei Variablen wurden in dieser Studie zur Messung der Outputs des Township Electrification Programms in den beiden untersuchten Gemeinden verwendet: "Stromversorgungsmenge" und "Versorgungsqualität" der Solar-PV-Anlagen. Als Resultat der Studie konnten bezüglich dieser Variablen fünf Ergebnisse identifiziert werden:

Erstens wurden nicht alle Haushalte der beiden Gemeinden an die Stromversorgung durch die durch das Programm erbauten Solar-PV-Anlagen angeschlossen, die erreichte Quote beträgt in Namcuo 98,2%, in Saierlong nur 74%. Zweitens erreichte das Programm nicht das gesteckte Ziel einer installierten Kapazität von 100W pro Person. In Saierlong wurde 25W pro Person im Jahr 2003 und 17W pro Person im Jahr 2007 erreicht. In Namcuo wurde 100W pro Person im Jahr 2003 und 71W pro Person im Jahr 2007 erreicht. Drittens konnten mit der erreichten Stromversorgung nicht die Bedürfnisse der privaten Haushalte befriedigt werden. Durchschnittlich 77% der Haushalte in beiden Gemeinden beurteilte die Stromversorgung durch die Solar-PV-Anlagen als unzulänglich. Viertens war die Stromversorgung nicht regelmäßig, die tägliche Dauer der Stromversorgung schwankte. In Namcuo wurde eine Stromversorgung von 5 Tagen pro Woche, in Saierlong von 3,5 Tagen pro Woche erreicht. In Namcuo konnte eine Stromversorgung von konstant täglich sechs Stunden pro Tag erreicht werden. In Saierlong sank die Stromversorgung im Laufe der drei Jahre von täglich 12 Stunden auf nur 3 Stunden. In beiden Gemeinden waren die Haushalte nicht in der Lage, die Anfangs- und Endzeit der täglichen Stromversorgung vorab zu bestimmen. Fünftens hat die unzuverlässige Versorgungsqualität zu einer geringen Zufriedenheit hinsichtlich der Stromversorgung geführt. Im Durchschnitt waren in beiden Gemeinden nur 21,7% der Haushalte mit der Versorgungsqualität der Solar-PV-Anlagen zufrieden. Die Beschwerden der Haushalte hinsichtlich der Versorgungsqualität drehten sich alle um die mangelnde Zuverlässigkeit der Stromversorgung. Dieses Ergebnis widerspricht dem politischen Ziel des Township Electrification Programms, zuverlässige Stromversorgung für die ländliche Bevölkerung in abgelegenen Gebieten zu gewährleisten.

5) Politikbewertung – Resultate und Outcomes

Outcomes des politischen Programms bewertet die tatsächliche Veränderung von Verhaltensweisen oder Einstellungen, die sich aus den Outputs ergeben haben. Als Variable zur Messung der direkten Outcomes des Township Electrification Programms in den beiden untersuchten Gemeinden wurde die Veränderung des Energieverbrauchmusters der Haushalte von traditionellen Energiequellen (wie Kerzen und Batterien) hin zu Strom von Solar-PV-Anlagen verwendet. Die Ergebnisse zeigen, dass es nach der Umsetzung des Programms zu einer Veränderung der Energieverbrauchsmuster der privaten Haushalte weg von traditionellen Energiequellen hin zur Stromerzeugung aus Solar-PV-Anlagen gekommen ist. Nach der erfolgten Elektrifizierung durch das Programm nutzten alle untersuchten Haushalte in beiden Gemeinden Strom aus den Solar-PV-Anlagen. Traditionelle Energiequellen wurden dadurch jedoch nicht vollständig ersetzt. In Saierlong verwenden alle untersuchten Haushalte weiterhin Kerzen für Licht, 76,8% der Haushalte nutzen Batterien zur Beleuchtung und für den Betrieb elektrischer Geräte. In Namcuo verwenden 89,1% der untersuchten Haushalte weiterhin Kerzen für Licht, 87,3% der Haushalte nutzen Batterien zur Beleuchtung und für den Betrieb elektrischer Geräte. Grundsätzlich bleiben die Haushalte auch nach der Durchführung des Programms weiterhin auf herkömmliche Energiequellen wie Kerzen und Batterien angewiesen.

Das Ausmaß der Energiegewinnung aus herkömmlichen Energiequellen für Beleuchtung und zum Betrieb elektrischer Geräte wird nach der Elektrifizierung jedoch deutlich reduziert, insbesondere gilt dies für die Verwendung von Kerzen. Die durchschnittliche Anzahl der für die Beleuchtung verwendeten Kerzen sank in Saierlong von 16,02 Kerzen pro Monat und Haushalt vor der Elektrifizierung auf 1,71 Kerzen danach. In Namcuo sank die Anzahl der Kerzen von 31,82 pro Monat und Haushalt auf 8,73 Kerzen danach. Die durchschnittliche Zahl der verwendeten Batterien zur Beleuchtung und für den Betrieb elektrischer Geräte sank hingegen in Saierlong nur sehr geringfügig von 1,79 Batterien pro Monat und Haushalt vor der Elektrifizierung auf 1,71 Batterien danach. In Namcuo sank die Zahl von 4,35 Batterien pro Monat und Haushalt auf 2,51 Batterien danach.

Neben diesen direkten Resultaten (Outcomes) des politischen Programms können weitere, indirekte Resultate des Township Electrification Programms festgestellt werden, wie eine zusätzliche explorative Studie ergab. Die Ergebnisse zeigen keine statistisch signifikante Veränderung von Arbeitszeit und Freizeit in beiden untersuchten Gemeinden vor und nach der Elektrifizierung. Jedoch konnte festgestellt werden, dass die Haushalte oft 1,5 Stunden später zu Bett gingen und so nach der Elektrifizierung zusätzliche „wache“ Stunden am Abend hatten. Die Elektrifizierung veränderte außerdem die Freizeitbeschäftigungen der Haushalte von Gesprächen und Besuchen in der Nachbarschaft vor der Elektrifizierung zu Fernsehen und Lesen danach.

6) Politikbewertung – Auswirkungen und Impacts

Eine Impact-Analyse eines politischen Programms bewertet die langfristigen Auswirkungen dessen im Verhältnis zur angestrebten Zielerreichung. Drei Variablen wurden in dieser Studie verwendet, um die Langzeitauswirkungen des Township Electrification Programms in den beiden untersuchten Gemeinden zu messen: Verbesserung der sozio-ökonomischen Situation der privaten Haushalte, Verbesserung der Entwicklung der Gemeinden sowie ihre Umweltverträglichkeit.

Auf der Ebene der Privathaushalte führte das Programm in den untersuchten Gemeinden zu einer „geringen“ Verbesserung der sozio-ökonomischen Situation. Das Programm brachte keine signifikanten ökonomischen Vorteile für die Haushalte, wie eine Zunahme der Einkommen (nur 25% der untersuchten Haushalte bejahten dies) oder eine Zunahme von Beschäftigungsmöglichkeiten (nur 16,25% der Haushalte bejahten dies). Dies liegt daran, dass die Verwendung des Solarstroms nur für private Zwecke gestattet wurde. Dem gegenüber brachte das Programm einige Vorteile hinsichtlich der sozialen Situation der Haushalte wie die Zunahme der Unterhaltungsmöglichkeiten (76,7% der Haushalte bejahten dies), den verbesserten Zugang zu Nachrichten und Informationen (72,25%), die Verbesserung der persönlichen Sicherheit (60,45%), die höhere Flexibilität in der zeitlichen Gestaltung häuslicher Aufgaben (57,7%) und die Effizienzsteigerung bezüglich häuslicher Aufgaben (56,9%).

Auf Gemeindeebene führte das Programm zu einer „geringen“ Verbesserung der Entwicklung beider untersuchten Gemeinden. Dies beinhaltet vor allem die Verbesserung der Bildung (91,85% der Haushalte bejahten dies), was durch die zusätzliche Stromversorgung durch die Solar-PV-Anlagen für Schulen, den der Rest der öffentlichen und sozialen Einrichtungen nicht hatte, zu erklären ist. Aus diesem Grund geringer war daher die Beurteilung der Verbesserung der Gesundheitsversorgung (52,2%), der Administration (42,35%), der Veterinärdienste (46,38%), der Beschäftigungsmöglichkeiten (35,25%), und der Chancen für kleine Unternehmen (60,7%). Obwohl die Solarenergie eine umweltfreundliche Art der Stromerzeugung ohne Treibhausgasemissionen darstellt, waren die tatsächlichen positiven Auswirkungen des Programms auf die Umwelt sehr beschränkt. Durch die nur kaum abgenommene Verwendung von Batterien nach der Elektrifizierung konnte durch das Programm nur wenig zur Abnahme der Negativ-Folgen unsachgemäßer Entsorgung von Batterien beigetragen werden.

Schlussfolgerungen

Ländliche Programme zur Elektrifizierung wurden oft dafür kritisiert, vor allem nicht-Arme und besser gestellte Gemeinden, die in der Lage sind, sich den Strom zu leisten, zu bevorzugen (World Bank, 2008). Im Gegensatz dazu konzentrierte sich das Township Electrification Programm ausdrücklich auf die Menschen mit den geringsten Chancen für einen Zugang zu elektrischem Strom, insbesondere um Arme in nicht elektrifizierten Gemeinden in entlegenen ländlichen Gebieten Westchinas. Die Zielsetzung des Programms war dabei nicht nur rein wirtschaftlich, wie die Erzielung einer guten Kapitalrendite oder eines guten Kosten-Nutzen-Verhältnisses, sondern auch sozial, wie Armutslinderung und die Verbesserung der Lebensbedingungen. Hauptzielgruppe des Programms waren daher die Armen in weniger wohlhabenden Regionen Chinas.

Wie jedoch im Rahmen der Studie herausgefunden werden konnte, hat das Programm nicht zu einer signifikanten Verbesserung der sozio-ökonomischen Bedingungen oder Armutsminderung der Menschen geführt. Dies liegt daran, dass die Stromversorgung unzuverlässig, unberechenbar und nicht ausreichend ist. Zugang zu Strom bedeutete zudem nicht gleichzeitig, dass diese Elektrizität auch tatsächlich genutzt wurde. Nach der Elektrifizierung durch das Programm waren die Haushalte teilweise weiterhin auf herkömmliche Energiequellen wie Kerzen und Batterien zur Beleuchtung und für den Betrieb elektrischer Geräte angewiesen, Strom aus den Solar-PV-Anlagen ersetzte also nur in geringem Maße die traditionellen Energiequellen. Die Auswirkungen der Programme auf die Verringerung der Armut und die Verbesserung der Lebensbedingungen waren somit begrenzt. Die Kluft zwischen der politischen Zielsetzung (Armutsminderung und Verbesserung der Lebensbedingungen) und der politischen Umsetzung (ungenügende, unzuverlässige und unberechenbare Stromversorgung) ist auf die mangelhafte Durchführung des Programms zurückzuführen. Elektrifizierung des ländlichen Raums dreht sich nämlich nicht nur um die Auswahl der passenden Technologie und die Zuteilung von Geldmitteln. Im Gegensatz dazu bedarf die erfolgreiche Implementierung eines solchen ländlichen Elektrifizierungsprogramms den langfristigen Aufbau lokaler Kapazitäten für das Management der finanziellen Mittel, der Ausbildung des benötigten Personals sowie die Stärkung lokaler Institutionen, die zuständig für die Betreibung und Wartung der Anlagen sind. Nur so kann langfristig, verlässliche Stromversorgung garantiert werden.

Empfehlungen für die chinesische Regierung

In den nächsten fünf bis zehn Jahren werden weitere Anstrengungen unternommen werden, um die Energieversorgung abgelegener, ländlicher Gebiete aus erneuerbaren Quellen zu erreichen. Dies stellt ein wichtiges Instrument für die soziale und wirtschaftliche Entwicklung in diesen Bereichen nach dem 11. Fünfjahresplan (2006 bis 2010) und der nationalen, mittel- und langfristigen Strategieplanung der chinesischen Regierung dar. Es ist geplant, dass ab dem Jahr 2020 der Zugang zu Strom für die bisher nicht elektrifizierte Bevölkerung garantiert wird. Nach der Durchführung des Township Electrification Programms plante die Regierung zwei weitere auf erneuerbaren Energien basierende Programme der ländlichen Elektrifizierung: das „Village Electrification Program“ und das „Household Electrification Program“. Das Village Electrification Programm dient der Schaffung von Zugang zu Strom aus erneuerbaren Energien für 20.000 bisher nicht elektrifizierte Dörfer in Westchina bis 2010. Ziel des Household Electrification Programs ist es, Zugang zu Strom auf Basis erneuerbarer Energien für den Rest der bisher nicht elektrifizierten 8,5 Millionen Menschen in Westchina bis zum Jahr 2020 zu erreichen. Die von dieser Studie abgeleiteten Empfehlungen an die chinesische Politik bieten der chinesischen Regierung einige Hinweise hinsichtlich der zukünftigen Gestaltung der auf erneuerbaren Energien basierenden Programme zur ländlichen Elektrifizierung sowie für deren Umsetzung bis in das Jahr 2020:

Erstens sollte die Regierung eine Evaluierung der bisherigen Ergebnisse der auf erneuerbaren Energien basierenden ländlichen Elektrifizierungsprogramme wie dem Brightness Program, dem Township Electrification Programm und anderer Projekte der internationalen Zusammenarbeit durchführen, um in Erfahrung zu bringen, in welchem Umfang die Programme ihre offiziell angegebenen Ziele erreicht haben.

Zweitens sollten vor der Formulierung der Programme zur ländlichen Elektrifizierung auf Basis erneuerbarer Energien die unterschiedlichen lokalen Bedingungen geprüft werden, um den effizientesten und effektivsten Weg zur Elektrifizierung wählen zu können und so die Verschwendung von Ressourcen und Investitionen zu vermeiden.

Drittens sollte vor einer Formulierung eines solchen Programms der lokale Energiebedarf der Endnutzer überprüft werden.

Viertens sollte Wert auf den Aufbau eines unterstützenden institutionellen Rahmen, die finanzielle Nachhaltigkeit, den Aufbau von Personalkapazitäten und die Qualität der Administration, insbesondere auf lokaler Ebene, gelegt werden. Dies kann eine langfristige und zuverlässige Stromversorgung in den entlegenen ländlichen Gebieten

Westchinas gewährleisten.

Fünftens sollte die Regierung Strategien zur Verbesserung der lokalen wirtschaftlichen Entwicklung und zur Schaffung von Möglichkeiten zur Einkommensgenerierung in die Programme zur ländlichen Elektrifizierung aufnehmen.

Sechstens sollte die Regierung im Hinblick auf das Township Electrification Programm neue Maßnahmen prüfen, mit Hilfe derer die weitere Inbetriebnahme und Wartung der etablierten Solar-PV-Anlagen gewährleistet werden kann.

Implikationen für Entwicklungsländer

Die Elektrifizierung des ländlichen Raums ist eine gemeinsame Herausforderung für die Entwicklungsländer. Im Jahr 2005 lebten mehr als 99% der Bevölkerung ohne Stromzugang (1,6 Mrd.) in Entwicklungsländern, 80% (1,26 Mrd. EUR) von diesen in Afrika südlich der Sahara und in Südasien. Die nicht elektrifizierte Bevölkerung lebt vor allem in abgelegenen, ländlichen Gebieten dieser Entwicklungsländer. Dezentrale Stromsysteme auf Grundlage erneuerbarer Energieträger werden weithin als Option für die ländliche Elektrifizierung in diesen abgelegenen ländlichen Gebieten der Entwicklungsländer angesehen. Das chinesische Township-Programm ist bis heute das weltweit größte Programm zur ländlichen Elektrifizierung auf Basis erneuerbarer Energien. Die chinesischen Erfahrungen bieten dabei auch für andere Entwicklungsländer hilfreiche Einsichten:

Erstens sollten nationale Regierungen und Parlamente bei der Festlegung eines politischen Rahmens für ländliche Elektrifizierung eine Führungsrolle einnehmen und darauf Wert legen, dass die daraus abgeleiteten Programme besonders arme Bevölkerungsschichten in abgelegenen, ländlichen Gebieten berücksichtigen.

Zweitens benötigen Programme der ländlichen Elektrifizierung mit Hilfe erneuerbarer Energien eine angemessene finanzielle Ausstattung.

Drittens sollte die Gestaltung der Programme zur Elektrifizierung ländlicher Gebiete darauf achten, entsprechende lokale Kapazitäten, die eine nachhaltige Nutzung und

Betreibung der Anlagen ermöglicht, aufzubauen.

Viertens sollten erneuerbare Energie-Elektifizierungsprogramme in andere nationale Entwicklungspläne und Pläne zur ländlichen Entwicklung integriert werden, um so eine gegenseitige positive Ergänzung dieser zu ermöglichen.

1 Introduction

1.1 Background of research

Energy is a driving force of economic, social, and human development (World Bank, 2001; United Nations, 2000; United Nations, 2004: 221; UNDP, 2003; Haas and Göllner-Scholz, 2004; Mapako and Mbewe, 2004). "If the vicious circle of energy poverty and human under-development is to be broken, governments must act to improve the availability and affordability of modern energy services, especially electricity" (IEA, 2004: 353). Electricity serves as the basis for satisfying fundamental human needs, such as food production, water access, education services, health services, and social services, etc. Access to electricity can play a variety of direct and indirect roles in helping to achieve several UN Millennium Development Goals (MDGs)[1] (DFID, 2002; UNDP, UNDESA and WEC, 2004; Flavin and Aeck et al., 2005):

1. Halving extreme poverty: Access to electricity facilitates economic development, such as micro-enterprise, livelihood activities beyond daylight hours, locally owned businesses that create employment, and assists in bridging the 'digital divide'.

2. Reducing child mortality, to improve maternal health, and to reduce diseases: Electricity is a key component of a functioning health system, for example, lighting, refrigerating vaccines and other medicines.

3. Achieving universal primary education, and to promote gender equality and empowerment of women: Access to electricity reduces the time spent by women and children (especially girls) on basic survival activities (gathering firewood, fetching water, cooking, etc.); lighting permits home study, increases security, and enables the use of educational media and communications in schools, including information and communication technologies.

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[1] The complete list of United Nations Millennium Development Goals:
Goal 1 - Eradicate extreme poverty and hunger;
Goal 2 - Achieve universal primary education;
Goal 3 - Promote gender equality and empower women;
Goal 4 - Reduce child mortality;
Goal 5 - Improve maternal health;
Goal 6 - Combat HIV/AIDS, malaria and other diseases;
Goal 7 - Ensure environmental sustainability;
Goal 8 - Develop a global partnership for development.
Retrieved 17 November, 2009 from http://www.un.org/millenniumgoals and http://mdgs.un.org/unsd/mdg/Resources/Attach/Indicators/OfficialList2008.pdf. Also see United Nations (2009a) and Holtz (2003: 5; 2010: 3-8).

4. Ensuring environmental sustainability: Improved energy efficiency and use of renewable energy can help to achieve sustainable use of natural resources, as well as reduce emissions, which protects the local and global environment.

The definition of electricity access used in this study corresponds to the International Energy Agency's (IEA) definition: "The number of people who have electricity in their home. It comprises electricity sold commercially, both on-grid and off-grid. It also includes self-generated electricity" (IEA, 2002: 395). In 2005, 1.6 billion people, around a quarter of the world population, who lived mostly in rural areas of developing countries, had no access to electricity (IEA, 2006). In the same year, the IEA estimated the number of people without electricity in 2015 will be only 'slightly' reduced compared to 2005 numbers, and that achievement of halving the proportion of people living on less than USD 1 (1.25 in 2005 prices)[2] a day by 2015 is highly unlikely unless electricity be provided to those who lack access (IEA, 2004; IEA, 2006).[3]

Most governments in developing countries give high priority to rural electrification to meet economic, social, political, and regional development goals (World Bank, 1996a). But in general, remote rural areas in developing countries have little prospect of having access to grid-based electricity (United Nations, 2000). Electrification programs have been criticized for being implemented in the areas where it is most cost effective for electrification or where communities could afford electricity service (World Bank, 2008: 18-19). Electrification programs favor mainly the non-poor and better-off communities although the poor are also included in the electrification programs (World Bank, 2008: 18-21). Grid-based electrification usually only extends to densely populated urban areas, where a large customer base justifies heavy expenditure for the electricity infrastructure. One option for electrification in remote rural areas is to decentralize electricity systems based on renewable energy sources (United Nations, 2000; UNDP, 2003; World Bank,

[2] "In order to have a common benchmark the World Bank introduced the one-dollar definition. According to this definition, anyone who has at their disposal less than one dollar a day – converted into local purchasing power parity – lives in absolute or extreme poverty. In August 2008, in the light of improved data, the poverty line was adjusted to 1.25 US dollars per day. Thereupon, the World Bank had to correct the number of absolute poor for 1990 to 1.8 billion and for 2005 to 1.4 billion people globally. That did not however alter the trend: global poverty has seen a marked decline" (see www.bmz.de/en/figures/millenniumsentwicklungsziele/mdg1.html, retrieved 23 November, 2009).

[3] IEA estimated that achieving the target of halving the proportion of people living on less than USD 1 a day by 2015 would need to be accompanied by providing electricity to 600 million to about 1 billion people mainly in sub-Saharan Africa and South Asia with additional investment for about USD 200 billion (IEA, 2004).

2000a; Asian Development Bank, 2005b).[4] However, such an option is not universally agreed upon. In their 2004 empirical study, Mapako and Mbewe (2004: 36) criticize the idea that renewable energy can serve as an ideal option of choice for electrification for the dispersed rural households in Africa, doubting that renewable energy is a cheaper option than grid-based electricity in the long-term. Therefore, it is debatable if renewable energy-based rural electrification programs are more feasible, cheaper, and less problematic solutions for improving electricity access in remote rural areas of developing countries than grid extension electrification programs based on fossil fuel, hydro, or nuclear.

In 2002[5], the Chinese government launched the 'Township Electrification Program, acknowledging the continued existence of 12.9 million people without electricity[6] living primarily in isolated rural areas away from the main power grid. Known as the world's largest renewable energy-based rural electrification program in terms of investment volume ever carried out by a country, the Program was implemented in 1013 non-electrified townships in remote rural areas of 11 western provinces, providing electricity for 300,000 households and 1.3 million people (CAS, 2007a).[7]

While enacted, initially little was known about how this ambitious Program was implemented at the local level in remote rural areas of western China, especially

[4] IEA (2004: 553) defined renewable energy sources as follows: solar, wind, hydro, geothermal, tide/wave/ocean, combustible renewables and waste (including solid biomass, charcoal, biogas, liquid, biofuel, and municipal waste). Compared to other types of energy, e.g. coal, oil, gas, and nuclear, renewable energy has a less negative impact on human, ecosystem, and natural environments. The application of renewable energy for rural electrification range from solar photovoltaic (PV), wind turbine generators, micro-hydro, and hybrid systems of the combination of solar PV/wind/diesel/micro-hybrids (United Nations, 2000: 6-11). Decentralized electricity systems based on renewable energy sources can be offered in different sizes and more flexible in meeting different energy needs in remote rural areas (UNDP, 2003).

[5] Some literature gave different information of the year when the Township Electrification Program was launched, such as late 2001 (NREL, 2004b). But most of the literature, especially the Chinese literature, used year 2002 (see CAS, 2007a; CAS, 2007b; CAS, 2007c; NDRC, 2007a; Ma, 2004).

[6] The literature gives different numbers of the population without electricity in China in different years (see IEA, 2002; IEA, 2004; IEA, 2006; Ma, 2004; Ma, Yin, and Kline, 2006; CAS, 2007a; CAS, 2007b; CAS, 2007c). The data concerning the number of the population without electricity in China used in this study is from the data of International Energy Agency (see IEA, 2002; IEA, 2004; IEA, 2006).

[7] Different literature (see NREL, 2004b; Ma, 2004; Martinot and Li, 2007; NDRC, 2007a; CAS, 2007a; CAS, 2007b; CAS, 2007c) gave different data of the implementing results of the Township Electrification Program, such as the number of electrified townships, households, people, as well as the implementing provinces. The data used here are based on the data from the Chinese Academy of Sciences (see CAS, 2007a; CAS, 2007b; CAS, 2007c).

empirical studies on the impacts of the Program for the lives of rural people.[8] To fill the knowledge gap, this study was designed to assess the implementation, outputs, outcomes, and impacts of the Township Electrification Program in the remote rural areas of western China. The experiences and lessons learned in this study provide new insights into the debate over the feasibility, cost, and practicality of renewable energy-based rural electrification for improving electricity access in remote rural areas of developing countries. In addition, the experiences and lessons learned in this study offer potentially useful ideas for the design of new renewable energy-based rural electrification programs in China and other developing countries.

1.2 Research objectives

The aims of this study are as follows:

1) To learn about the background of the formulation of the Township Electrification Program within the political framework of the People's Republic of China (PR China);
2) To learn about the results of the implementation of the Township Electrification Program in remote rural areas of western China;
3) To learn from local people in remote rural areas of western China about their electricity needs, the benefits, and the existing problems of the Township Electrification Program;
4) To learn about the impacts of the Township Electrification Program on the local people, townships, and environment in remote rural areas of western China;
5) To suggest policy recommendations for the Chinese government based on the scientific results;
6) To discuss policy implications of the Township Electrification Program for other developing countries.

1.3 Research questions

[8] The literature about the Township Electrification Program is mainly the introduction, facts, and implementing results of the Program (NREL, 2004b; Martinot and Li: 2007; Ma, Yin, and Kline, 2006; Ma, 2004).

This study aims to answer the following sets of research questions:[9]

1) When and why did electricity access in remote rural areas of western China receive the attention of Chinese policy-makers and become a policy problem included on the Chinese government's policy agenda? Why did the Chinese government identify the policy problem with the solution of renewable energy-based rural electrification programs instead of fossil fuel-based grid extension programs?
2) What are the characteristics of the formulation and adoption of the Township Electrification Program within the political framework of the PR China? What are the pros and cons of such a 'centralized public sector energy initiative'?
3) What are the implementation results of the Township Electrification Program in remote rural areas of western China? What are the factors that determine the sustainability of the Program?
4) What are the outputs of the Township Electrification Program in remote rural areas of western China? What was the situation of electricity supply and electricity service of the Program at the local level?
5) What are the outcomes of the Township Electrification Program in remote rural areas of western China? To what extent did the Program influence changes in household energy use patterns from traditional energy sources to electricity from solar PV power stations?
6) What are the impacts of the Township Electrification Program in remote rural areas of western China? To what extent did the Program contributed to improving socio-economic benefits for households, township development, and environmental sustainability at the local level?
7) To what extent has the Township Electrification Program achieved sustainable energy supply in remote rural areas of western China?

1.4 Methodology and data collection

1.4.1 Case selection

[9] This study formulated research questions, instead of hypotheses. Research questions forced the researcher to be very specific about what to be studied in his or her thesis (see Wester, Oorthuizen, Prins, Mollinga, 2002).

According to Cook et al. (2005), a priority for future energy studies is to conduct more in-depth empirical research using qualitative and participatory methods to help gain insight into energy projects. However, doing in-depth research is difficult, as limited resources limit the sort of study undertaken (Singleton and Straits, 2005). For example, many difficulties surround the conduct of field research in remote rural areas of western China. Different studies have described the difficulties for conducting field research in remote rural areas of western China (see World Bank, 2000a; CAS, 2006a; CAS, 2006b; Hölzer and Huba, 2007; Bruehl and Haskamp, 2003a; Bruehl and Haskamp, 2003b; Haskamp, 2004a; Haskamp, 2004b; Zange, 2005; Schaber, 2005; Zheng and Zange, 2006; Klingshirn and Mueller, 2005). Under such constraints, two townships in two different provinces were selected for this study as the cases for an in-depth examination of rural electrification practices in remote rural areas of western China.

1) Selection of provinces

The ‘Township Electrification Program’, was implemented in the remote rural areas of 11 western provinces: Tibet Autonomous Region (AR)[10], Xinjiang AR, Qinghai Province, Sichuan Province, Inner Mongolia AR, Gansu Province, Shaanxi Province, Hunan Province, Yunnan Province, Chongqing Municipality, and Jiangxi Province. The selection of the case provinces is ‘purposive sampling’. Unlike probability sampling, purposive sampling has the weakness of not being able to control for investigator bias during selection process (Singleton and Straits, 2005). The selection of the case provinces in this study is based on the following two reasons:

First, when there are only few cases, probability sampling is less reliable and generation from sample to population becomes a matter of judgment (Singleton and Straits, 2005: 132). The selection of cases is better left to expert or researcher judgment to select a representative or typical case (Singleton and Straits, 2005: 133). Among the 11 western provinces, Xinjiang AR, Qinghai Province, and Tibet AR have the most serious problems of electricity access, especially Tibet AR. From the number of installed solar

[10] Autonomous regions in China are areas associated with one or more ethnic minorities. The Chinese government officially recognizes 55 ethnic minorities, excluding the dominant ethnic group of Han Chinese. Ethnic minorities are given additional autonomy regarding their culture in the PR China.

PV power stations in the Township Electrification Program, Xinjiang AR, Qinghai Province, and Tibet AR were the main target provinces (see Table 1-1). Hence, these three provinces were selected in the first stage as potential case provinces.

Table 1-1 Implementation results of the 'Township Electrification Program': Solar PV power stations and solar PV/wind hybrid power stations

Province	The quantity of power station	Total Installed capacity (kWp)	The number of households benefited	The number of people benefited
Tibet AR	329	6,763	28,966	141,635
Xinjiang AR	159	2,378	18,416	105,887
Qinghai Province	112	2,715	8,640	40,650
Sichuan Province	46	1,817	5,500	24,900
Inner Mongolia AR	42	752	2,840	11,369
Gansu Province	23	995	4,164	37,942
Shaanxi Province	9	100	520	1,856
Hunan Province	1	20	100	420
Total	721	15,540	69,147	340,395

Source: Compiled by author based on NDRC, 2005a; CAS, 2007a; CAS, 2007c.

Second, under certain circumstances, when certain individuals or institutions refuse to cooperate in a study or when a researcher is unable to gain access to research targets, the researcher has to accept a purposive sampling or abandon the study altogether (Singleton and Straits, 2005: 132). In China, it is not common for individual researchers to carry out household surveys, particularly in rural areas. Household surveys are usually done by the government, such as through Statistic Bureaus. However, without governmental support or approval, carrying out survey research is usually impossible in China. Among the three potential case provinces, this study was only granted governmental support to carry out survey research in Qinghai and Tibet. Because of this constraint, this study could only select townships in Qinghai and Tibet and had to abandon the inclusion of the Xinjiang AR.

2) Selection of townships

The selection of townships was relied on experts' judgment and recommended by this study's provincial research partners, Mr. Tsultrim Dargye and Mr. Osmanla. Both men worked for GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit, German Agency for Technical Cooperation) at the GTZ Qinghai and Tibetan provincial offices. Both men were research assistants for GTZ's 'Sino-German Technical Cooperation Project of Renewable Energies in Rural Areas' from 2001 to 2007. Together, they possessed 6 years of project experience and had both visited a number of townships and villages which applied renewable energy at remote and rural areas, as well as carried out survey studies with German experts. Mr. Dargye and Mr. Osmanla had also visited a number of townships that implemented the 'Township Electrification Program'. Ethnically, both were local Tibetan, and spoke not only Chinese and English, but also Tibetan which was spoken widely in remote and rural areas of these two provinces. Besides these qualifications, both men had very good contacts with provincial government and local governments.

Two criteria were used to select the township. First, the township should be one of the targeted townships of the Township Electrification Program. Second, it should be possible to get research support from the provincial and township government.[11]

The selection process started from a list of the townships suggested by research partners according to the two selection criteria. Discussions and communications with potential case townships and provincial governments about this study and research activities then ensued to decide the case townships. Finally, Saierlong Township in Qinghai Province and Namcuo Township in Tibet province were selected as case townships in this study.

1.4.2 Research approaches

A combination of available data research, field research, and survey research were

[11] Government approval was a key factor if this study was to be successfully carried out in remote rural areas of western China with the support from provincial governments, township governments, and village heads since field research and survey research were rarely conducted in these areas and it was politically sensitive to conduct field research and survey research in these areas. Without the support of provincial and township governments, field research and survey research could not have been accomplished in these areas.

chosen as research approaches, to carry out this study.[12]

For 11 months from July 2007 to May 2008, field research was carried out in Beijing Municipality, Qinghai Province, and Tibet AR. This approach aimed to gain firsthand knowledge of the Township Electrification Program that was implemented in remote rural areas of western China, and to collect information of the problems and benefits of the Program from the households. The study combined quantitative and qualitative methods, including observation, interviews, and household surveys.

Three field research trips were carried out in the two selected townships in Qinghai Province and Tibet AR. The first field research trip during October 2007 was a pilot study, and aimed to examine if the selected research sites were appropriate for this study, to develop a basic understanding of the research sites, and to arrange future research trips and activities with provincial and township officials. During this initial trip, transition walks, mapping, observation, semi-structured interviews, and unstructured interviews to learn about the township, people's living conditions, energy situation, energy needs and problems, education, medical, public services, and small businesses which were related to electricity supply from renewable energy sources. This research trip helped to clarify research objectives, refine research questions, specify subtopics for semi-structured interviews, and revise the questionnaire for survey.

The second field research trip was carried out from November to early December 2007 in Saierlong Township, Qinghai Province. During this trip further, a household survey was conducted and several semi-structured interviews were conducted with township officials, operators of the solar PV station, the principal of the township school, and the director of the health center. The final field research trip was conducted in Namcuo Township, Tibet AR in December 2007. A household survey and several semi-structured interviews were undertaken to collect primary data.

1.4.3 Methods of data collection

[12] There are four basic research approaches for social sciences: experiments, surveys, field research, and the use of available data (Singleton and Straits, 2005). More detail regarding these four approaches are described in Singleton and Straits (2005), chapter 6 to 11.

Both qualitative and quantitative methods are applied in this study to collect data. The aim of combining both methods is to cross check the validity of collected data and reduce the weakness of one method by the strengths of another.

1.4.3.1 Qualitative methods

Several qualitative methods were used in this study to collect data. The aim was to get rich and varied information about the townships, the households, and the implementation situation of the Township Electrification Program in both selected townships. These methods enabled local people to analyze, enhance and share their knowledge of local conditions for this study (Gerke, 2006).

1) Observations

Observations were conducted in the field to understand the implementing situation of the Program in both selected townships and at the households.

2) Unstructured interviews

Unstructured interviews provided a less formal structure and allowed for more wide ranging discussions, and spontaneous questioning of research subjects (Singleton and Straits, 1999: 222-223). Several unstructured interviews were conducted at the beginning of the field research with government officials, operators of the solar PV power stations, poor households, rich households, and key informants in order to get basic information about the townships, local opinions of the implementation situation of the Program in both selected townships and at the households.

3) Transect walks

Transect walks with knowledgeable local people in both selected townships were conducted to observe and discuss the implementation situation of the Program and related problems by visiting the townships and the solar PV stations. The transect walks helped to identify which parts of the townships were not connected to the solar PV stations.

4) Mapping

Maps of the townships and electricity distribution were drawn by township officials, operators, and local people to provide an overview of the townships and electricity distribution situation in the two selected townships.

5) Semi-structured interviews

Semi-structured interviews guided by a list of open-ended questions were conducted with experts, government officials, township leaders, operators, households, and key informants to gain information about different perceptions of the implementation situation of the Program in the two selected townships (see Photograph 1-1 left). The semi-structured interviews helped to revise the draft questionnaire of the household survey.

Photograph 1-1 Semi-structured interview (left) and household survey (right)

Source: Photographs taken by author in the field from October to December, 2007.

1.4.3.2 Quantitative method

A household survey was carried out in the two selected townships to collect data of energy situation, energy needs, problems and socio-economic benefits of the Township Electrification Program, as well as household characteristics (see Photograph 1-1 right).

1) Unit of analysis

The unit of analysis in this study is households, and is based on the rationale that in remote rural areas electricity demand is mostly from households (World Bank, 2000a).

2) Population frame

The population frame is the number of the households in the two selected townships. There are 250 households[13] in Saierlong Township and 60 households in Namcuo Township.

3) Sample design

Households in the selected townships did not have addresses to identify house numbers. Besides, township leaders could not provide complete lists of households for this study. Hence, 'systematic sampling' was applied to select samples. Doing so followed a World Bank's study (2000) assessing markets for renewable energy in rural areas of northwestern China, the survey used 'systematic sampling' because there were no house numbers and no available lists of households. The sampling started with a randomly chosen case of the population, and then selected every *K*th case, e.g. fifth or tenth, from the population (Singleton and Straits, 2005: 131-132). The sampling interval (*K*) was the ratio of the number of cases in the population to the desired sample size. For example, if the desired sample size was 100 households out of a population of 400 households, the ratio would be 4. The selection of households began with selection of one household at random in the township, and then walking through the entire township taking every fourth household encountered. Systematic sampling was also a probability sampling, utilized to ensure that every household had an equal chance of being included in the sample, and that the probability of being included in the sample could be known (Singleton and Straits, 2005: 119).

4) Sample size

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[13] The number of households in Saierlong Township excluded 150 monk households, which were located in the monastery area of the township. It was the local tradition to respect monk's still and quite life. Township officials required that the research activities should not disturb the monks.

Given limited resources and difficulties of survey research in Saierlong Township, the confidence level[14] of the study was to reach 90% with a minimum sample size[15] of 76 households (see Table 1-2). In Namcuo Township, the objective confidence level to be reached was 95% with a minimum sample size of 52 households (see Table 1-2).

Table 1-2 Required minimum sample size for household survey

Province	**Township**	**Nr. of households**	**Required minimum sample size (90% confidence level)**	**Required minimum sample size (95% confidence level)**
Qinghai	Saierlong	250	76	152
Tibet	Namcuo	60	26	52

Source: Compiled by author.

In Saierlong Township, the total number of the households was 250. Given a required sample size of 76, the sampling interval would be 3.4. The selection of households started with selecting one household at random in the township, and then walking through the entire township and choosing every third household encountered. However, certain difficulties arose while undertaking the systematic sampling in Saierlong Township. First, households were distributed in a wide and unsystematic way which made the selection of the households difficult to achieve precisely and systematically

[14] The definition of a 'confidence level' arose from Singleton and Straits (2005: 124, 558) work, which they stated as: Statistical probability that a random variable lies within the confidence interval of an estimate. This definition, in turn, differed from that of 'confidence interval' which they defined as: "A range (interval) within which a population value is estimated to lie at a specific confidence level; used to qualify sample estimates to take into account sampling error. For example, a researcher might report that she is 99 percent confident (confidence level) that the mean personal income for a population lies within plus or minus $359 of the sample mean of $18,325 (i.e., confidence interval of $18,648 - $17,966)" (Singleton and Straits, 2005: 558).

[15] The formula for estimating the sample size and a table for determining the sample size (based on confidence level needed from a given population) could be found in Krejcie and Morgan (1970: 607-610).

$$S = \frac{X^2 NP(1-P)}{d^2 (N-1) + X^2 P(1-P)}$$ where

S = required sample size

N = the given population size

P = population proportion that for table construction has been assumed to be .50, as this magnitude yields the maximum possible sample size required

d = the degree of accuracy as reflected by the amount of error that can be tolerated in the fluctuation of a sample proportion p about the population proportion P - the value for d being .05 in the calculations for entries in the table, a quantity equal to $\pm 1.96\sigma_p$

X^2 = table value of chi square for one degree of freedom relative to the desired level of confidence, which was 3.841 for the .95 confidence level represented by entries in the table

Retrieved 17 November, 2008 from http://www.okstate.edu/ag/agedcm4h/academic/aged5980a/5980/newpage15.htm.

every third household encountered without error. Second, households that herded on the grassland were not available for the household survey. Third, households in which young people herded only had old people and children who were not able to answer the questionnaires. In the end, a total of 81 questionnaires were completed in Saierlong Township and 56 questionnaires were completed in Namcuo Township (see Table 1-3).

Table 1-3 Sample size for household survey

Province	Township	Nr. of households	Nr. of households selected	Confidence level
Qinghai	Saierlong	250	81	At least 90 %
Tibet	Namcuo	60	56	At least 95 %

Source: Compiled by author.

5) Process of survey research

In the early stages of this study, a draft of a questionnaire was developed based on the above mentioned research questions, as well as the questionnaires conducted in remote rural areas of western China by the World Bank (2000a) and GTZ (Hölzer and Huba, 2007). Subsequently, the questionnaire was revised by researchers at the Research Center for Sustainable Development, Chinese Academy of Social Sciences (CASS), experts at GTZ Beijing Office, and provincial research partners. The questionnaire was pre-tested in the selected townships in October, 2007.[16] A final questionnaire was then administered following adjustments made according to local conditions and culture (see Bruehl and Haskamp, 2003b), the result of pre-tests, the advices of provincial research partners, and local people who participated in the pre-tests (see Appendix for the questionnaire).

The survey research was arranged and assisted by provincial, county, township, and village officials. A survey team of 5 research assistants in Saierlong Township and a survey team of 9 research assistants in Namcuo Township were trained to conduct survey research. The two survey teams were composed of a group of local officials, doctors, teachers, students, and provincial research partners. The criteria for selecting research assistants included the ability to speak, read, and write Chinese and Tibetan.

[16] Several pre-tests of questionnaire were carried out to gain information about whether the questions were clearly understood by the households. Ambiguous or misleading questions were omitted after pre-tests.

Completed questionnaires were checked in the field. If questionnaires were missing responses, response inconsistencies, or vague answers, research assistants were asked to go back to the households to complete valid questionnaires. The aim of this action was to ensure that information on questionnaires was as complete, error-free, and readable as possible and ready to be transferred to the computer for analysis (Singleton and Straits, 2005: 447).

6) Data processing

Before data entry, a codebook for guiding data entry was designed in Beijing. Completed questionnaires were brought to Germany for data entry.[17] Software used in this study for data entry is SPSS Statistics 17.0 for Windows. Several steps were taken in this study to check the accuracy of data entry from the paper-and-pencil questionnaire to a data set in the computer, particularly to detect and resolve errors in coding and transmitting the data to the computer. First, data was randomly chosen to check the consistency of all records and variables in the data set against the original completed questionnaires. Second, a wild-code checking of every variable in the data set was used in the data processing to detect and resolve errors, as well as wild-code checking of the frequency distribution tables for all variables.[18] Lastly, a consistency checking of certain questions in the data set was used during data processing to determine if responses to certain questions were related in reasonable ways.[19] After assessing the 'cleanness' of the data, data was inspected, modified, processed, and analyzed with SPSS Statistics 17.0 for Windows.

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[17] "A codebook is like a dictionary that defines the meaning of the numerical codes for each named variable […] Codebooks also may contain question wording, interviewer directions, and coding and editing decision rules, such as how to handle two answers circled to a single-response question" (Singleton and Straits, 2005: 455). For example, codes for sex of respondents are '1' for 'male' and '2' for 'female'.

[18] Wild-code checking is used to exam if the value recorded for each item is out-of-range code (Singleton and Straits, 2005: 452). For example, cooking energy has code '1' for 'Dried animal dung', '2' for 'solar energy', '3' for 'Coal', '4' for 'LPG', '5' for 'Others', and '99' for 'missing'. If there are codes, such as '6', '9', and '13' for cooking energy, these codes are not legitimate codes which needed to be checked against the original completed questionnaires again.

[19] Consistency checking is to see whether responses to certain questions are related in reasonable ways to responses to particular other questions (Singleton and Straits, 2005: 452). For example, it would be unreasonable to find a respondent who was a father with age 7, or a household without having any transportation vehicles and electrical generators use the energy of gasoline and diesel as daily basis.

1.4.4 Validity of collected data

All forms of validation in social sciences are subjective in the sense that judgments on the validity of collected data ultimately rest with the verdict of the scientific community (Singleton and Straits, 2005: 99).[20] One means to bolster the validity of social scientific findings is though triangulation. Triangulation of different multiple methods can help reduce the weaknesses of any one method by emphasizing the strengths of other methods for increasing the validity of collected data (Singleton and Straits, 2005: 397-401).[21] The use of multiple methods, such as qualitative interviews and quantitative survey, improves the validity and plausibility of arguments or claims by triangulating on the same object with data obtained from two or more instruments (Dunn, 1994: 8). The validity of collected data in this study is cross-checked according to diverse information and data collected with the various methods outlined above.

1.4.5 The constraints of methods

Methodological constraints and problems exit for all research (Anderson, 1975). This study is not without its share, especially given the complexity of the research topic.

First, solid evidence, facts, or data were often hard to acquire or simply not available. Even if it was possible to get needed data, it was usually the observed value, not the data's true value. The observed value always included two types of errors: random measurement error and systematic measurement error (Singleton and Straits, 2005: 91-94).

It was not possible for the design of social science research to control all the factors in a real-world situation. Random measurement errors result from chance factors, such as different interviewers conducting interviews with different procedures; different interviewers not translating all questions from Chinese to Tibetan in the same way; a

[20] There are several methods of validity assessment in social sciences, such as subjective validation, criterion-related validation, and construct validation (see Singleton and Straits, 2005: 98-105).

[21] Different methods have their strengths and weaknesses (see Singleton and Straits, 2005: 398-399). For example, "surveys are best for estimating population characteristics and describing the distribution of attitudes and opinions; field research affords access to actors' definitions of complex situation and events; and the analysis of available data often provides the best and/or means of studying the past and larger social units" (Singleton and Straits, 2005: 399).

tired or bored respondent potentially giving erroneous responses without paying attention to questions asked; temporary variations in implementation of the survey; or different unnoticed errors that occurred during the process of coding and data entry. Random measurement errors are unpredictable and uncontrollable from one question to the next or from one respondent to the next. Random measurement errors result in inaccurate and imprecise measurements which affected reliability[22] of the measurement. Special attention should be brought to one random measurement error in this study: language translation. Most of the households in the two selected townships spoke only Tibetan. Interviewees either did not speak Mandarin Chinese, or their Mandarin Chinese was not fluent. Hence, interviews and household survey conducted in the field relied on the interpretation of the research partners[23] and research assistants[24]. Correctness and preciseness of interpretation, therefore, was hard to control, and affected the correctness and preciseness of collected data determining the research findings.

Systematic measurement errors refer to the process of measurement or the concept being measured. For example, respondents give different answers to the same question when they are alone or in front of strangers or friends or in different settings. Or respondents give social desirable answers to questions. Or respondents may give stereotyped responses when sequences of questions are asked in a similar format. Systematic measurement errors affect the accuracy or validity of measurement which underestimates or overestimates the true value.[25]

The following issues accounted for systematic measurement errors in this study. First, government officials tended to give positive answers to interview questions to show the success of the Township Electrification Program. Second, field researchers, accompanied by the government officials, biased interviewees when they answered the

[22] Reliability means if the measurement indeed measure ‘something’ consistently and stably (Singleton and Straits, 2005: 91). For example, do different interviewers get the same answers of one question from the same interviewee?

[23] The two research partners spoke Chinese, Tibetan, and English, and were familiar with translating Chinese/Tibetan/English for foreign projects and GTZ.

[24] The research assistants participating in the field survey team were mainly local people with higher education and Chinese/Tibetan translation ability. Before carrying out the field survey, they were trained uniformly to be familiar with the questions, the way how to ask questions, the way how to record answers and missing data, and the way how to proceed the interview, etc.

[25] Validity means if the measurement indeed measure the concept correctly and accurately (Singleton and Straits, 2005: 91). Do questions truly reflect the concept? A highly unreliable measure cannot be valid. One can not measure something accurately if the results fluctuate widely. But a very reliable measure still may not be valid.

questions. In some cases, households were reluctant to give information, express an honest opinion, or criticize the Program. While most of the time provincial, county, township, or village officials did not accompany the research team to households to conduct household surveys, households perceived the survey research as part of the government's activities even though the research team explained that the study was for academic purposes only. The possibility of giving socially or politically correct or governmentally desirable answers could happen when households answered the questionnaires. Third, households may give underestimated or overestimated answers. In the past, households in Namcuo Township ever received some financial or development aid from the government or foreign donors. When the research team, identified as a German research project, carried out the research in the field accompanied by provincial and county government officials, households had the tendency to underestimate real household incomes and living conditions in order to show a more serious poverty situation in order to receive financial support or assistance from this study, although the research team explained that this study was not a development aid project. Fourth, some respondents had the tendency to give the same or similar answers in the last part of the questionnaire which the questions have similar format.[26]

Another constraint of this study is the extent to which the selected townships represent the whole population. It was not feasible within the scope of this study to generate results from the two selected townships that implemented the Township Electrification Program in remote rural areas of western China to all townships. The results of the two selected townships provide only chance explanations of a common phenomenon associated with implementation of the Program. While limited cases as these make result generation difficult, at the same time they also provide important insights for analyzing rural electrification project implementation.

Lastly, different policy analysts and researchers may give different or even contradictory explanations to the same information and data. Besides, the selection of information or data for analysis also relies on researcher's values about what is worth for attention. The analysis of the Township Electrification Program in this study is not

[26] The possible reasons for giving similar or the same answers for a set of questions could be: It is faster to finish the questionnaire or the respondents have felt tired or bored after the long interview.

value-free. No matter the data is of a qualitative, quantitative or factual nature, interpretation of results of the data continue to draw on the researcher's subjective insights and creativity.

1.5 Research framework

Several different models exist for policy analysis. These models include: institutional model, policy-making process model, group model, elite model, rational model, incremental model, game theory model, public choice model, and systems model (Dye, 1998: 14). This study applies the 'policy process model' as the research framework to analyze the Township Electrification Program. The advantage of analyzing a policy using the policy process model is that each stage can be examined separately. The disadvantage is that policy processes in the real world are complicated processes, composed of different dynamics and ongoing activities occurring over time. These activities seldom occur in a clear-cut manner or sequence of steps (Dye, 1998: 317). For analytical purposes, it is practical and useful to break policy processes into different components or stages, in order to analyze the various activities involved in the creation of a public policy (Dye, 1998: 317). Making use of this model helps to facilitate scientific understanding of a policy in a complex social context. Doing so also helps to create knowledge from the analysis of different stages of a policy and transfer the knowledge to practical policy recommendations.

Different political scientists identify policy process with different stages (see Table 1-4) (Dye, 1998; Anderson, 1975; Dunn, 1994). However, the substance of their arguments is more or less similar. In this study, policy process is defined as the composition of the following stages: policy problem identification, policy formulation, policy adoption, policy implementation, and policy evaluation (see Table 1-5).

Table 1-4 Stages of policy process

Dye (1998)	Anderson (1975)	Dunn (1994)
■ Identification of policy problems ■ Agenda setting ■ Formulation of policy proposals ■ Legitimation of policies ■ Implementation of policies ■ Evaluation of policies	■ Policy problems ■ Policy agenda ■ Policy formulation ■ Policy adoption ■ Policy implementation ■ Policy evaluation	■ Agenda setting ■ Policy formulation ■ Policy adoption ■ Policy implementation ■ Policy assessment

Source: Summarized from Dye (1998), Anderson (1975), and Dunn (1994).

Table 1-5 Definition of stages of policy process

Stages of policy process	Definition
Policy problem identification	'Policy problem identification' refers to placing a public problem on the government policy agenda as a policy problem.
Policy formulation	'Policy formulation' refers to the development of policy alternatives for dealing with a policy problem on the government policy agenda.
Policy adoption	'Policy adoption' refers to the adoption of a policy alternative through political actions by parliament/congress, president/chancellor, government bureaucracy, or court.
Policy implementation	'Policy implementation' refers to all kinds of activities designed to carry out an adopted policy by administrative units.
Policy evaluation	'Policy evaluation' refers to a variety of ways carried out by different actors to assess outputs, outcomes, and impacts of a policy and examine whether and to what extend a policy has achieved its objectives and goals.

Source: Definitions were developed based on Dye (1998), Anderson (1975), and Dunn (1994).

Based on the research framework, the scope of analysis in this study is outlined in Table 1-6. Since the Township Electrification Program is a national policy implemented in the townships of different provinces, defining the scope of analysis is necessary for this study to set the boundary of analysis. Realizing that national policy frameworks and public policy do not adequately empower or integrate the needs and aspirations of local level, it is important to go beyond the national level and take various sub-national dynamics, such as provincial and township micro politics and policy-issues, into consideration (Pfaff-Czarnecka, 2007).

Table 1-6 Scope of analysis

Policy process	**Scope of analysis**	**Target**
Policy problem identification	International level National level	Central government of PR China
Policy formulation	National level	Central government of PR China
Policy adoption	National level	Central government of PR China
Policy implementation	National level	11 western Provinces
	Provincial level	Qinghai Province Tibet AR
	Township level	Saierlong Township, Qinghai Province Namcuo, Tibet AR
Policy evaluation	Township level	Saierlong Township, Qinghai Province Namcuo, Tibet AR

Source: Compiled by author.

The identification of policy problem of the Township Electrification Program is assessed at the international level and national level to understand the policy history in a broader context. The formulation, adoption, and implementation of the Program are assessed at the national level to understand the Program within the specific political framework of PR China. The implementation and evaluation of the Program is assessed at the provincial and township levels to understand what has actually happened in the field after the Program was implemented, such as the outputs, outcomes, and impacts of the Program.

1.6 Structure of the dissertation

Table 1-7 provides an overview of the structure of the dissertation.

Table 1-7 Structure of dissertation

Chapter	**Theme**
Chapter 1	Introduction
Chapter 2	Policy problem identification
Chapter 3	Policy formulation & Policy adoption
Chapter 4	Policy implementation
Chapter 5	Policy evaluation I – Policy output
Chapter 6	Policy evaluation II – Policy outcome
Chapter 7	Policy evaluation III – Policy impact
Chapter 8	Conclusions and Recommendations

Source: Compiled by author.

Chapter 1 describes the background, objectives, questions, methods, data collection, and framework of this study, and includes a brief introduction of each chapter of this dissertation.

