

**PV GAP
RECOMMENDED
SPECIFICATION**

PVRS 10

Draft
2003-08

**Code of Practice for
Installation of Photovoltaic Systems**



Reference number
PVRS 10 : 2003

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PRICE

FOREWORD

- 1) PV GAP (Global Approval Program for Photovoltaics) is a not-for-profit international organization, dedicated to the sustained growth of global photovoltaics (PV) markets to meet energy needs world-wide in an environmentally sound manner. Its mission is to promote and encourage the use of internationally accepted standards, quality management processes and organizational training in the design, fabrication, installation, sales and services of PV systems. To this end, it joins with PV related industries, international organizations, testing laboratories, government agencies, financing institutions, non-governmental organizations, and private foundations, in developing and developed countries.
- 2) PV GAP co-operates closely with the International Electrotechnical Commission (IEC) in respect of standardization (principally with IEC Technical Committee N° 82, Solar Photovoltaic Energy Systems) and certification (with the IEC System for Conformity Testing and Certification of Electrical Equipment, IECEE).

PV GAP publishes specifications that have been developed and recommended by experts from the PV industry and other organizations, to be used as interim, recommended specifications until the corresponding IEC standards can be completed. The acceptance of these PV GAP “Recommended Specifications” is voluntary. PV GAP only recommends these specifications but disclaims any liability for their utilization.

It should be noted that, as soon as a corresponding IEC standard is issued, the PV GAP “Recommended Specification” is withdrawn. This is announced on the PV GAP website www.pvgap.org, together with information about the new IEC standard.

- 3) *(to be added after being approved)* The present PV GAP Recommended Specification has been endorsed by the PV GAP Technical Committee, and approved by the PV GAP Executive Board. Members of the Technical Committee and the Executive Board bodies are listed on the website www.pvgap.org.
- 4) General enquiries about PV GAP may be addressed to the publisher, which is the PV GAP Secretariat, c/o IEC Central Office, 3 rue de Varembé, Box 31, CH 1211 Geneva 20, Switzerland, E-mail rk@iec.ch, TP +41 22 919 02 16, TF +41 22 919 03 01.

The publisher will be pleased to receive any comments from users of this PV GAP Recommended Specification. All comments will be acknowledged.

Whilst every effort has been made to ensure the accuracy of the contents of this PV GAP Recommended Specification, the publisher can accept no responsibility for any errors that may have occurred.

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0.1 Foreword

This PV GAP Photovoltaic Recommended Specification (PVRS) is based on Uganda National Bureau of Standards (UNBS) Standard US 152:2000 and is reproduced by permission of UNBS. UNBS is a parastatal under the Ministry of Tourism, Trade and Industry established by the Act of Parliament of 1983, of the Laws of Uganda. UNBS is

- (i.) a member of International Organisation for Standardisation (ISO) and
- (ii.) a contact point for the WHO/FAO Codex Alimentarius Commission on Food Standards, and
- (iii.) the national Enquiry Point on TBT.SPS Agreements of the World Trade Organisation (WTO).

The work of preparing Uganda standards is carried out through Technical Committees. A Technical Committee is established to deliberate on standards in a given field or area and consists of representatives of consumers, traders, academicians, manufacturers, Government and other stake-holders.

Draft Uganda standards adopted by the Technical Committee are widely circulated to stake-holders and the general public for comments, which are reviewed before recommending them to the National Standards Council for declaration as national standards.

0.2 Committee membership

The following organisations were represented on the Technical Committee

Physics Department, Makerere University Kampala- Chairman

Department of Electrical Engineering, Makerere University Kampala

Uganda Telecom Limited

Uganda Electricity Board

Ministry of Energy and Mineral Development

Uganda Photovoltaic Pilot Project for Rural Electrification (UPPPRE)

Solar Energy (U) Limited

Uganda Solar Energy

INCAFEX Solar

Uganda Renewable Energy Association (UREA)

MAGRIC (U) Limited

GITT (U)

Lwanga Electronics and Electrical Machinery

Uganda Batteries Limited

0.3 PV GAP's photovoltaic Recommended Specifications (PVRS)

PV GAP's PVRSs are established using the following procedure:

The PV GAP Technical Committee (TC) is an open ended Committee. Membership of the PV GAP TC is open to any qualified person from any country

with interest to help to develop a consensus for a proposed PVRS. After the TC reaches consensus, the PVRS draft is submitted to the PV GAP Executive Board for approval.

