CHAPTER 8

USING A PV SYSTEM

GOOD PERFOMANCE COMES FROM PROPER OPERATION

Everyone wants to be able to run their TV, radio or lights as long as is desired without running out of power. Unfortunately, unless you have a very large PV panel, there are limits to the amount of time the PV system will operate the appliances before running out of power. How long it will provide power depends on mainly two things: how much energy is going in from the panel and how much energy is going out to the appliances.

ENERGY IN

The amount of energy going in from the panel depends on the amount of sun that shines on the solar panel. When there are many clear days, the high level of sunshine falling on the panel produces much more electricity than when the skies are cloudy. If there have been several cloudy days, then the panels have not been able to charge the battery so well and there is less energy available to operate the appliances. Because the energy in depends on the amount of sun that is shining on the panel, the user has no control over that.

ENERGY OUT

The amount of energy going out of the PV system depends on the amount of power needed to operate the appliances and the length of time that the appliances are turned on.

Different appliances take different amounts of power. A 7W light uses 3 to 4 times as much power as a radio while a TV uses two or more times as much power as a light. What this means is that you can operate a radio 3-4 times as long as a light and use the same energy. So if the PV system is able to power a light for 4 hours, it can power a radio for 12-16 hours. But that same PV system can only power a TV about 2 hours.

If more than one appliance is operated at a time, the energy use for each must be added. So if a light and a radio are operated at the same time, then both can only operate together about 3 hours, less than either the radio or the light by themselves. If a light and a TV are operated together, the two appliances will only operate about 1-1/2 hours before the power is finished.

THE ENERGY BALANCE

As long as the energy in is greater than the energy out, the PV system will keep the battery charged and there is no problem. But if the energy out is greater than the energy in, even by a small amount, the battery will run down and the power will soon shut off. Once the power goes off, it may take from 3 sunny to 10 cloudy days to recharge the battery and regain power.

CONSERVING ENERGY FOR THE BEST USE

Because it takes so long to recover the charge after the power goes off, when it has been cloudy for several days and the amount of energy available to operate appliances is very limited, the electricity should be used only for the purpose most important at that time. If the family wants to watch a TV show, the radio and the lights should be turned off during the show. If there is a need to have the light on, the TV and radio should not be operating at the same time.

AVERAGING THE LOAD

When fully charged, the battery contains enough energy to operate the appliances for several days without any recharging. So it may be possible to use a lot of energy on one day, then on the next use very little so the average power for the two days is the normal usage. So if there is a need to operate a light for 6 hours on one day, then the next day the light should only be operated 2 hours, not 4. If the TV is operated 4 hours on one day, then the next day it should not be operated at all.

So the idea is that if appliance use is unusually high on one day, then the next day its use should be unusually low to compensate. By doing this, it is possible to take extra energy from the battery on special days, but you have to make up for that use the next day by using less energy if you do not want to have your PV system shut off the power.

USING THE RIGHT CONNECTIONS AND WIRES FOR THE APPLIANCES

Any time there is not a good connection for the electricity to flow from the solar system to the appliances, power is lost and the time that the appliances can be operated is reduced. For maximum performance, a proper power plug and proper sized wire has to be used. Inserting bare wires into the power socket, twisting wires together to make a connection or using telephone wire instead of larger electrical wire all cause loss of energy and reduce the time the appliances will operate before the power is shut off at the solar system.

Also, long wires lose power too. So the wire connecting the appliance to the solar system should run as directly as practical to from the appliance to the power point.

KEEP THE APPLIANCES CLEAN

Dirt, dead insects and water or grease all can lower the effectiveness of electrical appliances and cause energy loss. Keep appliances clean, do not cover cooling vents in radios and TVs and keep them out of the sun in order to have the longest life and lowest energy use for your lights, radios and TVs.

CHAPTER 9

MAINTENANCE

INTRODUCTION

For anything to last a long time and work properly, it must be taken care of. A house, a car, even your own body will last longer and perform better if taken care of. This continuing care is called maintenance. Solar PV systems must also be taken care of and require continuing maintenance if they are to last long and work well.

It is always better to keep a boat from leaking instead of waiting until it sinks to fix it. With a solar PV system, it is much better to regularly check everything and to fix small problems before they become big ones.

Because maintenance is so simple and so little seems to be done at each visit, it may seem unimportant. It is not unimportant. The little problems, like little cracks in a boat hull, soon become big problems if not taken care of. By doing the easy task of regular maintenance the big task of major repair is not so likely.

It takes little time and money to regularly maintain a solar PV system but it can take much time and money to repair one once it fails. Regular maintenance is what makes the difference between a PV system that works without problem for years and one which is always breaking down.

WHAT IS DONE DURING REGULAR MAINTENANCE

1) The user is questioned about the operation of the system to see if there are any problems.

The user of the PV system is most familiar with how well it works. Just as when you are becoming sick, you notice changes in the way your body works, when a PV system is starting to have problems, the user will notice changes in the way it works. When changes in system operation are noticed by the user, it is time to do an exceptionally careful check of the system. Even if you find nothing wrong in the system, always write down what changes the user has noticed so if a problem does develop there will be a record of how it started.

2) Every part of the solar PV system is checked for proper operation, cleanliness and good connections.

Problems with any part of the system will cause the entire system to work poorly. In particular, problems with wiring, panels or the controller can damage the battery and greatly shorten its life. Dirt and corrosion always cause problems with electrical equipment. Connections which are loose or corroded will cause problems. Every part should be checked at every maintenance visit.

3) Components that are not in good condition are repaired or replaced

If a component is not working properly, if it is not immediately repaired or replaced with a good unit, the system will not work properly and other components, particularly the expensive battery, may be damaged.

4) The system is checked to be sure that no changes have been made which have not been authorised.

It is not unusual for a user to add more appliances to a solar PV system. Because the system has been carefully designed around the original set of appliances, adding any new appliances will cause the system to have problems and the battery life to be shortened. If more appliances are wanted by the user, sufficient additional panels and a large enough battery MUST *be installed at the same time as the new appliance otherwise the system will soon fail.*

5) A record is made of any action taken during the maintenance visit

Problems with PV systems often develop slowly. If careful records are kept, it will be much easier to know what repairs to make when the system finally does break down. Also, a record of maintenance activities will point out particular components that are not working the way they are supposed to and the manufacturers can be contacted for improvement.

RULES FOR MAINTENANCE

To be useful, maintenance must be carried out on a regular basis. A monthly check is best for batteries though a very thorough check of all components needs to be done at least every six months.

Panels

1. Check the panel mounting to be sure it is strong and well attached. If it is broken or loose, repair it. Be sure if you make a repair that when you are finished that the panel has the correct tilt and is pointed in the right direction.

2. Check to be sure the glass is not broken. If it is, the panel will have to be replaced.

Wires

1. Check the wire covering (insulation) for cracks or breaks. If the insulation is damaged, replace the wire. If the wire is outside the building, be sure and use wire with weather resistance insulation.

2. If someone has added more wires to the system without permission, remove them.

3. Check the connections for corrosion and tightness, particularly at the battery posts.

Controller

1. Check that the controller is still firmly attached. If it is not, attach it properly with screws.

2. Keep the controller clean. If insects are found in the controller area, clean thoroughly with soap and water.

Appliances

1. Turn on each appliance and check for proper operation
2. Check that appliances are mounted properly. If loose or incorrectly mounted, attach them properly.
3. Clean all exposed parts of the appliance. Clean lights so that there is no loss of light due to dirt or bugs in the light.

Battery

1. Check connections for tightness and corrosion. Clean and tighten as needed.
2. Clean the battery with fresh water and a rag.
3. Check each cell with a hydrometer and record the readings.
4. If any cells are low on water, add distilled water to raise it to the proper level. *Never* add more acid, only distilled water. Remember that if anything but completely pure water, like distilled water, is used that the battery may be damaged. *Never* use well water or bottled drinking water.
5. If any of the caps for the cells have been lost or broken, cover the holes loosely with plastic or glass until the proper replacement caps can be provided. Never cover the fill holes with paper, cork, cloth or metal. Never leave the holes uncovered. Be careful that the temporary cover that you install does not plug the holes tightly because the cells must have air.

MAINTENANCE RECORDS

As long as the solar PV system is working well, maintenance records have little value but they become very important when something goes wrong. By looking at the maintenance records it is often possible to immediately figure out what is wrong with a system. It is also possible to see problems developing with batteries and appliances by looking at properly kept maintenance records. Maintenance records are also proof that you have properly taken care of the system.

Records are kept on a form filled out in duplicate. One copy stays with the system in a plastic protective bag and the other is sent to the field technician's supervisor. Be sure to carefully complete all parts of the form. It is important to know all the things listed if there is to be a full understanding of how well the system is working.

CHAPTER 10

TROUBLESHOOTING AND REPAIR

INTRODUCTION

Properly designed, installed and maintained solar PV systems are very reliable and have a long trouble free life, but sooner or later there will be a failure. The process of determining what has caused the failure is called troubleshooting. The process of making the system work properly again is called repair.

TYPES OF SYSTEM FAILURES

There are three different types of solar PV system failures:

Failure Type 1:

The system stops working entirely. No appliances work.

