IEC TR 61850-90-9

Edition 1.0 2020-09

TECHNICAL REPORT

colour inside

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

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CONTENTS

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

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

FOREWORD

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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.

Such content is any text found between the markers <CODE BEGINS> and <CODE ENDS>, or otherwise is clearly labelled in this standard as a Code Component.

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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
Namespace IEC specific information	
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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- 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[1], 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[2].

[1] Under preparation. Stage at the time of publication: IEC/PRVC 61850-7-420:2020.

[2] 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
Namespace nameplate	
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
Namespace dependencies	
Extends	IEC 61850-7-420:2019A version :2019 revision :A
Namespace transitional status	
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 formated 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*[3]

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 EEES 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.

[3] 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 hvae 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.

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; acceleration (deprecated: use Accl instead)
Accl	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
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
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
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
Ch	Channel
Cha	Charger
Chg	Change
Chk	Check
Chr	Characteristic
Chs	Chassis
Circ	Circulating, circuit
Cl	Cooling, coolant, cooling system (see also CE)
Clc	Calculate, calculated
Clip	Clip
Clk	Clock
Cloud	Cloud
Clr	Clear
Cls	Close, closed
Cm	Centimetres
Cmbu	Combustible, combustion
Cmd	Command
Cmpl	Completed, completion, complete
Cmut	Commute, commutator
Cndct	Conductivity, Conducting
Cnt	Counter
Cntt	Contractual
Cnv	Converter
Col	Coil
Comm	Communication
Comp	Compensation
Conf	Configuration

Term	Description
ConfRev	Configuration revision (confRev from IEC 61850-7-2)
Conn	Connected, connections
Cons	Constant (general)
Cor	Correction
Core	Core
Cost	Cost
Crank	Crank
Crd	Coordination
Crit	Critical
Crl	Correlation
Crp	Creeping, slow movement
Crv	Curve
Csmp	Consumption, consumed
Ctl	Control
Ctr	Center
Cum	Cumulative
Cur	Current
Cut	Cut, cut-out, cut-in
Cvr	Cover, cover level
Cw	Clockwise
Cwb	Crowbar
Cyc	Cycle
D	Derivate
DC	DC, direct current
DER	Distributed energy resource
DExt	De-excitation
DPCSO	Double point controllable status output

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
Diag	Diagnostics
Dif	Differential, difference
Dig	Digital
Dip	Dip
Dir	Direction
Dis	Distance
Dist	Distribution
Dith	Dither
Dl	Delay
Dlt	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
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
Edt	Edit, edited
Efc	Efficiency
El	Elevation
Ela	Elasticity
Em	Emission
Emg	Emergency
En	Energy
Ena	Enabled, enable, allow operation
Enc	Enumerated control
Encl	Enclosure
End	End

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
Exc	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
Fil	Filter, filtration system
Fire	Fire
Fish	Fish
Fix	Fixed
Fld	Field
Flk	Flicker
Fll	Fall
Flm	Flame
Flood	Flood
Flsh	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
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
Ia	Information available
Iafm	Information available force majeure
Iano	Information available non-operative
Ianofo	Information available non-operative forced outage
Ianopca	Information available non-operative planned corrective action
Ianos	Information available non-operative suspended
Ianosm	Information available non-operative scheduled maintenance
Iao	Information available operative
Iaog	Information available operative generating
Iaogfp	Information available operative generating with full performance
Iaogpp	Information available operative generating with partial performance

Term	Description
Iaong	Information available operative non-generating
Iaongel	Information available operative non-generating out of electrical specification
Iaongen	Information available operative non-generating out of environment specification
Iaongrs	Information available operative non-generating requested shutdown
Iaongts	Information available operative non-generating technical standby
Ice	Ice
Id	Identity, identifier
Ieee	IEEE definition
IeeeKH	Proportional gain HF (High Frequency). Defined in IEEE 421.5
IeeeKH1	Proportional gain HF positive. Defined in IEEE 421.5
IeeeKH11	Lead gain HF positive. Defined in IEEE 421.5
IeeeKH17	Lead gain HF negative. Defined in IEEE 421.5
IeeeKH2	Proportional gain HF negative. Defined in IEEE 421.5
IeeeKI	Proportional gain IF (Intermediate Frequency). Defined in IEEE 421.5
IeeeKI1	Proportional gain IF positive. Defined in IEEE 421.5
IeeeKI11	Lead gain IF positive. Defined in IEEE 421.5
IeeeKI17	Lead gain IF negative. Defined in IEEE 421.5
IeeeKI2	Proportional gain IF negative. Defined in IEEE 421.5
IeeeKL	Proportional gain LF (Low Frequency). Defined in IEEE 421.5
IeeeKL1	Proportional gain LF positive. Defined in IEEE 421.5
IeeeKL11	Lead gain LF positive. Defined in IEEE 421.5
IeeeKL17	Lead gain LF negative. Defined in IEEE 421.5
IeeeKL2	Proportional gain LF negative. Defined in IEEE 421.5
IeeeKs1	Gain Ks1. Defined in IEEE 421.5
IeeeKs2	Gain Ks2. Defined in IEEE 421.5
IeeeKs3	Gain Ks3. Defined in IEEE 421.5

Term	Description
IeeeM	Ramptrack lowpass degree M. Defined in IEEE 421.R
IeeeN	Ramptrack overall degree N. Defined in IEEE 421.5
IeeeT1	Time constant T1. Defined in IEEE 421.5
IeeeT10	Time constant T10. Defined in IEEE 421.5
IeeeT11	Time constant T11. Defined in IEEE 421.5
IeeeT2	Time constant T2. Defined in IEEE 421.5
IeeeT3	Time constant T3. Defined in IEEE 421.5
IeeeT4	Time constant T4. Defined in IEEE 421.5
IeeeT7	Time constant T7. Defined in IEEE 421.5
IeeeT8	Time constant T8. Defined in IEEE 421.5
IeeeT9	Time constant T9. Defined in IEEE 421.5
IeeeTH1	Time constant TH1 (High frequency positive). Defined in IEEE 421.5
IeeeTH10	Time constant TH10 (High frequency negative). Defined in IEEE 421.5
IeeeTH11	Time constant TH11 (High frequency negative). Defined in IEEE 421.5
IeeeTH12	Time constant TH12 (High frequency negative). Defined in IEEE 421.5
IeeeTH2	Time constant TH2 (High frequency positive). Defined in IEEE 421.5
IeeeTH3	Time constant TH3 (High frequency positive). Defined in IEEE 421.5
IeeeTH4	Time constant TH4 (High frequency positive). Defined in IEEE 421.5
IeeeTH5	Time constant TH5 (High frequency positive). Defined in IEEE 421.5
IeeeTH6	Time constant TH6 (High frequency positive). Defined in IEEE 421.5
IeeeTH7	Time constant TH7 (High frequency negative). Defined in IEEE 421.5
IeeeTH8	Time constant TH8 (High frequency negative). Defined in IEEE 421.5
IeeeTH9	Time constant TH9 (High frequency negative). Defined in IEEE 421.5

Term	Description
IeeeTI1	Time constant TI1 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI10	Time constant TI10 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI11	Time constant TI11 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI12	Time constant TI12 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI2	Time constant TI2 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI3	Time constant TI3 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI4	Time constant TI4 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI5	Time constant TI5 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI6	Time constant TI6 (Intermediate frequency positive). Defined in IEEE 421.5
IeeeTI7	Time constant TI7 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI8	Time constant TI8 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTI9	Time constant TI9 (Intermediate frequency negative). Defined in IEEE 421.5
IeeeTL1	Time constant TL1 (Low frequency positive). Defined in IEEE 421.5
IeeeTL10	Time constant TL10 (Low frequency negative). Defined in IEEE 421.5
IeeeTL11	Time constant TL11 (Low frequency negative). Defined in IEEE 421.5
IeeeTL12	Time constant TL12 (Low frequency negative). Defined in IEEE 421.5
IeeeTL2	Time constant TL2 (Low frequency positive). Defined in IEEE 421.5
IeeeTL3	Time constant TL3 (Low frequency positive). Defined in IEEE 421.5
IeeeTL4	Time constant TL4 (Low frequency positive). Defined in IEEE 421.5

Term	Description
IeeeTL5	Time constant TL5 (Low frequency positive). Defined in IEEE 421.5
IeeeTL6	Time constant TL6 (Low frequency positive). Defined in IEEE 421.5
IeeeTL7	Time constant TL7 (Low frequency negative). Defined in IEEE 421.5
IeeeTL8	Time constant TL8 (Low frequency negative). Defined in IEEE 421.5
IeeeTL9	Time constant TL9 (Low frequency negative). Defined in IEEE 421.5
IeeeTw1	Time constant wash out Tw1. Defined in IEEE 421.5
IeeeTw2	Time constant wash out Tw2. Defined in IEEE 421.5
IeeeTw3	Time constant wash out Tw3. Defined in IEEE 421.5
IeeeTw4	Time constant wash out Tw4. Defined in IEEE 421.5
IeeeVHMax	Maximum limit set-point HF. Defined in IEEE 421.5
IeeeVHMin	Minimum limit set-point HF. Defined in IEEE 421.5
IeeeVIMax	Maximum limit set-point IF. Defined in IEEE 421.5
IeeeVIMin	Minimum limit set-point IF. Defined in IEEE 421.5
IeeeVLMax	Maximum limit set-point LF. Defined in IEEE 421.5
IeeeVLMin	Minimum limit set-point LF. Defined in IEEE 421.5
IeeeVsi1Max	Input High Limit 1. Defined in IEEE 421.5
IeeeVsi1Min	Input Low Limit 1. Defined in IEEE 421.5
IeeeVsi2Max	Input High Limit 2. Defined in IEEE 421.5
IeeeVsi2Min	Input Low Limit 2. Defined in IEEE 421.5
IeeeVstMax	Output High Limit. Defined in IEEE 421.5
IeeeVstMin	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
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
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
Ll	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
Los	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
Mem	Memory
Min	Minimum
Mir	Mirror
Mlt	Multiple
Mns	Mains
Mod	Mode
Mot	Motor
Mrg	Margin
Mrk	Market
Mst	Moisture
Msv	Main signaling voltage
Msvcb	Multicast sampled values control block
Mth	Method
Mult	Multiplier
Mvm	Movement, moving
N2	Nitrogen
NOx	Nitrogen oxide
NQS	Average partial discharge current
Nam	Name
Name	Name (reserved for use in data objects EEName and LNName only)
Ndl	Needle (used in Pelton turbines)
NdsCom	Needs commissioning
Neut	Neutral
Ng	Negative
Ngt	Nogotiation
Nhd	Net head
Night	Night

Term	Description
No	No, not
Nom	Nominal, normalising
Num	Number
Nxt	Next
O2	Oxygen
O3	Ozon, trioxygen
Obl	Obligation
Oc	Open circuit
Odd	Odd
Of	Offline
Off	Off, device disengaged, not running
Ofs	Offset
Oil	Oil
On	On, device applied, running
Oo	Out of
Op	Operate, operating, operation
Operate	Operate order to any device
Opn	Open, opened
Ord	Order
Out	Output
Ov	Over, override, overflow
Ovl	Overload
Ox	Oxidant
P	Proportional
PF	Power factor
PH	Acidity, value of pH
PNV	Phase-to-neutral voltage

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
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
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
Reso	Resonance
Reuse	Reuse
Rev	Revision
Rf	Refreshment
Rin	Reinsertion
Ris	Resistance
Rl	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
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 arrestor
Sat	Saturation
Sc	Short circuit
Scale	Scale
Schd	Schedule
Scnd	Secondary
Sco	Supply change over
Sec	Security
Sel	Select
Self	Self
Seq	Sequence

Term	Description
Ser	Series, serial
Set	Setting
Sgcb	Setting group control block
Sh	Shunt
Shar	Shared
Shft	Shaft
Shld	Shielded
Sig	Signal
Sign	Sign
Sim	Simulation, simulated
Sld	Solidity
Slnt	Salinity, saline content
Slp	Sleep; slip
Smok	Smoke
Smp	Sampling
Snd	Sound pressure
Snpt	Snapshot
Snr	Signal to noise ratio
Snw	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
Sq	Square
Src	Source
Srfc	Surface
St	Status, state
Sta	Station, function at plant level
Stab	Stabilizer
Stat	Statistics
Stc	Stack
Std	Standard
Stdby	Standby
Step	Step
Stk	Stroke
Stl	Still, not moving
Stnd	Stand, standing
Sto	Storage, e.g. activity of storing data
Stop	Stop
Storm	Storm
Stow	Stow
Str	Start
Strg	String
Stt	Stator
Stuck	Stuck, cannot move
Sub	Sub
Sum	Sum
Sup	Supply
Sv	Sampled value
SvCBRef	SV control block reference

