

# TECHNICAL SPECIFICATION



**Electrical energy storage (EES) systems –  
Part 3-1: Planning and performance assessment of electrical energy storage  
systems – General specification**



## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2018 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

#### IEC Catalogue - [webstore.iec.ch/catalogue](http://webstore.iec.ch/catalogue)

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

generated by EVS



# TECHNICAL SPECIFICATION



---

**Electrical energy storage (EES) systems –  
Part 3-1: Planning and performance assessment of electrical energy storage  
systems – General specification**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 13.020.30

ISBN 978-2-8322-5973-3

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

## CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references .....	8
3 Terms, definitions and symbols.....	9
3.1 Terms and definitions.....	9
3.2 Symbols.....	9
4 General structure of EES systems .....	9
4.1 Architecture of an EES system.....	9
4.2 Subsystem specifications .....	10
4.2.1 Accumulation subsystem .....	10
4.2.2 Power conversion subsystem.....	11
4.2.3 Auxiliary subsystem .....	11
4.2.4 Control subsystem .....	11
5 Planning of EES systems.....	12
5.1 General.....	12
5.2 EES system environment .....	13
5.2.1 General .....	13
5.2.2 Grid parameters and requirements.....	13
5.2.3 Service conditions .....	14
5.2.4 Standards and local regulations.....	15
5.3 Sizing of EES systems .....	15
5.3.1 Requirements at primary POC .....	15
5.3.2 Sizing recommendations.....	16
5.4 Main electrical parameters of EES systems.....	17
5.4.1 General .....	17
5.4.2 Input and output power rating .....	17
5.4.3 Rated energy capacity .....	18
5.4.4 Auxiliary power consumption .....	18
5.4.5 Self-discharge .....	18
5.4.6 Roundtrip efficiency.....	18
5.4.7 Duty cycle roundtrip efficiency.....	19
5.4.8 Recovery times.....	19
5.4.9 End-of-service life values .....	19
5.5 Functional system performance .....	20
5.5.1 General .....	20
5.5.2 Operation states of control subsystem .....	22
5.5.3 Grid frequency support .....	22
5.5.4 Islanding control and black start capability.....	23
5.5.5 Active power limitation.....	23
5.5.6 Manual active power control .....	24
5.5.7 Pattern active power control .....	24
5.5.8 Automatic load following control .....	25
5.5.9 Power control modes for grid voltage support .....	25
5.6 Communication interface.....	27
5.6.1 General .....	27

5.6.2	Information model for an EES system .....	27
5.6.3	Remote monitoring and control .....	29
6	EES system performance assessment .....	33
6.1	Factory acceptance test (FAT) .....	33
6.2	Installation and commissioning .....	34
6.2.1	General .....	34
6.2.2	Installation phase .....	34
6.2.3	Commissioning phase .....	34
6.3	Site acceptance test (SAT) .....	35
6.4	Performance monitoring phase .....	36
Annex A (informative)	Examples of EES system applications .....	38
A.1	EES system designed for reserve control .....	38
A.1.1	General .....	38
A.1.2	Example of an EES system for primary frequency control .....	38
A.1.3	Example of an EES system for secondary frequency control .....	39
A.1.4	Example of an EES system for dynamic frequency control .....	40
A.2	EES system in conjunction with renewable energy production .....	42
A.2.1	General .....	42
A.2.2	Example of EES system for renewable (energy) firming .....	42
A.2.3	Example of EES system for renewable (power) smoothing .....	43
A.3	EES system for grid support applications .....	44
A.3.1	Example of an EES system for grid voltage support ( $Q(U)$ control mode) .....	44
A.3.2	Example of an EES system for power quality support by voltage-related active power injection .....	47
Annex B (informative)	Aspects to be considered with regard to EES system installation .....	49
B.1	Site-assembling .....	49
B.2	Protection against disaster – Fire prevention .....	49
B.3	Transportation and on-site storage .....	49
Bibliography	.....	50
Figure 1	– Typical architectures of EES systems .....	10
Figure 2	– Example of classification of EES systems according to energy form .....	11
Figure 3	– Sample performance versus time characteristics for EES systems .....	19
Figure 4	– Sample consideration to design the service life of EES systems .....	20
Figure 5	– Example of EES system operation states .....	22
Figure 6	– Example for $P(f)$ strategy .....	23
Figure 7	– Example of setting of active output power at primary POC .....	24
Figure 8	– Example of day pattern operation at primary POC .....	25
Figure 9	– Example of peak shaving application .....	25
Figure 10	– Example of a general control characteristic .....	26
Figure 11	– Reference diagram for information exchange .....	27
Figure 12	– EES system as an aggregation of several EES systems at the same primary POC .....	28
Figure A.1	– Sample duty cycle for a primary frequency control application with 30-s power output every 30 min shown over 2 h .....	38
Figure A.2	– Sample power output for a secondary frequency control application with 20-min power output over 3 h .....	40

