

# Data communication test report

DREM – DSO ROLE IN ELECTRICITY MARKET  
D6.3 DATA COMMUNICATION TEST REPORT

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# 1 Introduction and scope

The DREM project is a R&D project partly funded by the partners and the EUDP program.

DREM stands for – **D**istributed system operators **R**ole in the **E**nergy **M**arket

Partners in the project are: Radius Elnet (project leader), HOFOR, DTU, Markedskraft and EURISCO

The objective of the DREM project is to investigate specific problems faced by DSOs in a future energy system where power system balancing services are provided by flexibility assets, connected at the distribution level.

Large scale use of flexibility assets may cause congestion problems as well as market conflicts between operators, and the overall socio-economic objectives may be hampered by private financial objectives.

DREM will investigate how the DSO could provide a service in a form of a *Trade Permission System* (TPS) to secure that trade on electricity markets is not causing congesting problems in the distribution system.

The communication scheme that forms the basic instrument in TPS is expected to utilize and further develop the communication protocol developed and tested in another R&D project called CHPCOM (Combined Heat and Power Communication - [www.chpcom.dk](http://www.chpcom.dk)) where congestion issues from the DSOs point of view, was not investigated completely.

CHPCOM developed and tested a standardized communication platform<sup>1</sup> primary for the CHP, which is facilitating easy and safe communication between energy assets in general. The perspective of the CHPCOM project was precisely to enable such communication used further in a smart energy future and in this way, facilitate market models and smooth competition.

## 1.1 The scope of this document

- ✓ Introduction to RISØ Proof-of-Concept demonstration
- ✓ Technologies for the DREM TPS Proof-of-Concept – demonstration and findings
- ✓ Technologies for the real-time communication to FlexHeat

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<sup>1</sup> CHPCOM used IEC 61850, which is generally agreed to be the international standard. Energinet.dk has in Regulations since 2007 recommended this standard.

## 2 Introduction to the ‘Proof-of-Concept’

The basic idea behind a ‘Proof-of-Concept’ is to show whether an idea is feasible from a technology standpoint. The term proof of concept often characterizes several distinct processes with different objectives and participant roles: vendor business roles may utilize a proof of concept to establish whether a system satisfies some aspect of the purpose it was designed for.

The reason for doing a Proof-of-Concept for the DREM TPS platform and the real-time data communication setup for FlexHeat, was to get as many technical details and evaluation results as possible. It could seem like a waste of resources to do this early stage software implementation, which does not have an on-going operation purpose. But only doing theoretical desk-research, would have been too limiting for this kind of ICT based concept development.

### 2.1 Who are the actors and what are their goals?

The main actors are shown in figure 1, with the DSO and BRP as main operators, the FlexHeat as the grid connected unit which in this scenario is emulated as a flexibility asset at RISØ SYSLAB – and then the DREM TPS platform as the main ICT system for static and dynamic information exchange.

Within the context of this project, the main goal for the DSO will be to avoid or eliminate a possible congesting conflict at the distribution grid level. The different conflict cases are described in detail in D2.2, but in this PoC the main focus has been on a flexibility asset controlled by the BRP – which might cause the congestion.

The BRP will always control the flexibility asset on market terms, which means their goal is an economical optimum, within the limits of the flexibility asset owners production plan, in this case FlexHeat.

HOFOR who owns the flexibility asset (FlexHeat) has a goal of always providing the needed heat to the end-users and at the lowest price.

