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TECHNICAL SPECIFICATION

Recommendations for small renewable energy and hybrid systems for rural electrification –
Part 5: Acceptance, operation, maintenance and replacement

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RECOMMENDATIONS FOR SMALL RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 6: Acceptance, operation, maintenance and replacement

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62257-6, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This technical specification is based on IEC/PAS 62111(1999); it cancels and replaces the relevant parts of IEC/PAS 62111.

This technical specification is to be used in conjunction with

IEC 62257-1: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 1: General introduction to rural electrification*

IEC 62257-2: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 2: From requirements to a range of electrification systems*

IEC 62257-3: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 3: Project development and management*

IEC 62257-4: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 4: System selection and design* (to be published)

IEC 62257-5: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 5: Safety rules: Protection against electrical hazards* (to be published)

IEC 62257-6: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 6: Acceptance, operation, maintenance and replacement*

IEC 62257-7-1: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 7-1: Generators photovoltaic arrays* (under consideration)

IEC 62257-9-2: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 9-2: Microgrid (under consideration)*

IEC 62257-9-3: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 9-3: Integrated system – User's interface (under consideration)*

IEC 62257-9-4: *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 9-4: Integrated system – User's installation (under consideration)*

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/371/FDIS	82/384/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International Standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The IEC 62257 series intends to provide to the different players involved in rural electrification projects (such as project implementers, project contractors, project supervisors, installers, etc.) documents for the setting-up of renewable energy and hybrid systems with a.c. nominal voltage below 500 V, d.c. nominal voltage below 750 V and nominal power below 100 kVA.

These documents are recommendations:

- to choose the right system for the right place;
- to design the system;
- to operate and maintain the system.

These documents are focused only on rural electrification concentrating on but not specific to developing countries. They must not be considered as all inclusive to rural electrification. The documents try to promote the use of renewable energies in rural electrification; they do not deal with clean mechanisms developments at this time (CO_2 emission, carbon credit, etc.). Further developments in this field could be introduced in future steps.

This consistent set of documents is best considered as a whole with different parts corresponding to items for safety, sustainability of systems and at the lowest life cycle cost as possible. One of the main objectives is to provide the minimum sufficient requirements, relevant to the field of application that is: small renewable energy and hybrid off-grid systems.

The purpose of this technical specification is to propose a methodology to achieve the best technical and economic conditions for acceptance, operation, maintenance and replacement of equipment and complete system life cycle.

RECOMMENDATIONS FOR SMALL RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 6: Acceptance, operation, maintenance and replacement

1 Scope

This technical specification is intended to describe the various rules to be applied for acceptance, operation, maintenance and replacement (AOMR) of decentralized rural electrification systems (DRES) which are designed to supply electric power for sites which are not connected to a large interconnected system, or a national grid, in order to meet basic needs.

The majority of these sites are:

- isolated dwellings;
- village houses;
- community services (public lighting, pumping, health centers, places of worship or cultural activities, administrative buildings, etc.);
- economic activities (workshops, micro-industry, etc.).

It proposes a methodology to achieve the best technical and economic conditions for acceptance, operation, maintenance and replacement of equipment and complete system life cycle.

It does not substitute for technical manuals provided by manufacturers for each equipment. The complexity of the system and application will dictate the level of required AOMR documentation.

2 Normative reference

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62257 (all parts) *Recommendations for small renewable energy and hybrid systems for rural electrification*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
AOMR actions
acceptance, operation , maintenance and replacement actions

3.2
implementation contract
contract between project developer and project implementer usually the result of a competitive sollicitation for proposals developed by the project developer on the basis of the general specification

3.3
electric equipment
item used for such puposes as generation, conversion, transmission, distribution or utilization of electric energy, such as electric machines, transformers, switchgear and controlgear, measuring instruments, protective devices, wiring systems, current-using equipment

[IEV 826-16-01].

3.4
REN
renewable energy

4 General aspects

4.1 Introduction to AOMR actions

Isolated electrification systems are designed to supply power to those individuals, communities or loads located in remote areas not connected to national grids.

These systems can be broken down into three categories:

- process electrification systems (for instance for pumping),
- individual electrification systems (IES) (single user, load or application),
- collective electrification systems (CES) (multiple user load or application).