Term	Description
Svc	Service
Sw	Switch, switched
Swg	Swing
Swl	Power quality event swell
Syn	Synchronisation, synchronous, synchronism, synchrocheck
Sys	System
TP	Three pole/phase
Ta	Armature time constant
Tag	Tag (maintenance work in progress)
Tap	Tap
Task	Task
Td	Transformer derating
Td0p	Td0'
Td0s	Td0''
Tdd	Total demand distortion
Tdf	Transformer derating factor
Tdp	Td'
Tds	Td''
Tech	Technology
Term	Termination
Test	Test
Tgt	Target
Thd	Total harmonic distortion
Thm	Thermal
Ti	Telephone influence
Tilt	Tilt
Tm	Time

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
Trp	Transient Performance Class
Trs	Transient
Trunk	Trunk
Ts	Total signed
Tu	Total unsigned
Tun	Tuning
Tur	Turbine
Tx	Transmit, transmitted
Typ	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
VA	Apparent power (volt amperes)
VAh	Apparent energy
VAr	Reactive power (volt amperes reactive)
VArh	Reactive energy
Va	Variation
Vac	Vacuum
Val	Value
Vbr	Vibration
Ver	Vertical
Viol	Violation
Vis	Visibility
Visc	Viscosity
Vlan	VLAN
Vld	Valid, validate, validated
Vlm	Volume
Vlv	Valve
Vol	Voltage DC or non-phase-related AC
VolAmpr	Non-phase-related AC reactive power
Vss	Steady state voltage
W	Active power
W200	Watts peak at 200 W/m2
Wac	Watchdog
Wash	Washout
Watt	Active power non-phase-related AC
Wav	Wave, waveform
Wd	Wind
Week	Week

Term	Description
Wei	Weak end infeed
Wet	Wet
Wgt	Weight
Wh	Watt hours
Wid	Width
Win	Window
Wkup	Wake up
Wld	Welding
Wnd	Winding
Wrm	Warm
Wrn	Warning, warning trigger status
Wrs	Warning trigger status set
Wtr	Water (physical aspect: river, cooling, etc.)
Wup	Windup
X	Reactance (imaginary part of impedance)
X0	Zero sequence reactance
X1	Positive sequence reactance
X2	Negative sequence reactance X2
Xd	Synchronous reactance Xd
Xdir	X-direction
Xdp	Transient synchronous reactance Xd'
Xds	Subtransient reactance Xd''
Xm	Mutual reactance
Xq	Synchronous reactance Xq
Xqp	Transient synchronous reactance Xq'
Xqs	Subtransient reactance Xq''
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

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.

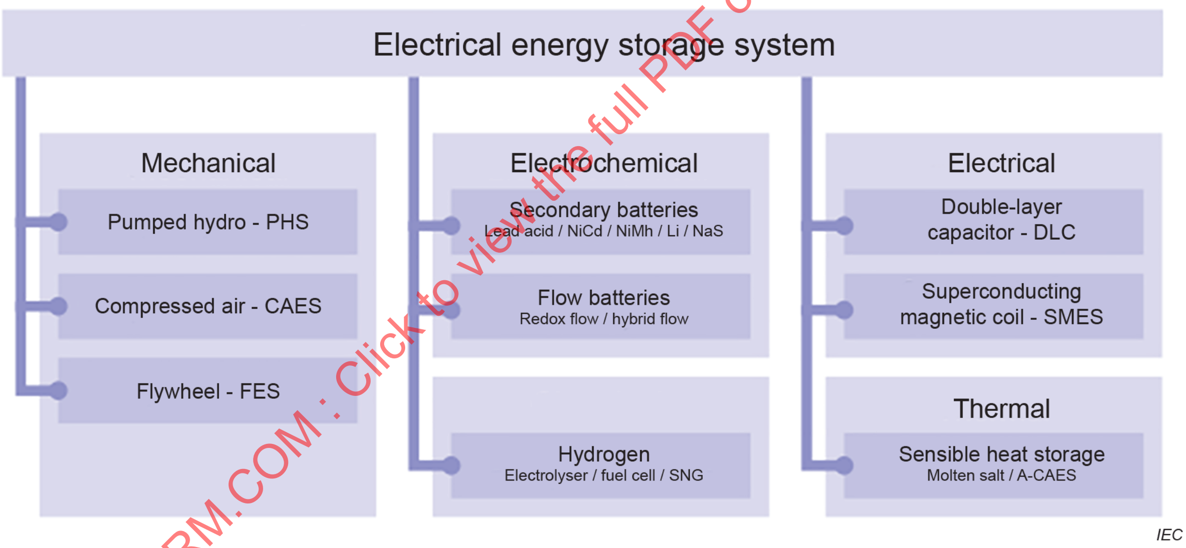
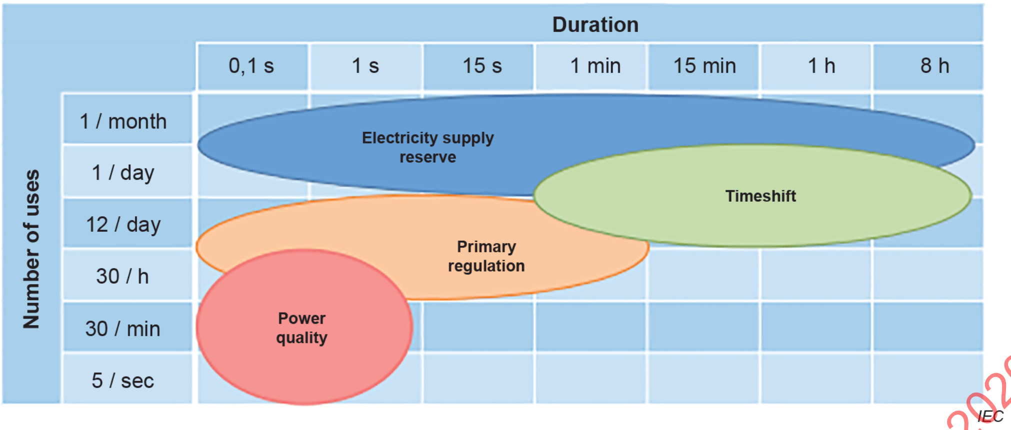


Figure 1 – Classification of electrical energy storage systems according to energy form. IEC-WP [IEC White Paper Electrical Energy Storage:2011])

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/AMD1:2019 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.

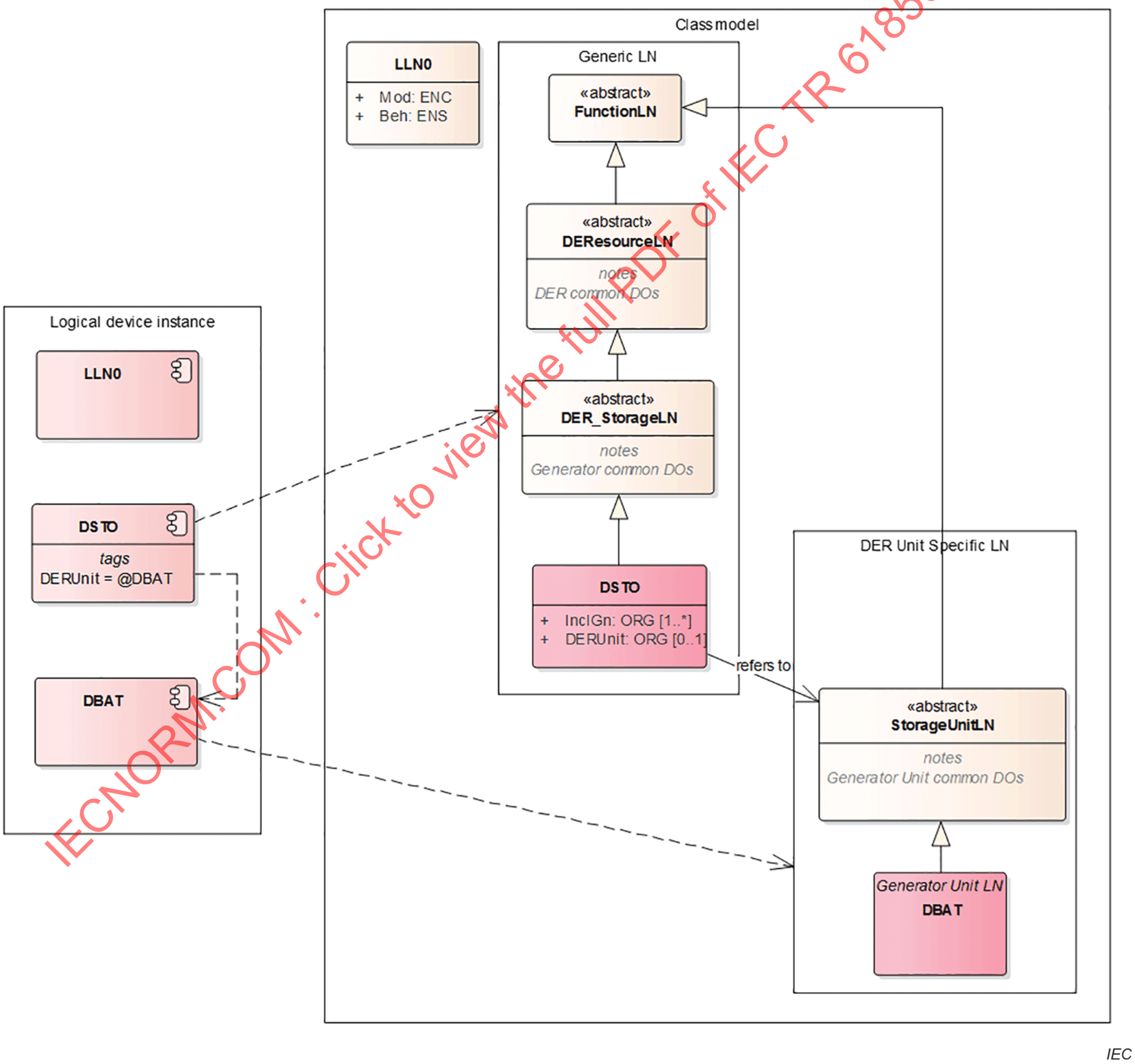


Figure 3 – Simple storage resource model of a battery storage unit (instance & class)

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 DEResourceLN);
- 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).

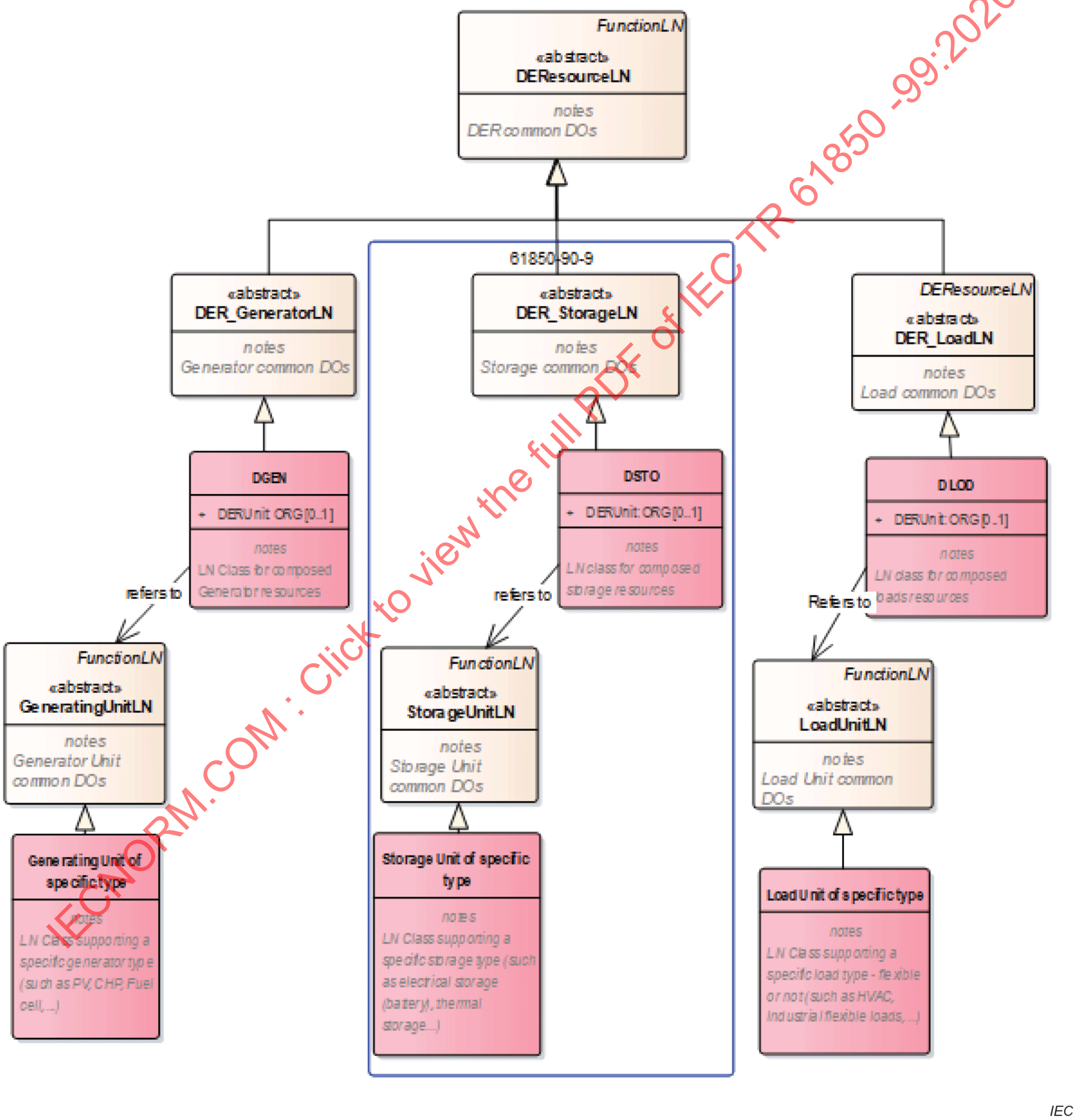


Figure 4 – Hierarchical class model of DER resources – (blue outlined area showing EESS)

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[4] 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.