Chapter 2 introduces the analytical framework of policy problem identification, the importance of electricity access for human development, the situation of electricity access in China, the development of the policy problem - electricity access in remote rural areas of western China, the identification of the policy problem by the Chinese government with the solution of renewable energy-based rural electrification programs, the development of different renewable energy-based rural electrification policies for coping with the policy problem, and the development of the Township Electrification Program.

Chapter 3 introduces the analytical framework of policy formulation and policy adoption, the political framework of the People's Republic of China, analyzes the formulation and adoption of the Township Electrification Program within the Chinese political framework, and discusses the pros and cons of China's 'centralized public sector energy initiative'.

Chapter 4 introduces the analytical framework of policy implementation, the overall implementation results of the Township Electrification Program in remote rural areas of western China and the two selected provinces, investigates the implementing situation of the Program in the two selected townships, and identifies the implementation problems in the two selected townships.

Chapter 5 introduces the analytical framework of policy evaluation[27] and policy output and evaluates two policy outputs, electricity supply and electricity service, of the Township Electrification Program in the two selected townships.

[27] Policy evaluation consists of three different approaches to evaluate a policy: policy output, policy outcome, and policy impact. This study evaluate the Township Electrification Program in remote rural areas of western China with these three approaches: policy output (chapter 5), policy outcome (chapter 6), and policy impact (chapter 7).

Chapter 6 introduces the analytical framework of policy outcome and evaluates one direct policy outcome, changes in energy use patterns, as well as several indirect policy outcomes, of the Township Electrification Program in the two selected townships.

Chapter 7 introduces the analytical framework of policy impact and evaluates three policy impacts of the Township Electrification Program in the two selected townships: the improvement of socio-economic benefits for households, the improvement of township development, and the impacts of the Program on the environment.

Chapter 8 summarizes research findings in this study, draws conclusions, suggests policy recommendations for the Chinese government, discusses policy implications for other developing countries, and gives recommendations for future research.

2 Policy Problem Identification: Access to Electricity in Remote Rural Areas of Western China

2.1 Policy problem identification

The analysis of policy problem identification enables researchers to discover hidden assumptions, map and diagnose possible causes, and synthesize conflicting views of the actors involved in the design of public policies (Dunn, 1994: 17). According to Anderson, a public policy is a 'purposive' or 'goal-oriented' government action rather than random or chance behaviors (Anderson, 1975: 3-4). However, before a public policy is formulated, a public problem or a set of problems requiring government actions must be identified. Policy problem identification is the most critical part in the policy making process. Deciding what will be a policy problem is more important than deciding what will be the solution, because the way a policy problem is identified determines its solutions (Dye, 1998: 321). Inadequate or faulty identification of a policy problem may result in solving a wrongly identified policy problem with a correct solution.

Any analysis of policy problem identification has limitations (Dunn, 1994: 140-142; Nakamura and Smallwood, 1980). First, policy makers and policy analysts hold different, sometimes conflicting assumptions about human nature, functions of government, and opportunities for social change possible through public policies. Policy problem identification is, after all, selectively defined or explained by the subjective judgment of policy analysts. Second, policy problems which occur in a complex environment are oftentimes interdependent, dynamic, and changing through time. A policy problem in one policy area, such as energy, also affects other policy problems in other policy areas, like environment, health, economy, or climate. The analysis of policy problem identification in this study is based on author's understanding of the policy problem from available literature and information, and is limited to my judgment and ability, therefore potentially oversimplifying the complexity of the actual policy problem discussed.

To begin an analysis of this nature, the question 'what is a problem' must be posed. In his paper, Smith defined a problem as "a condition or situation that produces a human need, deprivation, or dissatisfaction, self-identified or identified by others, for which relief is sought" (Smith, 1964: 607-610, cited from Anderson, 1975: 55-56). These conditions or situations include but are not limited to: traffic jams, unemployment, air pollution, the high price of energy, nature disasters, financial crises, etc. These conditions or situations produce anxiety, dissatisfaction or tensions which cause people to seek relief or redress (Anderson 1975: 56).

But characteristics or qualities make a problem 'public' rather than 'private'. A public problem exists when many people become directly or indirectly involved or perceive themselves as being directly or indirectly affected (Anderson 1975: 57). An illustration may help convey the meaning. Lack of electricity access has made the Chinese government identify it as a public problem because it has affected the living quality of millions of people in remote rural areas of western China. Therefore, a public problem refers to a set of broader consequences and influences which affect 'many people' directly or indirectly. A private problem can become a public problem if it develops to an extent that it ends up either directly or indirectly having influence on more people.

Another dimension of public policy analysis is how does a 'public' problem become a 'policy' problem? Thousands of public problems occur daily at the local, national, and international level. And while such issues exist, not all public problems are policy problems. A public problem becomes a policy problem only when a public problem is given serious and active attention by policy makers and is placed on a government's 'policy agenda' (Anderson 1975: 59). Furthermore, a public problem becomes a policy problem when policy makers either choose or feel compelled to act upon it. And lastly, a policy problem might also come from older public issues dealt with by different public policies, like the situation of electricity access in remote rural areas of western China addressed by this study.

A number of different factors help trigger the conversion of public problems into policy problems, such as political leaders, media, interest groups, general public, crises, and natural disasters (Cobb and Elder, 1982; Anderson, 1975; Dye, 1998). Whether motivated by public or their own political interests, political leaders, such as government leaders, parliamentarians, or political party leaders, can greatly influence which public problems should be dealt with by the government. Media acts as a triggering factor by influencing the general public's and political leaders' attitudes and values toward some specific public problems by giving a particular policy problem greater or lesser attention. Interest groups can influence the public policy making process through attempts to persuade the government to take action aimed at protecting a group's own interests. When one interest group successfully secures backing from the government, it may produce a reaction from other interest groups concerning the same interests. Another triggering factor affecting the conversion of a public problem into a governmental policy problem is 'protest or violence' by the public. A final factor contributing to policy problem identification is crises and natural disasters. Crises and natural disasters dramatize a particular public problem and attract wide public attention. The public pressure on a crisis or natural disaster urges the government to take specific actions to put a particular public problem on the government's policy agenda. For example, the poisonous milk in China in 2008 and earthquake in Sichuan Province helped push the issue of 'food safety' and 'disaster management' onto the Chinese government's policy agenda.

While several different triggering factors facilitate the conversion of public problems into policy problems on government policy agendas, the most influential and decisive factor is ultimately 'political leaders'. The preferences of political leaders are more directly reflected in public policies than the preferences from the general public, media, and interest groups (Dye, 1998: 319-320). This does not mean that public policies are determined only by political leaders' preferences, but simply that political leaders have better and more advantageous positions in policy-making process than the general public, media, and interest groups, particularly in authoritarian or dictatorial regimes, such as the People's Republic of China.

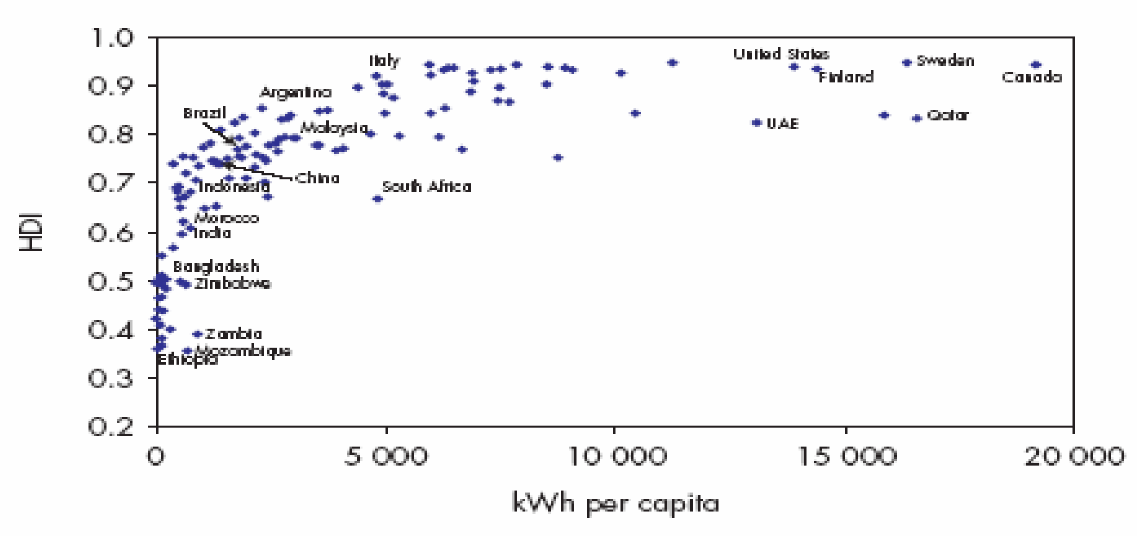
2.2 Electricity access for human development

Electricity access is a public problem which affects many people in many developing countries, a fact represented by a number of studies (IEA, 2004; Chung, 2004; World Bank, 2001; UNDP, 2001). As indicated by these studies, there exists a growing consensus that electricity is particularly crucial to human development.[28] During the

[28] Human development is defined by the United Nations Development Programme (UNDP) as: "[…] putting people at the centre of development. It is about people realizing their potential, increasing their

early stages of development, the amount of electricity consumption by populations is a key contributor to human development (IEA, 2004). A strong correlation exists between electricity consumption per capita[29] and Human Development Index (HDI)[30] (see Figure 2-1). HDI is strongly correlated to electricity consumption per capita below 5,000 kWh per year. The lower the HDI scores, the less per capita electricity consumption per year. HDI reaches a plateau when per capita electricity consumption reaches around 5,000 kWh per year. Yet when an HDI score reaches to at least 0.8, per capita growth of electricity consumption is possible.

Figure 2-1 Per capita electricity consumption per year and HDI in 2002



Source: IEA, 2004.

Lack of electricity access is also linked to poverty which affects human development (World Bank, 2008; World Bank, 2001; World Bank, 1996b). A strong correlation exits between electricity access and the number of people who live below two dollars per day (see Figure 2-2).

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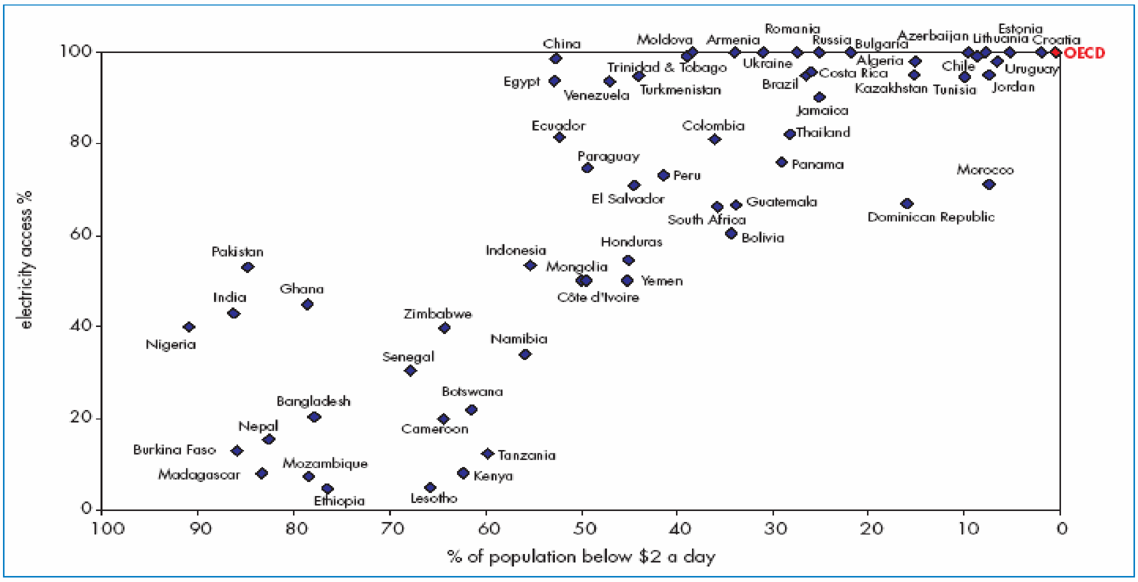
choices and enjoying the freedom to lead lives they value. Since 1990, annual Human Development Reports have explored challenges including poverty, gender, democracy, human rights, cultural liberty, globalization, water scarcity, climate change, and mobility." (Retrieved 23 November, 2009 from http://hdr.undp.org/en/reports/global/hdr2010)

[29] One should be aware that electricity consumption per capita might give a distorted impression that a very small number of people in one country may consume enormous amounts of electricity, while the majority of the population consumes little amounts of electricity.

[30] The Human Development Index (HDI) is an indicator to measure the stage of human development in different countries. The HDI use four different indicators to measure human development in a country: life expectancy at birth; adult literacy rate and combined gross enrolment ratio in primary, secondary and tertiary level education; and GDP per capita in Purchasing Power Parity US dollars (PPP USD) (UNDP, 2007: 225). It was first used by the UNDP in its annual Human Development Report in 1990.

Figure 2-2 Electricity access and share of population living under poverty line



Source: IEA, 2002; World Bank, 2001.

Even though the proportion of the world's population without electricity access has fallen quite sharply from 51% in 1970 to 25% in 2005,[31] the number of people without electricity is still 1.58 billion (see Table 2-1).

Table 2-1 Electrification rates in 2005

Area	Population (million)	Population without electricity (million)	Electrification rate (%)
World	6452	1577	75.6 %
OECD and transition economics	1510	8	99.5 %
Developing countries	4943	1569	68.3 %
Africa	891	554	37.8 %
North Africa	153	7	95.5%
Sub-Saharan Africa	738	547	25.9%
Latin America	449	45	90.0 %
East Asia	1951	224	88.5 %
South Asia	1467	706	51.8 %
Middle East	186	41	78.1 %
China	1311	8.5	99.4%

Source: Compiled by author based on IEA, 2006.

[31] The proportion of the world's population without electricity access in 1970 was 51%, in 1990 41%, in 2000 27%, and in 2005 25% (IEA, 2002; IEA, 2004; IEA, 2006).

The improvement of electricity access is currently mainly in OECD and transition economics countries, where electrification rate reaches 99.5%. But in developing countries, the electrification rate is only 68.3%. More than 99% of the people who do not have electricity access live in developing countries, and 80% of them live in sub-Saharan Africa and South Asia (IEA, 2006). Despite greater prosperity and more advanced technology, the improvement of electricity access in developing countries is still very slow in comparison to OECD countries (see Table 2-2).

Table 2-2 Electrification rate and population without electricity in 2000, 2002, and 2005

Area	2000	2002	2005
	Electrification rate (%) Population without electricity (million)	Electrification rate (%) Population without electricity (million)	Electrification rate (%) Population without electricity (million)
World	**72.8 %** 1645 million	**73.7 %** 1623 million	**75.6 %** 1577 million
OECD and transition economics	**99.2 %** 8.5 million	**99.5 %** 7 million	**99.5 %** 8 million
Developing countries	**64.2 %** 1634.2 million	**65.5 %** 1615 million	**68.3 %** 1569 million
North Africa	90.3 % 13.4 million	93.6 % 9 million	95.5 % 7 million
Sub-Saharan Africa	22.6 % 508.9 million	23.6 % 526 million	25.9 % 547 million
Latin America	86.6 % 55.8 million	89.2 % 46 million	90.0 % 45 million
East Asia	86.9 % 240.7 million	88.1 % 221 million	88.5 % 224 million
South Asia	40.8 % 800.7 million	42.8 % 798 million	51.8 % 706 million
Middle East	91.1 % 14.7 million	91.8 % 14 million	78.1 % 41 million
China	**98.6 %** 17.6 million	**99.0 %** 12.9 million	**99.4%** 8.5 million

Source: Compiled by author based on IEA, 2002; IEA, 2004; IEA, 2006.

At the time of research, projection from the IEA stated that the number of people without electricity in 2015 will be only slightly smaller than in 2002, and 1.4 billion people[32] will still not have electricity access in 2030 (IEA, 2002; IEA, 2004). Without rigorous policy interventions by governments to accelerate the process to bring electricity to the poor, the problem of electricity access will not be significantly improved.

2.3 Electricity access in China

As a developing country[33] (see country profile of the People's Republic of China in Box 2-1), China has managed to improve its electrification rate to the average electrification rate of the OECD and transition economics countries (see Table 2-2). As of 2005, China's electrification rate reached 99.4%, leaving 8.5 million people without electricity access.

Box 2-1 Selected indicators of the People's Republic of China

Surface area (thousand square kilometres): 9,598 (2004)
Population (millions): 1,304 (2005)
Population growth (%): 0.9 (1990-2004)
Rural population (% of total): 60 (2004)
Rural population growth (%): -0.4 (1990-2004)
Gross domestic product (GDP) (billions US dollar): 2228.9 (2005)
Gross domestic product growth (%): 9.4 (1990-2004)
Gross national income (billions US dollar): 1,938 (2004) (ranked 5)
Gross national income per capita (US dollar): 1,500 (2004) (ranked 129)
Population below one US dollar a day (millions): 180 millions (2002)
Population below one US dollar a day (%): 14 (2002)
Population below two US dollar a day (millions): 533 millions (2002)
Population below two US dollars a day (%): 41.6 (2002)
HDI (Human Development Index) index: 0.77 (81 out of 177)
BTI (Bertelsmann Transformation Index) index[34]: 4.7 (85 out of 125)

Source: Compiled by author based on World Bank, 2006; Bertelsmann Stiftung, 2007; UNDP, 2006.

[32] 1.4 billion people represent around 17% of the world's population (IEA, 2002).
[33] IEA defined China as a developing country in the analysis of data (IEA, 2002; IEA, 2004; IEA, 2006).
[34] Bertelsmann Stiftung defined BTI index as "a global ranking of transition processes in which the state of democracy and market economic systems as well as the quality of political management in 125 transformation and developing countries" (Bertelsmann Stiftung, 2007: 1).

The improvement of access to electricity in China is considered a successful story for developing countries, even though more than 40% of its people live below the internationally defined poverty line of less than USD 2 a day (IEA, 2002: 373-374; World Bank, 2006). The key factor in this improvement is the central government's determination and ability to mobilize national resources and push electrification programs at the local level (IEA, 2002). Before 1980, electrification development in China was slow. The electrification rate was only 65% (Pan et al., 2006). But since the 1980s, by making electricity more affordable to the poor through subsidies and low interest loans, the Chinese government has formulated several policies to promote investment in electricity supply (IEA, 2002). These subsidies have helped many people in China avoided falling into a situation common in many developing countries - people were unable to pay their electricity bills on time (IEA, 2002).

In 1983, the first rural electrification policy, "Suggestions to Reinforce the Development of Rural Energy", was formulated by the Chinese government as part of the government's poverty alleviation campaign in the 1980s. Since then, rapid electrification polices and programs launched by the government have contributed to the rapid growth of the country's rate of electrification. In 1994, the State Development Planning Commission,[35] the State Economic and Trade Commission, and the Ministry of Electricity Industry jointly initiated the 'Electricity for Poverty Alleviation Program' (Pan et al., 2006). By 1996, a total of 2.1 billion RMB was spent on alleviating poverty by increasing electricity access (Li, 2003). From 1985 to 2000, the Chinese government managed to secure electricity access for almost 700 million people, and generate nearly 1,000 TWh of electricity (IEA, 2002).[36] Most of the increased electricity was generated with coal, accounted for 80%, and a small amount of the increased electricity was generated with hydro power, accounting for 15% to 18% (IEA, 2002; Pan et al., 2006).[37]

[35] The State Development Planning Commission (SDPC) was renamed in 2003 as the National Development and Reform Commission (NDRC).

[36] The period, from 1985 to 1990, accounts for the most of the progress of electrification rate in China (IEA, 2002).

[37] Compare to other types of energy, China had more coal reserves and coal was relatively inexpensive to produce and use. From 1985 to 2000, there was only some 'small' scale of renewable energy-based rural electrification programs. In the 6th Five-Year-Plan (1981-1985) and 7th Five-Year-Plan (1986-1990), the Chinese government started to encourage the use of renewable energy for electricity generation by supporting small home solar PV systems from a few to tens of watts (CAS, 2007c).

Certain shortcomings, however, exist behind the successful story of China's high electrification rate (IEA, 2002). First, electricity infrastructures, particularly power plants, are old, outdated, and have low energy efficiency. Second, heavy dependence on combustion of coal for electricity generation have caused severe pollution and had negative environmental impacts in China. The most critical issue is the widening electricity consumption gap between rural and urban areas as well as among eastern, central, and western regions.

Electrification has kept pace with urbanization (IEA, 2006). In 2005, the world urban electrification rate was 90.4%, which is much higher than the rural electrification rate of 61.7% (IEA, 2006). The difference between the rate of urban and rural electrification rate is even more apparent in developing countries, such as the PR China (IEA, 2006). While annual electricity consumption per capita in China has increased noticeably in the past two decades from 65 kWh in 1978 to 1062 kWh in 2000,[38] the gap in electricity consumption between rural and urban areas is wide (CAS, 2007b). The annual electricity consumption per capita in urban areas in 2000 was 1864.9 kWh (see Table 2-3). This number is 7.15 times the annual electricity consumption per capita in rural area (260.9 kWh). In 2005, electricity consumption per capita in urban areas grew to 3479.7 kWh, which is 7.55 times the annual electricity consumption per capita in rural area (461.1 kWh)

Table 2-3 Electricity consumption per capital in rural and urban areas in China

Electricity consumption per capita	**2000**		**2005**	
	kWh	% of national consumption per capita	kWh	% of national consumption per capita
National electricity consumption per capita	1062.9	100.00	1970.4	100.00
National urban electricity consumption per capita	1864.9	175.45	3479.7	176.60
National rural electricity consumption per capita	260.9	24.54	461.1	24.17

Source: Compiled by author based on NBSC, 2000a, 2001a, 2002a, 2003a, 2004a, 2005a, 2006a; NBSC, 2000b, 2001b, 2002b, 2003b, 2004b, 2005b, 2006b; CAS, 2007b.

[38] In 2000, the average world level of annual electricity consumption was 2548 kWh per capita (CAS, 2007b). China's annual electricity consumption per capita (1062 kWh) was around half of the average world level of annual electricity consumption.

Even in rural areas, there is a widening gap in electricity consumption among eastern, central, and western regions. The rural electricity consumption level in eastern China is much higher than central and western China (see Table 2-4). In 2000, the rural electricity consumption per capita in eastern China was 495.8 kWh, which is 3.7 times central China's rural electricity consumption level (134.1 kWh) and 4.2 times western China's rural electricity consumption level (118.4 kWh) (see Table 2-4). In 2005, the rural electricity consumption per capita in eastern China grew to 970.9 kWh, which is 5.6 times central China's rural electricity consumption level (172.6 kWh) and 6 times western China's rural electricity consumption level (162.5 kWh).

Table 2-4 Rural electricity consumption per capital in eastern, central, and western China

Electricity consumption per capita	**2000**		**2005**	
	kWh	% of national consumption per capita	kWh	% of national consumption per capita
National rural electricity consumption per capita	260.9	24.54	461.1	24.17
Eastern[1] rural electricity consumption per capita	495.8	46.64	970.9	50.90
Central[2] rural electricity consumption per capita	134.1	12.61	172.6	9.05
Western[3] rural electricity consumption per capita	118.4	11.14	162.5	8.51

Note:
1. Eastern China (11 provinces): Liaoning, Hebei, Beijing, Tianjin, Shandong, Jiangshu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan.
2. Central China (8 provinces): Heilongjiang, Jinlin, Shanxi, Henan, Anhui, Hebei, Hunan, and Jiangxi.
3. Western China (12 provinces): Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet AR, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang AR, and Inner Mogolia AR.

Source: Compiled by author based on NBSC, 2000a, 2001a, 2002a, 2003a, 2004a, 20005a, 2006a; NBSC, 2000b, 2001b, 2002b, 2003b, 2004b, 2005b, 2006b; CAS, 2007b.

The gap in electricity consumption in China reveals one public problem: the lack of electricity access in remote rural areas of western China. In China, mainly the eastern and central parts of the country are electrified,[39] as well as the urban areas in western China, leaving un-electrified townships, villages, and households mostly in remote and rural areas of western China (see Table 2-5).

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[39] Electricity access in rural areas of coastal provinces is almost 100% (Pan et al., 2006).

Table 2-5 Rural electrification rate in China

Year	Electrification rate (%)		
	Townships	Villages	Households
1993	97.4	93.0	89.6
1994	97.8	95.0	91.3
1995	98.3	96.1	93.3
1996	98.6	96.7	94.7
1997	99.0	97.7	95.9
1998	99.2	98.1	96.9
1999	98.3	97.8	97.4
2000	98.5	98.2	98.0

Note: The drop of electrification rate in 1999 is due to the change of administrative boundaries, such as some prefectures and counties disappeared while others emerged, some counties were turned from rural counties into cities (Pan et al., 2006).
Source: Compiled by author based on Ministry of Electricity/National Power Company, 1994, 1995, 1996, 1997, 1998, 1999, 2000, and 2001.

2.4 Policy problem: Electricity access in remote rural areas of western China

2.4.1 The triggering factor: Political leaders

As noted above, several factors trigger the conversion and facilitation of a public problem into a policy problem on the government's policy agenda. Because China is a communist dictatorship regime,[40] most public policies are formulated based on political leaders' preferences. Political leaders decide which specific public problems should be dealt with by the government. The political system is also structured to allow political leaders to turn a public problem into a policy problem on the government's policy agenda. This type of structuring in turn allows political leaders to make sure that every policy problem is identified only by them.

Other triggering factors, such as general public, media, and interest groups, have very limited impact on political leaders' decision. Instead, political leaders resort more frequently to repressing the media, critics, and political activities (Bertelsmann Stiftung,

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[40] In Article 1 of the *Constitution of the People's Republic of China* (Adopted on December 4, 1982), it stated "The People's Republic of China is a socialist state under the people's democratic dictatorship led by the working class and based on the alliance of workers and peasants." (Retrieved 1 December, 2009 from http://english.people.com.cn/constitution/constitution.html). However, many scholars defined the People's Republic of China as a communist authoritarian regime (see Landry, 2008: 2; Saich, 2004; Lieberthal, 1992; Lieberthal and Okenberg, 1988; Lampton, 1992).

2007). In China, the media is strictly controlled by the government, which ultimately decides what issues will be given attention and what issues will be ignored.[41] The Chinese government's control of the media also lets the government control the general public's opinions on particular public problems or public policies. In China, the general public does not have the right to protest or demonstrate publicly to bring a public problem to the attention of the government.[42] Where interest groups and non-governmental organizations (NGOs) are involved, the situation is also determined by government mandate. Interest groups or NGOs are often government-organized interest groups or NGOs under the supervision of the Chinese government (Plummer and Taylor, 2004), and hardly influence any key public issue which appears on the government's policy agenda.[43]

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[41] Most influential media are controlled and/or owned by the Chinese government. "Amid increasing social unrest, journalists covering controversial issues, criticizing the CPC or deviating from state propaganda increasingly suffer harassment. The PR China has jailed more journalists than any other country and Reporters Without Borders ranks China 159th out of 167 countries on its global press freedom index. In mid-2006, a proposal for new legislation was put forward which would allow the government to fine media outlets that run independent reports on public emergencies, further restricting press freedom. Moreover, in September 2006, the Chinese government released new restrictions on press freedom, giving the governmental Xinhua News Agency control over distribution within China of information from foreign agencies and authorizing Xinhua to censor news covering topics related to national unity or social stability" (Bertelsmann Stiftung, 2007: 6). Besides, the control of media and restrictions on the internet is also strictly tightened. "[…] Critical websites and chat rooms were shut down and access to foreign websites was interrupted; moreover, the email correspondence of political activists is spied on, resulting in the detention of several bloggers and cyber-dissidents. Unfortunately, foreign Internet companies have largely cooperated with the Chinese government on censorship enforcement" (Bertelsmann Stiftung, 2007: 7).

[42] The *Constitution of the People's Republic of China* guarantees certain civil rights, such as freedom of speech, freedom of the press, freedom of assembly, freedom of association, freedom of demonstration, freedom of religious belief, freedom of person, etc. The amendment to the constitution on March 2004 explicitly codified the protection of human rights (see *Constitution of the People's Republic of China*, Chapter II The Fundamental Rights and Duties of Citizen, Article 33 to 56). However, interference with these rights by the Communist Party of China (CPC) and state organs has become increasingly frequent (Bertelsmann Stiftung, 2007: 8). There is a lack of democratic legal mechanisms for public participation (Pan, 2006). The public can not find a way to turn their problems, worries, and complaints into legal appeals (Pan, 2006).

[43] Since the late 1970s, the NGOs and interests groups in China have proliferated and become more diversified. Today, NGOs concentrate mainly on nonpolitical issues, such as culture, environmental protection, social issues, health, philanthropy, animal welfare, representation of the interests of marginalized groups (women, the disabled, ethnic minorities, children), and also provide services for the population, such as legal aid and consumer protection. There are more than 133,000 officially registered NGOs, as well as many grassroots NGOs which are not officially registered (Bertelsmann Stiftung, 2007: 9). "Since NGOs are required to register with the relevant state agencies, their work is strictly controlled by the government. As long as NGOs are not outspokenly critical of the regime, they are tolerated by the government as providers of beneficial services in areas where the adverse effects of economic development are affecting people's lives (environmental protection; health care/AIDS; support for the disabled, orphans, etc.), and where governmental agencies lack the funds and/or the will to provide relief themselves" (Bertelsmann Stiftung, 2007: 6).

2.4.2 The interests of the political leaders: Social stability

Acceleration of the development of electrification in remote rural areas of western China was first emphasized in the government's 10^{th} Five-Year-Plan[44] (2001-2005) (NREL, 2004d). What interests motivated Chinese political leaders to put the public problem of electricity access in remote rural areas of western China on the government's policy agenda? Primary reasons included the unequal economic development of urban eastern and rural western China, and its potential to create social instability that might threaten the governance of the Communist Party of China (CPC) (Pan et al., 2006; Bertelsmann Stiftung, 2007).

Since 1990, China has experienced high economic growth with an annual growth rate of about 9% (see Box 2-1). Even so, the benefits of economic growth have not been fairly spread in whole China.[45] As Table 2-6 illustrates, a distinct economic development difference between eastern and western China in terms of GTP and GTP per capita exists even with the high rate of economic growth (see Table 2-6).[46]

Table 2-6 Economic indicators of eastern, central, and western China in 2000

Region	**Population (%)**	**GDP (%)**	**Per Capita GDP (Yuan)**
Eastern China	37.9	57.3	11,335
Central China	32.1	25.6	5,982
Western China	27.4	17.1	4,687

Source: Compiled by author based on NBSC, 2001; Asian Development Bank, 2005a.

After the economic reforms of the 1980s, the gap in income per capita between urban and rural areas among different regions has widened (see Table 2-7). In 1990, the annual urban household income was 1,510 RMB per capita,[47] which was 2.2 times the

[44] The Five-Year-Plan is the most important national development initiative, which aims to arrange national key construction projects, manage the distribution of productive forces for national economy, map the direction of future development, and set targets for future development. In 1953, the Chinese government launched its first Five-Year-Plan. Except for a period of economic adjustment between 1963 and 1965, to date a total of 11 Five-Year-Plans have been made and implemented. (Chinese Government's Official Web Portal, retrieved on 27 April, 2009 from http://www.gov.cn/english/2006-04/05/content_245556.htm).

[45] "The income gap is widening with the richest 10% of households accounting for over 40% of the nation's wealth and the poorest 10% only for 2%" (Bertelsmann Stiftung, 2007: 3).

[46] The GDP per capita of the country's wealthiest province is more than 10 times that of the poorest province (Bertelsmann Stiftung, 2007: 3).

[47] 1 RMB = around 0.1 Euro = around 0.15 USD

annual rural household income per capital of 686 RMB, 1.6 times the annual rural household income per capita in eastern China of 972 RMB, 2.3 times the annual rural household income per capita in central China of 655 RMB, and 2.7 times the annual rural household income per capita in western China of 552 RMB. In 2005, the annual urban household income reached 10,493 RMB per capita. This number was 3.2 times the annual rural household income per capital of 3,255 RMB, 2.2 times the rural household income per capita in eastern China of 4968 RMB, 3.5 times the annual rural household income per capita in central China of 3029 RMB, and 4.7 times the rural household income per capita in western China of 2219 RMB. The remaining rural poverty is mainly in rural areas of western China which are relatively underdeveloped with weaker basic infrastructure (Asian Development Bank, 2005a).

Table 2-7 Income per capita of eastern, central, and western China

Income per capita	**1990**		**1995**		**2000**		**2005**	
	RMB	% of urban income per capita	RMB	% of urban income per capita	RMB	% of urban income per capita	RMB	% of urban income per capita
National urban household	1510	100	4283	100	6280	100	10493	100
National rural household	686	45.4	1578	36.8	2253	35.9	3255	31.0
Eastern rural household	972	64.3	2357	55.0	3374	53.7	4968	47.3
Central rural household	655	43.4	1449	33.8	2075	33.0	3029	28.9
Western rural household	552	36.5	1062	24.8	1533	24.4	2219	21.15

Source: Compiled by author based on NBSC, 2000a, 2001a, 2002a, 2003a, 2004a, 20005a, 2006a; NBSC, 2000b, 2001b, 2002b, 2003b, 2004b, 2005b, 2006b; CAS, 2007b.

The serious disparities in income between the poorer rural western regions and the richer urban eastern regions have the potential to create social instability and threaten the rule of the Communist Party. Beginning in the 1990s, the Chinese government launched several government campaigns, such as 'Well-off Society'[48], 'Building New

[48] The term '*Well-off Society*', also called '*Xiaokang Society*', was first used by the Chinese leader Deng Xiaoping and was continuously pursued by the current Chinese leaders as a goal to build a society in which all people lead a fairly comfortable life.

Socialist Countryside'[49], showed the government's concerns and determination to cope with the serious income disparities between the poorer western regions and the richer urban eastern regions. This concern has been emphasized by the current leader Hu Jintao with two concepts. The first is the 'Scientific Outlook on Development', introduced as a grand strategy of 'comprehensive, coordinated, and sustainable development' with which the new leadership distanced itself from the growth-only mentality of the first two decades of economic reforms and instead promised to balance economic development with social equality and environmental protection (Holbig and Gilley, 2010: 18-19; Bertelsmann Stiftung, 2009: 18). This concept is complemented by another, the 'Harmonious Society'[50], which acknowledges the existence of social tensions and claiming to tackle their root causes (Holbig and Gilley, 2010: 19).

In 2000, the Chinese government adopted a long-term strategy, called 'Western Development Strategy', to support the development of western China. A leading group of government officials, chaired by Premier Zhu Rongji, Vice Premier Wen Jiabao, and 23 other ministers, was organized to develop and coordinate the implementation of the Strategy (Asian Development Bank, 2002). The goal of the Strategy was to make people who live in western China 'better off' in terms of economic and social development. The main governmental actions of the Strategy included investment in infrastructure development, like transportation, electricity, and telecommunications, in order to enable the essential productivity for economic activities. Improving electricity access, particularly in remote rural areas of western China, was an integrated part of the Strategy (SDPC, 2001).

2.5 Policy problem identification: Renewable energy-based rural electrification programs

[49] 'Building New Socialist Countryside' is a government's campaign to develop and modernize rural areas, resolve poverty in rural areas in order to decrease the gap between rich and poor, and further promote social and economic development in rural areas. "The rural electrification construction must adapt to the current situation and follow scientific plan so as to contribute to 'Building New Socialist Countryside' " (CAS, 2007b: 13).

[50] The term '*Harmonious society*', also called '*Hexie Shehui*', was first used by Chinese leader Hu Jingtao as a socio-economic vision to achieve the goal of building a comprehensive '*Well-off Society'* by 2020. It was first proposed by the Chinese government under Hu Jingtao's Administration during the 2005 National People's Congress. The idea was to change China's focus on economic growth to overall societal balance and harmony. It promoted harmony among economic, social, and environmental development, rural and urban development, and domestic development and international cooperation. Also see the official website of 'Building Socialist Harmonious Society' (retrieved 12 December, 2009 from http://www.chinaview.cn/hxsh0627/index.htm).

Several options exist for rural electrification, such as extension of existing grids, creation of mini-grids, or creation of isolated off-grid power generation systems (IEA, 2003). Rural electrification programs in China have been dominated by fossil fuel-based grid extension programs. In 2002, electricity from state grids accounted for 80% of total rural electricity consumption (Pan et al., 2006). But the process of rural electrification has been a shift from fossil fuel-based grid extension programs to renewable energy-based rural electrification programs. Two main reason account for why the Chinese government identified the problem of electricity access in remote rural areas of western China, with the solution of designing 'renewable energy-based rural electrification programs'.

2.5.1 Geographic limitations

The first reason concerns geographic limitations. Such limitations forced the government to identify renewable energy to provide electricity, instead of connecting grids to remote rural areas of western China (SDPC, 2001; NDRC, 2005b; Pan et al., 2006). In eastern and central China, the connection and distribution of electricity with grid extension is technically workable and financially affordable.[51] In western China, the grid is mainly extended to urban areas and the nearby rural areas where higher population density justifies the investment of electrification.

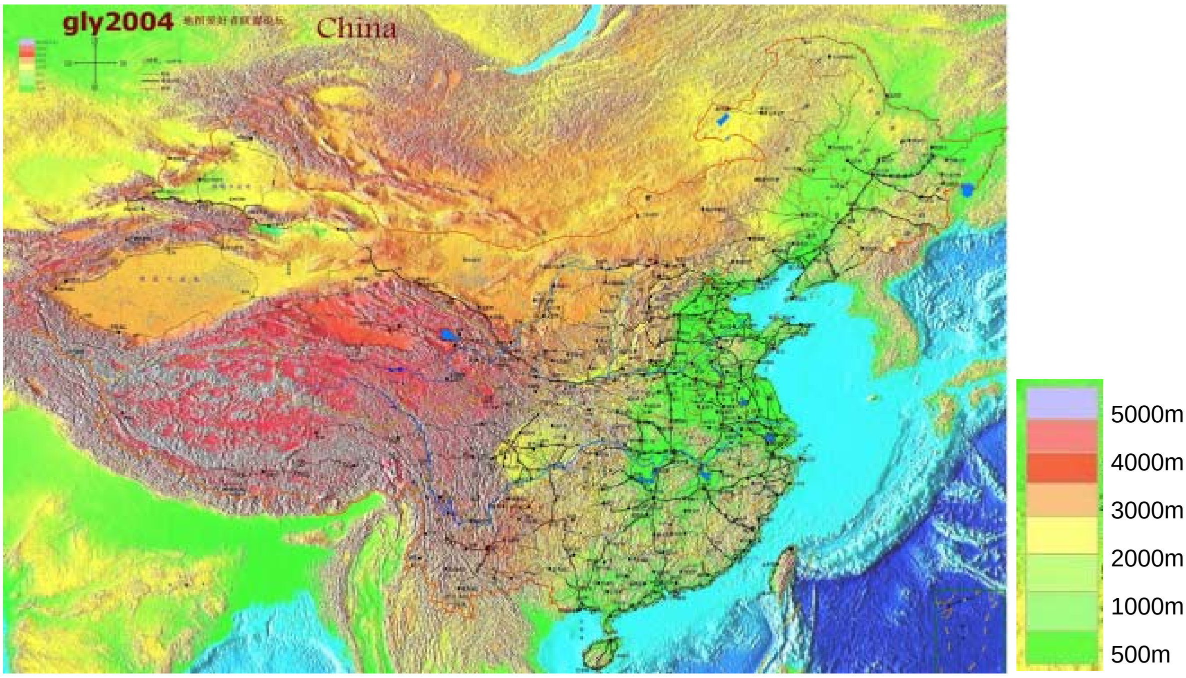
But the remote rural areas of western China, which are mainly covered with high mountains, plateau, and desert with highly dispersed population (see Map 2-1 and Map 2-2), presents unique technical and financial challenges for rural electrification with the extension of power grids (Asian Development Bank, 2005b; Baring-Gould and Lilienthal, 2000; Bhattacharjee, 2002; Zhou and Byrne, 2002).[52] It is difficult and costly to build transmission lines, distribution lines, and grid infrastructure in such vast

[51] Eastern and central China are geographically flat and plain areas compared to western China (see Map 2-1). This makes power grid extension technically workable. In addition, largely urbanized with high populations and higher income in eastern and central China justify the investment in electricity infrastructure encountered.

[52] The average altitude of Tibet AR (the 2nd largest province) and Qinghai Province (the 4th largest province) is 5000 and 3000 meters above sea level (see Map 2-1 and Map 2-2). Xinjiang Uyghur AR (the 1st largest province), Inner Mongolia AR (the 3rd largest province), and Gasu Province are mainly covered with vast desert and plateau (see Map 2-1 and Map 2-2). Such geographic limitations present unique technical and financial challenges for rural electrification with the extension of power grids.

and remote areas with dispersed townships and villages. Besides, low population density, low household income, and low electricity demand pose other challenges to offset the high cost of electricity delivery service.

Map 2-1 Topographic map of PR China



Source: NSF IGERT China Program, University of Wisconsin-Madison.[53] Redesigned by author.

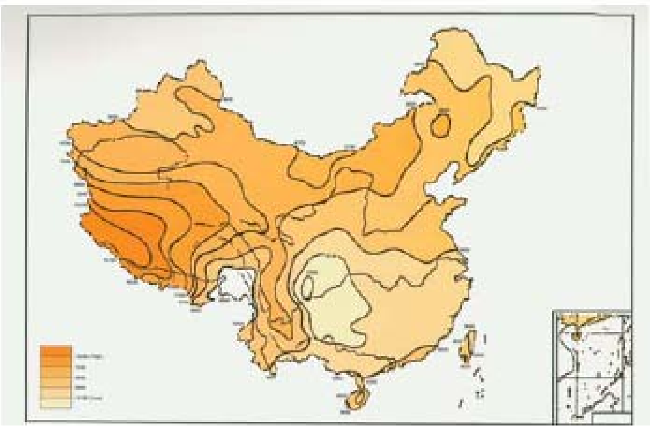
Map 2-2 Provinces of PR China

Source: Society for Anglo-Chinese Understanding.[54] Redesigned by author.

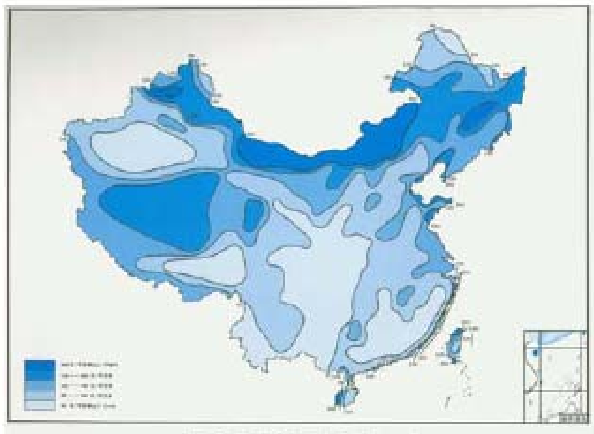
[53] Retrieved 27 November, 2009 from www.swchina.wisc.edu/maps.en.html.

If grid extension is not a possible solution for electrification in remote rural areas of western China, the use of decentralized systems - isolated off-grid power generation systems with available indigenous energy sources, such as solar, wind, and hydro - is one feasible solution for electrification in these areas to reach remote populations. Compared to other regions in China, western China has relatively more renewable energy sources, such as solar, wind and geothermal resources (see Map 2-3, Map 2-4, and Map 2-5) (McKinsey&Company, 2009: 110-113). The best solar energy resource in China is in Tibet AR, Qinghai province, Xinjiang AR, and Gansu province. The best wind energy resource in China are located in Inner Mongolia AR, Tibet AR, Qinghai province, Xinjiang AR, and Gansu province. The best geothermal resource in China is in Tibet AR.

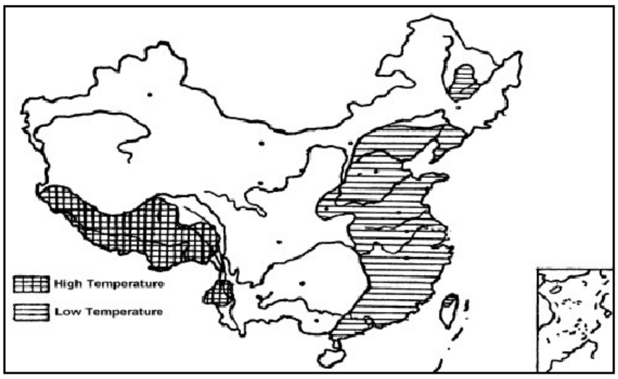
Map 2-3 Solar resource distribution in China



Map 2-4 Wind resource distribution in China



Map 2-5 Geothermal resource distribution in China



Note:
1. The darker the orange color in Map 2-3 the stronger the solar energy is.
2. The darker the blue color in Map 2-4 the stronger the wind power density is.
3. The darker color in Map 2-5 the stronger the geothermal energy is.

Source: Global Energy Network Institute, Beijing Bergey Windpower Co.[55] Redesigned by author.

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54 Retrieved 27 November, 2009 from www.sacu.org/provmap.html.

55 Retrieved 27 November, 2009 from http://www.geni.org/. For solar resource distribution in China:

Therefore, because of geographic limitations and the potential benefit of utilizing renewable energy in these areas, the Chinese government ultimately identified the policy problem with renewable energy-based rural electrification programs, instead of fossil fuel-based rural electrification programs.

2.5.2 Government's national development plan to promote renewable energy

Since the mid-1990s, development of renewable energy has been an important policy direction for China's energy policy (see Table 2-8). The term 'renewable energy' first appeared in the Chinese government's 9th Five-Year-Plan (1996-2000), at which point the focus of the Chinese government's energy policy was not only 'energy conservation', but also 'the development of renewable energy'. In the 10th Five-Year-Plan (2001-2005), the promotion and development of renewable energy became one of the main objectives for the Chinese government's energy policy to achieve sustainable development.[56]

Table 2-8 China's renewable energy policies

Year	Policy name
1996	9th Five-Year-Plan (1996-2000) 2010 New and Renewable Energy Development Program by the State Economic and Trade Commission (SETC), the State Planning Commission (SPC), and the State Science and Technology Commission (SSTC)
2001	10th Five-Year-Plan (2001-2005) Renewable Energy Commercialization Development by the State Economic and Trade Commission (SETC)
2003	Renewable Energy Promotion Plan
2005	Renewable Energy Law
2007	Medium and Long-term Renewable Energy Development Plan

Source: Compiled by author based on NREL, 2004a; NREL, 2004b; NREL, 2004c; NDRC, 2007b; Taylor and Bogach, 1998; Cheng, 2008.

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http://www.geni.org/globalenergy/library/renewable-energy-resources/world/asia/solar-asia/solar-china.shtml. For wind resource distribution in China: http://www.geni.org/globalenergy/library/renewable-energy-resources/world/asia/wind-asia/wind-china.shtml. For Geothermal resource distribution in China: http://www.geni.org/globalenergy/library/renewable-energy-resources/world/asia/geo-asia/geo-china.shtml.

[56] The 10th Five-Year-Plan set several objectives for energy policy to achieve sustainable development: 1) sufficient utilization of clean energies, such as natural gas, hydropower, and nuclear power; 2) promoting new energy and renewable energy; 3) advancing clean coal technology; 4) diminishing the proportion of coal directly used for terminal consumption; 5) achieving sustainable development of energy, economy and environment (NREL, 2004d).

Ever since, a series of national law, plans, and regulations have been formulated promoting the development of renewable energy (see Table 2-8). The most important law is the "Renewable Energy Law"[57] which was ratified on February 28, 2005 and went into effect on January 1, 2006. If well implemented, the law could help catalyze renewable energy markets on an unprecedented scale (Energy Foundation, 2007).[58] To further develop and promote renewable energy, in 2007, the Chinese government launched the "Medium and Long-Term Renewable Energy Development Plan". This Plan sets targets to achieve 10 % of the primary energy supply from renewable energy sources with 250 Mtoe by 2010, and 16 % of the nation's primary energy supply from renewable energy sources with 400 Mtoe by 2020 (NDRC, 2007a).[59] The Plan also set specific targets of renewable energy by type by 2010 and 2020 (see Table 2-9), and adopted solar home PV system and solar PV mini-grid power station as electricity supply for non-electrified villages and residents in remote rural areas (CAS, 2009: 17).

[57] The aim of the *Renewable Energy Law of the People's Republic of China* is 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" (see Article 1 of the *Renewable Energy Law of the People's Republic of China*, Retrieved 1 December, 2009 from http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=5371). It was passed together with nine other monitorial regulations. One of the monitorial regulations is *Financial Support Policy for Promoting Renewable Energy in Rural Area*.

[58] In the UN's *World Economic and Social Survey 2009*, this report points out several barriers of renewable energy development in China: "(a) the high cost of developing renewable energy; (b) the difficulty of connecting renewable energy to the grid; (c) institutional impediments; (c) the lack of international investment; (e) a weak legal and regulatory framework; (f) an uncertain level of future demand and thus of prices for renewable energy" (United Nations, 2009b: 121).

[59] In 2006, the nation's primary energy supply from renewable energy sources accounted for 8% of the total primary energy supply with 200 Mtoe, in which hydropower for 150 Mtoe, solar energy accounts for 36 Mtoe, biomass energy for 9 Mtoe, wind energy for 2 Mtoe, and geothermal energy for 3 Mtoe (Wang, Wang, Shi, and Li, 2006). The Chinese government's definition of renewable energy includes hydro power and biomass. Article 2 of the *Renewable Energy Law of the People's Republic of China* defines renewable energy as "non-fossil energy of wind energy, solar energy, water energy, biomass energy, geothermal energy, and ocean energy, etc." (Retrieved 1 December, 2009 from http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=5371).) This law does not apply the IEA's definition of renewable energy which does not include hydro power and biomass. If one uses IEA's definition, China's renewable energy accounts only for 1.5% of total primary energy supply with 41 Mtoe.

Table 2-9 China's renewable energy targets by type by 2010 and 2020

Type of energy	2006	2010	2020
Total hydropower (GW)	130	190	300
Small hydropower (GW)	47	60	85
Wind power (GW)	2.6	5	30
Solar power (GW)	0.08	0.3	1.8
Solar thermal (million square meters)	100	150	300
Biomass power (GW)	2	5.5	30
Geothermal energy (Mtce)	N/A	4	12
Tidal Power (MW)	N/A	N/A	100
Ethanol (million tons)	1	2	10
Biodiesel (million tons)	0.05	0.2	2
Biomass pellets (million tons)	~0	1	50
Biogas and biomass gasification (billion cubic meters)	8	19	44

Source: Compiled by author based on Medium and Long-Term Renewable Energy Development Plan, 2007; Martinot and Li, 2007; Cheng, 2008.

But what drives the development and promotion of renewable energy as a key focus of the Chinese government's energy policy?

First, increasing energy demand and the pressure of energy shortage have driven the development and promotion of renewable energy as a key focus of the Chinese government's energy policy. In the 1980s and 1990s, China was consistently energy self-sufficient with more energy export than energy import. But since 2001, domestic energy supply has not kept pace with the domestic energy demand. Therefore, starting in 2002, China had its first net energy import of 1 % (IEA, 2004), with net energy import increasing to 7 % in 2004 (IEA, 2007), which is due to the rapid growth of energy demand.

Large population, rapid urbanization and booming economic development have contributed to the rapid growth of energy demand and placed burdens on energy supply.[60] Compared to the total primary energy supply of 405 Mtoe in 1971, the total primary energy supply increased twice to 877 Mtoe in 1990, and four times to 1,627 Mtoe in 2004 (sees Table 2-10). In 2004, the total primary energy supply accounted for

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[60] China is the most populous country in the world with population of 1.3 billion, one-fifth of the world population. China is the second largest economy in the world after the United States, with the average GDP growth rate of 8-10 % annually.

15% of the world primary energy supply, the second largest in the world after the United States (IEA, 2007).

Table 2-10 China's total primary energy supply by type in 1971, 1990, and 2004

Type of energy	**1971**		**1990**		**2004**	
	Energy demand (Mtoe)	Share (%)	Energy demand (Mtoe)	Share (%)	Energy demand (Mtoe)	Share (%)
Coal	192	47 %	534	61 %	999	61 %
Oil	43	11 %	116	13 %	319	20 %
Gas	3	1 %	16	2 %	44	3 %
Nuclear	0	0 %	0	0 %	13	1 %
Hydro	3	1 %	11	1 %	30	2 %
Biomass[1]	164	41 %	200	23 %	221	14 %
Other renewables[2]	0	0 %	0	0 %	0	0 %
Total	405	100 %	877	100 %	1626	100 %

Note:
1. Biomass includes solid biomass and animal products, gas and liquids derived from biomass, industrial waste and municipal waste (IEA, 2004: 553).
2. Other renewables include solar, wind, geothermal, tide, and wave energy for electricity generation. Direct use of geothermal and solar heat is also included in this category (IEA, 2004: 553).
Source: Compiled by author based on IEA, 2004; IEA, 2006.

Increasing energy demand and the pressure of energy shortage have forced the Chinese government to develop new and alternative energy sources. China has rich renewable energy resources and the exploration potential of renewable energy resources is very high (World Bank, 1996c). Besides hydro power, which is explored with a rate of 38.11%, the exploration level of other renewable energy resources, such as wind, solar, geothermal, biomass and tide is relatively low ranging from 0.01% to 1.2% (see Table 2-11).

The development of renewable energy can not only increase energy supply from variety of energy sources, but also change the energy structure with more diversified energy sources.

Table 2-11 Renewable energy resource capacity and exploration ratio in China

Renewable energy		Resource capacity (GW)	Explored capacity (GW)	Exploration ratio (%)
Hydro power	Large and medium hydro	379	108.26	38.11
	Small hydro[1]	65	30.80	
Wind power	Inland development	253	0.76	0.08
	Offshore development	750	0.00	
Solar PV		520	0.06	0.01
Geothermal		3	0.03	1.13
Biomass[2]		500-600	6.00	1.00-1.20
Tide power		2	0.01	0.06

Note:
1. 'Small' hydro means the capacity is below 25MW.
2. The utilization of biomass includes biogas and power generation. The unite is GtCe (Gigatonnes of carbon equivalent).
Source: Compiled by author based on China Energy Development Report, 2007; CAS, 2007b.