Failure Type 2:

Some appliances work normally, others do not.

Failure Type 3:

The system works sometimes but runs out of power too quickly.

Each type of system failure has a different type of cause and troubleshooting methods are different.

FAILURE TYPE 1: TOTAL SYSTEM FAILURE

When the system fails completely, it is usually due to a broken wire, bad connection or a controller failure. The problem is to isolate the fault in the system. The first thing to check is the battery charge using a hydrometer or voltmeter.

DISCHARGED BATTERY

If the battery is discharged, the fault lies between the battery and the panel. Disconnect the leads to the panel terminals of the charge controller. When the sun is out, use an meter or indicator lamp and check for panel power at the disconnected leads. First check the voltage. For a 12 V system it should be over 14 Volts. For a 24 Volt system it should be over 28 V. If no voltage is present, there is a break in the wire or a bad connection in the panel circuit.

If the Voltage measures o.k., check the available current from the panels. If the sun is shining, there should be at least one Ampere of current available for every panel installed in a 12 V system. So if there are four panels, you should measure at least four Amperes of current. In a 24 V system there should be at least one Ampere of current for every two

panels installed. Then if there are four panels installed you should measure at least 2 Amperes of current. If this test is not passed, it is likely that there is a corroded or loose connection somewhere between the controller and the panels. It is also possible that one or more wires connecting panels in parallel have come loose or are broken.

If the voltage and current readings are o.k., reconnect the panel wires to the controller. Check the voltage at the battery connections on the controller when the sun is shining. If the voltage is the same as the battery voltage, the charge controller probably has failed and should be replaced. If the voltage is different from the battery voltage, the wires between the controller and the battery should be checked carefully for breaks or loose connections.

Though it is possible that the battery has failed, it is not likely and the panels, wires and controller should be eliminated as problems before suspecting the battery. One type of battery failure which can cause this problem is if one cell of the battery is shorted or so damaged that it cannot be charged. This will be obvious in an open cell battery since the bad cell will show a much different reading than the other cells. Often a damaged cell will have cloudy electrolyte or a white scum on the electrolyte. In a maintenance free battery, it will be necessary to connect the suspect battery to a working solar panel and see if it will take a proper charge. If the maintenance free battery refuses to take a charge when connected to a solar panel for several sunny days, it is bad and must be replaced.

CHARGED BATTERY

When the battery is charged even though the appliances do not work, it is most likely that a wiring fault exists between the battery and the appliances.

To isolate the fault, first use a meter to check the voltage at the load connections on the discharge controller. If the meter shows that there is voltage about equal to the battery voltage, the fault probably lies in the wiring between the controller and the appliances. If the voltage is zero or much lower than the battery voltage, the discharge controller may not be working. As a check, disconnect the load wires and briefly touch them to the battery terminals of the controller. If there is a significant spark or noise when the terminals are touched, the load wires may be shorted together or one of the appliances short circuited and must be repaired. If no wiring faults are found, disconnect each appliance one at a time to see if removing the appliance from the circuit clears up the fault. If it does, that appliance should be checked for shorts or wiring problems. After the wiring or appliance fault is repaired, the controller still may not work. Check any fuses or circuit breakers in the controller since the short in the load circuit may have caused them to open. The short may have damaged the discharge controller and it may have to be replaced. To be sure, now perform the following checks.

If there is no spark or noise when the battery terminals are touched by the load wires, temporarily connect the load wires to the battery terminals and see if the appliances work properly. If they work, the discharge controller is not functioning and should be replaced.

FAILURE TYPE 2: SOME APPLIANCES WORK SOME DO NOT

This type of failure rarely is due to PV panel, controller or battery failure. It is almost always either a problem with the appliances themselves or with the wiring between the discharge controller and the appliances.

Disconnect each appliance that is not working properly and connect it directly to a charged battery. If the appliance works properly, carefully check the wiring between the discharge controller and the appliance for breaks, corrosion and loose connections. Also be sure that the wire is the right size for the appliance. It may have been changed or extended and the new wire is too small for the appliance.

FAILURE TYPE 3: THE SYSTEM WORKS BUT RUNS OUT OF POWER

This is the most common problem with solar PV systems and can be caused by many things acting alone or in combination.

This type of failure is an indication that there is not enough charge in the battery to operate the appliances as long as the user desires. This can be caused by:

1) **Too little charge from the panels.** This can be due to shading, damaged panels, wiring problems or dirt on the panels.

Corrective Action: Remove the cause of the shade or move the panels so they are no longer shaded, replace the panels if damaged, fix the wires or clean the panels.

2) **Adding more or larger appliances to the system.** This takes more energy from the battery than the system was designed for and causes the battery to discharge too quickly.

Corrective Action: Add more panels and increase the battery capacity or remove the extra appliances.

3) **Operating the appliances longer than originally intended.** This takes more energy from the battery than the system was designed for.

Corrective Action: Add more panels and increase the battery capacity or the user must reduce the time appliances are used to that originally designed for.

4) **Incorrect adjustment of the charge controller.** This prevents the battery from attaining full charge. This is determined by letting the battery charge for several sunny days without using the load at all. Then check the battery voltage. If it is less than the full charge voltage it indicates that the controller disconnects the panels from the battery before full charge is reached.

Corrective Action: Replace the controller and send the mis-adjusted unit for repair.

5) **Incorrect adjustment of the discharge controller.** This causes the appliances to be disconnected from the battery before the allowable charge has been taken from the

battery. If the battery shows more than half charge voltage when the appliances go off, the discharge controller is probably out of adjustment.

Corrective Action: Replace the controller and send the mis-adjusted unit for repair.

6) **The battery is getting weak and no longer can store sufficient charge to operate the appliances the full time.** This can be determined through a battery Ampere-hour capacity test. The battery should be suspected if one or more cells show readings much different from the others or the battery is more than four years old. If the battery is less than four years old, its failure may have been caused by another problem in the system. Any time a battery that is less than four years old must be replaced, check the rest of the system very carefully, be sure that the panels are not being shaded part of the day and be sure that the user is not trying to take more power from the system than it was designed to deliver. All of these things may have seriously shortened the life of the old battery and if allowed to continue will ruin the new battery as well.

Corrective Action: Replace the battery but monitor the replacement carefully. If after the first month the system once again does not seem to be providing power as long as expected, one of the other five reasons for failure exists and must be corrected or else the new battery will also be rapidly weakened and fail.

BATTERY REPLACEMENT

Persons who do not know about the way a solar PV system works often replace the battery any time the system is not working properly. Sometimes the old battery was not bad at all and in a few weeks the system will once again stop working properly because something else is wrong. Other times the battery has gone bad because of another problem and replacing the battery with a new one will make things work for a while but unless the other problem is fixed, the new battery will wear out quickly.

The battery is not only the most expensive part of the solar system, it is also the part most easily damaged. Any time you must replace a battery, especially if that battery is less than four years old, always check the other components to see if they are working properly and always check to see if the appliances and their use are what was originally intended.

Most early battery failures can be traced to either too much shading on the panels or having too few panels in the installation. If shading is not a problem the system size may be too small for the load being applied. Any system which seems to wear out batteries too fast should be checked for proper controller adjustment and if that is correct, more panels should be added and the battery increased in size when next replaced.

SUMMARY

The components used in properly designed solar PV systems are usually reliable if not mistreated. Most of the problems encountered with solar PV systems are due to installing too small a system for the needs of the user, excessive shading of the panels, and unauthorised changes to the system which cause damage or excessive power drains. When a system must be repaired, always check for shading problems, sizing problems and for

unauthorised changes to the system. Part of repairing the system must be to correct the problems which contributed to the failure. Eliminate shading problems, increase system size where needed and remove modifications to the system which are not authorised by the designer.

APPENDIX - 3

FINANCIAL EVALUATION

GOVERNMENT OF ZIMBABWE GLOBAL ENVIRONMENTAL FACILITY (GEF) SOLAR PHOTOVOLTAIC (PV) PROJECT (ZIM 92/G31)

AGREEMENT

BETWEEN

The Government of Zimbabwe;

AND

The United Nations Development Programme

AND

Zimbabwe Electricity Supply Authority (ZESA)

Relating To

Solar Photovoltaic for Household and
Community Use in Zimbabwe (ZIM/92/G31)

[xesamou]

1.0 General

1.1 This Memorandum expresses the understanding of the United Nations Development Programme (hereinafter referred to as UNDP), The Government of Zimbabwe (hereinafter referred to as GOZ), and The Zimbabwe Electricity Supply Authority (hereinafter referred to as ZESA) concerning the responsibilities and contributions of the participating parties in the establishment and operation of a utility based delivery mode of home and community use solar electric systems, under the Solar Photovoltaic Project for Household and Community Use in Zimbabwe (ZIM/92/G31) (hereinafter referred to as Project) with the aim of addressing Global warming : using solar photovoltaic electric systems for rural electrification.

1.2 Joint reviews of this agreement will be carried out every 6 months by UNDP, ZESA and Ministry of Transport and Energy.

