CHAPTER 7 MONITORING AND ANALYSIS

7.1 Monitoring Operation and Maintenance

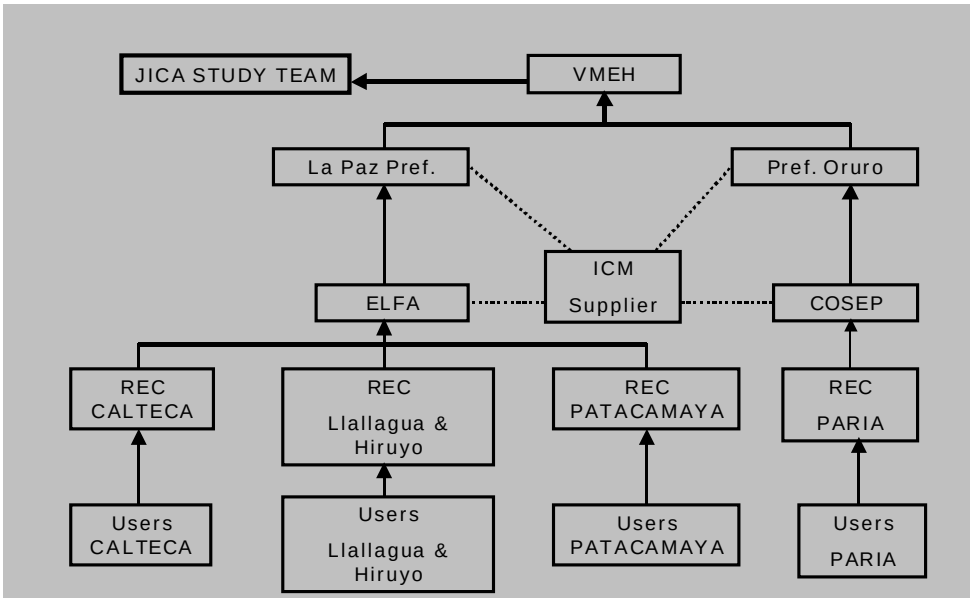
Monitoring was conducted to follow up the operation and maintenance of the installed PV system and the payment from users. The monitoring conducted during the study period consists of the following:

1) Monitoring on system use by data loggers
2) Monitoring on operation and maintenance by Operator
3) Monitoring on payment

For collecting data of PV function and the related meteorological information, data loggers were installed at three places; two in La Paz and one in Oruro. Analysis of the system use was also made based on the collected data from the data loggers. For monitoring operation and maintenance by Operators, monitoring sheets (refer to Attachment 5-8) were prepared, on which monitoring results were recorded.

The flow of the monitoring for operation and maintenance is as presented below.

Monitoring Flow



Source: JICA Study Team

7.1.1 Transfer the PV Systems Installed

Prior to the commencement of the monitoring, 270 systems were installed both in La Paz and Oruro. After the installation, operation and maintenance service was provided by Operators. The PV systems the users of which did not pay the power tariff for consecutive two months or so were to be removed and transferred to new users according to the agreement.

The table below indicates the numbers of PV systems installed and transferred to new users after the initial installation.

Location of the Installed PV System

(unit:household)

Community	End of March 2000	End of May 2000	End of July 2000	End of Dec. 2000	End of April 2001
La Paz					
Calteca	12	12	12	10	10
Chiarumani	26	26	26	6	5
Muruchapi	23	23	23	22	22
Millo	37	37	37	30	30
Catavi	12	12	12	12	12
C.C. Alto	3	3	3	3	3
Hiruyo	27	27	27	19	7
Llallagua	14	14	14	14	4
Sipe Sipe	25	25	25	1	1
Calacachi	-	-	-	32	41
St. de Llallagua	-	-	-	-	7
Canuma	-	-	-	-	13
Schools/Church	-	-	-	-	5
Removed	-	-	-	30	18
Plaza Sica Sica	-	-	-	-	1
VMEH	1	1	1	1	1
Spare	20	20	20	20	20
La Paz Total	200	200	200	200	200
Oruro					
P.Pampita	18	18	18	16	18
Milluni	23	23	23	23	23
L.Ancocota	44	44	44	44	44
Minas	5	5	5	5	5
Removed	-	-	-	2	-
Spare	10	10	10	10	10
Oruro Total	100	100	100	100	100

Source: JICA Study Team

The removed PV systems are being transferred to new users through the arrangement of Operators. The following photos show the case of the transfer.

Removal of the installed PV System

Removed equipments in Sipe Sipe

The user pays delayed fees to keep installed PV System

7.1.2 Monitoring on OM

The result of the monitoring on system use is explained in more detail in the succeeding section and the results of the monitoring on operation and maintenance are explained in the following.

Although the Operators' visit for inspection was originally scheduled once every two months, actual inspection conducted was once every three or four months. This is because of the social problem in 2000 and long rainy days from December 2000 to February 2001.

The results of the monitoring are presented in the following table.

Result of Monitoring on OM

(August – October 2000)

(unit:household)

		Equipments				Number of Additional Loads	
Community	Household	Number defective Lamp (1)	Black-ish Bulb (2)	Noise on Radio (3)	Battery Water (4)	Radio Cassette (5)	TV (6)
La Paz							
Calteca	10	1	2	3	3	8	-
Chiarumani	6	1	3	2	2	5	-
Muruchapi	22	2	5	20	8	20	-
Millo	30	4	8	25	12	27	-
Catavi	12	1	3	10	5	10	-
C.C. Alto	3	-	1	3	1	3	1
Hiruyo	19	2	2	15	6	18	-
Llallagua	14	1	4	13	9	14	-
Calacachi	32	-	-	2	-	32	3
VMEH	1	-	1	-	-	-	-
Oruro							
P.Pampita	16	3	2	13	5	15	1
Milluni	23	5	8	22	16	23	-
L.Ancocota	44	9	12	38	39	40	-
Minas	5	1	2	1	2	5	-
Total	238	35	53	167	108	220	5

Source: JICA Study Team

(1) Defective Lamp

35 lamps, which are 4.9% of 714 of the total lumps installed, were found with defective performance. The JICA Study Team requested Operators to replace them under the warranty of the supplier. Although the reasons for the defective lamps were not clarified yet, several lumps were fixed over the fire place in the kitchens. Operators changed the location of the installation.

(2) Blackish Bulb

53 lumps, 7.4% of the total lamps installed, were found with blackened end. The JICA Study Team decided to replace the ballasts.

(3) Noise on Radio

167 users complained of noise problem on radio when used near the fluorescent lamp. The JICA Study Team discussed the solution and decided to fix filters in the lamps.

(4) Battery Water

Interval of the refilling water to battery was originally set at once every two months. However, the interval of every three months was practically satisfactory.

(5) Radio Cassette and (6) TV

As shown in the above table, 92% of the total users use radios or radio cassettes. Since possible sites for TV are limited in Altiplano, only 5 users have TV so far.

Although there were some problems as indicated above, the PV systems function in order which satisfy users. The performance of Operators for operation and maintenance were satisfactory in general.

7.1.3 Monitoring on Payment

After the completion of the installation, the monitoring commenced since April 2000. The result of the payment in May 2000 are not satisfactory. Collection rates of the Initial Payment and Monthly Fee were 8.0% and 5.5%, respectively in La Paz, and 11.0% and 8.6%, respectively in Oruro.

To follow up the results, analysis was made on the delayed payment and the following actions were taken to improve the situation.

(1) Re-Orientation for User

During the fourth field survey, the JICA Study Team and Operators visited three communities and conducted re-orientation to users for clarifying the misunderstanding and explaining the present PV system and its operation and maintenance.

(2) Modified Payment Schedule

The Monthly Fee and Initial Payment were reduced as explained in Chapter 6.

(3) Modified User OM

For supplementing the function of Operators, a appointment of technical assistant was proposed to be selected in each community who carries out the following tasks:

- To coordinate with Operator
- To inspect cable and wiring connections and tighten or re-connect cable and wires
- To fill the distilled water to batteries
- To make regular report to Operator

Through the implementation of re-orientation and modified payment scheme the payment situation was improved as summarized below:

Collection Ratio (Paid amount / Full amount to collect)

(unit: %)

Month	La Paz		Oruro	
	Initial Payment	Monthly Fee	Initial Payment	Monthly Fee
May 2000	8.0	5.5	11.0	8.6
July 2000	16.9	28.5	19.6	25.9
Dec. 2000	38.7	56.2	47.7	46.3
Apr. 2001	42.4	67.2	51.1	41.4

Source: JICA JICA Study Team

The details of payments are as presented in Table 7.1 – 7.8.

7.2 Monitoring of Users

7.2.1 Survey of Users

After installation of PV pilot project, monitoring survey was conducted in the following schedule:

- the first survey: June 2000

- the second survey: January 2001
- the third survey: May 2001

Main objectives of the survey were to monitor the following aspects for formulating sustainable implementation plan for rural electrification by PV system through this pilot project.

- change of user's life after introduction of PV system,
- payment situation for initial payment and monthly fee, and
- situation of the operation and maintenance.

The methods of key informant survey and household survey were applied to the survey. The interview survey using the Rapid Rural Appraisal (RRA) method was carried out for the users of the PV pilot project sites in La Paz and Oruro.

(1) Location and Sample Size

The location and size of the sample for household survey are as presented in the next table. Total numbers of the selected sites were four communities: two sites each in La Paz and Oruro. The selected samples for the household survey were 42 for the first survey, 25 for the second survey and 33 for the third survey.

Location and Size of User's Survey

	Operator	Community of Selected PV site	* Number of Interviewees			TV Broadcasting
			1st	2nd	3rd	
La Paz	ELFA	Calteca	5	6	6	No
		Muruchapi	15	7	9	No
Oruro	COSEP	Paria Pampita	14	12	12	Yes
		Laguna Ancocota	8	-	6	No
Total		4 sites	42	25	33	

Source: JICA JICA Study Team

(2) Change in Household Energy Situation

Average time using fluorescent lamps ranged from 2.5 hours in Calteca to 3.2 hours in Paria Pampita in the third survey as shown in Table 7.9. The using time was not different between the first survey to the third survey. Besides, a kerosene lamp, about one or two liter(s) of kerosene per month, was still being used even after the PV installation.

The average time of radio listening ranged from 1.6 hours in Calteca to 2.5 hours in Paria Pampita in the third survey. The average time in this survey was not so different from the former two surveys. However, users would use radio more after solving the noise problem. A cassette recorder was rarely used. The average time of watching TV for three users in Paria Pampita was 2.4 hours per day.

The following complaints were raised mainly due to the lack of the user's understanding on the capacity of PV system:

- Users complained that the capacity of PV system was not satisfactory compared to the monthly fee and also to that of the grid line system,
- Users seemed discontent with noise problem of radio that was not caused by PV system, but by weak radio waves, and
- Users in remote and/or hilly areas were not satisfied with the situation that TV broadcasting was not available due to the weak waves in their communities.

(3) Change in Financial Source for Payment of User Charge

The main source of the initial payment and monthly fee was selling agricultural products and/or livestock products, the same as indicated in the initial benchmark survey as presented in Table 7.10. Around 42% of users in Muruchapi, 25% in Paria Pampita, and 16% in Calteca sold agricultural products such as potato, chuño, carrot and onion. About 58% of users in Paria Pampita, 42% in Muruchapi, and 33% in Calteca sold livestock such as sheep, llama, and cattle.