Second, the pressure of environmental protection, human health, and climate policy has driven the development and promotion of renewable energy (NDRC, 2005c; Taylor and Bogach, 1998; World Bank, 1996). The pattern of energy use in China is mainly based on fossil fuel. In 2004, fossil fuel accounted for 84% of China's primary energy supply, in which coal accounted for 61%, oil accounted for 20%, and gas accounted for 3% (see Table 2-10). China relies heavily on coal and is the largest global coal consumer and producer in the world (IEA, 2006). Due to limited oil and gas reserves and hydro power potential, coal will remain the most important element of China's long-term energy mix in the future as it continues dominate the primary energy supply (Knecht, 2006). Continued use of coal poses a great challenge for the Chinese government to reduce adverse environmental impacts associated with rapid economic growth in a fossil fuel-based economy (World Bank, 1996c).[61]

At the national level, heavy fossil fuel consumption, especially combustion of coal, causes severe energy-related environmental and human health problems. Urban air

[61] In 2007, the major emission pollutants are SO_2 with 24.681 million tons, soot with 9.863 million tons, and industrial dust with 6.99 million tons (CAS, 2009: 14). "According to the statistics, 70% of soot emission, 85% of SO_2 emission, 67% of nitrogen oxides emission, and 80% of CO_2 are from coal combustion." (CAS, 2009: 14). The Chinese government planed to close 14 GW of small and inefficient coal power plants every year until 2010 to improve the overall efficiency of coal-fired power plants (McKinsey&Company, 2009: 107). But to reduce the power generation sector's dependence on coal, the Chinese government should develop either cleaner energy sources, such as renewable energy, small hydro power plants, and nuclear plants, or use cleaner coal-based power technology, such as integrated gasification combined cycle, and carbon capture and storage (McKinsey&Company, 2009: 104).

pollution in many cities exceeds international standards by a factor of three to five times (World Bank, 1996c). A 2006 World Bank pollution survey showed that 16 of the 20 most polluted cities in the world are in China (Jiang et al., 2007). Chronic pulmonary disease which is the largest single cause of adult deaths in China and linked closely to air pollution accounts for 26 percent of adult deaths in China (World Bank, 1996c).

At the global level, China's fossil fuel-based energy supply and heavy dependence on coal implies the rapid increase of CO_2 emissions, both of contribute to global warming and climate change.[62] It is also evident that, for China as well, "climate change threatens not a one-time catastrophe but a slowly unfolding disaster" (Holtz, 2007: 14). In 2004, China produced the highest yearly percentage of global CO_2 emissions with 24.4 % (see Table 2-12). The figure have drawn international attention to the Chinese government's climate and energy policy, and placed pressure on the government to commit to reducing CO_2 emissions in order to tackle global climate change.[63] In 2002, the government ratified the *Kyoto Protocol* which went into force in China in 2005.[64] The development and promotion of renewable energy is developed as one of the main strategies by the Chinese government to reduce CO_2 emissions and mitigate climate change while it also increase energy supply for domestic needs (NDRC, 2007a; NPC, 2009; Holtz, 2007; Cheng, 2008; Krahl, 2009: 5).[65]

[62] Also see BMZ, 2008: 60-68.

[63] China is a signatory of the *United Nations Framework Convention on Climate Change* (UNFCCC). Beginning in the 1990s, China adopted a strategy of constructive involvement and more actively engaged in international affairs, particularly under the framework of the United Nations, to build a harmonious world (Gao, 2008: 2-4). The concepts of 'harmonious world', 'peaceful development', and 'win-win cooperation' are the three pillars of China's foreign strategy (Gao, 2008: 2).

[64] But being a developing country, China does not have to fulfill specific emission targets as other developed countries. However, China is an active participant in the Clean Development Mechanism (CDM) established under the *Kyoto Protocol* (Lewis, 2007). China is the largest source of CDM credits, accounting for over 40 percent of CDM credits (Lewis, 2007).

[65] In the *Resolution of the Standing Committee of the National People's Congress of China on Actively Responding to Climate Change* (adopted at the Tenth Meeting of the Standing Committee of the Eleventh National People's Congress on 27 August 2009), developing renewable energy is one of the Chinese government's strategy to tackle climate change.

Table 2-12 Annual CO2 emissions by country in 2004

Rank	Countries	Annual CO_2 emissions (million tones)	Percentage of total emissions (%)
1	China	7,010	24.4%
2	United States	6,049	22.2 %
3	Russian Federation	1,525	5.6 %
4	India	1,343	4.9 %
5	Japan	1,258	4.6 %
6	Germany	860	3.1%
	World	27,246	100%

Note: The data considers only carbon dioxide emissions from the burning of fossil fuels. It does not include emissions from deforestation, and fossil fuel exporters, etc.
Source: The data was collected in 2007 by the Carbon Dioxide Information Analysis Center (CDIAC) for United Nations.

Electrification with renewable energy in remote rural areas of western China constitutes part of the government's national development plan to promote renewable energy (Pan et al., 2006). The 10th Five-Year-Plan (2001-2005) states that 0.8 million households in remote rural areas must be electrified by renewable energy (SDPC, 2001; CAS, 2007a).[66] In the "Renewable Energy Law", the government encourages and supports the development and use of renewable energy in the rural areas, focusing on the use of biomass and biogas, home solar energy, small wind energy, and small-scale hydropower.[67]

[66] The first priority of rural electrification in remote rural areas is utilization of hydro power if the areas have water resources. For areas with scare or no water resources, solar and wind energy are the main options to provide electricity.

[67] The "Renewable Energy Law of the People's Republic of China" Article 18 states: "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" (Retrieved 1 December, 2009 from http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=5371).

The "Renewable Energy Law of the People's Republic of China" Article 24 states: "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" (Retrieved 1 December, 2009 from http://www.ccchina.gov.cn/en/NewsInfo.asp?NewsId=5371).

2.6 Brightness Program

The Brightness Program is the first national policy formulated by the Chinese government to address the policy problem - bring electricity to remote rural areas of western China by means of renewable energy. The phrase ‘Brightness Program’ was first introduced during the 1996 World Solar Peak Conference in Zimbabwe, and was an international effort designed to bring electricity to rural areas (NREL, 2004a). The Program was formulated under the leadership of the State Development Planning Commission (SDPC).[68] The overall target of the Brightness Program is to provide electricity with renewable energy for 17.6 million people in remote rural areas and eventually ensure 100 watts of capacity per person by 2010 (CAS, 2007a).[69] Several pilot projects of the Brightness Program were launched in 2000 in Inner Mongolia AR, Tibet AR, and Gansu Province to provide electricity access for non-electrified households and villages, as well as to establish financing schemes, markets, industries, technical capacity, and training systems. The State Council allocated about 40 million RMB (around 4 million EURO) to support the pilot projects (NREL, 2004a). The implementation results of these pilot projects are shown in Table 2-13. The pilot projects installed 5,515 solar home systems, 518 wind/solar PV hybrid home systems, and 5 station systems. In addition, the pilot projects established national and local government bureau financing mechanisms for renewable energy, set up distribution and service network for renewable energy, and developed a technical training system.

Table 2-13 Implementation results of the pilot projects of the Brightness Program

Province	**Outputs**	**Capacity**
Inner Mongolia AR	■ 518 sets of wind/solar hybrid home systems ■ 1 set of wind/diesel hybrid station	217 kW (155 kW wind, 62 kWp solar PV)
Tibet AR	■ 4 sets of 6 kWp solar PV station	24 kWp
Gansu	■ 5,515 sets of solar home PV systems	125 kWp

Source: Compiled by author based on NREL, 2004a; CAS, 2007a.

While the scale of the pilot projects in the three western provinces is small, emphasis was focused on exploring different perspectives of applying wind and solar PV

[68] In 2003, the State Development and Planning Commission (SDPC) was renamed the National Development and Reform Commission (NDRC).
[69] In 2000, the number of people without electricity access in China equaled 17.6 million (IEA, 2002).

technologies. Examples of applications explored include: system installation, financing mechanisms, distribution network, service network, and technical training system, all done to provide different levels of training for local technicians and engineers.

2.7 International cooperation

Besides the Brightness Program, the Chinese government also launched several international cooperation projects with international organizations and foreign governments to address the policy problem - improve electricity access by means of renewable energy in remote rural areas of western China. Examples of cooperation projects include: the China-Japan 'NEDO' Project, China-Germany Financial Cooperation 'Western Solar Energy' Project,[70] China-Germany Technical Cooperation 'Rural Renewable Energy' Project,[71] China-World Bank-Global Environmental Facility 'Renewable Energy Development' Project, China-the Netherlands 'Lighting the Silk Road' Project, and China-Canada 'Rural Electrification of Western China through Solar Energy - A Strategy for Eliminating the Global Climate Variation' Project. The total investment of these international cooperation projects is more than 800 million RMB (around 80 million EURO). The contents of these projects are summarized in Table 2-14.

[70] Also see BMZ, 2008: 67.
[71] Also see BMZ, 2008: 67 and GTZ website for project information (Retrieved 1 December, 2009 from http://www.gtz.de/de/weltweit/asien-pazifik/china/8640.htm).

Table 2-14 International cooperation projects for renewable energy-based rural electrification in China

Project	Period	Grant (Million RMB)	Content	Provinces
China-Japan 'NEDO' Project	1998-2002	40	- Construct 14 solar PV stations - Install 187 sets of 140W solar home PV systems - Total installed capacity: 128.45kW	Tibet AR, Xinjiang AR, Inner Mongolia AR, Qinghai, Gansu, Shaanxi, Ningxia, Sichuan, Yunnan, Guangdong, Zhejiang, Hebei
China-Germany Financial Cooperation 'Western Solar Energy' Project (BMZ/KfW)	2001-2005	260	- Install 210 solar PV stations and solar/diesel hybrid stations - Offer 10,000 households, 40,000 people electricity	Xinjiang AR, Qinghai, Gansu, Yunnan
China-Germany Technical Cooperation 'Rural Renewable Energy' Project (GTZ/BMZ)	2001-2007	46	- Offer technical support - Assist developing strategy - Improve management efficiency - Build capacity - Train local technicians	Tibet AR, Qinghai, Gansu, Yunnan
China-World Bank-Global Environmental Facility 'Renewable Energy Development Project'	2001-2007	200	- Subsidize 35,000 sets of 10W solar home PV systems - Total installed capacity: 10MW	Tibet AR, Xinjiang AR, Inner Mongolia AR, Qinghai, Gansu, Yunnan, Sichuan, Shaanxi, Ningxia
China-the Netherlands 'Lighting the Silk Road' Project	2002-2006	140	- Provide 78,800 sets of 25W solar home PV systems - Offer 78,800 households electricity	Xinjiang AR

China-Canada 'Rural Electrification of Western China through Solar Energy – A Strategy for Eliminating the Global Climate Variation' Project	2003-2005	130	- Construct 2 demonstration solar PV stations - Promote local research and technical training	Inner Mongolia AR

Source: Compiled by author based on CAS, 2007a; CAS, 2007b; GTZ, 2008a; GTZ, 2008b.

2.8 Township Electrification Program

As indicated above, many efforts were undertaken by the Chinese government to address issue of insufficient electricity supply to remote rural areas in western China. Yet the small scale of the pilot projects of the Brightness Program and the variety of international cooperation projects alone was inadequate for solving the policy problem of electrifying the remaining 12.9 million people living in these places.[72] As a result, the need for more unified policy action was required by the government in order to meet this challenge.

In 2002, the 'Township Electrification Program' was initiated by the State Development and Planning Commission (SDPC) to provide electricity for the townships which had no electricity access by means of solar energy, wind energy, and hydro power.[73] The Program is financed by the Chinese government with total investment of 2,600 million RMB (260 million EURO). The scale is much larger than the pilot projects and international cooperation projects (see Table 2-15 and Table 2-14).

[72] In 2002, the number of people without electricity access in China is 12.9 million (IEA, 2004: 362).
[73] The Township Electrification Program is known as *Song Sian Dao Xiang* in Chinese.

Table 2-15 Comparison of the pilot projects of the Brightness Program and the Township Electrification Program

Project	Period	Grant (Million RMB)	Content	Total installed capacity (kWp)	Provinces
Pilot Projects of the Brightness Program	2000-2002	40	- Construct 4 solar PV stations - Install 518 sets of wind/solar hybrid home systems - Install 5,515 sets of solar home systems	366	Tibet AR, Inner Mongolia AR, Gansu
Township Electrification Program	2002-2003	2,600	- Construct 670 solar PV stations and 51 solar PV/wind hybrid stations with installed capacity 15,540 kWp - Construct 146 small hydro power stations with installed capacity 113,765 kW	129,305	Tibet AR, Xinjiang AR, Qinghai, Sichuan, Inner Mongolia AR, Gansu, Shanxi, Hunan, Shaanxi, Yunnan, Chongqing, Jiangxi

Source: Compiled by author based on CAS, 2007a; CAS, 2007b.

At the time of research, the Township Electrification Program represented the world's largest renewable energy-based rural electrification program in terms of investment volume ever carried out by a country (CAS, 2007a).[74] The Program was the largest in terms of scale of dissemination of renewable energy technologies for decentralized rural electrification ever implemented in China (CAS, 2007a). To date, the Program facilitated the development of solar PV industry in many ways.[75] The detailed formulation, adoption, and implementation of the Township Electrification Program are introduced in chapter 3, 4, and 5.

[74] "Tens of thousands of mini-grids exist in China, while hundreds or thousands exit in India, Nepal, Vietnam, and Sri Lanka. […] Only around 1,000 such hybrid mini-grids exist in the developing world, mostly in China, where they have been installed through the Township Electrification Program since 2002." (Flavin and Aeck, 2005 et al., 2005: 22-23)

[75] In 2008, China became the world largest PV manufacturing base, with 95% of its production for the export market (UNEP and NEF, 2009; McKinsey&Company, 2009: 112). China is also among the top countries in respect of the number of its patents for renewable energy technologies (United Nations, 2009b: 121).

3 Policy Formulation and Adoption: The 'Township Electrification Program'

3.1 Policy formulation and policy adoption

In the real political world, it is often difficult to separate policy formulation from policy adoption, because neither policy formulation, nor policy adoption necessarily "have to be performed by separate individuals at different times in different institutions" (Anderson, 1975; Jones, 1970: 53). However, policy formulation and policy adoption have different distinct functional activities in policy-making process (Anderson, 1975: 71).

According to Dunn, policy formulation occurs when "officials formulate alternative policies to deal with a problem" (Dunn, 1994: 16). Anderson argues that policy formulation occurs when there is "development of pertinent and acceptable proposed courses of action for dealing with a public problem" (Anderson 1975: 66-67). And adding a third perspective to the issue of policy formulation and adoption is Dye, who defines policy formulation as the development of policy alternatives for dealing with policy problems on policy agenda (Dye 1998: 325). But, as is often the case, policy alternatives do not always result in policies, programs, executive orders, administrative rules, court decisions or proposed laws (Anderson, 1975). In other words, a policy problem that appears on a government's policy agenda for formulating policy alternatives does not necessarily mean that a government action will be taken until one policy alternative is adopted.

Policy adoption occurs when "a policy alternative is adopted with the support of a legislative majority, consensus among agency directors, or a court decision" (Dunn, 1994:16). Dye outlines several characteristics of policy adoption: selecting a proposal, building political support for it, and enacting it as a law (Dye, 1998: 17). Policy adoption is a process of legitimating a public alternative within a specific political framework.

The analysis of policy formulation and adoption in this study focuses on both the actors involved and the process itself. Actors involved in policy formulation often include governments, parliaments, congress, interest groups, think tanks, etc (Anderson, 1975;

Dye, 1998). The analysis of the actors is to examine who are involved in the development of policy alternatives. Actors involved in policy adoption often include parliaments, congress, presidents, prime ministers, and government officials (Anderson, 1975; Dye, 1998). The analysis of the actors is to examine who adopt or enact a policy. In regard to the process of policy formulation and adoption, this study examines how a policy is formulated, adopted or enacted within a specific political framework. A public policy which is formulated and adopted by a legal process by legal institutions, authorities, or officials is considered legitimate. Usually, the process of policy adoption is stated in constitutions or different laws as an unchangeable process.

Even with the above understanding of policy formulation and adoption in place, analysis of policy formulation and adoption in this study is limited. While analysis attempts to denote the underlying set of actors involved and the nature of the process of policy formulation and adoption within the formal Chinese political framework, quite a bit remains unknown or unexplained due to 'informal' political influences affecting how a public policy is formulated and adopted in PR China.

3.2 Political framework of People's Republic of China

As Uwe Holtz explains, very rarely do theories of development take into consideration the influence of political frameworks on the formulation and adoption of policy (Holtz, 2004). However, focus on political framework can help illustrate the policy-making process that is crucial to the shaping of public policies in a specific country. Yet before introducing the political framework of China, a short review of the historical development of its contemporary political structure, particularly after the Communist Party of China (CPC) took control of China in 1949, is provided. A review of this historical development helps to explain the key role played by the CPC within China's political framework.

3.2.1 Development of China's contemporary political structure

The review of the historical development of China's current political structure begins with the CPC's rise to power in the mid-20th century. The discussion is divided into two parts: Mao's leadership from 1949 to1978 and China under reform from 1978 to now.

1949 – 1978: Mao's leadership

After twenty-two years of conflict with its domestic rival the Kuomintang (KMT) and the international invader Japan, the CPC took control of China in 1949. In the mid-1950s, the CPC unified China and completed its objective of rural revolution, shortly thereafter providing social stability and economic growth after the wars. From 1956 to 1966, Mao developed his own version of socialism, which marked the origins of what has come to be known as the 'Chinese Path to Socialism' (Saich, 2004: 37-43).[76] In 1966, Mao started the Cultural Revolution, a ten year period marked by the radicalization of politics and class struggles.[77] With the Cultural Revolution, Mao and his party were able to take control of almost every aspect of the economy and society. But as the Cultural Revolution unfolded, Mao and his party also move from a focus on state-building to state destruction (Saich, 2004: 26). The Cultural Revolution created many problems and imbalances in economy and politics and represents what is historically known as the 'ten lost years' by the Chinese. Subsequently, it was only after Mao's death in1976 that new economic and political reforms were undertaken by the government to help stabilize the country.

1978 to now: China under reform

Reforms were launched under the leadership of Deng Xiaoping in 1978, and were mainly economic in nature and enacted under tight political control. Criticism of Mao by CPC officials for his Cultural Revolution, lead Deng to claim that the CPC's legitimacy was closely linked to its ability to achieve the country's economic development (Saich, 2004). As a result, economic reforms led to a significant liberalization of party control over the economy and society, especially in comparison to the control exercised by the previous Mao's regime. However, from 1985 to 1991, problems with reforms occurred in both the economy and in politics. Economic reforms were deeply contested by opponents on the basis of ideological purity, as well as by

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[76] The Chinese Path to Socialism is socialism with Chinese characteristics. It claimed that the state had ownership of a large fraction of the Chinese economy.

[77] The Cultural Revolution, also known as the Great Proletarian Cultural Revolution, was launched by Mao Zedong, the chairman of the CPC, on May 16, 1966. It was a mass movement which was carried out largely by the Red Guard. It intended to eliminate counterrevolutionary elements in the government, but resulted in purges of the intellectuals and socioeconomic chaos.

groups who felt disadvantaged by the reforms, and by those who felt that reforms had not progressed enough. Politically, Deng's regime faced the student protest in Tiananmen in 1989, but the CPC put down the students' protest, ultimately sparing China from the collapse of the communist regimes in Eastern Europe and the profound changes experienced by those living in Gorbachev's Soviet Union (Saich, 2004). After such economic and political instability, Deng sought even greater change from reforms, instead of pursuing incremental change to push China once again along the road of reforms. In 1992, Deng concluded that continued economic reforms were vital for establishing the CPC's legitimacy, claiming that "if China's economic reforms were reversed, the party would lose the people's support [,] and could be overthrown at any time and […] it would certainly not have survived the trauma of Tiananmen" (Saich, 2004: 76). Therefore, in retrospect, reforms brought difficulties to the CPC regarding control over the economy and society, manifesting in the form of friction between state and society.

After Deng's retirement in 1992, Jiang Zemin was elected President of People's Republic of China by the CPC. Yet, even with Jiang's election, Deng was still considered leader of the country, and someone with great influence over politics. Following Deng's death in 1997, reform led by Jiang began to slow. Given that economic reforms were considered by the Party essential to the maintenance of social stability, the CPC continued to refrain from overall control of the economy and society. But even as the CPC held back from exercising direct control, reforms still helped to strengthen the CPC as a key institutional actor in crucial areas of the economy and society. Unlike Deng, Jiang adopted a more cautious approach to political control, which was aimed at slowing down the rapid pace of economic transition. Jiang also ignored political reforms which were proposed by some groups in the CPC in order to maintain state stability. Commenting on this shift is Tony Saich, who writes, "In 1998, Jiang made it clear that radical or Western-inspired models of economic and political reforms were not for China […] In this context, he suggested that the bold reforms of earlier in the year would be moderated for people to adjust to the consequences" (Saich, 2004: 84). In 2003, Hu Jintao succeeded Jiang as president of the People's Republic of China. Differing from Jiang, Hu paid greater attention to the rural economy and problems of inequality existing in Chinese society. Unlike their predecessors, President

Hu and his Premier Wen Jiabao have been portrayed as more concerned about the poor and rural people.

In contrast to the Jiang and his Premier Zhu Rongji, both Hu Jintao and Wen Jiabao had spent significant periods of their political careers in poorer western provinces, like Tibet and Gansu, whereas Jiang and Zhu had worked primarily in the more developed coastal provinces, in places like Shanghai. Up to now, Hu's leadership has shown greater concern for those who have not benefited from the economic reforms, and he and his party have "called for the countryside to be accorded [to] the highest policy preference and acknowledged that rural problems were even more intractable than those of the urban areas" (Saich, 2004: 89). Ever since Hu's leadership, more national resources and budgets began to allocate to the rural areas particularly in the western provinces.

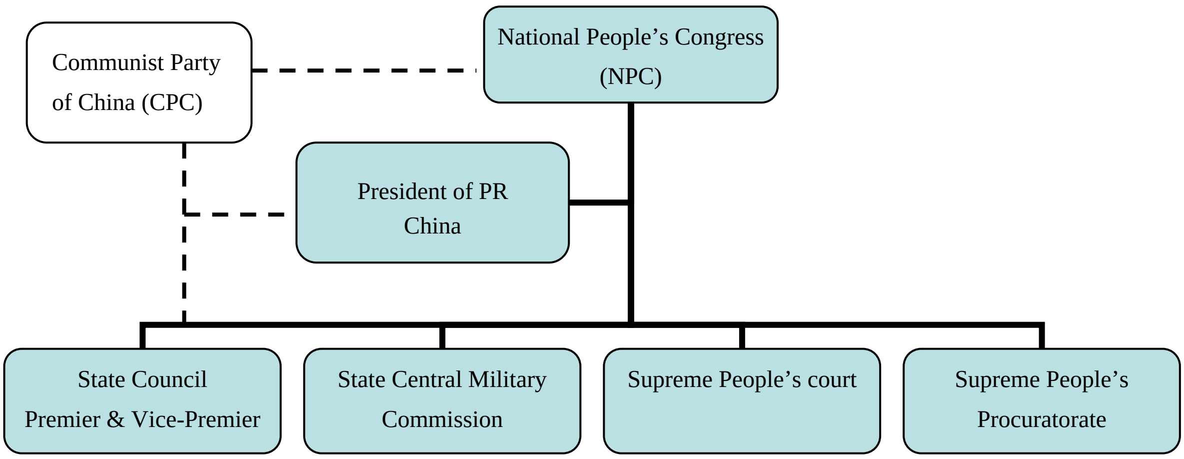
Economic reforms, led by the CPC in China, are characterized by a centrally planned economy that is predominantly socially owned. From 1975 to 2004, economic reforms in China were accompanied by yearly growth rates of about 8.4% and relatively low levels of inflation (Bertelsmann Stiftung, 2007: 3). However, the so-called 'successful' economic reforms instituted by the CPC did not bring significant political reforms. As explained, top leaders in the CPC slowed down the pace of political reforms once reforms brought potential social unrest and affected the CPC's political control over the whole political system (Saich, 2004; Bertelsmann Stiftung, 2007). However, the CPC has adjusted itself gradually with some political reforms to accommodate socio-economic changes within China to maintain its hold on power (Brodsgaard &Yongnian, 2006: 1-13). While dramatic political reforms at national level did not happen, several new political reforms did take place in the form of local level experimentation. Many observers predicted that with the expansion of market economy, the role of the state would decline, like the transitional economies countries (Saich, 2004). But according to Saich, such a decline was not the case in China (Saich 2003). In China, the role of the state expanded into new areas, such as state-owned enterprises, while old functions of the state have not been terminated.

3.2.2 Political framework

The political framework of PR China can be understood in terms of being one based on a paramount individual in the leadership role, e.g. Mao (1949-1976), Deng (1978-1997), Jiang (1998-2003), and Hu (2003-present). Some institutions which do not appear in the 'formal' government structure, such as the CPC, are actually the key to understanding China's political framework and the political power relationship among different institutions. Nevertheless, the formal government structure and institutions shape the nature of the state and politics.

Theoretically, the formal primary organs of state power are the National People's Congress (NPC), the president, and the State Council (see Figure 3-1). But in reality, the CPC dominates the whole formal primary organs of state power. Thus, the discussion of the Chinese political framework includes the following institutions: the National People's Congress (NPC), the President, the State Council, and the CPC. The role of the local governments within the Chinese political framework is also included in the discussion.

Figure 3-1 Political framework of PR China



Source: Drew by author.

1) National People's Congress (NPC)

Under the *Constitution of the People's Republic of China*, the NPC is the highest organ of state power and the only legislative body.[78] All state organs, the executive and the

[78] See Article 57 and Article 58 of the *Constitution of the People's Republic of China*. Retrieved 1 December, 2009 from http://english.people.com.cn/constitution/constitution.html.

judiciary at the central level as well as at the local levels, are responsible to the NPC (Bertelsmann Stiftung, 2007: 7). Deputies of the NPC are elected by the people in the provinces, autonomous regions, municipalities, special administrative regions, and People's Liberation Army every five years, and are mainly nominated by the CPC.[79] At the 11th National People's Congress in 2009, the NPC had 2985 deputies.[80] Annually, deputies meet for two weeks to review and approve major personnel changes, laws, state budget, constitution, and social and economic plans.[81] But because meetings are so brief in occurrence, the NPC is not truly capable of exercising power. Theoretically, the power of the NPC seems extensive. But in reality, decisions and personnel appointments are made by the Politburo Standing Committee of the CPC and ratified by the Central Committee of the CPC. Final decisions and personnel appointments are then present to the NPC for consideration and approval. For example, O'Brien explains that the NPC lacked the organizational muscle to even tell the subordinated State Council and Ministries what to do (O'Brien 1990: 79). Under the NPC are several important institutions, such as the State Council, the State Central Military Commission, the Supreme People's Court, and the Supreme People's Procuratorate. The State Central Military Commission, which, theoretically is under the supervision of the NPC to exercise the command and control of the People's Liberation Army, is in reality under the control of the CPC. The Central Military Commission of the CPC has the supreme military command and control over the People's Liberation Army. Judges' decisions in the Supreme People's court are to be approved by the courts' CPC party committees (Bertelsmann Stiftung, 2007: 7).[82]

2) The President

The president of the People's Republic of China is the head of the state. The president and vice-president are elected by the NPC for five-year terms.[83] According to the

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[79] See Article 59 and Article 60 of the *Constitution of the People's Republic of China*. Although elections are held regularly at all levels of the government, the elections fail to qualify as free and competitive (Bertelsmann Stiftung, 2007: 6).

[80] Retrieved 24 December, 2009 from the NPC official website, http://www.npc.gov.cn.

[81] See Article 61, Article 62, and Article 63 of the *Constitution of the People's Republic of China*.

[82] "The judiciary is not independent; especially in sensitive cases involving public disturbances, state secrets, etc., political involvement in the judicial process and in decision-making is frequent" (Bertelsmann Stiftung, 2007: 8).

[83] See Article 79 of the *Constitution of the People's Republic of China*.

Constitution, the president cannot serve for more than two successive terms.[84] Election of the president and vice-president is always a 'single-candidate' election, and the candidate is nominated by the Politburo Standing Committee of the CPC. The president has the power to appoint the premier upon the decision of the NPC, promulgate statutes, give special presidential decrees, declare a state of emergency, and declare war.[85] Since the early 1990s, the President also serves as the General Secretary of the CPC, who is the head of the CPC. Furthermore, the President is always a member of the Politburo Standing Committee of the CPC.

3) State Council

The State Council, namely the Central People's Government of the People's Republic of China, is the highest executive and administrative authority in China.[86] In theory, the State Council is accountable to the NPC. In reality, it is responsible and accountable to the CPC. The premier, as the head of the government, is nominated by the President and approved by the majority of the NPC. The premier cannot serve more than two successive five-year terms, and is also a member of the Politburo Standing Committee of the CPC.[87] The four vice-ministers, five state councilors, and twenty-eight ministers are nominated by the premier, approved by the NPC, and appointed by the president.[88] The vice-ministers, state councilors, and ministers are also high level senior members of the CPC. As a result, relations between the State Council and the CPC are tightly intertwined.

The main functions of the State Council include formulating policies, issuing administrative orders, monitoring policy implementation, drafting legislative bills, administering the civil bureaucracy, preparing economic plans and state budgets, and also directly overseeing the subordinate provincial governments. Policies and laws are normally formulated by the State Council, reviewed and endorsed by the CPC's Politburo Standing Committee, and then adopted by the NPC.[89] Twenty-seven commissions and ministries, one special commission, sixteen organizations, four

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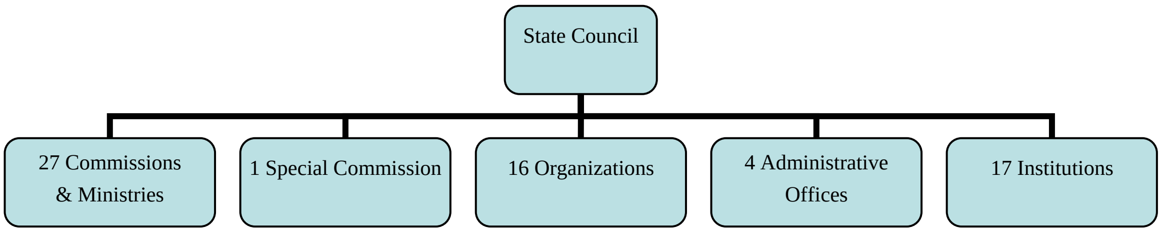
[84] Ibid.
[85] See Article 80 and Article 81 of the *Constitution of the People's Republic of China*.
[86] See Article 85 of the *Constitution of the People's Republic of China*.
[87] See Article 87 of the *Constitution of the People's Republic of China*.
[88] See Article 86 of the *Constitution of the People's Republic of China*.
[89] See Article 89 of the *Constitution of the People's Republic of China*.

administrative offices, and seventeen institutions exist under the State Council (see Figure 3-2). Several political reforms in the State Council have been carried out by the CPC since 1980s, but reforms have mainly focused on restructuring the commissions and ministries. Compared to eight-six commissions and ministries in 1992, the current number of commissions and ministries is the lowest in PR China's political history.

Figure 3-2 Organization structure of the State Council



Source: Drew by author.

4) Communist Party of China (CPC)

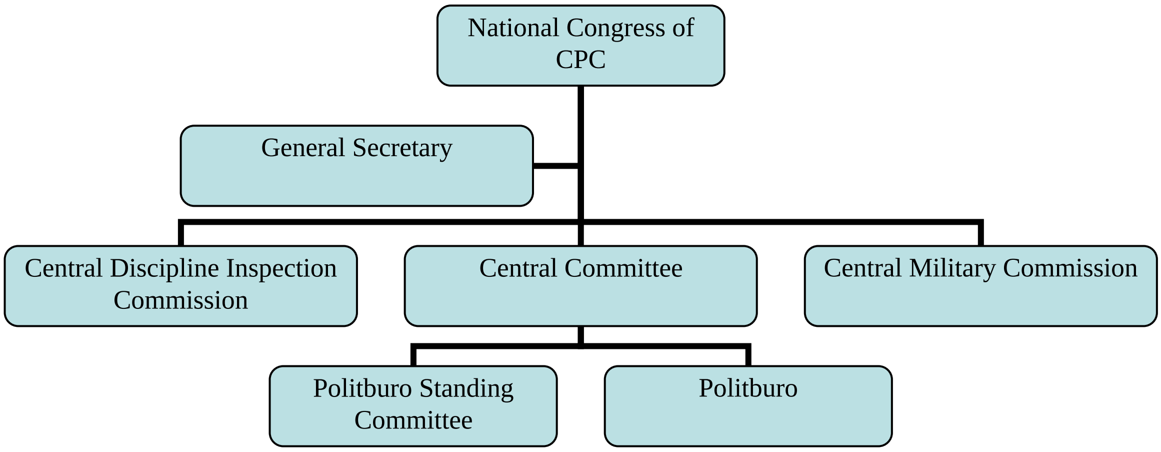
The CPC plays an important role in China's political system, and has a very strong influence on Chinese public policies. It is impossible to understand policy-making under China's political framework without knowing the predominate role of the CPC and its influence on public policies.

Today, the CPC continues to follow the principals of political control outlined by the Leninist model of state socialism (Saich, 2004). But the structure now in existence greatly differs from the political structure in existence under Mao. The organizational structure of the CPC is illustrated in Figure 3-3. Theoretically, the National Congress of CPC (NCCPC) is the party's highest body. The NCCPC meets every five years and the current number of delegates is 2,217[90]. When the NCCPC is not in session, the Central Committee theoretically leads the party. The Central Committee meets once a year and the number of delegates is 204 full members and 167 alternates. But such a large number of delegates and infrequent meetings of the NCCPC and its Central Committee indicates that these bodies are not the main bodies which exercise power within the

[90] The number of the delegates present during the latest, Seventeenth Party Congress on October 15, 2007 was 2,217.

party. The main role of the NCCPC is a symbolic role within the party by displaying of power and unity of the CPC every five years. More importantly, the NCCPC carries the symbolic meaning of demonstrating 'milestones' in the party's history. The Central Committee, while in reality nothing more than a 'rubber stamp' as regards decisions, does possess some real importance, as it serves as a transmission belt passing down policy proposals from the Politburo Standing Committee and Politburo to the NCCPC.

Figure 3-3 Organization structure of the CPC



Source: Drew by author.

The Politburo Standing Committee and Politburo, in practice, form the center of the decision-making process within the Chinese political framework (Held and Merkle, 2009: 32). The power of the CPC actually lies within the Politburo Standing Committee, which is comprised of nine members and the Politburo, which is comprised of twenty-two members. The Politburo Standing Committee is the most powerful political organ in China.

Other important institutions exist under the NCCPC, such as the General Secretary, the Central Discipline Inspection Commission, and the Central Military Commission. The General Secretary, which is the head of the Party, leads the Secretariat for principal administrative mechanism for the CPC. The Central Discipline Inspection Commission is in charge of internal 'party life', such as investigating commitments of the members to the Party, as well as corruption.[91] The Central Military Commission is the most powerful military body in China, and is, in practice, subordinate to the Central Military Commission of the CPC, which ensures the CPC's overall control of the national military system.[92]

No matter in executive, legislature, judicial, or military functions, the CPC possess a dominate role within the China's political framework. All important high-ranking positions in the Chinese government also represent the important high-ranking members in the CPC (Bertelsmann Stiftung, 2007: 8). The close link of the CPC and the government ensures the CPC's unique dominance and control over the Chinese political framework.

5) Local government

Local governments in China are subordinated under the central government, namely the State Council, and are hierarchically structured at five different levels: the provincial level, the prefecture level, county level, township level, and village level (see Table 3-1). While every administrative unit is allocated to a clearly defined level, some units enjoy greater decision-making power than other units at the respective level (Held and Merkle, 2009: 29). Each level in the hierarchy is responsible for supervising the work carried out by lower levels. The CPC appoints one Party secretary at each level of local government. The head of the local government, usually called a governor, mayor or magistrate, is theoretically elected by the people.[93] Candidates are nominated by the CPC. The power of the Party secretaries who act to make policies at local governments is in reality above

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[91] Corruption cases at all levels of the government are mainly handled by the CPC, not by the courts (Bertelsmann Stiftung, 2007: 7). "At the higher and central levels, corrupt officials are often exempt from punishment; only a few 'showcases' have been treated with extensive media coverage in order to substantiate the CPC and government's decidedness decision to reign in corruption" (Bertelsmann Stiftung, 2007: 7).

[92] The highest military leadership over the armed forces, the People's Liberation Army, is the Central Military Commission of the CPC instead of the State Central Military Commission of the NPC or the Ministry of National Defense of the State Council.

[93] "Since 1998, local (i.e., township and county level) elections have been implemented nationwide. To date, deputies to local-level people's congresses as well as village chiefs are elected directly; however, in most cases they have been approved beforehand by the CPC" (Bertelsmann Stiftung, 2007: 6). However, "most citizens are apathetic about elections at the local level since deputies have little influence on policy-making, and the local People's Congresses are usually viewed as rubber stamps" (Bertelsmann Stiftung, 2007: 9).

the heads of the local government who only implement policies. The CPC retains very powerful influence on the functions of the local governments.

Table 3-1 Levels of local government in PR China

Level	Name of level	Types	Number[1]
1	Province level	- Provinces[94]	22
		- Autonomous regions (AR)[95]	5
		- Direct-controlled municipalities[96]	4
		- Special administrative regions (SAR)[97]	2
2	prefecture level	- Prefectures	17
		- Prefecture-level cities	283
		- Autonomous prefectures	30
		- Leagues	3
3	county level	- Counties	1,464
		- Autonomous counties	117
		- County-level cities	374
		- Districts	852
		- Banners	49
		- Autonomous banners	3
		- Forestry areas	1
		- Special districts	2
4	township level	- Towns	19,522
		- Townships	14,677
		- Ethnic townships	1,092
		- Sub-districts	6,152
		- District public offices	11
		- Sumu	98
		- Ethnic sumu	1
5	village level	- Neighborhoods Committees	80,717
		- Neighborhood	
		- Communities	
		- Village Committees or Village groups	623,669
		- Administrative villages	
		- Natural villages	

Note: The numbers of each administrative unit are dated 31 December, 2005 (Retrieved 08 December, 2009 from http://en.wikipedia.org/wiki/Administrative_divisions_of_China)
Source: Compiled by author based on information found in Held and Merkle 2009: 29.

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94 There are 22 Provinces in China: Anhui, Fujian, Gansu, Guangdong, Guizhou, Hainan, Hebei, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Qinghai, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, and Zhejiang.
95 There are 5 Autonomous Regions in China: Guangxi Zhuang Autonomous Region, Inner Mongolia Autonomous Region, Ningxia Hui Autonomous Region, Tibet Autonomous Region, and Xinjiang Uyghur Autonomous Region.
96 There are 4 Municipalities in China: Beijing, Chongqing, Shanghai, and Tianjin.
97 There are 2 Special Administrative Regions (SAR) in China: Hong Kong and Macau.

Given China's immense size, large population, and local complexity and diversity, despite the formal government structure and conformity, one national policy may have different impacts on different level of local governments in various ways, sometimes with unexpected results (Saich, 2004). Therefore, to make a coherent generalization about policy implementation across different local governments in China among provinces, autonomous regions, municipalities, and special administrative regions is often difficult, as no uniformity of outcome exists (Saich, 2004).

3.2.3 Legislative process and policy making process

Legislative and policy making processes help to illustrate the process of policy formulation and adoption in China. In the early 1980s, legislative and policy making processes were treated more like an internal working procedure that involved very limited institutions and persons (Li and Otto, 2002: 26). In recent years, legislative and policy making process have become more systematic and transparent, even though transparency remains at a rather low level (Li and Otto, 2002: 26). In general, legislative process and policy making process in China can be divided into two levels: the central level and the local level. This study analyzed only the central level which the policy 'Township Electrification Program' was formulated and adopted at.[98]

Legislative and policy making process at the central level in China is broken down into the following three categories (Li and Otto, 2002: 3-17):[99]

1) Process of national law-making by the NPC

According to the *Constitution*, legislative power in China lies with the NPC and its Standing Committee.[100] Yet as discussed, deputies of the NPC meet annually only two

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[98] Legislative and policy making processes at the local level were distinguished by the State Council into four levels: provincial, national autonomous areas, special economic zones, and capitals of provinces and autonomous regions and other large cities. For a more detailed analysis of the legislative and policy making process at the local level, see Li and Otto (2002).

[99] The analysis of the legislative process and policy making process at central level is largely based on Li and Otto's (2002) analysis , in which they utilized Chinese legal documents and literature. Some literature in English also provided insightful analysis on the legislative process and policy making process at central level, such as Keller (1994), Clarke (1991), O'Brien (1994), and Tanner (1996).

[100] See Article 58 of the *Constitution of the People's Republic of China*.

weeks. When the NPC is not in session, it functions through its Standing Committee and Special Committees.[101] The Standing Committee[102] consists of 175 members (11th NPC), elected by the NPC from among its deputies for a term of five years and meets once every two months.[103]

The process of national law-making by the NPC can be divided into six stages:

a) Making a legislative plan: The making of a legislative plan is a recent phenomenon that first appeared during the 7th Standing Committee in 1991. In 1993, the 8th Standing Committee started to draw up the five-year legislative plan for the period 1993 to 1998. As a result, development of the five-year legislative plan is a process followed through to the current moment. The plan consisted of legislative subjects, the organs which are to be responsible for the drafting work, etc. Based on the five-year legislative plan, the Standing Committee then decided its annual legislative work.

b) Drafting a bill: Under the NPC, the body responsible for the drafting of laws is primarily the Legislative Affairs Commission under the Standing Committee, although the Special Committees of the NPC can also act as a legislative drafting body.[104] In addition, deputies of the NPC and members of the Standing Committee can make draft proposals.[105] The Legislative Affairs Office of the State Council and Ministries or Commissions under the State Council can also draft bills.[106]

c) Introducing a draft bill: The following organs and persons can propose a bill to the NPC: the Presidium of the NPC, the Standing Committee, the Special Committees of the NPC, the State Council, the Central Military Committee, the Supreme People's

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[101] See Article 67 and Article 70 of the *Constitution of the People's Republic of China*. Currently there are nice special committees: Ethnic Affairs committee, Law Committee, Internal and Judicial Affairs Committee, Finance and Economic Committee, Education, Science, Culture and Public Health Committee, Foreign Affairs Committee, Overseas Chinese Affairs Committee, Environmental Protection and Resources Conservation Committee, and Agriculture and Rural Affairs Committee (Retrieved 7 December, 2009 from the official website of the NPC, http://www.npc.gov.cn/englishnpc/Organization/node_2849.htm).

[102] For the main functions and powers of the Standing Committee, see Article 67 of the *Constitution of the People's Republic of China*.

[103] Retrieved 7 December, 2009 from the official website of the NPC, http://www.npc.gov.cn/englishnpc/Organization/node_2849.htm

[104] See Article 70 of the *Constitution of the People's Republic of China*.

[105] See Article 72 of the *Constitution of the People's Republic of China*.

[106] See Article 89 of the *Constitution of the People's Republic of China*.

Court, the Supreme People's Procuratorate, and deputies of the NPC. In practice, most of the bills are introduced to the NPC either by the Standing Committee or the State Council. The Presidium of the NPC determines whether a bill is to be included in the agenda of the NPC. However, in reality, all bills which are presented to the NPC are first put forward to the Standing Committee to decide whether or not a bill is to be included in the agenda.

d) Reviewing a bill: Draft bills are reviewed by the Standing Committee under the specific review procedure.

e) Passing a bill: A bill is passed by the NPC or the Standing Committee if the majority of the deputies or members present votes in its favor. Yet in practice, if a bill is put to the vote, it is always passed. If the bill is highly controversial, it will not be put to the vote until a high degree of consensus is built among the deputies of the NPC and the members of the Standing Committee.

f) Promulgation and publication of an enacted law: The President of the PR China promulgates the laws passed by the NPC and the Standing Committee. Once promulgated, laws are then published in the *People's Daily* and the *Gazette of the Standing Committee*.

2) Process of regulation-making and policy making by the State Council

The State Council's legislative acts and policies are generally referred to as administrative regulations, policies, rules, decisions, and orders.[107] The Legislative Affairs Office of the State Council is responsible for the legislative and policy work. The process of regulation-making and policy making by the State Council is similar to that of the NPC, except that there is no voting and the time needed for making a regulation or policy is shorter. The Legislative Affairs Office, in consultation with the ministries and commissions, is responsible for drawing up the five-year and annual legislative plans of the State Council. The drafting work for regulations and policies is undertaken either by the Legislative Affairs Office, or by relevant ministries or commissions. Draft regulations and policies are then reviewed by the Legislative

[107] See Article 89 of the *Constitution of the People's Republic of China*.

Affairs Office before submission to the State Council for approval. The Premier takes the final responsibility for the promulgation of administrative regulations, policies, rules, decisions, and orders. Once the administrative regulations, policies, rules, decisions, and orders are enacted, they are published in the *Gazette of the Standing Committee*.

3) Process of rule-making and policy making by the Ministries and Commissions

Ministries and commissions under the State Council can, in their own policy fields, make administrative rules, policies, decisions, and orders in accordance with the *Constitution*, laws, administrative regulations, and policies of the State Council.[108] The administrative rules, policies, decisions, and orders are in principle concerned with the implementation of higher regulations of the State Council. In practice, there are often no administrative regulations on a particular subject. In such case, ministries' and commissions' administrative rules, policies, decisions, and orders become an important source of regulations and policies. The process of rule-making and policy making by the ministries and commissions is similar to those of national law making mentioned above. At each stage the procedure is simpler and faster. Most ministries and commissions have a division that is in charge of legal affairs. These divisions are responsible for drawing up annual legislative plans. The drafting work of administrative rules, policies, decisions, and orders is undertaken either by a drafting team led by the divisions of legal affairs or the relevant divisions of the ministries and commissions. Once completed, final drafts are then submitted to the executive meeting of the ministries and commissions for review and approval. If passed, the ministers and commissioners then sign the documents. Within thirty days of their enactment, all administrative rules, policies, decisions, and orders must be reported to the State Council to be recorded.

In conclusion, in addition to the legislative and policy making process, one should note that the Chinese legal draftsmen, no matter at the NPC, the State Council, Ministries or Commissions, not only have legal issues to deal with, but also have to take into account politics, especially the invisible hand of the CPC (Li and Otto, 2002: 27). Politics can constrain law makers and policy makers because legal and policy issues are not always be ideally resolved by legislation or policy making (Li and Otto, 2002: 27).

[108] See Article 90 of the *Constitution of the People's Republic of China*.

3.2.4 Characteristics of the political framework

China's political framework is characterized as a centralized socialist dictatorship under the rule of the CPC (Bertelsmann Stiftung, 2007: 8).[109] "Over the last two decades, China's economic, legal, and social systems have undergone tremendous transformation, but the same degree of change has not been evident in the political sphere" (Li and Otto, 2002: 28). Even though the position of the CPC is not apparent in written laws, politics continue to remain under the control of the CPC. The CPC is regarded as superior to the *Constitution* and the NPC is subject to CPC directives and control (Bertelsmann Stiftung, 2007: 7). Important laws, policies, regulations, and rules all need to have the approval of the CPC. The formal arrangement of political institutions is also controlled by the CPC. The *Constitution of People's Republic of China* does not establish a system of separation of powers; therefore, separation of the CPC and state powers under the law do not exist in China (Bertelsmann Stiftung, 2007: 7). In addition, the transparency, public participation, and democratization of the legislative process and policy making process in China remain at a rather low level and still need to be strengthened (Li and Otto, 2002: 27).[110]

Many scholars defined the Chinese political framework as a horizontally and vertically fragmented authoritarian system (Landry, 2008: 2; Saich, 2004; Lieberthal, 1992; Lieberthal and Okenberg, 1988; Lampton, 1992). A fragmented authoritarian system usually possesses the following two characteristics (Lieberthal and Okenberg, 1988): First, problems tend to be pushed up to the highest bureaucratic bodies, or to the highest party bodies that are able to coordinate responses and have sufficient leverage to bring together different interests. Second, in order to successfully adopt a policy, the policy needs to be supported by top leaders. With such a system in place, the process of bargaining and negotiation among the CPC, central government, and local governments makes it difficult to assure a policy is formulated and implemented as it should be because each part of the political framework seeks to bend the policy in favor of its own advantages. Coordination by the top leadership of the CPC is crucial to maintaining a

[109] The Chinese government refers to itself as a "socialist state under the people's democratic dictatorship" (see Article 1 of the *Constitution of the People's Republic of China*).
[110] Other political parties or organizations in competition with the CPC are prohibited and suppressed (Bertelsmann Stiftung, 2007: 8).

general consensus within the Chinese political framework to keep a policy moving forward.

3.3 Policy formulation of the 'Township Electrification Program'

3.3.1 The actor

The National Development and Reform Commission (NDRC)[111] under the State Council played a key role of formulating the Chinese energy policy and climate policy (Krahl, 2009: 2-3); this commission is also responsible for initiating and formulating the 'Township Electrification Program'. The formulation of the national 'Township Electrification Program' occurred under the mandate of the NDRC's 'Western Region Development Program' to develop poorer western provinces in pursuit of sustainable development in energy sector.

The NDRC is one of the twenty-eight commissions and ministries under the State Council. In practice, commissions outrank ministries. Commissions set policies and coordinate the related administrative actions among different ministries, organizations, administrative offices and institutions under the State Council (see Figure 3-2). Generally speaking, the NDRC is the most powerful and important administrative organ among the twenty-eight commissions and ministries, and plays an important role in guiding overall national economic and social development (Saich, 2004). The NDRC is also involved in formulating and coordinating strategies of annual, medium and long-term development plans, guiding economic reforms and economy transition from the planned economy to market-based economy, monitoring and adjusting the performance of the national economy, and formulating and promoting sustainable energy, environment, and climate policy, as well as the Western Region Development Program.[112] And unlike other government bodies, the NDRC is viewed as the most

[111] The predecessor of the NDRC was the State Planning Commission (SPC), which managed China's central planned economy from 1952. The SPC was renamed the State Development Planning Commission (SDPC) in 1998. In 2003, the SDPC was restructured and merged with the State Council Office for Restructuring the Economic System (SCORES) and part of the State Economic and Trade Commission (SETC) into the newly created NDRC.
[112] See the main functions of the NDRC at its official website (retrieved 10 December, 2009 from http://en.ndrc.gov.cn/mfndrc/default.htm).

proactive government body which has undergone greater reform, and has a more pioneering, and innovative mindset (Zhang, 2009).

But in practice, the NDRC is incapable of adopting a more professional and rational role for policy formulation due to political influence from the CPC. The main policy directions of the NDRC are usually decided by the CPC. In a message from Zhang Ping, Chairman of the NDRC, appearing on the NDRC official website, Zhang states: "The NDRC now undertakes challenging tasks and important responsibilities to live up to our mission and perform duties by the Communist Party of China and the people […]" (Zhang, 2009).[113] It is still judicious for the State Council and its commissions and ministries to follow the CPC's policy directions (Saich, 2004).

3.3.2 The process

The NDRC, like other commissions and ministries under the State Council, is the main government organ that formulates public policies. The process of policy formulation in China is a 'centralized and closed top-down approach' (Saich, 2004; White et al., 1990; Lieberthal and Oksenberg, 1988; Lieberthal and Lampton, 1992). The process features a rigidly centralized and hierarchic characteristic of policy formulation process. The formulation of the Township Electrification Program also adopted this approach (Chung, 2004; Peng and Pan, 2004). The Program was imposed and formulated by the NDRC, with almost no input from the bottom, the local governments or local people, and reflected the preferences and values of the governing elites of the NDRC, instead of those of rural people's. These discrepancies arose due to a lack of democratic legal mechanisms for public participation in the government's decision making process (Pan, 2006). Elite theory helps to illustrate and explain the process of policy formulation under communist regimes, such as in China. Elite theory suggests that the general public is apathetic and ill informed about public policies and elites in reality shape mass opinion on public problems more than the mass shape elite opinions (Anderson, 1975). Public policies are preferences and products of governing elites, reflecting their values and serving their interests. The formulation of public policies flows downward from top governing elites to the bottom, where on encounters the majority of the people, instead

[113] This statement was made by the current Chairman of NDRC, Mr. Zhang Ping, on the NDRC website (Retrieved 6 April, 2009 from http://en.ndrc.gov.cn/mfczp/default.htm).

of arising from the bottom to the top. As a result, the people are not able to voice their demands for specific policies.

Governing elites share in a consensus about fundamental norms underlying the social and political system and “only policy alternatives that fall within the shared consensus will be given serious consideration” (Dye, 1998: 24). Shared attitudes about the social and political system among governing elites does not mean that elites do not disagree or compete each other; rather, what this consensus building implies is that elites agree more often than they disagree. “The movement of non-elites to elite positions must be slow and continuous to maintain stability and avoid revolution. Only non-elites who have accepted the basic elite consensus can be admitted to governing circles” (Dye, 1998: 23). Changes and innovations in public policies happen only when governing elites redefine their own values and interests. Therefore, changes in public policy are usually incremental rather than revolutionary. Changes can occur more rapidly when special events threaten the system and governing elites have to act on it to preserve the system and their status.