In order to satisfy the various energy requirements both in terms of quality and quantity, six types of isolated micropower systems have been identified (see IEC 62257-2).

AOMR actions are introduced in Table 1.

A basic system acceptance process description is given in Table 2.

Table 1 – AOMR actions

Acceptance	• checking process to ensure that the system installation meets the requirement set forth in the implementation contract between the project developer and the project implementer • testing process to ensure that the micropower system operates according to the functional part of the implementation contract • once the parties have come to agreement, transfer the responsibility of the system
Operation	• managing business of system operation • monitoring «normal» system operation ("normal" operation = system supplies power complying with all the characteristics of the expected service, with the original designed configuration) • managing system electrical operation = executing actions on electrical circuits (configuration changes) • response to abnormal operating conditions = to provide service outside of the boundaries of the implementation contract (prolonged absence of REN sources) • response to abnormal system operation corrective actions (manual or automatic), troubleshooting and repair system or system components (diagnosing the cause(s) for failure fault finding = to service the plant and restore its operating conditions further to an unpredictable failure • guaranteeing safety while performing (servicing) actions on the plant • performing analysis and retrofit of the system to account for new operating conditions
Maintenance	• preventive maintenance: keeping and maintaining the system to its «normal» operating state • corrective maintenance: adjusting, fixing or replacing components after fault recognition • conducting periodic tests and inspection
Replacement	• replacing the equipment on «normal» life cycle completion • replacing the equipment for upgrading purpose • dismantling and recycling at end of life cycle

Table 2 – System acceptance process description

Acceptance process		Objective	Responsible Party	Implementers	Content of a suggested data sheet
Phase 1	Preparation	To collect all information on the system	Project implementer	Project implementer/ subcontractor	List of contractual documents to be provided
Phase 2	Check of existing documentation, contract clauses	To check that all non operational contractual requirements are met: Documentation, manuals, spare parts, drawings, procedures, warranty contracts, etc.	Project developer	Consultant engineer	List of contractual documents to be provided
Phase 3	Commissioning step 1: Evaluation of the conformity of the installed system with the accepted design	To check that the equipment complies to the contractual accepted design and any differences are explained	Project developer	Consultant engineer	Equipment list: Initial design list/as built list/comments
	Commissioning step 2: Evaluation of qualification of the installation	To check that the system is ready to be operated	Project implementer	Project implementer/ subcontractor	Letter
	Commissioning step 3: Preliminary tests	To test that the system components operate correctly	Project developer	Consultant engineer	Component by component, verification: Proper type and reference according to the as built list Proper installation: check list of key points Proper operation: list of tests with targeted performances to be obtained
	Commissioning step 4: Performance testing	To check all the operating performances of the whole system	Project developer	Consultant engineer	List of system tests with targeted performances to be obtained
Phase 4	Agreement	Transfer of responsibility	Project implementer/ developer/ operator/ owner		Letter of acceptance

4.2 Conditions impacting AOMR actions and guidelines

4.2.1 Characteristics of the project/systems to be managed

Characteristics of systems and their installation environment will have an influence on the organizational schemes to perform AOMR actions.

Among these influence factors the following are highlighted:

- geographical layout: number of systems, their location and dispersion will determine spare parts and tool requirements, technician and equipment transportation means, mean time to repair and perhaps methodology for collecting money;
- systems size and technology will have an influence on the maintenance program, the skill level of technician, and final user's involvement;
- the degree of multiple system standardization will impact training and skill levels for operators and maintenance staff;
- the importance of specific applications (health, water pumping, telecommunications) can be considered more critical and managed more carefully.

4.2.2 Organization of AOMR personnel and responsibilities

The following different parties to be involved in the rural energy systems may be involved in the AOMR activities:

- owner
- project developer
- engineering consultant
- project implementer
- subcontractor
- operator
- maintenance contractor
- training provider
- user

The specific roles of each party are described in greater detail in IEC 62257-3.

AOMR activities are dispatched according to the contractual responsibilities of the different parties as shown in Table 3, considering that one person may have several roles.

