Lighting a Billion Lives

TECHNICAL MANUAL

Maintenance and Troubleshooting of Centralized Solar Lantern Charging Station

NORWEGIAN EMBASSY

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Overview

Solar lantern charging station

The SLCS (solar lantern charging station) is a charging station that enables a number of solar lanterns to be charged simultaneously. It consists of the following components.

- Solar module (also known as solar panel)
- Junction boxes
- Lanterns

Each of the above-mentioned component is described in the subsequent sections.

A typical LaBL (Lighting a Billion Lives) SLCS is a modular concept consisting of a solar lantern, a junction box, and a solar module. Each unit charges 10 lanterns by one solar module through one junction box having 10 ports. The junction box is used as an interface between the solar modules and lanterns with in-built protection and control required for effectively charging the lantern.

The SLCS concept is more reliable, versatile, and cost effective than standalone, individual solar lantern charging. LaBL SLCS is designed for the following.

- Charging CFL (compact fluorescent lamp) lantern
- Charging LED (light-emitting diode) lantern

SLCS for charging CFL lantern

One unit for charging 10 lanterns in a typical LaBL SLCS consists of the following

- One 80Wp (watt peak) solar module
- 10 7W (watt) CFL solar lantern (with 12V [volt] storage battery)
- One junction box having 10 ports for charging 10 lanterns
- 10 charging cords (approx. 2 metre length) for charging the lanterns from the junction box

Fig 1 SLCS for charging the CFL lantern

Fig 2 SLCS for charging LED lantern

SLCS for charging LED lantern

One unit in a LaBL SLCS for charging LED lantern consists of the following

- One 30Wp solar module
- 10 LED lanterns (with 12V storage battery)
- One junction box having 10 ports for charging 10 lanterns
- 10 charging chords (approx. 2 metre length) for charging the lanterns from the junction box

Components of SLCS

Solar module

A solar module (as shown in Figure 3) is a combination of solar cells. It collects sunlight and converts it into DC (direct current) electricity. The DC electricity generated is then used to charge the battery placed inside the lantern(s). The rated capacity of the solar module is denoted as Wp.

The Wp and voltage rating of the solar module depends upon the (i) wattage of the lighting device (CFL/LED), (ii) rating of the battery used inside the lantern (6V or 12V), and the (iii) number of lanterns to be charged simultaneously.

Fig 3 Solar Module

Based on this rating system, currently

- The solar module used for charging 10 CFL lanterns: 80Wp rating
- The solar module used for charging 10 LED lanterns: 30Wp rating

The solar module is installed with a proper mounting structure and inclined at a proper angle (to the horizontal) in order to get maximum solar radiation throughout the year. The current generated from the solar module varies with solar radiation, for example, the current generated from a solar module during a full sunny day (non-foggy and non-cloudy) at peak sunshine hours (10 a.m.–3 p.m.) is almost double of the current generated from the same solar module during foggy and cloudy season. Therefore, generally the number of lanterns (with similar field conditions), which are charged from the solar module during non-sunny/foggy days, are more than the number of lanterns charged in foggy/cloudy days.

Junction box

The junction box is an interface between the solar module and the lantern. It has in-built protection and control circuits. The solar module is connected to the junction box for providing electricity required for the lantern charging. There are 10 ports in each junction box for charging 10 lanterns (Figure 4). A maximum of 10 lanterns can be charged at a time. However, if there are less number of lanterns to be charged, they can be put in the junction box.

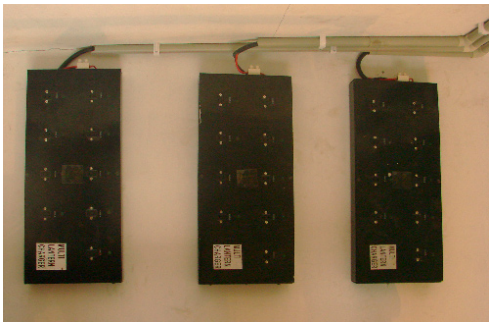


Fig 4 Junction box

Although the working principle of both the junction boxes (for CFL and LED) is same, the rating of the junction box for LED and CFL lantern are different. It is recommended that the junction box, made for LED lantern charging, should be used for LED lantern only, and the junction box made for CFL lantern charging should be used for CFL lantern only.