The formulation of the Township Electrification Program is one example of how policy is not necessarily designed to solve a public problem, but more so to serve elite interests, like social control and maintenance of social stability. Governing Chinese elites were aware that the gap between the rich eastern provinces and poor western provinces in China might create potential social instability and threaten the governance of the CPC. Hence, the Western Region Development Program which was designed to improve rural economy and living conditions in western China became one of the important tasks for the NDRC. The formulation of the ‘Township Electrification Program’ by the NDRC is to develop remote rural areas of western China with electrification. The objectives and content of the Program were formulated based on the perspective of the governing elites of the CPC and NDRC in Beijing, instead of the perspective of the rural people in western China. Many rural electrification programs, successful and unsuccessful ones, indicate that the extent to which the community and end-users can influence the formulation of the programs has a direct bearing on the success of the programs (CAS, 2006a). Governing elites within the NDRC determined the energy needs for rural people and the way the Program should be implemented, such as how much wattage of installed capacity a household should have, in what way electricity should be generated (with renewable energy or fossil fuel, with mini-grid systems or isolated systems), and so forth.

3.4 Policy adoption of the 'Township Electrification Program'

3.4.1 The actor

In democratic countries, parliaments usually are the main actors of adopting public policies.[114] The role of parliaments is crucial in the process of policy adoption because parliaments have the last word on laws, budgets, policies, and institutional arrangements (Holtz, 2004). As China is not a democratic regime, but a dictatorship, the so-called parliament, the NPC, in reality has little to say regarding public policies.[115]

According to the Constitution, the NPC is the highest organ of state power to adopt laws, enact major policies, amend the Constitution, and approve national economic plans and state budgets. In reality, the proposals of the law, major policies, and economic plans usually are ratified by the Central Committee of the CPC before the proposals are passed to the NPC for approval (Saich, 2004). The function of the NPC in the process of policy adoption is like 'rubber stamp'.

In addition, not all national policies need to be adopted or enacted by the NPC, since it meets only two weeks each year. Only major policies need to be adopted by the NPC,

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[114] Democracy requires the following conditions: free, fair, and regular elections with the possibility to change government; separation of powers; independent judiciary; rule of law; the respect for and protection of inalienable human rights and civil and political liberties (Holtz, 2004). Parliaments have the following six *idealiter* roles and functions (see 'parliamentary hexagon', Holtz, 2005: 22): Making laws (legislative power), deciding on the budget (power of the purse), holding government accountable and exercising control of executive action (power of parliamentary oversight), representing publics (power of representation and discourse), electing the executive (elective power), and influencing foreign policy and international relations (treaty and war power, power of mediation between the public and international organisations and institutions). Parliaments represent the basis for good governance grounded on democratic institutions that are responsive to the needs of the people, the rule of law, anti-corruption measures, and so on (Holtz, 2004).

[115] "The prospects for future democratization are not favorable, because the CPC leadership is not prepared to share power with other political actors and constantly rules out the adoption of a Western model of pluralist democracy in the PR China. In China, at least at the central level, there are no democratic institutions as such. […] Democratic procedures, such as the election of heads of village committees, have been implemented on an experimental basis, but only at the local, that is, village level. These first steps are not intended to influence developments at the central level; the Chinese leadership still refuses to consider establishing a Western-style democratic, multiparty system" (Bertelsmann Stiftung, 2007: 8).

such as national economic plans, the Three Gorges Project on the Yangtze River, etc. Most national policies, such as the Township Electrification Program, theoretically are enacted and adopted by the State Council. But in reality, the Politburo Standing Committee of the CPC has great influence over the adoption of national policies (Andrews-Speed, Liao and Dannreuther, 2002). On the official website of the State Council, the State Council is “responsible for carrying out the principles and policies of the Communist Party of China as well as the regulations and laws adopted by the NPC, and dealing with such affairs as China's internal politics, diplomacy, national defense, finance, economy, culture and education.”[116] Hence, it was the State Council formally, but the CPC informally, that actually put the Township Electrification Program into effect.

3.4.2 The process

The process of adopting the Township Electrification Program theoretically followed the ‘process of rule-making and policy making by the State Council’ discussed in section 3.2.3. After the NDRC formulated the Program, it was submitted to the State Council for review and approval.

In practice, the process of policy adoption depended on the top leadership of the Politburo Standing Committee of the CPC, which respectively represents the top leadership of the government. The subservient administrative bureaucracy, the State Council, implemented the policies. A small group of nine members of the Politburo Standing Committee could easily have coordinated and successfully broken through the fragmented and competing bureaucratic structure. But this group was criticized that the process of policy adoption within the Chinese political framework was still a system where few individuals hold immense power and control (Saich, 2004). Lampton (1992) commented that it was why the legal framework of policy adoption in China was poorly developed under the current political framework.

3.5 The pros and cons of ‘centralized public sector energy initiatives’

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[116] The statement is retrieved from the official website of the State Council of PR China on 2 December, 2009 from http://english.gov.cn/2005-08/05/content_20763.htm.

The characteristic of policy formulation and policy adoption of the Township Electrification Program within the Chinese political framework is ‘centralized, closed, and top-down’. Even with economic reforms in place, the government continues to play a dominate role in the energy sector, particularly for energy production and distribution (Pan et al., 2006). This is quite different from the energy initiatives in many developing countries, which are decentralized and based on market mechanisms. In such cases, the private sector plays a more important role for energy production and distribution than the government.

It is beyond the scope of this study to conclude whether centralized public sector energy initiatives or decentralized private sector energy initiatives are better for renewable energy-based rural electrification in western China. However, by presenting the pros and cons of centralized public sector initiatives within China’s particular political framework, one can gain more insight into policy formulation and adoption of the Township Electrification Program.

3.5.1 The pros

If one looks at the ‘electrification rate’, the centralized public sector energy initiatives in China have performed quite well. As a developing country, the electrification rate in China in 2005 has reached 99.4%, which was at the same level of OECD countries and far beyond the average electrification rate of developing countries, which averaged 68.3%. The high electrification rate in China has shown that the centralized public sector energy initiatives in China performed efficiently in terms of the production and distribution of electricity. The high electrification rate was achieved by the efforts and abilities of the Chinese central government and the CPC to mobilize national resources to back rural electrification programs with tremendous subsidies. Electrification programs, particularly in ‘rural’ areas where no or less potential commercial benefits for the private sector to provide electricity, especially need government support and subsidies to improve electricity access. In practice, many developing countries have tried to open up their electricity sectors to private capital from domestic and foreign sources, but such investment has slumped since 1997 because of poor returns and uncertainty about possible regulatory development (IEA, 2003). Policy support and financial subsidies from the government make rural electrification possible when investment returns in remote rural areas are not possible. The centralized, closed, and top-down public sector energy initiative, the Township Electrification Program, facilitated the resolution of the public problem ‘electricity access for the poor in remote rural areas of western China’ with national resources and support from different level of governments.

Many rural electrification programs in developing countries were supported by international organizations, such as the World Bank, or foreign governments. However, the effects were not promising (Chung, 2004; World Bank, 2008). Before the launch of the Township Electrification Program, several international cooperation projects funded by international organizations or foreign governments to improve electricity access with renewable energy in rural areas of western China were undertaken. Yet the effects of these projects were limited (Chung, 2004). The projects in question were usually based on the interests of the cooperating partner countries or organizations which decided the way how and where the projects should be implemented. Hence, there were different projects applying different renewable energy-based rural electrification programs for rural people in different western provinces. This resulted in different levels of development of electrification in rural areas of western provinces. Some areas and some provinces were improved due to the projects. However, most rural areas were totally neglected. Even among the project areas and provinces, there were different levels of development of electrification due to different scales of projects. A centralized planning for rural electrification, like the Township Electrification Program, has its advantages for an overall planning for all rural areas in all western provinces which have different levels of development of electrification.

3.5.2 The cons

Centralized public sector energy initiatives are often criticized for being ineffective, of poor quality, and wasteful of resources and lacking in accountability (World Bank, 2001; Mapako and Mbewe, 2004). But some scholars, Mapako and Mbewe, argue that the decentralized private sector energy initiatives are better placed to effectively produce and distribute electricity in rural areas than centralized public sector energy initiatives (Mapako and Mbewe, 2004). These scholars argue that the role of government should be limited to regulatory interventions in the form of policies, and that production and distribution of electricity in rural areas should be decentralized and handed over to the private sector to enable the private sector to produce and distribute electricity in rural areas to meet local energy needs with better quality and less cost.

Behind the high rate of electrification rate figure in China are several problems. First, electricity services are often unreliable and of poor quality (IEA, 2002). Second, old and out-of-dated transmission and distribution networks often need very large investment to meet modern standards (IEA, 2002). Third, policy makers in Beijing do not necessarily understand the local electricity needs of people living in remote rural areas of western China. There exists no participation of local stakeholders and target communities in policy formulation, and the monopoly of the centralized public sector energy initiatives without competition make the design of energy programs ineffective. And lastly, corruption and patronage often associated with monopoly public sector energy initiatives affect the effectiveness of energy programs in western rural China (World Bank, 2001). If the centralized public sector energy initiatives lack transparency, corruption among different implementing governmental bodies and contracting system providers is more prone to occur.[117] All of these problems combined results in poor quality of electricity systems and electricity services, waste of resources, and a lack of accountability.

[117] Corruption in China is closely linked to the rise of so-called ‘special interest groups’ which bribe and collude from government monopolies or projects, such as centralized public sector energy initiatives. “These groups are mainly formed by central and local government officials and their relatives as well as national and foreign businesses. They bribe and collude with government officials, exploit legal loopholes, or profit from government monopolies in electricity, transportation, telecommunications and energy. […] It will be essential for the success of President Hu’s economic and social reforms to bring down these groups; however, since even the children and relatives of senior central government officials belong to these groups, it will be very difficult to rein in their influence. […] There is no efficient auditing and public oversight; public servants often neglect their duties and misuse their positions for personal gain” (Bertelsmann Stiftung, 2007: 18-19).

4 Policy Implementation of the 'Township Electrification Program' in Remote Rural Areas of Western China

4.1 Policy implementation

Hayes defined policy implementation as "organized activities by government directed toward the achievement of goals and objectives articulated in authorized policy statements" (Hayes, 2002: 1). Dunn defined policy implementation as "an adopted policy is carried out by administrative unites which mobilize financial and human resources to comply with the policy" (Dunn, 1994: 16). Policy implementation includes a wide range of activities, such as creating new organizations, assigning new responsibilities to existing organizations, translating the policy into operational rules and regulations, hiring personnel, disbursing funds, making loans, awarding grants, signing contracts, performing tasks, disseminating policy information, and negotiating with different level of governments, departments, businesses, citizens, or even other countries (Dye, 1998; Edwards, 1980). Once a policy is formulated and adopted, this does not mean it will definitely be implemented successfully. The way that a policy is implemented directly influences the final results of a policy and determines the success or failure of a policy (Spicker, 2006). If a policy is implemented poorly, no matter how well it is designed, it might fail to resolve the problem identified in the policy.

Different approaches exist to analyze policy implementation. Some scholars focus on the analysis of the implementing actors, implementation process (bureaucratic setting and organizational process), and implementation results (Anderson, 1975; Sabatier and Mazmanian, 1981; Spicker, 2006; Hill, 2005). Some scholars focus on politics and environments of policy implementation (Nakamura and Smallwood: 1980), whereas other scholars focus on identifying implementation problems or on identifying problems, obstacles, and constraints associated with implementation (Dunn, 1994; Edwards, 1980).

This study does not intend to analyze every aspect of implementation mentioned above, but will briefly analyze actors, the process, results, and environments associated with the implementation of the Township Electrification Program. Unsurprisingly, all governments encounter different problems and difficulties while implementing policies

(Edwards, 1980). This study grants greater attention to the two townships as a way to identify problems related to implementation of the Township Electrification Program. The examination of implementation problems is critical for improving the Township Electrification Program and offering new insights into future renewable energy-based rural electrification programs in China and other developing countries.

4.2 Policy implementation of the 'Township Electrification Program' in remote rural areas of western China: An overview

After the adoption of the national Township Electrification Program in 2002, the Program was implemented from 2002 to 2004 in 1013 non-electrified townships in 11 western provinces – Tibet AR, Xinjiang AR, Qinghai Province, Sichuan Province, Inner Mongolia AR, Gansu Province, Shaanxi Province, Hunan Province, Yunnan Province, Chongqing Municipality and Jiangxi Province - providing electricity for 300,000 households and 1.3 million people (CAS, 2007c). Actors responsible for implementation were the contracting system integrators which were selected through central government's public bidding. In 2002 and 2003, six public biddings with twenty-five packages occurred in order to select thirteen system integrators to implement the Township Electrification Program (CAS, 2007c). The implementation process was aimed at building solar PV power stations, solar PV/wind hybrid power stations, and small hydro power stations in non-electrified townships.

The Program was fully financed by the Chinese government with 2,600 million RMB (260 million EURO). Three different financing schemes were applied to different provinces (see Table 4-1). For Tibet AR, the central government covered the entire costs of the implementation of the Program. For Qinghai Province, the central government covered 80% of the cost of the implementation of the Program and the provincial government covered the remaining 20%. For the remaining provinces, the central government covered 50% of the cost of the implementation of the Program and the provincial governments covered the other 50%.

Table 4-1 Financing schemes of the 'Township Electrification Program'

Province	Total investment (million RMB)	NDRC grant (%)	Provincial grant (%)
Tibet AR	800	100	0
Xinjiang AR	177	50	50
Qinghai Province	266	80	20
Sichuan Province	180	50	50
Inner Mongolia AR	68	50	50
Gansu Province	120	50	50
Shaanxi Province	8	50	50
Hunan Province	N/A	50	50
Yunnan Province	N/A	50	50
Chongqing Province	N/A	50	50
Jiangxi Province	N/A	50	50

Source: Compiled by author based on NREL, 2004b; CAS, 2007a; CAS, 2007c.

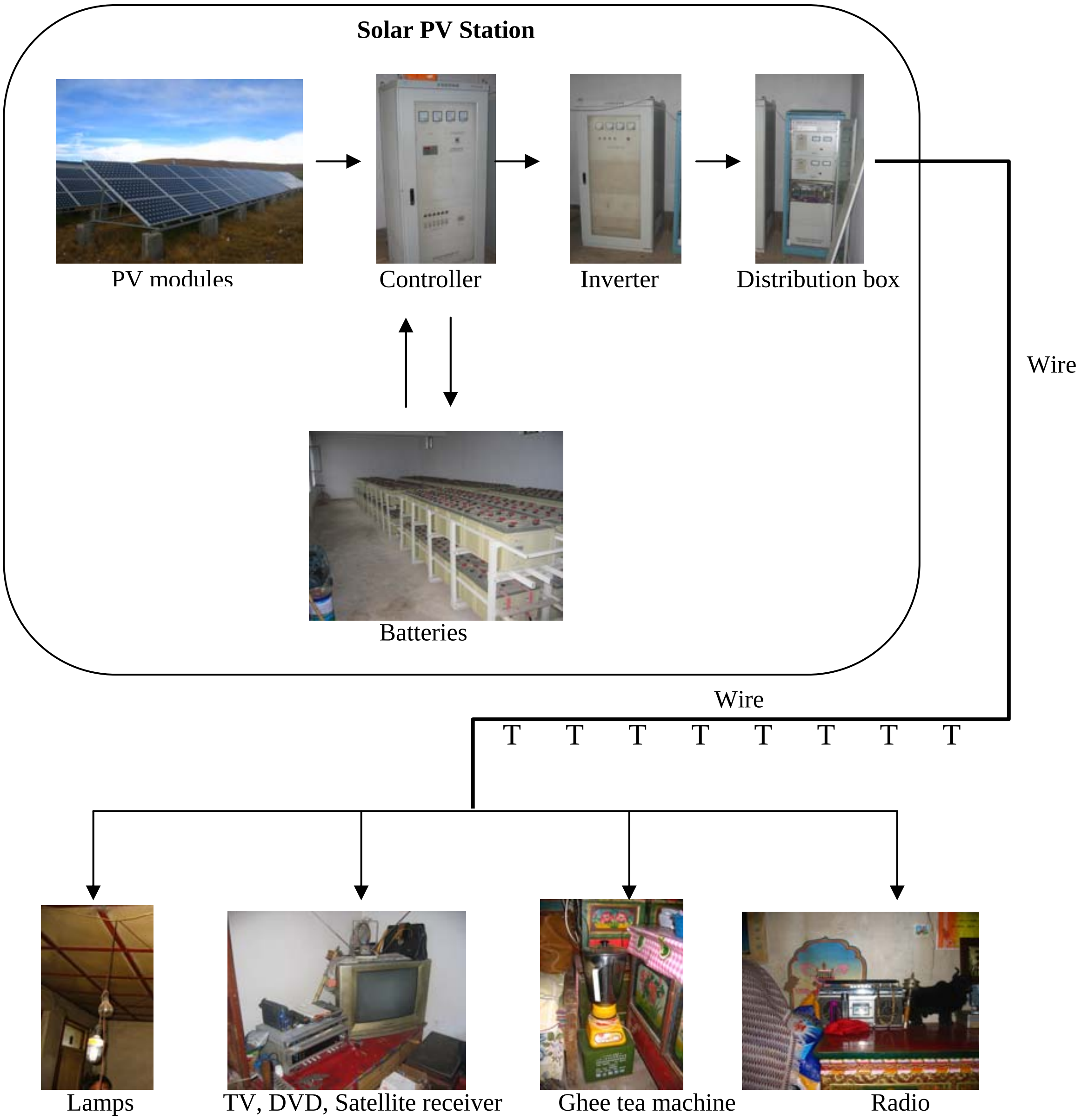
In just 20 months, 670 solar PV power stations and 51 solar PV/wind hybrid power stations were constructed in 8 western provinces with total capacity more than 15,000 kWp, providing electricity to 644 non-electrified townships, 70,000 households and 340,000 people (see Table 4-2). The average installed capacity per station is 21.7 kWp, while the average installed capacity per household is 225 Wp. The average installed capacity per person is 47 Wp. The solar PV power stations which were constructed under the Program were all off-national grid, stand-alone, and mini-grid systems (see Figure 4-1).

Table 4-2 Implementation results of the 'Township Electrification Program': Solar PV power stations and solar PV/wind hybrid power stations

Province	The quantity of power station	Total Installed capacity (kWp)	The Number of households benefited	The number of people benefited
Tibet AR	329	6,763	28,966	141,635
Xinjiang AR	159	2,378	18,416	105,887
Qinghai Province	112	2,715	8,640	40,650
Sichuan Province	46	1,817	5,500	24,900
Inner Mongolia AR	42	752	2,840	11,369
Gansu Province	23	995	4,164	37,942
Shaanxi Province	9	100	520	1,856
Hunan Province	1	20	100	420
Total	721	15,540	69,147	340,395

Source: Compiled by author based on NDRC, 2005a; CAS, 2007a; CAS, 2007c.

Figure 4-1 Configuration of stand-alone mini-grid solar PV power station[118]



Source: Drew by author. Photographs taken by author in the field from October to December, 2007.

The construction of the stations and installation of the systems were implemented by the contracting Chinese system integrators. The equipment used by the systems, such as inverters, controllers, and PV modules were primarily made in China. The Township Electrification Program counted as the first large scale dissemination of renewable

[118] Configuration of stand-alone mini-grid solar PV power system (CAS, 2007d): when PV modules are exposed to sunshine, the light energy converts into electric energy, current and voltage is produced, and DC power is generated via PV modules. Via a controller, the batteries are charged with DC power. Via an inverter, the DC power converts to AC power. Via a distribution box, the AC power electricity is distributed to the loads.

energy technologies for rural electrification ever implemented in China (CAS, 2007c). The total installed solar PV capacity in China increased dramatically during the year 2002 to 2004, the period when the Township Electrification Program was implemented (see Table 4-3).

Table 4-3 Solar PV installed capacity in China from 1980 to 2006

Year	Capacity of year (MWp)	Accumulative total capacity (MWp)
1980	8	17
1985	70	200
1990	500	1,780
1995	1,550	6,630
2000	3,300	19,000
2001	5,700	24,700
2002*	20,300	45,000
2003*	10,000	55,000
2004*	10,000	65,000
2005	5,000	70,000
2006	15,000	85,000

Note: * There was a significant increase in installed solar PV capacity when the Township Electrification Program was implemented from 2002 to 2004.
Source: Compiled by author based on CAS, 2007c.

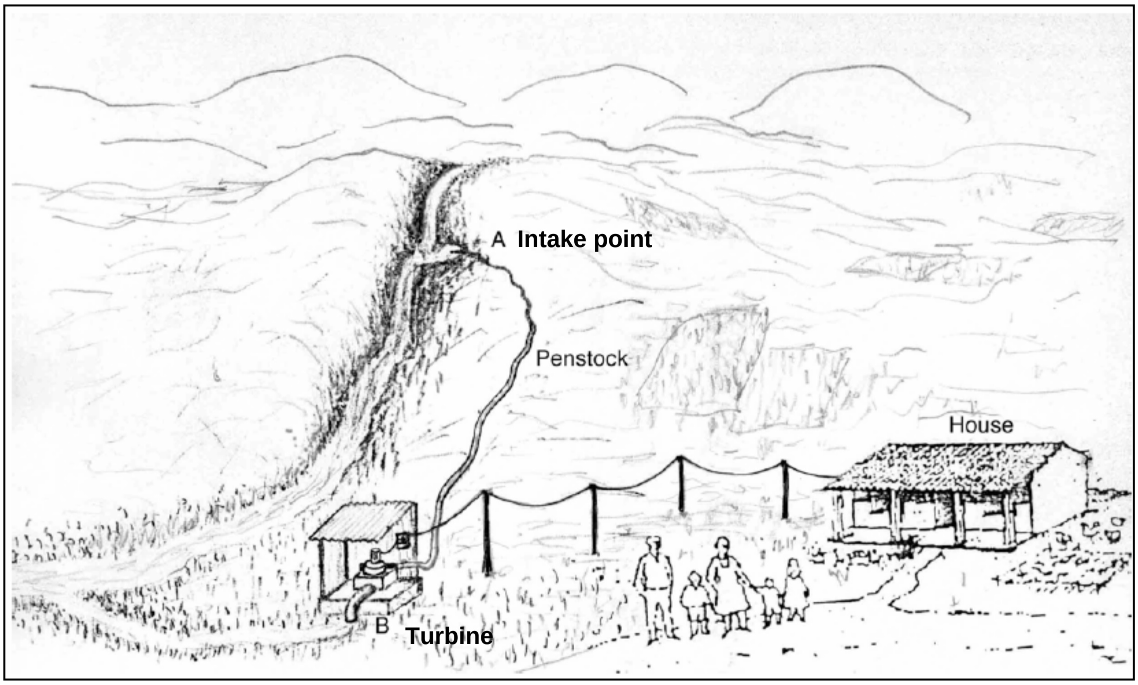
Besides utilizing solar and wind power for rural electrification, 146 small hydro power stations were constructed in 9 western provinces with a total capacity of more than 113,000 kW, providing electricity to 369 non-electrified townships, 230,000 households, and 960,000 people (see Table 4-4). The average installed capacity per station is 774 kW. The average installed capacity per household is 491 W. The average installed capacity per person is 118 W. The small hydro power stations were off-national grid, stand-alone, and mini-grid systems providing electricity for townships or villages (see Figure 4-2).

Table 4-4 Implementation results of the 'Township Electrification Program': Small hydro power stations

Province	The quantity of Power Station	Total installed capacity (kW)
Tibet AR	72	16,470
Sichuan Province	21	21,990
Hunan Province	19	7,070
Shaanxi Province	16	21,985
Yunnan Province	4	4,460
Gansu Province	8	35,190
Chongqing Municipality	3	4,840
Jiangxi Province	2	1,650
Xinjiang AR	1	110
Total	146	113,765

Source: Compiled by author based on NDRC, 2005a; CAS, 2007a; CAS, 2007c.

Figure 4-2 Configuration of stand-alone mini-grid small hydro power system



Source: Schroeder, 2007.

4.3 Policy implementation of the 'Township Electrification Program' in the two selected townships

Based on the existing government documents and literature, information concerning how the Township Electrification Program was implemented at the local level is lacking. In order to understand how the Township Electrification Program was implemented at the local level, this study selected two townships, Saierlong Township in Qinghai Province and Namcuo Township in Tibet AR, for in-depth research.

4.3.1 Policy implementation of the 'Township Electrification Program' in the two selected provinces: An overview

4.3.1.1 Qinghai Province

Qinghai is the fourth largest province in China, covering 721,000 km^2. The longest distance from east to west is 1,200 km and from north to south, 800 km. Provinces neighboring Qinghai include: Gansu Province, Xinjiang AR, Tibet AR, and Sichuan Province (see Map 2-2). Qinghai has a population of 5.4 million, among which Han-Chinese account for 55%, Tibetans for 21%, Hui (or ethnic Chinese Muslims) for 16%, Tu for 4%, and others for 4%.[119] Qinghai is the second least densely populated province in China, with a population density of 7.48 persons per km^2.[120] Most of the people live in the north-east, where the capital Xining is located. Qinghai's Human Development Index (HDI) is the fifth lowest among all provinces in China at 0.702 (in 2006) (UNDP, 2008: 139). Main economic activities carried out in Qinghai Province are agriculture and livestock raising. The agriculture area is mainly located in the north-east. The livestock raising area is located in the remainder of the province.

Geographically, Qinghai is situated on the Qinghai-Tibet Plateau, and the average altitude in Qinghai is 3000 meters (see Map 2-1 and Map 2-2). The vast and elevated plateau, with an elevation of over 4,500 meters, covers more than half of Qinghai mainly in the south-west. The Qinghai-Tibet Plateau is surrounded by towering mountain ranges, which makes it often difficult to reach townships in this area where there are high mountains and rugged paths affected by changeable weather patterns. Most of the non-electrified townships in Qinghai are located in this area where it is difficult to connect grids. But a positive effect is generated by the townships location on

[119] Others include Salar for 1.8% and Mongol for 1.8%. Data was retrieved on 2 December, 2009 from http://en.wikipedia.org/wiki/Qinghai.
[120] Data was retrieved on 2 December, 2009 from http://en.wikipedia.org/wiki/Qinghai. The overall population density of PR China was 139 persons per square kilometer in 2004 (United Nations Population Division, retrieved 2 December, 2009 from http://esa.un.org/unpp/).

the plateau, as Qinghai has the best solar resource among all provinces in China with solar radiation above 3000 hours per year (8 hours per day) (see Table 4-5).

Table 4-5 Solar resource distribution in China

Category	**Solar radiation per year (hour)**	**Solar resource per year (kW . h/m^2 . a)**	**Solar resource per day (kW . h/m^2 . a)**	**Areas**
1	3200 - 3300	1889 - 2334	5.1 – 6.4	Tibet AR, Xinjiang AR, Qinghai, Gansu, Ningxia
2	3000 - 3200	1625 - 1889	4.5 – 5.1	Tibet AR, Xinjiang AR, Qinghai, Gansu, Ningxia, Inner Mongolia AR, Shanxi, Hebei
3	2200 - 3000	1389 - 1625	3.8 – 4.5	Xinjiang AR, Gansu, Shanxi, Hebei, Shaanxi, Yunnan, Shandong, Henan, Jilin, Liaoning, Jiangsu, Anhui, Fujian, Guangdong
4	1400 - 2200	1167 - 1389	3.2 – 3.8	Shaanxi, Jiangsu, Anhui, Fujian, Guangdong, Hunan, Hubei, Guangxi, Jiangxi, Zhejiang, Heilongjiang
5	1000 - 1400	930 - 1167	2.5-3.2	Sichuan, Guizhou

Source: Compiled by author based on Liu, Wu, Yang and Zhai, 2007; Luo and Tao, 2007.

In 2002, the Qinghai New Energy Corporation (QNEC), which won the public biddings for constructing solar PV power stations in the province for the Township Electrification Program, was appointed by the Qinghai Provincial Development and Reform Commission (PDRC) and the NDRC as the main implementing body for the Program in Qinghai Province. In 2004, 112 solar PV power stations and solar PV/wind power hybrid stations were built by the QNEC with a total capacity of 2,715 kWp, providing electricity to 8,640 households and 40,650 people (see Table 4-2). The average installed capacity per station was 24.2 kWp, per household 314 Wp, and per person 67 Wp. Total investment for the power stations was 266 million RMB, of which 80% was provided by the central government and 20% by the provincial government.

The QNEC, in theory, is responsible for system operation, maintenance, and management (CAS, 2007c). However, in practice, the QNEC requested that township governments operate, maintain, and manage the stations, with the QNEC visiting the stations twice a year. The tariff of electricity was set by the township governments. Therefore, tariffs on electricity in Qinghai Province differed from township to township, ranging from 1 to 2 RMB/kWh (CAS, 2007c).

4.3.1.2 Tibet AR

Tibet AR is the second largest province in China, covering 1,228,400 km^2. Neighboring provinces include: Xinjiang AR, Qinghai Province, Sichuan Province, and Yunnan Province (see Map 2-2). As one of China's most western provinces, Tibet also neighbors India, Nepal, Bhutan, and Myanmar (see Map 2-2). The population of Tibet AR is 2.8 million, among which Tibetan account for 95%, Han-Chinese for 4%, and others account for 1%.[121] Tibet AR is the least densely populated province in China, with a population density of only 2.21 persons per km^2.[122] The Human Development Index (HDI) of Tibet AR is also the lowest among all provinces in China at 0.621 (in 2006) (UNDP, 2008: 139). The main economic activity in Tibet AR is the raising of livestock. The central government gives Tibet AR special financial aid by exempting its residents from all taxation, and by also covering 90% of the autonomous region government's annual expenditures.[123]

The majority of Tibet AR is situated on the Qinghai-Tibet Plateau, at an average altitude of 5000 meters (see Map 2-1 and Map 2-2). Most of the non-electrified townships in Tibet AR are located on the Qinghai-Tibet Plateau, and are surrounded by mountain ranges. It is technically and financially difficult to connect grids to these remote areas. However, Tibet AR has the best solar energy resources of all provinces in China, and the second best in the world, followed only by the Saharan area in Africa (Luo and Tao, 2007). The annual solar energy in different regions of China ranges from 930 to 2333 $kW \cdot h/m^2 \cdot a$, with a median value of 1626 $kW \cdot h/m^2 \cdot a$. But the solar energy resource in Tibet AR can yearly reach 2333 $kW \cdot h/m^2 \cdot a$ (daily 6.4 $kW \cdot h/m^2 \cdot a$), with more than 3000 hours solar radiation per year (8 hours per day) (see Table 4-5).

121 Data was retrieved on 2 December, 2009 from http://www.china.org.cn/english/null/163485.htm.
122 Data was retrieved on 2 December, 2009 from http://www.china.org.cn/english/zhuanti/tibet%20facts/163178.htm.
123 Information was retrieved on 2 December, 2009 from http://en.wikipedia.org/wiki/Economy_of_Tibet.

The main bodies which implemented the Township Electrification Program in Tibet AR were the six system integrators that won the public bidding. In 2004, 329 solar PV power stations and solar PV/wind power hybrid stations were built by the six system integrators, with a total capacity of 6,763 kWp, providing electricity to 28,966 households and 141,635 people in the province (see Table 4-2). The average installed capacity per station was 20.6 kWp, per household 234 Wp, and per person 48 Wp. The average installed capacity per station, per household and per person in Tibet AR was slightly lower than in Qinghai. The total investment of the Program in Tibet AR was 800 million RMB, all of which was covered by the central government.

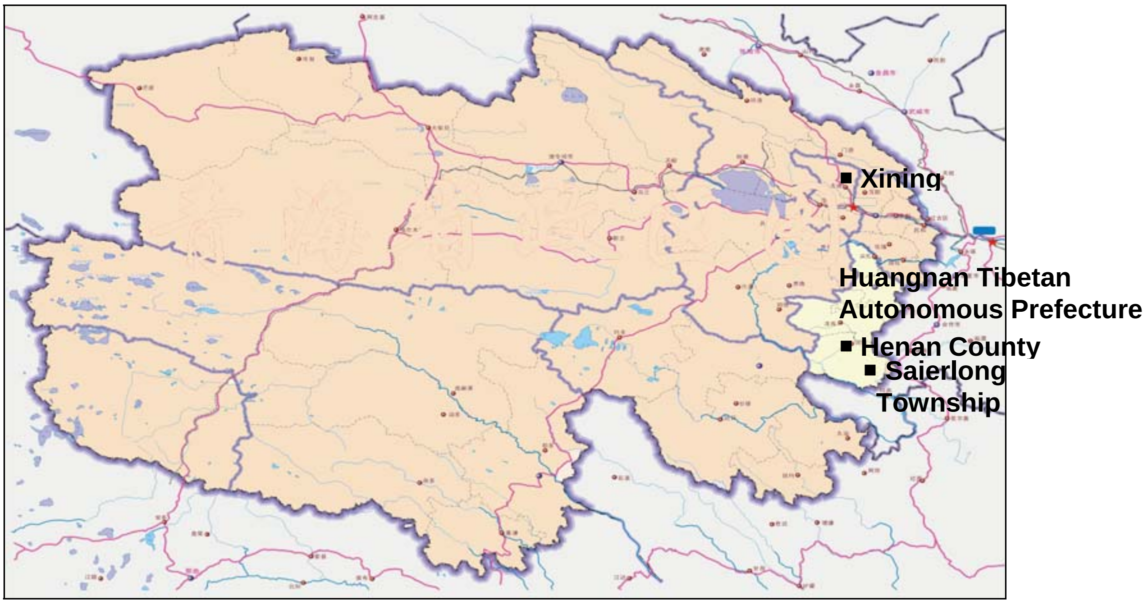
Slightly different from Qinghai, the township governments in Tibet AR were responsible for system operation and management after installation (CAS, 2007c). The six system integrators are responsible only for maintenance and technical support, and run two normal checks per year to insure the stable operation of the stations. The tariff of electricity was set by the township governments. Therefore, the tariffs differed in Tibet AR from township to township, ranging from 0.4 to 1.5 RMB/kWh (CAS, 2007c).

4.3.2 Policy implementation of the 'Township Electrification Program' in the two selected townships

4.3.2.1 Saierlong Township

Saierlong Township is located in the south-east of Qinghai (see Map 4-1). The distance from Saierlong Township to the provincial capital, Xining, is around 450 km, and the township is under the governance of the Henan Mongol Autonomous County and Huangnan Tibetan Autonomous Prefecture (see Table 4-6). Four villages fall under the governance of Saierlong Township: Gake Village, Jianke Village, Gaqian Village and Lanlong Village. In general, settlement of the township is dispersed. The distance between Saierlong Township and its villages ranges between 15 and 50 km, and roads connecting the township and its four villages are mainly dirt roads. The Township Electrification Program was implemented only at Saierlong Township, not in other four villages.

Map 4-1 Qinghai Province



Source: Plateau Perspectives.[124] Redesigned by author.

Table 4-6 Local government structure of Qinghai Province

Structure	Name
Province	Qinghai Province
Prefecture	Huangnan Tibetan Autonomous Prefecture
County	Henan Mongol Autonomous County
Township	Saierlong Township
Village	Gake Village, Jianke Village, Gaqian Village, Lanling Village

Source: Compiled by author.

Saierlong Township (see Photograph 4-1) is located 3600 meters above sea level, and is made up of around 400 households and 1800 inhabitants. The major ethnic group is Mongolian. Mongolians settled in Saierlong Township during the Yuan Dynasty (1271-1368), when the area used to be part of Tibet. Since then, Mongolians in Saierlong Township have adapted to Tibetan culture. The common language spoken is Tibetan, instead of Mongolian and Mandarin. The main economic activity is the raising of livestock, which helps to provide food for self-sufficiency and some cash income. Micro and small businesses also exist in the township. The township has one monastery and three temples. Many Buddhist artifacts such as prayer wheels, prayer chains, prayer flags and prayer paintings are frequently seen at the township. The religion, Tibetan

[124] Retrieved 27 November, 2009 from http://www.plateauperspectives.org/maps/county/Qinghai%20counties.jpg.

Buddhism, plays an important and significant role for the people. Most of the people chant, pray, and worship at the pilgrimages and temple several times a day.

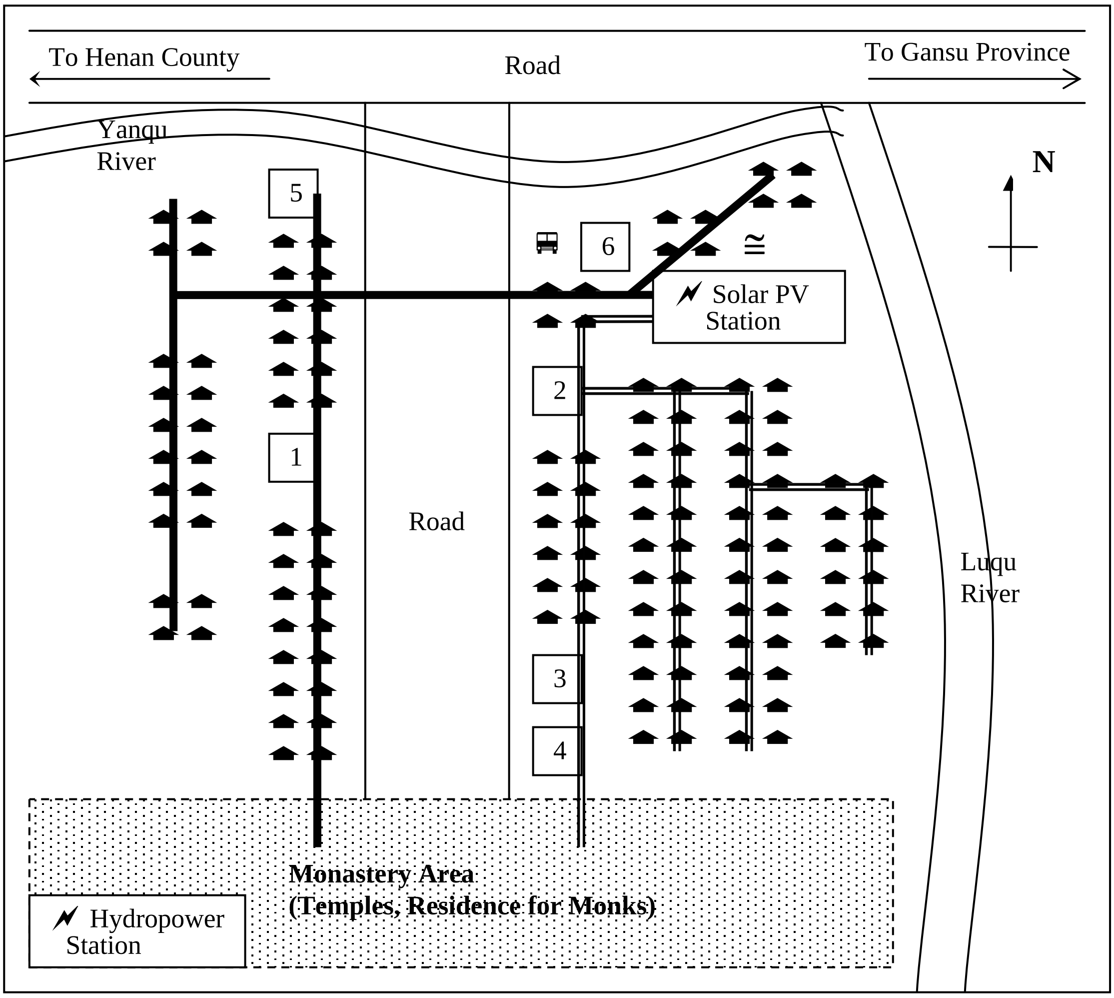
Photograph 4-1 Saierlong Township

Source: Photographs taken by author in the field from October to December, 2007.

In terms of formal social institutions, Saierlong Township is made up of one school, one health center, one private clinic, one veterinary hospital, one gasoline station, and one bank (see Map 4-2). In terms of infrastructure, Saierlong possesses one main paved road, which was built in 2005, while the rest of the roads in the township are dirt. There are around 20 small shops, such as restaurants, grocery stores, motorcycle repairing shops, workshops, pharmacy, and so on. The shops are mainly located on both sides of the main road. Water access in the township is mainly from underground water wells. Some households get water from Luqu River, which is around 500 meters from the township center. No fixed telephone line infrastructure exists in the township, but one mobile phone receiver does exist, which is powered by an individual solar PV system. The electricity infrastructure of the township is one small hydro power system built in 1998, and one solar PV power station built in 2003 under the Township Electrification Program.

The improvement of electricity service is considered by households in the township as its main priority. Based on the results of the household survey conducted by this study, things most urgently in need of improvement in the township for better living conditions and township development are: electricity (66.7%), education services (23.5%), health services (7.4%), drinking water (1.2%), and housing (1.2%).

Map 4-2 Saierlong Township



1	Township government	2	School	3	Health center
4	Veterinary hospital	5	Gasoline station	6	Bank
(bus symbol)	Bus station	≅	Mobil phone receiver	(power symbol)	Power station
═	Wire from solar PV station (Section 1)	▬	Wire from solar PV station (Section 2)		

Source: Drew by author.

The solar PV power station located in Saierlong Township was built by the Township Electrification Program's contractual system integrator, QNEC, in December 2003. The capacity of the system was 30 kW. The electricity is distributed with two inverters to two different parts of the township (see Map 4-2). The system is a stand-alone mini-grid solar PV power station, composed of 414 PV modules,[125] 1 controller,[126] 220 batteries,[127] 2 inverters,[128] and 1 distribution box.[129] Detailed system information is recorded in Table 4-7. All parts used in the system were manufactured by local Chinese manufactures.

Table 4-7 System information of the solar PV power station in Saierlong Township

System	**Information**	**Manufacture**
PV modules	414 PV modules Wp: 75W Each string contains 18 modules in series, 23 strings are connected via array connection box and charge controller in parallel. Capacity: 18 x 23 x 75 = 31.05 kWp	Xinghai Guofai, Isovolta
Controller	220 VDC / 180A	Hefei Sunlight Power
Battery set	Each string contains 110 Lead Acid batteries[130] connected in series, 2 strings are connected parallel 2 V x 1800 Ah = 3600 Wh 3600 x 110 x 2 = 792 kWh	Sacred Sun
Inverter	2 inverters, each inverter support one section of the township 220VDC, 220VAC	Hefei Sunlight Power
Distribution box	20 kW	Xian Jiatong University Solar Power Research Institute

Source: Compiled by author. Data was collected in the field from October to December, 2007.

[125] PV modules are used to convert light energy into electric energy to produce current and voltage (CAS, 2007d).

[126] A controller can switch and adjust the working state of the battery bank under various conditions, such as charging, discharging, or floating charging, according to the sunshine intensity and load change to assure the continuity and stability of the solar PV system (CAS, 2007d).

[127] Batteries are used to keep DC voltage stable and to store energy to assure that power is constantly supplied when there is no sunshine at night or on rainy/cloudy days (CAS, 2007d).

[128] DC output of solar PV modules and batteries is changed via inverter to AC for the loads (CAS, 2007d).

[129] Via a distribution box, AC power is distributed to power the loads (CAS, 2007d).

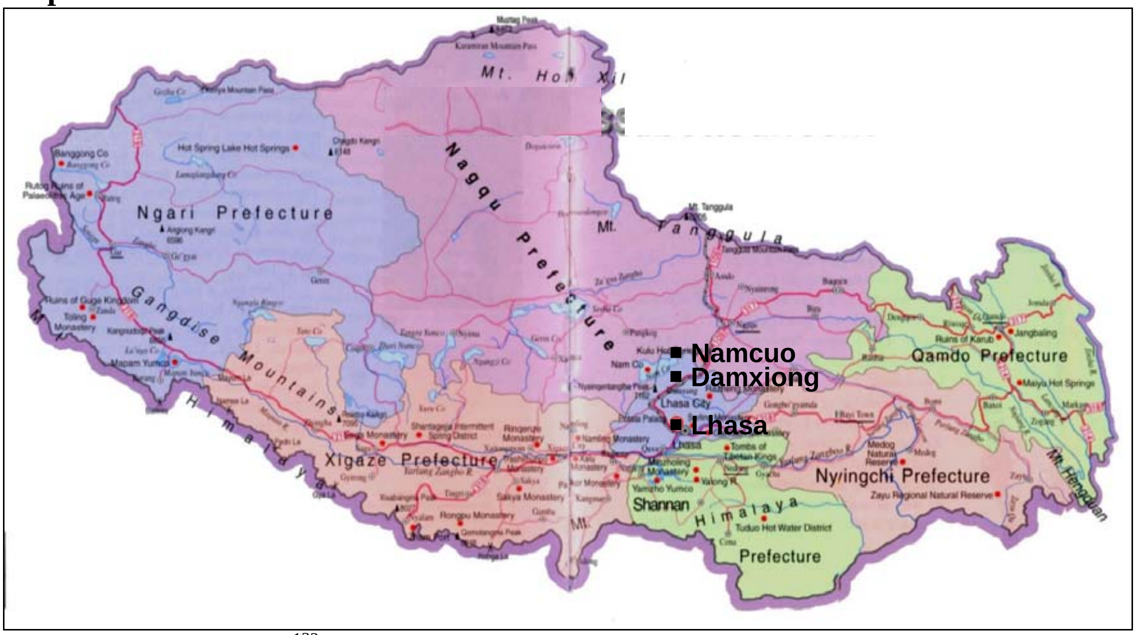
[130] There are two main types of batteries for solar PV systems: Lead-acid batteries and Cd-Ni batteries (CAS, 2007d). Lead-acid batteries are cheaper than Cd-Ni batteries. Lead-acid batteries (5-8 years) have shorter life expectancy than Cd-Ni batteries (more than 10 years). Voltage for charging and discharging of Lead-acid batteries should be strictly controlled, while Cd-Ni batteries do not have problems of over-charging or over-discharging.

After the construction of the station, the technicians of the QNEC stayed one month to assure that the system functioned safely and was stable. At the same time, technicians trained local operators to operate and maintain the system. After these actions were taken, the station was then handed over to the township government for operation, maintenance and management. When there were technical problems, the township government requested help from the QNEC for maintenance and repair.

4.3.2.2 Namcuo Township

Namcuo Township is located in the center of Tibet AR (see Map 4-3). The distance from Namcuo Township to the region’s capital, Lhasa, is around 180 km. Namcuo Township is under the governance of Dangxiong County and Lhasa City (see Table 4-8).[131] Four villages are under the governance of Namcuo Township: Dabu Village, Nacuo Village, Qiaga Village, and Sede Village. Like with Saierlong, the settlement of the township is dispersed. The distance between Namcuo Township and its villages ranges from 7 to 50 km, and roads connecting the township and its four villages are all dirt in poor condition.

Map 4-3 Tibet AR



Source: Access Tibet Tour.[132] Redesigned by author.

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[131] Lhasa is a prefecture-level city that consists of one district and seven counties. The district comprises the urban area of Lhasa and is called Chengguan District. The seven counties are Lhünzhub, Dangxiong, Nyêmo, Qüxü, Doilungdêqên, Dagzê, and Maizhokunggar.

[132] Retrieved 27 November, 2009 from http://www.accesstibettour.com/tibet-map.html.

Table 4-8 Local government structure of Tibet AR

Structure	Name
Province	Tibet AR
Prefecture	Lhasa Prefecture-level City
County	Dangxiong County
Township	Namcuo Township
Village	Dabu Village, Nacuo Village, Qiaga Village, Sede Village

Source: Compiled by author.

Four solar PV power stations are found in Namcuo Township. The solar PV power station at Qiaga village with a capacity of 20 kW is the only station built under the Township Electrification Program, and has the main function of providing electricity for residential purposes. The other three solar PV power stations found in the township were constructed and are used for other purposes, like providing electricity only to schools[133] or only to the township government[134]. For these reasons, research was located in Qiaga village, where a solar PV power station was built under the Township Electrification Program.

Photograph 4-2 Qiaga village, Namcuo Township

Source: Photographs taken by author in the field from October to December, 2007.

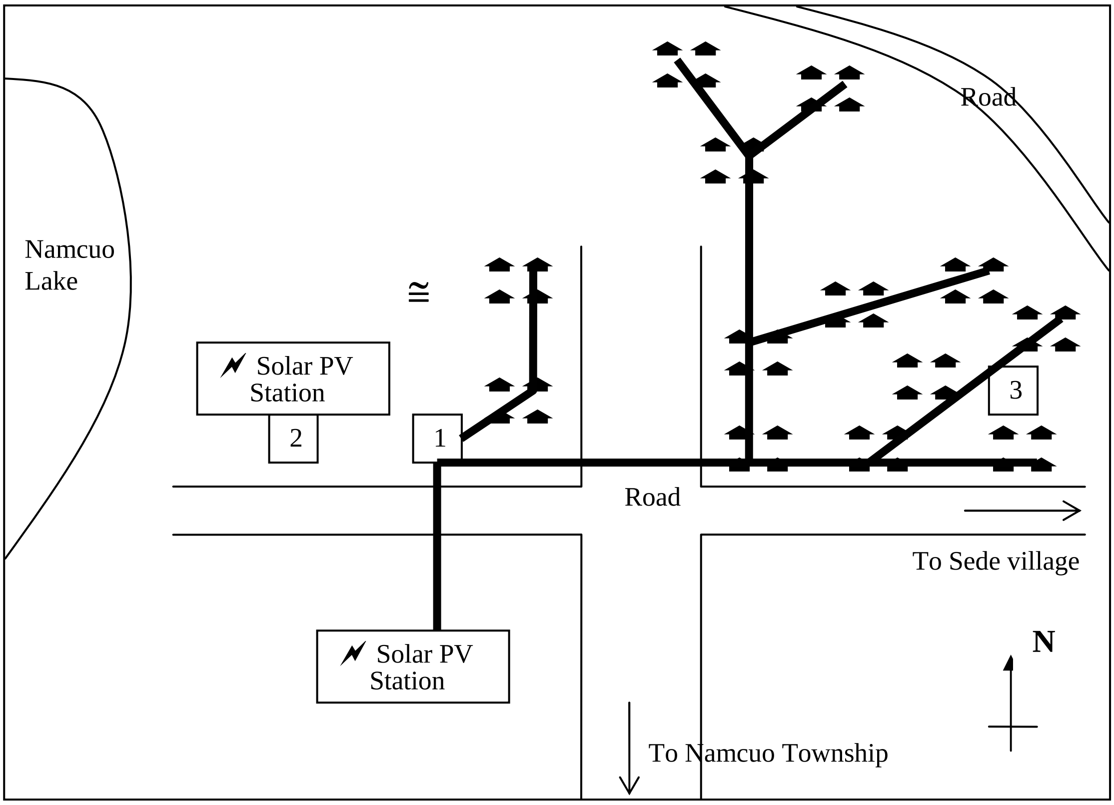
Qiaga village (see Photograph 4-2) has around 60 households with 278 inhabitants. The major ethnic group is Tibetan, and the main economic activity is nomadic livestock rearing. Around five small businesses, such as grocery stores, tea shops, and restaurants

[133] The two solar PV power stations with capacities of 10 kW and 5 kW, which are located at the township school in Qiaga village and one branch of the township school in Sede village, provide electricity only for the school, not for the residents in the villages.
[134] Another solar PV power station with a capacity of 3 kW was built in 2007 to provide electricity only for township government, not for the residents.

can be found in the village. The township is much less prosperous than Saierlong Township.

Qiaga has one school and one veterinary hospital (see Map 4-4). The township government, health center, and bank are located 7 km away. Water access is from two underground water wells. The Namcuo Lake, which is located beside Qiaga village, is the second largest salt lake in China. The lake does not provide drinking water. In terms of infrastructure, no fixed telephone line exists in the village, but one mobile phone receiver does, which is powered by an individual solar PV system. There are two solar PV power stations in the village. One station is a 20 kW solar PV power station, which was built in 2002 under the Township Electrification Program provides electricity for the residents. The other station is a 10 kW solar PV power station, which was built in 2007, and provides electricity only for the school.

Map 4-4 Giaga village, Namcuo Township



1	Village government	2	School	3	Veterinary hospital
ϟ	Power station	≅	Mobil phone receiver	▬	Wire

Source: Drew by author.

The improvement of electricity service is considered by the households as the main priority of the township. Based on the results of the household survey, the most in need of improvement in the township for better living conditions and township development are: electricity (60.7%), road (10.7%), drinking water (8.9%), job opportunities (8.9%), poverty (5.4%), health services (1.8%), and housing (1.8%).

The 20 kW solar PV power station was built by the Township Electrification Program's contractual system integrator, Beijing Corona Corporation (BCC), in 2002. The electricity is distributed with one inverter to the whole village (see Figure 4-8). The system is a stand-alone mini-grid solar PV power system, composed of 135 PV modules, 1 controller, 220 batteries, 1 inverters and 1 distribution box. Information regarding the system is recorded in Table 4-9. All parts used by the system were manufactured by local Chinese manufactures, except for PV modules, which were manufactured by a foreign manufacturer.

Table 4-9 System information of the solar PV power system in Namcuo Township

System	Information	Manufacture
PV modules	135 PV modules Wp: 150 Wp Capacity: 135 x 150 = 20.25 kWp	Shell Solar
Controller	220 VDC/180A	Beijing New Energy and Technology Development Co., Tibet Hua Guan Technology Co.
Battery set	Each string contains 110 Lead Acid batteries connected in series, 2 strings are connected parallel 2 V x 800 Ah =1600 Wh 1600 x 220 = 352 kWh	Helpon Sun
Inverter	1 inverters 220VDC, 220VAC	Beijing New Energy and Technology Development Co., Tibet Hua Guan Technology Co.
Distribution box	20 kW	Tibet Hua Guan Technology Co., Sichuan Hong Guang Co.

Source: Compiled by author. Data was collected in the field from October to December, 2007.

After the construction of the station, the station was handed over to the township government for operation, maintenance and management. The system integrator BCC ran two normal checks per year to insure the stable operation of the stations. When technical problems occurred, the township government requested help from the BCC for maintenance and repair.

4.3.3 Current energy situation in the two selected townships

The analysis of current energy sources in both investigated townships gives an overview of all types of energy used by the households and their preferences. The analysis is based on the 'purpose' of energy used at the households in both townships.[135] The purposes of energy used at the households in remote rural areas of western China were usually categorized into the following five purposes: lighting, entertainment/information, cooking, heating, and transportation. Energy for 'productive use' was not included in the analysis, because the Township Electrification Program did not allow electricity to be used for productive activities.