Some of the users were small-scale farmers who could not afford to sell agricultural products and livestock. For the payment, 25% of users in Paria Pampita, 16% in Calteca, and 14% in Muruchapi worked temporarily in the informal sector in the neighbor communities or cities.

The following complaints and comments were raised during the monitoring survey.

- Monthly fee is collected every month whether the users have income or not.

- Prefecture continues to hold the ownership of PV system even if the users pay the initial payment.
- The users would not like to sell their valuable livestock animals in early rainy season and dry season because the selling price of skinny livestock is low.
- Cash income from agricultural production is normally once a year due to their rain-fed cultivation.
- Job opportunity of temporary works is quite limited.

(4) Change of Life

Users, 91% of interviewees in Paria Pamita, 87% in Muruchapi, 85% in Laguna Ancocota and 83% in Calteca, recognized that their daily lives were improved after using the PV system as presented in Table 7.11. The main reason of the better life was improved conditions at night, while 18% of total interviews considered that their situation did not change.

The capacity of the PV system is not sufficient. According to the comments of the users, installation of larger power system was requested to implement an integrated rural development.

- to develop irrigated agriculture with PV water pump,
- to promote cottage industry in rural area for getting cash income,
- to develop a deep well drinking water with PV water pump, and
- to use other electric appliance for domestic use such as electric iron and sewing machine.

(5) Operation and Maintenance by Users

The water level of battery was kept well by all users. When the PV system had a problem, users normally informed the chief of the Rural Electrification Committee. The chief communicated and requested the Operators to settle the problem. Communication between the users and the Operator was, however, limited by the following reasons:

- Users were not at home and worked outside in the daytime when the operators visited the user's houses for the maintenance and the fee collection, and
- Some of the representatives of the Rural Electrification Committee did not always stay in his community, but in the city where his family lived.

7.2.2 System Use Monitored by Data Logger

Monitoring was conducted mainly for investigating power generation and the corresponding consumption using the data loggers installed at VMEH office and at community chief's houses in Calteca of La Paz and in Paria Pampita of Oruro.

The monitoring of the system use was made for the three different types of users, optimum user, light user and heavy user. The results of the monitoring are summarized below.

(1) Optimum User

Total daily use of the PV system was regulated within 105Wh which is equivalent to 7 hours use of three 15W fluorescent lamps. With respect to the unit of Ampere hour (Ah), the daily limit is 8.75Ah which is taken as benchmark in the pilot project.

The daily use of the lamps was fixed at the level indicated above, using a timer as follows:

- Lamp 1 : 3 hours
- Lamp 2 : 2.5 hours
- Lamp 3 : 1.5 hours total 7 hours

The graph below shows the system operation data as follows:

- Radiation [kWh/m^2]
  Daily radiation for the month are as presented in the first graph.
  15.0 on the left scale indicates 0 of Radiation. 16.0 on the scale indicates 1kWh/m^2.
  The daily average for the month was 5.12 kWh/m^2

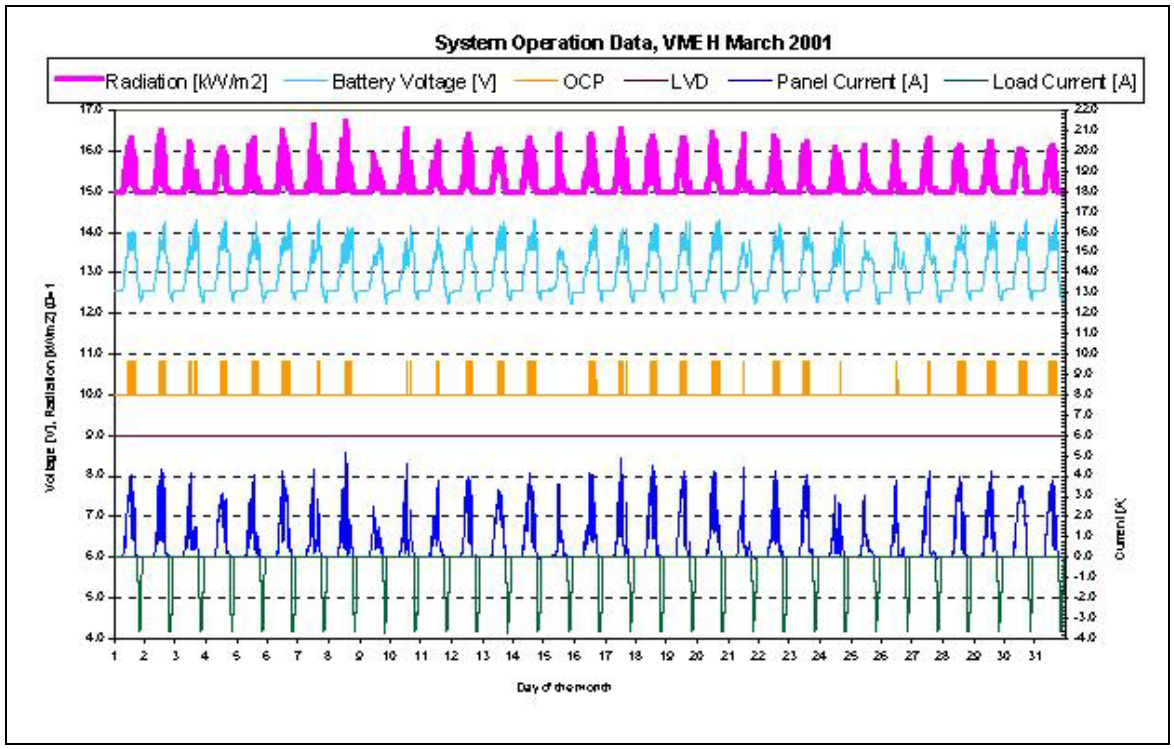
- Battery Voltage[V]
  The voltage indicated lower in the days of 9th, 15th, 21st and 25th because of less radiation.

- OCP: Over charge protection
  If the protection works, the positive line between 10 and 11 of the left scale is indicated. If there is no work of protection, the line is flat the whole day. As the consumption level was not so high, OCP worked in 28 days of 31 days.

- LVD : Low voltage disconnection
  If the disconnection works, the positive line between 9 and 10 of the left scale is indicated. As the consumption was not so high, no LVD worked in the month.

- Panel Current [A]:
  Generated power is indicated as Panel Current.

- Load Current [A]:
  This is the power consumed by the loads. The level of the consumption is within the power generated, because the daily consumption was fixed at 8.75Ah.



Source: JICA Study Team

The level of load consumption was fixed at 8.75Ah for one month. As the consumption level is within the generated electricity, the battery charge balance is very stable. This shows optimum use.

(2) Light User

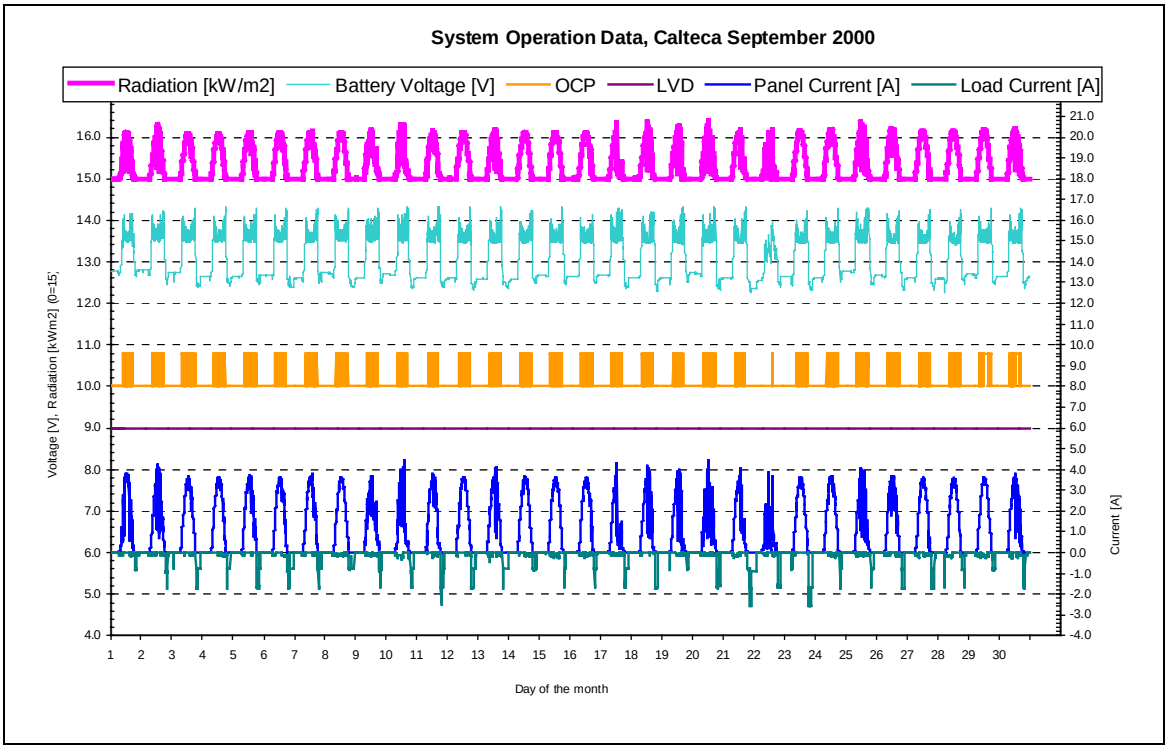
Data from Calteca (September 2000)
The load use (daily average) was:

- Lamp 1: 0.76 hours
- Lamp 2: 1.02 hours
- Lamp 3: 1.74 hours
- Radio : 0.84 hours

The daily average use was 4.36 hours. This is 62% of the benchmark level.

The graph below shows the system operation data as follows:

- Radiation [kWh/m^2]
  The daily average of the radiation for the month was 7.21 kWh/m^2
- Battery Voltage[V]
  The voltage indicated lower in the day of 22nd was because of the less radiation.
- OCP: Over charge protection
  As the consumption level was low, the battery was always charged enough. Therefore, OCP worked everyday in the month. In the day of 22nd, OCP worked only once, because the radiation was less.
- LVD : Low voltage disconnection
  As the consumption was very low, no LVD worked in the month.
- Panel Current [A]:
  Generated power is indicated as Panel Current.
- Load Current [A]:
  This is the power consumed by the loads. The average of daily consumption was 2.91Ah.



Source: JICA Study Team

The above results are due to less consumption of electricity.

