CHAPTER 4
ADAATSAG SUM, DUNDGOVI AIMAG

CHAPTER 4 ADAATSAG SUM, DUNDGOVI AIMAG

4.1 Pilot Plant Site and Surrounding Condition

Adaatsag Sum of Dundovi Aimag is located on the semi desert area of Mongolia, north 46°26' east 105°44' and 200 km away from Ulaanbaatar. The population of Adaatsag Sum is 3,062. A pilot plant has been installed beside a hospital and supplies generated electricity to the hospital. The position of the pilot plant equipment was planned to be in the protected area of a lightning rod. In addition, the position of the wind turbine was considered to avoid turbulence caused by obstacles such as buildings or trees in upwind. The position of the PV array was selected to be out of the shadow area of the wind turbine and other buildings. Photo II.4.1-1 shows the pilot plant in Adaatsag Sum and Figure II.4.1-1 shows the plot plan of pilot plant equipment.

Photo II.4.1-1 Pilot Plant in Adaatsag Sum

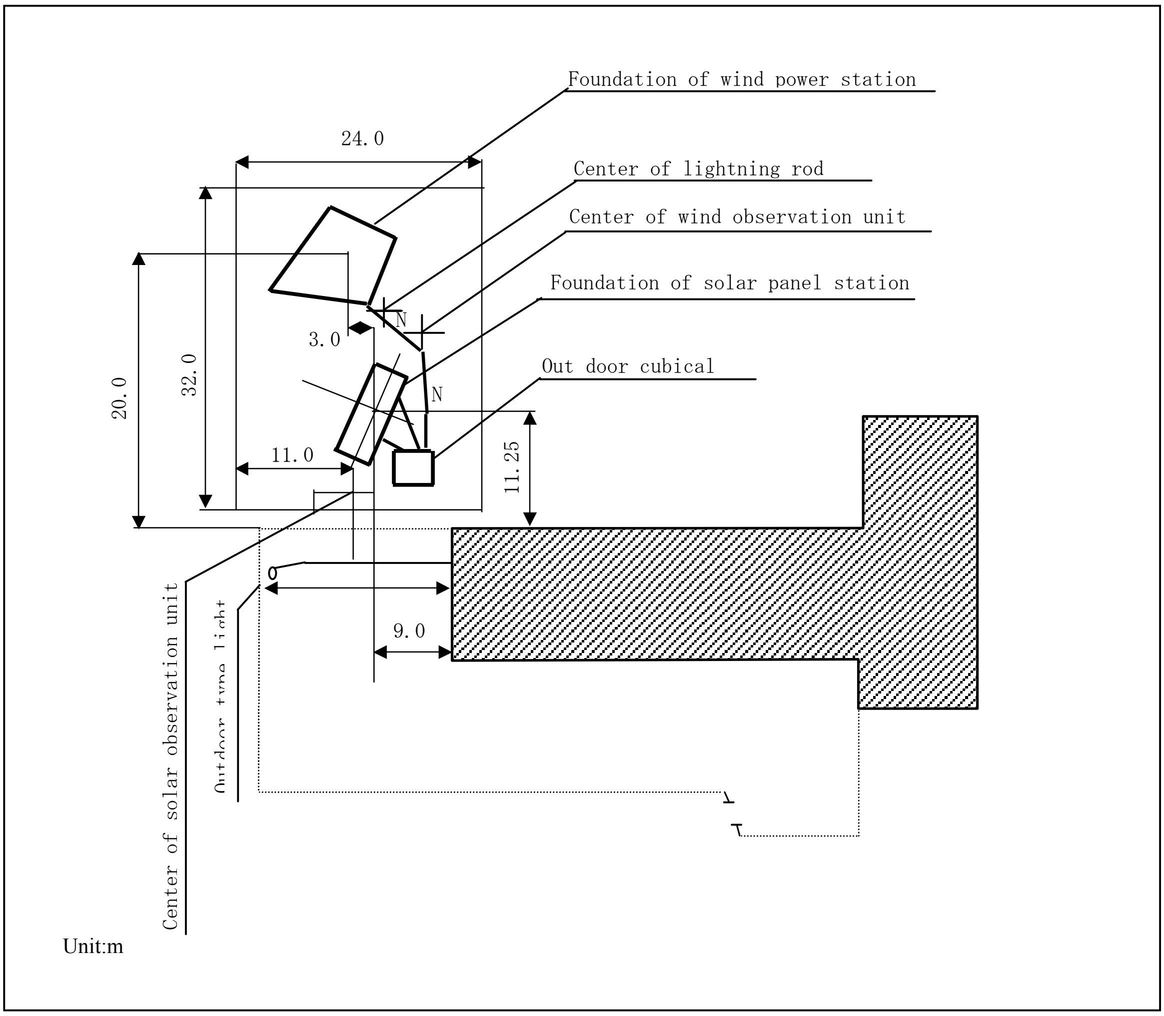

Figure II.4.1-1 Plot Plan of Pilot Plant (Adaatsag)

4.2 Calculation of Generation Capacity and Power Output

4.2.1 PV Power Generation

In Adaatsag Sum, power output by using PV system (installation angle is 65 degrees and 100 % output) was estimated on the basis of solar irradiation data at Mandalgovi where the capital of Dundgovi Aimag is located, because the data are not available at Adaatsag Sum center. The solar irradiation data at the pilot plant has been collected since June 1999. Both solar irradiation data, from the Meteorological Department and pilot plant, are compared to clarify the difference. Table Ⅱ.4.2-1 shows estimated power output and actual output of the PV system on the basis of solar irradiation data that was collected by the Meteorological Department and pilot plant.

Table II.4.2-1 Power Generation by PV System Against Standard Generation and Comparison of Measured Average Global Solar Irradiation Level

Item	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Standard average global solar irradiation*** （kWh／m²･day）	6.3	5.6	5.1	4.9	3.9	2.4	1.5	2.0	2.8	4.5	5.4	5.6
Estimated average generating power （kWh／day） （Calculation based on standard average global solar irradiation）	16.2	15.2	15.9	19.6	21.7	19.6	13.5	15.9	19.0	20.3	17.9	15.2
Actual measured average global solar irradiation**** （kWh／m²･day）	7.2	6.5	5.5	4.4	3.7	2.3	1.8	1.6*	3.7**	4.6	5.7	6.6
Actual measured average generated power （kWh／day）	9.7	13.0	12.8	13.4	12.1	13.5	12.8	8.5*	16.1**	15.0	14.2	12.6
Estimated average generating power[1] （kWh／day） （Calculation based on measured average global solar irradiation）	17.9	16.9	17.2	17.9	20.9	17.5	15.5	13.1	24.7	22.3	19.2	17.9
Theoretically average generating power[2] （kWh／day） （Calculation based on measured average global solar irradiation）	15.2	14.3	14.6	15.2	17.8	14.9	13.2	11.1	20.9	18.9	16.3	15.2
Ratio of average global solar irradiation （Measured／Standard）	1.14	1.16	1.08	0.9	0.95	0.95	1.2	0.8	1.32	1.02	1.05	1.17

1Estimeted average generating power: Computed inclined solar irradiation based on global irradiation and multiplied by total array capacity。

2Theoretical average generated power: On the basis of measured global solar irradiation, average generation power is estimated considering deviation from Pmax point, dirtiness of surface of module, deterioration and so on

* Due to the data recording error, average value is for 5 days, May 1-5.

** Due to the data recording error, average value of collected data after restarting data logger, from February 5-29 2000.

*** A standard average global solar irradiation is the data of Mongolian Meteorological Agency from 1988 to 1997 years (10 years average).

****An actual average global solar irradiation is the data recorded at pilot plant site from July 1999 to June 2000.

From the above table, it could be understood that the difference in the ratio between standard and measured average global irradiation differs every month, where an actual measured value from

September to November is smaller than the standard average global irradiation value. This is because the data wasn't completely recorded due to the failure of a data-recording device for one and half months in the case of January and February. The actual measured value of the generated power shows a value closer to the theoretically computed generating power except for the months July and October of 1999, and January and February of 2000, with February recording the maximum value. Possible causes of difference in the standard and the measured average global solar irradiation data are a difference in the measurement years, a difference in the measurement point, the possible recording error of the observation staff, yearly differences of the weather conditions and so on. In the case of generated and estimated generating power, theoretically, even if a system has power generating ability, when the voltage of the storage battery reaches at the over-charging prevention point or when a storage battery becomes fully charged and load isn't used, it disconnects the PV array to protect the storage battery. Due to this possible reason, the amount of measured generated power is smaller than the amount of theoretically generated power.

4.2.2 Wind Power Generation

Power output from wind turbine is estimated on the basis of average wind speed by the Meteorological Department. The power output, which is estimated on the basis of wind data of Meteorological Department and pilot plant, is compared. Rayleigh distribution, a kind of probability density function, was used for power output estimation from wind turbine. Table II.4.2-2 shows the difference of actual and estimated power output on the basis of Meteorological Department data and pilot plant data.

Table II.4.2-2 Actual and Estimated Power Output on the Basis of Meteorological Department Data and Pilot Plant Data.

Adaatsag	1999 Jun	Jul	Aug	Sep	Oct	Nov	Dec	2000 Jan	Feb	Mar	Apr	May
Average wind speed (M/H department data) (m/s)[1]	7.4	6.2	5.1	5.2	5	5.2	5.3	4	4.9	6	7	7.3
Estimated power generation (M/H department data) (kWh/day)	15.8	11.9	8.0	8.4	7.7	8.4	8.7	4.4	7.3	11.2	14.6	15.5
Average wind speed (Pilot Plant data) (m/s)[2]	5.6	4.4	4.8	4.7	4.2	4.1	3.6	-	3.1	5	6.2	5.6
Estimated power generation (Pilot Plant data) (kWh/day)	9.8	5.6	7.0	6.6	5.0	4.7	3.2	1.9	7.7	11.9	9.8	1.0
Actual power output (kWh/day)	3.9	1.4	1.5	2.5	2.4	3.6	2.6	-	0.8	4.4	4.0	3.4
Pilot Plant／M/H data	0.8	0.7	0.9	0.9	0.8	0.8	0.7	-	0.6	0.8	0.9	0.8
*1 Average data of Mongol Meteorological Agency is from year 1988 to												
*2 Data of Pilot plant from June 1999 to May 2000.												