4.3.3.1 Lighting

In Saierlong Township, households mainly used the following energy sources for lighting: candles (100%), dry cell batteries (77.8%), the small hydro power system (76.5%), the solar PV station (69.1%), and solar home PV systems (29.6%) (see Table 4-10). Only a few households had electrical generators powered by gasoline (3.7%) or diesel (2.5%) for lighting.

In Namcuo Township, households mainly used the following energy sources for lighting: the solar PV station (98.2 %), candles (89.3%), dry cell batteries (87.5%), and solar home PV systems (35.7%) (see Table 4-10). Only one household used an electrical generator powered by gasoline for lighting.

[135] This type of analysis (based on the purpose of energy used at the households) has been used in other survey research in remote rural areas of western China (see Bruehl and Haskamp, 2003a; Bruehl and Haskamp, 2003b; Haskamp, 2004a; Haskamp, 2004b; Schaber, 2005; Zange and Haberland, 2005a; Zhange and Haberland, 2005b; Zheng, 2006; Hölzer and Huba, 2007).

Table 4-10 Energy sources for lighting in Saierlong Township and Namcuo Township

Energy sources for lighting	Saierlong / Qinghai % of household (n=81)	Namcuo / Tibet % of household (n=56)
Township solar PV station	69.1 %	98.2%
Small hydro power system	76.5 %	0.0%
Solar home PV system	29.6 %	35.7%
Candle	100.0 %	89.3%
Dry cell battery	77.8 %	87.5%
Gasoline (electrical generator)	3.7 %	1.8%
Diesel (electrical generator)	2.5 %	0.0%

Note: n is sample size.
Source: Data processed by author based on author's field survey from October to December, 2007.

As for energy preference for lighting, in Saierlong Township, households preferred to use energy from the small hydro power system (51.9%) mostly because it provided 24 hours of electricity, which was much longer than electricity generated from the solar PV station, which was only 4 to 5 hours in the evening (see Table 4-11). In addition, the tariff of electricity fee of the small hydro power system was four times cheaper than the electricity fee tariff of the solar PV power station. Of the households surveyed in the township, 30.9% preferred electricity generated from the solar PV station, because this type of energy provided more stable voltage which made lighting brighter than electricity from the small hydro power system. Around 11% of households preferred electricity generated from solar home PV systems for lighting, because the systems were convenient to use and did not cost any money after the up-front investment.

Table 4-11 First preference of energy source for lighting in Saierlong Township

First preference of energy sources for lighting	% of household (n=81)	Reasons (account)
Small hydro power system	51.9	- Longer period of electricity provision (39) - Cheap (9)
Township solar PV station	30.9	- Stable voltage (18) - Lighting is brighter (2) - Others (4)
Solar home PV system	11.1	- Convenient (7) - Cheap (1)
Candle	3.7	- Cheap (1)
Diesel (electrical generator)	2.5	- Longer period of electricity provision (2)

Note: n is the households which used energy for lighting.
Source: Data processed by author based on author's field survey from October to December, 2007.

In Namcuo Township, households preferred to use electricity generated from the township's solar PV station (91.1%), because the lighting from the station was brighter than that generated by other types of energy sources (see Table 4-12). Few households preferred to use solar home PV systems (8.9%) because using solar home PV systems did not cost any money after the first investment of the systems.

Table 4-12 First preference of energy source for lighting in Namcuo Township

First preference of energy sources for lighting	% of household (n=56)	Reasons (account)
Township solar PV station	91.1	- Lighting is brighter (31) - Cheap (1)
Solar home PV system	8.9	- Cheap (1)

Note: n is the households which used energy for lighting.
Source: Data processed by author based on author's field survey from October to December, 2007.

In general, households in both townships were not satisfied with the energy for lighting, and explained that they did not have sufficient energy for lighting (see Table 4-13).

Table 4-13 Households' evaluation of energy for lighting in Saierlong Township and Namcuo Township

Category	Evaluation	Saierlong Township % of household (n=81)	Namcuo Township % of household (n=56)
Satisfied with energy for lighting	Satisfied	14.8	30.4
	Unsatisfied	85.2	69.6
Sufficient energy for lighting	Sufficient	12.3	26.8
	Insufficient	87.7	73.2

Note: n is the households which used energy for lighting.
Source: Data processed by author based on author's field survey from October to December, 2007.

4.3.3.2 Entertainment and information

In Saierlong Township, households mainly used the following energy sources for entertainment and information: the small hydro power system (71.6%), the solar PV station (64.2 %), and dry cell batteries (24.5%) (see Table 4-14).[136] Few households used electrical generators powered by gasoline (3.7%) or diesel (2.4%) for entertainment and information. Solar home PV systems were not used for entertainment and information, but only for lighting.

[136] Dry cell batteries were mainly used to power radios.

In Namcuo Township, 91.1% of households used electricity generated from the solar PV station for entertainment and information (see Table 4-14). The percentage of households using other energy sources for entertainment and information, such as dry cell batteries (2%) and gasoline (1.8%), was, in general, fairly low.

Table 4-14 Energy sources for entertainment and information in Saierlong Township and Namcuo Township

Energy sources for entertainment & information	Saierlong / Qinghai % of household (n=81)	Namcuo / Tibet % of household (n=56)
Township solar PV system	64.2 %	91.1%
Small hydro power system	71.6 %	0.0%
Solar home PV system	0.0 %	0.0%
Dry cell battery	24.5 %	2.0%
Gasoline (electrical generator)	3.7 %	1.8%
Diesel (electrical generator)	2.5 %	0.0%

Note: n is sample size.
Source: Data processed by author based on author's field survey from October to December, 2007.

As for energy preference for entertainment and information, households in Saierlong Township preferred to use electricity generated from the small hydro power system (64.8%), primarily because doing so provided longer periods of electricity than energy provided by the township solar PV station (see Table 4-15). Around 22.5% of households surveyed preferred to use electricity generated from the township solar PV station, as doing so offered more stable voltage to power electrical appliances. In Namcuo Township, households preferred to use electricity generated from the township solar PV station (98.1%), primarily because it was the only energy source capable of powering televisions (see Table 4-16).

Table 4-15 First preference of energy source for entertainment and information in Saierlong Township

First preference of energy sources for entertainment and information	% of household (n=71)	Reasons (account)
Small hydro power system	64.8	- Longer period of electricity provision (43) - Cheap (8)
Township solar PV station	22.5	- Stable voltage (11) - Others (4)
Dry cell battery	9.9	- Convenient (6)
Gasoline (electrical generator)	2.8	- Longer period of electricity provision (1) - Stable (1)

Note: n is the households which used energy for entertainment and information.
Source: Data processed by author based on author's field survey from October to December, 2007.

Table 4-16 First preference of energy source for entertainment and information in Namcuo Township

First preference of energy sources for entertainment and information	% of household (n=52)	Reasons (account)
Township solar PV station	98.1	- We could watch TV (28) - Convenient (1)
Dry cell battery	1.9	N/A

Note: n is the households which used energy for entertainment and information.
Source: Data processed by author based on author's field survey from October to December, 2007.

In general, households in both townships were not satisfied with the energy for entertainment and information and did not have sufficient energy for entertainment and information (see Table 4-17).

Table 4-17 Households' evaluation of energy for entertainment and information in Saierlong Township and Namcuo Township

Category	Evaluation	Saierlong Township (% of households) (n=71)	Namcuo Township (% of households) (n=52)
Satisfied with energy for entertainment and information	Satisfied	15.5	5.8
	Unsatisfied	84.5	94.2
Sufficient energy for entertainment and information	Sufficient	11.3	3.8
	Insufficient	88.7	96.2

Note: n is the households which used energy for entertainment and information.
Source: Data processed by author based on author's field survey from October to December, 2007.

4.3.3.3 Cooking

In Saierlong Township, the households mainly used coal (81.5%) and dry animal dung (61.7%) for cooking (see Table 4-18). Few households used wood (4.9%) for cooking. In Namcuo Township, all households used dry animal dung for cooking, and only 8.9% of households used solar cookers, which do not cost any money after the up-front investment. Out of the households surveyed, 10.7% used liquefied petroleum gas, which is a very expensive type of energy for cooking in remote rural areas of western China.

Table 4-18 Energy sources for cooking in Saierlong Township and Namcuo Township

Energy sources for cooking	Saierlong / Qinghai % of household (n=81)	Namcuo / Tibet % of household (n=56)
Dried animal dung	61.7 %	100.0%
Coal (and coal briquette)	81.5 %	0.0%
Solar energy	0.0 %	8.9%
LPG (liquefied petroleum gas)	0.0 %	10.7%
Wood	4.9 %	0.0%

Note: n is sample size.
Source: Data processed by author based on author's field survey from October to December, 2007.

As for energy preference for cooking, in Saierlong Township, 66.7% of the households preferred to use coal, because doing so was more convenient[137] and more efficient (see Table 4-19).[138] Of household surveyed, 33.3% indicated that they preferred to use dry animal dung because it was cheap,[139] or easy to get for free.[140] In Namcuo Township, almost all households preferred to use dry animal dung most because it was free. Only one household preferred to use LPG most because it was convenient and fast.

[137] In general, coal lasted longer after burning. When cooking using dry animal dung, households frequently needed to add dry animal dung every half an hour. Compared to coal, use of dry animal dung was not as convenient as using coal for cooking, because dry animal dung burns more quickly.
[138] The fire of coal is stronger than the fire of dry animal dung.
[139] The price of coal is much higher than dry animal dung. One ton of coal costs 600 RMB, whereas one bag of dry animal dung in Saierlong Township costs 3 or 3.5 RMB, and 5 RMB in Namcuo Township.
[140] The households could collect dry animal dung for free. Collecting dry animal dung is usually the tasks of female household members.

Table 4-19 First preference of energy source for cooking in Saierlong Township and Namcuo Township

First preference of energy sources for cooking		% of household	Reasons (account)
Saierlong Township (n=81)	Coal	66.7	- Convenient/last longer (18) - Strong/more efficient (18)
	Dry animal dung	33.3	- Cheap/free/coal is too expensive (11) - Easy to get (5) - No other choice (1)
Namcuo Township (n=56)	Dry animal dung	98.2	- Free (41)
	LPG	1.8	- Convenient and fast (1)

Note: n is the households which used energy for cooking.
Source: Data processed by author based on author's field survey from October to December, 2007.

In general, households in both townships were satisfied with the energy available for cooking, and had enough energy for cooking (see Table 4-20).

Table 4-20 Households' evaluation of energy for cooking in Saierlong Township and Namcuo Township

Category	Evaluation	Saierlong Township (% of households) (n=81)	Namcuo Township (% of households) (n=56)
Satisfied with energy for cooking	Satisfied	98.8	80.4
	Unsatisfied	1.2	19.6
Sufficient energy for cooking	Sufficient	98.8	82.1
	Insufficient	1.2	17.9

Note: n is the households which used energy for cooking.
Source: Data processed by author based on author's field survey from October to December, 2007.

4.3.3.4 Heating

In Saierlong Township, households mainly used coal (81.5%) and dry animal dung (61.7%) for heating (see Table 4-21), and few households used woods (4.9%) for heating. In Namcuo Township, the only energy for heating is dry animal dung.

Table 4-21 Energy sources for heating in Saierlong Township and Namcuo Township

Energy sources for heating	Saierlong / Qinghai % of household (n=81)	Namcuo / Tibet % of household (n=56)
Dried animal dung	61.7 %	100.0%
Coal	81.5 %	0.0%
Wood	4.9 %	0.0%

Note: n is sample size.
Source: Data processed by author based on author's field survey from October to December, 2007.

As for energy preference for heating, in Saierlong Township, 66.7% of households preferred to use coal, because coal was more convenient to get and more efficient in heating (see Table 4-22). Of households surveyed, 33.3% indicated that they preferred to use dry animal dung mainly because it was cheap and easy to get for free. In Namcuo Township, all households preferred to use dry animal dung because it was free.

Table 4-22 First preference of energy source for heating in Saierlong Township and Namcuo Township

<table>
<tr><th colspan="2">First preference of energy sources for cooking</th><th>% of household</th><th>Reasons (account)</th></tr>
<tr><td rowspan="2">Saierlong Township (n=81)</td><td>Coal</td><td>66.7</td><td>- Convenient/last longer (18)
- Strong/more efficient (18)</td></tr>
<tr><td>Dry animal dung</td><td>33.3</td><td>- Cheap/free/coal is too expensive (11)
- Easy to get (5)
- No other choice (1)</td></tr>
<tr><td>Namcuo Township (n=56)</td><td>Dry animal dung</td><td>100</td><td>- Free (41)
- Strong (1)</td></tr>
</table>

Note: n is the households which used energy for heating.
Source: Data processed by author based on author's field survey from October to December, 2007.

In general, households in both townships were satisfied with the energy made available for heating, and had enough energy for heating (see Table 4-23).

Table 4-23 Households' evaluation of energy for heating in Saierlong Township and Namcuo Township

Category	Evaluation	Saierlong Township (% of households) (n=81)	Namcuo Township (% of households) (n=56)
Satisfied with energy for heating	Satisfied	98.8	87.5
	Unsatisfied	1.2	12.5
Sufficient energy for heating	Sufficient	98.8	87.5
	Insufficient	1.2	12.5

Note: n is the households which used energy for heating.
Source: Data processed by author based on author's field survey from October to December, 2007.

4.3.3.5 Transportation

Households in both townships used gasoline and diesel as energy for transportation (see Table 4-24). In Saierlong Township, 60.5% of the surveyed households had transportation vehicles, of which were 45 motorcycles, 2 trucks, and 2 tractors. In Namcuo Township, only 39.9% of the surveyed households had transportation vehicles, of which 17 were motorcycles, 2 were trucks, 2 were tractors, and 1 was a car.

Table 4-24 Energy sources for transportation in Saierlong Township and Namcuo Township

Energy sources for transportation	Saierlong / Qinghai % of household (n=81)	Namcuo / Tibet % of household (n=56)
Gasoline	58.0 %	35.7%
Diesel	7.4 %	10.7%

Note: n is sample size.
Source: Data processed by author based on author's field survey from October to December, 2007.

In general, households in both townships were satisfied with the energy made available for transportation, and in general had enough energy for this purpose (see Table 4-25). Even so, some households expressed that gasoline and diesel was too expensive.

Table 4-25 Households' evaluation of energy for transportation in Saierlong Township and Namcuo Township

Category	Evaluation	Saierlong Township (% of households) (n=48)	Namcuo Township (% of households) (n=22)
Satisfied with energy for transportation	Satisfied	98.5	77.3
	Unsatisfied	4.2	22.1
Sufficient energy for transportation	Sufficient	100.0	81.8
	Insufficient	0.0	18.2

Note: n is the households which used energy for transportation.
Source: Data processed by author based on author's field survey from October to December, 2007.

4.3.3.6 Overall evaluation of current energy situation

In general, households in both townships were unsatisfied with the energy made available for lighting, entertainment and information, but were satisfied with the energy available for cooking, heating, and transportation, even though the households had access to electricity after the implementation of the Township Electrification Program.

4.4 Implementation problems of the 'Township Electrification Program' in the two selected townships

Many renewable energy-based rural electrification programs involving photovoltaic systems have experienced implementation problems (World Bank, 2000a). Most problems, however, arise from limited experience and a variety of challenges associated with organizing and managing renewable energy-based rural electrification programs, particularly stand-alone mini-grid systems (Flavin and Aeck et al., 2005: 23). During the implementation of the Township Electrification Program, the Chinese government spent only two years finishing construction of 721 power stations and putting them into operation to supply electricity to townships located in remote rural areas of western China. Considering the large scale and speed of the construction of power stations, it is no surprise that problems with implementation occurred at the local level.

Based on the analysis of the current energy situation in the two investigated townships, most households were unsatisfied with the energy available for lighting, entertainment and information. Households raised several concerns over the electricity supply and service available to them (see Table 4-26): There was often unnoticed disruption of electricity supply; the time of electricity supply daily was too short; electricity supply was irregular and unpredictable; electricity supply was not enough, etc. After field research, several problems associated with implementation of the Township Electrification Program were found in the two investigated townships that affected electricity supply and service.

Table 4-26 Problems of electricity service raised by the households in Saierlong Township and Namcuo Township

Electricity source	Problems (account)	
	Saierlong Township	**Namcuo Township**
Solar PV power station	■ There is 'often' unnoticed disruption of electricity supply (42) ■ The time of electricity supply daily is too short (40) ■ Electricity supply is irregular and unpredictable (9) ■ 'Sometimes' there is no electricity supply at all (3) ■ Electricity is too expensive (1)	■ The time of electricity supply daily is too short (37) ■ Electricity supply is irregular and unpredictable (26) ■ Electricity supply is not enough (2)
Small hydro power system	■ Unstable and low voltage[141] (58) ■ No electricity supply in winter[142] (24)	N/A

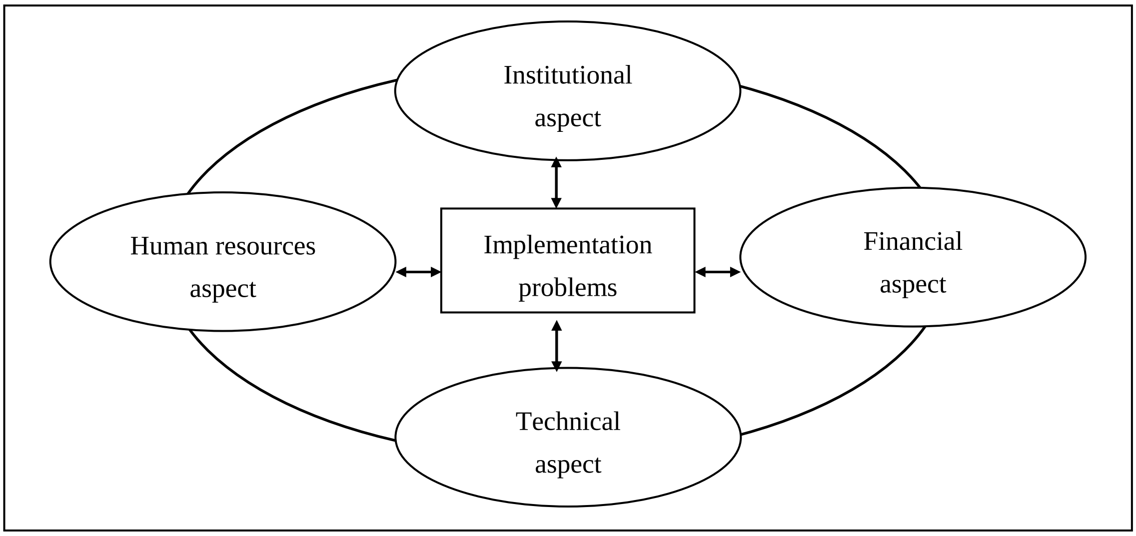
Source: Data processed by author based on author's field survey from October to December, 2007.

For analytical purposes, the problems surrounding implementation of the Township Electrification Program were categorized into four aspects: technical, financial, human resources, and institutional aspect. As a result, analysis is focused on understanding how these four aspects influenced the supply of electricity and electricity service in the two investigated townships. In reality, these four aspects were interlinked and influenced each other, therefore hindering the electricity supply and electricity service in remote rural areas of western China. Figure 4-3 depicts these entanglements and how they worked to influence one another.

[141] The voltage of electricity from the small hydro power system was very low and unstable during the electricity consumption peak hours from 18:00 pm to 22:00 pm in the evening. The voltage was so low in fact that was not enough to power televisions, and the luminousness of the lamps was very low and dim.

[142] In winter (from October to April), due to river freezing, the small hydro power system was incapable of providing any electricity.

Figure 4-3 Implementation problems of the Township Electrification Program at the local level



Source: Drew by author.

4.4.1 Technical aspect

In terms of the technical aspect, one implementation problem was found in this study: inefficient technical support.

In Qinghai, the system generator QNEC was responsible for technical support for the 112 townships which implemented the Township Electrification Program. However, the average distance from the 112 townships to the QNEC which is located in the provincial capital, Xining, is 780 km (Bopp, 2004). The distance from some townships to the QNEC was more than 1000 km. Furthermore, these townships are difficult to reach because of mountainous and dirt roads affected by changeable weather conditions. Normally, technicians required several days to travel from the QNEC to the townships. The case township, Saierlong Township is located 450 km away from the QNEC. On average, technicians normally spent one week to arrive at the township after a request for technical support had been made (Ma, personal comments, October 2007). During this time no electricity supply was available from the solar PV station.

In Tibet AR, the technical support system was better designed. There are six system generators which are responsible for the technical support for the townships in four areas of Tibet: Lhasa/Naqu, Chengdu, Rikaze, and Shannan. The system generator, BCC was responsible for the technical support for all townships in the Lhasa/Naqu area, where Namcuo Township is located. The distance from the currently installed townships to the BCC is between 150 km to 700 km. The case township, Namcuo Township, is located 180 km away from the QNEC. Normally, technicians needed several days to one week to arrive at the township after a request of technical support was made (Taqing, personal comments, 17 October 2007).

Operators of power stations in both townships expressed that they did not have sufficient knowledge and capacity to maintain the stations (Ma, personal comments, 11 October 2007; Taqing, personal comments, 17 October 2007). They do not have the knowledge to understand the parameters, display, and function of the controllers, inverters, and distribution boxes (Ma, personal comments, 11 October 2007; Taqing, personal comments, 17 October 2007). As a result of this inability to understand, it was difficult for them to detect malfunctions in the systems when repair and special maintenance were needed.

For example, on some occasions the systems did not function, and the operators did not know what to do and could only request technical support from the system generators (Ma, personal comments, 11 October 2007; Taqing, personal comments, 17 October 2007). Hence, some 'regional' technical support centers should be set up to offer more efficient technical support so that the technicians could arrive in the townships more quickly, within one or two days (Bopp, 2004).

4.4.2 Financial aspect

In terms of the financial aspect, five implementation problems were found in this study: unaffordable electricity tariff, inappropriate electricity fee collection scheme, households' unwillingness and inability to pay electricity fee, lack of financial management of collected electricity fee, and unstable and low salary for operators.

1) Unaffordable electricity tariff

Setting an appropriate electricity tariff which is affordable for rural people is one of the most common problems for renewable energy-based rural electrification program

(Mapako and Mbewe, 2004; World Bank, 2000b; Asian Development Bank, 2006; Asian Development Bank, 2005b; Zhao, 2003). Such a situation was also a problem for the Township Electrification Program. Generally speaking, the electricity tariff was set either by the township governments or the system generators, and the electricity tariff differed from townships to townships and from provinces to provinces (see Table 4-27).

Table 4-27 Electricity tariff of the Township Electrification Program

Province	**Electricity tariff (RMB/kWh)**	**Charging department**
Tibet AR	0.4 - 0.5	System generators and township government
Xinjiang AR	No charge	N/A
Qinghai	1.0 – 2.0	System generators and township government
Sichuan	0.4 – 0.8	System generators
Inner Mongolia AR	0.5 – 3.0	System generators and township government
Gansu	0.8	System generators
Shaanxi	0.49	System generators

Source: Compiled by author based on CAS, 2007a; CAS, 2005.

In Saierlong Township, the electricity tariff of the solar PV station (2 RMB/kWh) was four times higher than the tariff for electricity from the small hydro power station (0.5 RMB/kWh). Even though the electricity tariff of the solar PV station was subsidized by the government[143], the electricity tariff was still four times more than the tariff for electricity in other parts of China.[144] Overall, the tariff for electricity in China is between 0.5 and 0.6 RMB/kWh (CAS, 2007a). On average, people in Beijing or Shanghai, who have relatively higher income, pay four times less in electricity tariffs than do people in Saierlong Township. From the result of the household survey, 57.1% of the households felt that the tariff on electricity from the solar PV station was expensive,[145] and 65.5 % of the households complained that the tariff on electricity tariff from the solar PV station was not reasonable.[146] According to households, a reasonable electricity tariff would be 0.6 RMB/kWh[147].

[143] The actual cost per kWh of solar PV power stations was estimated by CAS (2005) in Qinghai at 5 RMB/kWh.
[144] The electricity tariff of the provincial grid in Qinghai was 0.45 RMB/kWh (CAS, 2005).
[145] In one CAS survey (2006a), conducted with 79 households in 21 villages in Qinghai, Yunnan, and Xinjiang AR, 26.6% of the households complained that the electricity tariff was too expensive.
[146] However, 97 % of households in Saierlong Township felt that the electricity tariff of the small hydro power station was reasonable.
[147] The mean of the reasonable tariff which answered by the households is 0.5972 RMB/kWh.

In Namcuo Township, the tariff for electricity was not calculated based on the amount of electricity consumed, because the households have no electric meters. Instead, the fee for electricity was charged based on specific loads. For example, the fee for electricity for one lamp was 5 RMB/month, and for one television 8 RMB/month. Based on the household survey, 63.6% of households felt that the tariff for electricity from the solar PV station was expensive, and 86 % of households complained that the tariff for electricity from the solar PV station was not reasonable.

It is doubtful if households in remote rural areas of western China where there is a lot of poverty can afford higher electricity tariffs than people in urban areas. While the Chinese government has subsidized the construction of power stations and the installation of the systems, more subsidies for more affordable electricity tariffs for remote rural townships is still needed.

2) Inappropriate electricity fee collection scheme

Electricity fee collection schemes in both townships were not appropriate in terms of equality and energy saving.

In Saierlong Township, there existed two different electricity fee collection schemes. The electricity fee was basically collected based on electric meters. However, from the result of the household survey, 16.1 % of the households did not have electric meters and more than half of the households' electric meters were broken. For the households which did not have electric meters, or if their electric meters were broken, the electricity fee was charged based on a 'lamp sum' fee. Each household paid 10 RMB per month for electricity (Ma, personal comments, 11 October 2007). The amount of money charged for electricity fee per household per month, 10 RMB, was decided by the operator (Ma, personal comments, 11 October 2007).

In Namcuo Township, the fee for electricity was charged based on specified loads. The electricity fee for one lamp was 5 RMB/month, and for one television 8 RMB/month. The amount of money charged for electricity per load per month was decided by the township government (Taqing, personal comments, 14 December 2007). The electricity fee was not charged according to the amount of electricity consumed.

It is problematic in terms of equality to have two different electricity fee collection schemes in a township. Besides, the fee for electricity which was charged either based on lamp sum fee or specified loads did not reflect the actual amount of electricity consumed per kilowatt hour. Such a system contradicted the development of end-users' awareness of how to save energy. The amount of electricity generated from solar PV power stations was usually very limited. However, usually no other alternative electricity sources exist in most of the townships in remote rural areas of western China. Hence, energy saving is critical to secure more available electricity. A more appropriate electricity collection scheme would be electric meters.

3) Households' unwillingness and inability to pay electricity fee

Key to the success of electrification programs is that customers pay their bills on time (IEA, 2002). In order to run the solar PV power stations, the township governments needed to collect electricity fees to pay operators' salaries and to accumulate capital for the replacement of parts of the systems, such as batteries and PV modules. However, operators in both townships had difficulties collecting electricity fees from the households.

In Saierlong Township, households paid an average of 11.61 RMB in electricity fees from the solar PV power station per month.[148] Only 1.8% of households expressed that they had difficulty paying the electricity fee. Yet in contrast, the operator complained that around 60-70 % of the households did not pay their electricity fees (Ma, personal comments, 11 October 2007).[149] "There are indeed some households which have difficulty affording the electricity fee. But most of the households can afford the electricity fee. They simply don't want to pay" (Ma, personal comments, 11 October 2007). When households refused, or were unable to pay their electricity fees, no payment reinforcement mechanism or sanction for those who did not pay the electricity fee was in place to help fix the situation. According to the operator in the township,

[148] "The average household income is round 1000 RMB/month in Saierlong Township" (Lee, Director of Saierlong Township Health Center, personal comments, 28 November 2007).

[149] In one CAS survey report (2006b), conducted with 33 operators in 22 villages in Qinghai, Gansu, Yunnan, and Xinjiang AR, 19% of the investigated operators were not able to collect electricity fee from the households.

"The problem of households' unwillingness to pay electricity fee is getting worse and worse in the township." (Ma, personal comments, 11 October 2007). The operator complained how difficult it was for him to collect fees for electricity from households, especially as no actions were taken by the township government to cope with this problem (Ma, personal comments, 11 October 2007).

In Namcuo Township, households paid an average of 11.05 RMB in electricity fees from the solar PV power station per month.[150] Around 50 % of households expressed that they had difficulty paying electricity fee. And around 30 % of households which relied on the government's food subsidy did not pay their electricity fees on a regular basis, because they did not have any cash income (Taqing, personal comments, 14 December 2007).

The reasons why households failed to pay their electricity fees were different in either township. In Saierlong Township, households were able, but unwilling to pay their electricity fees. Hence, there should be some reinforcement mechanism or sanction requiring households to pay their electricity fees. For example, if households do not pay their bills on time, their connections should be cut off. In Namcuo Township, however, households were too poor to pay their electricity fees. Hence, government subsidies for setting an affordable tariff must take into consideration the situation of household income. The degree of government's subsidy should therefore vary from township to township, and be evaluated yearly according to updated household income figures.

4) Lack of financial management of collected electricity fee

In Saierlong Township, after the operators collected fees for electricity use, they separated the money for their own salary out of what was paid (Ma, personal comments, 11 October 2007). The money was not submitted to the township government, or to the County Financial Bureau for concentrated management. Neither the township nor the county government, however, was concerned about the financial management of collected electricity fee (Ma, personal comments, 11 October 2007), and no consideration was given to accumulating capital for the repair of broken components or

[150] "The average household income is round 250 RMB/month in Namcuo Township" (Zhabagedan, Namcuo Township leader, personal comments, 16 October 2007).

replacement of out-dated components, such as batteries and PV modules.[151] The 220 batteries which had around 5 years of life expectancy performed inefficiently after 4 years in use (Ma, personal comments, 11 October 2007). But no funding from the Township Electrification Program was made available for investment in new batteries, and the township government did not accumulate any capital for the replacement of the batteries. In addition, 11 solar PV modules were stolen and 1 solar PV module was broken during the time of research (see Photograph 4-3). If the batteries expire, the station will stop functioning, and the township will once again become non-electrified.

Photograph 4-3 Missing solar PV modules (left) and broken solar PV modules (right) in Saierlong Township

Source: Photographs taken by author in the field from October to December, 2007.

In Namcuo Township, after the operator collected fees for electricity, he handed the money over to the township government for concentrated management (Taqing, personal comments, 17 October 2007). But the leader of the Namcuo Township government expressed that the collected electricity fee was only enough for the payment of the operator's salary, and that there was almost no accumulated capital (Zhabagedan, personal comments, 16 October 2007). Half of the batteries in the system were out of order after 5 years in use. Additionally, the operator expressed his worry that the other half of the batteries might soon stop functioning (Taqing, personal comments, 17 October 2007). In response to these concerns, the leader of Namcuo Township government expressed that there was no capital for the replacement of batteries, and that the township government was unable to afford them with its current financial situation

[151] In GTZ's evaluation report of its project 'Renewable Energies in Rural Areas, China', GTZ also found the same problem that it is not clear who should be responsible for the replacement of the batteries after an expected technical life span of 4 to 5 years and for covering the future cost of maintenance (GTZ, 2008).

(Zhabagedan, personal comments, 16 October 2007).

Basically, both townships had problems financially managing their power stations, even though the Namcuo Township government concentrated management of the collected electricity fee. The implementation of the Township Electrification Program did not take the financial management of the station into the consideration. After the stations were built, the financing scheme for the costs of running the station was not planned in the Program. The Program ignored the operation and maintenance costs of the power stations built, even though initial capital for construction of stations accounts for the major cost. Therefore, it is critical for the success of the Program that self-sufficient financial management schemes in the townships for long-term operation of the stations be undertaken. The Chinese government should consider new policies to finance the stations for replacing batteries on the regular basis of every 5 years.

5) Unstable and low salary for operators

In Saierlong Township, the salary of the operators dramatically decreased and became very unstable during the time of this study. On average, operators could collect electricity fee of only 300 to 400 RMB per month, because more than 60 percent of the households did not pay their electricity fees (Ma, personal comments, 11 October 2007). Hence, each operator was paid only 150 to 200 RMB per month. In the first two years of the operation of the station, the operator was able to collect fees for electricity fee around 1000 RMB per month, and therefore have a salary of around 500 RMB per month (Ma, personal comments, 11 October 2007). Both operators were very unsatisfied with their low and unstable salary (Ma, personal comments, 11 October 2007 & 26 November 2007).[152] When asked how much a reasonable salary should be, the operators told us, "1000 RMB should be the reasonable salary" (Ma, personal comments, 11 October 2007). Yet as the director of the Health Center at the township told us, "according to their survey, the average household income is round 1000 RMB/month" (Lee, personal comments, 28 November 2007). In order to earn enough money to support a family, both operators had other jobs, on which they spent most of their time. In reality, the operation and maintenance of the solar PV station was to them

[152] In a CAS survey (2006c) conducted with 37 operators at 24 solar PV power stations in Qinghai, Gansu, Yunnan, and Xinjiang AR, all investigated operators were unsatisfied with their current salary.

a secondary job, and they simply came to the station to turn on the distribution box to distribute electricity at 18:00 or 19:00 and came again to turn it off at 21:00 or 22:00 (Ma, personal comments, 11 October 2007 & 26 November 2007). When they had time, they sometimes cleaned the modules and batteries (Ma, personal comments, 11 October 2007 & 26 November 2007). Basically, operators did not operate and maintain the station on a regular basis.

In Namcuo Township, the operator had stable salary of 200 RMB per month, which was provided by the township government. But the operator was also not satisfied with his salary, because it was not enough to support his family (Taqing, personal comments, 17 October 2007). When asked how much a reasonable salary should be, the operators told us, “500 to 800 RMB should be the reasonable salary” (Taqing, personal comments, 14 December 2007). However, the township leader told us, “The average household income is round 250 RMB/month” (Zhabagedan, personal comments, 16 October 2007). The operator expressed his need to have another job at the school to earn enough money for his family. Like the operators in Saierlong Township, he also only went to the station to turn the system on and off. Essentially, he also did not operate or maintain the station on a regular basis.

The implementation of the Township Electrification Program did not set standards for operators’ salaries. A survey carried out by CAS (2006c) to investigate 24 solar PV stations in Qinghai, Xinjiang AR, Yunnan, and Gansu province showed that the salary for operators ranged between 200 RMB and 1200 RMB, and that the average salary for the investigated 37 operators was 650 RMB per month. Another survey carried out by CAS (2006b) investigating 33 operators of solar PV power stations in Qinghai, Xinjiang AR, Yunnan, and Gansu showed that current salaries were not enough to motivate operators, and some trained operators left their job due to low and unstable salary. In Qinghai, the rate of trained operators leaving their job was 26.1 % (CAS, 2007c), and their replacements were unable to carry out their tasks well because they did not have any training before they started working as an operator (CAS, 2006b).

Even with these issues made clear, it is difficult to set appropriate standards for operators’ salary for all townships. The workload and working hours differ due to different system capacities and different numbers of households to be served. However, an appropriate and stable salary for operators to keep them working full time at the stations is necessary for the operation, maintenance and management of the station. If operators are not paid decently, then motivation to operate and maintain stations is highly affected. Since the solar PV power stations are high technology systems with large investment, careful maintenance is important to keep stations function regularly and normally.

4.4.3 Human resources aspect

In terms of human resources, two implementation problems were found in this study: lack of training for operators and lack of household/community participation.

1) Lack of training for operators

It is required by the Township Electrification Program that operators finish specific training before they are allowed to carry out their duty as the operators at the solar PV power stations (CAS, 2007c). According to one CAS report, "[…] operators of each station [must] have been trained by system integrators and keep the simplified operation manual in hand. Operator could handle general problems" (CAS, 2007c: 19). However, operators at the two investigated townships did not receive any training and were not able to handle some technical problems.

In Qinghai, the system generator QNEC requires that all operators finish training and receive the certifications of Special Electrician and Qualified Trainees to become the operators of the solar PV power stations (CAS, 2007c: 15).[153] In Saierlong Township, the operator who received the training and got the certification left the solar PV station due to low salary after several months on the job (Ma, personal comments, 11 October 2007). The two current successive operators did not receive any training, and each had only the Rural Electrician Certification which qualified them to be the operators of small hydro power systems. But because of their professional experiences as the operators of small hydro power stations for more than 20 years, they were hired by the township government to operator and maintain the solar PV power station. But the

[153] In one CAS survey (2006c) conducted with 17 operators at 11 solar PV power stations in Qinghai, only 70.6% of the investigated operators ever received training.

operators expressed the urgent need for professional training to help gain knowledge, skills, capacity and security awareness to operate and maintain the solar PV power station (Ma, personal comments, 11 October 2007 & 26 November 2007). However, no training opportunities were provided (Ma, personal comments, 11 October 2007 & 26 November 2007). Even though they knew how to turn the system on and off, adjust power supply according to the weather conditions, clean the PV modules, battery set, station and field, check the distribution lines, wires and cables, operators still had problems detecting malfunctions in the system because they were not able to understand the display or parameters of controller and inverter.[154] When problems occurred, operators could only call the QNEC. Besides, operators lacked the awareness that they should not smoke at the solar PV power station, considering that batteries could release inflammable gas when being charged (CAS, 2007d). Operators also did not have any pole climbing tools, such as safety belt lanyards, waist ropes, pole climbers and climbing irons. When a need to climb up poles and check wires arose, operators had to borrow the climbing tools from the operator of the small hydro power station (Ma, personal comments, 11 October 2007 & 26 November 2007).

The operator in Namcuo Township also did not receive any professional training. Like the operators in Saierlong, he too expressed the need for professional training, because he had only very limited knowledge about the system (Taqing, personal comments, 17 October 2007). Before becoming the operator of the solar PV station, he had no related experiences as an operator. Instead, he learned by doing (Taqing, personal comments, 17 October 2007). Only one trained operator stayed remained to maintain the 3 kW solar PV power station for the township government. But he was not responsible for regular maintenance of the solar PV power station in Qiaga village. Also, this operator did not have any safety equipment, such as electrician's clothes and shoes to protect him in case of accidents during electrical operation (Taqing, personal comments, 17 October 2007).

The training provided by the system generators was only available during the 'initial' period of the implementation of the Township Electrification Program (CAS, 2007c).

[154] In a CAS survey (2006b) conducted with 33 operators in 22 villages in Qinghai, Gansu, Yunnan, and Xinjiang AR, 64% of investigated operators did not know how to measure the current, and 33% of the investigated operators did not understand the parameters on the controllers and inverters.

After the initial period of the Program, no further training programs were offered. Once the trained operators left their jobs, their local successors lacked opportunities for further training. Based on these findings, it is necessary for the system generators to provide regular training programs for local-level operators in order to assure their qualification as operators. The system generators have to assure that operators are trained and obtain the necessary certification before operators are allowed to start.

2) Lack of household/community participation

It is suggested that the implementation of renewable energy-based electrification programs at the local level invokes a greater chance of success by involving local community participation (Martinot and Wallace, 2003; Cook et al., 2005).[155] In regard to the Township Electrification Program, two problems regarding household/community participation were found in the two investigated townships: the payment of electricity fee and the behavior of using electricity.

a) Payment of electricity fee

To run a power station, end-users must pay electricity fees. In Saierlong Township, more than 60% of households did not pay electricity fees.[156] Some households circumvented, or broke electric meters to avoid or escape payment of electricity fees (Ma, personal comments, 11 October 2007 & 26 November 2007).[157] In Namcuo Township, theft of electricity through illegal connection was not apparent, but more than 30 % of the households investigated could not afford electricity fee.

While tariff and electricity collection schemes were not appropriately or fairly designed, households in both townships should have possessed the awareness that the electricity

[155] Community participation in the context of development projects was defined as “the creation of opportunities to enable all members of a community and the larger society to actively contribute to and influence the development process and to share equitably in the fruits of development” (Midgley, 1986: 24). The advantages of community participation for development projects are to gain insights into local conditions, build local capacity for self-governance, enhance effectiveness of reaching objectives of the projects, and enhance sustainability of the projects (Slochum et al., 1995: 4; Plummer and Taylor, 2004).

[156] In a CAS survey (2006a) conducted with 79 households in 21 villages in Qinghai, Yunnan, and Xinjiang AR, 24% of the households did not pay their electricity fees on time.

[157] In a CAS survey (2006a) conducted with 79 households in 21 villages in Qinghai, Yunnan, and Xinjiang AR, CAS researchers also found that households bypassed electric meters or connected wires to escape the payment of electricity fees.

provided under the Township Electrification Program was not free. In general, the government's subsidy covered only the construction of the stations, not their operation and maintenance. In order to run the stations properly, the households must pay for electricity consumed. Related subsidy policy to assist the payment of electricity fees should be designed to assist households that are not able to afford electricity fees. Related regulations to reinforce the payment of electricity fee and the sanction for theft and unmetered connections should also be designed at the local level to assure that end-users pay electricity consumed.

b) Behavior of using electricity

Load control at all households in a township is crucial to keep a solar PV power station functioning normally and stably. When a solar PV power station becomes overloaded, unnoticed disruption of electricity supply can occur. According to the Township Electrification Program Maintenance and Operation Regulations, households are allowed to only use compact fluorescent lamps for lighting, and the use of incandescent lamps is strictly prohibited.[158] Furthermore, certain electrical appliances that consume a lot of electricity are not allowed to be used, such as refrigerators, rice cookers, or electric ovens. Productive machines which consume a lot of electricity are also not allowed, such as winnowing machines, electric drills, saws, compressors, planers, grinders, or wheels. The concern is that the system capacity is very limited and insufficient to meet the basic household needs, like lighting.[159] If households use a lot of incandescent lamps, high-power electrical appliances, and productive machines, then solar PV stations will be soon overloaded and unnoticed disruption of electricity supply will occur.

The situation of using incandescent lamps was not found in Namcuo Township. All investigated households used only compact fluorescent lamps for lighting (see Table 4-28). But in Saierlong Township, more than 60% of investigated households used

[158] Compact fluorescent lamps, also called energy saving lamps, have the characteristic of a contract configuration, energy saving, high illumination efficiency and long life expectancy. Since lighting consumes roughly 19 percent of all electricity produced on the global grid, substituting incandescent lamps with compact fluorescent lamps could reduce global lighting energy demand by nearly 40 percent by 2030, offsetting a cumulative total of 16.6 billion tons of carbon dioxide (Worldwatch Institute, 2008).

[159] The Township Electrification Program first sought to provide electricity to meet the basic needs of every household in remote rural areas of western China, such as lighting or powering TV.

incandescent lamps instead of compact fluorescent lamps for lighting (see Table 4-28).[160] According to the Qinghai Province Township Electrification Program Maintenance and Operation Regulation, "Only energy efficient lamps under 20W are allowed for lighting. Incandescent lamps […] are forbidden" (CAS, 2006b: 24). Even with prohibitions in place, some grocery stores sold only incandescent lamps. Although compact fluorescent lamps (30 RMB/per lamp) were 20 times more expensive than incandescent lamps (1.5 RMB/per lamp), the cost of electricity fee saved by the use of compact fluorescent lamps exceeded the use of incandescent lamps (see Table 4-29). Besides, the electricity saved by the use of compact fluorescent lamps also exceeded the use of incandescent lamps (see Table 4-29). Using a 100W incandescent lamp would consume nine times more energy and cost nine times more money for electricity fee than using a 10W compact fluorescent lamp. What the above findings indicate is that the use of one 100W incandescent lamp can provide another 'nine' 10W compact fluorescent lamps for lighting, or 'five' 10W compact fluorescent lamps for lighting and 'one' 50W TV. Using incandescent lamps can strongly affect the amount of available electricity for all households in a township.

Table 4-28 Percentage of using incandescent lamps and compact fluorescent lamps for lighting in Saierlong and Namcuo Township

Township	Incandescent lamp (%)	Compact fluorescent lamp (%)
Saierlong (n= 68)	63	37
Namcuo (n= 70)	0	100

Note: n is the number of lamps which use electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

Table 4-29 Comparison of incandescent lamps and compact fluorescent lamps

Lampe type	Watt	Price (RMB)	Using one lamp for 5 hours a day in one year	
			Electricity fee (RMB) (Tariff: 2 RBM/kWh)	Electricity consumption (kW)
Incandescent lamp	100	1.5	365.0	182.50
Compact fluorescent lamp	10	30.0	36.5	18.25

Source: Compiled by author. Price information was collected in the field from October to December, 2007.

Another common behavior of households which affects electricity supply is the use of

160 In one CAS survey (2006a) conducted with 79 households in 21 villages in Qinghai Province, Yunnan Province, and Xinjiang AR, CAS also found that 26.7% of the investigated households used incandescent lamps instead of compact fluorescent lamps for lighting.

high-power electrical appliances and productive machines. In Namcuo Township, no high-power electrical appliances or productive machines were found at the investigated households. But in Saierlong Township, some high-power electrical appliances and productive machines were found at some investigated households: one 400W washing machine, two 550W noodle machines, three 1000W refrigerators and one 2200W freezer (see Photograph 4-4).[161] Since the solar PV power station in Saierlong Township only has a capacity of 30 kW and the average capacity for a household is only 75W, the use of high-power electrical appliances and productive machines at some households highly affects the amount of available electricity for the majority of the households in the township. Such use can lead to overload of the station and result in an unnoticed disruption of electricity supply which affects every household in the township.

Photograph 4-4 High-power electrical appliances, 500W noodle machine (left) and 2200W freezer (right), in Saierlong Township

Source: Photographs taken by author in the field from October to December, 2007.

Household/community participation in the Township Electrification Program by paying electricity fee on time and changing their behavior of using electricity to save energy is a key factor in the success of the Program. If households do not actively cooperate with the operators and township governments, then achieving the Program's objective of long-term and reliable electricity supply becomes impossible. In order to secure long-term operation of the station, people must be educated on the importance of the payment of their electricity fees and proper behavior of using electricity.

[161] In a CAS survey (2006a) conducted with 79 households in 21 villages in Qinghai, Yunnan ,and Xinjiang AR, CAS found that 48% of the investigated households used high-power electrical appliances and productive machines, such as washing machines (520W), electric cookers (1200W), disintegrators (2500W), and pig grass machines (750W).

4.4.4 Institutional aspect

In terms of the institutional aspect, one implementation problem was found in this study: lack of good governance.[162]

The quality of governance at the local level for renewable energy-based rural electrification programs is critical and essential, particularly institution design and capacity, regulatory framework, and good management (Holtz, 2008; Holtz, 2007; IEA, 2002; European Environmental Agency, 2001; Taylor and Bogach, 1998; Asian Development Bank, 2003).[163] Many persistent development problems reflect failures of governance (Holtz, 2004; Holtz, 2008). Poor and week governance hamper efforts of renewable energy-based rural electrification programs to improve living conditions of rural people and the poor. Three problems were found regarding the quality of governance in the two investigated townships.

First, the implementation of the Township Electrification Program did not clearly define responsible institutions for the management of the stations (see Table 4-30).[164] The management of rural electrification existed as an overlap of responsibilities among different level of governments (central, provincial, county, and township governments) and it was not clear who was ultimately responsible for the operation and management of rural electrification (Pan et al., 2006). Basically, the solar PV power stations were all state-owned assets. But there were no formal documents issued by the Supervision and Administration of State-owned Assets Commission to specify the ownership of stations

[162] Governance is defined by Holtz (2007: 18) as "the rules, processes and behaviour by which interests are articulated, resources are managed, and power is exercised. […] Governance includes participation, accountability, efficiency, transparency, and coherence, as well as capable public institutions and individuals, a responsible state management and the rule of law." Good governance is "the transparent and accountable management of human, natural, economic and financial resources for the purposes of equitable and sustainable development" (European Union, 2006: 9).

[163] The criteria or characteristic of good governance includes participation, rule of law, transparency, responsiveness, equity, effectiveness and efficiency, accountability, strategic vision, adequate framework conditions and institutions, good management, the use of appropriate fiscal instruments, the responsible handling of funds, the inclusion of civil society, and better training at national and international levels (Holtz, 2007: 19; Welch and Nuru, 2006). Pfaff-Czarnecka (2007) suggested that democratic institutions are an important base for good governance.

[164] In GTZ's evaluation report of its project 'Renewable Energies in Rural Areas, China', GTZ researchers also found the same problem that it was not clear who owns the solar PV power stations, and who should manage the stations (GTZ, 2008).

(CAS, 2007a). Hence, different institutions were partly responsible for the current management of the stations (see Table 4-30). In most cases, stations were constructed by the system generators and then handed over to the township government for management. The system generators were responsible for offering technical support of the systems. The township government was responsible for the operation and management of the stations.

Table 4-30 Institutions for management of solar PV power stations

Province	**Responsible institutions for management of the stations**	**Present institutions for management of the stations**
Tibet AR	Unknown	System generators and township government
Xinjiang AR	Unknown	System generators and township government
Qinghai	Unknown	System generators and township government
Sichuan	Unknown	County power company
Inner Mongolia AR	Unknown	System generators and township government
Gansu	Unknown	System generators and township government
Shaanxi	County power company	County power company

Source: CAS, 2007a.

In practice, no institutions took full responsibility for the management of the stations in both investigated townships. The quality of governance was, in general, weak and poor. In both investigated townships, township leaders and operators did not clearly know which institution was mainly responsible for the management of the stations. The operator in Saierlong Township expressed that “nobody cares about the station, neither the township government nor the system generator. I have no way but to be in charge of the management of the station” (Ma, personal comments, 11 October 2007 & 26 November 2007). When he had problems managing the station, such as collecting electricity fee, or if he needed replacements for the batteries and PV modules, or help dealing with households which did not pay electricity fee, no institutions could help him (Ma, personal comments, 11 October 2007 & 26 November 2007). The same situation also occurred in Namcuo Township. According to the township leader, “The management of the solar PV power station is the responsibility of the system generator, not the township government. The operator at the township is only responsible for operation and basic maintenance of the system" (Zhabagedan, personal comments, 16 October 2007). However, the system generator claimed that the management of the stations was the responsibility of the townships (CAS, 2007a). From both investigated case townships, the eligible institutions for the management of the stations were not clearly defined.

Second, there was a lack of the awareness of regulatory framework in both investigated townships. Operators in both townships were not aware of the existing Maintenance and Operation Regulation. When operators were asked to provide the Maintenance and Operation Regulation, they could not find them and did not know exactly what the Maintenance and Operation Regulations were for.[165] The operation, maintenance, and management of the station simply relied on the operators' individual way which ignored the existing Maintenance and Operation Regulations.

Third, implementation of the Township Electrification Program did not include an effective monitoring system to monitor the management of the solar PV power stations and the quality of electricity service provided to end-users. According to the Construction Project Management Regulation in China, projects should pass the acceptance stage in order to complete the legal process (CAS, 2007a). However, all the stations, including the two investigated stations, have not yet gone though the acceptance stage (CAS, 2007a). The Township Electrification Program represents the first time that the Chinese government initiated such a large scale program of renewable energy-based rural electrification. Without monitoring the management of the solar PV power stations and the quality of electricity service, the government is unaware of the potential problems regarding the management of the solar PV power stations and the quality of electricity service at local level. The only available monitoring system of the Program is the quality of equipments and systems installed at the solar PV power stations. However, such a system is a self-monitoring system by many different Chinese manufacturers and system suppliers (CAS, 2007a). Different problems have been reported regarding the quality of equipments and systems, such as the capacity of batteries and PV modules, the efficiency of inverters, and so on (CAS, 2007a).

[165] In one CAS survey (2006b) conducted with 33 operators in 22 villages in Qinghai, Gansu, Yunnan, and Xinjiang AR, only 21% of the investigated operators followed the Solar PV Power Stations' Maintenance and Operation Regulation.

Specifying the eligible institutions for the management of the stations and effectively reinforcing the regulations should help to improve the quality of governance of the Township Electrification Program at the local level. An effective and reliable monitoring system should be established to control each stage of implementation of the Program to assure the quality of governance of the Township Electrification Program at the local level.

4.5 Overall evaluation of policy implementation of the 'Township Electrification Program' in the two selected townships

Martinot and Wallace (2003) suggested that greater attention should be paid to local capacity building for implementing renewable energy policies in China.[166] The implementation of the Township Electrification Program was mainly construction of stations, in other words, installation of systems and supply of equipments. Once the stations were built, the systems were installed, and people had lighting at their home, the implementation of the Program in the remote rural areas of western China was considered finished by the central government (CAS, 2007a). As such, implementation of the Program focused on the technical capacity building and undermined the importance of financial, human resources, and institutional capacity building in both investigated townships (see Figure 4-4). However, these three aspects are key factors for

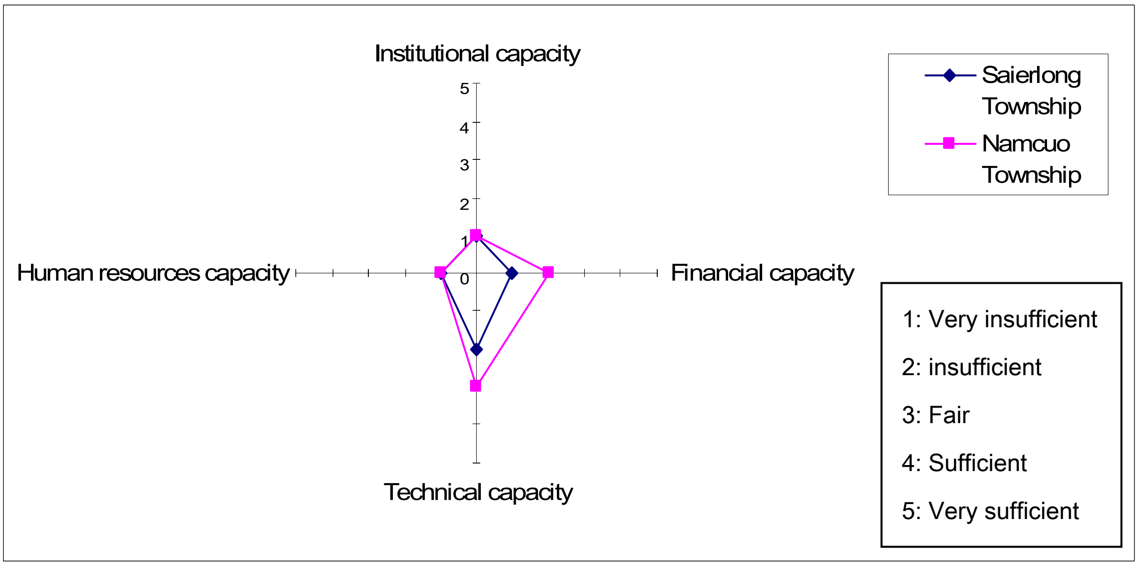
[166] Capacity is defined by the UNDP (2006) as "the ability of individuals, institutions, and societies to perform functions, solve problems, and set and achieve objectives in a sustainable manner" (Retrieved 23 January, 2007 from http://www.capacity.undp.org/index.cfm?module=Library&page=Document&DocumentID=5510).