(3) Heavy User

Data from VMEH (August 2000)
The load use (daily average) was:

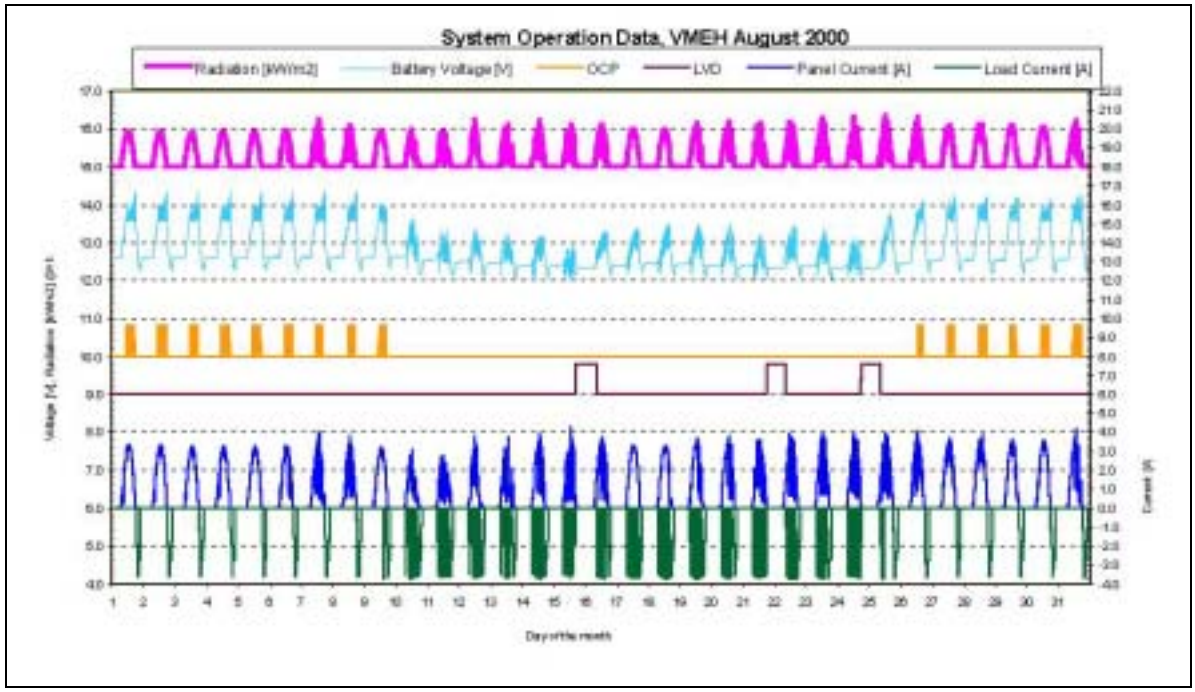
- Lamp 1: 4.47 hours
- Lamp 2: 2.81 hours
- Lamp 3: 3.41 hours

The daily average use was 10.69 hours. This is 152% of the benchmark level.

The graph below shows the system operation data as follows:

- Radiation [kWh/m^2]
  The daily average of the radiation for the month was 5.64kWh/m^2
- Battery Voltage[V]
  The voltage indicated lower during the days of the 9th to 25th because of high consumption.

- OCP: Over charge protection
  As the consumption level was high for 17 days during 9th to 25th, the battery was in the condition of much discharged level. Therefore, OCP did not work on those days.
- LVD : Low voltage disconnection
  As the consumption was very high during those 17 days, LVD worked three times on the days of 15th, 22nd and 24th in the month.
- Panel Current [A]:
  Generated power is indicated as Panel Current.
- Load Current [A]:
  This is the power consumed by the loads. The average of daily consumption was 13.27Ah for the month. However, the average consumption during the 17 days was 16.32Ah which was much higher than the generated electricity.



Source: JICA Study Team

The heavy consumption may cause the lifetime of the battery to be shorter.

7.3 Technical Evaluation of PV System

The JICA Study Team and Operators examined the PV systems installed for 15 to 18 months through the operation and maintenance. The results of the surveys proved the function of the systems satisfactory in general as follows:

- The PV panel of 55Wp generates sufficient power for charging 100Ah battery.
- The controller works well for over charging protection and over discharging protection of batteries.
- The battery has enough capacity for the normal use.

No specific major troubles happened nor were there any accidents caused by lightning in the hilly area. The systems installed in the communities are, therefore, considered to be appropriate ones from the technical point of view.

Several minor problems and lessons learnt for the future project are as explained below.

7.3.1 Technical Problems and Solutions

Through the monitoring of operation and maintenance the following technical problems of the PV system were identified:

- Bulbs with blackened end
- Lamp with defective ballasts
- Noise on radio

(1) Blackish bulbs

Some users in La Paz and Oruro complained of this problem. To improve this, the JICA JICA Study Team advised Operators both in La Paz and Oruro to collect all the blackened bulbs and ordered them to request the replacement to the supplier before the warranty expires .

The replacement was completed in April 2001. This problem is due to the imperfect inspection of the bulb before delivery.

(2) Lamps with defective ballasts

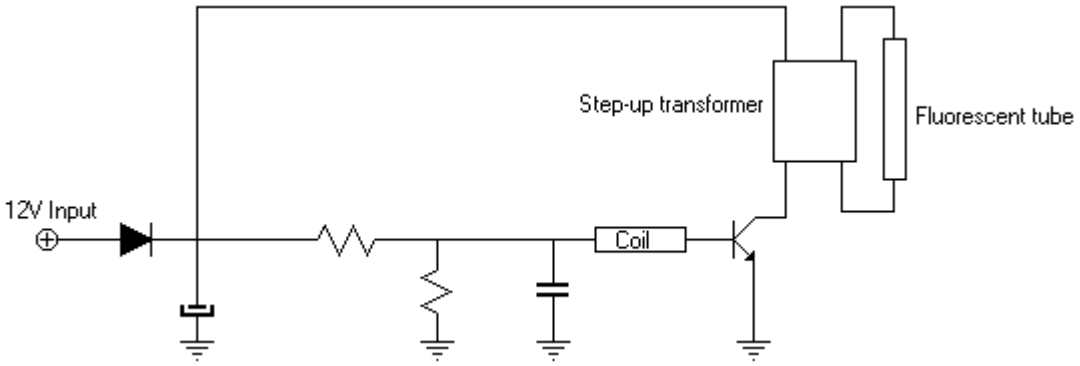
Some lamps were not functioning in Oruro and La Paz. The JICA JICA Study Team recognized that the problem was caused by defective ballast and proposed to replace all ballasts. New ballasts were procured and the replacement was completed by the end of April 2001. Specifications and schema of the ballast to have been installed are presented below.

Specifications of Ballast

1. Specifications:

- Nominal power: 15W
- Nominal input voltage: 12V
- Starting voltage range: 11 to 15V
- Peak ratio: 1.6
- Lifespan: 4000 hours
- Working Temperature Range: -10 to 40˚C
- Designed for 15W fluorescent tube
- Reverse polarity protection
- Attenuated Noise Output

2. Schema of Ballast:



(3) Noise on Radio

Noise on radio was another complaint from users, when they put the radio near the fluorescent lamp. To solve the problem of the radio noise, the JICA Study Team procured and installed a filter inside the lamp. The installation to the PV systems was completed at the end of April 2001.

The problem of the noise was solved after the installation of the filter. Specifications and scheme of the filter are explained below.

Specifications of Filter

1. Specifications:

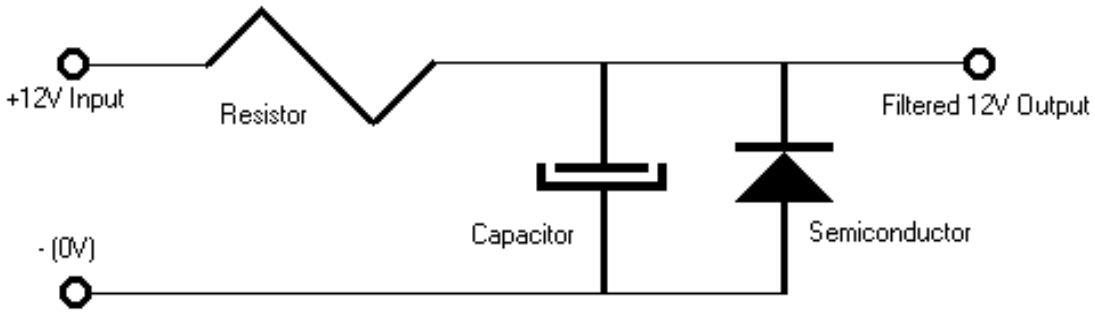
The filter element designed to reduce radio noise generated by DC-12V fluorescent tube ballasts.

- Attenuation: 6dB/octave
- Cutoff frequency: 50Hz
- Efficiency 95%
- Power consumption: 95mA

2. Materials:

- 3300uF 25V Industrial temperature range capacitor
- 1 Ohm 1W Wire type ceramic coated resistor
- Noise shunting semiconductor
- Solder
- Silicone
- Insulating tape

3. Schema of Filter:



7.3.2 Comment on the System Capacity

During the field surveys conducted for this pilot project, a PV system with a large capacity was requested to be installed by the residents with the following objectives.

- Lighting for livestock
- TV, computer and video deck for school
- Water pumping system for drinking and irrigation

Their requests on the PV system were for more than house lighting and aiming more income generation and productive use.

On the other hand, many people are still on subsistence level who cannot afford the payment of monthly fee of US$3 in our pilot project.

Under this situation, if the PV system with different capacities were provided depending on the users' selection, users would be satisfied more with the system and payment of the tariff would increase.

The PV system of different capacities are:

- Small Size PV: 30Wp Battery: 40Ah
- Middle Size PV: 50Wp Battery: 100Ah
- Large Size PV: 100Wp Battery: 200Ah

" Middle Size" is the system applied to the pilot project which cost US$886. The price of the "Small Size" is approximately 40% less than the price of the system for the pilot project. The price of "Large Size" is estimated at 60% more than the existing one.

7.4 Evaluation of OM System

7.4.1 Evaluation of the Performance

The proposed structure and function for the operation and maintenance consisting of Users/REC, Operator and Prefecture were originally formulated taking into account the following situation of the pilot project sites.

(1) Level of users' technology

PV systems have been installed several areas in La Paz and Oruro. However, use of batteries in the rural areas seems quite limited compared to other developing countries. This fact leads to the proposed operation system that Operator plays main role in OM ,while Users take less responsibility.

(2) Level of income

For sustainable maintenance of the PV system, replacement cost of battery and controller is to be secured every 5 years or so. However, income level of the households in the Altiplano area is very low. The proposed tariff was, therefore, set covering such replacement cost and more expensive than that for simple maintenance.

Through the monitoring of the pilot project, evaluation was made on their performance. Result of the evaluation is satisfactory in general, but, several problems were identified as explained below:

1) Maintenance service of the Operator was not fully implemented. This is partly due to the location of the pilot project (isolated and far from main road) and partly due to frequent absence of users during Operator's inspection.

2) Coordinating function of the Prefecture / VMEH was expected for the efficient operation and maintenance. However, the expected function was not fully implemented due to the limited manpower available and difficulty in daily communication.

3) Payment of the tariff was delayed and the tariff payment rate was still around 50% though it was improved after modification and enforcement of the system. According to the result of interview survey on user reasons of the delay are:
   - PV system was misunderstood as the donation from JICA
   - no regular income and/or limited income opportunity
   - higher expectation for PV versus limited installed capacity

As indicated above, the current monthly fee of Bs. 22 is recognized as an expensive one for users.

7.4.2 Proposed Improvement

For solving the problems of operation and maintenance mentioned above, the following improvement is proposed and partly implemented.

(1) OM system mainly conducted by User/REC

Most of the tasks conducted by the Operator are to be transferred to Users/REC. For this, technical assistants are selected in REC who coordinate major operation and maintenance after getting training from Operator.

