Deliverable 2.2

Generic interface specification for DER components and registry

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OS4ES

D2.2 Generic interface specification for DER components and registry

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Executive Summary

This deliverable is the IEC 61850 data model for DER systems.

The basis for this deliverable is D4.2 “DER Semantic Model” [1]. Data defined in the DER Semantic Model is mapped to the IEC 61850 standard “Communication networks and systems for power utility automation communication standard” and holds the IEC 61850 specific Logical Nodes with their data objects along with a semantic description.

This deliverable is organized as follows:

1. Introduction
2. Data model

The IEC 61850 data model presented in this deliverable will be presented in the respective standardization committee TC57 WG17 in Task Force 90-15 with the aim to incorporate it in the Technical Report IEC 61850-90-15 (IEC 61850 based DER Grid Integration). Besides, it will be promoted for inclusion in the second edition of the standard IEC 61850-7-420 Basic communication structure – Distributed energy resources logical nodes.

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1 Introduction

1.1 Scope of the document

This deliverable provides the mapping of the specification of the DER Semantic Data Model of deliverable D4.2 [1] to IEC 61850 Logical Nodes (LN) and data objects (DO).

The IEC 61850 contains all the data objects of Annex A of D4.2 and has additional data objects that have been identified as reasonable or necessary in the data model.

1.2 Notations, abbreviations and acronyms

CDC	Common Data Class
DO	Data Object
FC	Functional Constraint
LN	Logical Node
OS4ES	Open System for Energy Services
PCC	Point of Common Coupling

Table 1 : Acronyms list

2 IEC 61850 data model

2.1 Overview of IEC 61850 model

From the DER Semantic Data Model the following Logical Nodes have been derived for the IEC 61850 model:

- LN DPCC – LN for the Point of Common Coupling (PCC)
- LN DDER – LN for the DER System
- LN DSVC – LN for the DER System Energy Service “Autonomous Voltage Control”
- LN DSRP – LN for the DER System Energy Service “Reactive Power”
- LN DSTS – LN for the DER System Energy Service “Flexibility - Time Shiftable Profile”
- LN DSAP – LN for the DER System Energy Service “Active Power”
- LN DPAP – LN for partial reservation of the DER System Energy Service “Active Power”
- LN DSEC – LN for the DER System Energy Service “Flexibility – Energy Corridor”
- LN DSFC – LN for the DER System Energy Service “Autonomous Frequency Control”
- LN DPFC – LN for partial reservation of the DER System Energy Service “Autonomous Frequency Control”

The data objects of these Logical Nodes are defined in IEC 61850 Logical Node tables. Section 2.3 provides a description of these Logical Node tables and section 2.5 holds the Logical Node tables with their data objects.

To model forecast and partial reservation, two new Common Data Classes (CDC) are introduced:

- MTV – time unit value series for analogue values (measurands)
- STV – time unit value series for binary status

Section 2.2 provides a description of these CDCs and section 2.4 holds the CDCs with their data attributes.

Optional schedules that are used to control the behavior of the DER system are modeled as described in IEC 61850-90-10 [5].

2.2 IEC 61850 CDC tables

The six columns of the CDC tables hold the following information (for details see [2]):

- Data attribute name
- Type: the type of the data attribute. This can be a basic type or a constructed attribute type
- FC: the functional constraint of the data attribute
- TrgOp: the trigger option that will trigger the sending of a report
- Value/Value range: constraints of the possible value.
- M/O/C: Informs if the entry of the data attribute is mandatory (M), optional (O) or conditional (C)

The data attributes in the CDC table are grouped for the convenience of the reader into the following categories:

- Status or measured values: these are data attributes where the values are changed based on process conditions
- Configuration, description and extensions: these are data attributes that hold configuration values associated to the common data class (FC=CF), descriptive information (FC=DC) or that are used with extensions of the standard data model (FC=EX).

2.3 IEC 61850 LN tables

The first row of the LN table contains the LN name.

The five columns of the LN table hold the following information:

- Data object name: Lists the name of the data object
- Common data class: Lists the common data class defined in IEC 61850-7-3
- T: Shows if the data object is transient (T) or non-transient (blank)
- Explanation: Provides a textual description (semantics) of the data object
- M/O/C: Informs if the entry of the data object is mandatory (M), optional (O) or conditional (C)

The data objects in the logical node classes are grouped for the convenience of the reader into the following categories, according to their respective common data class categories defined in IEC 61850-7-3:

- Descriptions
  Description lists data objects, which give information about the LN itself or an allocated device. This information consists of identification information and general properties like configuration revision, hard and software revisions, etc.

- Status information
  Status information contains data object, which show either the status of the process or of the function allocated to the LN class. This information is produced locally and cannot be changed via communication for operational reasons unless substitution is applicable. Data objects such as “start” or “trip” are listed in this category. Most of these data objects are mandatory.
- Measured and metered values
  Measured values are analogue data objects measured from the process or calculated in the functions such as currents, voltages, power, etc. This information is produced locally and cannot be changed remotely unless substitution is applicable.
  Metered values are analogue data objects representing quantities measured over time, for example energy. This information is produced locally and cannot be changed remotely unless substitution is applicable.
- Controls
  Controls contain data objects which are changed by commands such as switchgear state (ON/OFF), tap changer position or resettable counters. They are typically changed remotely, and are changed during operation much more often than settings.
- Settings
  Settings are data objects which configure the function for its operation. Since many settings are dependent on the implementation of the function, only a commonly agreed minimum is standardised. They may be changed from remote, but normally not very often.

2.4 IEC 61850 CDC

2.4.1 Time unit value series for analogue values (MTV)

This CDC is used to describe a series of analog values to be applied over a series of fixed length time intervals.