Lanterns

The lantern is a portable lighting system consisting of a lighting device (CFL/LED), a maintenance-free storage battery, and electronics, all placed in a case made of plastic or fibreglass. During the day, the storage battery is charged by the electricity generated through the solar module and

through the junction box. At night, when the lantern is fully charged, it is disconnected from the junction box and then can be used as an independent, portable source of light. The lantern is suitable for both indoor and outdoor lighting applications.

Depending upon the lighting source used, two different types of lanterns are used in the LaBL campaign.

- CFL lantern
- LED lantern

A comparison can be made between the lanterns on the basis of light output, typical wattages available, cost, and lamp life. A brief description of each of the lantern is given below.

CFL lantern

The CFL lantern used in the LaBL campaign consists of

- A highly efficient CFL, which operates at high-frequency AC voltage
- A storage battery
- An electronic PCB (printed circuit board)

Fig 5 CFL Lantern

Components of a CFL lantern

Fig 6 CFL

Compact fluorescent lamp

It is a highly efficient lamp, which operates at a high-frequency AC voltage. The CFL used in the lantern as depicted in Figure 6 is 7 W, which gives light equivalent to that of a 40 W incandescent bulb and five kerosene lamps.

Battery

The battery used with the CFL lantern is an 12V SMF (sealed maintenance free) lead-acid-type battery. Other type of batteries such as NiMH (nickle metal hydride), Li-ion (lithium-ion), and Ni–Cd (nickle–cadmium) can also be used with the lantern. The size/rating of the battery is based on the daily number of hours of operation/usages required. The capacity/rating of the battery, used in the CFL lantern as depicted in Figure 7.

Fig 7 Battery

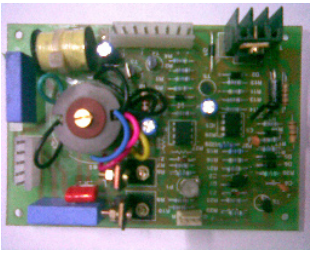


Fig 8 Electronic PCB card

Electronic PCB card

The electronics used with the lantern consist of a charge controller and an inverter circuit. All the protection required for effective operation of the lantern is incorporated in the PCB (Figure 8).

Fig 9 Fuse

Fuse

A fuse is provided with the lantern in order to protect the circuit in case excess current flows into the lantern. The fuse depicted in Figure 9 is of 1 ampere.

LED lantern

The LED lanterns used in the LaBL campaign consist of

- High-power white LED
- A storage battery
- An electronic PCB

Fig 10 LED

Components of a LED lantern

Fig 11 LED

Light emitting diode

LED is a special type of diode, which emits light when connected to DC power supply. The LED is 2-pin type as depicted in Figure 11. A typical LED lantern used in the LaBL campaign consists of a number of high-power white LEDs.

Battery

The battery used with the LED lantern is an 6V SMF lead-acid-type battery. Other type of batteries such as NiMH (nickle metal hydride), Li- ion (lithium-ion), and Ni–Cd (nickle–cadmium) can also be used in the lantern. The size/rating of the battery is based on the daily number of hours of operation/usages required. The capacity/rating of the battery used in the given LED lantern is depicted in Figure 12.

Fig 12 Battery

Fig 13 Electronic PCB card

Electronic PCB card

The electronics used with the lantern consist of a charge controller and driver circuit (Figure 13). All the protection required for effective operation of the lantern is incorporated in the PCB.

Fuse

Fuse used for LED lantern is the same as that used for CFL lantern (Figure 9).

Indications for CFL/LED lantern

If red LED is glowing: battery is discharged

If green LED is glowing: battery is charging

(For other details of lantern such as features, indications, and so on, refer to lantern manual)

Installation and operation

Overview

The solar module is installed on the rooftop of the charging station and all other components, viz, junction boxes, lantern racks, and lanterns are placed inside the room. The schematic of a typical LaBL lantern charging station is depicted in Figure 14.