2.0 Executing Authorities

The Executing Authorities for the ZESA Solar Installation Facility will be:

a) The United Nations Development Programme (UNDP)

b) The Ministry of Transport and Energy through the Department of Energy (hereinafter referred to as DOE):

c) Zimbabwe Electric Supply Authority (ZESA)

3.0 Objectives of the Project:

3.1 To finance solar electric energy as an alternative source of energy to farmers and other consumers in the communal, resettlement and small scale commercial areas;

3.2 To make solar components and modules more readily available on the local market;

3.3 i) To supply households, communities and institutions in the rural areas with solar electric systems, in cases were grid connections is not feasible in the forseable future.

ii) Each installation shall be within the range of five to fifty thousand Zimbabwe dollars.

4.0 Financial Administration

4.1 The ZESA Solar Project will derive its funds from the following sources;

- Zimbabwe currency equivalents of the cost of importation of solar equipment
- Payment for system installation by customers and use by customers
- Interest earned on investments of funds
- Direct seeding of the fund by ZESA to cover the initial cost of administration
- Direct seeding by the project

4.1 The funds available in the ZESA Solar Project will be applied as follows;

- Financing of ZESA Solar Project revolving fund
- Administration of the Solar Project
- The Inspectorate and Research Fund
- Solar electric system Insurance Protection Scheme
- The stabilization fund

4.2 Funds for the financing of the ZESA Solar Project will be provided by UNDP and ZESA will provide initial administrative costs. The revolving fund will take over after the initial capital outlay for the pilot scheme is in place.

5.0 ZESA Solar Project Administration

5.1 It shall be the responsibility of ZESA to open a bank account to administer the ZESA Solar Project.

5.2 The ZESA Solar Project shall benefit credit worth customers within the following categories.

a) Groups of farmers and/or established co-operatives;

b) Domestic and commercial customers in rural areas

c) Individual farmers;

e) Rural institution;

f) Any other eligible persons and/or ventures identified by ZESA.

5.3 Clients who propose to use the PV systems for viable projects will be given to priority in the provision of service.

5.4 The Scheme shall have a minimum repayment period of least five years and maximum repayment period of ten years.

5.5 ZESA shall design an appropriate tariff to be paid for the service. The tariff shall be reviewed annually by ZESA.

5.6 The client will pay a total of 16% annual interest rates Which is composed of the following elements;

- ZESA administration
- Stabilization Fund
- Contribution to the capital base of the fund
- The Inspectorate and Research Fund
- Insurance Protection Scheme

5.7 ZESA shall register Insurance Protection Scheme or/and shall stipulate in the loan Agreement with the end user any other provisions to protect the solar electric system from theft and vandalism thereto as loan security.

5.8 The procedure for system installation will be as follows;

i) Client fills in ZESA application forms and submits them to their nearest ZESA office.

ii) Upon approval of the application by ZESA, the Client is notified to pay his deposit and ZESA simultaneously notifies the client on the connection schedule.

iii) Upon approval of the technical submissions by the client, ZESA will proceed to install or will subcontract the installation.

iv) Client and ZESA sign a completion of work form.

v) ZESA inspects and pays contracted solar installing company and submits data to the PMU for records.

vi) The PMU at its descition inspects the work completed.

5.9 In case of default ZESA shall disconnect the system and institute legal procedures to recover the owed amount and effect disconnection. The PMU shall be informed so as to update their records. After recovering of the costs, if there still remains some residual debt ZESA will clear the debt form the Stabilization Fund.

5.10 ZESA shall produce half yearly (in March and September) statements on the credit Facility account as well as audited annual statements for submission to PMU.

5.11 All loan repayments including interest receivable shall be credited to the Credit Facility Account.

5.12 Any excess funds will be invested by ZESA. The income from such investments will be credited to the Facility on the basis of the prevailing AMA Bill rate.

5.13 The Stabilization Fund will cover the Credit Facility on bad debts in the event of default by untraceable clients.

5.14 All clients for the Project will pay a %age contribution to the capital base of the fund.

5.15 Solar electric system Insurance protection Scheme guarantees payment of the loan in the event of the death of clients aged 65 years and below. Insurance Claims must be lodged with Insurers within 6 months of date of death.

6.0 Warranty

6.1 The quality of the solar equipment is guaranteed and warranted by ZESA as per the DOE/GEF Solar Project Interim standards.

6.2 The client ZESA or PMU shall promptly notify the Local supplier of any claim arising under equipment guarantees and warranties.

6.3 Upon receipt of such notice, the Local Supplier shall, with all reasonable speed, replace or repair the defective goods, without costs to the client.

7.0 Patent Rights

7.1 The ZESA shall indemnify the client against all third party claims of infringement of patent, trademark or industrial design rights arising from the use of the system or any part thereof in Zimbabwe.

8.0 Maintenance and Repair of Systems

The ZESA will maintain and replace the panels, batteries charge controller and the accessories that goes together with the above items. The customer shall be responsible for the maintenance of internal fixtures.

9.0 User Training

It shall be responsibility of ZESA to provide basic training to the users on the operation and basic maintenance of the system as provided under Exhibit 3. The cost and expenses of such training shall be borne by the Facility.

10.0 Settlement of Differences and Termination of this Understanding:

All parties undertake to settle amicably by consultation any differences arising under or in relation to this agreement, Failing Agreement, this Agreement shall be terminated by either party giving three months notice of intention to terminate. All parties mutually undertake not to terminate this Agreement within the first 12 months from the date of signing.

11.0 Amendments

Amendments to this Memorandum may be made at any time by Agreement through an exchange of letters between the signatories.

SIGNATURES

Signed AT .....

this ..... Day of .....

FOR Government OF ZIMBABWE Date

FOR THE UNDP Date

FOR ZINBABWE ELECTRICITY SUPPLY AUTHORITY

WITNESSED BY

DIRECTOR OF THE DEPARTMENT OF ENERGY Date

NATIONAL PROJECT MANAGER Date

Appendix 3-2

GOVERNMENT OF ZIMBABEW GLOBAL ENVIRONMENTAL FACILITY(GEF)
SOLAR PHOTOVOLTAICS (PV) PROJECT (ZIM/95/G31)

MEMORANDUM OF UNDERSTANDING

BETWEEN

Government of Zimbabwe

The United Nations Development Programme

AND

BIOMASS USERS NETWORK (BUN)

Relating To The NGO Delivery Mode

Solar Photovoltaics for Household

and

Community Use in Zimbabwe (ZIM/95/G31)

[BUN MOU]

1.0 General

1.1 This Memorandum expresses the understanding of the United Nations Development Programme (hereinafter referred to as UNDP), The Government of Zimbabwe (hereinafter referred to as GOZ), and Biomass Users Network (herein referred to as BUN) concerning the responsibilities and contributions of the participating parties in the establishment and operation of an NGO delivery mode of the home and community use solar electric systems, under the Solar Photovoltaics Project for Household and Community Use in Zimbabwe (ZIM/92/G31)(hereinafter referred to as Project) with the aim of addressing Global warming using solar photovoltaic electric systems for rural electrification.

1.2 Joint reviews of this agreement will be carried out every 3 months at Technical Operations Officer level and every 6 months at National Manager level by UNDP,BUN and Ministry of Transport and Energy through the Project Management Unit(PMU)

1.3 At the expiration of the GEF Pilot phase the responsibilities of the PMU will revert to the Department of Energy(DOE) Ministry of Transport and Energy.

2.0 Parties to the Memorandum of Understanding

Parties to the Memorandum for BUN Solar Installation delivery mode will be:

a) The United Nations Development Programme (UNDP)

b) The Ministry of Transport and Energy through the Department of Energy (hereinafter referred to as DOE) - GEF Executing Agency,

c) Biomass Users Network(BUN)

3.0 Objectives of the Project:

3.1 To finance and disseminate solar electric energy as an alternative source of energy to rural groups and other consumers in the communal, resettlement and small scale commercial areas;

3.2 To make solar components and modules more readily available on the local rural market:

3.3. 1. To supply households, communities and institutions in the rural areas with solar electric systems in cases where grid connection is not feasible in the foreseeable future with particular reference to low cost solar systems.

2. Each installation shall be within the agreed rates for the NGO mode(Annex).

4.0 Financial Administration

4.1 BUN Solar Project will derive its funds from the following sources:

1. Payment for systems installation by customers
   - non refundable application free of $30.00
   - a minimum deposit of 25% of the full system cost
   - installments
   - interest on loans of 15% annually
2. Interest earned on investments of funds

4.2 The funds available in BUN Solar Project will be applied as follows:

1. Repayment to the main fund of the Project
2. Financing of Solar Project systems
3. Administration of the Solar Project
4. Stabilization of capital base
5. Solar electric system default insurance cover

4.3 Funds for financing BUN Solar Project will be provided by UNDP and BUN will meet initial administrative costs. The finance scheme will operate after the initial capital outlay for the pilot scheme is in place.

5.0 Equipment Drawdown

5.1 BUN's total allocation of $ 665 000.00 (to install 200 equivalent 45 Watt solar systems) comprises imported and local equipment, and an allocation for balance of systems which shall be drawn as cash. The detailed allocation breakdown shall be:

1.	Imported components	$395 000
2.	Local Components	$270 000
3.	Balance of systems allocation in cash	$120 000*(included in 2)*

5.2 PMU reserves the right to be allocate the above amounts so as to ensure balanced allocation of solar system components.

