ADB

Technical Assistance Consultant's Report

Project Number: 3625501
May 2007

MON: Renewable Energy for Small Towns and Rural Areas

Financed by the Government of Denmark

Prepared by IT Power
Hampshire, U.K.

For the Department of Fuel and Energy
Ministry of Infrastructure

This consultant's report does not necessarily reflect the views of ADB or the Government concerned, and ADB and the Government cannot be held liable for its contents. (For project preparatory technical assistance: All the views expressed herein may not be incorporated into the proposed project's design.

Asian Development Bank

ASIAN DEVELOPMENT BANK

TA 3965-MON

Renewable Energy For Small Towns and Rural Areas

Final Report

May 2007

ITP/0804

ITPower

Asian Development Bank

Renewable Energy for Small Towns and Rural Areas

Client contract No.: **TA 3965-MON**

IT Power reference: **0804**

Final Report

April 2007

Contractor:

IT Power
Grove House, Chineham Court,
Lutyens Close, Chineham,
RG24 8AG, United Kingdom.

Tel. +44 1256 392700
Fax. +44 1256 392701
E-mail: itpower@itpower.co.uk
http://www.itpower.co.uk

Document control	
File path & name	I:\0WorkITP\0Projects\0804 ADB Mongolia\5 Reports to client\4 Draft Final Report\0804 Final Report v2.doc
Author	KS / RO / AD / RG
Project Manager	Anthony Derrick
Approved	Anthony Derrick
Date	5th May 2007
Distribution level	Not for distribution

Template: ITP REPORT Form 005

TABLE OF CONTENTS

LIST OF ACRONYMS

A	Ampere
Ah	Ampere hour
ADB	Asian Development Bank
CFL	Compact fluorescent light
CHP	Combined Heat and Power
CNY	Chinese Yuan or Renmimbi (RMB). 1 USD is approximately 8.3 CNY
Danida	Danish International Development Agency
DH	District Heating
ESDP	Education Sector Development Programme
ESMAP	World Bank Energy Sector Management Assistance Program
EU	European Union
GoM	Government of Mongolia
GTZ	German corporation for international co-operation (Deutsche Gesellschaft für technische Zusammenarbeit)
HPP	Hydro power plant
JICA	Japan International Co-operation Agency
kVA	kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt-hour
kW_p	Kilowatt peak. Rating for PV systems (power at standard test conditions)
MAS	Mongolian Academy of Sciences
MNT	Mongolian Tugrik. 1 USD is approximately 1,100 MNT
MOH	Mongolian Ministry of Health
MoI	Mongolian Ministry of Infrastructure
MOSTEC	Mongolian Ministry of Science, Technology, Education and Culture
NEDO	Japanese New Energy and Industrial Technology Development Organisation
PTA	Mongolian Post and Telecommunications Authority
PUSO	Public Urban Services Organisation
PV	Photovoltaic
RE	Renewable Energy
REC	Renewable Energy Corporation
TA	Technical Assistance
TACIS	The EU TACIS Programme provides grant-financed technical assistance to countries in Eastern Europe and Central Asia
TEVT	Technical Educational and Vocational Training
UBEDO	Ulaanbaatar Electricity Distribution Office
UNDP	United Nations Development Programme
USAID	US Agency for International Development
USD	US Dollar
V	Volt
W	Watt
W_p	Watt peak. Rating for PV modules at standard test conditions

EXECUTIVE SUMMARY

IT Power was contracted to provide the Technical Assistance to the Government of Mongolia for the ADB project TA 3965-MON "Renewable Energy for Small Towns and Rural Areas".

The aim of the project was to assist the Government to undertake a comprehensive assessment of the technical feasibility and economic viability of new renewable energy technology under Mongolian circumstances, as a basis for decision making and policy formulation. Therefore this work can assist the Government to develop a renewable energy policy for isolated rural areas and to formulate strategies for its implementation.

The work was broken down into a number of stages relating to policy and RE implementation including the design and implementation of a pilot programme. The work and results of each stage of work are given in more detail in the following sections.

The overall conclusions of the project show that although the technical feasibility of the use of renewable energy was proven, the introduction of renewable energy *alone* at Soum Centres was shown to be insufficient for successful implementation. It is necessary to introduce energy efficiency measures first, to provide significant training and there is a real need for behavioural changes in users.

Pilot Project Development and Recommendations for Future Soum RE systems

Two pilot projects were developed as part of the project; a PV diesel hybrid power system was installed to provide power to the Soum centre of Zereg, Khovd Province; and a second pilot system was installed in Darvi, Govi-Altai Province. This was a wind power system operating in conjunction with the existing diesel generator to supply power to the hospital only.

The work commenced with surveys of potential sites and the selection of two pilot sites. The results of site surveys, initial designs and preliminary equipment selection were completed early in the project. The designs for the two pilot systems were then finalised and the equipment was procured after approval by the ADB project officer.

Both pilot systems were installed by a Mongolian company. IT Power supervised installation and commissioning, and also worked closely with the Soum Administrations and hospital staff. Monitoring took place, and the results as well as general lessons learnt are described in the report.

The following conclusions were drawn from the pilot projects and recommendations drawn for future Soum RE systems:

- The pilot project did not reach its objectives to provide a limited electric service for the whole of the Soum centre for 24 hours per day. The level of co-operation which this would have required could not be reached. However, many valuable lessons could be learned from the pilot projects.
- Significant progress was made regarding energy efficiency measures. The distribution of CFLs reduced electricity demand significantly. Losses could be reduced within the mini grid as well as within buildings.
- The pilot project demonstrated that it is technically feasible to integrate a small renewable energy system with an existing diesel generator and mini grid, but that it is much more difficult to achieve significant changes in user behaviour. Such changes are essential, in order to make best use of a renewable energy system.

- The potential for energy efficiency in rural Mongolia is huge. Implementation of energy efficiency measures should go hand in hand with the introduction of renewable energy schemes.
- The effort required for refurbishing an existing mini grid and electrical installations in buildings must not be underestimated.
- Training and capacity building is required to enable local people to maintain their electricity distribution system.
- Measures to encourage efficient use of energy should be introduced. The flat-rate electricity tariff commonly used in Soum centres does not encourage people to conserve energy, and should be replaced by a consumption-based tariff.
- The use of a consumption-based tariff requires metering of electricity. Measures must be taken to ensure that meters are not bypassed by users.
- Alternative concepts of operation and possibly ownership of the power system should be explored.
- For future renewable energy schemes, a two-stage approach is recommended; with the successful implementation of demand-side measures as a pre-requisite for the installation of a renewable energy system.

Policy Development

A comprehensive analysis of past renewable energy activities undertaken in Mongolia and overseas was carried out. The study focused on projects where private sector participation is being particularly encouraged and the lessons learnt in creating a favourable environment for enterprise development and a sustainable market for renewable energy technologies. Experiences from these reviews were used to help input into Mongolia RE policy development.

A key part of the TA was to assist the Ministry of Infrastructure (MoI) to develop a draft Renewable Energy Action Plan (REAP). Following a review of the April 2001 Law of Mongolia on Energy, Draft Energy Efficiency Law, Draft Renewable Energy Law, Environmental Protection Law, other Mongolian laws and various renewable energy and energy efficiency laws from other countries detailed comments and feedback were provided to the MoI on the REAP. In addition a workshop was organised to discuss the REAP with national and international stakeholders prior to the Action Plan being submitted to the Great Hural. The REAP was submitted to the Government and the Renewable Energy Law was passed in January 2007.

RE Market Improvement, Economic Review and Financing.

As part of RE market improvement best ways for renewable energy hybrids to be operated and maintained were proposed to encourage private sector participation. In addition a financial model was developed to enable the setting of tariffs for soum RE systems and sources of finance were identified.

Exhibition and Capacity Building

As part of the capacity building of this project a Renewable Energy Exhibition and two study tours were organised. An exhibition was held from the 8th - 11th September 2004 at the National Information Technology Park of Mongolia in Ulaanbaatar. The exhibition and seminar, titled: Sustainable Energy for Small Towns and Rural Areas of Mongolia, attracted some interest from neighbouring countries but was successful in highlighting Mongolian industry.

1 INTRODUCTION

IT Power was contracted to provide the Technical Assistance to the Government of Mongolia for the ADB project TA 3965-MON "Renewable Energy for Small Towns and Rural Areas". The aim of the project was to assist the Government to undertake a comprehensive assessment of the technical feasibility and economic viability of new renewable energy technology under Mongolian circumstances, as a basis for decision making and policy formulation. Therefore this work can assist the Government to develop a renewable energy policy for isolated rural areas and to formulate strategies for its implementation.

Mongolia's Sustainable Energy Sector Strategy was approved by the Cabinet of the Government of Mongolia on 4 July 2002. This strategy is based on five principles:

- To provide a stable and independent financial system for the energy sector;
- To complete the implementation of the energy sector restructuring;
- To improve energy conservation and efficiency;
- To improve capacity building within the energy sector;
- To improve energy supply in rural areas and introduce price and tariff mechanisms reflecting the payment ability of the consumers.

All the proposed activities of the Technical Assistance Project "Renewable Energy Development in Small Towns and Rural Areas" were reviewed in the context of the new 2002 strategy and it was concluded that they will contribute to Mongolia's Sustainable Energy Strategy in a timely and positive way.

About half of Mongolia's population are nomadic people, who for health, education and other basic services depend on an administrative centre (small town), called the Soum. Of the 340 Soum Centres only 117 are connected to the grid and the reliability of electricity supply is poor. Off-grid Soums operate small diesel generators but typically only for 2-5 hours each day and many are not used in the summer. The diesels are plagued with operation and maintenance problems that hamper the success of poverty reduction programmes in health, education and municipal services. However, given abundant solar and wind resources and the remoteness of these areas, the potential to benefit from renewable energy in an economic and reliable way is significant. The rural areas are vital to the country's economy, supplying food and raw materials to the cities. Hence the provision of reliable renewable energy supplies, where economically justified, will support Mongolia's development and be in synergy with the Millennium Development Goals.

The project started on 1st July 2003 and the majority of the activities were completed by 2005, in particular the pilot projects and their monitoring, the review and input into the Renewable Energy Action Plan and the organisation of a Renewable Energy Exhibition. However as discussed in the report there were some difficulties in finalising some of the project activities and this then delayed the project and has made it difficult to complete. Therefore there has been a very significant delay in the submission of this final report.

2 RENEWABLE ENERGY EXPERIENCE AND USE

2.1 Introduction

To provide a background to the project a thorough review and analysis was undertaken of the status of renewable energy, rural electrification and renewable resources in Mongolia as well as of the relevant lessons that could be learnt from overseas experiences.

2.2 Experience of Renewable Energy and Rural Electrification in Mongolia

A substantial collection of information on renewable energy and rural electrification experience in Mongolia relevant to this project was gathered, compiled and reviewed. An overview of National and International Mongolian renewable energy projects was carried out covering projects from 1970 up to the present day. The review and list of projects is included in Annex 1. The report includes a Japanese study of power systems in Mongolia and the institutional set up in Mongolia for energy planning. Mongolia has three main electricity power systems as well as a number of Aimags which are not connected to the three main grids. The study also highlighted some major problems in operation, maintenance and management of systems targeted at Soum centres including organisational problems, insufficient training and lacking finances.

In addition a review of projects on rural telecommunication supply and energy efficiency in the district heating sectors was carried out, as well as GTZ and EU activities. Finally a review of the institutions and enterprises working in renewable energy in Mongolia was carried out from interviews with the various organisations.

A study of previous ADB contracts in Mongolia is also included in the Annexes since elements of these projects are considered relevant to rural electrification in Mongolia. A brief review of the following projects was undertaken and is included in Annex 2:

- TA 3299-MON Capacity Building in Energy Planning
- T2414 Health Sector Development
- T2228 Preparation of Education Development
- TAR-MON 31243 Preparing Integrated Development of Basic Urban Services in Secondary Towns
- TA MON 28201-01 Rural Finance
- TAR MON 31214 Second Education Development Project
- TAR MON 27536 Agricultural Sector Programme

2.3 Experience of Renewable Energy and Private Sector Involvement in Rural Electrification Abroad

Information on past and on-going rural electrification programmes and projects, in countries which may have lessons that are transferable to Mongolia, was collected, focusing primarily on utilisation of renewable energy and experience of private sector participation in rural electrification in remote areas.

In particular four short case studies of recent rural electrification initiatives in Senegal, South Africa, Morocco and Kenya. The rural electrification programmes in these countries show a variety of implementation schemes but they have certain aspects in common such as utilisation of renewable energy technologies and promotion of private sector participation. The analysis focuses on actions and incentives taken in these countries to mobilise private sector investment in rural electrification, the obstacles and risks identified and lessons learnt where feedback is available. The case studies are included in Annex 3.

2.4 Resource Assessment and Renewable Energy Inventory in Mongolia

Mongolia has significant solar, wind and hydro power resources. A resource assessment was carried out as part of the project. An overview of renewable energy for remote areas in the medium term was carried out, which first considered briefly the whole of Mongolia and was then followed by a more detailed assessment for the Aimags considered for the pilot schemes and visits to the selected Soum centres. This assessment is included in Annex 4.

In addition to the resource assessment, an inventory of renewable energy technologies was compiled, listing solar, wind and hydro energy projects in Mongolia, for both institutions and households (typically herders). The inventory is included in Annex 5.

2.5 Recommendations for the integration of renewable energy in Soum electricity systems

An energy audit and technical study was then carried out by the RE Experts having visited Soum Centres using diesel generation and looking at the likely method that wind and solar technologies could be typically integrated with the existing electricity system. A number of different options for integration were identified, including:

1. Fully Integrated System
2. Renewable Energy System Supplying Separate, Independent Grid
3. Renewable Energy System Supplying Priority Loads
4. Fully Independent Renewable Energy System

From the studies a number of general recommendations for renewable energy hybrid systems in Soum centres were put forward and include:

- Integration of the renewable energy system into the existing power system (e.g. mini-grid) is preferable. This solution means that electricity from the renewable energy system is made available to all, thus everybody benefits from the system, rather than just the institutions or selected households.
- The installation of a separate renewable energy grid is not recommended. This doubles up on existing infrastructure thus adding costs to the project.
- Having two separate operators also doubles some of the administration requirements. Whilst competition between operators may encourage savings, these could easily be outweighed by the additional costs of two administrative structures. Having a single operator means that synergies between the diesel and the renewable energy system can be utilised. Particularly if the renewable energy system is relatively small it may not be worthwhile to create a new, additional operator structure.
- Energy efficiency measures must be seen as essential for renewable energy projects. For renewable energy power supply systems, the investment costs are strongly related to the energy demand which is to be supplied. Many energy efficiency measures, which will reduce demand, are likely to be more cost effective than the alternative of installing a larger renewable energy system.
- A private operator model is recommended to achieve longer-term sustainability. If a person's livelihood is tied to the operation of the renewable energy system, they are more likely to ensure its continued operation than employees of the local administration. However, the setup and contractual arrangements require careful planning as there is little experience in private sector involvement in rural energy supply. It is the policy of the Mongolian government to encourage private sector involvement for energy

operations. As a step towards private sector involvement, the power system should, as a minimum, be operated as a separate cost centre within the local administration, with its own accounts.

- For longer-term sustainability, it is essential to make arrangements to ensure that financial provisions for repairs and replacement of components are made. Ideally, a fund should be set up which has some form of external control, to avoid that funds are misused for other purposes. For example, the fund could be under joint control of the Soum administration and an independent body such as the Aimag administration or part of central government.
- To ensure longer-term sustainability, capacity building is required to provide the operator and maintenance personnel with the skills necessary to ensure continued operation in the long-term.

These recommendations were later fed into the design of the pilot projects.

3 POLICY DEVELOPMENT

3.1 Study of Energy-related Laws in Mongolia

A key part of the TA work was to assist the Ministry of Infrastructure to develop a 'Renewable Energy Action Plan' in order to facilitate the electrification of rural Soums with renewable energy technologies where appropriate.

In order that the Renewable Energy Action Plan fits within the context of the existing legislative framework of Mongolia, a short review of the existing laws was undertaken. The review also covered relevant Draft Laws that, at that time, had not yet come into effect. The review laid a particular emphasis on the relevance and impact of these laws with regard to renewable energy and rural electrification in Mongolia. The review is presented in Annex 7.

The legislation reviewed includes:

- The Draft Renewable Energy Law
- The Draft Energy Efficiency Law
- The Energy Law
- The Environmental Protection Law
- Rules of Electricity Consumption (Resolution no.263)

A brief summary of the following laws is also included with a particular emphasis on their impact on the import, supply, sale and installation of renewable energy and energy efficiency components and systems.