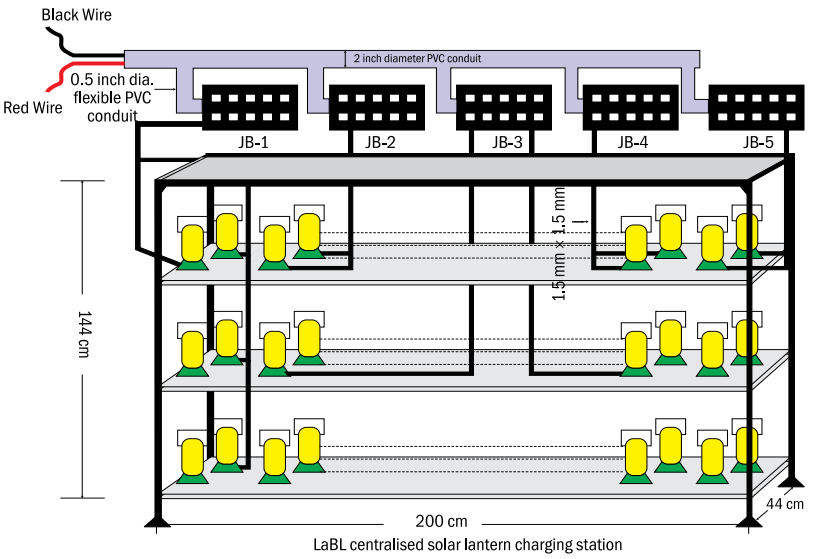


Fig 14 The schematic of a typical LaBL lantern charging station

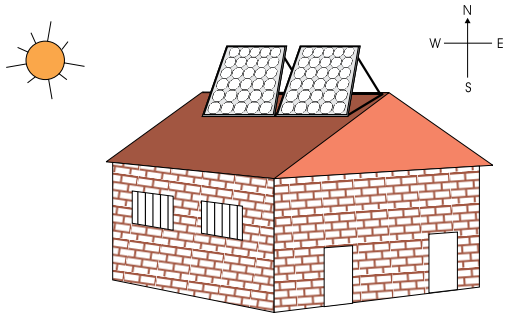
Installation and operation of solar module

Processes followed during the installation of SLCS

The following steps are to be followed for installing the SLCS.

1) Instruction for identification of appropriate location

- Mariner's compass should be used to orient the solar panels in the south-facing direction to ensure maximum solar radiation throughout the day.



Compass

Fig 15 The schematic of a typical LaBL lantern-charging station

- Obstructions such as trees, tall buildings, and other objects to solar radiation reaching the solar module shall be looked out for and it should be ensured that no object obstructs solar radiation from reaching the module. Shadow area is to be avoided while selecting the place for installing solar panels (Figure 16).

Fig 16 Selection of an appropriate site for installing the solar modules

2) Instruction for solar modules with mounting structure

- Panels should be arranged in such a pattern that none of the panels obstruct the path of solar radiation for the other panels (Figure 17).

Fig 17

Solar panel obstruct radiation path to others

Solar panels do not obstruct radiation path to others

- Vertical load down to the foundation and the type of roof surface have to be taken into account at the time of installation. There are basically two ways of installing the station—one on heavy roof, the other on pitched roof. These are explained as follows.

  Heavy Roof This is a roof with roofing materials made of concrete, tiles, slates, and so on.

  On a heavy roof, installation of solar panels should be done on the roof itself because these type of roofs are known to hold the panels weight easily. Once the orientation is decided and the place for installation of solar panels is finalized, the mason should fix the solar panel, grouted to the roof with bricks, cement, and sand (Figure 18).

Fig 18 Installation of solar panels on a heavy roof

Pitched Roof This is a roof having its exterior surface typically made of wood, thin metal sheet, rough tiles, and so on.