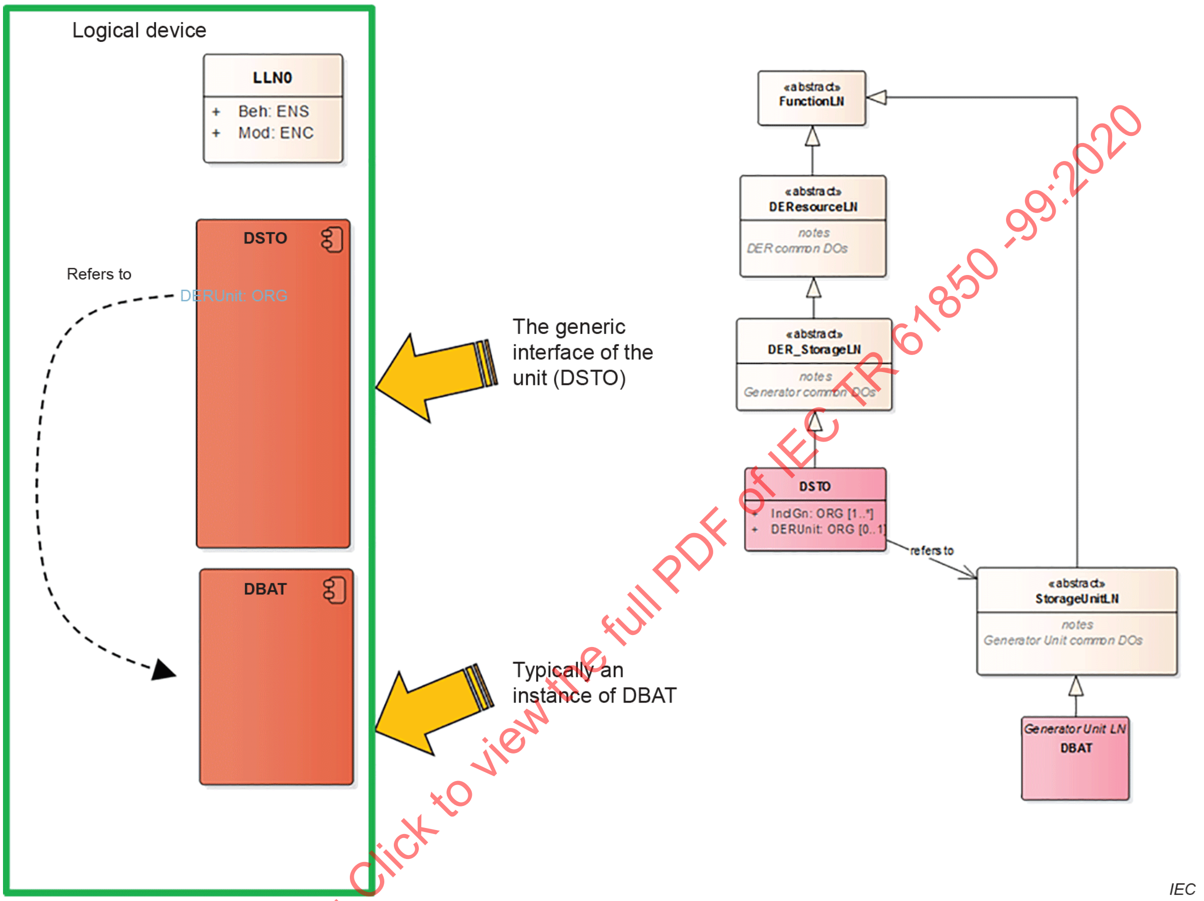


Figure 5 – Exposing the generic interface of a DER unit (Case of a storage unit as an example)

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.

4 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).

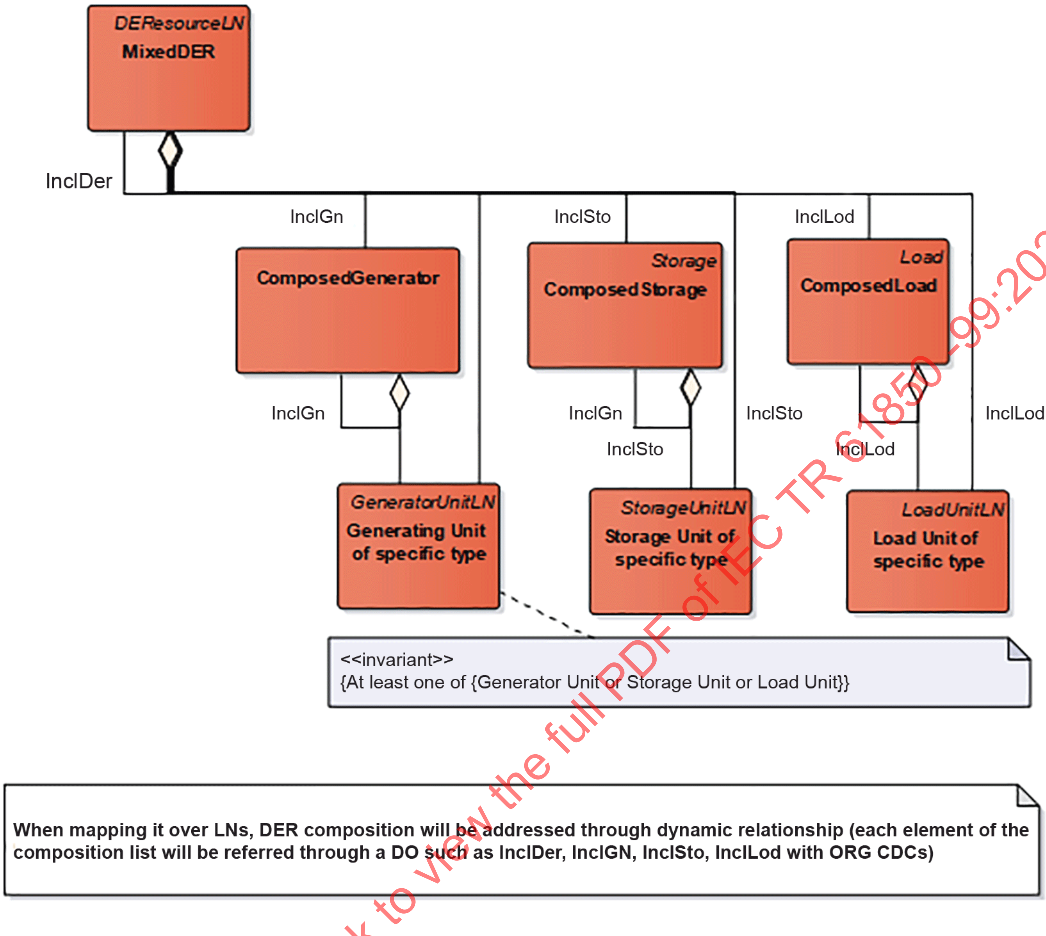


Figure 6 – DER composition model principles

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:

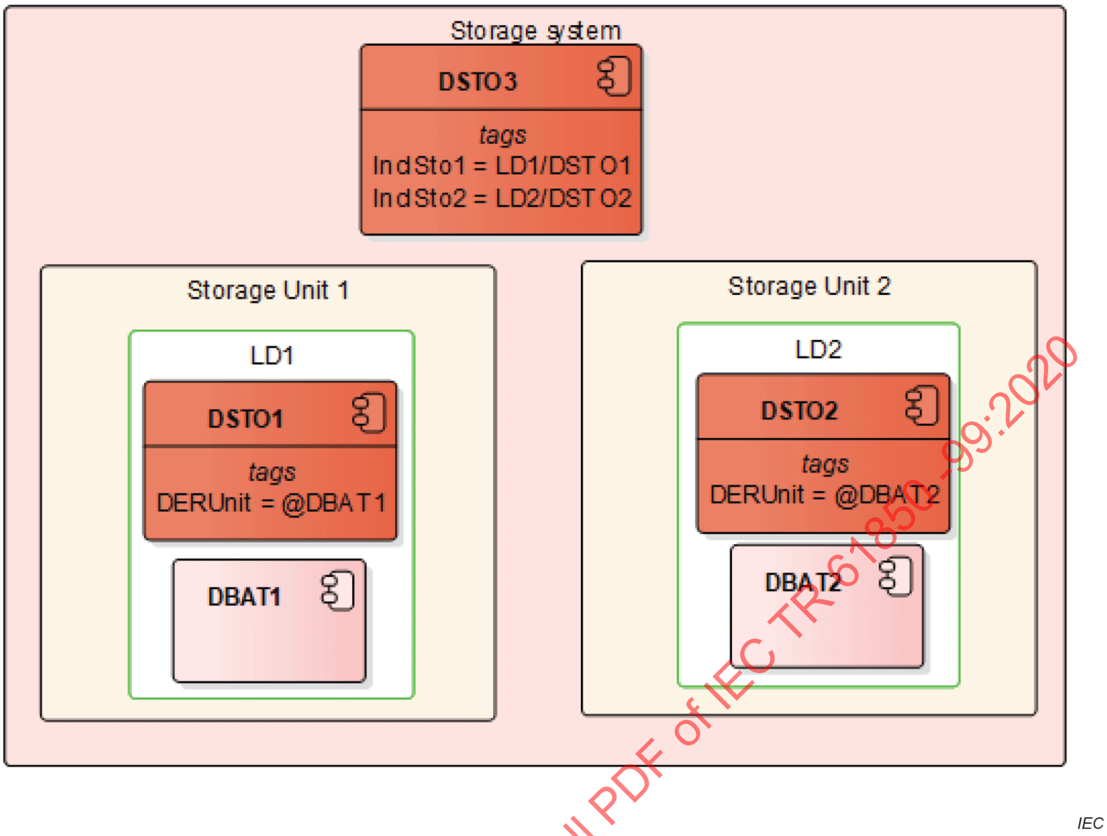


Figure 7 – LN mapping related to a storage system composed of two storage units

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.

