CHAPTER 10
PRELIMINARY STUDY ON POWER SUPPLY MASTER PLAN

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10.1 General

The Master Plan of the optimum power supply system is to be formulated for the target Sum centers of which the Master Plan includes a long-term development plan from the year 2001 to 2015. The Master Plan is required to be prepared considering the site situation and needs of people in the target Sum centers after careful review and versatile study of the current issues. A power generation plan is the most important item in the power supply master plan. There are lots of planning methods for establishment of power supply system plan, such as WASP[*1], EGEAS[*2], etc.. There exist various planning methods of power supply systems such as linear planning method, dynamic planning method, etc. which are able to smoothly analyze the complicated network structure. As for the recent methods, which are able to promptly analyze the large-scale network structures including a non-linear variable, the modern humanistic methods such as fuzzy system theory, genetic algorithms, simulated annealing methods, etc. are used for analysis of the complicated large-scale systems.

The objective of the Study is to determine the least cost alternatives of supplying electric power to 167 Sum centers by (1) transmission line extension, (2) independent diesel power generators, (3) solar power generation systems, (4) wind power generation systems, and (5) a suitable hybrid system combined above, and to plan an optimum power supply system for 167 Sum centers. Mini-hydropower generation plants may be taken into consideration in the Master Plan Study, only if any existing feasibility study reports in English are available to the Study after review of the existing feasibility reports.

After the democracy reform in 1990, the Mongolian social and economic situation has been undergoing a major transformation to a market regime, but the current situation is on the way to the goal, and basic data for formulation of the optimum power supply plan vary remarkably. Under such situations, it is not fit to apply the formularized analysis methods mentioned above for the formulation of the optimum power supply plan. Therefore, the new method is applied for the Study based on the collected data and information and considering the social and economic conditions and needs of people in the target Sum centers. The planning method and preliminary study of the power supply plan are described in the subsequent clauses.

*1 WASP : Wien Automatic System Planning Package

*2 EGEAS : Electric Generation Expansion Analysis System

10.2 Methodology for Power Supply System Planning

The method and procedure for power supply system planning is shown in Figure I.10.2-1.

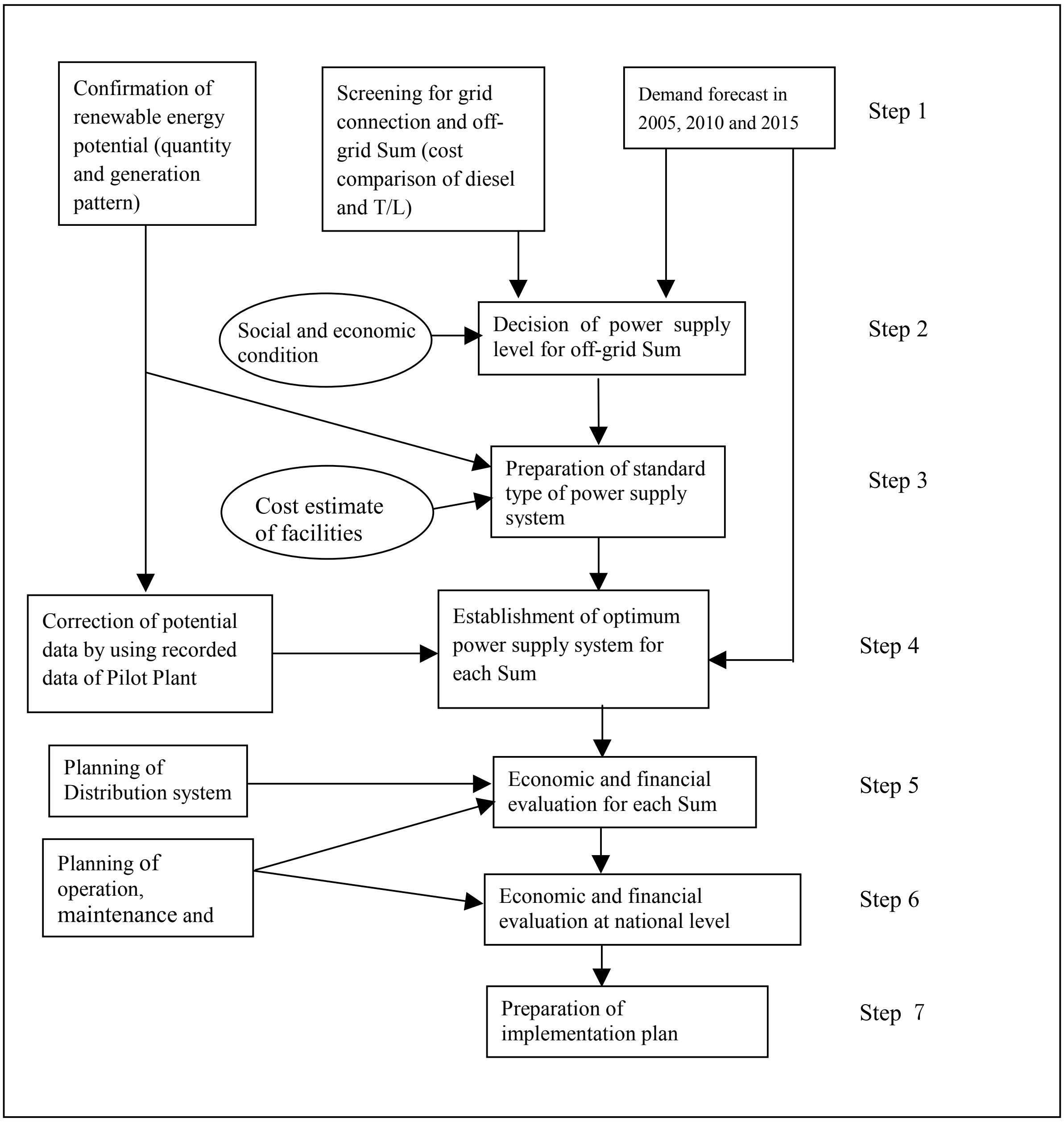


Figure I.10.2-1 Method and Procedure of Power Supply System Planning

(1) Step 1

Screening for the selection of an isolated Sum or grid connected Sum. The criteria of this screening is the economic comparison between a diesel generator and the construction cost of transmission lines from the nearest tapping point. As the transmission lines are extending even at present, the construction costs of the transmission lines are estimated based on the existing grid condition as of the end of 1999. Some Sum centers are scheduled to connect to the grid in/after 2000. In case that some Sum centers are connected to the grid in/after 2000, these Sum centers are excluded from the target of the isolated power supply at the time of connection.

(2) Step 2

As already mentioned, the stages of the examination for the master plan are years 2005, 2010 and 2015. The demand forecast for each stage is worked out in Chapter 8. If the master plan is established to cover all the demand at one time, there is a tendency for the construction cost to become an overinvestment considering the current prices of the PV panels and the other facilities, and present economic situation. On the other hand, if the decision is made only from the economic point of view, there is a possibility for the effective countermeasures not to be applied to the Sum centers. Therefore, it is important to decide the level of quantity and reliability of power supply in each stage against the forecasted demand, considering the social factor in Sum centers as well as economic conditions

(3) Step 3

It is effective way for establishment of the master plan to decide the standard type of power supply facilities; wind generators, PV panels, batteries and fuel cells. The standard types are prepared based on the potential of renewable energy, and the present and estimated cost in each stage of wind and PV generator sets and fuel cells.

(4) Step 4

The potential data of renewable energy is corrected to increase its reliability and precision in comparison with the meteorological data recorded by the pilot plants. The standard types of power supply facilities are applied to each target Sum center based on the corrected potential data and the forecasted demand. By this work, the power supply systems - a part of power source - for all the target Sum centers in each stage are established.

(5) Step 5

Besides the above, a rehabilitation plan of a distribution system, operation and maintenance plan of the total system are prepared. The economic and financial evaluation is carried out for each Sum including those costs.

(6) Step 6

The economic and financial evaluation of the project is carried out on a national level. In this step, the operation, maintenance and management plans on a national level are incorporated.

(7) Step 7

Finally, the implementation plan of the project is examined. Regarding the financial plan, the following are incorporated.

1) JBIC special loan for environmental project
2) Soft loan of international financier
3) BOT/BOO
4) Cases of applying equity to the above

10.3 Power Supply through Transmission Line Extension

10.3.1 Comparison Method for Transmission Line Extension and Independent Power Generation

The choice between transmission line extension and independent power generation is largely an economic problem. Based on life-cycle costs of investments and operation and maintenance, the power delivery costs can be compared to conduct objective decision-making.

(1) Calculation of Transmission Extension Costs

The electricity cost in the case of transmission line extension is due to the increase in proportion to the distance from the nearest existing transmission line. The unit cost per distance can be applied to the measured distance on the map from the nearest transmission line to the Sum center. The costs arising from maintenance and transmission loss should be added to the above cost.

(2) Independent Power Generation (Diesel) Cost

In the case of independent power generation, the differences arising from location is insignificant in the independent power system. The unit construction cost is annualized and added to the unit maintenance and fuel cost.

(3) Financial Comparison of Costs

The distance where two unit power costs are at equilibrium will be called the Break Even Point (BEP.) At the Sum centers that are located beyond the BEP, independent power generation becomes more economical while at those within the BEP transmission line, extension is more economical.

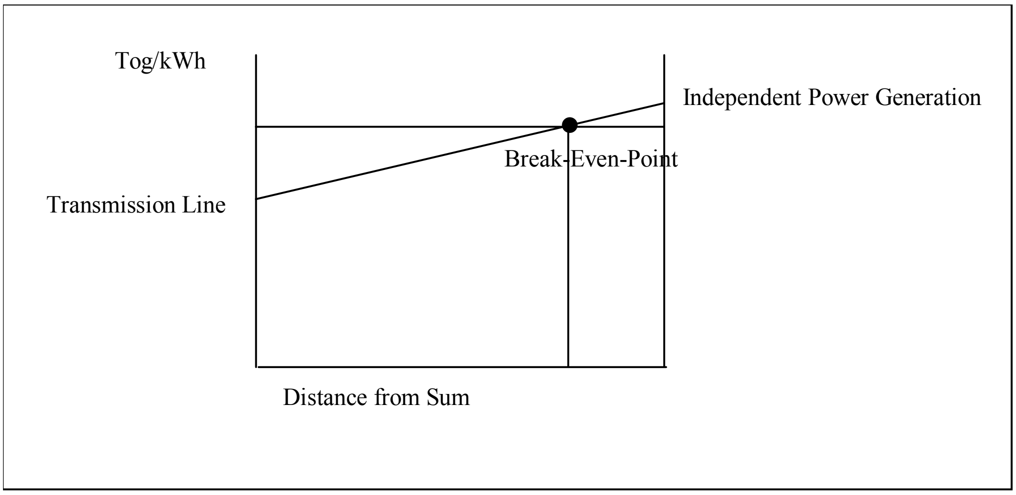


Figure I.10.3-1 Break Even Point

10.3.2 Unit Power Cost Calculation Method

As mentioned above, it is necessary to derive the unit power costs of both transmission line extension and independent power generation for the comparison of the two systems.

In the case of transmission line extension, the unit cost is comprised of 1) power generation cost by the coal fired power generation 2) Investment cost for the transmission line extension to the nearest transmission line and 3) the maintenance cost for the transmission line. In the case of the independent power generation, the power generation costs by the diesel generator including the investment and operation and maintenance are incorporated. The distribution cost of power to each user is ignored since it is needed for both systems

10.3.3 Power Generation Cost

First, power generation costs are compared between diesel generators and coal-fired power plants.

(1) Capital Recovery Value

The base data for the calculation of the fixed cost is the construction cost per unit capacity. Different power generation systems have different life years. To equilibrate the difference arising from life periods, the investment cost is annualized by the use of capital recovery rate. The annual fixed costs for the operation are added to the annualized investment cost to drive the total fixed cost per kW per year as shown in Table I.10.3-1.

Table I.10.3-1 Calculation of Capital Recovery Value

		unit	Coal Fired Thermal	Diesel Engine
1)	kW Construction Cost	US $/kW	2200	750
2)	Fixed Cost	US $/kW	20	7.2
3)	Equipment Life	year	30	15
4)	Construction Period	year	1	1
5)	Discount Rate		10%	10%
6)	Capital Recovery Rate		0.10608	0.13147
7)	Capital Recovery Value	US $/kW/year	253	106

(2) Fuel Cost

The largest cost component in the variable costs of power generation is the fuel cost. Applying the fuel efficiency to the fuel costs as shown in Table I.10.3-2 derives the fuel costs for the two power generation systems.

Table I.10.3-2 Fuel Cost Calculation

		Coal Fired Thermal		Diesel Engine	
8)	Fuel Price	15	US $/ton	450	US $/ kl
9)	Calorific Value	5,300	kcal/ton	9,600	kcal/ kl
10)	Heat Efficiency	35	%	0.25	%
11)	Energy Conversion	-	kcal/kWh	860	kcal/kWh
12)	Heat Rate	2867	cal/kWh	-	cal/kWh
13)	Fuel Consumption	0.54	ton /kWh	0.36	kl/kWh
14)	Fuel Cost	0.008	$/kWh	0.161	$/kWh

(3) O/M Costs

The operation and maintenance costs are assumed to be a fixed proportion to the investment costs. The annual operation hours are set at 7884 hours by assuming a 90% utilization rate for the coal-fired thermal of the Central Grid System and 1752 hours for the independent diesel system[1]. Table I.10.3-3 compares the O/M costs.

[1]The load factor for the sum power demand was assumed to be 0.2. See chap. 8 for the detailed estimation.

Table I.10.3-3 Comparison of O/M Costs

		unit	Coal Fired Thermal	Diesel Engine
15)	Operation and Maintenance Cost	% of construction cost	2%	15%
16)	Annual Ope. Hour	hour	7884	1752
17)	O/M Cost/kWh	US $/kWh	0.0056	0.064

(4) Total Power Generation Costs

Adding all the above costs of fuel and O/M costs to the capital recovery value derives the total power generation costs. The annual operation hour of 7884 for coal-fired thermal and 1752 for independent diesel system is used to covert costs per kW to cost per kWh. Table I.10.3-4 compares the total power generation costs.

Table I.10.3-4 Total Cost

			unit	Coal Fired Thermal	Diesel Engine
18)	Variable Cost/kWh	14)+17)	US $/kWh	0.014	0.225
19)	Fixed Cost	7) / 16)	US $/kWh	0.032	0.060
20)	Total kWh Cost	18)+19)	US $/kWh	0.046	0.286

10.3.4 Transmission Loss and Voltage Drop

In transmission line extension, there is a hidden cost of transmission costs in addition to investment and operation costs. For the Sum centers under the Study the required capacity for the power output is less than 200 kW except for a few large Sum centers. The attached Table I.10.3-5 shows the voltage received and voltage drop via 10kV transmission line to send 200 kW. A lenient value adopted here for the voltage drop is 10% which shows 60 km as the maximum allowable distance.

Similarly TableI.10.3-6 shows the voltage received and voltage drop via 35 kV transmission line to send 200 kW.

10.3.5 Receiving Power Cost of Transmission Line

The final cost of the transmitted power consists of three elements. First there is an investment cost of a switch required to branch out power from the existing transmission line. The second element is the construction cost of transmission which increases in proportion to distance. The third element is the above calculated transmission loss. Adding all the three elements in addition to the power generation cost by the coal fired power plant derives the final cost. The attached Table I.10.3-7 and Table I.10.3-8 show the results of the tabulation.

10.3.6 Break Even Point Analysis

Comparing independent power generation cost to transmission line extension cost by distance can derive the Break Even Point (BEP). Since the cost of independent power generation is US $ 0.286/kWh, the BEP for 35 kV is 25 km and for 10 kV is 35 km.

10.3.7 Potential Sum Centers for Transmission Line Extension

The Sums that fall into the radius of 30 km are chosen on the map to be deemed economical as explained in Section 10.3.6. The Sums that are receiving power from China or Russia are excluded, as there is no possibility for internal transmission extension. The Sums that are only potential candidates to receive power from these two countries are included since the chance is very low for implementation within the year 2000. As a result, the Sums that are selected for transmission extension are 4 in total as shown in Table I.10.3-9.

Table I.10.3-9 Potential Sum Centers for Transmission Extension

No.	ID	Sum	Aimag	Distance(km)
1	63	SUKHBAATAR	SUKHBAATAR	40
2	110	TOSONTSENGEL	KHUVSGUL	47
3	170	BAYAN-NUUR	BAYAN-ULGII	15
4	171	ALTAN-TSUGTS	BAYAN-ULGII	5

10.4 Power Supply for Off-grid Sum Centers

Screening for off-grid and grid connected Sum centers was executed in Section 10.5. The grid connected Sum centers are realized as 24-hour power supply.

In this Chapter, the levels of power supply for the off-grid Sum centers are decided in each stage and the basic system configuration to realize the power supply levels are examined.

10.4.1 Power Supply for Off-grid Sum Centers in 2005

(1) Level of Power Supply

It was found in the inventory and sample survey that the actual power supply is limited even though they have diesel generators. On the other hand, there is a strong request to improve public services for BHN, especially for the function of hospitals and schools. Besides, the request for increasing the function of the Sum office exists in order to activate the industry of the Sum center. Therefore, it is strongly hoped that power will be supplied 24 hours a day to the hospital, school and Sum office.

However, the price decrease of PV panels and wind generators is not expected so much in this stage. Also, the price of battery, which compensates the intermittent of renewable energy, seems to be still high. Usual economic comparison brings the advantage of a diesel generator even in the Sums with the high potential for renewable energy. On the contrary, the point of the problem is the fact that the people in Sum centers are forced to receive the limited power supply even though they have diesel generators due to the lack of finance to procure the fuel and spare parts.

Therefore, the level of power supply is decided by paying much attention to the following matters, not only the economic point of view.

- Satisfaction of BHN and activation of Sum
- Decrease of fuel consumption or keeping current level of that by diesel generator
- Contribution to the environment to suppress CO_2
- Economical point making the most of the advantage of renewable energy

Therefore, the power supply level for the off-grid Sum centers in the stage 2005 is decided as follows.

- 24 hour power supply to hospitals, schools and Sum office
- To the other consumers than the above, it depends on Sums' policy

(2) Plan of Power Supply

The following two types of power supply system are proposed to realize the above power supply level.

- Diesel generators
- Combination of renewable energy and diesel generators

Diesel generators are economical judging from the initial investment, and are able to provide a perform stable power supply. Power is supplied only by diesel generators in the Sum centers where the potential of renewable energy is judged low. In this case, some subsidiary countermeasures are necessary to satisfy the level of power supply because the budget too short to purchase the fuel and spare parts.

In the Sum centers where the potential of renewable is judged high, the power supply is performed by the combination of diesel generators and renewable energy. The renewable energy includes solar, wind and small hydro. The reason why the combination with diesel generators was made is to suppress the initial cost of the system. The initial cost of a renewable power source is three to seven times higher than that of a diesel generator. Besides that, a battery is required with the renewable power source for the stable power supply, and that battery is costly.

In order to minimize the initial cost of the system, the policy for the power supply by renewable energy is as follows:

- Limiting power supply by renewable energy to three public facilities (school, hospital and Sum office)
- Ensuring a 24-hour power supply by renewable energy only in the summer season
- Supplementing lack of power supply to the public facilities in the winter season with diesel generators

The reason why the 24-hour power supply by renewable energy is limited to the summer season is that the demand in the summer is lower than that in the winter and also the solar potential in the summer is higher than that in the winter.

10.4.2 Power Supply for Off-grid Sum Centers in 2010

(1) Level of Power Supply

The level of power supply in 2010 is defined as follows:

- 24 hours power supply to all the consumers in a Sum center

(2) Plan of Power Supply

The following two types of power supply system are proposed in the stage 2010 same as that in 2005 to realize the above power supply level.

- Diesel generators
- Combination of renewable energy and diesel generators

Power is supplied only by diesel generators in the Sum centers where the potential of renewable energy is judged low. On the other hand, improvement of the management for the power supply and the price down of wind and solar facilities are expected in the stage 2010. Therefore, it is possible to increase the capacity of solar and wind facilities in the Sum centers where the potential of renewable energy is judged high.

The policy of power supply by renewable energy in 2010 is as follows:

- Power supply by renewable energy to all the consumers in a Sum center
- Ensuring a 24-hour power supply by renewable energy only in the summer season
- Supplementing lack of power supply in the winter season with diesel generators

10.4.3 Power Supply for Off-grid Sum Centers in 2015

(1) Level of Power Supply

The level of power supply in 2015, which is same as that in 2010 from the consumers' point of view, is defined as follows:

- 24 hours power supply to all the consumers in a Sum center

The difference from that of 2010 is the realization of to realize the power supply without fossil fuel and without diesel generators.

(2) Plan of Power Supply

The power supply to the off-grid Sum centers is performed by the combination of renewable energy and diesel generators in the year 2005 and 2010. However , in the year 2015, the power supply system that consists of only renewable energy is proposed.

The advantage of the proposed system in 2015 is as mentioned below:

- The security of energy supply in Mongolia is held by foreign countries because all the oil of domestic consumption is imported; it is remembered that Russia stopped the export of petroleum products to Mongolia in 1999, and which harmfully affected the economic activities (especially transportation) in Mongolia. The production of energy by renewable source to cover the consumption of countryside enables Mongolia to secure a stable power supply, economic activities and life in the countryside.

- It is possible to establish zero emission of CO_2 from fossil fuel on power supply since there is no use of diesel generators. It contributes much to decreasing the greenhouse effect.

The major world auto makers declared to start the mass production of fuel cell cars in 2003 or 2004. Similarly, the major makers of electric appliances set the target year of mass production of fuel cells at 2003 or 2004. Therefore, the drastic price down of fuel cells and hydrogen production and storing system are expected, and the plan to introduce such a hydrogen system to the Sum centers becomes a realistic idea.

By storing renewable energy as hydrogen, the intermittent of renewable energy is conquered and the application of renewable energy becomes economical. Then, it becomes possible to introduce the renewable energy to the Sum centers where the potential of that is considerably low. In the Sum centers of economically no potential of that, they can bring the hydrogen from places where high renewable energy potential exists, and generate power with the hydrogen by fuel cells.

Therefore, the standard types of power supply system in 2015 are as follows:

- Renewable energy and fuel cell (including hydrogen production and storing system)
- Fuel cell (including hydrogen storing system)

In the case of a fuel cell system, hydrogen is transported from the high potential area where the hydrogen is produced by renewable energy. By the establishment of this system, the energy self-sustenance in the rural area is completed in this stage.

10.4.4 Role of Diesel Generators

As mentioned above, diesel generators are essential even in the Sum centers to which the renewable energy is applied in the stages of 2005 and 2010. By the time when fuel cell becomes popularly used as a new energy source, a diesel generator will supplement the intermittent and high initial cost of the renewable energy.

It is important to reconfirm the role of diesel generators in the system of 2005 and 2010 in order not to get the false idea of double investment from the simple image of the combination of diesel generators and renewable energy sources.

The roles of diesel generators in the combination system are as follows:

- Year 2005 : Ensuring the power supply to all the consumers except the three public facilities throughout the year
- Year 2005 : Ensuring the power supply to the three public facilities at the peak time in the winter season and increasing the reliability of power supply by renewable energy in the summer season
- Year 2010 : Ensuring the power supply to all the consumers at the peak time in the winter season and increasing the reliability of power supply by renewable energy in the summer season

As stated in Section 7.4, Japanese grant of diesel generators to Sun centers has been proceeding. As of January 2000, the number of Sum centers where the diesel generators were installed and committed to be installed are 99. 96 Sum centers out of 99 are the target Sum centers of the off-grid power supply system in the master plan. In these Sum centers, the granted diesel generators are able to be incorporated in this master plan. From this point, it can be mentioned that the grant aid project is well coordinated with this master plan.

10.5 Images of Power Supply Systems

Any of the following systems are applied as the power supply system to the Sum centers until 2015.

1) Grid connection
2) Diesel generator
3) Combination of renewable energy and diesel generator
4) Renewable energy and fuel cell (including hydrogen production and storing system)
5) Fuel cell (including hydrogen storing system)

The images of the above are shown in the attached Figure I.10.5-1 with the application period. As renewable energy, solar, wind and small hydro are available in Mongolia. In this Section only solar and wind are regarded as renewable energy since small hydro is mentioned in Section 10.7.4.

The system of the each stage is explained below.

10.5.1 System Image in 2005

The Sum centers, where a grid connection is judged economically better than an off-grid power source in the examination of Section 10.3, are to be fed with power by the grid through extension of transmission lines. In the target Sum centers for the off-grid power source, the Sum centers with low renewable energy potential are supplied power by diesel generators, and the Sum centers with high renewable energy potential are supplied power by a combination of renewable energy and diesel generators.

The system configuration of the combination of renewable energy and diesel generators is shown in Figure I.10.5-2.