Table II.4.2-2 indicates that the monitor of wind speed in Adaatsag has a tendency to record the wind speed larger than the actual speed. The difference between actual power output and estimated power output is caused by the system of pilot plant. To protect storage batteries, the power is consumed by dump load when battery voltage reaches over charging prevention voltage or is fully charged with no load. Therefore, the actual power output becomes smaller than that of estimated output.

4.3 Load of the Pilot Plant Facility

In Adaatsag Sum, generated electricity from the pilot plant is being supplied to a hospital because Adaatsag Sum requested the hospital as a pilot test facility. The main load of the pilot facility is fluorescent lamps for operation and treatments at night. The other loads are DC input refrigerators, audiovisual equipment such as televisions and video decks. An electric kettle was supplied to the hospital due to the necessity of a water heating system for emergency cases despite the high power consumption. Those loads are selected to have balance with power output in winter when power output estimation is lowest throughout the year. Table II.4.3-1 shows expected power output by PV-Wind hybrid system. Table II.4.3-2 shows load capacity and estimated power consumption.

Table II.4.3-1 Expected Power Generation from PV - Wind Hybrid System.

	Expected power generation from Wind turbine (kWh/day)	Expected power generation from PV array (kWh/day)	Total power generation (kWh/day)	Inverter output(1) (kWh/day)
Adaatsag	0.79	14.49	15.28	10.97

(1) DC refrigerator power consumption (1.56kWh/day) and)Inverter loss 80 %

Table II.4.3-2 Load Capacity and Estimated Power Consumption

Load	Load Capacity		Daily utilization (Winter)		Consumption
	No.	W	Hours	Time period	Power (Wh)
Lighting					
Room	7	40	12	5:00～9:00	3,360
Room	1	20	12	17:00～23:00	240
Corridor	5	20	17	6:00～23:00	1,700
Toilet	1	25	5	--	125
Television	1	75	5	--	375
Video-deck	1	20	2	--	40
Electric kettle	1	2,000	2.2	--	4,400

Total 10,240（Wh）

（Source : JICA Study Team, Site survey）

4.4 Power Distribution Equipment and Electrical Wiring

4.4.1 Power Distribution Equipment

Power distribution equipment for the pilot plant was arranged in Mongolia. As an example, electrical lines that connected the PV array and wind turbine to the cubicle were settled underground. The cables are shown as follows.

- Wind turbine to Cubicle : $38mm^2$, 3 core cable, single line
- PV array to Cubicle : $22mm^2$, 3 core cable, double line

4.4.2 Electrical Wiring

Settled electrical new wires prevent accidents caused by existing old wires. Those wires were connected to only new provided electric equipment due to limited power output from the system.

Figure II.4.4-1 shows the internal electrical wiring of the pilot plant at Adaatsag Sum.

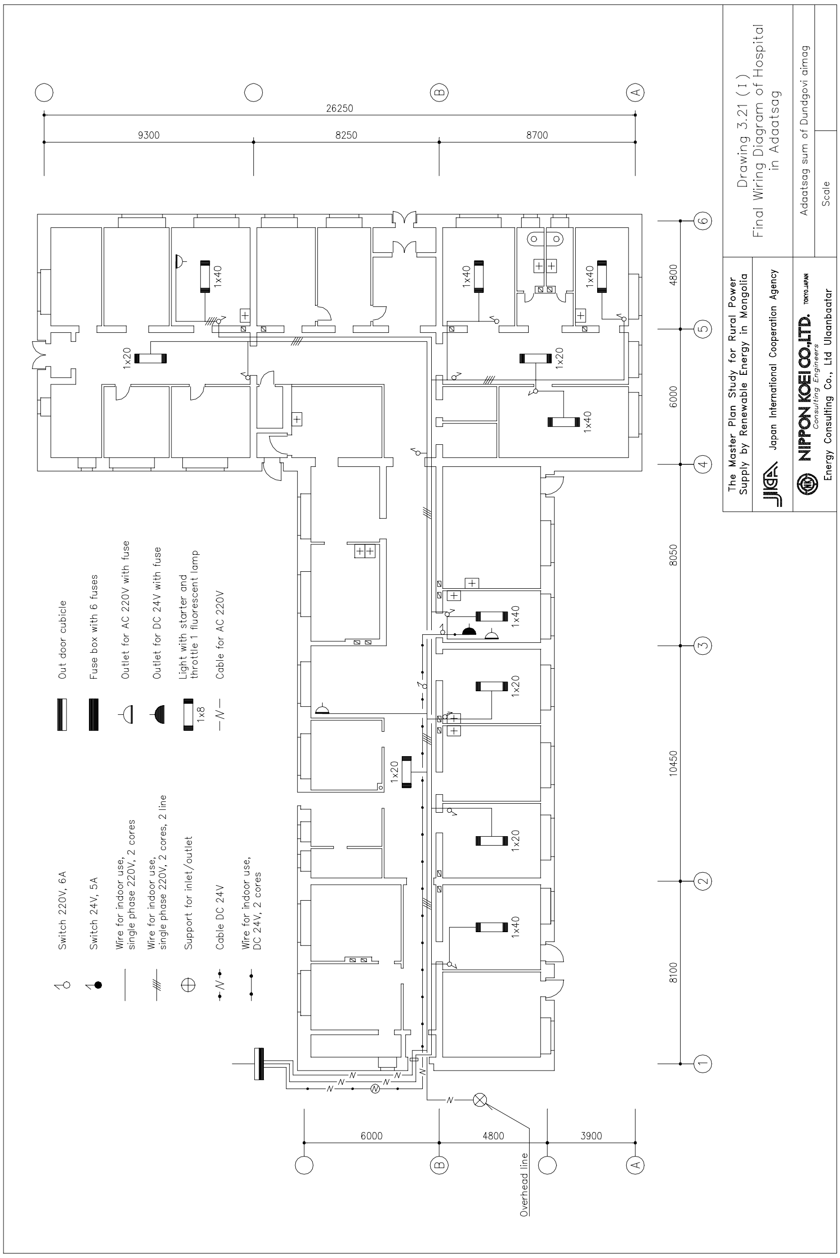

Figure II.4.4-1 Electrical Diagram of Adaatsag

CHAPTER 5
OPERATION AND MAINTENANCE CONTROL

CHAPTER 5 OPERATION AND MAINTENANCE CONTROL

5.1 Present Situation of Operational and Maintenance Organization for Power Stations in Sum Center

At pilot plants installed at three Sum Centers, seminars on technology transfer were held at the time of the completion of the plant. In the technology transfer seminars, the following were pointed out as the major problems in the operation and maintenance organization at the existing diesel power plants in Sum centers:

- Daily cleaning and checkup are not conducted sufficiently. Repair is considered after the machine gets out of order
- Only operators in the diesel power plant take the responsibility for maintenance and management. Supervision and advice are not given to the operators satisfactorily.
- Some Sums do not keep the record of operation, checkup and repair of their diesel power plants.
- Electricity users take little interest in maintaining and managing the power plant.
- There has been no external technical or managerial support for operation and maintenance of power plants in Sum centers.

5.2 Current Situation of Tariff Collection

The users of the pilot power plants are all public institutions. They are either hospitals only or together with a school dormitory. The payment for the power comes from the Sum office budgets. Two out three Sums were allocating the payment regularly. The Sum relies the majority of its finance on the revenue transfer from the central government. Therefore, it often faces a liquidity problem when the payment from the central government is delayed as often happens.

At Adaatsag, the power tariff was collected according to the tariff that the MOID instructed originally (100 Tg/kWh during winter.) The Sum pays 18,000 Tg to an operator every month. This wage payment exceeds the revenue most of the time. In response to criticism that the wage payment is too large for a light workload of less than two hours per day, the Sum officials replied that the payment is necessary to have one person committed to a special task. The official also stressed the responsibility of the proper maintenance of an important pilot power plant.

At Bayan-Undur at the time of the survey in February 2000, the tariff collection was not conducted according to the agreement. The reasons that the Sum officials cited are that there is a 2-3 month delay in the payment of the subsidy from the central government and national insurance which comprises the majority of the revenue of the hospital. Also, the budget for power supply is used up for the pump that the hospital is operating for heating. As the Sum realized the importance of the proper operation of the pilot plant, the officials promised a better tariff collection thereafter. The liquidity is a major financial problem for the Sum office and there seems to be some anxiety of pooling a fund.

At Tariat, the Sum office has set up a separate account at a bank for tariff collection. As of February 29, 2000, the account had the balance of 118,000 Tg.

5.3 Recommendations for Operational and Maintenance Organization in Pilot Plants

Based on the analysis of the current operational and maintenance organization, the following points were recommended for a new operational and maintenance organization in pilot plants. All Sums agreed the necessity of establishing a new operational and maintenance organization proposed in the technology transfer seminars and decided to follow JICA Study Team's recommendations. The new system for operation and maintenance of pilot plants is shown in Figure II.5.3-1.

