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TECHNICAL SPECIFICATION

Recommendations for renewable energy and hybrid systems for rural electrification –
Part 7-2: Generator set – Off-grid wind turbines

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colour inside

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

FOREWORD 6
INTRODUCTION 8
1 Scope 9
2 Normative references 10
3 Terms and definitions 10
4 Symbols and abbreviated terms 15
4.1 Abbreviated terms 15
4.2 Symbols 16
5 Wind turbine (WT) 16
5.1 Types of wind turbines 16
5.1.1 Horizontal axis wind turbine (HAWT) 16
5.1.2 Vertical axis wind turbine (VAWT) 17
5.1.3 SWT classes 18
5.2 General characteristics of SWT 18
5.2.1 Basic technical characteristics 18
5.2.2 Most important technical characteristics 19
5.3 Working conditions of SWT 20
6 Off-grid Small Wind Power Systems (SWPS) 20
6.1 General 20
6.2 Major components in SWPS 20
6.2.1 SWT 20
6.2.2 Tower 21
6.2.3 Controller 22
6.2.4 Brake 22
6.2.5 Inverter 23
6.2.6 Storage system 23
6.2.7 Dump load 23
6.3 Design Procedure of SWPS 23
6.3.1 General 23
6.3.2 Wind resource assessment 23
6.3.3 Site assessment 24
6.3.4 Determine the capacity of the SWPS 24
6.3.5 Select SWT 24
6.4 Configuration of SWPS 24
6.4.1 General 24
6.4.2 Layout SWT(s) on site 28
7 Selection of SWPS 28
7.1 General 28
7.2 Selection criteria 29
7.2.1 General factors in selection of SWT 29
7.2.2 Rule of thumb 29
7.2.3 Wind turbine height 29
7.2.4 Turbulence 30
7.3 Design of a microgrid or Isolated Microgrid with SWT 30
7.3.1 Meet national rural grid standards 30
7.3.2 Design microgrid and wiring into households 30

8 Safety issues 30
8.1 General 30
8.2 General 30
8.3 Personal safety 31
8.3.1 Safety training and regulation following 31
8.3.2 Basic safety guidelines 31
8.4 Equipment safety 32
8.4.1 SWT 32
8.4.2 System current and voltage 32
8.4.3 Wiring and disconnection requirements 32
8.4.4 Grounding 32
8.4.5 Other safety issues and anti-theft 33
8.5 SWPS safety for isolated microgrid 33
8.5.1 System safety 33
8.5.2 Extreme climate proof 34
8.5.3 High elevation for electronics 34
8.6 Protection against electric shock and fire 34
9 SWT and SWPS installation 34
9.1 General 34
9.1.1 Overview 34
9.1.2 General installation methods 35
9.1.3 Rooftop installation 35
9.1.4 Verticality 35
9.2 Installation of SWPS of isolated microgrid 36
9.2.1 Transportation 36
9.2.2 Preparations 36
9.2.3 Infrastructure 36
9.2.4 Civil works 37
9.2.5 Installation of equipment 38
10 Tests and acceptance 40
10.1 General 40
10.2 Individual equipment test 40
10.3 System self-test 40
10.4 Acceptance test 40
10.4.1 General 40
10.4.2 Preparation 41
10.4.3 Documentation 41
10.4.4 Commissioning 41
10.4.5 Agreement 42
11 Operation and maintenance 42
11.1 General 42
11.2 Safety 42
11.3 Operation and maintenance procedures 42
11.4 General inspection, routine and troubleshooting 43
11.4.1 Inspection 43
11.4.2 Check list 43
11.5 Troubleshooting 43
12 Marking and documentation 44

