

# TECHNICAL REPORT



**Communication networks and systems for power utility automation –  
Part 90-9: Use of IEC 61850 for Electrical Energy Storage Systems**

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Part 90-9: Use of IEC 61850 for Electrical Energy Storage Systems**

INTERNATIONAL  
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## CONTENTS

|                                                                                                            |    |
|------------------------------------------------------------------------------------------------------------|----|
| FOREWORD.....                                                                                              | 6  |
| INTRODUCTION.....                                                                                          | 8  |
| 1 Scope.....                                                                                               | 10 |
| 1.1 Scope of this document.....                                                                            | 10 |
| 1.2 Namespace.....                                                                                         | 10 |
| 1.3 Data model Namespace Code Component distribution .....                                                 | 10 |
| 2 Normative references .....                                                                               | 11 |
| 3 Terms, definitions and abbreviated terms .....                                                           | 12 |
| 3.1 Terms and definitions.....                                                                             | 12 |
| 3.2 Abbreviated terms.....                                                                                 | 14 |
| 3.3 Acronyms and abbreviated terms proposed specifically for the data model<br>part of this document ..... | 14 |
| 3.4 Common abbreviated terms used for the data model part of this document .....                           | 15 |
| 4 Overview of EESS .....                                                                                   | 34 |
| 4.1 EESS system description .....                                                                          | 34 |
| 4.2 Functional requirements of EESS.....                                                                   | 35 |
| 4.3 EESS participating in grid operations as a DER system .....                                            | 35 |
| 4.3.1 General .....                                                                                        | 35 |
| 4.3.2 Constraints, assumptions, and design considerations .....                                            | 36 |
| 4.4 Hierarchical class model of DER resources.....                                                         | 36 |
| 4.5 DER resource class and composition model for EESS .....                                                | 37 |
| 4.5.1 General .....                                                                                        | 37 |
| 4.5.2 DER class model principles for a single storage unit.....                                            | 37 |
| 4.5.3 Expressing the composition of storage elements .....                                                 | 39 |
| 4.5.4 Expressing equivalent capabilities .....                                                             | 41 |
| 4.5.5 Complete DER model resulting from equivalent and composed<br>principles.....                         | 43 |
| 4.5.6 LN mapping example in case of a complex storage installation .....                                   | 45 |
| 4.6 State machine of the EESS.....                                                                         | 47 |
| 4.7 Definitions of the capacity and the state of charge of an EESS .....                                   | 49 |
| 5 Use cases .....                                                                                          | 50 |
| 5.1 General.....                                                                                           | 50 |
| 5.2 Use case overview.....                                                                                 | 50 |
| 5.2.1 Diagram.....                                                                                         | 50 |
| 5.2.2 Actors.....                                                                                          | 51 |
| 5.2.3 List of use cases.....                                                                               | 51 |
| 5.2.4 Information flow (basic flow) .....                                                                  | 52 |
| 5.2.5 Summary of exchanged information in use cases.....                                                   | 57 |
| 6 IEC 61850 based information modelling.....                                                               | 62 |
| 6.1 Logical Nodes from 61850-90-9 namespace.....                                                           | 62 |
| 6.1.1 General .....                                                                                        | 62 |
| 6.1.2 Abstract LNs related to the 61850-90-9 namespace (AbstractLN_90_9).....                              | 66 |
| 6.1.3 Logical Nodes from Group D (LNGroupD_90_9) .....                                                     | 71 |
| 6.1.4 Logical Nodes from Group S (LNGroupS_90_9).....                                                      | 78 |
| 6.2 Enumerations.....                                                                                      | 81 |
| 6.2.1 General .....                                                                                        | 81 |
| 6.2.2 Battery Test Results (BatteryTestResultKind) .....                                                   | 82 |



|                                                                                                                                                                         |                                                                                                                    |     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----|
| 6.2.3                                                                                                                                                                   | Type of Battery (BatteryTypeKind) .....                                                                            | 82  |
| 6.2.4                                                                                                                                                                   | Storage charging/discharging permissions (ChargeSourceKind) .....                                                  | 83  |
| Annex A (informative) Concrete case 1&2: YSCP (Yokohama Smart City Project) DER MS (Battery SCADA) system use cases .....                                               |                                                                                                                    | 84  |
| A.1                                                                                                                                                                     | System use cases #1: Online power system control with aggregated battery based EESS (virtual energy storage) ..... | 84  |
| A.1.1                                                                                                                                                                   | Descriptions of function .....                                                                                     | 84  |
| A.1.2                                                                                                                                                                   | Step by step analysis of function .....                                                                            | 88  |
| A.1.3                                                                                                                                                                   | Auxiliary issues – Revision history .....                                                                          | 97  |
| A.2                                                                                                                                                                     | System use case #2 Active power schedule updating by using aggregated battery-based EESS .....                     | 97  |
| A.2.1                                                                                                                                                                   | Descriptions of function .....                                                                                     | 97  |
| A.2.2                                                                                                                                                                   | Step by step analysis of function .....                                                                            | 106 |
| A.2.3                                                                                                                                                                   | Auxiliary issues – Revision history .....                                                                          | 113 |
| Annex B (informative) DER functions to meet EESS energy application requirements .....                                                                                  |                                                                                                                    | 114 |
| Annex C (informative) Energy service by electrical energy storage system use case #1 (Energy supply and demand adjustment using customer's battery system) .....        |                                                                                                                    | 118 |
| C.1                                                                                                                                                                     | Use case description .....                                                                                         | 118 |
| C.1.1                                                                                                                                                                   | Use case name .....                                                                                                | 118 |
| C.1.2                                                                                                                                                                   | Use case scope and objectives .....                                                                                | 118 |
| C.1.3                                                                                                                                                                   | Use case detailed description .....                                                                                | 119 |
| C.2                                                                                                                                                                     | Use case diagrams .....                                                                                            | 120 |
| C.3                                                                                                                                                                     | Technical details – Actors .....                                                                                   | 123 |
| C.4                                                                                                                                                                     | Information exchanged .....                                                                                        | 124 |
| Bibliography .....                                                                                                                                                      |                                                                                                                    | 125 |
| Figure 1 – Classification of electrical energy storage systems according to energy form. IEC-WP [IEC White Paper Electrical Energy Storage:2011]) .....                 |                                                                                                                    | 34  |
| Figure 2 – Different uses of electrical energy storage in grids, depending on the frequency and duration of use .....                                                   |                                                                                                                    | 35  |
| Figure 3 – Simple storage resource model of a battery storage unit (instance & class) .....                                                                             |                                                                                                                    | 37  |
| Figure 4 – Hierarchical class model of DER resources – (blue outlined area showing EESS) .....                                                                          |                                                                                                                    | 38  |
| Figure 5 – Exposing the generic interface of a DER unit (Case of a storage unit as an example) .....                                                                    |                                                                                                                    | 39  |
| Figure 6 – DER composition model principles .....                                                                                                                       |                                                                                                                    | 40  |
| Figure 7 – LN mapping related to a storage system composed of two storage units .....                                                                                   |                                                                                                                    | 41  |
| Figure 8 – Needed association to express DER generic capabilities .....                                                                                                 |                                                                                                                    | 42  |
| Figure 9 – Exposing the generic interfaces of a storage DER (battery storage as example) .....                                                                          |                                                                                                                    | 43  |
| Figure 10 – Principles of the hierarchical class model of DER resources with examples of specific DER types at the lowest level (blue outlined area showing EESS) ..... |                                                                                                                    | 44  |
| Figure 11 – LN mapping of an EESS composed of 2 storage units with equivalent capabilities defined at all levels .....                                                  |                                                                                                                    | 45  |
| Figure 12 – A simple electrical energy storage system .....                                                                                                             |                                                                                                                    | 46  |
| Figure 13 – A more complex electrical mixed system, including storage – example of possible LN mapping .....                                                            |                                                                                                                    | 46  |
| Figure 14 – DER common state diagram .....                                                                                                                              |                                                                                                                    | 48  |
| Figure 15 – Logic definitions associated to the DER common state diagram .....                                                                                          |                                                                                                                    | 49  |

|                                                                                                                                                     |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Figure 16 – EESS state of charge: effective and usable capacities and states of charge reflected using the IEC 61850 model naming conventions ..... | 50  |
| Figure 17 – Use case diagram .....                                                                                                                  | 51  |
| Figure 18 – The entire sequence of EESS use cases .....                                                                                             | 52  |
| Figure 19 – Sequence of UC1: retrieving current capabilities/status of EESS information to Storage Management System .....                          | 53  |
| Figure 20 – Sequence of UC2: set Charging power to EESS .....                                                                                       | 55  |
| Figure 21 – Sequence of UC3: Set discharging power to EESS .....                                                                                    | 55  |
| Figure 22 – Sequence of UC4: set operational function/schedule to EESS .....                                                                        | 56  |
| Figure 23 – Sequence of UC5: Alarm/Asset Monitoring of EESS .....                                                                                   | 57  |
| Figure 24 – Class diagram LogicalNodes_90_9::StorageLNs_Global arrangement .....                                                                    | 62  |
| Figure 25 – Class diagram LogicalNodes_90_9::StorageLNs_Details .....                                                                               | 63  |
| Figure 26 – Class diagram LogicalNodes_90_9::StorageLNs_90_9_1 .....                                                                                | 64  |
| Figure 27 – Class diagram LogicalNodes_90_9::StorageLNs_90_9_2 .....                                                                                | 65  |
| Figure 28 – Class diagram DOEnums_90_9::DOEnums_90_9 .....                                                                                          | 82  |
| Figure A.1 – Load Frequency control by battery aggregation .....                                                                                    | 85  |
| Figure A.2 – Actors .....                                                                                                                           | 86  |
| Figure A.3 – Calculation of the total surplus potential for the default plan .....                                                                  | 104 |
| Figure A.4 – Calculation of the schedule of batteries for the default plan .....                                                                    | 104 |
| Figure A.5 – Calculation of the schedule of batteries for the default plan .....                                                                    | 105 |
| Figure A.6 – Calculation of the schedule of batteries for the plan .....                                                                            | 105 |
| Table 1 – Tracking information of (Tr)IEC 61850-90-9:2018A namespace building-up .....                                                              | 7   |
| Table 2 – Attributes of (Tr)IEC 61850-90-9:2018A namespace .....                                                                                    | 10  |
| Table 3 – Generic acronyms and abbreviated terms .....                                                                                              | 14  |
| Table 4 – Normative abbreviations for data object names .....                                                                                       | 15  |
| Table 5 – Normative abbreviations for data object names .....                                                                                       | 16  |
| Table 6 – List of actors .....                                                                                                                      | 51  |
| Table 7 – List of use cases .....                                                                                                                   | 52  |
| Table 8 – Information exchange in UC1: Sequence of retrieving current capabilities/status of EESS information to Storage Management System .....    | 53  |
| Table 9 – Information exchange Step1-2 in UC1 current capability /status information .....                                                          | 54  |
| Table 10 – Information exchange in UC2: Set Charging power to EESS .....                                                                            | 55  |
| Table 11 – Information exchange in UC3: Set discharging power to EESS .....                                                                         | 56  |
| Table 12 – Information exchange in UC4: set operational function to EESS .....                                                                      | 56  |
| Table 13 – Information exchange in UC4: set schedule to EESS .....                                                                                  | 57  |
| Table 14 – Information exchange in UC5: Alarm/Asset Monitoring of EESS .....                                                                        | 57  |
| Table 15 – Summary of exchanged Information in use cases with corresponding DOs/LNs .....                                                           | 58  |
| Table 16 – Data objects of Storage_Control_LN .....                                                                                                 | 66  |
| Table 17 – Data objects of StorageOperationalSettingsLN .....                                                                                       | 66  |
| Table 18 – Data objects of StorageNameplateRatingsLN .....                                                                                          | 68  |
| Table 19 – Data objects of DER_StorageLN .....                                                                                                      | 70  |
| Table 20 – Data objects of DBAT .....                                                                                                               | 71  |

|                                                    |    |
|----------------------------------------------------|----|
| Table 21 – Data objects of DSTO .....              | 74 |
| Table 22 – Data objects of SBAT .....              | 78 |
| Table 23 – Literals of BatteryTestResultKind ..... | 82 |
| Table 24 – Literals of BatteryTypeKind .....       | 83 |
| Table 25 – Literals of ChargeSourceKind .....      | 83 |

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## COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

### Part 90-9: Use of IEC 61850 for Electrical Energy Storage Systems

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IEC 61850-90-9, which is a technical report, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

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

|               |                  |
|---------------|------------------|
| Enquiry draft | Report on voting |
| 57/2128/DTR   | 57/2184/RVDTR    |

Full information on the voting for the approval of this technical report 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 61850 series, published under the general title *Communication networks and systems for power utility automation*, can be found on the IEC website. This IEC standard includes Code Components i.e. components that are intended to be directly processed by a computer.

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Table 1 shows all tracking information of (Tr)IEC 61850-90-9:2018A namespace building-up

**Table 1 – Tracking information of (Tr)IEC 61850-90-9:2018A namespace building-up**

| Attribute                                                               | Content                                                  |
|-------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Namespace IEC specific information</b>                               |                                                          |
| Version of the UML model used for generating the document (informative) | WG17build6                                               |
| Date of the UML model used for generating the document (informative)    | 2020-05-19                                               |
| Autogeneration software name and version(informative)                   | j61850DocBuilder 01v03 based on jCleanCim 02v02-NS beta6 |

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

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- amended.

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## INTRODUCTION

IEC 61850 consists of the following parts, under the general title *Communication networks and systems for power utility automation* (all parts may have not been published yet).

- Part 1: Introduction and overview
- Part 2: Glossary
- Part 3: General requirements
- Part 4: System and project management
- Part 5: Communication requirements for functions and device models
- Part 6: Configuration description language for communication in electrical substations related to IEDs
- Part 7-1: Basic communication structure – Principles and models
- Part 7-2: Basic communication structure – Abstract communication service interface (ACSI)
- Part 7-3: Basic communication structure – Common data classes
- Part 7-4: Basic communication structure – Compatible logical node classes and data classes
- Part 7-410: Hydroelectric power plants – Communication for monitoring and control
- Part 7-420: Basic communication structure – Distributed energy resources logical nodes
- Part 8-1: Specific communication service mapping (SCSM) – Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3
- Part 80-1: Guideline to exchange information from a CDC based data model using IEC 60870-5-101/104
- Part 9-2: Specific communication service mapping (SCSM) – Sampled values over ISO/IEC 8802-3
- Part 90-1: Use of IEC 61850 for the communication between substations
- Part 90-2: Using IEC 61850 for the communication between substations and control centres
- Part 90-3: Using IEC 61850 for condition monitoring
- Part 90-4: Network Engineering Guidelines – Technical report
- Part 90-5: Using IEC 61850 to transmit synchrophasor information according to IEEE C37.118
- Part 90-7: Object models for power converters in distributed energy resources (DER) systems
- Part 90-8: Object model for E-mobility
- Part 90-10: Object model for scheduling
- Part 10: Conformance testing

In addition to the above, the IEC 61850 basic communication structure for Wind Turbines has been published as IEC 61400-25, *Wind turbines – Communications for monitoring and control of wind power plants*.

This technical report is primarily based on the recommendation 5.7.4. “interface, control and standard data elements”, of the IEC white paper “Electrical Energy Storage” published in December 2011 by the MSB. The recommendation proposes the necessity of a standardization of interfaces between storage and other grid elements, protocols for data exchange and control rules, and data elements for input, output and control information supplied by or to storage systems. In Chapter 5 of the white paper “Large Capacity EESS”, EESS systems are expected to play an important role in integrating renewable energy by providing flexibility for the grid.

This document also describes the basic functions of Electric Energy Storage System (EESS) and the information model of the interface to integrate EESS in intelligent grids and establish the necessary communication with standardised data objects.

This document is connected with IEC 61850-7-420 Edition 2<sup>1</sup>, as well as IEC 61850-7-4:2010 and IEC 61850-7-4/AMD1:2015, explaining how the control system and other functions in a battery based electric energy storage unit utilizes logical nodes and information exchange services within the IEC 61850 framework to specify the information exchanged between functions as well as information that individual functions need and generate. IEC 61850-7-420:2009 provides an information model for batteries which was derived from the proposed data objects of part 7-4. Those data objects (as well as the models proposed within IEC TR 61850-90-3) follow the requirements of batteries that are supposed to be used in substations as an auxiliary power system and as backup power supplies. For this purpose, it was enough to only model the discharge function. Therefore, it is necessary to prepare new logical nodes to be applicable for grid connected electrical energy storage systems, i.e. the scope of this technical report.

This document provides necessary information within the IEC 61850 based object model in order to model functions of a battery based electrical energy storage system as a DER unit. For intelligently operated and/or automated grids, storing energy for optimising the grid operation is a core function. Therefore, shorter periods of storing energy with charging and discharging capability are also an indispensable function. Charging and discharging operations need to be modelled thoroughly and are in the focus of this technical report.

Once agreed, the content of this report is intended to be merged within a new edition of IEC 61850-7-420. In order to facilitate such merge, this document already mentions by anticipation some elements extracted from a forthcoming second edition of IEC 61850-7-420, and which appear to be key to guarantee the consistency between the future DER model proposed in the forthcoming second edition of IEC 61850-7-420 and the detailed electrical energy storage system model, presented in this document.

These elements are specifically tagged as “referring to the forthcoming second edition of IEC 61850-7-420” and should be updated as soon as this new edition is officially published.

This document has also been worked upon in order to be as close as possible to the forthcoming IEC 62933 series<sup>2</sup>.

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<sup>1</sup> Under preparation. Stage at the time of publication: IEC/PRVC 61850-7-420:2020.

<sup>2</sup> Under consideration.

## COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

### Part 90-9: Use of IEC 61850 for Electrical Energy Storage Systems

## 1 Scope

### 1.1 Scope of this document

This technical report, which is part of the IEC 61850 series, describes the IEC 61850 information model for electrical energy storage systems (EESS). Therefore, this document only focuses on storage functionality in the purpose of grid integration of such systems at the DER unit level. Higher level Interactions are already covered in IEC 61850-7-420.

### 1.2 Namespace

This new subclause is mandatory for any IEC 61850 namespace (as defined by IEC 61850-7-1/AMD1).

Table 2 shows all attributes of (Tr)IEC 61850-90-9:2018A namespace.

**Table 2 – Attributes of (Tr)IEC 61850-90-9:2018A namespace**

| Attribute                            | Content                                                                                                                                                                                                                                                                   |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Namespace nameplate</b>           |                                                                                                                                                                                                                                                                           |
| Namespace Identifier                 | (Tr)IEC 61850-90-9                                                                                                                                                                                                                                                        |
| Version                              | 2018                                                                                                                                                                                                                                                                      |
| Revision                             | A                                                                                                                                                                                                                                                                         |
| Release                              | 3                                                                                                                                                                                                                                                                         |
| Full Namespace Name                  | (Tr)IEC 61850-90-9:2018A                                                                                                                                                                                                                                                  |
| Namespace Type                       | transitional                                                                                                                                                                                                                                                              |
| <b>Namespace dependencies</b>        |                                                                                                                                                                                                                                                                           |
| Extends                              | IEC 61850-7-420:2019A version :2019 revision :A                                                                                                                                                                                                                           |
| <b>Namespace transitional status</b> |                                                                                                                                                                                                                                                                           |
| Future handling of namespace content | The name space (Tr)IEC 61850-90-9:2018A is considered as "transitional" since the models are expected to be included in further editions IEC 61850-7-4xx. Potential extensions/modifications may happen if/when the models are moved to the International Standard status |

### 1.3 Data model Namespace Code Component distribution

The Code Components are in light and full version:

- The full version is named: *IEC\_TR\_61850-90-9.NSD.2018A.Full*. It contains definition of the whole data model defined in this standard with the documentation associated and access is restricted to purchaser of this part.
- The light version is named: *IEC\_TR\_61850-90-9.NSD.2018A.Light*. It does not contain any documentations but contains the whole data model as per full version, and this light version is freely accessible on the IEC website for download at: <http://www.iec.ch/tc57/supportdocuments>, but the usage remains under the licensing conditions.



The Code Components for IEC 61850 data models are formatted in compliance with the NSD format defined by the standard IEC 61850-7-7. Each Code Component is a ZIP package containing:

- the electronic representation of the Code Component itself (possibly multiple files),
- the grammar files (XSD) enabling to check the consistency of the associated files against the defined version of NSD, but as well against the IEC 61850 flexibility rules in case of private extensions,
- a file describing the content of the package (IECManifest.xml).

The IECManifest contains different sections giving information on:

- The copyright notice
- The identification of the code component
- The publication related to the code component
- The list of the electronic files which compose the code component
- An optional list of history files to track changes during the evolution process of the code component.

The life cycle of a code component is not restricted to the life cycle of the related publication. The publication life cycle goes through two stages, Version (corresponding to an edition) and Revision (corresponding to an amendment). A third publication stage (Release) allows publication of Code Component in case of urgent fixes of InterOp Tissues, thus without need to publish an amendment.

Consequently new release(s) of the Code Component may be released, which supersede(s) the previous release, and will be distributed through the IEC TC57 web site at: <http://www.iec.ch/tc57/supportdocuments>.

The latest version/release of the document will be found by selecting the file named *IEC\_TR\_61850-90-9.NSD.{VersionStateInfo}.Light* with the filed VersionStateInfo of the highest value.

## 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 TS 61850-2, *Communication networks and systems for power utility automation - Part 2: Glossary*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation - Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)*  
IEC 61850-7-2:2010/AMD1:2020

IEC 61850-7-3:2010, *Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes*  
IEC 61850-7-3:2010/AMD1:2020

IEC 61850-7-4:2010, *Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes*

IEC 61850-7-4:2010/AMD1:2020

IEC 61850-7-420, *Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical nodes*<sup>3</sup>

IEC TS 62933-3-1, *Electrical energy storage (EES) systems - Part 3-1: Planning and performance assessment of electrical energy storage systems - General specification*

### 3 Terms, definitions and abbreviated terms

#### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 62933-3-1, IEC TS 61850-2, IEC 61850-7-2 and IEC 61850-7-420, as well as 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

##### **Actual Power Capability (includes Emergency mode)**

value of power at a given time considering as a result of temperature or other factors

##### 3.1.2

##### **Actual State of Charge of an EESS**

relation between the available energy from an EESS and the actual energy capacity, expressed as a percentage of the actual energy capacity

##### 3.1.3

##### **available energy**

maximum electrical energy that can be extracted from the EESS system from the current state of charge of the EESS system

Note 1 to entry: Joule (J) is the base unit, other units may be chosen for convenience as well (kWh, MWh).

Note 2 to entry: Depending on the technology used, the available energy can differ by ambient temperature, self-discharge, power conversion losses, c-rate (for batteries) and other factors.

[SOURCE: IEC 62933-1:2018]

##### 3.1.4

##### **controllable load**

load whose energy consumption may be increased or decreased through control actions by other entities

Note 1 to entry: “Controllable load” and “load” are considered equivalent in this document.

##### 3.1.5

##### **distributed energy resource**

##### **DER**

generation, storage, and controllable load connected at the low or medium voltage distribution level

Note 1 to entry: DER may include associated protection, control, and monitoring capabilities, and may consist of aggregated DER units.

<sup>3</sup> Under preparation. Stage at the time of publication: IEC/PRVC 61850-7-420:2020.

Note 2 to entry: DER may also interact with the distribution network by providing energy to the distribution network, by adapting their behaviour based on distribution network conditions, and/or by providing other transmission and distribution network-related services.

### **3.1.6**

#### **distributed energy resource (DER) unit**

##### **DER unit**

individual DER device inside a group of DER that collectively form a system

### **3.1.7**

#### **distributed energy resource (DER) system**

##### **DER system**

collection of DER Units

### **3.1.8**

#### **effective actual energy capacity**

EESS system energy capacity at a given time as a result of a degraded state of health and other factors

### **3.1.9**

#### **emergency energy capacity**

EESS system energy capacity at a given time which can be used under emergency condition with potential risk to the asset (health)

### **3.1.10**

#### **emergency power capability**

assigned value of the power in emergency conditions

### **3.1.11**

#### **rated energy capacity**

##### **nameplate energy capacity**

assigned value of the energy content of the EESS system in continuous operating conditions, starting from a full state of charge and discharging continuously at rated active power, measured at the primary POC

### **3.1.12**

#### **rated power capability**

##### **nameplate power capability**

assigned value of the power in operating conditions measured at the primary PCC

### **3.1.13**

#### **state of charge of an EESS**

relation between the available energy from an EESS and the actual energy capacity, typically expressed as a percentage

### **3.1.14**

#### **state of total usable charge of an EESS**

relation between the available energy from an EESS and the total usable energy capacity, expressed as a percentage of the total usable energy capacity

### **3.1.15**

#### **state of usable charge of an EESS**

(per user) relation between the available energy from an EESS and the usable energy capacity, expressed as a percentage of the usable energy capacity

### 3.1.16

#### **total usable energy capacity**

energy capacity that all users are permitted to have access to, computed (in the simplest case just summing up) usable energy capacity out of those of the corresponding group of EESS, based on the decisions of EESS manufacturers or EESS owner/operators

### 3.1.17

#### **usable energy capacity (split)**

energy that each user is permitted to have access to, which is based on the decisions of EESS manufacturers or EESS owner/operators

### 3.1.18

#### **usable power capability**

power capability which it is permitted to set, which is based on the decisions of EESS manufacturers or EESS owner/operators

### 3.1.19

#### **usable energy capacity (split)**

energy capacity that each user is permitted to have access to, which is based on the decisions of EESS manufacturers or EESS owner/operators

## 3.2 Abbreviated terms

Table 3 presents generic acronyms and abbreviated terms used throughout this document.

**Table 3 – Generic acronyms and abbreviated terms**

|        |                                       |
|--------|---------------------------------------|
| DER    | Distributed Energy Resource           |
| DER MS | DER Management System                 |
| DERCtl | DER Unit Controller                   |
| DSO    | Distribution System Operator          |
| ECP    | Electrical Connection Point           |
| EPS    | Electrical Power System               |
| EESS   | Electrical Energy Storage System      |
| FDEMS  | Facility DER Energy Management System |
| IED    | Intelligent Electronic Device         |
| PCC    | Point of Common Coupling              |
| SoC    | State of Charge                       |
| TSO    | Transmission System Operator          |
| VPP    | Virtual Power Plant                   |

## 3.3 Acronyms and abbreviated terms proposed specifically for the data model part of this document

Table 4 shows normative terms that are combined to create data object names.

**Table 4 – Normative abbreviations for data object names**

| Term | Description     |
|------|-----------------|
| Cea  | Cease           |
| Eff  | Effective       |
| Engz | Energize        |
| Mx   | Maximum         |
| Rnt  | Round trip      |
| Rtn  | Return          |
| Soh  | state of health |
| Trn  | Turn            |

### 3.4 Common abbreviated terms used for the data model part of this document

(Extract from IEC 61850-7-4:2010/AMD1:2020 and partly used in this document).

Table 5 shows normative terms that are combined to create data object names.

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Table 5 – Normative abbreviations for data object names

| Term  | Description                                              |
|-------|----------------------------------------------------------|
| A     | Current; phase A (L1)                                    |
| AC    | AC, alternating current                                  |
| AGC   | Automatic generation control                             |
| ASG   | Analogue setting CDC                                     |
| AWatt | Wattmetric component of current                          |
| Abr   | Abrasion                                                 |
| Abs   | Absolute                                                 |
| Absb  | Absorbing                                                |
| Acc   | Accuracy;<br>acceleration (deprecated: use AccI instead) |
| AccI  | Acceleration                                             |
| Accm  | Accumulated                                              |
| Ack   | Acknowledgement, acknowledge                             |
| Acs   | Access                                                   |
| Act   | Action, activity, active, activate                       |
| Actr  | Actuator                                                 |
| Acu   | Acoustic                                                 |
| Addr  | Address                                                  |
| Adj   | Adjustment                                               |
| Admin | Administrative                                           |
| Adp   | Adapter, adaptation                                      |
| Aff   | Affected                                                 |
| Age   | Ageing                                                   |
| Ahr   | Ampere hours                                             |
| Air   | Air                                                      |
| Alg   | Algorithm                                                |

| Term | Description                                |
|------|--------------------------------------------|
| Alm  | Alarm, alarm trigger status                |
| Als  | Alarm trigger status set                   |
| Alt  | Altitude                                   |
| Altn | Alternate                                  |
| Amnt | Amount                                     |
| Amp  | Ampere, current DC or non-phase-related AC |
| An   | Analogue                                   |
| Anc  | Ancillary                                  |
| Ane  | Anemometer                                 |
| Ang  | Angle                                      |
| Ap   | Access point                               |
| Apc  | Analogue point control                     |
| App  | Apparent                                   |
| Ar   | Amperes reactive (reactive current)        |
| Arc  | Arc                                        |
| Area | Area                                       |
| Arr  | Array                                      |
| Asyn | Asynchronous                               |
| At   | At                                         |
| Auth | Authorisation                              |
| Auto | Automatic                                  |
| Aux  | Auxiliary                                  |
| Av   | Average                                    |
| Avl  | Availability                               |
| Ax   | Axial                                      |
| Azi  | Azimuth                                    |
| B    | Bushing; phase B (L2)                      |

| Term  | Description                          |
|-------|--------------------------------------|
| C2H2  | Acetylene                            |
| C2H4  | Ethylene                             |
| C2H6  | Ethane                               |
| CB    | Circuit breaker                      |
| CE    | Cooling equipment (see also Cl)      |
| CG    | Core ground                          |
| CH4   | Methane                              |
| CHP   | Combined heat and power              |
| CO    | Carbon monoxide                      |
| CO2   | Carbon dioxide                       |
| Cab   | Cable                                |
| Cal   | Calorie, caloric                     |
| Cam   | Cam, e.g. rotating non-circular disk |
| Can   | Cancel                               |
| Cap   | Capability, capacity                 |
| Capac | Capacitance                          |
| Car   | Carrier                              |
| Cbr   | Calibration                          |
| Ccw   | Counter clockwise                    |
| Ccy   | Currency                             |
| Cds   | Condensation                         |
| Ceil  | Ceiling                              |
| Cel   | Cell                                 |
| Cf    | Crest factor                         |
| Cff   | Coefficient                          |
| Cfg   | Configuration                        |
| Cg    | Combusted Gas                        |

| Term | Description                      |
|------|----------------------------------|
| BG   | Before Gain                      |
| Bac  | Binary-controlled analogue value |
| Bar  | Barrier                          |
| Base | Base                             |
| Bat  | Battery                          |
| Bck  | Backup                           |
| Bec  | Beacon                           |
| Beh  | Behaviour                        |
| Ber  | Bit error rate                   |
| Bias | Bias                             |
| Bl   | Blade                            |
| Blb  | Bulb                             |
| Blk  | Block, blocked                   |
| Blow | Blowby                           |
| Bnd  | Band, bandwidth                  |
| Boil | Boiler                           |
| Bot  | Bottom                           |
| Brcb | Buffered report control block    |
| Brg  | Bearing                          |
| Brk  | Brake                            |
| Bsc  | Binary status control            |
| Bst  | Boost                            |
| Bt   | Heartbeat                        |
| Bub  | Bubbling                         |
| Bus  | Bus                              |
| Byp  | Bypass                           |
| C    | Carbon; phase C (L3)             |

| Term  | Description                                    | Term    | Description                                         |
|-------|------------------------------------------------|---------|-----------------------------------------------------|
| Ch    | Channel                                        | ConfRev | Configuration revision (confRev from IEC 61850-7-2) |
| Cha   | Charger                                        | Conn    | Connected, connections                              |
| Chg   | Change                                         | Cons    | Constant (general)                                  |
| Chk   | Check                                          | Cor     | Correction                                          |
| Chr   | Characteristic                                 | Core    | Core                                                |
| Chs   | Chassis                                        | Cost    | Cost                                                |
| Circ  | Circulating, circuit                           | Crank   | Crank                                               |
| Cl    | Cooling, coolant, cooling system (see also CE) | Crd     | Coordination                                        |
| Clc   | Calculate, calculated                          | Crit    | Critical                                            |
| Clip  | Clip                                           | Crl     | Correlation                                         |
| Clk   | Clock                                          | Crp     | Creeping, slow movement                             |
| Cloud | Cloud                                          | Crv     | Curve                                               |
| Clr   | Clear                                          | Csmp    | Consumption, consumed                               |
| Cls   | Close, closed                                  | Ctl     | Control                                             |
| Cm    | Centimetres                                    | Ctr     | Center                                              |
| Cmbu  | Combustible, combustion                        | Cum     | Cumulative                                          |
| Cmd   | Command                                        | Cur     | Current                                             |
| Cmpl  | Completed, completion, complete                | Cut     | Cut, cut-out, cut-in                                |
| Cmut  | Commute, commutator                            | Cvr     | Cover, cover level                                  |
| Cndct | Conductivity, Conducting                       | Cw      | Clockwise                                           |
| Cnt   | Counter                                        | Cwb     | Crowbar                                             |
| Cntt  | Contractual                                    | Cyc     | Cycle                                               |
| Cnv   | Converter                                      | D       | Derivate                                            |
| Col   | Coil                                           | DC      | DC, direct current                                  |
| Comm  | Communication                                  | DER     | Distributed energy resource                         |
| Comp  | Compensation                                   | DExt    | De-excitation                                       |
| Conf  | Configuration                                  | DPCSO   | Double point controllable status output             |



| Term    | Description              |
|---------|--------------------------|
| Diag    | Diagnostics              |
| Dif     | Differential, difference |
| Dig     | Digital                  |
| Dip     | Dip                      |
| Dir     | Direction                |
| Dis     | Distance                 |
| Dist    | Distribution             |
| Dith    | Dither                   |
| DI      | Delay                    |
| Dit     | Delete                   |
| Dlv     | Delivery                 |
| Dmd     | Demand                   |
| Dn      | Down, downstream         |
| Dpc     | Double point control     |
| Dpt     | Departure                |
| Drag    | Drag hand                |
| Dropout | Dropout                  |
| Drp     | Droop                    |
| Drt     | Derate                   |
| Drtb    | Draft tube               |
| Drv     | Drive                    |
| Dsa     | Disable, disabled        |
| Dsc     | Discrepancy              |
| Dsch    | Discharge                |
| Dscon   | Disconnected             |
| Dsp     | Displacement             |
| Dtc     | Detection                |