Code of Practice for installation of Photovoltaic systems

1.0 Scope

This code of Practice is intended to

- a) form a basic reference document for use in all photovoltaic installations in places where no such Code exists.
- b) promote the installation of safe, high quality photovoltaics, in such a way as to generally promote the adoption of Photovoltaic power as an energy source.

Any contract adhering to these general procedures with the intention of providing such a quality installation may be eligible to apply for certification to this standard.

1.1 Field of application

The application of this Code of Practice shall include everything necessary to provide lights and outlets for power as part of a photovoltaic power system. This covers 12V dc PV systems for residential applications, the so-called Solar Home Systems and is not intended to be used for other PV systems such as PV – pumping systems, Grid –connected systems etc.

This code shall be read in conjunction with the relevant parts of the local Wiring Regulations for Electrical Installations, however named, or if such local Regulations do not exist, then with the current IEE Regulations for Electrical installations, and shall apply to installation of Direct Current (DC) Photovoltaic (PV) energy systems, where not otherwise specified in particular specifications, drawings or instructions. Such system to be specified by the client, or as shown on the contractors drawings, including PV-panels, batteries, controllers, fuses and/or circuit breakers, switches, socket outlets, wiring, appliances, etc., the work shall also include repair of all damages to buildings and grounds caused by the installation where not otherwise specified by the client. Although this code has been drafted for 12V systems it may be used, by extension, for 24V systems as well.

2.0 Normative references

The following standard contains provisions which, though reference in this text constitute provisions of this standard. All standards are subject to revision and, since any reference to a standard is deemed to be a reference to the latest edition of that standard, parties to agreements based on this standard are encouraged to take steps to ensure the use of the most recent editions of the standard indicated below. Information on currently valid national and international standards may be obtained from the local National Bureau of Standards Information and Documentation Center, however named.

IEE *Regulations for Electrical Installation* – BS 7671, latest edition, see www.iee.org/Publish/WireRegs/

US 218:2000 *Definitions, Abbreviations, Symbols, and Terminology of Photovoltaic Systems*

US 149-1:2000 *Batteries for photovoltaic systems. Part 1: Specification*

IEC 61215:1993 *Crystalline silicon terrestrial photovoltaic PV modules – Design qualification and type approval* or IEC 61646:1996 *Thin-film terrestrial photovoltaic (PV) module -. Design qualification and type approval*.

ISO 9001:2000 *Quality management systems - Requirements*

3.0 Definitions

All definitions of electrical terms in the current IEE Regulations shall apply to these specifications. The following terms used in this Code of Practice are defined as follows:

3.1 client

A person, company or organization that commissions the installation of a photovoltaic power system

3.2 contractor

A person, company or organization that is commissioned by a client to design, supply or install a photovoltaic power system

3.3 essential service(s) (*ES*)

These are services, which are deemed to be of particular importance to maintain in a continuous functional state, e.g., domestic refrigerators, appliances in health facilities (vaccine refrigerators).

3.4 non –essential services (*NES*)

These are services other than *ES*. These may be general light in houses and institutions, radio/TV and other domestic appliances

3.5 array current

This shall be determined from the Manufacturer's data (IV-Curve). The following conditions should apply:

Solar Radiation: 1kW/m² or less

Module Temperature: 55°C or more

Output Voltage: 15.1V or more

3.6 daily load (*DL*) unit Ah

The maximum measured or estimated demand over a period of 7 x 24 hours divided by 7

3.7 conduit

Any form of cable carrier, whether plastic or metal conduit, mini-trunking or double insulated cable specifically designed to be used without external conduiting

4.0 Workmanship

Where no detailed specifications are provided by the client for choice of materials or workmanship, standard practice for the trade shall be followed.