In case of major problems of equipment including replacement, Operator is to provide technical service under the agreement with REC/Users.

(2) Participation of Municipality in OM

Instead of Prefecture or VMEH, a representative of the municipality is to be included for necessary coordination in operation and maintenance for the PV system. In view of the location of municipality and intimate relation with users, the participation of municipality seems more practical for improvement. This involvement becomes more important now since municipality is to be an executing agency for the rural development including rural electrification after PRSP enforcement. However, further capacity building for the staff of municipality might be required.

(3) Improved tariff system

For easy payment, the monthly fee is to be set at the minimum that covers only cost of distilled water and manpower cost of technical assistants and is to be collected by the technical assistants monthly or bi-monthly. However, replacement is required for battery and controller every 5 years or so. Some users can arrange the fund for the replacement, but, most of the users may not.

In order to arrange such fund and the fund for initial payment, creation or arrangement for establishing micro credit seems required. Through this kind of institutional support, the fund collected from the initial payment can be used as the revolving fund for rural electrification.

CHAPTER 8 PV POTENTIAL AND SELECTION OF PV PRIORITY SITES

8.1 Potential of PV Power

8.1.1 Radiation Analysis in La Paz and Oruro Departments

Radiation data were collected from the three data loggers installed in the PV sites. The collected data indicate the following characteristics of the radiation.

- May to July: Winter / the lowest orbit of the sun:
  This is compensated by longer hours of sunshine in Dry Season.
- November to January: Summer / Rainy Season:
  This is compensated by strong sunshine from the High Orbit of the sun

High radiation was recorded all through the year because of the above and this confirms the high potential for PV generation in La Paz and Oruro.

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Summary of the radiation data collected from three data loggers is presented below.

(1) La Paz City

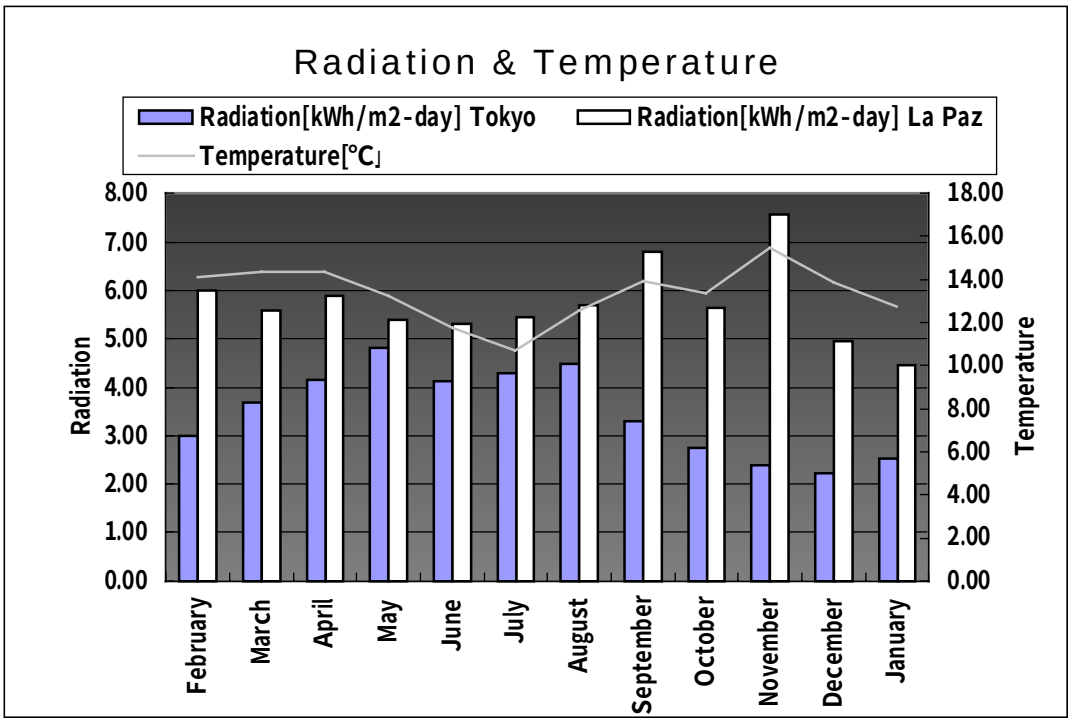
The maximum radiation measured is in November 2000 and the minimum in January 2001 in the city of La Paz as shown below:

- Annual average: 5.72 kwh/m^2/day
- The maximum: 7.58 (November 2000)
- The minimum: 4.44 (January 2001)

The seasonal average data are as follows:

- February to April: 5.82 (Autumn)
- May to July: 5.38 (Winter: Dry season)
- August to October: 6.03 (Spring)
- November to January: 5.66 (Summer: Rainy season)

La Paz City



Source : JICA Study Team and NEDO,Japan

(2) Calteca

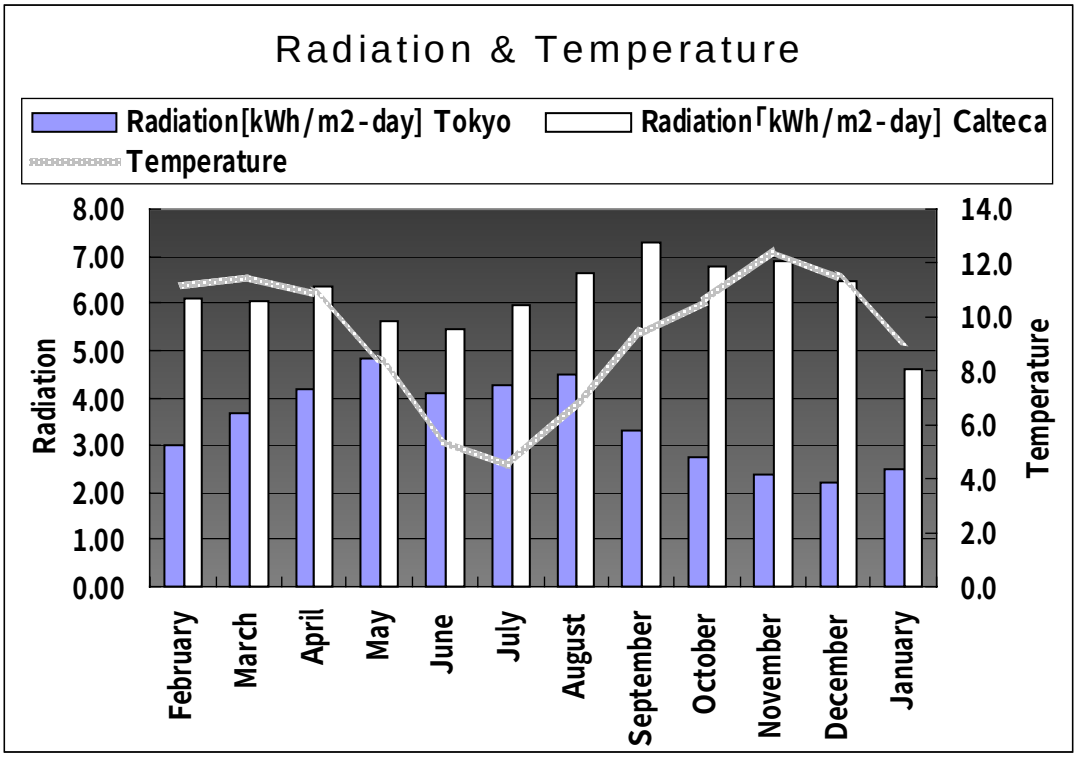
The maximum radiation measured is in September 2000 and the minimum in January 2001 in Calteca as shown below:

- Annual average: 6.19 kwh/m^2/day
- The maximum: 7.26 (September)
- The minimum: 4.61 (January)

The seasonal average data are as follows:

- February to April: 6.18 (Autumn)
- May to July: 5.68 (Winter: Dry season)
- August to October: 6.88 (Spring)
- November to January: 6.00 (Summer: Rainy season)

Calteca



Source : JICA Study Team and NEDO,Japan

(3) Paria Pampita

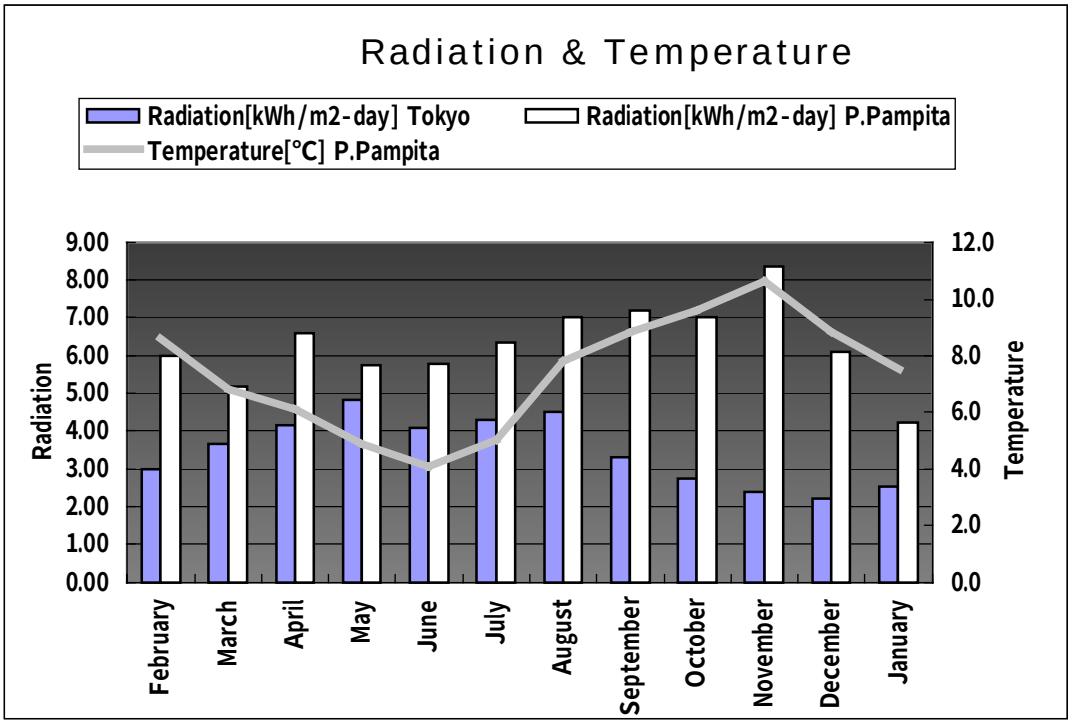
The maximum radiation measured is in November 2000 and the minimum in January 2001 in Paria Pampita as shown below:

- Annual average: 6.29 kwh/m^2/day
- The maximum: 8.35 (November)
- The minimum: 4.23 (January)

The seasonal average data are as follows:

- February to April: 5.91 (Autumn)
- May to July: 5.96 (Winter: Dry season)
- August to October: 7.08 (Spring)
- November to January: 6.22 (Summer: Rainy season)

Paria Pampita



Source : JICA Study Team and NEDO, Japan

In addition to the above, data on radiation in La Paz and Oruro were collected by 9 monitoring systems installed for the wind monitoring. To check and confirm the PV potential in La Paz and Oruro, average of the radiation for each station was estimated, on the basis of which classification of PV potential was made in accordance with the following criteria.