| Term  | Description                                  |
|-------|----------------------------------------------|
| DQ0   | Direct, quadrature, and zero axis quantities |
| DS    | Device state                                 |
| DT    | Daylight saving time                         |
| Dam   | Dam                                          |
| Damp  | Damping                                      |
| Date  | Date, date and time of action                |
| Day   | Day                                          |
| Db    | Deadband                                     |
| Dcl   | DC-link                                      |
| Dct   | Direct                                       |
| De    | De (prefix)                                  |
| Dea   | Dead                                         |
| Dec   | Decrease                                     |
| Deg   | Degrees                                      |
| Dehum | De-humidifier                                |
| Del   | Delta                                        |
| Den   | Density                                      |
| Dep   | Dependent                                    |
| Desc  | Description                                  |
| Det   | Detected                                     |
| Detun | Detuning                                     |
| Dev   | Device                                       |
| Dew   | Dew                                          |
| Dff   | Diffuse                                      |
| Dfl   | Deflector (used in Pelton turbines)          |
| Dft   | Default                                      |
| Dia   | Diaphragm                                    |

| Term | Description                         |
|------|-------------------------------------|
| Eng  | Engine                              |
| Ent  | Entity, entities                    |
| Entr | Entry, entries                      |
| Env  | Environment                         |
| Eq   | Equalization, equal, equivalent     |
| Err  | Error                               |
| Est  | Estimated                           |
| Ev   | Evaluation                          |
| Evn  | Even                                |
| Evt  | Event                               |
| Ex   | External                            |
| ExIm | Export/import                       |
| Excd | Exceeded                            |
| Excl | Exclusion                           |
| Exp  | Expired                             |
| Exps | Expansion                           |
| Expt | Export                              |
| Ext  | Excitation                          |
| F    | Float                               |
| FA   | Fault arc                           |
| FPM  | Fuel processing module              |
| Fa   | "Fire all" sequence (to thyristors) |
| Fact | Factor                              |
| Fail | Failure                             |
| Fan  | Fan                                 |
| Fbc  | Field breaker configuration         |
| Fer  | Frame error rate                    |

| Term | Description                             |
|------|-----------------------------------------|
| Dur  | Duration                                |
| Dust | Dust                                    |
| Dv   | Deviation                               |
| Dw   | Delta Omega                             |
| Dyn  | Dynamic                                 |
| EE   | External equipment                      |
| EF   | Earth fault                             |
| EFN  | Earth-fault neutraliser (Petersen coil) |
| EMA  | E-mobility Account                      |
| ENG  | Enumerated status setting CDC           |
| ENS  | Enumerated status CDC                   |
| EPC  | Emergency Power Control                 |
| EV   | Electrical Vehicle                      |
| EVSE | EV Supply Equipment                     |
| Echo | Echo                                    |
| Ecp  | Electrical connection point             |
| Edit | Edit, edited                            |
| Efc  | Efficiency                              |
| EI   | Elevation                               |
| Ela  | Elasticity                              |
| Em   | Emission                                |
| Emg  | Emergency                               |
| En   | Energy                                  |
| Ena  | Enabled, enable, allow operation        |
| Enc  | Enumerated control                      |
| Encl | Enclosure                               |
| End  | End                                     |

| Term  | Description               |
|-------|---------------------------|
| Fil   | Filter, filtration system |
| Fire  | Fire                      |
| Fish  | Fish                      |
| Fix   | Fixed                     |
| Fld   | Field                     |
| Flk   | Flicker                   |
| Fll   | Fall                      |
| Flm   | Flame                     |
| Flood | Flood                     |
| Flish | Flash, flashing           |
| Flt   | Fault                     |
| Flush | Flush                     |
| Flw   | Flow, flowing             |
| Fol   | Follower, following       |
| Forc  | Forced                    |
| Fu    | Fuse                      |
| Fuel  | Fuel                      |
| Full  | Full                      |
| Fun   | Function                  |
| Fwd   | Forward                   |
| Gain  | Gain                      |
| Gas   | Gas                       |
| Gbx   | Gearbox                   |
| Gdv   | Guide vane                |
| Gen   | General                   |
| Glob  | Global                    |
| Gm    | Grand master              |

| Term    | Description                                    |
|---------|------------------------------------------------|
| Gn      | Generator                                      |
| Gnd     | Ground                                         |
| GoCBRef | GOOSE control block reference                  |
| Gocb    | GOOSE control block                            |
| Gr      | Group                                          |
| Gra     | Gradient                                       |
| Grd     | Guard                                          |
| Gri     | Grid                                           |
| Gross   | Gross                                          |
| Gs      | Grease                                         |
| Gte     | Gate                                           |
| Gust    | Gust                                           |
| H       | Harmonics (phase-related)                      |
| H2      | Hydrogen                                       |
| H2O     | Water (chemical aspect: liquid, steam, etc.)   |
| HP      | Hot point                                      |
| HPH     | Harmonics phase                                |
| Ha      | Harmonics (non-phase-related AC)               |
| Har     | Harmonic                                       |
| Hb      | Harmonic bin                                   |
| Hd      | Head                                           |
| Health  | Health                                         |
| Heat    | Heater, heating, heat (see also Ht)            |
| Hello   | Hello signal, Live signal, "I am alive" signal |
| Hi      | High, highest                                  |
| Hlf     | Half                                           |
| Hold    | Hold                                           |

| Term     | Description                                                                     |
|----------|---------------------------------------------------------------------------------|
| laong    | Information available operative non-generating                                  |
| laongel  | Information available operative non-generating out of electrical specification  |
| laongen  | Information available operative non-generating out of environment specification |
| laongrs  | Information available operative non-generating requested shutdown               |
| laongts  | Information available operative non-generating technical standby                |
| Ice      | Ice                                                                             |
| Id       | Identify Identifier                                                             |
| leee     | IEEE definition                                                                 |
| leeeKH   | Proportional gain HF (High Frequency). Defined in IEEE 421.5                    |
| leeeKH1  | Proportional gain HF positive. Defined in IEEE 421.5                            |
| leeeKH11 | Lead gain HF positive. Defined in IEEE 421.5                                    |
| leeeKH17 | Lead gain HF negative. Defined in IEEE 421.5                                    |
| leeeKH2  | Proportional gain HF negative. Defined in IEEE 421.5                            |
| leeeKI   | Proportional gain IF (Intermediate Frequency). Defined in IEEE 421.5            |
| leeeKI1  | Proportional gain IF positive. Defined in IEEE 421.5                            |
| leeeKI11 | Lead gain IF positive. Defined in IEEE 421.5                                    |
| leeeKI17 | Lead gain IF negative. Defined in IEEE 421.5                                    |
| leeeKI2  | Proportional gain IF negative. Defined in IEEE 421.5                            |
| leeeKL   | Proportional gain LF (Low Frequency). Defined in IEEE 421.5                     |
| leeeKL1  | Proportional gain LF positive. Defined in IEEE 421.5                            |
| leeeKL11 | Lead gain LF positive. Defined in IEEE 421.5                                    |
| leeeKL17 | Lead gain LF negative. Defined in IEEE 421.5                                    |
| leeeKL2  | Proportional gain LF negative. Defined in IEEE 421.5                            |
| leeeKs1  | Gain Ks1. Defined in IEEE 421.5                                                 |
| leeeKs2  | Gain Ks2. Defined in IEEE 421.5                                                 |
| leeeKs3  | Gain Ks3. Defined in IEEE 421.5                                                 |

| Term    | Description                                                         |
|---------|---------------------------------------------------------------------|
| Hor     | Horizontal                                                          |
| Horn    | Horn                                                                |
| Ht      | Heating, heating system (see also Heat)                             |
| Htex    | Heat-exchanger                                                      |
| Hub     | Hub                                                                 |
| Hum     | Humidity                                                            |
| Hy      | Hydraulic, hydraulic system                                         |
| Hyd     | Hydrological, hydro, water                                          |
| Hys     | Hysteresis                                                          |
| HZ      | Frequency                                                           |
| HZ1     | Frequency at side 1                                                 |
| HZ2     | Frequency at side 2                                                 |
| I       | Integral, integration                                               |
| ING     | Integer status setting CDC                                          |
| INS     | Integer status CDC                                                  |
| ISCSO   | Integer status controllable status output                           |
| la      | Information available                                               |
| lafm    | Information available force majeure                                 |
| lano    | Information available non-operative                                 |
| lanofo  | Information available non-operative forced outage                   |
| lanopca | Information available non-operative planned corrective action       |
| lanos   | Information available non-operative suspended                       |
| lanosm  | Information available non-operative scheduled maintenance           |
| lao     | Information available operative                                     |
| laog    | Information available operative generating                          |
| laogfp  | Information available operative generating with full performance    |
| laogpp  | Information available operative generating with partial performance |

| Term     | Description                                                                 |
|----------|-----------------------------------------------------------------------------|
| leeeT1   | Time constant T11 (Intermediate frequency positive). Defined in IEEE 421.5  |
| leeeT10  | Time constant T110 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeT11  | Time constant T111 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeT12  | Time constant T112 (Intermediate frequency negative). Defined in IEEE 421.5 |
| leeeT12  | Time constant T12 (Intermediate frequency positive). Defined in IEEE 421.5  |
| leeeT13  | Time constant T13 (Intermediate frequency positive). Defined in IEEE 421.5  |
| leeeT14  | Time constant T14 (Intermediate frequency positive). Defined in IEEE 421.5  |
| leeeT15  | Time constant T15 (Intermediate frequency positive). Defined in IEEE 421.5  |
| leeeT16  | Time constant T16 (Intermediate frequency positive). Defined in IEEE 421.5  |
| leeeT17  | Time constant T17 (Intermediate frequency negative). Defined in IEEE 421.5  |
| leeeT18  | Time constant T18 (Intermediate frequency negative). Defined in IEEE 421.5  |
| leeeT19  | Time constant T19 (Intermediate frequency negative). Defined in IEEE 421.5  |
| leeeTL1  | Time constant TL1 (Low frequency positive). Defined in IEEE 421.5           |
| leeeTL10 | Time constant TL10 (Low frequency negative). Defined in IEEE 421.5          |
| leeeTL11 | Time constant TL11 (Low frequency negative). Defined in IEEE 421.5          |
| leeeTL12 | Time constant TL12 (Low frequency negative). Defined in IEEE 421.5          |
| leeeTL2  | Time constant TL2 (Low frequency positive). Defined in IEEE 421.5           |
| leeeTL3  | Time constant TL3 (Low frequency positive). Defined in IEEE 421.5           |
| leeeTL4  | Time constant TL4 (Low frequency positive). Defined in IEEE 421.5           |

| Term     | Description                                                         |
|----------|---------------------------------------------------------------------|
| leeeM    | Ramtrack lowpass degree M. Defined in IEEE 421.5                    |
| leeeN    | Ramtrack overall degree N. Defined in IEEE 421.5                    |
| leeeT1   | Time constant T1. Defined in IEEE 421.5                             |
| leeeT10  | Time constant T10. Defined in IEEE 421.5                            |
| leeeT11  | Time constant T11. Defined in IEEE 421.5                            |
| leeeT2   | Time constant T2. Defined in IEEE 421.5                             |
| leeeT3   | Time constant T3. Defined in IEEE 421.5                             |
| leeeT4   | Time constant T4. Defined in IEEE 421.5                             |
| leeeT7   | Time constant T7. Defined in IEEE 421.5                             |
| leeeT8   | Time constant T8. Defined in IEEE 421.5                             |
| leeeT9   | Time constant T9. Defined in IEEE 421.5                             |
| leeeTH1  | Time constant TH1 (High frequency positive). Defined in IEEE 421.5  |
| leeeTH10 | Time constant TH10 (High frequency negative). Defined in IEEE 421.5 |
| leeeTH11 | Time constant TH11 (High frequency negative). Defined in IEEE 421.5 |
| leeeTH12 | Time constant TH12 (High frequency negative). Defined in IEEE 421.5 |
| leeeTH2  | Time constant TH2 (High frequency positive). Defined in IEEE 421.5  |
| leeeTH3  | Time constant TH3 (High frequency positive). Defined in IEEE 421.5  |
| leeeTH4  | Time constant TH4 (High frequency positive). Defined in IEEE 421.5  |
| leeeTH5  | Time constant TH5 (High frequency positive). Defined in IEEE 421.5  |
| leeeTH6  | Time constant TH6 (High frequency positive). Defined in IEEE 421.5  |
| leeeTH7  | Time constant TH7 (High frequency negative). Defined in IEEE 421.5  |
| leeeTH8  | Time constant TH8 (High frequency negative). Defined in IEEE 421.5  |
| leeeTH9  | Time constant TH9 (High frequency negative). Defined in IEEE 421.5  |

| Term  | Description                 |
|-------|-----------------------------|
| Inc   | Integer control             |
| Incl  | Inclination                 |
| Incr  | Increment, increase         |
| Ind   | Indication                  |
| Indp  | Independent                 |
| Iner  | Inertia                     |
| Inh   | Inhibit                     |
| Inl   | Inline                      |
| Inlet | Inlet                       |
| Inn   | Inner                       |
| Ins   | Insulation                  |
| Insol | Insolation                  |
| Inst  | Instantaneous               |
| Int   | Integer                     |
| Intm  | Intermediate                |
| Intn  | Internal                    |
| Intr  | Interrupt, interruption     |
| Intv  | Interval                    |
| Inv   | Inverter, inverted, inverse |
| Isc   | Integer status control      |
| Isld  | Islanded                    |
| Iso   | Isolation                   |
| Iu    | Information unavailable     |
| Ix    | Index                       |
| Jmp   | Jump                        |
| Jnt   | Joint                       |
| K     | Constant (regulation)       |

| Term        | Description                                                       |
|-------------|-------------------------------------------------------------------|
| leeeTL5     | Time constant TL5 (Low frequency positive). Defined in IEEE 421.5 |
| leeeTL6     | Time constant TL6 (Low frequency positive). Defined in IEEE 421.5 |
| leeeTL7     | Time constant TL7 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTL8     | Time constant TL8 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTL9     | Time constant TL9 (Low frequency negative). Defined in IEEE 421.5 |
| leeeTw1     | Time constant wash out Tw1. Defined in IEEE 421.5                 |
| leeeTw2     | Time constant wash out Tw2. Defined in IEEE 421.5                 |
| leeeTw3     | Time constant wash out Tw3. Defined in IEEE 421.5                 |
| leeeTw4     | Time constant wash out Tw4. Defined in IEEE 421.5                 |
| leeeVHMax   | Maximum limit set-point HF. Defined in IEEE 421.5                 |
| leeeVHMin   | Minimum limit set-point HF. Defined in IEEE 421.5                 |
| leeeVIMax   | Maximum limit set-point IF. Defined in IEEE 421.5                 |
| leeeVIMin   | Minimum limit set-point IF. Defined in IEEE 421.5                 |
| leeeVLMMax  | Maximum limit set-point LF. Defined in IEEE 421.5                 |
| leeeVLMMin  | Minimum limit set-point LF. Defined in IEEE 421.5                 |
| leeeVsi1Max | Input High Limit 1. Defined in IEEE 421.5                         |
| leeeVsi1Min | Input Low Limit 1. Defined in IEEE 421.5                          |
| leeeVsi2Max | Input High Limit 2. Defined in IEEE 421.5                         |
| leeeVsi2Min | Input Low Limit 2. Defined in IEEE 421.5                          |
| leeeVstMax  | Output High Limit. Defined in IEEE 421.5                          |
| leeeVstMin  | Output Low Limit. Defined in IEEE 421.5                           |
| Imb         | Imbalance                                                         |
| Imp         | Impedance non-phase-related AC                                    |
| Impact      | Impact                                                            |
| Impt        | Import                                                            |
| In          | Input                                                             |
| Ina         | Inactivity                                                        |

| Term   | Description                                  |
|--------|----------------------------------------------|
| K0Fact | Zero-sequence (residual) compensation factor |
| KFact  | K factor (harmonics)                         |
| Kck    | Kicker                                       |
| Key    | Key, physical control device                 |
| L      | Lower (action)                               |
| LDC    | Line drop compensation                       |
| LDCR   | Line drop compensation resistance            |
| LDCX   | Line drop compensation reactance             |
| LDCZ   | Line drop compensation impedance             |
| LED    | Light-emitting diode                         |
| LTC    | Load tap changer                             |
| Last   | Last                                         |
| Ld     | Lead                                         |
| Ldp    | Link discovery protocol                      |
| Leap   | Leap (second)                                |
| Len    | Length                                       |
| Lev    | Level                                        |
| Lft    | Lifting, lift                                |
| Lg     | Lag                                          |
| Life   | Lifetime                                     |
| Lim    | Limit                                        |
| Lin    | Line                                         |
| Liv    | Live                                         |
| Lkd    | Locked                                       |
| Lkg    | Leakage                                      |
| LI     | Last long (interval)                         |
| Lo     | Low (state or value)                         |

| Term  | Description                       |
|-------|-----------------------------------|
| Loc   | Local                             |
| Locb  | Log control block                 |
| Lod   | Load, loading                     |
| Log   | Log                               |
| Lok   | (use Lkd instead) Locked          |
| Loop  | Loop                              |
| Loss  | Loss                              |
| Ls    | Last short (interval)             |
| Lst   | List                              |
| Lub   | Lubrication                       |
| Lum   | Luminosity                        |
| M     | Minutes                           |
| MV    | Measured value CDC                |
| Mac   | Media access control, MAC-address |
| Made  | Made                              |
| Mag   | Magnetic, magnitude               |
| Maint | Maintenance                       |
| Man   | Manual                            |
| Mat   | Material                          |
| Mau   | Medium access unit                |
| Max   | Maximum                           |
| Mbr   | Membrane                          |
| Md    | Motor drive                       |
| Mdul  | Module                            |
| Meas  | Measurement                       |
| Mech  | Mechanical                        |
| Media | Media                             |

| Term   | Description                                                    | Term    | Description                         |
|--------|----------------------------------------------------------------|---------|-------------------------------------|
| Mem    | Memory                                                         | No      | No, not                             |
| Min    | Minimum                                                        | Nom     | Nominal, normalising                |
| Mir    | Mirror                                                         | Num     | Number                              |
| Mlt    | Multiple                                                       | Nxt     | Next                                |
| Mns    | Mains                                                          | O2      | Oxygen                              |
| Mod    | Mode                                                           | O3      | Ozon, trioxigen                     |
| Mot    | Motor                                                          | Obl     | Obligation                          |
| Mrg    | Margin                                                         | Oc      | Open circuit                        |
| Mrk    | Market                                                         | Odd     | Odd                                 |
| Mst    | Moisture                                                       | Of      | Offline                             |
| Msv    | Main signaling voltage                                         | Off     | Off, device disengaged, not running |
| Msvcb  | Multicast sampled values control block                         | Ofs     | Offset                              |
| Mth    | Method                                                         | Oil     | Oil                                 |
| Mult   | Multiplier                                                     | On      | On, device applied, running         |
| Mvm    | Movement, moving                                               | Oo      | Out of                              |
| N2     | Nitrogen                                                       | Op      | Operate, operating, operation       |
| NOx    | Nitrogen oxide                                                 | Operate | Operate order to any device         |
| NQS    | Average partial discharge current                              | Opn     | Open, opened                        |
| Nam    | Name                                                           | Ord     | Order                               |
| Name   | Name (reserved for use in data objects EEName and LUName only) | Out     | Output                              |
| Ndl    | Needle (used in Pelton turbines)                               | Ov      | Over, override, overflow            |
| NdsCom | Needs commissioning                                            | Ovl     | Overload                            |
| Neut   | Neutral                                                        | Ox      | Oxidant                             |
| Ng     | Negative                                                       | P       | Proportional                        |
| Ngt    | Negotiation                                                    | PF      | Power factor                        |
| Nhd    | Net head                                                       | PH      | Acidity, value of pH                |
| Night  | Night                                                          | PNV     | Phase-to-neutral voltage            |



| Term   | Description                           |
|--------|---------------------------------------|
| Po     | Polar                                 |
| Pol    | Polarizing                            |
| Polytr | Polytropic                            |
| Port   | Port                                  |
| Pos    | Position                              |
| Pot    | Potentiometer                         |
| Prc    | Price, pricing                        |
| Pre    | Pre-                                  |
| Prec   | Precondition, initial status          |
| Pres   | Pressure                              |
| Prg    | Progress, in progress                 |
| Prim   | Primary                               |
| Prio   | priority                              |
| Prm    | Permissive                            |
| Pro    | Protection                            |
| Proc   | Process                               |
| Proxy  | Proxy                                 |
| Prs    | Presence                              |
| Prt    | Parts, part                           |
| Ps     | Positive                              |
| Psk    | Penstock                              |
| Pss    | PSS, power system stabiliser function |
| Pst    | Post, short-term flicker severity     |
| Pt     | Point                                 |
| Pth    | Pitch                                 |
| Pwr    | Power                                 |
| Qty    | Quantity                              |

| Term | Description                           |
|------|---------------------------------------|
| POW  | Point on wave switching               |
| PP   | Phase to phase                        |
| PPV  | Phase to phase voltage                |
| PT1  | Low-pass exponential time rate filter |
| Pa   | Partial                               |
| Pair | Pair, paired                          |
| Pap  | Paper                                 |
| Par  | Parallel                              |
| Pas  | Passive                               |
| Path | Path                                  |
| Pcb  | Power quality classifier bin          |
| Pct  | Percent, percentage                   |
| Pdm  | Power quality demodulation            |
| Pe   | Electric Power                        |
| Per  | Periodic, period                      |
| Ph   | Phase to reference                    |
| Phs  | Phase                                 |
| Phy  | Physical                              |
| Pi   | Instantaneous real power              |
| Pin  | Pin                                   |
| Pipe | Pipe                                  |
| Pk   | Peak                                  |
| Pl   | Plant                                 |
| Plg  | Plug                                  |
| Pls  | Pulse                                 |
| Plt  | Plate; long-term flicker severity     |
| Pmp  | Pump                                  |

| Term  | Description            |
|-------|------------------------|
| Reso  | Resonance              |
| Reuse | Reuse                  |
| Rev   | Revision               |
| Rf    | Refreshment            |
| Rin   | Reinsertion            |
| Ris   | Resistance             |
| RI    | Relation, relative     |
| Rm    | Mutual resistance      |
| Rmp   | Ramping, ramp          |
| Rms   | Root mean square       |
| Rn    | Rain                   |
| Rnbk  | Runback                |
| Rng   | Range                  |
| Rod   | Rod                    |
| Root  | Root                   |
| Rot   | Rotation, rotor        |
| Rpt   | Repeat, repetition     |
| Rs    | Reset, resettable      |
| Rsl   | Result                 |
| Rst   | Restraint, restriction |
| Rsv   | Reserve                |
| Rt    | Ride-through           |
| Rte   | Rate                   |
| Rtg   | Rating                 |
| Rub   | Run-up/back            |
| Run   | Run                    |
| Rv    | Reverse                |

| Term  | Description                               |
|-------|-------------------------------------------|
| Qu    | Queue                                     |
| Qud   | Quad                                      |
| R     | Raise, increase                           |
| Rad   | Radiation                                 |
| Ral   | Rail                                      |
| Ramp  | Ramp                                      |
| Rat   | Ratio                                     |
| Rb    | Runner blade                              |
| Rcd   | Record, recording                         |
| Rch   | Reach                                     |
| Rcl   | Reclaim                                   |
| Rct   | Reaction                                  |
| Rdy   | Ready                                     |
| Re    | Retry                                     |
| React | Reactance, reactive                       |
| Rec   | Reclose                                   |
| Rec1  | Reclose after single phase fault          |
| Rec13 | Reclose after evolving fault              |
| Rec3  | Reclose after three phase fault           |
| Recha | Recharge, recharging                      |
| Rect  | Rectifier                                 |
| Red   | Redundant; (deprecated meaning) reduction |
| Ref   | Reference                                 |
| Reg   | Regulation                                |
| Rel   | Release                                   |
| Req   | Requested                                 |
| Res   | Residual                                  |

| Term  | Description                                 |
|-------|---------------------------------------------|
| Rvc   | Rapid voltage change                        |
| Rvrt  | Revert                                      |
| Rwy   | Runaway, e.g. in runaway speed              |
| Rx    | Receive, received                           |
| S10   | Coefficient S1.0                            |
| S12   | Coefficient S1.2                            |
| SM    | Servo, servo-motor                          |
| SNL   | Speed-no-load, connected but not generating |
| SOx   | Sulphur oxide                               |
| SPCSO | Single point controllable status output     |
| SPG   | Single point setting CDC                    |
| SPS   | Single point status CDC                     |
| SPI   | Single pole/phase                           |
| ST    | Standard time                               |
| Saf   | Safety                                      |
| Sag   | Sag                                         |
| Sar   | Surge arrester                              |
| Sat   | Saturation                                  |
| Sc    | Short circuit                               |
| Scale | Scale                                       |
| Schd  | Schedule                                    |
| Scond | Secondary                                   |
| Sco   | Supply change over                          |
| Sec   | Security                                    |
| Sel   | Select                                      |
| Self  | Self                                        |
| Seq   | Sequence                                    |

| Term  | Description                 |
|-------|-----------------------------|
| Ser   | Series, serial              |
| Set   | Setting                     |
| Sgob  | Setting group control block |
| Sh    | Shunt                       |
| Shar  | Shared                      |
| Shift | Shaft                       |
| Shld  | Shielded                    |
| Sig   | Signal                      |
| Sign  | Sign                        |
| Sim   | Simulation, simulated       |
| Sld   | Solidity                    |
| Sint  | Salinity, saline content    |
| Slip  | Sleep; slip                 |
| Smok  | Smoke                       |
| Smp   | Sampling                    |
| Snd   | Sound pressure              |
| Snpt  | Snapshot                    |
| Snr   | Signal to noise ratio       |
| Shw   | Snow                        |
| Soc   | State of charge             |
| Sof   | Switch on to fault          |
| Spc   | Single point control        |
| Spcf  | Specific                    |
| Spd   | Speed                       |
| Spec  | Spectra                     |
| Spir  | Spiral                      |
| Spt   | Setpoint                    |

| Term    | Description                            | Term  | Description                                             |
|---------|----------------------------------------|-------|---------------------------------------------------------|
| Sq      | Square                                 | Svc   | Service                                                 |
| Src     | Source                                 | Sw    | Switch, switched                                        |
| Srfe    | Surface                                | Swg   | Swing                                                   |
| St      | Status, state                          | Swl   | Power quality event swell                               |
| Sta     | Station, function at plant level       | Syn   | Synchronisation, synchronous, synchronism, synchrocheck |
| Stab    | Stabilizer                             | Sys   | System                                                  |
| Stat    | Statistics                             | TP    | Three pole/phase                                        |
| Stc     | Stack                                  | Ta    | Armature time constant                                  |
| Std     | Standard                               | Tag   | Tag (maintenance work in progress)                      |
| Stdby   | Standby                                | Tap   | Tap                                                     |
| Step    | Step                                   | Task  | Task                                                    |
| Stk     | Stroke                                 | Td    | Transformer derating                                    |
| Stl     | Still, not moving                      | Td0'  |                                                         |
| Stnd    | Stand, standing                        | Td0'' |                                                         |
| Sto     | Storage, e.g. activity of storing data | Tdd   | Total demand distortion                                 |
| Stop    | Stop                                   | Tdf   | Transformer derating factor                             |
| Storm   | Storm                                  | Tdp   | Td'                                                     |
| Stow    | Stow                                   | Tds   | Td''                                                    |
| Str     | Start                                  | Tech  | Technology                                              |
| Strg    | String                                 | Term  | Termination                                             |
| Stt     | Stator                                 | Test  | Test                                                    |
| Stuck   | Stuck, cannot move                     | Tgt   | Target                                                  |
| Sub     | Sub                                    | Thd   | Total harmonic distortion                               |
| Sum     | Sum                                    | Thm   | Thermal                                                 |
| Sup     | Supply                                 | Ti    | Telephone influence                                     |
| Sv      | Sampled value                          | Tilt  | Tilt                                                    |
| SvCBRef | SV control block reference             | Tm    | Time                                                    |

| Term  | Description                          |
|-------|--------------------------------------|
| Trp   | Transient Performance Class          |
| Trs   | Transient                            |
| Trunk | Trunk                                |
| Ts    | Total signed                         |
| Tu    | Total unsigned                       |
| Tun   | Tuning                               |
| Tur   | Turbine                              |
| Tx    | Transmit, transmitted                |
| Type  | Type                                 |
| UPS   | Uninterruptible power supply         |
| UTC   | Coordinated Universal Time           |
| Uhf   | Ultra-high-frequency                 |
| Un    | Un-; under                           |
| Unav  | Unavailable                          |
| Unb   | Unbalanced                           |
| Unld  | Unload                               |
| Unt   | Unit, production unit                |
| Up    | Up, upstream                         |
| Ups   | Uninterruptible Power Supply         |
| Urcb  | Unbuffered report control block      |
| Use   | Use                                  |
| Used  | Used                                 |
| Usvcb | Unicast sampled values control block |
| Util  | Utility                              |
| V     | Voltage                              |
| V1    | Voltage at side 1                    |
| V2    | Voltage at side 2                    |

| Term | Description                           |
|------|---------------------------------------|
| Tm1  | Time constant 1                       |
| Tm2  | Time constant 2                       |
| Tm3  | Time constant 3                       |
| Tmh  | Time in h                             |
| Tmm  | Time in min                           |
| Tmms | Time in ms                            |
| Tmp  | Temperature (°C)                      |
| Tms  | Time in s                             |
| Tnk  | Tank                                  |
| Tns  | Tension (stress)                      |
| Top  | Top (position)                        |
| Topo | Topology                              |
| Torq | Torque                                |
| Tot  | Total                                 |
| Tow  | Tower                                 |
| Tp   | Test Point                            |
| Tpc  | Teleprotection                        |
| Tpy  | Temporarily                           |
| Tq0p | Tq0'                                  |
| Tq0s | Tq0"                                  |
| Tqp  | Tq'                                   |
| Tqs  | Tq"                                   |
| Tr   | Trip (electrical protection function) |
| Trf  | Transformer                           |
| Trg  | Trigger                               |
| Trip | Trip (non-electrical function)        |
| Trk  | Track, tracking                       |

| Term    | Description                            | Term | Description                                   |
|---------|----------------------------------------|------|-----------------------------------------------|
| VA      | Apparent power (volt amperes)          | Wei  | Weak end infeed                               |
| VAh     | Apparent energy                        | Wet  | Wet                                           |
| VAr     | Reactive power (volt amperes reactive) | Wgt  | Weight                                        |
| VArh    | Reactive energy                        | Wh   | Watt hours                                    |
| Va      | Variation                              | Wid  | Width                                         |
| Vac     | Vacuum                                 | Win  | Window                                        |
| Val     | Value                                  | Wkup | Wake up                                       |
| Vbr     | Vibration                              | Wld  | Welding                                       |
| Ver     | Vertical                               | Wnd  | Winding                                       |
| Viol    | Violation                              | Wrm  | Warm                                          |
| Vis     | Visibility                             | Wrn  | Warning, warning trigger status               |
| Visc    | Viscosity                              | Wrs  | Warning trigger status set                    |
| Vlan    | VLAN                                   | Wtr  | Water (physical aspect: river, cooling, etc.) |
| Vld     | Valid, validate, validated             | Wup  | Windup                                        |
| Vlm     | Volume                                 | X    | Reactance (imaginary part of impedance)       |
| Vlv     | Valve                                  | X0   | Zero sequence reactance                       |
| Vol     | Voltage DC or non-phase-related AC     | X1   | Positive sequence reactance                   |
| VolAmpr | Non-phase-related AC reactive power    | X2   | Negative sequence reactance X2                |
| Vss     | Steady state voltage                   | Xd   | Synchronous reactance Xd                      |
| W       | Active power                           | Xdir | X-direction                                   |
| W200    | Watts peak at 200 W/m2                 | Xdp  | Transient synchronous reactance Xd'           |
| Wac     | Watchdog                               | Xds  | Subtransient reactance Xd''                   |
| Wash    | Washout                                | Xm   | Mutual reactance                              |
| Watt    | Active power non-phase-related AC      | Xq   | Synchronous reactance Xq                      |
| Wav     | Wave, waveform                         | Xqp  | Transient synchronous reactance Xq'           |
| Wd      | Wind                                   | Xqs  | Subtransient reactance Xq''                   |
| Week    | Week                                   | Xsec | Cross-section                                 |

| Term | Description              |
|------|--------------------------|
| Ydir | Y-direction              |
| Yw   | Yaw                      |
| Z    | Impedance                |
| Zer  | Zero                     |
| Zero | (use 'Zer' instead) Zero |
| Zm   | Mutual impedance         |
| Zn   | Zone                     |
| Zro  | Zero sequence            |
| km   | Kilometre                |
| ppm  | Parts per million        |

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## 4 Overview of EESS

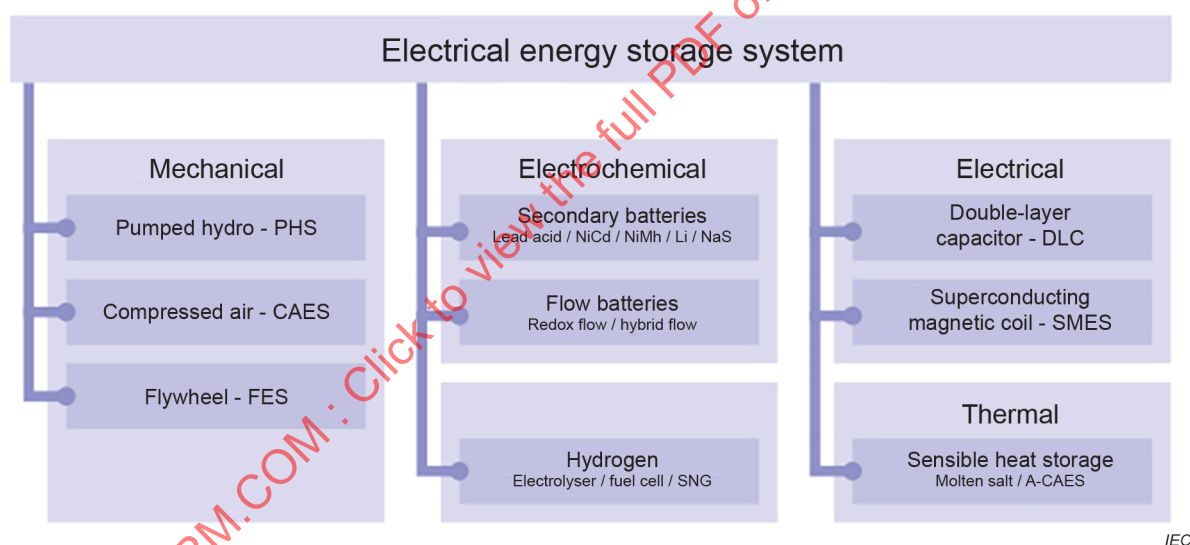
### 4.1 EESS system description

An electrical energy storage system (EESS) is a system which is used for the purpose of intermediate storage of electrical energy. The type of storage, the amount of energy, charging and discharging rates as well as self-discharge rate and many other characteristics are technology dependent and therefore can be very different. However, the general meaning of the characteristics and parameters are identical.

The objective of this document is to define a standardized and general approach to information modelling for operating an EESS regardless of any specific technique, which supports an efficient way of integrating an EESS into grid operation and other businesses.