12.1 Markings and signs 44
12.1.1 General 44
12.1.2 Equipment marking 44
12.1.3 Requirements for signs 44
12.2 Labelling 44
12.2.1 Labelling of SWT 44
12.2.2 Labelling of disconnection devices 44
12.3 Documentation 44
Annex A (informative) Main characteristics of an off-grid wind turbine 45
A.1 Example of battery charging horizontal axis SWT's characteristics, see Table A.1 45
A.2 Example of battery charging vertical axis SWT's characteristics, see Table A.2 46
Annex B (informative) Wind shear exponent, α 47
Annex C (informative) Example of labelling 48
Annex D (informative) Example of inspection and maintenance schedule 49
D.1 General 49
D.2 Example of inspection and maintenance schedule for a SWPS with HAWT 49
D.3 Checklist for inspections 49
Annex E (informative) Example of troubleshooting for a SWPS with HAWT SWT 51
Annex F (informative) Example of commissioning records sheet for SWT 53
Annex G (informative) Case study of SWPS design 55
G.1 Basic information 55
G.2 Local renewable energy resource – Wind resource 55
G.3 Required wind power capacity in the HPS 55
G.4 Select wind turbine (s) 55
G.5 Calculate the power output of unit SWT based upon local wind resource and power curve of selected SWT 56
Annex H (informative) Example of oscillation method to determine natural frequency and tension 57
H.1 General 57
H.2 Oscillation method for tensioning guy cables 57
Bibliography 58

Figure 1 – General functional configuration of SWT(s) in an off-grid hybrid power system 9
Figure 2 – Example of wind turbine with active yaw system 17
Figure 3 – Rotors with different number of blades of a HAWT 17
Figure 4 – Four typical VAWTs 17
Figure 5 – Variety of tower options 22
Figure 6 – AC bus system 25
Figure 7 – DC bus system 25
Figure 8 – Obstruction of the wind by a building or a tree 30
Figure 9 – Pads for tilt-up tower 38
Figure 10 – Acceptance test procedure of SWPS 41
Figure C.1 – Sample label in English 48
Figure C.2 – Sample label, bilingual (English and French) 48

Figure G.1 – Annual monthly average wind speed pattern 55
Figure G.2 – Power curve of selected SWT 56
Figure G.3 – Power output from one 10 kW SWT 56

Table 1 – Basic parameters for SWT classes 18
Table 2 – Equipment having a nominal voltage below 750 V DC 26
Table 3 – Equipment having a nominal voltage below 750 V DC 27
Table 4 – AC systems having a nominal voltage between 100 V and 1 000 V inclusive and related equipment 28
Table 5 – Installation methods of different SWPSs 35
Table A.1 – Example of battery charging horizontal axis SWT's characteristics 45
Table A.2 – Example of battery charging vertical axis SWT's characteristics 46
Table B.1 – Surface roughness and lengths and the wind hear exponents α 47
Table E.1 – Example of troubleshooting guide for SWT 51
Table F.1 – Acceptance of wind generators 53
Table F.2 – Example of commissioning records sheet for SWT operation 54

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 7-2: Generator set – Off-grid wind turbines

FOREWORD

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IEC TS 62257-7-2 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
82/1956/DTS	82/1995/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

INTRODUCTION

The IEC 62257 series of publications 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 AC voltage below 500 V, DC voltage below 750 V and power below 100 kW.

These publications provide recommendations for:

- choosing the right system for the right place;
- designing the system;
- operating and maintaining the system.

These publications are focused only on rural electrification concentrated in, but not specific to, developing countries. They are not considered as all-inclusive of rural electrification. The publications try to promote the use of renewable energies in rural electrification. They do not deal with clean mechanism developments at this time (CO2 emission, carbon credit, etc.). Further developments in this field could be introduced in future steps.

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

The purpose of this document is to provide guidance for the deployment of small wind turbines (a wind turbine with a rotor swept area smaller than or equal to 200 m^2, see IEC 61400-2: 2013) used in off-grid hybrid power system in rural electrification.

This document is a general introduction followed by more specific documents dedicated to the generation technologies which are the most currently used in rural electrification projects.

RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 7-2: Generator set – Off-grid wind turbines

1 Scope

This document applies to all small wind turbines (SWTs) with a swept area smaller than or equal to 200 m^2, and designed for supplying electrical power to isolated sites used in systems as described in IEC TS 62257-2.