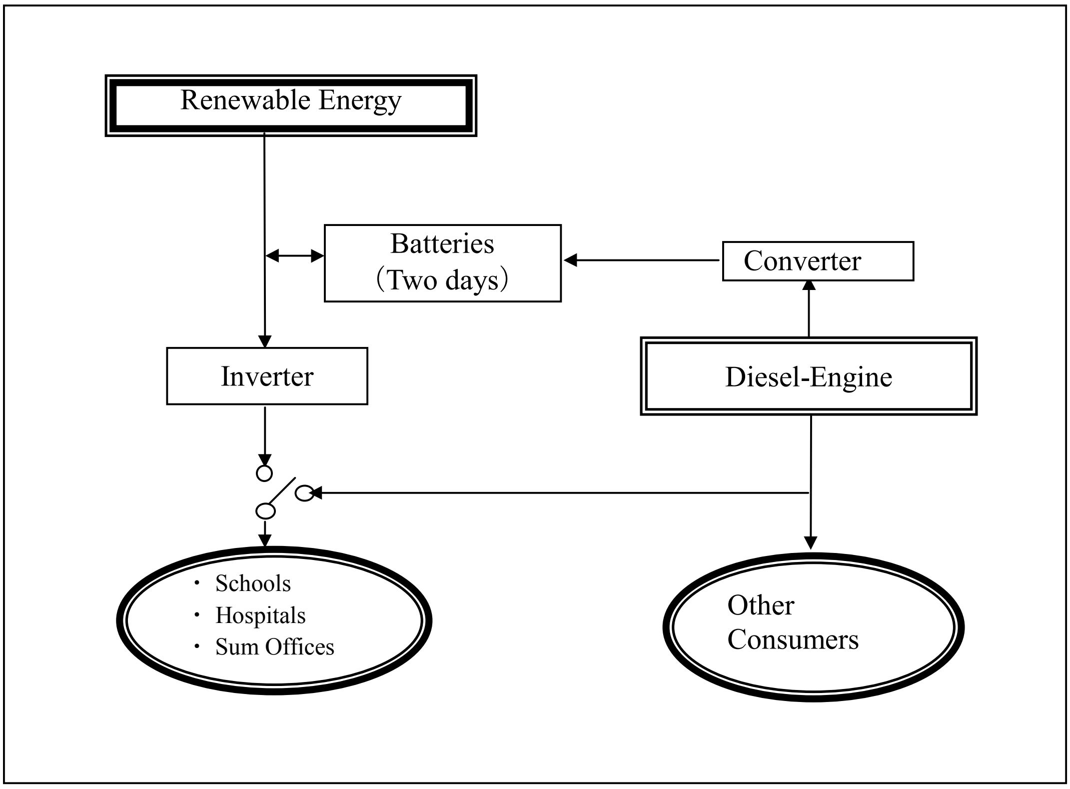


Figure I.10.5-2 System Configuration of Renewable Energy and Diesel Generator in 2005

The renewable power source consists of solar and wind or solar alone. The solar and wind system is called a hybrid system*1. In the summer season, power supply to the three public facilities is performed by renewable energy. A battery has to be provided with renewable power sources in order

*1 The system that act as one power source to completely combine more than two sources is called as hybrid system in this report. DC circuits of wind and solar are connected, then the system can be called a hybrid system. However, the combination of diesel and renewable energy is called hybrid system only in the case where the system is operated synchronously in AC circuit.

to ensure a stable power supply. The capacity of battery is decided so as to keep continuous power supply for two days without generation from wind or solar in the summer season. In the winter season, the potential of renewable energy usually becomes low. Then, the system is designed to be able to charge the battery by the diesel generators. Selection of power sources, diesel generators or renewable energy, for the three public facilities is realized by a manual changeover switch based on the economical and easy maintenance points of view.

10.5.2 System Image in 2010

Though the system configuration is basically the same as that in 2005, the major different point from the 2005 system is that diesel generators and renewable power sources are combined as hybrid system of performing synchronous operation. The hybrid system encourages increasing power supply reliability and decreasing fuel consumption of diesel generators, which will bring about economic effect.

The hybrid system of renewable power source and diesel generator is shown in Figure I.10.5-3.

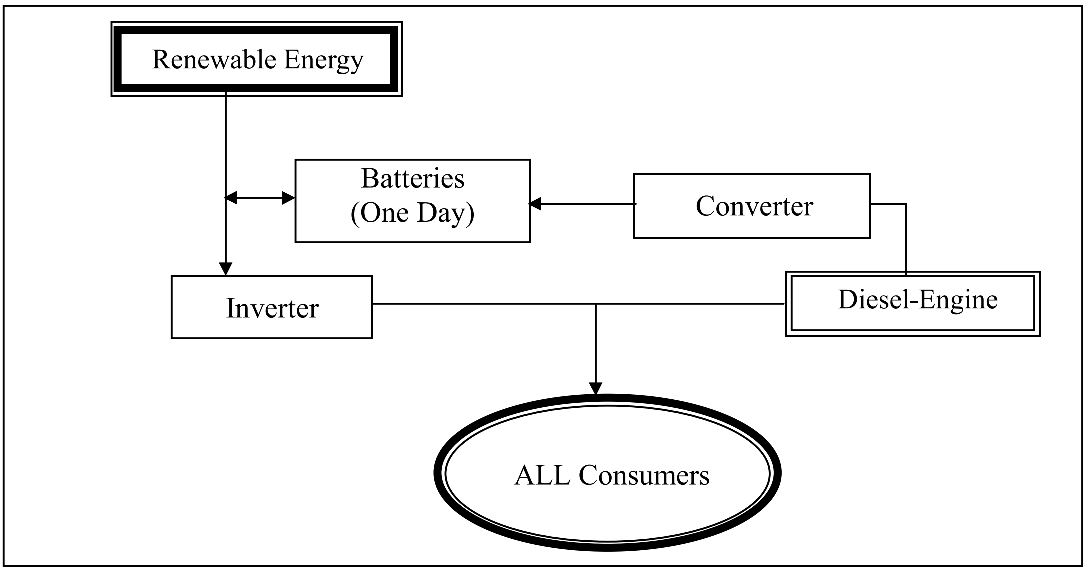


Figure I.10.5-3 System Configuration of Renewable Energy and Diesel Generator in 2010

The difference of power supply condition from that in 2005 is that all the consumers in a Sum center are supplied by a renewable power source in the summer season. Therefore, it is necessary to install a considerably large capacity of battery to keep the stable power supply to the consumers. In order to depress the cost of the battery, the target ability of the battery is set lower than that in 2005 so as to continue the power supply for one day without generation of solar or wind in the summer season. By this lower setting of capacity, the possibility of a lack of power supply will be increased. When the rest of power in the battery becomes low, the priority of power supply is given to the public facilities.

10.5.3 System Image in 2015

The system configuration in 2015 is drastically changed. The grid connections remain as they are. However, the diesel generators and batteries are not applied. Instead, fuel cells and a hydrogen system are adopted.

Figure I.10.5-4 indicates the system configuration in 2015.

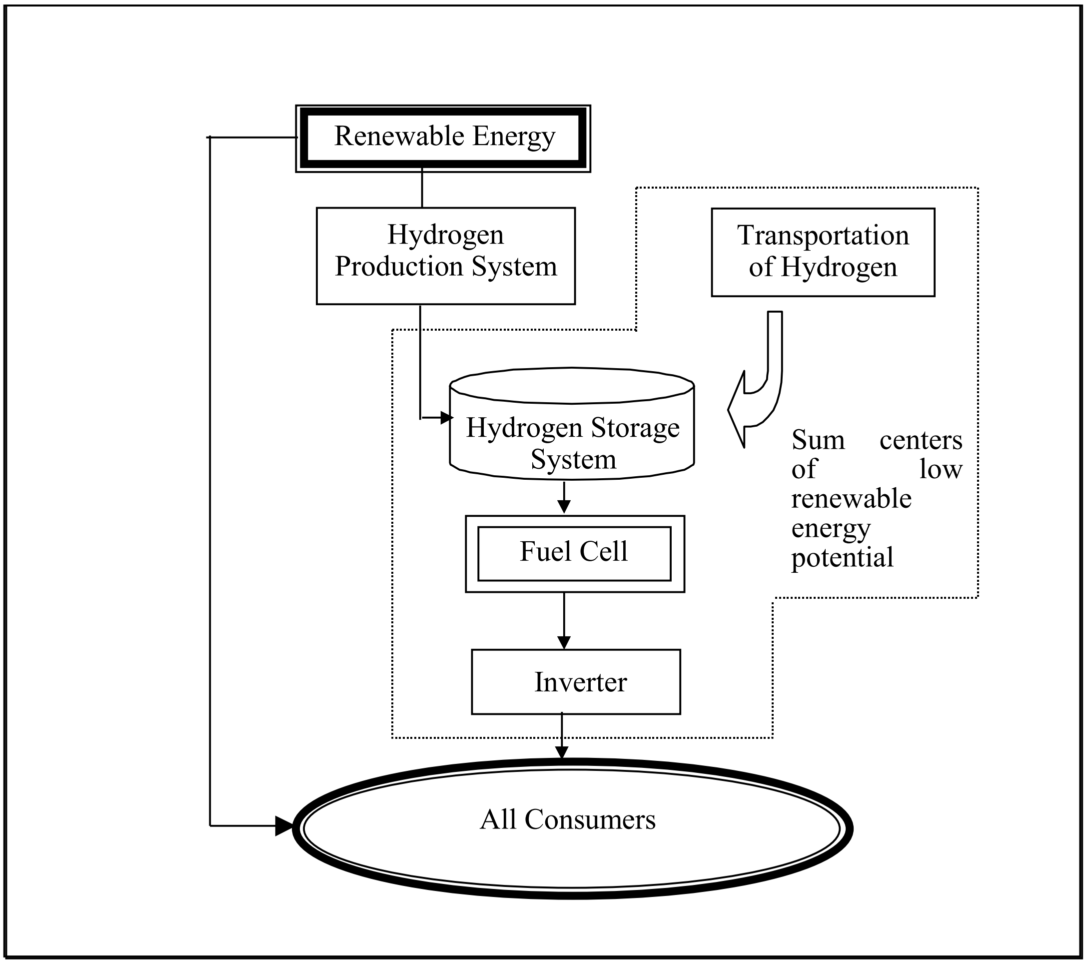


Figure I.10.5-4 Configuration of Power Supply System in 2015

The power generated by renewable sources produces hydrogen as well as being fed to the consumers. The principle of the hydrogen production system is same as the electrolysis of water, where hydrogen is made from water. Produced hydrogen is reserved in the hydrogen storage system and converted to electricity upon demand of the consumers. In this case the battery is not necessary because energy is reserved as hydrogen.

Even in the Sum centers where the renewable energy will not have been applied by 2010 because of low potential, there is the possibility of introducing the renewable energy due to the price decline of renewable energy facilities and the improvement of the efficiency for harnessing renewable energy. In the Sum centers where the renewable energy is still not applied in this stage, hydrogen is transported from the other region of high potential and stored. Fuel cell generates electricity consuming this hydrogen as fuel.

10.6 Standard Type of Power Supply System by Off-grid Power Source

The same types of power supply system are commonly applied to almost all of the Sum centers. The power supply system explained qualitatively in Sections 10.4 and 10.5 are examined quantitatively in this Section. As mentioned in Section 10.5, the renewable power sources are solar and wind for the standard types.

10.6.1 Standard Types of the Year 2005

(1) Diesel Generator

At present, the power is supplied by diesel generator in each Sum center. The unit capacity of diesel generator is unified to 60 kW and 100 kW. The diesel generators granted by Japan also adopt the same unit capacity of 60 kW and 100 kW.

Then, the following standard type are applied:

- Diesel generator : Standard unit capacity 60 kW or 100 kW
- Power house : Existing Power of diesel generator

In the Sum centers where the demand is over the unit capacity, some numbers of generators are installed. In this case, one value of unit capacity is applied to operate diesel generator synchronously.

(2) Combination of Diesel Generator and Renewable Energy

The standard type of power supply system in 2005 is as follows:

- Diesel generator : Standard unit capacity 60 kW or 100 kW
- Power house : Existing power house of diesel generator

- PV panel : Standard unit capacity 2 kWp (minimum 2 kWp & maximum 12 kWp per Sum)
- Wind generator : Standard unit capacity 2.5 kW & 5.0 kW (minimum 2.5 kW & maximum 10.0 kW per Sum)
- Inverter : Standard unit capacity 2kVA (minimum 2 kVA & maximum 8 kVA per Sum)
- Converter : Standard unit capacity 10 kVA (minimum 10 kVA & maximum 50 kVA per Sum)
- Battery : Standard unit capacity 6 kAh (60 x 100 Ah) (minimum 6 kAh & maximum 48 kAh per Sum)
- Power house : New construction for renewable energy
- Distribution lines : Exclusive line for three public facilities
- Indoor wiring : Wiring in three public facilities

The solar and wind facilities are installed outside the Sum center, one to two kilometers from the center of the Sum center, to decrease the noise of wind turbines, easy land acquisition and considering expandability in the years 2010 and 2015. The new power house is constructed at the place and battery, inverter, converter and control equipment are stored in the power house. The generated power is transmitted to the Sum center through a 10 kV distribution line, stepped down to 230 V by transformer and distributed to the three public facilities. All the distribution lines to the three public facilities are to be exclusive lines so as to prevent power losses and leaks. Besides that, the exclusive indoor wiring is put on the wall in the three public facilities for the same reason.

10.6.2 Standard Type of the Year 2010

(1) Diesel Generator

The specification of standard types is the same as that in 2005.

(2) Combination of Diesel Generator and Renewable Energy

The standard type of power supply system to be newly installed in 2010 is as follows:

- Diesel generator : Standard unit capacity 60 kW or 100 kW
- Power house : Existing power house of diesel generator
- PV panel : Standard unit capacity 5 kWp (minimum 5 kWp & maximum 100 kWp)
- Wind generator : Standard unit capacity 10 kW, 30 kW & 50 kW (minimum 10 kW & maximum 130 kW)

- Inverter : Standard unit capacity 10 kVA
  (minimum 10 kVA & maximum 140 kVA)
- Converter : Standard unit capacity 10 kVA
  (minimum 10 kVA & maximum 20 kVA)
- Battery : Standard unit capacity 6 kAh (60 x 100 Ah)
  (minimum 6 kAh & maximum 240 kAh)

The difference from the system in 2005 is that the diesel generators and the renewable power sources are combined into a hybrid configuration.

10.6.3 Standard Type of the Year 2015

(1) Combination of Renewable Energy and Fuel Cell

The standard type of power supply system consisting of renewable energy and fuel cell to be newly installed in 2015 is as follows:

- PV panel : Standard unit capacity 10 kWp
  (minimum 10 kWp & maximum 200 kWp)
- Wind generator : Standard unit capacity 30 kW, 50 kW & 100 kW
  (minimum 30 kW & maximum 300 kW)
- Inverter : Standard unit capacity 50 kVA
  (minimum 50 kVA & maximum 250 kVA)
- Fuel cell : Standard unit capacity 50 kW
  (minimum 50 kW & maximum 300 kW)
- Hydrogen production system : Standard unit capacity 50 kWh
  (minimum 50 kW & maximum 450 kW)
- Hydrogen storage system : Standard unit capacity 10 MWh
  (minimum 10 MWh & maximum 100 MWh)

(2) Fuel Cell

The system consisting of fuel cell without renewable power source is as follows:

- Inverter : Standard unit capacity 50 kVA
  (minimum 50 kVA & maximum 105 kVA)
- Fuel cell : Standard unit capacity 50 kW
  (minimum 100 kW & maximum 150 kW)
- Hydrogen storage system : Standard unit capacity 10 MWh
  (minimum 30 MWh & maximum 70 MWh)

Some transportation measures of hydrogen from the other region and storage measures are necessary in the system. The measures of transportation and storage of hydrogen are under development for exploring the practical level of those; by high pressure hydrogen, liquid hydrogen, metallic alloy for hydrogen storage, methanol, liquid compound of hydrogen and alloy. The measures of the those seem to be converged in the most economical way due to the mass production of fuel cell cars by the major auto manufacturers in 2003 or 2004.

10.7 Optimum Power Supply System in Sum Center

10.7.1 Application Policy of Standard Type

In this section, optimum application of photovoltaic and wind power generation systems are described in the first part. Then optimum electricity supply system by using diesel generator and the other equipment are explained.

(1) Application Policy of PV/Wind Power Generation

Figure I.10.7-1 shows the flow chart of PV / Wind power generation system planning.

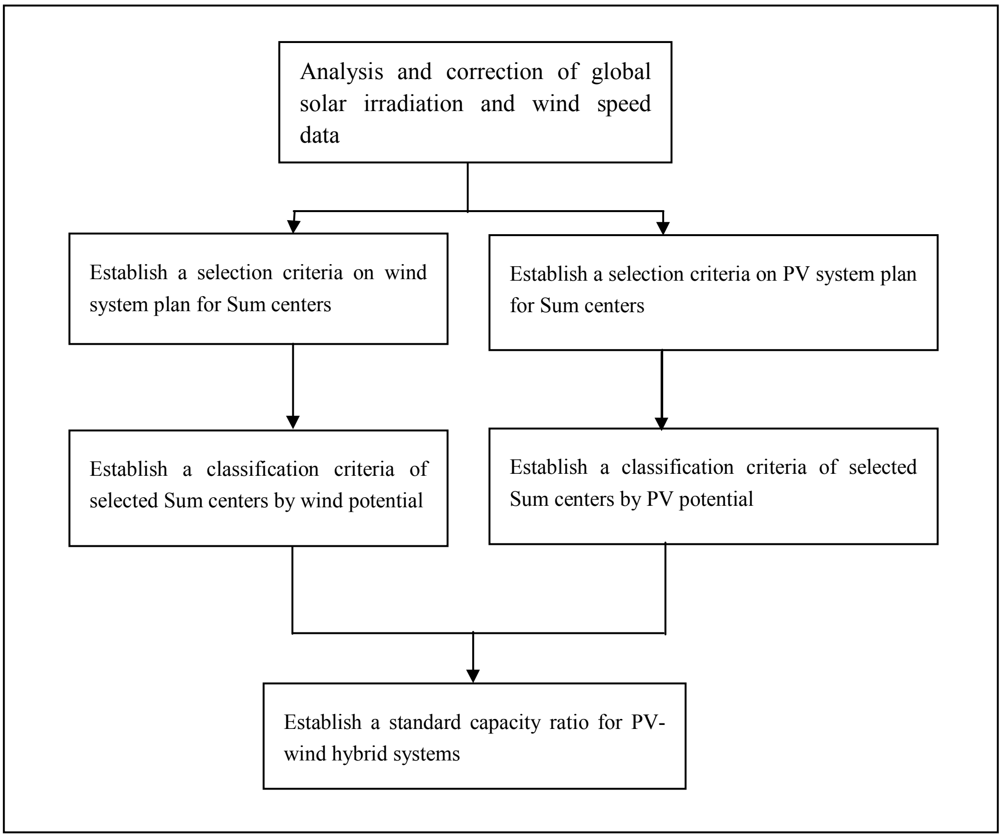


Figure I.10.7-1 Flow Chart of PV / Wind Power Generation System Planning

(a) Analysis and Correction of Solar Irradiation and Wind Speed Data

To decide the applicable standard of photovoltaic and wind power generation system for the Sum centers of the whole country, accurate solar irradiation and wind speed data of each particular site is required. At present the base data on the whole country level are the data of the Mongolian Meteorological Department, but a doubt is left in the data about the accuracy and reliability because observation equipment is old. Though there are observation data by the precise observation equipment installed at the pilot plants of this Master Plan Study and by other organs recently, a measurement point is limited. Therefore, compensation is done in the Meteorological Department data compared with Meteorological Department data and precise observation equipment data to decide an applicable standard if necessary.

i) Photovoltaic power generation

Table I.10.7-1 in Data Book summarizes the ratio of Meteorological Department and precise observation equipment data.

The next items can be understood from the table.

- Difference between the Meteorological Department data and the data of Pilot Plants in Adaatsag and Bayan-Undur which belong in the semi desert area, and the step area is small. The average value of the summer shows about the same as the Meteorological Department observation value, especially to make an important judgment of the adoption or rejection of the system.
- The difference between the data collected by the Meteorological Department and at the pilot plant is big with Tariat which belong in the hilly area. (The data of Meteorological Department are small).
- A result of the comparison with the Meteorological Department observation data with the data on other organs shows some small differences at each month comparing and almost same value in annual average.

From the above, the compensation of the Meteorological Department data is done only on the hilly area. As a compensation, the possibility that the amount of global solar irradiation level differences due to changes in the weather condition, the observation regional differences, and so on is considered to be 15%, which is reduced from the average ratio 1.36 of Tariat. And 1.16 that is 85% of the average ratio is compensated to annual average global solar irradiation data of the Meteorological Department.

ii) Wind Power Generation System

Table I.10.7-2 in Data Book shows the ratios of precision wind monitoring equipment/Russian-style wind monitoring equipment for each month.

While it is acknowledged that the monitoring margin of error depends on the individual monitor, the table shows that 6 out of 8 Sums were evaluated as having insufficient wind power, and that there is an overall tendency to underestimate wind speed. In order to minimize the monitoring margin of error for precision wind monitoring equipment and the Russian-style wind monitoring system, a comparative investigation was conducted into the value recorded in the same period. As a result of this investigation, it was considered appropriate to set the correction value at 1.29 times, this being the average value for the 32 months. Hereafter, this project will therefore consider the average wind speed as 1.29 times the value recorded by the Russian-style wind monitoring system

(b) Selection Criteria vis-à-vis Sums Suitable for PV/Wind Power Generation System.

i) Photovoltaic power generation

The selection criteria of Sums that applies photovoltaic power generation system is made as follows.

(Criteria for the Year 2005 and 2010)

- Solar irradiation is 4.0 kWh/m^2 per day or above

As an index that the introduction of the photovoltaic power generation system is judged in comparison with the substitutive power supply which is thought to be influence (1) Economy, (2) Operation and maintenance, (3) Environment (4) Reliable power supply etc. Only an especially important economy was taken up to make it a concise judgment standard though these elements were examined synthetically and should judge the propriety of the introduction. The amount of annual average horizontal solar irradiation more than 4.0 kWh/m^2 per day is the selection criteria here referring to the simulation result*[1] that an Asian Development Bank used on the occasion of the photovoltaic power generation system introduction.

*1 SOLAR PHOTOVOLTAIC POWER GENERATION USING PV TECHNOLOGY, The Economics of PV Systems Volume 2, copyright: ADB Workshop, Manila (P. 55 Figure 32, P. 49 Figure 26).

(Criteria for the Year 2015)

- In addition to the Sum centers selected above, the Sum centers where solar irradiation is expected to be around 4.0 kWh/m^2 per day judging from the locations of the candidate Sum centers referring the locations of selected Sum centers and the topographical natures around the candidates.

It is necessary to increase the accuracy of meteorological data for critical judgement in 2015. And the sharp decline in the price of PV system is expected. The above criterion is tentatively prepared at present for the year 2015 with the condition that the meteorological data be collected by accurate measuring instruments in the future. According to the criterion, the additional selection is done from the Sum centers located even in the area where the irradiation is under 4.0 kWh/m^2 per day consequently.

ii) Wind Power Generation System

Selection criteria vis-à-vis Sums suitable for wind power generation is shown as follows:

(Criteria for the Year 2005 and 2010)

- Average wind speed is 4.1 m/s or more at a height of 10 m above ground level.
- In July and August, when average wind speeds are at their lowest, the average wind speed is 3.7 m/s or more at a height of 10 m above ground level.

While the cost of installing wind turbine generation systems varies depending on ease of road access and proximity of electrical power, a capacity factor standard exists as a general break-even economic index, considered to be 20%. This value of targeted capacity factor is a plan for a grid connected large size wind turbine, not for a stand alone type small wind turbine which is being considered in this master plan. The cost of an electricity supply system in Sum centers that are located far outside from existed grid line is high due to the high cost of grid extension and the transportation of diesel for long distance. Compare to such a high cost electricity supply system, using a small wind turbine in a small capacity factor has the possibility of becoming more cost effective plan.

In the many cases of large sized wind turbine plants, the cost of energy is around 5 ¢/kWh. One can safely state that the cost of energy using small wind turbine with the same capacity factor of large turbine, becomes around 15 ¢/kWh because the cost of small wind turbine installation is almost three times as high as that of a large wind turbine. On the other hand, it is assumed that the cost of energy using a diesel generator is around 30 ¢/kWh in a Sum center. Therefore, using a small wind turbine instead of a diesel generator for this master plan, smaller capacity factor around 10%, half of a large turbine's 20%, can be accepted.

A selection criteria vis-à-vis Sums suitable for wind system is decided, a 12% or more annual capacity factor and an 8% or more average capacity factor in the summer when average wind speeds are lowest. The relation of capacity factor vs. average wind speed of small wind turbine in market base shows that a 4.1m/s or more annual wind speed and 3.7m/s or more summer average wind speed are necessary at a height of 10m above ground level.

(Criteria for the Year 2015)

- Average wind speed is 3.9 m/s or more at a height of 10 m above ground level.
- In July and August, when average wind speeds are at their lowest, the average wind speed is 3.5 m/s or more at a height of 10 m above ground level.

Increase in the performance in the range of low wind velocity and decline in the prices of wind generators are expected in 2015. Consequently the application of wind generation becomes available even in the area with the lower average wind speed in 2015. However, it is difficult to make an appropriate judgement because the accurate wind data is available only for the limited area. The precise meteorological observation units are therefore installed across Mongolia in 2005, the observation being continued, and judging from the observed data wind generation, is additionally applied to the new Sum centers in the stage 2015. At present the selection criteria of 2015 are temporarily made as above.