- First band: average radiation is over 6.5kWh / m^2 day
- Second band: 6.0 to 6.5
- Third band: 5.5 to 6.0
- Fourth band less than 5.5

On the basis of the above criteria the PV potential of the monitoring sites was evaluated as summarized below.

Department	Province	Site	Average Radiation (kWh/m^2 day)	Grade
La Paz La Paz	Kapac	S. Taquiri	6.69	1
	Pcajes	Charana	6.54	1
		Calteca	6.19	2
	Aroma	Stgo. De Llagua	5.94	3
	Murillo	La Paz	5.72	3
	Saavedra	General Gonzales	5.36	4
Oruro	Ladislao Cabrera	Salinas de G. Mendosa	6.66	1
	Avaroa	Sevaruyo	6.40	2
	Atahuallapa	C. Coipasa	6.36	2
	Cercado	Paria Pampita	6.29	2
	Sajama	Caripe	6.29	2
		Chachacomani	6.17	2

Though the available records of the radiation are quite limited, it is recognized that radiation is high in the north-east direction which goes down along the south-west direction. Range of radiation is 3.5 kWh/m^2 to the high of 7.5kWh/m^2 in La Paz and Oruro.

For comparison average radiation, data in other countries are presented below.

Radiation Data in Asia & South America

(unit: kWh/m^2)

	Location	Annual average	Highest	Lowest
Asia	Tokyo / Japan	3.48	4.81 / May	2.22 / December
	Jakarta / Indonesia	4.13	4.50 / September	3.55 / January
South America	B.Aires/Argentina	4.69	7.07 / January	2.15 / June
	Lima / Peru	4.55	6.01 / February	2.97 / July

Source: NEDO, Japan

By comparing the radiation data recorded in our study with the above figures, high PV potential was identified both in La Paz and Oruro.

8.1.2 PV Potential Map

The PV potential map was planned to be prepared. However, the number of the sampling data is quite limited and there is no other reliable data on radiation in La Paz and Oruro. To supplement the limited available data, estimate of the national radiation

prepared by GTZ was used and difference in the topographic conditions of the area was checked and duly taken into account for the evaluation.

The PV potential map, thus prepared, is still a preliminary one, but provides some ideas for selecting high priority sites for electrification by the PV system (PV potential map is presented in Figure 8.1 and 8.2)

As indicated in the map, Oruro has much potential for PV than La Paz in general. About 90% of Oruro department belongs to 2nd Band, while two thirds of La Paz, northern part of the department, belong to 4th Band. However, as the main part for residential area, southern part of the department, belong to 1st -3rd Band, La Paz is considered to have substantial potential for PV.

Using the PV potential map, 21 provinces in La Paz are classified as follows:

Province	1st Band	2nd Band	3rd Band	4th Band
Kapac	O			
Ingavi	O	O		
M.Pando	O			
Manco		O		
Los Andes	O	O	O	
Pacajes	O	O		
Aroma		O	O	
G.Villarrroel		O		
Saavedra			O	O
Camacho		O		
Munecas			O	O
Larecaja			O	O
Omasuyos		O		
Murrilo			O	O
Loayea			O	
Inquisivi			O	O
Iturralde				O
Franz Tamayo			O	O
Nor Yungas				O
Sud Yungas			O	O
Caranavi				O

Source: JICA Study Team

There are 16 provinces in Oruro. The following table shows the distribution of radiation by province.

Province	1st Band	2nd Band	3rd Band	4th Band
Atahuallapa	O	O		
Mejillones	O	O		
Lad. Cabrera	O	O		
Sajama		O		
Litoral		O		
Sn. De Totora		O		
Carangas		O		
Sud Crangas		O		
Auaroa		O	O	
T.Barron		O		
Cercado		O	O	
Dalenge		O	O	
Poopo		O	O	

Source: JICA Study Team

8.2 Selection of PV Priority Sites

8.2.1 Criteria for Selection

As indicated in the economic comparison of power generation cost, the energy cost of PV system is the highest among renewable energy source. The PV system is to be installed in the isolated area where no micro-hydro and wind power potential exists. For the selection of PV sites for rural electrification plan, the following criteria were applied in due consideration of the above:

1) far from the existing grid line and outside the expansion plan within foreseeable future
2) low population density
3) Basic Human Needs (The lower the BHN is, the higher priority is given)

8.2.2 Selected Priority Sites and PV Implementation Plan

Using the selection criteria mentioned in the preceding section, the priority sites for the PV system were selected mainly from C and D areas both in La Paz and Oruro presented in the grid extension priority map (refer to priority map for grid extension, chapter 5 of the Main Report).

According to the result of the economic comparison, higher priority will be given to micro-hydro and wind power development among renewable energies and the implementation plan of electrification by using PV both in La Paz and Oruro was formulated within the framework of allocated fund for the total renewable energy development as summarized below:

PV Implementation Plan

(unit: household)

Phase / Department	Phase 1 (2002-2006)	Phase 2 (2007-2011)	Total
La Paz	660	3,361	4,021
Oruro	2,235	4,637	6,872
Total	2,895	7,998	10,893

Source: JICA Study Team

CHAPTER 9 IMPLEMENTATION STRUCTURE AND DISPOSAL OF BATTERY

9.1 Implementing Structure for PV System

After reviewing the existing organizations for implementation, and through the operation and maintenance on PV pilot project, the following implementation structure is being proposed for sustainable development of rural electrification by PV system.

PV systems are being installed in rural area under the Model 2 and Model 3 schemes of the VMEH. In case of the Model 2, PV system suppliers are responsible for all of the project implementation for users. In case of the Model 3, NGO committed by local government manages the project implementation with support of the system supplier. Referring to this experience, the following two types of implementation organization are proposed for PV system.

(1) Public-oriented

The public-oriented is that municipality as an implementing organization utilizes the DUF fund mainly and conducts a rural electrification project. This is applicable to the RPONER Model 3. Target area is poor area where rural electrification by renewable energy is difficult to expand without governmental financial support. Under the PRSP, Figure 9.1 presents proposed organization for a project implementation. The role of organizations related to the project implementation is summarized as follows.

DUF (fund source)

- to evaluate, approve and finance a project plan applied by municipality in cooperation with the VMEH

VMEH (technical support)

- to guide DUF for technical supports on rural electrification development when DUF evaluates the project plan applied by municipality

Municipality (implementing organization)

- to give a guidance of project scheme and user's responsibilities including initial payment and monthly fee for local people
- to make an agreement with the REC after receiving the request of the rural electrification project

- to prepare a project plan with technical support of prefecture and/or consultants/NGO, and apply for the finance to DUF
- to select a private company or NGO which manages and supervises the whole project implementation. (However, most of the municipalities have the limited capacity to manage the project implementation. Consultants/NGO is to be employed by the municipality, which provides necessary services such as selection of supplier/operator and procurement assistance and the supervision of the whole project.)

Private sector / NGOs (installation and training for operation and maintenance)

- to install the system and carry out training on the operation and maintenance for beneficiaries and technical assistants of REC

REC/ cooperative (beneficiaries)

- to organize a rural electrification committee (REC) or cooperative after receiving the guidance of project scheme and beneficiary's responsibilities including initial payment and monthly fee through the municipality and/or consultants/NGO
- to request the rural electrification project and make an agreement with the municipality
- to receive the training on the operation and maintenance for beneficiaries and technical assistants of REC

Prefecture (technical support or implementing organization)

- to support municipality for preparing the project plan when municipality applies the plan to DUF
- In case of a project implemented not through DUF, prefecture is to be responsible for the project implementation in cooperation with VMEH.

(2) Private-oriented

The private-oriented is that the PV system suppliers work for procurement of equipment, installation, training of daily operation and maintenance for local users and technical service when users require as an implementing organization without governmental financial support. This system is, thus, applied for relatively rich local people who have a capacity to pay for the PV equipment applicable to the RPONER Model 2. Under implementing the PRSP, as private businesses, private companies such as a system supplier promote and implement PV projects.

9.2 Recommended Operation and Maintenance System of PV in La Paz and Oruro

Through the experience of the PV pilot project, users and a rural electrification committee (REC) should carry out ordinary operation and maintenance of PV system. In this sense, initial training to users and technical assistants of the REC is very important for the sustainable operation and maintenance.

The training is to be conducted by the system supplier or operator during the project implementation. Proposed operation and maintenance system of PV is as summarized below and presented in detail in the Section 6.1 in response to the PV pilot project.

(1) Users

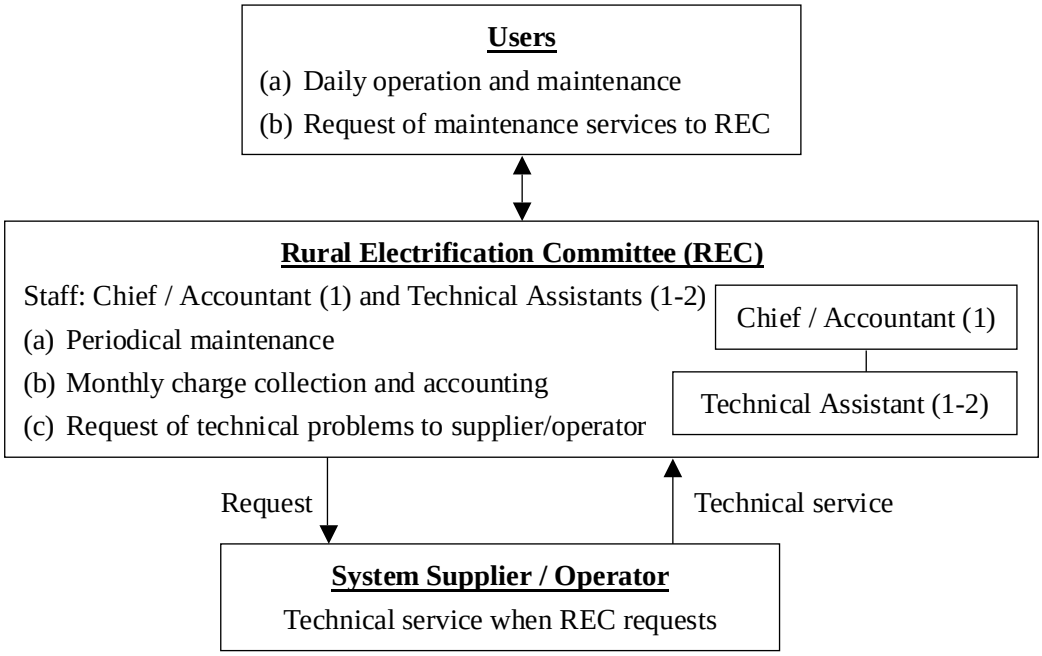
- to be responsible for the daily operation and maintenance
- to request maintenance services to the technical assistants of REC, if required

(2) REC: Technical assistants

- to carry out the periodical maintenance
- to collect monthly charge and accounting
- to request for solving major technical problems to the system supplier/operator

(3) System Supplier/Operator

- to provide REC with technical services when REC requests (under service agreement).



9.3 Disposal of Used Battery

The number of batteries consumed in Bolivia is around 250,000-300,000 units per year including imported and recycled ones. There exists one private firm, BATEBOL which produces about 30% of the local consumption. BATEBOL produced around 1,700 batteries for PV, which is less than 2% of the company's total production.