Various types of EESS, such as battery, pumped hydro, superconducting magnetic energy storage, flywheels, etc., are defined in the "IEC White Paper on Electrical Energy Storage". According to the white paper, EESS systems are classified by energy form, advantages/disadvantages to the specific usages or the purpose of the implementation.

Figure 1 illustrates types of classification for storage systems according to their form of energy storage.

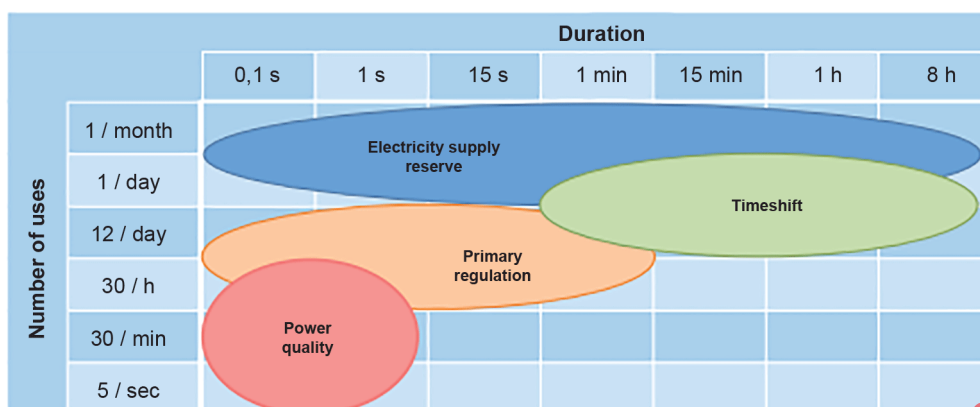


**Figure 1 – Classification of electrical energy storage systems according to energy form. IEC-WP [IEC White Paper Electrical Energy Storage:2011])**

As illustrated in Figure 2, typical purposes for operating EESS from a utility (T&D) point of view include providing electricity supply reserves, time shifting, primary regulation and power quality management. Due to the fluctuating power supply of PV and wind, EESS can also be used to smooth the total output of the PV/wind facility.

The practical application of EESS systems is constrained by the capability, characteristics, and various conditions of the installation.





NOTE From IEC White Paper [IEC White Paper Electrical Energy Storage:2011]

**Figure 2 – Different uses of electrical energy storage in grids, depending on the frequency and duration of use**

## 4.2 Functional requirements of EESS

The main functionality of EESS connected to the grid for operational purposes is storing electrical energy for use in a different timeframe. In particular, EESS is capable of both providing and/or absorbing electricity to and/or from the grid, according to the operational request from the grid operator or the aggregator or service provider. In the past, the electrical energy storage system was conventionally expected to be used mainly for backup purposes, to supply power during emergency situations to replace the regular source of power.

EESS acts as both generator and load. Charging operations of EESS are similar to controllable load absorbing electrical power from the grid, while discharging operations of EESS are similar to a generator providing power to the grid. Therefore, for generator and load operations, the information models can use the appropriate generation and load DXXX LNs in the second edition of IEC 61850-7-420. However, any storage-specific characteristics are represented by the new storage LN(s) for EESS systems. Such storage-specific characteristics include:

- Data objects which are agnostic with respect to the storage technology such as state of charge, maximum stored energy, charging-discharging round trip efficiency, self-discharge rate, and capacity degradation rate.
- Data objects which are specific to the type of storage concerned. In that case the report only considers battery type storage.

Typically, an EESS includes an electronic based power converter. In case of more detailed modelling of EESS power flow behavior, the converter information model in IEC 61850-7-420 can be used.

## 4.3 EESS participating in grid operations as a DER system

### 4.3.1 General

To realize the effective operation and monitoring of EESS from the utility grid point of view, the EESS should be operated according to its rated characteristics and present capabilities through the information exchanged with local (facility or plant) and/or remote power management systems. Utility system operators in DSO/TSO may directly or indirectly manage EESS.

The use case of EESS participating as DER to support grid operations describes an electrical energy storage system that is connected to a distribution network and is part of a virtual power plant (VPP). The VPP control system directly controls the EESS based on the capabilities declared by the EESS and the requirements from the grid.

#### 4.3.2 Constraints, assumptions, and design considerations

EESS have constraints on their capabilities which must be taken into account when it is supporting grid operations via a local or remote power management system. The information exchanges for identifying these constraints include:

- Nameplate characteristics as well as operational characteristics from the EESS.
- Actual and forecast capabilities and status values from the EESS.
- Setpoints and direct commands to the EESS from the power management system.
- As an option, control through modes or schedules may be implemented for managing the EESS operational functions (information models for these operational functions are defined for all types of DER in IEC 61850-7-420).

In modelling an EESS, the generic view of the system is considered. The focus is on the generic functionalities.

#### 4.4 Hierarchical class model of DER resources

As discussed in IEC 61850-7-420:2009 (first edition), the battery system logical device with ZBAT/ZBTC logical nodes were used to describe the characteristics of batteries. However, ZBAT/ZBTC LNs are intended to be used for batteries that provide auxiliary power, as a source of excitation current, as IED power supply, or as other auxiliary purposes, and are not adequate for EESS used for power utility grid operations. There is a need to fulfil the emerging requirements to make better use of EESS sophisticated capabilities, such as load shifting, frequency control, generation following, etc.

In addition, new DER generator /Controllable load /storage LNs have been developed in the upcoming second edition of IEC 61850-7-420 which represents generic functionalities to support all types of DER. Figure 3 shows a DER hierarchical Class model (inheriting from the IEC 61850-7-4:2010 and IEC 61850-7-4/AMD 1:2019 abstract classes) which could be used for different parts of DER management systems, including Storage management system for EESS systems.

Three types of storage elements shall be considered:

- Storage Unit elements (of a specific storage technology type) such as battery
- Composed Storage elements (composed of storage units and possibly including other composed storage elements)
- Generic storage elements, able to reflect the status, characteristic and properties of the “storage part” of a mixed DER, or of a specific storage unit

Since composed generator is de facto agnostic from any technology and thus generic, composed and generic storage elements are covered through the same model, DSTO. The only particularity of composed storage versus generic one is its ability to include references to the storage elements included in the composition. This explains why the presence condition of the DO hosting such references to included storage element (InclSto of ORG type) is Omulti (from 0 to many).

The purpose of this document is therefore to provide modelling details related to electrical energy storage systems and especially battery-based systems.

Goals of this modelling proposal are to:

- Maximize common DOs between the Generic/composed storage and the Storage Unit model (reflecting specific technologies)
- Maximize common DOs between the different types of storage elements

- Maximize the common DOs to reflect some very specific generator or load properties, status, characteristics of storage element and respectively generator or load equivalent properties.

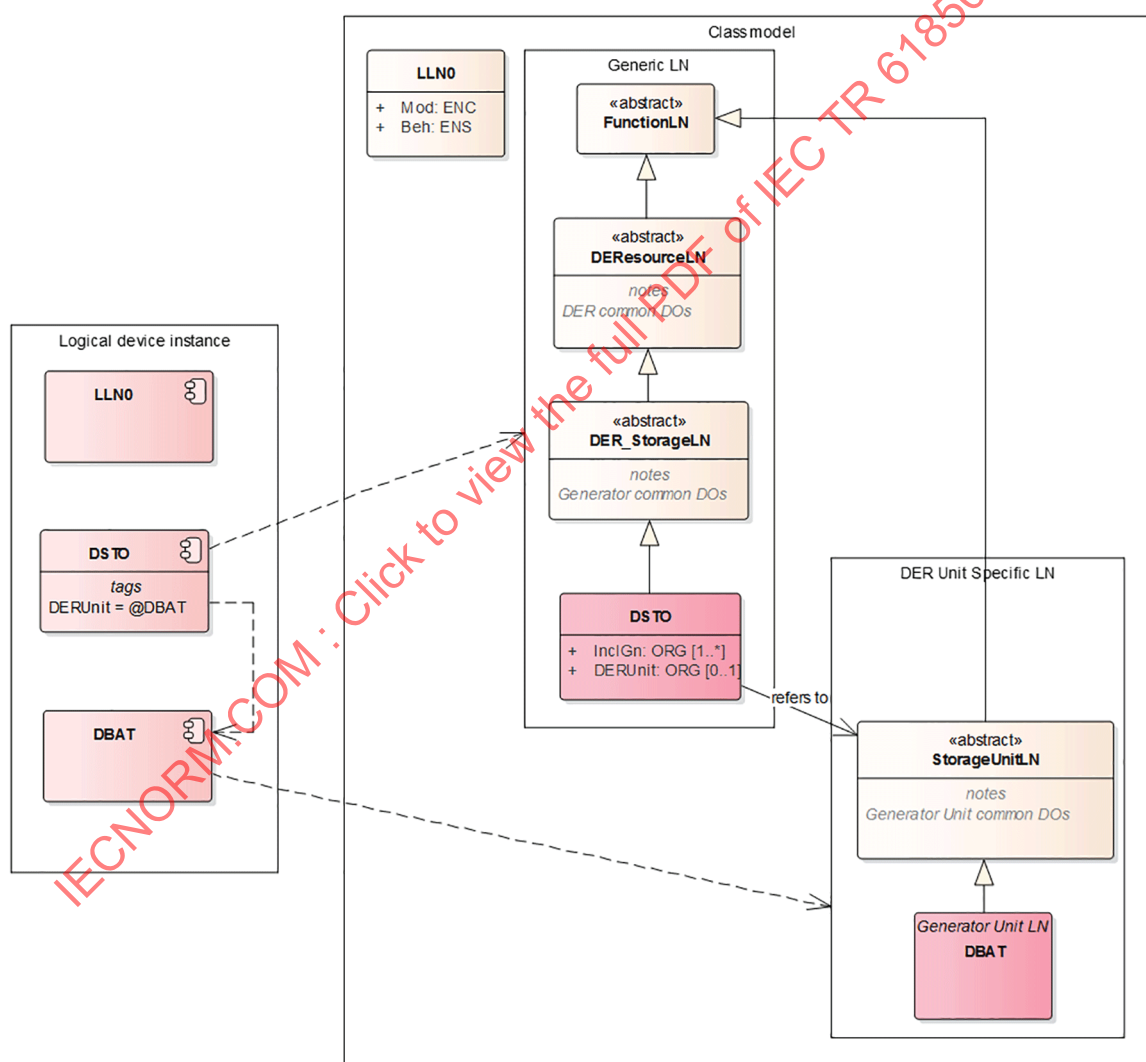
## 4.5 DER resource class and composition model for EESS

### 4.5.1 General

Subclause 4.5 relies on concepts which are developed in the upcoming second edition of IEC 61850-7-420.

### 4.5.2 DER class model principles for a single storage unit

The simplest DER resource model for EESS consists of a Storage DER unit (e.g. a battery storage system that includes the physical and electrical characteristics of the unit itself) plus charging/discharging/storage information (e.g. nameplate, operational data on what are its operational characteristics). See Figure 3.



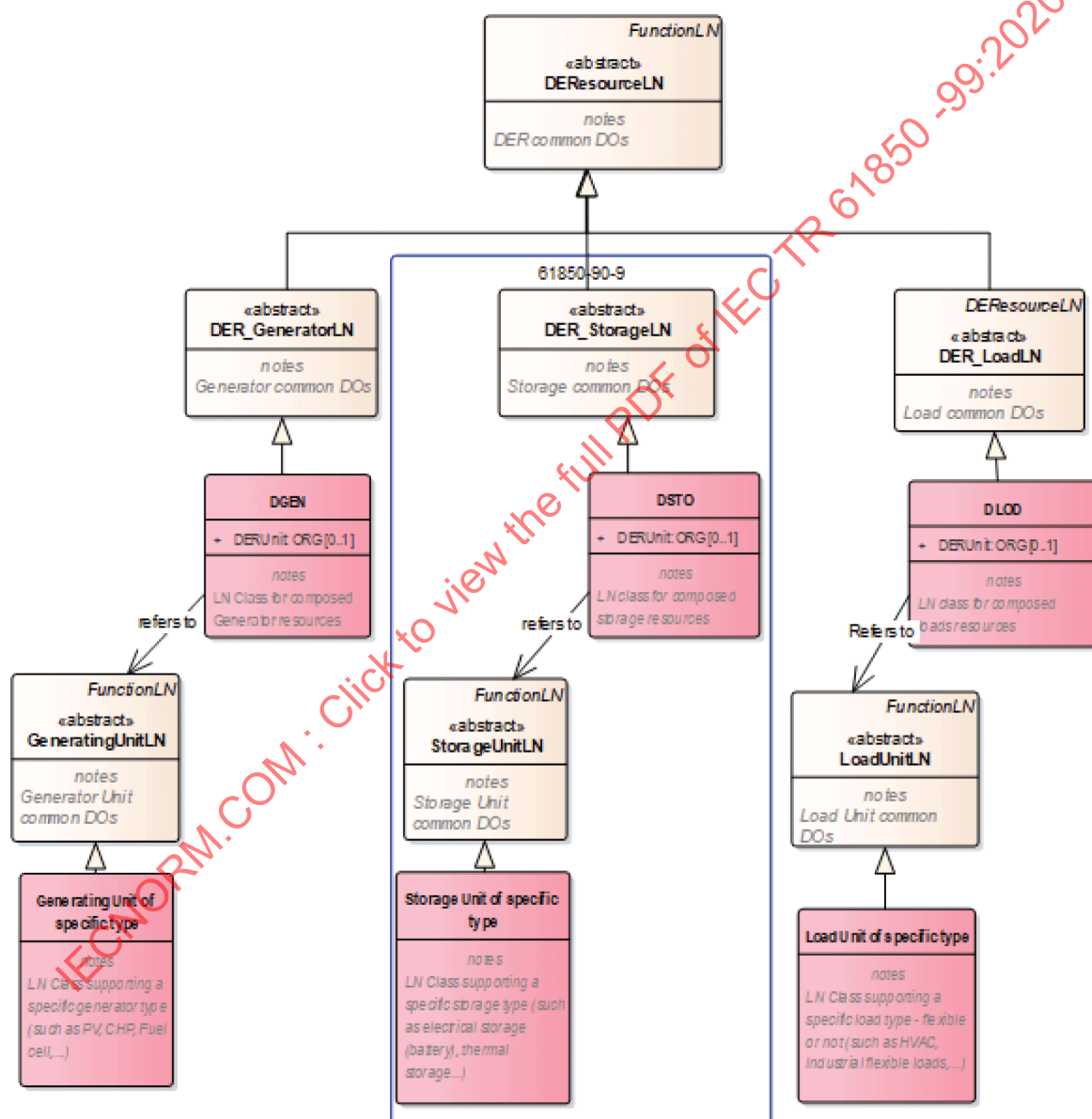
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**Figure 3 – Simple storage resource model of a battery storage unit (instance & class)**

More globally the model includes all possible types of DERs while reusing as much as possible all common elements and sticking to a "single inheritance" schema. Typically, the storage related model expresses that:

- A mixed DER (i.e. including DERs with a mix of generators and/or storage and/or loads) is a DER (i.e. child of DERResourceLN);
- A composed storage is a “generic” storage which is a DER;
- A storage unit of type battery, compressed air, capacitor, etc., is a storage unit, which is a “generic” storage which is a DER, however associated with a LN specific holding the specific features related to the specific storage technology. Both LNs should be hosted within the same logical device.

This DER class model of different composed DERs is illustrated in Figure 4 (Storage related model indicated at the center in the blue box).

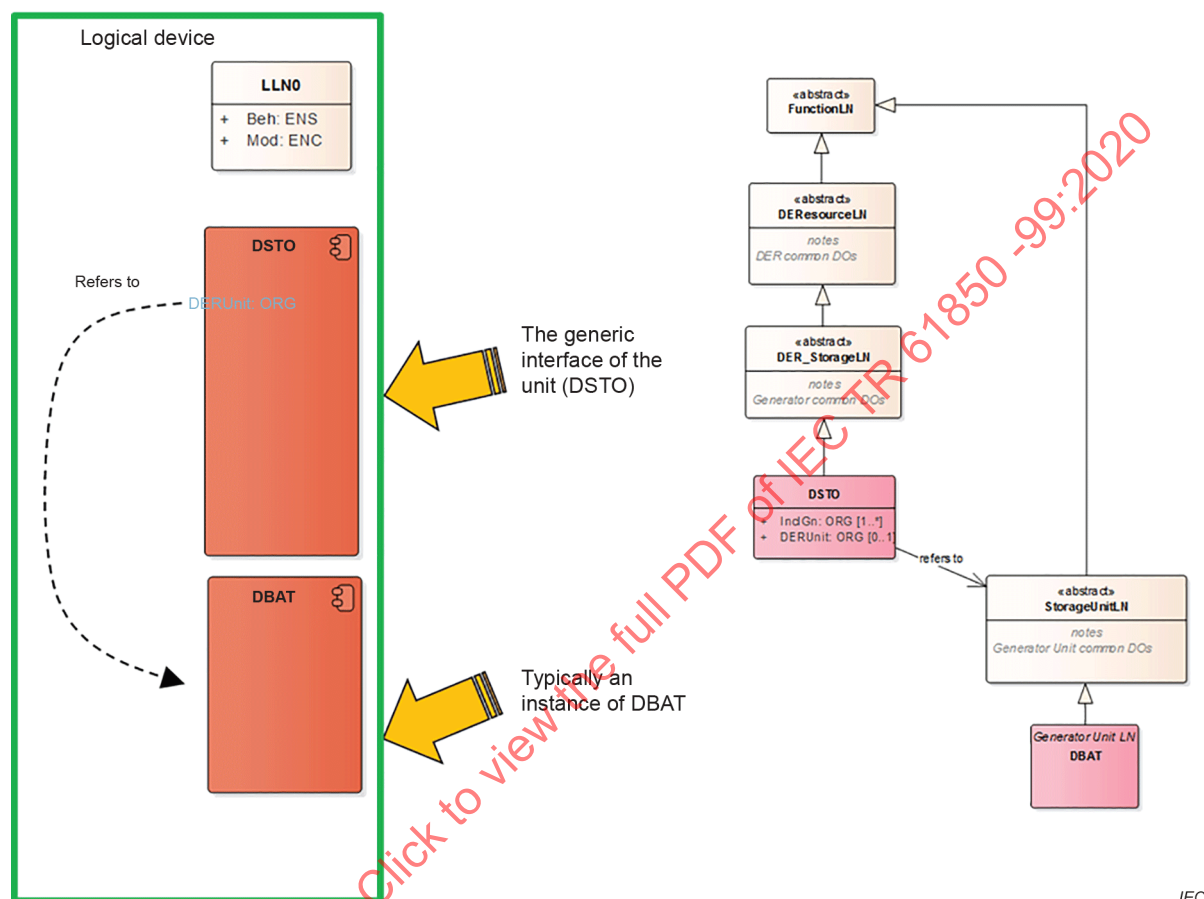


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Figure 4 – Hierarchical class model of DER resources – (blue outlined area showing EESS)

In the case of a specific DER physical unit, the main question to solve is how to offer a way to access the same information but through a generic name. This is obtained through the systematic usage to the generic capabilities, modelled through respectively DGEN, DSTO and DLOD<sup>4</sup> for generators, storage and loads, and to accompany the generic LN hosting these generic features with a specific LN holding the specific features of the DER technology.

This mechanism is shown in Figure 5, considering storage as one example.



**Figure 5 – Exposing the generic interface of a DER unit  
(Case of a storage unit as an example)**

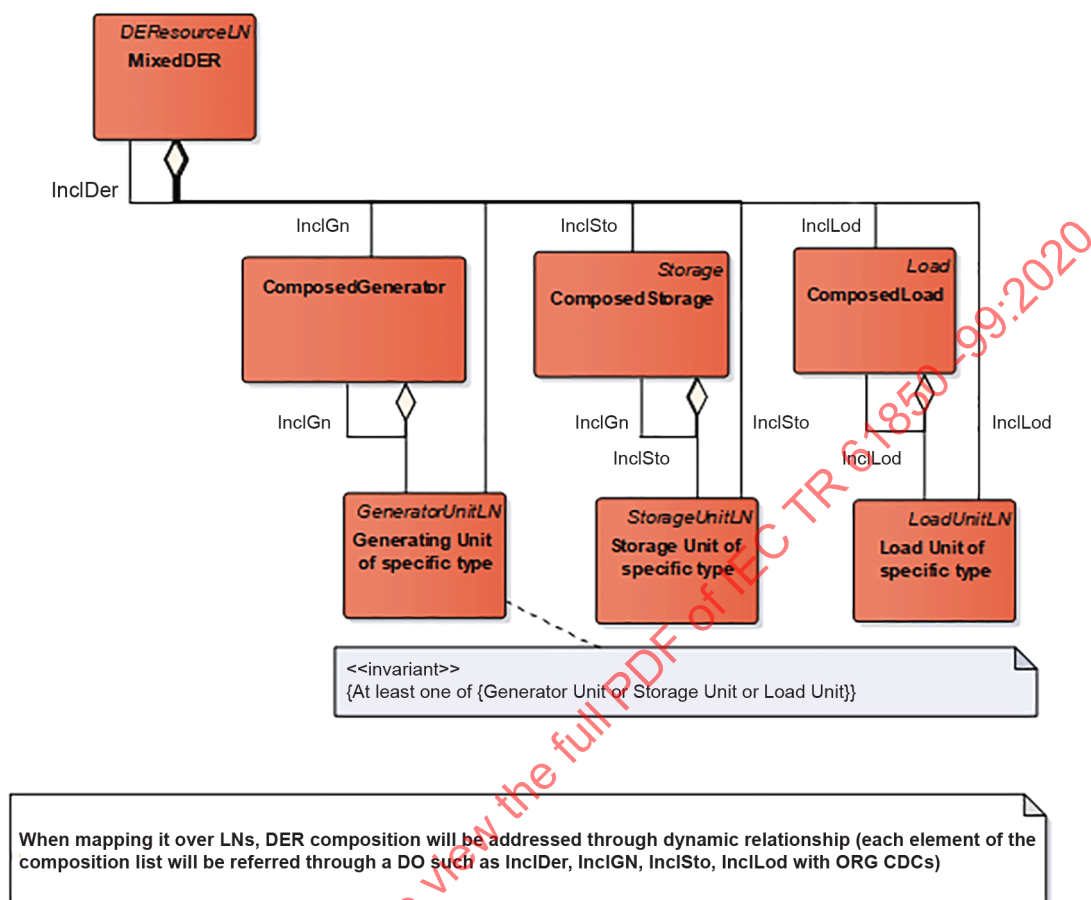
As indicated in Figure 5, the two instances of DSTO and DBAT are recommended to be hosted in the same logical device to ensure that both LNs will behave consistently (in regards typically of Mod/Beh and local/remote features) using the behavior of the logical device itself.

#### 4.5.3 Expressing the composition of storage elements

Since DERs are hierarchical, the resource models of DERs are also hierarchical. DER storage can consist of a single storage unit or can be composed of multiple storage units that are aggregated to be used as a single DER composed storage resource. Similarly, DER generator/load can consist of a single generator/load unit or can be composed of multiple generator/load units that are aggregated to be used as a single DER composed generator/load resource.

<sup>4</sup> These DGEN, DSTO and DLOD LNs are the ones which are also supporting the “composed” DER resources model.

Another way of showing the hierarchical nature of the model is to illustrate that individual DER units as well as previously composed DER can be aggregated into a composite (composed) DER (see Figure 6).

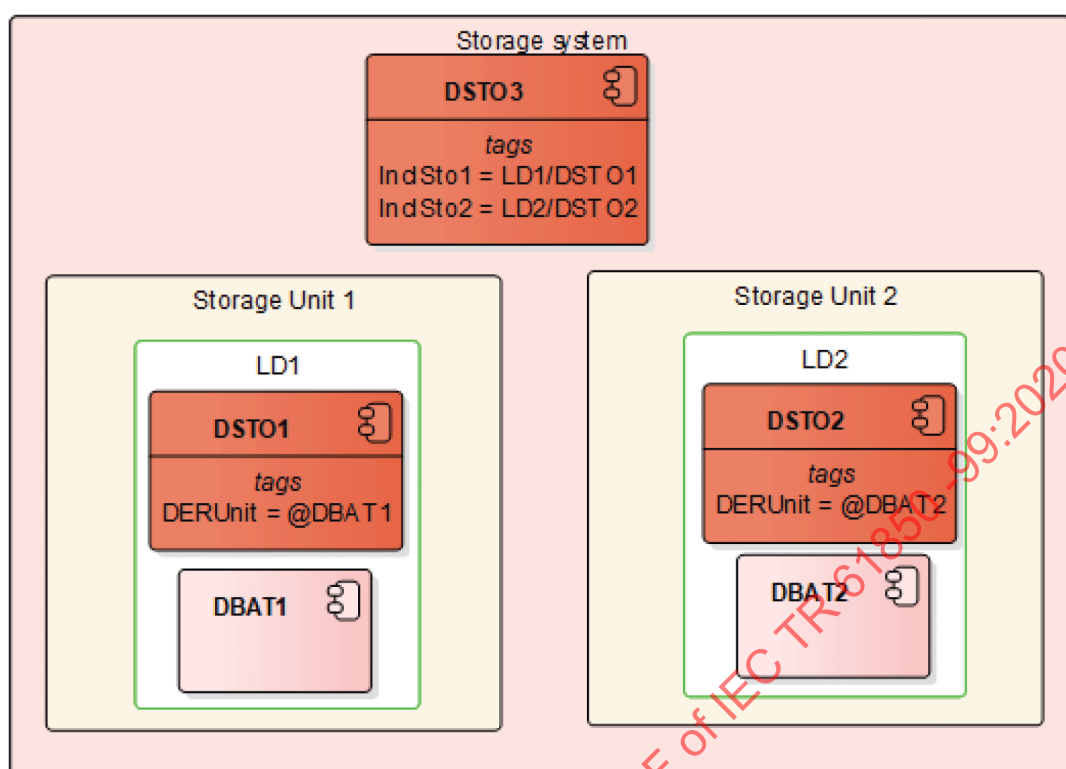


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**Figure 6 – DER composition model principles**

Due to the implementation choice which leads to use the same LN class to reflect composed DERs and generic ones (typically DGEN, DSTO, DLOD and DMDR for mixed DER), the requirement for expressing the generic capabilities of a composed resource is de facto fulfilled.

This would mean, for example, that a storage system composed of two storage units will be modelled as shown in Figure 7:



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**Figure 7 – LN mapping related to a storage system composed of two storage units**

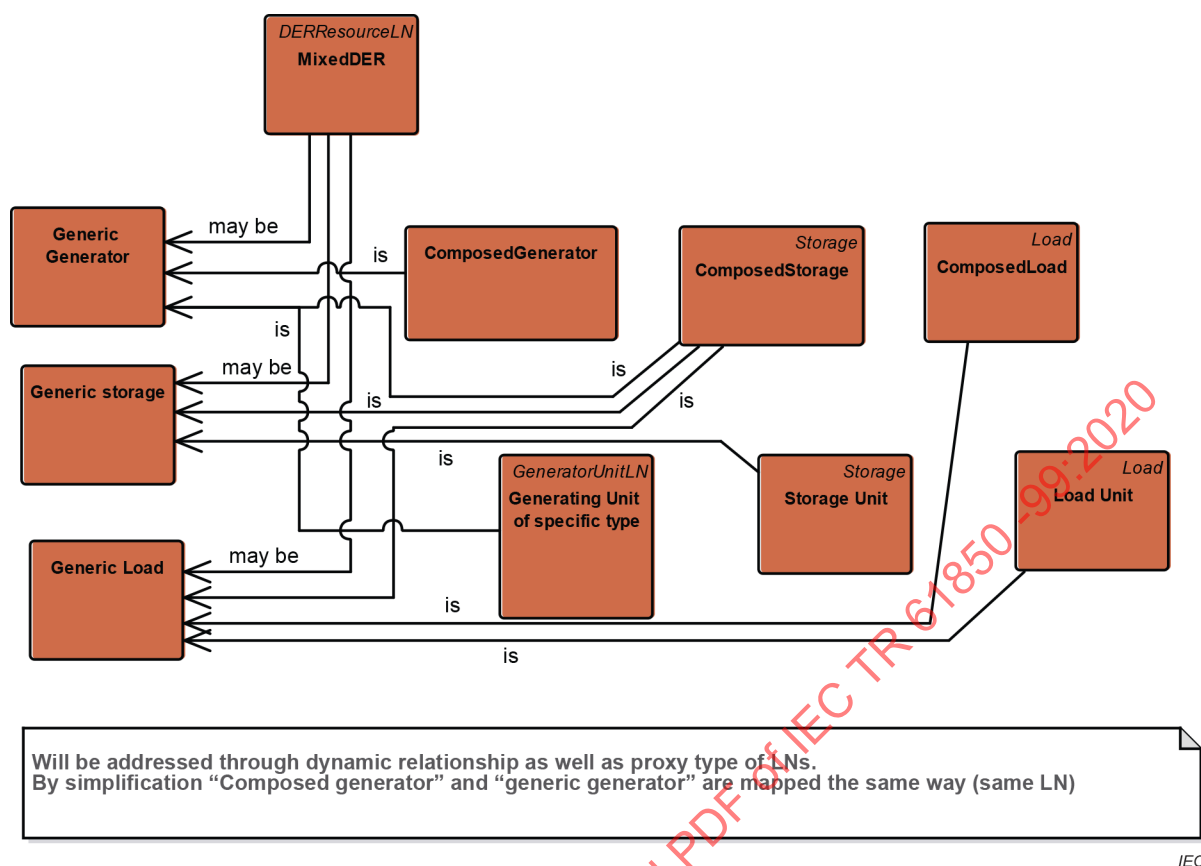
#### 4.5.4 Expressing equivalent capabilities

##### 4.5.4.1 General

This subclause deals with the important requirement that any DER has the possibility to expose in a generic way (i.e. independent from the DER technology or composition) its generator, load or storage capabilities.

This requirement is summed up in the diagram of Figure 8.





**Figure 8 – Needed association to express DER generic capabilities**

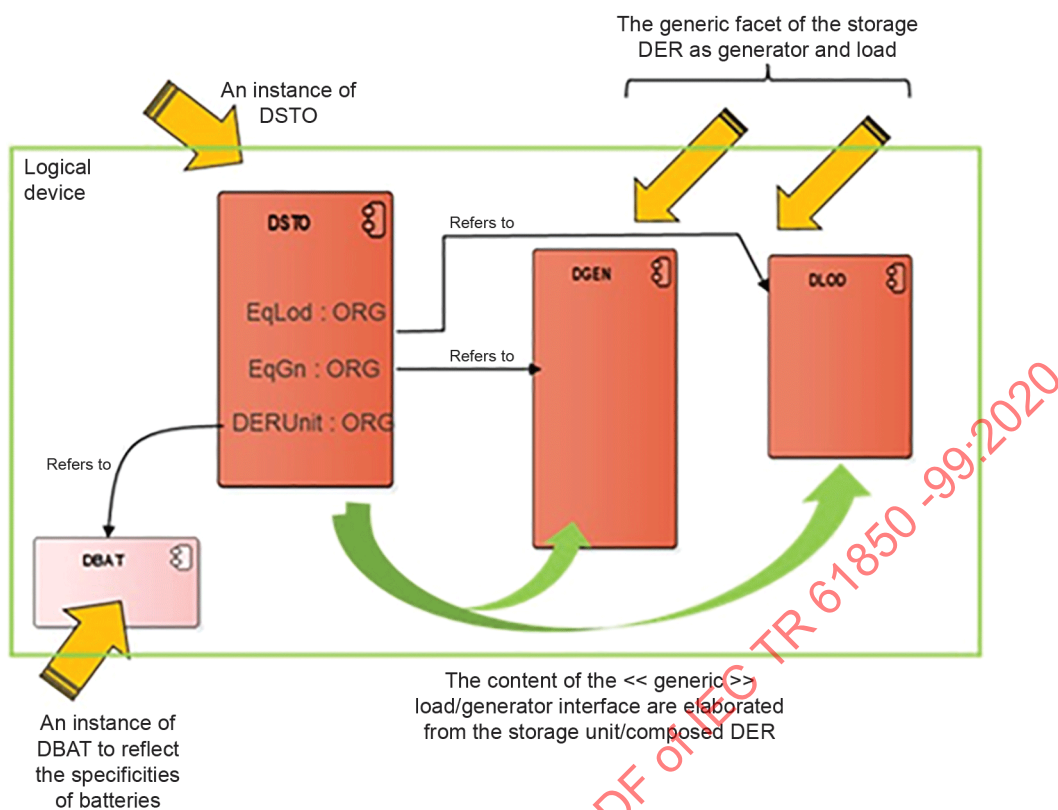
These associations are expressed through the systematic usage to the generic capabilities, modelled through respectively DGEN, DSTO and DLOD<sup>5</sup> for generators, storage and loads. As expressed in 4.5, DER units are accompanied with their specific LN holding the specific features of the DER technology.

#### 4.5.4.2 Expressing the generic generator and load capabilities of a storage resource

In the case of a storage resource, the information hosted by the generic generator and load interfaces needs to be computed, as shown in Figure 9. In case the DER storage element is a physical unit, the principles expressed in Figure 9 apply, i.e. by accompanying the generic feature by a specific LN hosting the specific features of the storage technology.

<sup>5</sup> These DGEN, DSTO and DLOD LNs are the ones which are also supporting the "composed" DER resources model.