Table 2 – Time unit value series for analogue values

MTV class					
Data attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
status					
mag	ARRAY 0..maxPts-1 OF AnalogueValue	MX	dchg, dupd		M
prob	ARRAY 0..maxPts-1 OF INT32U	MX	dchg, dupd	0 ... 100 000	O
strTm	TimeStamp	MX	dchg, dupd		M
q	Quality	MX	qchg		M
t	TimeStamp	MX			M
configuration, description and extension					
numPts	INT16U	CF	dchg	0 < numPts ≤ maxPts	M
tIntv	INT32U	CF	dchg		M
tUnits	Unit	CF	dchg		M
units	Unit	CF	dchg		O
maxPts	INT16U	CF			M
d	VISIBLE STRING255	DC			O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M
Services					
.					

The data attributes have the following meaning:

- mag: the array represents the series of analogue values
- prob: in the case of forecast this is the probability in percentage for the associated value
- strTm: time when the value series start
- numPts: the number of entries that are valid in that value series
- tIntv: the duration of a time interval in tUnits
- tUnits: the unit for the time interval (seconds, ms, etc)
- maxPts: the maximal number of entries that the time series can host

For more explanations see Figure 1.

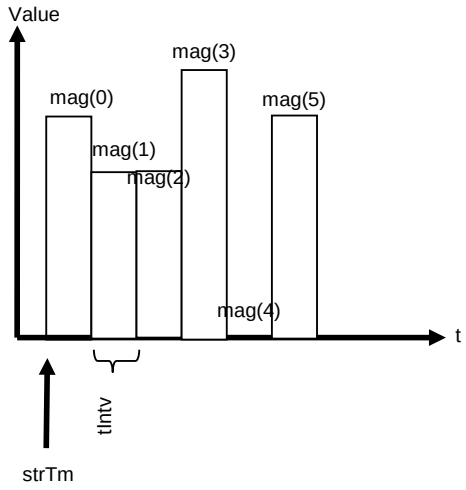

Figure 1: Time unit value series

2.4.2 Time unit value series for binary status values (STV)

This CDC is used to describe a series of binary status values to be applied over a series of fixed length time intervals.

Table 3 – Time unit value series for binary status values

STV class					
Data attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
status					
stVal	ARRAY 0..maxPts-1 OF BOOLEAN	ST	dchg, dupd		M
prob	ARRAY 0..maxPts-1 OF INT32U	ST	dchg, dupd	Probability in percentage 0 ... 100 000	O
strTm	TimeStamp	MX	dchg, dupd		M
q	Quality	ST	qchg		M
t	TimeStamp	ST			M
configuration, description and extension					
numPts	INT16U	CF	dchg	0 < numPts ≤ maxPts	M
tIntv	INT32U	CF	dchg	The duration of a forecast entry in tUnits	M
tUnits	Unit	CF	dchg		M
units	Unit	CF	dchg		O
maxPts	INT16U	CF			M
d	VISIBLE STRING255	DC			O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M
Services					
.					

2.5 IEC 61850 Logical Nodes

2.5.1 LN: DER system characteristics at the PCC Name: DPCC

This logical node defines the characteristics of a Point of Common Coupling at which DER systems are connected to the grid.

Table 4 shows all data objects of DPCC.

Table 4 – Data objects of DPCC

DPCC				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Descriptions				
PCCId	ING		Identification of the PCC DER systems are connected to the grid at a PCC.	M
Settings				
VLevPCC	ASG		Nominal voltage level at the PCC	M
VLevECP	ASG		Nominal voltage level at the ECP	M
ECPDis	ASG		Distance of the ECP to the PCC. The ECP corresponds to the electrical connection point of the DER resource inside the customer premises, downstream the PCC. If ECP = PCC this entry would be “0”	M
ConnPhs	ENG		Phase to which the DER system is connected to (applicable to 1-phase systems)	M
ConnTyp	ENG		Connection type of the DER system at the ECP. Can be 1-phase or 3-phase.	M

2.5.2 LN: DER system Name: DDER

This logical node defines the characteristics of a DER system.

Table 5 shows all data objects of DDER.

Table 5 – Data objects of DDER

DDER				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Status information				
DetTyp	ENS		Behaviour of the DER system. Possible entries are: • deterministic • non-deterministic • hybrid	M
SysTyp	ENS		Type of the DER System. Possible entries are: • Generator • Load • Reversible Storage	M
TechTyp	ENS		Technology of the DER System. Possible entries are: • Hybrid • PV • CHP • Wind • Fuel cell • Reciprocating engine • Battery • EV • Controllable load • Flywheel	M
Controls				
SwOff	DPC		Control for remotely switching on and off the DER system.	M
Settings				
Rely	ING		Aggregated value of the reliability assessment of all the services that have been provided by a DER system	O
IntnId	ING		DER system identifier, assigned by the registry once the DER system has been successfully registered	M
FcCap	SPG		Indicates the capability of the DER system to provide a forecast	O
SchdCap	SPG		Capability of accepting schedules. Describes the ability of a service to execute a schedule. If a DER System is not able to execute schedules it should receive setpoints for the various points in time. Just applicable to the constant watt service, as constant frequency and constant voltage are only based on setpoints	O
MaxStrTm	ING		Maximum time from switch on to grid connection	M
MaxStopTm	ING		Maximum time from switch off to grid disconnection	M
MinOffTm	ING		Minimum time the DER system needs to stay off after being switched off	O
MinOnTm	ING		Minimum time the DER system needs to stay on after being switched on	O
Rated Generator Capabilities				
GnNomW	ASG		Nominal rated active power supply	O
GnMaxW	ASG		Maximal rated active power supply (under overload conditions)	O