5.3 Drawdown of components under 5.1.1 and 5.1.2 shall be quarterly at a rate to be determined by the BUN Business Plan and the intensity of the installations in the field. Such drawdown should be completed by June 1997.

5.4 Balance of system cash shall be drawn in two tranches as follows:

15 August 1996	$80 000
2 January 1997	$40 000

5.5 BUN undertakes to use the funds or equipment provided above solely for the Project NGO delivery mode execution.

5.6 BUN shall create a sustainable solar revolving fund from net earnings not used to repay the Project.

5.7 Subsequent equipment disbursements will be made upon acknowledgment by GEF PMU of satisfactory performance by BUN.

5.8 BUN shall install at least 200 equivalent 45 Watt solar systems as per DOE/GEF standards and specifications.

6.0 Repayments

6.1 BUN will repay the GEF Solar Project by the 15th of each month through the AFC GEF Solar Project fund account. The amount to be repaid shall be the total allocated, that is $665 000. No interest shall be charged.

6.2 50% of net earnings per month shall be repaid to the GEF Solar Project after a grace period of 8 months until full payment is realized from the date of signature of the MOU to allow BUN to build up a sufficiently large revenue base through installation of solar systems. The last installment shall be on 31 December 2000.

6.3 In the event that the repayment conditions mentioned in 6.2 are not met, Government of Zimbabwe will reserve the right to terminate the MOU and/or institute legal proceedings against BUN to recover monies owed.

7.0 BUN Solar Project Administration

7.1 It Shall be the responsibility of BUN to open a separate bank account to administer BUN Solar Project.

7.2 BUN Solar Project shall benefit credit-worthy customers within the following categories:

1. Individual rural groups.
2. Established co - operatives.
3. Business establishment in rural areas.
4. Rural institutions (schools, clinics, churches and community halls).
5. Other categories of consumers which will be considered on merit through consultation with PMU and BUN.

7.3 Clients who propose to use the PV systems for viable projects will be given top priority in the provision of service.

7.4 The Scheme shall have a maximum repayment period of three years.

7.5 The applicable cost to be paid for the installed system in detailed in annex x.

7.6 The client will pay a total of 15% annual interest rate which is composed of the following elements:

1. 10% BUN administration fee
2. 3% Stabilization Fund/Insurance Protection Scheme to be retained as part of the main BUN fund
3. 2% Contribution to the capital base of the fund shall also be part of the main fund

7.7 BUN shall register Insurance Protection Scheme and/or shall stipulate in the loan agreement with the end-user any other provisions to protect the solar electric system from theft and vandalism thereto as loan security.

7.8 The procedure for system installation will be as follows:

1. Client fills BUN application forms (Annex xx) and submits them to the BUN office together with a non-refundable application fee of Z$30.00 (to be reviewed jointly from time to time by PMU and BUN.

2. Upon approval of the application by BUN the Client is notified to pay his/her deposit.

3. The details required from the client include the following:

   Customer Data

   * Name
   * Postal Address
   * Site District
   * Site Ward
   * Nearest Town

   Next of kin

   * Name
   * Postal Address

   Written Directions to Site

The completed application forms should include the following to be prepared by the installer:

* Floor Plan of House.
* Location of Battery, Controller, Lights, Socket Outlet.
* Nearby Shading Objects.
* Proposed Location and Type of Solar Module.

* Indication of North Direction.

- Solar Electric System Quotation (listing all system components and itemized prices)

- Battery Charge Utilization Table (see Annex xxx)

4. Upon approval of the technical submissions by BUN, BUN will proceed to install or will subcontract a local company to install the solar system.

5 The PMU reserves the right to inspect and or approve, or disapprove pending modification, or condemn the quality of the installation. BUN is expected to establish its own inspection scheme. Condemned systems should be rectified or future disbursement shall be withheld.

6. Client and BUN sign a Completion of Work form. A copy of the COW form and application form will be submitted to the PMU.
(Annex xxxx).

7.9 BUN shall produce half yearly (in June and December) statements on the Facility account, as well as audited annual statements for submission to PMU, starting December 1996. The December and June reports are due on the subsequent 15th of January and 15th of July respectively.

7.11 All BUN loan repayments from endusers including interest receivable shall be credited to the BUN Solar account.

7.12 Any excess funds will be invested by BUN in short non risk investment portfolios. The income from such investments will be credited to the BUN Solar account.

7.13 The Stabilization Fund is a provision for bad debts and its utilization shall be jointly sanctioned by BUN and PMU. The residual funds in the year 2000 will be remitted to the main GEF/AFC account.

7.14 All Clients for the Project will pay 2% capital base contribution to the BUN Solar account.

7.15 Solar electric system Insurance Protection Scheme guarantees payment of the loan in the event of the death of clients aged sixty five years and below Insurance Claims must be lodged with insurers within 6 months of date of death. For clients older than 65 years they should have their credit guaranteed by a person below 65 years of age.

8.0 Warranty/Guarantee

8.1 BUN shall guarantee and warranty the quality of the solar equipment is as per the DOE/GEF Solar Project Interim Standards (Annex 5x).

8.2 BUN or PMU shall promptly notify the supplier of any claim arising under equipment guarantees/warranties.

9.0 Patent and other Rights

9.1 BUN shall indemnify the client against all third party claims of infringement of patent, trademark or industrial design rights arising from the use of the system or any part thereof in Zimbabwe.

10.0 Maintenance and Repair of Systems

For the first year after installation BUN shall undertake after sales service with transport cost charged to clients.

11.0 User Training

It shall be the responsibility of the PMU to provide basic training to BUN on the operation and basic maintenance of the system as provided for under annex 5x.
The cost and expenses of such training shall be borne by the (PMU).

12.0 Settlement of Differences and Termination of this Understanding:

All parties undertake to settle amicably by consultation any differences arising under or in relation to this Agreement. Failing concurrence, this Agreement shall be terminated by either party giving three months written notice of intention to terminate. All parties mutually undertake not to terminate this Agreement within the first 6 months from the date of signing.

13.0 Amendments

Amendments to this Memorandum may be made at any time by agreement through an exchange of letters between the signatories. Annexures to this Memorandum from an integral part of it.

SIGNATURES

Signed AT ....., this ..... Day of 1996

RECOMMENDED BY:

NATIONAL PROJECT MANAGER (GEF)	Date

APPROVED BY:

DIRECTOR OF THE DEPARTMENT OF ENERGY(GOVERNMENT OF ZIMBABWE)	Date
UNDP (RESIDENT REPRESENTATIVE)	Date
COUNTRY DIRECTOR(BUN)	Date

AFC Solar Energy Loan Statistics

	Loans Received		Loans Granted		Value of Loans Disbursed (ZSM)	No. of Clients Assisted (ZSM)
	No.	Value(Z$M)	No.	Value(Z$M)		
1993-94	540	4.418	451	2.790	0.595	450
1994-95	1094	10.062	845	7.490	6.254	839
1995-96	1065	11.326	767	6.906	4.175	767
1996-97	2034	23.592	1407	12.895	5.061	1612
1997-98*	261	3.538	153	1.706	0.280	153
TOTAL	4994	52.936	3623	31.787	16.365	3821

**Statistics from March to June 1997 only.*

Study on the Promotion of Photovoltaic Rural Electrification
In the Republic of Zimbabwe
JAPAN INTERNATIONAL COOPERATION AGENCY
Questionnaire

1. Name of Company _____
2. Contact Address and Phone/Fax #'s: _____

_____

_____

3. Nature of Business.(e.g.PV module supplier, installer)

_____

4. Start of operations(date)_____
5. Size of Company

5.1 Number of Employees(as of May 1997)

- ☐ 1-20 employees
- ☐ 21-60 employees
- ☐ 61-100 employees
- ☐ More than 100 employees
  How many? _____

5.2 Net Assets

- ☐ Less than US$5,000
- ☐ US$5,001_10,000
- ☐ US$10,001_20,000
- More than US$20,000

5.3 Net Revenue

- ☐ Less than US$5,000
- ☐ US$5,001_10,000
- ☐ US$10,001_20,000
- More than US$20,000

6. Since commencing your business, have you ever availed of any loan from a bank or financial intermediary to fund your operations?

☐ Yes ☐ No

7. If your answer to #6 is yes,

7.1 What kind of financial institution did you approach?

- ☐ Commercial bank
  _____(name of bank)
- ☐ State-owned financial intermediary
  - ☐ Agricultural Finance Corporation
  - ☐ Small Enterprise Development Corporation
  - ☐ Zimbabwe Development Bank
- ☐ Others_____

7.2 For what specific purpose did you use the loan?(e.g. bulk purchase of PV panels, purchase of equipment, expansion of existing facilities, etc.)