For such a roof, installation on the surface is not recommended (Figure 19). Therefore, a place is selected near the charging station and installations should be completed by pole mounting.

Fig 19 Not recommended for solar panel installation

Pole mounting In cases where roofs are not comfortable for installation, the solar panel has to be fastened and bolted with mounting structure at a height of 6 feet above the ground. A special four-pole mounting structure should be made to hold the solar panel (Figure 20).

Fig 20 Solar panel installation by pole mounting

- The solar panels should be fixed with anti-theft screw with the mounting structure properly or fixed to the truss using proper nuts and bolts (in case of tin/ asbestos sheet) as shown in Figure 21.
- The mounting structure should be of metallic frame of M S flat/angle with corrosion-resistant paint to hold the solar PV

Fig 21 Solar panel installation on tin/ asbestos roof

(photovoltaic) array. The frame structure should have provisions to adjust its angle of inclination to horizontal between 0–45 degree so that it can be installed at the specified tilt (latitude of the point of installation).

Installation and operation of the junction box

Installation of junction boxes with proper wiring from the solar modules to the junction boxes (Figure 22)

- Dedicated space should be arranged inside the entrepreneur's occupancy for five junction boxes and 50 lanterns preferably within a set of shelves.
- The space allocated should be clean and safe, devoid of any possible pests that could damage the apparatus.
- The junction boxes should be installed and fixed on the wall, using proper screw arrangement, just above the top of the rack where solar lanterns are kept.
- Wires from the junction boxes, connecting to the lanterns, should be tied together by a flexible conduit (spiral wire) and should not be allowed to travel individually to the lanterns.
- The wires/cables from the solar panel to the junction boxes should be through a proper PVC (polyvinylchloride) conduit (flexible or otherwise)
- The red wire (positive of the solar module) should be connected to the positive terminal in the junction box and the black wire (the negative of module) to the negative terminal of the junction box.

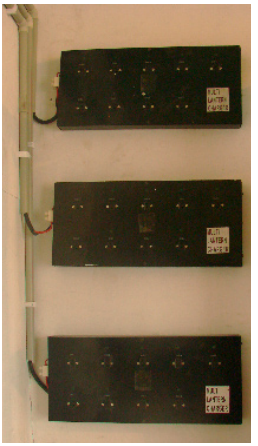


Fig 22 Junction box

Indications: The glowing of the green LED of the junction box indicates that the connection between the solar module and the junction box is proper.

Operation of the solar lantern

Unpacking of the lantern

Take the lantern out of the packet and see whether there is any physical damage. Ensure that the fuse is intact. To insert a fuse, unscrew the cap of the fuse holder. Put the fuse inside the fuse holder (Figure 23) and then close the fuse cap by tightening in the opposite direction.

Fig 23 Opening of the lantern

Checking the lantern

- Remove the gummed tape, if put on the on/off switch.
- The switch is a two-position switch.
- Press down the switch to the 'on' position, the CFL will glow, if the CFL does not glow and red LED glows then the battery is low, and it should be charged immediately. If the CFL and the red LED do not glow, then check the fuse and the CFL and contact the system installer/ supplier immediately (Figure 24).

Fig 24 Checking the lantern

Connecting the lanterns with the junction boxes and charging the lantern

- Connect the lantern-charging chord, provided with each lantern, to the junction box properly (Figure 25).
- Insert one end of the charging cord, provided in the lantern, to the charging socket, provided in the lantern, and the other end with the socket provided in the junction box.
- Once the junction boxes and lanterns have been connected through the charging chord/connectors, each lantern should be checked for proper charging. When the lantern is connected to the junction box for charging, the red LED should stop glowing and the green LED in the lantern should start glowing.