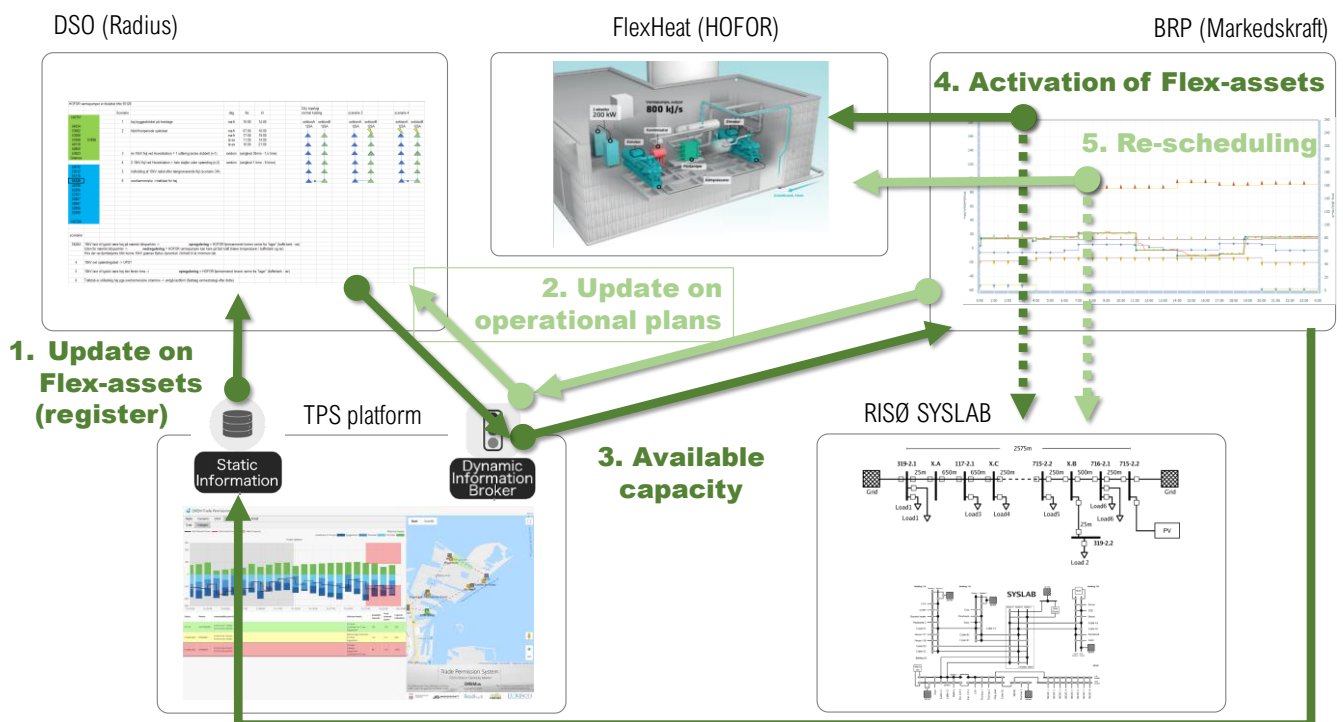


Figure 1: Actors and basic sequence of operation

## 2.2 The end-2-end data exchange concept

The DREM TPS concept starts (1) with the BRP registering the flexibility asset in the 'Static Information' database in the TPS platform. This information can always be read by the DSO, for distribution grid planning.

The BPR can optionally also use the 'Dynamic Information Broker' to upload the latest operational plans from the flexibility assets, which will give the DSO very valuable data for eventual state estimation and outage planning.

In the case of a DSO making state-estimation and suddenly encountering a possible congestion problem on a specific feeder, the DSO can then update the 'Dynamic Information Broker' with the restricted available capacity for this specific feeder.

The BRP ICT-system always browsing for latest information on the 'Dynamic Information Broker' will then automatically detect the possible congestion issue, do a very fast re-dispatch of all the flexibility assets in the BRP portfolio and as soon as possible, do a re-scheduling of the flexibility assets.

The FlexHeat will in case of too much load on the feeder, reduce the load to the limit suggested by the DSO and will hereby not end up in a brown-out or even worse, black-out scenario for this feeder.

## 2.3 TPS platform with static and dynamic information services

The ENTSO-E Transparency Platform has from the very beginning of the project, been the concept that has inspired the DREM TPS concept for the distribution grid.

On 5 January 2015, in compliance with Regulation (EU) No 543/2013 on the submission and publication of data in electricity markets, ENTSO-E launched a new central transparency platform: the ENTSO-E Transparency Platform.

The ENTSO-E Transparency Platform provides free, continuous access to pan-European electricity market data for all users, across six main categories: Load, Generation, Transmission, Balancing, Outages and Congestion Management.

The ENTSO-E Transparency Platform has a very different scope, with focus on TSO cross-border issues and not lower level distribution grid, but that has also been the scientific challenge and reason for building the Proof-of-Concept TPS platform.

One of the main differences between the DREM TPS platform and the ENTSO-E Transparency Platform, has been the development of the 'Static Information' and 'Dynamic Information Broker' parts, with focus on basically two difference scenarios – the *Foreseen* and the *Unforeseen* cases of congestion issues.

The figure 2 and section 3.1 will describe in more detail the *Foreseen* scenario and give some more detailed insight to the basic idea of the 'Static Information' and 'Dynamic Information Broker' services.

### 3 Technologies for the DREM TPS Proof-of-Concept

This section will go through some of the technologies and methods used in the Proof-of-Concept development process. A more detailed technical description is documented in D6.2.

#### 3.1 Sequence diagram for the TPS data exchange and parameters

In a working process with WP2, sequence diagram with parameter exchange has been developed. This is a vital part of any ICT system development and in this project, also important for detailed coordination of the Proof-of-Concept development.