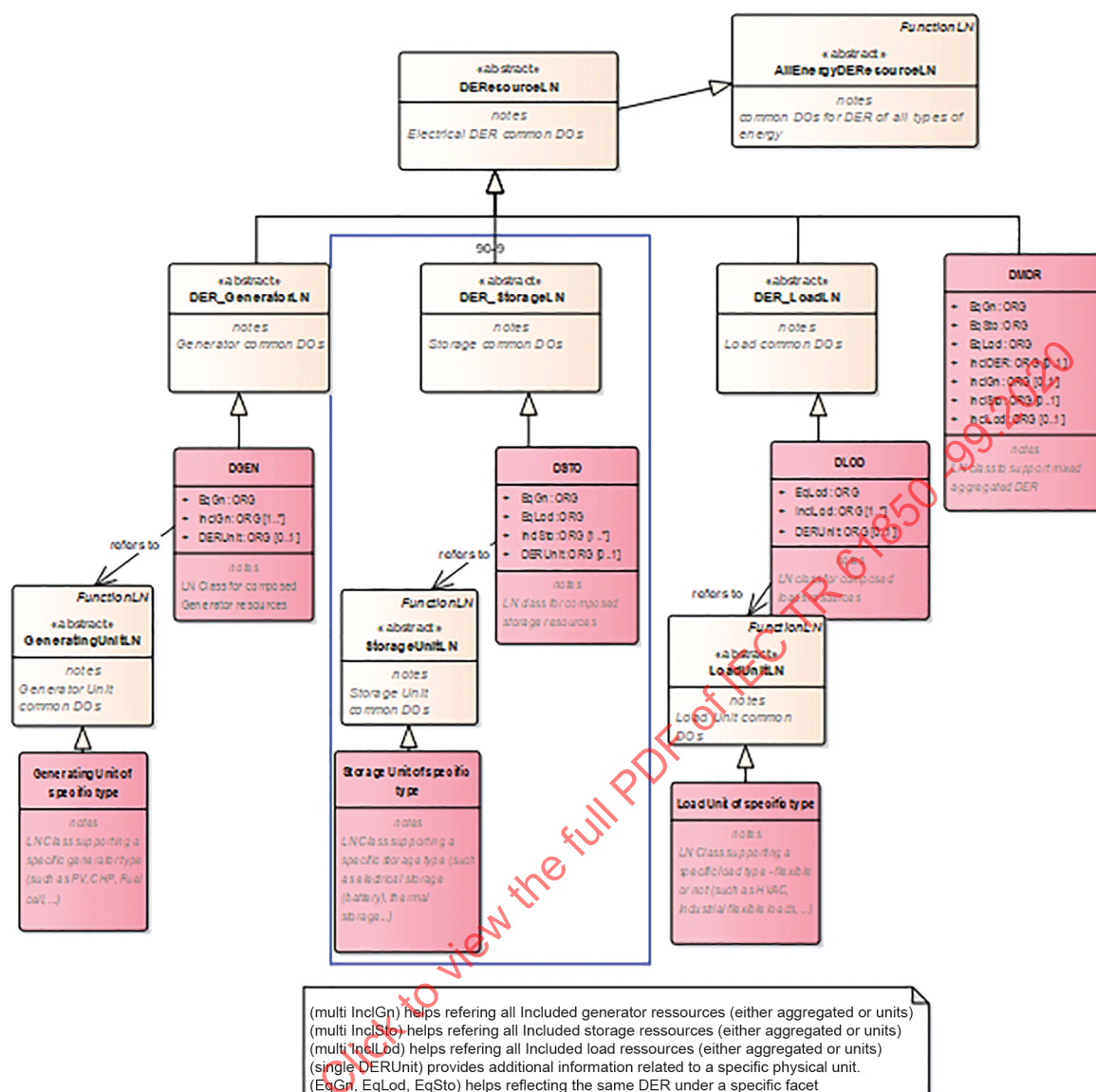
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**Figure 9 – Exposing the generic interfaces of a storage DER (battery storage as example)**

As exposed in Figure 9, the generic interface of the storage (DSTO), its generator facet or load facets, and with potentially the additional features related to a specific storage technology (DBAT in the example of Figure 9) should be hosted in the same logical device, to ensure that the same mode (expressed in LLN0 of the LD) apply de facto to all LNs implies in modelling the resource

#### 4.5.5 Complete DER model resulting from equivalent and composed principles

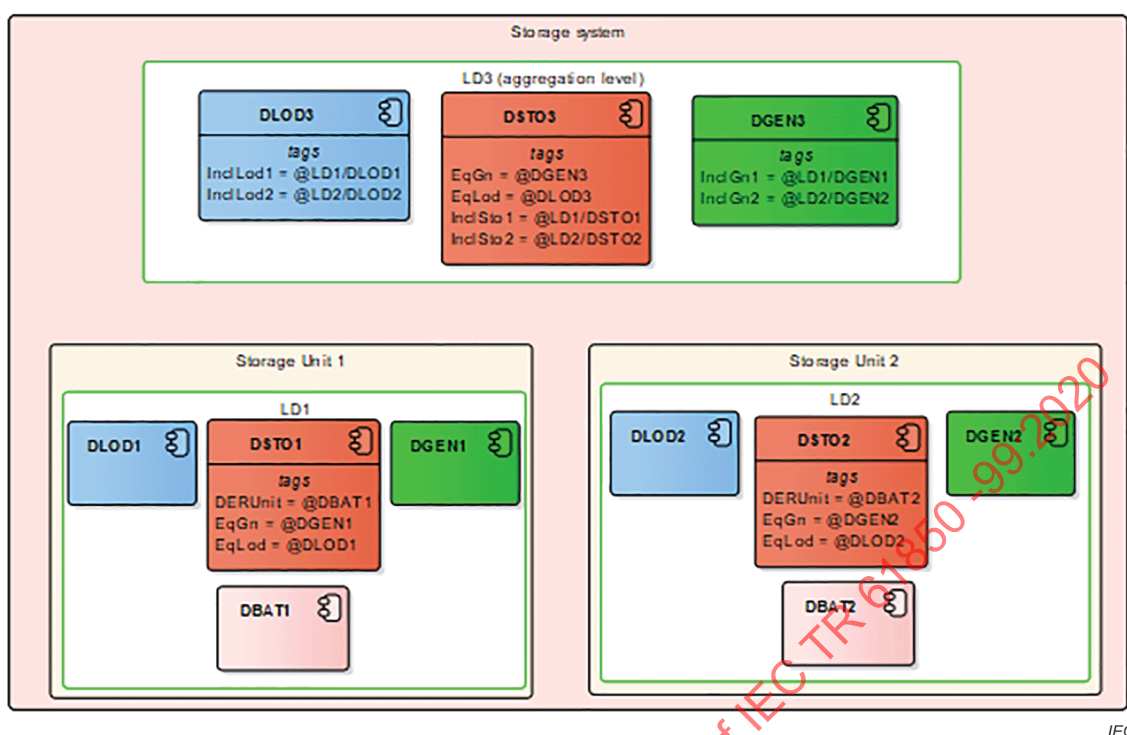
The principles presented in 4.5.3 and 4.5.4 are complementary and can co-habit. This leads to consider the full DER hierarchical class structure as presented in Figure 10.



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**Figure 10 – Principles of the hierarchical class model of DER resources with examples of specific DER types at the lowest level (blue outlined area showing EESS)**

Applying this approach to the simple example provided in 4.5.3, with an EESS system composed of two storage units, would lead to complement the LN mapping as depicted in Figure 11.



**Figure 11 – LN mapping of an EESS composed of 2 storage units with equivalent capabilities defined at all levels**

#### 4.5.6 LN mapping example in case of a complex storage installation

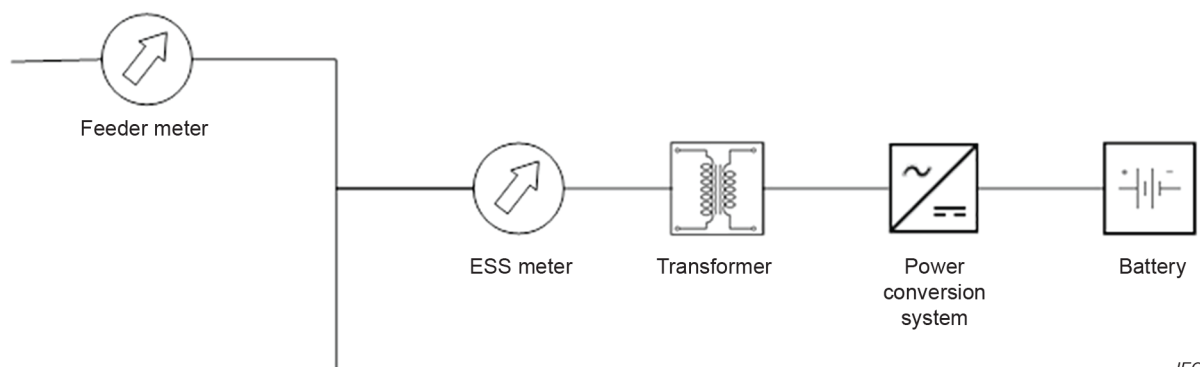
##### 4.5.6.1 LN mapping components

The energy storage battery system functional model describes the characteristics of rechargeable batteries used to store energy. These batteries could be used as part of an uninterruptible power supply (UPS) backup power, the source of excitation current to start a generator, or as a DER electrical energy storage system. The rechargeable batteries for energy storage are covered in this standard as DBAT. Flow batteries, compressed air, capacitors, pumped storage, and other storage systems have not yet been modelled.

The LNs could include:

- DSTO: electrical energy storage characteristics.
- DBAT: battery system characteristics. The battery system characteristics covered in the DBAT logical node reflect those required for remote monitoring and control of battery system functions and states. These may vary significantly based on the type of battery.
- SBAT: Sensor and other historical data related to batteries.

Energy storage systems come in many shapes and sizes. A simple EESS may consist of a single battery, a power conversion system, and one or two meters as shown in Figure 12.

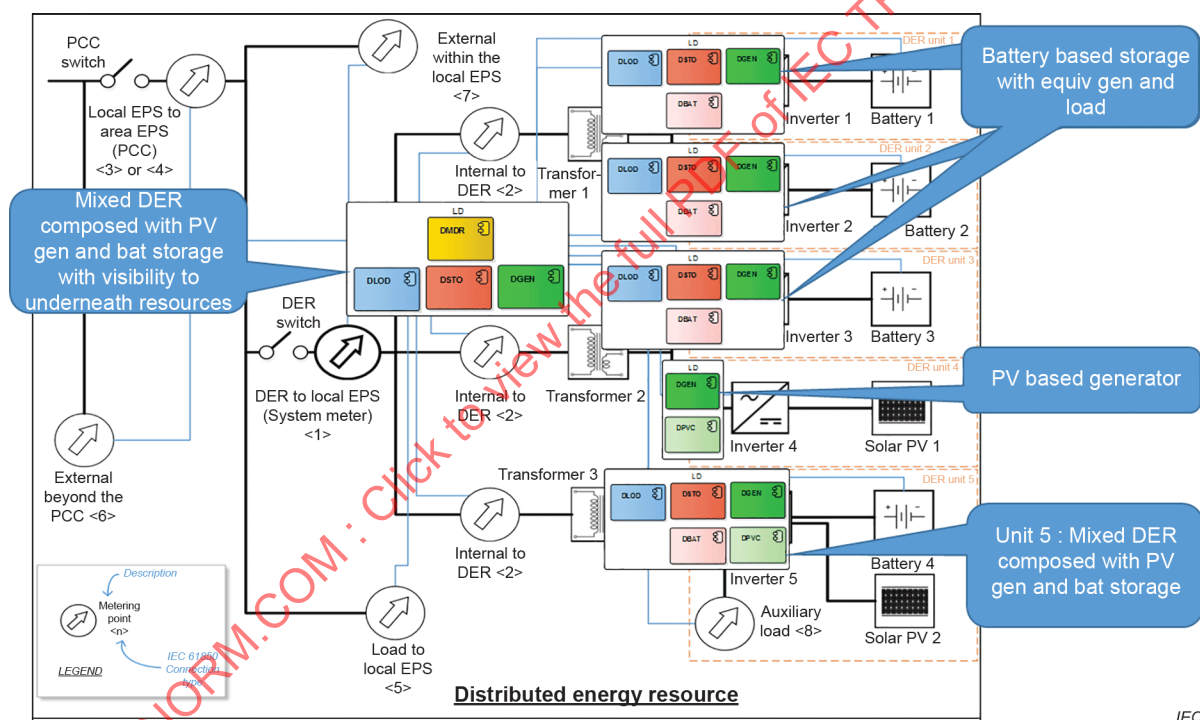


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**Figure 12 – A simple electrical energy storage system**

More complex energy systems might include multiple inverters and battery pairs, and they may utilize additional meters to ensure the proper monitoring and control of the ESS.

Figure 13 provides an example of a more complex electrical energy storage system.



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**Figure 13 – A more complex electrical mixed system, including storage – example of possible LN mapping**

Figure 13 presents a quite complex case of mix DER including PV and storage units, and a possible corresponding mapping with the LN set described below:

- At each storage unit level, each battery is associated to a DSTO LN instance and its two equivalent parts DGEN and DLOD to reflect the generator and load capabilities of this resource, and, in addition, some battery specific information are handled within a DBAT LN class instance.
- At the PV “only” unit level, the PV generator is associated to a DGEN LN instance and, in addition, some PV specific information are handled within a DPVC LN class instance.

- At the Unit5 level which is composed of mix of PV and battery, a DMDR LN instance describes the generic interface of this resource, by the set of the 3 equivalent capabilities (DGEN, DLOD, DSTO), and some additional information are respectively hosted in a DBAT LN class instance and a DPVC LN class instance for supporting battery and PV specific information. The details of included resources capabilities at that level (i.e. the Solar PV2 and the Battery 4 resources) is voluntary omitted (as an example).
- At the system level, a DMDR LN instance describes the generic interface of this resource, by the set of the 3 equivalent capabilities (DGEN, DLOD, DSTO). It is supposed that the same DMDR provides information of the included resources, i.e. has:
  - 3 instances of InclSto DO to point respectively to the battery unit 1 to 3 DSTO LN instances,
  - 1 instance of InclGn DO to point to the PV1 generator DGEN LN instance,
  - 1 instance of InclDER to point to the mix DER Unit 5 DMDR LN instance.

#### 4.5.6.2 Full DER LN class model

The full class model, shown in Figure 10, completes the first class model shown in Figure 4, by including:

- the composition model (i.e. each resource has a way to specify the list of included DERs, whatever its type: mixed, composed or unit)
- the “equivalency” model (i.e. each resource has the ability to appear/expose its interface as a generic generator, and/or a generic storage, and/or a load)

Such functional relationships could have been modelled using SCL, if they were static, i.e. not modifiable dynamically. However, there is a clear requirement in the DER world to make such modifications dynamically, on site, and this justifies the use of ORG-typed DOs to support these associations.

The same is true for the relationship between resources and the electrical reference point. Thus, the same modelling principles based on ORG-type DOs also apply to support these functional relationships.

Regarding this latest case, and as stated in 4.2, and as far as generation and load properties of the storage element are concerned, the principles exposed in Figure 9 apply:

The use cases depicting storing energy functions usage are described in Clause 5 while the related logical nodes required by EESS applications are described in Clause 6 of this document.

#### 4.6 State machine of the EESS

The behavior of EESS is based on a “generic” state machine for DER (extracted from the upcoming second edition of IEC 61850-7-420), as shown in Figure 14, completed by information presented in Figure 15.

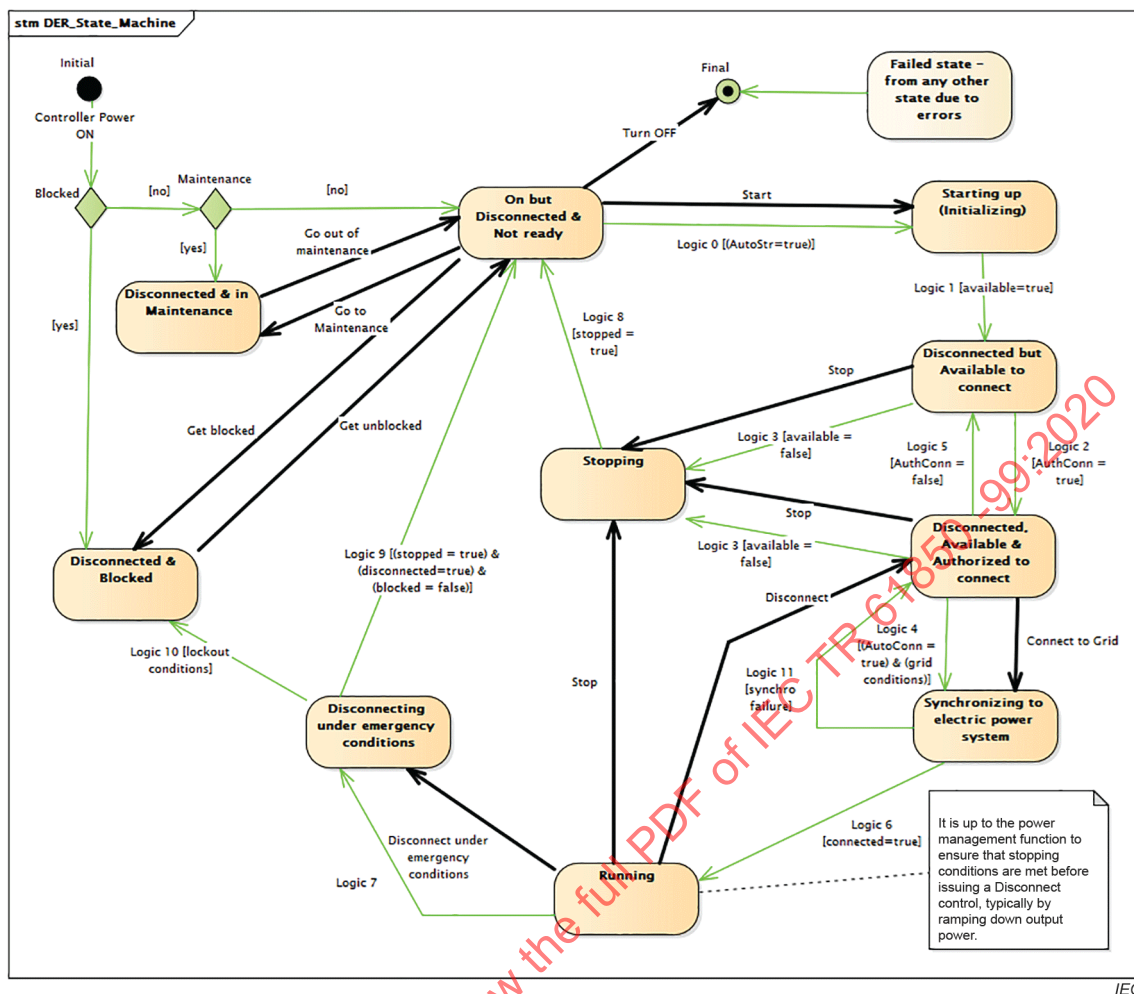
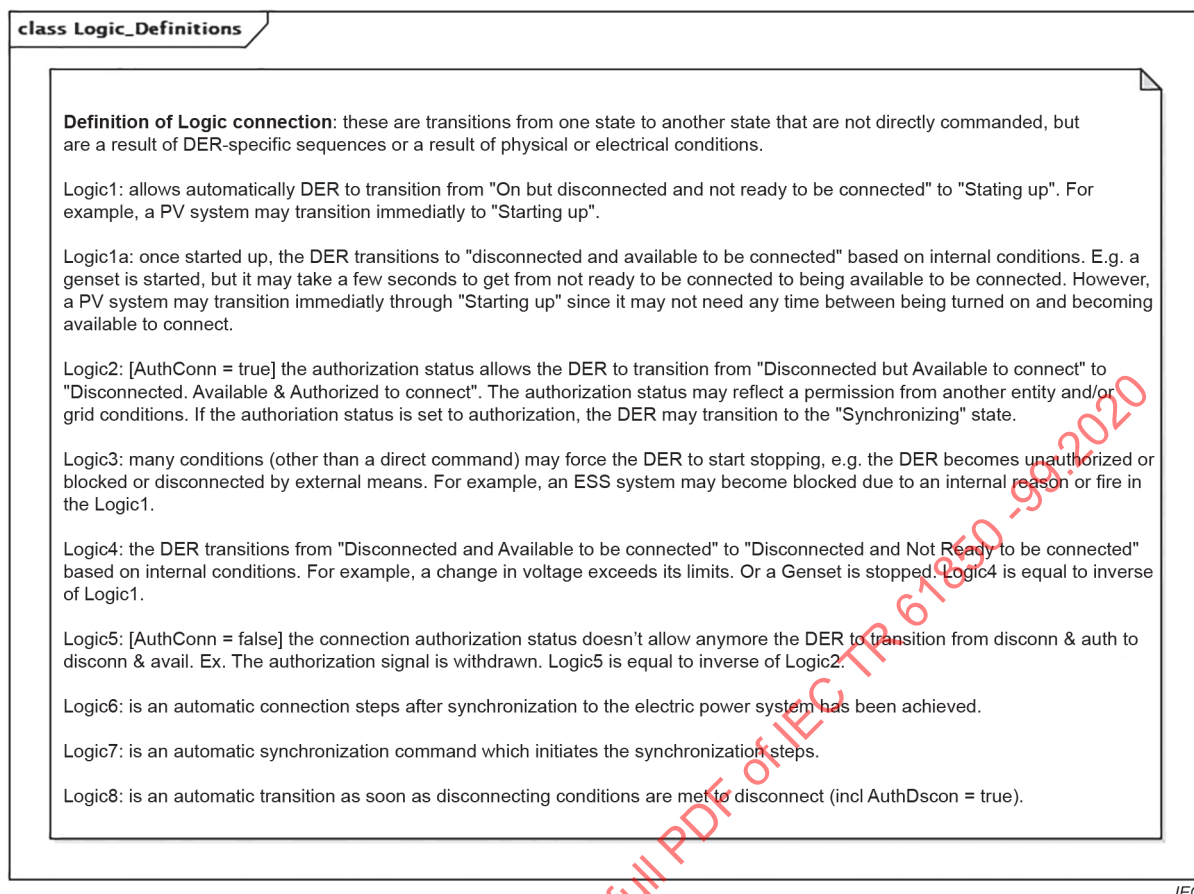


Figure 14 – DER common state diagram





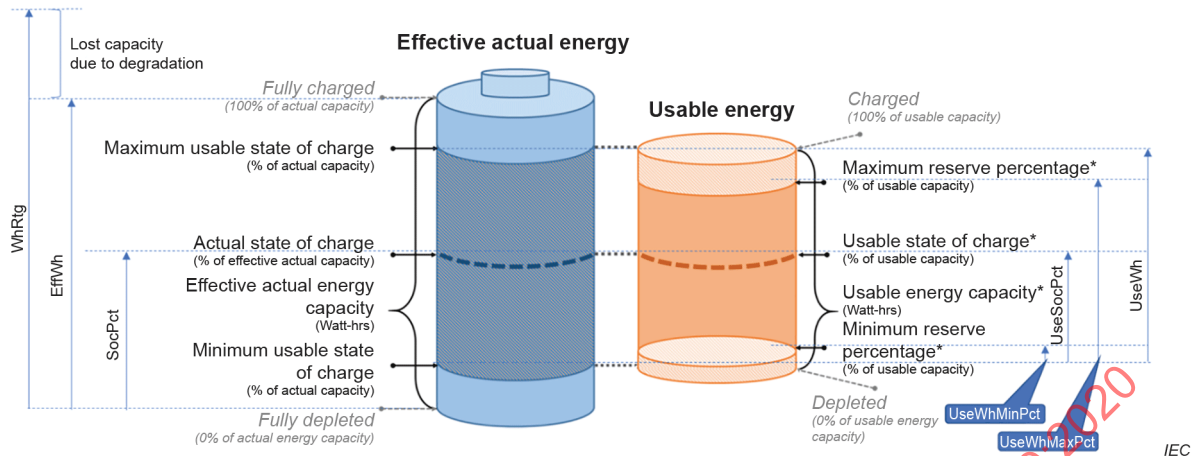
**Figure 15 – Logic definitions associated to the DER common state diagram**

#### 4.7 Definitions of the capacity and the state of charge of an EESS

The definition of the capacity of an EESS depends upon what is important to different types of users. For instance, the vendor of an EESS is concerned about the actual capacity of the EESS, while an operator is only interested in what capacity is available to be used. Therefore, as illustrated in Figure 16, two types of capacities are envisioned: the “effective” actual EESS capacity and the usable EESS capacity. The effective actual EESS capacity is the nameplate information potentially modified over time as the EESS characteristics degrade. The usable EESS capacity is what users are permitted to have access to, which is based on the decisions of EESS manufacturers or EESS owner/operators. Figure 16 also positions the main IEC 61850 EESS parameters related to effective and usable capacities and states of charge.

In addition to usable capacities, EESS owner/operators may choose to establish maximum and/or minimum reserve capacities (as a percentage of usable capacity) that would normally not be used, but could be used either for emergency situations or other special circumstances.

State of charge (SoC) would be based on these capacity definitions, in which the “actual state of charge” is the percentage of effective actual capacity, while the “usable state of charge” is the percentage of usable capacity. The SoC could be just stated by the EESS or could be calculated from the maximum and minimum usable capacity.



NOTE At current stage this document only considers a single user of the stored energy.

**Figure 16 – EESS state of charge: effective and usable capacities and states of charge reflected using the IEC 61850 model naming conventions<sup>6</sup>**

## 5 Use cases

### 5.1 General

This clause describes use cases and information modelling of EESS. Generally, the EESS has various functions within the grid that are addressed in other IEC documents. EESS has major components in common regardless of the types and features of the electrical energy storage mechanisms. In this technical report the main focus is the direct interaction between the storage management system and EESS.

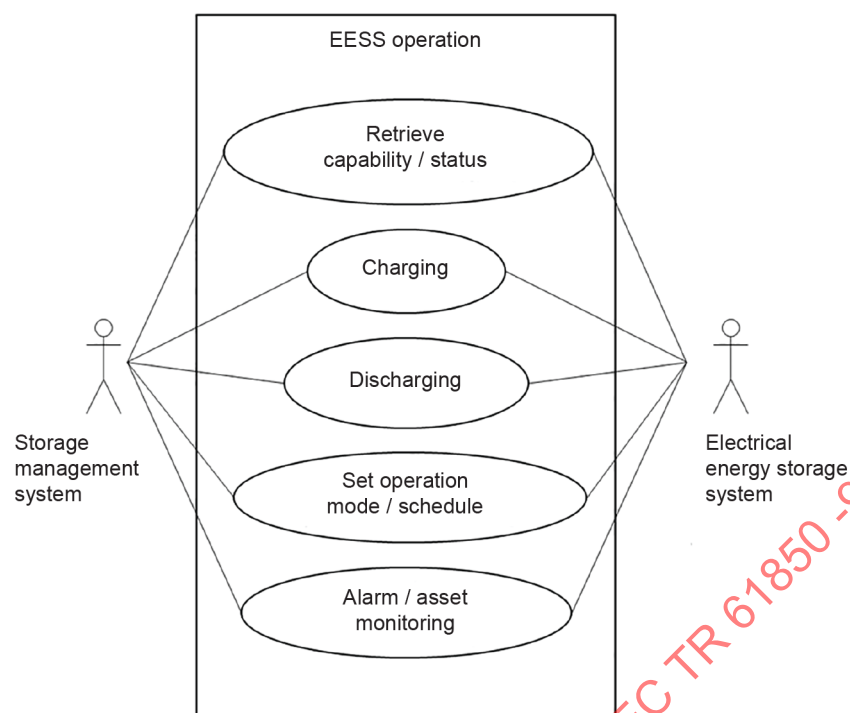
### 5.2 Use case overview

#### 5.2.1 Diagram

Figure 17 shows the overview of the use cases for the interactions between storage management system and EESS.

<sup>6</sup> Common Functions for Smart Inverters, 4<sup>th</sup> Edition. EPRI, Palo Alto, CA: 2016. 3002008217.





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**Figure 17 – Use case diagram**

### 5.2.2 Actors

Table 6 describes the list of actors appearing in Figure 17.

**Table 6 – List of actors**

| Name                                 | Role description                                                                                                                                                                                                               |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Storage Management System            | The system that is owned by the TSO/DSO or Facility Operator, interacting with EESS by sending operating commands and receiving current status of EESS. Storage management system may interact with multiple EESS.             |
| Electric Energy Storage System (EES) | The electrical energy storage system that are composed of one or a plurality of energy storage devices and the controller. Each storage device is capable of absorbing (charging), providing (discharging) and storing energy. |

### 5.2.3 List of use cases

Table 7 shows basic sequence flows. Each use case is represented by combinations of the sequence flows. The practical communication sequences are constructed out of combinations of these simple use cases.

**Table 7 – List of use cases**

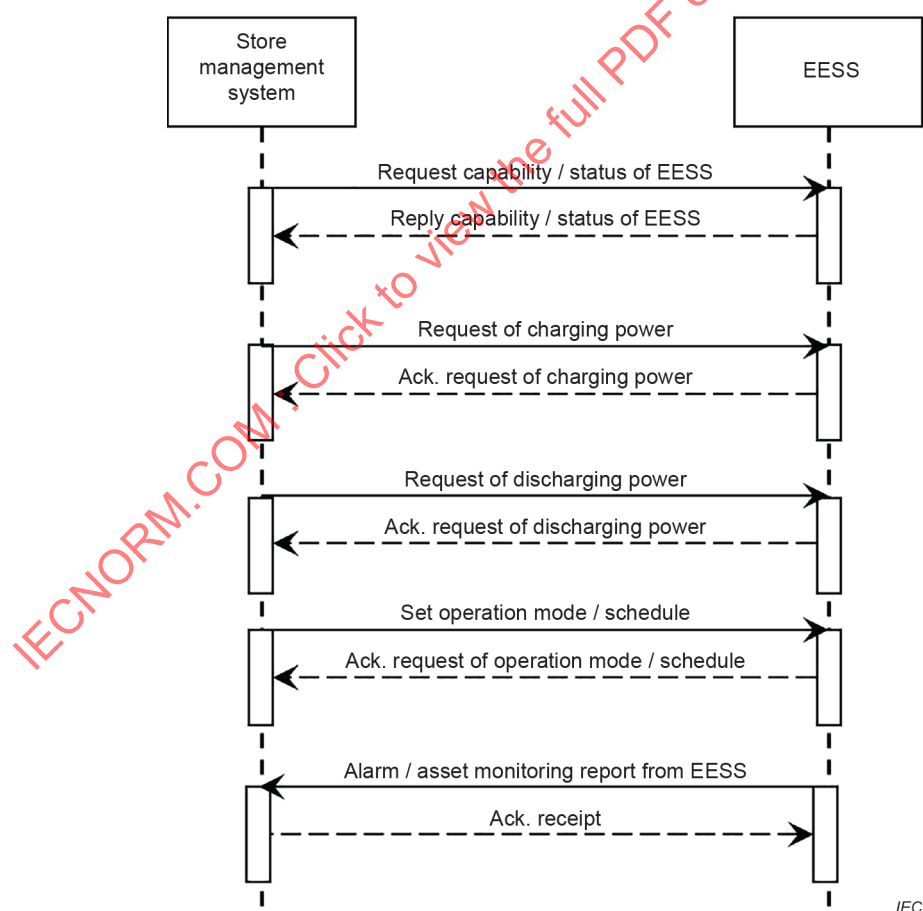
|     | Name of common/basic flow     | Services or information provided                                                                |
|-----|-------------------------------|-------------------------------------------------------------------------------------------------|
| UC1 | Retrieve capabilities /Status | Storage management system retrieves the current electrical capabilities from the storage system |
| UC2 | Charging                      | Storage management system is setting the charging power to the (battery) storage EESS           |
| UC3 | Discharging                   | Storage management system is setting the discharging power to be supplied by the EESS           |
| UC4 | Set operation mode/schedule   | Storage management system is setting a specific operational function/ schedule on the EESS      |
| UC5 | Alarm / asset monitoring      | Storage management system receives status of alarms and asset information from EESS.            |

Information flow and step by step interaction and information exchanges in individual use case are described in 5.2.4.

## 5.2.4 Information flow (basic flow)

### 5.2.4.1 Overall sequence diagram

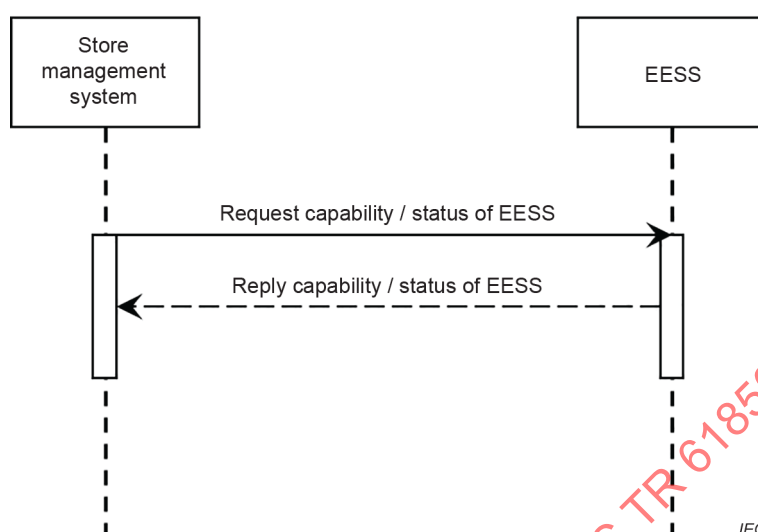
Figure 18 shows the sequence of the entire set of use cases of EESS.



**Figure 18 – The entire sequence of EESS use cases**

#### 5.2.4.2 UC1: Retrieve current capabilities/status of the registered EESS

Figure 19 shows the sequence of retrieving current capabilities/status of EESS information to Storage Management System, i.e. UC1.



**Figure 19 – Sequence of UC1: retrieving current capabilities/status of EESS information to Storage Management System**

Table 8 describes information exchange in each step in UC1 corresponding to Figure 19.

**Table 8 – Information exchange in UC1: Sequence of retrieving current capabilities/status of EESS information to Storage Management System**

| Use case step | Description                                                                                 | Information exchanged                                                                                                                                                              |
|---------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Step 1-1      | Storage Management System requests the current capability /status information of the EESS   | EESS ID (nameplate), reporting request, list of status information                                                                                                                 |
| Step 1-2      | The EESS units send current capability /status information to the Storage Management System | Categories of status:<br>1-2-1) EESS generic status<br>1-2-2) EESS storage unit inverter/converter status<br>1-2-3) EESS storage unit (battery) status<br>1-2-4) EESS measurements |

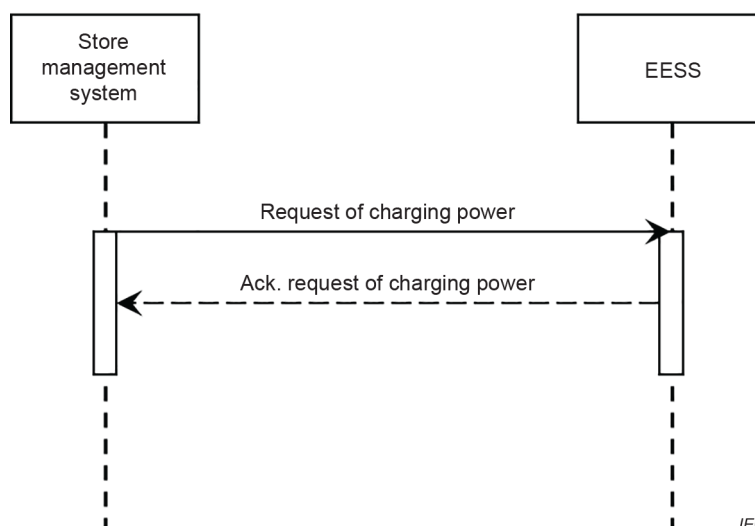
Table 9 describes typical data exchanged in step 1-2 in UC1.