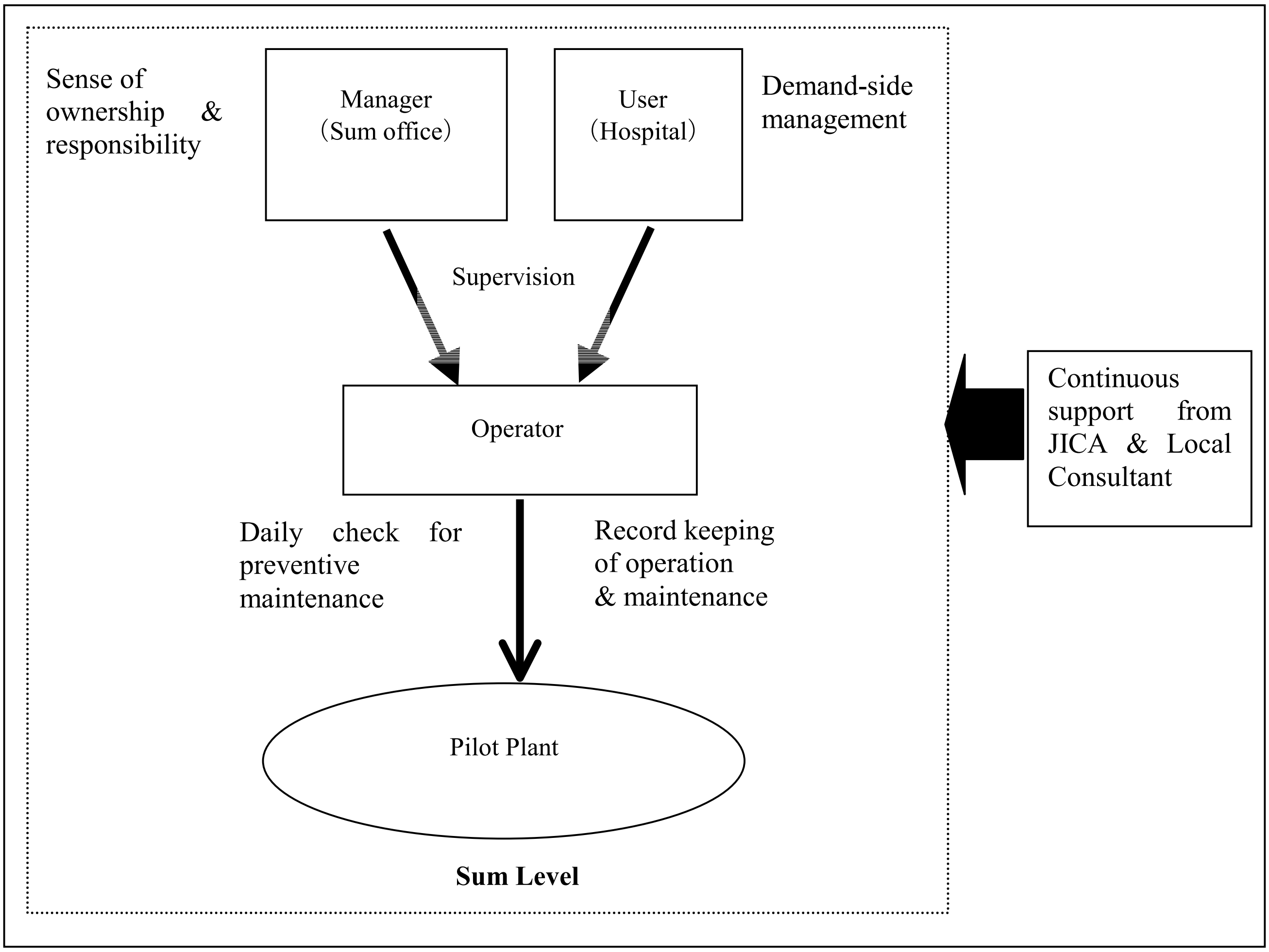

Figure II.5.3-1. New System for Operation and Maintenance of Pilot Plants

- The most important thing is that all the Sum residents recognize the importance of the pilot plant and develop awareness of keeping the plant by themselves. The Sum Office needs to appeal to the residents including the children for understanding the importance of the plant and their responsibility to keep the plant in good condition. Especially for children, the Office should teach them not to throw stones at the plant out of mischief.

- A Sum Office appoints a "person in charge" of daily maintenance and management jobs, who should be familiar with electricity and machinery. (Usually the “operator” will play this role.)

- A Sum should establish a new system that the officials at the Sum Office ("manager") can supervise and train the "person in charge" of maintenance and management on a regular basis, in cooperation with representatives of electricity users such as hospitals and schools. To describe the system in detail, the "person in charge" keeps the "work record" shown in Table II.5.3-1 and the "manager" checks the record every day. Once a month, the "person in charge", "manager", and "representative of electricity users" gather and hold a monthly meeting to discuss if they have any problems in maintenance and management.

After one year of operation, the following achievements have been observed in Pilot Plants:

- Increased sense of ownership by Sum office
- Better management of operators
- Regular preventive maintenance (through daily check)
- Keeping daily records of operation and maintenance
- Better demand-side management by users

But it is important to note that it takes one year for each Sum center to achieve these. During this one year, JICA Study Team visited the pilot plants every 3 months in order to monitor the operation and maintenance and provide training and seminars if necessary, and the local consultants also visited the pilot plants every month in order to collect various data and check the condition of the operation and maintenance. This experience clearly indicates the need for “continuous” technical and managerial support after installation of the renewable energy plants. Therefore it is very important for the Mongolian Government to set up a new organization to “continuously” monitor and support power supply in Sum Centers.

Table II.5.3-1 Format of Work Record (Year: , Month:)

Date	Day of week	Name of person in charge	Working hours	Daily inspection	Daily cleaning	Any problem happened? If yes, describe it.	Actions taken	Signature of supervisor
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
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31								

5.4 Recommendations for Tariff Collection

As pointed out in Section 5.2, the following recommendations are in order.

1) It is quite possible that the tariff payment is difficult when the Sum office has a cash flow problem. In such case, the delay in payment should be recorded as a liability for the pilot plant and should be cleared when the fund is available.

2) The payment to the pilot plant should be included in the budgeting process as a cost item every year.

3) The Sum office should consider a kind of service fee collection from the beneficiaries of the medical or education services.

4) The Sum office should work on cost saving for the maintenance of the pilot plant such as having the operator work other jobs.

5.5 Proposal vis-à-vis Technical Maintenance and Control of Pilot Plant

A problem occurred in Adaatsag and Bayan-Undur in August in relation to the control of charge/discharge of storage battery. The amount of electricity used during the period of poor wind and low solar irradiation was not regulated, and as a result, the voltage of the storage batteries dropped to the excess discharge prevention voltage. Therefore, the entire system automatically shut down temporarily in order to protect the storage battery. The cause of this problem was the failure to regulate the amount of electricity used in accordance with weather conditions. Unlike the diesel generation that is used in the Sums in Mongolia, natural weather conditions must be taken into account in the use of the renewable energy , responding to seasonal and temporal changes. Therefore, it is necessary to shift the traditional method of using electricity depending on the amount of fuel accumulated and the ability to purchase it. The following proposals are recommended for the technical maintenance and control of the pilot plant:

① The amount of electricity used must be controlled in order to ensure the maintenance of constant supply to cope with hospital emergencies. Wasteful consumption of electricity during the daytime must therefore be avoided by considering the adverse effects of weather changes on the natural conditions required for the generation of electricity by wind power and sunlight.

② On days when wind and sunlight conditions are unsuitable for the generation of power, use generated power during nighttime. It is therefore necessary to limit the load used in the daytime so that the storage battery becomes fully charged. For this it is important to check the voltage of the storage battery on the control panel meter which indicates the stage of charge. If wind and sunlight conditions unsuitable for power generation continue for several consecutive days, further curtail daytime use of load, while at the same time shutting down the inverter for the time it is not utilizing a load. In the nighttime, impose time restrictions on load utilization. If the adverse conditions continue for an even longer period, suspend daytime electricity usage completely except in the case of emergencies, and shut down the inverter and also in the nighttime, supplement time restrictions with load restrictions. It is important to ensure that every day, without fail, the voltage record chart for the storage battery is completed, and to have the voltage and power consumption checked.

③ If the storage battery is fully charged in the daytime and the PV cuts out automatically, utilize electricity to the full capacity in order to consume as much of the surplus as possible. If both PV groups automatically cut out, aim to use a total load less than 1kW. If one group cuts out, aim to use 500W or less. Washing machines, irons, electric kettles, and so forth are considered potential uses to consume surplus power.

CHAPTER 6
ANALYSIS AND EVALUATION OF PILOT PLANT TEST RESULTS

CHAPTER 6 ANALYSIS AND EVALUATION OF PILOT PLANT TEST RESULTS

6.1 Analysis of Management of the Implementation Body

Table II.6.1-1 summarizes the electricity tariff collection systems of the three Sum centers where pilot plants are located. Every Sum uses the fixed tariff system. Tariat has three layers of tariff collection according to the income level. The highest fixed tariff charged is by Bayang-Undur with 6000 Tg/month, which belongs to a high tariff category among the Sums under the Study.

Table II.6.1-1 Pilot Plant Sum Electricity Tariff System

		Adaatsag	Bayan-Undur	Tariat
Consumer	Household	116	75	160
	Public Facility	6	5	8
	Private entity	1	1	1
Output (kW)		60	60	90
Collection system		Fixed	Fixed	Fixed (3 levels)
Tariff charge (household)		4600 Tg/month	6000 Tg/month	3500 Tg/month 4500 Tg/month 4700 Tg/month

Table II.6.1-2 shows the financial summary of each Sum power supply operation. Roughly the revenues from the household users consists of 70% of the total revenue and the fuel payment constitutes a little less than 90% in the total expenditure, indicating a similar management system.