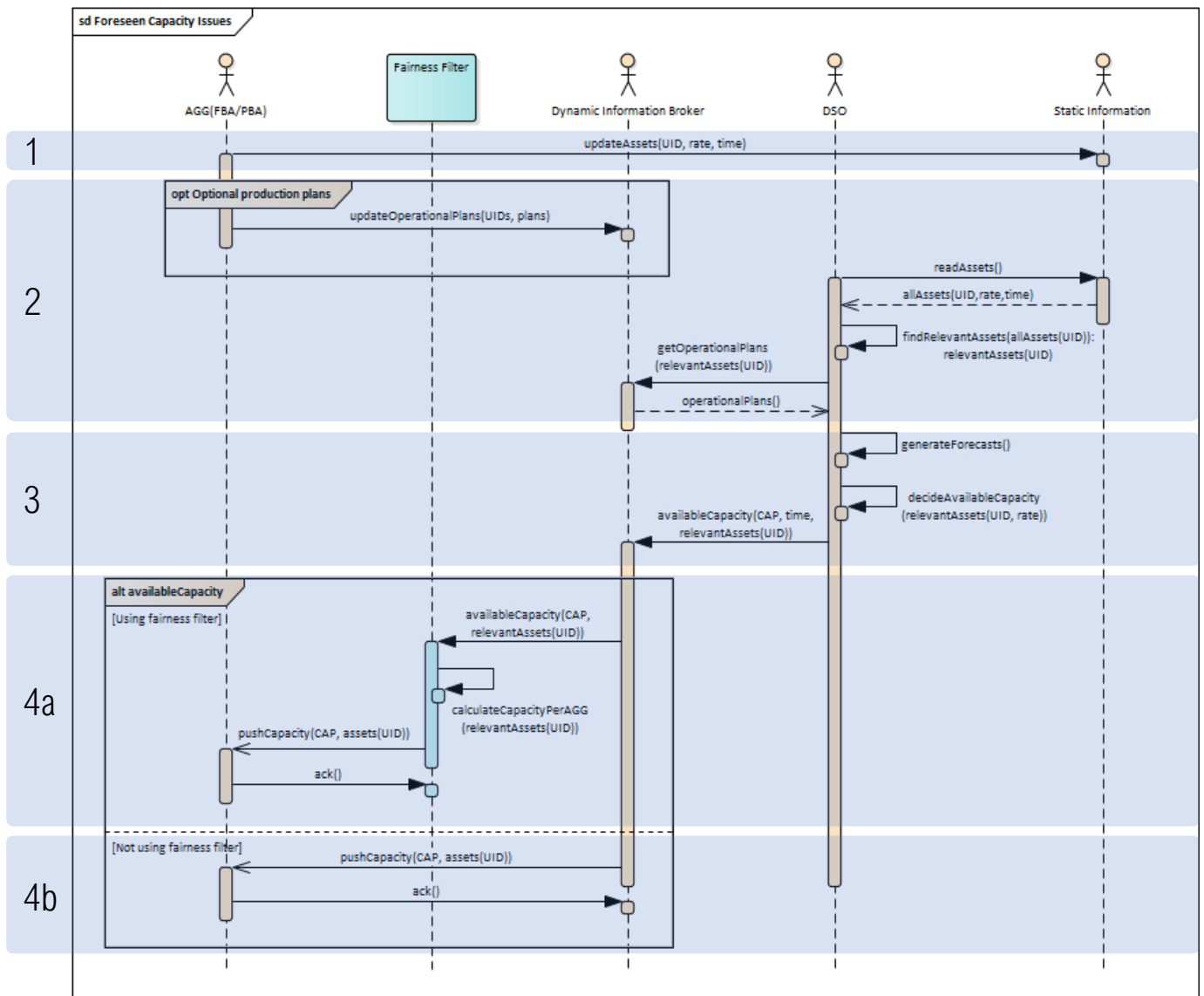


Figure 2: Actors and basic sequence of operation – UML diagram

- 1) The AGR or BRP updates the Static Information system with information about the flexibility assets that they operate. The data will reflect which AGR/BRP operates the flexibility asset, where the flexibility asset is electrically connected in the power grid and the capabilities of the flexibility assets. This update should happen whenever flexibility assets are connected to or disconnected from the power grid, or if flexibility assets gets reassigned to a different operator.
- 2) On a regularly basic (e.g. daily), the DSO will retrieve a list of flexibility assets connected to their power grid. The list will not disclose details on who operates the flexibility assets. Also, the DSO checks for operational plans for

the flexibility assets, submitted by the AGRs/BRPs to the Dynamic Information Broker. These plans reflect the production and/or consumption planned for the flexibility assets. While submitting operation plans is not mandatory, it will greatly help the DSO when determining capacity issues. Without any operational plans, the estimations must include a greater safety margin, hence will allow less operational flexibility compared to if operational plans are provided.

- 3) Based on knowledge about scheduled maintenance of the power grid that the DSO operates, historical power flow in the grid and flexibility asset operational plans, the DSO estimates expected power production and consumption in the grid and determines limits in the available capacity. Information about the limits and which flexibility assets are affected by these limits and sent to the Dynamic Information Broker.
- 4) The Dynamic Information Broker communicates the capacity limits to the AGR/BRPs that operates the flexibility assets involved. The TPS shall distribute the limits between the AGR/BRPs, so that they get a fair share of the total limit. As determining the meaning of “fair” is a complex matter, it is deemed out of scope of DREM. In the proof-of-concept implementation, the sharing is based on a ‘percentage of total’ that each AGR/BRPs operates in the affected section of the grid.

### 3.2 Static information services

In the DREM TPS platform (<https://drem-tps.eurisco.dk/>) under the folder ‘Static Information’ there is a map of Energy Nordhavn with a fictional grid used in the Proof-of-Concept’ evaluation.

This fictional grid was aligned with the test grid used at RISØ SYSLAB, which means that under the testing process and also for the demonstration workshop at RISØ – there was a coordinated setup between the laboratory and the real-life operational grid, where FlexHeat is connected.

The table shows the naming, type and rated power for all the flexibility assets in the ‘Static Information’ service and with the unique EIC code for the identification (tag) of the flexibility assets. Especially the identification of flexibility assets between the DSO and BPR domain is very important.