Regarding the approval of quality, assessing capacity of PV-panels, batteries, controllers and other components, the client or contractor may seek assistance from the local National Bureau of Standards (UNBS), however named.

4.1 System Design

Where the layout of the installation is shown in drawings or detailed specifications, these shall be accurately followed. Where no detailed drawings are provided, the installation shall be designed as efficiently as possible to minimise the loss of energy through cables and junctions.

A system design specified for a client by a contractor should be in a form that may be readily explained to a non-technical client. This design information should be kept on file by the contractor, and may prove useful after completion of the installation in case of any subsequent dispute.

In the case of a client-specified installation, it is the responsibility of the contractor to inform the client of any areas that do not conform to this Code of Practice. The contractor is entirely responsible for any deviations from the established code of practice and wiring standards and written dispensation from the client should be obtained where necessary to protect the interests of the contractor. Under no circumstances, even by client dispensation, shall any unsafe practice be acceptable.

4.2 Installation/Finishing

The installation must also include the completion and tidying up of any work that is a direct result of the installation. Any damage to surface walls or fittings caused by or as a result of the installation should be repaired by the contractor. An element may be included in the original quotation to allow for this. All visible parts of the installation must be completed in a tidy and clean manner.

Since a large portion of solar PV installations will be on domestic premises, due consideration must be given to the aesthetic appearance of the installation. An installation that may be acceptable for use in a school or industrial environment may well be unsuitable for use in a kitchen or living room.

5.0 Material and Installation

5.1 Wiring and Cables

5.1.1 General

Surface mounted conduit with single wire conductors shall be used unless otherwise specified, or shown on drawings. Conduits must be supported using saddles or supports. Drooping or unsupported runs must be avoided. PVC conduit may be used under floors but steel conduit should be used in all places where heavy or unpredictable loads may occur. Under floor conduit should not be less than 19 mm to allow for subsequent maintenance.

5.1.2 Design of Circuits

The dimensions of the conductors shall be according to the relevant tables in the IEE Regulations (See Annex A) and must comply with the following requirements:

5.1.2.1 Capacity

The rated current carrying capacity at 35°C for any given wire cross section shall not be exceeded. Wires of cross section area less than 2.5mm² are not recommended for use with photovoltaic systems.

5.1.2.2 Maximum Appliance Voltage Drops

The voltage across any appliance shall not be less than the battery terminal voltage less by 5% volts. Under no conditions is a voltage of less than 10.5V permissible across an appliance. The voltage shall be measured with all appliances in the circuit, including those connected to socket outlets, switched on (See Annex A and B).

5.1.2.3 The Battery/PV-Panel Voltage Drop

Voltage drop between the PV-panels and batteries shall not exceed 1.0V or 5% measured at maximum charging current. This voltage drop measurements will include any series or protection Diodes.

5.1.2.4 Minimise Junction Losses

To avoid using long cable runs with large numbers of T and star junctions, the load may be split into several circuits from the controller.

5.1.3 Use of existing 240V AC Wiring

Where existing wiring of 240V AC is installed, this may be used, provided it complies with other conditions in 5.1.2. If new wiring is installed in 240V AC conduits, it shall also be in accordance with IEE regulations for 240V AC.

5.1.4 Cables Connection

Cables can be connected by the use of junction boxes, block connectors or soldering joints (with insulating sleeves). All cable joints must be contained within a suitable junction box. The rated capacity through the joints shall not be less than for the circuit they form a part of. All joints made within rooms or other places where they will be visible shall be enclosed in junction boxes. Lights and socket may be used as junction boxes where this is practicable.

5.1.5 Installation of Cables and Conduit

5.1.5.1 Surface Mounted Cables

Surface mounted cables will be installed using appropriate fasteners at suitable intervals to prevent sagging.

5.1.5.2 Attachment of Cables

Attachment of cables or conduit to concrete, bricks or mortar, walls etc. shall be made with appropriate fasteners. Attachment of cables to metal or asbestos sheeting or similar material shall be made by use of suitable toggles.

