IEC TS 62257-1

Edition 3.0 2015-10

TECHNICAL SPECIFICATION

colour inside

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

IEC TS 62257-1:2015-10(en)

International Electrotechnical Commission

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 1: General introduction to IEC 62257 series and rural electrification

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 62257-1, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It was developed in cooperation with other IEC technical committees and subcommittees dealing with renewable energies and related matters, namely IEC technical committee 21 (Secondary cells and batteries), subcommittee

21A (Secondary cells and batteries containing alkaline or other non-acid electrolytes), IEC technical committee 64 (Electrical installations and protection against electric shock), IEC technical committee 88 (Wind turbines).

This third edition cancels and replaces the second edition issued in 2013. It constitutes a technical revision.

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

– Redefine the maximum AC voltage from 500 Va.c. to 1 000 Va.c., the maximum DC voltage from 750 Vd.c. to 1 500 Vd.c. and removal of the limitation of 100 kVA system size. Hence the removal of the word “small” in the title and related references in this technical specification.

This technical specification shall be used in conjunction with the other documents of the IEC 62257 series.

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

Enquiry draft	Report on voting
82/942/DTS	82/979/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.

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.

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INTRODUCTION

Rural electrification is one of the predominant policy actions designed to increase the well-being of rural populations together with access to clean water, improved healthcare, education, personal advancement and economic development.

Several strategies can be adopted to implement rural electrification. Rural electrification can be completed through connection to a national or regional electrification grid. The IEC 62257 series applies to cases where the grid is too far away (too costly) or the individual demand centres are too small to make grid access economic, where autonomous power systems may be used to supply these services.

This series IEC 62257 provides technical specifications to different players involved in rural electrification projects (such as project developers, project implementers, installers, etc.) for the setting up of renewable energy and hybrid systems with AC voltage below 1 000 Vac and DC voltage below 1 500 Vdc.

These specifications are recommendations:

a) to choose the right system for the right place,
b) to design the system,
c) to operate and maintain the system.

The specifications focus on rural electrification concentrating on, but not specific to, developing countries. They must not be considered as all inclusive to rural electrification. That means that they could be used for rural electrification or electrification of remote sites in developed countries also. They try to promote the use of renewable energies in rural areas, but they do not deal with clean mechanisms development 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: renewable energy and hybrid off-grid systems.

RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 1: General introduction to IEC 62257 series and rural electrification

1 Scope

This part of IEC 62257 first introduces a methodology for implementing rural electrification using autonomous hybrid renewable energy systems.

Secondly, it provides a guide for facilitating the reading and the use of the IEC 62257 series for setting up decentralized rural electrification in developing countries or in developed countries, the only difference being the level of quality of service and the needed quantity of energy that the customer can afford.

The IEC 62257 series is designed as follows:

- Parts 2 to 6 are methodological supports for the management and implementation of projects.
- Parts 7 to 12 are technical specifications for individual or collective systems and associated components.

2 Normative references

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

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 62257-3:2015, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 3: Project development and management*

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, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 7: Generators*

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

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

IEC TS 62257-8-1:2007, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 8-1: Selection of batteries and battery management systems for stand-alone electrification systems – Specific case of automotive flooded lead-acid batteries available in developing countries*

IEC TS 62257-9-1, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-1: Micropower systems*

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

IEC TS 62257-9-3, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-3: Integrated system – User interface*

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

IEC TS 62257-9-5, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-5: Integrated system – Selection of stand-alone lighting kits for rural electrification*

IEC TS 62257-9-6:2008, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-6: Integrated system – Selection of Photovoltaic Individual Electrification Systems (PV-IES)*

IEC TS 62257-12-1, *Recommendations for renewable energy and hybrid systems for rural electrification – Part 12-1: Selection of self-ballasted lamps (CFL) for rural electrification systems and recommendations for household lighting equipment*

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms, definitions and abbreviations apply. The main glossary used in the IEC 62257 series is given in Annex A.

3.1
Collective Electrification System
CES
micropower plant and microgrid that supplies electricity to multiple consumption points using a single or multiple energy resource points

3.2
GS
general specification

3.3
hybrid system
multi-energy sources system

3.4
Individual Electrification System
IES
micropower plant system that supplies electricity to one consumption point usually with a single energy resource point

3.5
micropower plant
power plant that produces less than 50 kVA through the use of a single resource or hybrid system

3.6
microgrid
grid that transfers a capacity level less than 50 kVA and powered by a micropower plant

3.7
RE
renewable energy

4 Methodology for rural electrification using hybrid renewable energy systems

4.1 Rural electrification: which solution to choose?

When developing a policy of electrification for a given country or region, there is a requirement to envision the target situation in the medium term (10 years) and long term (20 to 30 years). This means that a “master plan” for electrifying the country or this region should preferably be constructed in order to define the lowest life cycle cost solution. Essentially, this master plan shall take into account both grid extension and autonomous systems solutions.

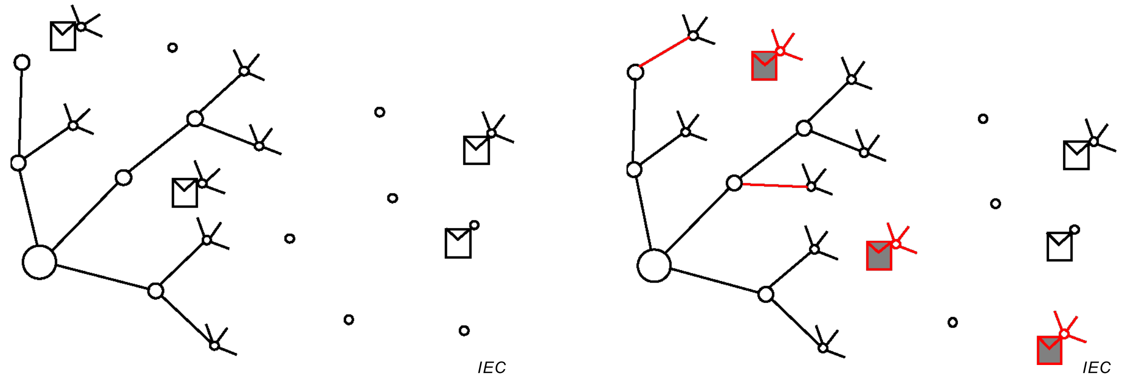
The master plan should allow selection between two modes of electrification (national/regional grids or decentralized system) and also, to determine the most suitable time frame to execute the work. Regarding the decentralized part, each village needs to be investigated to obtain a variety of sociological, economical and geophysical data. With this approach, the demand needs can be assessed for each village. This assessment should include possible changes in the power requirements as a function of the future economic development for each village. The urban development and the demographic characteristics of each village are also important to determine the best electrification solution and to assess the amount of capital investment needed.

Electrification can be achieved by installing decentralized systems if at some points the community can be (economically) interconnected. Provision can also be made for the integration or relocation of such systems. Obviously, the solution of using both a local (grid) and dispersed RE sources generation may be appropriate.

Geographical Information Systems (GIS) are readily available off-the-shelf today and allow a beneficial and useful graphical presentation of the master plan. In such a representation, each village can be identified on an appropriate map with colour codes depicting the corresponding type of power supply.

Furthermore, in such a master plan, villages can be prioritized for further scheduling of the electrification work on a yearly or 5 year basis. In this process, the cost effectiveness of the electrification per village would be taken as one of the most significant prioritizing criteria.

This criterion is less important in the developed world but is critical in developing countries. Simulations can also be made by varying all the relevant parameters to allow a comprehensive financial analysis of the selected system. Figure 1 is an illustration of electrification progress following such a master plan methodology.



Year n electrification work progress   Year $n + 1$ electrification work progress

Key

Collective isolated electrification system

Individual isolated electrification system

Grid line

Figure 1 – Example of electrification progress following a master plan methodology

In the same way, the best strategy shall be determined for electrifying a village or a small town, according to its topography. Figure 2 shows a village with a densely populated core and a sparsely populated peripheral zone.

The economic calculation shows that the most economical solution is to electrify the centre of the village with Collective Electrification Systems (micropower stations and microgrids) and to electrify the peripheral zone with IES (Individual Electrification Systems) as the cost per consumer of the microgrid would be higher than the cost of the IESs in this zone.