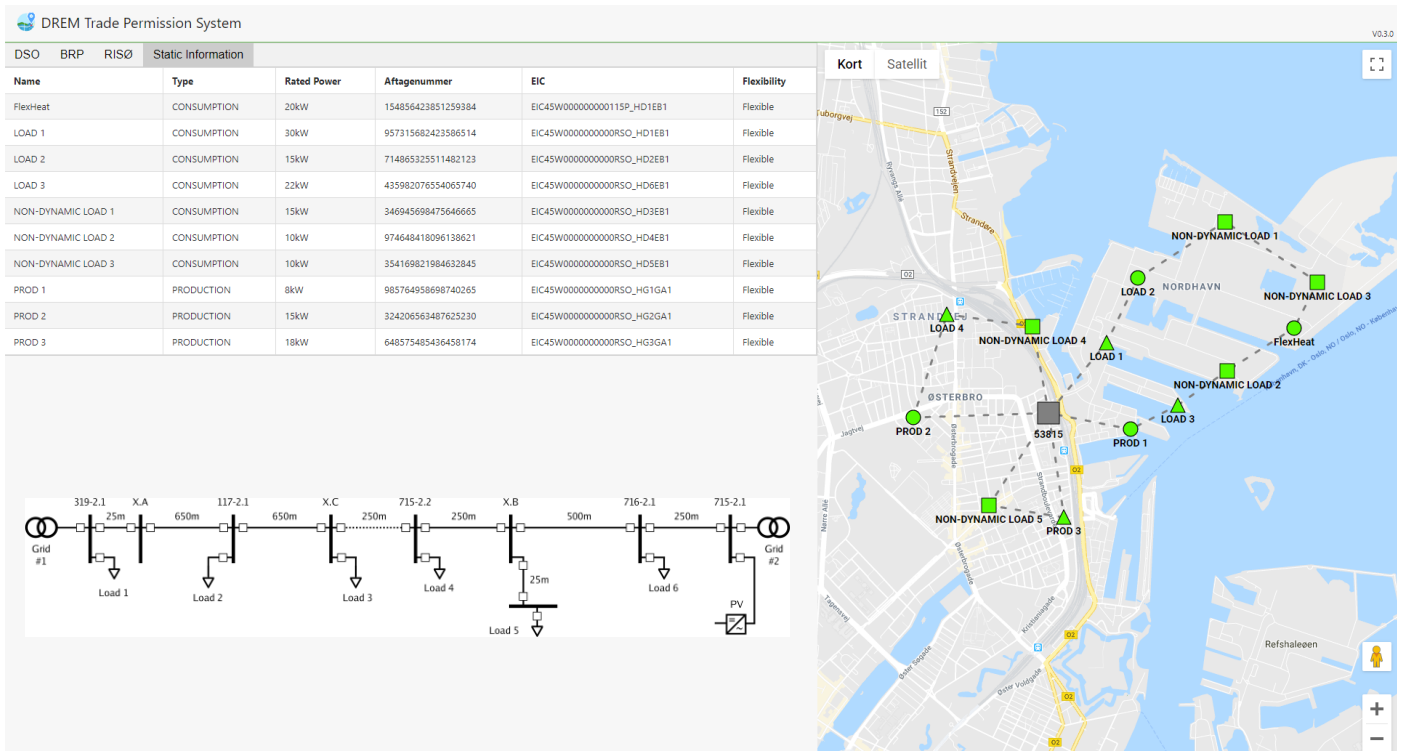


Figure 3: DREM TPS and link to RISØ implementation and test



### 3.3 Status on flexible loads using IEC 61850 modelling

#### 3.3.1 Energy Identification Codes (EICs)

The EIC coding scheme has been developed, managed and maintained within ENTSO-E (under the Common Information Model Expert Group) to facilitate cross-border exchanges relating to the Internal Energy Market (IEM) and its operations. This is known as the Energy Identification Coding (EIC) scheme, approved by ENTSO-E for the harmonization and implementation of standardized electronic data interchanges.

The scheme is supported by a central issuing office (CIO – ENTSO-E’s Secretariat) and ENTSO-E-authorized local issuing offices (LIOs) across Europe. The LIO for Denmark is managed by Energinet and for more information, please refer to: <https://energinet.dk/EI/Elmarkedet/EIC>

According to the documentation at <http://www.eiccodes.eu>, an EIC code is defined using three sections:

- a two-character Local Issuing Office (LIO) code. In Denmark, this is always the number 45.
- a one-character object type code:
  - Y: Areas - Areas for inter System Operator data interchange
  - Z: Measuring Points - Energy Metering points
  - W: Resource objects - Production plants, consumption units, etc.
  - T: Tie-lines - International tie lines between areas
  - V: Location - Physical or logical place where a market participant or IT system is located
  - A: Substations
- 12 characters allocated by the issuing office.
- one check character to ensure the code validity. The algorithm for calculating the check character is described in the EIC Code implementation guide.