DDER				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
GnMinW	ASG		Minimal rated active power supply (minimum while switched on)	O
GnMaxPsVAr	ASG		Maximal rated positive reactive power. Positive reactive power generated means that reactive power is flowing from the generator to the utility grid	O
GnMinPsVAr	ASG		Minimal rated positive reactive power (minimum while switched on).	O
GnMaxNgVAr	ASG		Maximal rated negative reactive power. Negative reactive power generated means that reactive power is flowing from the utility grid to the generator	O
GnMinNgVAr	ASG		Minimal rated negative reactive power (minimum while switched on)	O
WVArCrv	CSG		Collection of operation points in terms of couples of active/reactive power values	O
Rated Load Capabilities				
LodNomW	ASG		Nominal rated active power demand	O
LodMaxW	ASG		maximal rated active power demand (under overload conditions)	O
LodMinW	ASG		minimal rated active power demand (minimum while switched on)	O
LodMaxPsVAr	ASG		Maximal rated positive reactive power. Positive reactive power is caused by inductive loads such as motors and transformers (especially at low loads).	O
LodMinPsVAr	ASG		Minimal rated positive reactive power.	O
LodMaxNgVAr	ASG		Maximal rated negative reactive power. Negative reactive power is caused by capacitive loads. This can include lighting ballasts, variable speed drives for motors, computer equipment, and inverters (especially when idle).	O
LodMinNgVAr	ASG		Minimal rated negative reactive power.	O
LodPF	ASG		Power factor of load	O
Rated Storage Capabilities				
StoGnEn	ASG		Installed energy storage capacity that can be supplied to the grid	O
StoLodEn	ASG		Installed energy storage capacity that can be consumed from the grid	O

The data object “LDName” of Annex A of D4.2 is implicitly given by the object reference of the instantiated model and is therefore not modelled as data object of this LN.

In order to model the data objects “GPSLat”, “GPSLong” and “OwnerName” listed in Annex A of D4.2 the data attribute “PhyNam” of the Logical Node LPHD (see Figure 2) - introduced in the IEC 61850 standard to model common issues for physical devices – is used. It has the Common Data Class (CDC) DLP (Device Name Plate) which contains - among other data objects - “owner”, “latitude” and “longitude” (see Figure 3). As currently a revision of IEC 61850-7-3 is done in which the CDC DPL is defined, it is envisaged to add the data object “OwnerID” as a new DO in this CDC. Consequently the LN DDER does not contain the data

objects “GPSLat”, “GPSLong” “OwnerName” and “OwnerID” but reuses an existing IEC 61850 data object with a CDC providing these Dos.

LPHD class				
Data object name	**Common data class**	**Explanation**	**T**	**M/O/C**
Data objects				
Descriptions				
PhyNam	DPL	Physical device name plate		M
Status information				
PhyHealth	ENS	Physical device health		M
OutOv	SPS	Output communications buffer overflow		O
Proxy	SPS	Indicates if this LN is a proxy		M
InOv	SPS	Input communications buffer overflow		O
NumPwrUp	INS	Number of power-ups		O
WrmStr	INS	Number of warm starts		O
WacTrg	INS	Number of watchdog device resets detected		O
PwrUp	SPS	Power-up detected		O
PwrDn	SPS	Power-down detected		O
PwrSupAlm	SPS	External power supply alarm		O
Controls				
RsStat	SPC	Reset device statistics	T	O
Sim	SPC	Receive simulated GOOSE or simulated SV		O
Settings				
Data sets (see IEC 61850-7-2)				
Inherited and specialised from logical node class (see IEC 61850-7-2)				
BufferedReportControlBlock (see IEC 61850-7-2)				
Inherited and specialised from logical node class (see IEC 61850-7-2)				
UnbufferedReportControlBlock (see IEC 61850-7-2)				
Inherited and specialised from logical node class (see IEC 61850-7-2)				
Services (see IEC 61850-7-2)				
Inherited and specialised from logical node class (see IEC 61850-7-2)				

Figure 2: LN LPHD of IEC 61850-7-4 (ed. 2)

DPL class					
Data attribute name	**Type**	**FC**	**TrgOp**	**Value/Value range**	**M/O/C**
DataName	Inherited from GenDataObject Class or from GenSubDataObject Class (see IEC 61850-7-2)				
DataAttribute					
configuration, description and extension					
vendor	VISIBLE STRING255	DC			M
hwRev	VISIBLE STRING255	DC			O
swRev	VISIBLE STRING255	DC			O
serNum	VISIBLE STRING255	DC			O
model	VISIBLE STRING255	DC			O
location	VISIBLE STRING255	DC			O
name	VISIBLE STRING64	DC			O
owner	VISIBLE STRING255	DC			O
ePSName	VISIBLE STRING255	DC			O
primeOper	VISIBLE STRING255	DC			O
secondOper	VISIBLE STRING255	DC			O
latitude	FLOAT32	DC			O
longitude	FLOAT32	DC			O
altitude	FLOAT32	DC			O
mRID	VISIBLE STRING255	DC			O
d	VISIBLE STRING255	DC			O
dU	UNICODE STRING255	DC			O
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M
Services					
As defined in Table 60.					

Figure 3: Common Data Class DLP of IEC 61850-7-3 (ed. 2)

The data objects “ExtAddr” and “JID” stemming from D4.2 Annex A are not modelled as DO of this LN but would be modelled in an IEC 61850 SCL file.

The DO “P” and “Q” of the UML class “Generic controls and measurements” can be modelled with the existing IEC 61850 LN class “MMXU” (see Figure 4).