Table 3 – AOMR participant involvement

Nature of participant	AOMR actions				Responsibilities versus AOMR concerns
	A	O	M	R	
Owner	I			I	Long term financial and contractual responsibility for the system.
Project developer	I	C	C	C	Responsible for defining operating rules, maintenance policy and replacement time schedule
Engineering consultant	I	C	C	C	On the basis of a service to be supplied and under the project developer's responsibility, defines AOMR rules and levels which will allow the provision of this service.
Project implementer	I				May provide information relevant to AOMR to the project developer
Subcontractor	I		I	I	Specific to warranty of equipment
Operator		I	I	I	Upon acceptance of the work, gives his consent and declares the micropower plant "accepted for operation". Is then responsible for the application of AOMR rules on site Responsible for insuring the proper maintenance of the production, distribution and demand subsystems including earthing arrangements.
Maintenance contractor			I		Committed to visit the system at regular intervals for checking the condition of those components subjected to aging. Performs maintenance and reconditioning operations. Committed to inform the participants and mainly the operator about major events regarding the operation of the system.
Training provider		T	T		Provides relevant knowledge and related training actions to make people able to perform their allocated AOMR actions.
User		I	I		By applying instructions provided, the user can supply feed back to the operator and may perform simple operation and maintenance actions depending on the system design. Reports any maintenance issues to the operator.
C = conceptual role I = implementation role T = training role					

As described in IEC 62257-2, a system is structured into three subsystems (production subsystem, distribution subsystem and demand subsystem).

The different subsystems may be owned by the same or different bodies or individuals. The different functional roles described here are the responsibility of and may be performed by or delegated to other participants designated by the owner

All the functional roles shall be defined for all parts of the system and covered by contractual arrangements.

Each participant category represented in Table 3 shall be fulfilled although more than one category may be fulfilled by the same individual or group. An important example of this is that the user and the operator may be the same in many small systems.

4.2.3 Needed technical capabilities of AOMR participants

Two kinds of skill levels are defined:

- skill level necessary for safety considerations
- skill level for management and technical issues

It may occur that a number of operating features will be provided for using logic control. This may be the case for monitoring, operating and diagnostic tasks.

Table 4 gives the level of skill necessary for safety considerations.

Table 4 – Levels of skill for safety

Level 1	Skilled person	Person with relevant education or experience to enable him/her to perceive risks and to avoid hazards which electrical, chemical or mechanical equipment may create
Level 2	Instructed person	Person adequately advised or supervised by skilled persons to enable him/her to perceive risks and to avoid hazards which electrical, chemical or mechanical equipment may create
Level 3	Ordinary	Person who is neither a skilled person nor an instructed person

Table 5 gives the level of skill necessary for management and technical issues.

Table 5 – Levels of general skill

Management issues		
Level 0	Person with relevant education or experience to enable him/her to conduct management operations (staff management, customer management, etc.)	
Technical issues		
Level 0	Engineering	Person with relevant education or experience to enable him/her to elaborate maintenance plan and comprehend the interaction between components
Level 1	Skilled person	Person with relevant education or experience to enable him/her to conduct or supervise detailed actions on the system
Level 2	Instructed person	Person adequately advised or supervised by skilled persons to enable him/her to perform specific tasks of operation and maintenance
Level 3	Ordinary	Person who has no skill relevant to system operation and maintenance

Specific tasks or service items that require specific skills should be identified as such in the project documentation.

4.3 Training

The training plan, defined under the responsibility of the project developer, shall take into account the different levels of skill described in Table 4 and Table 5. Some specific considerations are:

- some verification shall be implemented to ensure proper training is being carried out and that the personnel understand how to perform duties called for;
- training manuals shall be provided in the appropriate languages and quantity to ensure use;
- training is a continuous process, people shall be periodically retrained and updated as necessary.

5 Rules for systems

5.1 System identification and operational data record keeping

The following minimum information shall be prominently and legibly displayed on the indelibly marked system nameplate that shall be installed on a critical component of the micropower system:

– manufacturer's name and/or brand name;
– model and serial number, revision number of power system;
– installation date.

The accompanying documentation shall contain the manufacturer's name, address and contact information.

The general specification shall specify all information needed to properly define the system.

During the commissioning process, this information shall be transferred to the person or group identified by the owner to be responsible for updating this data (including upgrading, design changes, replacement, history of failure, history of maintenance, replacement, repairs, etc.). This individual or group is likely to be the consulting engineer or the operator.