This methodology provides the lowest electrification cost per customer.

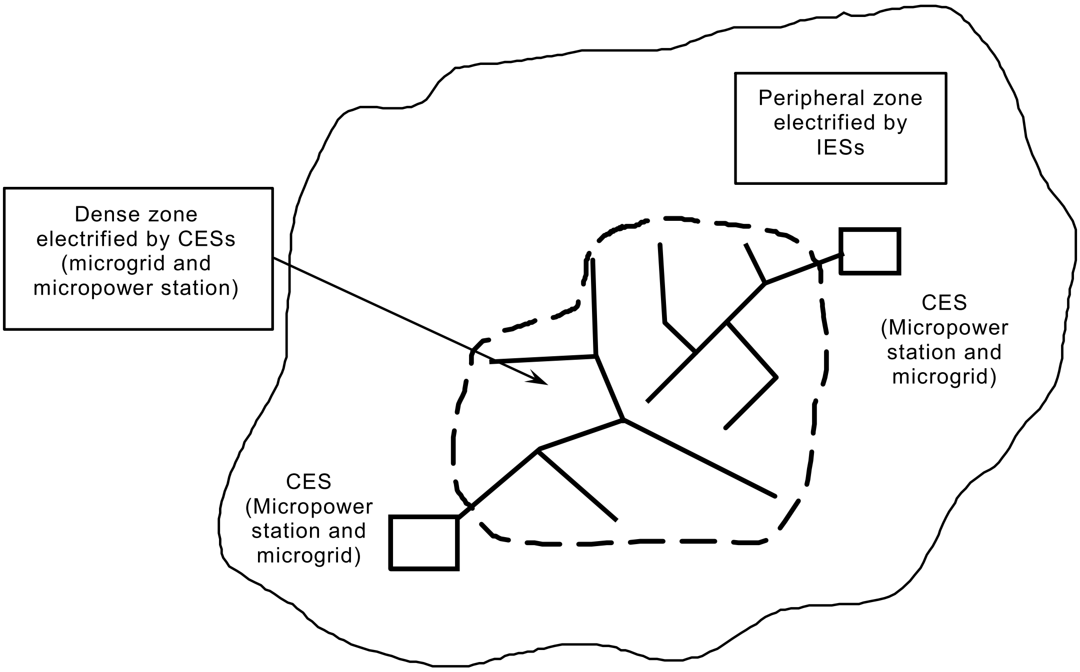


Figure 2 – Example of electrification of a village using both CESs and IESs

4.2 Decentralized electrification requiring a range of systems

Rural electrification using decentralized systems is designed to supply power to demand points located in rural areas that cannot be easily (economically) connected to national grids.

In most cases, these consumption points would consist of the following types of demand:

– specific processes (for example public pumping, battery charging center),
– isolated homes,
– collective facilities (for example public lighting, schools, health and care center, places of worship, administrative buildings, etc.),
– business activities (for example workshop, micro industry, trade, etc.).

The decentralized system solution can have two basic topologies: Collective Electrification Systems (CES) which supply electricity to multiple consumption points using a single (or multiple energy resource points) and Individual Electrification Systems (IES) which supply electricity to one consumption point (usually with a single energy resource point).

CES systems may be appropriate for rural, relatively highly populated areas, for example, large villages whereas the IES may be appropriate for more sparsely populated regions and (or) isolated households.

Individual Electrification Systems (IES) for single users would incorporate two subsystems:

– one electrical power production subsystem,
– one subsystem for utilizing this electrical power.

Collective Electrification Systems (CES) for multiple users on the other hand would incorporate three subsystems:

– an electrical power production subsystem,

  by convention, this part is designated as “micropower plant” where ‘micro’ refers to a modest production power level (from a few kVA to a few tens kVA),

– a secondary grid for sharing/distributing this power,

  by convention, this part is designated as "microgrid" where the prefix 'micro' refers to a modest transit capacity level,

– a demand subsystem including the in-house wiring and user's electrical appliances.

The decision whether to utilize a CES or IES can be made by looking at the two technological solutions and calculating the discounted costs. Such an analysis, however, shall take into account the pertinent sociological and cultural aspects.

The final decision may also be influenced by other considerations, for example, the daily operating time. Simply designed systems making use of small gensets and a microgrid are required for sharing and distributing power among the users. Typically, gensets often are run for limited periods of time during the day, for example between 7 p.m. and 10 p.m.

The use of hybrid micropower plants can allow for a better reliability of the supply. Power is produced by renewable energy sources when available and stored in batteries. Power can be made available to the microgrid during a greater part of the day or even all day. Additional power may be supplied from the gensets when renewable energies are insufficient.

In many developing countries, there is often a very low demand of electricity in rural households and a concurrent limited capacity for payment. The individual users requirements typically range between a few tens and a few thousands Wh/day. In developed countries, energy requirements may be larger as is the expected quality of service.

With very scattered houses, the IES solution may be the obvious choice. If the individual electricity demand is low, the cost of such systems can also be relatively low – provided the systems can be produced in large quantities. Table 1 shows some of the advantages and disadvantages of collective and individual systems.

Table 1 – Some advantages and disadvantages of the proposed single and multiple user systems

	Advantages	Disadvantages
Individual Electrification Systems (IES)	• Power consumption is user managed. Consumption will be user determined from one day to another. • Systems failures imply only one user. • Systems can be exchanged and returned to manufacturer.	• In case of inadequate management of the power, the user will be self-impaired. • Failures. • Monitoring individual systems can be expensive and difficult. • Maintenance and repair service are not commonly organized in rural areas especially in developing countries.
Collective Electrification Systems (CES)	• Power saving can be practiced (possibly) using improved management tools without impairing the reliability of power supply. • Telemetry can be economic for monitoring system status.	• No possibility exists of exceeding the subscribed credit of power (assuming an automatic cut off). • If the central system fails, everybody is cut off. • Systems generally need to be serviced on site.

In both cases the electrical appliances used should be of the low power/energy efficient type, for example high efficiency fluorescent lighting. Using such appliances can be a drawback because this type of equipment can cost more than standard electrical appliances. For example, low consumption lighting is still considerably more expensive than tungsten incandescent lamps.

The use of low consumption or efficient loads should be compulsory in these projects. This means that supply of the demand items, as far as possible, may be best included as part of the energy supply package. This should include as a minimum low consumption lamps but also mechanisms to purchase high efficiency appliances.

5 How to use the IEC 62257 series for a rural electrification project

5.1 Overview

The summary of the series is given in Table 2. The different parts have been designed following the main topics about rural decentralized electrification. The documents are classified accordingly.

Through the following information the reader is guided and assisted for finding the right information needed for each phase of the project.

This guide is organized following the phasing of the setting up of a rural electrification project. Table 3 gives a presentation of the documents and establishes links between the phases of the projects and the content of the documents.

Table 2 – Contents of the 62257 series

Introduction to IEC 62257 series and decentralized rural electrification
IEC TS 62257-1 (2015) Ed. 3.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 1: General introduction to IEC 62257 series and rural electrification
Management of project – rules for designing, managing and operating rural electrification systems
IEC TS 62257-2 (2015) Ed. 2.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 2: From requirements to a range of electrification systems
IEC TS 62257-3 (2015) Ed. 2.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 3: Project development and management
IEC TS 62257-4 (2015) Ed. 2.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 4: System selection and design
IEC TS 62257-5 (2015) Ed. 2.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards
IEC TS 62257-6 (2015) Ed. 2.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 6: Acceptance, operation, maintenance and replacement
Technical specifications
IEC TS 62257-7 (2008-04) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 7: Generators
IEC TS 62257-7-1 (2010-09) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 7-1: Generators – Photovoltaic arrays
IEC TS 62257-7-3 (2008-04) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 7-3: Generator set – Selection of generator sets for rural electrification systems
IEC/TS 62257-8-1 (2007-06) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 8-1: Selection of batteries and battery management systems for stand-alone electrification systems – Specific case of automotive flooded lead-acid batteries available in developing countries
IEC TS 62257-9-1 (2008-09) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-1: Micropower systems
IEC TS 62257-9-2 (2006-10) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-2: Microgrids
IEC TS 62257-9-3 (2006-10) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-3: Integrated system – User interface
IEC TS 62257-9-4 (2006-10) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-4: Integrated system – User installation
IEC TS 62257-9-5 (2015) Ed. 3.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-5: Integrated system – Selection of stand-alone lighting kits for rural electrification projects
IEC TS 62257-9-6 (2008-09) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 9-6: Integrated system – Selection of Photovoltaic Individual Electrification Systems (PV-IES)
IEC TS 62257-12-1 (2007-06) Ed. 1.0 Recommendations for renewable energy and hybrid systems for rural electrification – Part 12-1: Selection of self-ballasted lamps (CFL) for rural electrification systems and recommendations for household lighting equipment