MMXU class				
Data object name	**Common data class**	**Explanation**	**T**	**M/O/C**
LNName		The name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to IEC 61850-7-2, Clause 22.		
Data objects				
Measured and metered values				
TotW	MV	Total active power (total *P*)		O
TotVAr	MV	Total reactive power (total *Q*)		O
TotVA	MV	Total apparent power (total *S*)		O
TotPF	MV	Average power factor (total *PF*)		O
Hz	MV	Frequency		O
PPV	DEL	Phase to phase voltages (*VL*1,*VL*2, ...)		O
PNV	WYE	Phase to neutral voltage		O
PhV	WYE	Phase to ground voltages (*VL*1ER, ...)		O
A	WYE	Phase currents (*IL*1, *IL*2, *IL*3)		O
W	WYE	Phase active power (*P*)		O
VAr	WYE	Phase reactive power (*Q*)		O
VA	WYE	Phase apparent power (*S*)		O
PF	WYE	Phase power factor		O
Z	WYE	Phase impedance		O

Figure 4: Extract of the standardized LN MMXU of IEC 61850-7-4 (ed. 2)

2.5.3 LN: Autonomous Voltage Control Name: DSVC

This logical node defines the characteristics of the DER system energy service “Autonomous Voltage Control”.

Table 6 shows all data objects of DSVC.

Table 6 – Data objects of DSVC

DSVC				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Status information				
NoAvl	SPS		This indicates that the service is currently not available.	M
NoAvlSchd	STV		This allows to schedule time frames within the service registration life time for which the service will not be available. During that time, the service is not available by decision of the DER system owner due to maintenance or due to a decision of the DER system owner based on its business intelligence. In the simplest case there would be no unavailability periods declared, so the availability would coincide with the time frame of the service registration. For those periods of time for which there is no coincident declared unavailability, the service is considered to be available.	O
Measured and metered values				
LoVArBndFc	MTV		Forecast for the lower band value the DER system can provide	O
UpVArBndFc	MTV		Forecast for the upper band value the DER system can provide	O
Controls				
Act	SPC		Activate / Deactivate the energy service autonomous voltage control by a control request	M
Settings				
Disp	SPG		Dispatchable means that the DER system is able to be operated with setpoints provided from an aggregator. Note: It is assumed that all services can be switched off, so the schedule associated to the off state is not considered as a valid schedule for assessing a service to be dispatchable or not. A DER system that is not dispatchable, once switched on, will provide the services based on the current capabilities; e.g. supply as much of active power as is produced	M
Pred	SPG		Means that the baseline (or the expected schedule) is provided by the DER resource itself. If the service provision is not predictable there will be no forecast provided by the DER resource (going into the Registry). In that case, the Aggregator could estimate it (not going into the Registry)	O
Rely	ING		Reliability of the service or the DER system	O
SvcRegisStr	TSG		Starting date and time of the period for which the service registration is valid	M
SvcRegisEnd	TSG		Ending date and time of the period for which the service registration is valid	M

DSVC				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
SvcId	ISG		Identifier for service	M
RsvId	ISG		Identifier for reservation	M
Pricing information				
CostRsv	CUG		Costs for reservation of the service; price is in currency per reserved power where partial reservation is possible; otherwise it is in currency per unit	O
CostEn	CUG		Costs for supplied energy; price is in currency per energy	O
CostFut	CUG		Costs for supplied energy that has been reserved as futures; price is in currency per energy	O
CostStr	CUG		Costs for starting the DER system; price is in currency per unit	O
Rated parameters				
NomV	ASG		Nominal voltage of the control droop, for which the reactive power injected is 0	M
UpVArBnd	ASG		The upper limit of the control band is given in percent of nominal positive reactive power	M
LoVArBnd	ASG		The lower limit of the control band is given in percent of nominal negative reactive power	M
DrpSlop	ASG		The droop is the quotient of the relative quasi-stationary voltage deviation in the system (ΔV/VN) and the relative reactive power change (ΔQG/QGN) of the machine under the influence of the primary controller	M
RteChgDecVAr	ASG		Rate of change for reactive power decrease	M
RteChgIncrVAr	ASG		Rate of change for reactive power increase	M

If a schedule is used for activation of the energy service, the following LNs are required in addition:

- LN FSCC with ActSchdRef=DSVC.Act
- Multiple instances of LN FSCH with ValSPG used as schedule

2.5.4 LN: Reactive Power Name: DSRP

This logical node defines the characteristics of the DER system energy service “Reactive Power”.

Table 7 shows all data objects of DSRP.

Table 7 – Data objects of DSRP

DSRP				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Status information				
NoAvl	SPS		This indicates that the service is currently not available.	M
NoAvlSchd	STV		This allows to schedule time frames within the service registration life time for which the service will not be available. During that time, the service is not available by decision of the DER system owner due to maintenance or due to a decision of the DER system owner based on its business intelligence. In the simplest case there would be no unavailability periods declared, so the availability would coincide with the time frame of the service registration. For those periods of time for which there is no coincident declared unavailability, the service is considered to be available.	O
Measured and metered values				
MaxNgVArInst	MV		Actual maximal negative reactive power	O
MaxNgVArFc	MTV		Forecast of maximal negative reactive power	O
MaxPsVArInst	MV		Actual maximal positive reactive power	O
MaxPsVArFc	MTV		Forecast of maximal positive reactive power	O
MinNgVArInst	MV		Actual minimal negative reactive power	O
MinNgVArFc	MTV		Forecast of minimal negative reactive power	O
MinPsVArInst	MV		Actual minimal positive reactive power	O
MinPsVArFc	MTV		Forecast of minimal positive reactive power	O
Controls				
VArSpt	APC		Setpoint for reactive power	M
Settings				
Disp	SPG		Dispatchable means that the DER system is able to be operated with setpoints provided from an aggregator. Note: It is assumed that all services can be switched off, so the schedule associated to the off state is not considered as a valid schedule for assessing a service to be dispatchable or not. A DER system that is not dispatchable, once switched on, will provide the services based on the current capabilities; e.g. supply as much of active power as is produced	M
Pred	SPG		Means that the baseline (or the expected schedule) is provided by the DER resource itself. If the service provision is not predictable there will be no forecast provided by the DER resource (going into the Registry). In that case, the Aggregator could estimate it (not going into the Registry)	O

