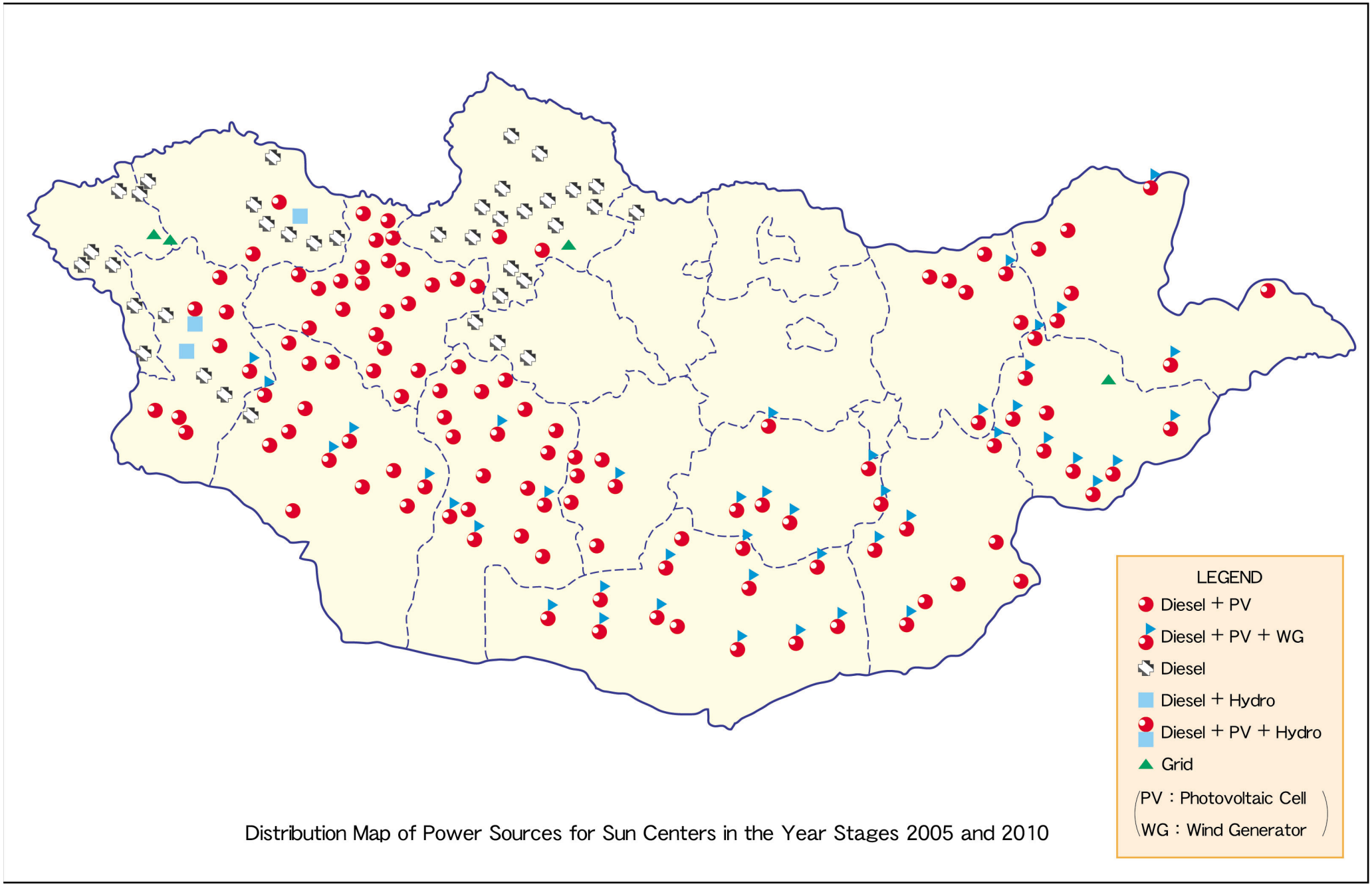


Distribution Map of Power Sources for Sun Centers in the Year Stages 2005 and 2010