Table II.6.1-2 Financial Summary of Pilot Plant Sum Power Supply Operation

	Adaatsag	Bayan-Undur	Tariat
Household share in revenue	70%	69%	65%
Fuel share in expenditure	87%	90%	88%

6.2 Technical Analysis of Maintenance Conditions

At the Transfer of Technology Seminar held during the 4th field survey, checks were carried out on the state of the installations and the situation with regard to their operation. In addition, reports on the operation and maintenance control of the installations were received from the operators and supervisors in charge of the pilot plants. On the basis of this information, together with the data being gathered from the pilot plants, an analysis was carried out on the technical aspects of operation and maintenance of pilot plants and on the management of the pilot plant facilities.

(1) Technical Maintenance of Pilot Plants

It was confirmed that a good cleaning has been conducted in all 3 pilot plants. Inspection of photovoltaic and wind power generation systems was carried out under favorable conditions, and it was confirmed that the systems were being operated correctly under adequate supervision, despite the fact that these were the first systems.

In the pilot plants of Adaatsag and Bayan-Undur, a problem occurred in August relating to the control of storage battery charge and discharge. The amount of power used during the period of poor wind and solar irradiation was not regulated, and as a result, the voltage of the storage batteries dropped to the excess discharge prevention voltage. Therefore, the entire system automatically shut down temporarily in order to protect the storage battery. This indicates a failure to regulate the load in accordance with weather conditions. The importance of regulating the load and the usage time band was explained at the Technology Transfer Seminar. The Tariat's pilot plant is being operated satisfactorily. In Tariat, power consumption reaches its peak between evening and nighttime, so independent controls are being effected to minimize daytime consumption levels.

(2) Technical Maintenance of Pilot Plant Facilities

The pilot test facilities in Adaatsag are being maintained favorably in respect to technical matters. Apart from one defective lighting apparatus in the hospital, everything was in good condition. In the future, repairs will have to be carried out on broken equipment using collected electricity charges.

The pilot plant facilities in Tariat are being maintained favorably in respect to technical matters. It was reported that the outdoor lights were replaced at the expense of the hospital. A proactive approach to maintenance of the facilities is being taken at the hospital, with a detailed record being made of the daily load usage.

The pilot plant facilities in Bayan-Undur are being managed favorably in respect to technical matters. The student dormitory does not have its own watt-hour meter, but has indicated a desire to control its consumption of electricity by installing a private watt-hour meter at its own expense in the future.

6.3 Analysis of Energy Saving

The situation of power supply of the Pilot Plant is shown on the data recorded by the data logger. It may be a little difficult to judge only from the recorded data if the consumers, hospital staff and school, have the intention of saving energy. However, the consumers seem to have the mind of saving energy and act based on the mind. This is judged from the record of a power supply trip due to over discharge of the batteries.

The trip occurred at Adaatsag and Bayan-Undur in August 1999. It can be said that the main reason of the trip is that the people of the Sum centers were not so familiar with the Pilot Plant because the installation was completed in July. The data indicates the over charging of the battery after the trip in August and September. This record proves that the people acted with the mind of energy saving after learning the necessity of saving energy from the trip. Hours of sunlight become shorter in November, which means smaller generation. The people seem to control the consumption to save the energy realizing the smaller generation.

Based on such judgement from the limited data, it can be said that the users of the pilot plant gradually understand the nature of renewable energy, raise their mind of energy saving and act toward energy saving.

6.4 Analysis of Demand Side Management

DSM such as energy consumption at the same time as generation by the renewable energy is surely executed. The users of the pilot plant seem to understand well the necessity of DSM because the matter was explained repeatedly at the technology transfer seminars.

It is found that the peak load often appears in the daytime according to the data record of the Pilot Plant. As the peak load of Sum centers usually appears in the nighttime, the daytime peak is considered to be controlled intentionally.

The maximum load of Pilot Plant is the electric pot of 1 kW. Then using the pot in the daytime means execution of the demand side management. This is the simple action but this mind and action make the Sum centers able to carry out DSM of a larger system in the future.

6.5 The Analysis of the Retrieved Observation Data

After the installation completion of the Pilot plant, the analytic result of the retrieved data until now is shown in the following. The results are from a data analysis in Adaatsag and Bayan-Undur in June and from a data analysis in Tariat in July.

6.5.1 Photovoltaic (PV)

After the installation completion of the Pilot plant, the analytic result of the retrieved data until now is shown in the followings. In Adaatsag and Byan-Undur a data analysis results from June 1999 to May 2000, and data of Tariat from July 1999 to June 2000. The retrieved data of each pilot plant is arranged and attached at the 'Data Book' as a monthly chart II.2-1 of Adaatsag, Chart II.2-2 of Bayan-Undur and chart II.2-3 of Tariat.

The data collected in each Pilot plant were divided into two groups as summer (April to September) and winter (October to March), and again these six months of summer and winter is divided further consisting three months in each group, and the analysis is carried out. In the case of Adaatsag, data of January are removed, and in February it becomes the analysis of the data recorded from 15th (14 days) of February because a data record device stopped from the beginning of January 2000, until the middle of February.

(1) Ambient Temperature

(a) Average Ambient Temperature

The plotted graph of average ambient temperature by time series at each Sum is shown in II.4.1 on the Data book. From these figures in the case of Adaatsag, the average of summer months from July to September records the highest and the average of winter months from January to March records the lowest value. Even if it is summer, it exceeds 20 degrees only during 12 noon to 8 p.m., and 21.8 degrees at about 4 p.m. is recorded as a maximum temperature. It is understood that the average ambient temperatures of April to June goes down to 5 degrees around 6 a.m. It reaches below freezing point throughout the whole day, and about from 6 p.m. to 8 p.m. recording -12.4 degrees as a minimum temperature in winter. It can be seen through observing the whole day, whether it is summer or winter, the maximum temperature is recorded at around 4 p.m. and the minimum temperature is recorded in the morning. As for the difference in the minimum and maximum temperature of summer and winter, it is understood that the difference is more than 10 degrees.

In the case of Bayan-Undur as well, the average of summer months from July to September records the highest and average of winter months January to March records the lowest value. Even if it is summer, from 2 p.m. to 6 p.m. it exceeds 20 degrees, and 20.2 degrees at about 4 p.m. is recorded as a maximum temperature. It is understood that the average ambient temperature of April to June goes below 5 degrees around 6 a.m. It reaches below freezing point during the whole day, and at about 8 a.m., records -19.4 degrees as a minimum temperature in the winter season. It can be seen through observing the whole day, whether it is summer or winter the maximum temperature is recorded at around 4 p.m. and the minimum temperature is recorded in the morning. As for the difference in the minimum and maximum temperature of summer and winter seasons, it is understood that the difference is more than 10 degrees.

In the case of Tariat as well, like the other two pilot plants the average of summer months from July to September records the highest and the average of winter months January to March records the lowest value. Even if it is summer, from 2 p.m. to 8 p.m. temperatures exceed 15 degrees, and 15.7 degrees at about 4 p.m. to 5 p.m. is recorded as a maximum temperature. In winter, it reaches below freezing point through whole day, and at 8 a.m. recording –22.3 degrees as a minimum temperature in winter. It is understood that when observed through the whole day, either in summer or in winter, the morning hour records the minimum and around 4 p.m. records the maximum temperature. As for the difference in the minimum and maximum temperature of summer and winter, it is understood that the difference is more than 10 degrees.

(b) Average Temperature of Cubicle

The plotted graph of average temperature of cubicle by time series at each Sum is shown in II.4.1.2 on the Data book. From these figures in the case of Adaatsag, an average of the summer months from July to September records the highest and average of winter months while January to March records the lowest value, same as in the case of ambient temperature. The recorded data shows that an average temperature of cubicle 27.1 degrees is the maximum and 10.6 degrees is the minimum from April to June, and 28.6 degrees is the maximum and 15.8 degrees is the minimum for the months from July to September of the summer season. It is understood that in the case of April to June, the maximum is 10 degrees and minimum is around more than 5 degrees. And in the case of July to September, the maximum is 6 degrees and minimum is 3 degrees higher compared with respective period data of ambient temperature. On the other hand, in the case of October to December, the maximum is 9.0 degrees and minimum is –5.6 degrees, and from January to March, the maximum is 10.4 degrees and minimum is –7.7 degrees recorded as an average temperature of cubicle for the winter season. It is understood that, in the case of October to December, the maximum is more than 10 degrees and minimum is around 4 degrees, and in January to March, the maximum is more than 12 degrees and minimum is more than 4 degrees higher compared with the respective period data of ambient temperature. As for an average temperature of the cubicle in the winter season, it is understood that from 11 a.m. to 9 p.m., the temperature maintains above 0 degrees.

In the case of Bayan-Undur as well, an average of the summer months from July to September records the highest and the average of the winter months from January to March records the lowest value, the same as in the case of ambient temperature. The recorded data shows that an average temperature of cubicle 26.9 degrees is the maximum and 9.8 degrees is the minimum from April to June, and 27.6 degrees is the maximum and 13.8 degrees is the minimum from July to September of the summer season. It is understood that, in the case of April to June the maximum is more than 10 degrees and minimum is more than 5 degrees. And in the case of July to September the maximum is more than 7 degrees and minimum is more than 4 degrees higher compared with respective period data of ambient temperature. On the other hand, in the case of October to December the maximum is 10.4 degrees and minimum is more than –5.8 degrees, and in January to March the maximum is 6.6 degrees and minimum is –13.1 degrees recorded as an average temperature of the cubicle for the winter season. It is understood that, in the case of October to December the maximum is more than 10 degrees and minimum is around 5 degrees, and in January to March maximum is more than 13 degrees and the minimum is more than 6 degrees higher compared with respective period data of ambient temperature. As for an average temperature of cubicle in the winter season, it is understood that from 11 a.m. to 9 p.m. the temperature maintains above 0 degrees.