5.2 Organizational issues

5.2.1 System limit definition of the AOMR domain

A clear definition of the physical limits of the three parts of the system (production, distribution, demand) in relation to operation, maintenance and replacement actions shall be drawn up. The identification of the relevant personnel or organizations responsible for the different subsystems is also required. This is required for both organizational and safety reasons.

5.2.2 Planning of AOMR actions

AOMR actions shall be planned and conducted in accordance with a set schedule. A list of specific system level tasks associated with each AOMR action is provided below.

a) The acceptance date shall be clearly confirmed as it is a starting point for the warranty.
b) Operation activities shall be managed in order to guarantee the service contractually defined. When faults occur, spare parts and man power shall be available to conduct repairs.
c) Maintenance activities shall be planned for technical and economic reasons. It is necessary to have an overview of all the expected maintenance actions to be implemented for the life of the system to guarantee its availability

Based on information provided by the manufacture and consulting engineer, a table as illustrated in Table 6 shall be developed by the project implementer and updated by the operator as needed.

Table 6 – Maintenance actions planning (example)

System component	System lifetime					
	Period 1	Period 2	...	....	...	Period N
PV field	• Action • Actor • Cost			• Action • Actor • Cost		
Batteries	• Action • Actor • Cost		• Action • Actor • Cost	• Action • Actor • Cost		• Action • Actor • Cost
Charge controller				• Action • Actor • Cost		
Inverter			• Action • Actor • Cost		• Action • Actor • Cost	
Genset	• Action • Actor • Cost	• Action • Actor • Cost	• Action • Actor • Cost	• Action • Actor • Cost	• Action • Actor • Cost	• Action • Actor • Cost
...						

d) Replacement activities shall be planned in a similar fashion.

For some components it is possible to determine the loss of performance and decide when replacement will be needed. The project implementer shall provide a recommendation for each piece of equipment or component in order to enable the operator to decide on the relevant replacement actions.

5.2.3 Traceability of AOMR actions

Information on any change or action within the systems shall be recorded in order to trace the technical life of the system and the relationship with the user. This document will be required to support any warrantee claims and should be kept in duplicate.

5.3 Technical issues

5.3.1 Electrical safety

The equipment concerned pertains to either of the following voltage domains as indicated in Table 7:

Table 7 – Voltage domains

Voltage domain	Nominal voltage (U_n in volts)	
	Alternating current	Smoothed direct current
ELV	$U_n \leq 50$ V	$U_n \leq 120$ V
LV	50 V < $U_n \leq 1000$ V	120 V < $U_n \leq 1500$ V

Operation actions shall be conducted according to the local safety regulations. If these do not exist, the following rules should be followed:

- all electrical work or work where there is the potential for electrical shock will be performed with the power shut off;
- disconnecting supply leads from a terminal strip as the sole procedure for disconnecting this part of the system is not acceptable;
- all the equipment from which disconnecting device operation must be inhibited shall be provided with a padlocking or lockout mechanism;
- disconnecting devices shall be located in a secure enclosure accessible by authorized people. It shall be accessible in all circumstances without having to enter a private property.

5.4 Acceptance issues

The commissioning procedure shall verify the technical performance of the system in two steps:

a) verification of the performance of each piece of the system (equipment or component):
   - check the conformity of the design of the piece of equipment to the implementation contract. Examples of commissioning sheets are provided in the relevant technical specifications IEC 62257-7 to IEC 62257-13;
   - perform the tests according to the implementation contract. Examples are provided in the relevant technical specifications IEC 62257-7 to IEC 62257-10;

b) verification of the performance of the whole system:
   - perform system tests according to the implementation contract.

5.5 Recommended practices for intervention

Due to the interlinked nature of the many potential different energy producing devices typically found in micropower stations, it is important to carefully consider issues of component isolation in the initial design and construction of the power system. Due to both the nature of renewable energy devices and the degree of automated system operation typical in micropower plants, it is possible for devices to start and/or produce energy without warning.

A clear and concise isolation plan should be developed to ensure that each component of a micro-power plant can be safely separated from the power system to allow maintenance, repair or replacement. In some cases it may be more appropriate to shut down the complete system instead of separating individual components.

It is the responsibility of the project developer to see that this is completed and will likely be conducted by the consulting engineer or project implementer.

It should be noted that the presence of capacitors incorporated into any component of the micro-power system may result in voltage even if completely disconnected from external sources.

