

TECHNICAL SPECIFICATION



**Recommendations for renewable energy and hybrid systems for rural
electrification –
Part 9-1: Integrated systems – Micropower systems**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.160

ISBN 978-2-8322-3585-0

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references.....	9
3 Terms and definitions	9
4 General	11
4.1 Boundary of a micropower plant	11
4.2 Composition of a micropower plant	12
4.3 General functional layout of a micropower plant	12
5 Design.....	13
5.1 Design criteria.....	13
5.2 Power generation mix.....	14
5.2.1 General	14
5.2.2 Internal combustion generator sets.....	15
5.3 Electrical design.....	15
5.3.1 System voltage selection.....	15
5.3.2 Interconnection of generators	16
5.4 Mechanical and civil works	16
5.4.1 Civil works	16
5.4.2 Technical room	16
5.4.3 Battery room	17
5.4.4 Specific requirements.....	17
6 Safety issues.....	17
6.1 Electrical issues	17
6.1.1 General	17
6.1.2 Specific requirements.....	17
6.2 Mechanical issues.....	21
6.3 Thermal and fire issues	21
6.4 Noise issues	21
6.5 Access security.....	22
7 Erection of equipment.....	22
7.1 Siting.....	22
7.1.1 Photovoltaic array	22
7.1.2 Wind turbine	22
7.1.3 Micro-hydro turbine	22
7.1.4 Generator set.....	23
7.1.5 Technical room	23
7.1.6 Battery bank (battery enclosure).....	23
7.2 Equipment installation	24
7.2.1 Mechanical	24
7.2.2 Electrical	24
8 Acceptance process.....	27
8.1 General.....	27
8.2 Phase 1: Preparation.....	27
8.3 Phase 2: Documentation	27

8.4	Phase 3: Commissioning	27
8.4.1	Step 1: Evaluation of the conformity of the installed system with the accepted design.....	27
8.4.2	Step 2: Evaluation of qualification of the installation.....	27
8.4.3	Step 3: Preliminary tests	27
8.4.4	Step 4: Performance testing	28
8.5	Phase 4: Agreement.....	29
8.6	Commissioning records	29
9	Operation, maintenance and replacement	29
10	Marking and documentation	29
10.1	Marking.....	29
10.1.1	Information for emergency services	29
10.1.2	Information for maintenance	29
10.1.3	Information for batteries	30
10.1.4	Signs	30
10.2	Documentation.....	30
Annex A (informative)	Selectivity of protection.....	32
Annex B (informative)	Risk assessment of lightning stroke.....	34
B.1	General.....	34
B.2	Risk assessment simplified methodology	34
B.3	Risk assessment multi-criteria methodology.....	34
Annex C (normative)	Voltage domains.....	37
Annex D (informative)	Battery room.....	38
D.1	Administrative formalities	38
D.2	Battery siting.....	38
D.3	Characteristics of the battery storage site: specific battery room or locker	38
D.4	Electrical equipment.....	39
D.5	Safety instructions.....	40
D.6	Battery enclosure examples (informative)	40
Annex E (informative)	Energy fraction calculations	45
Annex F (informative)	Noise control.....	46
F.1	General.....	46
F.2	Assessment of noise annoyance.....	46
F.3	Principles of noise attenuation.....	46
F.4	Noise reduction methods for specific items of equipment.....	47
F.4.1	Generator sets	47
F.4.2	Wind turbines.....	47
F.4.3	Inverters and other electronic equipment	47
Annex G (informative)	Commissioning record sheet (examples)	48
Bibliography	59
Figure 1	– Micropower system limits.....	12
Figure 2	– Example of functional layout for a micropower plant supplying a.c. energy.....	13
Figure 3	– Interconnection configuration with d.c. bus and a.c. bus	16
Figure 4	– Interconnection configuration with a.c. bus only	16
Figure 5	– Example of protection against effects of lightning and over-voltage for generators with two live conductors output (d.c. or a.c.) TNS P+N	18

Figure 6 – Example of protection against effects of lightning over-voltage for three phase generators with four live a.c. conductors (TNS P+N scheme) – Generator side.....	19
Figure 7 – Example of a simplified lightning protection including a crow’s foot earth termination	19
Figure 8 – Protection of a photovoltaic array.....	20
Figure 9 – Wiring arrangement for equipotential link	21
Figure A.1 – Example of the selectivity of protection	33
Figure D.1 – Two examples of a battery installed in a dedicated equipment room showing clearances from equipment.....	41
Figure D.2 – Example of a battery enclosure within a room where the battery enclosure is vented to outside the building	42
Figure D.3 – Example of a battery enclosure with equipment enclosure immediately adjacent	43
Figure D.4 – Example of a battery enclosure with the intake and outlet vents on the same wall	44
Table 1 – Minimum dimensions for lightning protection wires	20
Table 2 – Cross-section of 230 V a.c. power cables	25
Table 3 – Fuse ratings for protection from short-circuiting in 230 V/400 V a.c. circuits	26
Table 4 – Fuse ratings for protection from short-circuiting in 120 V/208 V a.c. circuits	26
Table 5 – Circuit-breaker ratings for protection from short-circuiting.....	26
Table B.1 – Stake index values	34
Table B.2 – Construction index values.....	35
Table B.3 – Height index values	35
Table B.4 – Situation index values	35
Table B.5 – Lightning prevalence index values	35
Table B.6 – Assessment of risk and need for protection	36
Table C.1 – Voltage domains	37