As an example, the power plant at Silkeborg exists as two codes:

- 45V0000000000245 for the location (IT system)
- 45W0000000000099Y for the production or consumption resources

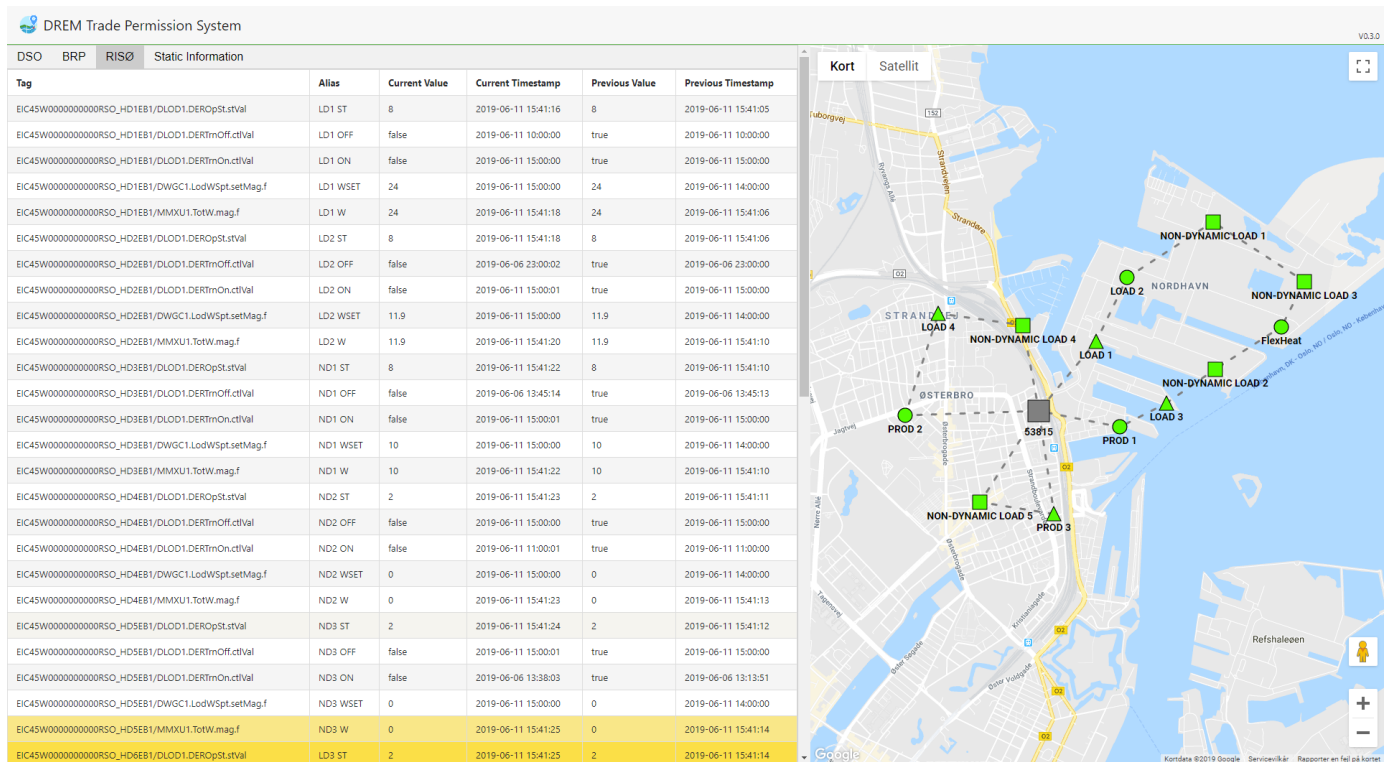


Figure 4: DREM TPS and real-time IEC 61850 modelling

### 3.3.2 Reference Designation System Rules according to ISO/IEC 81346

The signals in the reference signal list are named according to the following format:

**<Logical Device name>/<Logical Node name>. <Data Object name>. <Data Attribute name>**

where the section before the ‘/’ separator follows rules specified by ISO/IEC 81346 and the section after the ‘/’ separator is specified by the structure of the IEC 61850 information model.

ISO/IEC 81346 (also known as RDS – Reference Designation System) specifies classification and structure based on different structure types.

In this specification, the flexibility assets facility is the top level and is using a location-type structure (identified by a leading ‘+’ character). The levels below identify the flexibility asset systems and flexibility asset units and are using a function-type structure (identified by a leading ‘=’ character).

NOTE: In the current edition 2 of IEC 61850-8-1, the MMS protocol does not allow object references to include other characters than a-z, A-Z, 0-9 and ‘\_’ (underscore), and the first character must be a letter. As a work around, this specification replaces the leading ‘+’ with the letters “EIC” and the first ‘=’ sign with an underscore. The following unsupported characters are just left out, which is in accordance with the rules of ISO/IEC 81346. E.g. the code “+45W00000000099Y=HG2=GA1=EM” is to be represented in the IEC 61850 tag as “EIC45W00000000099Y\_HG2GA1EM”.

The ISO/IEC 81346 standard provides some options for naming of the topmost location name (top name). In this specification, the flexibility asset facility is named according to the Energy Identification Coding scheme (EIC) codes defined by the ENTSO-E organization and used in the EU transparency platform for identification of actors, sub stations, power plants, etc., in the European public electricity grid

Next to the top location name IEC 81346-2:2019 is used for functional naming of the component to which the information in the IEC 61850-7-x Logical Node refers. See examples in IEC 61850-6 and IEC 61850-7-1.