Cap-Net of Capacity Building for Integrated Water Resources Management (2002) defined capacity as "the ability of individuals and organizations or organizational units to perform functions effectively, efficiently and sustainably. This implies that capacity is not a passive state but part of a continuing process and that human resources are central to capacity development" (Retrieved 23 January, 2007 from http://www.cap-net.org/FileSave/9_Capacity_building_strategy,_December_2002.doc).

Capacity building is defined by the Global Development Research Center (GDRC) with three concepts as "human resource development, the process of equipping individuals with the understanding, skills and access to information, knowledge and training that enables them to perform effectively; Organizational development, the elaboration of management structures, processes and procedures, not only within organizations but also the management of relationships between the different organizations and sectors (public, private and community); Institutional and legal framework development, making legal and regulatory changes to enable organizations, institutions and agencies at all levels and in all sectors to enhance their capacities" (Retrieved 23 January, 2007 from http://www.gdrc.org/uem/capacity-define.html). Hence, capacity building had three basic elements: First, creation of an enabling environment with appropriate policy and legal frameworks; second, institutional development, including community participation; third, human resources development and the strengthening of managerial systems (Alaerts et al., 1991).

the success of the Program to assure long-term electricity supply in remote rural areas of western China. If local technical, financial, human resources, and institutional capacity was not built in order to help run the solar PV stations at the local level, then the effects of the Program would be short-lived and ultimately count as a failure.

Figure 4-4 Sufficiency of local capacity for managing electricity supply from the solar PV power stations in Saierlong Township and Namcuo Township



Source: Drew by author.

The Chinese government planned to run the solar PV power stations which were built under the Township Electrification Program for at least 15 to 25 years (CAS, 2007a). However, the solar PV power stations in both investigated townships currently function poorly in terms of financial, human resources, and institutional aspect. After the construction of the stations in 2002/2003, both stations faced the problem of financing new sets of batteries to keep the stations functioning. The other 721 solar PV power stations which were built under the Township Electrification Program will ultimately face similar problems as well. If old battery sets are not replaced in time, all the solar PV power stations constructed will stop functioning, townships will revert to being non-electrified, and remotely located rural households will have no access to electricity.

5 Policy Evaluation I – Policy Outputs of the 'Township Electrification Program' in the Two Selected Townships: Rural Electricity Supply with Solar Energy

5.1 Policy evaluation

Generally, policy evaluation refers to "use a range of research methods to systematically investigate the effectiveness of policy interventions, implementation and processes, and to determine their merit, worth, or value in terms of improving the social and economic conditions of different stakeholders" (Cabinet Office, 2003: 3). But more specifically, policy evaluation is oriented towards learning whether policies have achieved their stated goals - at what costs, with what effects, intended and unintended, on society (Dye, 1998: 333). In other words, policy evaluation seeks to answer 'how close a governmental program has come to achieving its stated policy goals' (Nakamura and Smallwood, 1980: 67).

However, "does the government really know what it is doing? Generally speaking, no" (Dye, 1998: 338). The following questions must be asked of what a government knows about its policies: How much money they spend? How many people are given various public services? How much these public services cost? How their policies or programs are organized, managed, and operated? Even if policies or programs are well organized, efficiently operated, adequately financed, widely utilized, and generally supported by target groups, one might be interested to know (Dye, 1998: 338): What are the consequences of public policies? Do policies or programs work? Do policies or programs have any beneficial effects on society? Are the effects immediate, short term, or long term? Are the effects positive or negative? Yet as argued by Dye, Unfortunately, governments have done very little to answer these basic questions (Dye, 1998: 338). Since policy-making is an ongoing process, each phase is related to the next and the last phase (policy evaluation) is linked to the first (policy problem identification) (Dunn, 1994: 15-16; Anderson, 1975: 132). Through evaluating their policies, governments can learn from problems occurring in existing policies or programs to determine if those policies should be continued, modified, or terminated. The need for good and sound policy evaluation is at the heart of policy making (Cabinet Office 2003: 3).

To evaluate a public policy, policy objectives and policy goals must first be identified and differentiated (see Table 5-1; Dunn, 1994: 195-196). In practice, policy objectives and policy goals are not necessary clearly defined or differentiated by policy makers. But for analytical purposes, policy objectives and policy goals must be distinguished in order to know what ends analysis hopes to achieve (Spicker, 2006).

Table 5-1 Characteristics of policy objectives and policy goals

Characteristic	**Policy objectives**	**Policy goals**
Purpose	Concretely stated (e.g. to increase the number of physicians by 10 percent)	Broadly stated (e.g. to upgrade the quality of health care)
Definition of the terms	Operational definition (e.g. the quality of health care refers to the number of physicians per 100,000 persons)	Non-operational definition (e.g. the quality of health care refers to accessibility of medical services)
Time period	Specified (in the period of 2001 to 2005 or before 2010)	Unspecified (e.g. in the future)
Measurement procedure	Frequently quantitative (e.g. the number of insured persons covered per 1000 persons)	Non-quantitative (e.g. adequate health insurance)
Treatment of target groups	Specifically defined (e.g. families with annual income below $10,000)	Broadly defined (persons in need of care)
Township Electrification Program	■ Installed capacity 100W per person ■ Provide long-term and reliable electricity service	■ Improve living conditions ■ Reduce poverty

Source: Compiled by author based on Dunn, 1994: 196.

Second, one should identify two types of policy evaluation: systematic policy evaluation and unsystematic policy evaluation. In practice, policy evaluation is normally conducted by policy makers or government officials. Policy evaluations carried out by governments are usually unsystematic and impressionistic (Dye, 1998). Their approaches for policy evaluation, using selective and favorable information or controlling the indicators of the policy outputs, outcomes, and impacts, are often designed to achieve specific political objectives (Dye, 1998). Hence, it is doubtful policy makers and government officials can evaluate objectively, and therefore, be held accountable for policies' successes and failures.

Systematic policy evaluation conducted by professional evaluators or scientists viewing policy evaluation as a technical exercise to produce scientifically valid findings is relatively rare; because doing so requires methodological capacities to evaluate policies in measurable and quantitative terms instead of only qualitative statements which unsystematic policy evaluations usually use (Dye, 1998; Nakamura and Smallwood, 1980). Hence, systematic policy evaluations that depend on a series of methodological requirements are often absent from government evaluation processes (Nakamura and Smallwood, 1980). In some dictatorship, authoritarian or closed regimes, such as PR China, due to political sensitivity[167], the government is usually unwilling to allow independent systematic evaluations which may find evaluation results contrary to a government policy (Chung, 2004).

Yet while systematic policy evaluations aspire to be an objective exercise, one fact cannot be ignored - that the results of such evaluations are often not totally objective or value-free. After all, policy evaluation is the process of judging the performance of policy makers and government officials. "This is true even if the evaluator is a university researcher who thinks of himself as objectively in pursuit of knowledge" (Anderson, 1975: 141-142). Thus systematic policy evaluations that seem neutral, objective or value-free are ultimately political, involving evaluators' judgments (Nakamura and Smallwood, 1980). For as Spicker explains, policy evaluation is not only a technical exercise, but often a social process which influences governments (Spicker, 2006: 180).

The evaluation of a policy consists of different approaches, requiring an evaluator to choose an approach most suitable to the case in question. Levy, Meltsner and Wildavsky (1974) distinguished three different approaches that can be used for systematic policy evaluation: policy output, policy outcome, and policy impact. Each approach applies a number of different analytical tools, methodological procedures, and criteria (Dunn, 1994; Cabinet Office, 2003).[168]

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[167] Policy evaluations are also sensitive to political change, such as new elections, and new regimes. Baker (2000) listed three evaluation studies which were cancelled because of political change.

[168] Dunn suggested six criteria for policy evaluation: effectiveness, efficiency, adequacy, equity, responsiveness, and appropriateness (Dunn, 1994: 405-406). Nakamura and Smallwood suggested five

1) Policy output

Policy output is defined by Dunn as "a good, service, or resource received by target groups and beneficiaries" (Dunn, 1994: 396). Policy outputs are often tangible or measurable results of a policy action. Policy outputs often refer to the quantity of the activities, services or resources of a policy action, for example number of people served, per capital welfare expenditure, per capita highway expenditure, units of home food service received by the elderly, miles of roads built (Nakamura and Smallwood, 1980; Anderson, 1975; Dunn, 1994). Taking the example of education policy, an output of an education program may consist of the number of pupils actually receiving instruction or per pupil school expenditure (Dunn, 1994). The primary objective of this type of evaluation is to determine whether or not the policy has achieved its officially stated objectives. The analysis of policy outputs is the easiest among the three approaches listed to measure quantitatively. This approach is also the dominant approach for policy evaluation research, and many efforts have been made to develop more sophisticated and refined techniques that can be used to count specific outputs of a policy in order to produce objective and value-free findings (Nakamura and Smallwood, 1980).

2) Policy outcome

Policy outcome is defined by Dunn as "an observed consequence of a policy action" (Dunn, 1994: 85). Policy outcome evaluates the actual change of behaviors or attitude that results from 'policy outputs' (Anderson, 1975). Hence, a policy outcome is usually more qualitative, and has only short-term implications (Nakamura and Smallwood, 1980). To once again use the example of education policy, only knowing policy outputs, such as how many pupils receives instruction or how much is spent on pupils, indicates nothing about the effect of an education program on the cognitive and other ability of students. In reality, an outcome of an education program would be changes in a pupil's test scores, study habits, or improvement of self-estimates of ability (Dunn, 1994). This

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criteria for policy evaluation: policy goal attainment, efficiency, constituency satisfaction, clientele responsiveness, and system maintenance (Nakamura and Smallwood, 1980: 146-151). For evaluating development assistance, OECD suggested five criteria for evaluating programs and projects: efficiency, effectiveness, impact, relevance, and sustainability (see OECD website: http://www.oecd.org/document/22/0,2340,en_2649_34435_2086550_1_1_1_1,00.html, retrieved 30 November, 2009; also see FASID, 2005).

approach involves short-term changes in behaviors or attitude which are often subjective and difficult to measure objectively.

3) Policy impact

According to Anderson, policy impact is defined as the change of real-life conditions resulting from a policy outcome (Anderson, 1975: 134-135). Policy impacts usually have longer-term consequences for a society, like reduction in unemployment rate, or improvement in the health of a target group (Nakamura and Smallwood, 1980). To once again use the example of education policy, an impact of an education program would be increase of literate population or increase of society's economic productivity (Dunn, 1994). The evaluation of policy impacts is the most difficult among the three approaches listed to measure. The determination of the actual impacts of policies is often a very complex and difficult task (Nakamura and Smallwood, 1980; Anderson, 1975). This difficulty comes from needing to prove that the change in real-life conditions is indeed due to a policy and not other factors, especially since changes may happen with or without a policy. For example, action A is taken and condition B develops. This does not necessarily mean that a cause-and-effect relationship exists. The development of condition B might be caused by other factors which one might never discover, especially in social scientific studies.

In theory, policy evaluation should evaluate policy outcomes and policy impacts rather than only policy outputs (Spicker, 2006). Policy outputs generally do not provide information on changes in behavior and attitude which result from the intervention of a policy. To claim that a particular policy or program has attained a high or low level of performance not only requires that policy outcomes and impacts are consequences of a policy action, but also that policy outcomes and impacts should have specific meaning to some individuals, groups or a society (Dunn, 1994: 404-405).

Lastly, one must be aware of the methodology of policy evaluation associated with these three approaches. In theory, the success of a policy evaluation is dependent on an evaluator's ability to construct reliable and valid measures by specifying different variables (Dunn, 1994: 340). However, in practice, frequently the precise definitions of these valuables did not exist. Dunn suggests two kinds of definitions of variables to cope with this methodological problem: constitutive definitions and operational definitions (Dunn, 1994: 340-341).

Constitutive definitions give meaning to words used to describe variables by using other synonymous words, for example, educational opportunity could be constitutively defined as “the freedom to choose learning environments consistent with one’s ability” (Dunn, 1994: 340). Since it is in fact impossible to measure education opportunity directly, constitutive definitions provide the most tenuous links with the ‘real world’ for evaluation.

Operational definitions give meaning to a variable by specifying the operations required to experience and measure it (Dunn, 1994: 340). For example, one could easily go beyond the constitutive definition of educational opportunity by specifying that educational opportunity is “the number of children from families with less than $6,000 annual income who attend colleges and universities, as documented by census data” (Dunn, 1994: 340-341). Operational definitions not only specify procedures required to experience and measure something, but also help specify indicators of variables (Dunn, 1994: 341). Indicators of variables are directly observable characteristics that are substituted for indirectly observable or unobservable characteristics (Dunn, 1994: 341). For example, although one cannot directly observe air quality, the amount of sulfur dioxide in the air or a citizen’s feeling of air condition acts as an indicator of air quality. Sometimes it is possible to construct an index which is a combination of two or more indicators that together provide a better measure of variables for policy outputs, outcomes, and impacts than any one indicator does by itself (Dunn, 1994: 341). Many alternative indicators can be used to operationally define one variable. Some indicators are more adequate than others. Therefore, it is suggested to use multiple indicators of one variable to evaluate policy outputs, outcomes, and impacts (Dunn, 1994: 341).

Based on the above discussion, the analytical framework for evaluating the Township Electrification Program in both selected townships is outlined in Table 5-2. The respective results and discussion are presented in chapters 5, 6, and 7.

Table 5-2 Analytical framework for policy evaluation of the Township Electrification Program

Category	Policy output (Chapter 5)	Policy outcome (Chapter 6)	Policy impact (Chapter 7)
Definition of the term	■ A good, service, or resource received by target groups and beneficiaries	■ An observed consequence of a policy action ■ The actual change of behavior or attitudes that result from policy outputs	■ The change of real-life conditions resulting from policy outcomes ■ Longer-term consequences on society
Policy objectives and goals of the National Township Electrification Program	Policy objectives: ■ Installed capacity 100W per person ■ Long-term and reliable electricity service	Short-term policy goals: ■ People change their energy use behavior from traditional energy (e.g. candles, dry cell batteries) to electricity	Long-term policy goals: ■ Improve living conditions ■ Reduce poverty
Variables for evaluation of the Township Electrification Program	■ Electricity supply ■ Electricity service	■ The change of energy use patter	■ Improvement of socio-economic benefits for households ■ Improvement of township development ■ Environmental impact

Source: Compiled by author.

5.2 Policy outputs

The policy outputs of the Township Electrification Program are electricity and electricity service. Hence, two variables are used in this study to evaluate the policy outputs of the Program: electricity supply and electricity service.

5.2.1 Electricity supply

Four indicators are used to evaluate ‘electricity supply’ (see Table 5-3).

1) Electrification rate

The Township Electrification Program aimed to provide electricity for the households in non-electrified townships in remote rural areas of western China. Hence, electrification rate, or the number of households with electricity access, is an indicator used to evaluate if electricity is indeed supplied to all households in the townships which implemented the Program.

2) Installed capacity per person/per household

The Chinese government has planned that 23 million people in remote rural areas will have access to electricity with renewable energy with installed capacity of 100W per person by 2010 (Ma, 2004). Hence, installed capacity per person/per household is an indicator to evaluate if the Township Electrification Program has achieved this target in the townships implementing the Program.

3) Electricity supply per household per day

The installed capacity per household/per person does not give any information about the exact amount of electricity actually supplied to households. Because this information is unknown, it was possible that a high capacity system provides only limited amounts of electricity for households due to different reasons. Hence, electricity supply per household per day is an indicator to evaluate the amount of electricity each household gets per day in the townships which implemented the Program.

4) Households' evaluation of the sufficiency of electricity supply.

Households in remote rural areas of western China comprised the target of the Township Electrification Program, and households' evaluation of the sufficiency of electricity supply provides important data on end-users' overall evaluation of electricity supply in the townships which implemented the Program.

5.2.2 Electricity service

Two indicators are used in this study to evaluate another variable 'electricity service' (see Table 5-3).

1) Reliability of electricity service

The policy objective of the Township Electrification Program was to provide long-term and reliable electricity service to people in remote rural areas of western China (CAS, 2007a). Therefore, reliability of electricity service is an indictor to evaluate if electricity was provided regularly and predictably.

2) Households' evaluation of electricity service.

End-user's satisfaction or dissatisfaction with public services, their perspective on quality and performance, and their experience of service delivery are important parts of the evaluation of policy outputs (Spicker, 2006). Many evaluators take quantitative surveys of end-user satisfaction about public services as basic indicators of policy output. In addition, qualitative data in the form of complaints from end-users also provided valuable insight into the weaknesses and strengths of the public services (Spicker, 2006). Close examination of end-user's complaints helps evaluators to identify service gaps, such as what has gone wrong, or how to set the services right. Since the target group of the Township Electrification Program was made up of households located in remote rural areas of western China, households' evaluation of electricity service provided important information from the end-users on their satisfaction and complaints of electricity service.

Table 5-3 Indicators for evaluation of policy outputs of the Township Electrification Program

Variable	Indicator
Electricity supply	■ Electrification rate ■ Installed capacity per person/per household ■ Electricity supply per household per day ■ Households' evaluation of the sufficiency of electricity supply
Electricity service	■ Reliability of electricity service ■ Households' evaluation of electricity service

Source: Compiled by author.

5.3 Evaluation of policy output: Electricity supply

5.3.1 Policy output

Four indicators were used to evaluate the policy output, electricity supply, in the two selected townships.

1) Electrification rate

In Saierlong Township, 60 out of 81 surveyed households had an electricity connection to the solar PV power station. The electrification rate of the solar PV power station was 74.1% (see Table 5-4). In Namcuo Township, 55 out of 56 surveyed households had an electricity connection to the solar PV power station, and the electrification rate of the solar PV power station was 98.2% (see Table 5-4).

Table 5-4 Electrification rate in Saierlong and Namcuo Township

Indicators	**Saierlong**	**Namcuo**
Number of sampled households	81	56
Number of sampled households having electricity access from the solar PV power station	60	55
Electrification rate of the Township Electrification Program	**74.1%**	**98.2%**
Number of sampled households having electricity access from the small hydro power station	62	N/A
Electrification rate of the small hydro power station	**76.5%**	**N/A**
Number of sampled households having electricity access from solar home PV systems	24	20
Electrification rate of the solar home PV systems	**29.6%**	**35.7%**
Number of sampled households without any electricity access from the solar PV power station, the small hydro power station, or solar home PV systems	2	0
Electrification rate	**97.5%**	**100%**

Source: Data collected by author based on author's field survey from October to December, 2007.

In general, the overall rate of electrification in both townships was quite high. In Saierlong Township, although the rate of electrification of the solar PV power station was only 74.1%, access of electricity from the small hydro power station and solar home PV systems pushed the overall electrification rate to 97.5% (see Table 5-4). In Namcuo Township, all households had access to electricity (see Table 5-4).[169]

2) Installed capacity per person/per household

In Saierlong Township, a 30 kW configuration solar PV power station was built in 2003 providing electricity for 300 households and 1200 inhabitants (Bopp, 2004). In 2003, the installed capacity was 100 Watt per household and 25 Watt per person (see Table 5-5). But by the end of 2007, while field research was carried out, the total number of households increased to around 400 and the number of inhabitants increased to around 1800. As a result, the installed capacity in 2007 was 75 Watt per household and 17 Watt per person (see Table 5-5).

In Namcuo Township, a 20 kW configuration stand-alone mini-grid solar PV power station was built in 2002, providing electricity to 50 households and 200 inhabitants. In 2003, the installed capacity was 400 Watt per household and 100 Watt per person (see Table 5-5). Yet by the end of 2007, the total number of households increased to around 60 and the number of inhabitants increased to around 280 inhabitants. These changes meant that the installed capacity in 2007 was 333 Watt per household and 71 Watt per person (see Table 5-5).

Table 5-5 Installed solar PV capacity per household/per person in Saierlong Township and Namcuo Township

Installed capacity	**Watt**	
	Saierlong	**Namcuo**
Installed capacity per household in 2003	100	400
Installed capacity per person in 2003	25	100
Installed capacity per household in 2007	75	333
Installed capacity per person in 2007	17	71

Source: Data processed by author based on author's field interviews and site investigation from October to December, 2007.

3) Electricity supply per household per day

169 In Namcuo Township, almost all households were connected to electricity from the solar PV power station, except for one very remote household, which had a solar home PV system for electricity access.

In Saierlong Township, the total supply of electricity until November 26, 2008 was 65,240 kWh, while the total supply of electricity per month was 1359 kWh[170]. During that same period, the total supply of electricity per household per month was around 3.883 kWh,[171] while the total electricity supply per household per day was around 130 Wh.[172]

In Namcuo Township, the distribution box did not record the total electricity supply of the system. Therefore, no data was provided to know how much electricity was supplied in the township after the installation of the system.

4) Households' evaluation of the sufficiency of electricity supply

Of the total number of households surveyed, 73.2% in Saierlong Township and 81.8% in Namcuo Township expressed frustration over the insufficiency of electricity supply for their needs (see Table 5-6).

Table 5-6 Sufficiency of electricity supply in Saierlong Township and Namcuo Township

Question: Is the electricity supply from the solar PV power station sufficient for your household needs?	Saierlong (n=56)		Namcuo (n=55)	
	Account	Percentage	Account	Percentage
Not sufficient for household needs	41	73.2%	45	81.8%
Sufficient for household needs	15	26.8%	10	18.2%

Note: n is the number of the households which used electricity from the solar PV power station.
Source: Data processed by author based on author's field survey from October to December, 2007.

5.3.2 Evaluation

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[170] The system started functioning in December 2003. Until November 2008, while the data was recorded, there are total 48 months. The total electricity consumption 65,240 kWh divides 48 months. The total electricity consumption per month is therefore 1359 kWh.

[171] Since the number of households in Saierlong Township changed in these 48 months, this study used the mean of the number of households in 2003 (300 households) and 2007 (400 households) to calculate the total electricity consumption per household per month. The mean number of household is therefore 350. The total electricity consumption 1359 kWh divides 350 households. The total electricity consumption per household per month is therefore 3.883 kWh.

[172] If the average number of days in a month is 30, the total electricity consumption per household per month 3883 Wh divides 30 days. The total electricity consumption per household per day is therefore 129.4 Wh.

What was the situation of electricity supply of the Township Electrification Program in the two selected townships, Saierlong Township and Namcuo Township?

1) Electrification rate

The objective of the Township Electrification Program was to provide every household with access to electricity from solar PV power stations in remote rural areas of western China. However, survey results show that not all households have an electricity connection to the solar PV power stations, particularly in Saierlong Township. Approximately one forth of the households sampled in Saierlong Township did not have access to electricity from the solar PV power station.

2) Installed capacity per person/per household

The Chinese government set a clear and measurable objective for the Township Electrification Program, which was an installed capacity of 100 Watt per person. The installed capacity per person in Namcuo Township in 2002 achieved the policy objective, but it dropped to 71 Watt per person after five years. The installed capacity per person in Saierlong Township in 2003 was 25 Watt per person, which did not achieve the policy objective. Due to population growth and increase of migrants from nearby non-electrified villages (Ma, personal comments, October 2007; Lee, personal comments, 28 November 2007), the installed capacity per person dropped to only 17W per person in 2007.

3) Electricity supply per household per day

Electricity supply per household per day offers a more in-depth analysis of actual electricity supply. In Saierlong Township, the amount of electricity supplied per household per day was only 130Wh, meaning each household either used 130 Watt in one hour, 65 Watt in 2 hours, 44 Watt in 3 hours, or 33 Watt in 4 hours. For example, 130Wh of electricity can provide only enough electricity to power one 15W compact florescent lamp and one 50W TV for a household for two hours a day. Therefore, the electricity supply per household per day in Saierlong Township was fairly insufficient.

In addition, the real figure of the electricity supply per household per day was much lower than 130Wh. The total electricity supply included the large amount of electricity supplied to the school, which had priority to use electricity and had 24 hours electricity supply. As a result, a large portion of electricity was provided for the school, not for households.

4) Households' evaluation of the sufficiency of electricity supply

End-users' evaluation of the sufficiency of electricity supply showed that the supply of electricity was insufficient for households' need in both investigated townships. In total, 77% of the households in both townships expressed discontent over the insufficiency of electricity supplied by the solar PV power stations.

5.3.3 Discussion: How can policy makers estimate sufficient electricity supply for households in remote rural areas?

The Township Electrification Program aimed to improve living conditions for rural people on the basis of the supply of electricity. From the evaluation results, the supply of electricity was insufficient to meet households' needs in both investigated townships because of a gap between electricity supply and demand. When the supply of electricity was not enough to meet households' needs, both the Program's short-term policy goal by changing people's energy use behavior from traditional energy (such as candles) to modern energy (electricity) and its long-term policy goal by improving living conditions and reducing poverty were difficult to be achieved.

However, it is not an easy task to decide the optimal supply on electricity for renewable energy-based rural electrification programs because the decision is not only a technical issue, but also possesses political and social meanings. Whenever possible, field surveys utilizing participatory approaches should be used to forecast user demand (Munasinghe, 1987; Chung, 2004). But the Township Electrification Program failed to carry out any baseline study to survey users' electricity needs before the implementation of the Program (Chung, 2004). The estimation of the users' electricity needs was instead based on the opinion of experts and policy makers, who did not know very much about these remote rural areas. Without taking local conditions into account, it was impossible to precisely estimate users' electricity needs for loads. Such information is important, because it can help determine how much capacity a system should have for a township and how long a system can be sustained when a population and loads increase.

Most renewable energy-based rural electrification programs or projects are conceived without sufficient recognition of the needs and preferences of end-users (Chung, 2004). In his work, Chung argues that renewable energy-based rural electrification programs are traditionally dominated by a supply-driven paradigm that mainly focuses on the supply of electricity, rather on end-users' demands (Chung, 2004). Current available information on the Township Electrification Program indicates this exact problem, especially considering the government's main focus on electricity supply, such as the number of stations built, the installed capacity, the amount of electricity generated, and the number of households and people electrified.

Hence, from the lessons learned in the two investigated townships, this study suggests four important factors which need to be taken into consideration when estimating rural electricity supply with end-users' electricity demand approach.

1) Basic electricity need for households

According to the Township Electrification Program, the Chinese government set the policy objective of installed system capacity 100 Watt per person, but this number does not define the minimum amount of electricity to be supplied to households. The United Nations defined a typical electricity requirement for a household in a remote rural area at 150Wh per day (United Nations, 2000: 6). But the households in different areas in different countries have different minimum electricity needs. According to an evaluation report on rural electrification projects in developing countries by the World Bank (2008) for its analysts concluded that the most common uses of electricity in rural areas are lighting and television. Basically, the electricity needs of a remote rural household can be classified into two types: lighting and electrical appliances (Barnes and Floor, 1996; World Bank, 2000a; Mapako and Mbewe, 2004; United Nations, 2000). Yet for the most part, lighting is considered the main part of electricity needs by rural households (Mapako and Mbewe, 2004; World Bank, 2000a; World Bank, 2008). Other common electricity needs of rural households include: low-power electrical appliances, such as TVs, radios, telephones, mobiles, VCD/DVD players, and satellite receivers. High-powered electrical appliances requiring more electricity, such as refrigerators, washing machines, electric cookers, and computers, are not common in rural households. But in China, refrigerators, washing machines, and electric cookers are widely considered ‘basic necessities’ (CAS, 2007a).

Field surveys to collect the information on the electricity needs of households in remote rural areas are crucial for estimating basic electricity supply.[173] The information includes loads, power of loads, and the amount of time using loads. Take the example of the two selected townships. In both townships, current electricity needs revolve around the use of lighting and electrical appliances. The average number of lamps per household in Saierlong Township was 2.26, and in Namcuo Township, 1.61 (see Table 5-7). The number and percentage of owning different electrical appliances in both townships is outlined in Table 5-8. Basically, the most common electrical appliances used by households Saierlong Township are: TVs, mobile phones, satellite receivers, VCD/DVD players, and radios. In Namcuo Township, common electrical appliances included TVs, mobile phones, VCD/DVD players, and Ghee tea machines. In both townships, electricity needs were similar, with only slight differences. The power of lamps and electrical appliances used in both townships is shown in Table 5-9. The average number of hours which the households use the lamps and different electrical appliances per day is shown in Table 5-10 and Table 5-11.

Table 5-7 Average number of lamps per household in Saierlong Township and Namcuo Township

Lighting	**Saierlong (n=81)**		**Namcuo (n=56)**	
	Total number of lamps of all surveyed households	Average number of lamps per household	Total number of lamps of all surveyed households	Average number of lamps per household
Lamp	183	2.26	90	1.61

Note: n is sample size.
Source: Data processed by author based on author’s field survey from October to December, 2007.

[173] This study took these two townships as an example to estimate the basic electricity needs of households in remote rural areas of western China.

Table 5-8 Ownership of electrical appliances in Saierlong Township and Namcuo Township

Electrical appliances	Saierlong (n=81)		Namcuo (n=56)	
	Account	Percentage	Account	Percentage
TV	57	70.4%	51	91.1%
Mobile phone	45	55.6%	10	17.9%
Satellite receiver	41	50.6%	0	0.0%
VCD/DVD player	33	40.7%	12	21.4%
Radio	22	27.2%	16	28.6%
Ghee tea machine	0	0.0%	15	26.8%
Computer	3	3.7%	0	0.0%
Refrigerator	4	4.9%	0	0.0%
Noodle machine	2	2.5%	0	0.0%
Washing machine	1	1.2%	0	0.0%
Freezer	1	1.2%	0	0.0%

Note: n is sample size.
Source: Data processed by author based on author's field survey from October to December, 2007.

Table 5-9 Power consumption of electrical appliances in Saierlong Township and Namcuo Township

Electrical appliance	Power of electrical appliance (Watt)	
	Saierlong	**Namcuo**
Incandescent lamp	100 W, 200 W (mean = 107 W)	N/A
Compact fluorescent lamp	8 ~ 18 W (mean = 13.93 W)	7 ~ 20 W (mean = 14.78 W)
TV	40 ~ 60 W (mean = 52.46 W)	40 ~ 130 W (mean = 55.78 W)
Mobile phone	3 W	3 W
Satellite receiver	20 W, 25 W	N/A
VCD/DVD player	20 W, 25 W	20 W, 25 W
Radio	18 ~ 25 W	9 ~ 20 W
Ghee tea machine	N/A	230 W, 300 W
Computer	250 W	N/A
Refrigerator	500 ~ 1000 W	N/A
Noodle machine	550 W	N/A
Washing machine	400 W	N/A
Freezer	2200 W	N/A

Source: Data processed by author based on author's field survey from October to December, 2007.

Table 5-10 Average number of hours for lighting per household per day in Saierlong Township and Namcuo Township

Season	**Average number of hours for lighting (hours)**	
	Saierlong	**Namcuo**
Summer	3.01 (From 19:32 to 22:33)	4.52 (From 18:49 to 23:20)
Winter	3.96 (From 18:25 to 22:22)	4.63 (From 18:31 to 23:08)
Average	3.485	4.575

Source: Data processed by author based on author's field survey from October to December, 2007.

Table 5-11 Average number of hours for electrical appliances per household per day in Saierlong Township and Namcuo Township

Electrical appliance	**Average number of hours using electrical appliances (hours)**	
	Saierlong	**Namcuo**
TV	2.91	4.12
Mobile phone	2.58	2.00
Satellite receiver	2.85	N/A
VCD/DVD	1.21	1.83
Radio	1.27	1.69
Ghee tea machine	N/A	0.33

Source: Data processed by author based on author's field survey from October to December, 2007.

Based on the information provided concerning the subject of loads, power of loads, and the amount of time using loads, one can estimate the basic electricity need for households. From the information collected in the field, the basic electricity need for a household in remote rural areas of western China per day is 2 compact fluorescent lamps (15W) for 4 hours, 1 TV (60W) for 3 hours and 1 mobile phone (15W) for 3 hours (see Table 5-12). The basic electricity need totaled 309 Wh per household per day. These numbers do not include other additional electricity needs for other electrical appliances, such as radios, satellite receivers, or VCD/DVD players (see Table 5-13). If one calculates the additional electricity need for other electrical appliances per day at 150Wh (see Table 5-13), then the total electricity need per household per day would be 460 Wh. This number is quite close to the basic amount of electricity consumed in rural areas estimated by the IEA (2003),[174] but much higher than the minimum need for electricity suggested by the United Nations of 150 Wh per household per day (United Nations 2000: 6).

[174] Basic electricity consumption in rural areas was estimated in 2003 to be 50 kWh per person per year (IEA, 2003). This number is equal to approximately 137 Wh per person per day. If a household consists of 3-4 persons, the total electricity consumed is estimated at 411-548 Wh per household per day.

Table 5-12 Estimated basic electricity need per household per day

Electrical appliance	Number	Watt	Hour	Wh
Compact fluorescent lamp	2	15	4	120
TV	1	60	3	180
Mobile phone	1	3	3	9

Source: Compiled by author.

Table 5-13 Estimated additional electricity need per household per day

Electrical appliance	Number	Watt	Hour	Wh
Radio	1	25	1	25
VCD/DVD player	1	25	1	25
Satellite receiver	1	25	3	75
Other electrical appliance: e.g. Ghee tea machine	1	300	0.5	150

Source: Compiled by author.

2) Future electricity need for households

Besides the estimation of basic electricity needs, policy makers may also have to consider future electricity needs. People going from 'no-electricity' to 'have-electricity' usually start consuming electricity for their basic needs, such as lighting and TV, and then increase their consumption to meet other needs, such as the use of VCD/DVD players, satellite receivers, refrigerators, washing machines, etc. (IEA, 2003). Because electricity needs develop and change over time, a household must have stable and consistent access to electricity access. In the two investigated townships, after households' basic electricity needs are met, households tend to improve their living conditions with acquisition of more electrical appliances, like washing machines (300-500W), refrigerators (500-1000W), electric stoves (500W), Ghee tea machines (300W), electric rice cookers (300-700W), computers (250-300W), and noodle machine (550W). These electrical appliances normally require more electricity supply (see Table 5-14).

Hence, policy makers have to decide whether the amount of electric supply from solar PV power stations should also include the estimation of future loads, especially for high-power electrical appliances. If the application of these high-power electrical appliances should be included in electricity supply, policy makers need to decide how much minimum electricity supply should be provided for these high-power electrical appliances per household per day.

Table 5-14 Electrical appliances planned by the households to buy in two years in Saierlong Township and Namcuo Township

Name of Electrical appliance (total accounts mentioned by the households)	
Saierlong (n=81)	**Namcuo (n=56)**
■ Refrigerator (24) ■ Washing machine (23) ■ TV (18) ■ Electric stove (13) ■ VCD/DVD player (12) ■ Electrical generator (7) ■ Radio (3) ■ Satellite receiver (2) ■ Computer (2) ■ Electric rice cooker (1) ■ Mobile phone (1) ■ Noodle machine (1) ■ Stereo (1)	■ TV (14) ■ Ghee tea machine (10) ■ Refrigerator (10) ■ Mobile phone (4) ■ VCD/DVD player (2) ■ Electric rice cooker (1) ■ Solar home PV system (1) ■ Sheep clipper (1)

Note:
1. n is sample size.
2. Each household could list maximum three electrical appliances which they planed to buy in two years.
Source: Data processed by author based on author's field survey from October to December, 2007.

3) Increase of population and households

Beyond estimating electricity needs based on the current number of households, policy makers should also consider the increase in population and households, so that electricity supply is sufficient on a long-term basis. In the two investigated townships, the total population and number of households increased after the implementation of the Township Electrification Program. In Saierlong Township, the total number of the households increased from 300 in 2003 to 400 in 2007. In Namcuo Township, the total number of households increased from 50 in 2003 to 60 in 2007. In both places, township leaders explained that the increase of households was due to the supply of electricity available in both townships (Lee, personal comments 28 November 2007; Zhabagedan, personal comments 16 October 2007). Electricity supply has attracted households in the nearby non-electrified villages to migrate to the electrified townships.

4) Other electricity demand

Other than electricity demand for households, other purposes of electricity demand exist, such as those that are industrial, commercial, and agricultural in nature. According to an evaluation report, the World Bank noted that most connections in rural areas are for residential purpose instead of other purposes, such as industrial, commercial, and agricultural purpose (World Bank, 2008). Policy makers have to decide if electricity supply should include public and social facilities, such as schools, clinics, township governments, street lightings, etc.[175] Benefits and costs of the electricity supply for these purposes, as well as the amount of electricity supply for these purposes, should be estimated when planning policy. Normally, non-residential users demand more electricity than residential users. Policy makers should be aware that electricity supply for other purposes should not affect residential electricity needs.

The electricity supply for households in one of the investigated townships, Saierlong Township, was affected by electricity demand from the school.[176] The school had the priority to use the electricity generated from the solar PV station. In principle, the school had 24 hours of electricity supplied by the station. But households had only 3 hours supply of electricity, for around 4 days a week. As a result, the government's policy had an unintended result: the station did not function mainly for the households, but for the school. In this case, the objective of building the solar PV power stations to provide long-term and reliable electricity supply for rural households was highly affected by electricity demands for other purposes.

5.4 Evaluation of policy output: Electricity service

5.4.1 Policy output

Two indicators were used to evaluate the policy output, electricity service, in the two investigated townships.

1) Reliability of electricity service

[175] Policy makers need to consider the benefits and costs of the electricity supply for these purposes.
[176] In Namcuo Township, the electricity supply for the school was separated from the electricity supply for households. The school had its own solar PV power stations to provide electricity only for the school.

This indicator evaluates if the time of electricity supply is regular, stable, and predictable. First, this study evaluated if electricity was provided every day regularly since the solar PV power stations went into operation. Second, this study evaluated if the amount of time electricity supplied daily was stable since the solar PV power station began functioning. And third, this study evaluated if the time of daily electricity supply was predictable by the end-users. The data used for analysis was from two sources, interview data with operators of the solar PV power station and household survey.

a) The number of days electricity supplied per week

In Saierlong Township, the operator of the local solar PV power station explained that electricity was supplied every day since the operation of the solar PV power station (Ma, personal comments, 11 October 2007). But according to the results of the household survey, electricity was only supplied for 3.57 days per week (see Table 5-15). In Namcuo Township, the operator also expressed that electricity was supplied on a daily basis since the solar PV power station went into operation (Taqing, personal comments, 14 December 2007). But contradicting his statement were the results of the household survey, which showed that electricity was supplied for only 5.16 days per week (see Table 5-15).

Table 5-15 Number of days electricity supplied from the solar PV power stations per week in Saierlong Township and Namcuo Township

Data source		Days of electricity supply from the solar PV power station per week	
		Saierlong (n=56)	Namcuo (n=55)
Operator (in 2007)		7	7
Household survey (in 2007)	Summer (May to September)	2.93	5.47
	Winter (October to April)	4.02	5.16
	Average	3.57	5.29

Note: n is the number of the households which used electricity from the solar PV power station.
Source: Data processed by author based on author's field survey from October to December, 2007.

b) The number of hours electricity supplied daily

In Saierlong Township, the operator stated that the number of hours electricity supplied daily was 12 hours in the first two years' operation of the solar PV power station (in 2003 and 2004), but the number of hours electricity supplied daily was currently (in 2007) only 4 hours (see Table 5-16) (Ma, personal comments, 11 October 2007). As the household survey indicated, the number of hours electricity supplied daily was only 3 hours (see Table 5-16). In Namcuo Township, the operator expressed that the number of hours electricity supplied daily in the first two years' operation of the solar PV power station was 6 hours (in 2002 and 2003), and the number of hours electricity supplied daily was currently (in 2007) also 6 hours (see Table 5-16) (Taqing, personal comments, 14 December 2007). Yet as the household survey indicated, the number of hours electricity supplied daily was actually 6 hours 15 minutes (see Table 5-16).

Table 5-16 Number of hours electricity supplied from the solar PV power stations per day in Saierlong Township and Namcuo Township

Data source		**Hours of electricity supply from the solar PV power station per day (Hours)**	
		Saierlong (n=56)	**Namcuo (n=55)**
Operator (in 2003 and 2004)	Summer (May to September)	12 (12:00-24:00)	6 (18:00-24:00)
	Winter (October to April)	12 (12:00-24:00)	6 (18:00-24:00)
	Average	12	6
Operator (in 2007)	Summer (May to September)	4 (19:00-23:00)	6 (18:00-24:00)
	Winter (October to April)	4 (18:00-22:00)	6 (18:00-24:00)
	Average	4	6
Household survey (in 2007)	Summer (May to September)	2:58 (20:08-23:06)	6 (16:48-22:48)
	Winter (October to April)	3:02 (19:10-22:12)	6:26 (16:42-23:08)
	Average	3	6:15

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

c) The time of daily electricity supply

In Saierlong Township, households experienced a starting time of daily electricity supply around 1 hour later than the time expressed by operator (see Table 5-16). But the ending time of daily electricity supply from households' experience and operator's experience was more or less the same. In Namcuo Township, households experienced both the starting and ending time of daily electricity supply around 1 hour earlier than the time stated by the operator (see Table 5-16).

2) Households' evaluation of electricity service

In Saierlong Township, only 8.9% of the households were satisfied with electricity service provided by the solar PV power station (see Table 5-17). The unsatisfied rate (35.7%) was higher than the satisfaction rate. In Namcuo Township, 34.5% of the households were satisfied with electricity supply from the solar PV power station (see Table 5-17), and the unsatisfied rate (25.5%) was lower than satisfaction rate.

Table 5-17 Household's satisfaction of electricity service from the solar PV power stations in Saierlong Township and Namcuo Township

Satisfaction of electricity service	Saierlong (n=56)		Namcuo (n=55)	
	Account	Percent (%)	Account	Percent (%)
Satisfied	5	8.9	19	34.5
More or less	31	55.4	22	40.0
Unsatisfied	20	35.7	14	25.5

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

5.4.2 Evaluation

What was the situation concerning electricity service of the Township Electrification Program in the two selected townships?

1) Reliability of electricity service

Even though electricity service in Namcuo Township was more reliable than in Saierlong Township, electricity service in both townships was, in general, unreliable and did not meet the policy objective of the Township Electrification Program of providing long-term and reliable electricity service. First, electricity was not regularly supplied on a daily basis. In Saierlong Township, electricity was provided for only half of a week, and households were not informed on which days there was to be no electricity supply. Second, the amount of time of daily electricity supply in one of the investigated township, Saierlong Township, was not stable. The number of hours electricity supplied daily decreased dramatically from 12 hours to 3 hours a day in five years. And lastly, households in both townships were unable to predict the starting and ending times of daily electricity supply.

2) Households' evaluation of electricity service

Households' satisfaction of electricity service from the solar PV power stations in both townships was quite low (in average 21.7%). Three problems concerning electricity service were pointed out by the households in both investigated townships (see Table 5-18). First, the amount of time electricity supplied daily was too short. Second, the time of electricity supply was irregular and unpredictable. Third, often unnoticed disruptions in electricity supply occurred (see Table 5-19).[177] These three problems are also closely linked to the first indictor, reliability of electricity service.

Table 5-18 Problems of electricity service from the solar PV power stations in Saierlong Township and Namcuo Township

Problems (times which mentioned by the households)	
Saierlong (n=56)	**Namcuo (n=55)**
■ There were 'often' unnoticed disruptions in electricity supply (42) ■ The amount of time electricity supplied daily was too short (40) ■ Electricity supply was irregular and unpredictable (9) ■ 'Sometimes' there was no electricity supply at all (3) ■ Electricity was too expensive (1)	■ The amount of time electricity supplied daily was too short (37) ■ Electricity supply was irregular and unpredictable (26) ■ Electricity supply was not enough (2)

Note:
1. n is the number of the households which used electricity from the solar PV power stations.
2. Each household could list maximum three problems of electricity service from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

[177] Disruption of electricity supply was mainly caused by overloads to the system. In Saierlong Township, 92.2% of the households expressed that electricity supply from the solar PV power station was often disrupted (see Table 5-19)

Table 5-19 Frequency of disruption of electricity supply from the solar PV power stations in Saierlong Township and Namcuo Township

Disruption of electricity supply	Saierlong (n=56)		Namcuo (n=55)	
	Account	Percent (%)	Account	Percent (%)
Often disrupt	52	92.2	19	34.5
Few disrupt	4	7.1	36	65.5

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

5.4.3 Discussion: How can 'reliable' electricity service be achieved in remote rural areas?

It is important that electricity is provided daily regularly within a period of time so that users can predict the amount of electricity service available. However, limitations of solar PV power stations pose problems to the reliability of providing electricity service, especially in comparison to fossil fuel-based rural electrification programs. With a certain fixed capacity, it is often difficult for solar PV power stations to provide 24 hours, non-disrupted and fully sufficient electricity. Except for increasing system capacity, the amount of electricity generated from solar PV power stations generally is not capable of meeting unlimited electricity demand.

Besides limited capacity, the amount of electricity generated from solar PV power stations also depends on weather conditions. When weather conditions are poor, a system can not generate the same amount of electricity as when the weather conditions are good, and sunshine is abundant. If bad weather conditions continue for a few days, or even a few weeks, no matter how large the system capacity, the reliability of electricity service will be affected.

In addition to limited capacity and uncontrollable weather conditions, the poor management of solar PV power stations (discussed in chapter 4) also affects the reliability of electricity service, such as the management of the solar PV power stations in the two investigated townships.

Knowing the above limitations, there are some ways to improve the reliability of electricity service. First, a hybrid system, such as solar/diesel hybrid system, solar/wind/diesel hybrid system, or wind/diesel hybrid system, with one additional energy source that is not affected by uncontrollable weather conditions, can provide a potential solution. When no electricity supply from solar or wind power is available, the system can instead use diesel to continue supplying electricity. But one should be aware of the expensive cost of using diesel to generate electricity, and the difficulties of transporting diesel to remote rural areas where there are often bad road conditions.

Second, with limited system capacity, it is necessary to reinforce ‘load control’ to keep electricity service reliable. Policy makers, or local communities, have to decide the maximum electricity loads for each household and set the rule of using high-power loads. If electricity loads in a township are controlled and are able to be forecasted, operators can predict if electricity supply would be able to meet local needs or not. If not, then notices of electricity disruption can be announced to households or in townships in advance, allowing households to adjust and plan the use of alternative energy sources.

Last, the overall management of solar PV power stations in technical, financial, human resource, and institutional terms is critical to improving the reliability of electricity service (discussed in chapter 4).

5.5 Overall evaluation of policy outputs of the ‘Township Electrification Program’

The policy output of the Township Electrification Program was electricity and electricity service. First, electricity access from the solar PV power station was not connected to all households in the two investigated townships implementing the Township Electrification Program. Second, the Program did not achieve its quantitative policy objective of assuring an installed capacity of 100W per person. Third, current electricity supply was insufficient to meet households’ needs. Fourth, the Program did not achieve its qualitative objective by providing long term and reliable electricity service because electricity was not provided daily on a regular basis, the amount of time electricity supplied daily was unstable, and the time of daily electricity supply was not predictable. Fifth, the unreliability of electricity service resulted in low satisfaction of electricity service. The complaints of electricity service from the households all referred to the unreliability of electricity service.

6 Policy Evaluation II – Policy outcomes of the 'Township Electrification Program' in the Two Selected Townships: A Shift from Traditional Energy Sources to Renewable Energy Sources

6.1 Policy outcomes

Policy outcomes evaluate the actual change of behaviors or attitude that result from policy outputs (Anderson, 1975). Knowing the policy outputs of the Township Electrification Program, electricity supply and electricity service, however, provides little information concerning the effect of the Township Electrification Program on actual changes on households' energy use behavior from traditional energy sources (such as candles) to electricity from solar PV power stations.

Before the evaluation of policy outcomes, it is important to define who or what counts as a policy's target group. Usually, a target group is made up of people whom the policy intends to affect (Spicker, 2006). The identified target group for the Township Electrification Program was households in non-electrified townships in remote rural areas of western China. In order to evaluate the policy outcomes of the Program, this study looked at the households with access to electricity from the solar PV power stations, instead of those households that did not have access to electricity from the solar PV power stations.

In addition to identifying the target group, definition of expected behaviors or attitudes which a policy is designed to change is also necessary (Anderson, 1975). Besides the direct policy outcomes, one should also notice that a policy may have indirect or unexpected outcomes which change other behavior or attitudes of target groups.

6.1.1 Direct policy outcome: Changes in energy use patterns

The direct policy outcome of the Township Electrification Program is changes in households' energy use patterns from traditional energy sources (such as candles) to electricity from solar PV power stations. Three indicators are used in this study to evaluate the variable of changes in energy use patterns in the two investigated townships (see Table 6-1). The first indicator is percentage of households using electricity from solar PV power stations. This indicator examines if households with access to electricity from solar PV power stations indeed use electricity from solar PV power stations. The second indicator is percentage of households using traditional energy sources. This indicator examines if households which already had electricity from solar PV power stations still relied on traditional energy sources for lighting and electrical appliances after implementation of the Township Electrification Program. The third indicator used was changes in the amount of traditional energy sources before and after electrification. This indicator examines if the amount of traditional energy sources used for lighting and electrical appliances decreased after the implementation of the Program and to what extent the amount of traditional energy used for lighting and electrical appliances decreased after electrification.

Table 6-1 Indicators for evaluation of policy outcomes of the Township Electrification Program

Variable	Indicator
Changes in energy use patterns (Direct policy outcome)	■ Percentage of households using electricity from solar PV power stations ■ Percentage of households using traditional energy sources ■ Changes in the amount of traditional energy sources before and after electrification
Changes in working hours (Indirect policy outcome)	■ The average number of working hours per day for household members before and after electrification
Changes in leisure hours (Indirect policy outcome)	■ The average number of leisure hours per day for household members before and after electrification
Changes in bedtime (Indirect policy outcome)	■ The time going to bed before and after electrification
Changes in household hobbies (Indirect policy outcome)	■ The hobbies of household members before and after electrification

Source: Compiled by author.

Before evaluation, the meaning of traditional energy sources in the local context needs to be defined. Table 6-2 lists all energy sources used for lighting and electrical appliances in both investigated townships. Traditional energy sources refer to candles and dry cell batteries. The non-traditional energy sources refers to electricity, regardless if electricity is generated by solar PV power stations, solar home PV systems, small hydro power stations, or electrical generators powered by gasoline and diesel.

Table 6-2 Traditional energy sources and non-traditional energy sources for lighting and electrical appliances in Saierlong Township and Namcuo Township

Purpose for electricity		**Saierlong Township (n=81)**	**Namcuo Township (n=56)**
Lighting	Traditional energy	- Candle (100%) - Dry cell battery (77.8%)	- Candle (89.3%) - Dry cell battery (87.5%)
	Non-traditional energy (electricity)	- Township solar PV station (69.1%) - Small hydro power system (76.5%) - Solar home PV system (29.6%) - Electrical generator powered by gasoline (3.7 %) - Electrical generator powered by diesel (2.5 %)	- Township solar PV station (98.2%) - Solar home PV system (35.7%) - Electrical generator powered by gasoline (1.8%)
Electrical appliances	Traditional energy	- Dry cell battery (24.5%)	- Dry cell battery (2.0%)
	Non-traditional energy (electricity)	- Township solar PV station (64.2%) - Small hydro power system (71.6%) - Electrical generator powered by gasoline (3.7 %) - Electrical generator powered by diesel (2.5 %)	- Township solar PV station (91.1%) - Electrical generator powered by gasoline (1.8%)

Note:
1. n is sample size.
2. Also see Table 4-10 and Table 4-14.
Source: Data processed by author based on author’s field survey from October to December, 2007.

6.1.2 Indirect policy outcomes

Besides the direct policy outcome, this study also examines some indirect policy outcomes. There are many possible indirect policy outcomes which the Township Electrification Program can bring to rural households. However, it is not possible to evaluate all the indirect policy outcomes of rural electrification programs because the exactly indirect or unexpected policy outcomes which occurred at households are unknown. Policy makers may want to know some specific indirect policy outcomes which rural electrification programs might bring to rural households. As an exploratory study, based on the literature, four variables are chosen in this study to evaluate the indirect policy outcomes of the Township Electrification Program (see Table 6-1).[178]

a) Changes in working hours

Certain studies have found that rural electrification can result in the extension of working hours, for example some work could be carried out in the evening, increasing business hours of small enterprises or home business, allowing more working hours for income generating activities (World Bank, 2008; United Nations, 2000).[179] Use of this indicator helps to evaluate if the Township Electrification Program introduced changes of working hours in both investigated townships.

b) Changes in leisure hours

Some studies suggested that rural electrification can result in the reduction of time spent on household work, particularly for female household members, as well as more free time for entertainment and leisure, like watching TV, family interaction, or social interaction (World Bank, 2008; United Nations, 2000). According to a World Bank's study, analysts indicated that women spent one hour less on household tasks as a result of rural electrification in the Philippines (World Bank, 2008). In GTZ's evaluation report of its project "Renewable Energies in Rural Areas, China", researchers also discovered that rural electrification brings more free time to women (GTZ, 2008). Whereas an ESMAP study showed that electrification helped women in Central America save time in cooking (ESMAP, 2004). But some studies argued that women might not benefit as much as others in the family because electricity was usually not used for cooking and heating which was normally the responsibility for women (World Bank, 2008; Chung, 2004).[180] Hence, the indicator of changes in leisure hours helps to

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[178] In several GTZ's survey research (Hölzer and Huba, 2007; Zheng and Zange, 2006; Zange and Haberland, 2005a; Zange and Haberland, 2005b; Haskamp, 2004b), the indicators used for evaluating indirect policy outcomes of the solar PV power stations are: the change of working hours and the change of leisure hours. In one study of CAS (2006c), the indicators used for evaluating indirect policy outcomes of the Township Electrification Program are: the change of household hobbies, the change of the time going to bed, and the change of dinner time.