**Table 9 – Information exchange Step1-2 in UC1 current capability /status information**

| Use case step                                                    | Information exchange                                                                                                          |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|
| 1-2-1<br>EESS generic<br>status                                  | • EESS on or off status                                                                                                       |
|                                                                  | • EESS storage available or not available                                                                                     |
|                                                                  | • EESS available operational functions                                                                                        |
|                                                                  | • Current synchronized state: connected or disconnected at its ECP                                                            |
|                                                                  | • Inverter on, off, and/or in stand-by status: inverter is switched on (operating), off (not able to operate), or in stand-by |
|                                                                  | • status, e.g. capable of operating but currently not operating                                                               |
|                                                                  | • Value of the output power setpoint                                                                                          |
|                                                                  | • Value of the output reactive power setpoint                                                                                 |
|                                                                  | • Value of the power factor setpoint as angle (optional)                                                                      |
|                                                                  | • Value of the frequency setpoint (optional)                                                                                  |
| 1-2-2<br>EESS inverter<br>/converter<br>status                   | • Battery amp-hour capacity rating                                                                                            |
|                                                                  | • Nominal voltage of battery                                                                                                  |
|                                                                  | • Maximum battery discharge current                                                                                           |
|                                                                  | • Maximum battery charge voltage                                                                                              |
|                                                                  | • Rate of output battery voltage change                                                                                       |
|                                                                  | • Internal battery voltage                                                                                                    |
|                                                                  | • Internal battery current                                                                                                    |
|                                                                  | • Type of battery                                                                                                             |
| 1-2-3<br>EESS associated<br>unit<br>(battery)<br>internal status | • EESS total active power (Total P): value                                                                                    |
|                                                                  | • EESS total reactive power (Total Q): value                                                                                  |
|                                                                  | • EESS average power factor (Total PF): value                                                                                 |
|                                                                  | • EESS storage remaining capacity (%and/or Ampere-hour and/or kWh)                                                            |
|                                                                  | • EESS storage free capacity (% and/or Ampere-hour and/or kWh)                                                                |
|                                                                  | • State of charge (energy % and/or Ampere-hour of maximum charge level)                                                       |
|                                                                  | • Battery reserve (minimum energy charge level allowed, % of maximum charge level)                                            |
|                                                                  | • Battery available energy (state of charge – Reserve – % and/or Ampere-hour and/or kWh)                                      |
|                                                                  | • EESS phase to ground voltages (VL1ER, ...): value                                                                           |
| 1-2-4<br>EESS<br>measurements                                    |                                                                                                                               |
|                                                                  |                                                                                                                               |
|                                                                  |                                                                                                                               |
|                                                                  |                                                                                                                               |
|                                                                  |                                                                                                                               |
|                                                                  |                                                                                                                               |
|                                                                  |                                                                                                                               |
|                                                                  |                                                                                                                               |
|                                                                  |                                                                                                                               |

#### 5.2.4.3 UC2: set charging power to EESS

Figure 20 shows the sequence of set charging power to EESS from Storage Management System, i.e. UC2.



**Figure 20 – Sequence of UC2: set Charging power to EESS**

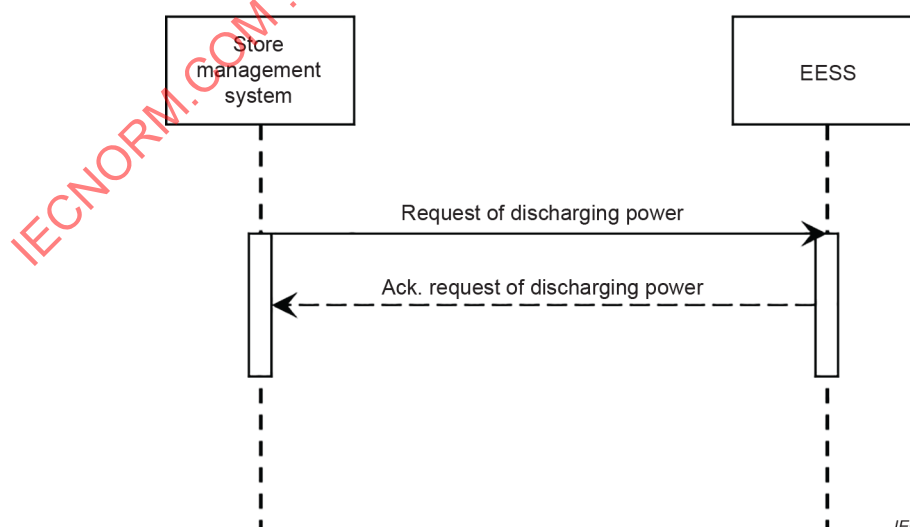
Table 10 describes information exchange in each step in UC2 corresponding to Figure 20.

**Table 10 – Information exchange in UC2: Set Charging power to EESS**

| Use case step | Description                                                              | Information exchanged                                                                                                                |
|---------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| Step 2-1      | Storage Management System sends charging power set point request to EESS | EESS ID (nameplate), control request, charging power set point (import active power setpoint setting), target reactive power setting |
| Step 2-2      | The EESS acknowledges charging power request                             | Status of EESS (normal/error), certificate of the acknowledgement                                                                    |

#### 5.2.4.4 UC3: set discharging power to EESS

Figure 21 shows the sequence of set discharging power to EESS from Storage Management System, i.e. UC3.



**Figure 21 – Sequence of UC3: Set discharging power to EESS**

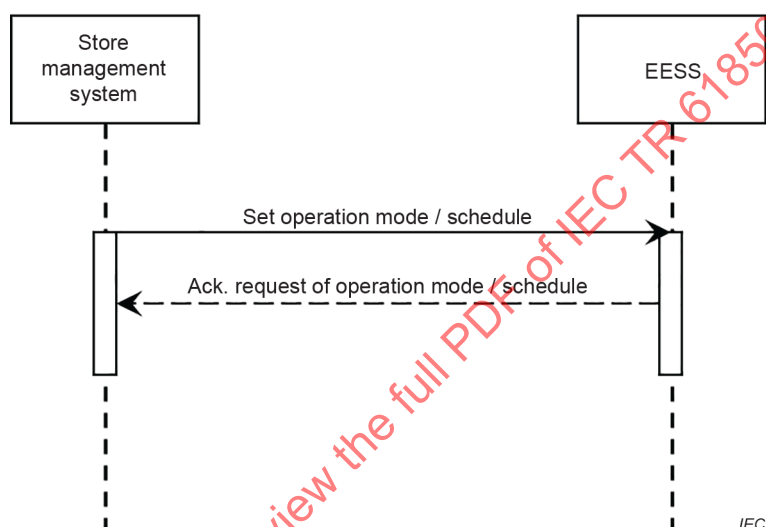
Table 11 describes information exchange in each step in UC3 corresponding to Figure 21.

**Table 11 – Information exchange in UC3: Set discharging power to EESS**

| Use case step | Description                                                                 | Information exchanged                                                                                                                   |
|---------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| Step 3-1      | Storage Management System sends discharging power set point request to EESS | EESS ID (nameplate), control request, discharging power set point (export active power setpoint setting), target reactive power setting |
| Step 3-2      | The EESS acknowledges discharging power request                             | Status of EESS (normal/error), certificate of the acknowledgement                                                                       |

#### 5.2.4.5 UC4: set operational function/schedule to EESS

Figure 22 shows the sequence of set operational function/schedule to EESS from Storage Management System, i.e. UC4.



**Figure 22 – Sequence of UC4: set operational function/schedule to EESS**

Table 12 describes information exchange in the first step in UC4 corresponding to the request from Storage Management System to EESS in Figure 22.

**Table 12 – Information exchange in UC4: set operational function to EESS**

| Use case step | Description                                                                                                                                             | Information exchanged                                                                        |
|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|
| Step 4-1-1    | Storage Management System activates a selected operational function by controlling the mode enable DO of the corresponding operational function of EESS | EESS ID (nameplate), EESS operational function mode enable DO control                        |
| Step 4-1-2    | The EESS acknowledges the operational function request                                                                                                  | Operational function mode enables DO Status(true/false), certificates of the acknowledgement |

Table 13 describes information exchange in the second step in UC4 corresponding to the request in Figure 22.

**Table 13 – Information exchange in UC4: set schedule to EESS**

| Use case step | Description                                                      | Information exchanged                                          |
|---------------|------------------------------------------------------------------|----------------------------------------------------------------|
| Step 4-2-1    | Storage Management System sends schedule setting request to EESS | EESS ID (nameplate), schedule request, EESS operating schedule |
| Step 4-2-2    | The EESS acknowledge / accept the operating schedule request     | Status (normal/error), certificate of the acknowledgement      |

#### 5.2.4.6 UC5: alarm/asset monitoring of EESS

Figure 23 shows the sequence of alarm/asset monitoring of EESS, i.e. UC5.

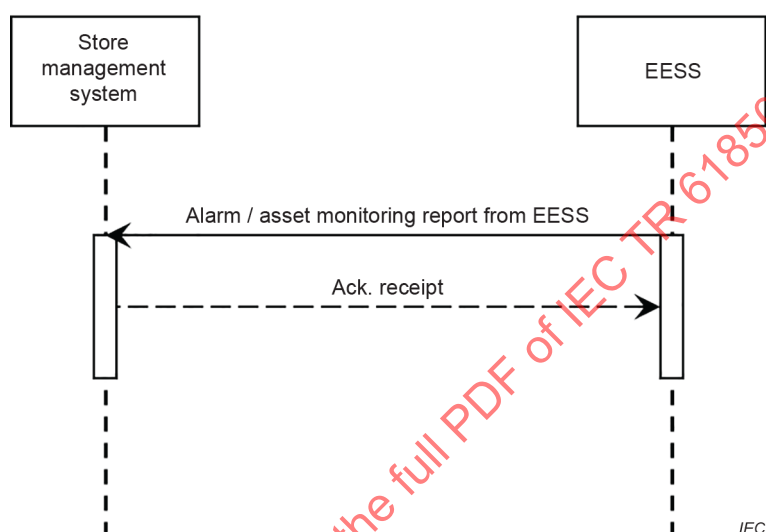
**Figure 23 – Sequence of UC5: Alarm/Asset Monitoring of EESS**

Table 14 describes information exchange in steps in UC5, shown in Figure 23.

**Table 14 – Information exchange in UC5: Alarm/Asset Monitoring of EESS**

| Use case step | Description                                                                  | Information exchanged                             |
|---------------|------------------------------------------------------------------------------|---------------------------------------------------|
| Step 5-1      | EESS sends alarm status/asset monitoring report to Storage Management System | EESS ID (nameplate), status of alarms (activated) |
| Step 5-2      | Storage Management System confirm the message from EESS                      | Certificate of received status (Normal/Error).    |

#### 5.2.5 Summary of exchanged information in use cases

Table 15 lists the summary of exchanged information in use cases with corresponding DOs/LNs.

**Table 15 – Summary of exchanged Information  
in use cases with corresponding DOs/LNs**

| Exchanged information                                                     | Step | Data Object Name                                                                                   | Logical Node                                 |
|---------------------------------------------------------------------------|------|----------------------------------------------------------------------------------------------------|----------------------------------------------|
| EESS ID                                                                   | *-1  | NamPlt                                                                                             | LLN0                                         |
| Certificate of the acknowledgement                                        | *-2  | Blk,CmdBlk,<br>Mod,Beh,Health                                                                      | LLN0                                         |
| Type of EESS                                                              | 0-3  | DERType                                                                                            | << abstract>><br>DER_NameplateRatingsLNs     |
| Type of battery                                                           | 0-3* | BatTyp                                                                                             | DBAT                                         |
| Capacity (Nameplate Ratings)                                              | 0-3  | WhRtg<br>WhMaxRtg<br>WhMinRtg                                                                      | << abstract>> Storage<br>Nameplate Ratings   |
| Capacity(Operational Ratings)                                             | 0-3  | EffWh, UseWh                                                                                       | << abstract>> Storage<br>Operational Ratings |
| Max/Min usable capacity of the reserve levels                             | 0-3  | UseWhMinPct/<br>UseWhMaxPct                                                                        | << abstract>> Storage<br>Operational Ratings |
| Max active/reactive power nameplate ratings<br>while charging/discharging | 0-3  | ChaWMaxRtg,<br>DschWMaxRtg<br>ChaAvarMaxRtg,<br>DschAvarMaxRtg<br>ChalvarMaxRtg,<br>DschIvarMaxRtg | << abstract>> Storage<br>Nameplate Ratings   |
| Max active/reactive power operational settings<br>while charging          | 0-3  | ChaWMax,<br>ChaAvarMax,<br>ChalvarMax                                                              | << abstract>> Storage<br>Operational Ratings |
| Max current while charging/discharging                                    | 0-3  | ChaAMaxRtg (AC),<br>DschAMaxRtg (AC),<br>ChaAmpMaxRtg (DC),<br>DschAmpMaxRtg (DC)                  | DBAT                                         |
| Voltage levels rating                                                     | 0-3  | VMaxRtg,VMinRtg                                                                                    | DERNameplate RatingsLN                       |
| Voltage levels rating while charging                                      | 0-3  | ChaVolLim                                                                                          | DBAT                                         |
| Ramp Rate (in/out)                                                        | 0-3  | ChaWRpuMaxRtg,<br>DschWRpuMaxRtg,<br>ChaWRpdMaxRtg<br>DschWRpdMaxRtg                               | StorageNameplateRatingsLN                    |
| Power setting (charging/discharging) (max W)                              | 0-3  | ChaWMaxRtg,<br>DschWMaxRtg,                                                                        | StorageNameplateRatingsLN                    |
| Reactive power (VAR)                                                      | 0-3  | ChaAvarMaxRtg,<br>ChalvarMaxRtg,<br>DschAvarMaxRtg,<br>DschIvarMaxRtg,                             | StorageNameplateRatingsLN                    |
| Round trip energy efficiency                                              | 0-3  | RntEfc                                                                                             | DER_StorageLN                                |
| Other nameplate information                                               | 0-3  | NamPlt                                                                                             | LLN0                                         |
| Warning high state of charge threshold of the<br>battery (in percent)     | 0-3  | SocHiWrsPct                                                                                        | DER_StorageLN                                |
| High state of charge alarm threshold of the<br>battery (in percent)       | 0-3  | SocHiAlsPct                                                                                        | DER_StorageLN                                |



| Exchanged information                                                                                                                                    | Step  | Data Object Name    | Logical Node                                                                                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|-------|---------------------|-----------------------------------------------------------------------------------------------------------|
| Warning low state of charge threshold of the battery (in percent)                                                                                        | 0-3   | SocLoWrsPct         | DER_StorageLN                                                                                             |
| Low state of charge alarm threshold of the battery (in percent)                                                                                          | 0-3   | SocLoAlsPct         | DER_StorageLN                                                                                             |
| Threshold alarm setting of the usable lower limit of the storage resource (in % of the usable capacity of the storage element (in Wh) – UseWh )          | 0-3   | SohLoAlsPct         | DER_StorageLN                                                                                             |
| Alarm threshold reflecting the maximum limit of voltage of a battery cell                                                                                | 0-3   | MaxCelVolAls        | SBAText                                                                                                   |
| Alarm threshold reflecting the minimum limit of voltage of a battery cell                                                                                | 0-3   | MinCelVolAls        | SBAText                                                                                                   |
| High level discharging current threshold alarm setting                                                                                                   | 0-3   | DschAmpHiAls        | SBAText                                                                                                   |
| Warning threshold defining the high discharging current warning limit of the battery (in amps)                                                           | 0-3   | DschAmpHiWrs        | SBAText                                                                                                   |
| if true, the maximum current threshold during charging of the battery has been exceeded                                                                  | 0-3   | ChaAmpHiAls         | SBAText                                                                                                   |
| if true, the warning current threshold during charging of the battery has been exceeded                                                                  | 0-3   | ChaAmpHiWrs         | SBAText                                                                                                   |
| High internal temperature alarm threshold of the battery (in °C)                                                                                         | 0-3   | IntnTmpHiAls        | SBAText                                                                                                   |
| High internal temperature warning threshold of the battery (in °C)                                                                                       | 0-3   | IntnTmpHiWrs        | SBAText                                                                                                   |
| Low internal temperature alarm threshold of the battery (in °C)                                                                                          | 0-3   | IntnTmpLoAls        | SBAText                                                                                                   |
| Low internal temperature warning threshold of the battery (in °C)                                                                                        | 0-3   | IntnTmpLoWrs        | SBAText                                                                                                   |
| Alarm threshold defining the difference limit of the imbalance of temperature of the battery component e.g. module, bank, pack, string or cell (in °C)   | 0-3   | UnbTmpAls           | SBAText                                                                                                   |
| Warning threshold defining the difference limit of the imbalance of temperature of the battery component e.g. module, bank, pack, string or cell (in °C) | 0-3   | UnbTmpWrs           | SBAText                                                                                                   |
| Alarm threshold defining the difference limit of the imbalance of voltage of the battery component e.g. module, bank, pack, string or cell               | 0-3   | UnbVolAls           | SBAText                                                                                                   |
| Warning threshold defining the difference limit of the imbalance of voltage of the battery component e.g. module, bank, pack, string or cell             | 0-3   | UnbVolWrs           | SBAText                                                                                                   |
| High level battery external voltage threshold alarm setting.                                                                                             | 0-3   | ExtVolHiAls         | SBAText                                                                                                   |
| Low battery external voltage threshold alarm setting.                                                                                                    | 0-3   | ExtVolLoAls         | SBAText                                                                                                   |
| High level battery internal voltage alarm threshold.                                                                                                     | 0-3   | IntnVolHiAls        | SBAText                                                                                                   |
| Low level battery internal voltage alarm threshold.                                                                                                      | 0-3   | IntnVolLoAls        | SBAText                                                                                                   |
| ES-DER on or off                                                                                                                                         | 1-2-1 | DERTrnOn, DERTrnOff | DERStateAbstractLN                                                                                        |
| Storage available or not available                                                                                                                       | 1-2-1 | DEROpSt             | DER_OperationalatngsLN                                                                                    |
| Read what operational functions are available                                                                                                            | 1-2-1 | Service             | GET Server Directory for getting the list of Logical Devices, Logical Nodes, Data Objects, and attributes |

| Exchanged information                                                                                 | Step     | Data Object Name                         | Logical Node                              |
|-------------------------------------------------------------------------------------------------------|----------|------------------------------------------|-------------------------------------------|
| Power system synchronization states to the power grid.                                                | 1-2-2    | GnSynSt                                  | DER_GeneratorLN                           |
| Operating with value true initiates the DER to go to standby                                          | 1-2-2    | DERGotoStdby                             | DERStateAbstractLN                        |
| Target active power of the inverter                                                                   | 1-2-2    | WTgt                                     | DERConverterLN                            |
| Target reactive power of the inverter                                                                 | 1-2-2    | VArTgt                                   | DINV                                      |
| Power factor setting as angle.                                                                        | 1-2-2    | OutPFSet                                 | DINV                                      |
| Frequency setting.                                                                                    | 1-2-2    | OutHzSet                                 | DINV                                      |
| Amp-hour capacity rating                                                                              | 1-2-3*   | AhrRtg, EffAhrRtg                        | DBAT                                      |
| Nominal voltage of battery                                                                            | 1-2-3*   | IntnVolNom                               | DBAT                                      |
| Maximum battery discharge current                                                                     | 1-2-3*   | DschAmpMxRtg                             | DBAT                                      |
| Maximum battery charge voltage                                                                        | 1-2-3*   | ChaVolMaxRtg                             | DBAT                                      |
| Rate of output battery voltage change                                                                 | 1-2-3*   | VolChgRte                                | DBAT                                      |
| External battery voltage (the component e.g. module, bank, pack, string or cell)                      | 1-2-3*   | ExtVolNom                                | DBAT                                      |
| Nominal internal battery voltage (the component e.g. module, bank, pack, string or cell)              | 1-2-3*   | IntnVolNom                               | DBAT                                      |
| Internal battery voltage (the component e.g. module, bank, pack, string or cell)                      | 1-2-3*   | IntnV (non DC),<br>IntnVol(DC)           | SBATExt                                   |
| Internal battery current                                                                              | 1-2-3*   | IntnA(non DC),<br>IntnAmp(DC)            | SBATExt                                   |
| State of charge (kWh, energy % of maximum charge level/Usable state of charge/Actual state of charge) | 1-2-3    | SocEffAhrPct<br>UseSocPct<br>SocEffWhPct | DBAT,<br>DER_StorageLN,<br>DER_StorageLN, |
| Reserve (min. energy charge level allowed, % of max. charge level)                                    | 1-2-3*   | AhrMinRtg                                | DBAT                                      |
| Type of battery                                                                                       | 1-2-3*   | BatTyp                                   | DBAT                                      |
| Total active power (total P): value, high and low limits                                              | 1-2-4    | TotW                                     | MMXU                                      |
| Total reactive power (total Q): value, high and low limits                                            | 1-2-4    | TotQ                                     | MMXU                                      |
| Average power factor (total PF): value, high and low limits, and average time                         | 1-2-4    | TotPF                                    | MMXU                                      |
| Storage remaining capacity (% and/or Ampere-hour and/or kWh)                                          | 1-2-4    | OutWh, AvlDschAhr                        | DER_StorageLN, DBAT                       |
| StorageFree capacity (% and/or Ampere-hour and/or kWh)                                                | 1-2-4    | InWh, AvlChaAhr                          | DER_StorageLN, DBAT                       |
| Phase to ground voltages (VL1ER, ...): value, high and low limits                                     | 1-2-4    | PhV                                      | MMXU                                      |
| Available charging time                                                                               | 2-1      | AvlChaWTm                                | DER_StorageLN                             |
| Output/Input power setting; (export/import active power setpoint setting)                             | 2-1, 3-1 | GnWSpt, LodWSpt                          | DWGC                                      |
| Target reactive power setting                                                                         | 2-1, 3-1 | VArTgt                                   | DVAR                                      |
| Available discharging time                                                                            | 3-1      | AvlDschWTm                               | DER_StorageLN                             |
| Enable selected operational function                                                                  | 4-1-1    | ModEna                                   | One of the operational functions          |

| Exchanged information                                                                                   | Step  | Data Object Name                                    | Logical Node  |
|---------------------------------------------------------------------------------------------------------|-------|-----------------------------------------------------|---------------|
| Operating Schedule                                                                                      | 4-2-1 | SchdRelTm,<br>SchdAbsTm,<br>ActWSchd,<br>ActAncSchd | FSCH,<br>FSCC |
| The high state of charge warning threshold of the battery has been exceeded                             | 5-1   | SocHiWrn                                            | DER_StorageLN |
| The maximum state of charge threshold of the battery has been exceeded                                  | 5-1   | SocHiAlm                                            | DER_StorageLN |
| The low state of charge warning threshold of the battery has been exceeded                              | 5-1   | SocLoWrn                                            | DER_StorageLN |
| The minimum state of charge threshold of the battery has been exceeded                                  | 5-1   | SocLoAlm                                            | DER_StorageLN |
| The predefined threshold of the low state of health of the storage resource (SohLoAls) has been reached | 5-1   | SohLoAlm                                            | DER_StorageLN |
| The maximum limit of cell voltage has been exceeded.                                                    | 5-1*  | MaxCelVolAlm                                        | SBAText       |
| The minimum limit of cell voltage has been exceeded.                                                    | 5-1*  | MinCelVolAlm                                        | SBAText       |
| If true, the maximum current threshold during discharging of the battery has been exceeded              | 5-1*  | DschAmpHiAlm                                        | SBAText       |
| If true, the warning current threshold during discharging of the battery has been exceeded              | 5-1*  | DschAmpHiWrn                                        | SBAText       |
| if true, the maximum current threshold during charging of the battery has been exceeded                 | 5-1*  | ChaAmpHiAlm                                         | SBAText       |
| if true, the warning current threshold during charging of the battery has been exceeded                 | 5-1*  | ChaAmpHiWrn                                         | SBAText       |
| The maximum internal temperature threshold of the battery has been exceeded                             | 5-1*  | IntnTmpHiAlm                                        | SBAText       |
| The high internal temperature warning threshold of the battery has been exceeded                        | 5-1*  | IntnTmpHiWrn                                        | SBAText       |
| The minimum internal temperature threshold of the battery has been exceeded                             | 5-1*  | IntnTmpLoAlm                                        | SBAText       |
| The low internal temperature warning threshold of the battery has been exceeded                         | 5-1*  | IntnTmpLoWrn                                        | SBAText       |
| The imbalance temperature alarm threshold of the battery has been exceeded                              | 5-1*  | UnbTmpAlm                                           | SBAText       |
| The imbalance temperature warning threshold of the battery has been exceeded                            | 5-1*  | UnbTmpWrn                                           | SBAText       |
| The imbalance cell voltage alarm threshold of the battery has been exceeded                             | 5-1*  | UnbVolAlm                                           | SBAText       |
| The imbalance cell voltage warning threshold of the battery has been exceeded                           | 5-1*  | UnbVolWrn                                           | SBAText       |
| The high external voltage of the battery has been reached                                               | 5-1*  | ExtVolHiAlm                                         | SBAText       |
| The low level threshold of the external voltage of the battery has been reached                         | 5-1*  | ExtVolLoAlm                                         | SBAText       |
| The high level threshold of the internal voltage of the battery has been reached                        | 5-1*  | IntnVolHiAlm                                        | SBAText       |
| The low level threshold of the internal voltage of the battery has been reached                         | 5-1*  | IntnVolLoAlm                                        | SBAText       |

NOTE Exchanged information at steps "0-3\*", "1-2-3\*" and "5-1\*" applied for battery based EESS

## 6 IEC 61850 based information modelling

<CODE BEGINS>

### 6.1 Logical Nodes from 61850-90-9 namespace

#### 6.1.1 General

Logical nodes of IEC 61850-90-9 to be moved to the upcoming second edition of 61850-7-420 as soon as this document is published. Common data classes referred to in this clause are referring to the ones defined in 61850-7-3.

The constructed classes structure and descriptions are part of the Code Component of this document and are available as electronic machine readable file in related NSD file.

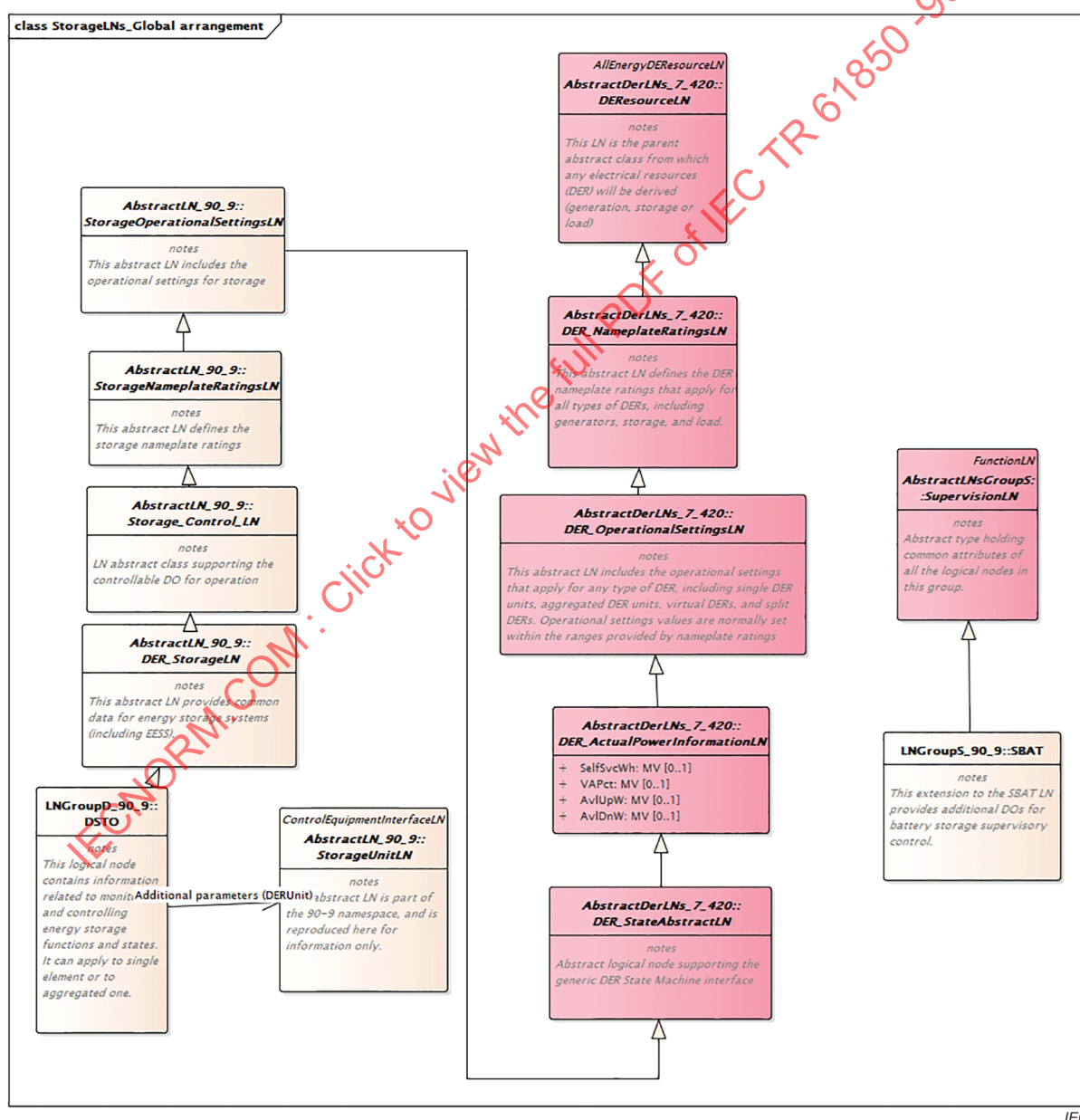


Figure 24 – Class diagram LogicalNodes\_90\_9::StorageLNs\_Global arrangement

Figure 24: LN structure of Electric Energy Storage Systems (EESS)



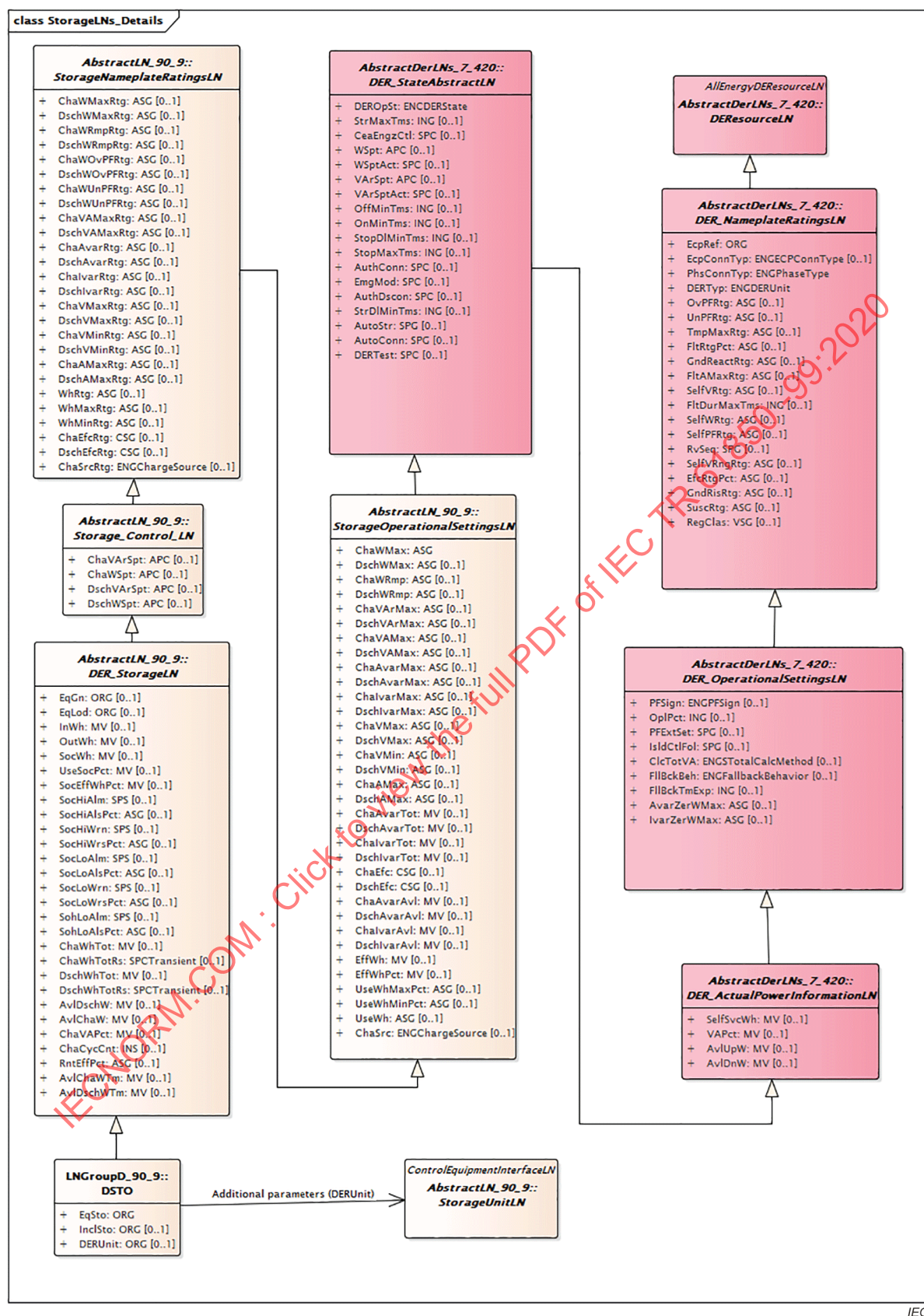


Figure 25: Modelling details of Storage related LNs



Figure 26: Diagram of LN classes from Group D from this namespace





Figure 27 – Class diagram LogicalNodes\_90\_9::StorageLNs\_90\_9\_2

Figure 27: Diagram of complementary LN classes from Group S from this namespace

## 6.1.2 Abstract LNs related to the 61850-90-9 namespace (AbstractLN\_90\_9)

### 6.1.2.1 General

Abstract LNs related to this namespace.

### 6.1.2.2 <<abstract>> LN: Storage Control LN Name: Storage\_Control\_LN

LN abstract class supporting the controllable DO for operation

Table 16 shows all data objects of Storage\_Control\_LN.

This class has as parent: StorageNameplateRatingsLN.

**Table 16 – Data objects of Storage\_Control\_LN**

| Storage_Control_LN |                   |   |                                                                                                                                                                                |              |
|--------------------|-------------------|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Data object name   | Common data class | T | Explanation                                                                                                                                                                    | PresConds/ds |
| <b>Controls</b>    |                   |   |                                                                                                                                                                                |              |
| ChaVArSpt          | APC               |   | Charge reactive power setpoint (unsigned). In case VArSpt (signed) is used, reading the value of this DO will reflect the charging setpoint value only (0 when discharging)    | O / O        |
| ChaWSpt            | APC               |   | Charge active power setpoint (unsigned). In case WSpt (signed) is used, reading the value of this DO will reflect the charging setpoint value only (0 when discharging)        | O / O        |
| DschVArSpt         | APC               |   | Discharge reactive power setpoint (unsigned). In case VArSpt (signed) is used, reading the value of this DO will reflect the discharging setpoint value only (0 when charging) | O / O        |
| DschWSpt           | APC               |   | Discharge active power setpoint (unsigned). In case WSpt (signed) is used, reading the value of this DO will reflect the discharging setpoint value only (0 when charging)     | O / O        |

### 6.1.2.3 <<abstract>> LN: Storage Operational Settings Name: StorageOperationalSettingsLN

This abstract LN includes the operational settings for storage

Table 17 shows all data objects of StorageOperationalSettingsLN.