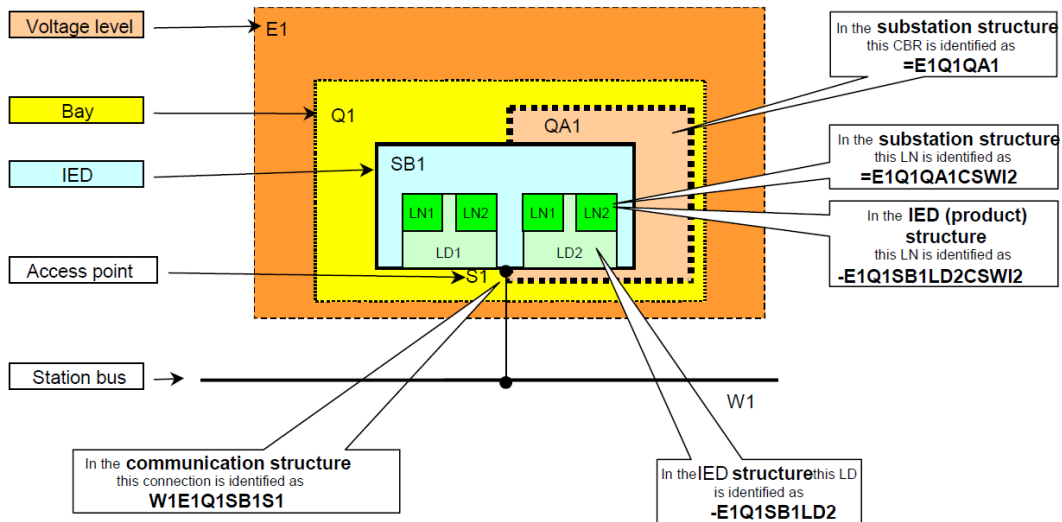


Figure 5: Names and structure of IEC61850 using IEC81346 topology

This means, the ISO/IEC 81346 logical device name for the logical node follows the information the of the physical device the logical node information represents. E.g. a central controller or can collect information from a circuit breaker and from a generator. In this case the IEC 61850 signal tag for the circuit breaker uses the ISO/IEC 81346 functional name for the circuit breaker and IEC 61850 signal tag for the generator uses the ISO/IEC 81346 functional name for the generator.

### 3.4 Planned and actual power for the BRP

The DREM TSP platform has a functionality that will emulate the BRP tool to be used for planning and dispatch of a portfolio of flexibility assets.

The graphical interface for this tool, has a graph for ‘before actual time’ marked with grey and a planning graph from the actual time and forward. The coloring scheme is that all LOAD is in blue and all PRODUCTION is in green. The red line is the actual power delivered and the black line is the planned actual power – so the difference between these lines, are the unbalance that might occur.

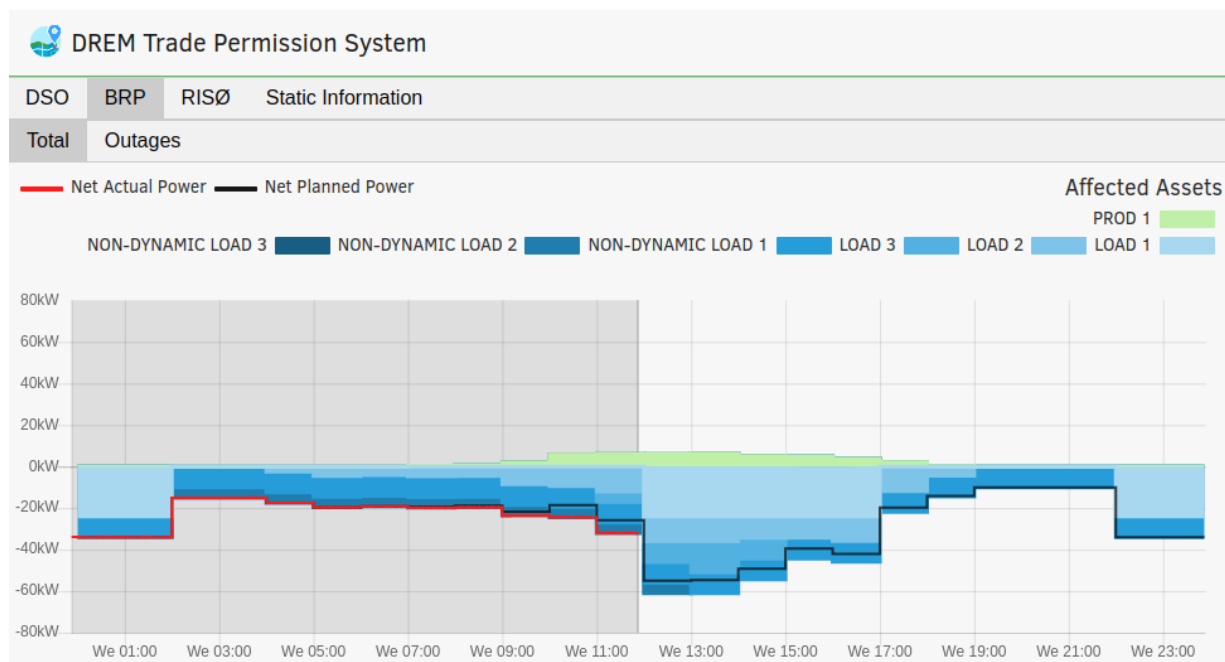


Figure 6: DREM TPS and graphics for BRP planned and actual power

The MKPlanner dispatching and planning tool is developed, owned and operated by Markedskraft who is a BRP. This tool is from a conceptual point, comparable with the DREM TPS tool shown in figure 6, and described more in detail in the WP7a report.