Master Plan Study for Rural Power Supply by Renewable Energy in Mongolia

The First Stage (2005) Profile of Development Plan

1. Name of Project	: Rural Power Supply by Renewable Energy	
2. Ministry in charge	: Ministry of Infrastructure Development (MOID)	
3. Targeted Site	: 167 Sums	
4. Objectives of Project	: To improve public services for BHN To change residents' mind for saving of resources	
5. Plan of Power Supply System		sums
	: Diesel Individual	: 38
	: Diesel＋PV	: 77
	: Diesel＋PV＋Wind	: 45
	: Diesel＋Small Hydro	: 2
	: Diesel＋Small Hydro＋PV	: 1
	: Grid extension	: 4
6. Renewable Energy Supply System	: Direct power supply to load by isolated renewable energy (Hydro・PV・Wind＋Battery)	
7. Power Distribution Plan	: Construction of new distribution line for public services (hospitals, schools、etc) Application of meter rated tariff system	
8. Capacity of Renewable Energy Supply	: PV 969MWh/year、Wind 226MWh/year	
9. Implementation Schedule	: Sept., 2002～Dec., 2004 (The 1st Stage) 2005 (Commencement)	
10. Operation & Maintenance Plan	: Establishment of management organization for electricity supply operation and of work group for maintenance Introduction of basic intelligent management system (IMS)	
11. Project Cost	: US$ 23.814 million	
12. Internal Rate of Return	: EIRR －3.3%, FIRR －11.3%	
13. Range of Rating per Sum Center	: PV	2 ～ 12 kWp
	Wind Generation	2.5 ～ 10 kW
	Battery (for 2 days)	6 ～ 48 kAh
14. Intelligent Management System	: each Sum (computer 2 sets＋observation unit) each Aimag (computer 2 sets)	
15. Saving on Fuel	: 1,815 kℓ／year	
16. Reduction of CO_2 emission	: 1,336 ton-CO_2／year	

Master Plan Study for Rural Power Supply by Renewable Energy in Mongolia

The Second Stage (2010) Profile of Development Plan

1. Name of Project : Rural Power Supply by Renewable Energy
2. Ministry in charge : Ministry of Infrastructure Development (MOID)
3. Targeted Site : 167 Sums
4. Objectives of Project : To improve the power supply to every household
   To stabilize the people's livelihood
5. Plan of Power Supply System

	sums
: Diesel Individual	: 38
: Diesel＋PV	: 77
: Diesel＋PV＋Wind	: 45
: Diesel＋Small Hydro	: 2
: Diesel＋Small Hydro＋PV	: 1
: Grid extension	: 4

6. Renewable Energy Supply System : Diesel power supply to load by isolated renewable energy (Hydro・PV・Wind＋Battery)
7. Power Distribution Plan : Construction/reinforcement of distribution line for every household
8. Capacity of Renewable Energy Supply : PV 7.1GWh/year、Wind 2.7GWh/year
9. Implementation Schedule : Mar., 2007～Dec., 2009 (The 2nd Stage)
   2010 (Commencement)
10. Operation & Maintenance Plan : Operation of the system throughout the year
    50% reduction of power distribution loss
    Reserving budget for the renewal of the systems
    Accumulation of know-how for steady power supply
11. Project Cost : US$ 43.858 million
12. Internal Rate of Return : EIRR 1.0%, FIRR －2.9%
13. Range of Rating per Sum Center : PV 5 ～ 100 kWp
    Wind Generation 10 ～ 130 kW
    Battery (for 1 day) 6 ～ 240 kAh
14. Intelligent Management System : each Sum (computer 2 sets)
    each Aimag (computer 2 sets)
    MOID (computer 2 sets)
    EA (computer 2 sets)
15. Saving on Fuel : 4,965 kℓ／year
16. Reduction of CO_2 emission : 3,654 ton-CO_2／year