5.1.5.3 Underground cables

Underground cables shall be at least 0.6m below the surface and be indicated with markers (coloured plastic tape, minimum 50mm wide or lining with bricks or slates, 0.2m above the cable). Underground cables shall be used across all areas with vehicular traffic. They may also be used for aesthetic reasons or to achieve a short cable run as instructed by the client. The cables must be designed for this type of application. Conduit must be able to withstand vertical loads if heavy vehicles are expected to cross the area.

5.1.5.4 Suspended Cables

Suspended cables shall be mounted so that the lowest point is at least 2.7m above ground level. The cables shall be held in position by suitable brackets and strain relief to prevent mechanical wear and stress on the electrical connections. For outdoor exposed usage, the cables shall be fully UV-resistant.

5.1.5.5 Cables through Roofing

Holes through roofing should be avoided where possible. Cables through roofing shall be contained in roof-entry boxes, which also shall form a waterproof seal to avoid leakage. Holes for cables should be drilled at top of corrugations. All holes in the roofing shall be thoroughly sealed and made waterproof with UV-resistant silicone sealant or equivalent.

5.1.5.6 Thatched Roofs (Flammable Materials)

Where wires or cables are fixed to or passing through particularly flammable materials (thatch, etc.) they should be shielded in non-flammable conduits. Fittings must be fastened to suitable supports, which may need to be provided if

not already present. No conduit or fitting should be attached directly to thatch, or any other non-supportive surface.

5.1.5.7 Through Wall Cabling

Holes for cables through walls shall be sealed with mortar or putty and the surfaces touched up with paint. Holes that penetrate external walls must slope upwards slightly towards the inside to prevent the ingress of water.

5.2 Switches

Standard switches for 240V AC may not be used as alternative to special switches for 12V DC. Unless written approval from the manufacturer is obtained which should include acceptable dc voltage and current limits. All switches must be rated at twice (2 times) their expected current carrying load. Where particularly required, special time switches, photosensitive switches, remote relay switches, etc. may be specified. These shall be of adequate quality and performance, as specified for each purpose. All switches should include a clear visual indication of their state (i.e. On or Off).

5.3 Power Point (Socket Outlets)

5.3.1 DC Sockets

Appliances shall be connected to the solar PV system through socket outlets where not otherwise specified. Socket outlets shall be designed for special 12V DC 2-pin plugs. It shall not be possible to reverse the polarity. Socket outlets and lights may be connected to the same circuits provided other requirements are complied with.

Note: 240 V AC Main sockets and plugs, both 13A and 15A types, are not acceptable for DC appliance connection. This is for safety reasons. Any 12V appliance with a 240V AC mains type plug attached constitutes an unacceptable risk to the user if the appliance is used in a 240V outlet.

5.3.2 Inverter Outlets (AC 240V) (optional)

Where 240V outlets from a DC-AC inverter are provided mains type sockets must be used. A label on each socket should be added to show the maximum power available from that socket. Extra protection for the circuit in the form of circuit breaker or fuses should be included if overload can cause damage to the inverter. All wiring in these circuits will conform to IEE regulations for 240VAC mains wiring. Circuit breakers and a proper safety earth system are necessary in these circumstances.

5.3.3 Polarity

All installations that have DC sockets shall be wired so that the large diameter pin in the plug is always positive. All **positive** connections shall be made with **Red** insulated wire, and all **negative** connections with **Black** insulated wires.

5.4 Light Fixtures

The following types of lights may be used:

5.4.1 Indoor (not exposed to weather)

Fluorescent lamps, due to their high efficiencies are recommended for general space lighting and tasklights. Halogen bulbs in approved adjustable or portable fixtures are acceptable for tasklight/spotlights. Incandescent lights may be specified for particular uses.

Where lamps are fitted next to thatch or flammable ceiling materials, a metal lamp fitting or a metal shield should be used to minimise the risk of fire.

5.4.2 Outdoor (exposed)

Sodium vapour or other monochrome high intensity lights for security lights, streetlights, etc may be used and fluorescent tubes for space lighting. All fixtures to be specially designed for outdoor exposed use i.e. weatherproof, insect proof, etc.