Table 3 – Utilization of the different parts of the IEC 62257 series according to the main project phases

Reference No.	Phases of a project	Phases of a rural electrification project	Player involved	Deliverable	IEC 62257 pertinent part
5.2.1	Opportunity study	- Master plan of electrification (Where to develop the national grid Where to develop off grid electrification)	- Owner/ Project developer - Engineering consultant	- Master plan - Time table of electrification (taking into account economic or political priorities) - Amount of investment (total and per year)	Part 1
5.2.2	Specification	- Target definition (location, size of the project)	- Project developer - Engineering consultant	- List and maps of small towns and villages to be electrified	Part 2 Part 3
5.2.3	Feasibility	- Feasibility (Technical and economical)	- Project developer - Engineering consultant (socio economical, financial)	- Renewable energies resource assessment - Socio economical study - Business plan	Part 2 socio economic study
5.2.4	Detailed technical studies	Writing of the General Specification	- Project developer - Engineering consultant	- General specification	Part 2 Part 3 Part 4 Part 5 Parts 7 to 12
5.2.5	Implementation	Erection, commissioning	- Project implementer - Suppliers - Sub-contractors - Training providers	- Electrical installations - Commissioning sheets	Part 5 Part 6
5.2.6	Validation	Assessment: does the service provided comply with the General Specification	- Project developer - Engineering consultant - Project implementer	- Quality of service assessment report	Part 6
5.2.7	On field operation	- Operation - Maintenance - Replacement - Management - Recycling	- Owner/ Project developer - Operator	- Quality of service - Quality of management - Customer relationship	Part 5 Part 6 and relevant technical specification

5.2 Review of the IEC 62257 series: links with the phases of a rural electrification project (see Table 3)

5.2.1 Opportunity study

A master plan for the electrification of a region of a developing country or the electrification of remote sites in developed countries shall take into account both the development of the national or the regional grid and the use of decentralized collective or individual systems.

Part 1 entitled:

> IEC TS 62257-1:2015*, Recommendations for renewable energy and hybrid systems for rural electrification – Part 1: General introduction to IEC 62257 series and rural electrification*

provides the basics on the rural electrification methodology using both the development of the grid and standalone systems and explains the different options to carry it out.

It especially introduces the advantages or disadvantages of collective and individual electrification solutions. Part 1 also introduces the different parts of the series which will be useful for the players involved for each part of the project.

Figure 1 of this Part 1 illustrates the implementation of a master plan year after year using both the development of the grid and the use of decentralized autonomous collective or individual systems.

5.2.2 Specification of a project

In this phase, the solvable needs of the future customers shall be assessed in order to define the technical solutions which are suitable to satisfy them.

Part 2 entitled

> 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*

presents the methodological approach to carry out this phase of the project.

It also presents a range of systems and provides assistance for choosing the right system according to the characteristics of the needs it can satisfy (range of services, power, quantity of energy, level of quality of service, etc.).

Examples of standardized range of services along with standardized systems architectures are also provided.

Part 3 entitled

> IEC TS 62257-3:2015*, Recommendations for renewable energy and hybrid systems for rural electrification – Part 3: Project development and management*

emphasizes the necessity of defining the different players involved in the project, their needed competencies, their respective responsibilities and the contracts that shall link them, prior to starting any work on the project.

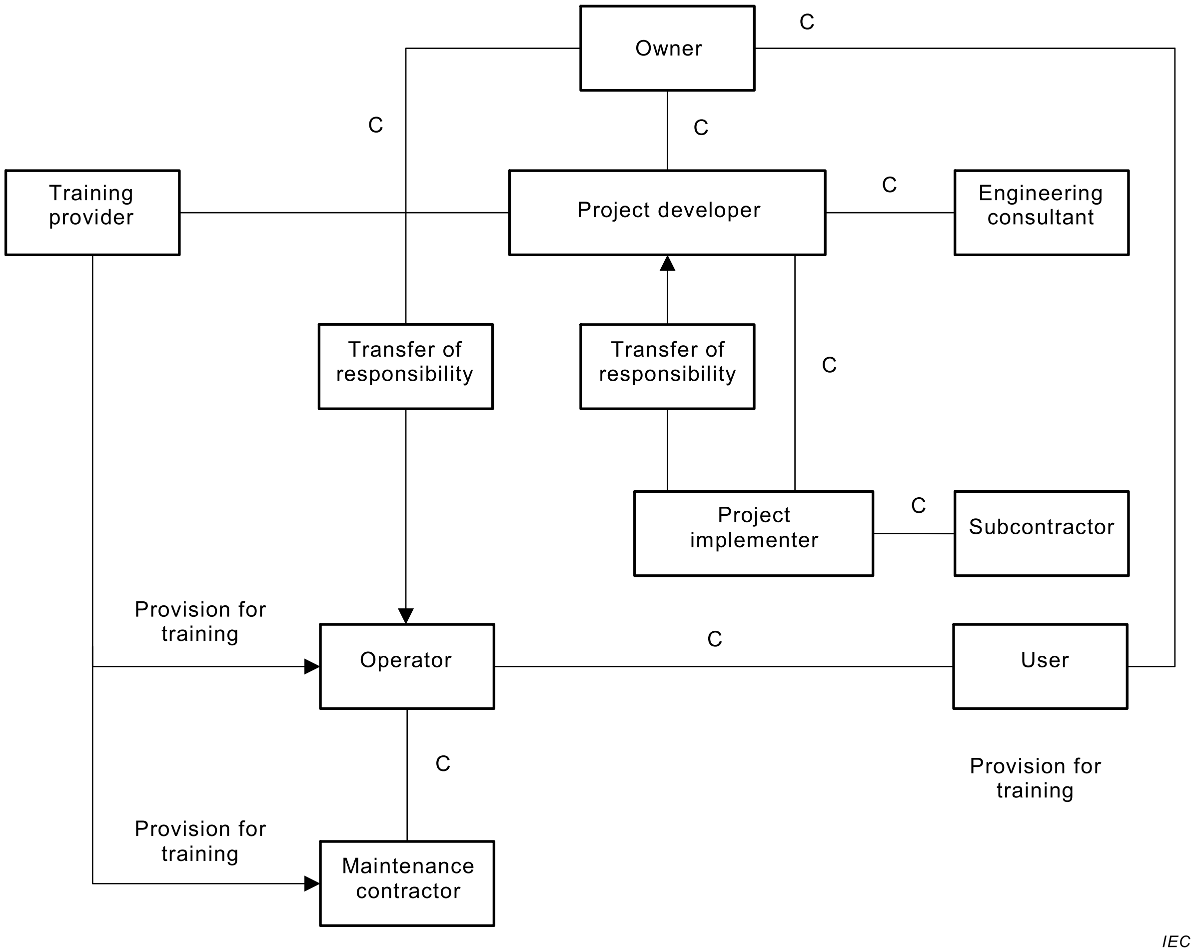
This preliminary action is one of the key elements for the successful implementation of the project.

Part 3 proposes the implementation of a quality assurance approach, allowing the owner and the project implementer to check at specified intervals that:

– the project is suitably designed to satisfy the needs of the future customers,
– the technical installations are implemented according to the General Specification,
– operation, maintenance, feedback and validation of the quality of service are correctly organized.

Figure 3 below is reproduced from Figure 1 of IEC TS 62257-3:2015. It illustrates the contractual links that shall be established between the stakeholders of the project.