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RECOMMENDATIONS FOR RENEWABLE ENERGY AND
HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –****Part 9-1: Integrated systems – Micropower systems**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- 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 62257-9-1, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This second edition cancels and replaces the first edition, issued in 2008. It constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

- Changing the voltage range covered by the technical specification to a.c. nominal voltage below 1 000 V and d.c. nominal voltage below 1 500 V (introduction)
- Defining the rating of the microgrids to be the output of the microgrid (introduction)
- Including 240 V 1-Ø/415 V 3-Ø, in the voltage levels (introduction)
- Specifying Non-separated MPPTs connecting LV d.c. arrays to ELV d.c. battery banks are not allowed (5.3.1.1)
- Noting that systems can now include a.c. bus arrangements and use MPPT's as the solar controllers thus increasing the internal voltages that occur in systems (5.3.1.2)
- Increased equipotential bonding for lightning protection from minimum 10 mm² to minimum 16 mm² (6.1.2.2)
- Included a new subclause (7.1.6) on battery enclosures including possible arrangements shown as Clause D.6
- Rewritten LV Multiple sources (7.2.2.3.1)
- Included start-up procedure in documentation (10.2)

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

Enquiry draft	Report on voting
82/1028/DTS	82/1087/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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

This technical specification is to be used in conjunction with the IEC 62257 series and with future parts of this series as and when they are published.

A list of all parts in the IEC 62257 series, published under the general title *Recommendations for renewable energy and hybrid systems for rural electrification*, can be found on the IEC website.

Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website 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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The IEC 62257 series of documents 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 1 000 V, and d.c. nominal voltage below 1 500 V.

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 (CO₂ 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.

RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 9-1: Integrated systems – Micropower systems

1 Scope

Decentralized Rural Electrification Systems (DRES) 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 centres, places of worship or cultural activities, administrative buildings, etc.);
- economic activities (workshops, micro-industry, etc.).

The DRESs fall into the following three categories:

- process electrification systems (for example, for pumping);
- individual electrification systems (IES) for single users;
- collective electrification systems (CES) for multiple users.

Process or individual electrification systems exclusively consist of two subsystems:

- an electric energy generation subsystem;
- the user's electrical installation.

Collective electrification systems, however, consist of three subsystems:

- an electric energy generation subsystem;
- a distribution subsystem, also called microgrid;
- user's electrical installations including interface equipment between the installations and the microgrid.

This technical specification applies to a micropower plant which is the electric energy generation subsystem associated with a decentralized rural electrification system.

It provides general requirements for the design, erection and operation of micropower plants and general requirements to ensure the safety of persons and property.

The micropower plants covered by this specification are low-voltage a.c., three-phase or single-phase, with rated capacity less than, or equal to, 100 kVA. The rated capacity is at the electrical output of the micropower plant, that is, the upstream terminals of the main switch between the micropower plant and the microgrid. They do not include voltage transformation.

The voltage levels covered under this specification are:

- the 240 V 1-Ø/415 V 3-Ø, the 230 V 1-Ø/400 V 3-Ø, the 220 V 1-Ø/380 V 3-Ø, and the 120 V 1-Ø/208 V 3-Ø systems at 60 Hz or 50 Hz; or obeyed by local code.

- the ELV (less than 120 V) d.c. systems.

The requirements cover “centralized” micropower plants for application in:

- process electrification;
- individual electrification systems and collective electrification systems.

It does not apply to distributed generation on microgrids.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-5-53:2001, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

IEC TS 62257-2:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 2: From requirements to a range of electrification systems*

IEC TS 62257-4:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 4: System selection and design*

IEC TS 62257-5:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards*

IEC TS 62257-6:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 6: Acceptance, operation, maintenance and replacement*

IEC TS 62257-7-1:2010, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 7-1: Generators – Photovoltaic generators*

IEC TS 62257-7-3:2008, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 7-3: Generator set – Selection of generator sets for rural electrification systems*

IEC TS 62257-9-2:2016, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-2: Integrated systems – Microgrids*

IEC TS 62257-9-4:2016, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-4: Integrated systems – User installation*

IEC 62548:2016, *Photovoltaic (PV) arrays – Design requirements*