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Recommendations for small renewable energy and hybrid systems for rural electrification –

Part 4: System selection and design

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 4: System selection and design

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.
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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 62257-4, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

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

This technical specification is to be used in conjunction with IEC 62257 series.

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

Enquiry draft	Report on voting
82/369/DTS	82/389/RVC

Full information on the voting for the approval of this standard 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.

IEC 62257 consists of the following parts, under the general title *Recommendations for small renewable energy and hybrid systems for rural electrification:*

Part 1: General introduction to rural electrification
Part 2: From requirements to a range of electrification systems
Part 3: Project development and management
Part 4: System selection and design
Part 5: Protection against electrical hazards
Part 6: Acceptance, operation, maintenance and replacement
Part 7: Technical specifications: generators [1]
Part 8: Technical specifications: batteries and converters [1]
Part 9: Technical specifications: integrated systems [1]
Part 10: Technical specifications: energy manager [1]
Part 11: Technical specifications: considerations for grid connection [1]
Part 12: Appliances [1]
Part 13: Other topics [1]

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

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- withdrawn,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

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

1 Under consideration.

INTRODUCTION

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

These documents are recommendations:

– to choose the right system for the right place,

– to design the system,

– to operate and maintain the system.

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

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

The purpose of this part of IEC 62257 is to provide a method to assist project contractors and project developers to select and design the electrification system for isolated sites while matching the identified needs, such as those described in IEC 62257-2.

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

Part 4: System selection and design

1 Scope

This part of IEC 62257 provides a method for describing the results to be achieved by the electrification system independently of the technical solutions that could be implemented.

IEC 62257-2 assessed the needs of the users and the different power system architectures which can be used for meeting these needs.

In relation to the needs of the different participants to the project, functional requirements that shall be achieved by the production and distribution subsystems are listed.

In Clause 5, energy management rules to be considered are described. These are key issues as they have a great influence on the sizing of the electrification system.

In Clause 6, the information that shall be provided by the system sizing process to allow the participants to select the equipment or component able to fulfill the functional requirements are listed.

To allow and facilitate the management of the micro-power plant and the maintenance of the whole electrification system, some information shall be collected and monitored. Clause 7 is dedicated to defining the parameters and specifying rules for data acquisition.

2 Normative references

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

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

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

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

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

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

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

IEC 62257-7, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 7: Technical specifications: generators* [2]

IEC 62257-8, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 8: Technical specifications: batteries and converters* [2]

IEC 62257-9, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 9: Technical specifications: integrated systems* [2]

IEC 62257-10, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 10: Technical specifications: energy manager* [2]

IEC 62257-11, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 11: Technical specifications: considerations for grid connection* [2]

IEC 62257-12, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 12: Appliances* [2]

IEC 62257-13, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 13: Other topics* [2]

3 Terms and definitions

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

3.1
REN
renewable energy

3.2
hybrid system
multi-sources system with at least two different kind of technologies

3.3
dispatchable power system
a source, generator, system is dispatchable if delivered power is available at any specified time

EXAMPLE: a genset is a dispatchable system, REN generator is usually a non dispatchable power system.

3.4
non dispatchable power system
a non dispatchable system is resource dependent; power might not be available at a specified time

3.5
storage
storage of energy produced by one of the generator of the system and which can be reconverted through the system to electricity

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2 Under consideration.

3.6
rural micro-power plant
power plant that produces less than 50 kVA through the use of a single resource or hybrid system

3.7
rural micro-grid
grid that transfers a capacity level less than 50 kVA and powered by a micro-power plant

3.8
Individual Electrification System
IES
micro-power plant system that supplies electricity to one consumption point usually with a single energy resource point

3.9
Collective Electrification System
CES
micro-power plant and micro-grid that supplies electricity to multiple consumption points using a single or multiple energy resource points

3.10
isolated site
electric characteristic to define a specific location not currently connected to a national/ regional grid

3.11
remote site/area
geographic characteristic to define a specific location far from developed infrastructures, specifically energy distribution

4 Functional requirements of production and distribution subsystems

4.1 Preliminaries

The purpose of Clause 4 is to provide a method for describing the results to be achieved by electrification systems for isolated sites as defined in IEC 62257-2. It describes the characteristics expected from these installations based on production of electricity from renewable and/or fossil energy sources.