Table 4 below is reproduced from Table C.1 of IEC TS 62257-2:2015; it gives examples of indicators which can be used to adapt the quality of service to the solvable and affordable needs of the future customers and specify them in the General Specification.



NOTE "C" represents a potential contractual arrangement between two connecting parties.

Figure 3 – Contractual relationship between project participants – (IEC TS 62257-3:2015, Figure 1)

Table 4 – Combined categorization – (IEC TS 62257-2:2015, Table C.1)

	Power quality indicators						
Requirement class	**Specified duration of service** [a] (h/day)	**Specified supply availability (%/year)**			**Required power quality**		
		1	2	3	1	2	3
A	= 24 h	≥ 99	≥ 98	≥ 95	$\lvert\pm\Delta U\rvert \leq$ 10 % U_N $\lvert\pm\Delta f\rvert \leq$ 1 Hz THD ≤ 3 %	$\lvert\pm\Delta U\rvert \leq$ 15 % U_N $\lvert\pm\Delta f\rvert \leq$ 2 Hz THD ≤ 5 %	$\lvert\pm\Delta U\rvert \leq$ 20 % U_N $\lvert\pm\Delta f\rvert \leq$ 3 Hz THD ≤ 10 %
B	16 ≤ h < 24						
C	8 ≤ h < 16						
D	4 ≤ h < 8						
E	h < 4						
F	Systems requiring power quality indicators either above or below these values may be specified according to special requirements.						

U_N The r.m.s. voltage at a given time at the supply terminals, measured over a given interval.

f The nominal frequency of the supply voltage U_N should be f. Under normal operating conditions the mean value of the fundamental frequency measured over 10 s should be within the range of $f \pm \Delta f$.

[a] Start time and end time of the period for the duration of service should be implemented in the contract.

Table 5 illustrates a specific example of the use of Table 4.

Table 5 – Service specification (example) – (IEC TS 62257-2:2015, Table C.2)

Cat 1		D	1	3
Maximum available power demand:	$P \leq$ 100 W	Weekly average service providing energy 4 h per day, as a maximum.	Service provided for more than 99 % of the year	$\lvert\pm\Delta U\rvert \leq$ 20 % U_N, $\lvert\pm\Delta f\rvert \leq$ 3 Hz, THD ≤ 10 %
Average energy provided over 24 h	$E \leq$ 0,5 kWh			

5.2.3 Feasibility study of a project

In this phase, the socio-economic characteristics of the future clients, the geographic and topographic characteristics and the renewable energies resources of the site are assessed in order to establish a business plan and verify the viability of the project.

These studies are essential for the next step which is to choose the technical solutions and write the General Specification.

The results of the socio-economic study, the methodology of which is explained in Part 2 are used to establish the profile of the future clients in terms of solvable needs for electrical services.

Part 4, entitled

> IEC TS 62257-4:2005*, Recommendations for renewable energy and hybrid systems for rural electrification – Part 4: System selection and design*

classifies the quality of the information that shall be collected in order to assess the resources of the site in terms of renewable energies which shall be taken into account when choosing and sizing the electrical installations and which affect the cost of these installations.

These informations added to the techno-economic calculations needed for the establishment of the business plan displayed in Part 4 are used to choose among the technical solutions presented in Part 2.

Figure 4 below reproduced from Figure 1 of IEC TS 62257-2:2015 gives an example of what could be the content of a socio-economic study.

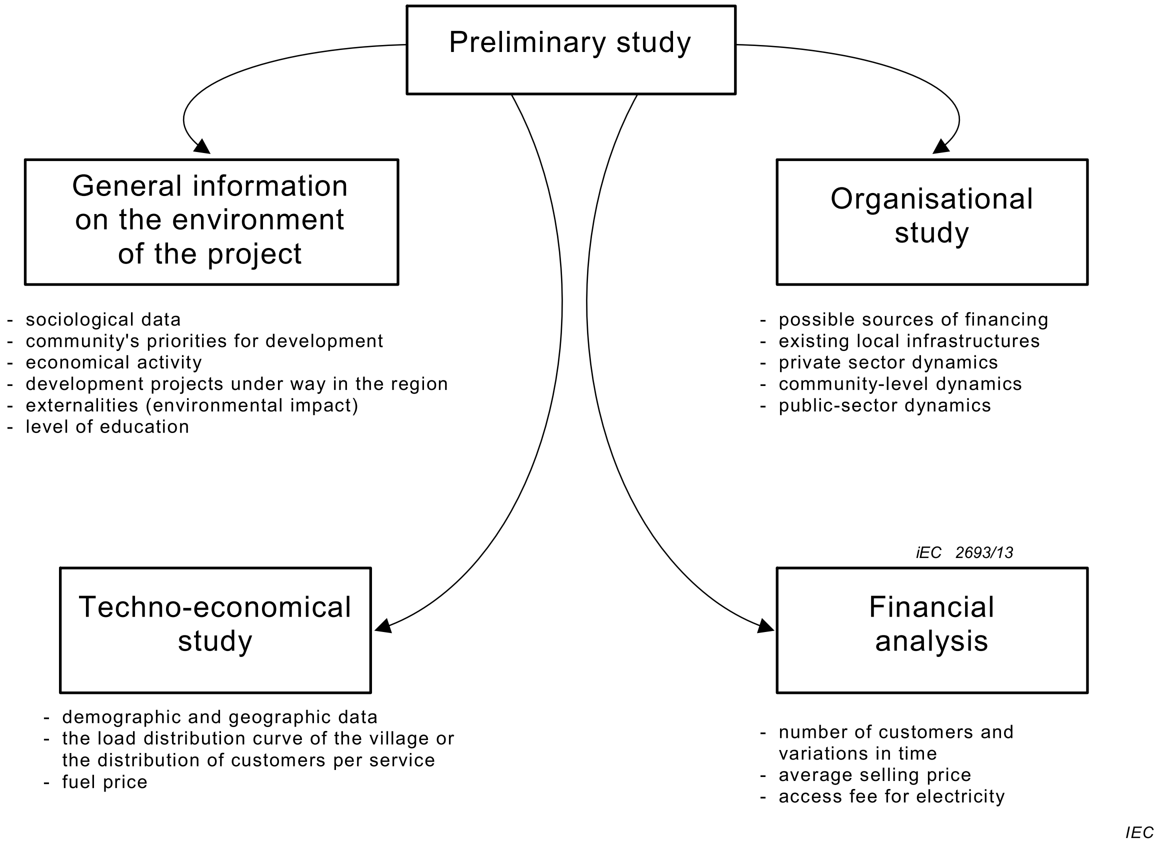


Figure 4 – Example of the content of a non-technical preliminary study – (IEC TS 62257-2:2015, Figure 1)

5.2.4 Detailed technical studies

The detailed technical solutions for the implementation of the project are chosen in this phase. This leads to the writing of the General Specification (GS), which is the reference document for the project and for the call for tenders.

Part 2 proposes architectures for individual or collective electrification systems able to provide the solvable needs identified by the socio economic study.

Part 3 is helpful for the writing of the GS, for defining the level and the affordability of the electrical services to be provided, and for defining the technical and administrative frame as well as the implementation schedule of the project.

Part 4 gives elements for defining the rules for the management of the energy produced and for defining the kind and the quality of the information to be collected for this management. It also helps introducing in the GS a common framework for the answers of the sub-contractors or manufacturers to the call for tenders. It gives criteria in order to help the owner and the project developer to compare the proposals and choose the best techno economic answer.

Part 5 entitled

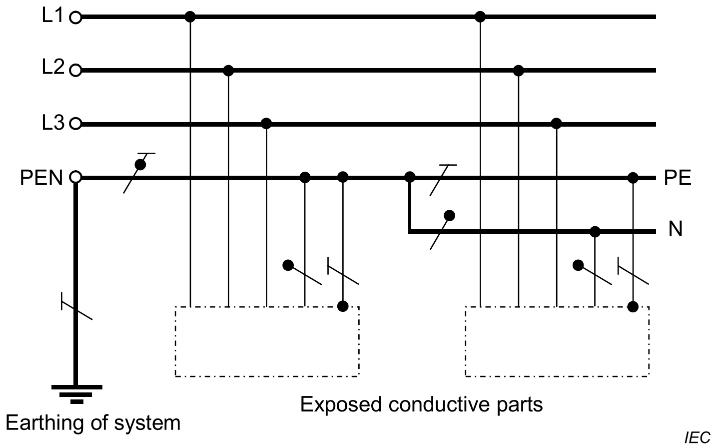
> IEC TS 62257-5:2015*, Recommendations for renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards*

details the level of safety that the future electrical installations shall offer (safety of persons, protection against overloading, over-voltages, against lightning and risks of fire) and that shall be prescribed in the GS.