- Customs Tariff Law
- The Value Added Tax Law
- General Law of Taxation
- Economic Entity and Organisation Income Tax Law
- Excise Tax Law

3.2 Study of Energy-related Laws and Policies Abroad

Relevant laws and policies of other countries were investigated, particularly with respect to rural electrification and development of renewable energy resource utilisation. Legislation from other countries that was obtained includes:

- Japanese Law on the Rational Use of Energy
- Korean Act on the Promotion of the Development, Use and Dissemination of New and Renewable Energy
- Korean Rational Energy Utilisation Act
- German Renewable Energy Sources Act
- Chinese Draft Promotion Law for Renewable Energy Development and Utilization
- Indian Energy Conservation Act

A brief summary of recent policies and laws in different countries in Europe and Asia to promote renewable energy, energy conservation and energy efficiency is provided in Annex

8. In addition to this, the table below gives a summary classification of support measures for renewable energy dissemination and implementation in various countries.

Table 1: Classification of Support Measures for Renewable Energy Proliferation in Various Countries

Classification	Specific measure	Description	Examples in various nations	Examples in Japan
Initial cost support	Subsidy (investment support)	Subsidizes part or all of the cost required for the purchase or installation of facilities	U.K., Germany, Netherlands, Italy, Belgium, Sweden, etc.	Home-use photovoltaic power generation by NEF (New Energy Foundation), NEDO's support for new-energy power-generation projects by local municipalities, REPP's and electric utilities' support for the installation of photovoltaic power-generation facilities
	Financing incentive	Preferentially finances the cost of the purchase or installation of facilities	Germany, Denmark, Netherlands, etc.	Low-interest-rate financing system by policy rate using fiscal investments and loans, preferential interest-rate measures for photovoltaic-generator-equipped homes through a home-builder / financial institution tie-up
	Tax break	Grants tax breaks (e.g., accelerated depreciation) for the cost required for the purchase of installation of facilities, exempts electricity users purchasing renewable power from environment, energy and other taxes, or grants tax reductions	Exemption, reduction and refund of environment, carbon, investment and other taxes. Widespread in Europe and the U.S.	7 % deduction (national tax) from the reference acquisition amount at the time of new-energy facility introduction, lot-tax easing measure for local-energy-utilizing facilities (local tax)
Sale / purchase support	Fixed-price purchase	Local electric utility purchases electricity generated by renewable energies at fixed prices	Germany, Denmark, Sweden, Spain, U.S., Italy, France, Netherlands, etc.	No purchase made to date as an obligation
	Quota + certificate trade (RPS)	Mandates that electricity distributors, suppliers and others generate or purchase at least a certain amount of electricity generated by renewable energies. Often used together with	U.K., Sweden, Italy, Netherlands, Australia, some states in the U.S., etc.	"Special Law on the Use of New Types of Energy by Electric Utility Companies (Japanese RPS Law)"

		certificate trade		
Financial support	Levy on other fuels	Imposes taxes on fossil and other fuels and appropriates part of tax revenues for renewable-energy proliferation	U.K., Germany	Power-supply special account (power-supply diversification account) Oil special account (account for energy demand-structure advancement)
Voluntary efforts	Voluntary and preferential purchase	Voluntary and preferential purchase of new and renewable energies by electricity distributors, suppliers and others, regardless of whether purchase is mandated		Excess-power (e.g., photovoltaic, wind, waste power generation) purchase by 10 utilities
	Green fund	Contribution-based: Establishes funds using contributions from consumers, ordinary citizens and others for the support of renewable-energy projects Investment-based: Finances promising projects at the preferred rate from funds established by investors. Investors receive returns in the form of dividends	Netherlands (investment-based)	Green-power funds (e.g., GIAC) in 10 regions across the nation (contribution-based)
	Green pricing	Electricity suppliers make available a wide variety of menus in accordance with new-and renewable-energy percentages and types, while customers select favourite menus and pay higher-than-normal tariffs	U.S., Germany, Netherlands, U.K., Sweden	No example in Japan
	Green power certificate	Establishes a link between customers wishing to purchase new and renewable-energy electricity and electricity generators, and regards customers' environment premium payments as green-power purchases	RECs in Europe, U.S.	Green-power certificate system by private businesses

Sources: S. Nakakuki, H. Kudo, "Discussion Points in Japan's Renewable Energy Promotion Policy – Effect, Impact and Issues of the Japanese RPS", Environment Group, The Institute of Energy Economics, Japan, September 2003
"Fumiki Akari: EU Committee Report on Treatment of Renewable Energies in the EU Power Electricity Market" – Overseas Electric Power (4/1999)

"Kimihito Ise and Fumiki Akisato: Renewable Energy Support Systems in EU Members (Volume I)" – Overseas Electric Power (5/1999), Advisory Committee for New Energy Division Documentation – Ministry of Economy, Trade and Industry (2001, 2001)
"Toshihisa Fujii: Renewable Energy Utilization Promotion Measures in U.S.," "Renewable Energy Policies in State of Texas" – Overseas Electric Power (4/2002)
Hiroyuki Ishida: 15th Basic Energy Course "New Energies: Outline and Future Prospects" (9/2002)

3.3 Regulatory Framework for Renewable Energy and the Renewable Energy Action Plan

3.3.1 Regulatory framework for Renewable Energy

There were five main bodies involved in renewable energy in Mongolia. IT Power consulted with the various agencies with a view to commenting on potential changes which could increase the use of renewable energy. The five main bodies were:

- The Fuel and Energy Policy and Coordination Department in the Ministry of Infrastructure, which is the primary body in charge of policy making in the electric power and energy sector, coordination of the related organizations, implementation of energy projects and applications for foreign assistance.
- The Energy Authority, which used to operate the electric power networks and independent electric supply systems in the Aimags (before they became independent corporations under the electricity sector reform of 2001) and now has the responsibility of providing technical and managerial advice to companies that run the electric power supply systems.
- The Renewable Energy Corporation under the Mongolian Academy of Sciences (MAS), which conducts researches, experiments, productions and sales of equipment for renewable energy development including PV and wind power technologies.
- The PTA-run Photovoltaic Power Division, which oversees the production of PV panels. Their production line is mainly aimed at supplying PV for telecommunication but the PTA is also eager to sell PV systems to public facilities in Soum centers and to nomadic people.
- Soum Autonomy Bodies, that operate and manage independent electric power generators and transmission and distribution lines in Soum centres which are not connected to the grid.

The review of these organisations showed that there was no single body that had overall responsibility for renewable energy and its implementation. Although it is covered to different degrees by the above organisations it is not coherent and therefore not considered a priority by any one organisation, with the exception of the Renewable Energy Corporation and its responsibility is only in the research and production, not in its implementation. It was therefore recommended that a body is established within government with specific responsibility for the implementation of renewable energy.

Since the review was carried out the National Renewable Energy Centre of Mongolia has been established and recently the Mongolian Renewable Energy Law was approved in January 2007.

3.3.2 Renewable Energy Action Plan

The Ministry of Infrastructure prepared a first draft of its Renewable Energy Action Plan. The document has been titled *Programme to provide Soums and Bags with Renewable Energy (PSBRE).* As part of this TA IT Power input into the development of the REAP through the submission of comments and feedback as well as in helping facilitate a stakeholder workshop to discuss the plan.

The objective of the Action Plan is to create an effective structure to enhance rural electricity supply and to facilitate the sustainable development of energy sector in the rural areas. The provision of electricity from renewable sources to those Soums and Bags not connected to the centralised energy systems will be implemented in order to promote the economic efficiency of the energy sector, alleviate poverty and ensure environmental sustainability.

It had been intended to submit the REAP for approval by the Mongolian Parliament in December 2003. This was not possible, as a stakeholder consultation had to happen first. This was scheduled to take place at the national Policy workshop in March / April but this was postponed further. IT Power received a copy of the *PSBRE* document in December 2003 and provided initial comments and feedback to the Ministry of Infrastructure in December 2003 August 2004. These are summarised in Annex 9.

IT Power, with the Ministry of Infrastructure, arranged a stakeholder workshop to provide an opportunity to review and input into the Action Plan before it was to be submitted to the Great Hural. The workshop was open to mainly national but also international stakeholders. Relevant government ministries, Aimag and Soum authorities were invited. The programme and participants are included in Annex 10. The workshop took place on 7th September 2004 in conjunction with the exhibition and seminar on Sustainable Energy for Small Towns and Rural Areas of Mongolia which took place from the 8th to the 11th September.

Following incorporation of the workshop comments the REAP was further revised.

The Ministry of Infrastructure was also developing a Renewable Energy Law in co-operation with GTZ and the Renewable Energy Corporation. The law aims to enhance the reliability of energy supply and promote economic development in the rural areas of Mongolia. This Law was also discussed at the workshop, as it is relevant to the development of the use of renewable energy for rural electrification in Soums. The law has recently been passed by the Great Hural (January 2007) and includes for a feed-in tariff for on-grid renewable energy. This shows that the priorities for renewable energy have changed somewhat away from off-grid Soum systems.

4 PILOT PROJECT DEVELOPMENT

4.1 Selection of Sites

Initial Surveys

During two field trips in Southern and Western Mongolia during September and October 2003, a total of 12 Soum Centres in 4 Provinces (Aimags) were visited with a view to installing pilot systems there. These Soum Centres were selected in close consultation with the Mongolian Ministry of Infrastructure. Discussions also took place with the Khovd Aimag administration. The main criterion for selection of the Soum Centres to be visited was that there should be no plans for connecting the Soum Centres to the grid.

During the visits, an initial survey was carried out to assess the suitability of the Soum Centres for a Pilot System. At each Soum Centre, discussions with the Soum governor and other representatives took place, followed by a brief initial audit of the institutional buildings. The diesel generator was inspected, and information on tariffs and on the operating structure was obtained. A general site assessment was also carried out, including suitability and options for potential siting of wind or PV generators.

Typical Electricity Supply in Remote Soum Centres

There were many similarities between the Soum Centres visited. All Soum Centres visited had a modern diesel generator powering the whole village via a mini grid. The diesel generators were typically owned and operated by the local Soum administration, and were only operated for a few hours per day (typically 4-6 hours) because the Soum administration could not afford to buy enough diesel fuel for continuous operation.

Almost all Soum Centres operated a flat rate tariff structure without electricity meters, i.e. all domestic users pay the same amount irrespective of how much energy they use. Schools and hospitals often seemed to subsidise the operation of the diesel generator by disproportionately high tariffs for their electricity. They in turn obtained a budget allowance for electricity from the Departments of Education and Health.

Typical Water Supply in Remote Soum Centres

Water supply varied between Soum Centres. There were usually several pumps, some were hand-operated, others were electrical pumps powered from the mini-grid or diesel pumps. Improvements to the water supply did not seem to be a very high priority for any of the Soum Centres visited.

Scope for Renewable Energy and Energy Efficiency

The project was looking for suitable pilot sites which could demonstrate that renewable energy power system could be integrated with an existing diesel generator, and significantly improve the electricity supply in a remote Soum Centre.

The system size required to supply a Soum Centre depends largely on who will be supplied (i.e. only priority loads such as a hospital or all of the Soum Centre) and on its size (e.g. the number of households, number of rooms in the hospital, school, etc). Generally, due to the limited budget of this project, the impact of a renewable energy pilot system would be greater for a small Soum Centre.

A number of Soum Centres would benefit from energy efficiency measures. Several of the Soum Centres visited operated their diesel generator at full load. Energy use has to be restricted, otherwise the diesel generator cannot meet the demand. If operated in overload condition, the diesel generator's fuel consumption and therefore the running costs increase disproportionately, and in the worst case, the diesel will cut out. Whilst Soums usually have a second generator, it is not possible to operate two generators concurrently for economic reasons. Energy efficiency measures, namely energy efficient lighting, could reduce energy consumption substantially, and would free generating capacity for demand which currently cannot be met.

Selection of Potential Pilot Sites

The Mongolian Ministry of Infrastructure indicated after the initial site visits that the implementation of pilot projects in Western Mongolia would be preferred, as this would avoid overlap with other programmes. Therefore the two best suited Soum Centres of the ones visited in Western Mongolia were chosen for a more detailed assessment.

The Soum Centre of Zereg in Khovd Aimag was chosen because it had a significantly lower population during the summer months. The relatively small population meant that the renewable energy system could potentially supply power for the whole Soum Centre, rather than just for priority loads. As the the diesel generator did not operate during the summer, the Soum Centre would benefit significantly from a renewable energy system supplying power during this time.

The Soum Centre of Darvi in Govi-Altai Aimag was chosen for a number of reasons. The fact that the diesel generator was operated every day makes it ideally suited for a battery system to supply the hospital. The layout of the Soum Centre was such that all institutional buildings were located around a central square, with private houses in two or three outlying areas. The mini-grid was connected in such a way that the institutional buildings could be supplied independently of the houses. The Soum Centre already had separate accounts for the operation of the energy system, and was therefore already a step closer to a private operator model. Also, at least the institutional buildings and some of the households already had electricity meters installed.

The above two Soum Centres were proposed to the Ministry of Infrastructure as locations for the pilot systems. The MoI agreed to the proposed sites. The design for the two pilot systems was developed in consultation with the MoI, and was agreed with the ADB Project Officer.

4.2 Pilot Project 1 – Village Power Supply for Zereg Soum (Khovd Aimag)

A PV-diesel hybrid system supplying electricity to the whole Soum Centre was implemented at this site. A 6 kW_p PV system was installed to supplement the existing diesel generator. The PV system was designed to supply electricity to households as well as institutional buildings in the whole of the Soum Centre during periods when the generator is not operational. Energy efficiency measures were implemented to reduce energy demand.

This section describes the process of implementing the pilot system at Zereg, from initial survey and design to implementation and evaluation of the pilot.

4.2.1 Results and Analysis of Survey and Energy Audit

A detailed survey and energy audit was carried out in Zereg, which is summarised below.

Socio-Economic Profile

Zereg is a Soum Centre situated in the Aimag of Khovd. The population varied significantly on a seasonal basis, fluctuating from 200 households in the winter to 50-60 households in the summer. Part of this fluctuation was due to the culture of the nomadic herders who took their animals to different grazing areas as the seasons change, but also due to civil servants who left the centre for the summer. The average size of a household in Zereg was 5, comprising 2 adults and 3 children (Source: Ministry of Infrastructure, 1997 data).

Of household heads surveyed, 53% defined themselves as nomad herders and 8% as farmers. Incomes from these occupations were seasonal although the household income was often supplemented by a second regular or secondary income. Productive activities reflect the central role of livestock within the culture with high levels of output of meat, wool, camel hair and cashmere. Remaining householders worked in the civil service (28%), business (6%) or were retired, and most benefited from regular wages or a state pension.

According to the survey carried out, the average household income was approximately 800,000 MNT per year. In comparison, the national poverty line is at one US dollar per day per adult (Ministry of Population), which equates to very nearly the same amount. It is not possible to be conclusive about income poverty levels however due to the lack of information on income distribution. Alternative poverty indicators illustrate that the centre benefited from a reasonable level of socio-economic development. Life expectancy was 64 years, and gross enrolment ratio for primary school was 62%. Water and health services were also classified as good by the local population. (Source: Ministry of Infrastructure, 1997 data). Electricity services and appliances were deemed average.

Willingness and Ability to Pay for Electricity

Households in Zereg paid on average almost 12,000 MNT per month on solid fuels such as wood, dung, and coal, or 13% of total household expenditure. It is not likely that this expenditure would decrease with the advent of increased electricity supply.

To establish the ability to pay for an improved electricity supply, a calculation was made of what households were paying for electricity services: this was generally a flat rate of 6,000 MNT per month. Expenditures on other energy sources that would be substituted under the new electricity service were also factored in: these were estimated to be an average of 1,000 MNT per month for batteries and 3,000 MNT per month for candles, assuming fuel switching to electricity of 66%. This amounts to a total of 10,000 MNT per month as an average household’s ability to pay for electricity.

All households surveyed stated that they would like to see the service extended, with a majority expressing a preference for 24 hour service. For such a service, households stated on average that they would be willing to pay a total of 10,000 MNT per month for electricity. Of all households surveyed, 88% said they would prefer to pay for services monthly in arrears and tied to consumption. All households surveyed were prepared to pay a one-off connection fee, although levels were not quantified.

Energy expenditure accounted for 25% of household expenditure, which is a significant cost. All energy was used for domestic purposes and none for productive use. It is anticipated that the increase in availability of electricity will encourage productive use. For example, one person said that she would use a sewing machine to generate additional income for the household if electricity was available.