Master Plan Study for Rural Power Supply by Renewable Energy in Mongolia

The Third Stage (2015) Profile of Development Plan

1. Name of Project : Rural Power Supply by Renewable Energy
2. Ministry in charge : Ministry of Infrastructure Development (MOID)
3. Targeted Site : 167 Sums
4. Objectives of Project : Steady power supply to every household
   Saving resources, Protection of the environment,
   Community development
5. Plan of Power Supply System

	sums
: Fuel Cell＋Hydrogen Production/Storage＋PV	: 93
: Fuel Cell＋Hydrogen Production/Storage＋PV＋Wind	: 53
: Fuel Cell＋Hydrogen Production/Storage＋PV＋Small Hydro	: 1
: Fuel Cell＋Hydrogen Storage	: 14
: Small Hydro	: 1
: Small Hydro＋PV	: 1
: Grid extension	: 4

6. Renewable Energy Supply System : Direct power supply to load by isolated renewable energy (Hydro・PV・Wind＋Fuel Cell)
7. Power Distribution Plan : Construction of distribution line for new household
8. Capacity of Renewable Energy Supply : PV 19.8GWh/year、Wind 14.9GWh/year
9. Implementation Schedule : Sept., 2011～Dec., 2014 (The 3rd Stage)
   2015 (Commencement)
10. Operation & Maintenance Plan : Improvement of service quality
    Reduction of power generating cost
    Attainment of perfect self-operation
11. Project Cost : US$ 80.490 million
12. Internal Rate of Return : EIRR 6.5%, FIRR 2.9%
13. Range of Rating per Sum Center :

PV	10 ～ 200 kWp
Wind Generation	30 ～ 300 kW
Fuel Cell	50 ～ 300 kAh

14. Intelligent Management System : version up of software for each Sum, each Aimag, MOID and EA
15. Saving on Fuel : 6,850 kℓ／year
16. Reduction of CO_2 emission : 5,042 ton-CO_2／year

Master Plan Study for Rural Power Supply by Renewable Energy in Mongolia

Executive Summary

1. Background and Objectives of the Study

In Mongolia some 50% of the total population of about 2.4 million are nomadic families. For the nomadic families, Sum centers are key places for supplying their vital goods, and also for taking the public services such as administration, medical care, education, etc.

As of November 1997, the electric power at 117 out of 314 Sum centers in total in Mongolia is being supplied from the national power transmission network. At the remaining 197 Sum centers, the electric power is supplied by the diesel engine generators by the operation by Sum centers independently. Most of these diesel generating facilities were manufactured during the former Soviet Union era and installed long ago from 1963 to 1990.

During the Social Republic era of the country, Mongolia depended on the Soviet Union for the supply of spare parts necessary for the maintenance of the generating equipment and in receiving technical guidances. Due to the corruption of the Soviet Union's economy in 1991 and associated transition to the market economy in Mongolia, the following four factors caused trouble in the operation and maintenance of the Sum's generating facilities: (1) the lack of business operating senses, (2) the interruption of spare parts supply, (3) the lack of technical capability and (4) shortage of management budget. The operation of much equipment has been obliged to remain stopped after failure since operators cannot repair them. Some generators may possibly still work, but the efficiency is quite low. Inadequate power supply might have a serious influence upon the daily lives of people in the Sum centers and serious effects to the socio-economic activities of the Sum centers.

Under such situations, the Government of Mongolia decided to formulate a master plan for supplying the stable electric power to the Sum centers by the renewable energy which exists in the country as indigenous and abundant solar and wind energy resources. The Master Plan Study was carried out in response to such a request with the following objectives.

(1) Formulation of a Master Plan for supplying stable electric power to the isolated 167 Sum centers from the power transmission system by renewable energy by the final target year 2015.

(2) Testing through actual operation of three renewable energy pilot power plants (hereinafter referred to as "the Pilot Plant") and observation of the system operation data to reflect the Master Plan.

(3) Establishment of management bodies and an operation and maintenance system in each Sum center,

(4) Transfer of the relevant technologies and know how, and

(5) Contribution to saving fuel oil resources and global environmental protection.