7.3 What were the terms for the loan?

Repayment Period _____

Interest Rate _____

Required Physical Collateral _____

Others _____

7.4 How many times have you availed of such kind of loan facility?

☐ Once ☐ Twice ☐ Three or more times

7.5 Do you intend to continue availing of this kind of loan facility in the future?

☐ Yes ☐ No ☐ Not sure

8. If your answer to #6 is no, what is the main source of your working capital?

☐ Own funds

☐ Other funding source

_____

9. In your opinion, what are the biggest constraints that PV companies in Zimbabwe are currently facing in terms of credit availment?

☐ High interest rate

☐ Stringent collateral requirements

☐ Short repayment period

☐ Others

_____

_____

_____

10. What kind of finance-related support should government extend to the local PV industry?

☐ Set up credit guarantee facility for PV companies

☐ Facilitate creation of special credit facilities catering to small PV enterprises in commercial banks & other lending institutions,
i.e., loans with more flexible terms such as lower interest rates, longer repayment periods, etc.

☐ Introduce more incentives such as removal of sales tax on PV panels

☐ Others

_____

_____

_____

_____

APPENDIX - 4

SPECIFICATION OF JICA CONTROLLER

DOE/JICA P.V SYSTEM CHARGE CONTROLLER OCD-03

[1] : OCD-03 SPECIFICATIONS AND INSTALLATION PRECAUTIONS

1.Working Voltage & Current Range

Normal: DC12(v) Max: DC23(v) (open voltage)

Electric Current Consumption DC 2 0 (mA)

2. Working Temperature Range

0-45deg/C

3. Charge and Discharge Control Current

PV Charge Current 8(A)

Supply Current Load 10(A)

4. Charge and Discharge Control Voltage

Parameter	Deep Cycle Battery	Automotive Battery
Panel Disconnect HVD	14.5 (v)	14.5 (v)
Panel Reconnect HVR	13.0(v)	13.0(v)
Load Disconnect LVD	11.5(v)	11.7(v)
Load Reconnect LVR	12.5(v)	12.7(v)

5. Battery Charge Indicator - Indications only when button is pushed

LED Yellow Fully Charged

LED Green Working Range

LED Red Over-discharge Range

The LED indicator will display only when the SW push button is depressed

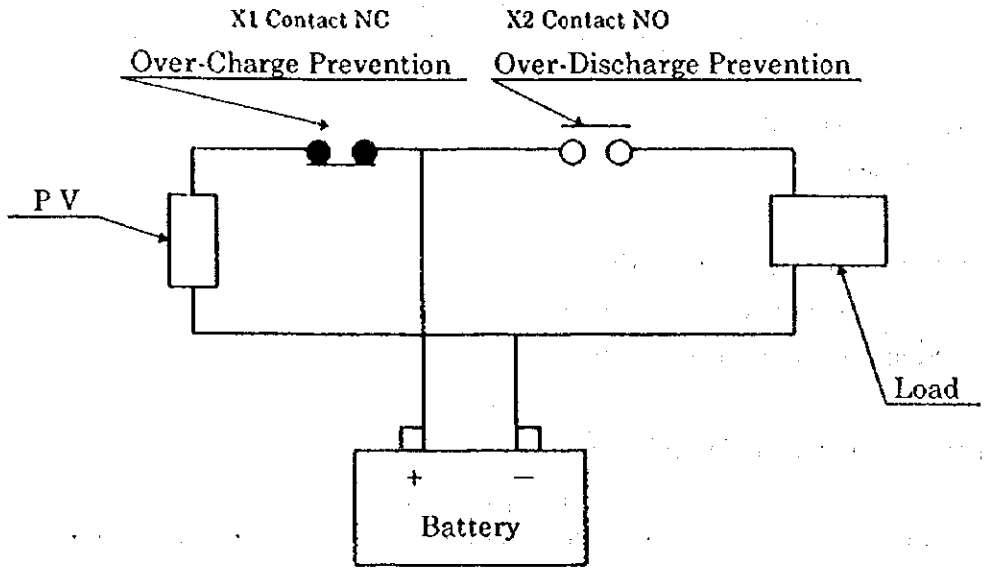
6. Fuse For Automobile use 10(A)

7. Connection Terminal (Pin terminal usage)

Solar Batteries	2	+ —
Battery	2	+ —
Load use	2	+ —

8. Receiving Box Internal Wall attachment

9. Relay Contact Explanatory Diagram



[2] Precautions for Wiring Installation

IMPORTANT PRECAUTION

If the battery only is removed from the system charge controller during use, the PV open voltage (DC22v) will be supplied by the load apparatus. Please take care as such action will result in damage to this apparatus.

1. Disconnecting the Load-side Electrical Equipment

Be sure to disconnect all load apparatus (lighting apparatus, radio cassettes and voltage reduction apparatus for radio cassettes, televisions, and other electrical apparatus) when installing the charge controller.

2. Connection Sequence

First: Connect the battery to the battery terminal

Second: Connect the PV to the PV terminal

Third: Connect the load to the load terminal

3. Precautions with Plus/Minus Polarity

Take care with plus minus polarity when connecting each of the terminals.

Faulty connection will result in damage to apparatus.

4. Pin Terminal Use

Use pin terminals for connecting each terminal, and be sure that each is completely connected.

5. Electric Charge Check

Confirm electric charge at clamp meter after wiring is completed.

6. Charge Display LED Check

Press switch to check the LED light.

[3] Precautions for Users

After completing all connections, please explain the following precaution to users.

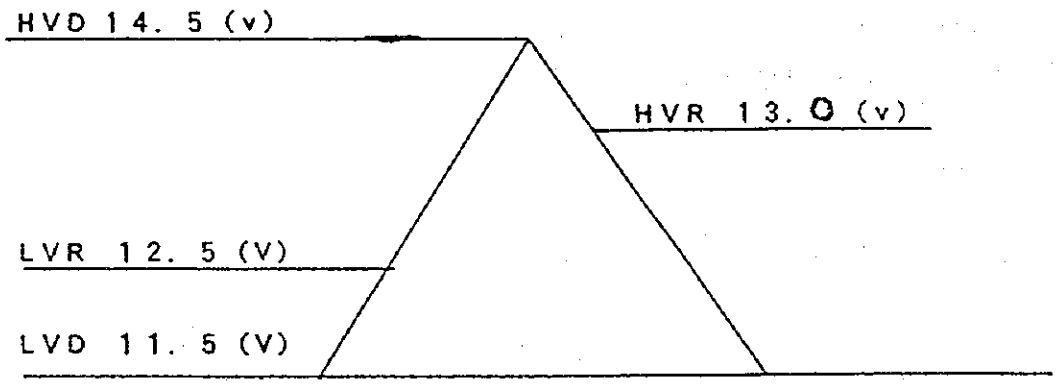
Do not remove the battery from the PV system. If the battery is removed the solar current open voltage (DC22v) will be supplied To the apparatus. As this will result in damage to the apparatus, please explain this point clearly.

Notice : Attached To The Charge Contollore Box

Precautions for Users
After completing all connections, please explain the following precaution to users.
Do not remove the battery from the PV system. If the battery is removed the solar current open voltage (DC22V) will be supplied to the apparatus. As this will result in damage to the apparatus , please explain this point clearly.