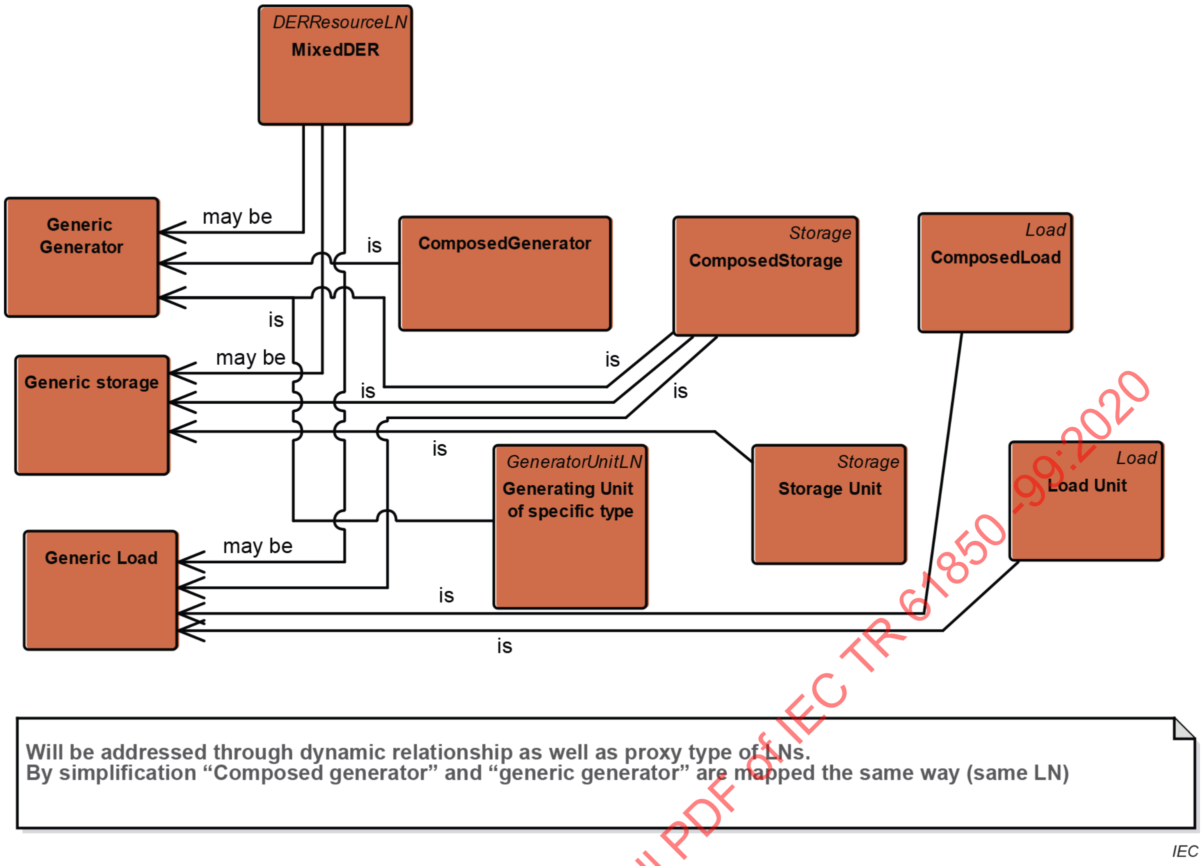


Figure 8 – Needed association to express DER generic capabilities

These associations are expressed through the systematic usage to the generic capabilities, modelled through respectively DGEN, DSTO and DLOD[5] 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.

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

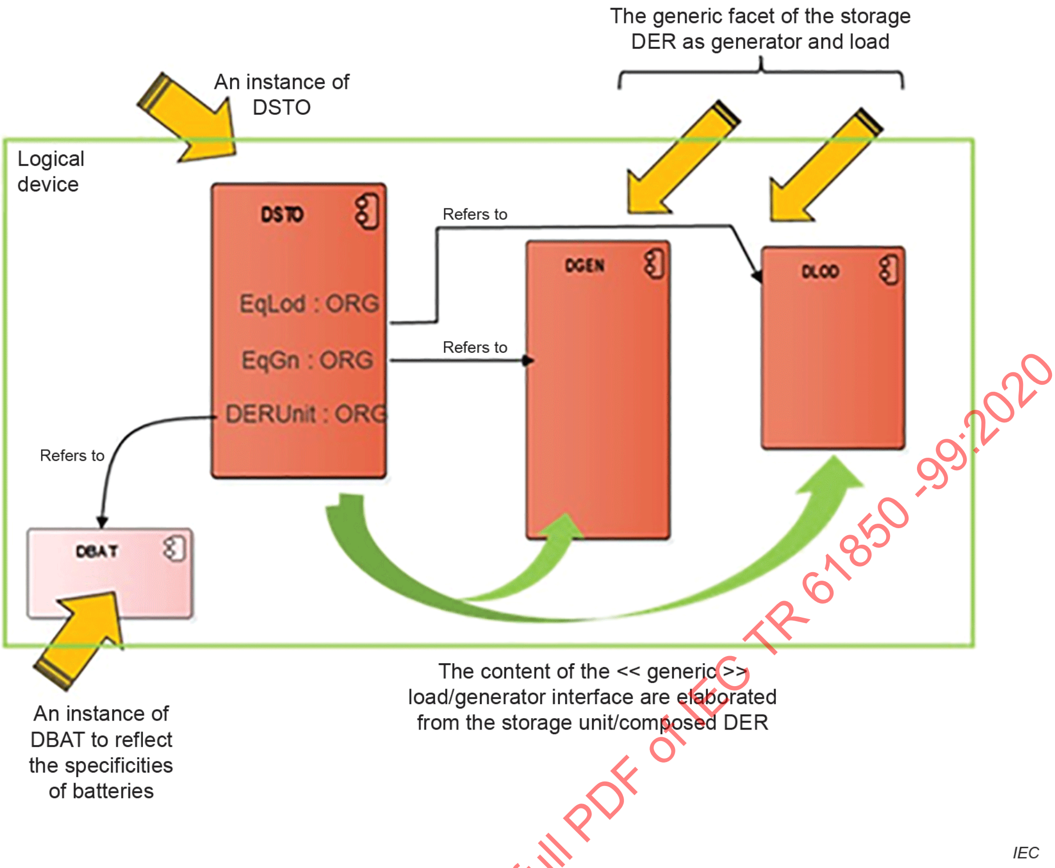


Figure 9 – Exposing the generic interfaces of a storage DER (battery storage as example)

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.

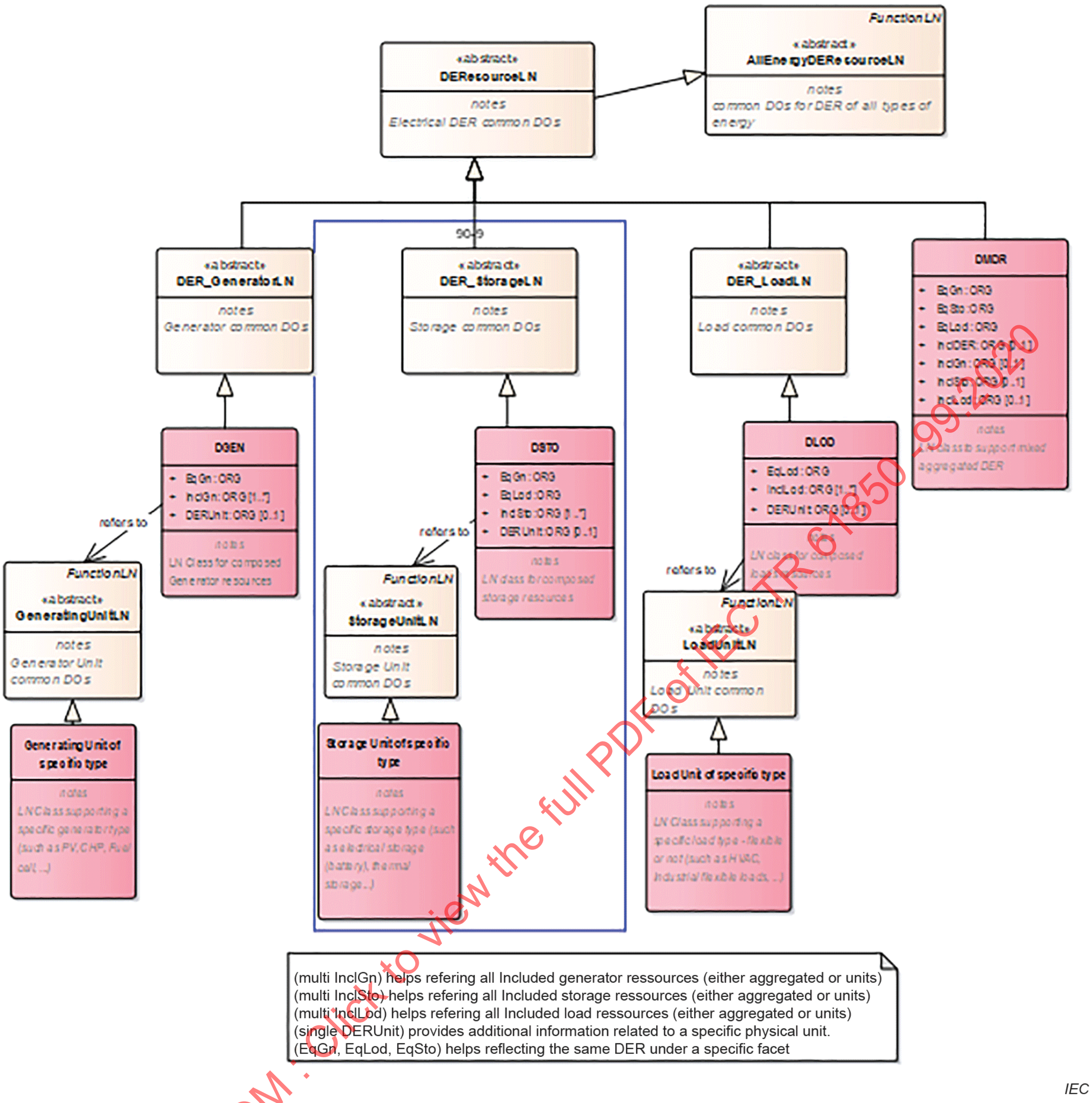


Figure 10 – Principles of the hierarchical class model of DER resources with examples of specific DER types at the lowest level (blue outlined area showing EESS)

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.

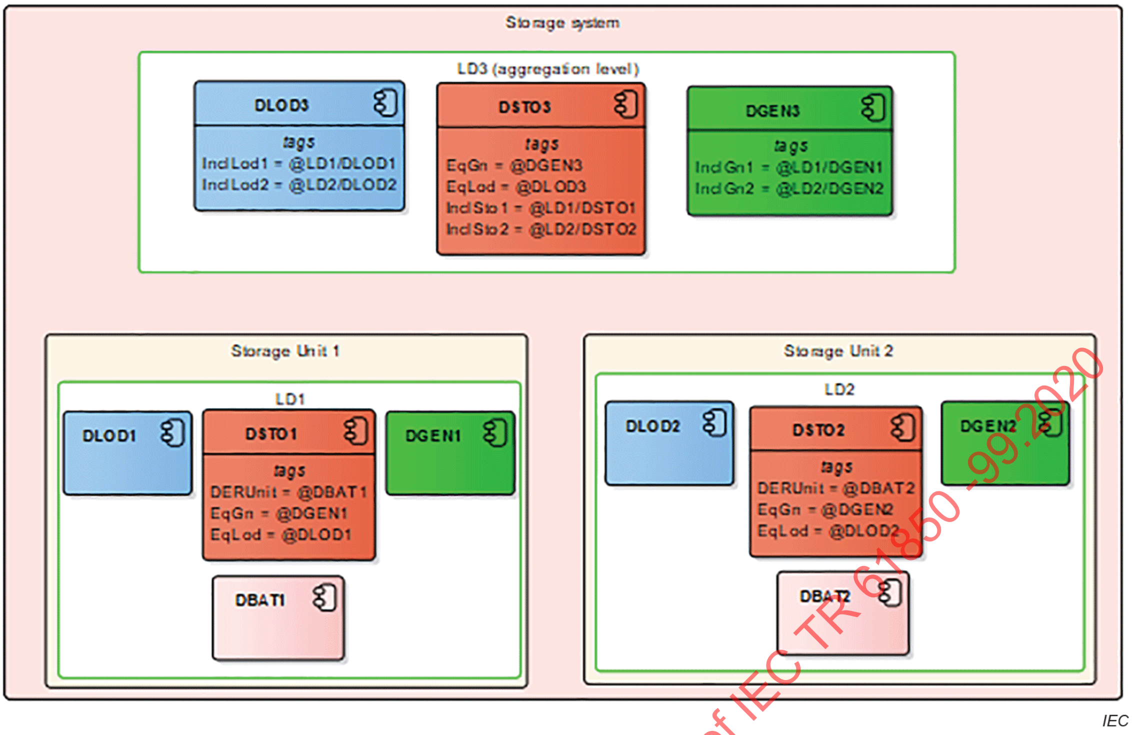


Figure 11 – LN mapping of an EESS composed of 2 storage units with equivalent capabilities defined at all levels

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.

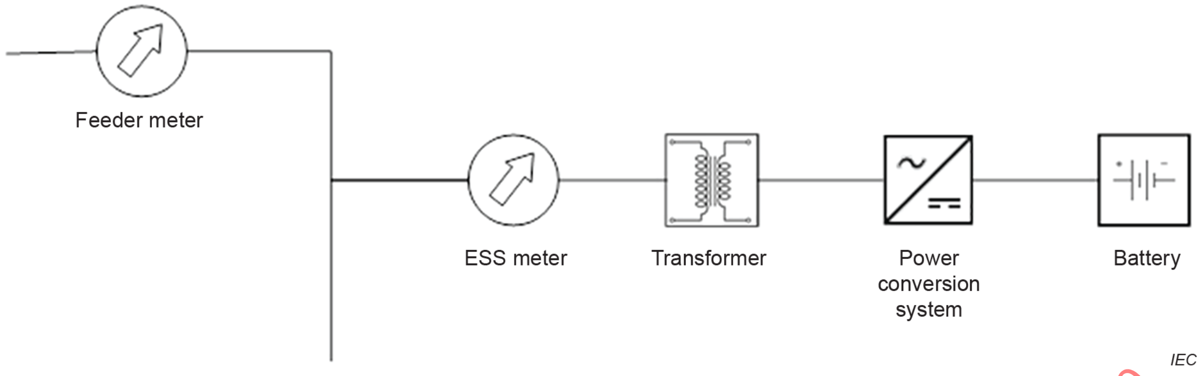


Figure 12 – A simple electrical energy storage system

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 EESS.