(c) Classification of Sums Suitable for PV/Wind Power Generation System

i) Classification of photovoltaic power generation system

As there is a difference in the amount of solar irradiation within the selected Sums for the applicable policy of the standard type of Photovoltaic power generation systemm it is difficult to introduce a system on the same condition. Therefore, applicable Sums are classified into three groups in accordance with the amount of global solar irradiation condition.

A classified standard is established as mentioned in the following.

- Group A: Annual average global solar irradiation beyond 5.0 kWh/m^2 per day

  Most of the south Gobi area belongs in this group. The such Sums are excluded with the possibility that where the amounts of solar irradiation decrease from the problem such as the geographical features from this group, even in comparative areas where the amount of solar irradiation is high throughout the year. The value of the amount of global solar irradiation that decides the applicable range is based on the data of the south Gobi area measured with precise observation equipment and the Meteorological Department observation.

- Group B: Annual average global solar irradiation from 4.5 to 5.0 kWh/m^2 per day

  Most of the semi desert and steppe area belongs in this group. It is distributed to each of the groups A and C if the problem such as the geographical features in the case as the outside of the above value. The value of the amount of global solar irradiation that decides the applicable range is based on the data of the Meteorological Department observation and pilot plant.

- Group C: Annual average global solar irradiation from 4.0 to 4.5 kWh/m^2 per day

  Most of the hilly area belongs in this group. The value of the amount of global solar irradiation that decides the applicable range is based on the data of the Meteorological Department observation and pilot plant.

ii) Classification of Wind Power Generation System

Sums suitable for wind power generation are classified according to average wind speeds in the summer period (July and August). The classification method used was to divide the average wind speeds into 3 equal groups, from the smallest value of 2.9 m/s, which is the standard for the selection of Sums suitable for the use of wind power, to the largest value of 5.7m/s.

<u>Classification Criteria</u>

Group A : Sums having average summer wind speeds of 4.7 m/s or more

Group B : Sums having average summer wind speeds of 3.8 m/s or more, and less than 4.7 m/s

Group C : Sums having average summer wind speeds of 2.9 m/s or more, and less than 3.8 m/s.

(d) Capacity Ratio for PV-Wind Hybrid Systems

In Mongolia, it has been established that in July and August when solar radiation is strong, wind power becomes weak. Also, the wind system generates electricity even at night or on rainy days but is difficult by PV a system. So in order to obtain a stable power output, wind and PV must be combined in a hybrid system to compensate for the intermittent nature of the seasons and time. The capacity ratio for PV-wind hybrid systems is shown in Table I.10.7-3

Table I.10.7-3 Principle for Use of PV-Wind

Wind	PV	Wind Capacity	PV Capacity	Wind Capacity Ratio (%) min (%)	max (%)	Ave (%)	PV capacity ratio (%) min (%)	max (%)	Ave (%)
A	A	70% and over	10% and over	70	90	80	10	30	20
A	B	70% and over	15% and over	70	85	77.5	15	30	22.5
A	C	70% and over	20% and over	70	80	75	20	30	25
B	A	60% and over	15% and over	60	85	72.5	15	40	27.5
B	B	60% and over	20% and over	60	80	70	20	40	30
B	C	60% and over	25% and over	60	75	67.5	25	40	32.5
C	A	50% and over	20% and over	50	80	65	20	50	35
C	B	50% and over	25% and over	50	75	62.5	25	50	37.5
C	C	50% and over	30% and over	50	70	60	30	50	40

In order to reduce the kW unit cost of hybrid systems, in the A-A combination, where both wind and PV are the strongest, the average value for the application of low unit cost wind power generation was set at its highest level of 80%.

The kW unit cost for each hybrid system combination is shown in Table I.10.7.1.

Table I.10.7-4 PV-Wind kW Unit Cost

		Hybrid Unit Cost USD/kW			Hybrid Unit Cost/PV Unit Cost (%)		
Wind	PV	2005	2010	2015	2005	2010	2015
A	A	3292	2714	2320	58	57	64
A	B	3366	2778	2360	59	58	66
A	C	3440	2843	2400	61	60	67
B	A	3514	2907	2440	62	61	68
B	B	3588	2971	2480	63	62	69
B	C	3662	3035	2520	65	64	70
C	A	3736	3100	2560	66	65	71
C	B	3810	3164	2600	67	66	72
C	C	3884	3228	2640	69	68	73

In order to compensate for the intermittent wind in summer, approximately 20% photovoltaic generation is necessary. As a result, in 2005, when wind power is in group

A, the kW unit cost will be reduced by 60% compared with PV only. Below, as wind power and solar irradiation decrease, PV capacity is set high in order to obtain stable output. In the C-C combination, where PV and wind power are the weakest, the kW unit cost increases because photovoltaic generation accounts for approximately 40% of the total capacity, but in 2005 the kW unit cost will decrease by 69% even when compared with the case of PV only.

(2) Application Policy of Diesel Generator

Diesel generators will be installed at all Sum centers that have an isolated power generation system. The capacity of the diesel generator is decided to cover the peak demand in the winter season. A diesel generator is added to the necessary number of generators to supply electricity during periodical maintenance or repair.

(3) Application Policy of the Other Facilities

Applications of the other facilities in each project stage include power supply and data control systems and are as shown in the following.

Year 2005

Power distribution system	:	Renewable energy plants installed Sums (An exclusive line for 3 public facilities)
Indoor wiring	:	Renewable energy plants installed Sums (An exclusive line for 3 public facilities)
Intelligent management system	:	All targeted Sums (167), Related Aimag center
Meteorological monitoring System	:	Study team selected Sums
Power station building	:	Renewable energy plants installed Sums

The distribution lines and the intelligent management system are mentioned in Section 10.8 and Sub-section 10.9, respectively. To minimize the power supply losses and for BHN purposes, the exclusive distribution lines will be constructed and indoor wiring will be renewed in the renewable energy plants installed Sum centers. Meteorological observation systems will be installed in the 107 Sum centers which were selected by the Study Team for collecting accurate meteorological data. It is necessary to build a new power station in the renewable energy plants. Installed Sum centers throughout the existing building of the diesel power station will be used in the Sum centers with only diesel generators being applied.

Year 2010

Power distribution system	:	All targeted Sums
Intelligent management system	:	All targeted Sums + Related Aimag center + MOID + Energy Authority

Year 2015

Power distribution system	:	All targeted Sums, For the expansion of system
Intelligent management system	:	All targeted Sums, For the expansion of system
Power station building	:	All target Sums for hydrogen energy

It is necessary to build a new power station building in the stage 2015 in the Sum centers where only diesel generator exist before 2015.

10.7.2 Optimum Power Supply System by Standard Type

Optimum power supply system for the target Sum centers in the stages of 2005, 2010 and 2015 are explained below.

(1) Sum Centers of PV and Wind Application

The following number of Sum centers were selected for PV and Wind application by using the selection criteria.

		(Year 2005 and 2010)	(Year 2015)
■ PV power generation system	:	123	148
■ Wind generation system	:	45	53

List of selected Sum centers in 2005 and 2010 for PV generation with three classifications in order of potential is shown in the attached Table I.10.7-5. And similarly a list of selected Sum centers for wind generation with three classifications in order of potential is shown in the attached Table I.10.7-6. All 45 Sum centers that are suitable for wind generation are included in the Sum centers to which PV generation is applied. Therefore the power supply system for the 45 Sum centers becomes a PV-Wind hybrid generation system.

The attached Table I.10.7-7 shows the additional Sum centers for PV and wind generation. Numbers of Sum centers for PV and wind generation are 25 and 8, respectively.

(2) Power Source Facilities for each Sum Center

i) Year 2005

The attached Table I.10.7-8 shows the power source facilities for each Sum center in 2005. The Table consists of the target 167 Sum centers including the grid extension and mini-hydropower. The distribution of sources for Sum centers across the country is shown in the distribution map in opening pages.

The numbers of Sum centers for each power source are shown as follows.

- Diesel : 38
- Diesel ＋ PV : 77
- Diesel ＋ PV ＋ Wind : 45
- Diesel ＋ Mini-Hydro : 2
- Diesel ＋ Mini-Hydro ＋ PV : 1 (Mankhan)
- Grid extension : 4

The demand of Tosontsengel Sum center of ZAVKHAN Aimag and Bulgan Sum center of KHOVD Aimag is too large to be satisfied with the standard type capacity that was mentioned in Section 10.6. These types of Sum centers are individually mentioned in Section 10.7.4.

ii) Year 2010

The attached Table I.10.7-9 shows the power source facilities for each Sum center in 2010. All of the systems in the 167 Sum centers were described in the table as the same as in 2005. The number of Sum centers for each power source is the same as that of 2005.

There are 8 Sum centers of which demand becomes larger than the upper limit of the standard type in 2010. The power supply of these Sum centers is also mentioned in Section 10.7.4.

iii) Year 2015

The attached Table I.10.7-10 shows the power source facilities for each Sum center in 2015.

In 2015, fuel cells will be introduced instead of diesel generators. The number of Sum centers for each power source are shown below.

- Full cell＋Hydrogen production and storage＋PV : 93
- Full cell＋Hydrogen production and storage＋PV＋Wind : 53
- Full cell＋Hydrogen production and storage＋PV＋Mini- hydro : 1[*1]
- Full cell＋Hydrogen storage : 14

- Mini-hydro : 1*2
- Mini-hydro＋PV : 1*3
- Grid extension : 4

*1 : Baruuntruun
*2 : Munkhkhairkhan
*3 : Mankhan

(3) Other Facilities for Each Sum Center

The other facilities i.e. distribution system, intelligent management system etc. for each Sum center are shown in the attached Table 10.7-11.

10.7.3 Mini-hydropower Generation System

A mini-hydropower generation plant has a high advantage for security of multi-energy resources in respect of easy operation and maintenance and quick start and stop of the plant. In general, the following basic conditions are considered for the basic plan of the mini-hydropower generation plant.

(a) Flow duration
(b) Economic evaluation on transmission line construction cost for interconnection of power system network or up to load center
(c) Prevention of natural disaster, hard rock foundation
(d) Easy construction of plant
(e) Avoiding negative environmental affect and resettlement
(f) Maintenance of river purgation
(g) Regulation of river water flow within limit and river water level within limit

The basic conditions of two mini-hydropower generation plants sites, Monkhairkhan and Baruunturuun, meet with the above conditions for further planning and design. Therefore, two mini-hydropower generation plants are taken up as the power sources of the power supply system to the targeted Sum centers after the assessment of the economic analysis of power operation, social needs and technical justification. Table I.10.7-12 shows the major features of two mini-hydropower plants. The estimated monthly power and energy outputs are shown in Table I.10.7-13. Photo I.10.7-1 shows the Monkhairkhan power plant site and Photo I.10.7-2 shows the Baruunturuun power plant site.

Table I.10.7-12 Major Features of Mini-hydropower Plants

Hydro-P/S	Aimag	Main Dam H x L	Design Flow	Gross Head	Installed Capacity	Type of P/S	Type of Turbine	Speed	Line Voltage	Line Length to Load
		(m x m)	(m^3/s)	(m)	(kW)			(rpm)	(kV)	(km)
Monkhairkhan	Khovd	2.5 x 90	2.5	8	150	Run-off River	Cross-Flow	375	10	4
Baruunturuun	Uvs	7.6 x 260	3.5	11	200	Dam toe	Cross-Flow	375	10	5

(Data Source: UCS in July 1999)

Table I.10.7-13 Estimated Monthly Power and Energy Outputs

Hydro-P/S	Aimag	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
		kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW	kW
		10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh	10^6* kWh
Monkhairkhan	Khovd	75	75	75	100	150	150	150	150	150	100	75	75
		0.02	0.02	0.02	0.025	0.03	0.03	0.03	0.03	0.03	0.025	0.02	0.02
Baruunturuun	Uvs	(-)	(-)	(-)	200	200	150	200	180	150	100	50	(-)
		(-)	(-)	(-)	0.048	0.15	0.11	0.15	0.133	0.11	0.074	0.036	(-)

(Data Source: UCS in July 1999)

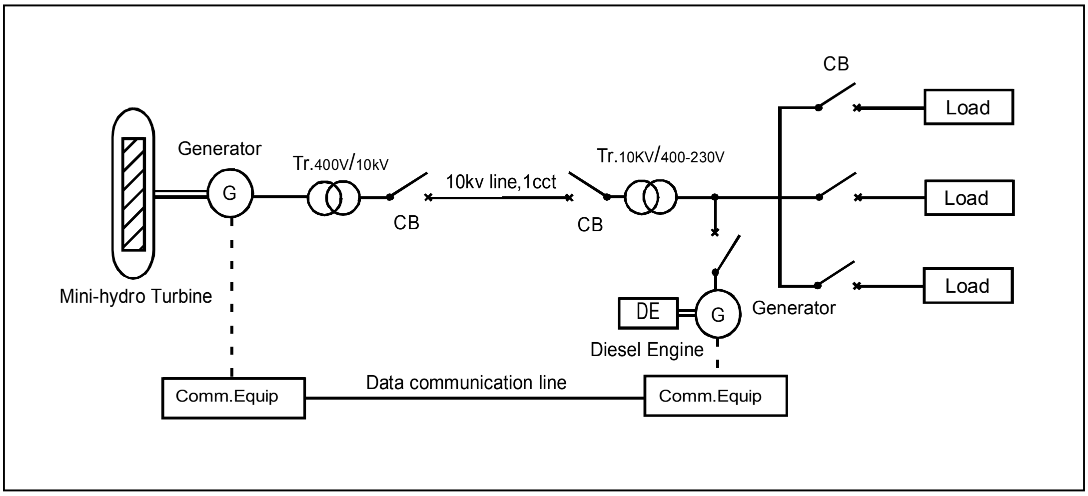
Photo I.10.7-1 Monkhairkhan Power Plant Site

Photo I.10.7-2 Baruunturuun Power Plant Site

As seen Table I.10.7-13, the annual energy generation by mini-hydropower plants exceeds that of the solar and wind power generation except diesel power generation. The mini-hydropower generation plants are suitable for power supply to the target Sum centers as base load operation in the summer season. Therefore, the mini-hydropower plants are planned to be used as base load operation. In case that the peak demand exceeds the generation capacity, another generating power plant is required to back up for meeting the system power demand by parallel operation of both mini-hydropower generation plant and another power generation plant. The supporting power generation plants for the peak power supply are selected out of diesel power plant, fuel cells, etc. The operation method of power generation is planned to be parallel operation or hybrid operation. The following are the considerable operation methods of power generation.

(a) Individual mini-hydro power generation
(b) Mini-hydro power generation + Diesel power generation
(c) Mini-hydro power generation + Fuel cells power generation

As the site of mini-hydropower generation plant is far from the Sum center, it is very difficult to conduct hybrid operation or parallel operation by interconnection of a low voltage system. Therefore, a high voltage interconnection method is applied for synchronous operation considering voltage drop and power losses. The connection diagram of mini-hydro power plant and diesel power plant is shown in Figure I.10.7-2 as a typical figure.



FigureI.10.7-2 Connection Diagram of Mini-hydro and Diesel Power Plant

Japanese made new diesel generators will be provided under the Japan's Grant Aid for all the Sum centers. Therefore, new diesel generators will be considered as the existing units for the Study.

10.7.4 Power Supply System Other than Standard Type

This section describes the power supply systems for the Sum centers of which demand is too large to be satisfied with the standard type mentioned in Section 10.7.3, or the systems which need special attention given.

(1) Year 2005

By the calculation under the condition of power supply level, i.e. power supply to the three public facilities for consecutive two days without sunshine, the required capacities of PV panels for Tosontsengel Sum of Zavkhan Aimag and Bulgan Sum of Khovd Aimag are 32 kWp and 19 kWp, respectively. Besides that, the capacities of batteries are worked out as 124 kAh and 73 kAh. The ceiling values of the standard type of capacities are 12 kWp for PV panel and 50 kAh for battery, then the standard type capacities cannot cover the required capacity. The lack of the capacity basically ought to be supplemented by diesel generators. However, in order to make the most of renewable energy the solar and wind generators are designed so as to ensure the power supply without diesel generation under the limited conditions mentioned below.

- Tosontsengel : One day power supply only to hospital without sunshine
- Bulgan : Two days power supply only to hospital without sunshine

A small hydro power station exists in Mankhan Sum of Khovd Aimag. It was observed that the power station did not operate due to turbine fault and repairing work of the canal at the site inspections on October 1998 and June 1999, respectively. As the reliability of the power station seems to be considerably low judging from the above situation, it is planned to install PV panels in the Sum centers.

(2) Year 2010

The target of power supply by renewable energy in 2010 is to all the consumers in the summer season. And ability of that is to continue the power supply for one day without sunshine. It is found that the capacities of PV panels and batteries for the seven Sum centers listed below are beyond the ceiling values, i.e. 100 kWp for PV panel and 240 kAh for battery, of standard type according to the calculation under the condition mentioned above.

a) Bayan-Uul Sum of Dornod Aimag
b) Bayan-Adraga Sum of Khentii Aimag
c) Binder Sum of Khentii Aimag
d) Bayan-Ovoo Sum of Khentii Aimag
e) Uyench Sum of Khovd Aimag

f) Bulgan Sum of Khovd Aimag
g) Tosontsengel Sum of Zavkhan Aimag

In these Sum centers, the lack of power supply is supplemented by diesel generators.

As already mentioned, the reliability of small power station in Mankhan is low. On the other hand, it is proved that hydro potential in this Sum center is high. In order to utilize the hydro potential efficiently, it is planed to renovate the hydro power station in Mankhan.

(3) Year 2015

Stable and sufficient hydro potential is expected through the year in Munkhkhairkhan where hydro power station would have been constructed in 2005. Therefore, no any hydrogen facilities applied to this Sum centers.

On the other hand, the power from hydro power station cannot be expected in the winter season in Baruunturuun because of frozen river. Then it is plan to install PV panels and hydrogen facilities.

The conditions to decide the capacity of the facilities are mentioned below:

- Power supply in the summer season is covered by hydro generation.
- The size of PV panels is decided to generate power enough to meet the demand in winter season for one year.

Regarding Mankhan Sum center, the existing small hydro power station has the record to generate power in the winter season. Though the hydro power station would have been renovated in 2010, the power station feeds enough power to Sum center through the year. Therefore, it is planed that neither solar, wind nor hydrogen system is installed in 2015. However, the hydro potential in the winter season is examined in detail at the time of renovation in 2010, and the plan in 2015 is reviewed based on the result of the examination.

10.8 Power Distribution Plan

10.8.1 General

There are lots of problems on the existing distribution systems in the Sum centers so the existing distribution system should be improved. These are caused by the deterioration of the distribution facilities, insufficient operation and maintenance, unstable power supply without balance of supply and demand, large power losses on the distribution system (including non-technical loss), etc.

In this Chapter, the optimum power distribution plan is formulated based on the power demand forecast after the assessment study of the existing problems and power supply conditions in the target Sum centers. The optimum power distribution plan is made in coordination to the optimum power generation plan, therefore, the study years are 2005, 2010 and 2015. The existing distribution system is to be improved step by step considering the economic conditions and urgency of the development. In the final study year of 2015, the master plan is optimized totally.

10.8.2 Optimum Power Distribution Plan

First, various problems on the existing distribution system have to be settled for the optimization of the future distribution system. After careful study on the improvement and augmentation plan of the distribution system, the optimum distribution plan is to be formulated. Table I.10.8-1 shows the problems on the existing distribution system and the improvement plans.

Table I. 10.8-1 Problems on the Existing Distribution System and Improvement Plans

Problems	Improvement Plans
1. Large power losses 2. Unreasonable tariff correction System 3. Poor supply reliability by Earth fault and short circuit 4. Lightning damage and long time Power outage 5. Insufficient management and O/M without quick and effective action 6. Deterioration of facilities	1. Rearrangement of circuit and increase of Conductor size 2. Installation of Watthour meters and Application of meter rated tariff 3. Adoption of insulated wire & power cables, installation of circuit breakers 4. Adoption of insulated wire & power cables, installation of lightning arrester and insulation transformer 5. Total power operation by communication network, quick and effective operation by computer system 6. Modernization of facilities by replacement of facilities

(1) Power Distribution Plan in 2005

A power supply system for the targeted Sum centers in 2005 is planned in conjunction with the power supply systems. The following three distribution plans are recommended.

(a) Installation of watthour meters and application of meter rated tariff system

The existing watthour meters are of a Russian made Electro-magnetic induction type. These watthour meters are able to used for a meter rated tariff system after readjustment and test.

Short Watthour meters are additionally provided for the consumers with the same type and rating. Wiring for Watthour meters is carried out by indoor power cables.

(b) Installation of circuit breaker for each consumer (molded case circuit breaker)

Power outage is caused by an arth fault or short circuit in the consumer's wiring, and the bad condition extends over the whole consumers. In addition to the said, power facilities are damaged by the fault. Installation of circuit breakers for each consumer is required for protection of power facilities and to secure supply reliability. The international standard molded case circuit breaker is used for safety measures.

(c) Construction of new distribution line

A new overhead distribution line is constructed for hospitals, schools, dormitories and Sum office from renewable energy generation plant with overhead insulation wires considering the economic effect and easy maintenance.

A list of necessary facilities for the optimum distribution system in 2005 is shown in the attached Table I.10.8-2 in Data Book. The major facilities are listed below.

- 10kV outdoor overhead power cable line materials (New installation: between Power Plant and substation for the Sum center).
- Low voltage outdoor overhead distribution facilities (New installation: between substation for the Sum center and public consumers as hospitals, schools, village office, etc.).
- High voltage substation facilities (New installation).
- Low voltage indoor wiring materials (Wiring in the buildings of hospitals, schools, village office, etc.).
- Safety breakers and watthour meters.

The distribution system will improve the existing system on the following aspects.

- Reduction of energy losses, especially non-technical loss,
- Application of appropriate power rate to consumers,
- Prevention of power faults and their effect on other consumers,
- Enhancement of public services, and
- Cost saving of diesel oil.

(2) Power Distribution Plan in 2010

Power supply system for the targeted Sum centers in 2010 is planned for supplying peak power and 24 hours supply. The planned distribution system plan in 2010 is described below.

(a) Rearrangement of circuits and increase of conductor size

i) Rearrangement of circuits

Distribution circuits are rearranged without excessive heavy load section considering the balance of loading to each circuit and peak load hours. For example, power and energy consumption of public facilities usually comes in the daytime, but general consumers use power mainly in the evening. The constitution of new distribution lines is required to rearrange the line considering the balance of loading for high efficiency operation of the system facilities. The distribution system is composed of three network systems which is same as the existing system. In the new distribution system, a by-pass circuit is arranged for back up power supply in the time of line fault.

ii) Increase of conductor size

The conductor sizes of the existing distribution lines are overhead bare aluminum wire of 16 – 25 mm^2 for the main lines. The new distribution line is planned to use overhead-insulated copper twist wire of 35 mm^2 or more for the main lines to increase the line capacity and reduce power losses. Power cable or insulated wire should be used for branch circuits and service wires. The conductor sizes of branch circuit and service wire are planned considering the power demand of consumers in future.

(b) Rehabilitation of the existing power facilities

The existing power facilities are deteriorated and this condition may cause injury to persons and animals and decrease of power supply reliability. Modernization of the power facilities is required including additional installation of protective equipment and switchgear.

(c) Lightning protection

For the protection of lightning surge to the power facilities, installation of lightning arresters and insulation transformer is required. In addition to the above, the power facilities shall be grounded solidly for protection of the facilities against surge and preventing persons and animals from touch voltage.

A list of necessary facilities for the optimum distribution system in 2010 is shown in the attached Table I.10.8-3 in Data Book. The major facilities are listed below.

- 10kV outdoor overhead power cable line materials (New installation: between Power Plant and substation for the Sum center).
- High voltage substation facilities (Augmentation).
- Low voltage outdoor overhead distribution facilities (Upgrading all the distribution system facilities in the Sum centers).
- Safety breakers and watthour meters.

The distribution system will improve the existing system on the following aspects.

- Stable power supply for 24 hours for all the consumers,
- Remarkable power loss reduction (5 % or less),
- Increment of confidence to power operation and application of appropriate power rate to consumers,
- Enhancement of reliability for power supply and prevention of power faults and their affect on other consumers,
- Enhancement of public services, and
- Cost saving of diesel oil.

(3) Power Distribution Plan in 2015

The power distribution system for all the Sum centers will already be rehabilitated by 2010 and a 24 hour power supply will be maintained. In 2015, the power supply system is planned to meet with the increasing power demand in the Sum center and for improvement of supply services and effective operation with multi-functions. Accordingly, the following distribution system is recommended as the optimum system in 2015.

(a) Expansion of the power distribution system

The expansion of the power distribution system is planned to meet with the increasing power demand in the Sum centers. Various information and data on the power operation are provided for the advancement of consumers' services to the respective consumers in the Sum center.

(b) Effective power operation and multi-function

For effective power operation, operational data and information are monitored and analyzed by the Authority. Computer aided works are promoted for the purpose of easy and quick operation and maintenance works and a preventive doctoring system is adopted to prevent the mal-operation and infliction of accidents and faults. A communication network is established for the effective operation and monitoring on the power operation management and also on energy management, heat distribution management, hospital management, etc. Detailed function is discussed in the subsequent Sub-sectoin 10.9.