In the case of Tariat as well, an average of the summer months from July to September records the highest and the average of the winter months from January to March records the lowest value the same as in the case of ambient temperature. The recorded data shows that an average temperature of cubicle 22.0 degrees is the maximum and 6.3 degrees is the minimum from April to June, and 25.0 degrees is the maximum and 10.6 degrees is the minimum from July to September of the summer season. It is understood that, in the case of April to June the maximum is little more than 10 degrees and minimum is more than 5 degrees, and in July to September the maximum is more than 9 degrees and minimum is little less than 5 degrees higher compared with respective period data of ambient temperature. On the other hand within the winter season months, in the case of October to December the maximum is 0.5 degrees and minimum is more than –11.1 degrees, and in January to March the maximum is –2.7 degrees and the minimum is –17.4 degrees recorded as an average temperature of cubicle for the winter season. It is understood that, in the case of October to December the maximum is around 5 degrees and the minimum is more than 1 degree, and in January to March the maximum is more than 10 degrees and the minimum is little less than 5 degrees higher compared with respective period data of ambient temperature. As for an average temperature of cubicle in winter season, it is understood that except for the average of the months from October to December the temperature goes below 0 degree for 16 - 17 hours of the day.

(2) Atmospheric pressure

The plotted graph of average atmospheric pressure by time series at each Sum is shown in II. 4.2 on the Data Book. From these figures in the case of Adaatsag, April to June records 776 hPa as a maximum and 774 hPa as a minimum. And in the case of July to September it records 780 hPa as a maximum and 777 hPa as a minimum and it looks like it is getting little higher from daytime to evening but actually there is no big difference between the average value of summer season months. On the other hand, in the case of October to December the maximum is 781 hPa and the minimum is 780 hPa, in the case of January to March the maximum is 776 hPa and the minimum is 774 hPa recorded as an average atmospheric pressure for winter season. It is understood that the average atmospheric pressure value between the months from April to June and January to March is almost the same, and together with this it seems that it fluctuates throughout the whole day though the difference between minimum and maximum value is very small.

In the case of Bayan-Undur, April to June records 763 hPa as a maximum and 761 hPa as a minimum, and in the case of July to September it records 765 hPa as a maximum and 764 hPa as a minimum average value of summer season months. On the other hand, in the case of October to December the maximum is 766 hPa and minimum is 765 hPa, in the case of January to March the maximum is 763 hPa and minimum is 762 hPa recorded as an average atmospheric pressure for the winter season. The difference between the minimum and maximum value shows that it is small with each average in summer as well in the winter season, though it is the lowest in the morning and shows a tendency of becoming the highest in the daytime though there is no big difference.

In the case of Tariat, April to June records 721 hPa as a maximum and 720 hPa as a minimum, and in the case of July to September it records 723 hPa as a maximum and 722 hPa as a minimum average value of summer season months. On the other hand, in the case of October to December the maximum is 681 hPa and minimum is 765 hPa, in the case of January to March the maximum is 715 hPa and minimum is 713 hPa recorded as an average atmospheric pressure for the winter season. The difference between the minimum and maximum value shows that it is small with each average in summer as well with winter season, though average atmospheric pressure from October to December shows the tendency of being smaller than average value in other months. In the case of Tariat, the entire recorded value of atmospheric pressure compared with the other two pilot plants, shows a smaller value.

(3) Global Solar Irradiation

(a) Monthly average global solar irradiation

A monthly variation of amount of global solar irradiation level is shown in figure II.6.5-1. From this figure it is understood that the Tariat which is in the high land area has almost the same level of global solar irradiation with Adaatsag which is in the semi desert area during the months of July to September, April and May. And again it is understood that during the months of November, February and March it records almost the same value as Bayan-Under that is in the steppe area and a little lower than Adaatsag. It is lower than the other two Sums in June, October and December. In the case of Bayan-Undur, it has almost the same value with the other two Sums in the months of July, August and November, and a little lower in June, September, April and May compared with the other two Sums, and in October and December the value lies between Tariat and Bayan-Undur. It is understood that the amount of monthly average global solar irradiation level decreases gradually from June towards winter and during the months September to February which lowers the value more than 4.0 kWh/m^2 per day. The maximum and minimum value is from June and December at Adaatsag and Bayan-Undur, and July and December at Tariat, of which 7.160 Wh/m^2 per day in July of Adaatsag is the maximum and 1.415 Wh/m^2・day in December of Tariat is the minimum recorded value.

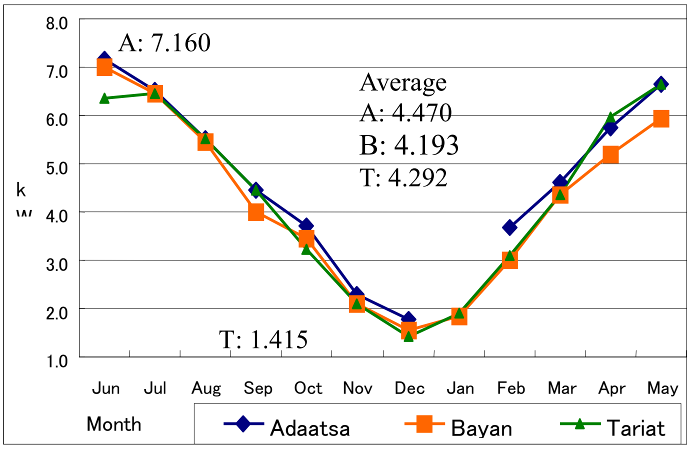

Figure II.6.5-1 Monthly Average Global Solar Irradiation

(b) The amount of average global irradiation by time series

The average global solar irradiation by time series of each Sum during the month of June 1999 to May 2000 is shown in Figure II.6.5-2 of Adaatsag, Figure II.6.5-3 of Bayan-Undur and Figure II.6.5-4 of Tariat. From these figures it is understood that in the case of Adaatsag, the amount of global solar irradiation decreases around 16% from July to September compared with the average value of April to June, 25% in January to March compared with July to September and 38% in October to December compared with January to March. The average amount of October to December in the winter season decreases greatly when compared with April to June in the summer season and 0.768kW/m^2 is the highest amount of global solar irradiation by time series from the average of April to June.

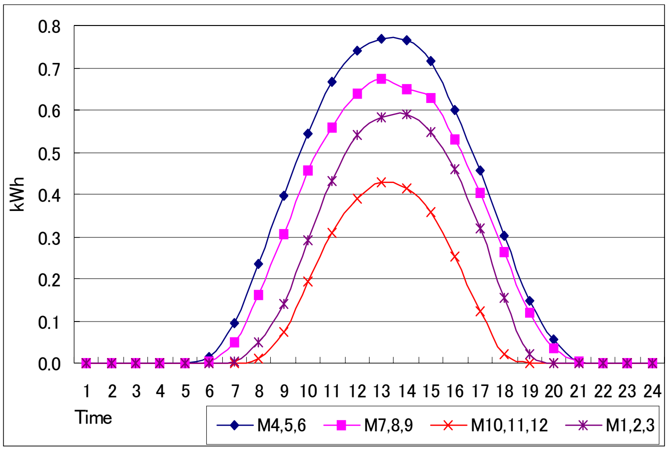

Figure II.6.5-2 Time wise Global Irradiation of Adaatsag

In the case of Bayan-Undur, it is understood that the amount of global solar irradiation decreases around 12% from July to September compared with the average value of April to June, 41% from January to March compared with July to September and 22% in October to December compared with January to March. The average amount of October to December in the winter season decreases greatly when compared with April to June in the summer season and 0.748kW/m^2 is the highest amount of global solar irradiation by time series from the average of April to June.

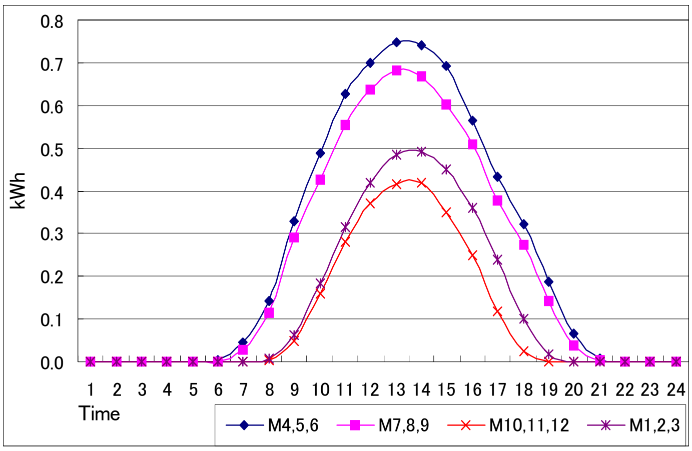

Figure II.6.5-3 Time wise Global Solar Irradiation of Bayan-Undur

In the case of Tariat the data of June is not considered, though it is the same as in the other two Sums in that the amount of global solar irradiation decreases around 15% from July to September compared with the average value of April and May, 42% in January to March compared with July to September and 28% in October to December compared with January to March. The average amount in the October to December of winter season decreases greatly when compared with April to June of summer season and 0.755kW/m^2 is the highest amount of global solar irradiation by time series from average of April to June.