This stage of defining the expected results of production precedes the technical dimensioning and details engineering stages.

4.2 Overall needs to be satisfied

4.2.1 The main factors to be considered

The Figure 1 illustrates the main factors influencing the design of the micro-power plant.

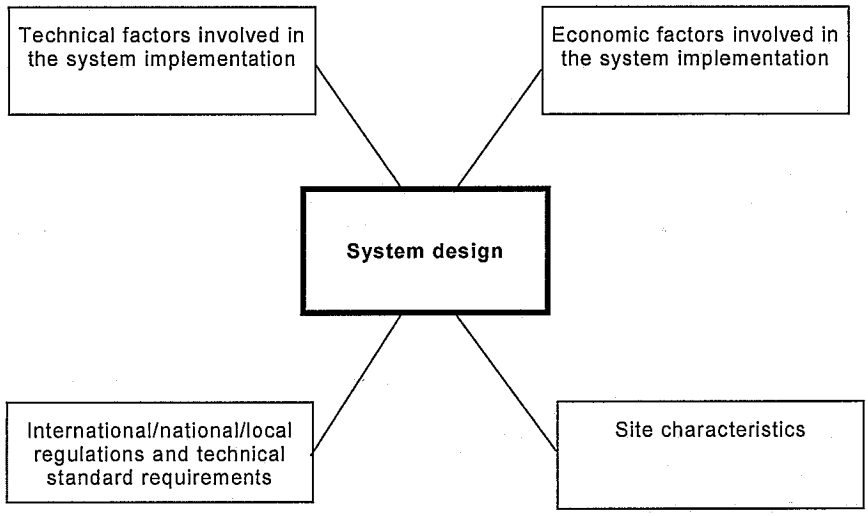

Figure 1 – Factors involved in the design of a system

4.2.2 Needs and characteristics to be considered

For each of the factors depicted in Figure 1, detailed needs or characteristics to be considered shall be identified. These needs and characteristics are defined in the following four tables.

1) Technical factors: needs or characteristics to be considered

Nature of participant	Needs or characteristics
Project developer/owner	Compliance with the general specification and relevant standards. Efficient use of energy (demand side management).
Project implementer/subcontractor	Easiest possible implementation: limited constraints in term of transportation means and lifting apparatus. Technology compatible with limited skills of local manpower. Limited installation work duration on field. Standardized equipment.
Operator	Simple operational rules to cope with possible limited skills of local operating agents. Simple mounting tools. Reliable equipment. Simple management rules. Clear and unambiguous contractual rules not liable to lead to situations of dispute or litigation. Relevant technical choices/customer management. Limited spare parts variety.
Maintenance contractor	Reliable and easy-to replace on site equipment. Limited spare parts variety.
Different users/loads	Types of energy services (see IEC 62257-2, Annex B).

2) Economic factors: needs and characteristics to be considered

Nature of participant	Needs or characteristics
Project developer/owner	Balance between initial capital costs and operational costs to make the project profitable and sustainable.
Project implementer	Balance between equipment cost (purchase and installation) and specified level of reliability.
Subcontractor	To make a correct living while fulfilling the project implementer's requirements.
Operator	Operational costs as low as possible.
Maintenance contractor	To have an economically viable activity while fulfilling the operator's requirements.
The different users/loads	Available services promised (lighting, TV, etc.) at the contractual level of quality, for the agreed price.