2. Basic Policy of the Study

The Study consists of two stages: the Master Plan Study stage and the Pilot Plant Installation Study stage (actual proof test stage) in the three Sum centers. The two stages of the Study were carried out at the same time. The data measured by the Pilot Plant were fed back to and utilized effectively for the formulation of the optimum power supply Master Plan. The Study was carried out in two years from October 1998 to September 2000. The Study started from the inventory survey, followed by the sample survey, renewable energy potential survey and analysis, and the implementation of an actual proof test by the Pilot Plant. Through these surveys and data analysis and confirmation of the Mongolian needs, a power demand forecast and a study of optimum power supply plan were made. After the completion of all the surveys and analysis, the Master Plan of Rural Power Supply by Renewable Energy was formulated. In addition, an economical and financial assessment was made based on the optimum power supply plan and adequacy and possibility of the implementation of the project by equity or various loans was studied.

3. Outline of the Master Plan

(1) Formulation Strategy

The Master Plan is formulated for such objectives as the security of people's living, sufficiency of Basic Human Needs (BHN), rural development and activation of rural economic activity through the realization of power supply for the Sum centers by the development of rich and indigenous renewable energy in Mongolia, where these Sum centers are not supplied the electric power from the national transmission line system by 2000. In addition, the realization of the project is expected to contribute to global environmental protection by the reduction of CO_2 and NO_x as well as effective power operation by reducing the imported fossil oil consumption.

(2) Summary of Development Plan

The development plan of Stage 1 by the year of 2005 is proposed to adopt a small-scaled renewable energy generation plant for the adequacy of BHN for the Sum centers. In Stage 2 by 2010, the renewable energy generation plants are installed to supply any power requirements covering peak power in summer for all the consumers including general consumers in the Sum centers. In Stage 3

by the final target year 2015, the power generation plants are installed for all the power requirements including peak power in winter in the Sum centers. It is a highlight that a combined power generation plant of renewable energy generation plant and fuel cells plant is installed in Stage 3 of the final target year 2015 of which the combined power generation plant has great advantages of non-fuel oil consumption, economic and ecosystem for the global environmental protection. A summary of the stage wise development plan is shown below.

Summary of Stage Wise Development Plan

Stage	Item	Description
Stage 1 (2005)	Objective	Sufficiency of BHN, consciousness change for saving energy
	Demand	Hospital, School, Dormitory, Sum Office
	Supply	Independent power supply by renewable energy, direct supply to consumers (solar, wind + battery)
Stage 2 (2010)	Objective	Stable power supply to general consumers, securing peoples stable life
	Demand	Public facilities and general consumers
	Supply	Independent power supply by renewable energy, direct supply to consumers (solar, wind + battery)
Stage 3 (2015)	Objective	Stable supply, saving fossil energy, rural development, global environmental protection
	Demand	All the consumers
	Supply	H2 production by renewable energy, power supply by fuel cells (solar, wind + fuel cells)

By the proposed plans described above, a stable power supply for the Sum centers will be secured by the final target year 2015 by such indigenous renewable energy as self-sufficing energy of solar and wind instead of a diesel power plant which uses fossil fuel oil.

A huge number of batteries will be installed in the years 2005 and 2010 according to the master plan. These batteries will be exhausted and disposed of in the years 2005 and 2010, respectively. In order to alleviate an environmental load, these batteries should be exhausted in a proper manner. As countermeasures, ① To procure the batteries from the manufacturers who obtain the environmental management standard ISO 14000. ② To oblige the contractors to receive and properly dispose of the exhausted batteries when installing new batteries and fuel cells in 2010 and 2015, respectively.

(3) Summary of Operation and Maintenance Plan

An operation and maintenance plan is proposed to achieve: 1) independent administration of power plants in the Sum centers and 2) establishment of a sustainable maintenance and management system.

By 2005, it aims at the "establishment of a responsible management system" by introducing a meter-rated tariff system, technical and financial system for maintenance, and proper record keeping system in operation and maintenance. By 2010, it aims at "stable power supply and technical accumulation" by realization of year-round operation, establishment of replacement funds, and reduction of transmission

loss by half. By 2015, it aims at "complete self-sufficient management" by improving service quality, reducing power generation cost, and achieving sustainable development.

In order to eliminate tariff gaps between central grid and Sum center users, and also to install sustainable Sum power operations, it is recommended that the subsidy borne out of central grid revenue be paid to the Sum center and the Sum centesr pay the lease charge for the equipment.