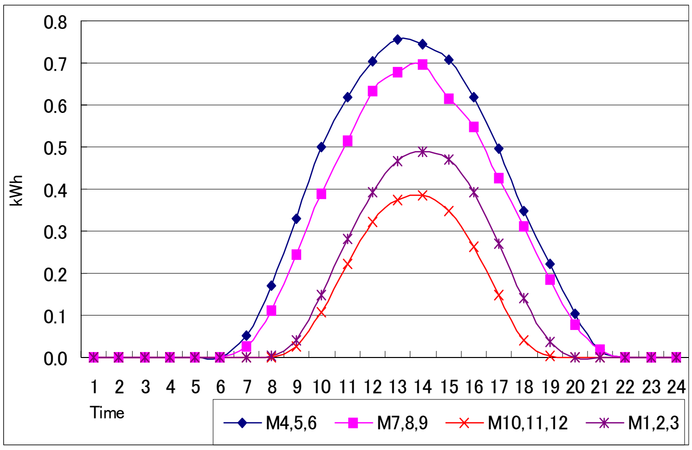

Figure II.6.5-4 Time wise Global Solar Irradiation of Tariat

(4) Monthly average Sunshine hour

The average monthly sunshine hour of each Sum is shown in Figure II.6.5-5. From this figure, it can be understood that the average sunshine hour of Tariat that is in the hilly area is less than the other two Sums except in February, April and September. In September, it is more than Bayan-Undur that is in the steppe area and less than Adaatsag that is in the semi desert area. As for February and April, it is understood that the value, which is about the same as Bayan-Under and Adaatsag, is shown. In the case of Adaatsag, the average sunshine hour is more than Bayan-Undur during the months of June to October, December, April and May. As for the way of changes, in the case of Tariat, it decreases gradually from July to December, and increases in January and again decreases in February, and after this it increases gradually. The other 2 Sums also show almost the same tendency as Tariat except for October. Through

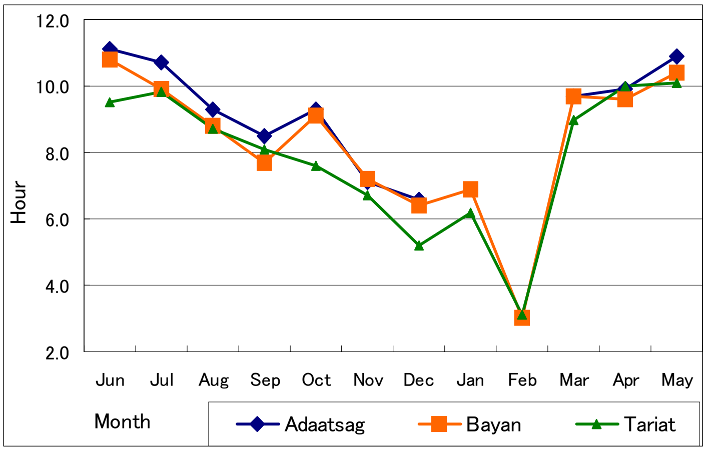

Figure II.6.5-5 Monthly average Sunshine hours

observation, 11.1 hours of Adaatsag in June is the maximum and 3.0 hours of Bayan-Undur in February is the minimum.

(5) Amount of generated power

(a) Monthly average power generated by photovoltaic

Monthly average of PV power generation is shown in Figure II.6.5-6. From this figure in the case of Adaatsag, the amount of power generation increases in July compared to June, decreases little in August comparing to July, and again increases in September. The amount of power generation increase and decrease tendency in every month from July until December is seen. The power generation decreases gradually from February to May. The amount of power generation increases higher than the other two Sums in July, December, February and March, thought it decreases and is lower than the other two Sums in June, October, April and May. It is understood that, in November and December, the amount of power generation is almost the same with Bayan-Undur and in November it is a little less compared with Tariat, though in December it increases and is higher than the other two Sums. By observing throughout the whole year, it is understood that there are fluctuations in the amount of power generation from PV.

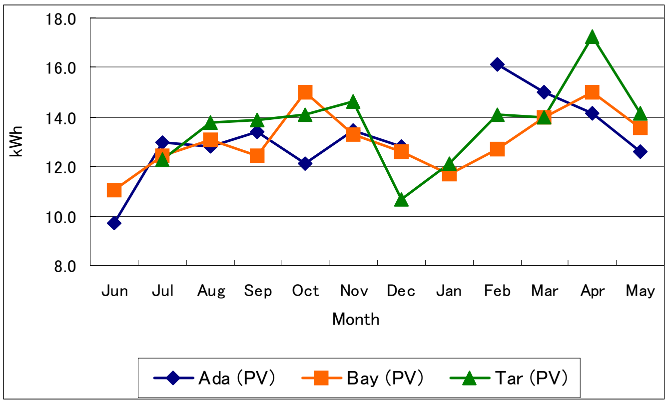

Figure II.6.5-6 Monthly average PV Power Generation

In the case of Bayan-Undur, it is understood that amount of power generation increases gradually from June to August and decreases once in September and again increases in October, and after that it decreases until January. Moreover, the amount of power generation increases gradually from February until April, and decreases again in May. It is understood that the amount of power generation is higher than the other two Sums in October, and lower in September and February. Though it is lower than the other two Sums, almost the same value with Adaatsag is shown in November and January as well. By observing throughout the whole year, as in Adaatsag there are fluctuations in the amount of power generation from PV.

In the case of Tariat, it is understood that the amount of power generation is almost equal in June and July, and increases gradually to November and decreases greatly in December compared to November. It is understood that the amount of power generation increases from December to February, and March is about the same as February, it increases once in April and decreases again in May. It is almost equal in July, January, March and May with that of Bayan-Undur and the amount of power generation is more than the other two Sums in June, August, September, November and April. It is understood that compared with the other two Sums there are small fluctuations, though for December the amount of power generation decreases greatly.

(b) Monthly average power generation by Wind generator

Monthly average wind power generation of each Sum is shown in Figure II.6.5-7. From this figure in the case of Adaatsag, it is understood that the amount of power generation decreases in July compared to June and increases from July to November. The amount of power generation decreases in December and February, and decreases until May. In March, though, it increases once. In November and March the amount of power generation is higher than the other two Sums and except for those months, it lies between the other two Sums. It is understood that there are fluctuations in the amount of power generation in the same way as PV power generation in Adaatsag.

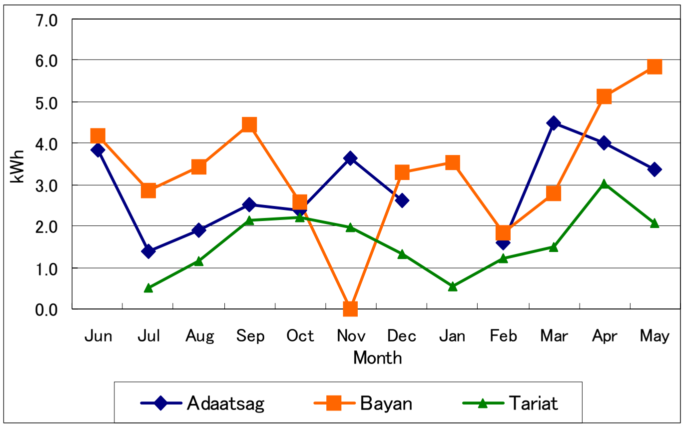

Figure II.6.5-7 Monthly average Wind Power Generation

In the case of Bayan-Undur as well, the amount of power generation decreases in July in comparison with June, comparison, and it increases from July until September. It is alsounderstood that it decreases greatly again until November. After that the amounts of power generation increases until November, and it is understood that the amount of power generation increases from March until May, In February, though, it decreases once. It is understood that it generates power more abundantly than the other two Sums except for in November and March in the case of Bayan-Undur. In November, there is no wind power generation because the wind generator isn't being used. It is understood that there are fluctuations in the amount of power generation, the same way as in Adaatsag in the case of Bayan-Undur as well.

In the case of Tariat the amount of power generation decreases in July compared to June, and after that it increases gradually until October, and it is understood that it decreases gradually from October until January. It is understood that it decreases again in May though the amount of power generation increases from January until March. There is no big fluctuation in power generation, though observing throughout the whole year, the amount of power generation is small in Tariat compared with the other two Sums.

(c) Monthly total average power generation from PV and Wind Hybrid System

The monthly total average power generations from PV and wind hybrid system at each Sum is shown in Figure II.6.5-8. From this figure in the case of Adaatsag, it is understood that even if the amount of total generated power increases gradually from June to September it is lower than the other two Sums in August and September.

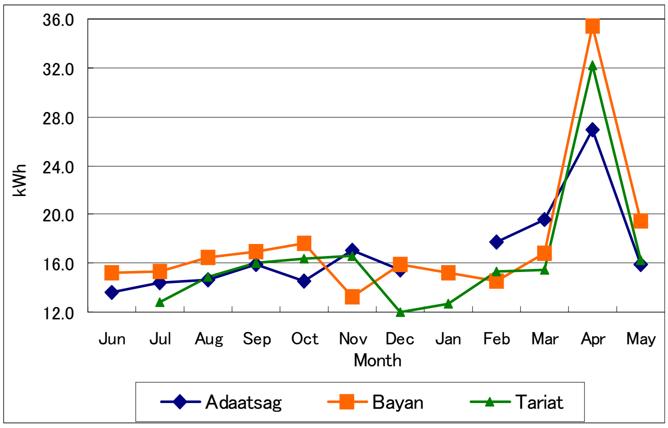

Figure II.6.5-8 Average Monthly Total Power Generation from PV and Wind Hybrid System

In October, total power generation decreases compared to September being less than the other two Sums, and once again having a big increase in November, which extends over the other two Sums. The amounts of total power generation decreases greatly in December compared to November, though it increases in March compared to February, and it is understood that it decreases again from March to May.

In the case of Bayan-Undur, it is understood that there is a big increase in total power generation during the months from June to October, which is more than the other two Sums but decreases much in November which is less than the other two Sums. It is due to the reason that there is no power generation from wind power generation system. Though the amounts of generating electricity in total increase in December compared to November, it is understood that the amounts of total power generation decreases again gradually from December until February. The amounts of total power generation increases from February to April, and it is understood that in April it increases greatly compared to March having almost same value as in Tariat.

In the case of Tariat, the total power generation decreases slightly in July compared to June and increases gradually until November, and having almost same value as Adaatsag in the month August and September. In decreases sharply in December and together with January it goes below the other two Sums. The amount of total power generation increases from December to April, and in April it increases greatly same way as in Bayan-Undur compared to March, and it is understood that it decreases again drastically in May.