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

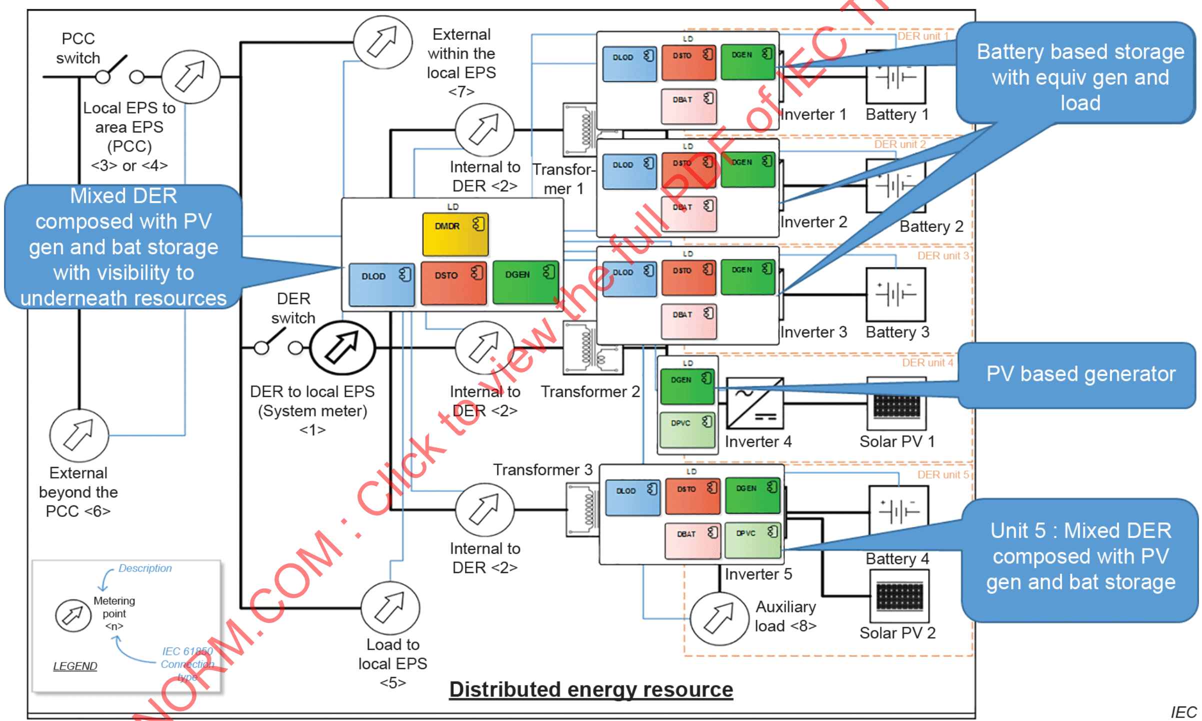


Figure 13 – A more complex electrical mixed system, including storage – example of possible LN mapping

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 additional, 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 additional, 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.

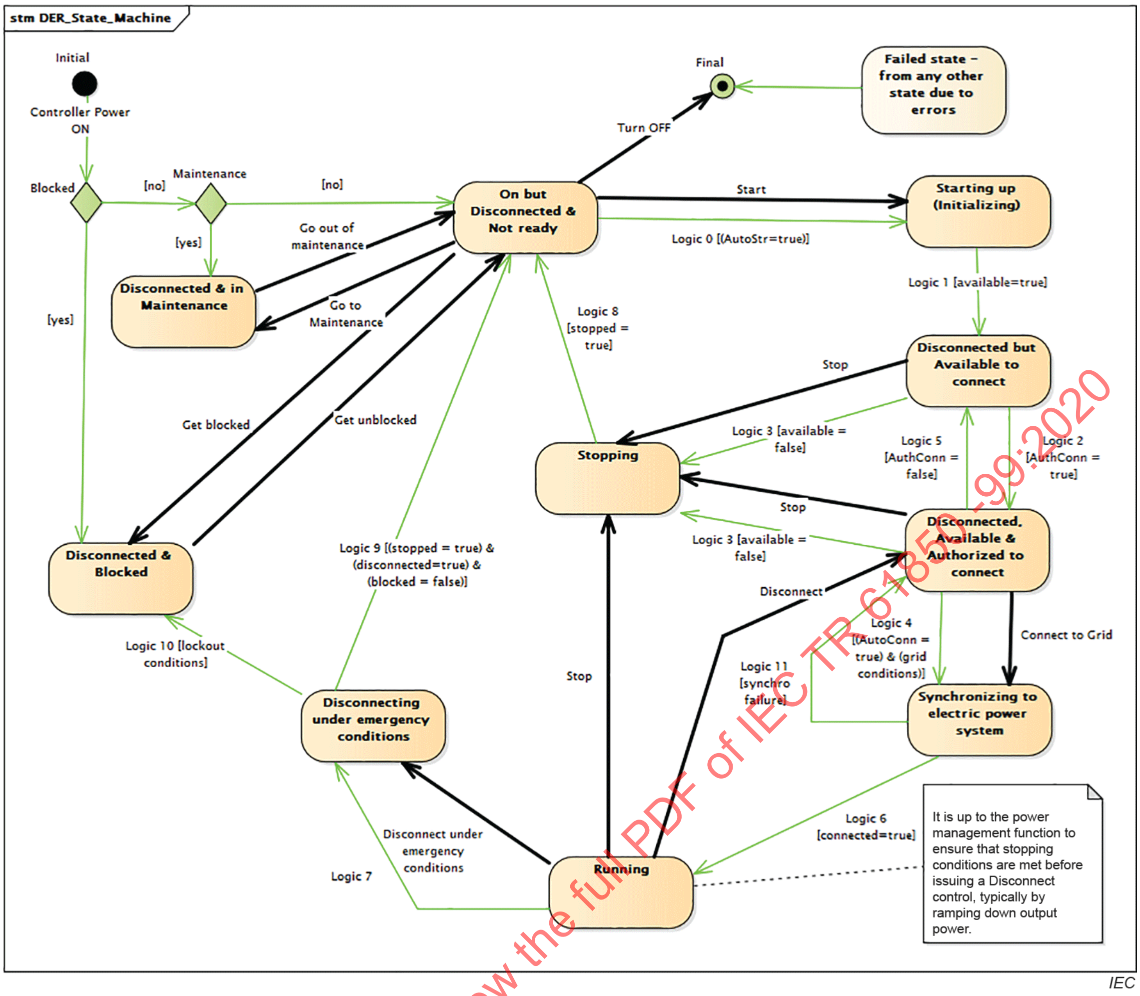


Figure 14 – DER common state diagram

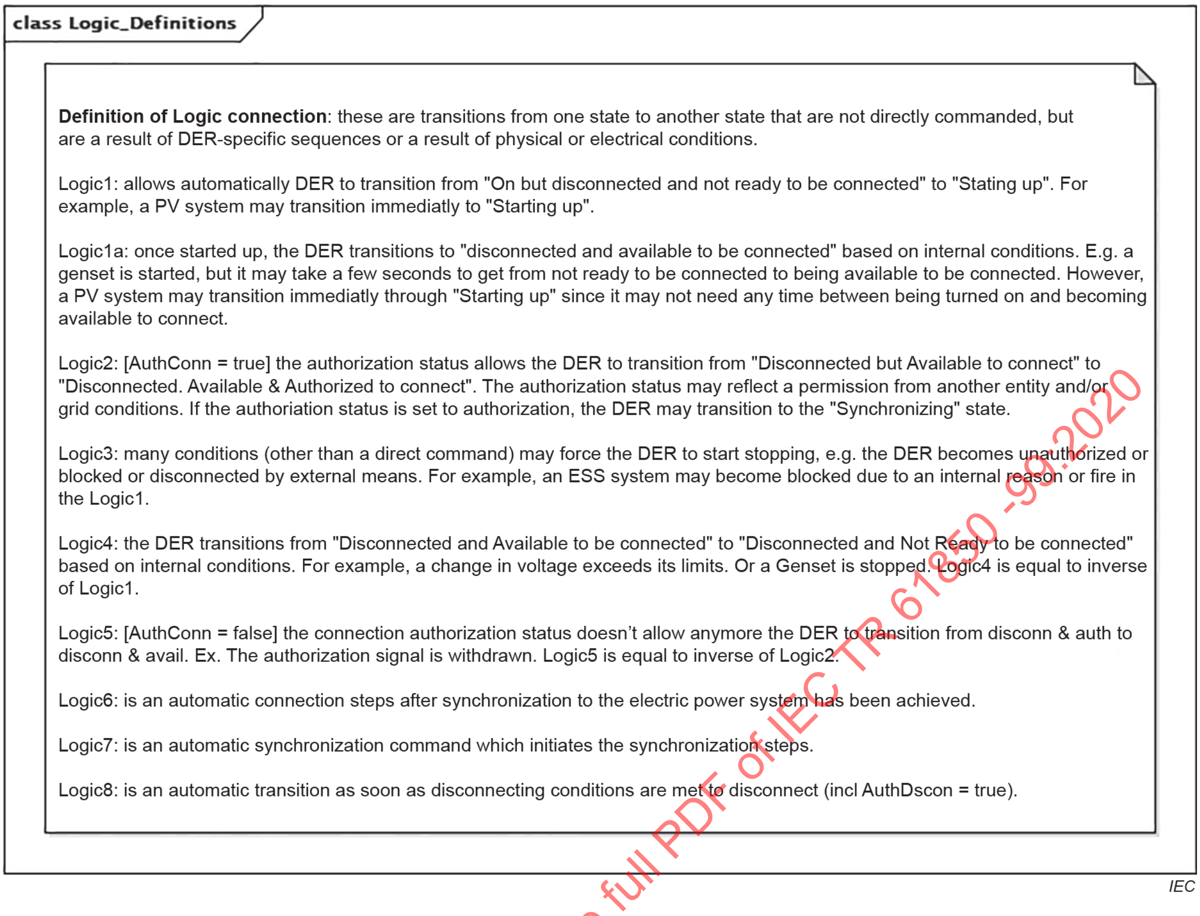


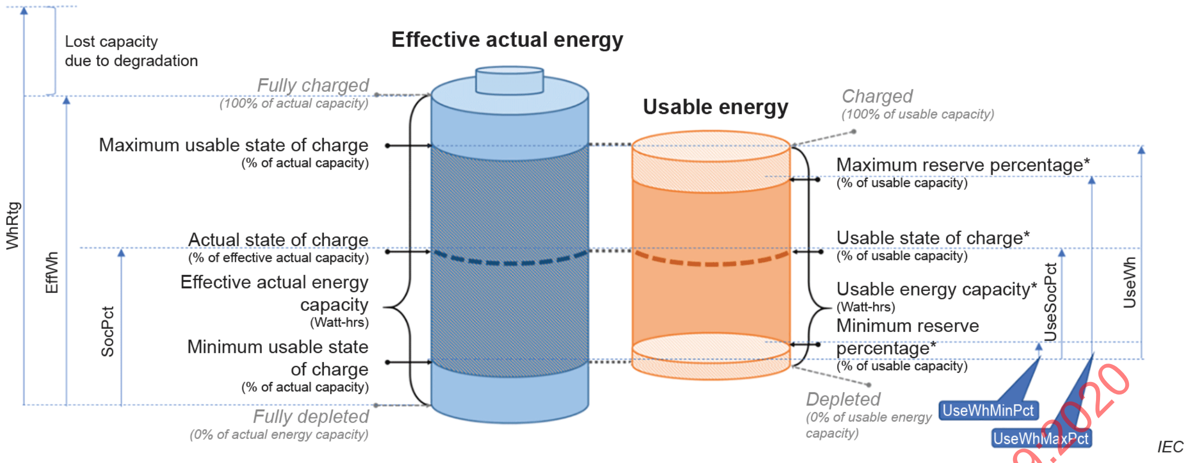
Figure 15 – Logic definitions associated to the DER common state diagram

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 618650 model naming conventions[6]

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.

6 *Common Functions for Smart Inverters*, 4th Edition. EPRI, Palo Alto, CA: 2016. 3002008217.