CURRENT CONSUMPUTION OF CHARGE CONTROLLER OCDP-02 AT DIFFERENT VOLTAGE SETPOINTS

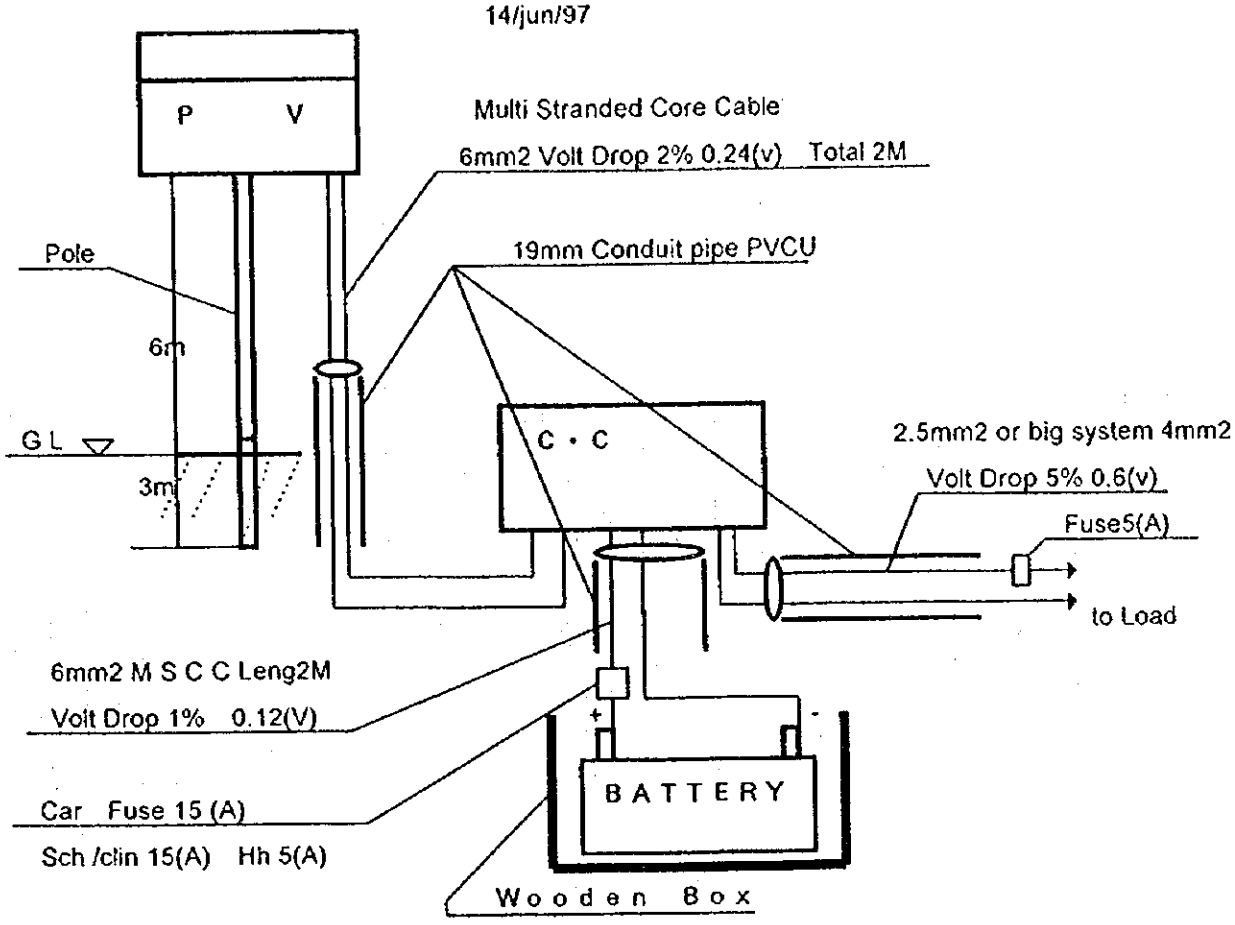
A charge controller consumes power when in operation. This is recorded as current consumed from the battery.



This proves that when designing solar systems, consideration must be taken of charge controller consumption. Therefore, controller designs should focus on minimal power consumption.

DOE/JICA Standards for PV Wiring

14/jun/97



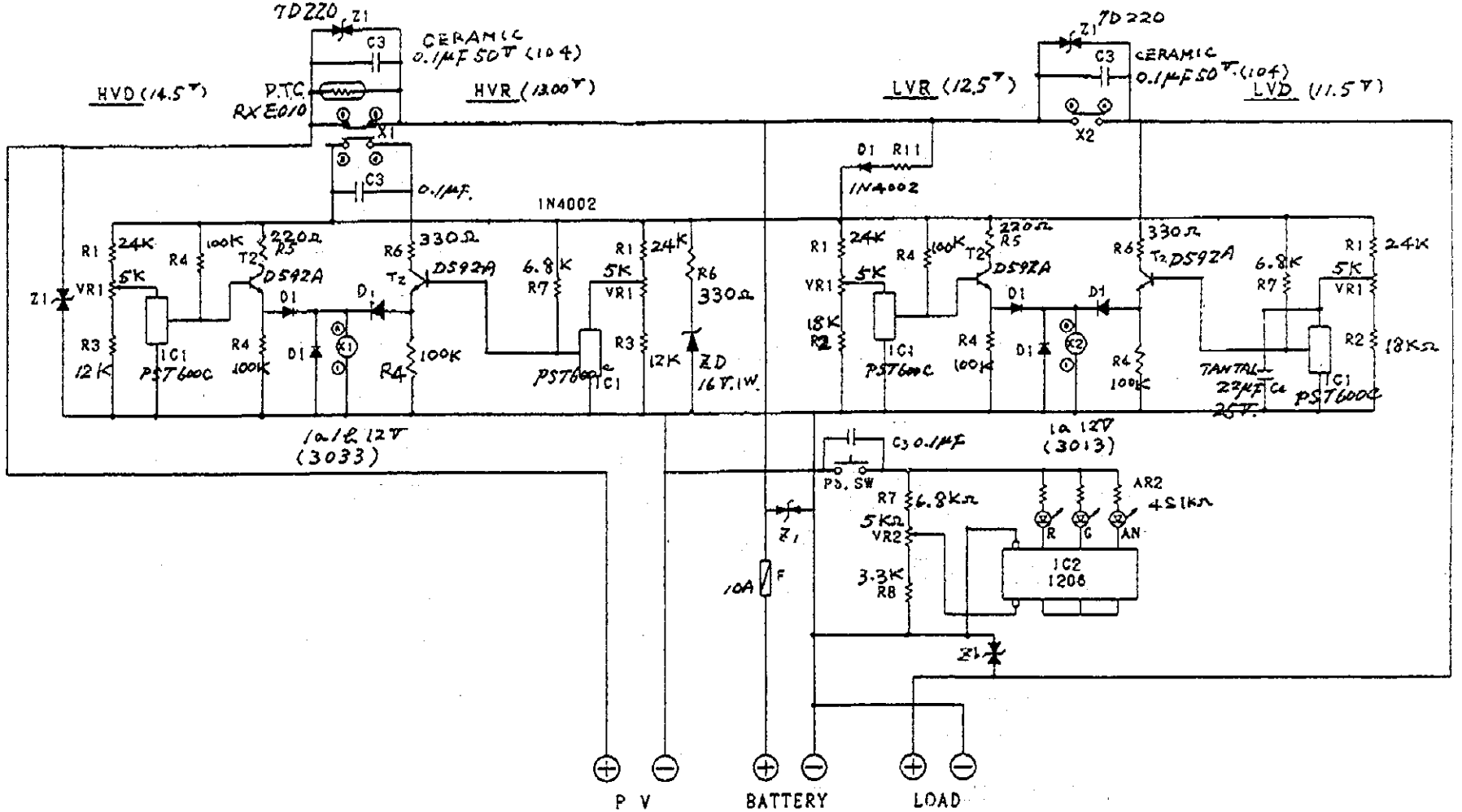
Materials List

1.Cable

1) from PV to C/C	2.5MM2	Multi stranded core cable
	total length abut 2M	
2) from c/c to Battery	6MM2	M S C C
3) Battery sense Cable	1.5MM2	
4) from C/C to Lode	2.5 MM2 or 4MM2 MSCC	

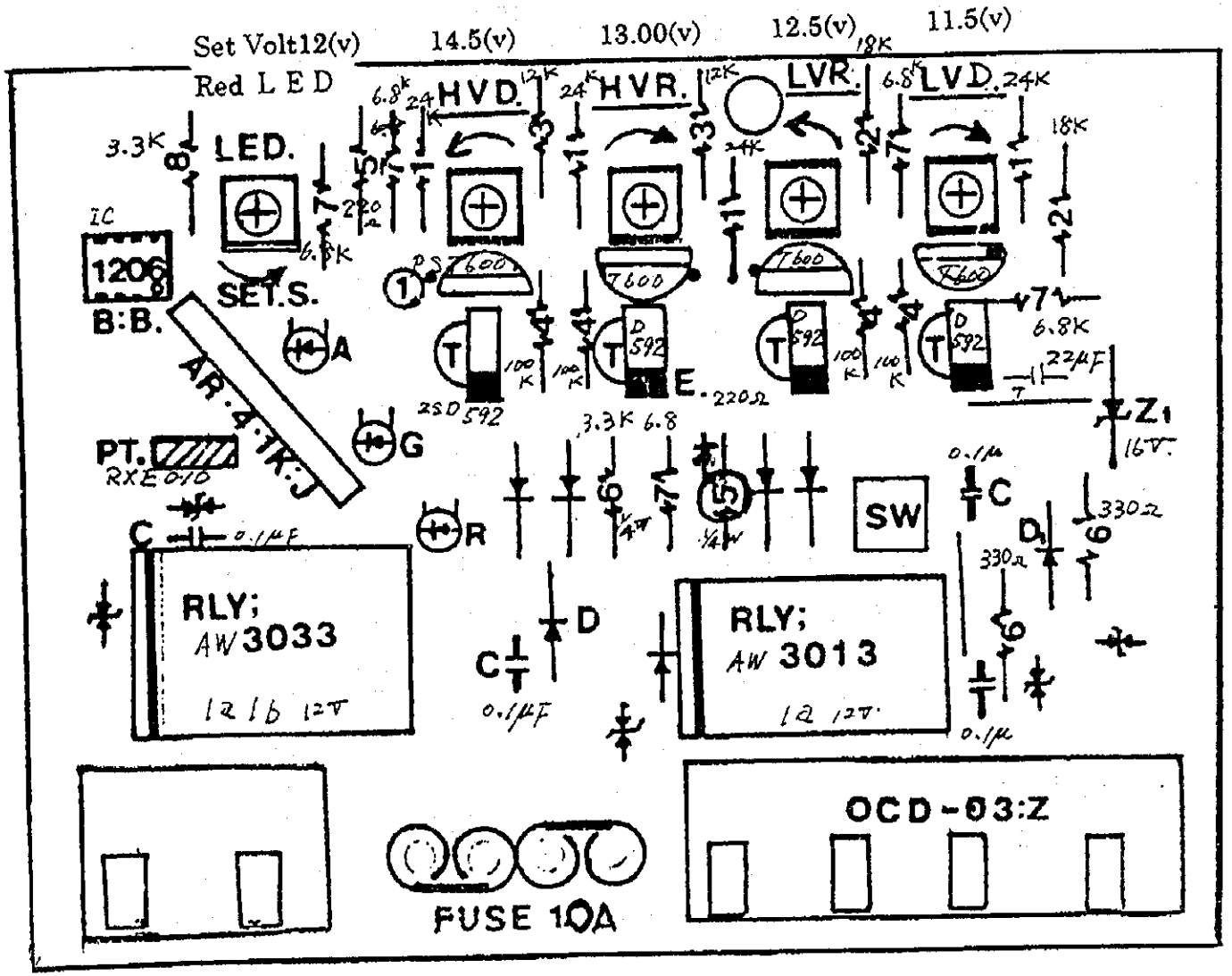
2. Conduit pipe	19 ϕ PVCU
3. Conduit Box	For 19 ϕ pipe
4. Battery box	Wooden BOX (put in Battery water 1L and 10(A)Fuse 5 pcs)
5. Pipe Sadole	For Pipe fiting
6.Fuse	For Battery 10(A) For F L Light 5(A)