(6) Charge/Discharge Amount of Storage Battery

Monthly average charge/discharge amount of storage battery at each Sum is shown in Figure II.6.5-9. From this figure in the case of Adaatsag, it is understood that the amount of charge is small compared with the amount of discharge in July, August, November, and from February to May, and the amount of charge is a little above the amount of discharge in June, September, October and December. The amount of discharge during June to August increases gradually, though it decreases slightly in September compared to August and also decreases much in October compared to September. The amount of discharge increases gradually after October until March, and decreases again in April, and it is understood that it increases again in May. When observed throughout the whole year, it is understood that the amount of charge in September and the amount of discharge in May are the highest values. As for the amount of discharge in May, it is understood that it is more than four times in comparison with June. When it is observed throughout whole year, as for storage battery in Adaatsag, it is understood that it discharges more than the amount of charges. It requires holding the amount of discharge to keep a balance of charge and discharge.

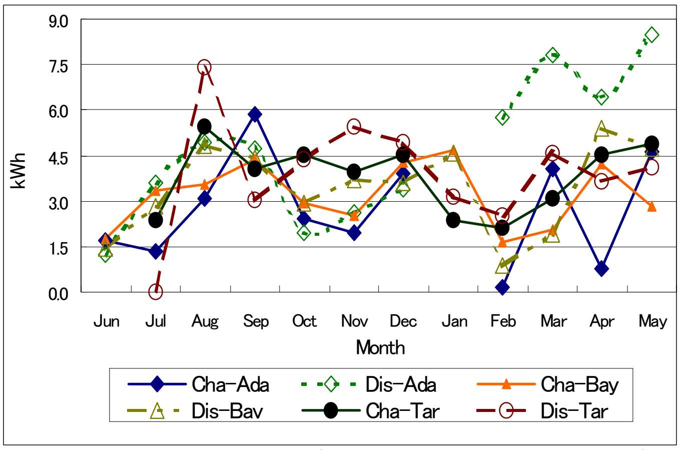

Figure II.6.5-9 Monthly Charge/Discharge Amount of Storage Battery

In the case of Bayan-Undur, it is understood that the amount of charge is small compared to the amount of discharge in August, November, April and May, and the amount of charge is a little above the amounts of discharge in June, July and February. The amount of discharge during June to August increases gradually, having almost same amount of charge/discharge in September and October, and once again in November the storage battery is in discharge condition. A storage battery becomes in charging condition in December, the amount of charge/discharge is almost equal in January, and it is understood that it is in discharge condition in February. The charge and discharge is almost equal again in March, and it is understood that it is at discharge condition in April and May. As for the storage battery, observing throughout whole year it is understood that it is in discharge condition. It requires holding the amount of discharge to keep a balance of charge and discharge.

In the case of Tariat, it is understood that it is in charge condition in June and July and the amount of charge is small compared to amount of discharge in August and from November to March. The amount of discharge increases drastically in August compared to July and decreases drastically in September. The amount of discharge increases gradually from September to December and even though the amount of discharge decreases from December until February the storage battery is still in discharge condition. It is understood that the amounts of discharge increases again in March and it is in the discharge condition, and the amount of discharge decreases in April and it is in charge condition in April and May. When it is observed throughout the whole year, a storage battery is in the charge condition, and it is understood that the amount of charge and discharge is comparatively well balanced compared with the other two Sums.

(7) The Amount of Supply power

(a) Amount of AC power supply

The monthly average amount of AC power supply from inverter at each Sum from June 1999 to May 2000 is shown in Figure II..6.5-10. From this figure, in the case of Adaatsag, it is understood that the amount of AC power supply is small compared to the Bayan-Undur and higher in July than the other two Sums. The amount of power supply decreases from July to September, increases a little bit in October but still is lower than the other two Sums. In November it increases greatly, having a value higher than Bayan-Undur and still lower than Tariat. It decreases again in December and the value is almost the same as Tariat. The amount of supply decreases gradually from February until May, being more than the other two Sums in February and March and less than other two Sums in April and May.

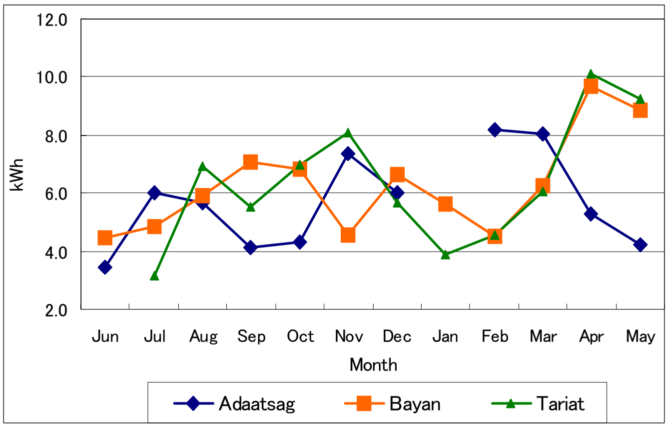

Figure II.6.5-10 Monthly average AC supply

In the case of Bayan-Undur, it is understood that the amount of AC power supply increases gradually from June to September, being higher than Adaatsag in June and August, and in September it becomes higher than the other two Sums. In October it is a little less than Tariat and higher than Adaatsag, and in November decreases greatly, and it is lower than the other two Sums. The amount of power supply increases again in December being more than the other two Sums, and it decreases gradually from December until February, being in between other two Sums and having almost the same value as Tariat in February. During February to April the amount of power supply increases sharply, being a little more than Tariat in March, and being less than Tariat and a lot more than Adaatsag in April. Though it decreases in comparison with April, it is understood that it is much more abundant than Adaatsag in May.

In the case of Tariat, it is understood that the amount of power supply in August increases greatly in comparison with July being higher than the other two Sums, and decreases beyond Bayan-undur in September. It increases gradually, from September to November and is higher than the other two Sums for October and November. In December and January, it decreases greatly in comparison with November, and it is goes below the other two Sums. During February to April the amount of supply power increases sharply as in Bayan-Undur, being almost the same as Bayan-Undur in February and a little less in March and more than the other two Sums in April. In April and May, it decreases in the same way as Bayan-Undur, and is more than the other two Sums.

From the above it is understood that there are big fluctuations in the amount of power supply at each Sum.

(b) Amount of DC power supply

The monthly average amount of DC power supply at each Sum from June 1999 to May 2000 is shown in Figure II.6.5-11. From this figure in the case of Adaatsag, it is understood that the amount of DC power supply is small coompared to Bayan-Undur in June, increases sharply in July and decreases during July to October, and increases once again in November and December. It is understood that amount of power supply increases gradually from February until May. It is understood that in July, August, and November to May it is higher than Bayan-Undur and almost the same value in September. It can be observed that the power is supplied throughout the whole year in Adaatsag.

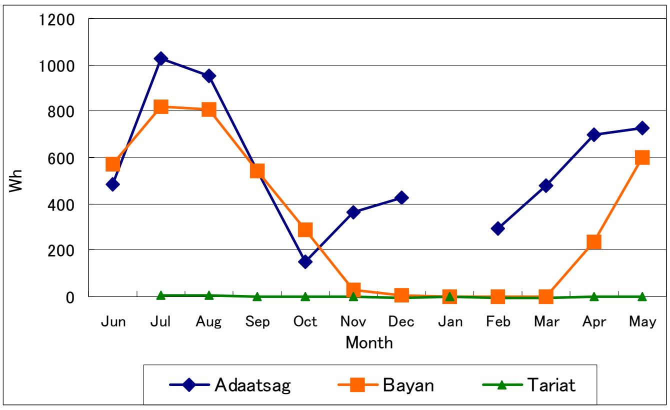

Figure II.6.5-11 Monthly average DC Power supply

In the case of Bayan-Undur, it is understood that the amount of DC power supply in July greatly increased than in June and has almost the same value in July and August, and decreases gradually from August to November. As for the amount of power supply, it is understood that it increases during the months of March to May. It is understood that from November until March, the power supply isn't done because a DC load is not in use.

In the case of Tariat, it is understood that there is no DC load (Refrigerator) utilization from the beginning, due to which there is no DC power supply.

6.5.2 Wind Power

(1) Average Wind Speed by Month

Figure II 6.5-12 shows variations in average wind speed by month from June 1999 to May 2000. It is evident from this figure that the average wind speed in the mountainous region of Tariat from April to September was low in comparison to the other two Sums, but that the reverse of this was true in October. As a result of the complex undulating terrain in Tariat, the influence of seasonal winds is small in comparison to the plateaus. It is thought that this is due to the fact that the winter winds blow down from the low temperatures of the summits to the basin and lakes, where temperatures have risen during the daytime, and become strong.

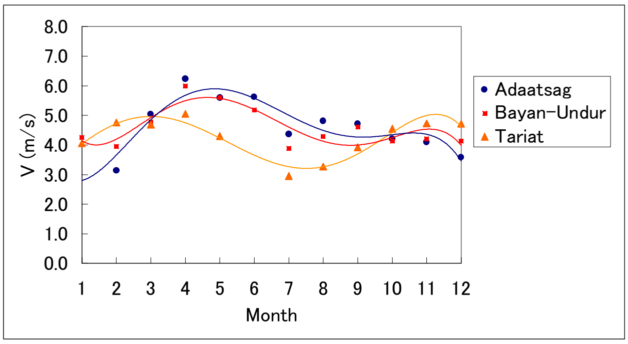

Figure II.6.5-12 Average Wind Speeds by Month (June 1999- May 2000)

(2) Time Series Variations

Figure II 6.5-13 shows time series variations in average wind speed for Adaatsag. In the summer, average wind speed is also high at nighttime, so the difference between nighttime and daytime average wind speed is small. In the winter months of October and November, on the other hand, nighttime average wind speed becomes low, creating a large difference between nighttime and daytime average wind speed. Figure II 6.5-14 shows time series variations in wind speed for Bayan-Undur. In Bayan-Undur, average wind speed is high in the afternoons, regardless the month. Figure II 6.5-15 shows time series variations in wind

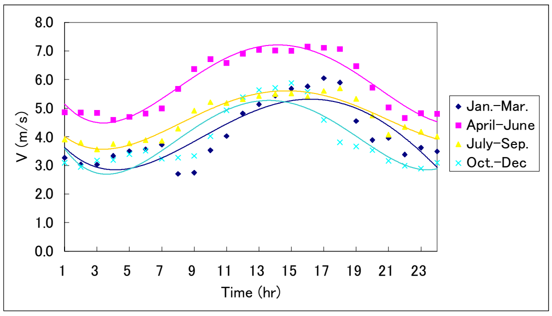

Figure II.6.5-13 Time Series Variations in Wind Speed (Adaatsag)

speed by month for Tariat. In Tariat, wind speed in winter is higher than in summer. Also, average wind speed is high in the nighttime in November, when it is possible to use wind power generation.