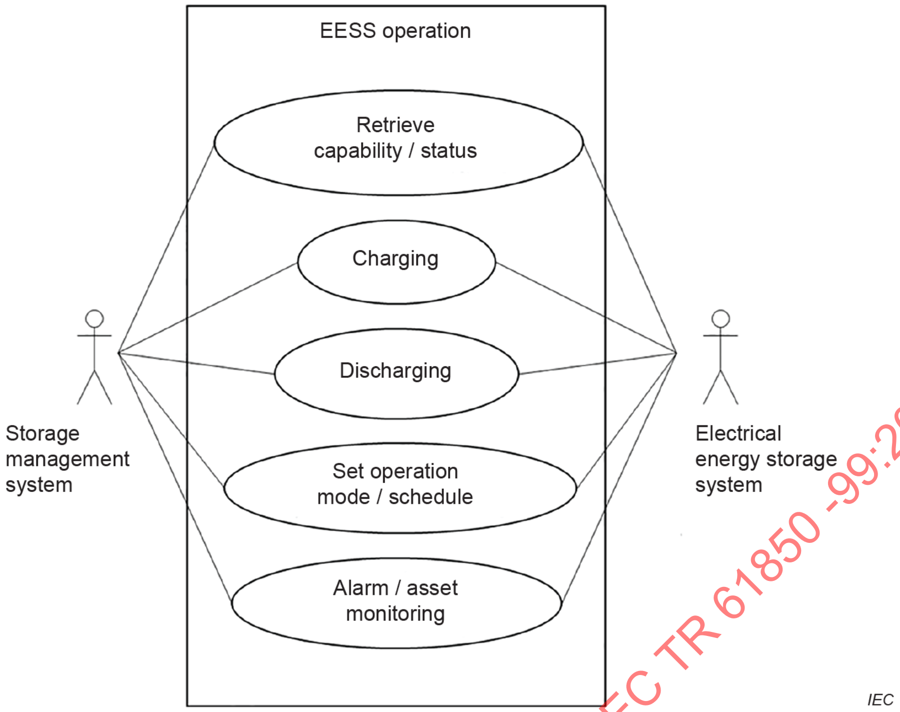


Figure 17 – Use case diagram

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 (EESS)	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.

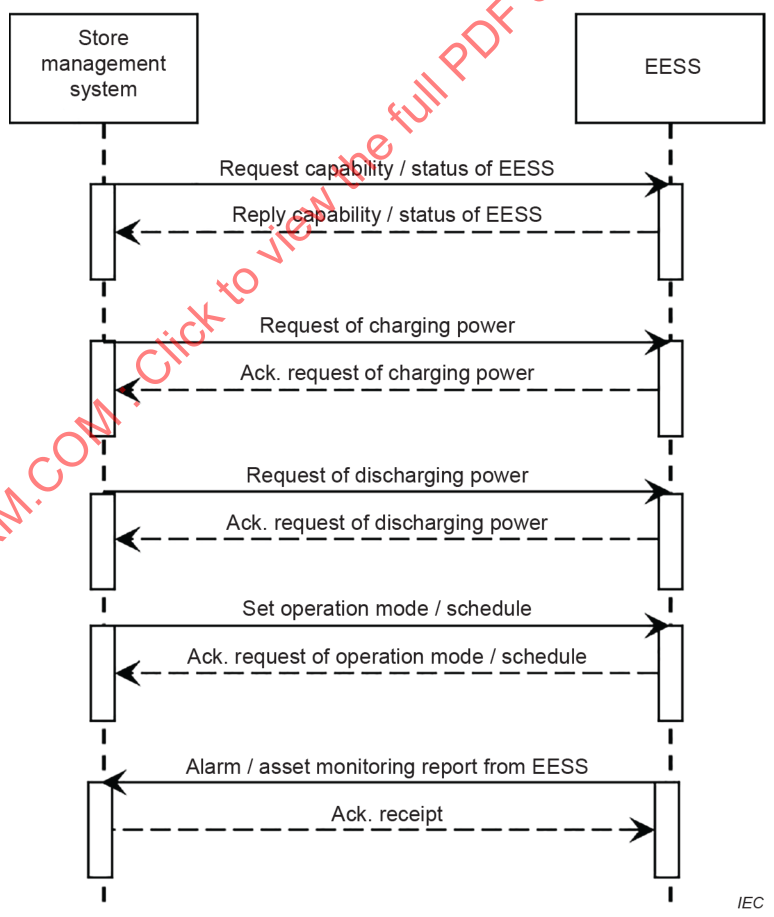


Figure 18 – The entire sequence of EESS use cases

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.

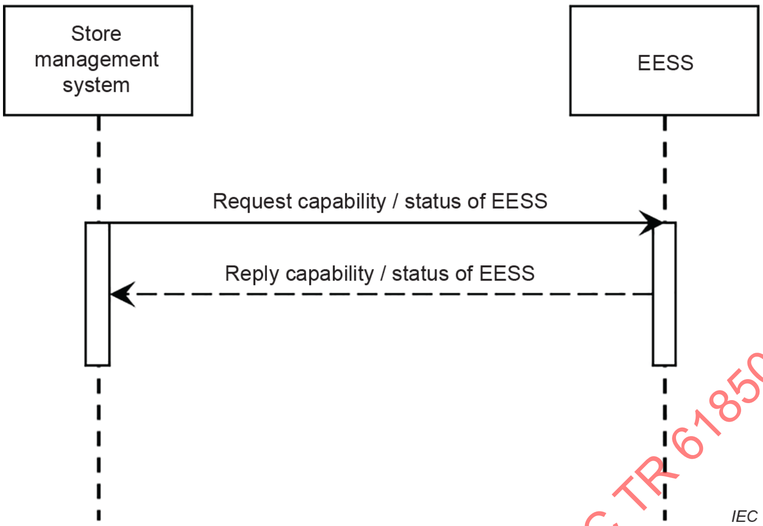


Figure 19 – Sequence of UC1: retrieving current capabilities/status of EESS information to Storage Management System

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: 1-2-1) EESS generic status 1-2-2) EESS storage unit inverter/converter status 1-2-3) EESS storage unit (battery) status 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 EESS generic status	• EESS on or off status
	• EESS storage available or not available
	• EESS available operational functions
1-2-2 EESS inverter /converter status	• 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)
1-2-3 EESS associated unit (battery) internal 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
1-2-4 EESS measurements	• 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

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.

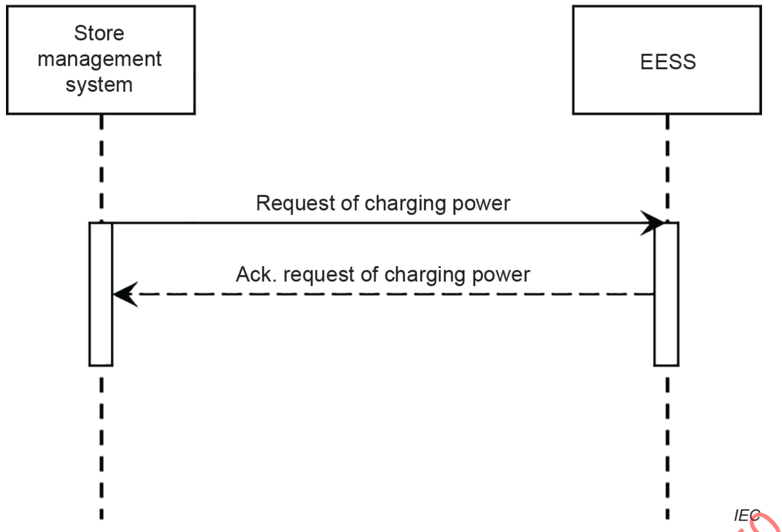


Figure 20 – Sequence of UC2: set Charging power to EESS

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.

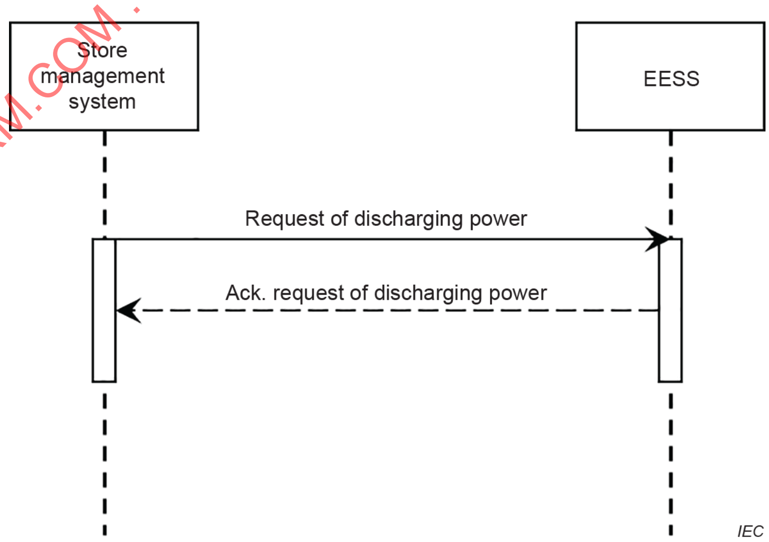


Figure 21 – Sequence of UC3: Set discharging power to EESS

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.

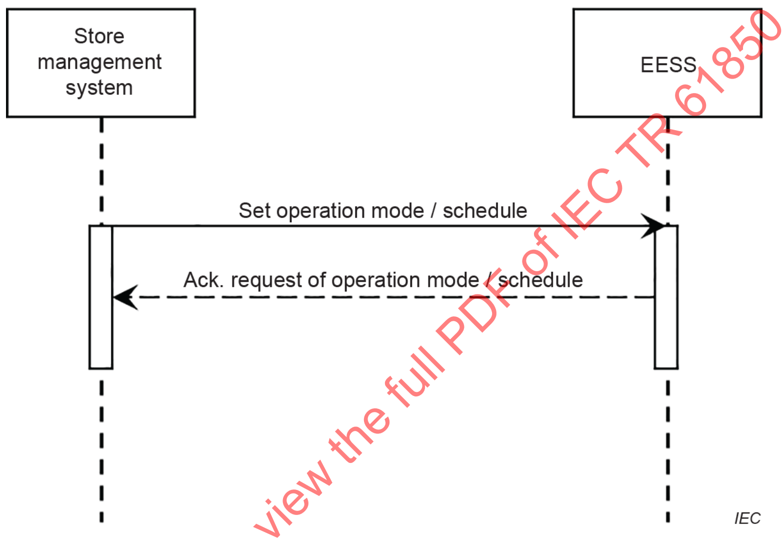


Figure 22 – Sequence of UC4: set operational function/schedule to EESS

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.

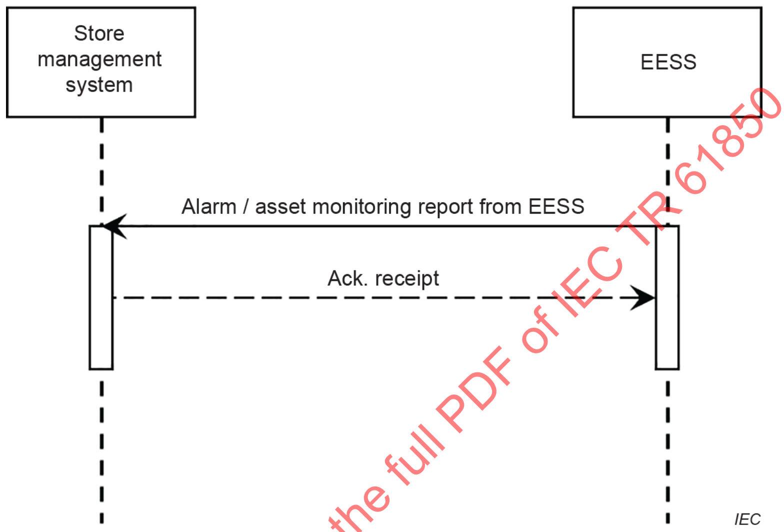


Figure 23 – Sequence of UC5: Alarm/Asset Monitoring of EESS

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, Mod,Beh,Health	LLN0
Type of EESS	0-3	DERTyp	<< abstract>> DER_NameplateRatingsLNs
Type of battery	0-3*	BatTyp	DBAT
Capacity (Nameplate Ratings)	0-3	WhRtg WhMaxRtg WhMinRtg	<< abstract>> Storage Nameplate Ratings
Capacity(Operational Ratings)	0-3	EffWh, UseWh	<< abstract>> Storage Operational Ratings
Max/Min usable capacity of the reserve levels	0-3	UseWhMinPct/ UseWhMaxPct	<< abstract>> Storage Operational Ratings
Max active/reactive power nameplate ratings while charging/discharging	0-3	ChaWMaxRtg, DschWMaxRtg ChaAvarMaxRtg, DschAvarMaxRtg ChaIvarMaxRtg, DschIvarMaxRtg	<< abstract>> Storage Nameplate Ratings
Max active/reactive power operational settings while charging	0-3	ChaWMax, ChaAvarMax, ChaIvarMax	<< abstract>> Storage Operational Ratings
Max current while charging/discharging	0-3	ChaAMaxRtg (AC), DschAMaxRtg (AC), ChaAmpMaxRtg (DC), 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, DschWRpuMaxRtg, ChaWRpdMaxRtg DschWRpdMaxRtg	StorageNameplateRatingsLN
Power setting (charging/discharging) (max W)	0-3	ChaWMaxRtg, DschWMaxRtg,	StorageNameplateRatingsLN
Reactive power (VAr)	0-3	ChaAvarMaxRtg, ChaIvarMaxRtg, DschAvarMaxRtg, 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 battery (in percent)	0-3	SocHiWrsPct	DER_StorageLN
High state of charge alarm threshold of the 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_OperationalatingsLN
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 synchronizaton sates 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), IntnVol(DC)	SBATExt
Internal battery current	1-2-3*	IntnA(non DC), IntnAmp(DC)	SBATExt
State of charge (kWh, energy % of maximum charge level/Usable state of charge/Actual state of charge)	1-2-3	SocEffAhrPct UseSocPct SocEffWhPct	DBAT, DER_StorageLN, 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, SchdAbsTm, ActWSchd, ActAncSchd	FSCH, 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.