DSRP				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Rely	ING		Reliability of the service or the DER system	O
SvcRegisStr	TSG		Starting date and time of the period for which the service registration is valid	M
SvcRegisEnd	TSG		Ending date and time of the period for which the service registration is valid	M
SvcId	ISG		Identifier for service	M
RsvId	ISG		Identifier for reservation	M
Pricing information				
CostRsv	CUG		Costs for reservation of the service; price is in currency per reserved power where partial reservation is possible; otherwise it is in currency per unit	O
CostEn	CUG		Costs for supplied energy; price is in currency per energy	O
CostFut	CUG		Costs for supplied energy that has been reserved as futures; price is in currency per energy	O
CostStr	CUG		Costs for starting the DER system; price is in currency per unit	O
Rated parameters				
MaxPsVAr	ASG		Maximal positive reactive power (inductive loads)	C1
MinPsVAr	ASG		Minimal positive reactive power (inductive loads)	C2
MaxNgVAr	ASG		Maximal negative reactive power (capacitive loads)	C1
MinNgVAr	ASG		Minimal negative reactive power (capacitive loads)	C2

C1: Either the data object MaxPsVAr or MaxNgVAr has to be entered depending whether it is an inductive or capacitive load

C2: Either the data object MinPsVAr or MinNgVAr has to be entered depending whether it is an inductive or capacitive load

If a schedule is used for activation of the energy service, the following LNs are required in addition:

- LN FSCC with ActSchdRef=DSRP.VArSpt
- Multiple instances of LN FSCH with ValASG used as schedule

2.5.5 LN: Flexibility – Time Shiftable Profile Name: DSTS

This logical node defines the characteristics of the DER system energy service "Flexibility – Time Shiftable Profile".

Table 8 shows all data objects of DSTS.

Table 8 – Data objects of DSTS

DSTS				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Status information				
NoAvl	SPS		This indicates that the service is currently not available.	M
NoAvlSchd	STV		This allows to schedule time frames within the service registration life time for which the service will not be available. During that time, the service is not available by decision of the DER system owner due to maintenance or due to a decision of the DER system owner based on its business intelligence. In the simplest case there would be no unavailability periods declared, so the availability would coincide with the time frame of the service registration. For those periods of time for which there is no coincident declared unavailability, the service is considered to be available.	O
Controls				
Str	SPC		Request for immediate start of the profile	C
Settings				
Disp	SPG		Dispatchable means that the DER system is able to be operated with setpoints provided from an aggregator. Note: It is assumed that all services can be switched off, so the schedule associated to the off state is not considered as a valid schedule for assessing a service to be dispatchable or not. A DER system that is not dispatchable, once switched on, will provide the services based on the current capabilities; e.g. supply as much of active power as is produced	M
Pred	SPG		Means that the baseline (or the expected schedule) is provided by the DER resource itself. If the service provision is not predictable there will be no forecast provided by the DER resource (going into the Registry). In that case, the Aggregator could estimate it (not going into the Registry)	O
Rely	ING		Reliability of the service or the DER system	O
SvcRegisStr	TSG		Starting date and time of the period for which the service registration is valid	M
SvcRegisEnd	TSG		Ending date and time of the period for which the service registration is valid	M
SvcId	ISG		Identifier for service	M
RsvId	ISG		Identifier for reservation	M

StrTm	TSG		Time when the profile shall start without interruption	C
Pricing information				
CostRsv	CUG		Costs for reservation of the service; price is in currency per reserved power where partial reservation is possible; otherwise it is in currency per unit	O
CostEn	CUG		Costs for supplied energy; price is in currency per energy	O
CostFut	CUG		Costs for supplied energy that has been reserved as futures; price is in currency per energy	O
CostStr	CUG		Costs for starting the DER system; price is in currency per unit	O
Rated parameters				
IntrProf	SPG		Execution of profile may be interrupted	O
LodProf	CSG		Load profile. This is a curve describing the required power over the time.	M
Actual values and forecast				
ErlStr	TSG		Earliest start	M
LatStr	TSG		Latest start	M
PrfStr	TSG		Preferred start	M

C: One of the two data objects must be available.

If a schedule is used for activation of the energy service, the following LNs are required in addition:

- LN FSCC with ActSchdRef=DSTS.Str (Note: if the profile is interruptible (DO IntrProf), the schedule is interpreted as status on/off; that means, when the scheduled value is TRUE, the profile is executed, when the value goes to FALSE, the execution is stopped and continued with the next scheduling to TRUE.
- Multiple instances of LN FSCH with ValSPG used as schedule

2.5.6 LN: Active Power Name: DSAP

This logical node defines the characteristics of the DER system energy service “Active Power”.

Table 9 shows all data objects of DSAP.

Table 9 – Data objects of DSAP

DSAP				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Status information				
NoAvl	SPS		This indicates that the service is currently not available.	M
NoAvlSchd	STV		This allows to schedule time frames within the service registration life time for which the service will not be available. During that time, the service is not available by decision of the DER system owner due to maintenance or due to a decision of the DER system owner based on its business intelligence. In the simplest case there would be no unavailability periods declared, so the availability would coincide with the time frame of the service registration. For those periods of time for which there is no coincident declared unavailability, the service is considered to be available.	O
Measured and metered values				
WSchdFut	MTV		Guaranteed Schedule for active power as futures	C
WSchdFutPct	MTV		Schedule for active power as futures in percent	C
Actual values and forecast				
... for generators				
GnMaxWInst	MV		Actual maximal power that can be delivered	M
GnMaxWFc	MTV		Forecast of maximal power that can be delivered	O
GnMinWInst	MV		Actual minimal power that can be delivered	M
GnMinWFc	MTV		Forecast of minimal power that can be delivered	O
... for loads				
LodMaxWInst	MV		Actual maximal power that can be consumed	M
LodMaxWFc	MTV		Forecast of maximal power that can be consumed	O
LodMinWInst	MV		Actual minimal power that can be consumed	M
LodMinWFc	MTV		Forecast of minimal power that can be consumed	O
Controls				
WSpt	APC		Setpoint for active power	C
WSptPct	APC		Setpoint for active power in percent	C
Settings				
Disp	SPG		Dispatchable means that the DER system is able to be operated with setpoints provided from an aggregator. Note: It is assumed that all services can be switched off, so the schedule associated to the off state is not considered as a valid schedule for assessing a service to be dispatchable or not. A DER system that is not dispatchable, once switched on, will provide the services based on the	M