Recycling of batteries is being conducted by another private company, COMMETAL, a sister company of BATEBOL. The company handles 40% of the used batteries in Bolivia and is functioning as a recycling center of battery. The capacity of disposal is reported at over 400,000 units of batteries per year.

In the Implementation Plan for Rural Electrification formulated in this study, about 2,895 PV systems and 7,998 PV systems are planned to be installed during Phase I (2002-2006) and Phase II (2007-2011), respectively. Even if these batteries are added to the present consumption, the COMMETAL as still enough capacity for recycling.

Taking into account the situation above, disposal system for the PV battery is proposed as follows.

1) Used batteries are collected by Technical Assistant of REC.

2) Agent/staff of BATEBOL(collectors) collects used batteries from REC and transports to COMMETAL for recycling.

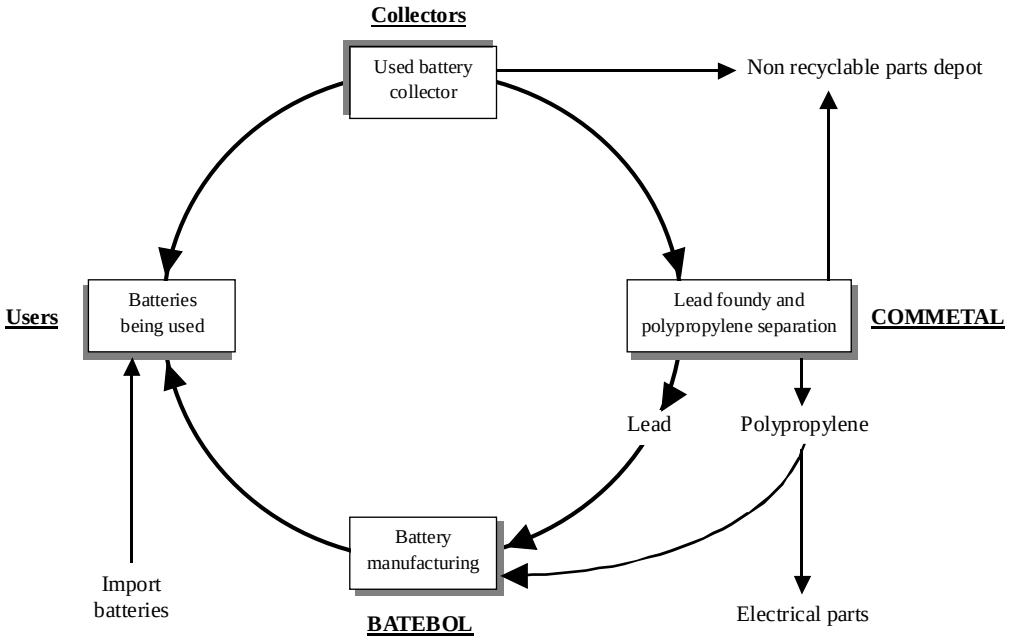
Collectors divide materials into recycle parts and non recycle parts as follows:

- Non recycle parts : Electrolyte, Metal fittings etc.
- Recycle parts : Electrode, Separator, Container

Non recycle materials are transferred to dealers which dispose them before transport to COMMETAL.

3) Through the recycling system, COMMETAL recovers lead and polypropylene. COMMETAL disposes residue from recycled materials and sells white type propylene as electrical parts.
4) Reuse the recycled material:
   - refined lead to be supplied to BATEBOL for reuse
   - recovered polypropylene to be supplied to BATEBOL for reuse

The process of the disposal and recycle of used batteries is presented below.



Source: JICA Study Team

TABLES

Table 4.1 Interviewee's Background

	La Paz				Oruro					Total
PV Site	Calteca	Sanfrancisco de Llallagua	Santiago de Hiruyo	Sub-Total	Iruma	Paria Pampita	Ancocota	Pazña	Sub-Total	
Age										
Less than 29 year	5	2	1	8	4	1	2		7	15
30-39	9	5	5	19	10	2		4	16	35
40-49	8	3		11	2	4	3	4	13	24
50-59	8		4	12	1	2	5	1	9	21
60-69	8			8	2			1	3	11
70 and more	2			2	1	1			2	4
Educational background										
No Education					2		3	2	7	7
Elementary school	4	10	2	16	9	7	5	6	27	43
Junior high school - level	17		4	21	6	3	2	2	13	34
Senior high school - level	19		4	23	3				3	26
University										
Main Occupation										
Farmer	4			4	3	1			4	8
Farmer + Herdsman	27	3	2	32	6	8	10	7	31	63
Farmer + Temporary work	4	7	4	15		1		3	4	19
Farmer + Private business	3		1	4						4
Farmer + Public sector			1	1						1
Farmer + Private sector			2	2						2
Farmer + Private business										
Private business	1			1						1
Salary worker in Private	1			1						1
Housekeeper					1				1	1
Total number of Interviewees	40	10	10	60	20	10	10	10	50	110

Source: JICA Study Team

Table 4.2 Household Economic Condition

	La Paz				Oruro					Total
PV Site	Calteca	Sanfrancisco de Llallagua	Santiago de Hiruyo	Sub-Average	Iruma	Paria Pampita	Ancocota	Pazña	Sub-Average	
Average Monthly Income	Bs. 277.4	Bs. 305.1	Bs. 348.5	Bs. 310.3	Bs. 246.0	Bs. 268.2	Bs. 110.4	Bs. 289.6	Bs. 228.5	Bs. 269.4
Average Monthly Consumption	Bs. 142.3	Bs. 293.3	Bs. 322.9	Bs. 252.8	Bs. 204.1	Bs. 217.1	Bs. 110.0	Bs. 253.8	Bs. 196.2	Bs. 224.5
- for Food	Bs. 97.9	Bs. 167.5	Bs. 241.4	Bs. 168.9	Bs. 172.5	Bs. 171.4	Bs. 100.0	Bs. 183.6	Bs. 156.8	Bs. 162.8
- for Energy	Bs. 24.6	Bs. 22.5	Bs. 27.8	Bs. 24.9	Bs. 22.9	Bs. 25.5	Bs. 15.9	PV installed	Bs. 21.4	Bs. 23.1

Source: JICA Study Team

Table 4.3 Household Economic Condition

PV Site	La Paz				Oruro					Average / Total
	Calteca	Sanfrancisco de Llallagua	Santiago de Hiruyo	Average / Sub-total	Iruma	Paria Pampita	Ancocota	Pazña	Average / Sub-total	
Average Farmland Size	3.2 ha	5.3 ha	5.8 ha	4.7 ha	0.8 ha	4.4 ha	4.9ha	6.2 ha	4.0 ha	4.3 ha
Average Number of Livestocks										
- Cattle	1.7	3	3.6	2.8	2	2.9	3.3	5.4	3.4	3.1
- Sheep	14.7	24	32.5	23.7	15.9	44.4	30.8	42.4	33.4	28.6
- Poultry	2.9	4	2.3	3.1	4	0.3	1.7	2.6	2.2	2.6
- Pig	0.2			0.1					0	0.0
- Burro	0.7	2	0.9	1.2		1.8	2.7	1.2	1.4	1.3
- Llama	0.2			0.1	11.8	40.3	3.8	5.8	15.4	7.7
Number of households that have farmland and/or livestocks animals										
- Farmland	37	9	10	56	17	9	10	9	45	101
- Cattle	31	10	10	51	1	8	9	8	26	77
- Sheep	33	10	10	53	9	9	8	9	35	88
- Poultry	16	9	4	29	1	1	0	2	4	33
- Pig	4	0	0	4	0	0	9	0	9	13
- Burro	16	7	4	27	0	9	7	5	21	48
- Llama	3	0	0	3	4	9	8	3	24	27
Total number of households	40	10	10	60	20	10	10	10	50	110

Source: JICA Study Team

Table 4.4 Electrical Appliance Purchased

(Unit: households)

PV Site	La Paz				Oruro				Total
	Calteca	Sanfrancisco de Llallagua	Santiago de Hiruyo	Sub-total	Iruma	Paria Pampita	Ancocota	Sub-total	
Existing appliances in a household									
- Radio	26	3	3	32	8	1	3	12	44
- Radio-cassette recorder	8	3	2	13	6	7	2	15	28
- Radio + Radio-cassette recorder	3	2	5	10	2	1		3	13
- Radio-cassette recorder + TV set					1			1	1
- Radio + Radio-cassette recorder + TV set						1		1	1
- do not have any appliance	3	2		5	3		5	8	13
Appliances desired after PV installation								0	0
- Radio	2			2				0	2
- Radio-cassette recorder	4	2		6	5		3	8	14
- Radio + Radio-cassette recorder								0	0
- TV set	18	6	8	32	3	8	2	13	45
- TV set + Radio					1		2	3	3
- TV set + Radio-cassette recorder	3	2	1	6	1	1	3	5	11
- No idea or Do not buy any appliances	13		1	14		1		1	15
Total number of households	40	10	10	60	20	10	10	40	100

Source: JICA Study Team

Table 4.5 Use of Kerosene Lamp

	La Paz				Oruro				Average
PV Site	Calteca	Sanfrancisco de Llallagua	Santiago de Hiruyo	Sub-average	Iruma	Paria Pampita	Ancocota	Sub-average	
Price of a Lamp (Bs.)	1.4	1.8	1.6	1.6	2.4	3.0	1.8	2.4	2.0
Life of the Lamp (year)	1.2	1.5	1.6	1.4	1.0	1.0	1.0	1.0	1.2
Monthly Consumption of Kerosene (liter)	1.1	2.8	2.6	2.2	4.2	3.8	2.3	3.4	2.8
Fuel Price (kerosene 1liter)	2.4	2.2	2.5	2.4	1.5	1.6	1.8	1.6	2.0
Monthly Consumption of Kerosene (Bs.)	2.6	6.2	6.5	5.1	6.3	6.1	4.1	5.6	5.6
Lamp Usage Hours per Day	2.4	1.7	2.5	2.2	3.0	4.0	2.6	3.2	2.7

Source: JICA Study Team

Table 4.6 Source for Initial Charge of PV system by Household

	La Paz				Oruro				Total
	Calteca	Sanfrancisco de Llallagua	Santiago de Hiruyo	Sub-total	Iruma	Paria Pampita	Ancocota	Sub-total	
from savings	5			5	4			4	9
borrow from relatives or friends	1			1					1
credit	1			1	2			2	3
sell agricultural products						2		2	2
sell livestock animals	10	5	5	20	2	2	5	9	29
sell farmland									0
temporary work	4			4	10			10	14
sell agricultural products + temporary work					2			2	2
sell livestock animals + temporary work		5	2	7		5	5	10	17
sell agricultural products + livestock animals	8			8		1		1	9
from savings + remittance	1			1					1
from savings + sell agricultural products			1	1					1
from savings + sell livestock animals	8		1	9					9
from savings + temporary work	1		1	2					2
from savings + borrow form relatives or friends	1			1					1
others									0
Total	40	10	10	60	20	10	10	40	100

Source: JICA Study Team

Table 4.7 Anticipated Source for the Monthly Fee of PV System by Household

	La Paz				Oruro				Total
	Calteca	Sanfrancisco de Llallagua	Santiago de Hiruyo	Sub-total	Iruma	Paria Pampita	Ancocota	Sub-total	
from savings	11		1	12	3			3	15
borrow from relatives or friends	1			1				0	1
credit	1			1	1			1	2
sell agricultural products				0		2		2	2
sell livestock animals	8	3	5	16			3	3	19
sell farmland				0				0	0
temporary work	5	2	1	8	5	3	2	10	18
sell agricultural products + temporary work				0	1		2	3	3
sell livestock animals + temporary work		3	2	5		5	2	7	12
sell agricultural products + livestock animals	5	2		7			1	1	8
from savings + sell livestock animals	6			6				0	6
from savings + temporary work	1		1	2				0	2
from savings + borrow form relatives or friends	1			1				0	1
remittance	1			1				0	1
others				0				0	0
Total	40	10	10	60	20	10	10	40	100

Source: JICA Study Team

Table7.1 Payment in La Paz

As of May End 2000

(unit: Bs.)