DOE/JICA SYSTEM CHARGE CONTROLLER OCD-03Z



				OCD-03-Z		
					BH 98-02-19	REV. NON
NO.	日付	改訂内容	承認		DWG 10TA-01	

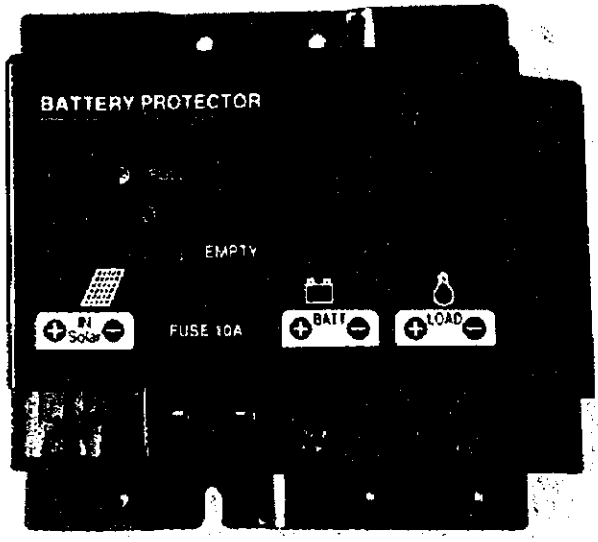
PV CHARGE CONTROLLER OCD-03
ARRENGMENT PARTS ON PCB

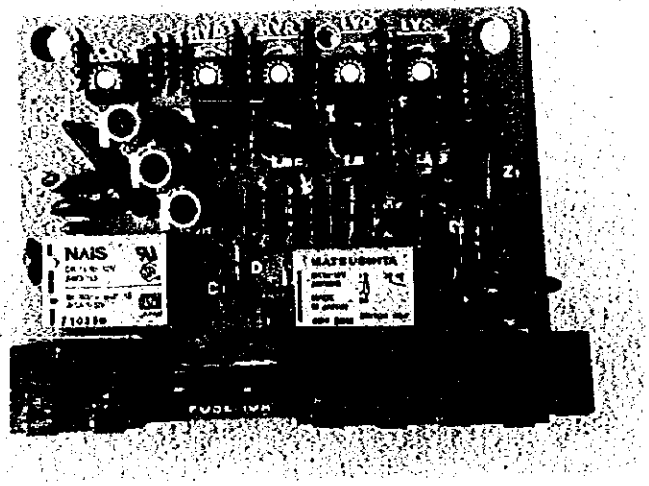


ODP-3R PARTS LIST

NO	PARTS NAME	MODEL NBR	Q'TY	MARK	REMARKS	PICH
1	TRANSISTOR	2SD592A(R)	4	T	EMITER MARK	
2	IC	PST-600C	4	●	1 PIN MARK	
3	IC	1206	1	◎	1 PIN MARK	10
4	ZENER DIODE	V16V1W	1		ZENER MARK	
5	LED	G/R/AN	3		LED	
6	CERAMIC C.	0.1μF50V	4	C		5
7	DIODE	1N4002	1	D		10
8	DIODE	1N4148	6			10
9	PTC SWITCH	RXE010	1	PT		5
10	RESISTER NET	RKC1/4841K	1	AR		
11	RESISTER	24KJ1/4W	4	1		10
12		18KJ1/4W	2	2		10
13		12KJ1/4W	2	3		10
14		100KJ1/4W	4	4		10
15		220ΩJ1/2W	2	5		10
16		330ΩJ1/2W	3	6		10
17		6.8KJ1/4W	5	7		10
18		3.3KJ	1	8		10
19	VR	PK50HIT502	5	SET		
20	HV.ABSOBER	7 DIA N220	5			
21	RELAY	1a1b12V(3033)	1	RLY		
22	RELAY	1a12V(3013)	1	RLY		
23	TERMINAL	4P	1			
24	TERMINAL	2P	1			
25	FUSE HOLDER	CQ111	2			
26	FUSE	10A CAR TYPE	1			
27	HOUSING	OCD-41	1			
28	PLATE	OCD-02	1			
29	BOTTOM INSUL.	OCD-44	1			
30	BOTTOM PLATE	OCD-38	1			
31	P.C.B	OCD-03R	1		1.6T 35μ	
32	SCREW	2.6φ	4		P.TAP	
33	SCREW	3φ	1		〃	
34	SCREW	2φ	1		〃	
35	TACT SWITCH	EVQPBD9K	1	SW		
36	CURRENT BAR	OCD-40	1			
37	CURRENT BAR	OCD-40-2	1			
38	INNER BOX		1			
39	WIRE END	2φ	6			
40	WIRE COLOR	RED	3			
41	WIRE COLOR	BLACK(BLUE)	3			
42	SILICA TUBE	3.5φ×12	1			
43	TANTAL C.	25V 20μ	1			
44	LED HOLDER		3			
	TOTAL		100 pcs			

DOE/JICA SYSTEM CHARGE CONTROLLER

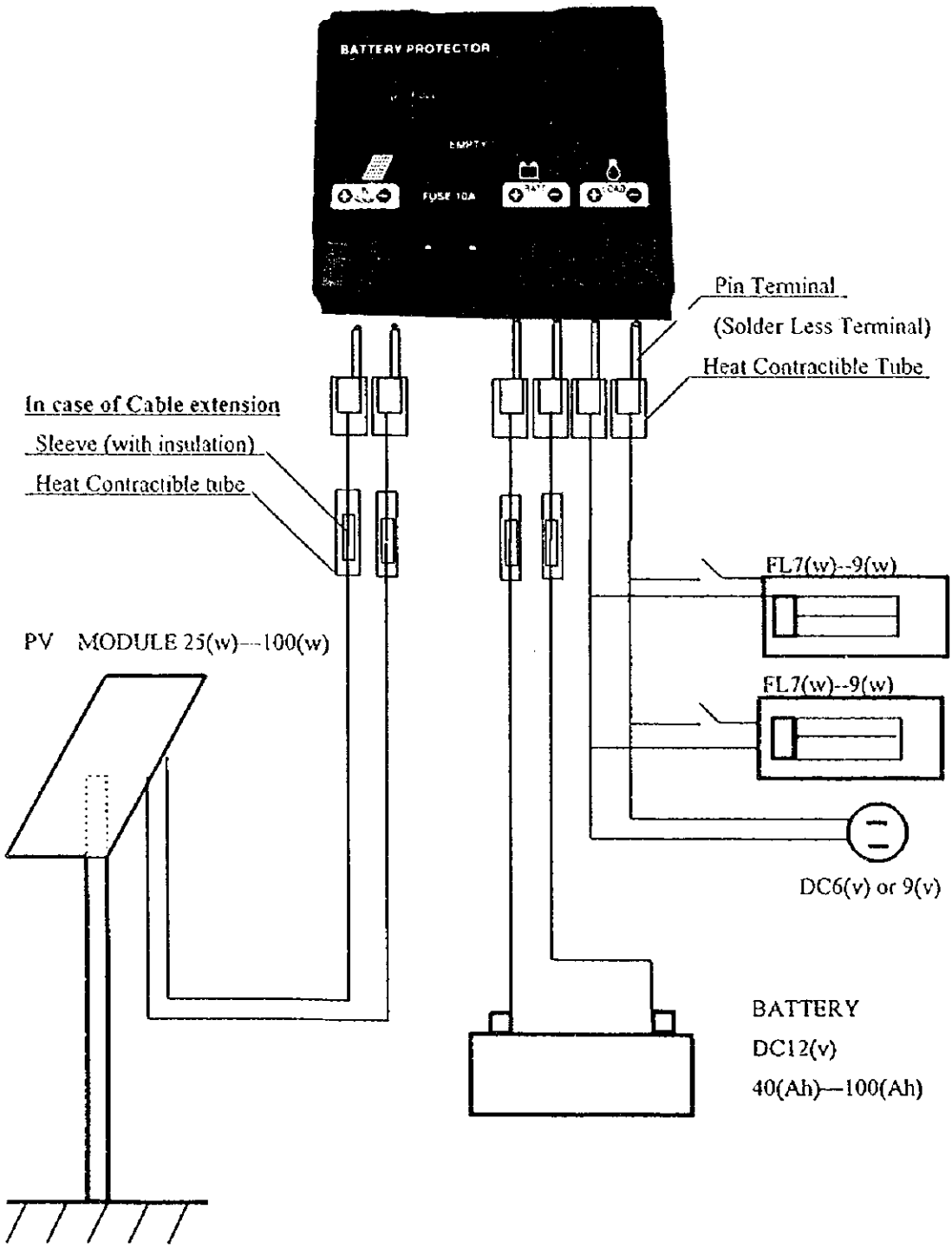




DOE/JICA SYSTEM CHARGE CONTROLLER

OCD-03Z

CHANGE EXPLANATION WIRING



APPENDIX - 5

LISTS OF MONITORING SYSTEM

Material List for PV Monitoring System (For 100 housholds)