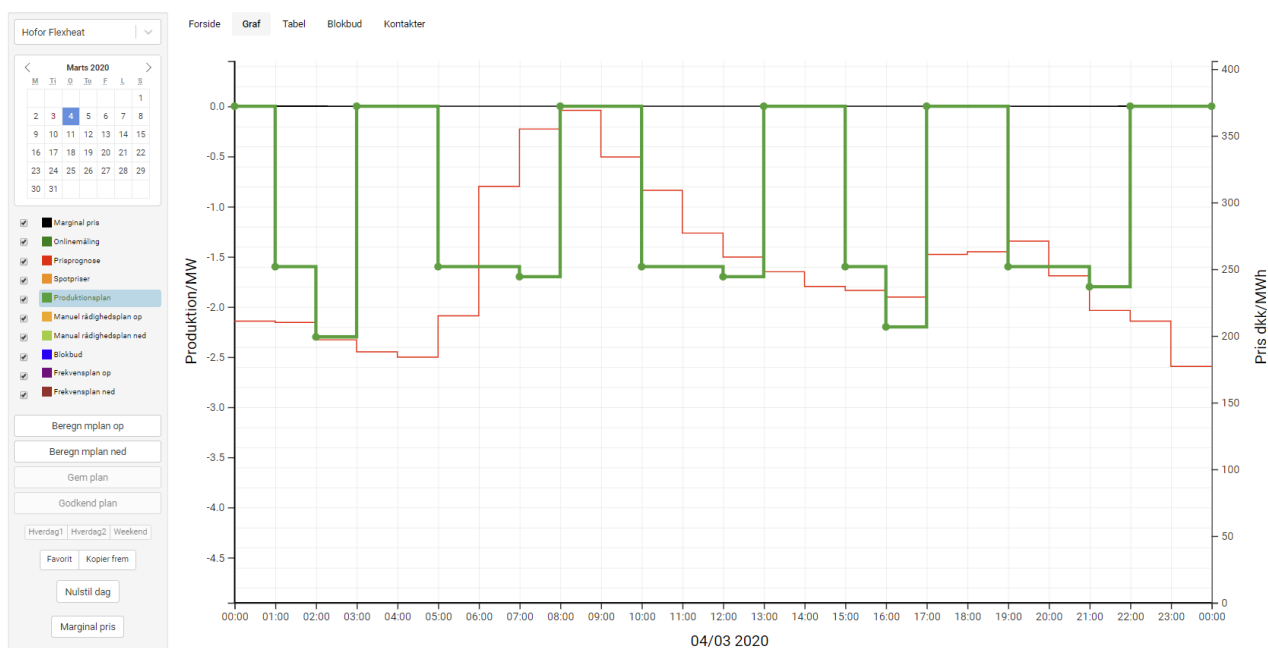


Figure 7: MKPlanner operation tool from Markedskraft

## 4 Technologies for the real-time communication to FlexHeat

IEC 61850 is a very comprehensive international standard, which has evolved during many years of development by industry, European standardization organizations and national standardization committees, like Dansk Standard and their members.

The standard is not just a data transfer protocol, but also a very detailed information model with standardized naming of all elements from a high-level domain like type of flexibility assets resource to the low-level data types and parameters.

The illustration below shows all the standard documents, but for this project it has been the following standards within IEC 61850, that has been in focus: IEC 61850-7-4 and IEC 61850-7-420