In order to specify electrical devices or systems that will be sourced through call for tenders, the GS makes reference to Parts 7 to 12 (see Table 1) which are technical specifications for electrical stand-alone systems, equipment or accessories. These technical specifications contain tests suitable for verifying the conformity to the GS of the equipment proposed by the suppliers.

The proposed tests have been designed in order to reduce their cost as much as possible and to require the most simple laboratory equipment.

For example Part 5 strongly recommends the use of the TN-C-S systems for the neutral system and the earthing of the microgrid of a village for the protection of persons against electric shocks as shown in Figure 5 which is reproduced from Figure B.2 of IEC TS 62257-5:2005.



Neutral and protective functions combined in a single conductor in a part of the system.

Figure 5 – TN-C-S system – (IEC TS 62257-5:2015, Figure B.2)

5.2.5 Implementation of a project

During this phase, the electrical installations are built in the field and commissioned.

Part 5 provides to the involved players all the needed technical information about the level of the safety that shall be ensured by the installations and how to verify that the prescriptions of the GS are really fulfilled.

Part 6 entitled

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

gives all necessary information in order to verify that all the electrical devices and installations comply with the requirements of the technical specifications (Parts 7 to 12) as prescribed in the GS.

Parts 7 to 12 are detailed technical specifications for the different equipment that shall be sourced in order to implement the project:

– Photovoltaic array (Part 7-1)
– Generator set (Part 7-3)
– Lead acid batteries (Part 8-1)
– Micropower systems including renewable energies and hybrid (Part 9-1)
– Microgrids (Part 9-2) – User interface (Part 9-3)
– Indoor installation (Part 9-4)
– PV portable lantern (Part 9-5)
– PV electrification systems (Part 9-6)
– Compact Fluorescent Lamps, CFL (Part 12-1)

Tests are provided in these technical specifications which can be performed by local organisations with very simple equipment and in local test conditions (close to the one of the project). For example Figure 6 below reproduced from Figure 2 of IEC TS 62257-8-1:2007 shows the phase A of a stamina test for automotive lead acid batteries used for PV systems.

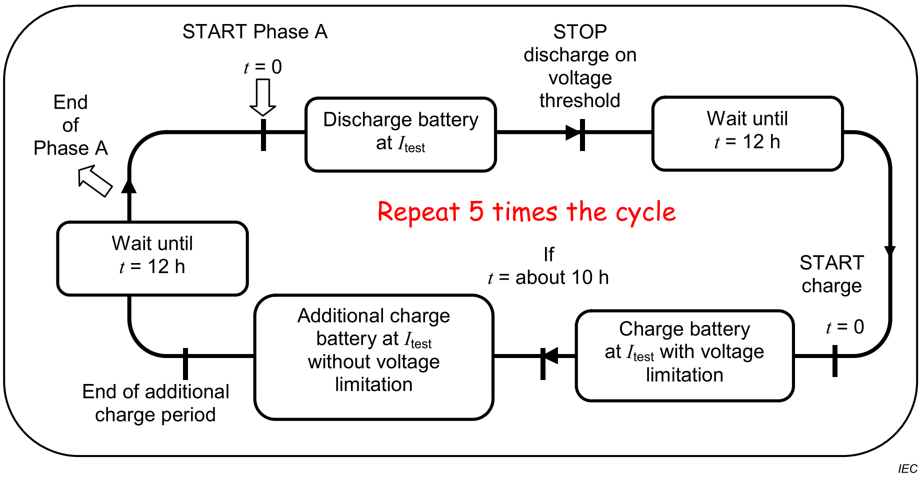


Figure 6 – Phase A battery endurance test – (IEC TS 62257-8-1:2007, Figure 2)

5.2.6 Validation of a project

Part 6 provides the necessary recommendations in order to commission the installations and verify their conformity to the GS.

This phase is the last one before the handing over of the installations to an operator.

Table 6 below reproduced from Table 8 of IECTS 62257-6:2015 summarizes the actions to be implemented in order to verify that the installations complies with the prescriptions of the GS according to the kind of electrification system as defined in Part 2.

Table 6 – Verification of the adherence to commitments – (IEC TS 62257-6:2015, Table 8)

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

Figure 7 below reproduced from Figure 3 of IEC TS 62257-9-6:2008 gives among others, indicators in order to make measurements able to assess by calculating “quality of service ratios” that the service rendered (lighting, TV, refrigeration, etc.) to the customers by the installations really complies with the GS prescriptions.

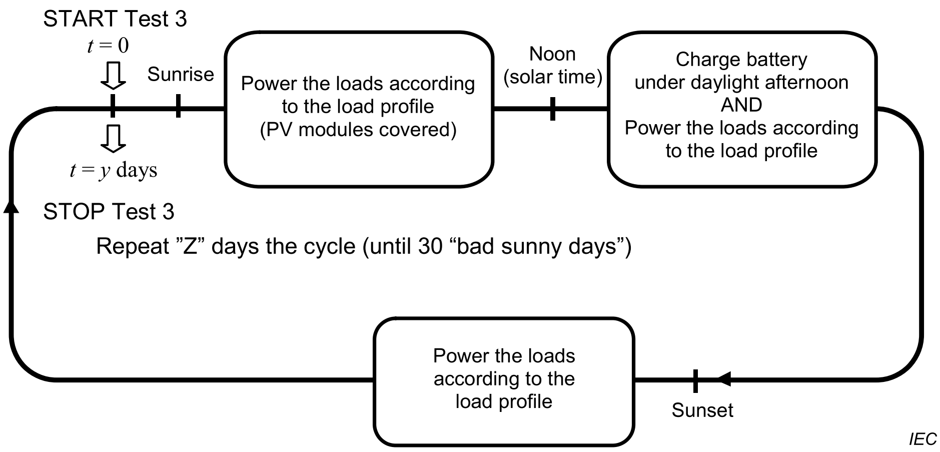


Figure 7 – Test 3, operating cycles – (IEC TS 62257-9-6:2008, Figure 3)

5.2.7 On field operation

During this phase operation is organized, maintenance plans are implemented and provisions are made for the necessary renewal of parts of the installations as well as the overall installation itself as planned in the business plan.

This phase is of the utmost importance for the permanence of the installation and of the service provided to the customer. In the past, a lot of projects have been implemented omitting this phase and have proved to be failures. Installations have failed and the service to the customer has been interrupted.

It is thus compulsory that the installations are handed over to a competent operator. The latter is responsible for the permanence of the service to the client after having verified that the installations he is going to operate are complying with the prescription of the GS.

Part 5 gives the needed elements for organizing the operation of the installations ensuring the safety of the clients and of the operating staff.

Part 6 allows to define clearly the responsibilities of all the stake holders involved. It provides elements in order to:

– organize the operation actions and define the level of competencies of all the staff, organize the operation actions with the adequate level of safety,
– prepare the maintenance plan,
– prepare the renewal of parts or of the overall installation,
– organize the recycling of dismantled parts.

Table 7 reproduced from Table 3 of IEC TS 62257-6:2015 defines the responsibilities of the different stake holders involved in the actions of commissioning, operation, maintenance and renewal in this phase of operation in the field (AOMR actions).

Table 7 – AOMR participant involvement – (IEC TS 62257-6:2015, Table 3)

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 ensuring 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.					