Fig 25 Connecting the lanterns with the junction boxes and charging the lantern

- While charging the battery in the lantern the on/off switch should be kept in 'off' position.
- The lanterns should be placed properly in the racks meant for placing them.
- Keep on charging the lantern until it is fully charged. However, during low sunshine hours, due to less availability of current at the solar module, the lantern does not get current. In such a scenario also the green LED stops glowing. So, to ensure that the lantern is fully charged, unplug the lantern from the junction box and switch it on, the lantern will start glowing. Now, switch off the lantern and plug it in the junction box port for charging, then the green LED should start glowing again and after 1–2 minutes.
- Disconnect lantern(s) from the junction box after charging. These lanterns should be kept at switch-off mode and can be rented out.

Maintenance and troubleshooting

Maintenance of the solar charging station

- Clean the solar lantern with cotton cloth.
- Occasionally, wipe/clean the module's surface with moist cloth (Figure 26).

Fig 26 Occasionally, wipe/clean the module's surface with moist cloth

Troubleshooting for lanterns and junction box

If the green LED of the lantern is not glowing, when put on charge, follow these steps.

- Ensure that proper sunlight is available for charging.
- Ensure that charging wire/chord of the lantern is properly connected to the junction box port.

If the green LED does not glow in spite of ensuring the above, the reason may be one of the following conditions.

a) *Lantern's LED is blown (refer to figure 27)* To check if the green LED of the lantern is blown plug another charged lantern in 'on' condition on this port. If the lantern goes off and the green LED of the lantern starts

glowing, then this means that the port is working and the LED of the previous lantern is blown. Replace the green LED of the previous lantern.



Fig 27 To check if the green LED of the lantern is blown, do the as shown

However, in such a case the charging port can be used for lantern charging.

b) Lantern is fully charged To see whether the lantern is fully charged, refer to the lantern manual.

c) Lantern is not charging In such a case, check the fuse and replace it if necessary, as per the instruction given in the lantern manual.

d) If the green LED is still not glowing, plug the same lantern on a different port, if the green LED is glowing with this new port, it means that the previous port of the junction box is defective.

e) If the green LED is still not glowing in the other port of the junction box, where other lanterns are getting charged, then there is some problem in the lantern. Contact the implementation partner, product supplier, and LaBL team of TERI in such cases.

In addition to the above mentioned points, the entrepreneur should know the following two points, mentioned below so that he/she can do the needful whenever he/she gets the instruction from the product supplier and the LaBL team.

Instruction to change the battery

- Slide the lantern in a horizontal position to access the four screws in the base plate.
- Unscrew all the four screws.
- Lift up the upper position of the lantern and let it rest on the side of the base plate.
- Remove the PCB circuit board with the plastic holder by pressing one of the side supports inside or use a small screwdriver to unlock it.

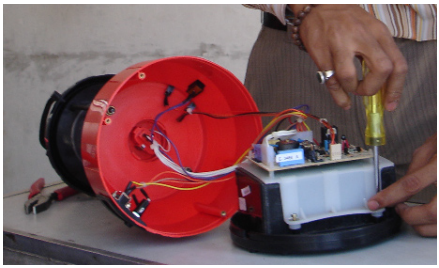


Fig 28 Changing the battery

- Remove the red and black connectors from the battery terminals along with the plastic insulators.
- Replace the battery and connect back the battery connectors (red wire to red marked positive terminals and black wire to the other battery terminal).
- Reassemble the lantern in the reverse order.

During winter/cloudy/foggy days

Basically, each junction box consists of 10 ports, and all the 10 ports are connected to 10 lanterns. During winters/cloudy/foggy days, lesser sunshine hours are available. Because of lesser or no sunshine hours, the charging may not take place or green LEDs may not glow. In such a case, it is recommended to decrease the number of lanterns simultaneously connected to the junction box. This means that the lanterns should be removed until the green LEDs in the connected lanterns start glowing as shown in Figure 29. This is because, as soon as the amount of the current required by the specific number of lanterns is drawn from PV, the green LED(s) will start glowing.