This document is not an exhaustive resource for the design, installation, operation or maintenance of small wind turbines and wind power systems, but is more focused on recommendations to provide strategies on selection and criteria which may affect the use of a small wind power system (SWPS) in a rural electrification project.

Only the hybrid collective electrification system (microgrid, isolated microgrid) including SWT(s) is considered in this document. SWT in an isolated microgrid can be a single wind turbine or multiple wind turbines. Isolated microgrid using only wind power generation is not discussed in this document. General functional configuration of SWT(s) in an off-grid hybrid power system is shown in Figure 1.

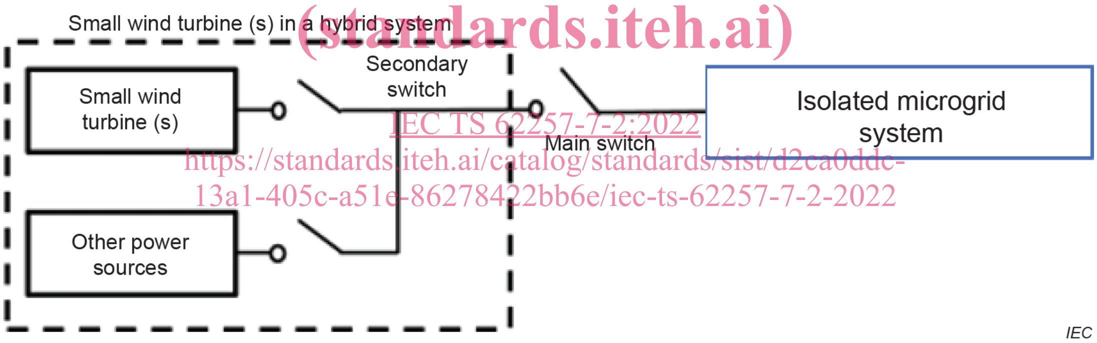

Figure 1 – General functional configuration of SWT(s) in an off-grid hybrid power system

The aim of this document is to provide users with the appropriate levels of reliability and safety of the equipment during its estimated service lifespan.

It describes the minimum safety requirements and does not claim to be an exhaustive instruction manual or design specification.

Compliance with this document does not exempt any person, organization, or corporation from the responsibility to comply with all other relevant regulations.

This document gives recommendations for the single SWT with a swept area smaller than or equal to 200 m^2, or multiple SWTs with other power sources of total capacity up to 100 kW in an off-grid hybrid power system.

The design life of a good quality modern wind turbine is 20 years. The real lifetime of a SWT is subjected to quite extreme loads throughout its life. This mostly depends on its designed structure and reliability of moving parts, because the power in the wind increases with the cube of the speed.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038:2009, *IEC standard voltages*
IEC 60038:2009/AMD1:2021

IEC 60287 (all parts), *Electric cables – Calculation of the current rating*

IEC 60721-2-1:2013, *Classification of environmental conditions – Part 2-1: Environmental conditions appearing in nature – Temperature and humidity*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61400-2:2013, *Wind turbines – Part 2: Small wind turbines*

IEC 61400-12-1, *Wind energy generation systems – Part 12-1: Power performance measurements of electricity producing wind turbines*

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

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

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

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

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

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

ISO 3864-1:2011, *Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/

- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
Annual Energy Production
AEP
calculated total energy that would be produced during a one-year period at an average wind speed of 5,0 m/s at hub height, assuming a Rayleigh wind speed distribution, 100 % availability, and the power curve derived from IEC 61400-12-1

SEE: 3.28.