This class has as parent: DER\_StateAbstractLN.

**Table 17 – Data objects of StorageOperationalSettingsLN**

| StorageOperationalSettingsLN       |                   |   |                                                                                                                              |              |
|------------------------------------|-------------------|---|------------------------------------------------------------------------------------------------------------------------------|--------------|
| Data object name                   | Common data class | T | Explanation                                                                                                                  | PresConds/ds |
| <b>Measured and metered values</b> |                   |   |                                                                                                                              |              |
| ChaAvarTot                         | MV                |   | The total amount of reactive power available for absorbing even if possibly impacting active power output while charging     | O / O        |
| DschAvarTot                        | MV                |   | The total amount of reactive power available for absorbing even if possibly impacting active power output while discharging. | O / O        |



| StorageOperationalSettingsLN |                   |   |                                                                                                                                                                                                                                                                                                                                                                  |                   |
|------------------------------|-------------------|---|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Data object name             | Common data class | T | Explanation                                                                                                                                                                                                                                                                                                                                                      | PresConds/ds      |
| ChalvarTot                   | MV                |   | The total amount of reactive power available for injecting even if possibly impacting active power output while charging                                                                                                                                                                                                                                         | O / O             |
| DschlvarTot                  | MV                |   | The total amount of reactive power available for injecting even if possibly impacting active power output while discharging                                                                                                                                                                                                                                      | O / O             |
| ChaAvarAvl                   | MV                |   | The amount of reactive power available for absorbing without impacting active power output while charging                                                                                                                                                                                                                                                        | O / O             |
| DschAvarAvl                  | MV                |   | The amount of reactive power available for absorbing without impacting active power output while discharging                                                                                                                                                                                                                                                     | O / O             |
| ChalvarAvl                   | MV                |   | The amount of reactive power available for injecting without impacting active power output while charging                                                                                                                                                                                                                                                        | O / O             |
| DschlvarAvl                  | MV                |   | The amount of reactive power available for injecting without impacting active power output while discharging                                                                                                                                                                                                                                                     | O / O             |
| EffWh                        | MV                |   | Effective actual total energy capacity (in Wh) provided by the storage resource. Due to degradation, the amount may be less than the rated total energy capacity (WhRtg).                                                                                                                                                                                        | AtLeastOne(1) / O |
| EffWhPct                     | MV                |   | Effective actual total energy capacity (expressed as percentage of WhRtg) provided by the storage resource. Due to degradation, the amount may be less than the rated total energy capacity (WhRtg).<br><br>In case both WhEffCapPct and WhEffCap DOs are present in a same LN instance, the application shall ensure to keep the values of both DOs consistent. | AtLeastOne(1) / O |
| Settings                     |                   |   |                                                                                                                                                                                                                                                                                                                                                                  |                   |
| ChaWMax                      | ASG               |   | Maximum active power while charging                                                                                                                                                                                                                                                                                                                              | M / F             |
| DschWMax                     | ASG               |   | Maximum active power while discharging. (This DO is optional because WMax could be used)                                                                                                                                                                                                                                                                         | O / F             |
| ChaWRmp                      | ASG               |   | Default ramp rate for changes in active power: percentage of WMax per second while charging                                                                                                                                                                                                                                                                      | O / F             |
| DschWRmp                     | ASG               |   | Default ramp rate for changes in active power: percentage of WMax per second while discharging                                                                                                                                                                                                                                                                   | O / F             |
| ChaVArMax                    | ASG               |   | Charging reactive power maximum                                                                                                                                                                                                                                                                                                                                  | O / F             |
| DschVArMax                   | ASG               |   | Discharging reactive power maximum                                                                                                                                                                                                                                                                                                                               | O / F             |
| ChaVAMax                     | ASG               |   | Maximum apparent charging power                                                                                                                                                                                                                                                                                                                                  | O / F             |
| DschVAMax                    | ASG               |   | Operational setpoint for maximum apparent power while discharging                                                                                                                                                                                                                                                                                                | O / F             |
| ChaAvarMax                   | ASG               |   | Operational setpoint for maximum absorbing reactive power while charging                                                                                                                                                                                                                                                                                         | O / F             |
| DschAvarMax                  | ASG               |   | Operational setpoint for maximum absorbing reactive power while discharging                                                                                                                                                                                                                                                                                      | O / F             |
| ChalvarMax                   | ASG               |   | Operational setpoint for maximum supply (injection) reactive power while charging                                                                                                                                                                                                                                                                                | O / F             |
| DschlvarMax                  | ASG               |   | Operational setpoint for maximum supply (injection) reactive power while discharging                                                                                                                                                                                                                                                                             | O / F             |
| ChaVMax                      | ASG               |   | Operational setting for maximum voltage while charging                                                                                                                                                                                                                                                                                                           | O / F             |
| DschVMax                     | ASG               |   | Operational setpoint for maximum voltage while discharging                                                                                                                                                                                                                                                                                                       | O / F             |
| ChaVMin                      | ASG               |   | Operational setting for minimum voltage while charging                                                                                                                                                                                                                                                                                                           | O / F             |

| StorageOperationalSettingsLN |                           |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |              |
|------------------------------|---------------------------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Data object name             | Common data class         | T | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | PresConds/ds |
| DschVMin                     | ASG                       |   | Operational setpoint for minimum voltage while discharging                                                                                                                                                                                                                                                                                                                                                                                                                             | O / F        |
| ChaAMax                      | ASG                       |   | Operational setting for maximum current under nominal voltage under nominal power factor while charging                                                                                                                                                                                                                                                                                                                                                                                | O / F        |
| DschAMax                     | ASG                       |   | Operational setpoint for maximum current under nominal voltage under nominal power factor while discharging                                                                                                                                                                                                                                                                                                                                                                            | O / F        |
| ChaEfc                       | CSG                       |   | Charging efficiency curve [% over SoC]                                                                                                                                                                                                                                                                                                                                                                                                                                                 | O / F        |
| DschEfc                      | CSG                       |   | Discharging efficiency curve [% over SoC]                                                                                                                                                                                                                                                                                                                                                                                                                                              | O / F        |
| UseWhMaxPct                  | ASG                       |   | The energy reserve level above which the storage system may only be charged in emergency situations, expressed as a percentage of the usable capacity, WhUseCap.                                                                                                                                                                                                                                                                                                                       | O / F        |
| UseWhMinPct                  | ASG                       |   | The energy reserve level below which the storage system may only be discharged in emergency situations, expressed as a percentage of the usable capacity, WhUseCap.                                                                                                                                                                                                                                                                                                                    | O / F        |
| UseWh                        | ASG                       |   | Operational setpoint for usable energy storage capacity in Wh                                                                                                                                                                                                                                                                                                                                                                                                                          | O / F        |
| ChaSrc                       | ENG<br>(ChargeSourceKind) |   | Net Energy Metering (NEM) Policy Mode which establishes whether the DER qualifies as renewable.<br><br>Mode A = Storage may charge from the grid but may not discharge to the grid (acts only as load).<br><br>Mode B = Storage may not charge from the grid but may discharge to the grid (charges from local energy source).<br><br>Mode C = Storage may charge or discharge from the grid at will / in response to commands for location where there are no NEM integrity concerns. | O / F        |

#### 6.1.2.4 <<abstract>> LN: Storage Nameplate Ratings Name: StorageNameplateRatingsLN

This abstract LN defines the storage nameplate ratings

Table 18 shows all data objects of StorageNameplateRatingsLN.

This class has as parent: StorageOperationalSettingsLN.

**Table 18 – Data objects of StorageNameplateRatingsLN**

| StorageNameplateRatingsLN |                   |   |                                                                                                  |              |
|---------------------------|-------------------|---|--------------------------------------------------------------------------------------------------|--------------|
| Data object name          | Common data class | T | Explanation                                                                                      | PresConds/ds |
| Settings                  |                   |   |                                                                                                  |              |
| ChaWMaxRtg                | ASG               |   | Nameplate maximum active power rating while charging                                             | O / F        |
| DschWMaxRtg               | ASG               |   | Nameplate maximum active power rating while discharging                                          | O / F        |
| ChaWRmpRtg                | ASG               |   | Nameplate ramp rate for changes in active power while charging: percentage of WMax per second    | O / F        |
| DschWRmpRtg               | ASG               |   | Nameplate ramp rate for changes in active power while discharging: percentage of WMax per second | O / F        |

| StorageNameplateRatingsLN |                           |   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |              |
|---------------------------|---------------------------|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Data object name          | Common data class         | T | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | PresConds/ds |
| ChaWOvPFRtg               | ASG                       |   | Active power charging rating at specified over-excited PF                                                                                                                                                                                                                                                                                                                                                                                                                                     | O / F        |
| DschWOvPFRtg              | ASG                       |   | Nameplate active power discharging rating at specified over-excited power factor, OvPFRtg                                                                                                                                                                                                                                                                                                                                                                                                     | O / F        |
| ChaWUnPFRtg               | ASG                       |   | Active power charging rating at specified under-excited PF                                                                                                                                                                                                                                                                                                                                                                                                                                    | O / F        |
| DschWUnPFRtg              | ASG                       |   | Nameplate active power discharging rating at specified under-excited power factor, UnPFRtg                                                                                                                                                                                                                                                                                                                                                                                                    | O / F        |
| ChaVAMaxRtg               | ASG                       |   | Nameplate maximum apparent charging power rating                                                                                                                                                                                                                                                                                                                                                                                                                                              | O / F        |
| DschVAMaxRtg              | ASG                       |   | Nameplate maximum apparent discharging power rating                                                                                                                                                                                                                                                                                                                                                                                                                                           | O / F        |
| ChaAvarRtg                | ASG                       |   | Nameplate rating for maximum absorbing reactive power while charging                                                                                                                                                                                                                                                                                                                                                                                                                          | O / F        |
| DschAvarRtg               | ASG                       |   | Nameplate rating for maximum absorbing reactive power while discharging                                                                                                                                                                                                                                                                                                                                                                                                                       | O / F        |
| ChalvarRtg                | ASG                       |   | Nameplate rating for maximum supply (injection) reactive power while charging                                                                                                                                                                                                                                                                                                                                                                                                                 | O / F        |
| DschlvarRtg               | ASG                       |   | Nameplate rating for maximum supply (injection) reactive power while discharging                                                                                                                                                                                                                                                                                                                                                                                                              | O / F        |
| ChaVMaxRtg                | ASG                       |   | Nameplate rating for maximum voltage while charging                                                                                                                                                                                                                                                                                                                                                                                                                                           | O / F        |
| DschVMaxRtg               | ASG                       |   | Nameplate rating for maximum voltage while discharging                                                                                                                                                                                                                                                                                                                                                                                                                                        | O / F        |
| ChaVMinRtg                | ASG                       |   | Nameplate rating for minimum voltage while charging                                                                                                                                                                                                                                                                                                                                                                                                                                           | O / F        |
| DschVMinRtg               | ASG                       |   | Nameplate rating for minimum voltage while discharging                                                                                                                                                                                                                                                                                                                                                                                                                                        | O / F        |
| ChaAMaxRtg                | ASG                       |   | Nameplate rating for maximum current under nominal voltage under nominal power factor while charging                                                                                                                                                                                                                                                                                                                                                                                          | O / F        |
| DschAMaxRtg               | ASG                       |   | Nameplate rating for maximum current under nominal voltage under nominal power factor while discharging                                                                                                                                                                                                                                                                                                                                                                                       | O / F        |
| WhRtg                     | ASG                       |   | Nameplate energy storage capacity rating in Wh                                                                                                                                                                                                                                                                                                                                                                                                                                                | O / F        |
| WhMaxRtg                  | ASG                       |   | Nameplate maximum amount of energy (in Wh) to be stored in the storage resource for e.g. supporting long life and avoid faster degradation                                                                                                                                                                                                                                                                                                                                                    | O / F        |
| WhMinRtg                  | ASG                       |   | Nameplate minimum amount of energy (in Wh) to be retained in the storage resource for e.g. supporting long life and avoid faster degradation or to ensure a reserve of energy stored for emergencies and other purposes.                                                                                                                                                                                                                                                                      | O / F        |
| ChaEfcRtg                 | CSG                       |   | Charging efficiency curve [% over SoC]                                                                                                                                                                                                                                                                                                                                                                                                                                                        | O / F        |
| DschEfcRtg                | CSG                       |   | Discharging efficiency curve [% over SoC]                                                                                                                                                                                                                                                                                                                                                                                                                                                     | O / F        |
| ChaSrcRtg                 | ENG<br>(ChargeSourceKind) |   | <p>Net Energy Metering (NEM) Policy Mode which establishes whether the DER qualifies as renewable.</p> <p>Mode A = Storage may charge from the grid but may not discharge to the grid (acts only as load).</p> <p>Mode B = Storage may not charge from the grid but may discharge to the grid (charges from local energy source).</p> <p>Mode C = Storage may charge or discharge from the grid at will / in response to commands for location where there are no NEM integrity concerns.</p> | O / F        |

### 6.1.2.5 <<abstract>> LN: Storage as DER Name: DER\_StorageLN

This abstract LN provides common data for energy storage systems (including EESS).

Table 19 shows all data objects of DER\_StorageLN.

This class has as parent: Storage\_Control\_LN.

**Table 19 – Data objects of DER\_StorageLN**

| DER_StorageLN                      |                   |   |                                                                                                                                                                                                  |                    |
|------------------------------------|-------------------|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|
| Data object name                   | Common data class | T | Explanation                                                                                                                                                                                      | PresCond<br>nds/ds |
| <b>Status information</b>          |                   |   |                                                                                                                                                                                                  |                    |
| SocHiAlm                           | SPS               |   | Alarm trigger status: if true, the maximum state of charge threshold of the battery has been exceeded                                                                                            | O / F              |
| SocHiWrn                           | SPS               |   | Warning trigger status: if true, the high state of charge warning threshold of the battery has been exceeded                                                                                     | O / F              |
| SocLoAlm                           | SPS               |   | Alarm trigger status: If true, the minimum state of charge threshold of the battery has been exceeded                                                                                            | O / F              |
| SocLoWrn                           | SPS               |   | Warning trigger status: if true, the low state of charge warning threshold of the battery has been exceeded                                                                                      | O / F              |
| SohLoAlm                           | SPS               |   | Alarm trigger status: If true, the predefined threshold of the low state of health of the storage resource (SohLoAls) has been reached                                                           | O / F              |
| ChaCycCnt                          | INS               |   | Count of the number of equivalent full charge cycles                                                                                                                                             | O / O              |
| <b>Measured and metered values</b> |                   |   |                                                                                                                                                                                                  |                    |
| InWh                               | MV                |   | Available energy capacity to be charged (in Wh)                                                                                                                                                  | O / O              |
| OutWh                              | MV                |   | Energy stored and available for discharging (in Wh)                                                                                                                                              | O / O              |
| SocWh                              | MV                |   | Actual state of charge expressed in Wh                                                                                                                                                           | O / O              |
| UseSocPct                          | MV                |   | Usable state of charge (expressed as percent of total usable energy capacity UseWh) which may be directly measured or calculated                                                                 | O / O              |
| SocEffWhPct                        | MV                |   | State of charge as percentage in relation to the effective energy capacity of the storage resource with respect to the degradation so far (EffWh).                                               | O / O              |
| ChaWhTot                           | MV                |   | Total Energy Charged since last reset (in Wh)                                                                                                                                                    | O / O              |
| DschWhTot                          | MV                |   | Total Energy Discharged since last reset                                                                                                                                                         | O / O              |
| AvlDschW                           | MV                |   | Available power                                                                                                                                                                                  | O / O              |
| AvlChaW                            | MV                |   | Available charging power                                                                                                                                                                         | O / O              |
| ChaVAPct                           | MV                |   | Actual volt-amps percentage charged based on ChaVAMax                                                                                                                                            | O / O              |
| AvlChaWTm                          | MV                |   | Available charging time                                                                                                                                                                          | O / O              |
| AvlDschWTm                         | MV                |   | Available discharging time                                                                                                                                                                       | O / O              |
| <b>Controls</b>                    |                   |   |                                                                                                                                                                                                  |                    |
| ChaWhTotRs                         | SPC               | T | (controllable) Operating with value true initiates the reset of the DO ChaWhTot (Total Energy Charged); operating with value false is ignored. The change of its status value is a local issue.  | O / F              |
| DschWhTotRs                        | SPC               | T | (controllable) Operating with value true initiates the reset of the DschWhTot (Total Energy Discharged); operating with value false is ignored. The change of its status value is a local issue. | O / F              |
| <b>Settings</b>                    |                   |   |                                                                                                                                                                                                  |                    |

| DER_StorageLN    |                   |   |                                                                                                                                                       |              |
|------------------|-------------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Data object name | Common data class | T | Explanation                                                                                                                                           | PresConds/ds |
| EqGn             | ORG               |   | Reference to the equivalent DGEN instance reflecting the generation aspects of storage                                                                | O / F        |
| EqLod            | ORG               |   | Reference to the equivalent DLOD instance reflecting the load aspects of storage                                                                      | O / F        |
| SocHiAlsPct      | ASG               |   | High state of charge alarm threshold of the battery (in percent)                                                                                      | O / F        |
| SocHiWrsPct      | ASG               |   | Warning high state of charge threshold of the battery (in percent)                                                                                    | O / F        |
| SocLoAlsPct      | ASG               |   | Low state of charge alarm threshold of the battery (in percent)                                                                                       | O / F        |
| SocLoWrsPct      | ASG               |   | Warning state of charge threshold of the battery (in percent)                                                                                         | O / F        |
| SohLoAlsPct      | ASG               |   | Threshold alarm setting of the usable lower limit of the storage resource (in % of the usable capacity of the storage element (in Wh) – CapWhUserRtg) | O / F        |
| RntEffPct        | ASG               |   | Roundtrip efficiency [%] at nominal conditions                                                                                                        | O / F        |

#### 6.1.2.6 <<abstract>> LN: Storage Unit DER Name: StorageUnitLN

This abstract LN is part of the 90-9 namespace, and is reproduced here for information only.

#### 6.1.3 Logical Nodes from Group D (LNGroupD\_90\_9)

##### 6.1.3.1 General

Logical Nodes from Group D to be moved to the upcoming second edition of IEC 61850-7-420 as soon as this document is published.

##### 6.1.3.2 LN: Battery System Name: DBAT

This logical node contains information related to monitoring and controlling power battery bank states and measurements.

Table 20 shows all data objects of DBAT.

**Table 20 – Data objects of DBAT**

| DBAT               |                                |   |                                                                                                                                                       |                     |
|--------------------|--------------------------------|---|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| Data object name   | Common data class              | T | Explanation                                                                                                                                           | PresConds/ds        |
| Descriptions       |                                |   |                                                                                                                                                       |                     |
| EENam              | DPL                            |   | inherited from: ControlEquipmentInterfaceLN                                                                                                           | O / F               |
| NamPlt             | LPL                            |   | inherited from: DomainLN                                                                                                                              | MONamPlt / MONamPlt |
| Status information |                                |   |                                                                                                                                                       |                     |
| SocPro             | SPS                            |   | State of the SOC protection of the battery. If true, this internal protection is activated, otherwise the battery is running under normal conditions. | O / F               |
| ChaSt              | SPS                            |   | If true, battery is charging                                                                                                                          | O / F               |
| DschSt             | SPS                            |   | If true, battery is discharging                                                                                                                       | O / F               |
| BatTestRsl         | ENS<br>(BatteryTestResultKind) |   | Battery test results                                                                                                                                  | O / F               |

| DBAT                        |                         |   |                                                                                                                                                                                               |                       |
|-----------------------------|-------------------------|---|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Data object name            | Common data class       | T | Explanation                                                                                                                                                                                   | PresConds/ds          |
| DCSwCls                     | SPS                     |   | If true, the battery DC contactor (switch) is closed otherwise open.                                                                                                                          | O / F                 |
| EEHealth                    | ENS (HealthKind)        |   | inherited from: ControlEquipmentInterfaceLN                                                                                                                                                   | O / F                 |
| OpTmh                       | INS                     |   | inherited from: ControlEquipmentInterfaceLN                                                                                                                                                   | O / O                 |
| Loc                         | SPS                     |   | inherited from: ControllingLN                                                                                                                                                                 | O / F                 |
| LocKey                      | SPS                     |   | inherited from: ControllingLN                                                                                                                                                                 | OF(Loc) / F           |
| Blk                         | SPS                     |   | inherited from: FunctionLN                                                                                                                                                                    | O / F                 |
| ClcExp                      | SPS                     | T | inherited from: StatisticsLN                                                                                                                                                                  | O / O                 |
| ClcNxtTmms                  | INS                     |   | inherited from: StatisticsLN                                                                                                                                                                  | O / O                 |
| Beh                         | ENS (BehaviourModeKind) |   | inherited from: DomainLN                                                                                                                                                                      | M / M                 |
| Health                      | ENS (HealthKind)        |   | inherited from: DomainLN                                                                                                                                                                      | O / O                 |
| Mir                         | SPS                     |   | inherited from: DomainLN                                                                                                                                                                      | MOcond(1) / MOcond(1) |
| Measured and metered values |                         |   |                                                                                                                                                                                               |                       |
| Amp                         | MV                      |   | Battery drain DC current.                                                                                                                                                                     | O / O                 |
| Watt                        | MV                      |   | Battery DC watts                                                                                                                                                                              | O / O                 |
| ChaAmpLim                   | MV                      |   | Instantaneous DC current limit on charging                                                                                                                                                    | O / O                 |
| EffAhr                      | MV                      |   | Effective Ampere-hour operational value, including after degradation                                                                                                                          | O / O                 |
| ChaVolLim                   | MV                      |   | Instantaneous voltage limit on charging                                                                                                                                                       | O / O                 |
| DschAmpLim                  | MV                      |   | Instantaneous DC current limit on discharging                                                                                                                                                 | O / O                 |
| CelStrgCnt                  | MV                      |   | Number of strings of cells currently connected                                                                                                                                                | O / O                 |
| AvlChaAhr                   | MV                      |   | Available charge capacity: not yet stored and available for being charged in Amp-hours                                                                                                        | O / O                 |
| AvlDschAhr                  | MV                      |   | Available discharge capacity: stored and available for discharging in Amp-hours                                                                                                               | O / O                 |
| ChaAhrTot                   | MV                      |   | Total amount charged since last reset in Amp-hour                                                                                                                                             | O / O                 |
| DschAhrTot                  | MV                      |   | Total amount discharged since last reset in Amp-hour                                                                                                                                          | O / O                 |
| SocEffAhrPct                | MV                      |   | State of charge as percentage in relation to the effective energy capacity of the storage resource with respect to the degradation so far (EffAhr)                                            | O / O                 |
| SocDvPct                    | MV                      |   | State of charge deviation between calculated (estimated) value with direct measured (real) value (in %)                                                                                       | O / O                 |
| VolChgRte                   | MV                      |   | Rate of battery voltage change over time.                                                                                                                                                     | O / O                 |
| DschVolLim                  | MV                      |   | Instantaneous voltage limit on discharging                                                                                                                                                    | O / O                 |
| CycSocRngPct                | MV                      |   | Soc (in Amp-hour) range (in %) at last time of the operating substantial charge cycle, defined as "discharge and subsequent recharge of a cell or battery to restore the initial conditions". | O / O                 |
| CycAmpAv                    | MV                      |   | Average current during last operating substantial charge cycle, defined as "discharge and subsequent recharge of a cell or battery to restore the initial conditions".                        | O / O                 |
| Controls                    |                         |   |                                                                                                                                                                                               |                       |
| CmdBlk                      | SPC                     |   | inherited from: ControlledLN                                                                                                                                                                  | O / F                 |
| OpCntRs                     | INC                     |   | inherited from: ControlledLN                                                                                                                                                                  | O / O                 |

| DBAT             |                            |   |                                                              |                 |
|------------------|----------------------------|---|--------------------------------------------------------------|-----------------|
| Data object name | Common data class          | T | Explanation                                                  | PresConds/ds    |
| LocSta           | SPC                        |   | inherited from: ControllingLN                                | OF(Loc) / F     |
| ClcStr           | SPC                        |   | inherited from: StatisticsLN                                 | O / O           |
| Mod              | ENC<br>(BehaviourModeKind) |   | inherited from: DomainLN                                     | O / O           |
| Settings         |                            |   |                                                              |                 |
| BatTyp           | ENG (BatteryTypeKind)      |   | Type of battery                                              | M / F           |
| ChaAmpMaxRtg     | ASG                        |   | Maximum battery charge DC current rating                     | O / F           |
| AhrRtg           | ASG                        |   | Amp-hour capacity rating                                     | O / F           |
| EffAhrRtg        | ASG                        |   | Effective total charge capacity rating in Amp-hours          | O / F           |
| AhrMinRtg        | ASG                        |   | Minimum resting amp-hour capacity rating allowed             | O / F           |
| ChaVolMaxRtg     | ASG                        |   | Maximum battery charge voltage                               | O / F           |
| DschAmpMxRtg     | ASG                        |   | Maximum battery discharge DC current rating                  | O / F           |
| ExtVolMaxRtg     | ASG                        |   | Rating reflecting the maximum battery voltage while charging | O / F           |
| ExtVolNom        | ASG                        |   | Nominal external voltage of battery                          | O / F           |
| IntnVolNom       | ASG                        |   | Nominal internal voltage of battery (DC)                     | O / F           |
| IntnVNom         | ASG                        |   | Nominal internal voltage of the battery (non DC)             | O / F           |
| SelfDschWRte     | ASG                        |   | Self discharge power rate                                    | O / F           |
| CelParCnt        | ING                        |   | Number of cells in parallel                                  | O / F           |
| CelSerCnt        | ING                        |   | Number of cells in series                                    | O / F           |
| DschWattCrv      | CSG                        |   | Discharge curve                                              | O / F           |
| DschWattTm       | CSG                        |   | Discharge curve by time                                      | O / F           |
| BlkRef           | ORG                        |   | inherited from: FunctionLN                                   | Omulti / F      |
| ClcMth           | ENG (CalcMethodKind)       |   | inherited from: StatisticsLN                                 | O / M           |
| ClcMod           | ENG (CalcModeKind)         |   | inherited from: StatisticsLN                                 | O / O           |
| ClcIntvTyp       | ENG (CalcIntervalKind)     |   | inherited from: StatisticsLN                                 | O / O           |
| ClcIntvPer       | ING                        |   | inherited from: StatisticsLN                                 | O / O           |
| NumSubIntv       | ING                        |   | inherited from: StatisticsLN                                 | O / O           |
| ClcRfTyp         | ENG (CalcIntervalKind)     |   | inherited from: StatisticsLN                                 | O / O           |
| ClcRfPer         | ING                        |   | inherited from: StatisticsLN                                 | O / O           |
| ClcSrc           | ORG                        |   | inherited from: StatisticsLN                                 | F / M           |
| InSyn            | ORG                        |   | inherited from: StatisticsLN                                 | O / O           |
| InRef            | ORG                        |   | inherited from: DomainLN                                     | Omulti / Omulti |

### 6.1.3.3 LN: Energy storage Name: DSTO

This logical node contains information related to monitoring and controlling energy storage functions and states. It can apply to single element or to aggregated one.

Table 21 shows all data objects of DSTO.

**Table 21 – Data objects of DSTO**

| DSTO                        |                         |   |                                              |                       |
|-----------------------------|-------------------------|---|----------------------------------------------|-----------------------|
| Data object name            | Common data class       | T | Explanation                                  | PresConds/ds          |
| Descriptions                |                         |   |                                              |                       |
| EENam                       | DPL                     |   | inherited from: ControlEquipmentInterfaceLN  | O / F                 |
| NamPlt                      | LPL                     |   | inherited from: DomainLN                     | MONamPlt / MONamPlt   |
| Status information          |                         |   |                                              |                       |
| SocHiAlm                    | SPS                     |   | inherited from: DER_StorageLN                | O / F                 |
| SocHiWrn                    | SPS                     |   | inherited from: DER_StorageLN                | O / F                 |
| SocLoAlm                    | SPS                     |   | inherited from: DER_StorageLN                | O / F                 |
| SocLoWrn                    | SPS                     |   | inherited from: DER_StorageLN                | O / F                 |
| SohLoAlm                    | SPS                     |   | inherited from: DER_StorageLN                | O / F                 |
| ChaCycCnt                   | INS                     |   | inherited from: DER_StorageLN                | O / O                 |
| EEHealth                    | ENS (HealthKind)        |   | inherited from: ControlEquipmentInterfaceLN  | O / F                 |
| OpTmh                       | INS                     |   | inherited from: ControlEquipmentInterfaceLN  | O / O                 |
| Loc                         | SPS                     |   | inherited from: ControllingLN                | O / F                 |
| LocKey                      | SPS                     |   | inherited from: ControllingLN                | OF(Loc) / F           |
| Blk                         | SPS                     |   | inherited from: FunctionLN                   | O / F                 |
| ClcExp                      | SPS                     | T | inherited from: StatisticsLN                 | O / O                 |
| ClcNxtTmms                  | INS                     |   | inherited from: StatisticsLN                 | O / O                 |
| Beh                         | ENS (BehaviourModeKind) |   | inherited from: DomainLN                     | M / M                 |
| Health                      | ENS (HealthKind)        |   | inherited from: DomainLN                     | O / O                 |
| Mir                         | SPS                     |   | inherited from: DomainLN                     | MOcond(1) / MOcond(1) |
| Measured and metered values |                         |   |                                              |                       |
| InWh                        | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| OutWh                       | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| SocWh                       | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| UseSocPct                   | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| SocEffWhPct                 | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| ChaWhTot                    | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| DschWhTot                   | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| AvlDschW                    | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| AvlChaW                     | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| ChaVAPct                    | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| AvlChaWTm                   | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| AvlDschWTm                  | MV                      |   | inherited from: DER_StorageLN                | O / O                 |
| ChaAvarTot                  | MV                      |   | inherited from: StorageOperationalSettingsLN | O / O                 |
| DschAvarTot                 | MV                      |   | inherited from: StorageOperationalSettingsLN | O / O                 |
| ChalvarTot                  | MV                      |   | inherited from: StorageOperationalSettingsLN | O / O                 |
| DschIvarTot                 | MV                      |   | inherited from: StorageOperationalSettingsLN | O / O                 |
| ChaAvarAvl                  | MV                      |   | inherited from: StorageOperationalSettingsLN | O / O                 |
| DschAvarAvl                 | MV                      |   | inherited from: StorageOperationalSettingsLN | O / O                 |



| DSTO             |                                            |   |                                                                                                      |                   |
|------------------|--------------------------------------------|---|------------------------------------------------------------------------------------------------------|-------------------|
| Data object name | Common data class                          | T | Explanation                                                                                          | PresConds/ds      |
| ChalvarAvl       | MV                                         |   | inherited from: StorageOperationalSettingsLN                                                         | O / O             |
| DschlvarAvl      | MV                                         |   | inherited from: StorageOperationalSettingsLN                                                         | O / O             |
| EffWh            | MV                                         |   | inherited from: StorageOperationalSettingsLN                                                         | AtLeastOne(1) / O |
| EffWhPct         | MV                                         |   | inherited from: StorageOperationalSettingsLN                                                         | AtLeastOne(1) / O |
| SelfSvcWh        | MV                                         |   | inherited from: DER_ActualPowerInformationLN                                                         | O / O             |
| VAPct            | MV                                         |   | inherited from: DER_ActualPowerInformationLN                                                         | O / O             |
| AvlUpW           | MV                                         |   | inherited from: DER_ActualPowerInformationLN                                                         | O / O             |
| AvlDnW           | MV                                         |   | inherited from: DER_ActualPowerInformationLN                                                         | O / O             |
| Controls         |                                            |   |                                                                                                      |                   |
| ChaWhTotRs       | SPC                                        | T | inherited from: DER_StorageLN                                                                        | O / F             |
| DschWhTotRs      | SPC                                        | T | inherited from: DER_StorageLN                                                                        | O / F             |
| ChaVArSpt        | APC                                        |   | inherited from: Storage_Control_LN                                                                   | O / O             |
| ChaWSpt          | APC                                        |   | inherited from: Storage_Control_LN                                                                   | O / O             |
| DschVArSpt       | APC                                        |   | inherited from: Storage_Control_LN                                                                   | O / O             |
| DschWSpt         | APC                                        |   | inherited from: Storage_Control_LN                                                                   | O / O             |
| DEROpSt          | ENC (DERStateKind, DERStateTransitionKind) |   | inherited from: DER_StateAbstractLN                                                                  | M / F             |
| CeaEngzCtl       | SPC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / F             |
| WSpt             | APC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / O             |
| WSptAct          | SPC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / F             |
| VArSpt           | APC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / O             |
| VArSptAct        | SPC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / F             |
| AuthConn         | SPC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / F             |
| EmgMod           | SPC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / F             |
| AuthDscon        | SPC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / F             |
| DERTest          | SPC                                        |   | inherited from: DER_StateAbstractLN                                                                  | O / F             |
| CmdBlk           | SPC                                        |   | inherited from: ControlledLN                                                                         | O / F             |
| OpCntRs          | INC                                        |   | inherited from: ControlledLN                                                                         | O / O             |
| LocSta           | SPC                                        |   | inherited from: ControllingLN                                                                        | OF(Loc) / F       |
| ClcStr           | SPC                                        |   | inherited from: StatisticsLN                                                                         | O / O             |
| Mod              | ENC (BehaviourModeKind)                    |   | inherited from: DomainLN                                                                             | O / O             |
| Settings         |                                            |   |                                                                                                      |                   |
| EqSto            | ORG                                        |   | Reference to the equivalent DSTO instance reflecting the generic storage aspects of the storage unit | M / F             |
| InclSto          | ORG                                        |   | References to Included storage, which could be virtual, aggregated, or physical                      | Omulti / F        |
| DERUnit          | ORG                                        |   | Reference to the DER Unit LN which may be associated to this generic model LN                        | O / F             |
| EqGn             | ORG                                        |   | inherited from: DER_StorageLN                                                                        | O / F             |
| EqLod            | ORG                                        |   | inherited from: DER_StorageLN                                                                        | O / F             |
| SocHiAlsPct      | ASG                                        |   | inherited from: DER_StorageLN                                                                        | O / F             |