DSAP				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
			current capabilities; e.g. supply as much of active power as is produced	
Pred	SPG		Means that the baseline (or the expected schedule) is provided by the DER resource itself. If the service provision is not predictable there will be no forecast provided by the DER resource (going into the Registry). In that case, the Aggregator could estimate it (not going into the Registry)	O
Rely	ING		Reliability of the service or the DER system	O
SvcRegisStr	TSG		Starting date and time of the period for which the service registration is valid	M
SvcRegisEnd	TSG		Ending date and time of the period for which the service registration is valid	M
SvcId	ISG		Identifier for service	M
RsvId	ISG		Identifier for reservation	M
Pricing information				
CostRsv	CUG		Costs for reservation of the service; price is in currency per reserved power where partial reservation is possible; otherwise it is in currency per unit	O
CostEn	CUG		Costs for supplied energy; price is in currency per energy	O
CostFut	CUG		Costs for supplied energy that has been reserved as futures; price is in currency per energy	O
CostStr	CUG		Costs for starting the DER system; price is in currency per unit	O
Rated parameters				
GnMaxW	ASG		Maximal rated active power supply for generation	M
GnMinW	ASG		Minimal rated active power supply for generation	M
LodMaxW	ASG		Maximal rated active power supply for load	M
LodMinW	ASG		Minimal rated active power supply for load	M
Step	ASG		Step of change of a discrete setpoint value range, starting from SetpointMinValue. The value is expressed in percentage related to the maximal value	M
SptLst1	ASG		Multiple instances of this data object provide a list of possible values of a discrete setpoint, including SetpointMinValue and SetpointMaxValue. The value is expressed in percentage related to the maximal value	M

C: Either the entries in absolute values or in percent should be supplied

If a schedule is used for activation of the energy service, the following LNs are required in addition:

- LN FSCC with ActSchdRef=DSAP.WSpt or DSAP.WSptPct
- Multiple instances of LN FSCH with ValAPG used as schedule

Active power scheduled as futures is used to inform the DER system about the guaranteed delivery that will be requested within the reserved amount. This is used by the DER system to derive additional services it can offer. The actual requested power is called options. This corresponds to the value provided in WSpt or WSptPct (or in the corresponding schedule). It shall be any value between the value scheduled as futures and the reserved amount. This is illustrated in the figure below.

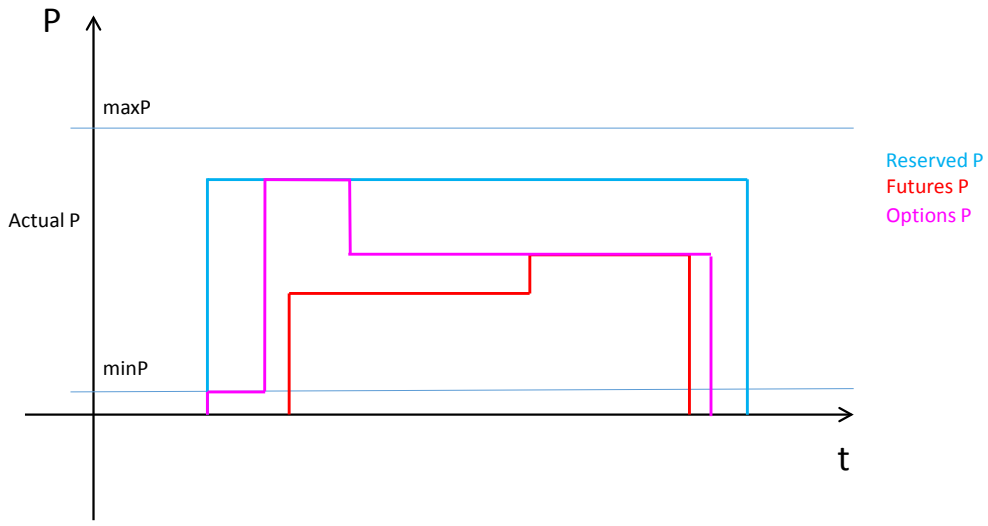

Figure 5: Options and futures

2.5.7 LN: Partial Reservation Active Power Name: DPAP

This logical node defines the characteristics of the DER system energy service "Partial Reservation Active Power".

Table 10 shows all data objects of DPAP.

Table 10 – Data objects of DPAP

DPAP				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Measured and metered values				
WSchdFut	MTV		Schedule for active power as futures	C1
WSchdFutPct	MTV		Schedule for active power as futures in percent	C1
Actual values and forecast				
... for generators				
GnMaxWInst	MV		Actual (instantaneous) maximal active power that can be delivered	M
GnMaxWFc	MTV		Forecast of maximal active power that can be delivered	O
GnMinWInst	MV		Actual minimal active power that can be delivered	M
GnMinWFc	MTV		Forecast of minimal power that can be delivered	O
... for loads				
LodMaxWInst	MV		Actual maximal active power that can be consumed	M
LodMaxWFc	MTV		Forecast of maximal active power that can be consumed	O
LodMinWInst	MV		Actual minimal active power that can be consumed	M
LodMinWFc	MTV		Forecast of minimal active power that can be consumed	O
Reservations				
... for generators				
GnRsvWSchd	MTV		Scheduled absolute active power that has been reserved (for generators)	O
GnRsvWSchdPct	MTV		Schedule percentage value of active power that has been reserved (for generators)	O
... for loads				
LodRsvWSchd	MTV		Scheduled absolute active power that has been reserved (for generators)	O
LodRsvWSchdPct	MTV		Schedule percentage value of active power that has been reserved (for generators)	O
Controls				
WSpt	APC		Setpoint for active power	C1
WSptPct	APC		Setpoint for active power in percent	C1
Settings				
Step	ASG		Step of change of a discrete setpoint value range, starting from SetpointMinValue. The value of the step size of the active power is expressed in percentage related to the maximal value	M
SptLst1	ASG		Multiple instances of this data object provide a list	M