It is almost impossible for the Ministry of Infrastructure Development, whose main role is policy making, to supervise and support all power plants in the Sum centers across the country. So it is proposed to establish a new organization which supervises power plants in the Sum centers, provides management guidance, and dispatches a regular patrol team to Sum centers in order to monitor the condition of power plants and train operators.

In order to realize the target organization, it is effective way to enhance the mobile maintenance team organized with Japan's Grant Aid for diesel generators and to incorporate that into Sum Power System Supporting Organization.

4. Test Results Evaluation of the Pilot Plants

Pilot plants that consist of a PV-Wind hybrid generation system and meteorological monitoring system such as a pyranometer and anemometer have been installed at three Sum centers for pilot tests. The generated power by using pilot plants is being supplied to a hospital at Adaatsag sum of Dundgovi aimag and Tariat sum of Arkhangai aimag, and to a hospital and school dormitory at Bayan-Undur sum of Uvurkhangai aimag. There are two main objectives for the pilot tests: 1.) to monitor the operation of renewable energy generation system by sums and 2.) meteorological data collection. The collected meteorological data at pilot plants have been used to correct the margin of monitoring error of the data that were monitored by Meteorological agency. On the basis of the corrected meteorological data, a master plan has been planned. At the beginning of the pilot plants operation, operators made some mistakes. For example, the system was shut down automatically because voltage of the storage batteries dropped to the excess discharge prevention voltage. However, operators are improving their operation skill of pilot plants with increase of their knowledge of the generation system by renewable energy.

5. Project Assessment

Project analysis provides an overall evaluation of the stage-based projects in terms of economic and financial viability, technological and institutional feasibilities, including the economic impacts of carbon dioxide reduction.

The index used for financial and economic analysis is the Internal Return on Investment (IRR) Technological evaluation focuses on the technological adaptability at each stage. Organizational analysis

checks the managerial capacity of the organizations involved with the project implementation. In social analysis, special attention is paid to public service and social welfare improvements, especially to the impacts on the poor.

The financial and economic evaluation is summarized as follows:

It is evident from the IRRs that it is not possible to supply power to the sum centers under the profit seeking market mechanism. The EIRR is –3.3% and the FIRR is –11.3%, all negative for the year 2005 program. However, if power supply to the rural areas to be continued, there is no clear alternative method. The diesel engine power generation system that was used as the alternative method is not economically superior to the proposed systems. The proposed systems are financially more viable under the assumption of 24-hour power supply. Lack of financial viability of the diesel engine system is forcing the current practice of severe power rationings. The IRR in relation to the alternative power supply for the year 2005 is 12.8%. The issue of the power supply to the BHN service providers in rural areas of Mongolia is an issue of how to divide the limited financial resources between city and rural areas in the field of social service.

As mentioned above, the returns on investment are negative for the year 2005 program, indicating a poor investment performance in the near future. Changing financing options such as equity financing, foreign borrowing, and privatization/BOT do not change the investment performance basically. Unless it is possible to reduce the implementation costs for the year 2005 program to improve the returns on investment, there is no other recourse than grant based financing to supply power to the rural areas. It is further recommended to elaborate the financing plan with a higher accuracy. For the second and third stage projects, the investment performances improve to a large extent. For the second stage of the year 2010, the EIRR is 1.0% and the FIRR is –2.9% and for the third stage of the year 2015, the EIRR is 6.5% while the FIRR is 2.9%.

The result of the technical evaluation is as follows:

Installations of renewable energy power supply systems to public facilities are planned by 2005 considering with the importance of Basic Human Needs. The planned system capacity is the same as that of the pilot plant in this master plan, so the experience gained through the pilot test will be fed back to the plan. The experience of the pilot plant makes the plan feasible. The renewable energy power supply system will be operated and synchronized with a diesel generator in 2010. The system will be planned on the basis of wind resource and solar radiation data monitored by a meteorological data monitoring system, installed by 2005 at each Sum centers. Furthermore, the increase of operation and maintenance skill through the experience of the plant operation from 2005 makes the larger size power supply system feasible. Fuel cell will be introduced by 2015. Technologies for fuel production by using a renewable energy source and power supply system from fuel cell are under development. So, introduction of information on fuel cell to Sum people and seminars or training on fuel cell are necessary.