| DSTO             |                           |   |                                              |              |
|------------------|---------------------------|---|----------------------------------------------|--------------|
| Data object name | Common data class         | T | Explanation                                  | PresConds/ds |
| SocHiWrsPct      | ASG                       |   | inherited from: DER_StorageLN                | O / F        |
| SocLoAlsPct      | ASG                       |   | inherited from: DER_StorageLN                | O / F        |
| SocLoWrsPct      | ASG                       |   | inherited from: DER_StorageLN                | O / F        |
| SohLoAlsPct      | ASG                       |   | inherited from: DER_StorageLN                | O / F        |
| RntEffPct        | ASG                       |   | inherited from: DER_StorageLN                | O / F        |
| ChaWMaxRtg       | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschWMaxRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaWRmpRtg       | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschWRmpRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaWOvPFRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschWOvPFRtg     | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaWUnPFRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschWUnPFRtg     | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaVAMaxRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschVAMaxRtg     | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaAvarRtg       | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschAvarRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChalvarRtg       | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschIvarRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaVMaxRtg       | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschVMaxRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaVMinRtg       | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschVMinRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaAMaxRtg       | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschAMaxRtg      | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| WhRtg            | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| WhMaxRtg         | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| WhMinRtg         | ASG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaEfcRtg        | CSG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| DschEfcRtg       | CSG                       |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaSrcRtg        | ENG<br>(ChargeSourceKind) |   | inherited from: StorageNameplateRatingsLN    | O / F        |
| ChaWMax          | ASG                       |   | inherited from: StorageOperationalSettingsLN | M / F        |
| DschWMax         | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaWRmp          | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| DschWRmp         | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaVArMax        | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| DschVArMax       | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaVAMax         | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| DschVAMax        | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaAvarMax       | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| DschAvarMax      | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChalvarMax       | ASG                       |   | inherited from: StorageOperationalSettingsLN | O / F        |

| DSTO             |                               |   |                                              |              |
|------------------|-------------------------------|---|----------------------------------------------|--------------|
| Data object name | Common data class             | T | Explanation                                  | PresConds/ds |
| DschIvarMax      | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaVMax          | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| DschVMax         | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaVMin          | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| DschVMin         | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaAMax          | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| DschAMax         | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaEfc           | CSG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| DschEfc          | CSG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| UseWhMaxPct      | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| UseWhMinPct      | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| UseWh            | ASG                           |   | inherited from: StorageOperationalSettingsLN | O / F        |
| ChaSrc           | ENG<br>(ChargeSourceKind)     |   | inherited from: StorageOperationalSettingsLN | O / F        |
| StrMaxTms        | ING                           |   | inherited from: DER_StateAbstractLN          | O / F        |
| OffMinTms        | ING                           |   | inherited from: DER_StateAbstractLN          | O / F        |
| OnMinTms         | ING                           |   | inherited from: DER_StateAbstractLN          | O / F        |
| StopDlMinTms     | ING                           |   | inherited from: DER_StateAbstractLN          | O / F        |
| StopMaxTms       | ING                           |   | inherited from: DER_StateAbstractLN          | O / F        |
| StrDlMinTms      | ING                           |   | inherited from: DER_StateAbstractLN          | O / F        |
| AutoStr          | SPG                           |   | inherited from: DER_StateAbstractLN          | O / F        |
| AutoConn         | SPG                           |   | inherited from: DER_StateAbstractLN          | O / F        |
| PFSign           | ENG (PFSignKind)              |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| OpIPct           | ING                           |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| PFExtSet         | SPG                           |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| IsIdCtlFol       | SPG                           |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| ClcTotVA         | ENG<br>(STotalCalcMethodKind) |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| FIIBckBeh        | ENG<br>(FallbackBehaviorKind) |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| FIIBckTmExp      | ING                           |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| AvarZerWMax      | ASG                           |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| IvarZerWMax      | ASG                           |   | inherited from: DER_OperationalSettingsLN    | O / F        |
| EcpRef           | ORG                           |   | inherited from: DER_NameplateRatingsLN       | M / F        |
| EcpConnTyp       | ENG (ECPCConnKind)            |   | inherited from: DER_NameplateRatingsLN       | O / F        |
| PhsConnTyp       | ENG (PhaseKind)               |   | inherited from: DER_NameplateRatingsLN       | M / F        |
| DERTyp           | ENG (DERUnitKind)             |   | inherited from: DER_NameplateRatingsLN       | M / F        |
| OvPFRtg          | ASG                           |   | inherited from: DER_NameplateRatingsLN       | O / F        |
| UnPFRtg          | ASG                           |   | inherited from: DER_NameplateRatingsLN       | O / F        |
| TmpMaxRtg        | ASG                           |   | inherited from: DER_NameplateRatingsLN       | O / F        |
| FltRtgPct        | ASG                           |   | inherited from: DER_NameplateRatingsLN       | O / F        |
| GndReactRtg      | ASG                           |   | inherited from: DER_NameplateRatingsLN       | O / F        |

| DSTO             |                           |   |                                        |                 |
|------------------|---------------------------|---|----------------------------------------|-----------------|
| Data object name | Common data class         | T | Explanation                            | PresConds/ds    |
| FltAMaxRtg       | ASG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| SelfVRtg         | ASG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| FltDurMaxTms     | ING                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| SelfWRtg         | ASG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| SelfPFRtg        | ASG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| RvSeq            | SPG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| SelfVRngRtg      | ASG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| EfcRtgPct        | ASG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| GndRisRtg        | ASG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| SuscRtg          | ASG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| RegClas          | VSG                       |   | inherited from: DER_NameplateRatingsLN | O / F           |
| DERId            | VSG                       |   | inherited from: AllEnergyDEResourceLN  | Omulti / F      |
| BlkRef           | ORG                       |   | inherited from: FunctionLN             | Omulti / F      |
| ClcMth           | ENG<br>(CalcMethodKind)   |   | inherited from: StatisticsLN           | O / M           |
| ClcMod           | ENG (CalcModeKind)        |   | inherited from: StatisticsLN           | O / O           |
| ClcIntvTyp       | ENG<br>(CalcIntervalKind) |   | inherited from: StatisticsLN           | O / O           |
| ClcIntvPer       | ING                       |   | inherited from: StatisticsLN           | O / O           |
| NumSubIntv       | ING                       |   | inherited from: StatisticsLN           | O / O           |
| ClcRfTyp         | ENG<br>(CalcIntervalKind) |   | inherited from: StatisticsLN           | O / O           |
| ClcRfPer         | ING                       |   | inherited from: StatisticsLN           | O / O           |
| ClcSrc           | ORG                       |   | inherited from: StatisticsLN           | F / M           |
| InSyn            | ORG                       |   | inherited from: StatisticsLN           | O / O           |
| InRef            | ORG                       |   | inherited from: DomainLN               | Omulti / Omulti |

#### 6.1.4 Logical Nodes from Group S (LNGroupS\_90\_9)

##### 6.1.4.1 General

Logical Nodes from Group S to be moved to the upcoming second edition of IEC 61850-7-420 as soon as this document is published.

##### 6.1.4.2 LN: SBAT Extension Name: SBAT

This extension to the SBAT LN provides additional DOs for battery storage supervisory control.

Table 22 shows all data objects of SBAT.

**Table 22 – Data objects of SBAT**

| SBAT             |                   |   |                          |                        |
|------------------|-------------------|---|--------------------------|------------------------|
| Data object name | Common data class | T | Explanation              | PresConds/ds           |
| Descriptions     |                   |   |                          |                        |
| NamPlt           | LPL               |   | inherited from: DomainLN | MONamPlt /<br>MONamPlt |

| SBAT               |                   |   |                                                                                                                     |                |
|--------------------|-------------------|---|---------------------------------------------------------------------------------------------------------------------|----------------|
| Data object name   | Common data class | T | Explanation                                                                                                         | PresCondnds/ds |
| Status information |                   |   |                                                                                                                     |                |
| BatEF              | SPS               |   | If true, Battery Earth Fault is present                                                                             | O / F          |
| CelVolLoAlm        | SPS               |   | Alarm trigger status: If true, the minimum limit of cell voltage has been exceeded.                                 | O / F          |
| CelVolHiAlm        | SPS               |   | Alarm trigger status: If true, the maximum limit of cell voltage has been exceeded.                                 | O / F          |
| DschAmpHiAlm       | SPS               |   | Alarm trigger status: If true, the battery discharging current has exceeded the maximum threshold                   | O / F          |
| DschAmpHiWrn       | SPS               |   | Warning trigger status: if true, the warning current threshold during discharging of the battery has been exceeded  | O / F          |
| ChaAmpHiAlm        | SPS               |   | Alarm trigger status: if true, the maximum current threshold during charging of the battery has been exceeded       | O / F          |
| ChaAmpHiWrn        | SPS               |   | Warning trigger status: if true, the warning current threshold during charging of the battery has been exceeded     | O / F          |
| IntnTmpHiAlm       | SPS               |   | Alarm trigger status: if true, the maximum internal temperature threshold of the battery has been exceeded          | O / F          |
| IntnTmpHiWrn       | SPS               |   | Warning trigger status: if true, the high internal temperature warning threshold of the battery has been exceeded   | O / F          |
| IntnTmpLoAlm       | SPS               |   | Alarm trigger status: If true, the minimum internal temperature threshold of the battery has been exceeded          | O / F          |
| IntnTmpLoWrn       | SPS               |   | Warning trigger status: if true, the low internal temperature warning threshold of the battery has been exceeded    | O / F          |
| UnbTmpAlm          | SPS               |   | Alarm trigger status: if true, the imbalance temperature alarm threshold of the battery has been exceeded           | O / F          |
| UnbTmpWrn          | SPS               |   | Warning trigger status: if true, the imbalance temperature warning threshold of the battery has been exceeded       | O / F          |
| UnbVolAlm          | SPS               |   | Alarm trigger status: if true, the imbalance voltage alarm threshold of the battery/component has been exceeded     | O / F          |
| UnbVolWrn          | SPS               |   | Warning trigger status: if true, the imbalance voltage warning threshold of the battery/component has been exceeded | O / F          |
| ExtTmpHiAlm        | SPS               |   | Alarm trigger status: If true, the high level threshold of the temperature external to the battery has been reached | O / F          |
| ExtTmpLoAlm        | SPS               |   | Alarm trigger status: If true, the high level threshold of the temperature external to the battery has been reached | O / F          |
| ExtVolHiAlm        | SPS               |   | Alarm trigger status: if true, the high external voltage of the battery has been reached                            | O / F          |
| ExtVolLoAlm        | SPS               |   | Alarm trigger status: If true, the low level threshold of the external voltage of the battery has been reached      | O / F          |
| IntnVolHiAlm       | SPS               |   | Alarm trigger status: If true, the high level threshold of the internal voltage of the battery has been reached     | O / F          |
| IntnVolLoAlm       | SPS               |   | Alarm trigger status: If true, the low level threshold of the internal voltage of the battery has been reached      | O / F          |

| SBAT                        |                         |   |                                                                                                                                                                                                                                              |                       |
|-----------------------------|-------------------------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| Data object name            | Common data class       | T | Explanation                                                                                                                                                                                                                                  | PresConds/ds          |
| Blk                         | SPS                     |   | inherited from: FunctionLN                                                                                                                                                                                                                   | O / F                 |
| ClcExp                      | SPS                     | T | inherited from: StatisticsLN                                                                                                                                                                                                                 | O / O                 |
| ClcNxtTmms                  | INS                     |   | inherited from: StatisticsLN                                                                                                                                                                                                                 | O / O                 |
| Beh                         | ENS (BehaviourModeKind) |   | inherited from: DomainLN                                                                                                                                                                                                                     | M / M                 |
| Health                      | ENS (HealthKind)        |   | inherited from: DomainLN                                                                                                                                                                                                                     | O / O                 |
| Mir                         | SPS                     |   | inherited from: DomainLN                                                                                                                                                                                                                     | MOcond(1) / MOcond(1) |
| Measured and metered values |                         |   |                                                                                                                                                                                                                                              |                       |
| IntnA                       | MV                      |   | Internal Battery current (non DC)                                                                                                                                                                                                            | O / O                 |
| IntnV                       | MV                      |   | Internal battery voltage (non DC)                                                                                                                                                                                                            | O / O                 |
| CelVolLo                    | MV                      |   | Minimum cell voltage measurement of all cells since last reset                                                                                                                                                                               | O / O                 |
| CelVolHi                    | MV                      |   | Maximum cell voltage measurement of all cells since last reset                                                                                                                                                                               | O / O                 |
| CelTmpMax                   | MV                      |   | Maximum temperature of all cells in the battery                                                                                                                                                                                              | O / O                 |
| CelTmpMin                   | MV                      |   | Minimum temperature of all cells in the battery                                                                                                                                                                                              | O / O                 |
| IntnTmp                     | MV                      |   | Internal battery temperature in degrees C                                                                                                                                                                                                    | Omulti / O            |
| ExtTmp                      | MV                      |   | External battery temperature in degrees C                                                                                                                                                                                                    | O / O                 |
| ExtVol                      | MV                      |   | External battery DC voltage.                                                                                                                                                                                                                 | O / O                 |
| IntnVol                     | MV                      |   | Internal battery DC voltage.                                                                                                                                                                                                                 | O / O                 |
| Controls                    |                         |   |                                                                                                                                                                                                                                              |                       |
| CelVolRs                    | SPC                     | T | (controllable) if set to true, initiates the reset of the calculated minimum and maximum of battery cell voltage measurements (CelVolLo and CelVolHi). Control with value false is ignored. The change of its status value is a local issue. | O / F                 |
| OpCntRs                     | INC                     |   | inherited from: SupervisionLN                                                                                                                                                                                                                | O / O                 |
| ClcStr                      | SPC                     |   | inherited from: StatisticsLN                                                                                                                                                                                                                 | O / O                 |
| Mod                         | ENC (BehaviourModeKind) |   | inherited from: DomainLN                                                                                                                                                                                                                     | O / O                 |
| Settings                    |                         |   |                                                                                                                                                                                                                                              |                       |
| CelVolLoAls                 | ASG                     |   | Alarm threshold reflecting the minimum limit of voltage of a battery cell                                                                                                                                                                    | O / F                 |
| CelVolHiAls                 | ASG                     |   | Alarm threshold reflecting the maximum limit of voltage of a battery cell                                                                                                                                                                    | O / F                 |
| DschAmpHiAls                | ASG                     |   | High level discharging current threshold alarm setting                                                                                                                                                                                       | O / F                 |
| DschAmpHiWrs                | ASG                     |   | Warning threshold defining the high discharging current warning limit of the battery (in amps)                                                                                                                                               | O / F                 |
| ChaAmpHiAls                 | ASG                     |   | High charging current alarm threshold of the battery (in amps)                                                                                                                                                                               | O / F                 |
| ChaAmpHiWrs                 | ASG                     |   | Warning threshold defining the high charging current warning limit of the battery (in amps)                                                                                                                                                  | O / F                 |
| IntnTmpHiAls                | ASG                     |   | High internal temperature alarm threshold of the battery (in °C)                                                                                                                                                                             | O / F                 |
| IntnTmpHiWrs                | ASG                     |   | High internal temperature warning threshold of the battery (in °C)                                                                                                                                                                           | O / F                 |
| IntnTmpLoAls                | ASG                     |   | Low internal temperature alarm threshold of the battery (in °C)                                                                                                                                                                              | O / F                 |

| SBAT             |                        |   |                                                                                                                                                          |                 |
|------------------|------------------------|---|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Data object name | Common data class      | T | Explanation                                                                                                                                              | PresConds/ds    |
| IntnTmpLoWrs     | ASG                    |   | Low internal temperature warning threshold of the battery (in °C)                                                                                        | O / F           |
| UnbTmpAls        | ASG                    |   | Alarm threshold defining the difference limit of the imbalance of temperature of the battery component e.g. module, bank, pack, string or cell (in °C)   | O / F           |
| UnbTmpWrs        | ASG                    |   | Warning threshold defining the difference limit of the imbalance of temperature of the battery component e.g. module, bank, pack, string or cell (in °C) | O / F           |
| UnbVolAls        | ASG                    |   | Alarm threshold defining the difference limit of the imbalance of voltage of the battery component e.g. module, bank, pack, string or cell               | O / F           |
| UnbVolWrs        | ASG                    |   | Warning threshold defining the difference limit of the imbalance of voltage of the battery component e.g. module, bank, pack, string or cell             | O / F           |
| ExtTmpHiAls      | ASG                    |   | High temperature external to battery alarm threshold.                                                                                                    | O / F           |
| ExtTmpLoAls      | ASG                    |   | Low temperature external to battery alarm threshold.                                                                                                     | O / F           |
| ExtVolHiAls      | ASG                    |   | High level battery external voltage threshold alarm setting.                                                                                             | O / F           |
| ExtVolLoAls      | ASG                    |   | Low battery external voltage threshold alarm setting.                                                                                                    | O / F           |
| IntnVolMxLim     | ASG                    |   | Internal instantaneous (duration up to implementation) maximum (DC) voltage limit                                                                        | O / F           |
| IntnVolMnLim     | ASG                    |   | Internal instantaneous (duration up to implementation) minimum (DC) voltage limit                                                                        | O / F           |
| IntnVolHiAls     | ASG                    |   | High level battery internal voltage alarm threshold.                                                                                                     | O / F           |
| IntnVolLoAls     | ASG                    |   | Low level battery internal voltage alarm threshold.                                                                                                      | O / F           |
| BlkRef           | ORG                    |   | inherited from: FunctionLN                                                                                                                               | Omulti / F      |
| ClcMth           | ENG (CalcMethodKind)   |   | inherited from: StatisticsLN                                                                                                                             | O / M           |
| ClcMod           | ENG (CalcModeKind)     |   | inherited from: StatisticsLN                                                                                                                             | O / O           |
| ClcIntvTyp       | ENG (CalcIntervalKind) |   | inherited from: StatisticsLN                                                                                                                             | O / O           |
| ClcIntvPer       | ING                    |   | inherited from: StatisticsLN                                                                                                                             | O / O           |
| NumSubIntv       | ING                    |   | inherited from: StatisticsLN                                                                                                                             | O / O           |
| ClcRfTyp         | ENG (CalcIntervalKind) |   | inherited from: StatisticsLN                                                                                                                             | O / O           |
| ClcRfPer         | ING                    |   | inherited from: StatisticsLN                                                                                                                             | O / O           |
| ClcSrc           | ORG                    |   | inherited from: StatisticsLN                                                                                                                             | F / M           |
| InSyn            | ORG                    |   | inherited from: StatisticsLN                                                                                                                             | O / O           |
| InRef            | ORG                    |   | inherited from: DomainLN                                                                                                                                 | Omulti / Omulti |

## 6.2 Enumerations

### 6.2.1 General

To be moved to the upcoming second edition of IEC 61850-420 as soon as this document is published.

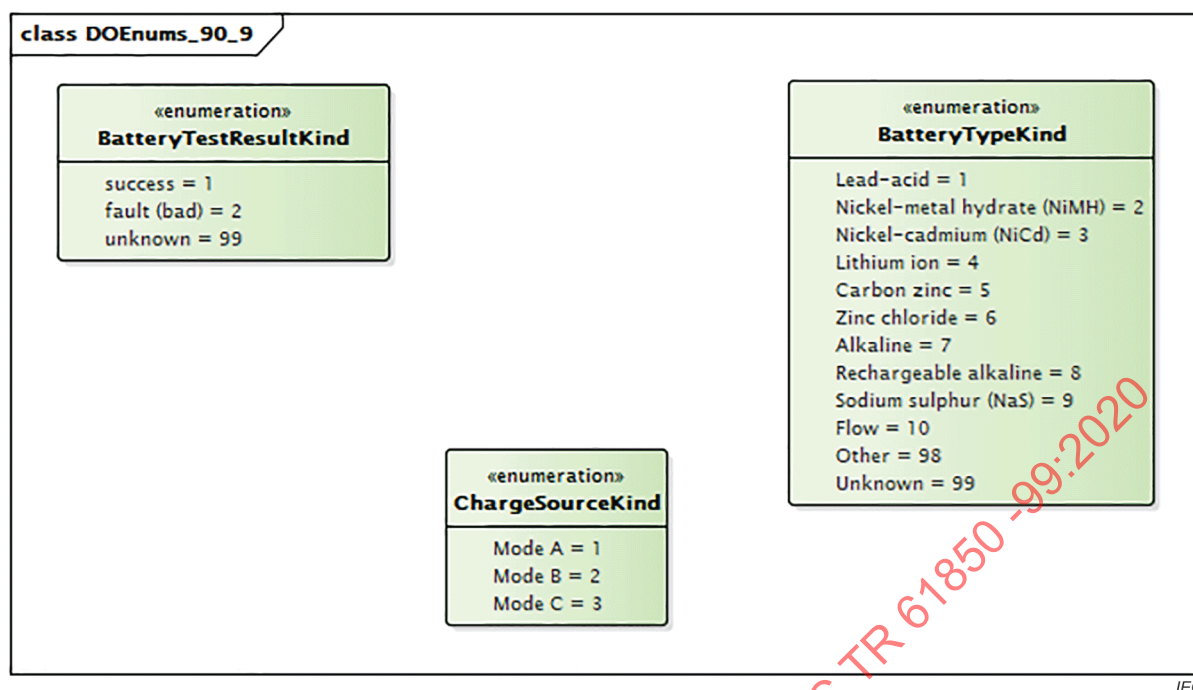


Figure 28 – Class diagram DOEnums\_90\_9::DOEnums\_90\_9

Figure 28: List of Enumerations

### 6.2.2 Battery Test Results (BatteryTestResultKind)

This enumeration lists the type of Battery Test Result (according to IEC 61850-7-420). Used in logical node DBAT.

Table 23 shows all enumeration items of BatteryTestResultKind.

Table 23 – Literals of BatteryTestResultKind

| BatteryTestResultKind |       |             |
|-----------------------|-------|-------------|
| enumeration item      | value | description |
| success               | 1     |             |
| fault (bad)           | 2     |             |
| unknown               | 99    |             |

### 6.2.3 Type of Battery (BatteryTypeKind)

This enumeration lists the type of Battery (according to IEC 61850-7-420)

Table 24 shows all enumeration items of BatteryTypeKind.



**Table 24 – Literals of BatteryTypeKind**

| BatteryTypeKind             |       |                                     |
|-----------------------------|-------|-------------------------------------|
| enumeration item            | value | description                         |
| Lead-acid                   | 1     | Lead-acid type Battery              |
| Nickel-metal hydrate (NiMH) | 2     | Nickel-metal hydrate (NiMH) Battery |
| Nickel-cadmium (NiCd)       | 3     | Nickel-cadmium (NiCd) Battery       |
| Lithium ion                 | 4     | Lithium ion Battery                 |
| Carbon zinc                 | 5     | Carbon zinc Battery                 |
| Zinc chloride               | 6     | Zinc chloride Battery               |
| Alkaline                    | 7     | Alkaline Battery                    |
| Rechargeable alkaline       | 8     | Rechargeable alkaline battery       |
| Sodium sulphur (NaS)        | 9     |                                     |
| Flow                        | 10    |                                     |
| Other                       | 98    | Other type of Battery               |
| Unknown                     | 99    |                                     |

#### 6.2.4 Storage charging/discharging permissions (ChargeSourceKind)

This enumeration lists the storage charging/discharging permissions

Table 25 shows all enumeration items of ChargeSourceKind.

**Table 25 – Literals of ChargeSourceKind**

| ChargeSourceKind |       |                                                    |
|------------------|-------|----------------------------------------------------|
| enumeration item | value | description                                        |
| Mode A           | 1     | Storage may not export to grid, but may charge     |
| Mode B           | 2     | Storage may export to grid, but not charge         |
| Mode C           | 3     | Storage may both charge or discharge from the grid |

<CODE ENDS>

## Annex A (informative)

### Concrete case 1&2: YSCP (Yokohama Smart City Project) DER MS (Battery SCADA) system use cases

#### A.1 System use cases #1: Online power system control with aggregated battery based EESS (virtual energy storage)

##### A.1.1 Descriptions of function

###### A.1.1.1 General

This use case describes interactions between Grid operator, grid EMS, DER MS(Battery SCADA), DER MS Operator(Battery SCADA operator) and Battery-based EESS during online power system control by battery aggregation. Battery SCADA controls many Battery-based EESS as a virtual battery.

###### A.1.1.2 Function name

Online power system control by battery aggregation.

###### A.1.1.3 Brief description

It is expected that many batteries will be deployed in smart grid near the future. Then the control technology for aggregated batteries will become important. Two scenarios that contain batteries aggregation control function are introduced in this use case.

The first scenario: Load Frequency Control by Aggregated Battery-based EESS (Virtual Energy Storage)

The second scenario: Reserve Margin by Aggregated Battery-based EESS (Virtual Energy Storage)

###### A.1.1.4 Narrative

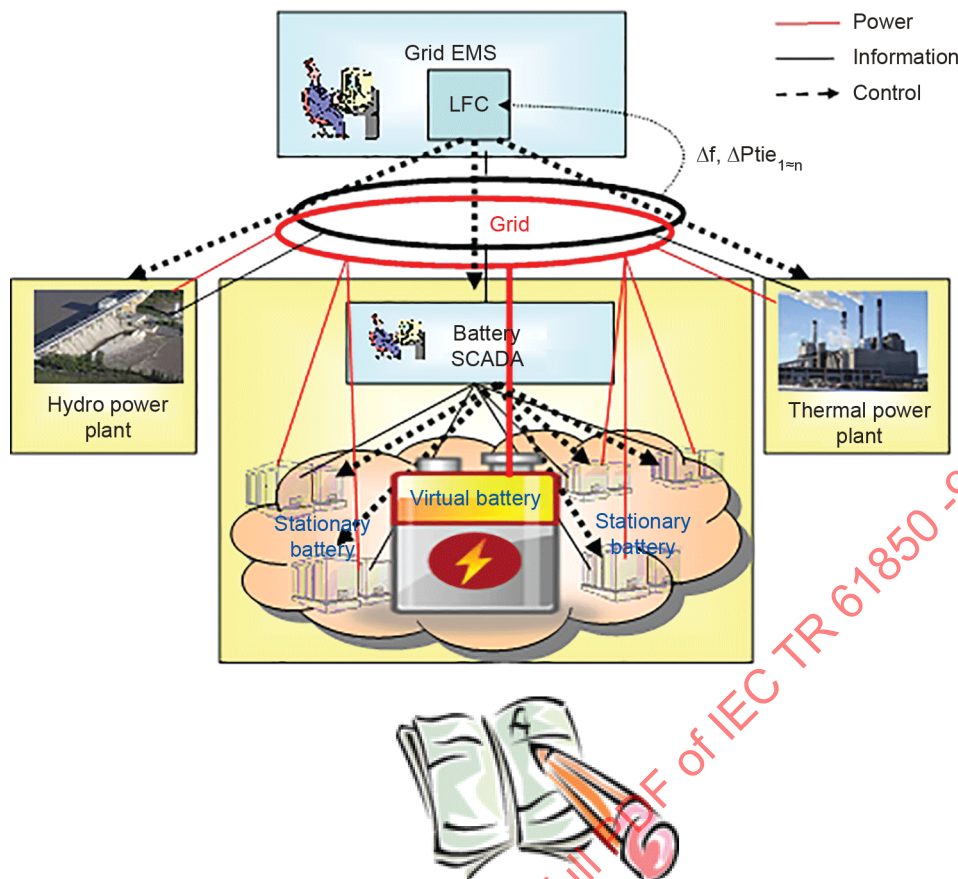
###### A.1.1.4.1 Overview of functions

Online power system control by Aggregated Battery-based EESS consists of two sub-functions and are described in this subclause

- Load Frequency Control by Aggregated Battery-based EESS (Virtual Energy Storage)
- Reserve Margin by Aggregated Battery-based EESS (Virtual Energy Storage)

###### A.1.1.4.2 Load frequency control by aggregated battery-based EESS (virtual energy storage)

Figure A.1 shows the overview of Load Frequency Control by Battery Aggregation function.



**Figure A.1 – Load Frequency control by battery aggregation**

Load Frequency Control (LFC) by aggregated battery-based EESS is as follows.

- 1) LFC enables a Grid operator to specify the total capacity of batteries for LFC.
- 2) LFC enables a DER MS (battery SCADA) operator to determine battery-based EESS to be used for LFC.
- 3) The Grid EMS calculates control value to be controlled by DER MS (battery SCADA) and sends it to the DER MS (battery SCADA).
- 4) DER MS (battery SCADA) receives control value and calculates charging/discharging control value for each battery-based EESS. Then DER MS (battery SCADA) sends it to each Battery-based EESS.
- 5) Each battery-based EESS receives charging/discharging control value from DER MS (battery SCADA) and charges or discharges according to charging/discharging control value. It also sends current status such as active power and SOC of each battery-based EESS to DER MS (battery SCADA).
- 6) Receiving active power and SOC of each battery-based EESS, DER MS (battery SCADA) calculates the total output power, total output upper limit and total output lower limit of battery-based EESS for LFC, then it sends them to the Grid EMS.
- 7) LFC enables a Grid operator to display the total output power, total output upper limit and total output lower limit of battery-based EESS for LFC as if a grid operator has a virtual battery for LFC.

#### **A.1.1.4.3 Reserve margin by aggregated battery-based EESS (virtual energy storage)**

Reserve margin by aggregated battery-based EESS (RMBA) is as follows

- 1) RMBA enables a Grid operator to specify the total capacity of batteries for RMBA.

- 2) RMBA enables a DER MS (Battery SCADA) operator to determine battery-based EESS to be used for RMBA.
- 3) RMBA controls battery-based EESS to charge for RMBA.
- 4) RMBA enables a grid operator to command battery-based EESS that are charged for RMBA to discharge.
- 5) RMBA enables a Grid operator to display the total output power of battery-based EESS as if a grid operator has a virtual battery for RMBA.

#### A.1.1.5 Actor (stakeholder) roles

Figure A.2 depicts the actors and their relationships.