Consultation

During the preparation for the pilot projects, consultation meetings were held. People were asked whether a limited electricity supply would be acceptable. The feedback was that a limited amount of electricity would be preferable to their current situation. During installation of the pilot system, people were given leaflets, and a public meeting was held to explain how the new power system works. People were encouraged to tell their neighbours

and friends, as the renewable energy system could only work if everyone contributed to its success by using the limited amount of energy available sensibly. People appeared to be receptive to this message.

Electricity Supply and Energy Audit

The Soum Centre had an existing diesel generator and mini grid. Two 100 kVA diesel generators had been installed under a Japanese programme approximately in 1998. However, only one of the generators was operated at any one time because of the high cost of fuel. At the time of the survey, the second generator was not operational due to a hole in the radiator. The diesel generator supplied electricity to the Soum Centre between 18.30 and 22.30 each day in winter (September to May) to meet demand for lighting and other electrical appliances. During summer, the diesel generator was not operating and no electricity was supplied.

The main electricity use was for lighting. All lighting was incandescent light bulbs. Other household appliances included radios (often battery powered), TVs, video/DVD players, kettles and irons. The institutional buildings' main electricity use was also for lighting. In addition, the school had a photocopier, six computers, and some equipment which was only used occasionally, e.g. projector and power tools. The school dormitory had a washing machine, a TV, and an iron. The local administration also had a computer and printer. The school, hospital and local administration each had a small petrol generator.

A large potential for energy efficiency measures was observed. All lighting was by incandescent light bulbs, giving a large energy savings potential by substitution of incandescent light bulbs with compact fluorescent lights (CFLs). It was observed that lights as well as other appliances were often not switched off, but were operating whenever the diesel generator was running. In fact, some lights in the school did not even have a switch so had to be left on at all times.

The mini grid as well as electrical installations in buildings also appeared not to be in the best state of repair, resulting in losses as well as unsafe installations. There appeared to be a general lack of following best practice, which seemed to be due to lack of trained and technically competent personnel.

The generator was only run for 4 hours per day in winter and not at all during the summer months, because the local administration could not afford fuel to operate the generator for longer. Hence the Soum Centre was without electricity all summer and for 20 hours each day during the winter months.

Energy Demand Forecast

Energy consumption and maximum power demand were forecast using the current winter demand as a starting point. It was anticipated that energy efficiency as well as tariff measures would lead to a significant reduction in energy demand. Taking these measures into account, future winter and summer energy requirements were calculated. For the sizing of inverters, the maximum power demand at any one time is required. This was calculated based on estimates of which appliances were likely to be used concurrently. The results were later used for the sizing of the PV hybrid system required. The energy demand of households and of public buildings is shown separately.

Table 2 below summarises both the energy consumption and the peak power demand for the whole of the Soum Centre, split into present and future winter as well as future summer estimates.

Table 2: Summary of Energy and Power Demand Forecast for Zereg

	Soum Centre Consumption (kWh/day)		
	Present Winter Consumption	**Future Winter Consumption**	**Future Summer Consumption**
Households	217	143	7.5
Institutional buildings	67	46	15.7
Soum Centre total	284	189	23.2

	Soum Centre Peak Power Demand (kW)		
	Present Winter Demand	**Future Winter Load**	**Future Summer Load**
Households	56	33	3
Institutional buildings	22	12	2.7
Soum Centre total	78	45	5.7

4.2.2 Design of Pilot System

System Concept

The permanent population of Zereg Soum Centre was relatively small, with only around 50 families remaining during the summer months. During the winter, the population increased to around 200 families. Owing to the small population remaining there in summer, the Soum administration could not afford to operate the diesel generator at all during these months (typically, users only paid for the months during which they were connected). Hence a renewable energy system supplying electricity to the whole Soum Centre during the summer months was perceived to be able to make a significant impact.

Coupled with demand side management and energy efficiency measures, even a small PV system would be able to provide a basic electricity service for the whole of the Soum Centre during the summer months. During the winter months, when solar irradiance is significantly lower, the PV system would operate as a hybrid system with the diesel generator. The diesel generator would make up any shortfall in supply from the PV system and charge the battery, utilising the energy saved by implementing energy efficiency measures. The existing mini-grid would be used for electricity distribution.

The concept was to use existing infrastructure (diesel and mini grid), and improve the service by the addition of a small renewable energy system. A small PV system was sized to supply a *basic* electricity service for 24 hours for the whole of the Soum centre. The starting point was the situation prior to the pilot system implementation, i.e. no electricity for 20 hours each day in winter, and no electricity at all from May to September. This situation was to be improved, to allow people to have power for lighting, radio and possibly a small black and white TV set.

Due to budget limitations, the size of the RE pilot system was very limited. Hence, it was not envisaged to supply unlimited power or to enable people to have the same level of service as during the hours of diesel generator operation. Even a basic electricity service would be a vast improvement over the previous situation. It would however require the cooperation of all people in the village.

The system was designed to provide a basic electricity service, predominantly power for lighting, TV and radio. The aim was not to supply power for high-power appliances such as electric cookers etc. However, as the Soum Centre population previously had had no electricity at all over the summer months as well as for twenty hours each day in winter, this was seen as a big improvement.

Energy Efficiency Measures

Energy efficiency formed an integral part in the concept for the pilot system. In order to ensure value for money, the high-value electricity generated from renewable energy sources should not be wasted. It was seen as crucial that energy efficiency measures should be implemented at the same time as the PV system.

In order to reduce the electricity demand, energy efficiency measures were planned as part of the pilot project. The biggest impact was from replacing incandescent bulbs with CFLs, which reduced lighting loads by an estimated 75%. In addition, poor quality connectors in the distribution system were replaced, thus reducing distribution losses. Additional lights switches were fitted, allowing lights to be switched off. Fittings such as sockets, light switches, etc were made safe and replaced where necessary.

Demand-Based Dual Electricity Tariff

Electricity meters were installed with the view to charge for electricity per kWh at a relatively high rate, to encourage energy efficiency. Dual tariff meters were used to allow a higher rate to be charged for PV supply, reverting to a lower tariff during the times when the diesel generator is running. This was implemented through simple timed meter operation. A tariff based on metered consumption is fairer as each user pays for what they actually use. It had been expected that this would lead to significantly lower electricity payments for users with for instance only a single light.

The relatively high cost of dual-tariff electricity meters is a drawback of the concept. An alternative way of limiting demand would have been the use of load limiters or current limiting devices. They were cheaper than meters, but had the disadvantage of limiting power demand rather than giving an incentive to reduce energy consumption. In order to gain experience with load limiters, it was agreed with the ADB project officer to install load limiters instead of electricity meters for a number of households. These were installed for users who only operated low-power appliances such as lights and radio. These users were to be charged a monthly flat rate.

The concept assumed that total electricity demand of the Soum Centre would be reduced to the amount that can be supplied by the PV system by a combination of energy efficiency and tariff measures. It had been anticipated that the tariff might have to be adjusted during the initial stages of the operation of the system. A preliminary tariff model was developed and is described in Section 5.

System Configuration

The schematic in Figure 1 illustrates the system configuration.

The PV array produces DC power, which can be stored in a battery. The DC power from the PV array passes through a charge controller into a 48 V battery bank. The charge controller prevents overcharging of the battery. A valve-regulated lead acid (VRLA) battery was specified. The battery bank consists of 12 individual blocks of 4V each. The battery bank is also connected to three 5kW inverters.

The diesel generator produced three-phase AC of 230V (phase-neutral), which was fed into the mini grid. As only single-phase appliances were used, three single-phase inverters were selected, one connected to each phase of the mini grid. The inverter outputs cannot be connected to the output of the diesel generator whilst it is running. To make sure that only

either the inverters or the diesel generator can be connected to the mini grid at any one time, a transfer switch was specified.

A circuit diagram is shown in Annex 11.

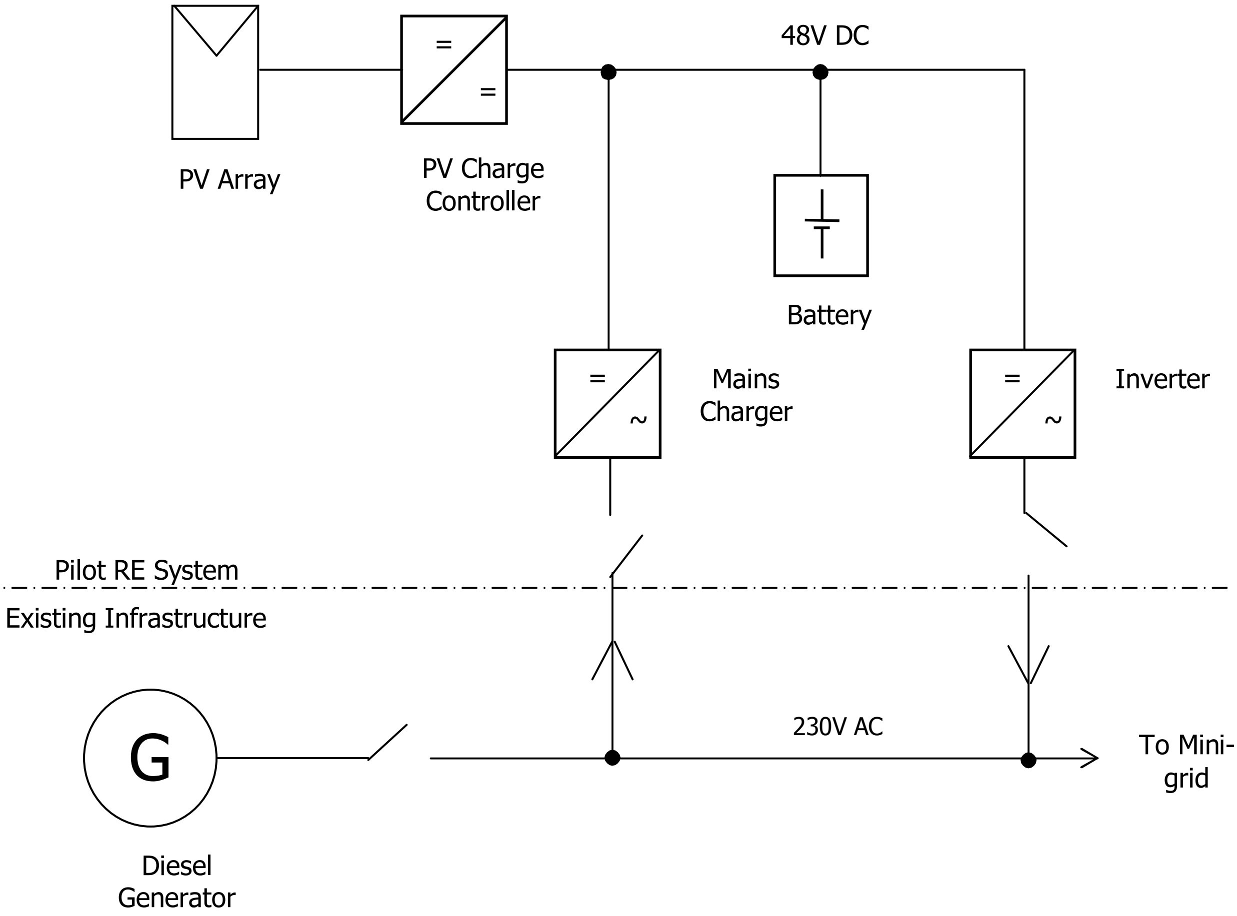

Figure 1 - System Design for RE Pilot at Zereg Soum Centre

4.2.3 Installation

A 6 kW_p PV system with battery, controller and inverters was installed in Zereg Soum Centre, and was connected to the existing diesel generator and mini grid. Intersolar, a Mongolian firm experienced in installing renewable energy systems, was subcontracted to carry out the installation work. The installation phase was planned in detail in close co-operation between IT Power's international and local Renewable Energy Experts, and Intersolar.

The PV array was installed on a flat area adjacent to the hospital, as shown in Figure 2. Although within the hospital fence, the array was enclosed by a basic fence to protect it against animals. The DC wiring was run underground to a room on the ground floor of the hospital, where the batteries, charge controller, inverters and other control gear were located. This is shown in Figure 3.

Figure 2: PV Array and Hospital Building

Figure 3: Battery Bank, Controller, Inverters and Associated Equipment

In order to provide power to the whole village using the existing mini grid, each inverter was connected to one phase of the mini grid. The output from the inverters was connected to the mini grid via a transfer switch, making sure that only either the inverters or the diesel generator can be connected at any one time. This was achieved by running a low-voltage (230V) overhead line to the power centre (the building with the diesel generator) and locating the transfer switch there. Figure 4 illustrates the construction of a short overhead line to connect the inverters to the mini grid.

Figure 4: Construction of Overhead Line to Connect to Mini Grid

In order to reduce the electricity demand, energy efficiency measures were implemented as part of the pilot project. The biggest impact was from replacing incandescent bulbs with CFLs, which reduced lighting loads by an estimated 75%. In addition to the PV system, kWh meters were installed in the households as well as in the institutional buildings.

The mini grid as well as electrical installations in buildings were in a poor state of repair. This included missing ceramic insulators (see Figure 5), perished insulation on cables (Figure 6), and poor connections to the overhead lines (Figure 7). Lack of sufficient insulation caused earth leakage currents, whilst poor connections led to increased conductor resistance resulting in voltage drops. Poor quality connectors in the distribution system were replaced, thus reducing distribution losses. Additional lights switches were fitted, allowing lights to be switched off. Many fittings such as sockets or light switches had been broken (see Figure 8) and were replaced.

Figure 5: Missing Ceramic Insulator on Overhead Line

Figure 6: Perished Insulation on Cables and Poor Connection

Figure 7: Poor Connection to Overhead Lines

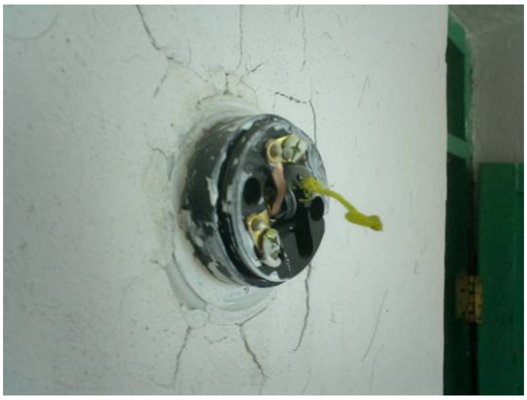

Figure 8: Light Switch Without Cover in School Dormitory

The extent of the problems with the mini grid and the electrical installations in the buildings only became apparent during installation and commissioning. During commissioning, the inverters operated at full load or were overloaded, even with all appliances turned off. This was caused by the losses in the mini grid as well as in the electrical installations in the buildings. Obviously, this had to be rectified in order to allow operation of the system.

During the installation period, IT Power had a number of meetings with representatives from the Soum Administration, namely the Soum Governor, the Vice-Governor, and the Soum accountant, to discuss the operation of the pilot system. Issues such as limited availability of energy from the PV system, electricity tariffs based on usage, theft of electricity, etc were discussed at length. A public meeting was held in order to explain the system to the

population of the Soum Centre (see Figure 9). A short leaflet was produced explaining what the system could provide and what its limitations were..

Figure 9: Public Meeting to Introduce the Pilot System

The Soum Administration decided that the day-to-day operation and maintenance of the PV system would be carried out by the operator of the diesel generator. Training for the operation of the PV system was provided by the installers, under the supervision of IT Power. Figure 10 shows the training of local personnel.

Figure 10: Training of Local Personnel

4.2.4 Operation and Monitoring of the Pilot Scheme

PV System

When the pilot system was installed, the PV system was connected to the mini grid, thus giving access to the energy from the PV system to all households and institutions.

During commissioning it became apparent already that is would not be easy to convince people to save energy. Whilst everyone agreed that they would contribute to saving energy, it was found that people left appliances on which were not used, and outdoor lights were found left on in broad daylight.

During the period just after installation, the PV system supplied energy to all households of the Soum centre. This coincided with the end of the holiday period, with only few families being at the Soum Centre. As more families moved back to the Soum Centre, the system became overloaded and frequent inverter tripping caused by overload occurred. The Soum administration did not manage to reduce consumption sufficiently to make the system work and decided to disconnect the households, leaving only the institutions and a few households

connected to the PV system. Attempts were made to connect households again, but in the long term, only around ten households remained connected permanently.

At the beginning of February 2005, the PV charge controller broke down. It is believed that the controller failure was due to a short circuit caused by the operator. Due to lead times of the supplier, the controller could not be replaced until May. Immediately following this breakdown, the PV system did not generate any power. The operator was then instructed to perform the charge controller function manually, by disconnecting the PV array at night and monitoring the battery voltage with a multimeter. This ensured that the PV system could be used to generate power whilst waiting for the replacement controller. Since May, no technical problems with the system have been reported.