5.4.3 Insect Precautions

Where lights are installed inside care must be taken that insects will not cause a nuisance. This may involve fitting insect screens to windows and doors where necessary. Where lamps with enclosures or diffractors are used they must be capable of being opened for cleaning by the client, as small insects may accumulate inside. Open lamps are preferable from this aspect. Where tools are necessary to open lamps for cleaning, such tools should be provided as part of the installation.

5.5 Appliances

All appliances (radios, fans, spotlights, rechargeable torches, refrigerators, special instruments, etc) to be connected to 12V DC systems shall be specially designed for such voltage or provided with suitable and efficient adaptors/inverters for safe functioning. The contractor should be able to advise the client of suitable appliances and precautions in their use.

5.6 Photovoltaic (PV) Modules

5.6.1 Specifications

The output current and voltage of the modules or panels should be appropriate for the application, and should be clearly established by the contractor from the manufacturer's documentation and stated in the contract. The pertinent conditions are solar irradiation of 1kW per m² or less. Cell temperature of 35°C or higher. The local National Bureau of Standards may be able to provide advice on quality and finish of panels, and test new panels under local conditions where necessary. The module shall have a quality mark from PV GAP on the module. This mark provides assurance that the module has been tested to IEC 61215 or IEC 61646 and that the manufacturing has ISO 9001:2000 certification and periodic auditing

5.6.2 Locations of PV-Panels

5.6.2.1 Position

No object (trees, buildings, etc.) should shade any part of the PV-panel at any time of the year between 90 minutes after sunrise and 90 minutes before sunset. Should shading be unavoidable, this shall be compensated for by reducing the daily energy output in the system design. Note that reduction in output due to partial shading will typically be much greater than the portion of the array that is shaded. Where possible, the PV-panel shall be installed on the roof of a building near the controller and battery bank.

5.6.2.2 Orientation

The panel must be installed facing in the prescribed direction, at the prescribed angle to horizontal plane, for the particular location.

5.6.2.3 Lightning Protection

PV-panels should be installed lower than the highest point of the building. The support frame may be provided with a short lightning rod if this becomes the highest point of the building. The local National Bureau of Standards or other specialised contractors will provide expert advice in case of doubt. The contractor should make the client aware of the risks that can arise due to unsafely earthed structures. Where grounding of structures for lightning protection is needed a cable of 16mm² minimum cross sectional area connected to a 1.5m earth spike should be used.

5.6.3 Support Structure

The support structure for panels shall be made of permanent materials, be strong enough to withstand all climatic conditions (wind, heat, water) without deflection or vibrations and be securely braced and fixed to the roof or the wall of a building or the ground. Frames, support structure and other metal parts shall be made of non-corroding materials, or protected against corrosion by galvanisation, painting, etc. as appropriate for the material used. It is good practice to keep dissimilar metals separate, unless they are well sealed against water by paint or sealing compound. Calculations and supporting documentation to demonstrate adequate design may be required.

5.6.3.1 Roof Mounting

Fixing to roofs shall be done so that leakages are prevented and no corrosion of roofing materials will occur. Bolts to be fixed through top of corrugations on corrugated metal roofs, to be secured to purlins, or special supports to be fixed to the roof structure if the purlins are of poor quality. All holes in the roofing shall be thoroughly sealed and made waterproof with UV-resistant silicone sealant or suitable sealing compound.

5.6.3.2 Ground Mounting

This method of mounting should be avoided whenever possible. Solid foundations shall be provided at each corner of the array with additional support as required by the design of the supporting structure. Panels shall not be mounted closer than 0.8m from the ground to avoid shading by grass and other vegetation. Small arrays may alternatively be fixed to a single pole, securely buried into the ground and if necessary secured with stays.

The location shall be chosen such that animals can cause no damage and the site shall be fenced.

5.7 Batteries

5.7.1 Type

Batteries shall be of a design suitable for PV applications. Deep discharge and long cycle life batteries are recommended.

Note: *Conventional car/truck starter batteries are not generally acceptable. For specifications for batteries, refer to US 149-1: 2000 Specification for batteries for photovoltaic systems (under development).*

The technical implications of the choice of battery and the costs and benefits of different types should be explained to the client in general terms.