Figure A.3 – Sample output power of an EES system for a dynamic frequency control application in spring, summer, autumn and winter .....	41
Figure A.4 – Sample output power of an EES system in a renewable (solar) energy firming application.....	43
Figure A.5 – Sample output power of an EES system for a renewable (solar) power smoothing application .....	44
Figure A.6 – Example of grid voltage at the POC of a photovoltaic power plant.....	45
Figure A.7 – Sample reactive power supply of an EES system at the POC.....	46
Figure A.8 – Sample duty cycle for power quality support by voltage-related active power injection with 5-min power output every 45 min over 12 h .....	48
Table 1 – Points of attention for planning phase.....	17
Table 2 – Example of day pattern operation .....	24
Table 3 – Example for messages of measurement and monitoring categories versus categories of messages .....	30
Table 4 – Example of messages of an EES system information model .....	31
Table 5 – Example of items to be taken into account in the different installation phases .....	34
Table 6 – Points of attention for commissioning phase.....	35
Table 7 – Points of attention for performance monitoring phase .....	36
Table 8 – Example of local measurements and monitoring of EES system .....	37
Table A.1 – Sample values of a duty cycle for primary frequency control for sudden loss of generation .....	39
Table A.2 – Sample values of recovery time for primary frequency control for sudden loss of generation .....	39
Table A.3 – Sample values of a duty cycle for secondary frequency control for sudden loss of generation .....	40
Table A.4 – Sample values of a duty cycle for dynamic primary frequency control.....	41
Table A.4 – Sample values of a duty cycle for renewable (energy) firming .....	43
Table A.5 – Sample values of a duty cycle for grid voltage support by $Q(U)$ control mode .....	47
Table A.6 – Sample values of a duty cycle for power quality .....	48

This document is generated by EVS

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL ENERGY STORAGE (EES) SYSTEMS –****Part 3-1: Planning and performance assessment of  
electrical energy storage systems – General specification**

## FOREWORD

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

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

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

Technical Specification IEC 62933-3-1 has been prepared by IEC technical committee TC 120: Electrical Energy Storage (EES) Systems.

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

Enquiry draft	Report on voting
120/118/DTS	120/123/RVDTS

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

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

A list of all parts in the IEC 62933 series, published under the general title *Electrical energy storage (EES) systems*, can be found on the IEC website.

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

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

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

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

generated by EVS

## INTRODUCTION

IEC 62933-2-1 should be used as a reference when selecting testing items and their corresponding evaluation methods as well as principal parameters. Principal terms used in this document are defined in IEC 62933-1. Environmental issues are covered by IEC TS 62933-4-1. The personnel safety issues are covered by IEC TS 62933-5-1.

This document is a preview generated by EVS

## ELECTRICAL ENERGY STORAGE (EES) SYSTEMS –

### Part 3-1: Planning and performance assessment of electrical energy storage systems – General specification

#### 1 Scope

This part of IEC 62933 is applicable to EES systems designed for grid-connected indoor or outdoor installation and operation. This document considers

- necessary functions and capabilities of EES systems
- test items and performance assessment methods for EES systems
- requirements for monitoring and acquisition of EES system operating parameters
- exchange of system information and control capabilities required

Stakeholders of this document comprise personnel involved with EES systems, which includes

- planners of electric power systems and EES systems
- owners of EES system
- operators of electric power systems and EES systems
- constructors
- suppliers of EES system and its equipment
- aggregators

Use-case-specific technical documentation, including planning and installation specific tasks such as system design, monitoring and measurement, operation and maintenance, are very important and can be found throughout this document.

NOTE This document has been written for AC grids, however parts can also apply to DC grids.

#### 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 60721-1, *Classification of environmental conditions – Part 1: Environmental parameters and their severities*

IEC 62351 (all parts), *Power systems management and associated information exchange – Data and communications security*

IEC 62443 (all parts), *Industrial communication networks – Network and system security*

IEC 62933-1:2018, *Electrical energy storage (EES) systems – Part 1: Vocabulary*

IEC 62933-2-1, *Electrical energy storage (EES) systems – Part 2-1: Unit parameters and testing methods – General specification*

IEC TS 62933-5-1, *Electrical energy storage (EES) systems – Part 5-1: Safety considerations for grid-integrated EES systems – General specification*

ISO/IEC 27000, *Information technology – Security techniques – Information security management systems – Overview and vocabulary*

### 3 Terms, definitions and symbols

#### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62933-1 and the following 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>

##### 3.1.1

**idle**, adj.

<period of time> time period where the EES system does not or is not able to perform any grid tasks related to active output power at the point of connection (POC)

##### 3.1.2

**recovery time**

duration needed by an EES system to recover from a duty cycle so that the following duty cycle is within its specified conditions for a certain operating mode and at continuous operating conditions

Note 1 to entry: The definition is loosely based on IEC 60050-447:2010, 447-05-08.

#### 3.2 Symbols

$P$	active power
$Q$	reactive power
$S$	apparent power
$U$	voltage
$I$	current
$\cos\varphi$	power factor
$f$	frequency

### 4 General structure of EES systems

#### 4.1 Architecture of an EES system

The typical architecture of an EES system, which internally feeds the auxiliary subsystem, is given in Figure 1 a).