Electricity meters were installed to monitor the total generation of the PV pilot system. Additional monitoring equipment was installed some while later to allow more detailed performance monitoring of the system. Until May 2005, monitoring data was collected regularly by the English teacher, an American living in Zereg. After he had left, it became very difficult to obtain monitoring data. There appeared to be a complete lack of interest in recording and forwarding performance data.

The monitoring data obtained showed that an average of 106 kWh of electricity was used per week. Over the summer, this corresponds with the electricity generated by the PV system; in the winter, some of the electricity had been generated by the diesel generator and stored in the batteries.

Energy Efficiency

The energy efficiency measures carried out as part of the project were very successful and led to very positive results. The work carried out on the mini grid and the installations in buildings reduced system losses. The biggest impact however was from the distribution of CFLs, which led to a significant reduction in power demand. The typical winter evening demand was reduced from 100-120 kW to 60-70 kW, and the autumn and spring demand from 80-90 kW to 50-60 kW. This in turn led to reduced fuel consumption. A summary of the savings is shown in Table 3. Previously, about 2,500 litres of fuel were used per month and after the installation of CFLs this was reduce to about 1,860 litres per month. This is a decrease in fuel consumption of about 25%, which has allowed the Soum centre administration to make a small profit which was used to repay debt. The financial savings also helped the Soum administration to be able to cope with fuel price increases without having to increase the electricity tariff.

Table 3: Energy Savings Resulting from Energy Efficiency Measures

	Before EE Measures	**After EE Measures**
Load (winter)	100-120 kW	60-70 kW
Load (summer)	80-90 kW	40-50 kW
Fuel price	550 MNT/litre	880 MNT/litre
Typical Fuel consumption	22 litres/h	14 litres/h

The measures undertaken to make the mini grid and the wiring in the houses more efficient were also successful. Losses due to leakage were reduced significantly after the installation of the PV system. However, not all problems could be eliminated, for instance due to practical problems such as lack of access to buildings because people were absent. Another problem was caused by the semi-nomadic lifestyle of the majority of the population. Families moving to the Soum centre in autumn and away again in spring meant that the mini grid and its subscribers was constantly changing. Often, people would even connect or

disconnect their supply themselves. This made it very difficult to maintain a high level of quality and to ensure the system has minimal losses. It also meant that this is an ongoing process, requiring constant attention, rather than a one-off action. Local personnel was trained to enable them to carry maintenance work out themselves.

The project failed to change user behaviour to a significant extent. Whilst positive and even enthusiastic responses had been received during meetings (both during the preparation phase and during implementation), in practice people did not change their behaviour. People had always been used to having as much electricity as they wanted (albeit not continuously). The idea that electricity is limited and therefore should be used sparingly, was totally new. In the short time available during this project, people could not be persuaded to change lifelong habits.

Introduction of Demand-Based Electricity Tariff

The project had aimed to use a tariff based on actual usage for billing of electricity. The concept of metering electricity and charging according to consumption had been explained to the Soum Governor and Vice-Governor during a number of meetings. During these meetings, they agreed to implement a tariff based on actual consumption. However, in practice, this tariff never really worked. It is difficult to assess whether the introduction of a new tariff failed due to lack of effort in implementing it, or whether the Soum Administration tried to implement it but failed to enforce it. The reason given for the new tariff scheme not working was that people would simply bypass the meters, and that the scheme therefore would not work. The Soum Administration stated that theft of electricity was a common problem in Mongolia. Due to the nature of the mini grid, people would simply connect to it without much regard for regulations or tariffs.

Overall Assessment

The pilot system demonstrated that it is technically possible to integrate a relatively small renewable energy system with an existing diesel generator and mini grid. However, the project failed to achieve its aim to provide a service of continuously available electricity to all subscribers. This was not because of technical problems, but due to social and institutional barriers.

It was found that people overused the system, both in terms of power capacity (too much power demand resulting in inverter overloads), and in terms of energy usage (leading to an empty battery and no power for anyone). The system was overused to such an extent that inverter trips due to overload occurred continually. The problem was exacerbated by new people moving back to the Soum centre for the beginning of the school year. This meant that the system could not operate as planned. In the end, the Soum administration gave up and disconnected the households from the PV system. The mini grid was reconfigured in such a way that only the institutional buildings and a few households were supplied by PV power.

4.3 Pilot Project 2 –Power Supply for Darvi Hospital (Govi-Altai Aimag)

A wind-diesel hybrid system supplying electricity to the hospital was implemented in Darvi, in order to gain experience with a wind hybrid system. A 1 kW wind turbine was installed to supply power just for the hospital during periods when the diesel generator is not operating.

4.3.1 Background

A detailed survey was done in Darvi. The results can be found in Progress Report I.

The permanent population of Darvi Soum Centre was larger than Zereg, with around 140 households remaining during the summer months. Due to the larger population as well as

budget constraints, a system supplying the whole of the Soum centre was not feasible. It was therefore decided to install a system which supplies power for the hospital, as the building with the highest priority.

The existing diesel generator supplied electricity for the operation of a water pump and of the district heating system. It operated all year round, for about three hours per day during the summer, and up to 12 hours per day during the winter (typically 06.00 – 12.00 and 18.00 - midnight).

4.3.2 Design of Pilot System

Figure 11 shows the configuration of the system. The wind hybrid system was designed to provide a basic electricity service for the hospital during the hours when the diesel generator is not operational. While the diesel generator is operating, the renewable energy system would operate as a hybrid system with the diesel generator, with the option of charging the battery from the diesel generator. If there was surplus energy available from the RE system, other priority loads (e.g. school/dormitory or local government building) could be supplied. Similar to the renewable energy system for Zereg, the wind power system was not able to supply power for high-power appliances such as electric cookers etc.

A circuit diagram is shown in Annex 11.

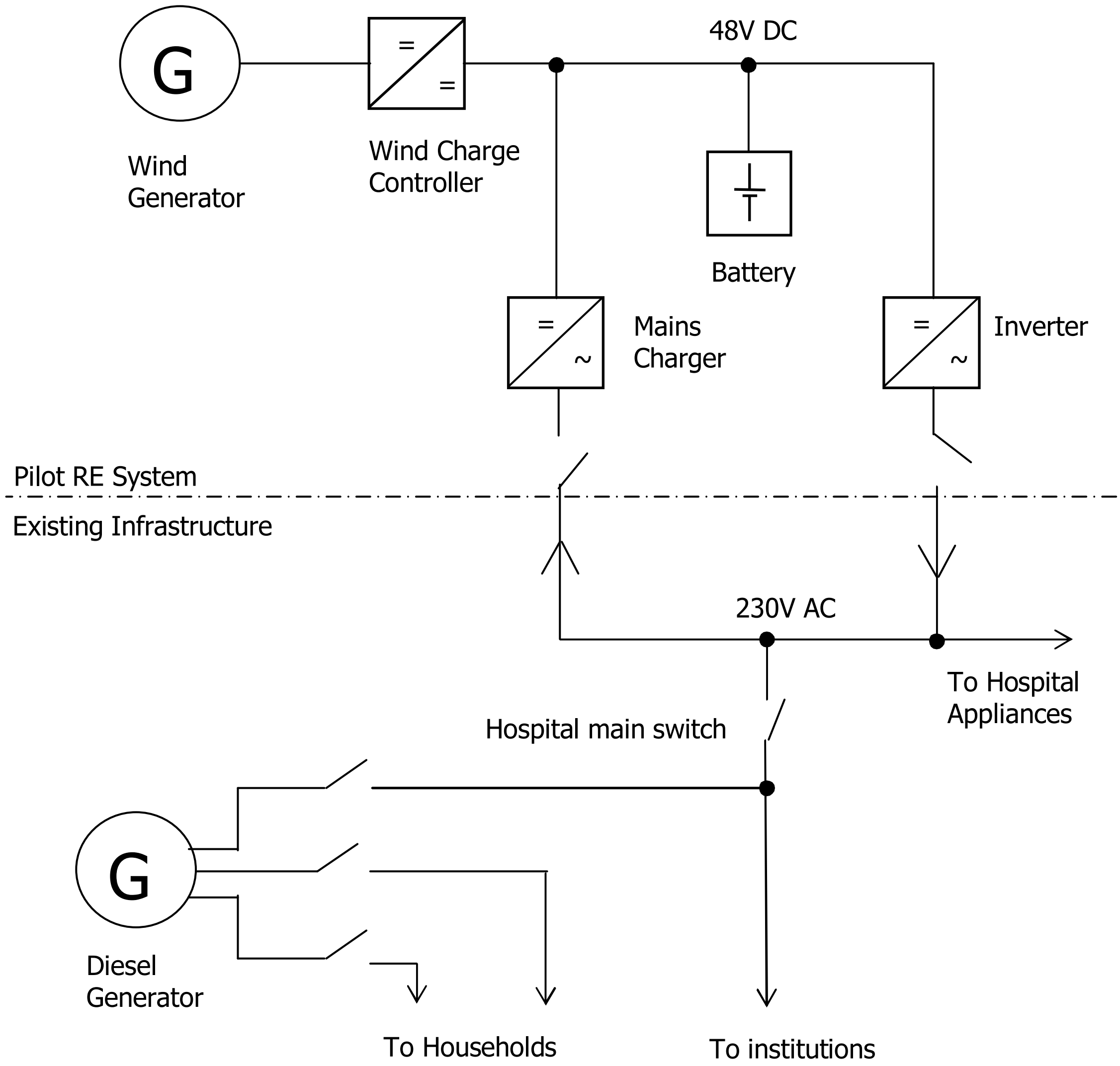

Figure 11: System Design for Pilot at Darvi Soum Centre

Responsibility for the operation of the wind system ultimately rested with the local administration. The day-to-day operation and maintenance of the wind power system was carried out by the hospital's caretaker. Basic training for the operation of the wind power system was provided by the installers, under the supervision of IT Power.

Some energy efficiency measures for the whole Soum Centre were implemented, in order to reduce energy demand and to promote good practice. As in Zereg, incandescent bulbs were replaced with CFLs to reduce lighting loads, and poor quality connectors in the distribution system were replaced to reduce losses.

It was recommended that financial provisions for repairs and component replacement should be made in line with recommendations made in the previous Progress Report.

4.3.3 Installation

A 1 kW wind turbine was installed on a small hill near the square on which the hospital was located, as shown in Figure 12. A cable was run underground from the wind turbine location to a room in the hospital, where the batteries, charge controller, inverter and other control gear were located. This is shown in Figure 13.

Figure 12: Wind Turbine in Darvi

Figure 13: Battery Bank, Controller, Inverters and Associated Equipment

4.3.4 Operation and Monitoring of the Pilot System

The wind power system only supplied power to the hospital, hence the Soum Centre's power system had very little impact on its operation. Its operation was not influenced by many factors and was therefore much less complex than in Zereg.

The system had been operational throughout from installation to the end of the monitoring period, and no problems were reported.

During the six months Nov 04 to Apr 05, the wind turbine generated approximately 500 kWh. An additional 700 kWh was provided by charging the battery from the diesel generator.

The Soum administration mentioned plans to extend the use of the wind power system to the school dormitory. Before this is realised, further analysis is recommended to ascertain that this additional load will not overload the system.

Energy efficiency measures in Darvi Soum consisted mainly in the distribution of CFLs. It became apparent in December 2004 that the Soum administration had not distributed half of the CFLs provided. In April 2005, the operator confirmed that the remaining CFLs had been distributed to the households, but that this had not affected the power and fuel used.

4.4 Lessons Learnt

State of the Electricity Distribution System

Particularly in Zereg, it was found that the electricity distribution system appeared to have been neglected for many years and was in a very poor state of repair. This applied to both the mini grid as well as electrical installations in buildings, resulting in losses as well as safety concerns. Possible reasons for this are a lack of suitably trained and technically competent personnel as well as lack of funding, possibly coupled with a lack of standards and regulations. Discussions with a representative from the provincial administration in Khovd indicated that the situation is similar in most Soum centres.

Any renewable energy scheme wishing to utilise the existing electricity distribution infrastructure will rely on this being in a serviceable state. It is recommended that a thorough survey is undertaken during the preparation of any similar future projects.

Another issue is ongoing maintenance and repairs. A distribution system with overhead wires will require some maintenance. The problem is exacerbated by the fact that nomadic householders are being disconnected and reconnected on a regular basis. It seemed that these connections are sometimes even done by the householders themselves.

Internal wiring is often done by the householders themselves. Wiring was often found to be unsafe. A certain amount of know how is required in order to avoid and detect faulty wiring which may lead to malfunctioning, earth faults and losses, and serious health and safety hazards. Wiring in the buildings was improved as part of the project, to reduce losses and to improve safety.

Bringing the whole of a Soum centre's electrical system up to a high standard is a huge task which must not be underestimated. Most likely, it would require a skilled national or international expert to be at hand for a period of several weeks, to supervise and train local personnel.

In order to ensure that best practice is adhered to at least to some degree, better local expertise is required. This would lead to reduced losses and a safer system. There is a definite need for training and capacity building in this area.

Potential for Energy Efficiency Measures

In the Soums visited and particularly in the Soums where the pilot systems were installed, a huge potential for energy efficiency was observed. It is very likely that this is the case throughout rural Mongolia. For any future renewable energy projects, it would make economic sense to implement energy efficiency before or at the same time as a renewable energy system is installed, in order to reduce the required capacity.

The largest energy saving potential can be realised by replacing incandescent light bulbs with CFLs. In the pilot locations, lighting accounts for the largest part of the load. Incandescent light bulbs use 4-5 times as much energy as CFLs for the same output. In the Soum Centres chosen for the pilot systems, large energy savings were foreseen and could be

realised simply by replacing incandescent bulbs with CFLs. CFLs were distributed as part of the pilot project, leading to a significant reduction in power demand.

Energy was also wasted due to losses in both the distribution network and in the wiring systems of the buildings. Losses resulted from leakage currents, and from poor connections.

A very important area was waste of energy due to user behaviour. This included not switching off lights and other appliances when they are not required. Many lights were seen on in broad daylight, serving no useful purpose. Previously, light switches were not really required as the diesel operating hours more or less coincided with the hours during which lighting was required. Once such habits are established, they cannot be changed overnight. A significant and prolonged educational effort is required to change user behaviour. This process was initiated by the project, by extensive discussions with local government representatives, and by public meetings.

The existing wiring encouraged or even required behaviour which is not sensible in terms of energy efficiency. Sometimes, power sockets were wired into a lighting circuit, requiring the lights to be on for charging a phone or running any appliance. Often, several lights are switched on with the same switch. As part of the pilot project, some of the wiring was changed to enable people to use energy more sensibly.

Tariffs

Measures to encourage efficient use of energy should be introduced. The flat-rate electricity tariff commonly used in Soum centres does not encourage people to conserve energy. The introduction of tariffs based on metered actual consumption should be encouraged as an incentive for energy efficiency. It is also a fairer way to charge for electricity.

A demand-based tariff is of no use if it cannot be enforced. Theft of electricity is a serious problem, in rural as well as in urban Mongolia. The legal powers to enforce payment and to deal with non-payers and people stealing electricity by bypassing meters are very limited. As a result, it is very difficult to use tariffs as an effective means to reduce consumption, or to direct consumption from periods of solar to period of diesel supply. Means should be provided to ensure that a new tariff can be enforced.

A demand-based tariff presents a completely new concept of paying for electricity for most of rural Mongolia. The introduction of such a tariff is unlikely to be without problems. The introduction may require some time, and external support and assistance may be required.

The social acceptance of such a tariff should not be taken for granted. Generally, poorer people with fewer appliances will benefit from a lower electricity bill. In order to make up for the shortfall, higher users will have to pay more. The users with the highest consumption are typically the richest and often the most influential subscribers. It is therefore important to convince them that the new tariff is in everyone's interest.

Ownership and Operation of System

Usually the local administration is responsible for the operation of the power system and the diesel generator, and is therefore likely to take responsibility for any renewable energy system as well. It is recommended that the accounts for the whole electricity supply system (i.e. for the operation of diesel generator and renewable energy system) are kept strictly separate from the Soum administration's general accounts.

Alternative operational models are possible. This is discussed in Section 5

Renewable energy systems are likely to require maintenance and replacement components before the end of their life. Most notably, the storage battery will need to be replaced after five or ten years. As the expenditure involved in major component replacement would be too great to be met from the normal operational budget, it is recommended that provisions

for repairs and component replacement should be made. Ideally, a separate fund for repairs and component replacement should be set up. This account should be under the joint control of the Soum and Aimag administrations, to avoid funds being diverted to other causes. Without a repairs and component replacement fund, it is possible that the whole renewable energy system might fall into disuse as a result of a component failure.