A list of necessary facilities for the optimum distribution system in 2015 is shown in the attached Table I.10.8-4 in Data Book. The major facilities are listed below.

- Low voltage outdoor overhead distribution facilities (Expansion).
- Safety breakers and watthour meters (Addition).

The distribution system will improve the existing system on the following aspects.

- Reduction of power production cost,
- Improvement of power distribution services to the consumers,
- Regional social development and economic promotion, and
- Level up of living standard, security of stable and comfortable life of the Sum people, and contribution to energy saving and protection of global environmental affect.

The optimum power distribution plans in 2005, 2010 and 2015 are shown in the attached Figure I.10.8-1, Figure I.10.8-2 and Figure I.10.8-3 in Data Book.

10.9 Operation Plan of Power Supply System

10.9.1 Power Supply System

Compared with grid connection and diesel generators which are able to supply stable power, solar and wind have the wider margin, by their intermittent nature, for raising the efficiency of energy use with operation.

This section describes the power supply plan by renewable energy in order to increase the efficiency of energy use.

(1) Operation Plan in 2005

The operation plan in 2005 is mentioned below.

(a) Minimizing loss of inverter:

The power consumption of inverter is large even in the no load condition. In order to reduce the no load loss of inverter, the unit capacity of inverter is designed to be small and the number of inverters in operation is to be minimized with on-off control by timer switch.

(b) On-off of main switch:

Schools and the Sum office are usually unmanned in the nighttime and on holidays, so power is not required in the period. In order to avoid the waste of the energy by forgetting to turn off the power switches, the main switch of power supply to each facility is equipped at each main entrance and is turned off when locking the main entrance door.

(c) Effective use of surplus power:

Surplus power is expected in the daytime especially in the summer season. Some effort is necessary to use the surplus power efficiently. As the measures that are able to be applied commonly to many Sum centers, installation of water heaters with thermos tanks in hospital and pumping up water to water supply tanks are effective.

(d) Installation of charging station:

A battery charging station seems to be an effective measure to use surplus power of the renewable energy efficiently. The possibility of no power supply to the domestic consumers in the summer season is high since the power is to be supplied by diesel generators; it may be difficult to purchase the fuel due to the shortage of budget. Then, the surplus power charges personal batteries in the charging station in the daytime, and the consumer uses the charged battery for lighting and TV through personal inverters. The batteries and inverters are sold on a market basis. By this measure, the charging fees are surely obtained from the consumers who need power indeed at charging time, which seems to financially support the power supply management in the Sum centers.

(e) Charging battery by diesel generator:

The capacities of the renewable energy facilities are designed to meet the demand and the potential in the summer. Therefore the possibility of over-discharge of batteries is high in the winter season. The batteries are charged by diesel generators to supplement the lack of charged power, which extends the power supply period and also the life of the batteries.

(f) Operator:

An exclusive operator operates the facilities and carries out daily and regular inspection.

(g) Power tariff:

Power tariffs are set individually in the summer and winter season for the efficient use of power.

(2) Operation Plan in 2010

The operation plans proposed for the year 2005 are basically applied to the year 2010. The other plans especially proposed for the year 2010 are mentioned below.

(a) Combination with diesel and load shedding:

The probability of lack of power supply is high because the capacity of the battery is decided so as to continue the power supply to all the consumers for just one day without sunshine. The system is composed as a hybrid system with diesel generators in 2010. Therefore it is an effective way to start up diesel generators when the power of battery becomes low for the continuous power supply. In the Sum centers where the diesel generators are not operated in the summer season, it is proposed to take the load shedding for the domestic consumers and ensure the stable power supply to the public facilities.

(b) Charging tariff of battery charging station:

The advantage of the battery station becomes low compared with that in 2005 since the power is supplied to all the consumers for 24 hours in the summer season in the stage 2010. However depressing the peak load in the nighttime, which is realized by personal batteries and inverters, is still important to extend the power supply period from the distribution system and the life of the system batteries. It is recommended to set the charging tariff lower than the power tariff of distribution system in order to keep the incentive of using the charging station.

(c) Planning based on precise meteorological data:

The extension and new installation of wind or solar generating facilities should be examined based on the meteorological data recorded by precise measuring instruments which will have been installed in 2005.

(3) Operation Plan in 2015

Since the fuel cells and hydrogen system will be installed in 2015, the consumers will receive the benefit of using power generated by renewable energy at any time. However, the importance of simultaneous use of energy with generation still remains considering energy losses in producing and storing hydrogen.

Therefore the operation plans regarding DMS in 2005 and 2010 are subsequently applied in the stage 2015.

10.9.2 Intelligent Management System

(1) System Configuration

For the purpose of quick action and effective management of the power operation, a communication network is recommended to be established among the target Sum centers, Aimag centers and capital centers by the target year of 2015. The System Configuration of the communication network is as follows.

(a) Remote control and supervisory equipment

Wind, solar, mini-hydro and fuel cells power generating facilities and meteorological equipment are the objects of the remote control and supervision. In these equipment one chip CPU is supported for data exchange, and information transmission and receipt functions are also supported for data exchange.

(b) Sum network server (SNT Server)

SNT Server is a computer for the management of data and information of the remote control and supervision equipment installed at the Sum centers. This server is connected with the Aimag network server for common use of the collected data and information.

(c) Aimag network server (ANT server)

All the data on the remote control and supervisory equipment, management data of power operation, meteorological data observed, heat distribution management data are monitored and managed by the authority at the Aimag centers. Data on operation of Aimag centers itself are able to be inputted into the ANT server.

(d) Energy Authority network server (ENET)

This server is located at the Energy Authority for supervision of the remote control and supervisory equipment, management data of power operation, meteorological data observed, heat distribution management data, and it can command orders to ANT server, if necessary. Desk top type personal computers or mobile type computers are available to connect with the line. In addition, Internet services are available for data exchange.

(e) Ministry of Infrastructure Development server (MOIDT)

The Ministry of Infrastructure Development server is used for monitoring all of the power operation data storing in ENET, but does not have a control function.

(a) and (b) above are used mainly for the field management works and the collected data and information are transmitted to the upstream authority. (c) and (d) are assigned for the managing authorities of the power operation of the whole Sum centers. (e) is the representative of the Government.

(2) Establishment of Communication Network

Communication network for connection among respective server stations constituted is able to be selected out of various current communications network systems. A local network for connection between the remote control and supervisory equipment and the SNT server is established in the Sum center using the distribution lines and power supply lines for communication lines with router (interface unit). Control cables are also available for communication lines. The existing telephone lines or microwave radio lines are available for the communication network between the SNT server and the ANT server. The existing telephone lines, microwave radio lines or satellite communication channels at some stations are able to be utilized for the communication line between the ANT server and ENET. For among ENET, MOIT and other monitoring servers, various wide area communication networks such as the existing telephone system network, mobile telephone system network or Internet are available for the communication lines. Table I.10.9-1 shows the communication network plan.

Table I.10.9-1 Communication Network Plan

System Equipment	Station	Comm. System
1. Control and Supervisory Equipment	Sum center	
	↓	Distribution lines Control cables
2. SNT Server	Sum center	
	↓	Public telephone Lines
3. ANT Server	Aimag center	
	↓	Public telephone lines or Internets
4. ENET	Ulaanbaatar	
	↓	Internet
5. MOIT	Ulaanbaatar	
	↓	Internet
6. Other Servers	Ulaanbaatar	

(3) Functions of Each Server Station

For effective power operation, the recommended equipment and constituted station servers should have the various functions for intelligence power operation system. Table I.10.9-2 shows the functions of each server station.

Table I.10.9-2 Functions of Each Server Station

Cont. & S/V	SNT SERVER	ANT SERVER	ENET	MOIT
1. LG & D/T of Operation Condition 2. LG & D/T of faults 3. LG & D/T of Met. Data 4. LG & D/T of Fuels 5. LG & D/T of distribution & load condition 6. LG & D/T of heating system 7. D/T of energy management data 8. D/T of Public service data	1. Collection & D/T of power facilities operation data 2 Filing & D/T of faults & accidents Data 3. Filing & D/T of power facilities management data 4. Filing & D/T of operation & maintenance data 5. Recording & D/T of command operation 6. Filing & D/T of production, use & sale of fuels	1. Collection & D/T of power facilities operation data 2. Filing & D/T of faults & accidents data 3. Filing & D/T of power facilities management data 4. Filing & D/T of operation & maintenance data 5. Making optimum operation plan & transmit to ENET 6. Making maintenance schedule & transmit to ENET	1. Collect. & analysis of power facilities operation data 2. Filing & analysis of faults & accidents data 3. Filing & analysis of power facilities management data 4. Filing & analysis of operation & maintenance data 5. Study of optimum operation plan & command to ANT 7. Study of maintenance schedule & command to ANT	1. Analysis of power facilities operation data & policy making 2. Analysis of maintenance data & making improvement plan & command to ENET 3. Storage of various data and documents 4. Coordination with other agents on data use & intelligent system 5. Policy making of integrated energy management system

(Note) S/V: Supervisory, D/T: Data Transmission, L/G: Logging, Met.: Meteorological

(4) Intelligent Management System in 2005

The power supply system in the target Sum centers in 2005 plans to use both the existing distribution system facilities and the existing diesel generator sets or all of the existing distribution system facilities, the existing diesel generator sets and the new renewable energy system. The management system of the power operation should be established to secure the self-responsibility system by this time, namely, it is to be managed without help as much as possible and the system facilities are to be operated and maintained effectively in the Sum center. In case that any unavoidable problems happen in the Sum center, they are required to be reported quickly to the Aimag center or upper authority immediately. The existing telephone system is useful for quick information and smooth settlement of the problems. Computer sets are also required for quick and effective management both at the Sum centers and Aimag centers. Considering the above circumstances, the communication network is to be established by 2005. The required facilities for the establishment of the system are shown in the attached Table I.10.9-3 in Data Book.

(5) Intelligent Management System in 2010

The power generation system in 2010 is almost the same as in 2005. Two different power supply systems are applied in 2010. One is the power supply by the diesel generator sets and the other one is by the renewable energy system. In these Sum centers a 24-hour power supply for all the consumers is secured and the power supply system by renewable energy system facilities is expanded to large scaled facilities. The distribution system while rehabilitated entirely by 2010. Fossil fuel base diesel generator sets are operated intermittently for saving fuel, and the optimum operation plan of the hybrid generation system is required to be established for smooth and effective power operation. For the purposes mentioned above, a computer aided management system is adopted for all the Sum centers and a communication network is established for connection of each server station. The required facilities for the establishment of the system are shown in the attached Table I.10.9-4 in Data Book.

(6) Intelligent Management System in 2015

The power operation system in 2015 is to be the full automatic management system and the supporting agent program should be installed at the Sum centers. All the servers should be able to communicate smoothly over the wide area communication system for effective operation of not only the power sector but also other sectors. The required facilities for the establishment of the system are shown in the attached Table I.10.9-5 in Data Book. The system configuration and functions at each server station are the same as described above (1) and (3). Figure I.10.9-1 attached in Data Book shows the overall intelligent management system in 2015.

10.10 Implementation Plan

10.10.1 General

(1) Project Site

The Project Site to be implemented under the Project is 167 Sum centers. 4 out of 173 Sum centers are planned to be supplied with the electricity by the transmission extension, and 67 Sum centers are planned to be supplied with the electricity by the independent diesel generator sets. 3 Sum centers are planned to be supplied with the electricity by the development of mini-hydropower plants. The remaining 95 Sum centers are planned to be supplied with the electricity by the development of renewable energy.

(2) Implementing Agency

The Implementing Agency will be the Ministry of Infrastructure Development for the implementation of the Project. Supervision work of the installation of the equipment and the civil engineering works will be assisted by the Energy Authority which is organized as an implementing enterprise under the control of the Ministry of Infrastructure Development.

(3) Scope of Work under the Project

The scope of work under the Project in each stage is shown in the attached Table I.10.7-8, Table I.10.7-9 and Table I.10.7-10 for power supply systems, Table I.10.7-11 for except for power sources, Table I.10.8-2, Table I.10.8-3 and Table I.10.8-4 for optimum distribution system and Table I.10.9-3, Table I.10.9-4 and Table I.10.9-5 for management facilities in Data Book.

10.10.2 Implementing Schedule

(1) Implementation Policy

The Project will be implemented with the following implementation policy and conditions.

- The Project will be implemented in three stages up to 2015.
- The detailed design of each stage of the Project will be completed within 10 months before the commencement of the Project construction work.
- The construction time in each stage is estimated as 18 months for stage 1, 24 months for stage 2 and 30 months for stage 3.
- The works of planning, design, supervision and management of the Project implementation will be undertaken by reputable and well experienced consultants.

(2) Consulting Services

The reputable and well experienced consultants will be employed for the management of the Project implementation. The consultants will be assigned for the detailed design and supervision works during the implementation period. The Terms of Reference of the Consulting Services are shown in Attachment-6 (Terms of Reference for Consulting Services).

(3) Mongolian Government Undertaking

The Ministry of Infrastructure Development on behalf of the Government of Mongolia will establish an organization for the Project implementation. Required assignment schedule is shown in Figure I.10.10-1. The required budget for the Project implementation will be allocated by the Ministry of Infrastructure Development.

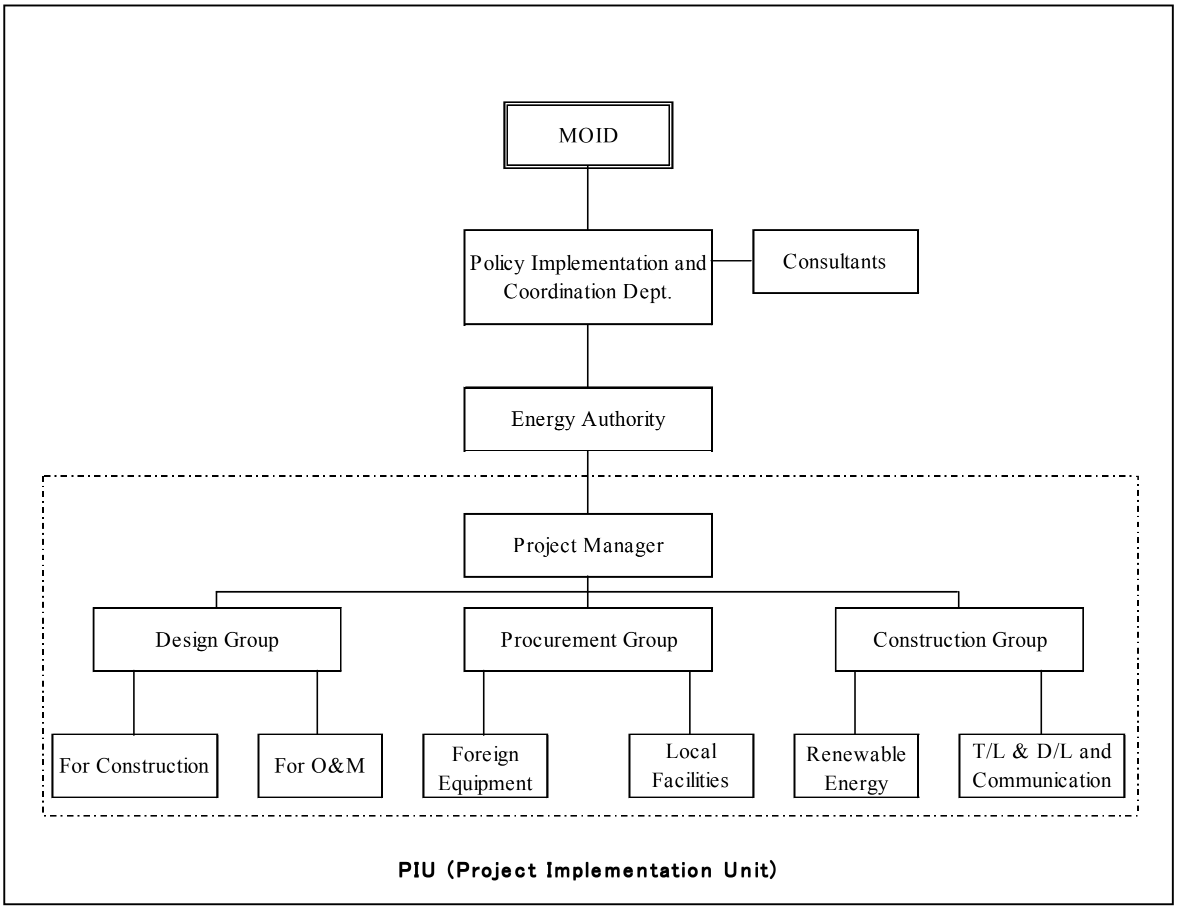


Figure I.10.10-1 Organization for Project Implementation

(4) Detailed Design and Construction Work

In the detailed design stage, the consultants will review the Master Plan Study, field survey, basic design, detailed design and preparation of tender documents. After these works, the selection of contractors will be made, and then the installation of equipment and construction of civil engineering works will be performed by the contractors. The overall construction time schedule is shown in the attached Table I.10.10-1 in Data Book.

10.10.3 Noting Items in Execution

The total number of Sum centers including newly add Sum centers in the year 2015 is 142, and will be supplied power by renewable energy sources. Where either standalone PV power generation system or PV and Wind hybrid power generation system will be establish. It is required to take the following noting items in execution into consideration to provide the power supply in a stable and effective manner.

(a) A larger capacity of PV array it makes impossible to be installed inside the Sum center. Therefore, the installation site will be at the edge of the Sum center where obstacles and installation angle should be considered to generate powers abundantly throughout the whole year.

(b) In the case of wind generator it is also impossible to be installed inside the Sum center. Therefore, the installation site will be at the edge of the Sum center where the consideration of the noise, the direction of the wind and the obstacle should be considered to generate powers abundantly throughout the whole year.

(c) As the installation of PV and Wind power generation system will be at the edge of the Sum center, the system voltage should be raised to avoid problems due to voltage drops. The generated power will be collected in the control room, converted to AC, and distributed to customers.

(d) In the year 2005, considering the BHN and cost, the power generation system will be established only to public welfare and service centers supplying only the required capacity of summer season.

(e) In the year 2010, the power generation system capacity will be based on the total demand of Sum centers in the summer season.

(f) In the year 2005, when there is bad weather or low wind days in the winter season, power supply will be provided by existing diesel.

(g) In the case of year 2010, same as in the year 2005, when there is bad weathers or low wind days and at peak demands in the winter season, power supply will be provided by existing diesel.

(h) The power storage is done by storage battery bank in the years 2005 and 2010. But as the almost all-existing diesel generator will ware off by the year 2015, a fuel cell will be used for power supply and hydrogen will be stored instead of storage batteries. A backup is provided with a diesel generator to those Sum centers where power demand is rather large to supply necessary capacity.

(i) Transportation of storage hydrogen between Sum centers is done by tank lorry.

(j) To those Sum centers where power generation by renewable sources was not a prior solution, other suitable power generation systems should be considered.

(k) The priority to the any newly emerged high reliable and cheap power generation system should be considered in the years 2010 and 2015.

10.11 Project Cost Estimate

10.11.1 Conditions of Estimate

The total cost of the project implementation for the target 173 Sum centers are estimated.

The conditions of estimate are as follows:

(a) Target Item : Materials, Transportation, Construction and Consultancy

(b) Estimate Time : Based on the cost in 1999, the costs in 2004, 2009 and 2014 are estimated corresponding to the stage 2005, 2010 and 2015, respectively.

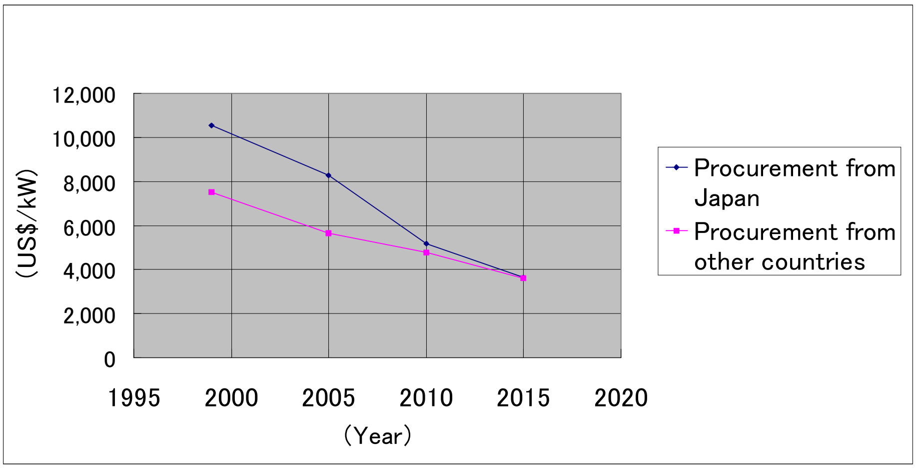
(c) Procurement : International competitive bidding

(d) Currency : US Dollar

(e) Exchange Rate : USD1.0 = Tg1000 = Yen110

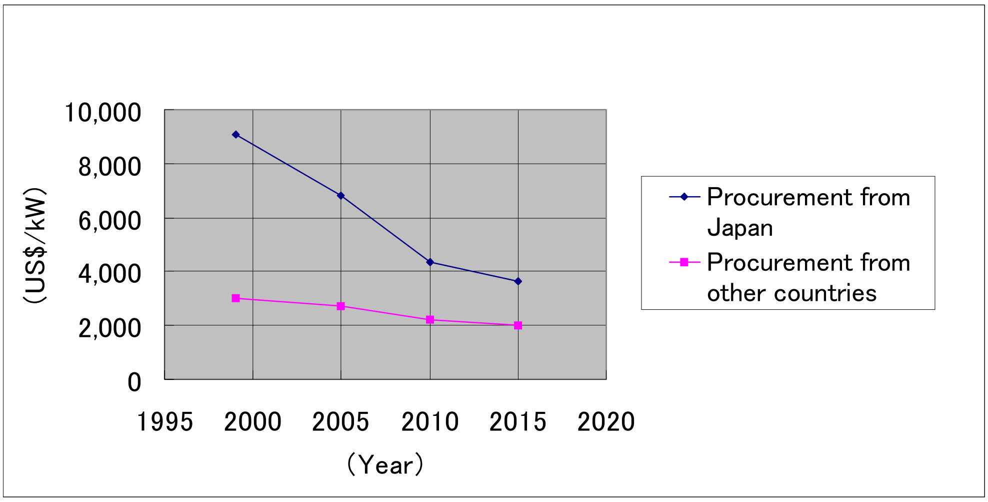
The cost is estimated in each stage including all the cost for implementing all the work in the stage.

There are still considerable differences in the material costs between procurement in Japan and international procurement. Figure I.10.11-1 to Figure I.10.11-3 indicate the total cost including installation of PV panel, wind turbine and battery, respectively, comparing the cases of procurement in Japan and international procurement.



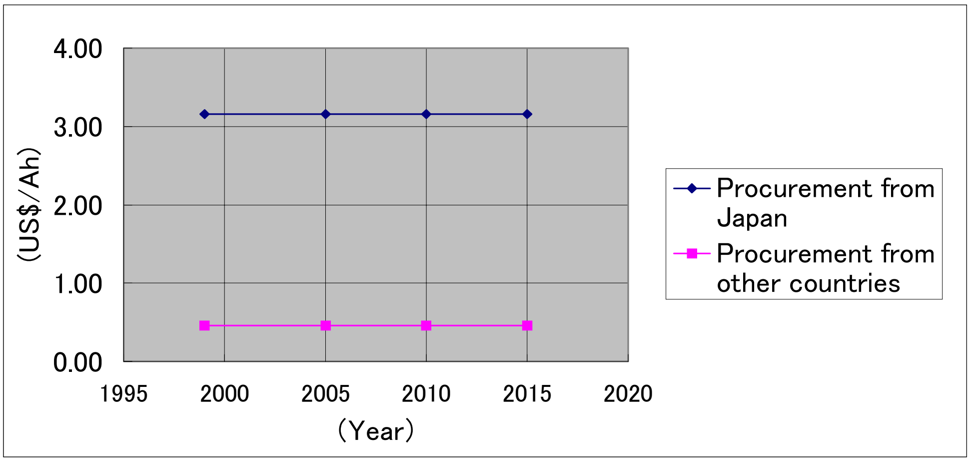
Source: Estimation of JICA Master Plan Study For Rural Power Supply

Figure I.10.11-1 Cost Comparison of PV Panel



Source: Estimation of JICA Master Plan Study For Rural Power Supply

Figure I.10.11-2 Cost Comparison of A Wind Generator



Source: Estimation of JICA Master Plan Study For Rural Power Supply

Figure I.10.11-3 Cost Comparison of A Battery

International competitive bidding prices are applied to the estimate giving priority to economical implementation of the project.

10.11.2 Adopted Unit Price

The adopted unit prices are shown in the attached Table I.10.11-1 in Data Book.

The policy to procure the local material as much as possible is applied for unit price setting. For example, the costs of batteries, construction of power houses, transmission lines, distribution lines and indoor wiring are local costs.

The costs of fuel cell and hydrogen production system are estimated as the proton exchange membrane type which is expected to be on mass production in the near future. As for the hydrogen storage and transportation system, the costs are expediently estimated based on the local costs of fuel tanks and Russian made tank trucks because the measures of storage and transportation are under development.

The consultancy fee is estimated as 10% of the construction cost including procurement and transportation.