The result of the organizational evaluation is as follows:

Because the system in 2005 is a comparatively small-scale renewable energy system targeting mainly public facilities such as hospitals and schools, it is quite possible for Sum offices to become accustomed with necessary technologies to operate and maintain the system, and to establish an operation and maintenance organization for it. Since the system in 2010 will supply electricity for all users in Sum including households, it is necessary for Sum office to strengthen the management capacity which will be established by 2005. But Sum offices can cope with this challenge, if the system is expanded gradually according to the Sum office's management capacity. The system in 2015 will include new technologies such as a hydrogen storage and a fuel cell, but Sum offices can master them with the technical and managerial capacity that has been accumulated by that time.

The result of the social evaluation is as follows:

At present, most Sum centers can afford to generate electricity only during the night time in the winter due to financial difficulty. So Sum hospitals are forced to conduct emergency operation and delivery service during the night time under the flame of a candle. In addition, Sum schools cannot utilize audio-visual facilities for language classes, machine tools for technical education and computers, due to the lack of power supply during the daytime. Thus, the shortage of electricity is severely hindering education in Sum centers. If Sum hospitals and schools can receive a stable power supply by 2005, it will improve the quality of social services and satisfy local people's needs. It will also minimize the negative effects on the poor and the disadvantaged caused by the transition from socialism to a market economy and by natural disasters such as the heavy snow. In this way, power supply will play the key role in maintaining the basic social services (basic human needs) for the poor.

6. Description of the Project

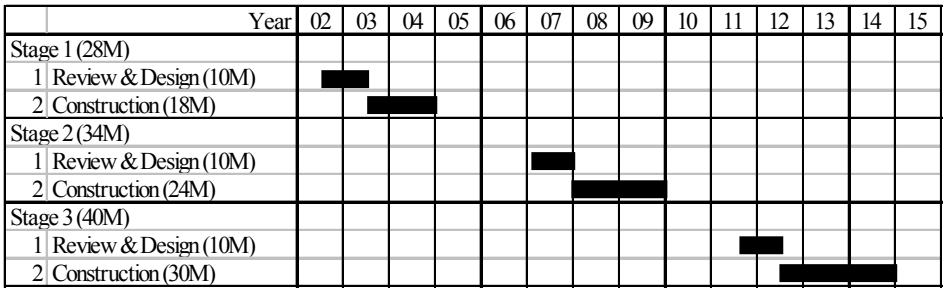
For the realization of the development plan, it is recommended to implement three stage development projects. The description of the Project is shown in the table below.

Description of the Project

Facility	2005 (Stage 1)		2010 (Stage 2)		2015 (Stage 3)	
	Q'ty	Description	Q'ty	Description	Q'ty	Description
Grid connection	(4 sums)		(4 sums)		(4 sums)	
Diesel generator	65 sums		0		0	All retire
Solar power	123 sums	New, small scale	123 sums	Expansion, large	148 sums	Expansion and new
Wind power	45 sums	New, small scale	45 sums	Expansion, large	53 sums	Expansion and new
Mini-hydro power	2 sums	New, small scale	1 sum	Rehabilitation	(3 sums)	No new plan
H2 production plant	0		0		137 sums	New
H2 storage plant	0		0		161 sums	New
Fuel cells	0		0		161 sums	New
Distribution system	376 km	Trans. 334 sets	7014 km	Trans. 668 sets	42 km	Expansion
In/outdoor wiring	90 km	Hospital, etc.	400 km	General consumers	10 km	Add. Consumers
Management system	350 sets	New server	354 sets	Renewal	0	Renewal software
MET observation	105 sets	New	0	Continuous use	0	Continuous use
Power house	123 sets	New	0	Continuous use	39	New

The general implementation schedule is shown below.

General Implementation Schedule



The total construction cost of the proposed Stage 1 Project by the renewable energy generation plant is estimated at about 23.8 million US dollars. The average investment per Sum center of the Stage 1 Project is about 143 thousand US dollars.