Implementation of Future Renewable Energy Projects

The introduction of renewable energy without utilising the existing potential for energy efficiency does not make technical or economic sense. A transition to an energy-efficient Soum would require significant co-operation and change of behaviour by users. The only way to achieve this is probably by charging electricity according to usage, to give people a financial incentive to save energy. To implement this in practice, electricity theft by bypassing meters must be eliminated.

For the implementation of similar renewable energy schemes in the future, a two-staged approach is recommended. This would start with the implementation of energy efficiency measures, metering of electricity and a new consumption-based tariff. The successful implementation and trialling of these would have to be demonstrated before the renewable energy system is installed. As people are very keen to get a renewable energy system, this would serve as a real incentive to make a success of the demand-side measures and reduce the demand. If the installation of a renewable energy system is conditional on the successful implementation of an energy efficiency programme, including changes in user behaviour, everyone would have a real incentive to co-operate fully. The longer implementation period and higher involvement of the local administration would hopefully also lead to a higher level of ownership of the whole scheme.

The following steps are given as example of this approach:

- Discuss the project in detail with the Soum administration as well as the people. This would require several meetings over a period of time for the beneficiaries to reflect.
- Draw up an agreement (relevant ministry and Soum administration) detailing the stages of project implementation and the conditions
- Implement energy efficiency measures (e.g. install CFLs and meters, improve the grid, introduce a usage-based tariff). User training.
- During a period of time, there should be a reduction in energy demand, as people learn to save money by saving energy. Any attempts to bypass meters should be identified, and penalised (if a fine is not possible, the user could be disconnected for a month or two). The Soum administration could during this time improve the quality of the grid (using local personnel trained by the project, and materials provided under the project)
- Carry out regular checks on the progress. Everyone should be aware that the installation of the renewable energy system is conditional on a successful outcome of the energy efficiency programme.
- Install renewable energy system, and train operators.

4.5 Conclusions from the Pilot Projects

- The pilot project did not reach its objectives to provide a limited electric service for the whole of the Soum centre for 24 hours per day. The level of co-operation which this would have required could not be reached. However, many valuable lessons could be learned from the pilot projects.
- Significant progress was made regarding energy efficiency measures. The distribution of CFLs reduced electricity demand significantly. Losses could be reduced within the mini grid as well as within buildings.

- The pilot project demonstrated that it is technically feasible to integrate a small renewable energy system with an existing diesel generator and mini grid, but that it is much more difficult to achieve significant changes in user behaviour. Such changes are essential, in order to make best use of a renewable energy system.
- The potential for energy efficiency in rural Mongolia is huge. Implementation of energy efficiency measures should go hand in hand with the introduction of renewable energy schemes.
- The effort required for refurbishing an existing mini grid and electrical installations in buildings must not be underestimated.
- Training and capacity building is required to enable local people to maintain their electricity distribution system.
- Measures to encourage efficient use of energy should be introduced. The flat-rate electricity tariff commonly used in Soum centres does not encourage people to conserve energy, and should be replaced by a consumption-based tariff.
- The use of a consumption-based tariff requires metering of electricity. Measures must be taken to ensure that meters are not bypassed by users.
- Alternative concepts of operation and possibly ownership of the power system should be explored.
- For future renewable energy schemes, a two-stage approach is recommended; with the successful implementation of demand-side measures as a pre-requisite for the installation of a renewable energy system.

5 RE MARKET IMPROVEMENT AND ECONOMIC REVIEW

5.1 Proposed Finance mechanisms and Private Sector participation for Soum Centres in Mongolia

5.1.1 Summary

This section presents recommendations for the organisational structure and financing of rural electrification in Mongolian Soum centres. The first part describes potential least cost financing schemes for Soum centres based on experiences from the two pilot schemes and the second suggests financing schemes and organisational structure for the electrification of further Soum centres in the future.

An organisational and financing mechanism for each of the Soum centres was recommended and is described below. The emphasis in these projects is to cover the O & M costs of the installations in order to achieve long term sustainability. The capital cost of the systems has been covered by an external grant (the ADB grant).

In the future, for the electrification of further Soum centres two scenarios must be considered, 1) financing mechanisms with grant for capital equipment and 2) how to finance electrification without a grant for capital equipment. These scenarios will be examined in the next section.

5.1.2 Typical Soum Administration

The Zereg Soum, with its previous existing 100 kVa diesel generators run by the Soum administration, was typical of soum electricity adminstration. The Soum administration operates and carries out the maintenance on the diesel system. The accounts for the electricity system are at present part of the whole Soum finance and accounting department, there is therefore no separate accounting for the electricity costs or income. The households pay a flat monthly rate for electricity in the winter and have no electricity in the summer. The households pay out of their income. The public buildings (hospital, school) also pay a flat rate, although this is higher than for the households. The public buildings receive a fixed budget from the state, part of which is allocated for electricity costs. The system is represented in Figure 14 below.

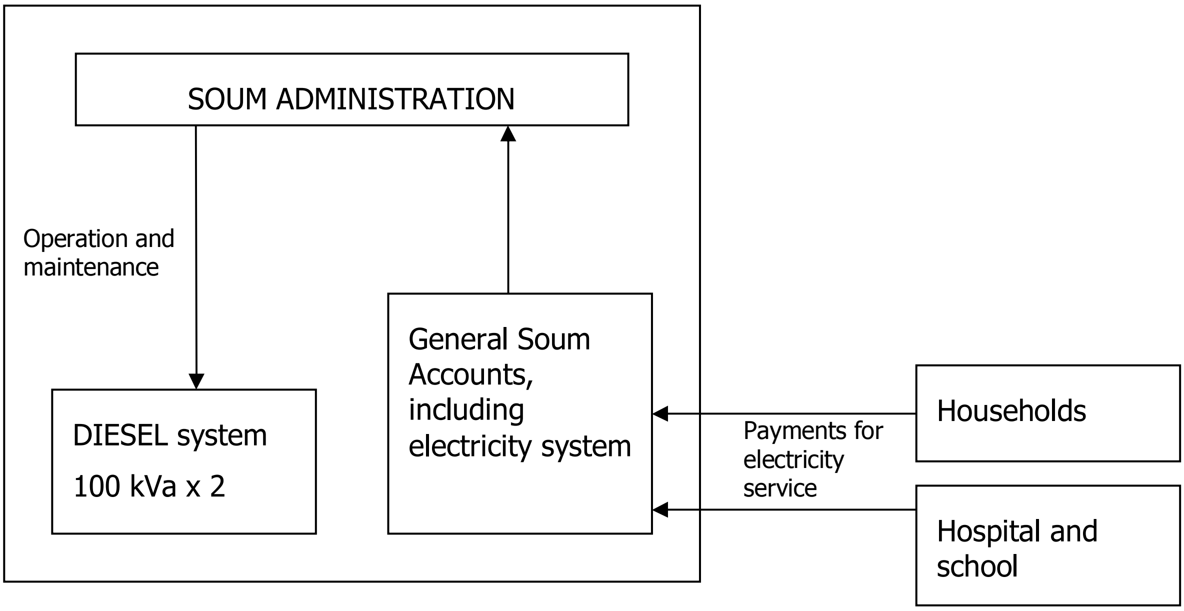

Figure 14. Zereg Soum electricity service organisation and accounts

Organisational and accounting scheme

With the integration of the PV system into the existing diesel mini-grid, a new organisational and accounting scheme should be put in place within the Soum administration. Consideration has to be given to how to keep the operation and maintenance costs at a minimum, while having a system that is accountable and can be self-sustaining.

It is therefore proposed to keep the operation and maintenance of the PV-diesel hybrid system under the responsibility of the administration, to minimise personnel costs and disruption to the maintenance of the diesel system. The staff responsible for maintenance of the diesel system will be trained to maintain the PV-diesel hybrid.

However, in order to move toward a private model for O& M of the system, it is recommended to make the accounts of the electricity system completely separate from the Soum's general accounts. This will enable the Soum to analyse costs of the system over the coming years and provide transparency on the costs of O&M.

It is also recommended that a separate fund is set up for O & M (repair /replacement fund described below), in particular in order to buy spare parts to replace broken parts or parts that come to the end of their useful life. This fund could be administered by the Soum and Aimag administration together to minimise the risk of misuse of the funds and could be under the responsibility of the Energy Committee (see below).

An essential part of the scheme to support the new hybrid system involves the setting-up of an Energy Committee within the Soum administration. The Energy Committee could be composed of the following members (these are simply suggestions with the final decision left in the hands of the Soum administration):

- Soum Governor;
- Director of school;
- Representative from hospital;
- representatives for households;

- Representative from Energy Authority Khovd branch office (mainly for tariff matters);
- Representative from Khovd Aimag government.

The functions and responsibilities of the Energy Committee would be as follows:

- Supervise the operator of the PV-diesel system;
- Resolve any problems, e.g. need for repairs, theft of electricity, etc.;
- Supervise meter reading and the collection of money;
- Adjust tariffs if necessary (increase or decrease), to generate enough income to cover operating costs and a surplus for repair / replacement fund;
- Responsible for the repair / replacement fund.

The new organisational and accounts system is represented in Figure 15.

The next step toward a private model for electricity service in the Soum, would be that the Soum could choose to tender out the O & M of the PV-diesel hybrid to a private company, paying a fixed lump sum to the company for its services, while continuing to collect payment from the households and public buildings. Payment to the private company could be linked to satisfaction of the clients with their services.

A final step to complete privatisation of the electricity service would be to also remove the payment collection function from within the Soum administration. A private company would take on a tendered contract to supply electricity and collect all payments from clients. These contracts could be established between the Soum and a private company over a period of 5 years, with perhaps a 1 year trial period at the start of the contract.

However, before these further steps can be envisaged it is important that the first step of separating the electricity accounts from the general Soum accounts is carried out. This will enable the electricity system to become accountable and the costs and income of the system to be transparent.

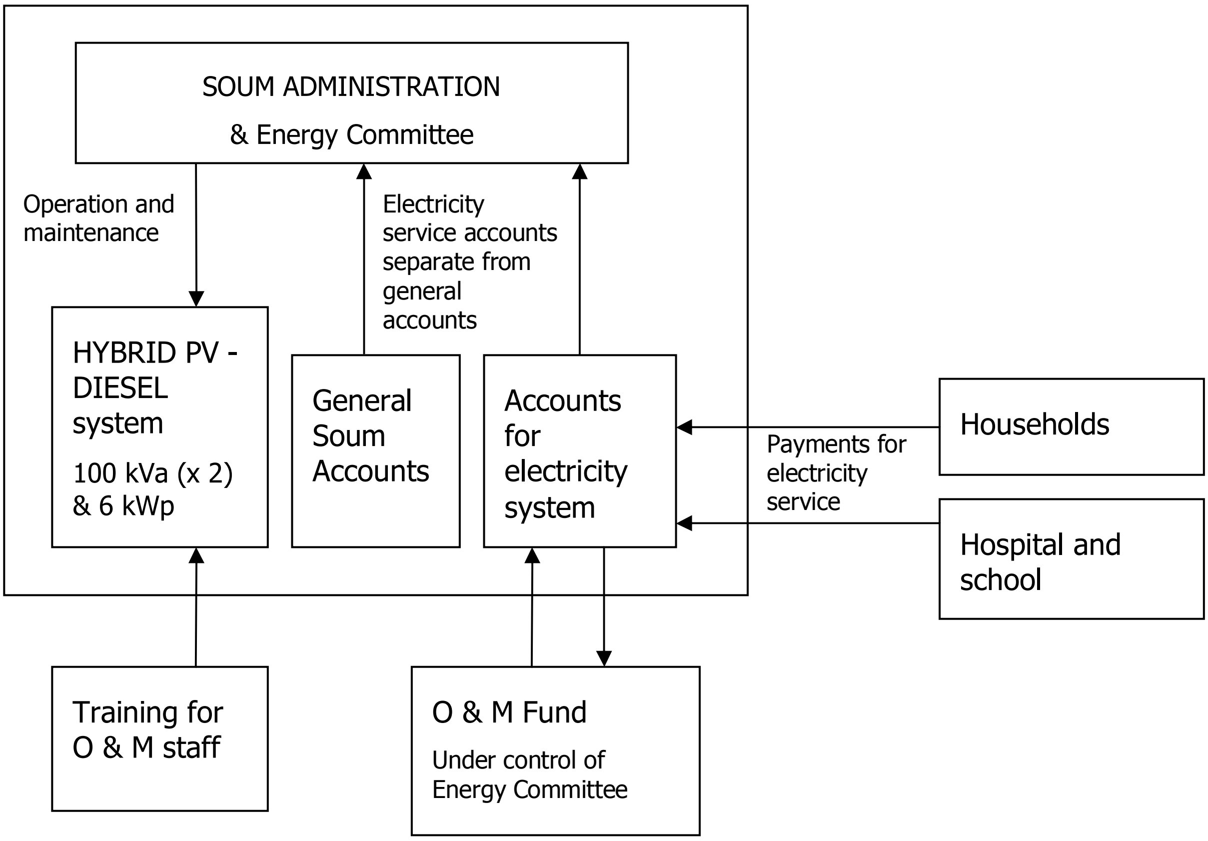

Figure 15. Zereg Soum electricity service recommended organisation and accounts

Proposed tariff system

The ideal payment mechanism is to introduce a tariff system with payment by consumption (kWh). Electricity will be charged according to usage; people who use more will have to pay more. However the pilot project showed that significant training and time is needed to be able to introduce this successfully.

The tariffs should be different in the winter and summer to reflect the cost of the system being used. A two-tariff system could be implemented. One tariff will apply during the times when the diesel generator is operating, i.e. during winter evenings. A second, more expensive tariff applies during the time when the diesel is not running and the PV system is providing electricity, i.e. during the summer. The meters which have been installed have two counters and switch over from one tariff to the other according to the time of day.

In the summer the PV system will be used exclusively. In the winter the system will work as a hybrid with the diesel generators providing electricity when the PV system is not producing. The reason for the high 'solar tariff' is to encourage people to use less electricity, because only a limited amount of energy is available from the PV system. The higher price should lead to a reduction in electricity consumption, and therefore enable the system to run for longer (and for 24 hours if everything works as planned).

During the initial stages, it may be necessary to change the tariff in order to find the level at which demand and available energy match. The initial tariff should be set too high rather than too low, as it would be easy to reduce it if was found to be too high, whereas there might be problems with public acceptance if the tariff had to be increased.

The tariff level should be set at such a level as to cover the O & M costs, including money to be set aside in the O & M fund for purchase of new parts and replacement of equipment at lifetime end. The tariff should also take into account the willingness and ability of the consumers to pay. In order to provide a minimum income for the Soum administration, a fixed monthly fee could be charged in addition to the kWh tariff.

The decision for setting the tariff rests with the Soum administration or ideally with the new Energy Committee. It is anticipated that further discussions with the representatives of the Soum administration are required. The tariff also has to be approved by the Energy Regulatory Authority.

Load limiters - fixed tariff

Experience from the pilots shows that for it is easier to introduce a fixed tariff in existing electrified soums due to the in-built experience. For users with only 1-2 lights and a radio, a device is available which limits the current which they can draw at any one time. These are to be used as a trial, on households that volunteer for load limiters. Only a limited number of load limiters is available.

Users with a load limiter will pay a monthly fee. The monthly amount should be similar to what a metered user with 1-2 lights would have to pay, and is less than the amount users pay now.

Theft of electricity by bypassing meters

It is relatively easy to bypass the meters by running a cable directly from the load to the grid. This is obviously a problem because the operator will receive less money. Also, the user will not have any incentive to conserve energy any more, which could lead to system overload. It is therefore important that, if this occurs, it is discovered quickly, and that it is stopped immediately. The operator may notice discrepancies in consumption (sudden drop of use of electricity), upon which he should investigate further.

There should be penalties for theft of electricity - e.g. disconnection for 3 or 6 months, or fines if this can be enforced.

Enforcing payment

Users who use more than they can afford should receive 1 or 2 warnings, and then be disconnected until they have paid their bill. A prepayment / deposit scheme should be considered if there are people who regularly can't afford to pay their bill (i.e. people pay a lump sum / deposit in advance, and are then billed for what they use. If they cannot pay, the deposit gets used, and non-payers can be disconnected before they are in arrears by a large amount.

Repair / Replacement Fund

No matter how well a system is designed and built, breakdowns will occur eventually. Breakdowns will usually be beyond the capabilities of the operator, hence require external assistance and possibly replacement components. If there is no budget to cover such eventualities, a minor fault could lead to the whole system being not useable and falling into disrepair. Therefore, for the long-term sustainability of the project, it is essential that a budget is available for necessary repairs.