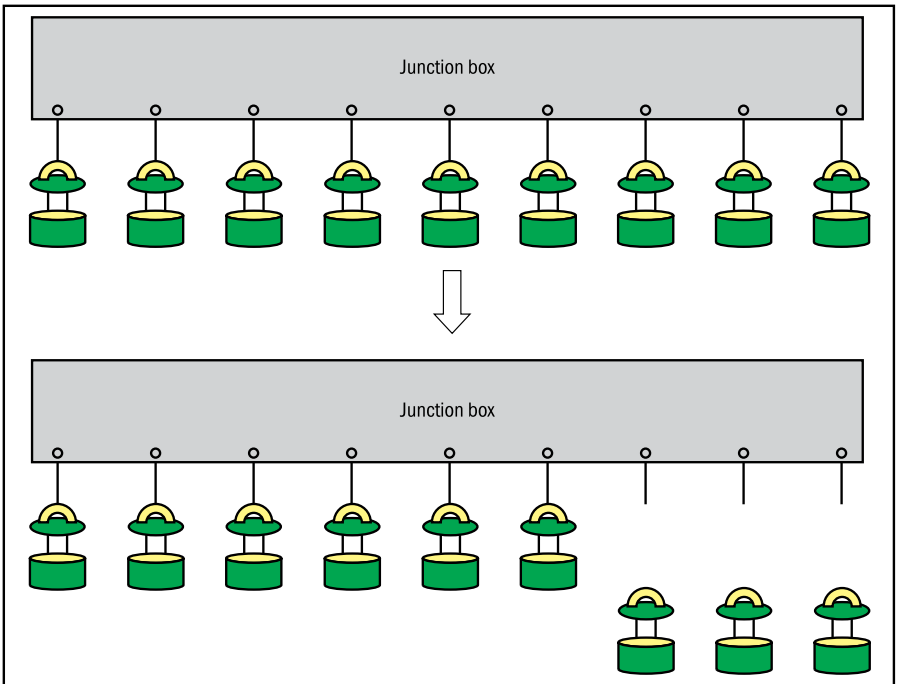


Fig 29 Conneting lesser number of lantern during winter/cloudy/ foggy days

Dos and Don'ts

Dos

Solar lantern and junction box

- Always charge the lantern completely through the junction box. (For full charge indication, refer to the lantern manual.)
- The battery of the lantern should be charged regularly even if the lantern is not in use or is out of order.
- Always clean the lantern with cotton cloth.
- Always charge the LED lanterns through the LED junction box only. Similarly, always charge the CFL lanterns through the CFL junction box only.
- In case of any technical issues, please refer to the 'Troubleshooting and Maintenance' section of the manual.

Solar modules

- Always clean the solar module with moist cotton cloth.
- Check and ensure proper connection of wires from the module to the junction box. This is ensured by observing that the green LED of the junction box is glowing when there is sunlight.

Don'ts

Solar lantern

- Do not connect the lantern to the AC mains supply.

LaBL lantern models

About the manual

With its vision to work for global sustainable development and its commitment towards creating innovative solutions for a better tomorrow, TERI has initiated the (Lighting a Billion Lives©a) campaign. The campaign aims to bring light into the lives of one billion rural people by replacing the kerosene and paraffin lanterns with solar lighting devices. This will facilitate education of children, provide better illumination and kerosene-smoke-free indoor environment for women to do household chores, and provide opportunities for livelihoods both at the individual level and at village level.

The implementation model for LaBL is a fee-for-service model where SLCS (centralized solar lantern charging stations) are set-up in villages for charging the lanterns and renting out the lanterns on a daily basis. The charging stations are operated and managed by LaBL Entrepreneurs who are selected and trained by TERI in association with its local partners called LaBL Associates.

A typical LaBL SLCS (solar lantern charging station) chiefly consists of the solar modules, junction boxes, and the lanterns. Effective maintenance and upkeep of the charging stations is crucial for sustaining the initiative in the villages. Towards this end, there is a need to build the capacity of LaBL Entrepreneurs who operate and maintain the SLCS to avoid any technological pitfall. This manual for LaBL SLCS, designed by TERI, is an effort to technically sensitize the Entrepreneurs and build their capacities towards smooth and effective operation and maintenance of the charging station and sustaining the LaBL campaign.

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