10.11.3 Project Cost

The estimated cost of each stage is as follows:

(1) Year 2005 US$23,814,000-
(2) Year 2010 US$43,858,000-
(3) Year 2015 US$80,490,000-

Project costs each Sum centers of each stage are show in the attached Table I.10.11-2, Table I.11-3 and Table I.11-4 in Data Book.

10.12 Power Supply Plan by Market Base Devices

(1) Power Supply Plan toward the Nomad.

The small capacity of a photovoltaic module and wind generators on a market basis has been extended and Nomads are using PV and Wind generators actually. In most of the case, nomads who have the ability to purchase the generators have many livestock. The number of nomads who have the generator will be increased because the price of PV and Wind generation systems becoming lower. However, to accelerate the extended number of the small generation system to nomads, subsidy by the Mongolian government is effective.

(2) Power Supply Plan with Sum Centers

It is effective to use inverters and storage batteries on a market basis to the electrification plan of Sum centers in this Master Plan. In chapter 10.7, installation of battery charge stations are suggested in years 2005 and 2010. Organization of the battery charge station system will increase the number of the people who buy the batteries and inverter, and the battery of Sum people can be charged at a battery charge station that is managed by the Sum center.

In the plan, installation the battery charge station using Sum budget is necessary. It is effective to introduce the concept of the work on the battery charge station to Sum people and order a large number of batteries for the people who want to purchase them.

(3) Additional New Power Supply with Market Base

Bio-gas engine is one of a small power generation systems on the market base except PV and Wind generation, inverter and battery.

The bio-gas engine generator uses gasoline or diesel engine and fuels the bio-gas. There are two types of gas, one is fermented gas such as methane and the other is carbon monoxide gas that is produced by roasted wood chips. In Mongolia, it is difficult to produce methane gas by fermented organic materials. On the other hand, it is possible to produce carbon monoxide gas from dried dung.

The compressed dried dung is roasted to produce carbon monoxide then generates electricity. The produced heat by the engine warm up the room in winter season. The bio-gas engine has a long history and the performance is still improving. There are few studies on bio-gas engines that are operated by dried dung. The important difference between bio-gas engines and PV or wind generation is the engine generate electricity whenever needed. In the food chain of Mongolian plateau, the large amount of fuel of the bio gas engine are produced. So, if such a large amount of fuel is available at the plateau, impact to life condition of nomad will be large.

10.13 Plan of Technology Transfer

Under this master plan, three-hybrid pilot plants were established for actual utilization of power supply scheme and demonstration by renewable resources and meteorological observation equipment was also enforced to collect weather data. The technology guidance was done, which affects the effective use of the equipment management and operation maintenance, utilization of generated power and loads to make a village itself so they could manage the daily control operation management and maintenance of pilot plant as much as possible. Furthermore, team members of the master plan carried out technology transfer to the Mongolian personnel concerning the occasion of the introduction of large scale renewable energy resources utilized for the power supply scheme in the future, much more efficiently, in each village and administrator, so that it can manage continuous operation and maintenance effectively.

In this chapter, the proposed technology transfer is described in case that Japan is concerned with materializing the master plan for rural power supply.

(1) Technology Transfer on Social Welfare (Society) and Economic Survey

Social and economic investigation is especially important for preparing the basic plan of rural power supply. The Mongolian counterparts have the thought that much skill was acquired in this Master plan decision work. But, there is a limit on the contents that the government staff members who hold much work in a small number of people can manage naturally. Accompanied field investigations made possible an efficient and more advanced technology transfer to local consultants and also to Renewable Energy Corporation team members, by carrying out the total work of the questionnaire and so on together.

From now on, local consultants will be actively involved in a process that realizes the master plan to turn, and the technology transfer under the actual work will be important. Moreover, effective technology transfer will become possible by including Renewable Energy Corporation on the over all investigation because it has the side of the private enterprise and business trust which can be utilized by the contract base, too.

(2) Technology Transfer on Meteorological Data Investigation

Weather monitoring using precision meteorological monitoring systems has been carried out in only a very small part of Mongolia. If renewable energy is to be used for the supply of electricity in the future, the technology for collection and analysis of weather data in each region is vital.

In this master plan, installation of a precision meteorological monitoring system in the future is proposed. It is considered to be effective for technology transfer of meteorological data collection and analysis to send a Japanese expert to Mongolia and receive a trainee from Mongolia.

(3) Technology Transfer on System Planning and Design

The efficient technology transfer will become possible by involving the private sector of Mongolia in all the activities in the same way as in the social and economic investigation.

(4) Technology Transfer on System Management and Maintenance Control

The establishment of the management/maintenance control of the system and the improvement of the management/maintenance control ability decides the success or failure of this master plan. The technology transfer of this field must put the power strongly in the meaning. As for the grant aid project of diesel generator to Sum centers which has already been carried out by JICA as well, long-term technology transfer training (soft/component) in Mongolia is being carried out under the same recognition.

If it follows in the number of Sum which copes with it increasing, even thought it is long term technology training in particular subject could not cope the overall technology problems. Due to the reason place of the constant technology training will become necessary for the long term and also for the future. This point is included, too, and it proposes technology transfer by the following in this master plan.

- Long-term technology training program at the time of the execution plan.
- The establishment of the facilities for constant technology training and the establishment of the management system.
- Dispatching the specialist who guides the control management/operation maintenance.

The building of the communication network is proposed with the purpose to support the control management/operation maintenance and also to support the establishment of the future plan in this master plan. Technology transfer on the data management and analysis of operation which this communication network is used for is thought to be carried out in the above mentioned plan, too.

It is indispensable with this master plan to introduce the system, in which a battery will be used for at 2005 years and 2010 years. But, as there is no battery manufacturing or recycling factory in Mongolian country, it is required to import from another country at the time of execution at the present condition. As there is no definite regulation for the disposal of used battery, for the disposal of the batteries, this master plan proposes (1) Making a contract with the battery supplier at time of purchase to take back a used battery after it’s life. (2) Methods to deal with the dealer’s responsibility for taking it back at the time of the renewal.

10.14 Project Evaluation

(1) General

The system of the year 2005 becomes the most realistic plan suppressing the implementation cost by limiting the system capacity to the BHN demand. The target consumers of the power supply in 2010 spreads to all the consumers in the Sum center. Then the ability of operation and maintenance becomes further important with the increase in the system capacity. The effort of each Sum center dominates the sustainable operation of power supply in 2010. The system in 2015 is found to be an ideal plan paying much attention to the environment. Though the plan may seem to be too novel, it would be said that the system is realistic judging from the drastic change in the energy field in the world.

(2) From Solar PV Power Generation System of View

As the 2005 project targets only public facilities, small capacity PV systems are required for each Sum center. In 2010 and 2015, however, all of the households in Sum centers will be targeted, so the capacity of the PV system will increase around 10 kW to 100 kW. Therefore, monitoring using precision weather monitoring equipment and data analysis is necessary for the project planning. The project plan in 2010 and 2015 will be reexamined based on the monitoring results from precision weather monitoring systems by 2005. The monitoring will enable more accurate project planning of the photovoltaic generation system, and it will reduce system cost, but it will also have the economic benefit of cost reduction. It plans to utilize 969MWh/year at year 2005, 7.1GWh/year at year 2010 and 19.8GWh/year at year 2015 by introducing the solar PV power generation system effectively.

(3) From Wind Power Generation System of View

Accurate wind data are necessary for power output estimation by wind turbine. Wind data are not available except for data monitored by the Mongolia Meteorological Agency at targeted Sums. Therefore, the data will be used for power output estimation in 2005. However, meddle or large size of wind turbines will be installed in 2010 and 2015, so the data monitored by using precision wind monitoring equipment and the result of the analyzed data are necessary. The project plan in 2010 and 2015 will be reexamined based on the results of wind monitoring by precision.

(4) From Economic Point of View

As described in detail in chapter 13, on the presumption of supplying power to the Sum centers, the proposed system has an economic advantage over the alternative system of diesel engine system, though its advantage diminishes as the system increases in the coverage in the later phases. From the financial point of view, the return on the investment is not very encouraging to sustain an independent operation. In other words, the Sums cannot be fully independent financially in power supply. From a macroeconomic view, the analysis proves that the systems proposed in the year 2010,and 2015 are increasingly more economical.

(5) From Social Point of View

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

CHAPTER 11
RECOMMENDATION FOR ENERGY SAVING AND ENVIRONMENTAL PROTECTION

CHAPTER 11 RECOMMENDATION FOR ENERGY SAVING AND ENVIRONMENTAL PROTECTION

11.1 Overview

These days when environmental problems such as global warming become pressing issues, it is the global trend to solve environmental problems by developing laborsaving and energy-saving technologies. Laborsaving and energy-saving technologies themselves cannot solve all the environmental problems, and it is necessary to understand the differences between the objectives of laborsaving and energy-saving technologies and environmental protection.

Developing laborsaving and energy-saving technologies has the objective of promoting the effective use of resources and the rational use of energy according to the economic and social environment. On the other hand, environmental protection has the objective of protecting the natural environment which is suitable for guarding people's health and livelihood. Environmental problems are not the problems on the supply side but on the demand side, and it is not an economic issue but an ethical one. To solve the environmental problems, it is sometimes necessary to introduce the regulations, which is contrary to the market economy.

In general, the basic ideas on promoting labor-saving and energy-saving technologies at the electricity facilities can be summarized into the following six points:

(1) Saving energy at the power plant through highly efficient operation
(2) Saving energy through the system reform of the power plant
(3) Saving resource and energy by making the size and weight of the machine smaller and lighter
(4) Saving energy by improving the efficiency of the machine
(5) Saving energy by reducing the production loss and promoting effective use
(6) Saving resource and labor by improving the materials and production method

The following is the list of the key issues, which are necessary to be considered for the current global environmental protection:

(1) Global warming
(2) Acid rain
(3) Desertification
(4) Forest logging
(5) Destruction of ozone layer

These issues result from the discharge of CO_2, NO_2, SO_2, etc., and in the future they may develop into bigger global problems affecting the stable supply of energy, health protection, and food supply.

In present Mongolia, this study recommends the following concrete actions to promote laborsaving and energy-saving technologies and protect the global environment:

(1) Saving energy through the system reform of the power plant
(2) Saving energy by reducing the production loss and promoting effective use
(3) Environmental protection through the reduction of the discharge of CO_2, NO_2, SO_2, etc.

The current situation and the future measures for promotion of laborsaving and energy-saving technologies and environmental protection at the targeted Sum Centers will be described in the latter part of this report.

11.2 Policy and Laws on Environmental Protection

The current environmental policies of Mongolia are dated from 1992 when they participated in the "Earth Summit" held in Rio de Janeiro and signed to the "Convention on Biological Diversity". In 1993, Mongolia started to draw up the action plan for convention on biological diversity, being supported by UNDP. After the completion of the plan in 1993, they established "National Council for Sustainable Development" in August 1993, and set to planning the action plan for Agenda 21, which was agreed at the Earth Summit. The Mongolian action plan is called the Mongolian Action Program for the 21st Century, MAP 21 in short. The MAP 21 which was completed in 1998 describes the following four goals and action plans to achieve sustainable development for the 21st century.

a) Sustainable social development
b) Sustainable economic development
c) Appropriate usage of natural resources and protection of nature and environment
d) Method of execution and people's involvement

As for the above c), the following issues are emphasized:

・Protection of ozone layer
・Reduction of air pollution
・Cooperation in arresting global warming
・Combat against desertification
・Maximum usage of renewable energy such as solar light, wind power, and water power

Mongolia used to have a diversity of laws concerning the environment. Since 1994 in cooperation with UNDP, the laws have been rearranged and reorganized. Now 16 laws shown in Table I.11.2-1 are enacted.

Table I.11.2-1 Mongolian Laws Concerning Environment
(the year of enforcement is shown in parenthesis)

- Law on Environmental Protection (1995)
- Law on Special Protected Areas (1995)
- Law on Hunting (1995)
- Law on Natural Plants (1995)
- Law on Forests (1995)
- Law on Land (1995)
- Law on Water (1995)
- Law on Air (1994)
- Law on Protection from Toxic Chemicals (1994)
- Law on Underground Resources (1994)
- Law on Mineral Resources (1994)
- Law on Protection of Livestock Genetic Fund and Health (1994)
- Law on Law on Natural Plant Use Fees (1995)
- Law on Water and Mineral Water Use Fees (1995)
- Law on Fees for Harvest of Timber and Fuelwood (1995)
- Law on Hunting Reserve Use Payments and on Hunting and Trapping Authorization (1995)

Source: Ministry of Nature and Environment

Among the above 16 laws, the first "Law on Environmental Protection" acts as the framework for the rest, like the environmental fundamental law. The contents of each law have a lot of problems to operate, because they have lots of defects, unclear definition of terms, vague application scope for the rules, indefinite appointment of administrative and supervisory authorities, inadequate penalty, and lack in consistency among the laws. Thus, though offenses against the enacted laws have frequently occurred, only a few arrests have been made.

In the Law on Environmental Protection, environmental impact assessment system is specified in order to prevent environmental destruction by forecasting and evaluating the influence of development projects on the environment. The Department of Environmental Impact Assessment under the Ministry of Nature and the Environment takes charge of the enforcement. The assessment must be executed by a Mongolian company specialized in environment assessment and authorized by the Ministry, when a great deal of influence on the environment is predicted through screening the project plan which was prepared by the project team and submitted to the Ministry and local government. The assessment is required for a project in 12 fields as shown in Table I.11.2-2.

Table I.11.2-2 Types of Projects for Which Environment Assessment is Required

- Mining industry
- Petroleum industry (transportation, storage, and refining)
- Power plant
- Heavy industry
- Light industry
- Food industry
- Agriculture
- Infrastructure
- Local service
- Preliminary survey for foreign investment (policy, master plan, planning a project)
- Other business (water supply, reservoir system, wrecker business, waste disposal)
- Special business

Source: Ministry of Nature and Environment

The law, which is closely related to the power plant, is Law on Air, which was enforced in June 1995. In this law, the environmental standard of the air is specified as seen in the Table I.11.2-3

Table I.11.2-3 Environmental Standard of Air

Pollutant	Average in 20 minutes	Average in a day
SO_2 (mg/m^3)	0.5	0.05
NO_2 (mg/m^3)	0.085	0.04
CO (mg/m^3)	5.0	1.0
Smoke (mg/m^3)	0.5	0.15

Source: Law on Air (Ministry of Nature and the Environment, 1995)

In Mongolia, air is contaminated especially in the urban areas including Ulaanbaatar. Regular survey or monitoring is rarely conducted, and no action is taken. Some major pollutants in the air pollution are identified: for example, smoke emitted from a thermal power station using coal, small-size boiler, smoke from stoves for home heating and cooking, and exhaust gas of cars. The estimated amount of smoke emitted from these pollutants is shown in Table I.11.2-4 below.

Table I.11.2-4 Estimated Amount of Smoke Emitted from Air Pollutants in 1993

(unit: thousand ton/year)

	SO_2	NO_2	Smoke
The 2nd thermal power station	1.8	1.6	3.9
The 3rd thermal power station	11.2	10.9	26.4
The 4th thermal power station	28.6	23.1	56.1
Small-size boiler	4.7	2.7	22.5
Stove for home use	2.4	0.8	10.4
Total	48.7	39.1	119.3

Source: Study on Comprehensive Coal Development and Utilization in Mongolia (Institute of Energy Economics, Japan, 1995)

When a smoke extraction apparatus is installed at a power plant or factory, the business owner must bear the expenses. Three thermal power stations in Ulaanbaatar are equipped with a dust chamber, but neither with desulfurization equipment nor denitration equipment. It is also said that the dust chamber does not work efficiently at full performance, because it became too old for use and has not been well maintained.

As for the standard of waste water, the Mongolian Law on Water enacted in 1995 does not have any stipulation, while the older version enacted in 1974 specifies the standard as shown in Table I.11.2-5. Because the standard is outdated, it is necessary to revise them, meeting the current situations.

Table I.11.2-5 Standard of Waste Water

Item	Permission standard for constructing filtration plant (mg/l)	Elimination rate at filtration plant (%)
floating molecular	500	92-95
BOD	400	92-95
COD	500	65-80
copper	0.5	80
oil	25	85-90
lead	0.1	50
selenium	0.1	50
chromium III	2.5	80
arsenic	0.1	50
mercury	0.005	-
zinc	1.0	70
SO_4	1.0	99.5
nickel	0.5	50
cadmium	0.1	60
Cobalt	0.1	50
Nitrogen	30	25

Source: Mongolian Law on Water (Ministry of Nature and the Environment, 1974)

As for noise and trembling pollution, there is no specific law to determine the standard.

11.3 Current Situation and Issues of Energy Saving

Since, the present tariff system is mostly a monthly fixed tariff system, the attitude toward energy saving is low. In trying to use as much electric power as possible for a constant amount of money, waste of energy is thought to be natural for the consumers. In socialist Mongolia before 1990, the former Soviet Union promoted rural electrification in Mongolia in order to spread the benefits of socialism by installing diesel generators in Sum centers throughout the country and supplying enough fuel to generate electricity for 24 hours a day year round. Therefore, many people in Mongolia still tend to think they can use electricity as much as they want. For example, many households in Sum centers still use energy-consuming electric stoves for cooking, because they have little concern for energy saving.

In the attitude of these consumers, there are lots of problems in consumer's equipment, and the consumer's action to save energy has little progress. Current electrical appliances of general households require large electric power consumption, due to the old-typed facilities. At schools, hospitals, and Sum offices, more incandescent lamps are equipped than required. Distribution lines have also been deteriorating; it is thought to have great power loss.

It is possible to solve the problem against labor saving and energy saving to improve the aspect of the attitudes and facilities.

11.4 Current Situation and Issues of Environmental Protection

Residents in the Sum centers who live in vast areas show little about the awareness toward environmental preservation. It may be true, that originally as Mongolian people who have been living as part of the Mother-nature keeping harmony with the environment, they are not aware of protecting the environment.

Although the garbage, which is dissolved through natural circulation, has no problems, if people leave the industrial product on the plain, it remains as is, and it contaminates the plain gradually. It seems to be the most urgent problem to improve the reality of dumping the garbage, which are lots of empty bottles, wastepaper and vinyl bags nearby Sum centers and along the side of the road.

However, probably the biggest environmental problem in Mongolia is the excessive population concentration in urban cities including Ulaanbaatar. The capital city Ulaanbaatar is now facing difficulty to provide adequate level of educational and medical services for its increased population. There are many people from rural areas who come to Ulaanbaatar with a herd of livestock in order to sell livestock. This causes an increased number of livestock around Ulaanbaatar, and the severe deterioration of pasture land. Although the parliament is discussing the future transfer of a capital city, the fundamental reason for population inflow and concentration into urban cities is the government's neglect of the rural area and the favorable policy and development for urban residents such as better infrastructure and social services.

So the provision of stable electricity and better social services in Sum centers is very important not only to improve living standards of rural households but also to protect Mongolia's environment, because rural development will effectively reduce the pressure on rural population to move into urban cities.

The ambient noise of the Diesel-engine generator has been surveyed in the sample survey on the power supply system. According to sample survey, the residents who live 100～200m away from the existing power station, said that “it sounds noisy”, but it has not become a serious problem. The serious problem seems to be in the scrap processing of the lubricating oil and machine parts.

As for the disposal of exhausted batteries, it must follow a new Law on Protection from Toxic Chemicals, if batteries contain toxic chemicals such as sulphuric acid or mercury. This law became effective in 2000, following the Government Decree No.50 in 1999 which required the registration of toxic chemicals which have the danger of damaging the natural environment. In case of sulphuric acid, it must be neutralized with alkali to reduce its toxicity before it is buried in the earth.

The importer of a product which contains toxic chemical must register it at Ministry of Nature and the Environment (MONE), and the user (such as factories) of the product is responsible for safe treatment and disposal of toxic chemical. MONE’ role is supervision of this process. If Sum office is the user of batteries in the proposed renewable energy plants, Sum office will be responsible for disposal of exhausted batteries, and the environment officer at Sum office will supervise this disposal.

There is no treatment facility for exhausted batteries in Mongolia, and some of the exhausted car batteries had been exported to China. Since there is little industrial waste in Mongolia, no project on industrial waste including construction of a battery disposal factory is currently planned or implemented. There is one on-going study on how to reduce waste from daily life in Ulaanbaatar, financed by Dutch government.

11.5 Recommendation on Energy Saving and Environmental Protection

We propose the following 4 points for energy saving and environmental protection.

- Prevention of population inflow into urban cities by emphasizing social and economic development in Sums
- Education/Enlightenment activity
- Power tariff collection by meter rated tariff system
- Improvement of indoor wiring in the public facility

Up to now, the Mongolian government has tended to put a priority on urban development, which is evidenced by the lower electricity tariff for households living in urban cities connected with the grid than those living in Sum centers which are not connected with the grid. Although about a half of the Mongolian population are nomadic, the Mongolian government has long neglected the development of Sums which can serve as a base for social services to the nomadic population. This favorable policy to urban areas tends to cause overpopulation in urban areas, which in turn causes pollution and environmental destruction, and never leads to sustainable development. So it can be said that the best environmental protection policy for Mongolia, where the nomadic population is the majority, is rural development at the Sum level which includes improvement of infrastructure such as electricity supply, social services and services for livestock, and development of local industries. Only this kind of a new policy can lead to sustainable development in which Mongolian people can continue to live in harmony with the nature.

Educational activities and awareness campaigns should be conducted for energy saving and environmental protection. It is most important to change the residents mind of Sum centers using the measures mentioned above. Conducting educational activities and awareness campaigns on energy saving and environmental protection in school classes will be effective.

It is obvious for each consumer to become sensitive about the electric power consumption by introducing the meter rated tariff system. Although the duty of power supply enterprise on the calibration and inspection of meter will increase, a meter rated tariff system should be installed by overcoming the difficulty.

As discussed before, large amounts of energy have been consumed by the complicated indoor wiring, and a lot of power loss has occurred in the public facility. To improve the problem mentioned above, improvement of the indoor wiring will be an immediately effective measure.

11.6 Disposal of Exhausted Batteries

A huge number of batteries will be installed in the years 2005 and 2010 according to the master plan. A lifetime of battery varies depend on number of charge-and-discharge, its depth and also maintenance quality. 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 disposed of in a proper manner.

The following are recommended for the proper disposal of batteries with the future technological innovation.

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) To give Sum centers the responsibility to take care and properly dispose of their own batteries.
4) To explore the possibility to adopt the newly developed high capacity condenser.

The manufacturers who obtained the environmental standard ISO14000 will take responsible for the disposal of their products. As batteries have the potential to bring about a heavy environmental burden, it is expected that the manufacturers with ISO14000 may present the way to dispose of exhausted batteries according to their companies' policy at the time of selling new batteries.

As mentioned in Clause 11.4, Sum centers should be responsible for the disposal of batteries in accordance with Law on Protection from Toxic Chemicals. Sum centers should appoint the person responsible for protecting the environment and they supervise the process of the disposal.

It is the most practical way to oblige the contractor who provide the facilities in 2010 and 2015 to receive exhausted batteries. In this case the cost of disposal needs to be incorporated in the budget for the project in these stages.

The fundamental countermeasure to solve the problem of exhausted batteries is not to bring about exhausted batteries. Now, a electrical double layer high capacity condenser is in the spotlight. This condenser has the identical specification for power storage equipment such as maintenance free, instantaneous charge-and-discharge and long lifetime more than 200 times of usual batteries. Though the price of it is still high, there is some estimation that the price goes down drastically. And the study for extending lifetime of batteries by applying this condenser is proceeding. Therefore, it is beneficial for the project to explore the possibility to adopt the condensers at time of project execution.

CHAPTER 12
MANAGEMENT AND MAINTENANCE PLAN

CHAPTER 12 MANAGEMENT AND MAINTENANCE PLAN

12.1 Outline

12.1.1 Background

The management of independent power generation systems in Mongolia is full of problems. The Sum center is a small settlement segregated in a vast Mongolian plain. It was a contradiction itself to govern these minute independent settlements through a centralized administration under the socialist regime. The shift to the market mechanism has not changed the system of public administration to a more decentralized structure. The problems in the current fiscal balance only are now putting pressures on decentralization. The management of Sum power stations that are connected to the central grid is not exempt from the problems even though their administrative responsibilities are limited to tariff collection and the maintenance of the distribution system.

Despite the fact that the transmission costs to the peripheral areas are quite large, the tariff charge of 40 Tog/kWh for the household in these Sums is basically the same as the central grid system. On the other hand, the independent power stations in the Sum centers are compelled to raise the tariff charges as various subsidies are gradually eliminated. In comparison to Aimag centers which receive financial as well technical assistances from the Energy Authority, the independent Sum power stations are discriminated against in many aspects. As the pressures to increase efficiency and independence of the Sum power systems are expected to intensify, it is increasingly becoming important to instill a fair and effective management for the power systems in the Sum centers.

One of the top priorities for the Sum centers is to reduce its dependence on the central government as many aid agencies are repeatedly suggesting to the Mongolian government. There is a strong undercurrent in Mongolia to shift from the centralized system to a more decentralized system. However, a drastic decentralization will increase the economic gap between rural and urban areas, leading to a large urban migration and social instability. It is a challenging task to find a policy that instills self-reliance and independence to local governments while maintaining social equity.