The purpose of the fund is to provide the necessary budget for any repairs which may be required and for a new battery when this will become due for replacement. The money in this fund should be kept entirely separately from other Soum funds, and safeguards should be put in place to avoid the money being misused for other purposes. It is suggested that an account is opened which requires two signatures to obtain money - one from the Aimag government or MoI, the other from the Soum Governor.

Tariffs have to be set at a level sufficiently high to allow regular saving into this fund. As a guide, about 25-30% of the income from electricity should go into the fund.

5.1.3 Darvi Soum

Existing system

In Darvi Soum there were three existing 100 kVa diesel generators run by the Soum administration. The Soum administration operates and carries out the maintenance on the diesel system. In contrast to Zereg, the accounts for the electricity system at Darvi Soum are already separate from the general Soum finance and accounting department. Another difference from Zereg is that the households already pay for consumption in the winter and summer, although hours of electricity supply are limited. The public buildings (hospital, school) pay a flat rate, as in Zereg. The system is represented in Figure 14 below.

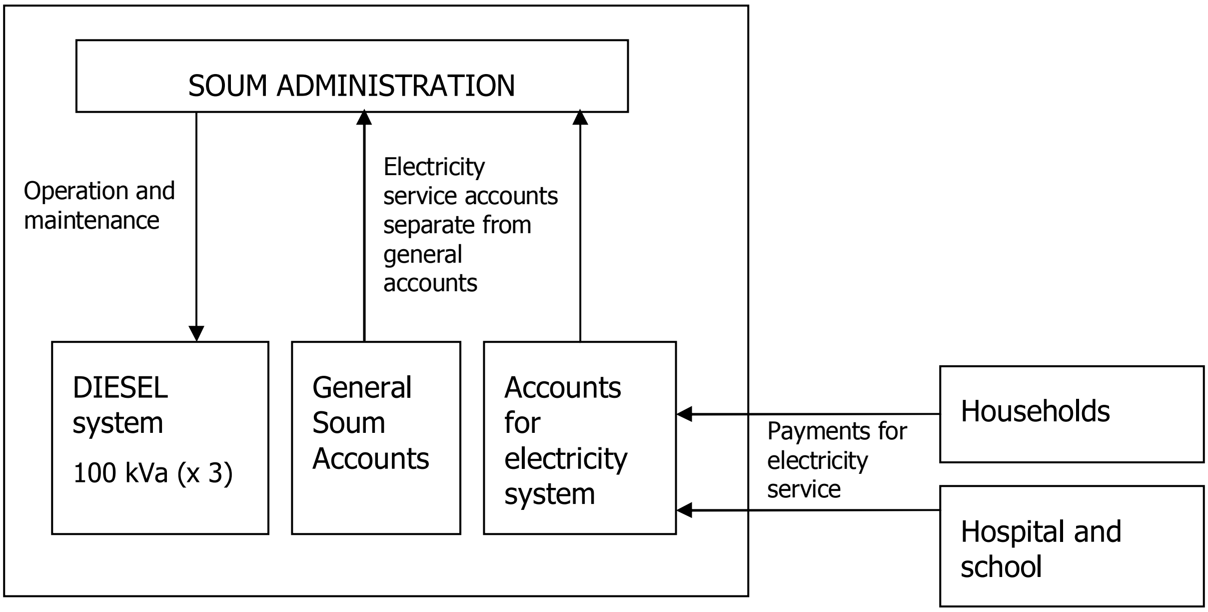

Figure 16. Darvi electricity service organisation and accounts

Organisational and financing scheme

Consideration has to be given to how to keep the operation and maintenance costs at a minimum, while having a system that is accountable and can be self-sustaining. It was therefore proposed to keep the operation and maintenance of the wind-diesel hybrid system under the responsibility of the administration, to minimise personnel costs and disruption to the maintenance of the diesel system. The staff (hospital staff?) responsible for maintenance of the diesel system will be trained to maintain the whole wind-diesel hybrid.

Since the electricity system is already accounted for separately, the first step toward a private model for O& M of the system has been taken. The Soum should be able to analyse costs of the system over the coming years and provide transparency on the costs of O&M. As at Zereg, it is recommended that a separate fund is set up for O & M, in particular in order to buy spare parts to replace broken parts or parts that come to the end of their useful life. This fund could be administered by the Soum and Aimag administration (under the Energy Committee) together to minimise the risk of misuse of the funds.

As at Zereg, an essential part of the scheme to support the new hybrid system involves the setting-up of an Energy Committee within the Soum administration. This would have a similar role and responsibilities as previously described for Zereg Soum.

Again, as for Zereg, the scheme can slowly move towards complete privatisation by tendering out the O & M and then eventually tendering out the O & M and collection of payments for electricity (as described in more detail above for Zereg).

The new organisational scheme is presented in Figure 17.

Proposed tariff system

Electricity is already metered and payed by the kWh in households at Darvi Soum. Tariff measures are proposed for the hospital which benefits from the hybrid system but up till now paid a flat monthly rate.

The use of dual tariff meters is recommended to allow a higher rate to be charged for electricity supplied by the wind system, reverting to a lower tariff during the times when the diesel generator is running. The tariff should be set at a relatively high rate, to encourage energy efficiency and reduce demand. This applies to the households as well as the hospital and any other institutions that may eventually benefit from the wind system.

As CFLs have been supplied which use significantly less energy, a higher tariff per kWh (currently 280 MNT/kWh for institutions) would be fully justified. Payments should be enforced, if necessary with disconnections.

The new tariff level will be set at such a level as to cover the O & M costs, including money to be set aside in the O & M fund for purchase of new parts and replacement of equipment at lifetime end. The tariff will also take into account the willingness and ability of the consumers to pay.

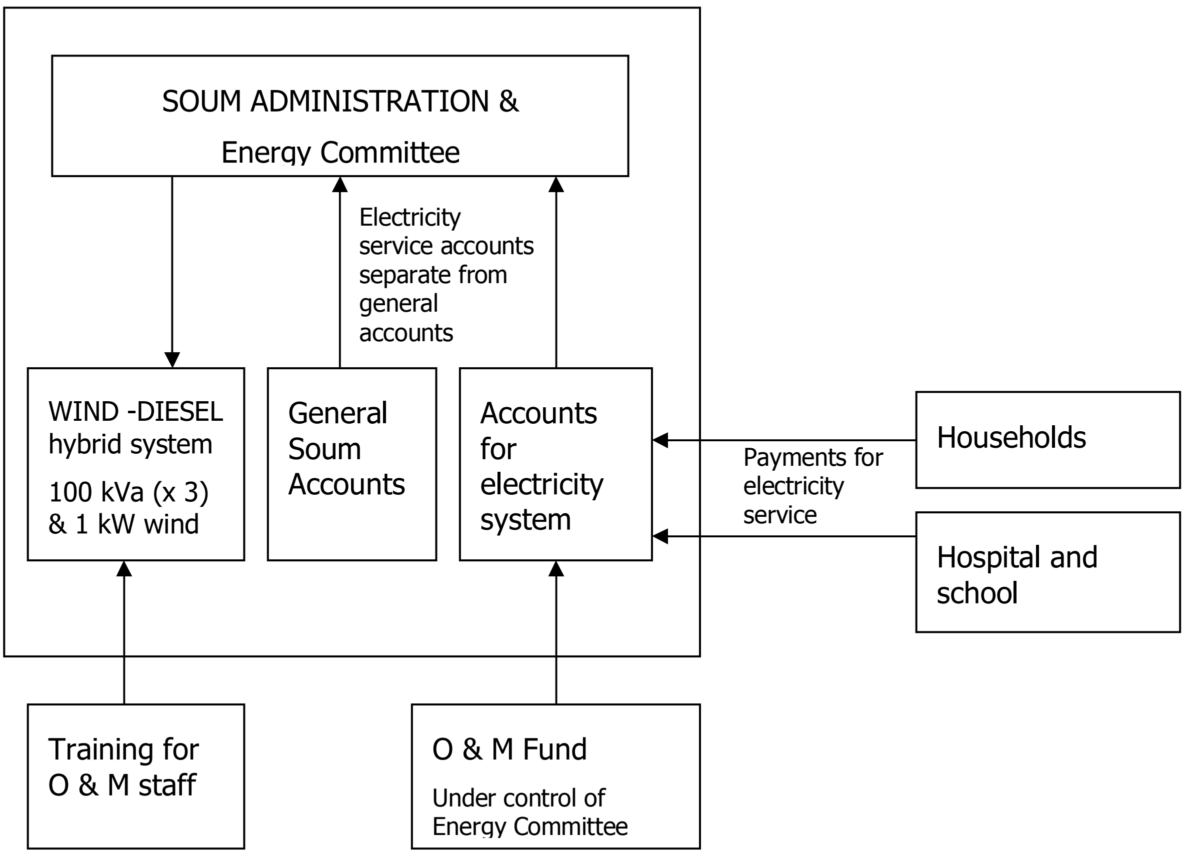

Figure 17. Darvi Soum electricity service recommended scheme

Repair / Replacement Fund

No matter how well a system is designed and built, breakdowns will occur eventually. Breakdowns will usually be beyond the capabilities of the operator, hence require external assistance and possibly replacement components. If there is no budget to cover such eventualities, a minor fault could lead to the whole system being not useable and falling into disrepair. Therefore, for the long-term sustainability of the project, it is essential that a budget is available for necessary repairs.

The ADB contract does not include a budget for ongoing operation and maintenance. Also, this being a pilot project, it is desirable to demonstrate ongoing sustainable operation without the need for external financial contributions. Therefore, a repair / replacement fund is to be set up.

The purpose of the fund is to provide the necessary budget for any repairs which may be required and for a new battery when this will become due for replacement. The money in this fund should be kept entirely separately from other Soum funds, and safeguards should be put in place to avoid the money being misused for other purposes. It is suggested that an account is opened which requires two signatures to obtain money - one from the Aimag government or MoI, the other from the Soum Governor.

Tariffs have to be set at a level sufficiently high to allow regular saving. As a guide, about 25-30% of the income from electricity should be put into this fund.

5.1.4 Tariff setting

A financial model was developed to enable the setting of tariffs for the pilot PV hybrid system in Zereg. A brief summary of the methodological approach taken is as follows and takes into account the structures outlined in section 5.1 above.

The tariff pricing structure needs to cover costs, remain affordable and allow for the constraint of the chosen system size.

Cost recovery needs to be satisfied in order to ensure that the pilot project will be sustainable within the community and not fall into disuse within a few years. This means that the price set has to cover the annual costs incurred with the new PV hybrid system as well as provide for future maintenance and renewal/replacement. These costs include:

- Operating costs for PV and diesel system including:

  Cost of all staff involved in the operation and administration of the system;

  Contingency for minor miscellaneous repair and maintenance costs; and

  Fuel costs.

- A Reserve fund that acts as a savings strategy for the system. This will enable ongoing provision of the system, past the original equipment's asset life. As a new asset is used, it will over time wear out and not be usable beyond its useful life, provided it has been maintained to the required level. Should maintenance not have been kept up to date, the asset will need to be replaced earlier. To enable a project to continue serving its purpose beyond the life of the original asset, a replacement strategy needs to be developed, such as accumulating a reserve fund that will enable the purchase of replacement equipment.

  If there are not enough funds available at the time of the physical expiry of the equipment, either the whole system will be at risk of collapse or an additional injection of

funding will be needed. As future external sources of funds cannot be guaranteed, this would then require users to provide a sudden lump sum to fund their share of new equipment. This is often unwelcome or at the least not well understood.

The reserve fund is to cover the costs for total replacement of system as require, and periodic replacement of parts such as batteries as required.

A profit margin has not been set. A profit margin would allow for contingencies and/or allow for the accumulation of surplus earnings for the electricity supplier. These surpluses should be invested into additional PV modules over time, thus expanding the capacity of the system and the electricity service offered.

Affordability was also taken into account when setting the tariff price. This involved determining current users' expenditure and willingness to pay for the use of current and possible future electricity levels. Allowance was made for inflation and population growth.

The tariff makes allowance for the limited size of the system by being set at a level where the total cost of the electricity output of the system matches the affordability level.

The model sets a tariff to meet all three conditions above. Using estimates of seasonal energy demand in kWh/day for both households and public institutions, a unit price was determined for the differing seasons as shown in Table 4 below.

Table 4: Electricity Tariff for Different Seasons

	Tariff per kWh (MNT) in 1st year (rising by inflation thereafter)
Winter: Public Buildings	203
Winter: Public Buildings	204
Summer: Households	1,387
Summer: Public Buildings	203

Further tariff development

Above are basic tariffs to meet costs, affordability and system constraints. It is envisaged that the tariffs designed for the pilot sites will ultimately incorporate a mechanism for varying according to the type of consumer (e.g. residential, public and commercial, vulnerable groups – to include persons such as pensioners, widows). This will require more detailed research as the project continues on the population of Zereg, so that effective social targeting can be ensured.

5.1.5 Creating a central fund for Soum electrification

A central fund for electrification of Soum centres should be created. This is a recommendation also made in the Rural Electrification Action Plan. The management of funds going in and out that are specifically ear-marked for rural electrification would be facilitated by the establishment of a Rural Electrification Fund (REF). This fund could be managed by a Rural Electrification Agency (REA) or, until an agency is set-up, by the MoI.

The fund would be primarily provisioned in funding from an annual budget from the government specifically aimed at rural electrification and from contributions from multi-lateral and bilateral organisations (such as ADB or GTZ).

In most cases in the rural areas of Mongolia, regardless of the RE technology, it is unlikely that any financial mechanism that seeks to recoup capital and O&M costs of any power project would be affordable by the rural population.

Even when the payback period of the installation that is used for any loan is appropriate to RE technologies it is still rarely affordable to the average household in Mongolia at this time. For the time being rural electrification in Mongolia will inevitably require donor aid/grants to cover capital costs of energy systems and these should be administered through the REF. However, fees for an energy service should be introduced and can cover O&M costs.

This fund would be used solely for the provision of different kinds of finance for setting up sustainable electrification schemes for the Soum centres. The following financing mechanisms will be available:

- Seed funding (a grant or a very long-term low interest loan) for revolving funds;
- Grant funding (for capital costs only and never for subsidising operational costs);
- Debt finance;
- Mezzanine finance;
- Equity finance;
- Guarantees.

The aim is that the funding will leverage further finance (debt and equity) from the local and regional finance institutions who currently believe that the sector is too risky to enter. Maybe further funding could be leveraged from NGOs and the Soum administrations themselves.

A Soum can propose an electrification project. Soum projects will be screened by a REF management team within the MoI or by the REA. On the other hand the government, based on recommendations by the MoI and the REA, can choose to electrify Soums based on a number of criteria, for example distance from the existing grid and likelihood o grid connection in the near future, or existence of a good renewable energy resource. Figure X below gives the overall layout of a rural electrification fund for Soum centres.

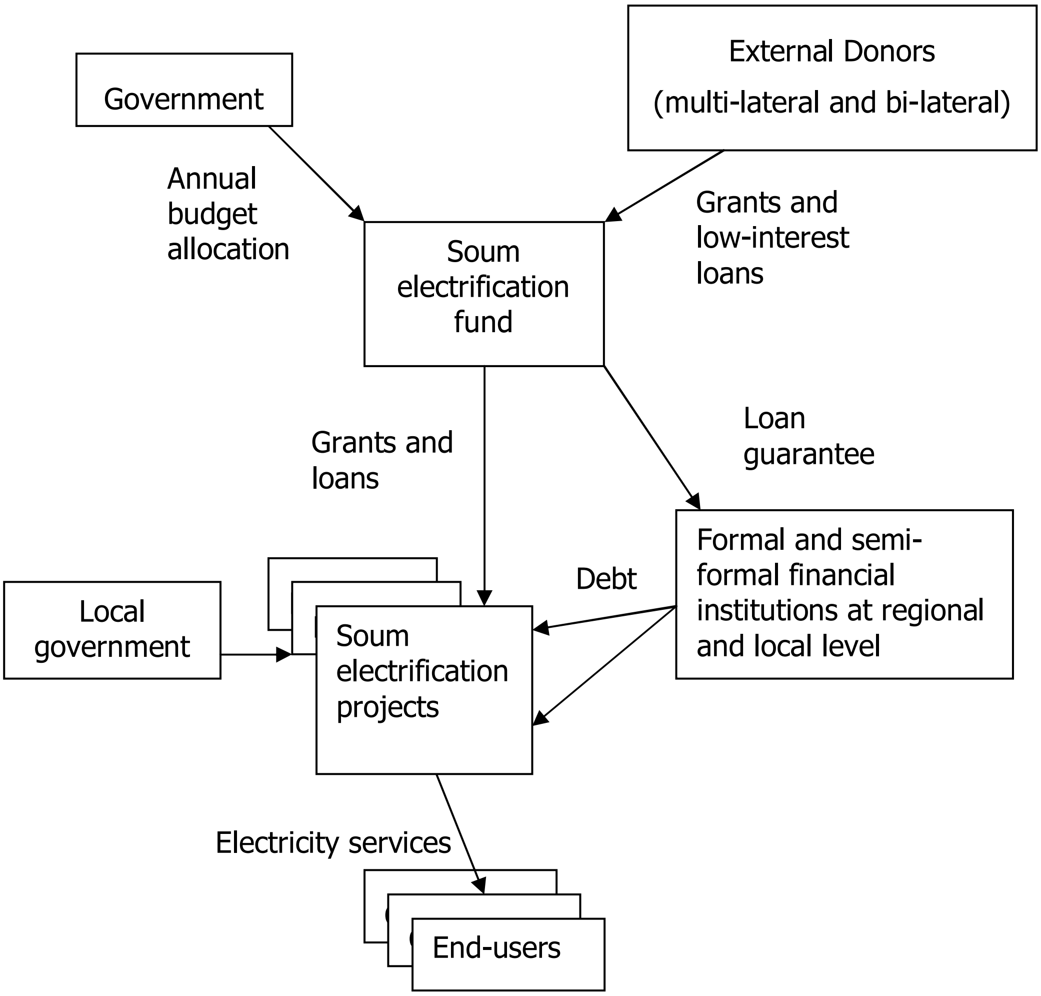

Figure 18. Overall layout of rural electrification fund

5.1.6 Process

When the electrification of a Soum centre is proposed (either by the Soum itself or by the REA / MoI) requiring funds from the electrification fund there will be an evaluation of the scheme by the management team of the fund. This will be a three step evaluation procedure:

(1) technical appropriateness of the scheme (lowest cost technology used);

(2) economic and financial evaluation; and

(3) sustainability in the long term (recovery of costs, minimum recovery of O&M costs and provision for spare parts replacement).