Annex A
(normative)

Terms, definitions and abbreviations in use in the IEC 62257 series

ambient temperature
temperature of the medium in the immediate vicinity of a battery

AOMR actions
acceptance, operation , maintenance and replacement actions
apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply

[SOURCE: IEC 60050-845:1987, 845-10-01]

readily available
capable of being reached for inspection, maintenance or repairs without necessitating the dismantling of structural parts, cupboards, benches or the like

block
part of a line between two consecutive stoppage poles

blocking diode
diode connected in series to module(s), panel(s), sub-arrays and array(s) to block reverse current into such module(s), panel(s), sub-array(s) and array(s)

BMS
battery management system (or battery charge/discharge controller)

bypass diode
diode connected across one or more cells in the forward current direction to allow the module current to bypass shaded or broken cells to prevent hot spot or hot cell damage resulting from the reverse voltage biasing from the other cells in that module

cable
assembly of one or more conductors and/or optical fibres, with a protective covering and possibly filling, insulating and protective material

cable core
the conductor with its insulation but not including any mechanical protective covering

capacity
capacity <of a cell or a battery>
quantity of electricity (electric charge), usually expressed in amperes-hour (Ah), which a fully charged battery can deliver under specified conditions

carrier
messenger
wire or a rope, the primary function of which is to support the cable in aerial installations, which may be separate from or integral with the cable it supports

CES
collective electrification system

charge rate <relating to secondary cells and batteries>
electric current at which a secondary cell or battery is charged

Note 1 to entry: The charge rate is expressed as the reference current It = Cr/n where Cr is the rated capacity declared by the manufacturer and n is the time base in hours for which the rated capacity is declared.

[SOURCE: IEC 60050-482:2004, 482-05-45]

class I equipment
equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that accessible conductive parts are connected to the protective earthing conductor in the fixed wiring of the electrical installation in such a way that accessible parts cannot become live in the event of a failure of the basic insulation

Note 1 to entry: Class I equipment may have parts with double insulation or parts operating at SELV. For equipment intended for use with a flexible cord or cable, this provision includes a protective earthing conductor as part of the flexible cord or cable.

class II equipment
equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions such as double insulation or reinforced insulation are provided, there being no provision for protective earthing or reliance upon installation conditions.

Note 1 to entry: Such equipment may be one of the following types:

– equipment having durable and substantially continuous enclosures of insulating material which envelops all metal parts, with the exception of small parts, such as nameplates, screws and rivets, which are isolated from live parts by insulation at least equivalent to reinforced insulation. Such equipment is called insulation-encased Class II equipment;

– equipment having a substantially continuous metal enclosure, in which double insulation is used throughout, except for those parts where reinforced insulation is used, because the application of double insulation is manifestly impracticable. Such equipment is called metal-encased Class II equipment;

– equipment that is a combination of the types described in the two preceding items.

Note 2 to entry: The enclosure of insulation-encased Class II equipment may form part of the whole of the supplementary insulation or of the reinforced insulation.

Note 3 to entry: If the equipment with double insulation or reinforced insulation throughout has an earthing terminal or earthing contact, it is considered to be of Class I construction.

Note 4 to entry: Class II equipment may be provided with means for maintaining the continuity of protective circuits, insulated from accessible conductive parts by double insulation or reinforced insulation.

Note 5 to entry: Class II equipment may have parts operating at SELV.

class III equipment
equipment in which protection against electric shock relies on supply at SELV and in which voltages higher than those of SELV are not generated

Note 1 to entry: Equipment intended to be operated at SELV and which have internal circuits that operate at a voltage other than SELV are not included in the classification and are subject to additional requirements.

Collective Electrification System
CES
micropower plant and microgrid that supplies electricity to multiple consumption points using a single or multiple energy resource points

color
the color characterictics of a lamp are defined by the color appearance and the color rendition (or rendering)

Note 1 to entry: The actual color of the lamp is called color appearance and is defined in terms of the spectral tristimulus values (color co-ordinates) according to the recommendations of the IEC.

Note 2 to entry: The spectral characteristics of the light emitted by the lamp have an effect on the appearance of the objects it illuminates; this effect is called rendition.

color temperature
temperature of a source whose radiation has the same chromaticity as that of a given stimulus

commissioning
final checking of installation and operation of a battery on site

compact fluorescent lamp
CFL
a tubular fluorescent lamp unit with a bended tube that incorporates, permanently enclosed, all elements that are necessary for starting and for stable operation, and which does not include any replaceable or interchangeable parts

constant current charge
charge during which the electric current is maintained at a constant value regardless of the battery voltage or temperature

[SOURCE: IEC 60050-482:2004, 482-05-38]

cycle
a sequence of a discharge followed by a charge or a charge followed by a discharge of a battery under specified conditions

cycling <of a cell or battery>
set of operations that is carried out on a secondary cell or battery and is repeated regularly in the same sequence

Note 1 to entry: In a secondary battery these operations may consist of a sequence of a discharge followed by a charge or a charge followed by a discharge under specified conditions. This sequence may include rest periods.

[SOURCE: IEC 60050-482:2004, 482-05-28]

density
commonly considered as the volumic mass, in kg / dm^3

Note 1 to entry: Density is also defined as a dimensionless magnitude expressing the ratio of the electrolyte mass to the water mass occupying the same volume at 4 °C.

dispatchable power system
source, generator, system is dispatchable if delivered power is available at any specified time (for example, a genset is a dispatchable system, REN generator is a non-dispatchable power system)

double insulation
insulation comprising both basic insulation and supplementary insulation

[SOURCE: IEC 60050-195:1998, 195-06-08]

DRES
decentralized rural electrification system

dry charged battery
state of delivery of some types of secondary battery where the cells contain no electrolyte and the plates are dry and in a charged state

[SOURCE: IEC 60050-482:2004, 482-05-30]

duration of service
number of hours when a load is powered

DWQIT
daily weighted quality of service

earth
conductive mass of the earth, whose electric potential at any point is conventionally taken as equal to zero

[SOURCE: IEC 60050-826:2004, 826-04-01]

earthing
a protection against electric shocks

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

[SOURCE: IEC 60050-826:2004, 826-16-01]

electrochemical cell or battery
an electrochemical system capable of storing in chemical form the electric energy received and which can give it back by conversion

[SOURCE: IEC 60050-482:2004, 482-02-29]

electrolyte
liquid or solid substance containing mobile ions which render it ionically conductive

Note 1 to entry: The electrolyte may be liquid, solid or a gel.

engineering consultant
organization, company or person responsible for translating the needs of the potential user into technical requirements, in accordance with the relevant IEC technical specifications, and preparing the call for tenders

environmental conditions
characteristics such as elevation, temperature, humidity, that may influence performances

equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

Note 1 to entry: The role of the equipotential bonding is to decrease the difference in potential that can exist between two exposed-conductive parts of an installation.

extra-low voltage
ELV
voltage not exceeding the relevant voltage limit of band I specified in IEC 60449

See also IEC 61201. Voltage not exceeding 50 V a.c. and 120 V d.c. ripple free are considered to be ELV

[SOURCE: IEC 60050-826:2004, 826-12-30]

fulfilment of service
ratio of a measured provided service to a required service

gassing of a cell
evolution of gas resulting from electrolysis of the water in the electrolyte of a cell

[SOURCE: IEC 60050-482:2004, 482-05-51]

General Specification
GS
specification prepared by the project developer using the present series of IEC 62257 documents which mainly defines the level and cost of services to be reached and project conditions including the administrative frame and techno-economic context of the project as well as of the project timetable

HMPS
hybrid micropower system: micropower system including generators from different technologies

hybrid system
multi-sources system

identification file
IF
document describing the equipment in terms of detailed technical specification, design and associated performance

Individual electrification system
IES
micropower plant system that supplies electricity to one consumption point usually with a single energy resource point

IK code
degree of protection provided by enclosures for electrical equipment against external mechanical impacts

illuminance <of an elementary surface>
symbol E
the luminous flux received by an elementary surface divided by the area of this surface

Note 1 to entry: In the SI system of units illuminance is expressed in lux (lx) or lumens per square metre (lm/m^2). 1 lux is the illuminance produced on a surface of 1 square metre by a luminous flux of 1 lumen uniformly distributed over that surface.

[SOURCE: IEC 60050-723:1997, 723-08-30]

illuminance meter
instrument for measuring illuminance

[SOURCE: IEC 60050-845:1987, 845-05-16]

$I_{MOD\_REVERSE}$
the current a module can withstand in the reverse direction to normal without damage to the module. This rating is obtained from the manufacturer at expected operating conditions.

