

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

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.

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.

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*