5.7.2 Installation

Batteries shall be installed in boxes, racks, or cupboards to protect the connections (terminals) against accidental short-circuiting while still being accessible for checking. At least 20mm free space shall be left between the

batteries, the wall, and the top of the box. Ventilation of the enclosure shall be ensured to avoid build up of explosive gases during charging. The box shall be made of suitable durable materials. If made of wood, it shall be well preserved against insects (termites), rot and acid. The box must be securely fixed in position. Each battery shall be marked with the date of manufacture and year and month of installation by the installer. Maintenance requirements shall be clearly laid out in the owner's manual.

5.8 Controllers and Circuit Breakers/Fuses

5.8.1 Controller

5.8.1.1 Overcharge and Over-discharge Protection

Controllers shall be designed and installed to protect the batteries against overcharging, as well as over-discharging. Voltage disconnect/reconnect settings will depend on the type of battery. The rated capacity of the controller shall be selected to handle the maximum short circuit current from the PV-array (defined as $1.25 \cdot I_{sc}$ @ STC) and the maximum load. The charge controllers and circuit breakers / fuses shall be certified under a recognized program such as the Global Approval Program for Photovoltaics (PV GAP, see www.pvgap.org). This certification shall provide the assurance that an accredited testing laboratory has tested the item to an appropriate standard or specification, that the manufacturing facility is certified to ISO 9001:2000, and that the product manufacturing is subject to periodic auditing.

5.8.1.2 Warning of Over-discharge

A warning system consisting of a light and or an audible alarm providing at least three minutes advanced warning of disconnection should be installed. Where the controller is installed in a room, which is not regularly used, a remote alarm should or may be installed at a place where it can be easily noticed.

5.8.1.3 Bypass of Over-discharge Protection

Essential Service (*ES*) circuits may be provided with a switch to facilitate bypass or the over-discharge protection or to bypass the regulator completely. Warning for low battery shall however be included as for Non-Essential Services (*NES*). The owners manual and markings on the bypass device should clearly indicate the implications and potentially irreversible damage that may be caused by bypassing this protection.

5.8.2 Circuit Breakers/Fuses

The system shall be protected against damage due to accidental short-circuits by use of fuses or circuit breakers. Consumer circuits shall have circuit breakers. Individual circuits from the battery shall have a maximum rated capacity of 25 Amperes where not otherwise specified. Each circuit shall be so designed that the peak demand does not exceed 80% of the rated capacity of the fuse or circuit breaker.

5.8.2.1 Installation

Required fuses and circuit breakers may be integrated in the controller box or installed separately in a fuse or distribution box positioned near the controller and battery. Each fuse or circuit-breaker shall be clearly marked with rated capacity and for which circuit it is used.

5.9 Samples

In the case of new components or of innovative techniques used by the contractor, the client may require samples of materials and equipment for

approval before installation commences. It is recommended, where possible, to show the client an existing installation so that any ambiguities may be explained.

6.0 System design

6.1 Design Data

The client may provide data for dimensioning of each system where the design is not prepared in detail by the contractor. It shall be the responsibility of the contractor to ensure that such system details are consistent.

- Type of lights and appliances
- Essential Services (*ES*) and Non-Essential Services (*NES*)
- Daily Load (*DL*)
- Autonomy, where the period of autonomous operation differs from that laid down in this document.

The contractor must specify the manufacturer, types of equipment with relevant rated capacities to be installed and enclosed calculations and other documentation to prove that all requirements are met.

6.2 Calculations

Calculations of requirements for a functional system shall depend on whether it is considered *NES* or *ES*. The system sizing rules outlined below are based on mathematical modelling with daily solar radiation records from Uganda over the period of at least 5 years, taking into account panel degradation as well as battery ageing. Similar system sizing rules should be obtained for other locations. Essential Service (*ES*) and Non-Essential Service (*NES*) systems should in general be installed as totally separate systems. Where a combination of *ES* and *NES* are connected to the same system, it shall be sized as if all services are *ES*, unless particular calculations are provided to prove that the design of all combined system will satisfy the requirements to both types of services.