It is not practically possible to maintain power supply in the Sum centers without assistance from the central government and the Aimags. At the same time, it is not possible to overcome various difficulties and prepare for future development without establishing an independent management system. It is the utmost important to restructure and improve the management system prior to the facility investments so as to have a working power supply system.

12.1.2 Establishment of Management Principles

It is not possible to establish a maintenance system for the new power generation and distribution system without having clearly defined management principles. In what ways does it become possible to change the management system of the Sum power supply and create proactive management bodies in the Sum centers? The first step toward the goal is to change the management mentality. The management principles should be presented in the simplest words. The proposed principles are as follows,

Principle 1.	Financial Normalization
Principle 2.	Introduction of Competition

Principle 1 suggests a moderate decentralization and independence. The management responsibilities should be written down clearly under a contract and the management has to bear the responsibility in the case of non-fulfillment. The central government in Ulaanbaatar cannot oversee the management of 167 Sum center power supply systems scattered throughout Mongolia. On the other hand, it is not practically possible to make all the Sum centers 100% accountable for financing of power supply. If total self-reliance of the Sum centers were imposed, it would create large gaps in the performance between the Sum centers. The reality requires some sort of compromise between self-reliance and dependence.

A solution is to clarify the division of financial responsibilities between the central government and Sum centers. The central government could finance the initial capital costs and lease the facilities to the Sum centers under a contract at a feasible price. The Sum centers would assume 100% responsibility of operation of power generation and distribution, with an option for financial bankruptcy. Such an institutional arrangement should nurture a more responsible management culture. Many hospitals are already given by international organizations a solar energy system, which is not utilized in most of the cases. The solar energy system is supposed to be maintenance free. There are many factors that cause the ineffectiveness but one large factor is the lack of sense of ownership of the system. The introduction of new technology does not solve a problem when there is a problem in the management. The successful power supply operation is based on the sound management that encourages productivity and quality improvement efforts. The sound management can only be sustained with a strong sense of responsibility.

Competition is a key to running decentralized systems efficiently. Nevertheless, it is not easy to introduce competition into the power sector because the isolated Sum centers offer a natural monopoly to the business. However, there is indirect competition among Sum centers as seen in different population movements among the Sum centers. It is possible to encourage competition among Sum centers. Previously the central government decided the location and capacity for the installation of diesel generators. As a result, even the Sum centers which lacked in management capability were given the generators. It is necessary to introduce a qualification system to screen the Sums centers prior to the installation of new power generation systems. Once the Sum centers become aware of competition, they will start working on the improvements of the management. Those which lag behind the progressive Sums will learn from the successful Sums. A practical model for introducing competition among the Sums is to have a pre-qualification and monitoring system to the Sum centers. Before doing any investment to upgrade the Sum power stations or distribution systems, the Sum centers should be required to submit a report on the management and maintenance capacities and should be ranked after the evaluation. Only the qualifying Sums should be granted investments in new facilities. This sort of competition will be the only means to break away from the dependency mentality that harbors inefficiency.

Some Sums are moving toward financial self-sufficiency, being alarmed by the financial crisis in Mongolia. There is a Sum center that solved the problem of incessant power overload by converting the tariff system to meter-based measurement after careful surveys and trials. The shift to the meter rated tariff system has turned the financial balance as well as the maintenance situations. This case presents a good example of crisis leading to an improvement in management.

12.2 Analysis of Operation and Maintenance Organization

12.2.1 Analysis of Operation and Maintenance Organization

The following are the possible operational forms of power stations in Sum centers:

a) Operation with Sum office's budget (financially dependent operation on Sum office)
b) Operation which is financially independent from Sum office (financially self-supporting operation)
c) Operation by a private company commissioned by Sum office (privatization)

However, in reality, regardless of operational forms of power stations, every power station is facing the same problem. That is, electricity tariff income from households is too small to cover the cost of fuel, so they have to make up the balance by charging the public facilities the higher electricity tariff or buying fuel with the Sum office's budget for heating, which has been heavily subsidized from the Aimag government. In fact, in many Sum offices, the budget for power supply and central heating system constitutes one combined category, so power supply operation has been able to use the money originally allocated for a central heating system.

However, an inefficient and fuel-consuming central heating system is becoming obsolete and is being replaced by a more effective individual heating system which heats an individual building only and needs less operational budget. After this replacement, Aimag government's subsidy for heating in Sum centers will be cut substantially. This cut of subsidy from the Aimag government has affected power supply operation badly, because now it is difficult to get subsidy from heating operation to power supply operation. So many power stations have to limit their operation time only during winter or cut the power supply time in a day substantially. This is the situation that most power stations in Sum centers are now facing, that is, serious cut-down of electricity supply.

In Sum centers where a central heating system is still working, electricity can be supplied throughout the year and for a longer time during and the electricity tariff is about 2,000 - 3,000 Tg./month per household, because power supply operation is subsidized by heating operation. But in Sum centers where a central heating systems were abolished and the subsidy from heating operation to power supply operation is no longer available, electricity supply has been drastically reduced. For example, electricity supply has been reduced to only 5 hours during winter, and the electricity tariff has been increased to 4,000 - 6,500 Tg./month per household in spite of shorter power supply time. As a result, residents in Sum centers are increasingly dissatisfied with the power supply service and the ratio of households who cannot afford to pay electricity tariff has increased up to 30 - 40% in some Sums.

Under such a difficult financial situation, financially independent operational forms of power stations such as the above b) and c) cannot be continued, and, as a result, power stations in most Sum centers are becoming operated by a Sum office's budget, that is, the operational form a). For example, among 15 Sums where JICA Study Team conducted a sample survey, Khalium Sum in Govi-Altai Aimag and Matad Sum of Dornod Aimag used to have a privatized power station. But since now both private power stations found they were unable to generate enough income for electricity supply, they decided that power stations would be returned to the Sum office.

As the currency of Mongolia becomes weak internationally, the price of diesel oil, which is imported from overseas, tends to rise, and this will make the operation cost of diesel power stations in Sum centers even higher in the future. Although some increase in income for power stations can be expected by revising electricity tariff system and improving the collection method (such as introduction of coulometers), it will be very difficult to attain the financially independent operation of power stations due to the expected rise in diesel oil price.

On the other hand, in the urban areas such as Ulaanbaatar and Sum centers connected with the grid, people can use electricity for 24 hours in a day and average households pay only about 2,000 - 4,000 Tg./month for electricity, based on the actual usage recorded by coulometers. As described above, many households in Sum centers which are not connected with the grid are paying an electricity tariff of 4,000-6,500 Tg./month, which is much higher than the tariff in urban areas. This is a very unfair situation and increases disparity between urban areas and rural areas.

Because of this unfair situation, many people, especially young people, prefer to move from rural areas to urban areas, and this population inflow into urban areas causes many urban and environmental problems. So it is the Government's responsibility and urgent task to stop this population exodus from rural areas by subsidizing power supply operation in Sum centers as well as improving social services such as education and medical service.

12.2.2 Problems in Management of Sum Power Stations

On the average, the management of the power supply systems in the Sum centers is poor. The generators are rarely maintained. The tariff collection is basically covering fuel costs and the operation is continued till the stock of fuel is depleted. This lax management system is the product of the socialist regime. During the socialist regime, the Sum center was created as an administrative lowest unit and does not owe its origin to any natural settlement. However, Sum centers have established themselves as a rural center serving for public services, cultural exchanges, and commerce. Though the basic tenet of the Sum administration is the dependency on the central government, there are a few Sums that are espousing an attitude toward self-reliance in the face of current social instabilities. The key is how to harness such new awareness into a new movement.

Under the centralized planned system, power generators were lent to the Sum centers without any financial charge. Coupled with artificially low-priced fuel, the Sum centers did not need to have financial prudence, supplying unlimited power 24 hours a day. The freely lent generators are now deteriorating rapidly, facing the risk of a permanent power supply cut. In fact, 10% of the Sum centers under the study already have no electricity supply. No measures are taken to offset the fuel price increases by managerial efforts. Many Sums collect electricity charges on a fixed basis instead of using meters. The JICA Study teams spent many hours on the issues of tariff collection at the focus group discussions during the Sample Survey. Sum administration was generally reluctant to agree to changing the tariff system to meter measurement. The administrators would cite many reasons for not adopting meters but the true reason appeared to boil down to their unwillingness to assume a larger administrative workload. On the other hand, the household users would claim that they are saving energy as best as they can, but in reality many are using heavy load appliances such as electric stoves without much restraint. The consequent high loads of output are forcing the generators to operate excessively and causing much damage. The power supply business in the Sum center is now caught in a vicious circle.

The crisis of massive break-downs of the diesel generators in the Sums was avoided by the JICA grant program to install new generators. However, without changing the current management system, the same crisis will be repeated in the near future when the new machines face maintenance problems or retirement.

During the Sample Survey, there was a Sum which did not have electricity supply for the last three years, contrary to the data record in the Inventory Survey. Under the centrally controlled regime, there was a moral hazard which encourages distortion of information, reporting only what the central government wanted to hear so as to reduce workload and avoid punishment. It is a formidable challenge to change such administrative culture developed during the centrally controlled regime.

12.3 Proposals for Operation and Maintenance

12.3.1 Guidelines for Management Improvement

The following management system is suggested in accordance to the above-mentioned management principles. The basic goal of the scheme is the clarification of management responsibilities based on self-reliance. The central government should procure the finance to introduce a new power generation system and lease it to the Sum center. MOID needs to provide technology transfer to make certain that the facilities be operated safely and efficiently. After the transfer, MOID needs to monitor the operations.

The MOID, whose basic mission is policy development and regulation, cannot and should not undertake the actual implementation of supporting the power supply business run by the 167 Sum centers which are scattered over the vast land of Mongolia. It is understaffed and effective communication with the Sum centers is not possible. There needs to be an executing organization with the field offices at Aimag levels. An available candidate for commissioning such management responsibilities is the Energy Authority. The Sum centers that are connected to the central grid belong to the Energy Authority. Even these Sum centers are not fully monitored or supported. It is questionable whether the Energy Authority can extend the support to a more complex hybrid power generation systems in the Sum centers under the current organization framework. On the other hand, the Energy Authority is one of the few organizations that operate nationwide successfully in Mongolia. If the Energy Authority is to be appointed by the government as a supporting agency, the clear definition of responsibilities should be established in a contract in commissioning to the Energy Authority.

Another possibility is to contract it out to a private company, although private businesses like consulting and service companies in the power sector are in infancy with much technical expertise to develop. However, the private sector will develop at a much faster speed if there is a potential market. Another merit is such move is in line with privatization policy in Mongolia.

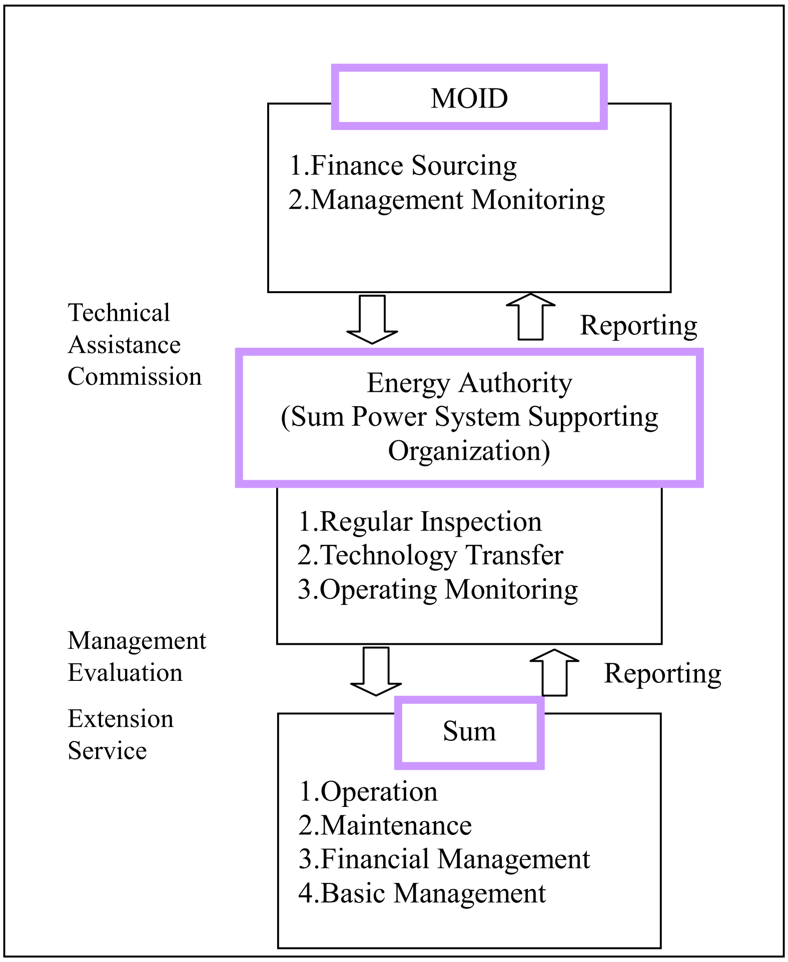


Figure I.12.3-1 Scheme of Management Organization

12.3.2 Functional Divisions

(1) Outline

It is not possible to effectively control and manage 167 independent and scattered power generation systems through a centralized integrated mechanism. The only sustainable way is to establish a more decentralized system, meaning that the Sum centers will have to assume final responsibilities. At the same time, the Sum centers are not equipped financially or technologically to assume the entire responsibilities. Hence it is important to clearly divide the responsibilities between all the organizations involved for the entire system to function effectively.

(2) Sum Center Functions

Simply stated, the Sum center's responsibility is field operation.

(a) Daily inspection and maintenance
(b) Daily operation record keeping

(c) Distribution system maintenance and extension
(d) Energy saving planning and implementation
(e) Service maintenance
(f) Troubleshooting and repair
(g) Tariff collection and accounting

(3) Supporting Organization Functions

The list of Sum center power system supporting organization's functions is as follows,

(a) Evaluation of pre-qualification of Sum centers for new investments
(b) Field extension service for regular inspection and maintenance
(c) Technology transfer to Sum centers
(d) Breakdowns and accidents services
(e) Monitoring of Sum center management
(f) Support to various agent programs
(g) Collection of various data

(4) MOID functions

The Ministry of Infrastructure Development (MOID) is the top government branch responsible for policy making and its implementation. Thus MOID is in the place to find financial sources for new investments and monitor the general performance of rural power supply.

(a) Policy making for Sum center power supply including tariff policy
(b) Monitoring general performance and supervision of management of Sum center power supply
(c) Various agency programs monitoring and supervision
(d) Finance sourcing and support to Sums
(e) Budgetary allocations

12.3.3 Requirements for Institutional Building

In order to have properly function three layers of institutions as shown above, there are three conditions to be fulfilled as follows:

1. **Adequate financing setup**
2. **Human resource development**
3. **Organizational reform**

The power supply businesses at Sum centers are not financially sustainable on their own. Therefore, it is an imperative to seek alternative financial sources to maintain the power supply. A pragmatic financial source is the Energy Authority. The Energy Authority already subsidies the Aimag center grids. It is a matter of extension of the assistance to the Sum centers beyond the Aimag centers that are currently subsidized. For the Sum Power System Supporting Organization to function properly at Aimag levels, there is a need for proper financing from the central government level.

The second requirement of human resource development is to develop the core of actual maintenance functions. The current operators of diesel engine generators who lack in electrical and electronic engineering skills need to be trained. The managers of Sum power supply operation need to be trained on modern business practices to reform themselves from lax communal management.

The organizational reform requires time and effort. It is necessary to expose the power supply operation to competitive environment to rid of the lax management culture and also sustain long lasting effects.

12.3.4 Human Resource Requirement and Financial Requirement

The Sum Power System Supporting Organization recommended in Section 12.3.1 will require a group of well-trained engineers and managers. The following is the rough estimate of the manpower requirement.

National headquarter:

1. Chief Executive: 1
2. Investment and Maintenance: 1
3. Finance: 1
4. Human resource management: 1
5. Staff: 4
6. Total: 8

10 Branches (per branch office)

1. Branch Manager: 1
2. Finance and Tariff Collection: 1
3. Monitoring and Maintenance: 4
   Mechanical engineer x 2, Electrical Engineer x 1 and Distribution Engineer x 1
4. Secretary: 1
5. Total: 6

Grand Total: 68

Financial Requirement:

The basic cost components of maintenance work are wages, spare parts and services.

The annual operation costs are estimated as follows,

The direct cost in Table I.112.3-1 is the total cost estimate for the maintenance work required for all the 167 Sum center power supplies. If part of the cost is borne by some Sum centers, the direct cost may be reduced accordingly. However, as the financial analysis shows, the Sum center does not have sufficient funds to cover this cost in principle.

Table I.12.3-1 Supporting Organization Operation Cost

Unit: US dollars

	Cost
Direct Cost (Spare Parts etc.)	1,440,000
Wages	135,000
Overhead	81,000
Total	1,656,000

The financial source needs to be identified since all the Sum power supply operations are expected to run a substantial deficit as described in Chapter 13. However, the supporting service should not be given to the Sum centers for free since it would send a wrong message to the Sum power supply operators. In other words, the Sum center may feel that there is no financial repercussion for not handling power generation and distribution equipment properly. Power generation should be subsidized to the extent that the minimum supply of power is affordable to the Sum center residents and the Sum should pay to the Supporting Organization out of the general revenue of the Sum center power supply budget including the subsidies.

12.3.5 Maintenance Reinforcement Program

The physical development of Sum power supply is planned to gradually increase the capacities in three stages. On the other hand, it is possible to step up the development speed if the Sum centers enhance its managerial capacity at an earlier date or the rural economies develop at a faster pace than anticipated. Therefore all the staged planning should not be viewed rigidly.

The reinforcement of the management systems in the Sum center power supply business is the precondition for the introduction of new power generation system. The pre-qualification of the Sum centers is in line with the second principle of Competition to create a culture for efficient management.

Without proper operation and management, new system introduction will not succeed. The first necessary condition is to establish a responsible management system by the year 2005. Stable Supply and Technology Accumulation are the goals for the year 2010 and Complete Self-Sufficiency is the target of year 2015.

(1) First Goals – Pre-qualifications

The pre-qualifications for the year 2005 before installing new power generation system are as follows:

Year 2005 – Responsible Management

1. **Meter-Rated Tariff Collection**
2. **Technical and Financial System for Maintenance**
3. **Proper Record Keeping in Operation and Finance**

Over 90% of the Sum centers collect electricity charges on a monthly fixed Sum basis. The first step to rationalize the power supply management is to introduce a meter rated tariff system. The fixed tariff system encourages the users wasteful use of electricity and also often subsidies the rich and taxes the poor. It is not a recommendable system in view of social equity. In terms of power supply, excessive consumption requires unnecessary capacity or creates overload on the generators causing unwanted damages. From a managerial viewpoint, lack of meters makes no data available on the consumption of electricity, especially loss of power through distribution. Shift to a meter rated system will require additional manpower for meter inspection, extra workload to prevent tampering by the users on the meters, and additional investment for installation of the meters. As the evidence of a Sum center which changed to meter rated system shows, it is perfectly feasible to change to meter-rated tariff by the Sum itself. According to an estimate, there should be at least 40-50% savings fuel by a meter rated tariff system in addition to saving of the damages caused by overload. The cost saving should enable the creation of financial sources for maintenance.

The second target of preparedness for maintenance is one of the crucial management elements missing in the Sum center power supply. Maintenance is the basis for self-reliant management. When the Sum center determines the monthly fixed charge, the Sum center, first, calculates the cost of the fuel for one month operation and adds wages and other expenses, and it divides the cost by the number of the users. The Sum centers that are suffering from financial liquidity collects the monthly charge in advance and operates the power generation as long as the fuel stock lasts. This type of ad hoc financial management cannot lead to any long term planning that prepares for accidents and breakdowns. When a breakdown occurs, the Sum center usually reimburses the power tariff for the lost days of power supply to the users. Hence, the financial situation of power supply operation is further deteriorated. Nevertheless, few Sum centers are fully aware of the importance of prevention of breakdowns and immediate recovery of power generation capacity in terms of business. The majority of the Sum centers does not conduct regular inspections and maintenance or have any funds available for the repair. It is necessary to change such lax management style.

The third target may be treated as a minor issue but is fundamental in instilling business culture of continuous improvements. During the Sample Survey, requests were made to reveal operational and financial records on very basic issues such as monthly fuel consumption, but no Sum center was capable of producing the requested data promptly. The majority of the Sums had to investigate into the original bills and accounts and calculate the required data. The operational records are limited to fuel consumption and operation hours. With these data, it is not possible to conduct scientific management analysis and planning. The majority of the Sums centers experience large seasonal fluctuations in population, some reducing to half during summer. The population of the Sum center peaks in January and February and starts declining in March or April as some of the households leave for grazing ground of their cattle, hitting the bottom in June or July. The families start coming back in September. In addition, yearly changes in permanent population is quite large, and many Sum centers experiencing a rapid decline. These drastic changes in the user base makes the management of the power supply different. For sound financial management, it is necessary to have a full grasp of monthly financial fluctuations under a rapidly changing user base.

It is premature to introduce a new power generation system, i.e. renewable energy system, to the Sum centers that cannot fulfill the above three targets. On the other, hand making it a mandate to fulfill these targets will have a big push effect in promoting sound management style among the Sum centers.

The Supporting Organization needs to be established by the year 2005 and should be capable of assessing the management capacities of the Sum centers in terms of these pre-qualifications. At the time of commissioning of new energy system, the Supporting Organization should be able to implement technology transfer followed by the monitoring of the installed systems.

(2) Year 2010 Targets

Year 2010 Targets－Stable Supply and Accumulation of Technologies

1. **Year Round Operation**
2. **Replacement Funds**
3. **Reduction of Transmission Loss**

Currently the majority of the Sum centers provides power only during peak hours in winter. Lack of access to modern telecommunication media such as TV due to no supply of power during summer or non-peak hours is making the local residents feel isolated from the society. Many mothers fear that there might be a negative educational impact on their children. Many wealthy nomadic households would purchase parabola antennas and renewable energy systems so that they can watch TV at any time. The parabola is needed because the Sum centers do not provide power to the TV relay station all the time. In that respect the lack of continuous power supply is increasing the living costs for the nomadic households outside of the Sum center as well. There is an indirect cost associated with the public services concerned with BHN as well. If emergency patients are brought into a hospital when there is no power supply, the hospital which suffers from proper staffing or fuel expense often cannot adequately supply power to itself, hindering proper medical care. There are other numerous examples which affect the economy and safety of the local residents due to lack of power. As a basic infrastructure, it is necessary to provide electricity throughout the year so that other social services would function properly.

The second target of putting aside the funds to replace retiring generators and other equipment is a difficult task for the Sum at the moment. The decision would lead to a substantial increase in power tariff. The current electricity prices of the Sum centers reach three to four times higher than that of the central grid system but do not reflect any depreciation cost. However, without having sufficient funds to reinvest in its own power business, the Sum center would never be able to become independent. Though at present the diesel generators are owned by the central government, the ultimate goal is for the Sum to become capable of purchasing these generators by themselves. To invest in new equipment, it may be possible to borrow money, but the Sums do not have any credit in such financing. Therefore, the only way is to accumulate some funds for future investment. It is not too early to start make some reserves at this stage for the future. However, the further price hike, if such action were necessitated, would pose a social equity problem between rural and urban areas of Mongolia.

It is not possible to set a numerical target for the reduction of distribution loss at this stage since there is no complete meter installation in the Sum centers to record the actual consumption. Nevertheless, it is generally known that the loss would reach at least 20-30% of generated power. There are some Sums that suffer from as much as 50 % distribution loss of power. The majority of loss may belong to technical loss while a substantial part comes from managerial loss. The reduction in power loss is tantamount to the creation of a new capacity for the power supply side. There should be a concerted effort of improvement in tariff collection and public education as well as investment in the distribution facilities.

(3) Year 2015 Targets

Year 2015 – Self-Sustainable Development
1. Quality Improvement
2. Power Generation Cost Reduction
3. Complete Self-Sufficiency

It is a futile argument to set up the targets for the year 2015 since the previous two staged targets need to be fulfilled first. Nevertheless it is a final goal stated for the future. By this time the Sum centers should resolve the price differences with the central grid system and further reduce power supply costs to improve public services. It is anticipated that the Sum center would need to operate a number of electronic devices and equipment including computers. To accommodate the use of accurate machinery, it is necessary to improve the quality of electricity including voltage and prevention of blackouts. Financially it is an ideal to attain independence from the central government so that the Sum centers can decide by themselves to invest in expansion of power supply facilities.

12.3.6 Management Organization of Sum Centers

(1) Organization Setup

The organization of Sum power supply business basically consists of administrative division and field operation division. There is no major difference to the current organizational structure. The power supply organization should be completely separated from the Sum center office. Shift to a meter rated tariff system would require additional manpower for tariff inspection and collection. The cost of additional wages can be fully recovered by the cost saving and revenue increase from metering. The operators need be assigned full time so that he or she can accumulate know-how of the operation and maintenance. The accountant can be part time, sharing responsibilities at the Sum center office. Among all the management decisions, the tariff pricing affects the most the financial stability of the power supply business. Currently, the manager of the power supply operation does not hold the final authority in pricing but it rests with the Sum chief. The monopolistic nature of power supply business makes it necessary for public intervention but pricing is often used to win political favor ignoring costing aspects. In fact there were the cases of tariff changes that appear to undermine the power supply business solvency or that were intended to transfer the benefits only to the wealthy residents. It is necessary to establish a third party organization to review tariff system so as to attain accountability from technical merit and the Sum chief should endorse the tariff.