5.6 Maintenance actions

Within most micropower systems maintenance shall be completed on each component as well as the system as a whole. In most cases, equipment manufacturers will provide maintenance guidelines for their specific component but no general maintenance guideline will be provided for the complete system.

Examples of specific non-component maintenance items include:

- cleaning wire conduits of animal or insect nests;
- maintenance of site access, grounds and buildings;
- building cooling system;
- site and systems communications;
- fuel delivery and storage systems.

As discussed previously in this clause, a system wide maintenance plan should be developed to ensure that timely maintenance is completed for all system elements.

Maintenance of all three subsystems (production, distribution, demand) shall be coordinated to ensure proper system operation.

Two types of maintenance are generally required:

- Preventive maintenance: maintenance that is completed on a scheduled basis and is conducted to ensure that the piece of equipment or system continues to operate effectively. Examples of preventative maintenance would include changing the oil in diesel generators at a specific frequency or checking the torque of the bolts on a wind turbine tower annually. This type of maintenance is conducted to ensure the expected life of the system components.
- Corrective maintenance: maintenance completed to repair or fix a problem that was identified as part of regular service or preventive maintenance but that would occur as part of normal operation prior to an actual failure. An example of corrective maintenance is the replacement of a bearing in a piece of rotating equipment or a failing cooling fan in a power converter. Corrective maintenance is designed to repair a known problem before it is allowed to propagate into many or larger problems.

5.7 Replacement factors

In most cases, replacement actions will be required for individual power plant components as compared to the complete system. In this case, a specific component will be replaced, potentially with a different but compatible component if required to maintain system performance requirements, but the remainder of the system will be left unchanged. Although generally not the case, occasionally the complete micropower system may need to undergo replacement. A number of cases are identified as follows:

a) End of the useful life of the majority of the system: if most of the system components have reached the end of their useful life it may be more cost effective to replace the complete power system compared to replacing each individual component;

b) Quality of the supply is no longer sufficient: changes in the community require a higher quality of supply than could be provided by the previous system;

c) Load has grown: the load in the community has grown to the extent that the system is no longer capable of providing sufficient power. In this instance it may be more cost effective to replace the whole power system. The old power system may then be moved to another community with lower power needs;

d) Step change in technology: a step change in technology may warrant the replacement of the complete system with a technology that provides higher quality of service at a lower cost;

e) Change in plant location: if the plant location must be changed for any reason.

5.8 Analysis of the conformity of the delivered service to the contractual commitments

It is necessary to implement a means to assess the adherence of the systems to fulfil the contractual commitments as defined for the project. Although this may be difficult, some level of performance criteria should be established.

Contractual commitments between the contractor and the owner (as defined in IEC 62257-3) are a function of the different types of systems (as defined in IEC 62257-2).

Adhering to the commitments means that provisions shall be made to prepare a balance data report of the delivered service (e.g. in terms of energy, operating days, pumped volume of water, etc.) within the commitment reference period.

This is carried out with AOMR actions as a function of the system type as illustrated in Table 8.

Table 8 – Verification of the adherence to commitments

Actions	System types					
	T1	T2	T3	T4	T5	T6
Check that appliance specifications are identical to those for initially installed appliances	x	x	x	x	x	x
Check that the delivered service at least equals the service defined under the contract	x					
Compare measured energies (production and consumption) for the contractually defined period. (for this comparison, user consumed a.c. and d.c. energies shall be metered)		x	x	x	x	x
Compare the fraction produced by the generator set against the fraction produced by REN if the contract requires a partial contribution of the genset.			x	x		
For collective systems: check contract managers/meters function (power limiters, energy limiter, etc.)		x	x	x	x	x

6 Rules for electric equipment

6.1 General aspects

Acceptance, operation, maintenance and replacement rules shall be defined for each part of the system, in accordance with the contractual commitments related to the service provided and also in relation to the recommendations of the equipment manufacturers.

In case of a lack of recommendations by manufacturers or installers, some practical guidelines on AOMR for different equipment are attached in the relevant parts of the IEC 62257 series. (IEC 62257-7 to IEC 62257-13)

Other technologies may exist and may be applicable but are not included in this technical specification.

6.2 Specific aspects related to electric equipment

For each piece of equipment, some considerations shall be applied in relation to the technology.