DPAP				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
			of possible active power values of a discrete setpoint, including SetpointMinValue and SetpointMaxValue. The value is expressed in percentage related to the maximal value	
RsvId	ISG		Identifier of the reservation	M
SvcId	ISG		Identifier for service	M
Pricing information				
CostRsv	CUG		Costs for reservation of the service; price is in currency per reserved power where partial reservation is possible; otherwise it is in currency per unit	O
CostEn	CUG		Costs for supplied energy; price is in currency per energy	O
CostFut	CUG		Costs for supplied energy that has been reserved as futures; price is in currency per energy	O
CostStr	CUG		Costs for starting the DER system; price is in currency per unit	O
... for generators				
GnRsvWInst	ASG		Absolute actual (instantaneous) active power that has been reserved (for generators)	C2
GnRsvWInstPct	ASG		Percentage value of actual (instantaneous) active power that has been reserved (for generators)	C2
... for loads				
LodRsvWInst	ASG		Absolute actual (instantaneous) active power that has been reserved (for loads)	C3
LodRsvWInstPct	ASG		Percentage value of actual (instantaneous) active power that has been reserved (for generators)	C3

C1: One of these entries is mandatory (either setpoint or schedule in either absolute values or in percent)

C2: one of these entries is mandatory (either absolute or percentage value)

C3: one of these entries is mandatory (either absolute or percentage value)

If a schedule is used for activation of the energy service, the following LNs are required in addition:

- LN FSCC with ActSchdRef=DPAP.WSpt or DPAP.WSptPct
- Multiple instances of LN FSCH with ValAPG used as schedule

2.5.8 LN: Flexibility – Energy Corridor Name: DSEC

This logical node defines the characteristics of the DER system energy service "Flexibility – Energy Corridor".

Table 11 shows all data objects of DSEC.

Table 11 – Data objects of DSEC

DSEC				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Status information				
NoAvl	SPS		This indicates that the service is currently not available.	M
NoAvlSchd	STV		This allows to schedule time frames within the service registration life time for which the service will not be available. During that time, the service is not available by decision of the DER system owner due to maintenance or due to a decision of the DER system owner based on its business intelligence. In the simplest case there would be no unavailability periods declared, so the availability would coincide with the time frame of the service registration. For those periods of time for which there is no coincident declared unavailability, the service is considered to be available.	O
Measured and metered values				
InstSoc	MV		Actual state of charge. The value is continuously updated	M
AvPReq	MV		Average power requested	O
EnStoCapInst	MV		Actual (instantaneous) energy storage capability	M
FinSoc	MV		Final state of charge to be reached at the end of the service period. If no specific final state of charge is required, that object can be missing.	M
MaxGnWInst	MV		Actual maximal power that can be produced based on current SOC	M
MaxLodWInst	MV		Actual maximal power that can be consumed based on current SOC	M
MinGnWInst	MV		Actual minimal power that can be produced based on current SOC	M
MinLodWInst	MV		Actual minimal power that can be consumed based on current SOC	M
Controls				
WSpt	APC		Setpoint for active power	M
Settings				
Disp	SPG		Dispatchable means that the DER system is able to be operated with setpoints provided from an aggregator. Note: It is assumed that all services can be switched off, so the schedule associated to the off state is not considered as a valid schedule for assessing a service to be dispatchable or not. A DER system that is not dispatchable, once switched on, will provide the services based on the current capabilities; e.g. supply as much of active power as is produced	M

DSEC				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Pred	SPG		Means that the baseline (or the expected schedule) is provided by the DER resource itself. If the service provision is not predictable there will be no forecast provided by the DER resource (going into the Registry). In that case, the Aggregator could estimate it (not going into the Registry)	O
Rely	ING		Reliability of the service or the DER system	O
SvcRegisStr	TSG		Starting date and time of the period for which the service registration is valid	M
SvcRegisEnd	TSG		Ending date and time of the period for which the service registration is valid	M
SvcId	ISG		Identifier for service	M
RsvId	ISG		Identifier for reservation	M
Pricing information				
CostRsv	CUG		Costs for reservation of the service; price is in currency per reserved power where partial reservation is possible; otherwise it is in currency per unit	O
CostEn	CUG		Costs for supplied energy; price is in currency per energy	O
CostFut	CUG		Costs for supplied energy that has been reserved as futures; price is in currency per energy	O
CostStr	CUG		Costs for starting the DER system; price is in currency per unit	O
Rated parameters				
EnStoCap	ASG		Energy storage capacity	M
MaxWGnSocCrv	CSG		Curve indicating maximum power as generator in relation to SOC	M
MaxPLodSocCrv	CSG		Curve indicating maximum power as load in relation to SOC	M
MinPGnSocCrv	CSG		Curve indicating minimum power as generator in relation to SOC	M
MinPLodSocCrv	CSG		Curve indicating minimum power as load in relation to SOC	M
StrgMaxGnEn	ASG		The maximum amount of energy which can be supplied by the storage service in [kWh]. E.g. batteries might not be completely discharged.	M
StoNomGnEn	ASG		The nominal amount of energy which can be supplied by the storage service in [kWh].	M
StoNomLodEn	ASG		The nominal amount of energy which can be stored by the storage service in [kWh].	M
StoWaitTmCha	TSG		Waiting time in [s], that has to be respected before a discharge is ordered.	M
StoWaitTm Dsch	TSG		Waiting time after discharging in [s], that has to be respected before a charge is ordered.	M

If a schedule is used for activation of the energy service, the following LNs are required in addition:

- LN FSCC with ActSchdRef=DSEC.WSpt
- Multiple instances of LN FSCH with ValAPG used as schedule

2.5.9 LN: Autonomous Frequency Control Name: DSFC

This logical node defines the characteristics of the DER system energy service “Autonomous Frequency Control”.