(2) System Organization

To sustain uninterrupted power supply at the Sum center, it is necessary to establish adequate management practices on preventive maintenance, procurement and storage of spare parts, repair and safety. There is a need to establish a manpower plan for 24-hour operation as well. Fig I.12.3-2 shows a schematic chart of a new Sum power supply organization.

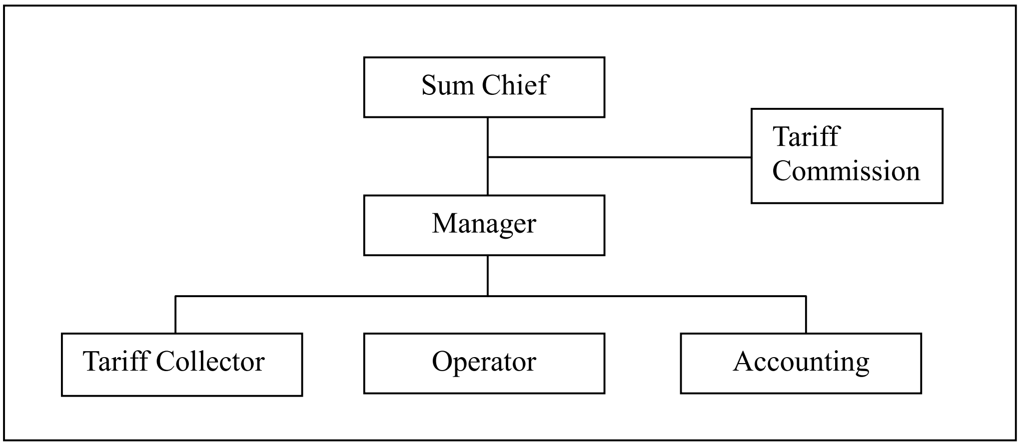


Figure I.12.3-2 Organization of Sum Power Supply System

12.4 Suggestions for Electricity Tariff System

12.4.1 Energy Saving Through Conversion to Meter Tariff System

The tariff system needs to be changed to a meter-based collection system as quickly as possible. Though the transition will require some investment in the purchase of meters, the investment is affordable to the Sum by itself. The meter system will necessitate the payment of the tariff after the consumption of electricity. Some Sums may suffer from liquidity problem if they are collecting the monthly tariff prior to the delivery of electricity. One countermeasure is to require a deposit equivalent to one month worth of tariff charge. Another merit for such deposit is to have some effect on curbing the tampering of the meters by the users.

The transition to a meter-based tariff collection will require the management to forecast the expenditure and revenue for the subsequent 6 months to one year and determine the tariff level to meet the financial requirements arising from fuel payment and unanticipated maintenance needs. Only such situation will create the Sums to realize the importance of management.

12.4.2 Correction of Tariff Gap

As described in Section I.5.6, there is a huge gap between the tariff levels of urban and rural power customers. It is estimated that the rural electricity users who have less cash income on the average are obligated to pay as much as four times the tariff that the urban counterparts are paying. There is a report that the fuel price hike in 1999 led to the total suspension of power supply even during the winter peak times at half of the Sum centers. Currently the Energy Authority is providing a 60% subsidy of the power generation cost for the Aimag Center power supply systems while there is no assistance at all to the Sum center power supplies. Needless to say, it is the Sum centers that need financial assistance badly since it is unavoidable to have a higher power generation cost.

Though there is a general trend to abolish subsidies for the sake of increasing efficiency, it is an unavoidable fact that the peripheries of network based infrastructure has higher costs. In view of social equity, it is a government obligation to make available the minimum social services to both urban and rural dewellers. If so, a subsidy is a must to have a functionable rural power supply. Henceforth, it is recommended to adopt a subsidy program for the Sum centers.

There are two possible sources for the Sum power subsidy. The first source is the revenue generated from the central grid power supply. The second source is the general revenue of the central government. With the current financial difficulties that the central government is facing, the more practical and expedient means is to tap the revenue of the Energy Authority. According to the long term marginal cost analysis, the power generation costs by the diesel engine (entire Sum center power supply) is 48 cent per kWh (500 Tg/kWh), and 1.1 dollars per kWh (1160 Tg/kWh) for PV and wind (power supply to BHN institutions) including the full coverage of investment, maintenance and running costs. Currently the Sum centers do not pay for the initial investment. If the Sum centers are exempted from the initial investment payment, the long-term marginal costs are 34 cents per kWh (350 Tg/kWh) for diesel engine and 15 cents kWh (160 Tg/kWh) for PV and wind including running and maintenance costs.

For the year 2005, the majority of the power demand for the Sum center is covered by the diesel engine power generation system. Thus the average power generation cost will be about 350 Tg/kWh. To completely eliminate the power tariff gap between the central grid and the Sum center, the subsidy would be 310 Tg/kWh. To lower the tariff gap to the Aimag center level, the subsidy would be 290 Tg/kWh. The tariff increase needed in the central grid to cover the transfer of subsidy to the Sum center would require an increase of 2.1 Tg/kWh for the total tariff gap elimination and 2.0 Tg/kWh for lowering to the Aimag level. This increase could cover the costs needed to operate the Sum Power Supporting Organization described in Section 12.3.4.

The Sum center should become fully aware of the power generation cost and the value of the investment to instill more serious management attitude. Otherwise proper maintenance work and preparation for the future investment would continue to be neglected. One way is to implement such management reform is to give the rational subsidy according to the power sales while charging a full value of investment as leasing according to the period. This give and take, reciprocal system can be termed "Lease and Subsidy." Under this system, the Sum centers would be forced to work hard to maintain uninterrupted power supply since leasing cost would be charged at the time of power cut. The next Fig I.12.4-1 shows an example to illustrate the effects of Lease and Subsidy System. In the case of leasing the initial cost of investment which is 150 Tg/kWh for diesel and 1000 Tg/kWh for PV and wind needed to be added on to the subsidy and charged as lump Sum monthly as the depreciation cost to the Sum center.

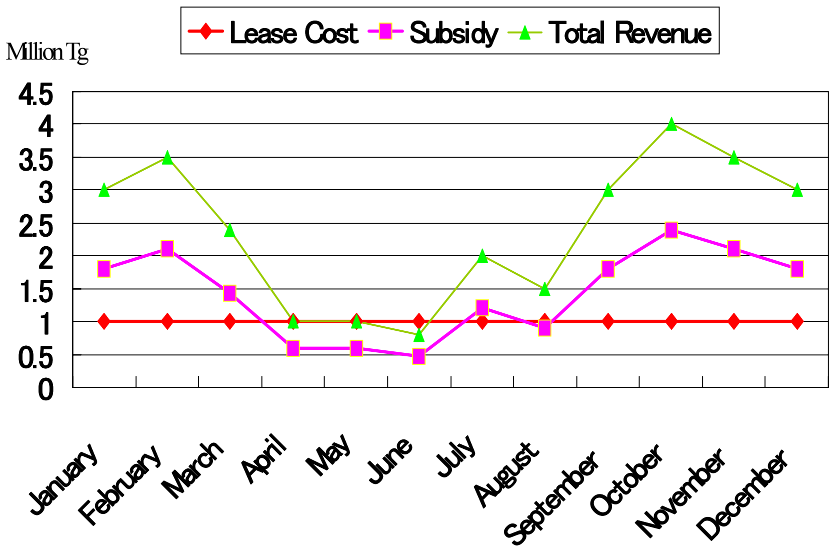


Figure I.12.4-1 Lease + Subsidy System Illustration

The above calculation is based on the 24-hour year around operation of power supply at the Sum center, thus should be viewed as a benchmark. If the Sum center opts for an irregular power supply practice such as during limited times and seasons, the subsidy level should be adjusted accordingly.

CHAPTER 13
ECONOMIC AND FINANCIAL ANALYSIS

CHAPTER 13 ECONOMIC AND FINANCIAL ANALYSIS

13.1 Methods of Economic and Financial Analysis

13.1.1 Objectives

The economic and financial analysis each has an independent objective. The financial analysis looks at the efficiency of capital invested into the project from the view from the investor. In order to separate the contribution of the studied project, it is necessary to isolate only the revenues and expenditures that are related to the project itself. The evaluation should be made to assess the long-term return on the investment of the project. The economic evaluation analyzes the project in view of the contribution to the national economy. The assessment of BHN and environmental contributions come to play a critical role in the economic evaluation. The benefits to the project in the economic evaluation are measured in terms of the realized welfare to the beneficiaries. As the third measure, the cost of power generation is compared to the alternative system, in this case, diesel systems. Since the alternative power generation system is diesel generators, the renewable energy system has an advantage in environmental protection.

This master plan basically proposes stand alone power systems for the Sums. Therefore, the evaluations are conducted for each Sum at first and aggregated as an entire system.

13.1.2 Assumptions and Premises

(1) Basic Framework

The proposed systems are phased for the year 2005, 2010, and 2015. Since each phase corresponds to the different segment of power demand, each phase is treated as an independent project. In a rough classification, the year 2005 system meets the demand from the BHN institutions. In most of the Sums the system largely comprises of PV and wind powered generators. In a small number of Sums the micro-hydro power and transmission extensions plan to cover the entire Sum center power demand. In addition there are some diesel engine power stand-alone systems. The systems other than PV and wind cover the entire Sum center power demand. The diesel engines are planned for the Sums which have not received the diesel engines from the Japanese government.

The systems design for the year 2010 stage is to meet the Sum center power demands during the summer and the one for the year 2015 is to meet the power demand for all year round. The system to be introduced in the year 2010 is basically the combination of renewable energy power generation and batteries. The system for the year 2015 uses the fuel cell and hydrogen generation equipment in addition to renewable energy power generation system to meet the year-round power demand of the Sum center. The principle that underlies any financial or economic analysis is to maintain the correspondence between the revenue and expenditure in respect to the studied project. The revenue streams for the year 2005 systems that use PV and wind will be restricted to the one that originates from the BHN institutions. Though the systems for the year 2010 supply to the summer power demands of the entire Sum centers, the investments for the power generation incorporate the generation capacities created by the year 2005 investments. Therefore to maintain the correspondence, the BHN power demand is subtracted from the power demands. The same principle applies to the year 2015 project.

The project life is set at 20 years, judging from the durability of the renewable energy devices. The first year of the project is set aside for the construction which lasts 12 months. Therefore, the project period for evaluation is 21 years. The batteries wear out more quickly and the replacement is assumed to take place at 7-year intervals. The residual value of the investment at the end of the project life is set at 5%. The electricity tariff is assumed to increase at 3% annually[1].

(2) Scope of Project for Year 2005

The project implementation plans in 2005 can be classified into eight categories for economic and financial evaluations and the scopes of project evaluation are defined as shown in the Table I.13.1-1.

Table I.13.1-1 Scope of Project Evaluation by Project Type

Type	Facility	Demand To Be Met
1	PV only（JICA Grant Diesel Gen.）	BHN
2	PV＆Wind Power（JICA Grant Diesel Gen.）	BHN
3	PV only＋New Diesel Gen.	BHN＋Entire Sum Center
4	PV＆Wind Power＋New Diesel Gen.	BHN＋Entire Sum Center
5	Hydro Power Generation	BHN＋Entire Sum Center
6	Transmission Extension	BHN＋Entire Sum Center
7	New Diesel Gen.	Entire Sum Center
8	JICA Grant Diesel Gen.	Out of scope of evaluation

For the Sum centers with a plan to install new diesel engine powered generators without any renewable energy system, it is assumed that the BHN are not fully met because the power supply pattern will be similar to the current practice of a limited supply during the night time. The diesel operation with current fuel prices cannot operate 24 hours continuously financially. Therefore, it is assumed that the new diesels analyzed for the year 2005 would run 12 hours a day to save fuel, but the operation would fetch 80% of the value assumed for non-stop operations.

[1] It is assumed that the GDP growth in 1998 will be applied to the purchasing power and willingness to pay.

(3) Scope of Analysis for Stage Year 2010

The basic objective of the year 2010 stage is to fulfill the summer power demand of the entire Sum center with the prospect of further price reductions in renewable energy products. The planned system cannot, however, meet the demand during winter since the demand increases in leaps. At the same time the power generation capacity during winter drops due to less radiation of the sun. The drop in power supply is assumed to be 80% for the analysis. The demand from the BHN facilities are presumed to be met by the facilities provided in the year 2005. During the summer 100% of the power demand is met by the proposed system except for BHN power demands. During winter, the proposed system supplies 80% level of the summer power demand and the balance of the demand is to be supplied by the diesel engine generators.

(4) Scope of Analysis for Stage Year 2015

The basic target of the year 2015 stage is to meet the entire power demand of the Sum centers throughout the year. Consequently the project analysis deals with the entire power demands throughout the year.

13.1.3 Assumptions for Economic Benefits

The economic benefits of power generation materialize through promoting the conveniences in social life and increasing economic productivities with the use of electricity. These benefits are represented by the utilities of the users termed as Willingness-To-Pay.

(1) Willingness-To-Pay By BHN Sector

The economic benefits to the BHN institutions are estimated from the budgets of these institutions. It is clear that electricity is vital to the healthy operations of these institutions from the previous studies. Very often adequate medical care has not been given to the patient in emergencies. Therefore the residents are willing to pay for the power supply to the BHN institutions. However, it is difficult to convert the willingness to monetary values. Nevertheless, the financial records give some measurement.

Table I.13.1-2 Financial Summary of Hospitals and School in Sums

Unit: Tog

	Hospital	School
Annual Expenditure	14,625,297	22,078,266
Expenditure Per Resident	4,235	6,393
Expenditure Per Student	N.A.	40,844
Annual Electricity Exp.	523,730	824,394
(%)	(10%)	(5%)

Source：JICA master plan study team
Note: sample 144

The willingness-to-pay is assumed as shown in Table I.13.1-3 by taking into account the enhanced conveniences and services that are brought about by the continuous access to electricity.

Table I.13.1-3 The Willingness-To-Pay By Hospitals and Schools

	Hospital	unit	School	unit
Total Budget	6,000	Tg/resident/year	60,000	Tg/student/year
Electricity Budget	600	Tg/resident/year	3,000	Tg/student/year
(%)	10.00%		5.00%	

(2) Household Willingness-To-Pay

The Sample Survey Family Interview surveyed the maximum amount of electricity charge each household is willing to pay per month for various degrees of services. In a strict sense the figure only corresponds to the average willingness to pay, therefore it does not represent the marginal utility. In a rural area that faces no power supply, their willingness-to-pay is fairly close to the marginal level and can be used as a surrogate for marginal utility. According to the survey, the average maximum willingness-to-pay is 6563 Tog/month for 24-hour power supply during summer. The average maximum willingness-to-pay for 24-hour service during winter is 6873 Tog/month. The average electricity consumption estimated by the Study is 13.3 kWh per month during summer and 21.1 kWh during winter. The average maximum allowable charge to be accepted by the residents of the Sums will be 493 Tog/kWh during summer and 326 Tog/kWh during winter, making the annual average 391 Tog/kWh.

Table I.13.1-4 Household Maximum Willingness-To-Pay Per kWh

	Average Maximum Willingness-To-Pay Tog/Month	Electricity Consumption kWh/Month	kWh Charge
Summer 24-h	6,563	16	421
Winter 24-h	6,873	26	252
Average	6,718	21	336

Based on our assumption of 3% annual increase the future tariff that is acceptable to the residents will be as shown in Table I.13.1-5.

Table I.13.1-5 Economic Benefits Per kWh

Unit : Tog/kWh

	Future kWh Charge
Year 2005	330
Year 2010	380
Year 2015	440

It is generally accepted in Mongolia that enterprises and public bodies are capable and willing to pay more for electricity service. The Sum centers generally charge these non-household entities 50 to 100% more per unit consumption compared to households. Such a large difference is partially attributable to an artificially low level of household electricity charge. For the purpose of the study it is assumed that the non-household entities are willing to be charged 30% more than households.

(3) Environmental Benefit

Renewable energy is a clean non-polluting energy. Though air pollution is hardly a local issue in rural Mongolia, the emission of pollutants contributes to global warming, however marginal it may be. The switch from a diesel power generation system to a renewable energy system will stop the consumption of fossil fuels that emit carbon dioxide. The assumption and benefit for the reduction of carbon dioxide volume are as follows;

1) Unit Carbon Dioxide Production: 736 kg C/kl
2) Marginal Benefit of Carbon Dioxide Reduction: US$ 28/Ton[2]

[2] Richard Baron, The Kyoto Mechanisms: How much flexibility do they provide?, International Energy Agency
The figure adopted here was taken from the average of estimated values under the assumption of global trading.

(4) Assumptions for Financial Analysis

The current electricity tariff is 50-159 Tog/kWh for general households and 100 to 300 Tog/kWh for public and business entities. It is assumed here that households would pay 200 Tog/kWh and the non-households would pay 400 Tog/kWh in 1999. The tariffs are escalated by the same annual increase of 3% as shown in Table I.13.1-6.

Table I.13.1-6 Electricity Tariff Rates For Financial Analysis

Unit: Tog/kWh

	public	household
Year 1999	300	200
Year 2005	360	240
Year 2010	420	280
Year 2015	480	320

(5) Assumptions for Diesel Alternative Power

The life of the diesel power generators as the alternative is set at 10 years. The capacity is determined for each Sum center with an assumption of a 5% load factor with the capacity increment of 10 kW for BHN institutions and 20% load factor with the capacity increment of 60 or 100 kW for Sum centers as a whole. In order to make certain that there is a continuous supply of power, the additional capacity of generator is assumed for BHN facilities and one additional 50 kW standby generator for the entire Sum center. The fuel consumption of diesel engines is assumed as by the following formula.

- **Annual Fuel Consumption (l/year)＝Hour consumption(l/h) x Annual Operation Hour(h)+ Power Based Consumption (l/kWh) x Annual Power Generation(kWh)**

Table I.13.1-7 Diesel Fuel Consumption Parameters

	100 kW	65 kW	30 kW	20 kW	10 kW
Hour Coefficient (l/hour)	3.50	3.30	2.00	1.55	1.10
Power Coefficient (l/kWh)	0.2	0.2	0.17	0.16	0.15

13.1.4 Assumptions for Expenditures

(1) Operation and Maintenance Cost

It is assumed that the operation and maintenance cost excluding wage and salary is 0.5% of the investment cost and that for micro-hydro power and transmission extension is 1.5% and 5% for diesel power generation.

(2) Wages and Salaries

The wages and salaries required for the Sum power station are assumed as shown in Table I.13.1-8 with an assumption of a 3% annual increase. The wages and salaries for the power supply to BHN in the year 2005 are excluded.

Table I.13.1-8 Wages and Salaries at Sum Power Station

US$/year

	Renewable Energy	Diesel/Hydro
Year 1999	1100	1400
Year 2005	1300	1700
Year 2010	1500	2000
Year 2015	1700	2300

(3) Diesel Operation

The plan for the year 2010 is to meet the entire summer power demand of the Sum centers. However, the sun radiation during winter goes down while the demand for the power increases substantially. Therefore, it is necessary to operate the diesel engines during the winter night. It is assumed that the renewable energy systems cover the demands during all the off-peak hours of 17 hours a day while the diesel engine meets the peak power demands for 7 hours at night. The fuel consumption is calculated on this operation shift between two systems.

The fuel cost of diesel engine is assumed to be 450 Tg/l which was the prevailing local market price at the end of the year 1999.

(4) Assumptions for Transmission Extension

The construction cost of transmission extension to the central grid is calculated on the distance from the existing transmission lines to the respective Sum centers. In addition, there are the costs of power generation and transmission losses. It is assumed that the power generation cost is that of coal fired thermal power generation. The power supply costs through transmission lines are assumed as shown in Table I.13.1-9.

Table I.13.1-9 Power Supply Cost Through Transmission

id		Sum	distance km	cost of power US$/kWh
1	63	Sukhubaatar	40	0.049
2	110	Tosontsengel	47	0.049
3	170	Bayan-Nuur	15	0.047
4	171	Altan-Tsugts	5	0.046

(5) Hydro Generation

The target Sum centers for mini-hydro generation are Munkhkhairkhan and Baruuntruun. At Baruuntruun it is not possible to generate for four months in winter season because of a freeze of the waters. As diesel generators feed the power in the four months winter period, the cost of diesel generation is separately added up.

(6) Equipment Life

Each type of equipment is assumed to have the following equipment life as shown in Table I.13.1-10.

Table I.13.1-10 Equipment Life

	Facility	Equipment Life
1	PV panel Wind Power Hydro power Transmission Weather Measurement	40 years
2	Diesel Engine	10-15 years
3	Battery	7 years

(7) Excluded Costs

There are several items among the project components that are excluded from economic and financial evaluation. The meteorological measurement equipment costs are excluded because the benefits of meteorological measurements are not limited to the renewable energy source power development in the Sum center. The refurbishment of the inner electrical wiring is considered to be part of building maintenance cost that is only incurred once at the beginning of the project implementation.

13.2 Economic Evaluation

The PV and wind power generation systems cater to the demand at BHN institutions all year round but just to meet the level demanded during summer. The revenues for these systems are the payments from these institutions. The electricity sale volume is based on the demand forecasts and the budgetary willingness-to-pay which is 3000 Tog per student for schools and 600 Tog per Sum resident for hospitals on an annual basis.

For the other systems of micro-hydro power, transmission line extension, and diesel power generation it is assumed to cover the entire power demands of the Sum centers throughout the year. The benefits other than from BHNs are calculated on kWh basis of willingness-to-pay.

13.2.1 Economic Evaluation of Year 2005

The economic evaluation for the year 2005 is shown in Table I.13.2-1.

Table I.13.2-1 Economic Evaluation 2005

Type	Facility	Scope of Project Analysis	EIRR w/o CO_2 benefits	EIRR w/ CO_2 benefits
1	PV only (JICA Grant Diesel Gen.)	BHN	-1.5%	0.1%
2	PV＆Wind Power (JICA Grant Diesel Gen.)	BHN	1.2%	3.0%
3	PV only＋New Diesel Gen.	BHN＋Entire Sum Center	-4.9%	-4.6%
4	PV＆Wind Power ＋New Diesel Gen.	BHN＋Entire Sum Center	-14.2%	-13.5%
5	Hydro Power Generation	BHN＋Entire Sum Center	-0.6%	0.0%
6	Transmission Extension	BHN＋Entire Sum Center	4.7%	-
7	New Diesel Gen.	BHN＋Entire Sum Center	-6.3%	-
8	Distribution Line Rehabilitation	Energy Saving	5.8%	6.6%
9	Meters Installation	Energy Saving	32.3%	34.9%

Economic Analysis based on the welfare of the beneficiaries shows that the returns on investment are positive with the PV & Wind power combined system, and transmission extension, but are negative with all other systems proposed. The poor performance of the combined systems is due to the negative cash flows that last over a long period due to large expenditure incurred for recurrent fuel consumption and the replacement of batteries for the renewable energy systems.

13.2.2 Impact of Meter Tariff System

The installation of watt-meters to all the users and a shift from a fixed rate to meter measurement system is proposed for the year 2005. The impact of the introduction of a meter rate is separated from other power generation system evaluations. The basic benefits of a meter rated tariff system comes from the reduction in fuel consumption as a result of energy saving efforts by the users. Therefore the scope of the project was limited to the Sum centers where new diesel engines are planned to be installed. It is assumed that half of the budget for the distribution facilities planned for the year 2005 is allocated for the purpose of meter installation.

The evaluation shows an EIRR of 34.9% with CO_2 reduction benefits and 32.3% without CO_2 reduction benefits.

13.2.3 Impact of Distribution Loss Reduction

Another measure that plans to reduce wastes in power supply at the Sum centers is the rehabilitation of the distribution lines for the year 2010. The estimated loss of power in distribution within Sum centers ranges from 20-30% of the total power production. The loss is mainly due to obsolescence of the facilities, thereby causing electric leakages. The goal of the rehabilitation is to reduce the loss at distribution within 5% of the power generation. Similarly the scope of evaluation is applied to the Sum centers with new diesel engines. The evaluation results show an EIRR of 6.6 % with CO_2 reduction benefits and 5.8% without CO_2 reduction benefits.

13.2.4 Economic Evaluation by Stage

Though there are varied types of power generation systems proposed for the year 2005, the systems for the later stages are unique at each stage. Therefore the overall performance evaluations are shown in the Table I.13.2-2. Obviously, the performance of economic return improves as the stage progresses. The return on the investment in the year 2005 as a whole is negative largely due to a negative impact of the diesel operation system.

Table I.13.2-2 Economic Evaluation By Stage

Year	EIRR w/o CO_2 benefits	EIRR w/CO_2 benefits
2005	-4.0%	-3.3%
2010	-0.2%	1.0%
2015	5.9%	6.5%

13.3 Financial Evaluation

13.3.1 Financial Evaluation for Year 2005

The results of financial evaluation are shown in Table I.13.3-1. Similar to economic evaluation, all the systems except for transmission line extension shows negative returns on the investment.