All three steps will be coordinated by the management team with the assistance of independent consultants where appropriate. The principal types of funding that will be available from the REF are grant funding and low-interest loans. The proposed electrification plan should specify what kind of funding it needs and for what activities. The management team will them decide what funding should be allocated.

5.1.6.1 Grant funding

Grant funding will be the most common form of funding from the REF to Soum centres for electrification. It will be available for capacity building, capital equipment and as seed finance

for micro-finance institutions if these need to be set-up within the Soum centre or within a region to provide a financial service to a number of Soum centres.

The capital costs of rural systems would also need to cover the capacity building required to make any fee for service electricity programme successful. For all renewable energy projects there is a strong need for capacity building to ensure the success of the project (financial and technical). This has only been emphasised by the experience of the two pilot projects undertaken in Zereg and Darvi under the present ADB programme.

In addition to the capital equipment costs for RE systems, there are costs for initial and ongoing capacity building in four main areas:

- Policy;
- Technical;
- Administration of energy services/fee collection / maintenance; and
- Manufacture/import of components.

It is expected that in Mongolia the infrastructure for implementing training and administration systems (initial and ongoing) for fee collection needs will need considerable strengthening, as people are not used to paying for electricity from renewable energy systems. End-users will also need to be educated on the real costs of electricity and how reducing energy consumption and paying for energy will in the long-term help improve the energy services that can be provided to them.

5.1.6.2 Debt finance (loans)

Loans are a very common financing vehicle for development projects because they continually replenish the development fund from which they are drawn. Therefore the REF will eventually recover some of the funds it has disbursed and eventually be able to fund new projects. The REF will create loans with generous repayment terms, low interest rates and flexible time-frames. These "soft-loans" are more likely to be effective in Mongolia where sources of financing and payment ability of the population are both quite limited. For developing Soum electrification projects these kinds of loans could be feasible used, where commercial loans would very likely have a too great interest rate and a too short repayment period.

Debt finance (or loans) will be made available to project developers to help develop the local market for renewable energy, and to local and regional banks, Soum and Aimag administrations, who can then on-lend to private sector renewable energy projects or for end-user finance / intermediary community finance.

5.1.6.3 Loan Guarantees

Loan Guarantees will be offered to regional and local finance institutions to allow them to on-lend onto Soum administrations and / or private sector renewable energy projects as well as to establish new loan products for renewable energy systems for consumers.

For any type of investment, the proposer should indicate the currency in which the investment is made. It is anticipated that the majority of the investments (and repayments) will be denominated in the local currency. In such cases, the Fund will consider accepting the foreign exchange risk.

The proposer should indicate the level and sources of co-finance proposed.

Proposers will be requested to indicate their plans for repayment of funds. Debt will be fixed term, with full repayment in less than xx years. Equity will have a pre-determined exit route e.g. refinancing from commercial sources once certain thresholds have been passed, flotation.

5.1.7 Project Size, Grouping and Type

Renewable energy project development is likely to fall into a number of categories and sub-categories in the different Soums:

- Small scale home systems (solar or wind) – these could be individually owned, owned by an Energy Service company (ESCO) or utility, or owned publicly. Finance could therefore be made available to either an ESCO to establish its business, or to an ESCO or bank to on-lend to consumers.
- Mini-grids or community services, for example government owned systems in hospitals and clinics, community or government owned mini-grids. Finance could be available for project developers, for on-lending to communities etc.
- Large scale renewable energy development for clusters of Soums – for example a small wind farm, hydro power etc. Finance could be made available to either the project developer directly and/or a local bank to leverage the remaining funds needed.

The fund will reduce the transaction costs for an individual project by grouping them together, however for some Soums there may still be capacity limitations developing one small project.

5.2 Summary of conditions of involvement of private companies

The four case studies reviewed in section 2 provide some clear conclusions with respect to the participation of private companies in rural electrification. It is worthwhile for Mongolia to consider these conclusions when fine-tuning the policy and implementation measures for rural electrification to ensure that as much private sector involvement as possible is allowable. The following lists the main points.

Political / Institutional

- Long term commitment of the government to the programme, that means in terms of tax breaks for equipment and services specific to the programme and regulatory framework (tariffs, electrification plans, etc.);
- Commitment of external donors in financing terms (who may be providing a large part of the capital for subsidies) but also in terms of political pressure to achieve government actions / incentives at a faster pace;
- Transparency on when and if villages are going to be connecting to the main network (availability of electrification plans, etc.) and clear boundaries between the remit of the national electricity operator (if there is one) and the rural electrification companies' market, role and rights;
- Creation of one-stop shops for private companies to get in touch with, in most countries this would be the rural electrification agency;
- Bundling of installations & maintenance, concessions, etc.

Economic / Financial

- A short payback period (under 7 years);
- IRR 10 -15 % ;
- Access to credit for companies;
- Possibilities to combine rural electrification with other business opportunities (for example electricity and telecoms, sales of electricity using appliances, etc.);
- Capital subsidies (50 up to 90 %);

- Partial guarantee fund / mechanism is desirable;

Information / Capacity building

- National programmes / international aid to stimulate capacity building at companies: Technical Assistance to increase technical competence and to increase management-, marketing- & business-skills;
- Availability of technical guidelines and standards.

5.3 External Finance

A brief review was made of current external finance available. There are a number of financing organisations active in the region, which can be categorised into a number of different groups. Each type of financing entity is likely to provide a different range of financing options. This financing could be used direct to fund an individual project or could be channelled into the Soum electrification fund, to then be dispersed to a number of different projects.

An overview to available financing is given in the table below. Further information regarding each of the organisations in the region is given in the following sections including an indication of their evaluation guidelines and investment criteria.

Table 1: Matrix of Financing Instruments[1]

	Market-based Loans	Soft Loans	Grants	Equity investments	Guarantees	Technical Assistance	Other
Multilateral Development Banks	X	X	Some	Some	X	X	
Bilateral Aid	X	X	Some			X	
Funds / Foundations	X	X	X	Some			
Green Investment				X			X
National Development Funds	X	X			X	X	
Commercial Loans & Investment	X			X			

5.3.1 Multilateral Development Banks (MDB)

The goals of most MDBs are to combat poverty, improve water and food supplies, improve access to electricity, provide education opportunities, develop infrastructure, develop job opportunities, and improve the standard of living. MDBs are likely to aim their financing at the development of infrastructure components such as providing training (capacity building), regional marketing, and small business development that will help the programme achieve

[1]Sources of Financing for PV-Based Rural Electrification in Developing Countries, IEA PVPS Task 9, May 2004

"sustainability" – e.g. working renewable energy systems providing electricity to the recipients for years to come.

MDB financing is principally made in the form of large loans to the national governments of developing countries[2]. The interest rates on these loans will often be at below-market levels with grace periods ranging from 3 to 10 years (during which no interest accrues). The following MDBs finance projects in Asia.

Global Environment Facility (GEF)

In addition to meeting specific environmental goals, projects must meet several clear guidelines to be considered for GEF funding, including: 1) reflecting national or regional priorities and demonstrating the support of the country or countries involved, and 2) improving the global environment or advancing the prospect of reducing risks to it. In addition, host countries need to have ratified any relevant international treaties (such as the UNFCCC) and must be eligible to borrow from the World Bank or receive technical assistance grants from UNDP. GEF often funds capacity building activities for national institutions and the private sector as part of a larger renewable energy or energy efficiency project.

The World Bank Group

The World Bank Group has three MDB subsidiaries. One, the International Bank for Reconstruction and Development (IBRD), provides loans to developing countries at more favourable terms than would be available from commercial lending organisations. For example, the loan terms for IBRD loans generally include 15-20 year repayment periods with 3-5 year grace periods during which no interest is charged. In 2002, IBRD provided loans totalling 11.5 USD billion in support of 96 projects in 40 countries[3].

Another component of the World Bank Group, the International Development Association (IDA), supports the reduction of poverty worldwide through loans, guarantees, and non-lending services, including analytical, policy, and advisory services. The International Finance Corporation (IFC) is a member of the World Bank Group that provides loans, equity finance and quasi-equity to private-sector projects in developing countries. It also offers financial risk management products and intermediary finance.

Asian Development Bank (ADB)

The ADB provided the finance for the technical assistance project in Mongolia. The ADB concentrates on projects which assist poverty alleviation and development, and so does not focus on energy or renewable energy projects.

European Commission (EC)

The EC channels its development financing through the EuropeAid Co-operation Office, the mission of which is to implement the external aid instruments of the European Commission. EuropeAid is funded by the European Community budget and the European Development Fund and provides external aid through either contracts to provide services, supplies or works to beneficiary countries, or through grants to non-profit organisations. EuropeAid releases calls for proposals to which programme planners can apply for funding[4]. The

---

[2] MDBs rarely accept proposals from private project developers, though the International Finance Corporation (IFC) of the World Bank is an exception to this and focuses on providing financing to private-sector developers.

[3] *Finance for the Developing Countries*. Richard Kitchen, 1986.

[4] http://europa.eu.int/comm/europeaid/index_en.htm

European Investment Bank (EIB) then implements the financial component of agreements concluded under European development aid and co-operation policies[5].

5.3.2 Bilateral Aid

The goals of bilateral lending agencies are determined by the legislation and administrations within each country. In addition to providing funding through their own national funds, the major developed nations also coordinate their development financing through the Organisation for Economic Co-Operation and Development (OECD), which provides its member nations with a forum called the Development Assistance Committee (DAC). The goal of the DAC is to increase the effectiveness of the sustainable development work of OECD member nations. The DAC has produced the following guidelines for awarding development funding, applicable for most bilateral agencies:

- First, projects should be relevant to the priorities and policies of the target group, recipient, and donor.
- Second, projects should effectively achieve the objectives they were designed to achieve.
- Third, projects should be designed in such a way as to create clear benefits in proportion with the resources needed to carry out the project. This generally requires comparing alternative approaches to achieving the same outputs, to see whether the most efficient process has been adopted.
- Fourth, projects should evaluate both the intended and potential unintended consequences of the project and the sustainability of the project's benefits.

In addition to coordinating development efforts through the DAC, the OECD Technical Assistance Committee (TAC) contributes to development projects by providing logistical and technical support.

Bilateral financing, like funding through MDBs, is generally open only to the national governments of developing countries. Bilateral organisations working in Mongolia include JICA (Japan) and GTZ (Germany).

5.3.3 Funds and foundations for rural energy development

Foundations, charities, and private funds set up to sponsor development projects often provide capital in the form of grants or soft loans. Some of these funds specifically target projects and investment in rural energy services in developing countries. Funds in the Asia region include the following:

United Nations Foundation which funds climate change mitigation and environmental work. (www.unfoundation.org)

Solar Electric Light Fund (SELF), USA – SELF provides assistance, training, financing and installation of PV. They have carried out a number of projects in Asia. (www.self.org)

Triodos Renewable Energy for Development Fund – Provides finance and business development support to private sector enterprises, financial institutions and organisations that facilitate the introduction of and widespread access to off grid renewable energy services to underserved people in developing countries. The Fund can provide finance to entrepreneurs and organizations that offer renewable energy solutions and services to non

[5] http://www.eib.eu.int/about/

electrified communities.
(www.triodos.com/com/international_funds/renewable_energy/general/?lang=)

E+Co funds sustainable energy enterprises in developing countries. E+Co supports viable energy enterprises that ensure the delivery of affordable and reliable energy services in rural off-grid areas. (www.energyhouse.com)

5.3.4 Green Investment

JREC Patient Capital

The Johannesburg Renewable Energy Coalition (JREC) was established in September 2002 after the Johannesburg World Summit on Sustainable Development (WSSD) and JREC Patient Capital is supported by the European Commission. The JREC Patient Capital Initiative (PCI) is a public sector investment initiative aimed at providing a sustainable financing scheme that could trigger significant private capital investment in the period 2005-2008. Patient capital is equity funds with return requirements below commercial norms so it is an investment structure for developing markets aimed at realising these externality benefits and thereby significantly accelerating growth of viable enterprises in the sector.

Funding will be provided to the renewables enterprise and project sector including a broad mix of investment opportunities (eg: wind, geothermal, solar, biomass and small hydro projects, consumer and SME finance vehicles, and manufacturing and assembly businesses). The proposed structure for the PCI is to pool capital in a Fund of Funds[6]. This Fund of Funds invests in specialist or regional sub-funds, which in turn invest in projects and companies:

(i) Top Tier – a Fund of Funds: Like-minded public and private investors affiliated with the JREC process that are seeking to play a global role will pool their "patient capital" in a new Fund of Funds with a light operational structure.

(ii) Middle Tier of Sub-Funds: The Fund of Funds will invest in existing or new sub-funds focussed on renewable energy and specialised by region or sector and managed by professional fund management teams. These sub-funds would attract substantial co-investment from commercially oriented investors (public, private and foundation).

(iii) Bottom Tier of Investments: The sub-funds will invest in companies and projects consistent with their investment mandate. The terms of the sub-funds' investments would normally require co-investment from private sector investors at the company/project level.

5.3.5 International Carbon Emissions Trading

The Clean Development Mechanism was established under the Kyoto Protocol with the aim of contributing to cost-effective mitigation of climate change and sustainable development. CDM allows countries with emission reduction targets/commitments (Annex 1 countries) to meet some of these reductions abroad in non Annex 1 countries. The CDM therefore allows developing countries to attract investment for clean energy projects.

For each metric tonne of CO2 equivalent that a project saves, a Certified Emission Reduction (CER) certificate is generated. Businesses, industries, or countries with reduction commitments can purchase these certificates. CERs may be used as a secure source of cashflow in the future allowing project developers to negotiate better project finance and increasing confidence from the finance sector. However, it is likely that most carbon finance will flow to larger projects and larger countries. Small projects are perceived as risky and

[6] Patient Capital Initiative Feasibility Study, DRAFT, Impax, May 2004.

cannot easily compete for private sector carbon finance even with some streamling in the CDM process for small projects[7]. Often potential projects require a lot of work to make them into bankable projects.

The number of emission buyers is still growing and now includes a large number of private funds, investors and brokers as well as government and multilateral actors. Some of the buyers will invest in the project in return for the CERs in the future although the majority of buyers will only pay on delivery of the CERs.

5.3.6 Commercial Loans and Investment and Venture Capital

Co-financing for renewable energy projects and enterprises can come from the commercial banking sector and venture capital. This could be from local banks in each country which would require reassurance to enter the market.

VC investors invest and fully participate in early stage technology companies. They demand a large equity stake and the returns they expect are in the order of 50 –60%.

5.4 Initiatives for RE Hybrids Operation & Maintenance

Since there is a wish to promote entrepreneurial initiatives and privage sector participation in rural electrification, IT Power investigated the best way for RE hybrid systems to be operated to ensure optimum reliability, economical operation and maximum lifetime of equipment.