[179] For example, women have opportunities to add household income by doing some handcraft work at home in the evening (World Bank, 2008; United Nations, 2000).

[180] In reality, there is usually no sufficient electricity in rural areas for cooking and heating purposes. It is also thermodynamically inefficient and financially expensive to use electricity for cooking and heating.

evaluate if the Township Electrification Program induced adjustment in household member's leisure hours in both investigated townships.

c) Changes in bedtime

A 2008 World Bank study found that households in rural areas of ten developing countries had an additional one to two 'waking hours' in the evening after electrification (World Bank, 2008: 46). This study also used the indicator, changes in bedtime, to evaluate if the Township Electrification Program also brought about such changes in both investigated townships.

d) Changes in household hobbies

According to the same World Bank's study, the households spent the additional one to two waking hours in the evening mainly for watching TV (World Bank, 2008). In addition, other studies have found that after electrification watching TV became a popular hobby for rural households in remote rural areas of western China (Hölzer and Huba, 2007; Zheng and Zange, 2006). As a result, this study used the indicator, changes in household hobbies, to evaluate if the Township Electrification Program was successful in bringing about this sort of changes in both investigated townships.

6.2 Evaluation of direct policy outcome: Changes in energy use patterns

6.2.1 Direct policy outcome

Three indicators were used to evaluate the direct policy outcome of the Township Electrification Program, changes in households' energy use patterns from traditional energy sources to electricity from the solar PV power stations, in Saierlong Township and Namcuo Township.

1) Percentage of households using electricity from solar PV power stations

In both Saierlong Township and Namcuo Township, households with access to electricity from solar PV power stations all used electricity from the solar PV power stations for lighting (see Table 6-3). Around 93% of households in both townships used electricity from the solar PV power stations for electrical appliances (see Table 6-3). However, in Saierlong Township, four households did not have any electrical appliances, so they did not use electricity from the solar PV power station for electrical appliances. In Namcuo Township, three households did not have any electrical appliances, and one household had a radio powered by dry cell batteries. Basically, as long as households had electrical appliances, they used electricity from the solar PV power stations.

Table 6-3 Percentage of households using electricity from the solar PV power stations for lighting and electrical appliances after electrification in Saierlong Township and Namcuo Township

Township	Purpose	Energy source	% of households	
			Before electrification	After electrification
Saierlong Township (n=56)	Lighting	Electricity (solar)	0.0%	100.0%
	Electrical appliances	Electricity (solar)	0.0%	92.9%
Namcuo Township (n=55)	Lighting	Electricity (solar)	0.0%	100.0%
	Electrical appliances	Electricity (solar)	0.0%	92.7%

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author’s field survey from October to December, 2007.

2) Percentage of households using traditional energy sources

In Saierlong Township, all households with access to electricity from the solar PV power station used candles, and 76.8% of households used dry cell batteries for lighting before and after electrification (see Table 6-4). In Namcuo Township, 89.1% of households used candles, and 87.3% of households used dry cell batteries for lighting before and after electrification (see Table 6-4). Therefore, no change could be detected in the use of traditional energy sources for lighting in both townships, both before and after the implementation of the Township Electrification Program.

Instead, the use of traditional energy sources for electrical appliances, such as dry cell batteries, increased after electrification in both investigated townships (see Table 6-4). In Saierlong Township, 3.5% more households used dry cell batteries for electrical appliances after electrification. In Namcuo Township, 21.9% more households used dry cell batteries for electrical appliances after electrification.

Table 6-4 Percentage of households using traditional energy sources for lighting and electrical appliances before and after electrification in Saierlong Township and Namcuo Township

Township	Purpose	Energy source	% of households use candles or dry cell batteries for lighting and electrical appliances	
			Before electrification	**After electrification**
Saierlong Township (n=56)	Lighting	Candles	100.0%	100.0%
		Dry cell batteries	76.8%	76.8%
	Electrical appliances	Dry cell batteries	17.9%	21.4%
Namcuo Township (n=55)	Lighting	Candles	89.1%	89.1%
		Dry cell batteries	87.3%	87.3%
	Electrical appliances	Dry cell batteries	3.6%	25.5%

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

On average, in Saierlong Township, households with access to electricity from the solar PV power station continued to use candles for lighting for 1.02 hour per day and dry cell batteries for lighting and electrical appliance for 0.77 hour per day. Whereas after electrification in Namcuo Township, households with access to electricity from the solar PV power station continue to use candles for lighting for 1.09 hour per day and dry cell batteries for lighting and electrical appliance for 1.11 hour per day after electrification.

3) Changes in the amount of traditional energy sources before and after electrification

The average number of candles used for lighting in Saierlong Township decreased from 16.02 candles per month per household before electrification to 1.71 candles per month per households after electrification (see Table 6-5). In Namcuo Township, the average number of candles used for lighting also decreased from 31.82 candles per month per household before electrification to 8.73 candles per month per households after electrification (see Table 6-5). Based on results of paired sample t-tests of the average number of candles used for lighting per month per household with a 95% confidence interval, a significant reduction was detected in the number of candles used for lighting per month per household in both townships (see Table 6-6).

Table 6-5 Average number of candles and dry cell batteries used for lighting and electrical appliances per household per month before and after electrification in Saierlong Township and Namcuo Township

Township	Purpose	Energy source	The average number of candles and dry cell batteries used for lighting and electrical appliances per household per month	
			Before electrification	After electrification
Saierlong Township (n=56)	Lighting	Candles	16.02	1.71
	Lighting & electrical appliances	Dry cell batteries	1.79	1.71
Namcuo Township (n=55)	Lighting	Candles	31.82	8.73
	Lighting & electrical appliances	Dry cell batteries	4.35	2.51

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

Table 6-6 Paired sample t-tests of average number of candles and dry cell batteries used for lighting and electrical appliances per household per month before and after electrification in Saierlong Township and Namcuo Township

Township	Energy source	Paired differences				t-test	df	Significance (2-tailed)
		Mean	Standard deviation	95% Confidence interval of the difference				
				Lower	Upper			
Saierlong Township (n=56)	Candles	-14.304	11.657	-17.425	-11.182	-9.182	55	.000*
	Dry cell batteries	-0.071	0.535	-0.215	0.072	-1.000	55	.322
Namcuo Township (n=55)	Candles	-23.091	26.454	-30.242	-15.940	-6.474	54	.000*
	Dry cell batteries	-1.836	2.559	-2.528	-1.145	-5.323	54	.000*

Note:
1. n is the number of the households which used electricity from the solar PV power stations.
2. * indicates a significant reduction in the average number of candles and dry cell batteries used for lighting and electrical appliances per household per month after electrification (with a 95% confidence interval).
Source: Data processed by author based on author's field survey from October to December, 2007.

The average number of dry cell batteries used for lighting and electrical appliances in Saierlong Township only very slightly decreased from 1.79 batteries per month per household before electrification to 1.71 batteries per month per households after electrification (see Table 6-5). In comparison, in Namcuo Township the average number of dry cell batteries used for lighting and electrical appliances decreased from 4.35 batteries per month per household before electrification to 2.51 batteries per month per households after electrification (see Table 6-5). Based on the results of paired sample t-tests of the average number of dry cell batteries used for lighting and electrical appliances per month per household with a 95% confidence interval, no significant reduction in the number of dry cell batteries used for lighting and electrical appliances per month per household was detected in Saierlong Township, but a significant decrease in the number of dry cell batteries used for lighting and electrical appliances per month per household in Namcuo Township (see Table 6-6).

6.2.2 Evaluation

To what extent did the Township Electrification Program change household energy use patterns from traditional energy sources to electricity from solar PV power stations in the two investigated townships?

Households with access to electricity from the solar PV power stations did, indeed, use electricity from the solar PV power stations for lighting and electrical appliances in both investigated townships. However, in both places, households still relied on traditional energy sources, such as candles and dry cell batteries. Electricity from the solar PV power stations did not fully replace traditional energy sources for lighting and electrical appliances in both investigated townships. Yet in general, the use of the amount of traditional energy sources, such as candles and dry cell batteries, for lighting and electrical appliances significantly decreased after electrification.

6.2.3 Discussion: Why electricity from solar PV power stations did not replace traditional energy sources in the two selected townships?

As discussed in chapter 5, electricity supplied by the solar PV power stations in both townships was insufficient to meet households' needs in both investigated townships. Additionally, the electricity service was unreliable, i.e. electricity was not provided regularly on a daily basis; the time of electricity supply is not predictable. As explained, when no electricity was supplied, households needed to use alternative energy sources, such as candles and dry cell batteries, for lighting and electrical appliances. Yet when a sufficient and reliable supply of electricity is available, households will be willing and motivated to use electricity from the solar PV power stations instead of other alternative energy sources.

Rural households rarely used only one type of energy source exclusively. Moreover, rural households, as other rational consumers, will seek to maximize their economic welfare by using a mix of available traditional and modern energy sources (Barnes and Floor, 1996). Thus, the price of the availability of electricity from the solar PV power stations should be affordable for households, and competitive with the price of other traditional energy sources. Otherwise, households will continue using traditional energy sources.

6.3 Evaluation of indirect policy outcomes

6.3.1 Indirect policy outcomes

Four variables were used to evaluate the indirect policy outcomes of the Township Electrification Program in the two selected townships.

1) Changes in working hours

In Saierlong Township, the average number of working hours per day equaled 7.30 hours before electrification, and 7.33 hours after electrification (see Table 6-7).[181] In Namcuo Township, the average number of working hours per day equaled 7.05 hours before electrification, and 7.69 hours after electrification (see Table 6-7).[182] Based on the results of paired sample t-tests of household members' average number of working

[181] In Saierlong Township, the average number of working hours per day for 'male' was 7.9 hours before electrification, and 7.94 hours after electrification. The average number of working hours per day for 'female' was 6.69 hours before electrification, and 6.72 hours after electrification. The average number of working hours per day in 'summer' was 7.82 hours, and in 'winter' were 6.81 hours.

[182] In Namcuo Township, the average number of working hours per day for 'male' was 6.91 hours before electrification, and 7.27 hours after electrification. The average number of working hours per day for 'female' was 7.18 hours before electrification, and 8.12 hours after electrification. The average number of working hours per day in 'summer' was 7.85 hours, and in 'winter' was 6.89 hours.

hours per day before and after electrification with a 95% confidence interval, no significant changes were detected in both townships, regardless if members were male or female (see Table 6-7 and Table 6-8).

Table 6-7 Average number of working hours per day before and after electrification in Saierlong Township and Namcuo Township

Township	Gender	Average number of working hours per day in summer		Average number of working hours per day in winter	
		Before electrification	After electrification	Before electrification	After electrification
Saierlong Township (n=56)	Male	8.47	8.43	7.36	7.45
	Female	7.14	7.24	6.24	6.20
Namcuo Township (n=55)	Male	7.49	7.78	6.33	6.76
	Female	7.48	8.63	6.88	7.60

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

Table 6-8 Paired sample t-tests of average number of working hours per day before and after electrification in Saierlong Township and Namcuo Township

Township	Working hours	Paired differences				t-test	df	Significance (2-tailed)
		Mean	Standard deviation	95% Confidence interval of the difference				
				Lower	Upper			
Saierlong Township (n=56)	Male/ summer	-.038	1.192	-.366	.291	-.230	52	.819
	Male/ winter	.094	.450	-.030	.218	1.526	52	.133
	Female/ summer	.102	.586	-.066	.270	1.219	48	.229
	Female/ winter	-.041	.538	-.195	.114	-.531	48	.598
Namcuo Township (n=55)	Male/ summer	.289	1.961	-.300	.878	.988	44	.329
	Male/ winter	.422	1.644	-.072	.916	1.722	44	.092
	Female/ summer	1.150	3.009	.188	2.112	2.417	39	.020
	Female/ winter	.725	2.660	-.126	1.576	1.724	39	.093

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

2) Changes in leisure hours

In Saierlong Township, the average number of leisure hours per day equaled 4.25 hours before electrification, and 4.56 hours after electrification (see Table 6-9).[183] In Namcuo Township, the average number of leisure hours per day equaled 4.20 hours before electrification, and 4.20 hours after electrification (see Table 6-9).[184] From the results of paired sample t-tests of the household members' average number of leisure hours per day before and after electrification with a 95% confidence interval, no significant changes were detected in both townships, regardless if household members were male or female (see Table 6-9 and Table 6-10).

Table 6-9 Average number of leisure hours per day before and after electrification in Saierlong Township and Namcuo Township

Township	**Gender**	**Average number of leisure hours per day in summer**		**Average number of leisure hours per day in winter**	
		Before electrification	**After electrification**	**Before electrification**	**After electrification**
Saierlong Township (n=56)	Male	3.83	3.91	3.83	4.85
	Female	4.33	4.44	5.00	5.04
Namcuo Township (n=55)	Male	3.96	4.27	5.18	5.11
	Female	3.03	2.95	4.63	4.48

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

[183] In Saierlong Township, the average number of leisure hours per day for 'male' was 3.83 hours before electrification, and 4.38 hours after electrification. The average number of leisure hours per day for 'female' was 4.67 hours before electrification, and 4.74 hours after electrification. The average number of leisure hours per day in 'summer' was 4.13 hours, and in 'winter' were 4.77 hours.

[184] In Namcuo Township, the average number of leisure hours per day for 'male' was 4.57 hours before electrification, and 4.38 hours after electrification. The average number of leisure hours per day for 'female' was 3.83 hours before electrification, and 3.72 hours after electrification. The average number of leisure hours per day in 'summer' was 3.55 hours, and in 'winter' was 4.85 hours.

Table 6-10 Paired sample t-tests of average number of leisure hours per day before and after electrification in Saierlong Township and Namcuo Township

Township	**Leisure hours**	**Paired differences**				**t-test**	**df**	**Significance (2-tailed)**
		Mean	Standard deviation	95% Confidence interval of the difference				
				Lower	Upper			
Saierlong Township (n=56)	Male/ summer	.074	.988	-.196	.344	.551	53	.584
	Male/ winter	1.019	1.732	.546	1.491	4.321	53	.000*
	Female/ summer	.104	1.057	-.203	.411	.683	47	.498
	Female/ winter	.042	.617	-.138	.221	.468	47	.642
Namcuo Township (n=55)	Male/ summer	.311	2.720	-.506	1.128	.767	44	.447
	Male/ winter	-.067	2.903	-.939	.805	-.154	44	.878
	Female/ summer	-.075	2.325	-.818	.668	-.204	39	.839
	Female/ winter	-.150	2.315	-.891	.591	-.410	39	.684

Note:
1. n is the number of the households which used electricity from the solar PV power stations.
2. * indicates a significant change in male household members' average number of leisure hours per day before and after electrification (with a 95% confidence interval). But if one aggregates the average number of leisure hours per day in summer and in winter before and after electrification, the results did not show any significant change in male household members' average number of leisure hours per day before and after electrification (with a 95% confidence interval).
Source: Data processed by author based on author's field survey from October to December, 2007.

3) Changes in bedtime

In Saierlong Township, the average bedtime was 22:09 before electrification, and 22:41 after electrification (see Table 6-11). On average, people went to bed 32 minutes later after electrification. In Namcuo Township, the average bedtime was 21:14 before electrification, and 22:52 after electrification (see Table 6-11). On average, people went to bed 1 hour and 28 minutes later after electrification.

Table 6-11 Average bedtime before and after electrification in Saierlong Township and Namcuo Township

Normally, when do your household members go to bed?	Before electrification	After electrification
Saierlong Township (n=56)	22:09	22:41
Namcuo Township (n=55)	21:14	22:52

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

4) Changes in household hobbies

In Saierlong Township, before electrification, main hobbies of households included: chatting, visiting neighbors, chanting, watching TV, and reading (see Table 6-12). After electrification, households' main hobbies included: watching TV, chatting, reading, chanting, and playing cards (see Table 6-12). As Table 6-12 shows, a dramatic increase occurred in the hobby of 'watching TV' and a slight increase occurred in the hobby of 'reading'. In Namcuo Township, households' main hobby was chatting (see Table 6-12). After electrification, main hobbies included watching TV and chatting (see Table 6-12). A dramatic increase was recorded in the hobby of 'watching TV'.

Table 6-12 Changes in household hobbies before and after electrification in Saierlong Township and Namcuo Township

What do your household members do when they have free time?	Before electrification	After electrification
Saierlong Township (n=56)	■ **Chat** (26) ■ **Visit neighbors** (17) ■ **Chanting** (13) ■ **Watch TV** (8) ■ **Reading** (8) ■ Play cards (7) ■ Listen to radio (2) ■ Go for a walk (1) ■ Sport (1) ■ Play chess (1) ■ Listen to music (1) ■ Weave sweater (1)	■ **Watch TV** (38) ■ **Chat** (18) ■ **Reading** (12) ■ **Chanting** (11) ■ **Play cards** (9) ■ Visit neighbors (7) ■ Listen to radio (4) ■ Go for a walk (1) ■ Sport (3) ■ Play chess (2) ■ Listen to music (1) ■ Weave sweater (1) ■ Use computer (1)
Namcuo Township (n=55)	■ **Chat** (55)	■ **Watch TV** (46) ■ **Chat** (38) ■ Read newspaper (1)

Note:
1. n is the number of the households which used electricity from the solar PV power stations.
2. The question was an open-ended question. Each household could list maximum three answers for this question.
Source: Data processed by author based on author's field survey from October to December, 2007.

6.3.2 Evaluation

What indirect policy outcomes did the Township Electrification Program produce for households in the two investigated townships?

As the above data shows, basically no significant changes occurred in the number of working and leisure hours in both investigated townships before and after electrification. Yet these results contradict the findings of a number of other studies investigating the effects of electrification programs in remote rural areas of developing countries (World Bank, 2008; ESMAP, 2004; United Nations, 2000).

In the case of the Township Electrification Program, households had an additional half to one and a half 'waking hours' in the evening after electrification. This finding is similar to the previously mentioned World Bank study, which found that electrification brought people an additional one to two ‘waking hours’ in the evening (World Bank, 2008). In general, additional hours in the evening were used for different purposes, such as household tasks, watching TV, chatting, income generating tasks, etc.

Electrification also changed the hobbies of the households from chatting and visiting neighbors to watching TV and reading (better lighting). These results also support the argument made in several studies that rural electricity is mainly used by rural households for TV, besides lighting (Barnes and Floor, 1996; World Bank, 2000a; Mapako and Mbewe, 2004; United Nations, 2000).

6.4 Overall evaluation of policy outcomes of ‘Township Electrification Program’

The direct policy outcome of the Township Electrification Program was changes in households’ energy use patterns from traditional energy sources to electricity from solar PV power stations. Findings of the study show that changes did, indeed, occur in households’ energy use patterns from traditional energy sources to electricity from solar PV power stations in the two investigated townships after the implementation of the Township Electrification Program. But even with these changes, traditional energy sources were not totally replaced by electricity. Generally, households must continue to rely on traditional energy sources, such as candles and dry cell batteries, but the amount of traditional energy sources used for lighting and electrical appliances has significantly decreased after electrification.

The indirect policy outcomes of the Township Electrification Program which this study selected for evaluation were changes in working hours, changes in leisure hours, changes in bedtime, and changes in household hobbies. Upon evaluation, the study discovered no significant changes in working hours and leisure hours in either of the investigated townships before and after electrification. But there were significant changes in bedtime and household hobbies in both investigated townships before and after electrification. People went to bed around half an hour to one and a half hour latter after electrification. After electrification, ‘watching TV’ became the main hobby for the households, and people changed their hobbies from chatting and visiting neighbors to watching TV and reading.

7 Policy Evaluation III - Policy Impacts of the 'Township Electrification Program' in the Two Selected Townships: Socio-economic Benefits for Households, Township Development, and Environmental Impact

7.1 Policy impacts

Policy impacts are the long-term changes of real-life conditions resulting from a policy action (Nakamura and Smallwood, 1980; Anderson, 1975). Policy impacts are usually more difficult and complex to measure than policy outputs and policy outcomes because most policy impacts are often subjective and difficult to measure objectively. But policy impacts offer important information to examine if a policy achieves its policy goals.

Various scholars have argued that renewable energy-based rural electrification programs help to improve the quality of life for rural people, such as through improvement in providing benefits to health, education, income generation, security, entertainment, access to information, and so on (Ross, 1972; Kessler et al., 1981; Goddard et al., 1981; Munasinghe, 1987; United Nations, 2000; World Bank, 2000a; ESMAP, 2002; Mapako and Mbewe, 2004; Cook et al., 2005; World Bank, 2008). For example, Saunier (1992) provides a list of more than 50 discrete benefits of rural electrification. But in contrast, some studies argue that the social and economic benefits of rural electrification tend to be over-estimated, and that the costs are often underestimated (Fluitman, 1983; Pearce and Webb, 1987). Therefore, it is unclear exactly what sort of benefits renewable energy-based rural electrification programs produce for rural people (Foley, 1992). This is due to the fact that the existing evaluation methods and results are vague (World Bank, 2008; Chung, 2004; Barnes, 1988; Foley, 1990; Schramm, 1993). It is especially challenging to carry out evaluation studies because the households are located in the remote areas where surveys rarely reach and basic statistical data are often not available. Besides, there is also time lag between the implementation of renewable energy-based rural electrification programs and the occurrence of impacts (Chung, 2004).

The long-term policy goal of the Township Electrification Program was improvement of people's living conditions and reduction of poverty in remote rural areas of western China. According to the Chinese government, the Program improved rural people's standard of living, social and economic development, poverty, and rural people's welfare (NDRC, 2005b). Additionally, Ma also claimed that the Program has "significantly improved living conditions of the local people and provided better opportunities for the social and economic development, although renewable energy power may only satisfy a limited range of household needs such as lighting, communication, and small-scale machinery and equipments" (Ma, 2004: 12).[185]

In this study, three variables were used to identify the impacts of the Township Electrification Program in remote rural areas of western China: the improvement of socio-economic benefits for households, the improvement of township development, and environmental impact. The reason to separate the unit of analysis into two levels, household level and township level, was due to how some renewable energy-based rural electrification programs which focus on providing electricity to 'households,' do not necessarily produce benefits for township development, either direct or indirect. In contrast, some renewable energy-based rural electrification programs which focus on township development by improving health services, education services, public services, employment, and economic conditions do not necessary produce direct or indirect benefits for the households.

Measurement of policy impacts is often a difficult and complicated task, because impacts are often intangible, and their identification subjected to one's own feeling. In their book, Singleton and Straits note that "no measure is perfect, but an imperfect measure is better than none at all" (Singleton and Straits, 2005: 105). This study used an end-user's survey to evaluate the policy impacts of the Township Electrification Program. This questionnaire focused on evaluating end-users' perception of improvement in socio-economic benefits and township development.

7.1.1 Improvement of socio-economic benefits for households

The variable 'improvement of socio-economic benefits for households' was used to evaluate whether and to what extent the Township Electrification Program improved

[185] Ma made this claim in his presentation at the International Conference for Renewable Energies in Bonn on 1-4 June, 2004. Retrieved 27 January, 2007 from http://www.renewables2004.de/en/documentation/speeches_presentations.asp.

households' socio-economic benefits in remote rural areas of Western China. Cook et al. (2005) suggest that research on the impacts of rural electrification programs should not only address 'economic benefits', but also benefits of a non-economic nature, such as 'social benefits'. Therefore, in following with previous research, the potential benefits of renewable energy-based rural electrification programs at the household level are summarized in Table 7-1 (United Nations, 2000; Cook et al., 2005; World Bank, 2000a; ESMAP, 2002; Wallace et al., 2006; World Bank, 2008; GTZ, 2008).

Table 7-1 Socio-economic benefits of renewable energy-based rural electrification at the household level

Source	**Aspects**
Socio-economic benefits of renewable energy systems at the household level (United Nations, 2000: 14-15)	- Ease the burden on women - Women have more opportunities to add household incomes at home - Children become more productive and better prepared for their schoolwork - Access to news and information - More time for entertainment and leisure
Socio-economic impacts of rural electrification at the household level in China, India, and Thailand (Cook et al., 2005: 183-189)	- Reduce energy costs - Generate income - Increase flow of information - Increase personal security
Perceived benefits of electricity at the household level at remote rural areas of Northwestern China (World Bank, 2000a: xiii-xiv, 63)	- Better lighting - Access to news and information - More entertainment - Enable family members, particularly children, to read, write, and study in the evening longer than before
The benefits of rural electrification at the household level in India (ESMAP, 2002)	- Contribution to children education - Contribution to family safety and security - Contribution to family entertainment - Contribution to income generation - Access to news - Improve the performance of household tasks
The benefit of rural electrification at the household level in rural areas, China (Wallace et al., 2006)	- Access to news and information - More entertainment - Increase social interaction and communication - Increase household income

The benefit of rural electrification at the household level in Bangladesh, Ghana, Indonesia, Morocco, Nepal, Nicaragua, Peru, the Philippines, and Senegal (World Bank, 2008)	- Health benefit - Education benefit - Reduce time for household work - Shift household work to the evening - Extend some hours for home business
The benefit of rural electrification at the household level in rural areas, China (GTZ, 2008)	- Improve working conditions for women - Improve learning conditions for children - Improve health conditions - Contribution to income generation

Source: Compiled by author based on United Nations, 2000; Cook et al., 2005; World Bank, 2000a; ESMAP, 2002; Wallace et al., 2006; World Bank, 2008; GTZ, 2008.

Based on previous studies of rural electrification projects in developing countries and the pilot study carried out in the two selected townships[186], multiple indicators are used in this study to measure socio-economic benefits of the Township Electrification Program for the households in remote rural areas of western China. The indicators in question are listed in Table 7-2.

Table 7-2 Indicators for evaluation of socio-economic benefits of the Township Electrification Program for households

Socio-economic benefits	Indicators
Social benefits	■ Improve learning conditions for children ■ Increase access to news and information ■ Increase entertainment ■ Increase flexibility of time for domestic tasks ■ Increase flexibility of time for income generating tasks ■ Increase efficiency for domestic tasks ■ Increase efficiency for income generating tasks ■ Save time for domestic tasks ■ Save time for income generating tasks ■ Increase family interaction ■ Increase social interaction ■ Increase personal security ■ Improve health and hygiene condition ■ Increase working hours for domestic tasks ■ Increase working hours for income generating tasks
Economic benefits	■ Increase household income ■ Increase household income sources ■ Decrease energy expenses

Source: Compiled by author.

[186] The pilot study was carried out in the two selected townships from 8 October 2007 to 20 October 2007 (see Section 1.4.2: research approach).

7.1.2 Improvement of township development

The variable of 'improvement of township development' was used to evaluate whether, and to what extent the Township Electrification Program has improved township development, such as health services, education services, public services, employment, and economic condition, in remote rural areas of western China. Based on the finding of earlier studies, the potential benefits of renewable energy-based rural electrification programs at village/community level are summarized in Table 7-3 (United Nations, 2000; Mapako and Mbewe, 2004; Cook et al., 2005; Wallace et al., 2006; World Bank, 2008; GTZ, 2008; Liu, 2005; Zhang, 2005).

Table 7-3 Impacts of renewable energy-based rural electrification on village/community

The benefit of rural electrification at the village level (United Nations, 2000: 14-15)	- Improve school facilities - Improve clinic facilities - Improve community public facilities
The benefit of rural electrification at the village level in Sub-Saharan Africa (Mapako and Mbewe, 2004)	- Improve agriculture productivity - Enhance and encourage small and micro rural businesses - Enhance income generation activities
The benefit of rural electrification at the village level in China, India, and Thailand (Cook et al., 2005: 183-189)	- Increase farm productivity - Promote the development of non-farm activities - Improve quality of education services - Improve quality of health services - Decrease pressure on woodlands - Increase community security - Promote more social participation in management of community recourses
The benefit of rural electrification at the village level in rural areas, China (Wallace et al., 2006)	- Improve education services - Improve health services - Enhance small rural business
The benefit of rural electrification at the community level in Bangladesh, Ghana, Indonesia, Morocco, Nepal, Nicaragua, Peru, the Philippines, and Senegal (World Bank, 2008)	- Health benefit - Education benefit - Extending hours for home business

The benefit of rural electrification at the township/village level in rural areas, China (GTZ, 2008)	- Create more jobs - Health benefit
Social and economic benefits of rural electrification in rural areas, China (Liu, 2005; Zhang, 2005)	- Contribution to local employment and income generation - Ecological and environmental protection - Promotion of industrialization and urbanization - Enhancement of agriculture production - Improvement in rural welfare, such as education, healthcare, culture, and information dissemination

Source: Compiled by author based on United Nations, 2000; Mapako and Mbewe, 2004; Cook et al., 2005; Wallace et al., 2006; World Bank, 2008; GTZ, 2008; Liu, 2005; Zhang, 2005.

As stated above, multiple indicators used in this study to measure the impacts of the Township Electrification Program for township development in remote rural areas of western China were drawn from previous studies conducted in other developing countries and the pilot study carried out in the two selected townships. The indicators in question are listed in Table 7-4 below.

Table 7-4 Indicators for evaluation of the impact of the Township Electrification Program for township development

Township development	Indicators
Social aspect	■ Improve educational services ■ Improve health services ■ Improve veterinary services ■ Improve government services
Economic aspect	■ Increase employment or job opportunities ■ Increase small and micro rural businesses

Source: Compiled by author.

7.1.3 Environmental impact

The variable of 'environmental impact' was used to evaluate whether, and to what extend the Township Electrification Program has impacts on environment. Studies investigating issues similar to those researched by this study often argue that renewable energy-based rural electrification programs have less negative environmental impacts, compared to fossil fuel-based rural electrification programs (World Bank, 2008; CAS, 2007b). However, this argument assumes that electricity is generated only from fossil fuel, and substitution of fossil fuel with renewable energy can reduce negative environmental impacts produced by reliance on fossil fuel, such as pollution, acid rain, or global warming, due to fewer emissions of CO_2, SO_2, and NO_x. The evaluation of environmental impacts of rural electrification programs is based on the calculation of the amount of emissions which could be reduced by using renewable energies.[187] However, these calculations do not indicate the 'actual' environmental impacts which are produced by renewable energy-based rural electrification programs. Instead, the actual environmental impacts of renewable energy-based rural electrification programs are to evaluate the 'real effects of the programs on the environment after the implementation of programs'.

As discussed in Chapter 6, traditional energy sources, such as candles and batteries, were not substituted by electricity provided by the solar PV power stations. The only change produced by the Township Electrification Program which affected households was a reduction in the number of candles and batteries used for lighting and electrical appliances. The use of candles has risks for human health, but does not have any impacts on environment.[188] But the use of dry cell batteries may have an impact on the environment, in particular, an impact related to the disposal of used dry cell batteries.[189] If used dry cell batteries are disposed by throwing them on the grassland instead of recycling them through a controlled disposal procedure, the toxic attributes of dry cell batteries can have negative environmental impacts.

The indicator used in this study to evaluate the environmental impact of the Township Electrification Program was the disposal of used dry cell batteries. This indictor evaluates how households dispose of used dry cell batteries, and to what extent the Township Electrification Program had an affect on the disposal of used dry cell batteries, and how this effect affected the environment after the implementation of the Program.

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[187] There is no standard method for calculation of emissions, and existing methods for calculation of emissions are limited to provide a complete evaluation of environmental impacts (CAS, 2007b).

[188] The health risks from candles were found recently by an Australian study in 1999 (World Bank, 2008). The lead used in candle wicks results in air lead concentrations at levels which are far beyond the established safety standards and could harm human health if one burns a candle for a few hours in an enclosed room (World Bank, 2008). Although many developed countries have banned the use of lead in wicks, but in many developing countries the use of lead in wicks still exists.

[189] In GTZ's evaluation report of its project 'Renewable Energies in Rural Areas', the direct environmental impacts of rural electrification programs were designed to evaluate the consumption and expenditure of dry cell batteries (GTZ, 2008).

7.2 Evaluation of policy impact: Improvement of socio-economic benefits for households

7.2.1 Policy impact

In Saierlong Township, 76.8% of households felt that the improvement of socio-economic benefits at the household level after the implementation of the Township Electrification Program was ‘slightly improved’ (see Table 7-5). Out of eighteen indictors used to evaluate the improvement of socio-economic benefits, the five most improved socio-economic benefits at the household level were: increased entertainment (64.3%), increased family interaction (57.1%), increased access to news and information (55.4%), increased flexibility of time for domestic tasks (55.4%), and increased personal security (48.2%) (see Table 7-6). The five least improved socio-economic benefits at the household level were: increased household income sources (14.3%), decreased energy expense (16.1%), increased efficiency for income generating tasks (19.6%), increased household income (21.4%), and increased working hours for income generating tasks (21.4%) (see Table 7-6).

In Namcuo Township, 81.8% of households felt that the improvement of socio-economic benefits at the household level after the implementation of the Township Electrification Program was ‘slightly improved’ (see Table 7-5); while the remaining of households (18.2%) indicated that the Program produced a significant improvement in socio-economic benefits at the household level (see Table 7-5). Out of eighteen indictors used for evaluating the improvement of socio-economic benefits, the five most improved socio-economic benefits at the household level were: increased entertainment (89.1%), increased access to news and information (89.1%), improved efficiency for domestic tasks (72.7%), increased personal security (72.7%), and increased flexibility of time for domestic tasks (60.0%) (see Table 7-6). The five least improved socio-economic benefits at the household level were: increased household income sources (18.2 %), increased working hours for income generating tasks (18.2%), saved time for income generating tasks (20.0%), increased flexibility of time for income generating tasks (21.8%), and increased household income (23.6%) (see Table 7-6).

Table 7-5 Improvement of socio-economic benefits for households after implementation of the Township Electrification Program in Saierlong Township and Namcuo Township

Improvement of socio-economic benefits at the household level	Saierlong Township (n=56)	Namcuo Township (n=55)
	% of households	% of households
No improvement at all	14.3	0.0
Slightly improved	76.8	81.8
Significantly improved	8.9	18.2

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

Table 7-6 Households' evaluation of socio-economic benefits of the Township Electrification Program at the household level in Saierlong Township and Namcuo Township

Socio-economic benefits at the household level	Saierlong Township (n=56)		Namcuo Township (n=55)	
	Improved (%)	Not improved (%)	Improved (%)	Not improved (%)
Improve learning conditions for children	42.9	57.1	27.3	72.7
Increase access to news and information	**55.4**	44.6	**89.1**	10.9
Increase entertainment	**64.3**	35.7	**89.1**	10.9
Increase flexibility of time for domestic tasks	**55.4**	44.6	**60.0**	40.0
Increase flexibility of time for income generating tasks	23.2	76.8	21.8	**78.2**
Increase efficiency for domestic tasks	41.1	58.9	**72.7**	27.3
Increase efficiency for income generating tasks	19.6	**80.4**	12.7	87.3
Save time for domestic tasks	32.1	67.9	40.0	60.0
Save time for income generating tasks	30.4	69.6	20.0	**80.0**
Increase family interaction	**57.1**	42.9	54.5	45.5
Increase social interaction	46.4	53.6	58.2	41.8
Increase personal security	**48.2**	51.8	**72.7**	27.3
Improve health and hygiene condition	32.1	67.9	45.5	54.5
Increase working hours for domestic tasks	37.5	62.5	43.6	56.4
Increase working hours for income generating tasks	21.4	**78.6**	18.2	**81.8**
Increase household income	21.4	**78.6**	23.6	**76.4**
Increase household income sources	14.3	**85.7**	18.2	**81.8**
Decrease energy expenses	16.1	**83.9**	43.6	56.4

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

7.2.2 Evaluation

To what extent did the Township Electrification Program influence the improvement of social-economic benefits for the households in the two investigated townships?

According to the findings based on household evaluations of the Township Electrification Program, the Program had only a 'slight' impact on the improvement of socio-economic benefits at the household level. Improvements in socio-economic benefits at the household level were more significant in Namcuo Township than they were in Saierlong Township. Out of 111 households surveyed, in response to an open-ended question on socio-economic benefits produced by electrification, twenty-six households expressed that life has become easier, happier, more colorful, more convenient, more comfortable, and safer due to electrification;[190] thirteen households expressed that they had better living condition due to electrification;[191] and fifty-one households expressed that they had better lighting, no longer had to use candles for lighting, could watch TV, could use mobile phones, could use electrical appliances, and that children had better conditions for learning.[192] But ten households responding to this open-ended question indicated that socio-economic benefits could be better improved if the solar PV power stations could provide sufficient electricity.[193] Whereas another ten households complained that there was no significant change in their living condition at all, because the solar PV power station seldom provided electricity.[194]

The impacts of the Township Electrification Program at the household level in the two investigated townships were mainly 'social' in nature. The five most important impacts were an increase in entertainment (average 76.7%), access to news and information (average 72.25%), personal security (average 60.45%), flexibility of time for domestic tasks (average 57.7%), and efficiency for domestic tasks (average 56.9%). Some social benefits, which were found in other studies, such as the children's learning condition, health and hygiene condition, time saving for domestic and income generating tasks, and more time for domestic and income generating tasking, were not found significantly

190 See question 4.1 in the questionnaire in Appendix A. See the list of households which answered this open-ended question in Appendix B.
191 Ibid.
192 Ibid.
193 Ibid.
194 Ibid.

in the two investigated townships. Compared to the social improvement, the impact of the Program at the household level on 'economic' conditions, especially related to household income generation, were very limited.[195]

1) Increase entertainment

Increases in entertainment was estimated by households in both investigated townships as the most improved benefit after implementation of the Township Electrification Program. Out of 111 households surveyed, fourteen households indicated they could have more entertainment by watching TV, VCD, and DVD (see Photograph 7-1),[196] and four households stated that "watching TV made their life colorful".[197] As discussed in Chapter 6, after electrification, 'watching TV' became the most popular hobby in both investigated townships.

Photograph 7-1 TVs /satellite receivers/ VCD players/ DVD players at households in Saierlong Township and Namcuo Township


Source: Photographs taken by author in the field from October to December, 2007.

2) Increase access to news and information

[195] The only economic benefit which was evaluated as more positive was the decrease of energy expense for the households in Namcuo Township (see Table 7-6). Households in Namcuo expressed that the price of electricity was much less than the price of candles. Therefore, households could save more money by using electricity rather than candles and dry cell batteries as energy sources for lighting and electrical appliances. The decrease of energy expense was due to the electricity fee collection scheme in Namcuo Township being based on a lump-sum cost, instead of the amount of electricity consumed. The decrease of energy expense, however, was not found to be significantly improved in Saierlong Township (see Table 7-6).

[196] See question 4.4 in the questionnaire in Appendix A. See the list of households which answered this open-ended question in Appendix B.

[197] Ibid.

Out of 111 households surveyed, eighteen households expressed that after electrification, they could get more information and news by watching TV (see Photograph 7-1).[198] For example, one household in Namcuo Township even stated that 'they got to understand the world by watching TV",[199] while one household in Saierlong Township commented that "besides watching TV, they [household members] got more information via using mobile phone".[200]

3) Increase personal security

After electrification, better lighting by using electricity from the solar PV power stations helped to increase personal security at the households. Out of 111 households surveyed, nineteen households said they had better lighting by using electricity from the solar PV power stations and made them feel safer than by using 'candles' (see Photograph 7-2).[201]

Photograph 7-2 Lighting situation at households in Saierlong Township and Namcuo Township

Source: Photographs taken by author in the field from October to December, 2007.

4) Increase flexibility of time for domestic tasks

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[198] See question 4.3 in the questionnaire in Appendix A. See the list of households which answered this question in Appendix B.
[199] Ibid.
[200] Ibid.
[201] See question 4.13 in the questionnaire in Appendix A. See the list of households which answered this question in Appendix B.

After electrification, better lighting by using electricity from the solar PV power stations has increased flexibility of time for domestic tasks. Out of 111 households surveyed, five households stated that with better lighting produced by using electricity from the solar PV power stations, they could do some of their household tasks in the evening, and did not have to rush to finish their tasks before it became dark.[202]

5) Increase efficiency for domestic tasks

After electrification, the use of some electrical appliances and better lighting by using electricity from the solar PV power stations increased the efficiency with which household members completed domestic tasks. Out of 111 households surveyed, five households indicated that they could do household tasks faster due to better lighting.[203] In addition, three households explained that the female household members could cook faster because of better lighting.[204] Yet besides better lighting, which increased the efficiency with which households could complete domestic tasks, one household in Saierlong Township said that its members could use electrical appliances to improve the efficiency of household tasks,[205] while one female household member living in Namcuo Township,[206] expressed that "by using Ghee tea machine, it saved her a lot of time" (see Photograph 7-3).[207]

[202] See question 4.5 in the questionnaire in Appendix A. See the list of households which answered this open-ended question in Appendix B.
[203] See question 4.7 in the questionnaire in Appendix A. See the list of households which answered this open-ended question in Appendix B.
[204] Ibid.
[205] Ibid.
[206] Ibid.
[207] Traditionally Tibetans drink Ghee tea many times a day. The making of Ghee tea is usually the responsibility of female household members. The traditional way of making Ghee Tea takes around 15 minutes, and requires a lot of strength from women to do so (see Photograph 7-3 left). But by using Ghee tea machine, which is powered by electricity from the solar PV power station, it takes less than one minute, and nothing more than the press of a button (see Photograph 7-3 right).

Photograph 7-3 Traditional way of making Ghee tea (left) and using Ghee tea machine (right)

Source: Photographs taken by author in the field from October to December, 2007.

7.2.3 Discussion: Why did the Township Electrification Program fail to have a significant impact on economic benefits for the households in the two selected townships?

One of the policy goals of the Township Electrification Program was to reduce poverty in remote rural areas of western China with electrification. However, the research findings showed the Program produced very little and also very limited economic benefits for the households in the two investigated townships. The Program did not produce more income or more income generation activities. Neither did the Program help income generation activities in terms of efficiency and time saving.

Basically, electricity supplied was not for productive activities, but only for residential use. As discussed in chapter 5, households were not allowed to use high-power electrical appliances for productive activities, such as noodle machines, freezers, and other electrical machines. As a result, the Program did not help to produce significant economic benefits for households in terms of an increase of income or an increase of income generating activities. Therefore, in summary, since production of economic benefits was not a possibility, the goal of reducing poverty through electrification was not successfully achieved. Many households without any income in Namcuo Township still rely totally on government's subsidy and food provision after the implementation of the Program. The World Bank's studies on the evaluation of welfare impact of rural electrification also came to the conclusion that renewable energy-based rural electrification programs have very limited impacts on productive activities, except when there has been a complementary program to assist productive uses of electricity (World Bank, 2008).

Even though economic benefits were not identified as a significant outcome of the Program, some social benefits were experienced by households in both investigated townships. Therefore the Program did, to some degree, achieve its other stated policy goal of improving households' living conditions in remote rural areas of western China.

7.3 Evaluation of policy impact: Improvement of township development

7.3.1 Policy impact

In Saierlong Township, 89.2% of households felt that the improvement of township development after the implementation of the Township Electrification Program was 'slightly improved' (see Table 7-7). Out of six indictors used for evaluating the improvement of township development, the two most improved conditions were: improvement in education services (94.6%) and health services (57.1%) (see Table 7-8). The two least improved conditions were an increase in employment or job opportunities (19.6%) and improvement of veterinary services (41.1%) (see Table 7-8).

In Namcuo Township, 78.2% of households felt that the improvement of township development after the implementation of the Township Electrification Program was 'slightly improved' (see Table 7-7). The remainder of households (21.8%) felt that the Program produced significant improvements in township development (see Table 7-7). Out of six indictors used for evaluating the improvement of township development, the two most improved conditions were: education services (89.1%) and the increase of small and micro rural businesses (57.1%) (see Table 7-8). The two least improved conditions were the improvement of veterinary services (43.6%) and the improvement of government services (56.4%) (see Table 7-8).

Table 7-7 Improvement of township development after implementation of the Township Electrification Program in Saierlong Township and Namcuo Township

Improvement of township development	**Saierlong Township (n=56)**	**Namcuo Township (n=55)**
	% of households	**% of households**
No improvement at all	5.4	0.0
Slightly improved	89.2	78.2
Significantly improved	5.4	21.8

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

Table 7-8 Households' evaluation of the impact of the Township Electrification Program on township development in Saierlong Township and Namcuo Township

Township development	**Saierlong Township (n=56)**		**Namcuo Township (n=55)**	
	Improved (%)	Not improved (%)	Improved (%)	Not improved (%)
Improve education services	**94.6**	5.4	**89.1**	10.9
Improve health services	**57.1**	42.9	47.3	52.7
Improve veterinary services	41.1	**58.9**	43.6	**56.4**
Improve government services	50.0	50.0	43.6	**56.4**
Increase employment or job opportunities	19.6	**80.4**	50.9	49.1
Increase small and micro rural businesses	50.0	50.0	**71.4**	26.8

Note: n is the number of the households which used electricity from the solar PV power stations.
Source: Data processed by author based on author's field survey from October to December, 2007.

7.3.2 Evaluation

To what extent did the Township Electrification Program influence the improvement of township development in the two investigated townships?

The findings of household evaluation showed that the Township Electrification Program had only a 'slight' impact on the improvement of township development in the two investigated townships. The three most important impacts of the Township Electrification Program at the township level in both investigated townships were the improvement of education services (average 91.9%), increase of small and micro rural businesses (average 60.7%), and improvement of health services (average 52.2%).

1) Education services

An improvement of education services was experienced by households in both investigated townships. After the implementation of the Township Electrification Program, schools in both townships had better lighting, and teachers were able to use electrical educational tools, such as computers, printers, photocopy machines, overhead projectors, science equipments (e.g. electrical microscopes), TVs, speakers, VCD and DVD players, and access long-distance education systems to help facilitate teaching (see Photograph 7-4 left) (personal comments of the principal of the Saierlong Township School, 17 October 2007; personal comments of the principal of the Namcuo Township School, 16 October 2007). Some teachers expressed that by using computers, photocopy machines and printers they were able to save time and doing so made their work more efficient and of better quality. The World Bank's evaluation study on the welfare impact of rural electrification also found that the impact of rural electrification on education improved teaching quality through the provision of electricity-dependent equipments (World Bank, 2008).

In addition, students' learning conditions at the schools in both selected townships improved by way of better lighting in the evening for learning (students did not have to use candles), using freezers to store food, using noodle machines to make noodles, and so on (personal comments of the principal of the Saierlong Township School, 17 October 2007; personal comments of the principal of the Namcuo Township School, 16 October 2007).[208]

Photograph 7-4 Computer classroom (left) and dormitory (right) at Saierlong Township School

Source: Photographs taken by author in the field from October to December, 2007.

[208] Many of students lived at the school dormitories (see Photograph 7-4 right) because the nearby villages were very far away from the school (around 7 to 50 km).

Even with these improvements, however, the principal of the Saierlong Township school expressed one problem regarding electricity supply from the solar PV power station. The current amount of electricity supply was not enough for the school, especially not enough to power all the computers (personal comments of the principal of the Saierlong Township School, 17 October 2007). However, it is arguable whether the first priority of electricity supply from the solar PV power station should be given to students to use ‘computers,’ or to households in the township for ‘lighting’.

2) Small and micro rural businesses

Small and micro rural businesses in the two investigated townships directly benefited from the Township Electrification Program in two main ways: longer opening hours and improved facilities. The World Bank’s evaluation study on the welfare impact of rural electrification also found a positive impact of rural electrification on home business: The number of home business grew significantly more in communities where there are electrification programs than in those communities where there were no electrification programs (World Bank, 2008).

Out of 111 households surveyed, nine households which own small and micro rural businesses expressed that they could extend opening hours in the evening and earn more money (see Photograph 7-5 left).[209] For example, one restaurant owner in Saierlong Township said that by using the freezer and the noodle machine, the efficiency of the work has been greatly improved.[210] Whereas one motorcycle store owner in Saierlong Township expressed that due to electrification, he could use electrical equipments to repair motorcycles.[211] One tea house owner in Namcuo Township expressed that by using the Ghee tea machine, she could save a lot of time, and electrification made her work more efficient.[212] And lastly, one restaurant owner in Saierlong Township explained that due to electrification, he could use TV and VCD/DVD players in his restaurant to attract more customers, because the customers liked to eat and watch TV

[209] See question 4.27 in the questionnaire in Appendix A. See the list of households which answered this open-ended question in Appendix B.
[210] Ibid.
[211] Ibid.
[212] Ibid.

or VCD/DVD at the same time (see Photograph 7-5 right).[213] The effect of owning TV to increase business opportunities also found in the World Bank's evaluation study on the welfare impact of rural electrification. In Ghana, the female household prepared snacks to be sold to the people who came to her house to watch television in the evenings (World Bank, 2008).

Photograph 7-5 Grocery store (left) and restaurant (right) in Saierlong Township

Source: Photographs taken by author in the field from October to December, 2007.

The Township Electrification Program did not drive industrial development or productive activities in the two investigated townships, but it did help to assist small and micro rural businesses, usually household businesses.

3) Health services

The improvement of health services can directly benefit from rural electrification in two ways: improvement of medical facilities and longer opening hours (World Bank, 2008).

After the implementation of the Township Electrification Program, the doctors in both investigated townships were able to use electrical medical equipment to improve the quality of health services (see Photograph 7-6) (personal comments of the directorof the Saierlong Township Health Center, 26 November 2007; personal comments of the doctor of the Namcuo Township Health Center, 16 October 2007). The World Bank's evaluation study on the welfare impact of rural electrification also found that rural

[213] Ibid.

electrification could improve rural health services by improving health facilities (World Bank, 2008).

In addition, the health centers had better lighting in the evening, and patients could go to the centers in the evening or at night if an emergency arose (personal comments of the director of the Saierlong Township Health Center, 26 November 2007; personal comments of the doctor of the Namcuo Township Health Center, 26 November 2007).[214] GTZ's evaluation report of its project 'Renewable Energies in Rural Areas, China' also found that health centers in rural areas of China could provide health services throughout night after electrification (GTZ, 2008).

Photograph 7-6 Lighting situation at the Namcuo Township Health Center (left) and electrical medical equipments at the Saierlong Township Health Center (right)

Source: Photographs taken by author in the field from October to December, 2007.

While electrification improved rural health services in the two investigated townships, several problems arose which affected the improvement of rural health services, making the improvements less significant than those experienced by education services in the two townships.

The director at the Saierlong Township Health Center expressed that "the current electricity supply from the solar PV power station was not enough for the health center. In fact, sometimes, there was no electricity at all" (personal comments of the director of

[214] The health centers in both townships were opened twenty-four hours a day. The doctors worked on rotation and stayed in the health center dormitory.

the Saierlong Township Health Center, 26 November 2007). The amount of time of electricity supplied to the health center was the same as the amount supplied to households, meaning that the amount of time of electricity supplied was unpredictable and irregular.[215] According to the director, “If we needed to use electrical medical equipment, we needed to ask the households to bring their own electrical generators or borrow electrical generators from other households. If no electrical generators were available, we had to transfer the patients to the county hospital which was 70 km away. We often asked the operator of the solar PV power station if he could connect a special line, like the one connected to the school, for the health center to provide twenty-four hours electricity. But the operator said that the township government did not agree with this idea” (personal comments of the director of the Saierlong Township Health Center, 26 November 2007).

The doctor at the Namcuo Township Health Center expressed that “electricity supply from the solar PV power station was not enough for the health center and the time of electricity supply was not reliable and predictable” (personal comments of the doctor of the Namcuo Township Health Center, 16 October 2007). As he explained in an interview, “Most of the time, electricity was only used for lighting because it could not provide regular electricity for electronic medical equipments or refrigerators for keeping vaccines” (personal comments of the doctor of the Namcuo Township Health Center, 16 October 2007).[216]

While rural electrification managed to make the engagement in electricity-dependent medical equipments possible for the health centers in the two townships, the extent to which electrification helped to improve health services continued to depend on the quantity of electricity supply and the quality of electricity service.

7.3.3 Discussion: Why did the Township Electrification Program only significantly contribute to the improvement of education services in the two selected townships?

[215] In Saierlong township, the amount of time of electricity supply from the solar PV power station was only 3 to 4 hours a day in the evening, 3 to 4 days a week.

[216] Vaccines are sensitive to both heat and cold. Therefore, vaccines need to be kept between 2 and 8 degree Celsius (°C) (World Bank, 2008). To maintain a store of vaccine, clinics need refrigerators to keep the required temperature.

The improvement of education services was viewed as the most significant impact of the Township Electrification Program according to the six indicators used to track the impacts at the township level in the two investigated townships, due to the schools having more and a better supply of electricity. On the one hand, the school in Saierlong Township was given priority to use electricity from the solar PV power station, and the operators had to insure twenty-four hours electricity supply for the school. On the other hand, the school in Namcuo Township had a new solar PV power station with capacity 10 kWp which was built in 2007 to provide electricity only to the school.[217] Before this new solar PV power station was built, the school was also given priority to use electricity from the township solar PV power station. But the health centers, veterinary clinics, township governments, and small businesses in both townships had the same amount of electricity supplied as households. Hence, the improvement of health services, government services, veterinary services, employment opportunities, and business opportunities were limited.

The extent to which renewable-energy based rural electrification programs designed for residential purpose can also benefit township development depends on additional programs or special treatments of the existing programs designed for other different purposes, such as education services, health services, government services, business activities, employment situation, etc. Except for when complementary programs or special treatments of the existing programs are specially designed for these purposes, the impact of renewable energy-based rural electrification programs on township development are limited.