Table I.13.3-1 Financial Evaluation 2005

Type	Facility	Scope of Project Analysis	FIRR
1	PV only（JICA Grant Diesel Gen.）	BHN	-7.3%
2	PV＆Wind Power（JICA Grant Diesel Gen.）	BHN	-3.9%
3	PV only＋New Diesel Gen.	BHN＋Entire Sum Center	-13.0%
4	PV＆Wind Power＋New Diesel Gen.	BHN＋Entire Sum Center	-32.4%
5	Hydro Power Generation	BHN＋Entire Sum Center	-3.9%
6	Transmission Extension	BHN＋Entire Sum Center	0.8%
7	New Diesel Gen.	BHN＋Entire Sum Center	-15.8%

13.3.2 Financial Evaluation By Stage

As Table I.13.3-2 shows, the financial returns on investment are negative for the year 2005 and 2010 and turn positive for the year 2015.

Table I.13.3-2 Financial Evaluation By Stage

Year	FIRR
2005	-11.3%
2010	-2.9%
2015	2.9%

The results of the financial analysis imply that it is very difficult to operate the proposed plan on a self-sustaining basis such as by a private enterprise. The earlier stage system poses more difficulty in terms of financial sustainability.

13.4 Least Cost Comparison

The last measure for the evaluation is the comparison with an alternative system, which is a diesel engine powered generation system.

13.4.1 Least Cost Evaluation of Year 2005

The evaluation results show that the returns on investment in comparison with the alternative diesel engine system are all positive except for Hydro Power System. This implies that the renewable energy systems are quite robust in comparison to the diesel engine powered system in economic efficiency.

Table I.13.4-1 Least Cost Evaluation For Year 2005

Type	Facility	Scope of Project Analysis	IRR
1	PV only（JICA Grant Diesel Gen.）	BHN	13.1%
2	PV＆Wind Power（JICA Grant Diesel Gen.）	BHN	23.2%
3	PV only＋New Diesel Gen. *	BHN	13.1%
4	PV＆Wind Power＋New Diesel Gen. *	BHN	20.5%
5	Hydro Power Generation	BHN＋Entire Sum Center	-0.7%
6	Transmission Extension	BHN＋Entire Sum Center	7.9%

13.4.2 Least Cost Evaluation By Stage

Least cost evaluation shows that the proposed system is financially robust compared to the alternative power supply system of diesel engines. The return on investment is 12.8% that is well above the opportunity cost of the market. The proposed systems are not as competitive for the year 2010 and 2015 when the system becomes bigger.

Table I.13.4-2 Least Cost Evaluation By Stage

Year	Alternative Cost IRR
2005	13.1%
2010	-1.6%
2015	2.7%

13.5 Summary of Economic and Financial Evaluation

The next graph shows the summary of all investment return analyses. It indicates that the current proposed systems are not financially viable but based on the assumption of year around power supply, the renewable energy system is more economical for a small scale system in particular, compared to the present method of using diesel engines in the rural area of Mongolia.

* The diesel engines are excluded from the analysis for types 3 and 4 since comparison to a type of its own does not make sense. In other words type 1 and 3, type 2 and 4 are the same types.

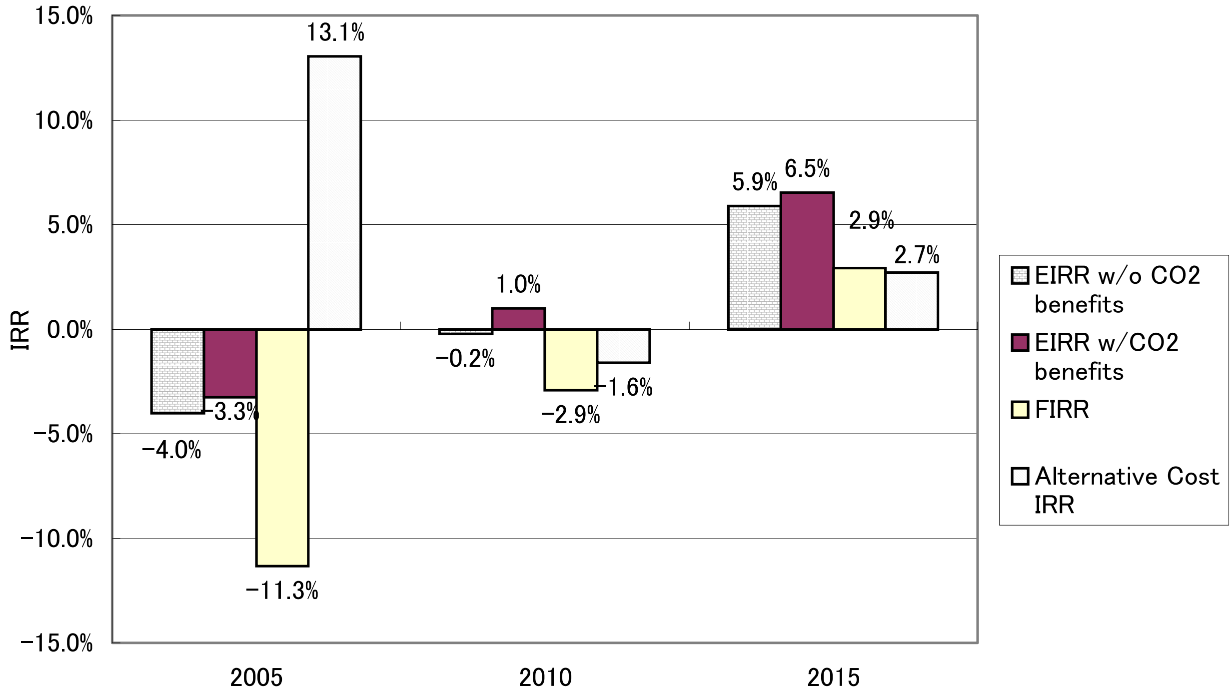


Figure I.13.5-1 Economic and Financial Evaluations By Stage

13.6 Sensitivity Analysis

Sensitivity analysis is conducted to test the changes on the return on investment performance of the projects when the underlying assumptions are changed. The changes in the parameters are mostly negative so as to test the resilience of the project viability. The changes that are tested are 1) 10% drop in project benefits, 2) 10% increase in investment cost, and 3) 10% increase in fuel price. The changes in the marginal cost of carbon dioxide reduction are tested in both directions of 50% increase and 50% decrease since the estimated costs are tentative and uncertain at present.

13.6.1 Year 2005

(1) Economic Sensitivity

Table I.13.6-1 shows the economic internal rate of return on the projects excluding the benefits from CO_2 reductions for the year 2005. The changes shift about 1 % in the returns on investment.

Table I.13.6-1 Economic (W/O CO_2 Benefits) Sensitivity Analysis, Year 2005

Type	Facility	EIRR BASE Case	EIRR Benefit -10%	EIRR Investment +10%	EIRR Fuel Price +10%
1	PV only (JICA Grant Diesel Gen.)	-1.5%	-2.7%	-2.3%	-1.5%
2	PV＆Wind Power (JICA Grant Diesel Gen.)	1.2%	0.1%	0.3%	1.2%
3	PV only＋New Diesel Gen.	-4.9%	-7.7%	-5.9%	-6.0%
4	PV＆Wind Power＋New Diesel Gen.	-14.2%	-19.0%	-15.2%	-16.4%
5	Hydro Power Generation	-0.6%	-3.1%	-2.7%	-1.8%
6	Transmission Extension	4.7%	3.2%	3.6%	4.7%
7	New Diesel Gen.	-6.3%	-10.0%	-7.4%	-7.8%
8	Distribution Line Rehabilitation	5.8%	5.8%	4.9%	6.7%
9	Meters Installation	32.3%	32.3%	28.8%	37.0%

The next table shows the changes in economic returns on investment including CO_2 reduction benefits after changing the assumed parameters. The changes shift about 1 % in the returns on investment.

Table I.13.6-2 Economic (W/ CO_2 Benefits) Sensitivity Analysis, Year 2005

Type	Facility	EIRR BASE Case	EIRR Benefit -10%	EIRR Investment +10%	EIRR Fuel Price +10%	EIRR CO_2 benefit +50%	EIRR CO_2 benefit -50%
1	PV only (JICA Grant Diesel Gen.)	0.1%	-0.9%	-0.7%	0.1%	0.9%	-0.7%
2	PV＆Wind Power (JICA Grant Diesel Gen.)	3.0%	2.0%	2.1%	3.0%	3.9%	2.1%
3	PV only＋New Diesel Gen.	-4.6%	-7.4%	-5.6%	-5.6%	-4.4%	-4.8%
4	PV＆Wind Power ＋New Diesel Gen.	-13.5%	-18.1%	-14.5%	-15.7%	-13.2%	-13.8%
5	Hydro Power Generation	0.0%	-2.4%	-2.0%	-1.1%	-0.7%	-1.3%
6	Transmission Extension	-	-	-	-	-	-
7	New Diesel Gen.	-	-	-	-	-	-
8	Distribution Line Rehabilitation	6.6%	6.6%	5.7%	7.5%	7.0%	6.2%
9	Meters Installation	34.9%	34.9%	31.1%	39.5%	36.1%	33.6%

(2) Financial Sensitivity

Table I-13.6-3 shows the sensitivity analysis of financial returns on investment by the type of project for the year 2005.

Table I.13.6-3 Financial Sensitivity Analysis, Year 2005

Type	Facility	FIRR			
		Base Case	Benefit -10%	Investment +10%	Fuel Price +10%
1	PV only (JICA Grant Diesel Gen.)	-7.3%	-8.4%	-7.9%	-7.3%
2	PV＆Wind Power (JICA Grant Diesel Gen.)	-3.9%	-4.9%	-4.6%	-3.9%
3	PV only＋New Diesel Gen.	-13.0%	-17.0%	-14.0%	-14.8%
4	PV＆Wind Power ＋New Diesel Gen.	-32.4%	-44.1%	-33.9%	-39.1%
5	Hydro Power Generation	-3.9%	-5.3%	-4.9%	-4.0%
6	Transmission Extension	0.8%	-0.6%	-0.2%	0.8%
7	New Diesel Gen.	-15.8%	-21.8%	-17.1%	-18.6%

13.6.2 Stage Based Sensitivity Analysis

(1) Economic Sensitivity

Table I.13.6-4 shows the sensitivity analysis of economic returns on investment without CO_2 reduction benefits by stage. The worsening of assumed parameters reduces the returns more or less one percent.

Table I.13.6-4 Economic (W/O CO_2 Reduction) Sensitivity Analysis By Stage

Year	EIRR			
	BASE Case	Benefit -10%	Investment +10%	Fuel Price +10%
2005	-4.0%	-6.4%	-5.0%	-4.8%
2010	-0.2%	-1.6%	-1.0%	-0.2%
2015	5.9%	4.5%	4.8%	5.9%

Table I.13.6-5 shows the sensitivity analysis of economic returns on investment with CO_2 reduction benefits by stage. Again the worsening of assumed parameters reduces the returns more or less one percent.

Table I.13.6-5 Economic (W/ CO_2 Reduction) Sensitivity Analysis By Stage

Year	EIRR					
	BASE Case	Benefit -10%	Investment +10%	Fuel Price +10%	CO_2 benefit +50%	CO_2 benefit -50%
2005	-3.3%	-5.6%	-4.3%	-4.0%	-3.0%	-3.7%
2010	1.0%	-0.2%	0.1%	1.0%	1.6%	0.4%
2015	6.5%	5.2%	5.4%	6.5%	6.9%	6.2%

(2) Financial Sensitivity

Table I.13.6-6 shows the sensitivity analysis of financial returns on investment by stage. Loss of benefits by 10% affects the returns most sensitively, reducing returns by almost 2%. Other worsening factors again reduce the returns more or less one percent.

Table I.13.6-6 Financial Sensitivity Analysis By Stage

Year	Base Case	FIRR		
		Benefit -10%	Investment +10%	Fuel Price +10%
2005	-11.3%	-14.5%	-12.2%	-12.6%
2010	-2.9%	-4.2%	-3.6%	-2.9%
2015	2.9%	1.9%	2.0%	2.9%

CHAPTER 14
EVALUATION BY TYPE OF FINANCING

CHAPTER 14 EVALUATION BY TYPE OF FINANCING

14.1 General

The return on investment derived for financial analysis is synonymous to the financial sourcing assumption of 100% equity without any borrowing. Modifications in financing structure will bring different returns on equities and impacts on cash flows. Here three cases of BOT, an environmental soft loan and ordinary soft loan are examined. The detailed of the cash flow analyses are included in the Appendix.

14.2 BOT

It is difficult to believe that any single enterprise would undertake a business of providing isolated power supply systems in the vast rural land of Mongolia where users are located far. Another possibility of every Sum taking it to their own hands has a very limited possibility due to a large financial requirement at the start. For the sake of exercise, the results are shown under the assumption that a single ownership takes over the project. The current power tariff in the Sum center ranges around 100 Tg / kWh. It is deemed very difficult to assume that the same price is achievable as assumed for the pure analysis by a private firm with all the Sum centers after political negotiations[1]. With an assumption that a BOT will attain the price level 80% of 240 Tg/kWh, i.e., 184 Tg/kWh, and the transfer takes place at the end of a 21-year period. Table I.14.2-1 shows the results of the evaluation, indicating all negative returns on investment.

Table I.14.2-1 Financial Analysis of BOT

Year	FIRR
2005	-18.6%
2010	-5.5%
2015	0.6%

[1] It needs to be reminded that the prevailing power tariff in the major cities and Aimags is 40 Tg/kWh.

14.3 Soft Loan for Environmental Project

The Japanese government offers a special purpose loan tied to global environmental improvements to the developing countries. With this scheme in mind the following assumptions are adopted for a soft loan based evaluation. The interest rate is set at 0.75% with the grace period of 10 years and repayment period of 30 years. Self-financing covers 1/3 of the initial investment and the remaining 2/3 is financed by the assumed soft loan scheme. In general, the longevity of renewable energy systems and the long payment period of the soft loan correspond well with each other. Still the return on investment for the year 2005 turns out to be –21.4%. However the return turned positive for the year 2010 at 3.1% and for the year 2015 at 15.9% as shown in Table I.14.3-1.

Table I.14.3-1 Financial Analysis of Environmental Special Loan

Year	FIRR
2005	-21.4%
2010	3.1%
2015	15.9%

14.4 General Soft Loan

The loan conditions for a general soft loan (such as offered by Asian Development Bank) are the interest of 1%, 10 year of grace period, and 30 year of repayment period. Similar to the case of the environmental special loan, the self-financing is assumed to be one third of the total required investment with the rest of two third relying on a soft loan borrowing. The FIRR is –22.9% for the year 2005 program, 2.5% for the year 2010 and 15.7% for the year 2015, showing a slightly lower performance than the environmental soft loan case.

Table I.14.4-1 Financial Analysis of Ordinary Soft Loan

Year	FIRR
2005	-22.9%
2010	2.5%
2015	15.7%

CHAPTER 15
CONCLUSION AND RECOMMENDATION

Chapter 15 CONCLUSION AND RECOMMENDATION

15.1 Introduction

The Study for the formulation of master plan of the rural power supply by renewable energy in Mongolia was conducted for 2 years between October 1998 and September 2000 by the Japanese study team consisting of 6 experts. For the realization of the project for rural power supply by renewable energy, the optimum power supply plan was recommended in conjunction with the Japan's grant aid projects of diesel power supply and in coordination with the other foreign assistance projects. This chapter summarizes the conclusion and recommendation of the Study. Furthermore, some additional study items and important problems for the Government to solve are included in this chapter necessary for the project implementation.

15.2 Conclusion and Recommendations

(1) Social Needs and Impacts

Currently, in most Sum centers, electricity is supplied only during the winter night time, so during the summer night time, medical treatment and delivery service in Sum hospitals are often conducted under the candle light. In addition, many Sum schools cannot use linguistic audio-visual facilities, machines in technical department, and computers because there is no electricity. So the quality of education is seriously hampered. If public facilities such as hospitals and schools are provided with stable supply of electricity by 2005, the quality of medical care and education, which Sum people need desperately, will be improved significantly, and it will help to minimize the negative impacts of transition from socialism to a market economy as well as of natural disasters such as excessive snow fall on the poor and disadvantaged people in Sum. In this way, electricity supply can play a critical role in enhancing basic human needs and improving social welfare for the poor population at Sum level.

(2) Renewable Energy Potentials and Development Plan

- Solar and Wind Energy Potentials and Development Plan

Renewable energy, PV and Wind energies have high potential in the east and southeast parts of Mongolia. The renewable energy potential for the power development is estimated 300 GWh/year. Most of the regions with high renewable energy potential have not been developed yet but under the development study is proceeding as same as this master plan. Should the realization of these plans be made, it is possible to generate electricity 1.195 GWh / year at

2005, 9.8 GWh / year at 2010 and 34.7 GWh / year at 2015 under this plan. In addition, the amount of fossil fuel consumption for power generation will be reduced by this plan. Moreover, the amount of exhausted gas from diesel generator such as CO_2 or NO_2 will be keep of a low level and it will be an effective means against the greenhouse effect.

■ Hydro Energy Potential and Development Plan

Hydro energy is one of the natural clean energies and there are rich hydro power potentials in the north and northwestern region in Mongolia. Available power output is assumed as 1,793 MW in total. The hydropower potential sites are located at the opposite sites of the solar and wind potential sites. Most of the hydropower potentials have not been developed yet, but the survey is in progress. The development study of the hydropower plant was completed on the 5-hydropower plants and the following 2 hydropower plants met the requirements of the rural power supply. Therefore, these hydropower plants were planned to be included in the Master Plan.

(a) Monkhairkhan mini-hydro: 2 sets x 75 kW (0.6 MWh/year)
(b) Baruunturuun mini-hydro: 2 sets x 100 kW (0.6 MWh/year)

(3) Power Demand Estimate

Since there was no record of the current power demands at Sum centers, the study started with the estimates of the current demand estimate with a view to a change of tariff system from the current practice of fixed charge to a meter-rated tariff collection. The future projection of the power demands was based on the changes in the population of the Sum centers and improvements of living standards. There is a possibility that rural industries may grow together with the development of infrastructures and improvements of living standards. However, it is not possible to foresee any particular potential industries at this moment. Therefore, the growth of industries is not taken into account in the present power demand projection. Such development potentials should be reviewed at the implementation of the year 2005 program.

(4) Optimum Power Supply Plan

Installation of renewable energy power supply systems to public facilities is planned by 2005 considering with the importance of Basic Human Needs. The planned capacity is 2 kW to 24 kW is the same as the pilot plant in this master plan, so the experience through the pilot test will be fed back to the plan. The experience of pilot plant management makes feasibility of the plan high. The renewable energy power supply system will be operates synchronized with a diesel generator in 2010. The system will be planned on the basis of wind resource and solar radiation data that will be monitored by a precious meteorological data monitoring system, installed by 2005 at each Sum center. Furthermore, the increase of operation and maintenance skill through the experience of the plant operation from 2005 will be made possible by the management of a larger size system. Fuel cell will be introduced by 2015. Technologies for fuel production by using 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.

(5) Power Distribution Plan

There are lots of problems on the existing power distribution systems in the Sum centers so that the systems should be improved. These are caused by the deterioration of the facilities, insufficient operation and maintenance, unstable power supply without balance of supply and demand, large power losses, etc. Modernization of the power distribution system was recommended as the optimum power distribution plan in the Master Plan is improving the system. The recommended plan was included the whole improvement plan of the existing power distribution system facilities. This plan contributes to the positive impacts of the stable power supply, application of appropriate power rate to consumers, reduction of power losses, etc.

(6) Management, Operation and Maintenance System

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 a Sum office 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 Sums including households, it is necessary for a Sum office to strengthen the management capacity which will be established by 2005. But a Sum office can cope with this challenge if the system is expanded gradually according to a Sum office's management capacity. The system in 2015 will include new technologies such as a hydrogen storage and a fuel cell, but a Sum office can master them with the technical and managerial capacity that has been accumulated by that time.

(7) Economic and Financial Analysis

It is not possible to maintain a standard quality of medical and educational services at the Sum centers without basic power supply. The economic analyses conducted are based on the cash affordability of the nomads living in the rural areas. Therefore, the economic benefits measured in monetary value is somewhat limited. The nature of medical services also works negatively to the evaluation as well. The needs for medical services are often unpredictable to the users. When medical emergencies arise at a Sum center, it is often the case that the hospital cannot provide adequate medical treatment due to lack of power supply. The expected probability and the associated cost is small to each person in *Ex Ante*. However, *Ex Post*, people are usually willing to pay a much larger sum for proper treatment in most cases. In other words, the measurement of the willingness-to-pay in the form of insurance in preparation of emergency poses a difficult problem in detecting a true willingness. It is a common sense that a public body needs to serve a wide reaching insurance mechanism to meet emergency medical needs. With these above issues in mind, the economic analyses conducted are more biased toward conservative results.

Another issue that requires a policy deliberation is the gap in power tariffs between urban and rural areas. Currently, the rural people are paying close to five times higher price for electricity than the urban residents pay in Mongolia. The rural areas of Mongolia is the backbone of the country which serves the supply of vital foodstuffs and also serves as a shelter in the time of economic crises. In consideration of these interlinkages that the rural areas have, it is quite reasonable to provide a certain level of assistance to these hard stricken areas.

The direct implication of the economic and financial analyses is that it is not possible to operate power supply operations financially under a pure market regime. It is clear that the returns on investment for the year 2005 program are negative. However, if power supply to the rural areas is to continue, there is no clear alternative method. The diesel engine powered power generation system that was compared as the alternative method is not economically superior to the proposed systems. Lack of financial viability is forcing the current practice of severe power rationings. The proposed systems are financially more viable with the assumption of a 24-hour power supply.

There is a societal question of how to divide the limited resources available between urban and rural areas to maintain the Basic Human Needs services, and also a question of how far economic efficiency needs to be pursued in basic social services.

There is an important caveat in the implementation of the project. There is a large cost that is not described in economic analyses, i.e. administrative costs. If the central authority is to control the whole stand-alone system centrally, the operation will incur a formidable administrative cost. The same should apply to the operation under BOT. It is beyond a mere side cost to establish the contractual agreements with 167 Sum centers alone. A few years ago, attempts to privatize the power supply operation at Sum centers all failed without exception within 1-2 years showing that privation is no panacea for economic viability. However, the alternate stringent central control is not a possibility. It is necessary to establish responsible management in each Sum center to effectively and efficiently manage power supply operation.

(8) Evaluation of Investment Program

- Investment Prospect

It is not possible to recover a large sum of investment in a short span of time spread over the vast rural area of Mongolia. Currently the livelihood of the rural households are hard-pressed by the economic crises and natural disasters with no particular prospect for industrial development. In other words, the investment climate on a financial basis is not very promising

- Investment Evaluation

Even the application of a specialized loan for environmentally positive projects generates the FIRR of –22% for the year 2005 program. However the returns on investment turn positive thereafter with 2.3% for the year 2010 and +15.9%.

(9) Project Benefits and Recommendation

- Project Benefits

Execution of the project recommended above would have many important benefits to 167 Sum centers (direct beneficiaries in 2005 are 180 thousand people, 200 thousand people in 2010, 220 thousand people in 2015 and indirect beneficiaries including such users as hospital and schools, etc.) and as stated below.

- Stable power supply is available (24 hour services).
- Economic power supply system without use of fossil fuel oil is secured.
- Reduction of fuel oil and CO_2 emission would be contributed as given below.

	2005	2010	2015
Reduction of fuel oil	1,815 kl/year	4,965 kl/year	6,850 kl/year
Reduction of CO_2 emission	1,336ton-CO_2/year	3,650ton-CO_2/year	5,042ton-CO_2/year

- 24-hour power supply is available for public facilities.
- Power distribution loss would be reduced (from about 30% to within 5%).
- Smooth and effective power operation would be expectable (reduction of personnel expenses).

These benefits are contributed to the people in the Sum centers indirectly on the following points.

- Adequacy of BHN

- People's stable life and enhancement of living level
- Improvement of various public services such as medical care, welfare, education, etc.

In addition to the above, the recommended plans should indirectly contribute to the protection of global environmental issues and regional development by the rehabilitation of infrastructures.

■ Recommendation

As mentioned above, the recommended plans met the Mongolian requirements in combination with the Japan' grant aid projects and other donors.

Consequently, Stage 1 project (targeted year 2005) is the most important and urgent project for adequacy of BHN considering the current situation that power supply by diesel generators is sometimes obliged to stop because of steep rises in fuel oil price. It is concluded that the Stage 1 project would be appropriate urgently by the cooperation in the form of grant aid on humane grounds.

(10) Additional Survey Items

The following surveys are required for the execution of the projects additionally.

- Establishment of management, operation and maintenance organization
- Establishment of power tariff system and collection system
- Review of power demand forecast (for each Sum center)
- Transportation plan of equipment and materials
- Study on installation of equipment and construction work (including land acquisition)
- Review of economic and financial assessment in detail
- Review of implementation program in detail
- Detailed design and preparation of tender documents

(11) 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 can have positive impacts on the global environment.

- Reformation of Energy Law and Provisions (preferential tax system, subsidy, discounted rate, etc.)
- Change of consumers' consciousness (saving energy/saving resources, promotion of DSM, etc.)

- Development promotion based on long term plan (control against foreign currency due to import of fossil fuel oil, security of energy, positive impact against global greenhouse effect, etc.)
- 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.