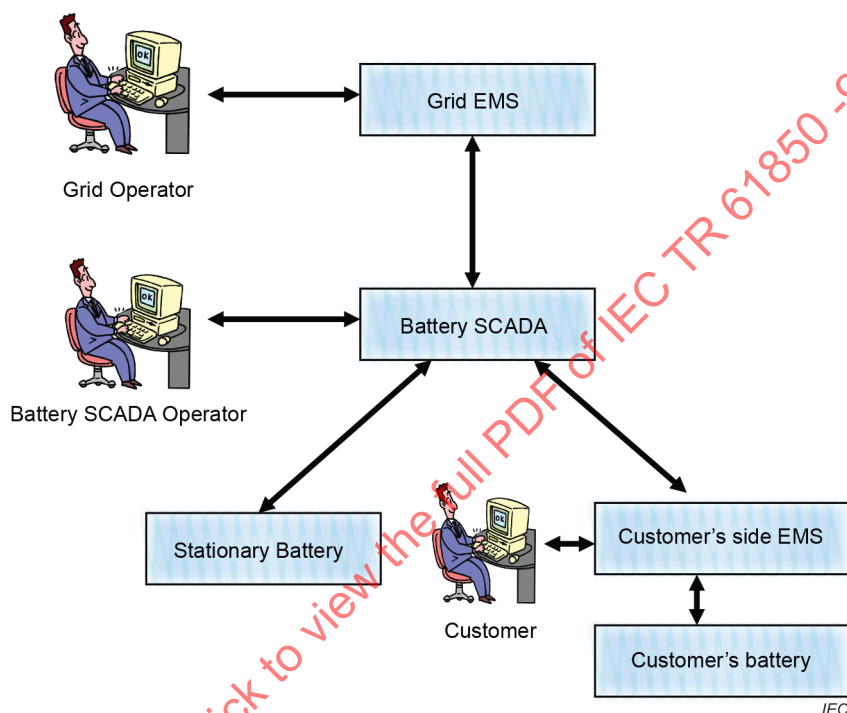


Figure A.2 – Actors

| Grouping (community)            |                                                                 | Group description                                                                                                                                                                                                                                    |
|---------------------------------|-----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Actors inside of Smart Grid     |                                                                 | Actors that perform their specific function inside of Smart Grid                                                                                                                                                                                     |
| Actor name                      | Actor type (person, organization, device, system, or subsystem) | Actor description                                                                                                                                                                                                                                    |
| Grid EMS                        | System                                                          | LFC function of Grid EMS controls generators to maintain Grid frequency.<br>In case of emergency, Grid EMS sends discharging command to Battery-based EESS via DER MS (Battery SCADA).<br>Grid EMS provides man-machine interface for Grid operator. |
| Grid Operator                   | Person                                                          | Grid Operator monitors and controls grid frequency.<br>Grid operator specifies the total capacity of Battery-based EESS for Load Frequency Control, and for RMBA.                                                                                    |
| DER MS (Battery SCADA)          | System                                                          | DER MS (Battery SCADA) controls Battery-based EESS to charge/discharge according to the LFC control value sent from grid EMS.<br>DER MS (Battery SCADA) provides man-machine interface for DER MS (Battery SCADA) operator.                          |
| DER MS (Battery SCADA) Operator | Person                                                          | DER MS (Battery SCADA) operator monitors and controls the Battery-based EESS via DER MS (Battery SCADA).<br>DER MS (Battery SCADA) operator specifies the Battery-based EESS for LFC, and RMBA.                                                      |
| Battery-based EESS              | Device                                                          | Battery-based EESS charges or discharges according to the control signal from DER MS (Battery SCADA).                                                                                                                                                |

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### A.1.1.6 Information exchanged

| Information object name                                       | Information object description                                                                                                                                                                                                |
|---------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The total capacity of Battery-based EESS for LFC              | This is a total capacity of Battery-based EESS that Load Frequency Control (LFC) function able to use.                                                                                                                        |
| Battery-based EESS for LFC                                    | This information specifies the Battery-based EESS that LFC function able to use.                                                                                                                                              |
| The total capacity of Battery-based EESS for RMBA.            | This is a total capacity of Battery-based EESS that RMBA function able to use.                                                                                                                                                |
| Battery-based EESS for RMBA.                                  | This information specifies the Battery-based EESS that RMBA function able to use.                                                                                                                                             |
| Grid data                                                     | Grid data consists of $\Delta f$ and $P_{tie}$ . Using this data, Grid EMS calculates control value for generators and DER MS (Battery SCADA). Where $\Delta f$ is deviation of frequency and $P_{tie}$ is the tie line flow. |
| LFC control value                                             | This information is the value to be controlled by DER MS (Battery SCADA). This value is calculated by Grid EMS.                                                                                                               |
| Current value of each Battery-based EESS                      | Current value of each Battery-based EESS includes the active power and SOC of each Battery-based EESS.                                                                                                                        |
| Charging/Discharging command                                  | This is a command for the Battery-based EESS. Upon receiving this command, the Battery-based EESS charges or discharges.                                                                                                      |
| Current status of virtual battery for LFC                     | Current status of Virtual Battery for LFC includes the total active power, the total output upper limit and the total output lower limit of all Battery-based EESS for LFC.                                                   |
| Current status of virtual battery for RMBA                    | Current status of virtual battery for RMBA includes the total output power and the total output upper limit of all Battery-based EESS for RMBA.                                                                               |
| Display Request of Current status of virtual battery for LFC  | This is an operator request to display the current status of virtual battery for LFC.                                                                                                                                         |
| Display Request of Current status of virtual battery for RMBA | This is an operator request to display the current status of virtual battery for RMBA.                                                                                                                                        |
| Activation Operation Command of using reserve margin          | This is a command to activate operation of using reserved margin                                                                                                                                                              |

### A.1.2 Step by step analysis of function

#### A.1.2.1 Steps to implement function – Load frequency control by aggregated battery-based EESS (virtual energy storage)

##### A.1.2.1.1 Preconditions and assumptions

| Actor/system/information/contract | Preconditions or assumptions                                                                                                                                     |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Grid Operator                     | Grid Operator is monitoring Grid frequency.<br>Grid Operator is going to specify the total capacity of batteries for LFC.                                        |
| Grid EMS                          | LFC Function installed in Grid EMS is controlling generators and Battery-based EESS via DER MS (Battery SCADA).                                                  |
| DER MS (Battery SCADA) operator   | DER MS (Battery SCADA) Operator is monitoring Battery-based EESS for LFC.<br>DER MS (Battery SCADA) Operator is going to specify the Battery-based EESS for LFC. |
| DER MS (Battery SCADA)            | DER MS (Battery SCADA) controls Battery-based EESS for LFC.                                                                                                      |
| Battery-based EESS                | Battery-based EESS are controlled by DER MS (Battery SCADA).                                                                                                     |

### A.1.2.1.2 Steps – Load frequency control by aggregated battery-based EESS (virtual energy storage)

| #     | Event                                                            | Primary actor                   | Name of process/activity                           | Description of process/activity                                                  | Information producer            | Information receiver            | Name of info exchanged                                     | Additional notes | IECSA environment |
|-------|------------------------------------------------------------------|---------------------------------|----------------------------------------------------|----------------------------------------------------------------------------------|---------------------------------|---------------------------------|------------------------------------------------------------|------------------|-------------------|
| 1.1.1 | At the time for LFC capacity preparation work                    | Grid Operator                   | Specifying the total Capacity of batteries for LFC | Grid operator specifies the total Capacity of batteries for LFC                  | Grid Operator                   | Grid EMS                        | The total capacity of Battery-based EESS for LFC.          |                  |                   |
| 1.1.2 | Completion of capacity specifying                                | Grid EMS                        | Sending the total Capacity of batteries for LFC    | Grid EMS sends the total Capacity of batteries for LFC to DER MS (Battery SCADA) | Grid EMS                        | DER MS (Battery SCADA)          | The total capacity of Battery-based EESS for LFC.          |                  |                   |
| 1.1.3 | Upon receiving the total capacity of Battery-based EESS for LFC  | DER MS (Battery SCADA)          | Displaying the total Capacity of batteries for LFC | DER MS (Battery SCADA) displays the total Capacity of batteries for LFC          | DER MS (Battery SCADA)          | DER MS (Battery SCADA) Operator | The total capacity of Battery-based EESS for LFC function. |                  |                   |
| 1.1.4 | Upon displaying the total capacity of Battery-based EESS for LFC | DER MS (Battery SCADA) Operator | Specifying the Battery-based EESS for LFC          | DER MS (Battery SCADA) operator specifies the Battery-based EESS for LFC         | DER MS (Battery SCADA) Operator | DER MS (Battery SCADA)          | Battery-based EESS for LFC                                 |                  |                   |
| 1.1.5 | Completion of specifying the Battery-based EESS for LFC          | DER MS (Battery SCADA)          | Recording the Battery-based EESS for LFC           | DER MS (Battery SCADA) records the Battery-based EESS for LFC                    | DER MS (Battery SCADA)          | DER MS (Battery SCADA)          | Battery-based EESS for LFC                                 |                  |                   |
| 1.2.1 | Every 1 second                                                   | Grid EMS                        | Collecting grid data                               | Grid EMS collects grid frequency and tie line flows                              | Grid                            | Grid EMS                        | Grid data                                                  |                  |                   |
| 1.2.2 | Completion of collecting grid data                               | Grid EMS                        | Calculation of LFC control value                   | Grid EMS calculates control value to maintain Grid frequency                     | Grid EMS                        | Grid EMS                        | LFC control value                                          |                  |                   |

| #     | Event                                                              | Primary actor          | Name of process/activity                                | Description of process/activity                                                                              | Information producer   | Information receiver   | Name of info exchanged                   | Additional notes | IECSA environment |
|-------|--------------------------------------------------------------------|------------------------|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|------------------------|------------------------|------------------------------------------|------------------|-------------------|
| 1.2.3 | Completion of Calculating LFC control value                        | Grid EMS               | Sending LFC control value                               | Grid EMS sends Load Frequency Control to DER MS (Battery SCADA)                                              | Grid EMS               | DER MS (Battery SCADA) | LFC control value                        |                  |                   |
| 1.2.4 | Upon receiving LFC control value                                   | DER MS (Battery SCADA) | Calculating charging/discharging command                | DER MS (Battery SCADA) calculating charging/discharging command for each Battery-based EESS                  | DER MS (Battery SCADA) | DER MS (Battery SCADA) | Charging/discharging command             |                  |                   |
| 1.2.5 | Completion of calculating charging/discharging command             | DER MS (Battery SCADA) | Sending charging/discharging command                    | DER MS (Battery SCADA) sends charging/discharging command to each Battery-based EESS                         | DER MS (Battery SCADA) | Battery-based EESS     | Charging/discharging command             |                  |                   |
| 1.2.6 | Upon receiving charging/discharging command                        | Battery-based EESS     | Charging/Discharging<br>Sending current value           | Battery-based EESS charges or discharges<br>Battery-based EESS sends current value to DER MS (Battery SCADA) | Battery-based EESS     | DER MS (Battery SCADA) | Current value of each Battery-based EESS |                  |                   |
| 1.2.7 | Upon receiving current value of each Battery-based EESS            | DER MS (Battery SCADA) | Calculation of current value of Virtual Battery for LFC | DER MS (Battery SCADA) calculates current value of Virtual Battery for LFC                                   | DER MS (Battery SCADA) | DER MS (Battery SCADA) | Current value of Virtual Battery for LFC |                  |                   |
| 1.2.8 | Completion of calculation current value of Virtual Battery for LFC | DER MS (Battery SCADA) | Sending Virtual Battery for LFC                         | DER MS (Battery SCADA) sends current value of Virtual Battery for LFC to Grid EMS                            | DER MS (Battery SCADA) | Grid EMS               | Current value of Virtual Battery for LFC |                  |                   |



| #        | Event                                                   | Primary actor | Name of process/ activity                                       | Description of process/ activity                                            | Information producer | Information receiver | Name of info exchanged                                       | Additional notes | IECSA environment |
|----------|---------------------------------------------------------|---------------|-----------------------------------------------------------------|-----------------------------------------------------------------------------|----------------------|----------------------|--------------------------------------------------------------|------------------|-------------------|
| 1.2.9    | Upon receiving Current value of Virtual Battery for LFC | Grid EMS      | Recording Current value of Virtual Battery for LFC              | Grid EMS records Current value of Virtual Battery for LFC                   | Grid EMS             | Grid EMS             | Current value of Virtual Battery for LFC                     |                  |                   |
| 1.2.10.1 | Upon operator request                                   | Grid Operator | Requesting display of Current status of Virtual battery for LFC | Grid Operator requests display of Current status of Virtual battery for LFC | Grid Operator        | Grid EMS             | Display Request of Current status of Virtual battery for LFC |                  |                   |
| 1.2.10.2 | Receiving display request                               | Grid EMS      | Displaying Current status of Virtual battery for LFC            | Grid EMS displays Current status of Virtual battery for LFC                 | Grid EMS             | Grid Operator        | Current status of Virtual battery for LFC                    |                  |                   |

### A.1.2.1.3 Post-conditions and significant results

| Actor/system/information/contract | Preconditions or assumptions                                                                                           |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Grid Operator                     | Grid Operator continues to monitor the Grid frequency.                                                                 |
| Grid EMS                          | LFC Function installed in Grid EMS continues to control generators and Battery-based EESS via DER MS (Battery SCADA).  |
| DER MS (Battery SCADA) Operator   | DER MS (Battery SCADA) Operator continues to monitor Battery-based EESS for LFC.                                       |
| DER MS (Battery SCADA)            | DER MS (Battery SCADA) continues to receive LFC control value from Grid EMS and to control Battery-based EESS for LFC. |
| Battery-based EESS                | Battery-based EESS continues to charge/discharge according to the command from DER MS (Battery SCADA).                 |

### A.1.2.2 Steps to implement function –Reserve margin by aggregated battery-based EESS (virtual energy storage)

#### A.1.2.2.1 Preconditions and assumptions

| Actor/system/information/contract | Preconditions or assumptions                                                         |
|-----------------------------------|--------------------------------------------------------------------------------------|
| Grid Operator                     | Grid Operator is going to specify the total capacity of batteries for RMBA.          |
| Grid EMS                          | Grid EMS does not control Battery-based EESS via DER MS (Battery SCADA).             |
| DER MS (Battery SCADA) operator   | DER MS (Battery SCADA) Operator is going to specify the Battery-based EESS for RMBA. |
| DER MS (Battery SCADA)            | DER MS (Battery SCADA) does not control Battery-based EESS.                          |
| Battery-based EESS                | Battery-based EESS are controllable but not controlled.                              |

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### A.1.2.2.2 Steps – Reserve margin by aggregated battery-based EESS (virtual energy storage)

| #     | Event                                                                        | Primary actor                   | Name of process/activity                                        | Description of process/activity                                                            | Information producer            | Information receiver            | Name of info exchanged                             | Additional notes | IECSA environment |
|-------|------------------------------------------------------------------------------|---------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|----------------------------------------------------|------------------|-------------------|
| 2.1.1 | At the starting time of Reserve Margin preparation                           | Grid Operator                   | Specifying the capacity of reserve margin of Battery-based EESS | Grid Operator specifies the capacity of reserve margin of Battery-based EESS               | Grid Operator                   | Grid EMS                        | The total capacity of Battery-based EESS for RMBA. |                  |                   |
| 2.1.2 | Completion of specifying the total capacity of Battery-based EESS for RMBA.y | Grid EMS                        | Sending the total capacity of Battery-based EESS for RMBA.      | Grid EMS sends the total capacity of Battery-based EESS for RMBA to DER MS (Battery SCADA) | Grid EMS                        | DER MS (Battery SCADA)          | The total capacity of Battery-based EESS for RMBA. |                  |                   |
| 2.1.3 | Upon receiving the total capacity of Battery-based EESS for RMBA.            | DER MS (Battery SCADA)          | Displaying the total capacity of Battery-based EESS for RMBA.   | DER MS (Battery SCADA) displays the total capacity of Battery-based EESS for RMBA.         | DER MS (Battery SCADA)          | DER MS (Battery SCADA) Operator | The total capacity of Battery-based EESS for RMBA. |                  |                   |
| 2.1.4 | Completion of Displaying the total capacity of Battery-based EESS for RMBA.  | DER MS (Battery SCADA) Operator | Specifying the Battery-based EESS for RMBA                      | DER MS (Battery SCADA) operator specifies the Battery-based EESS for RMBA                  | DER MS (Battery SCADA) Operator | DER MS (Battery SCADA)          | The Battery-based EESS for RMBA                    |                  |                   |
| 2.1.5 | Completion of specifying the Battery-based EESS for RMBA                     | DER MS (Battery SCADA)          | Sending charging/discharging command                            | DER MS (Battery SCADA) Sending charging/discharging command to Battery-based EESS for RMBA | DER MS (Battery SCADA)          | Battery-based EESS              | Charging/discharging command                       |                  |                   |
| 2.1.6 | Upon Receiving Charging/discharging command                                  | Battery-based EESS              | Charging or discharging<br>Sending current value                | Battery-based EESS charges or discharges and sends current value                           | Battery-based EESS              | DER MS (Battery SCADA)          | Current value of each Battery-based EESS           |                  |                   |

| #        | Event                                                                  | Primary actor          | Name of process/activity                                         | Description of process/activity                                                        | Information producer   | Information receiver   | Name of info exchanged                                        | Additional notes | IECSA environment |
|----------|------------------------------------------------------------------------|------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------------------|------------------------|------------------------|---------------------------------------------------------------|------------------|-------------------|
| 2.1.7    | Upon receiving current value                                           | DER MS (Battery SCADA) | Calculation of current value of Virtual Battery for RMBA         | DER MS (Battery SCADA) calculates current value of Virtual Battery for RMBA            | DER MS (Battery SCADA) | DER MS (Battery SCADA) | Current value of Virtual Battery for RMBA                     |                  |                   |
| 2.1.8    | Completion of calculation current value of Virtual Battery for RMBA    | DER MS (Battery SCADA) | Sending Virtual Battery for RMBA                                 | DER MS (Battery SCADA) sends current value of Virtual Battery for RMBA to Grid EMS     | DER MS (Battery SCADA) | Grid EMS               | Current value of Virtual Battery for RMBA                     |                  |                   |
| 2.1.9    | Upon receiving Current value of Virtual Battery for RMBA               | Grid EMS               | Recording Current value of Virtual Battery for RMBA              | Grid EMS records Current value of Virtual Battery for RMBA                             | Grid EMS               | Grid EMS               | Current value of Virtual Battery for RMBA                     |                  |                   |
| 2.1.10.1 | Upon operator request                                                  | Grid Operator          | Requesting display of Current status of Virtual battery for RMBA | Grid Operator requests display of virtual battery for RMBA                             | Grid Operator          | Grid EMS               | Display Request of Current status of Virtual battery for RMBA |                  |                   |
| 2.1.10.2 | Receiving display request                                              | Grid EMS               | Displaying Current status of Virtual battery for RMBA            | Grid EMS displays Current status of Virtual battery for RMBA                           | Grid EMS               | Grid Operator          | Current status of Virtual battery for RMBA                    |                  |                   |
| 2.2.1    | At the time of grid event occurs, Grid operator decides to use reserve | Power Grid             | Activating operation of using reserve margin                     | Grid Operator commands Grid EMS to activate reserve operation                          | Grid Operator          | Grid EMS               | Activation Operation Command of using reserve margin          |                  |                   |
| 2.2.2    | Upon receiving Activation Operation Command of using reserve margin    | Grid EMS               | Sending activation Operation command of using reserve margin     | Grid EMS Sends activation Operation command of using reserve to DER MS (Battery SCADA) | Grid EMS               | DER MS (Battery SCADA) | Activation Operation Command of using reserve margin          |                  |                   |

| #       | Event                                                               | Primary actor          | Name of process/activity                                                                                    | Description of process/activity                                                                                                                | Information producer   | Information receiver   | Name of info exchanged                                                                  | Additional notes | IECSA environment |
|---------|---------------------------------------------------------------------|------------------------|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------------------|-----------------------------------------------------------------------------------------|------------------|-------------------|
| 2.2.3   | Upon receiving Activation Operation Command of using reserve margin | DER MS (Battery SCADA) | Sending discharging command and discharges                                                                  | DER MS (Battery SCADA) sends discharging command and discharges to each Battery-based EESS                                                     | DER MS (Battery SCADA) | Battery-based EESS     | discharging command                                                                     |                  |                   |
| 2.2.4   | Upon receiving discharging command                                  | Battery-based EESS     | Sending current status                                                                                      | Battery-based EESS discharges and sends current status of each Battery-based EESS to DER MS (Battery SCADA)                                    | Battery-based EESS     | DER MS (Battery SCADA) | Current Status of each Battery-based EESS                                               |                  |                   |
| 2.2.5   | Upon receiving current Status of each Battery-based EESS            | DER MS (Battery SCADA) | Receiving current status of each Battery-based EESS<br>And calculation of current status of Virtual battery | DER MS (Battery SCADA) receives current status from Battery-based EESS<br>And it calculates total of Battery-based EESS output and virtual-SOC | DER MS (Battery SCADA) | DER MS (Battery SCADA) | Current status of each Battery-based EESS<br>Current status of Virtual battery for RMBA |                  |                   |
| 2.2.6   | Completion of calculating of current status of Virtual battery      | DER MS (Battery SCADA) | Sending Current status of Virtual battery                                                                   | DER MS (Battery SCADA) sends Current status of Virtual battery to Grid EMS                                                                     | DER MS (Battery SCADA) | Grid EMS               | Current status of Virtual battery for RMBA                                              |                  |                   |
| 2.2.7.1 | Upon operator request                                               | Grid Operator          | Requesting display of Current status of Virtual battery for RMBA                                            | Grid Operator requests display of virtual battery for RMBA                                                                                     | Grid Operator          | Grid EMS               | Display Request of Current status of Virtual battery                                    |                  |                   |

| #       | Event                     | Primary actor | Name of process/ activity                             | Description of process/ activity                             | Information producer | Information receiver | Name of info exchanged                     | Additional notes | IECSA environment |
|---------|---------------------------|---------------|-------------------------------------------------------|--------------------------------------------------------------|----------------------|----------------------|--------------------------------------------|------------------|-------------------|
| 2.2.7.2 | Receiving display request | Grid EMS      | Displaying Current status of Virtual battery for RMBA | Grid EMS displays Current status of Virtual battery for RMBA | Grid EMS             | Grid Operator        | Current status of Virtual battery for RMBA |                  |                   |

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**A.1.2.2.3 Post-conditions and significant results**

| Actor/activity                  | Post-conditions description and results                                  |
|---------------------------------|--------------------------------------------------------------------------|
| Grid Operator                   | Grid Operator continues to monitor the Grid                              |
| Grid EMS                        | Grid EMS continues to monitor Battery-based EESS for RMBA.               |
| DER MS (Battery SCADA) Operator | Grid EMS Operator continues to monitor Battery-based EESS for RMBA.      |
| DER MS (Battery SCADA)          | DER MS (Battery SCADA) continues to monitor Battery-based EESS for RMBA. |
| Battery-based EESS              | Battery-based EESS for RMBA continues to discharge                       |

**A.1.3 Auxiliary issues – Revision history**

| No | Date       | Author              | Description            |
|----|------------|---------------------|------------------------|
| 0. | 08-21-2011 | H.Miyaji            | Draft for Review 1     |
| 1  | 08-30-2011 | Y.Ebata             | Reviewed and revised 1 |
| 2  | 09-02-2011 | Y.Ebata & H.Hayashi | Reviewed and revised 2 |

**A.2 System use case #2 Active power schedule updating by using aggregated battery-based EESS****A.2.1 Descriptions of function****A.2.1.1 General**

This use case describes interactions between the grid operators, DER MS (Battery SCADA), the Battery-based EESS and the customer's side batteries, during active power schedule updating such as peak cut, load leveling for electric power utility using Aggregated Battery-based EESS.

NOTE Version 1.0 Aug.30. 2011

**A.2.1.2 Function name**

Active Power Schedule Updating by Using Aggregated Battery-based EESSs

**A.2.1.3 Brief description**

In this use case, one scenario will be described. The scenario describes the active power schedule updating by using Aggregated Battery-based EESS.

Firstly, with regards to the scenario (e.g. peak cut), the functional relationship between the grid operator, DER MS (Battery SCADA) and the customer's side battery will be described.

Active Power Schedule Updating is the function for peak shaving or load leveling. It supports a grid operator to make the plan for active power schedule updating, controls Battery-based EESS and communicates with the customer's side batteries so that a grid operator conduct the plan of active power schedule updating by using Aggregated Battery-based EESS.

DER MS (Battery SCADA) calculates the total surplus potential of all batteries deployed in the power system. Upon a grid operator request, DER MS (Battery SCADA) displays it, as if there is an Aggregated Battery-based EESS which capacity is same as the total surplus potential. A grid operator makes a plan of active power schedule updating considering the capacity of Aggregated Battery-based EESS.

A grid operator can request to check whether the plan of active power scheduling can be realized. When he requests to check it, DER MS (Battery SCADA) calculate the total surplus potential of Battery-based EESS and customer's side batteries, and negotiates with customer's side EMS such as HEMS or BEMS about utilization of its battery surplus. Then DER MS (Battery SCADA) evaluates the plan and display the result of its evaluation for a grid operator. These interactions are described in the scenario.

#### A.2.1.4 Narrative

##### A.2.1.4.1 Overview of functions

###### A.2.1.4.1.1 General

In this use case, the following functions will be described:

Active power schedule updating by using aggregated battery-based EESS.

###### A.2.1.4.1.2 Overall preconditions

| Actor/system contract   | Preconditions or assumptions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Grid EMS                | Grid EMS sends the active power schedule updating plan such as peak shaving or load leveling to DER MS (Battery SCADA).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Grid Operator           | Grid Operator inputs the active power schedule updating plan such as peak shaving or load leveling to DER MS (Battery SCADA).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| DER MS (Battery SCADA)  | DER MS (Battery SCADA) has the function of Active Power Schedule Updating by Using Virtual Energy Storage.<br><br>Active Power Schedule is essential to operate the grid and includes the expected system load and generation schedule. A grid operator makes it one day before generally. After he or she made and fixed it for tomorrow, if a new event is detected to have the possibility to happen on the following day, Active Power Schedule should be updated. For instance, if peak cut become necessary for the following day, this function will be applied. On the other hand, if weather forecast reflects sudden changes in the few hours ahead on the same day, this function can also be applied. In order to carry out this function, DER MS (Battery SCADA) sends control signals to Battery-based EESS via communication network, and it also sends demand request to customer's side HEMS via communication network. The demand request sent from DER MS (Battery SCADA) to customer's HEMS does not compel a customer to reduce its load, but request to use surplus of its battery capability. Above mentioned demand response is named Unrestrictive Demand Response. |
| Battery-based EESS      | Battery-based EESS is installed in the electric power substation generally. Electric power company is usually claimed as the owner. Battery-based EESS are connected to DER MS (Battery SCADA) via the communication line, and controlled by DER MS (Battery SCADA).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Customer's side battery | Customer's side battery is installed in a building or a house and controlled by Customer's side EMS such as HEMS, BEMS or FEMS according to the customer's strategy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Customer's side EMS     | This includes three main management systems, HEMS, BEMS and FEMS (where these are meant to manage the battery on the customers' side). Generally, Customer's side EMS can get a reward by responding demand request from DER MS (Battery SCADA) which does not restrict customer's utilization of electricity and is always charging or discharging request within the capability of the surplus power                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |



**A.2.1.4.1.3 Overview of post conditions**

| Actor/system contract   | Post-conditions description and results                                                                                                                                                                                                                                |
|-------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Grid EMS                | Grid EMS operates the power network equipment such as generators on the assumption that DER MS (Battery SCADA) will control batteries according to the plan of active power schedule updating.                                                                         |
| Grid Operator           | Grid operator will follow through the power demand and supply even after the active power schedule updating.                                                                                                                                                           |
| DER MS (Battery SCADA)  | DER MS (Battery SCADA) is running under continuous operation.<br>DER MS (Battery SCADA) collects the value of charging/discharging of customer's side battery corresponding to the Unrestrictive Demand Response and calculates and records a reward for contribution. |
| Battery-based EESS      | After controlled according to the active power schedule, Battery-based EESS are kept not to charge or discharge until the plan of next active power schedule updating is made.                                                                                         |
| Customer's side battery | After participating in the unrestrictive demand response <sup>7</sup> , Customer's side Battery is controlled according to the intention of the customer by the customer's side EMS.                                                                                   |
| Customer's side EMS     | After participating in the unrestrictive demand response, Customer's side EMS control Customer's side Battery according to the customers' intention.                                                                                                                   |

**A.2.1.4.2 Functions of active power schedule updating****A.2.1.4.2.1 General**

The following are the functions:

- 1) Default Plans Setting for Active Power Schedule Updating
- 2) Displaying Potential for Default Plans of Active Power Schedule Updating
- 3) Making Plan for Active Power Schedule Updating
- 4) Execution Notification of the Plan for Active Power Schedule Updating
- 5) Control of the Battery-based EESS
- 6) Operation of the Customer's side battery
- 7) Evaluating Operation of the Customer's side battery
- 8) Customer's side Battery Operation Plan Collecting
- 9) Monitoring of Active Power Schedule Updating

Explanations for the above 9 functions are as follow:

**A.2.1.4.2.2 Default plans settings for active power schedule updating**

Default plan is the typical plan such as peak shift or reduction of power demand. A grid operator can set default plans based on power system load characteristics. Default plans are represented by a pattern with *time* as the horizontal axis and the output power (%) as the vertical axis. A grid operator can add or delete default plans. For example, upon season change, a new default plan with regards to the specific season can be made and no changes would be required until the next season.

<sup>7</sup> A milder version and more flexible version of demand response that does not restrict the actions of the customers (e.g. to send commands to the customers to reduce their electrical consumption).

#### **A.2.1.4.2.3 Displaying potential for default plans of active power schedule updating**

DER MS (Battery SCADA) calculates the total surplus potential of all batteries corresponding to each default plan by using operation plan of customer's side batteries and their characteristics, and represents the result as if there is one Aggregated Battery-based EESS that has a virtual capacity same as the total surplus potential of all batteries. Upon a grid operator request, DER MS (Battery SCADA) displays the calculated result that is represented by a pattern with time as the horizontal axis and the output power (KW or MW) as the vertical axis for each default plan.

#### **A.2.1.4.2.4 Making plan for active power schedule updating**

A grid operator (or Grid EMS) can set the plan for active power schedule updating, if necessary. The plan is represented by a pattern with time as the horizontal axis and the output power (KW or MW) as the vertical axis. DER MS (Battery SCADA) calculates the total surplus potential of all batteries, and evaluates the plan whether the total surplus is greater than the plan. Then it displays the evaluation result as if there is one Aggregated Battery-based EESS that has a virtual capacity same as the total surplus potential of all batteries. The evaluation result includes schedules of Battery-based EESS and customer's side batteries for the plan, and recorded.

The total surplus is the sum of all surpluses of Battery-based EESS and all customers' side batteries. Before summing surplus of the customer's side battery, DER MS (Battery SCADA) inquires acceptance or rejection of the execution of the electrical charge and discharge schedule to each customer's side EMS. It sums surplus of the customer's battery, only when it gets acceptance from the customer's side EMS. (This procedure is named as the Unrestrictive Demand Response.)

#### **A.2.1.4.2.5 Execution notification of plan for active power schedule updating**

When the grid operator (or Grid EMS) determines that the plan for active power schedule updating is possible, he notifies the execution of the plan via the terminal of DER MS (Battery SCADA). Execution notification of the plan will be sent to respective customer's side EMS (e.g. HEMS, BEMS, etc.) from DER MS (Battery SCADA).

#### **A.2.1.4.2.6 Control of the battery-based EESS**

Upon execution notification of plan for active power schedule updating, DER MS (Battery SCADA) controls the battery-based EESS according to the schedule of batteries for the plan.

#### **A.2.1.4.2.7 Control of the customer's side battery**

When the customer's side EMS receives execution notification of the plan, it controls the customer's side storage battery according to the electrical charge and discharge schedule sent from DER MS (Battery SCADA).

#### **A.2.1.4.2.8 Evaluating operation of the customer's side battery**

Customer's side EMS will calculate the real charging/discharging power corresponding to the electrical charge and discharge schedule sent from DER MS (Battery SCADA). It sends calculated value to DER MS (Battery SCADA) periodically. DER MS (Battery SCADA) evaluates the results of the contribution to the active power schedule updating of each customer's side battery and records the evaluation results into the existing database.

#### **A.2.1.4.2.9 Customer's side battery operation plan collecting**

The customer's side EMS sends the detail schedule, the outline schedule or the surplus schedule of the customer's side battery to DER MS (Battery SCADA) to participate the plan for active power schedule updating conducted by DER MS (Battery SCADA). DER MS (Battery SCADA) records and uses them to calculate the total surplus potential of all batteries.

#### A.2.1.4.2.10 Monitoring of active power schedule updating

DER MS (Battery SCADA) displays 'the plan for the active power schedule updating' and 'the schedule of batteries for the plan'. It also calculates the total of charging/discharging of batteries which are included in the plan, and displays them upon a grid operator request. The grid operator can monitor the operation situation of active power schedule updating.

#### A.2.1.5 Actor (stakeholder) roles

| Grouping (community)        |                                                                             | Group description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------------|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Actors inside of Smart Grid |                                                                             | Actors that perform their specific function inside of Smart Grid                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Actor name                  | Actor type<br>(person,<br>organization,<br>device, system,<br>or subsystem) | Actor description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Grid EMS                    | System                                                                      | <p>This actor possesses many functions with regards the monitoring and controlling of the power system. That includes frequency and voltage quality maintenance of the power system, economical operation and reliability of the grid.</p> <p>Active Power Schedule Updating: The total demand will be forecasted 24 hours ahead, and the generation schedule designed to cover the total demand is made. Due to the considerable change in the forecast in the aggregate demand after making the plan for Active Power Schedule, or due to outage of the power generator appointed for use, if Active Power Schedule Updating is required, the plan for it will be sent to the DER MS (Battery SCADA) from Grid EMS.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Grid Operator               | Person                                                                      | <p>Responsible for the maintenance of the power system's frequency and voltage quality, economic operation and power system reliability by using the Grid EMS and DER MS (Battery SCADA).</p> <p>Due to the considerable change in the forecast in the aggregate demand or the outage of the power generator appointed for use after making the Plan for the Active Power Schedule, Grid operator carry out the active power schedule updating.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| DER MS (Battery SCADA)      | System                                                                      | <p>DER MS (Battery SCADA) enables grid operators to utilize Battery-based EESS and the surplus capability of the customer's side battery as one large Aggregated Battery-based EESS on its own.</p> <p>The DER MS (Battery SCADA) conducts the calculation of the total potential of the Battery-based EESS's and the customer's side battery's surplus power. And It displays calculated result for grid operators as if they have a large Aggregated Battery-based EESS.</p> <p>DER MS (Battery SCADA) controls Battery-based EESS to carry out active power schedule updating. It also sends demand request to use surplus of customer's side EMS.</p> <p>DER MS (Battery SCADA) collects detail schedule or outline schedule, or surplus schedule of customer's batteries based on which it calculates the total surplus of customer's batteries.</p> <p>DER MS (Battery SCADA) receives the real charging/discharging power corresponding to active power schedule updating from customer's side EMS and evaluates contribution of customer's batteries.</p> <p>Customer's side EMS will calculate the real charging/discharging power. It sends calculated value to DER MS (Battery SCADA) periodically. DER MS (Battery SCADA) evaluates the results of the contribution of the active power schedule updating of each customer's side battery and records the evaluation results into the existing database.</p> |
| Battery-based EESS          | Device                                                                      | Battery-based EESS charges and discharges according to the charging/discharging commands from DER MS (Battery SCADA).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Customer's side battery     | Device                                                                      | Customer's side batteries are controlled by Customer's side EMS that receives demand request from DER MS (Battery SCADA).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

| Grouping (community)        |                                                                             | Group description                                                                                                                                                                                                                                                                                                                                               |
|-----------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Actors inside of Smart Grid |                                                                             | Actors that perform their specific function inside of Smart Grid                                                                                                                                                                                                                                                                                                |
| Actor name                  | Actor type<br>(person,<br>organization,<br>device, system,<br>or subsystem) | Actor description                                                                                                                                                                                                                                                                                                                                               |
| Customer's side EMS         | System                                                                      | According to the conditions set by the customers, with connection of the customer's side EMS and the DER MS (Battery SCADA) through communication network, participation in the Unrestrictive Demand Response can be determined. Upon participation, Customer's side EMS controls Customer's Side Battery according to the request from DER MS (Battery SCADA). |
| Customer                    | Person                                                                      | The condition whether to participate in the Unrestrictive Demand Response (e.g. the peak shift etc.) is being inputted into the customer's side EMS. The conditions include the collateral condition and the maximum and minimum value of the battery output power.                                                                                             |

#### A.2.1.6 Information exchanged

| Information object name                               | Information object description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Request for Current Status                            | Command to request for the current status of the customer's side battery. Every 30mins, signals will be sent from the DER MS (Battery SCADA) to the customer's side EMS.                                                                                                                                                                                                                                                                                                                                                               |
| Current Status                                        | The current status of the battery. In the case of the customer's side battery, data such as SOC, active power and operation condition will be provided. In the case of the Battery-based EESS, data such as SOC, active power, operation condition and Remote/local condition will be provided.                                                                                                                                                                                                                                        |
| Default Plan for APSU(Active Power Schedule Updating) | Commonly used pattern for Active Power Schedule Updating. Time period is displayed by power in percentage.<br>Example 1. Peak-cut pattern for APSU: 13:00~14:00 90 %, 14:00~15:00 100 %,<br>Example 2. Strategy during lunch hours for APSU: 12:00~13:00 -100 % (Negative values refers to charging state)                                                                                                                                                                                                                             |
| The total surplus potential for default plan          | Absolute value (in MW) pattern that showed how much contribution can be actually done to each default plan for APSU by summing up the surplus power of Battery-based EESS and customer's side batteries. Display unit will be in MW per hour. A grid operator can suppose this to be the potential of the Aggregated Battery-based EESS.<br>Example1. Peak-cut pattern for APSU:13:00~14:00 90MW, 14:00~15:00 100MW,<br>Example 2. Strategy during lunch hours for APSU: 12:00~13:00 -70MW % (Negative values refer to charging state) |
| The schedule of batteries for the default plan        | This schedule is provided for each default plan by DER MS (Battery SCADA).<br>This schedule includes schedules of all Battery-based EESS and all Customers' side Batteries for the default plan. See Figure 2 and Figure 3.                                                                                                                                                                                                                                                                                                            |
| Request for Schedule                                  | Request command for schedule from the DER MS (Battery SCADA) to the customer's side EMS. It will be stated as the next day schedule or the same day schedule. Upon receiving this request, the customer's side battery sends the detail schedule, outline schedule or surplus schedule of it to DER MS (Battery SCADA).                                                                                                                                                                                                                |
| Detail Schedule of Customer's side Battery            | This schedule is On-the-day-Schedule or the next-day-Schedule of each customer's side battery, and includes the initial SOC, charging/discharging power of each period and the customer collateral condition.                                                                                                                                                                                                                                                                                                                          |
| Outline schedule of Customer's side Battery           | This schedule is On-the-day-Schedule or the next-day-Schedule of each customer's side battery, and includes the initial SOC, maximum charging/discharging power of each period, maximum/minimum SOC and the customer collateral condition.                                                                                                                                                                                                                                                                                             |
| Surplus schedule of Customer's side Battery           | This schedule is On-the-day-Schedule or the next-day-Schedule of each customer's side battery, and includes the initial SOC, surplus of charging/surplus of discharging power of each period and restriction of SOC of each period and the customer collateral condition.                                                                                                                                                                                                                                                              |