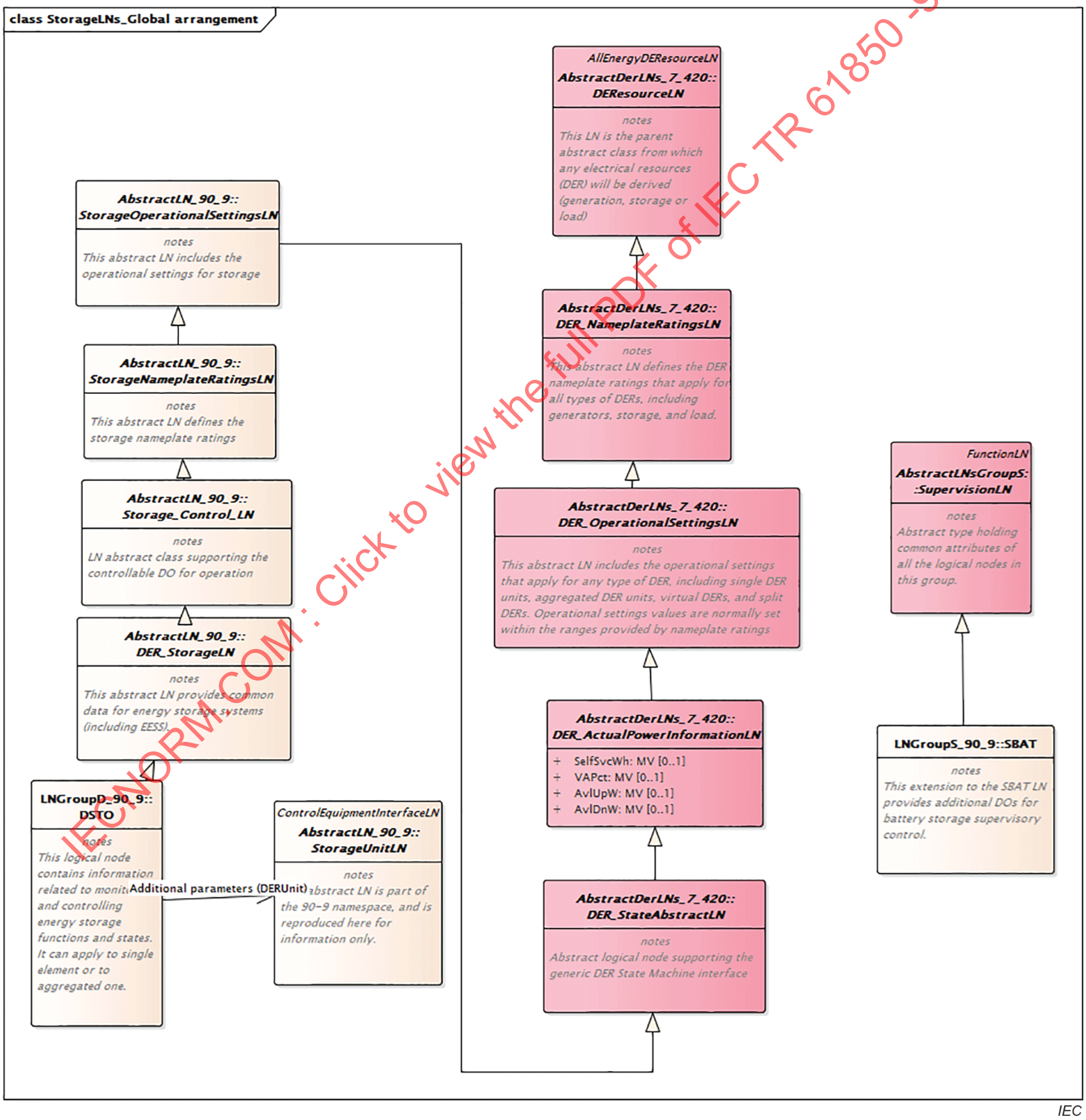


Figure 24 – Class diagram LogicalNodes_90_9::StorageLNs_Global arrangement

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

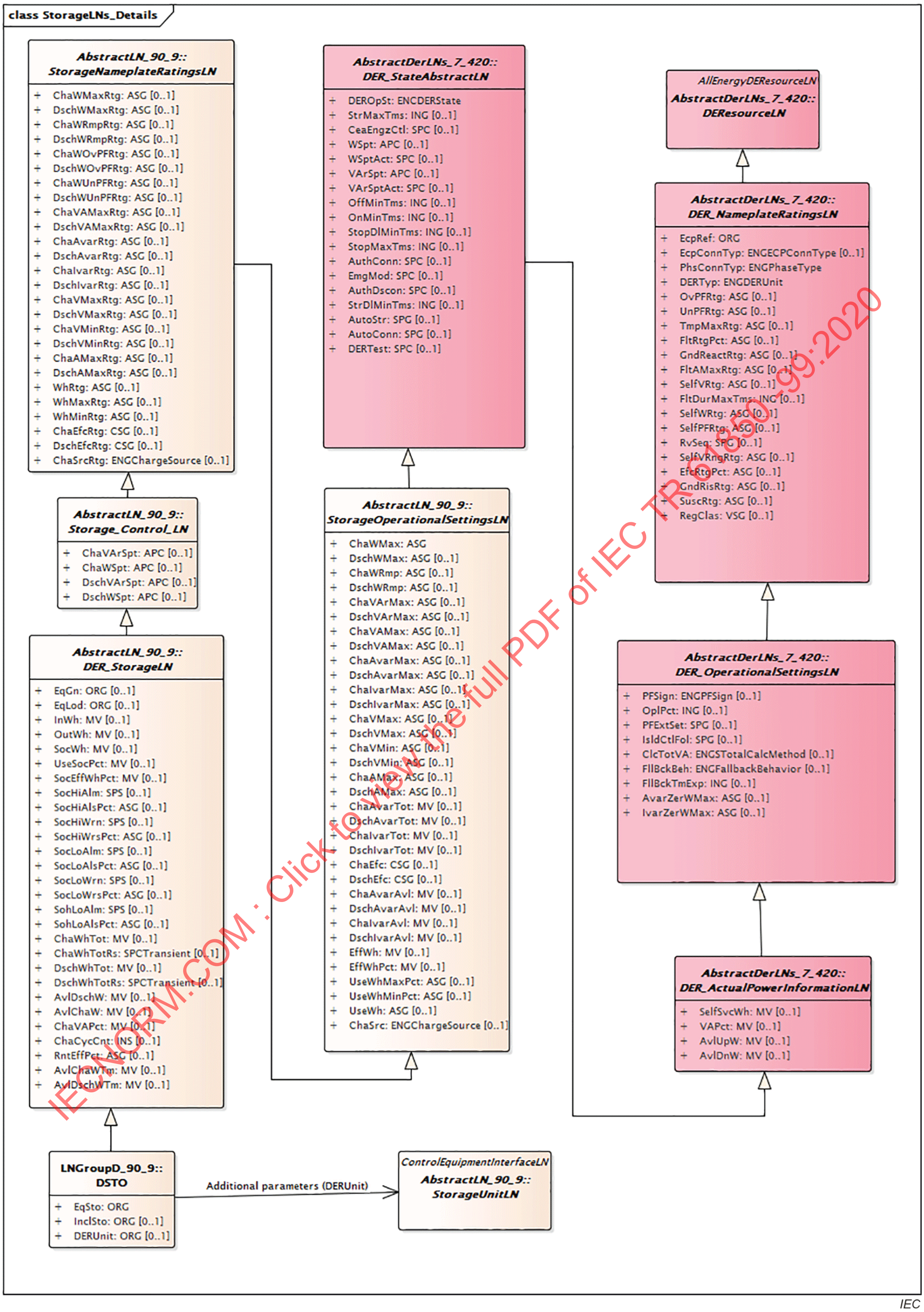


Figure 25 – Class diagram LogicalNodes_90_9::StorageLNs_Details

Figure 25: Modelling details of Storage related LNs

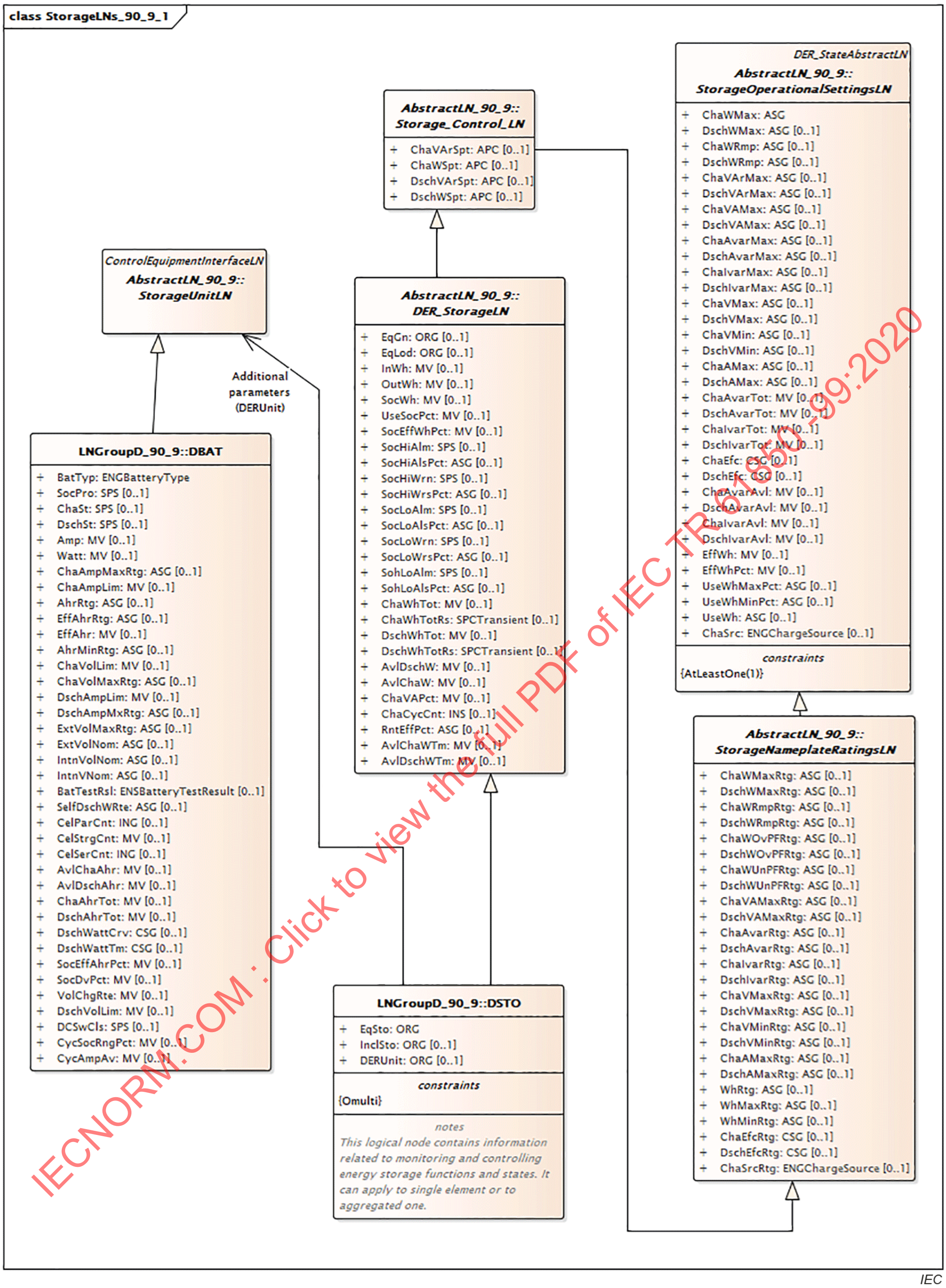


Figure 26 – Class diagram LogicalNodes_90_9::StorageLNs_90_9_1

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**	**PresCond nds/ds**
Controls				
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**	**PresCond nds/ds**
Measured and metered values				
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**	**PresCond nds/ds**
ChaIvarTot	MV		The total amount of reactive power available for injecting even if possibly impacting active power output while charging	O / O
DschIvarTot	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
ChaIvarAvl	MV		The amount of reactive power available for injecting without impacting active power output while charging	O / O
DschIvarAvl	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). 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
ChaIvarMax	ASG		Operational setpoint for maximum supply (injection) reactive power while charging	O / F
DschIvarMax	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**	**PresCond nds/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 be 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 be 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 (ChargeSourceKind)		Net Energy Metering (NEM) Policy Mode which establishes whether the DER qualifies as renewable. Mode A = Storage may charge from the grid but may not discharge to the grid (acts only as load). Mode B = Storage may not charge from the grid but may discharge to the grid (charges from local energy source). 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**	**PresCond nds/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**	**PresCond nds/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
ChaIvarRtg	ASG		Nameplate rating for maximum supply (injection) reactive power while charging	O / F
DschIvarRtg	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 (ChargeSourceKind)		Net Energy Metering (NEM) Policy Mode which establishes whether the DER qualifies as renewable. Mode A = Storage may charge from the grid but may not discharge to the grid (acts only as load). Mode B = Storage may not charge from the grid but may discharge to the grid (charges from local energy source). 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