3) Site characteristics

General characteristics of site	Detailed characteristics	Comments
Geographical environment	Weather statistics (T°, humidity, wind, precipitation,...)	General information about the standard conditions at the site.
	Climate and severe weather or other local hazards	The characteristics of the climate at the site will affect the design of the system and the nature of its constituent equipment. One may mention: – temperature differences; – hygrometry differences; – rainfall and snowfall; – superimposed loads on structures (caused by wind, cyclones, frost, etc.); – pollution (sand, salt, dust, other pollutant wastes).
	Energy resources	Definition of local energy resources. See Table 4 for further details.
	Means of access to and around the site	General access to the site, bridges road conditions and ease of access around the site (streets, rivers, etc.) will affect the difficulty in crossing obstacles and anticipating changes in the micro distribution network, etc.
	Nature of soil (geological environment)	This affects the type of structure (overhead or buried power lines) to be set up and the execution of certain installations (for example grounding system depending on the resistively characteristics of the ground and system foundations).
	Geographical distribution of the user points	This is a major factor in the cost of the distribution infrastructures. The scatter or concentration of the user points, their probable evolution (near or remote) time-wise and space-wise, will affect choices concerning the topology of the distribution network.
Human environment	Distance to/between homes /loads – production system	
	Type of homes /loads	
	Acceptable noise level	
	Acceptable waste disposal level	
	Type of building to house the rural micro-power plant	
Biological environment	Fauna	
	Flora	
	Type of tree cover	

General characteristics of site	Detailed characteristics	Comments
Technical environment	Type of grid in place, if any (overhead, buried)	
	Civil engineering	
	Quality of existing building	This may be either an ally or an enemy as regards to certain solutions for providing supports for conductors (the physical quality of the building, its height, etc.)
	Possible local maintenance at site	
	Available telecommunication facilities	
	Equipment restrictions	
	Local technical skills level	
	Soil resistivity	
Sociological environment	Energy needs of customers	How much energy will consumers need and be willing to pay for.
	Energy consumption habits	Load profiles for the community.
	Type of clientele	Distribution by a grid will take place on the basis of: Sociological criteria (rules of society, living habits. Economic criteria (combining the grid and the rural micro-power plant shall cost less than the sum of isolated individual production/distribution facilities whilst providing the same service. Technical criteria (a guaranteed level of service, security, etc.).
Economic environment	Cost of fuel delivered to site	
	Cost of technical services	
	Economic environments in place	
	Solvability of customers	
	Tariff basis for service	

4) Regulations and requirements to be considered

Regulatory area		References
Procurement quality		(to be filled for each project)
Electrical safety		
Distribution conditions		
Buildings	Generation/distribution	
Fuel storage		
Fuel transport		
Local environmental impact		
Classified site		
Miscellaneous decrees		
Possibility of recycling equipment		
Production/distribution specification		
Import duties		
Regulatory authorities		
Local labor requirements		

4.3 Introduction to subsystems

An electrification system shall be considered as a system

Ensuring a power supply service (production subsystem)

and

Providing an electric power distribution service (distribution subsystem)

and

Providing a service to the user (demand subsystem)

whilst at the same time

Complying with constraints (acting on all subsystems)

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

- an electrical power **production** subsystem,
- a **demand** subsystem for utilizing this electrical power.

Collective Electrification Systems (CES) for multiple users incorporate three subsystems:

- an electrical power **production** subsystem (rural micro-power plant);
- a **distribution** grid for sharing this power to individual users (rural micro-grid);
- a **demand** subsystem including home wiring and user's electrical appliances for all individual users.

These subsystems may correspond to systems operated and maintained by different persons or bodies. In certain cases, the entire system may be owned, operated and used by the same person.

4.4 Functional description of a production subsystem

4.4.1 General

The function of a production subsystem is to supply electric power and energy to an individual customer or a combination of permanent customers. This generating subsystem shall be capable of fulfilling its mission, despite contingencies of availability of the renewable and/or fossil energy sources supplying it and by managing the consumption patterns of the customers.

The technical objectives assigned to such an installation can be summarised in the following essential points:

- to produce and store the energy in a cost effective manner,
- if "REN" sources are used:
  - to give precedence to use of REN where they are locally available,
  - to store energy from the REN sources whenever they are available,
  - to use the back-up energy sources (generator sets) to meet the specified level of service when REN are not available or sufficient.