Community	Installed Households			Initial Payment			Monthly fee		
	Original Installation		As of May 2000	Total amount (A)	Payment up to April	% (B/A)	Total amount (C)	Payment up to April	% (D/C)
Calteca	12		12	8400	1500	17.86%	1080	300	27.78%
Chiarumani	26		26	18200	1500	8.24%	2340	510	21.79%
Muruchapi	23		23	16100	1150	7.14%	2070	0	0.00%
Millo	37		37	25900	1850	7.14%	2220	0	0.00%
Catavi	12		12	8400	600	7.14%	720	0	0.00%
C.C. Alto	3		3	2100	150	7.14%	180	0	0.00%
Hiruyo	27		27	18900	1350	7.14%	2430	0	0.00%
Llallagua	14		14	9800	700	7.14%	1260	0	0.00%
Sipe Sipe	25		25	17500	1250	7.14%	2250	0	0.00%
Calacachi									
Stgo. De Llallagua									
Canuma									
Schools Sica Sica					-				
Removed									
Plaza Sica Sica				-	-				
VMEH	1		1						
Spare	20		20						
Total	200		200	125300	10050	8.02%	14550	810	5.57%

Source:JICA Study Team

Table7.2 Payment in La Paz

As of July End 2000

(unit: Bs.)

Community	Installed Households			Initial Payment			Monthly fee		
	Original Installation		As of July 2000	Total amount (A)	Payment up to July 2000 (B)	% (B/A)	Total amount (C)	Payment up to July 2000 (D)	% (D/C)
Calteca	12		12	7200	2100	29.17%	1320	542	41.06%
Chiarumani	26		26	15600	1900	12.18%	2860	532	18.60%
Muruchapi	23		23	13800	1750	12.68%	2530	1276	50.43%
Millo	37		37	22200	1850	8.33%	3256	330	10.14%
Catavi	12		12	7200	600	8.33%	1056	528	50.00%
C.C. Alto	3		3	1800	550	30.56%	264	0	0.00%
Hiruyo	27		27	1350	1350	100.00%	4050	630	15.56%
Llallagua	14		14	700	700	100.00%	2100	330	15.71%
Sipe Sipe	25		25	1250	1250	100.00%	3750	1890	50.40%
Calacachi									
Stgo. De Llallagua									
Canuma									
Schools Sica Sica					-				
Removed									
Plaza Sica Sica				-	-				
VMEH	1		1						
Spare	20		20						
Total	200		200	71100	12050	16.95%	21186	6058	28.59%

Source:JICA Study Team

Table7.3 Payment in La Paz

As of December End 2000

(unit:Bs.)

Community	Installed Households			Initial Payment			Monthly fee		
	Original Installation		As of Dec. 2000	Total amount (A)	Payment up to April	% (B/A)	Total amount (C)	Payment up to April	% (D/C)
Calteca	**12**		**10**	6000	**2500**	41.7%	2200	**1182**	53.7%
Chiarumani	**26**		**6**	3600	**1350**	37.5%	1320	**440**	33.3%
Muruchapi	**23**		**22**	13200	**2700**	20.5%	4840	**1254**	25.9%
Millo	**37**		**30**	18000	**1450**	8.1%	5940	**858**	14.4%
Catavi	**12**		**12**	7200	**600**	8.3%	2376	**682**	28.7%
C.C. Alto	**3**		**3**	1800	**650**	36.1%	594	**220**	37.0%
Hiruyo	**27**		**19**	950	**950**	100.0%	5700	**3300**	57.9%
Llallagua	**14**		**14**	700	**700**	100.0%	4200	**1170**	27.9%
Sipe Sipe	**25**		**1**	50	**50**	100.0%	300	**120**	40.0%
Calacachi			**32**	19200	**13250**	69.0%			
Stgo. De Llallagua									
Canuma									
Schools Sica Sica									
Removed			**31**		**3150**			**6210**	
Plaza Sica Sica			**-**	-	-			-	
VMEH	**1**		**1**						
Spare	**20**		**19**						
Total	**200**		**200**	**70700**	**27350**	**38.7%**	**27470**	**15436**	**56.2%**

Source:JICA Study Team

Table7.4 Payment in La Paz

As of April End 2001

(unit: Bs.)

Community	Installed Households			Initial Payment			Monthly fee		
	Original Installation	As of Dec. 2000	As of April 2001	Total amount (A)	Payment up to April	% (B/A)	Total amount (C)	Payment up to April	% (D/C)
Calteca	12	10	10	6000	2600	43.33%	3080	1732	56.23%
Chiarumani	26	6	5	3000	1300	43.33%	1540	588	38.18%
Muruchapi	23	22	22	13200	2700	20.45%	6776	1254	18.51%
Millo	37	30	30	18000	1450	8.06%	8580	682	7.95%
Catavi	12	12	12	7200	600	8.33%	3432	726	21.15%
C.C. Alto	3	3	3	1800	650	36.11%	858	220	25.64%
Hiruyo	27	19	7	4200	350	8.33%	2156	1170	54.27%
Llallagua	14	14	4	2400	200	8.33%	1232	270	21.92%
Sipe Sipe	25	1	1	600	600	100.00%	308	300	97.40%
Calacachi		32	41	24600	16250	66.06%	3410	1914	56.13%
Stgo. De Llallagua		-	7	4200	1950	46.43%	462	330	71.43%
Canuma		-	13	7800	7800	100.00%	858	638	74.36%
Schools Sica Sica		-	5	3000	-	0.00%			0.00%
Removed		30	18		4300			12176	
Plaza Sica Sica		-	1	-	-		22	-	0.00%
VMEH	1	1	1						
Spare	20	20	20						
Total	200	200	200	96000	40750	42.45%	32714	22000	67.25%

Source:JICA Study Team

Plaza Sica Sica : 1 system installed in April 2001

Schools Sica Sica : 5systems installed in April 2001, 5systems installed in May 2001

Initial payment @Bs.600 x 10 = Bs.6000 paid in May from Sica Sica Municipality

Spare: 2 systems to be remained as spare before the end of August 2001

Table7.5 Payment in Oruro

As of May End 2000

(unit: Bs.)

Community	Installed Households			Initial Payment			Monthly fee		
	Original Installation		As of May 2000	Total amount (A)	Payment up to May 2000 (B)	% (B/A)	Total amount (C)	Payment up to May 2000 (D)	% (D/C)
Paria Pampita	**18**		**18**	12600	**2200**	17.5	2160	**630**	29.2
Milluni	**23**		**23**	16100	**1150**	7.1	2760	**0**	0.0
Laguna Ancocota	**44**		**44**	30800	**2200**	7.1	5280	**0**	0.0
Minas	**5**		**5**	3500	**1350**	38.6	600	**300**	50.0
Removed									
Spare	**10**		**10**						
Total	**100**		**100**	**63000**	**6900**	**11.0**	**10800**	**930**	**8.6**

Source:JICA Study Team

Table7.6 Payment in Oruro

As of July End 2000

(unit: Bs.)

Community	Installed Households			Initial Payment			Monthly fee		
	Original Installation		As of May 2000	Total amount (A)	Payment up to July 2000	% (B/A)	Total amount (C)	Payment up to July 2000	% (D/C)
Paria Pampita	**18**		**18**	10800	**3400**	31.5	2376	**1092**	46.0
Milluni	**23**		**23**	13800	**2350**	17.0	3036	**990**	32.6
Laguna Ancocota	**44**		**44**	26400	**2600**	9.8	5808	**572**	9.8
Minas	**5**		**5**	3000	**2250**	75.0	660	**432**	65.5
Removed									
Spare	**10**		**10**						
Total	**100**		**100**	**54000**	**10600**	**19.6**	**11880**	**3086**	**26.0**

Table7.7 Payment in Oruro

As of December End 2000

(unit: Bs.)

Community	Installed Households			Initial Payment			Monthly fee		
	Original Installation		As of December 2000	Total amount (A)	Payment up to July 2000	% (B/A)	Total amount (C)	Payment up to July 2000	% (D/C)
Paria Pampita	**18**		**16**	9600	**4520**	47.1	3520	**1327**	37.7
Milluni	**23**		**23**	13800	**6728**	48.8	5060	**3002**	59.3
Laguna Ancocota	**44**		**44**	26400	**11362**	43.0	9680	**3538**	36.5
Minas	**5**		**5**	3000	**2500**	83.3	1100	**1100**	100.0
Removed			**2**		**100**				
Spare	**10**		**10**						
Total	**100**		**100**	**52800**	**25210**	**47.7**	**19360**	**8967**	**46.3**

Source:JICA Study Team

Table7.8 Payment in Oruro

As of April End 2001

(unit: Bs.)

Community	Installed Households			Initial Payment			Monthly fee		
	Original Installation	As of Dec. 2000	As of April 2001	Total amount (A)	Payment up to April	% (B/A)	Total amount (C)	Payment up to April	% (D/C)
Paria Pampita	**18**	**16**	**18**	10800	**5830**	54.0	5544	**2063**	37.2
Milluni	**23**	**23**	**23**	13800	**7228**	52.4	7084	**3422**	48.3
Laguna Ancocota	**44**	**44**	**44**	26400	**12012**	45.5	13552	**4893**	36.1
Minas	**5**	**5**	**5**	3000	**2500**	83.3	1540	**1100**	71.4
Removed		**2**							
Spare	**10**	**10**	**10**						
Total	**100**	**100**	**100**	**54000**	**27570**	**51.1**	**27720**	**11478**	**41.4**

Source:JICA Study Team

Spare: 2 systems to be remained as spare before the end of August 2001

Table 7.9 Average Time using Electric Appliance per Day（unit: hour）

Department	La Paz						Oruro					
Community	Calteca			Muruchapi			Paria Pampita			Laguna Ancocota		
	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01
Fluorescent lamp	2.4	2.5	2.5	2.8	2.9	2.8	2.9	3.1	3.2	2.6	-	2.8
Radio	1.5	1.4	1.6	1.9	1.7	2.2	2.7	2.4	2.5	2.1	-	2.4
Cassette recorder	rarely	rarely	rarely	rarely	rarely	rarely	rarely	rarely	rarely	rarely	rarely	rarely
TV	Not receivable						2.5	2.2	2.4	Not receivable		
Kerosene lamp	2.4	-	-	2.5	-	-	3.0	-	-	2.8	-	-
Total interviewees	5	6	6	15	7	9	14	12	12	8	-	6

Note: * One TV channel from Oruro-city is available.