This current rating does not relate to bypass diode rating.

Note 1 to entry: Module reverse current is the current flowing through the PV cells in the reverse direction to normal current.

Note 2 to entry: A typical figure for crystalline silicon modules is between 2 and 2,6 times the normal short circuit current rating $I_{SC\ MOD}$.

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

initial charge
a commissioning charge given to a new battery to bring it to the fully charged state

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,
- to perform correctly the required task

IP degree
degree of protection provided by enclosures for electrical equipment against penetration by foreign bodies and dust/water

$I_{SC\ ARRAY}$
the short circuit current of the PV array at Standard Test Conditions, and is equal to:

$I_{SC\ ARRAY} = I_{SC\ MOD} \times S_A$

where S_A is the total number of parallel-connected PV strings in the PV array

$I_{SC\ MOD}$
the short circuit current of a PV module or PV string at Standard Test Conditions (STC), as specified by the manufacturer in the product specification plate.

As PV strings are a group of PV modules connected in series, the short circuit current of a string is equal to $I_{SC\ MOD}$.

$I_{SC\ S\text{-}ARRAY}$
the short circuit current of a PV sub-array at Standard Test Conditions (STC), and equal to:

$I_{SC\ S\text{-}ARRAY} = I_{SC\ MOD} \times S_{SA}$

where S_{SA} is the number of parallel-connected PV strings in the PV sub-array

isolated site
electric characteristic to define a specific location not currently connected to a national/regional grid

junction box
closed or protected connecting device allowing making of one or several junctions

[SOURCE: IEC 60050-442:1998, 442-08-03]

lead-acid battery
storage battery in which the electrodes are made mainly from lead and the electrolyte is a sulphuric acid solution

licensed person
person who is authorized to perform electrical work under the appropriate state or territory statutes and regulations. Only skilled or instructed persons can be licensed.

life <of a lamp>
total time for which a lamp has been operated before it becomes useless, or is considered to be so according to specified criteria.

Lamp life is usually expressed in hours.

[SOURCE: IEC 60050-845:1987, 845-07-61]

life test
test in which lamps are operated under specified conditions for a specified time or to the end of life and during which photometric and electrical measurements may be made at specified intervals

[SOURCE: IEC 60050-845:1987, 845-07-62]

light application
light produced by the lantern to allow a given activity

Note 1 to entry: Examples of categories of applications of the light are given in 5.1.

light output ratio <of a luminaire>
luminaire efficiency <USA>
ratio of the total flux of the luminaire, measured under specified practical conditions with its own lamps and equipment, to the sum of the individual luminous fluxes of the same lamps when operated outside the luminaire with the same equipment, under specified conditions

[SOURCE: IEC 60050-845:1987, 845-09-39]

light unit
assembly inside a casing of all parts such as lamps, optical apparatus, coloured glass, terminals, necessary to exhibit a light aspect

[SOURCE: IEC 60050-821:1998, 821-02-38]

lighting equipment
luminaire and lamp combination

lighting performance
ability of a product to provide the right illuminance for a given application

live part
conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-195:1998, 195-02-19]

luminaire
apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes, except the lamps themselves, all the parts necessary for fixing and protecting the lamps and, where necessary, circuit auxiliaries together with the means for connecting them to the electric supply.

[SOURCE: IEC 60050-845:1987, 845-10-01]

luminous efficacy
[lm/W]
quotient of the luminous flux emitted by the power consumed by the source

[SOURCE: IEC 60050-845:1987, 845-01-55]

maintenance contractor
organization, corporate company, operator or person contracted by the operator for performing maintenance operations on the installation

microgrid
subsystem of a DRES intended for power distribution of which the capacity does not exceed 100 kVA, and powered by a micropower plant

Note 1 to entry: The prefix “micro” is intended to express the low level of transmitting capacity.

micropower plant
power plant that produces less than 50 kVA through the use of a single resource or hybrid system

micropower system
subsystem of a DRES for power generation up to 100 kVA

Note 1 to entry: The prefix “micro” is intended to express the low power level generated (from a few kVA to a few tens of kVA).

micropowerplant
subsystem of a DRES for power generation up to 100 kVA

Note 1 to entry: The prefix “micro” is intended to express the low power level generated (from a few kVA to a few tens of kVA).

nominal capacity
suitable approximate quantity of electricity, used to identify the capacity of a cell or a battery

Note 1 to entry: This value is usually expressed in Ampere-hours (Ah).

non-dispatchable power system
a non-dispatchable system is resource dependent; power might not be available at a specified time

observed battery capacity
quantity of electricity or electrical charge that a battery in high state of charge can deliver under the proposed test conditions

Note 1 to entry: In practice, battery capacity is expressed in Ampere-hours (Ah).

operator
organization, company or person in charge of system operations, management and maintenance

ordinary person
person who is neither a skilled person nor an instructed person

owner
organization, company or person financially responsible for the whole system and maintaining titles of all the equipment. The owner could have also another role, such as project developer or operator, but may be a completely separate organization

PEL conductor
conductor combining the functions of both a protective earthing conductor and a line conductor

[SOURCE: IEC 60050-195:1998, 195-02-14]

PEN conductor
conductor combining the functions of a protective earthing conductor and a neutral conductor

[SOURCE: IEC 60050-826:2004, 826-04-25]

period of service
part of the day when a load is powered

portable
capable to be carried by one person

Note 1 to entry: The term “portable” implies often the additional ability to operate when carried.

[SOURCE: IEC 60050-151:2001, 151-16-47]

power conditioning unit
PCU
system that converts the electrical power delivered by the PV array into the appropriate frequency and/or voltage values to be delivered to the load, or stored in a battery or injected into the electricity grid

power conditioning unit, isolated
power conditioning unit where there is electrical separation between the input and output circuits (e.g. by means of an isolation transformer)

power conditioning unit, non-isolated
power conditioning unit where there is no electrical separation between the input and output circuits

power factor
under periodic conditions, ratio of the absolute value of the active power P to the apparent power S

power line
overhead or underground line installed to convey electrical energy for any purpose other than communication

project developer
organization, company or person who defines and promotes the rural electrification project, assigns the project implementer, determines compliance with the specifications and is also responsible for obtaining resources for financing the project

project implementer
general contractor
organization, company or person entrusted by the project developer to perform the work or have this work performed pursuant to the general specification (possibly through some subcontractors)

protected extra-low voltage
PELV
extra-low voltage system which is not electrically separated from earth, but which otherwise satisfies all the requirements for SELV

protective conductor
(identification: PE)
conductor provided for purposes of safety, for example protection against electric shock

Note 1 to entry: In an electrical installation, the conductor identified PE is normally also considered as protective earthing conductor.

[SOURCE: IEC 60050-195:1998, 195-02-09]

PV array

a) mechanically integrated assembly of modules or panels and support structure that forms a d.c. electricity-producing unit. An array does not include foundation, tracking apparatus, thermal control, and other such components

[SOURCE: IEC 61836:2007, definition 3.3.45 a)]

b) mechanically and electrically integrated assembly of PV modules, and other necessary components, to form a d.c. power supply unit

[SOURCE: IEC 60364-7-712:2002, definition 712.3.4]

Note 1 to entry: A PV array may consist of a single PV module, a single PV string, or several parallel-connected strings, or several parallel-connected PV sub-arrays and their associated electrical components. For the purposes of this standard the boundary of a PV array is the output side of the PV array disconnecting device. Two or more PV arrays, which are not interconnected in parallel on the generation side of the power conditioning unit, shall be considered as independent PV arrays.

PV array cable
output cable of a PV array that connects the PV array junction box to the PV array disconnecting device

PV array junction box
junction box where all strings of any array are connected

[SOURCE: IEC 60364-7-712:2002, definition 712.3.5, modified]

PV array voltage
the PV array voltage is considered to be equal to $V_{OC\ ARRAY}$ under worst case conditions

Note 1 to entry: The open circuit voltage is dependent on the cell temperature and technology.