7. Future Important Problems

The following important problems for the Government should be settled for the promotion of renewable energy development in the country so that the renewable energy power plant has a positive impact on the global environment.

- Policy making on Long-term Development Plan (restraint of outflow of foreign money by fuel oil import, energy security measures, positive impact against greenhouse effect and so on)
- Reformation of Consciousness of Consumers (Saving energy and fuel resources, demand side management, efficiency enhancement of management, operation and maintenance and so on)
- Legal Favorable Provisions for Promotion of Development (tax deduction measures, subsidy, power tariff discount and so on)
- Introduction of Meter-rated tariff system
- Reduction in the price gaps between power tariffs between urban and rural users
- Institutional building for operation and maintenance organizations and adequate allocation of the financial resources for rural power supply.

SUMMARY
CONTENTS

Abbreviations and Acronyms

(1) Domestic Organization

EA	:	Energy Authority of Mongolia
MOID	:	Ministry of Infrastructure Development
PTA	:	Post and Telecommunication Authority
UCS	:	State owned Hydropower Company

(2) International or Foreign Organization

ADB	:	Asian Development Bank
GTZ	:	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH, Germany
JBIC	:	Japan Bank for International Cooperation, Japan
JICA	:	Japan International Cooperation Agency, Japan
KFW	:	Kreditanstalt für Wiederaufbrau, Germany
NEDO	:	New Energy and Industrial Technology Development Organization, Japan
OECF	:	Overseas Economic Cooperation Fund, Japan
TACIS	:	Technical Assistance for Common-welfare Independent State, EU
UNDP	:	United Nations Development Program
USAID	:	The US Agency for International Development, USA
WB	:	World Bank
WHO	:	World Health Organization
ISO	:	International Organization for Standardization

(3) Others

BHN	:	Basic Human Needs
BOD	:	Biochemical Oxygen Demand
BOO	:	Build Own Operate
BOT	:	Build Operate Transfer
COD	:	Chemical Oxygen Demand
DSM	:	Demand Side Management
F/S	:	Feasibility Study
GDP	:	Gross Domestic Product
NGO	:	Non Government Organization
O&M,O/M	:	Operation and Maintenance
VAT	:	Value Added Tax

(4) Technical Term

AC	:	Alternative Current
DC	:	Direct Current
CO	:	Carbon Monoxide
CO2	:	Carbon Dioxide
NO2	:	Nitrogen Dioxide
NOx	:	Nitrogen Oxides
SO2	:	Sulfur Dioxide
SO4	:	Sulfur Tetroxide
SOx	:	Sulfur Oxides
ACSR	:	Aluminum Conductor Steel Reinforced
SCADA	:	Supervisory Control and Data Acquisition
TV	:	Television
NewDG	:	New Diesel Generator
ExDG	:	Existing Diesel Generator
PV	:	Photovoltaic Cell
WG	:	Wind Generator
FC	:	Fuel Cell
Hyd	:	Hydraulic Generator
Grid	:	Transmission Line
CES	:	Central Energy System
EES	:	East Energy System
WES	:	West Energy System
LDC	:	Load Dispatching Center
Indepen.	:	Independent (Electric System)

(5) Unit

Length	mm	:	millimeter
	m	:	meter
	km	:	kilometer
Area	mm^2	:	square millimeter
	km^2	:	square kilometer
Weight	mg	:	milligram
	ton, t	:	metric ton
Pressure	hPa	:	hecto Pascal
Time	mo	:	month
	yr	:	year
Electrical Measurement	V	:	Volt
	Hz	:	Hertz (cycle)
	kW	:	kilowatt
	MW	:	Megawatt
	Wp	:	Watt
	kWp	:	kilowatt
Other Measures	%	:	percent
	cal	:	calorie
	℃	:	degrees centigrade
Derived Measures	kWh	:	kilowatt hour
	GWh	:	Gigawatt hour
	MVA	:	Megavolt ampere
	Ah	:	ampere hour
Currency	Tg, tg	:	Tugrik, Mongolian Currency
	US$	:	US Dollar
	M.US$	:	Million US Dollar
	US ¢	:	US cent