7.4 Evaluation of policy impact: Environmental impact

7.4.1 Policy impact

In Saierlong Township, households disposed used dry cell batteries by throwing them in garbage cans (61%), throwing them on the grassland (20%), or burying them on the grassland (19%) (see Table 7-9). In Namcuo Township, households disposed used dry

[217] The school needed a new solar PV power station because the decreasing capacity of the township solar PV power station was not able to provide sufficient electricity for the school (personal comments of the principal of the Namcuo Township School, 16 October 2007).

cell batteries by throwing them on the grassland (91%) or throwing them in garbage cans (9%) (see Table 7-9).

Table 7-9 Disposal of used dry cell batteries in Saierlong Township and Namcuo Township

Disposal of used dry cell batteries	Saierlong Township (n=64)		Namcuo Township (n=33)	
	Account	**Percent**	**Account**	**Percent**
Throw them in the garbage can	39	61%	3	9%
Throw them on the grassland	13	20%	30	91%
Bury them on the grassland	12	19%	0	0%

Note: n is the number of the households which answered the question. The sample size in Saierlong Township was 81. The sample size in Namcuo Township was 56.
Source: Data processed by author based on author's field survey from October to December, 2007.

7.4.2 Evaluation

Basically, there is no specific way to recycle used dry cell batteries in the two selected townships. Households were not aware of the negative environmental impacts of the inappropriate disposal of used dry cell batteries. The batteries were thrown away either in the garbage cans as normal garbage, or in the nearby environment. Some households even burned them on the grassland. In several GTZ's baseline studies and monitoring studies of renewable energies in rural areas in several western provinces in China, they also found that used dry cell batteries were mainly thrown in the nearby environment and no special recycle measures were taken (Zange and Haberland, 2005; Zange and Zheng, 2006).

As discussed in chapter 6, electricity from the solar PV power station did not totally replace the use of dry cell batteries in both investigated townships. Households still had to use dry cell batteries for lighting and electrical appliances. But the amount of dry cell batteries used by households was 'slightly' reduced after the implementation of the Township Electrification Program (see Table 6-5 in chapter 6). The average number of dry cell batteries used per household per month decreased in Saierlong Township from 1.79 batteries before electrification, to 1.71 batteries after electrification, and in Namcuo Township from 4.35 batteries before electrification, to 2.51 batteries after electrification. Since there were no special recycle procedures for used dry cell batteries before and after the implementation of the Program, the only environmental impact of the

Township Electrification Program was the very slightly decreased amount of used dry cell batteries disposed in the environment. The negative environmental impact of the disposal of used dry cell batteries decreased very slightly in the two investigated townships after the implementation of the Program.

7.4.3 Discussion: Why did the Township Electrification Program fail to have significant environmental impacts in the two selected townships?

It is often claimed that renewable energy-based rural electrification programs have many positive environmental impacts (World Bank, 2008). But the harsh reality of these is that the direct environmental impacts of renewable energy-based rural electrification programs are not significant and are also limited (World Bank, 2008; Chung, 2004). As results of this study also show, the Township Electrification Program had very little and very limited environmental impacts in the two investigated townships.

The most significant negative environmental impact of the way rural households use energy is the use of traditional biomass (fuel wood) for cooking and heating. While use of traditional biomass for cooking and heating releases few carbon dioxide emissions, over-exploitation has negative environmental impacts, such as deforestation, damage to ecosystem, and soil erosion (IEA, 2002). It is a common misconception that electricity simply replaces the use of traditional biomass (IEA, 2002). In reality, electricity in poor rural areas does not replace traditional biomass for cooking and heating. As the results of this study also show, electricity was not used for cooking and heating in both investigated townships. The Township Electrification Program only slightly reduced the number of dry cell batteries used by households. Hence, the direct impact of the Township Electrification Program on the environment is very limited.

7.5 Overall evaluation of policy impacts of the ‘Township Electrification Program’

At the household level, the Township Electrification Program had a ‘slight’ impact on the improvement of socio-economic benefits for the households in the two investigated townships. The Program did not have a significant impact on the improvement of ‘economic’ benefits for the households. But some ‘social’ benefits, such as the increase of entertainment, access to news and information, personal security, flexibility of time and efficiency for domestic tasks, were experienced by the households in the two investigated townships. Basically, the Township Electrification Program did not have a significant impact on the improvement of the welfare of rural people in ‘economic’ terms, which could have lead to significant poverty reduction. Instead, the Program did have slight impact on the improvement of the welfare of rural people in ‘social’ terms, which lead to better living conditions.

At the township level, the Township Electrification Program had a ‘slight’ impact on the improvement of township development in the two investigated townships, mainly through improvement in education services. The improvement of health services, government services, veterinary services, employment opportunities, and business opportunities was limited. This limitation was due to the schools having additional electricity supplied, which other public and social facilities did not.

In regard to the environmental impact of the Township Electrification Program, the impact of the Program on environment is very limited in the two investigated townships. This limitation was due to the Program producing only less use of dry cell batteries, which reduced only slightly the negative environmental impact of inappropriate disposal of used dry cell batteries in the two investigated townships.

8 Conclusions and Recommendations

8.1 Summary of research findings

The research findings of this study are summarized in parallel with the reflection of research questions proposed in chapter 1.

1) Policy problem identification (chapter 2)

Research question: When and why did electricity access in remote rural areas of western China receive the attention of Chinese policy-makers and become a policy problem included on the Chinese government's policy agenda? Why did the Chinese government identify the policy problem with the solution of renewable energy-based rural electrification programs instead of fossil fuel-based grid extension programs?

Electricity access in remote rural areas of western China became a policy issue on the Chinese government's policy agenda in 2000. Political leaders' concern over the unequal economic development of eastern and western China, as well as rural and urban areas, which may potentially create social instability and threaten the rule of the Communist Party of China (CPC) was the main factor triggering inclusion of this issue in the government's policy agenda. The Chinese government identified the policy problem with the solution of designing renewable energy-based rural electrification programs, instead of fossil fuel-based grid extension programs, was the result of geographical limitations in remote rural areas of western China that posed difficulties for national grid extension as well as the government's national development plan for promoting renewable energy.

Since 2000, the Brightness Program, a national policy, and several international cooperation projects were launched by the Chinese government to cope with the policy problem. But these projects were limited to only certain areas and provinces. In general, the projects were not able to achieve the government's objective set by the 10th Five-Year-Plan (2001-2005) to provide electricity to 1 million households in remote rural areas. Hence, in 2002, the Chinese government launched the Township

Electrification Program which relied on renewable energy to provide electricity access to the households in remote rural areas of 11 western provinces.

2) Policy formulation and adoption (chapter 3)

Research question: What are the characteristics of the formulation and adoption of the Township Electrification Program within the political framework of the PR China? What are the pros and cons of such a 'centralized public sector energy initiative'?

The Communist Party has great influence over the process of policy formulation and adoption, and the role of the Chinese government in energy sector is a dominate one. Like other energy policies, the formulation and adoption of the Township Electrification Program without exception followed a 'centralized and closed top-down' approach. The program was designed by the National Development and Reform Commission (NDRC) under the State Council, and adopted by the State Council. It is suggested that local participation usually invokes a greater chance of success for energy projects. Since democratic mechanisms for public participation in the process of policy formulation and adoption are missing in China due to its communist political structure, the Township Electrification Program is not able to reflect the needs of local people and other stakeholders in remote rural areas of western China.

On the one hand, a centralized public sector energy initiative, like the Township Electrification Program, has its advantages. First, the Chinese government is able to mobilize national resources to back the Program. Second, the Chinese government can plan for all rural areas in all western provinces that have different levels of electrification. But on the other hand, a centralized public sector energy initiative also has its disadvantages. A major disadvantage of a centralized public energy sector initiative is monopoly. Without competition, electricity supply service is often inefficient, ineffective, of poor quality, wasteful of resources, and lacking in accountability. Besides, corruption more easily occurs among different implementing governmental bodies and private contracting system generators.

3) Policy implementation (chapter 4)

Research question: What are the implementation results of the Township Electrification Program in remote rural areas of western China? What are the factors that determine the sustainability of the Program?

Up until 2004, 670 solar PV power stations and 51 solar PV/wind hybrid power stations were constructed under the Township Electrification Program to provide electricity for 644 non-electrified townships, 70,000 households, and 340,000 people. Besides utilizing solar and wind power for rural electrification, 146 small hydro power stations were constructed in nine western provinces to provide electricity for 369 non-electrified townships, 230,000 households, and 960,000 people.

The implementation of the Program possessed a technical orientation (construction of the stations and installation of the systems) and underestimated financial, human resource, and institutional capacity building at the local level. In the two investigated townships, Saierlong Township in Qinghai Province and Namcuo Township in Tibet AR, different problems were found regarding financial capacity building (e.g. unaffordable electricity tariff, inappropriate electricity fee collection scheme, households' unwillingness and inability to pay electricity fee, lack of financial management of the collected electricity fee, and unstable and low salary for the operators), human resource capacity building (lack of training for operators and lack of household/community participation in the Program), and institutional capacity building (lack of good governance in terms of institutional setting, regulatory framework, and good management). These three above mentioned factors have seriously affected the sustainability of electricity supply in both investigated townships. The sustainability of the Program was determined not only by technical capacity, but also by financial resources, human resources, and institutional capacity building at the local level.

4) Policy evaluation I - policy output (chapter 5)

Policy evaluation consists of three different approaches to evaluate a policy: policy output, policy outcome, and policy impact. Each approach is applied in this study to evaluate the Township Electrification Program.

Research question: What are the outputs of the Township Electrification Program in remote rural areas of western China? What was the situation of electricity supply and electricity service of the Program at the local level?

Policy outputs evaluate goods, services, or resources received by target groups or beneficiaries. Two variables were used in this study to examine policy outputs associated with the Township Electrification Program in the two investigated townships: ‘electricity supply’ and ‘electricity service’ of the solar PV power stations. Five findings were identified as a result of this study regarding ‘electricity supply’ and ‘electricity service’ of the solar PV power stations.

First, electricity access to the solar PV power station implemented by the Program was not connected to all households in the two townships investigated. The electrification rate of the solar PV power station in Namcuo Township was 98.2% and in Saierlong Township only 74%. Second, the Program did not achieve its policy objective by assuring an installed capacity of 100W per person. The installed capacity in Saierlong Township in 2003 was 25W per person, and in 2007 only 17W per person. The installed capacity in Namcuo Township in 2003 was 100W per person, and in 2007 only 71W per person. Third, the current electricity supply was not sufficient for all households’ needs. On average, 77% of households in both townships indicated the insufficiency of electricity supply from the solar PV power stations. Fourth, electricity was not provided daily on a regular basis, and the amount of time of electricity supplied per day was not stable. And also the time of electricity supplied per day was not predictable. The electricity supply in Namcuo Township was 5 days per week and in Saierlong Township was 3.5 days per week. The number of hours during which electricity was supplied in Namcuo Township was stable, at 6 hours per day. But the amount of time of electricity supplied daily decreased dramatically in Saierlong Township from daily 12 hours to 3 hours over 5 years. Households in both townships were basically unable to predict the starting and ending time of the daily electricity supply. Fifth, the unreliable electricity service resulted in low satisfaction of electricity service. On average, only 21.7% of the households in both townships were satisfied with the electricity service of the solar PV power stations. Complaints concerning the electricity service from the households all referred to the unreliability of electricity service. This result contradicted the policy objective of the Township Electrification Program to provide reliable electricity service for remote rural people.

5) Policy evaluation II – policy outcome (chapter 6)

Research question: What are the outcomes of the Township Electrification Program in remote rural areas of western China? To what extent did the Program influence changes in household energy use patterns from traditional energy sources to electricity from solar PV power stations?

Policy outcomes evaluate the actual change of behaviors or attitudes that result from policy outputs. One variable used in this study to examine direct policy outcomes of the Township Electrification Program in the two investigated townships was changes in households' energy use patterns from traditional energy sources (such as candles and dry cell batteries) to electricity from solar PV power stations. The results showed that there were changes in households' energy use patterns from traditional energy sources to electricity from solar PV power stations in the two investigated townships after the implementation of the Program. Following electrification as a result of the Program, all investigated households in both townships used electricity from the solar PV power stations. But traditional energy sources were not totally substituted by electricity. In Saierlong Township, all investigated households still used candles for lighting and 76.8% of the households used dry cell batteries for lighting and electrical appliances. In Namcuo Township, 89.1% of the investigated households still used candles for lighting and 87.3% of the households used dry cell batteries for lighting and electrical appliances. Basically, after the implementation of the Program, households still had to rely on traditional energy sources, such as candles and dry cell batteries.

But the amount of energy produced from traditional energy sources used for lighting and electrical appliances is significantly reduced after electrification, particularly the use of candles. The average number of candles used for lighting in Saierlong Township dropped from 16.02 candles per month per household before electrification, to 1.71 candles per month per households after electrification. The average number of candles used for lighting in Namcuo Township also dropped from 31.82 candles per month per household before electrification, to 8.73 candles per month per households after electrification. But the average number of dry cell batteries used for lighting and electrical appliances in Saierlong Township only very slightly dropped from 1.79 batteries per month per household before electrification, to 1.71 batteries per month per households after electrification. The average number of dry cell batteries used for lighting and electrical appliances in Namcuo Township slightly dropped from 4.35 batteries per month per household before electrification, to 2.51 batteries per month per households after electrification.

Besides direct policy outcomes, this study also carried out an exploratory study to examine the possible indirect policy outcomes of the Township Electrification Program in the two investigated townships. Results indicated no statistically significant change in the working hours and leisure hours in both investigated townships before and after electrification. But households often went to bed half to one and a half hour later, and had additional ‘waking’ hours in the evening after electrification. Besides, electrification changed the hobbies of the households from chatting and visiting neighbors to watching TV and reading.

6) Policy evaluation III – Policy impact (chapter 7)

Research question: What are the impacts of the Township Electrification Program in remote rural areas of western China? To what extent did the Program contributed to improving socio-economic benefits for households, township development, and environmental sustainability at the local level?

Policy impacts evaluate the long-term changes of real-life conditions resulting from a policy. Three variables were used in this study to examine policy impacts of the Township Electrification Program in the two investigated townships: improvement of socio-economic benefits for households, improvement of township development, and environmental impact.

Three findings were made as a result of this study. At the household level, the Program had ‘slight’ improvement on socio-economic benefits for the households in the two investigated townships. The Program did not bring significant improvement of ‘economic’ benefits to the households, such as an increase in income generation (only

25% of the investigated households agreed) and an increase in income generating sources (only 16.25% of the investigated households agreed); because electricity from the solar PV power station was not allowed for productive use. However, the Program did bring some social benefits for the households, such as increase of entertainment (76.7% of the investigated households agreed), access to news and information (72.25% of the investigated households agreed), personal security (60.45% of the investigated households agreed), flexibility of time for domestic tasks (57.7% of the investigated households agreed), and efficiency for domestic tasks (56.9% of the investigated households agreed). At the township level, the Program also had ‘slight’ impacts on the improvement of township development in the two investigated townships, mainly on the improvement of educational services (91.85% of the investigated households agreed); because the schools had additional electricity supply from the solar PV power stations which the rest of public and social facilities did not have. Hence, the improvement of health services (52.2% of the investigated households agreed), government services (42.35% of the investigated households agreed), veterinary services (46.38% of the investigated households agreed), employment opportunities (35.25% of the investigated households agreed), and small business opportunities (60.7% of the investigated households agreed) was not apparent and limited. And finally, although solar energy was an environmental-friendly way to generate electricity and did not produce any green house gas emissions, the actual impact of the Program on the environment before and after electrification was very limited in the two investigated townships; because the Program encouraged only less use of dry cell batteries after electrification, slightly reducing the negative environmental impact caused by inappropriate disposal of used dry cell batteries.

8.2 Conclusions

Rural electrification programs have been criticized for favoring mainly non-poor and better-off communities that are able to afford electricity service (World Bank, 2008). The Township Electrification Program, in contrast, focused explicitly on those least able to access electricity, particularly the poor, in non-electrified townships in remote rural areas of western China. The Program was not merely designed for economic purposes, like return of investment (ROI) or cost-effectiveness, but also for other social purposes, like poverty reduction and improvement of living conditions. The Program gave first priority to the poor, deprived, and less well-off areas in China.

However, as indicated by this study, the Program did not achieve a significant improvement in socio-economic benefits or poverty reduction for the people it intended to achieve, due to an insufficient, unreliable, and unpredictable supply of electricity. Having electricity access did not mean that electricity was actually used in remote rural areas of western China. After becoming electrified through the Program, households continued to rely on traditional energy sources, such as candles and dry cell batteries for lighting and electrical appliances. Electricity generated from the solar PV power stations did not substitute traditional energy sources. The effects of the Program to reduce poverty and improve living conditions were therefore limited. The gap between policy goals (poverty reduction and improvement of living conditions) and policy implementation (insufficient, unreliable, and unpredictable electricity supply) was attributed to the poor governance of the Program. Rural electrification was not merely about picking the winning technology and allocating fund. For to be successful, the Program must ultimately maintain long-term access and supply of electricity to households in remote rural western China, while also provide local capacity building in financial resources, human resource, and other institutional aspects.

8.3 To what extent has the Township Electrification Program achieved sustainable energy supply in remote rural areas of western China?[218]

Although "renewable energies are a critical element for achieving sustainable development" (BMZ, 2004: 33), supplying electricity with renewable energy does not necessarily lead to a sustainable supply of energy in remote rural areas of western China. Many have argued that renewable energy electrification programs, particularly for rural areas, are not self-sustaining (Martinot et al., 2002; Nieuwenhout et al., 2001; Nieuwenhout et al., 2000; Chung, 2004). From 1980 to 2000, the amount of development aid available worldwide for renewable energy-based rural electrification

[218] This discussion is in line with the mission of the Center for Development Research (ZEF), University of Bonn. ZEF's mission is to give scientific support to the implementation of Agenda 21 and to contribute to a sustainable development which ensures a life in human dignity for everyone (Rector of University of Bonn, Prof. M. Huber, in a letter to the Untied Nations Secretary-General B. Butros-Ghali on April 1, 1996; cited from Holtz, 2004).

programs totaled about USD 3 billion (Chung, 2004). Yet as Martinot notes, many programs are considered failures (Martinot et al., 2002). In Nieuwenhout's research, about a quarter of the 13 solar home PV system projects investigated no longer functioned and an additional fifth were only partly operational (Nieuwenhout et al., 2001; Nieuwenhout et al., 2000). Hence, at the end of the dissertation, it is meaningful to discuss and reflect on one question: To what extent has the Township Electrification Program achieved sustainable supply of energy in remote rural areas of western China?

Before turning to this discussion, the concepts of 'sustainable development' and 'sustainability' need to be clarified and defined. 'Sustainable development' and 'sustainability' are often used in many situations interchangeably (Davis, 1992). However, the concept of 'sustainable development' is broader than the concept of 'sustainability' (Holtz, 2004). Sustainability means the capacity to endure or maintain a balance of a certain process or state in any system.[219] The concept of 'sustainable development' is more than 'sustainability'. The most commonly used definition of 'sustainable development' is the definition used in the 1987 United Nations Report of the World Commission on Environment and Development. This report defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987).[220] Sustainable development was often discussed in three dimensions: environmental sustainability, economic sustainability, and social sustainability, which corresponds to the three pillars of sustainable development (United Nations, 2005; Adams, 2006).[221] However, the UNESCO report, the Universal Declaration on Cultural Diversity suggests 'cultural sustainability' as the fourth dimension of sustainable development (UNESCO, 2001). But according to German development policy, 'political stability' should count as the fourth dimension of sustainable development in addition to economic efficiency, social justice, and ecological sustainability (Holtz, 2004). Holtz (2004) suggests that sustainable development must be centered on human beings and integrate economic development, social development, environmental

[219] Definition of sustainability was retrieved 13 July, 2009 from http://en.wikipedia.org/wiki/Sustainability.
[220] Definition of sustainable development was retrieved 13 July, 2009 from http://www.un-documents.net/ocf-02.htm#I.
[221] Jiang et al. (2007) developed integrated assessments of sustainable development, energy, and climate policy objectives with a number of key sustainable development indicators that reflect economic, social, and environmental dimensions of sustainable development to examine specific clean energy policies.

stewardship, and political stability[222]. While lastly, in Article 1 of the ACP-EU Partnership Agreement of 2000, an integrated approach of sustainable development is taken into account at the same time the five aforementioned dimensions: political, economic, social, cultural, and environmental aspects (EU, 2006: 6).

Regarding sustainable development in the context of energy, Ceselski argues that "the definition of sustainable energy today has broadened from the primarily economic development focus in 1970s, to concerns with environmental sustainability in the 1980s and financial sustainability in the 1990s, and finally to the current inclusion of social sustainability, equity and poverty in the past few years" (Ceselski 2002: 10), is which in line with current debates over the concept of sustainable development. From the research findings in this study, besides these three dimensions, a fourth political dimension is found vital for sustainable energy supply. This study integrated a political dimension into Chung's approach to the study of sustainable energy supply focused on economic, environmental, and social dimension to define sustainable energy supply for renewable energy-based rural electrification programs (Chung, 2004). In economic terms, sustainable energy supply refers to financial sustainability of renewable energy-based rural electrification programs, such as investment, subsidy, tariff, financial management, etc., as well as affordability of electricity service and connection (linked also closely to household income). In environmental terms, sustainable energy supply refers to less negative environmental impacts of renewable energy-based rural electrification programs and the maintenance of natural resources. In social terms, sustainable energy supply for renewable energy-based rural electrification programs refers to achieving equality of electricity access (particularly for the poor) and improving living conditions, socio-economic benefits, and human welfare. In political terms, sustainable energy supply for renewable energy-based rural electrification programs refers to good governance of public authorities at different levels of government, good management, and community/people participation.

To what extent has the Township Electrification Program achieved sustainable energy supply in remote rural areas of western China? In environmental terms, the Program achieved environmental sustainability by supplying electricity with renewable energy which did not cause negative environmental impacts and also maintained natural

[222] Such as democracy, human rights, rule of law, gender equality, etc (Holtz, 2004).

resources. The Program avoided greenhouse gas emissions and contributed to climate change mitigation. In economic terms, the Program did not achieve financial sustainability. Both investigated solar PV power stations faced financial difficulties to sustain functioning of the stations. In social terms, the program improved 'short-term' living conditions and provided social benefits for the rural people, but did not improve long-term living conditions or provide economic benefits. In political terms, the Program did not achieve good governance and good management of electricity supply. In general, the Program lacked institutional and regulatory frameworks to sustain the function of the stations at the local level. Overall, the Township Electrification Program did not achieve sustainable energy supply in remote rural areas of western China, especially in an economic and political sense. Merely supplying electricity with renewable energy does not necessarily lead to sustainable energy supply in remote rural areas of western China. Rather, it is how electricity is supplied and managed that paves the way for sustainable energy supply in remote rural areas of western China.

8.4 Policy recommendations for the Chinese government

According to the Chinese government's 11th Five-Year-Plan (2006 to 2010) and National Medium and Long-term Development Plan, more efforts will be made in the next five to ten years to strengthen electricity supply in remote rural areas with renewable energy in order to serve a major instrument for social and economic development in these areas (CAS, 2007b). It is planned that by year 2020 electricity access for non-electrified population should be resolved (CAS, 2007b). After implementation of the Township Electrification Program, the government planed another two renewable energy-based rural electrification programs: the 'Village Electrification Program' and the 'Household Electrification Program' (NREL, 2004b; Zhang, 2004; IEA, 2006). The 'Village Electrification Program' aims to provide electricity based on renewable energy to 20,000 non-electrified villages in western China by 2010. The 'Household Electrification Program' aims to provide electricity with renewable energy to the rest of the 8.5 million people currently without electricity access in western China by 2020.

According to the government's latest policy direction, rural electrification programs started from 2006 national grid extension will be given priority if it is possible to extend the grid (NDRC, 2007c; CAS, 2007b). The second priority for rural electrification is the construction of small hydro power stations if the areas have water resources (NDRC, 2007c). The third and last priority is solar PV and solar PV hybrid power stations if the areas prove too difficult for grid extension and are without water resources (NDRC, 2007c). Since the non-electrified population is located in remote areas where grid extension is often difficult and not possible, the hydro power is limited to water resource availability, it is predicted that solar PV and solar PV hybrid power stations will still remain the main option for electrification in remote rural areas (CAS, 2008c). Hence, the policy recommendations suggested by this study can offer the Chinese government some insights into the future of renewable energy-based rural electrification programs planned to be implemented by 2020.

The recommendations suggested by this study arise from insights gained from the analysis of the policy process associated with the Township Electrification Program. Since this study was not a research project funded by any organization or the Chinese government, the policy recommendations suggested by this study are based on knowledge from an evaluation of the Program. Recommendations are not intended to have a significant affect upon real policy decision-making for the Chinese government, such as adjusting or amending current policies or formulation of new policies.

One, the government should evaluate rigorously the existing renewable energy-based rural electrification programs, such as the Brightness Program, the Township Electrification Program, and international cooperation projects, to know whether the programs have achieved their officially stated goals and to what extent they do so. The Chinese government has claimed that one of the key means to realize the UN Millennium Development Goals, 'well-off society', 'harmonious society', and 'a new socialist countryside' is through rural electrification programs.[223] However, the actual effects of the Township Electrification Program on poverty reduction and improvement of the quality of life for remote rural people in the two investigated townships was very limited. Renewable energy-based rural electrification

[223] Generally, China has done very well in realizing the UN Millennium Development Goals, particularly achieving universal primary education and eradicating extreme poverty & hunger. Yet it needs to make more efforts toward ensuring environmental sustainability (Jiang et al., 2007: 30-34). For the performance of China's efforts on achieving the UN Millennium Development Goals, see UNESC for Asia and the Pacific, UNDP, and ADB, 2006.

programs were also viewed as a key mean for the Chinese government to transform its economy and society into a ‘low carbon’ and ‘low energy intensity’ economy and ‘resource conserving and environmentally friendly’ society. However, the actual effect of the Township Electrification Program on reducing the total greenhouse gas emissions and fossil fuel energy consumption of the whole country was very slight. While the Chinese government has invested great effort to integrate renewable energy-based rural electrification programs into wider national rural development policies, energy policies, and climate policies, the real effects and impacts of renewable energy-based rural electrification programs should not be over-emphasized and over-estimated. Thus, systematic evaluation of exiting renewable energy-based rural electrification programs, including their contents, implementation, effects, and impacts, can offer feedback for policy makers indicating whether such programs had achieved. With such information, policy makers can make long-term national development plans by formulating new renewable energy-based rural electrification programs and also continue, adjust, or strengthen the existing old programs.

Two, before formulation of renewable energy-based rural electrification programs, it is necessary to consider different local conditions to choose the most efficient and effective way for electrification to avoid wasting resources and investment. Normally solar PV power stations run very well for the first several months after installation, but most of them fail over the years due to being overloaded (Adelmann, 2009). This situation occurred in the two investigated townships where solar PV power stations began functioning poorly after 5 years in use. Both stations were due to cease functioning in 2009 or 2010 if the batteries affected by overloading were not replaced by new batteries. Therefore, it is arguable if solar PV power stations are a better solution for rural electrification than ‘solar home PV systems’ which are easier to operate and maintain than solar PV power stations. Because the Chinese government’s future policy objective for rural electrification is to provide electricity service for the current non-electrified ‘villages’ and ‘households’ not yet connected to electricity in remote areas of western China, an even lower population density in these areas would problematize justification of investment of solar PV power stations. If solar PV power stations run only 5 to 8 years instead of the 20 years initially planned, continued investment in such stations amounts to a huge waste for the government. Moreover, doubt exists over whether the current non-electrified villages or communities, even more remote than the townships that implemented the Township Electrification Program, would have the capacity and human resources to run solar PV power stations. Based on the experiences of the two townships analyzed, both townships had difficulties and limited local capacity in maintaining and managing the solar PV power stations. Hence, utilization of higher capacity (such as 150 Watt) 'solar home PV systems' with government's subsidies and technical support would be another solution for the remaining non-electrified villages and households. According to the households' experiences in this study, households gave quite positive evaluations of their experience using solar home PV systems.[224] In areas with a highly dispersed population, such as the remaining non-electrified villages and households in western China, more decentralized solar home PV systems provide a potential and more cost-effective solution for electrification.

Three, before formulation of renewable energy-based rural electrification programs, it is necessary to carry out a prior assessment to collect more information about the overall local situation and end-users' energy needs in the areas where electrification programs are intend to be implemented. The policy-making process of renewable energy-based rural electrification programs in China is a 'top-down centralized closed approach' that is deeply embedded in the political framework. Generally speaking, the exiting programs did not produce many positive results, or reduce poverty because they did not consider local needs or capacities before the programs were formulated. Planning of renewable energy-based rural electrification programs should combine the following two approaches: 'electricity supply-driven' planning that is oriented to meet the central government's development goals, and also 'electricity demand-driven' planning which is oriented to meet local needs. A prior assessment helps policy makers in Beijing to gain information and knowledge about local situation in remote rural areas and energy needs of local people to formulate new policies and programs for rural electrification.

Four, the formulation of renewable energy-based rural electrification programs should consider a supportive institutional framework, financial sustainability,

[224] Households in the two investigated townships evaluated solar home PV systems having the following advantages: easy to operate, providing longer hours of lighting, and no extra cost after the first initial investment.

human resource capacity building, and quality of governance, particularly at the local level, to guarantee a long-term and reliable supply of electricity in remote rural areas of western China. Sustainable energy supply is based not merely building solar PV power stations, distributing government funds, and increasing electricity access, but also through enhancing the quantity of electricity, quality of electricity service, and socio-economic effects of electricity. In the two investigated townships, supply of electricity was insufficient and unreliable. In addition, achievement of the policy goal to reduce poverty and improve rural socio-economic development was circumscribed. For the future programs, the government should focus on securing long-term sufficient electricity supply and reliable electricity service. From the lessons learned from this study suggests that sufficient electricity supply and reliable electricity service very much depends on technical, financial, human resource, and institutional capacity building at the local level.

Five, the government should incorporate strategies for enhancing local economic development and income generating activities into renewable energy-based rural electrification programs. Productive use of electricity involves the application of electricity to generate goods or services either directly or indirectly. Productive use of electricity facilitates small business and income generating activities resulting from new electricity input. However, the Township Electrification Program did not allow productive use of electricity. Hence, the effect of the Program on poverty reduction and household income generation was not significant in both investigated townships. For future renewable energy-based rural electrification programs, the government should incorporate strategies for enhancing local economic development and income generation activities into the programs.

Six, in regard to the Township Electrification Program, the government should consider new policies to continue financing the current solar PV power stations which were constructed under the Program. Batteries which were installed under the Program need to be replaced every 5 to 8 years to keep the solar PV power stations functioning. If batteries are not replaced in time, all townships which implemented the Program will once again become non-electrified. Based on the findings from the two investigated townships, the township governments were not able to afford the huge cost of replacing batteries. Without central governmental or provincial governmental financial support, the solar PV power stations constructed under the Program will not be able to continue supplying electricity. In addition, the subsidy of electricity tariff from the national or provincial government for the poor households which are not able to afford electricity is necessary in remote rural areas of western China. If people can not afford the use of electricity, the Program will become meaningless.

8.5 Policy implications for other developing countries

Rural electrification is a common challenge for developing countries. In 2005, 1.6 billion people, around a quarter of the world's population, did not have access to electricity (IEA, 2006). More than 99% of non-electrified population lives in developing countries and 80% (1.26 billion) of them live in sub-Saharan Africa and South Asia (IEA, 2006). The average electrification rate in developing countries is only 68.3% (IEA, 2006). The non-electrified population lives mainly in remote rural areas of developing countries (IEA, 2004). Decentralized electricity systems based on renewable energy sources are widely suggested as an option for rural electrification in remote rural areas of developing countries (United Nations, 2000; UNDP, 2003; World Bank, 2000a; Asian Development Bank, 2005b). Since the Township Electrification Program is, to date, the world largest renewable energy-based rural electrification program in terms of investment volume ever carried out by a country, the Chinese experiences can, to some degree, offer other developing countries insights into improving electricity access with renewable energy sources in remote rural areas, as well as for designing renewable energy-based rural electrification programs.

One, national governments and parliaments should take the lead in setting policy frameworks for rural electrification, and also should determine to resolve the problem of electricity access for the poor in remote rural areas of developing countries. The sustainability of renewable energy-based rural electrification programs largely depends on political decisions made by national governments and parliaments (GTZ, 2008). To resolve the problem of electricity access for the poor, national governments and parliaments play an important role to formulate supportive policies and institutional framework. In regard to China's Township Electrification Program, formulation of the Program was based on the national government's strong determination to improve electricity access in remote rural areas of western China through large national investment and strong subsidy. Many argued that it was the strong determination and favorable policy of the central government to mobilize national resources and push forward electrification programs at the local level; encouraging the development of rural electrification and improving the rate of electrification to the level of developed countries (ESMAP, 1996; IEA, 2002; Yang, 2003; Zhang and Heller, 2004). However, without governments' proactive role in pushing rural electrification, relying predominantly on private sector and private capital to develop electricity infrastructure from scratch is unlikely to succeed in remote rural areas of developing countries because high investment risks are involved (IEA, 2004). Private investors have little incentive to invest when rural people with low income can not afford the cost of electricity delivery, particularly the high cost of electricity generated from renewable energy sources. Although electricity in principle is a private good in most countries, providing electricity access has traditionally been considered an essential public good for which governments are primarily responsible (Flavin and Aeck, 2005: 38). Renewable energy-based rural electrification programs do not merely serve economic purposes, such as return of investment, but also other environmental and social objectives. When the private sector fails to act in public interests, the governments should step in (World Bank, 2001). Relying on development aid from other actors, like donors, development banks, international organizations, foreign governments, or non-governmental organizations, alone is also not a solution capable of resolving the problem of electricity access for the poor in developing countries even though international cooperation or public-private partnership among these actors can encourage the development of renewable energy-based rural electrification programs. Because of these realities, national governments and parliaments in developing countries still play a central role in devising supportive policies to resolve the problem of electricity access for the poor in remote rural areas.

Two, governments should subsidize renewable energy-based rural electrification programs, particularly for the poor in remote rural areas of developing countries. It is widely recognized that the immediate benefits of rural electrification programs seldom went to the poor who could not afford electricity connection and electricity fee (World Bank, 2008). Concerns regarding the equity of rural electrification investments and subsidies in developing countries are voiced especially when better-off villages and people benefit most and worsen rich-poor disparities (World Bank, 2008; Barnes, 1988).

In the case of China's Township Electrification Program, the Program was based solely on the government's investment of 2,600 million RMB to build solar PV power stations. Return of investment on changes made to the country's energy infrastructure was not the primary concern of the Program. Instead, the concern of the Program was improving electricity access in remote rural areas, by providing households in the area a free or cheap electricity connection and a relatively lower electricity tariff. Even renewable energy-based electrification in rural areas of industrialized countries is made possible through government support and cross-subsidies among electricity customers, such as Germany (BMZ, 2004: 40). The cost of electricity per kilowatt hour generated from renewable energy is still much higher than electricity per kilowatt hour generated from coal and hydro. Likewise, the economic rate of return for grid connections is normally greater than renewable-energy based rural electrification programs (World Bank, 2008). As a result, the cost of renewable energy-based electricity is often too expensive for rural people with lower income to afford. If rural people can not afford the connection and use of electricity, having electricity access or renewable energy-based rural electrification programs become meaningless for them. Therefore, to improve renewable energy-based electricity access and service, governments should ensure that subsidies made available to increase electricity access for the poor, electricity use by rural people, and affordability of electricity while ensuring that electricity utilities remain financially viable.

Three, the design of renewable energy-based rural electrification programs in developing countries should focus on 'local capacity building' to ensure sustainable electricity supply in remote rural areas. The implementation of renewable energy-based rural electrification programs takes place at the local level, although national governments determine the policy framework. In the case of China's Township Electrification Program, the national government set to resolve the problem of electricity access in remote rural areas, and invested large amounts of money to improve electricity access. But the design of the Program focused mainly on technical capacity building, undermining the importance of financial, human resource, and institutional capacity building at the local level. As a result, insufficient electricity supply and poor electricity service hampered the Program, preventing it from achieving its goals to reduce poverty and improve living conditions for remote rural people as outlined by the policy. In the future, the design of renewable energy-based rural electrification programs in developing countries should consider ‘local capacity building’ in technical (such as technical training of renewable energy systems, technical support), financial (such as electricity tariff, electricity fee collection schemes, financial sources for maintenance, repair, and replacement), human resource (such as operator training, community/people participation), and institutional terms (such as quality of governance, institutional framework, regulatory framework) to ensure sustainable electricity supply in remote rural areas.

Four, renewable energy-based rural electrification programs in developing countries should be integrated into wider national development plans and rural development plans. Renewable energy-based rural electrification programs have the potential to help developing countries meet the UN Millennium Development Goals. Electricity is essential for rural development. But electricity alone does not bring rural development. At present, no one knows if electricity drives the development of rural areas or the need for rural development drives the process of electrification. Besides rural electrification, rural development must be supported by a series of social, economic, and environmental development policies. In the case of China’s Township Electrification Program, the Program was one part of China’s ‘Western Development Strategy’ to support the development of western China. The Strategy included different programs to develop infrastructure (such as transport, energy, electricity, and telecommunications), promote educational services and health services, and protect ecological system (such as reforestation). Therefore, renewable energy-based rural electrification programs in developing countries should be linked to broader national development plans and rural development plans with other social, economic, and environmental development policies or programs, instead of just taking improvement of electricity access as an ultimate goal.

8.6 Recommendations for future research

This study suggests the following two recommendations for future research.

First, more empirical and in-depth studies with quantitative and qualitative methods in the field are valuable to understand how renewable energy-based rural electrification programs are actually implemented at the local level, even though it is often difficult, challenging, time-consuming, costly, and sometimes impossible to carry out field research in such places. Knowledge gained in the field is helpful for improving existing or future renewable energy-based rural electrification programs. Before carrying out field research in remote rural areas, however, researchers must bear in mind that there are uncontrollable, unforeseen, unexpected, and unknown incidents, as well as costs, which might hinder the progress of the research in the field and the achievement of intended research objectives.

Second, it is difficult and often impossible to evaluate the actual outputs, outcomes, and impacts of a particular program. However, scientific results of policy outputs, outcomes, and impacts of renewable energy-based rural electrification programs provide crucial information to help determine if a particular program has attained a high (or low) level of success. The exploratory evaluation methods used in this study to access the outputs (chapter 5), outcomes (chapter 6), and impacts (chapter 7) of the Township Electrification Program need to be further elaborated and developed with more case studies in different countries to improve the evaluation methods.

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APPENDIX A: Questionnaire

Renewable Energy Policy in Remote Rural Areas of Western China: Implementation and Socio-economic Benefits

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■ Basic Information of the Interview

Interview code: ☐ ☐☐ ☐☐☐ (Province code; interviewer code; household code)

Province: ___________________

County: ____________________

Township: __________________

Village: ____________________

Date of interview: ____________________ (DDMMYY)

Time start: ____________________ (HHMM)

Name of interviewer: ____________________

Name of respondent: ________________________________

Respondent's relationship to head of household:

____

Interview place: __________________________

Does your household have electricity from solar PV power station? _____

■ Coding:

(98) Don't know

(99) Do not apply

Please try to answer all questions! Try not to use "98"!

Section 1: General information about Household

Question	Answer
1.1 What are the three most important things that urgently need to be improved in your township for better living conditions and township development? Please indicate a priority! (e.g. electricity, drinking water, road, employment situation, poverty reduction, education service, health service, governmental service, veterinary service, etc.)	1. ______________________ 2. ______________________ 3. ______________________
1.2 Normally, when do your household members go to bed? _____ (HH)	
1.3 Before electrification from the township solar PV station, when did your household members go to bed? _____ (HH)	
1.4 What do your family members do when they have free time? (Maximum 3 answers!)	1. ______________________ 2. ______________________ 3. ______________________
1.5 Before electrification from the township solar PV station, what did your family members do when they had free time? (Maximum three answers!)	1. ______________________ 2. ______________________ 3. ______________________
1.6 What kind of transportation vehicles does your household own? (e.g. motorcycle, cars, trucks, tractor, etc.)	
1.7 Which appliances or machines (using electricity) do your household plan to buy in the coming 2 years? _____ (Maximum 3 answers!)	1. ______________________ 2. ______________________ 3. ______________________
1.8 How does your household dispose of used dry cell batteries?	

1.9 Working hours per day

	Working hours per day in summer (hour)	**Working hours per day in winter (hour)**
Male household member		
Female household member		

1.10 Before electrification from the township solar PV station, working hours per day

	Working hours per day in summer (hour)	**Working hours per day in winter (hour)**
Male household member		
Female household member		

1.11 Free time per day

	Free time per day in summer (hour)	**Free time per day in winter (hour)**
Male household member		
Female household member		

1.12 Before electrification from the township solar PV station, free time per day

	Free time per day in summer (hour)	**Free time per day in winter (hour)**
Male household member		
Female household member		

Section 2: Energy situation

2.1 Current energy source

Purposes	**Energy source** **(1) Yes** **(2) No**		**Preference ranking**	**Reasons of the 1st priority**
Lighting		(1) Township solar PV station	1. _____ 2. _____ 3. _____ 4. _____ 5. _____	
		(2) Small hydro power station		
		(3) Solar home PV system		
		(4) Candle		
		(5) Dry cell battery (e.g. flashlight)		
		(6) Rechargeable battery (e.g. flashlight)		
		(7) Gasoline, specify: ________________ (e.g. lamp, electric generator)		
		(8) Diesel, specify: ________________ (e.g. lamp, electric generator)		
		(9) Kerosene		
		(10) Other, specify: ______________		
Entertainment & Information		(1) Township solar PV station	1._____ 2. _____ 3. _____	
		(2) Small hydro power station		
		(3) Solar home PV system		
		(4) Dry cell battery (e.g. radio)		
		(5) Rechargeable battery (e.g. radio)		
		(6) Gasoline (e.g. electric generator)		
		(7) Diesel (e.g. electric generator)		
		(8) Other, specify: _______________		
Cooking		(1) Dried yak dung	1. _____ 2. _____ 3. _____	
		(2) Solar energy (e.g. solar cooker)		
		(3) Coal (and coal briquette)		
		(4) LPG (liquefied petroleum gas)		
		(5) Other, specify: _______________		
Heating		(1) Dried yak dung	1. _____ 2. _____ 3. _____	
		(2) Coal (and coal briquette)		
		(3) Other, specify: _______________		
Transport		(1) Gasoline	1._____ 2. _____	
		(2) Diesel		
		(3) Other, specify: _______________		

2.2 Evaluation of current energy situation

Purpose	Sufficient (1) Sufficient (2) Insufficient	Affordable (1) Affordable (2) Unaffordable	Satisfaction (1) Satisfied (2) Unsatisfied	Current Problems (Maximum two answers!)
Lighting				1. _______________ 2. _______________
Entertainment & Information				1. _______________ 2. _______________
Cooking				1. _______________ 2. _______________
Heating				1. _______________ 2. _______________
Transportation				1. _______________ 2. _______________

2.3 Energy expense

Energy source	Energy source: (1) Yes (2) No	Unit/ Month or Year	RMB/ Month or Year
(1) Township solar PV station		_____ kWh/ Month _____ Light bulb _____ TV _____ Other	_____ RMB/ Month
(2) Small hydro power station		_____ kWh/ Month	_____ RMB/ Month
(3) Candle		_____ Number/ Month	_____ RMB/ Month
(4) Dry cell battery		_____ Number/ Month Type: _______________	_____ RMB/ Month
(5) Rechargeable battery		_____ Number/ Year Type: _______________	_____ RMB/ Month
(6) Dried yak dung		_____ Bag/ Month	_____ RMB/ Year
(7) Coal (and coal briquette)		_____ Ton/ Year	_____ RMB/ Year
(8) LPG (liquefied petroleum gas)		_____ Bottle/ Month	_____ RMB/ Month
(9) Gasoline		_____ Liter/ Month	_____ RMB/ Month
(10) Diesel		_____ Liter/ Month	_____ RMB/ Month
(11) Kerosene		_____ Liter/ Month	_____ RMB/ Month
(12) Other, specify: ____________			

2.4 Before you had electricity from the township solar PV station, what was the cost of energy expenses for lighting, entertainment and information?

Energy source	**Energy source:** **(3) Yes** **(4) No**	**Unit/ Month or Year**	**RMB/ Month or Year**
(1) Small hydro power station		_____ kWh/ Month	_____ RMB/ Month
(2) Candle		_____ Number/ Month	_____ RMB/ Month
(3) Dry cell battery		_____ Number/ Month Type: _______________	_____ RMB/ Month
(4) Rechargeable battery		_____ Number/ Year Type: _______________	_____ RMB/ Month
(5) Gasoline		_____ Liter/ Month	_____ RMB/ Month
(6) Diesel		_____ Liter/ Month	_____ RMB/ Month
(7) Kerosene		_____ Liter/ Month	_____ RMB/ Month
(8) Other, specify: ____________			

2.5 Current electric appliances (Verify with interviewer)

Appliances	**Number**	**Electricity source** (1) Township solar PV station (2) Small hydro power station (3) Dry cell battery (4) Rechargeable battery (5) Other, specify: _____	**Power** (Watts)	**Total hours used per day**
Flashlight				
LED Flashlight				
TV				
Satellite receiver				
Radio/tape cassette				
VCD/DVD				
Mobil phone & charger				
Telephone				
Ghee tea machine				
Battery charger (rechargeable battery)				
Other, specify: _____				
Other, specify: _____				
Other, specify: _____				

2.6 Productive, herding or other machines using electricity, e.g. sewing machine, sheep clipper, milker, tools for animal husbandry, water pumping, winnowing machine, electric drill, saw, compressor, planer, grinder, wheel, etc. (Verify by interviewer)

Machine	**Number**	**Electricity source** (1) Township solar PV station (2) Small hydro power station (3) Electric generator (gasoline) (4) Electric generator (diesel) (5) Other, specify: _____	**Power** (Watts)	**Total hours that are used per day**

2.7 Current lighting situation using electricity (Verify by interviewer)

Type of bulb or tube (1) Compact fluorescent lamp (2) Incandescent lamp (3) Fluorescent light tube (4) Other, specify: _______	**Power** (Watts)	**Electricity source** (1) Township solar PV station (2) Small hydro power station (3) Solar home PV system (4) Other, specify: ______	**Total hours used per day**

2.8 Expense and quality of light bulbs

Type of bulb or tube (1) Compact fluorescent lamp (2) Incandescent lamp (3) Fluorescent light tube (4) Flashlight bulb (5) Other, specify: ________	**Number/per year**	**Power** (Watts)	**Price** (RMB)	**Total months in use**

2.9 Current lighting situation using other energy sources (electricity not included)

Energy source: (1) Candle (2) Dry cell battery (3) Rechargeable battery (4) Gasoline (5) Diesel (6) Kerosene (7) Other, specify: _____	**Total hours used per day**

Section 3: Electrification

Questions	**Township solar PV station**	**Small hydro power station**
3.1 In summer, how many days during the week do you have electricity from XXX? _____ Days		
3.2 In winter, how many days during the week do you have electricity from XXX? _____ Days		
3.3 In summer, what time of day is electricity supplied? From _____ (HH) to _____ (HH)		
3.4 In winter, what time of day is electricity supplied? From _____ (HH) to _____ (HH)		
3.5 Is electricity supplied from XXX enough for your household needs? (1) More than enough (2) Not enough (3) Just enough		
3.6 Is electricity from XXX often disrupted? (1) Often (2) Rarely		

3.7 Is your household satisfied with the electricity supplied from XXX? (1) Satisfied, why? _____ (2) Unsatisfied, why? _____ (3) More or less		
3.8 What sorts of problems are associated with electricity supplied from XXX? (Maximum 3 answers!)	1. _____________ 2. _____________ 3. _____________	1. _____________ 2. _____________ 3. _____________
3.9 Does your household have a meter to measure electricity from XXX? (1) Yes (2) No		
3.10 What do you think about the tariff on electricity from XXX? (1) Cheap (2) Expensive (3) Right price		
3.11 Do you think the tariff of electricity from XXX is reasonable? (1) Yes (2) No, why? _____		
3.12 What would be a reasonable tariff on electricity from XXX which your household can afford to pay? _____ RMB/ kWh		
3.13 Does your household have difficulties paying for electricity from XXX? (1) Yes (2) No		

Section 4: Socio-economic benefits after electrification from the township solar PV station

4.1 After electrification from the township solar PV station, what, if any, significant changes occurred at your household? ____

____

____

Questions	**Answers**	**Ranking**
Improved learning conditions for children 4.2 Does electrification help to improve learning conditions for children? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		**1.** _____ **2.** _____ **3.** _____ **4.** _____
Increased access to news and information 4.3 Does electrification help to increase access to news and information? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		**5.** _____
Increased entertainment 4.4 Does electrification help to increase your household members' access to entertainment? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
Increased flexibility of time for domestic tasks 4.5 Does electrification help to increase flexibility of time spent on domestic tasks? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
Increased flexibility of time for income generating tasks 4.6 Does electrification help to increase flexibility of time spent on income generating tasks? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
Increased efficiency for domestic tasks 4.7 Does electrification help to increase efficiency with which domestic tasks are undertaken? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		

Increased efficiency for income generating tasks 4.8 Does electrification help to increase efficiency with which income generating tasks are undertaken? (1) Yes, why? ________________________________ (2) No, why not? ________________________________		
Save time for domestic tasks 4.9 Does electrification help to save time when engaging domestic tasks? (1) Yes, why? ________________________________ (2) No, why not? ________________________________		
Save time for income generating tasks 4.10 Does electrification help to save time when engaging income generating tasks? (1) Yes, why? ________________________________ (2) No, why not? ________________________________		
Increased family interaction 4.11 Does electrification help to increase interaction of your household members? (1) Yes, why? ________________________________ (2) No, why not? ________________________________		
Increased social interaction 4.12 Does electrification help to increase opportunities for your household members to visit neighbors or for your neighbors to visit your household? (1) Yes, why? ________________________________ (2) No, why not? ________________________________		
Increased personal security 4.13 Does electrification help to increase your household members' sense of security? (1) Yes, why? ________________________________ (2) No, why not? ________________________________		
Improved health and hygiene condition 4.14 Does electrification help to improve your household member's health and hygiene conditions? (1) Yes, why? ________________________________ (2) No, why not? ________________________________		

Increased working hours for domestic tasks 4.15 Does electrification help to increase number of hours spent on domestic tasks? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
Increased working hours for income generating tasks 4.16 Does electrification help to increase number of hours spent on income generating tasks? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
Increased household income 4.17 Does electrification help to increase household income? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
Increased household income sources 4.18 Does electrification help to increase the number of household income sources? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
Decreased energy expenses 4.19 Does electrification help to decrease energy expenses? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		

Question	**Answer**
4.20 How would you rate the effects of electrification from the township solar PV station on improving the overall living conditions at your household? 0 – No improvement; 1 – Slightly improved; 2 – Greatly improved	

4.21 After electrification from the township solar PV station, what, if any, significant changes you household have been experienced occurred in your township? __________

____

____

Questions	**Answers**	**Ranking**
4.22 Is the quality of **education services** in your township improved after electrification from the township solar PV station? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		**1.** _____ **2.** _____ **3.** _____
4.23 Is the quality of **health services** in your township improved after electrification from the township solar PV station? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
4.24 Is the quality of **veterinary services** in your township improved after electrification from the township solar PV station? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
4.25 Is the quality of **government services** in your township improved after electrification from the township solar PV station? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
4.26 Are there more **employment or job opportunities** in your township after electrification from the township solar PV station? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		
4.27 Are there more **small and micro rural businesses** in your township after electrification from the township solar PV station? (1) Yes, why? ______________________________ (2) No, why not? ______________________________		

Question	**Answer**
4.28 How would you rate the effects of electrification from the township solar PV station on improving the overall township development? 0 = No improvement; 1 = Slightly improved; 2 = Greatly improved	

0	1	2
No improvement	Slightly improved	Greatly improved

Section 5: Evaluation of interview

5.1 Are the questions understandable? _____

(1) Yes, they are understandable

(2) No, they are not understandable, why? ________________________________

5.2 Is there anything you would like to add?

____

____

____

5.3 Contact information

Mobile phone number: ________________________

5.4 Interview finished at _____________ (HHMM)

5.5 Total time: ___________________ (HHMM)

5.6 Thank the household for their support

■ Interviewer

5.7 Please describe this interview in your own words.

____

____

____

APPENDIX B: List of Household Code Mentioned in the Dissertation

Footnote	Question in questionnaire	Household code	Number of households
192	4.1	110, 144, 145, 146, 151, 156, 159, 163, 164, 166, 180, 206, 211, 212, 219, 220, 221, 228, 231, 238, 243, 244, 247, 250, 253, 256	26
193	4.1	131, 132, 135, 139, 144, 145, 146, 151, 156, 159, 163, 164, 166	13
194	4.1	110, 110, 117, 118, 119, 121, 132, 135, 145, 201, 202, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 216, 217, 218, 219, 224, 227, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 247, 249, 250, 253, 254, 255, 256	51
195	4.1	106, 108, 114, 122, 123, 124, 125, 126, 155, 180	10
196	4.1	103, 105, 108, 114, 116, 122, 123, 124, 125, 126	10
199	4.4	108, 110, 111, 117, 118, 119, 132, 135, 161, 146, 154, 208, 234, 235	14
200	4.4	170, 171, 173, 174	4
201	4.3	110, 111, 167, 171, 172,173, 174, 177, 208, 216, 217, 220, 221, 228, 230, 235, 237, 254	18
202	4.3	234	1
203	4.3	111	1
204	4.13	110, 111, 119, 134, 135, 206, 211, 212, 219, 220, 221, 228, 231, 238, 234, 244, 247, 250, 256	19
205	4.5	127, 133, 173, 208, 234	5
206	4.7	110, 119, 127, 208, 233	5
207	4.7	110, 119,127	2
208	4.7	128	1
209	4.7	234	1
214	4.27	118, 146, 151, 154, 157, 167, 170, 172, 204	9
215	4.27	118	1
216	4.27	167	1
217	4.27	234	1
218	4.27	118	1