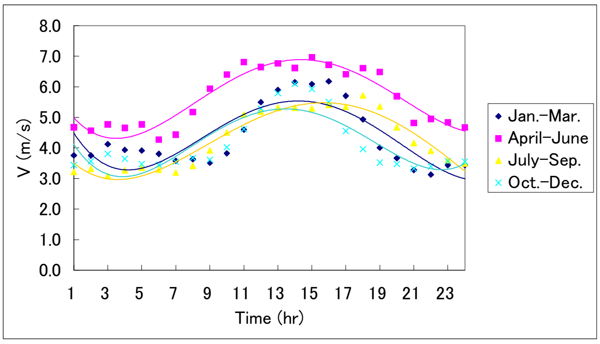

Figure II.6.5-14 Time Series Variations in Wind Speed (Bayan-Undur)

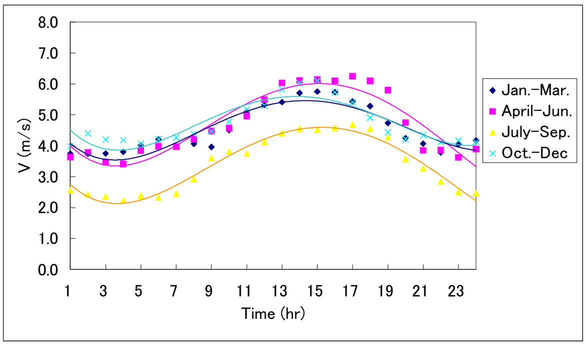

Figure II.6.5-15 Time Series Variations in Wind Speed (Tariat)

(3) Wind Direction

Figure II 6.5-16 shows the wind rose for Adaatsag from June to November. In Adaatsag, the predominant wind direction is north to north-west. However, in comparison with the other 2 Sums the winds are not very stable. Figure II 6.5-17 shows the wind rose for Bayan-Undur from June to November. Bayan-Undur has predominantly northerly winds, which are stable. Figure II 6.5-18 shows the wind rose for Tariat from July to November. Tariat has predominantly westerly winds, which are stable. The monthly wind rose for each pilot plant is shown in the appended data.

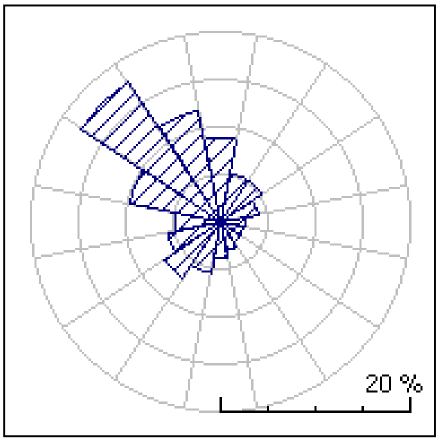

Figure II.6.5-16 Wind Rose (Adaatsag)

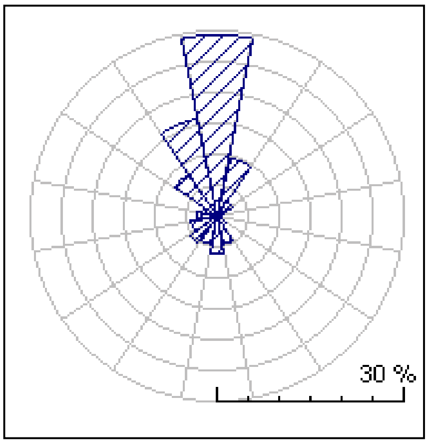

Figure II.6.5-17 Wind Rose(Bayan-Undur)

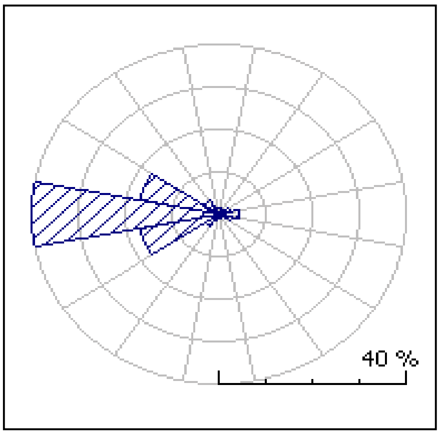

Figure II.6.5-18 Wind Rose (Tariat)

(4) Weibull Distribution

The emergence frequency by wind speed is shown from the data monitored until November. Figure II 6.5-19 shows the Weibull distribution for Adaatsag. The average wind speed for Adaatsag during the monitoring period is 4.7 m/s. The shape parameter k of the Weibull distribution is 1.51, and the emergence frequency by wind speed is often on the low side. Figure II 6.5-20 shows the Weibull distribution for Bayan-Undur. The average wind speed for Bayan-Undur during the monitoring period is 4.6 m/s. The shape parameter k of the Weibull distribution is small at 1.42, and the emergence frequency by wind speed is often on the low side. Figure II 6.5-21 shows the Weibull distribution for Tariat. The average wind speed for Tariat during the monitoring period is 4.3 m/s. The shape parameter k of the Weibull distribution is large at 2.14, and the emergence frequency by wind speed is often on the high side. The monthly wind rose for each pilot plant is shown in the appended data.

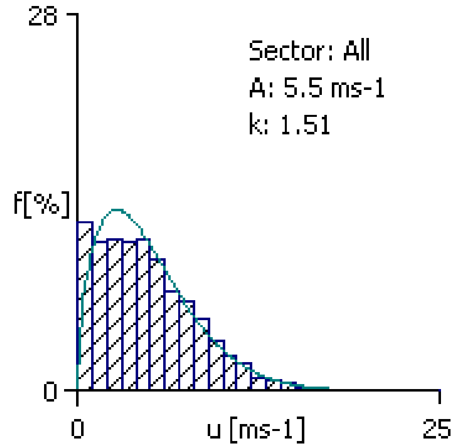

Figure II.6.5-19 Weibull Distribution (Adaatsag)

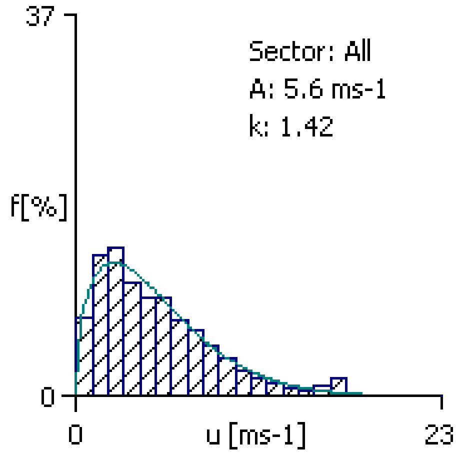

Figure II.6.5-20 Weibull Distribution (Bayan-Undur)

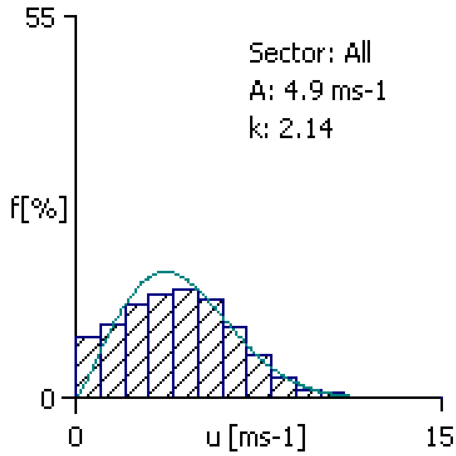

Figure II.6.5-21 Weibull Distribution (Tariat)

(5) Evaluation

Previous results of monitoring by the Meteorological Agency have shown year-round low wind speed in the mountainous region of Tariat. However, the results of wind monitoring in the pilot plants show a tendency for wind power, while remaining weak in summer, to become strong in winter. Since no wind monitoring by precision wind monitoring system has yet been carried out in this region, the wind regime characteristics are still unconfirmed. Therefore, the possibility of making use of wind power during the winter period in mountainous regions cannot yet be ruled out, and this will depend on the results obtained by future wind monitoring.

6.6 Conclusion

The trial operation of the Pilot Plant is concluded in the Master Plan Study as follows:

(1) It was confirmed that the local contractors are able to install such size of PV panels, wind generators and peripheral facilities under the supervision of Japanese engineers.

(2) It was found that the Sum people are able to execute the daily operation of the system. However, the some advice from Japanese engineers was needed when the fault occurred with the system. In case of faults, the local consultant in Ulaanbaatar played the vital role in repairing the faults.

(3) The power supply to the hospitals and school dormitory greatly improved their function.

(4) Further monitoring is necessary for ensuring operation and maintenance.

(5) The Sum people understood the necessity of DSM through the technology transfer seminar and actually executed DSM.

(6) By obtaining precise meteorological data, the data of the Meteorological Agency of Mongolia were corrected.

As mentioned above, important data and information were obtained from the trial operation of the pilot plant. The data and information were fed back to the master plan. Therefore, it can be said that the main purposes of the pilot plants were accomplished.