Table 12 shows all data objects of DSFC.

Table 12 – Data objects of DSFC

DSFC				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Status information				
NoAvl	SPS		This indicates that the service is currently not available.	M
NoAvlSchd	STV		This allows to schedule time frames within the service registration life time for which the service will not be available. During that time, the service is not available by decision of the DER system owner due to maintenance or due to a decision of the DER system owner based on its business intelligence. In the simplest case there would be no unavailability periods declared, so the availability would coincide with the time frame of the service registration. For those periods of time for which there is no coincident declared unavailability, the service is considered to be available.	O
Measured and metered values				
UpWBndFc	MTV		Forecast for the upper band value the DER system can provide	O
LoWBndFc	MTV		Forecast for the lower band value the DER system can provide	O
Controls				
Act	SPC		Activate / Deactivate the energy service autonomous frequency control by a control request	M
Settings				
Disp	SPG		Dispatchable means that the DER system is able to be operated with setpoints provided from an aggregator. Note: It is assumed that all services can be switched off, so the schedule associated to the off state is not considered as a valid schedule for assessing a service to be dispatchable or not. A DER system that is not dispatchable, once switched on, will provide the services based on the current capabilities; e.g. supply as much of active power as is produced	M
Pred	SPG		Means that the baseline (or the expected schedule) is provided by the DER resource itself. If the service provision is not predictable there will be no forecast provided by the DER resource (going into the Registry). In that case, the Aggregator could estimate it (not going into the Registry)	O
Rel	ING		Reliability of the service or the DER system	O
SvcRegisStr	TSG		Starting date and time of the period for which the service registration is valid	M
SvcRegisEnd	TSG		Ending date and time of the period for which the service registration is valid	M

DSFC				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
SvcId	ISG		Identifier for service	M
RsvId	ISG		Identifier for reservation	M
Pricing information				
CostRsv	CUG		Costs for reservation of the service; price is in currency per reserved power where partial reservation is possible; otherwise it is in currency per unit	O
CostEn	CUG		Costs for supplied energy; price is in currency per energy	O
CostFut	CUG		Costs for supplied energy that has been reserved as futures; price is in currency per energy	O
CostStr	CUG		Costs for starting the DER system; price is in currency per unit	O
Rated parameters				
DrpSlop	ASG		The droop is the quotient of the relative quasi-stationary frequency deviation in the system (∆f/fN) and the relative active power change (∆PG/PGN) of the machine under the influence of the primary controller.	M
NomFreq	ASG		Nominal frequency of the control droop, for which the active power injected is 0	M
RteChgIncrW	ASG		Rate of change for active power increase.	M
RteChgDecW	ASG		Rate of change for active power decrease.	M
UpWBnd	ASG		The PC (primary control) band is given in percent of the nominal active power. The upper value provides the positive active power the DER System could provide as percentage of its nominal active power in underfrequency situations.	M
DnWBnd	ASG		Same as *AFCUpPBand* but for the negative active power.	M

If a schedule is used for activation of the energy service, the following LNs are required in addition:

- LN FSCC with ActSchdRef=DSFC.Act
- Multiple instances of LN FSCH with ValSPG used as schedule

2.5.10 LN: Partial Reservation Autonomous Frequency Control Name: DPFC

This logical node defines the characteristics of the DER system energy service "Partial Reservation Autonomous Frequency Control".

Table 13 shows all data objects of DSFC.

Table 13 – Data objects of DSFC

DSFC				
Data object name	**Common data class**	**T**	**Explanation**	**M/O/C**
Measured and metered values				
RsvUpWBndSchd	MTV		Partial reservation: Schedule for the upper active power band	M
RsvLoWBndSchd	MTV		Partial reservation: Schedule for the lower active power band	M
Controls				
Act	SPC		Activate / Deactivate the energy service autonomous frequency control by a control request	M
Settings				
RsvId	ISG		Identifier of the reservation	M
SvcId	ISG		Identifier for service	M
Pricing information				
CostRsv	CUG		Costs for reservation of the service; price is in currency per reserved power where partial reservation is possible; otherwise it is in currency per unit	O
CostEn	CUG		Costs for supplied energy; price is in currency per energy	O
CostFut	CUG		Costs for supplied energy that has been reserved as futures; price is in currency per energy	O
CostStr	CUG		Costs for starting the DER system; price is in currency per unit	O

If a schedule is used for activation of the energy service, the following LNs are required in addition:

- LN FSCC with ActSchdRef=DSVC.Act
- Multiple instances of LN FSCH with ValSPG used as schedule

2.6 OS4ES abbreviations for data object names

This section lists the abbreviation for data object names that are not part of the latest list of normative abbreviations for data object names of IEC 61850-7-4 Ed. 2.1.

Term	**Description**
Det	Deterministic
Disp	Dispatchability
Erl	Earliest
Fc	Forecast
Fut	Future
Lat	Latest
Opt	Option
PCC	Point of Common Coupling
Pred	Predictability
Prf	Preferred
Prof	Profile
Regis	Registration
Rely	Reliability
Slop	Slope
Wait	Wait(ing)
Fin	Final

References

[1] Deliverable D4.2

[2] IEC 61850-7-3

[3] IEC 61850-7-4

[4] IEC 61850-7-420

[5] Future IEC 61850-90-10