Source: JICA Study Team

Table 7.10 Sources of Initial Payment & Monthly Fee

Department	La Paz						Oruro					
Community	Calteca			Muruchapi			Paria Pampita			Laguna Ancocota		
	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01
Selling agricultural products				5	2	3	2	2	3	2		4
Selling livestock animals	1	1	1	5	2	2	5	6	5			1
Selling agricultural products & livestock animals		1	1	2	1	2	2	1	1			
Selling livestock animals & Temporary works							1					
Temporary works	1	1	1		1	1	4	3	3			1
Savings				1								
Remittance	1	1	1									
Pension	1	1	1									
Charity	1	1	1	1	1	1						
Not yet paid				1						6		
Total interviewees	5	6	6	15	7	9	14	12	12	8	-	6

Source: JICA Study Team

Table 7.11 Change of User's Life

Department	La Paz						Oruro					
Community	Calteca			Muruchapi			Paria Pampita			Laguna Ancocota		
	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01	Jun-00	Jan-01	May-01
Very well	1	1	1	2	2	2	2	2	2	0		1
Well	3	4	4	11	4	5	10	9	9	6		5
- to spend in a bright room at night	(4)	(5)	(5)	(13)	(6)	(7)	(12)	(11)	(10)	(7)		(6)
- to read a book at night	(2)	(3)	(2)	(8)	(3)	(3)	(5)	(5)	(4)	(3)		(4)
- to do school's homework at night	(2)	(2)	(3)	(7)	(3)	(3)	(5)	(4)	(5)	(4)		(3)
- to sew at night	(1)	(1)	(1)	(3)	(1)	(2)	(3)	(2)	(3)	(1)		(1)
- to take care of a baby at night		(1)	(2)	(2)	(1)	(2)		(2)	(1)	(1)		(2)
- to repair agricultural tools at night		(2)	(2)		(1)	(1)	(1)	(2)	(2)	(1)		(1)
- to converse with family at night	(1)	(1)	(2)	(5)	(2)	(3)	(3)	(3)	(4)	(2)		(2)
No change	1	1	1	2	2	2	2	1	1	2		2
Worse	0	0	0	0	0	0	0	0	0	0		0
Total number of Interviewees	5	6	6	15	7	8	14	12	12	8	-	7

Note: including plural answers

Source: JICA Study Team

FIGURES

DEPARTAMENTO DE
LA PAZ

N

Legend
kWh/m 2
> 6.5
6.0 - 6.5
5.5 - 6.0
< 5.5

0 20 40 60 80 100Km.

ITURRALDE
TAMAYO
FRANZ TAMAYO
LARECAJA
SUD YUNGAS
CARANAVI
NOR YUNGAS
INQUISIVI
LOAYZA
MURILLO
ARCE
VILLARROEL
LOS ANDES
OMASUYOS
SAAVEDRA
MUÑECAS
CAMACHO
MANCO KAPAC
INGAVI
PACAJES
M. PANDO

THE STUDY ON RURAL ELECTRIFICATION
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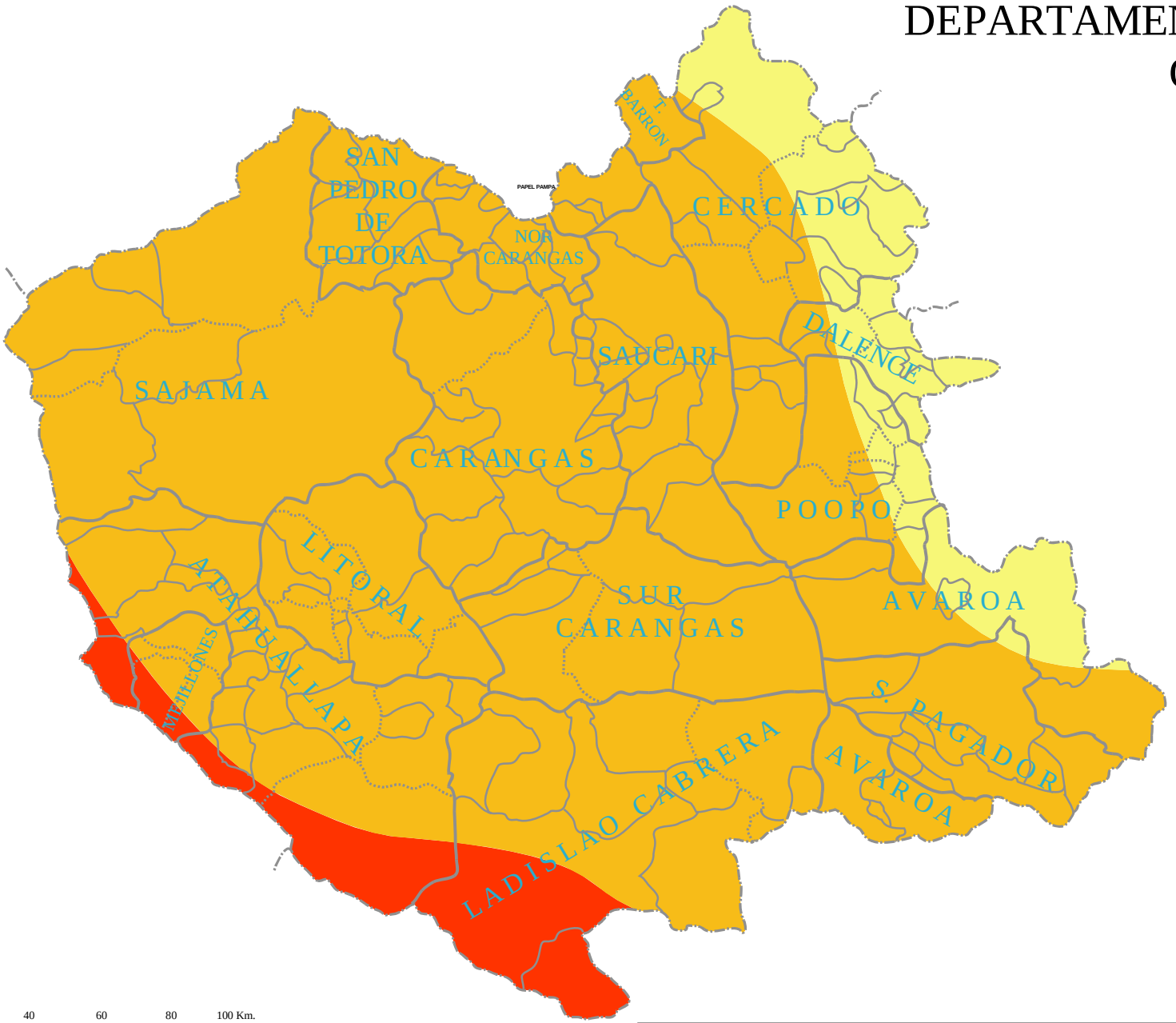
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 8.1

PV Potential Map (La Paz)
(2002-2006, 2007-2011)

DEPARTAMENTO DE ORURO



N

Legend

kWh/m^2

- > 6.5
- 6.0 - 6.5
- 5.5 - 6.0
- < 5.5

0 20 40 60 80 100 Km.

THE STUDY ON RURAL ELECTRIFICATION IMPLEMENTATION PLAN BY RENEWABLE ENERGY IN THE REPUBLIC OF BOLIVIA

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 8.2

PV Potential Map (Oruro)
(2002-2006, 2007-2011)

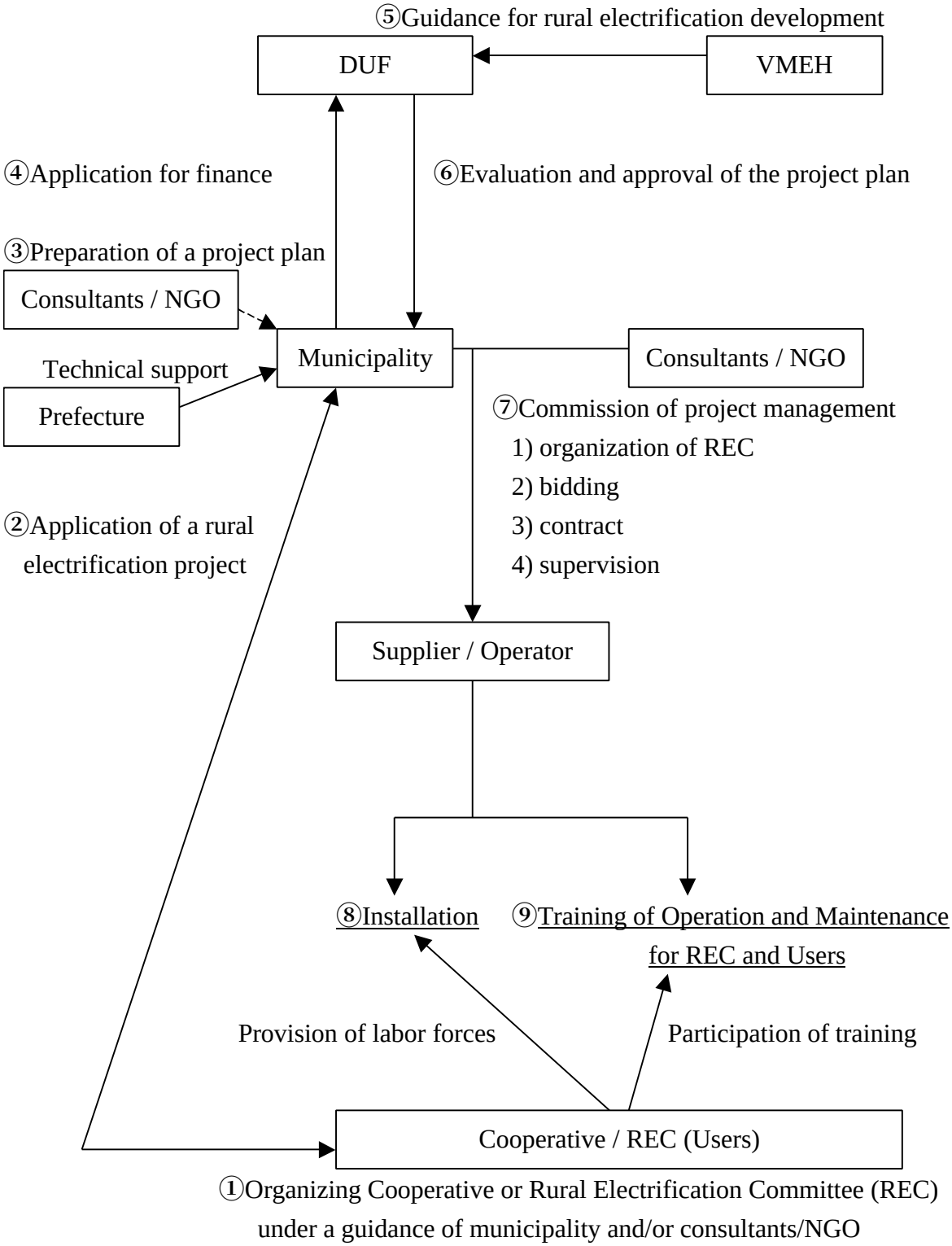


Figure 9.1 Proposed Project Implementation for PV System

Source: JICA Study Team