PV array, earthed
PV array where one of the poles of the d.c. output circuit is electrically bonded to earth

PV array, floating
PV array where none of the poles of the d.c. output circuit is electrically bonded to earth and connected to an application circuit which is either unearthed or double isolated

PV array, isolated
PV array where there is at least a simple electrical separation between the PV array output circuit (d.c. side) and the a.c. system

Note 1 to entry: A simple electrical separation of power circuits is usually achieved by means of a power transformer.

PV array, unearthed
PV array where none of the poles of the d.c. output circuit is electrically bonded to earth

PV cell

a) basic unit of photovoltaic conversion, a semiconductor device that can convert light directly into electrical energy;
b) basic photovoltaic device

Note 1 to entry: The preferred term is "solar photovoltaic cell" or "photovoltaic cell", colloquially referred to as a "solar cell".

[SOURCE: IEC 60904-3:2008]

PV module junction box
enclosure affixed to a PV module, where the electrical connections to the PV module are made

PV module
smallest complete environmentally protected assembly of interconnected cells

Note 1 to entry: Colloquially referred to as a "solar module".

[SOURCE: IEC 60904-3:2008]

PV string cable
cable connecting the modules in a PV string, or connecting the string to a junction box or to the d.c. terminals of the power conditioning unit

PV string
circuit of series-connected modules

PV sub-array cable
output cable of a PV sub-array that carries only the output current of its associated sub-array in normal operation, and that connects the PV sub-array with the other PV sub-arrays that constitute the PV array

Note 1 to entry: PV sub-array cables are only relevant for PV arrays that are divided into sub-arrays.

PV sub-array junction box
enclosure where all the PV strings of a PV sub-array are electrically connected in parallel and where protection devices may be located if necessary

Note 1 to entry: PV sub-array junction boxes are only relevant for PV arrays that are divided into sub-arrays.

PV sub-array
portion of an array that can be considered as a unit

QI
quality of service index

rated capacity <of a cell or a battery>
quantity of electricity, declared by the manufacturer, which a cell or a battery can deliver under specified conditions after a full charge

Note 1 to entry: The rated capacity shown on the battery label is given for a discharge period which depends on the technology used in the battery.

Note 2 to entry: The capacity of a battery is higher when it is discharged slowly. For example, variations are in the order of 10 % to 20 % between a capacity measured over 5 h and a capacity measured over 100 h.

rated color
color appearance as declared by the manufacturer or responsible vendor, or the color corresponding to the color designation marked on the lamp

rated frequency
frequency marked on the lamp or declared as such by the manufacturer or responsible vendor

rated voltage v
[V]
voltage specified by the manufacturer and rated for the nominal functioning of the lamp

RE
renewable energy

real power
effective power
apparent power multiplied by the power factor

Note 1 to entry: Real power, i.e.the actual power delivered to or consumed by the load, is expressed in watts.

reference irradiation
value of irradiation taken in consideration for the design of the system, approved by the project implementer and specified in the GS of the project

reinforced insulation
insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation

Note 1 to entry: Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation.

[SOURCE: IEC 60050-195:1998, 195-06-09]

remote site/area
geographic characteristic to define a specific location far from developed infrastructures, specifically energy distribution

ripple-free d.c.
for sinusoidal ripple voltage, a ripple content not exceeding 10 % r.m.s.

Therefore the maximum peak value does not exceed 120 V for a nominal 108 V ripple-free d.c. system

secondary cell
cell which is designed to be electrically recharged

Note 1 to entry: The recharge is accomplished by way of a reversible chemical reaction.

[SOURCE: IEC 60050-482:2004, 482-01-03]

section of an overhead line
part of a line between two tension poles

Note 1 to entry: A section generally includes several spans.

selectivity
protection coordination
ability of a protection to identify the faulty section and/or phase(s) of a power system

[SOURCE: IEC 60050-448:1995, 448-11-06]

self-discharge
phenomenon by which a cell or battery loses energy in other ways than by discharge into an external circuit

Note 1 to entry: See also charge retention.

[SOURCE: IEC 60050-482:2004, 482-03-27]

SELV
safety extra-low voltage
extra-low voltage system which is electrically separated from earth and from other systems in such a way that a single fault cannot give rise to the risk of electric shock

service connection line
conductors between the supplier's mains and the customer's installation

Note 1 to entry: In the case of an overhead service connection, this means the conductor between a supply-line pole and the customer's installation.

service life <of a battery>
period of useful life of a battery under specified conditions

service ratio
extent in which the service required by the GS is fulfilled by the system

Sgood
Sbad
service ratio

shield <of a cable>
surrounding earthed metallic layer to confine the electric field within the cable and/or to protect the cable from external electrical influence

Note 1 to entry: Metallic sheaths, armour and earthed concentric conductors may also serve as shields.

[SOURCE: IEC 60050-461:2008, 461-03-04]

short-circuit current
maximum current given by a battery into a circuit of a very low resistance compared with that of the battery, under specified conditions

simple separation
separation between electric circuits or between an electric on a local earth by means of basic insulation

[SOURCE: IEC 60050-826:2004, 826-12-28]

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
- to perform or supervise correctly the required task

span
part of a line between two consecutive poles

SPD
Surge Protection Device

stay
steel wire, rope or rod, working under tension, that connects a point of a support to a separate anchor

STC
Standard Test Conditions

standard set of reference conditions used for the testing and rating of photovoltaic cells and modules. The Standard Test Conditions are:

a) PV cell temperature of 25 ºC;

b) irradiance in the plane of the PV cell or module of 1 000 W/m^2;

c) light spectrum corresponding to an atmospheric air mass of 1,5

storage battery
secondary battery
two or more secondary cells connected together and used as a source of electric energy

storage
storage of energy produced by one of the generators of the system and which can be reconverted through the system to electricity

subcontractor
organization, company or person in charge of the execution of a selected part of the work relative to the project

supplementary insulation
independent insulation applied in addition to basic insulation, for fault protection

[SOURCE: IEC 60050-195:1998, 195-06-07]

supply point
contractual limit between the grid and the user's installation

Note 1 to entry: In rural electrification systems, it is generally located on the input terminals (microgrid side) of the user's interface.

Surge Protective Device
SPD
surge arrester
device that is intended to protect the electrical apparatus from transient overvoltages, divert surge current and to limit the duration and frequently, the amplitude of the follow-on current; it contains at least one non-linear component

[SOURCE: IEC 60050-811:1991, 811-31-09]

technical room
cabinet
room or cabinet where are located devices and apparatus dedicated to inter-connection of the different generators, protection of the different circuits, monitoring and control of the micropower system and interfacing with the application

terminal
pole
conductive part provided for the connection of a cell or battery to external conductors

total harmonic distortion
THD
ratio of the r.m.s. value of the harmonics (in this context harmonic currents I_n of the order n) to the r.m.s. value of the fundamental, viz

$$THD = \sqrt{\sum_{n=2}^{40} \left(\frac{I_n}{I_1} \right)^2}$$

Note 1 to entry: This definition has been chosen in accordance with the relevant standard, IEC 61000-2-2.

training provider
organization, company or person contracted by the project developer to provide training to the different participants in charge of using, operating and maintaining the system

trip current
current which activates the protection device

TWQIT
total weighted quality of service

user
person or organization that makes use of the installation service(s) to satisfy their energy demand

$V_{OC\ ARRAY}$
the open circuit voltage at Standard Test Conditions of a PV array, and is equal to:

$V_{OC\ ARRAY} = V_{OC\ MOD} \times M$

where M is the number of series-connected PV modules in any PV string of the PV array

Note 1 to entry: This technical specification assumes that all strings within a PV array are connected in parallel; hence the open circuit voltage of PV sub-arrays and PV strings is equal to $V_{OC\ ARRAY}$.

$V_{OC\ MOD}$
open circuit voltage of a PV module at the coldest expected operating condition

voltage
differences of potential normally existing between conductors and between conductors and earth as follows:

a) extra-low voltage: not exceeding 50 V a.c. or 120 V ripple-free d.c.;
b) low voltage: exceeding extra-low voltage, but not exceeding 1 000 V a.c. or 1 500 V d.c.;
c) high voltage: exceeding low voltage

Note 1 to entry: In consideration of ELV status, $V_{OC\ ARRAY}$ shall be used.

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