3.2
annual average
mean value of a set of measured data of sufficient size and duration to serve as an estimate of the expected value of the quantity

3.3
annual average wind speed
V_{ave}
wind speed averaged according to the definition of annual average

3.4
brake
device capable of reducing the rotor speed or stopping rotation of a wind turbine system

3.5
collective electrification system
<isolated microgrid>
micro-power plant and micro-grid that supplies electricity to multiple consumption points using a single or multiple energy resource points

3.6
consumer label
label for the benefit of consumers consisting of two parts: the label itself, and a test summary report made available by a web site

3.7
control system
sub-system that receives information about the condition of the wind turbine system and/or its environment and adjusts the turbine in order to maintain it within its operating limits

3.8
start-up wind speed
wind speed at which the rotor first begins to turn after being at rest once spinning, wind turbine rotors can coast to lower wind speeds than those necessary to start the rotor revolving

3.9
cut-in wind speed
Vin
lowest mean hub height wind speed bin value at which the wind turbine system produces a net positive power output. The turbine does not produce power between start up wind speed and cut in wind speed.

3.10
cut-out wind speed
Vout
highest mean wind speed at hub height at which the wind turbine system is designed to produce power

3.11
downwind
in the main direction of wind flow

3.12
emergency shutdown
rapid shutdown of the wind turbine system triggered by a protection system or by manual intervention

3.13
external condition
factor affecting the operation of a wind turbine system including the environmental conditions (temperature, snow, ice, etc.) and the electrical network conditions that are not part of the wind turbine system

3.14
extreme wind speed
highest average wind speed, averaged over t seconds, that is likely to be experienced within a specified time period (recurrence period) of T years

3.15
fail-safe
design property of an item which prevents its failures from resulting in critical faults

3.16
hybrid power system
HPS
power system including generators from different technologies

3.17
horizontal axis wind turbine
HAWT
type of wind turbine in which the axis of the rotor's rotation is nominally parallel to the horizontal ground surface

3.18
hub
fixture for attaching the blades or blade assembly to the rotor shaft of a wind turbine system

3.19
hub height
height of the geometric center of the swept area of the wind turbine rotor above the terrain surface

3.20
mean wind speed
statistical mean of the instantaneous value of the wind speed averaged over a given time period which can vary from a few seconds to 1 year

Note 1 to entry: Though wind speed varies over a continuum, measurements used to develop power curves group power measurements into separate discrete registers or bins, for wind speed in m/s, typically 0,5m/s wide. The 5 m/s bin, for example, would represent winds from 4,75 to 5,25 m/s.

3.21
nacelle
housing which contains the drivetrain and other elements on top of a horizontal axis wind turbine tower

3.22
noise label
defined graphical and textual representation of the acoustic noise data pertaining to a small wind turbine system

3.23
overspeed control
action of a control system, or part of such system, which prevents excessive rotor speed

3.24
power form and voltage
physical characteristics which describe the form in which power produced by the wind turbine system is made deliverable to the load (e.g. 230 V AC, 50 Hz, 1 ph; or e.g. 48 V DC)

3.25
protection system
system which ensures that a wind turbine generator system remains within the design limits

3.26
rated power
maximum continuous electrical output power which a wind turbine system is designed to achieve at the connection facilities under normal operation

Note 1 to entry: The rated power of SWT is its output at 11 m/s at standard sea-level condition.

Rated power of SWT varies roughly proportionally to the swept area of the rotor. Blade design and technology developments are therefore one of the keys to increasing wind turbine capacity output. By doubling the rotor diameter, the swept area and therefore power output is increased by a factor of four.

3.27
rated wind speed
wind speed at which a wind turbine system's rated power is achieved. The distribution depends on one adjustable parameter – the scale parameter, which controls the average wind speed.

3.28
maximum design wind speed
highest allowable wind speed for turbine operations

Note 1 to entry: It is expressed in m/s.

3.29
swept area
projected area perpendicular to the wind direction that a rotor will describe during one complete rotation

Note 1 to entry: It is expressed in m^2.

3.30
Rayleigh distribution
probability distribution function often used for wind speeds

3.31
reference annual energy
calculated total energy that would be produced during a one-year period at an average wind speed of 5,0 m/s at hub height, assuming a Rayleigh wind speed distribution, 100 % availability, and the power curve derived from IEC 61400-12-1 (where it is referred to as Annual Energy Production (AEP))

Note 1 to entry: The AEP from IEC 61400-12-1 is either the "AEP-measured" or the "AEP-extrapolated", and is either "sea-level normalised" or "site-specific".