6.3 System Autonomy

The period of autonomy of a Photovoltaic system may be defined as the total period for which the system shall provide power to its regular load without solar energy input. Simplified this is the period for which the system will operate normally without sunlight. The autonomy of a system depends mostly on the depth of discharge of the batteries under normal daily loads and the number of batteries included in the system. If a battery is only discharged by a small fraction of its total capacity each day, it will clearly provide more days of operation than a battery that is discharged by a large fraction each day.

The overall life of a battery is affected by the depth of its regular daily discharge; - the life being in general inversely proportional to the depth of discharge (i.e. the shallower the discharge the longer the battery life). The contractor should give careful consideration to the sizing of the batteries in relation to the system load requirements. The cost implications of this should be presented clearly to the client.

6.4 Essential Services (*ES*)

The battery capacity shall be at least 5 times the maximum daily load in Ah. This provides a normal cycle depth of 20% or less, assuming ample battery service life, and will provide 5 days autonomy in case of total array failure. The array output current i in amperes under conditions as specified above shall be at least $DL(Ah)/4(h)$.

6.5 Non-Essential Services (NES)

The total nominal capacity of the batteries in Ah shall be at least 4 times the daily load in Ah. The array output current i in amperes under conditions as specified above shall be: $DL(Ah)/4(h)$.

7.0 Labels

Supply and fixing of labels shall be carried out by the contractor. Labels shall be made of a permanent non-erasable material with clearly legible letters and shall be displayed in prominent position(s), providing the following information (text in English and/or any other appropriate local language)

7.1 Battery enclosure

“Danger! Explosive gas. Do not smoke. Do not use open flames. Do not short circuit battery terminals!”

7.2 At Controller

- Name and address of electrical contractor responsible for installation
- Date of installation
- How to read performance (display or coloured lights)
- Operation of circuit breakers or fuses (replacement of fuses)
- Identification of circuits from the controller
- Instructions on maintenance/cleaning of photovoltaic panels.

7.3 Distribution Board (if using wiring for 240V AC)

“Use 12Volt appliances only”.

7.4 Remote Warning (if Installed)

Explanation of the warning signals.

7.5 At Main Entrance to Building or home

The following text in English and/or any other appropriate local language.

“Please save energy. Switch off lights and appliances when leaving room”.

8.0 Inspection and testing

On completion of installation the system shall be inspected to ensure expected operation. In addition to checking that all parts are correctly installed and operating satisfactorily, the electrician will certify in writing that:

- Voltage drop (loss) in cables does not exceed specifications
- Output from PV modules is within 5% of manufacturers specified value
- All wiring has been installed in an appropriate manner
- No safety hazards exist
- All signs and labels have been sensibly placed.

9.0 Maintenance and spare parts

The following spares and equipment shall be supplied to the client as a part of the installation.

Spare parts and expertise for maintenance and repair shall be made available by the contractor for the equipment after installation following completion or expiry of the warranty period. Cost should be separately detailed in the original quotation.

The contractor will still be liable for all repair or replacement as per the installation warranty that he will provide.

9.1 Warranties

Notwithstanding any third party warranties that may be passed on by the contractor, the minimum warranty period of some important system components is suggested to be as follows;

Components	Minimum Warranty Period
Light Bulbs/Accessories	1 year
Batteries	1 year
PV modules and Wiring to PV modules	5 years
Controller/Inverter	3 years
Complete system	1 year

10. Registration, approval and acceptance by local National Bureau of Standards

10.1 Application for Approval

Any contractor who wishes to apply for registration should write to his local National Bureau of Standards.

10.2 Acceptance and Certification

All successful applicants may be issued a certificate to that effect and may be entitled to use the title and logo of “ Approved Contractor” in their Company and promotional literature. The certificate may be issued subject to a nominal certification fee, and may be uniquely numbered with the contractor’s number. The certificate may remain the property of the local National Bureau of Standards, as the agent for the Code of Practice control body. The Code of Practice Control Body may reserve the right to publicise all newly approved contractors in the public media nationally.