Number of set 100

No.	Name of instrument	Type or specification	Maker	Q'ty/unit		Total Q'ty		Note
1-1	PV module	MM250-A, 25W	Anit	1	pieces	100	pieces	
1-2	PV module	MSX-56, 56W	Solarex			50	pieces	
2-1	Battery	12V, 60Ah (For car use)	Battery world	1	pieces	50	pieces	
2-2	Battery	12V, 40Ah (For deep cycle MF type)	Battery world	1	pieces	50	pieces	
3-1	Charge controller	SOLAR REGULATOR (Modified Type for JICA)	Battery world	1	pieces	50	pieces	LVD=11.7V±0.05V, LRC=12.7V±0.05, HVD=14.5±0.05V, C/CRC=13.5V±0.05
3-2	Charge controller	SOLAR REGULATOR (Modified Type for JICA)	Battery world	1	pieces	50	pieces	LVD=11.5V±0.05V, LRC=12.5V±0.05, HVD=14.5±0.05V, C/CRC=13.5V±0.05
4	Fluorescent light	7W, 12Vdc with inverter (for 4pins). Model: SLH	Sollatek	2	pieces	200	pieces	
5	Voltage dropper	For radio (Vin: 12V, Vout: 9V), with ac plug and dc plug for radio	Sollatek	1	pieces	100	pieces	Voltage dropper shall be plug connected type (ac plug and dc plug for radio)
6	Battery box	Made of wood (W D H) for 60Ah battery	Battery world	1	pieces	100	pieces	
7	Fluorescent light bulb for spare parts	7W, 12Vdc for 4pins	Philips	5	pieces	500	pieces	
8	Fuse for spare parts	5A for car use (For FL lamp)		5	pieces	500	pieces	Car type fuse
9	Fuse for spare parts	10A for car use (For battery)		5	pieces	500	pieces	Car type fuse
10	Distilled water for battery	1 litter bottle		1	litter	100	litter	
11								
12	Material for installation	All necessities for installation except mentioned below	Installer	1	sets	100	sets	Tilt angle of PV array shall be 17.5 degree ±2.5 degree.
13	Ditto	Wall socket	Installer	1	pieces	100	pieces	
14	Ditto	Fuse (5A) with socket for FL lamp	Installer	2	pieces	200	pieces	Car type fuse
15	Ditto	Fuse (10A) with socket for battery	Installer	1	pieces	100	pieces	Car type fuse
16								
17	Installation work	Above 25W PV, 2 lights and 1 socket system	Installer	1	sets	100	sets	Two lights and one wall soket with voltage dropper system.
18	Transportation to the site	km	Installer	1	sets	100	sets	

Material List for PV Monitoring System (For 10 clinics)

Number of set 30

No.	Name of instrument	Type or specification	Maker	Q'ty/unit		Total Q'ty		Note
1	PV module	MSX83 83W	Sollatek	1	pieces	30	pieces	
2	Battery	12V, 100Ah (deep cycle MF type)	Battery world	1	pieces	30	pieces	
3	Charge controller	SOLAR REGULATOR (Modified Type for JICA)	Battery world	1	pieces	30	pieces	LVD=11.5V±0.05V, LRC=12.5V±0.05, HVD=14.5±0.05V, C/CRC=13.5V±0.05
4	Fluorescent light	11W, 12Vdc with inverter (for 4pins) Model: SLH	Sollatek	2	pieces	60	pieces	
	Fluorescent light	9W, 12Vdc with inverter (for 4pins) Model: SLH	Sollatek	2	pieces	60	pieces	
	Fluorescent light	7W, 12Vdc with inverter (for 4pins) Model: SLH	Sollatek	2	pieces	60	pieces	
5	Voltage dropper	For radio (Vin: 12V, Vout: 9V), with ac plug and dc plug for radio	Sollatek	1	pieces	30	pieces	Voltage dropper shall be plug connected type (ac plug and dc plug for radio)
6	Battery box	Made of wood (W D H) for 1 pieces of 100Ah batteries	Battery world	1	pieces	30	pieces	
7	Fluorescent light bulb for spare parts	11W, 12Vdc for 4pins	Philips	3	pieces	90	pieces	
	Fluorescent light bulb for spare parts	9W, 12Vdc for 4pins	Philips	3	pieces	90	pieces	
	Fluorescent light bulb for spare parts	7W, 12Vdc for 4pins	Philips	3	pieces	90	pieces	
8	Fuse for spare parts	5A for car use (For FL lamp)		3	pieces	90	pieces	Car type fuse
9	Fuse for spare parts	20A for car use (For battery)		3	pieces	90	pieces	Car type fuse
10	Distilled water for battery			5	litter	150	litter	
11								
12	Material for installation	All necessities for installation except mentioned below	Installer	1	sets	30	sets	Tilt angle of PV array shall be 17.5 degree ±2.5 degree.
13	Ditto	Wall socket	Installer	1	pieces	30	pieces	
14	Ditto	Fuse (5A) with socket for FL lamp	Installer	6	pieces	180	pieces	Car type fuse
15	Ditto	Fuse (20A) with socket for battery	Installer	1	pieces	30	pieces	Car type fuse
16								
17	Installation work	Above 2×83W PV, 12 lights and 2 wall socket system	Installer	1	sets	30	sets	12 lights system
18	Transportation to the site	km	Installer	1	sets	30	sets	

Material List for PV Monitoring System (For 2 schools)

Number of set 8

No.	Name of instrument	Type or specification	Maker	Q'ty/unit		Total Q'ty		Note
1	PV module	MSX83 83W	Sollatek	1	pieces	8	pieces	
2	Battery	12V, 100Ah (deep cycle MF type)	Battery world	1	pieces	8	pieces	
3	Charge controller	SOLAR REGULATOR (Modified Type for JICA)	Battery world	1	pieces	8	pieces	LVD=11.5V±0.05V, LRC=12.5V±0.05, HVD=14.5±0.05V, C/CRC=13.5V±0.05
4	Fluorescent light	11W, 12Vdc with inverter (for 4pins) Model: SLH	Sollatek	2	pieces	16	pieces	
	Fluorescent light	9W, 12Vdc with inverter (for 4pins) Model: SLH	Sollatek	2	pieces	16	pieces	
	Fluorescent light	7W, 12Vdc with inverter (for 4pins) Model: SLH	Sollatek	2	pieces	16	pieces	
5	Voltage dropper	For radio (Vin: 12V, Vout: 9V), with ac plug and dc plug for radio	Sollatek	1	pieces	8	pieces	Voltage dropper shall be plug connected type (ac plug and dc plug for radio)
6	Battery box	Made of wood (W D H) for 2 pieces of 100Ah batteries		1	pieces	8	pieces	
7	Fluorescent light bulb for spare parts	11W, 12Vdc for 4pins	Philips	3	pieces	24	pieces	
	Fluorescent light bulb for spare parts	9W, 12Vdc for 4pins	Philips	3	pieces	24	pieces	
	Fluorescent light bulb for spare parts	7W, 12Vdc for 4pins	Philips	3	pieces	24	pieces	
8	Fuse for spare parts	5A for car use (For FL lamp)		3	pieces	24	pieces	Car type fuse
9	Fuse for spare parts	20A for car use (For battery)		3	pieces	24	pieces	Car type fuse
10	Distilled water for battery			5	litter	40	litter	
11								
12	Material for installation	All necessities for installation except mentioned below	Installer	1	sets	8	sets	Tilt angle of PV array shall be 17.5 degree ±2.5 degree.
13	Ditto	Wall socket	Installer	1	pieces	8	pieces	
14	Ditto	Fuse (5A) with socket for FL lamp	Installer	6	pieces	48	pieces	Car type fuse
15	Ditto	Fuse (20A) with socket for battery	Installer	1	pieces	8	pieces	Car type fuse
16								
17	Installation work	Above 2×83W PV, 12 lights and 2 wall socket system	Installer	1	sets	8	sets	12 lights system
18	Transportation to the site	km	Installer	1	sets	8	sets