6.1.2.5 <<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 nds/ds**
Status information				
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
Measured and metered values				
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
Controls				
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
Settings				

DER_StorageLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/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) – CapWhUseRtg)	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**	**PresCond nds/ds**
Descriptions				
EEName	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 actived, 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 (BatteryTestResultKind)		Battery test results	O / F

DBAT				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/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**	**PresCond nds/ds**
LocSta	SPC		inherited from: ControllingLN	OF(Loc) / F
ClcStr	SPC		inherited from: StatisticsLN	O / O
Mod	ENC (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**	**PresCond nds/ds**
Descriptions				
EEName	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
ChaIvarTot	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**	**PresCond nds/ds**
ChaIvarAvl	MV		inherited from: StorageOperationalSettingsLN	O / O
DschIvarAvl	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	PresCond nds/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
ChaIvarRtg	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 (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
ChaIvarMax	ASG		inherited from: StorageOperationalSettingsLN	O / F

DSTO				
Data object name	Common data class	T	Explanation	PresCond nds/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 (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
OplPct	ING		inherited from: DER_OperationalSettingsLN	O / F
PFExtSet	SPG		inherited from: DER_OperationalSettingsLN	O / F
IsldCtlFol	SPG		inherited from: DER_OperationalSettingsLN	O / F
ClcTotVA	ENG (STotalCalcMethodKind)		inherited from: DER_OperationalSettingsLN	O / F
FllBckBeh	ENG (FallbackBehaviorKind)		inherited from: DER_OperationalSettingsLN	O / F
FllBckTmExp	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 (ECPConnKind)		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**	**PresCond nds/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 (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

6.1.4 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**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		inherited from: DomainLN	MONamPlt / MONamPlt

SBAT				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/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**	**PresCond nds/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**	**PresCond nds/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 618507-420 as soon as this document is published.

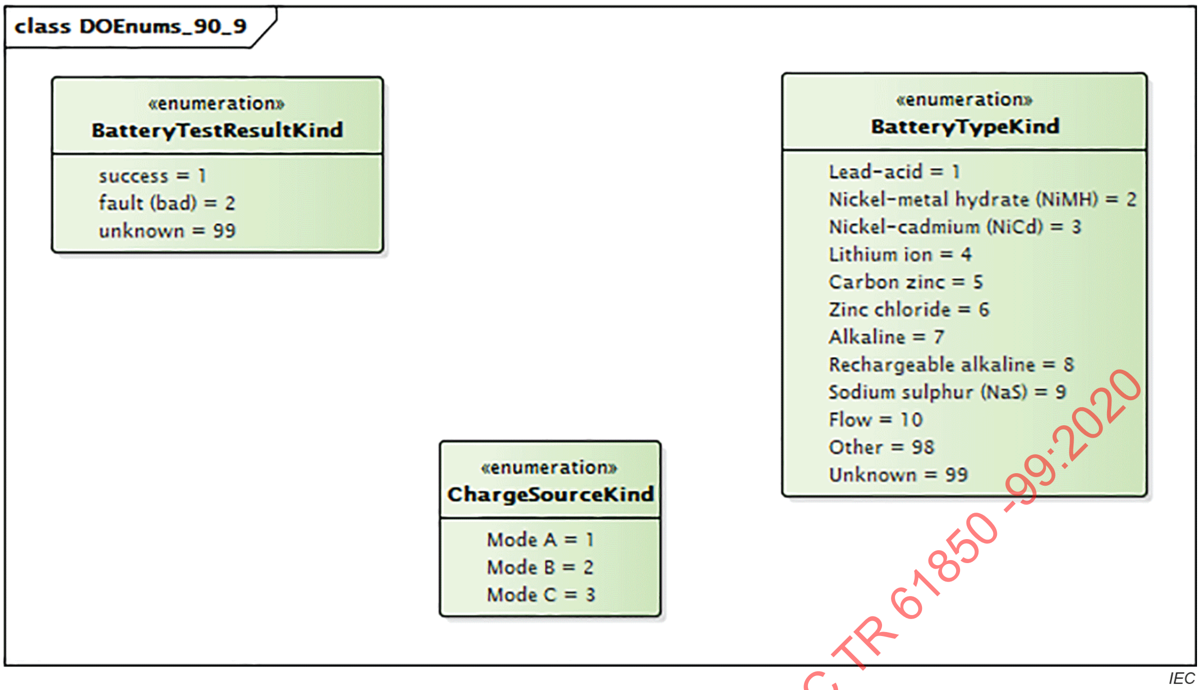


Figure 28 – Class diagram DOEnums_90_9::DOEnums_90_9

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.

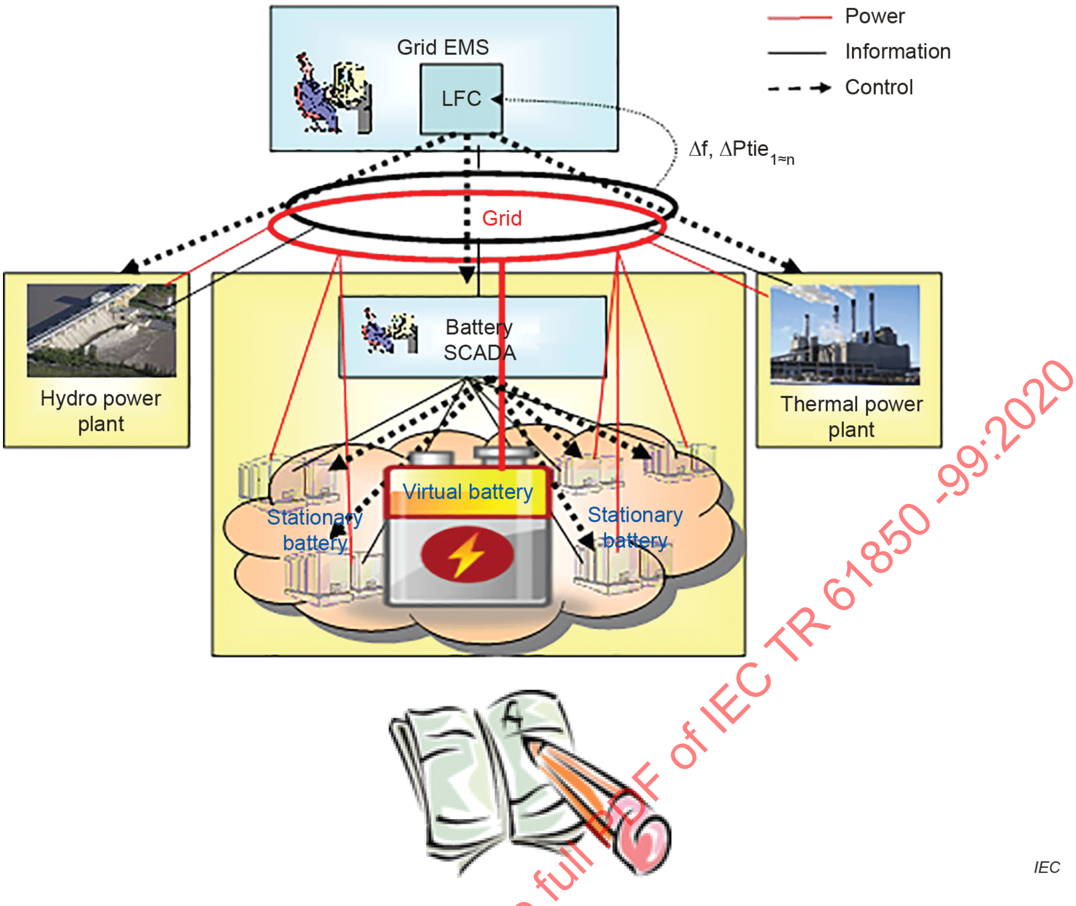


Figure A.1 – Load Frequency control by battery aggregation

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 CADA) 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.

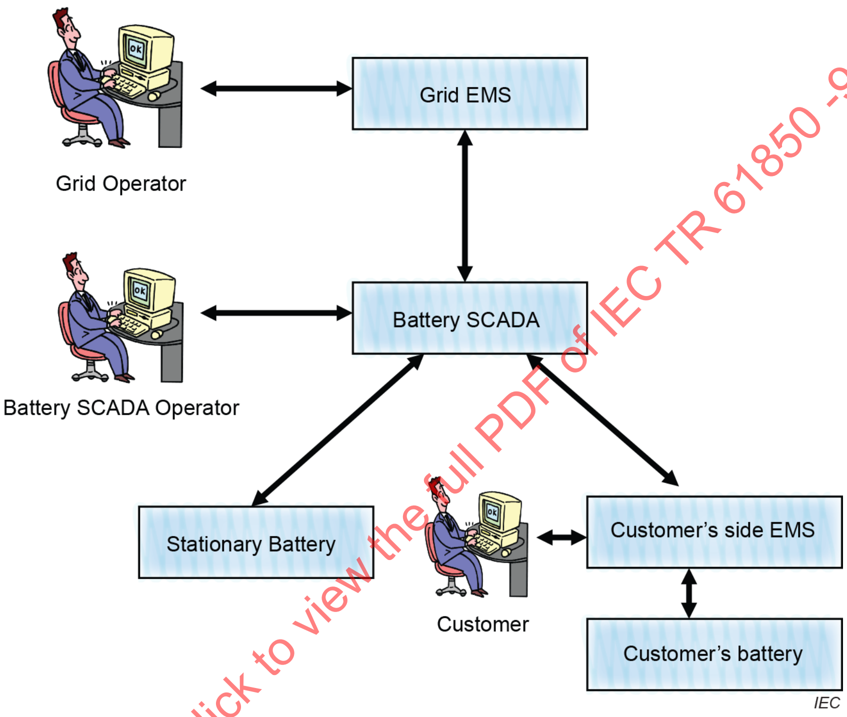


Figure A.2 – Actors

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. In case of emergency, Grid EMS sends discharging command to Battery-based EESS via DER MS (Battery SCADA). Grid EMS provides man-machine interface for Grid operator.
Grid Operator	Person	Grid Operator monitors and controls grid frequency. 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. 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). 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).

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 Δf and Ptie. Using this data, Grid EMS calculates control value for generators and DER MS (Battery SCADA). Where Δf is deviation of frequency and Ptie 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. 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. 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 valued	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 Sending current value	Battery-based EESS charges or discharges 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.

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 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 And calculation current status of Virtual battery	DER MS (Battery SCADA) receives current status from Battery-based EESS 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 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		

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 EESs

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. 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 dose 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. 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[7], 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.

[7] 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 (person, organization, device, system, or subsystem)	Actor description
Grid EMS	System	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. 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.
Grid Operator	Person	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). 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.
DER MS (Battery SCADA)	System	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. 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 gird operators as if they have a large Aggregated Battery-based EESS. 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. 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. 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. 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.
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 (person, organization, device, system, 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. Example 1. Peak-cut pattern for APSU: 13:00~14:00 90 %、14:00~15:00 100 %、 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. Example1. Peak-cut pattern for APSU:13:00~14:00 90MW、14:00~15:00 100MW、 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). 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.