10.3 Installation and Notification

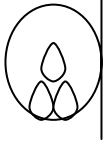

All contractors may be required to maintain numbered records of all Photovoltaic installations they perform. Such records may include the date, system type, unit installed, serial number, etc. The contractor may then required to inform the local National Bureau of Standards of the date, type and system details of all new installation, but may only refer to his own internal reference number. No commercial or financial information may asked for. The Control Body may at random select installations from each contractor by these reference numbers for follow up inspections. It may be planned to inspect one installation per year for each approved installation.

Annex A

Maximum Current Carrying Capacities of PVC Insulated Copper Wire

Table 1. Maximum Current Carrying Capacities of PVC Insulated Copper Wire

(at Ambient Temperatures of 35°C, 40°C and 45°C)

Wire Cross Section Area	 Buried Wiring			 Surface Wiring		
	35°C	40°C	45°C	35°C	40°C	45°C
mm ²						
2.5	18.3	17.0	15.4	22.6	20.9	19.0
4	24.4	22.6	20.5	30.1	27.8	25.3
6	32.0	29.6	26.9	38.5	35.7	32.4
10	43.2	40.0	36.3	53.6	49.6	45.0
16	57.3	53.1	48.2	71.4	66.1	60.0
25	75.2	69.6	63.2	94.9	87.9	79.8

The above table shows the maximum safe currents (A) that may be carried by PVC insulated cables of the given cross-section areas when wired in plastic or metal conduit. Currents are shown for surface mounted conduit, and for buried conduit, (conduit may be buried within a wall or floor).

Annex B

Maximum Cable Lengths

Table.2 Maximum lengths of cable runs to provide a voltage drop of less than 1V

Cable Section mm ²	Load				
	20W	50W	100W	200W	500W
	Maximum Cable Length for 1.0V Drop (m)				
1	12	4	2	-	-
1.5	20	8	4	-	-
2.5	32	12	6	3	-
4	50	20	10	4	2
6	80	32	16	8	4
10	126	50	24	12	6
16	200	80	40	20	8
25	320	126	64	32	12

The above table provides a summary of the maximum cable lengths that will give a voltage drop of less than 1V – this values is for cables only to allow up to 0.5V of voltage drop in connectors and junctions, and to still allow the recommended limits to be met. A cable run assumes an out and return wire of the same diameter. Diameters are for solid core copper wire only.

Figures used assume a battery voltage of 12V, the maximum (permissible drop of 1.0V may not be exceeded).

Annex C

(informative) Bibliography

- [1] US 149-1: 2000 *Batteries for PV systems - Specification.*
- [2] BS EN 55015 *Limits and methods of measurements of radio disturbance of electrical lighting and similar equipments.*
- [3] US 218: 2000 *Definitions, Abbreviations, Symbols, and Terminology of Photovoltaic Systems.*
- [4] IEC 61215:1993 *Crystalline silicon terrestrial photovoltaic PV modules – Design qualification and type approval* or IEC 61646:1996 *Thin-film terrestrial photovoltaic (PV) module - Design qualification and type approval.*
- [5] ISO 9001:2000 *Quality management systems - Requirements.*

[6] *Code of practice for Photovoltaic Installation in Botswana.*

[7] *PV GAP PV Quality Mark and Seal: PV GAP 01:1998 PV GAP Reference Manual*

Certification Marking

Example

Products that conform to Uganda standards may be marked with Uganda National Bureau of Standards (UNBS) Certification Mark shown in the figure below.

The use of the UNBS Certification Mark is governed by the Standards Act, and the Regulations made thereunder. This mark can be used only by those licensed under the certification mark scheme operated by the Uganda National Bureau of Standards and in conjunction with the relevant Uganda Standard. The presence of this mark on a product or in relation to a product is an assurance that the goods comply with the requirements of that standard under a system of supervision, control and testing in accordance with the certification mark scheme of the Uganda National Bureau of Standards. UNBS marked products are continually checked by UNBS for conformity to that standard.

Further particulars of the terms and conditions of licensing may be obtained from the Director, Uganda National Bureau of Standards.