5.4.1 Options for Promoting Entrepreneurial Initiatives

This section considers options for promoting entrepreneurial initiatives for operating and maintaining a Soum centre's power system, including the diesel generator.

The following basic models can be adapted for the operation and maintenance of the power system:

- *Operators as employees of local government (typical current setup)*

The operator or operators are employed by the local administration. Their remit is as wide as is required for the local situation (e.g. diesel only, diesel and PV, diesel and district heating).

- *Operation and/or maintenance contract for diesel generator*

The diesel generator is operated and/or maintained by a private company. Ownership of equipment rests with the local administration. The local administration collects payments for electricity and carries all risks.

- *Operation and maintenance contract for electric power system (diesel only)*

The diesel generator and the mini grid are operated and maintained by a private company. The diesel generator and mini grid are owned by and leased from the local administration. Private operator collects payments for electricity and carries risks for non-payment, not enough subscribers, etc.

- *Operation and maintenance contract for electric power system (diesel and RE)*

The diesel generator, other generators (e.g. PV system) and the mini grid are operated and maintained by a private company. Diesel generator and mini grid are owned by / leased

[7] Economic Decarbonisation – The next big bang for the financial sector, Ficci and Rabo India, November 2003, Delhi

from the local government. Private operator collects payments for electricity and carries risks for non-payment, not enough subscribers, etc. The renewable energy system could be owned by / leased from the local administration, or operator owned. Operator could make decision to invest in additional PV or other forms of generation.

- *Operation and maintenance contract for electric power system and district heating*

As previous, but in addition the district heating plant is operated by the contractor.

Questions to be considered

The following questions will have to be considered for each case:

- How well do the economics stack up? Does the local administration currently subsidise the power system?
- Which risks should/can be borne by a private operator? (e.g. breakdown of diesel requiring major repair/refurbishment)
- Will someone be prepared to take the commercial risk?
- Should ownership of major assets (diesel generator / mini grid) pass to a private operator?
- What degree of freedom should the operator have regarding tariffs? What regulatory limitations are imposed by the national Energy Authority? How much control should the local administration have over the private operator? Who should the regulator be – the local administration or a local energy committee, the national Energy Authority, or a mix between local / provincial / national?

6 EXHIBITION AND CAPACITY BUILDING

6.1 RE Exhibition

A large renewable energy exhibition was organised and took place in September 2004, from 8th- 11th September at the National Information Park of Mongolia in Ulaanbaatar.

The IT Park was chosen as the most appropriate place for an exhibition which could be open to the public, while at the same time providing a seminar hall with sufficient capacity for the one-day seminar.

Publicity materials were prepared including a leaflet and a website. A "First Announcement" leaflet was prepared and distributed in June 2004. A further second leaflet with finalised details of the exhibition and seminar was distributed in July and August.

Prior to the Exhibition it became apparent that a GTZ supported conference in Mongolia was due to cover similar subjects as the ADB supported seminar. At the time these events were to be held one week apart. Hence it was agreed by all parties to co-operate to develop a joint event. It should be noted however that the exhibition and associated seminar for this project was an information dissemination event, principally aimed at Mongolian stakeholders, whereas the GTZ conference was promoted more as a scientific international conference.

The exhibition/seminar was held as part of a "Sustainable Energy Week" comprising various events organised by the ADB project and the GTZ project. This "Sustainable Energy Week" included:

- ADB project supported Policy Workshop (invitees only) on 7th September (see section 2);
- A one-day information dissemination seminar: Sustainable Energy and Energy Efficiency for Small Towns and Rural areas incorporated into the GTZ Two-day International Conference: 2nd international Conference – Use and potential of Renewable Energy in Mongolia 8-10th September.
- ADB project supported Exhibition: Sustainable Energy for Small Towns and Rural Areas of Mongolia.

Companies in the renewable energy and energy efficiency sector from Europe, the USA, Australia, Japan, Korea, China, Russia and India were contacted to exhibit by e-mail and letter invitations as well as Mongolian companies in the renewable energy and energy efficiency sector. The exhibition space was offered free of charge to the exhibitors to encourage as many as possible to come and present their products at this public exhibition. Companies from Germany and China attended and the Exhibition highlighted the domestic renewable energy sector. In addition publicity material was distributed from other European companies. These companies covered all technologies from solar PV, to wind systems and battery technologies.

The flyer for the exhibition is included in Annex 12.

6.2 Overseas Training for Key Policy Makers

A training programme was initially designed and organised for five (5) key Mongolian renewable energy policy makers/experts to travel to Europe and the United States. However, following discussions with ADB a modified study tour programme was requested from IT Power with an emphasis on regional contacts and enabling the participation of a maximum number of technicians and policy makers.

Finally study tours were undertaken to China and the USA.

6.2.1 China study tour

It was recommended to send technicians / policymakers to China (depending on budget restrictions) to attend a Conference in Beijing and to visit institutional and private sector organisations in the renewable energy and energy efficiency sectors. The study tour to China took place over a one-week period in May 2004 for three representatives of the Mongolian Government and local industry. The participants were Mr Tunenjargal , Mr Batbayar and Mr Bat-Erdene.

The rationale for this study tour was three fold: (1) because much equipment supply will come from China in the future, (2) the recently passed renewable energy Law in China (February 2005) and (3) the similarity of requirements for energy for remote rural areas (especially between Inner Mongolia and Mongolia).

The China Study tour included a visit to CREIA (Chinese Renewable Energy industry Association) and a number of renewable energy technology manufacturers, in particular SunTech, PV manufacturers, in Wuxi.

The participants took part in the four day RE Asia 2005 - the 2nd Asian Renewable Energy Fair and Conference in Beijing which covered the following technologies and subjects:

- Wind, Solar, Geothermal, Marine, Bio-energy and Hydropower technologies
- Policies and Market
- Economies, Society and Environment
- Off Grid Systems, Hybrid Systems and Storage
- Grid Connected Systems
- Financing
- Education and Training
- R & D of Technology

There was also an international trade exhibition accompanying the conference. It featured, accessory equipment, technologies and services from all the different renewable energy technologies.

6.2.2 US study tour

A US Study tour took place in May 2004 including Mr Enerbish and Mr Ochirkuu, the Minister for Fuel and Energy. The tour included attending the American Wind Energy Conference and meetings with staff at the World Bank, USAID, NREL (New and Renewable Energy Laboratories) and GEF (the Global Environment Facility).

The rationale for the study tour was to learn of renewable energy approaches and technology developments in the US and to discuss the possibilities of future funding for renewable energy in Mongolia.

7 CONCLUSIONS AND RECOMMENDATIONS

Applicability of hybrid systems for remote rural soum centres

The use of renewable energy hybrid systems for remote soum centres is certainly technically feasible as demonstrated by the pilot projects. However despite the technical elements of the pilots being successful, in practice the pilots were not successful because people were overusing the system. Consumption-based charges did not work, possibly mainly due to the fact that the Soum administration was not convinced of its effectiveness and was not willing to try it. The time available for this project was very short, with limited time available for experts to be in the field; hence the installation of the PV system and the introduction/installation of kWh meters occurred at the same time. A gradual introduction over a longer period of time might have led to better results.

A summary of the issues and recommendations for further use of hybrid systems in Mongolia are given here.

Technical applicability

In a previous project, Noyon Soum, a total of 100 kWp of PV was installed as part of a PV-diesel hybrid system to supply a small village of less than 100 households. This approach relies essentially on oversizing the PV array to ensure that demand is met, without much effort to reduce electricity demand. However, in a world with finite resources and a growing recognition that energy has to be used sparingly, this approach cannot be recommended.

As part of this project in Zereg Soum, a different approach was taken with the installation of a 6 kWp of PV as part of a PV-diesel hybrid system to supply a small village of 50 households in summer and 200 households during winter. The system could theoretically provide a basic electricity service assuming users were careful in their use and a number of energy efficiency measures were implemented.

Many parts of Mongolia have sufficient wind resources for small wind turbines, which are considerably cheaper for the same amount of energy output compared to PV. The main disadvantage of wind energy is its seasonal variation, leaving the user without power for parts of the year. Another disadvantage is their higher maintenance requirements.

Where these is sufficient time for the introduction of a renewable energy hybrid system it is recommended, however for a project of a short duration, the implementation of a hybrid system combining a new wind or PV system with an existing diesel generator is not recommended.

State of the Electricity Distribution System / Lack of training and skills

Particularly in Zereg and reportedly in other soums the electricity distribution system appeared to have been neglected for many years and was in a very poor state of repair. This applied to both the mini grid as well as electrical installations in buildings, resulting in losses as well as safety concerns. Any renewable energy scheme wishing to utilise the existing electricity distribution infrastructure will rely on this being in a serviceable state. It is recommended that a thorough survey is undertaken during the preparation of any similar future projects.

Another issue is ongoing maintenance and repairs. A distribution system with overhead wires will require some maintenance. The problem is exacerbated by the fact that nomadic householders are being disconnected and reconnected on a regular basis. It seemed that these connections are sometimes even done by the householders themselves.

Internal wiring is often done by the householders themselves. Wiring was often found to be unsafe. A certain amount of know how is required in order to avoid and detect faulty wiring

which may lead to malfunctioning, earth faults and losses, and serious health and safety hazards. Wiring in the buildings was improved as part of the project, to reduce losses and to improve safety.

Bringing the whole of a Soum centre's electrical system up to a high standard is a huge task which must not be underestimated. Most likely, it would require a skilled national or international expert to be at hand for a period of several weeks, to supervise and train local personnel.

In order to ensure that best practice is adhered to at least to some degree, better local expertise is required. This would lead to reduced losses and a safer system. There is a definite need for training and capacity building in this area.

Potential for Energy Efficiency Measures

In the Soums visited and particularly in the Soums where the pilot systems were installed, a huge potential for energy efficiency was observed. It is very likely that this is the case throughout rural Mongolia. For any future renewable energy projects, it would make economic sense to implement energy efficiency before or at the same time as a renewable energy system is installed, in order to reduce the required capacity.

The largest energy saving potential can be realised by replacing incandescent light bulbs with CFLs. In the pilot locations, lighting accounts for the largest part of the load. Energy was also wasted due to losses in both the distribution network and in the wiring systems of the buildings. Losses resulted from leakage currents, and from poor connections.

The existing wiring encouraged or even required behaviour which is not sensible in terms of energy efficiency. Sometimes, power sockets were wired into a lighting circuit, requiring the lights to be on for charging a phone or running any appliance. Often, several lights are switched on with the same switch. As part of the pilot project, some of the wiring was changed to enable people to use energy more sensibly.

User behaviour

A very important area was waste of energy due to user behaviour. This included not switching off lights and other appliances when they are not required. Previously, light switches were not really required as the diesel operating hours more or less coincided with the hours during which lighting was required. Once such habits are established, they cannot be changed overnight. A significant and prolonged educational effort is required to change user behaviour. This process was initiated by the project, by extensive discussions with local government representatives, and by public meetings.

Tariffs

Measures to encourage efficient use of energy should be introduced. The flat-rate electricity tariff commonly used in Soum centres does not encourage people to conserve energy. The introduction of tariffs based on metered actual consumption should be encouraged as an incentive for energy efficiency. It is also a fairer way to charge for electricity.

A demand-based tariff is of no use if it cannot be enforced. Theft of electricity is a serious problem, in rural as well as in urban Mongolia. The legal powers to enforce payment and to deal with non-payers and people stealing electricity by bypassing meters are very limited. As a result, it is very difficult to use tariffs as an effective means to reduce consumption, or to direct consumption from periods of solar to period of diesel supply. Means should be provided to ensure that a new tariff can be enforced.

A demand-based tariff presents a new concept of paying for electricity for most of rural Mongolia. The introduction of such a tariff is unlikely to be without problems. The introduction will require some time, and external support and assistance may be required.

The social acceptance of such a tariff should not be taken for granted. Generally, poorer people with fewer appliances will benefit from a lower electricity bill. In order to make up for the shortfall, higher users will have to pay more. The users with the highest consumption are typically the richest and often the most influential subscribers. It is therefore important to convince them that the new tariff is in everyone's interest.

How to get people to pay for electricity

Make it clear that people will be disconnected at least for a defined period if they are caught stealing electricity, or if they do not pay their bills. The implementation of this must be ruthless. It is also important that those with power in the area buy into this, as it may be difficult to take sanctions against them and where necessary peer pressure should be considered. The use of pre-payment meters should also be considered.

People are sometimes used to power cuts as a result of non-payment as existing diesel generators sometimes do not operate for a while until people have paid up allowing the purchasing of fuel.

Ownership and Operation of System

Usually the local administration is responsible for the operation of the power system and the diesel generator, and is therefore likely to take responsibility for any renewable energy system as well. It is recommended that the accounts for the whole electricity supply system (i.e. for the operation of diesel generator and renewable energy system) are kept strictly separate from the Soum administration's general accounts.

Renewable energy systems are likely to require maintenance and replacement components before the end of their life. Most notably, the storage battery will need to be replaced after five or ten years. As the expenditure involved in major component replacement would be too great to be met from the normal operational budget, it is recommended that provisions for repairs and component replacement should be made. Ideally, a separate fund for repairs and component replacement should be set up. This account should be under the joint control of the Soum and Aimag administrations, to avoid funds being diverted to other causes. Without a repairs and component replacement fund, it is possible that the whole renewable energy system might fall into disuse as a result of a component failure.

Implementation of Future Renewable Energy Projects

The introduction of renewable energy without utilising the existing potential for energy efficiency does not make technical or economic sense. A transition to an energy-efficient Soum would require significant co-operation and change of behaviour by users. The only way to achieve this is probably by charging electricity according to usage, to give people a financial incentive to save energy. To implement this in practice, electricity theft by bypassing meters must be eliminated.

For the implementation of similar renewable energy schemes in the future, a two-staged approach is recommended. This would start with the implementation of energy efficiency measures, metering of electricity and a new consumption-based tariff. The successful implementation and trialling of these would have to be demonstrated before the renewable energy system is installed. As people are very keen to get a renewable energy system, this would serve as a real incentive to make a success of the demand-side measures and reduce the demand. If the installation of a renewable energy system is conditional on the successful implementation of an energy efficiency programme, including changes in user behaviour, everyone would have a real incentive to co-operate fully. The longer implementation period and higher involvement of the local administration would also lead to a higher level of ownership of the whole scheme.

If an approach like in Zereg is to be taken, a much longer implementation period with several stages is recommended. Firstly, energy efficiency measures should be introduced, and the mini grid should be brought up to an acceptable standard with considerably reduced losses. Then consumption-based charging should be implemented. Only when the effectiveness of this scheme has been fully demonstrated, should a renewable energy system be installed. Everybody in the village should be aware that the installation of the renewable energy system is conditional on a fully working tariff scheme. Local expertise should be built up both for technical system maintenance and for administering the tariff scheme. It is envisaged that this process would take several years.

A large emphasis should be placed on energy efficiency. Many soum centres struggle to meet their electricity demand, whilst a large amount of it is simply wasted. The introduction of CFLs and metering/consumption-based charging is likely to have the biggest impact.

Recommendations for Supporting Measures for RE Action Plan

1. Awareness Raising - Information and Marketing

The exhibition during the project's conference demonstrated very well that the Mongolian renewable energy industry has little concept of marketing themselves. Appropriate marketing could vastly increase the commercial market for renewable energy systems. This will require capacity building.

The government has a role to play regarding awareness raising, for instance by information campaigns, advertising etc.

The main incentive for getting a renewable energy system is often not electric light, but television. This should be recognised and utilised during information and marketing campaigns.

2. Creation of a distributed dealer network

As Mongolia is a very large country, it is essential that technical expertise is available locally, rather than just in the capital. Again, capacity building is required. Local representatives should be able to supply and install systems as well as provide spares and carry out maintenance and repairs.

Suppliers should also supply suitable appliances such as DC TV sets, satellite receivers and CFLs.

Maybe lessons could be learnt from Inner Mongolia in China, where small companies have been set up in towns in the rural areas, supplying systems and components as well as after-sales service (spares, maintenance and repairs). It is however recognised that Mongolia is much more sparsely populated, with few centres in the rural areas, making it more difficult to establish an effective dealer network.

3. Financing

For herders, their wealth is represented in their livestock. Unlike in many other countries, where people are simply unable to raise sufficient money to buy a RE system outright, in Mongolia at least some of the herders will be able to afford the cost. As income is seasonal (sale of cashmere), the sales of systems is likely to have a seasonal pattern too.

In recent years, many herders have lost large parts of their livestock due to unusually harsh winters. This will mean that in some parts of the country higher subsidies may be required.

Subsidy levels must be kept low enough that users have to make a significant contribution of their own, to ensure ownership/buy-in.