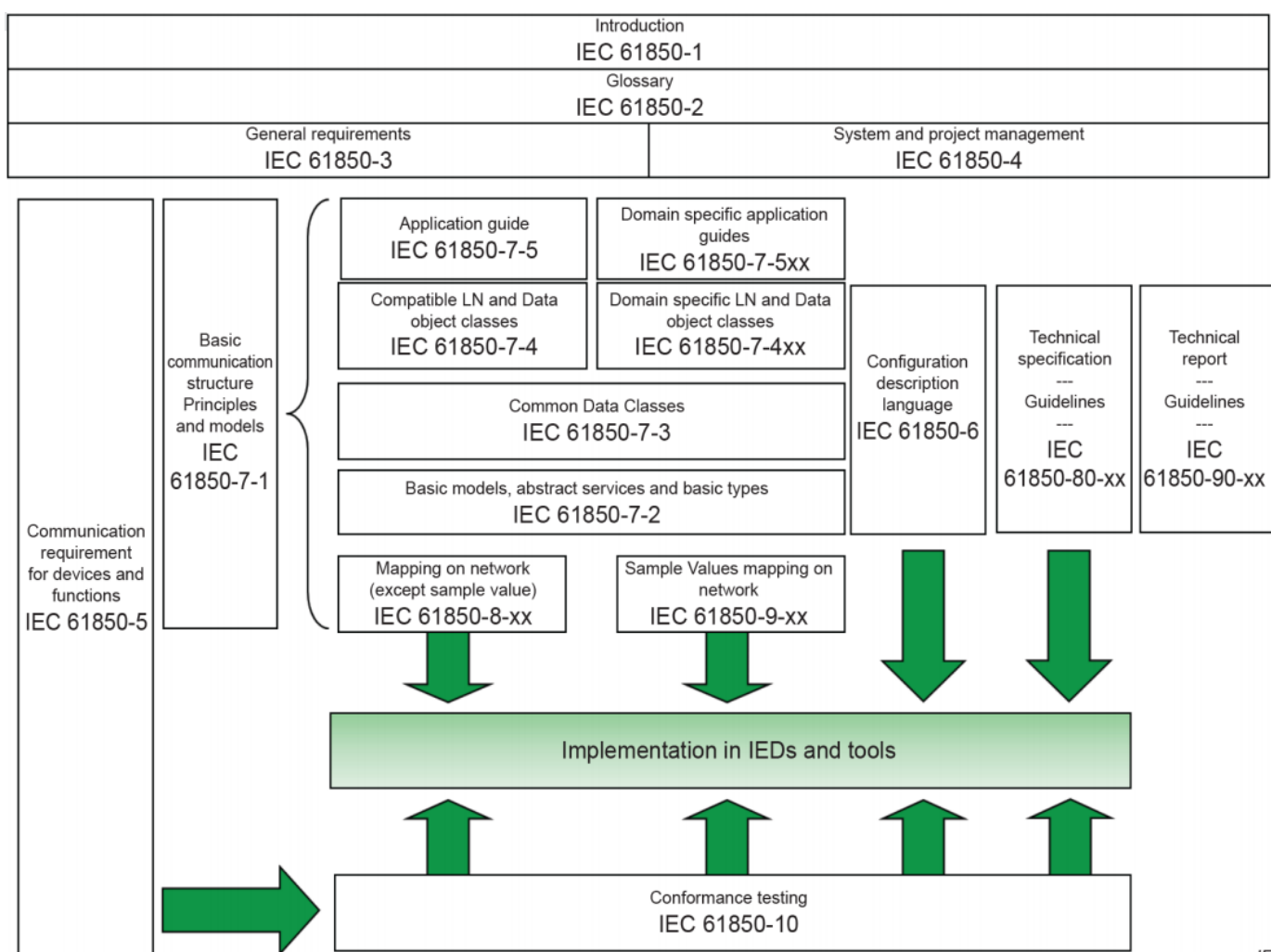


Figure 8: IEC 61850 series overview

To keep it as simple as possible, 4 signals has been used in DREM for the real-time data exchange to FlexHeat.

The next section will give a description of these 4 signals and how they are modelled in IEC 61850.

It is important to notice that some parts marked ‘modified from CHPCOM project’ has been a Danish contribution, which is still in process of been included in the new edition of the standard.

The following table shows a ‘screen-shot’ from the CDGs database, with the 4 signals in focus:

	iec_vnam character varying (129)	rid bigint	ts_insert timestamp without time zone
1	EIC45W000000000115P_HD1EB1/DRCS1.OpSt.stVal	7896833	2020-03-16 08:13:06.872
2	EIC45W000000000115P_HD1EB1/DRCS1.AutoMan.stVal	7896823	2020-03-16 08:12:20.457
3	EIC45W000000000115P_HD1EB1/DRCS1.Loc.stVal	7896822	2020-03-16 08:12:19.457
4	EIC45W000000000115P_HD1EB1/MMXU1.TotW.mag.f	7817407	2020-03-09 12:17:25.677

#### 4.1 Operational status (electrical boiler and heat pumps)

Operational status is a single point status signal to indicate if FlexHeat is ‘in service’ if it is ‘running’ or if it is ‘stopped’

What is shown in red is the Logical Node and data objects, which is explained in the tables below.

- HD1EB1/DRCS1.OpSt.stVal

#### 4.2 Control status (electrical boiler and heat pumps)

Control status is a single point status signal to indicate if FlexHeat is in ‘Manual’ or ‘Automatic’ control and if it is controlled internally by the plant ‘Local’ or controlled by a BRP ‘Remote’

What is shown in red is the Logical Node and data objects, which is explained in the tables below.

- HD1EB1/DRCS1.AutoMan.stVal
- HD1EB1/DRCS1.Loc.stVal

LN: flexibility asset controller status  
ED1

Name: DRCS

From IEC 61850-420 FDIS

The flexibility asset Controller Logical Node defines the control status of one flexibility asset unit or aggregations of one type of flexibility asset device with a single controller.

flexibility asset Controller Status, LN DRCS

DRCS Class				
Data Name	CDC	Explanation	T	M/O/C
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)		
<b>Data</b>				
<i>System Logical Node Data</i>				
		LN shall inherit all Mandatory Data from Common Logical Node Class		M
OpTmh	INS	Operation time		M
		Other data from LLNO may optionally be used		O
<i>Status information</i>				

DRCS Class										
Data Name	CDC	Explanation	T	M/O/C						
ECPConn	SPS	Electrically connected to the ECP that it is physically connected to: <table border="1"> <thead> <tr> <th>Value</th> <th>Explanation</th> </tr> </thead> <tbody> <tr> <td>True</td> <td>Electrically connected</td> </tr> <tr> <td>False</td> <td>Not connected</td> </tr> </tbody> </table>	Value	Explanation	True	Electrically connected	False	Not connected		M
Value	Explanation									
True	Electrically connected									
False	Not connected									
AutoMan	SPS	<b>Automatic or Manual mode:</b> <table border="1"> <thead> <tr> <th>Value</th> <th>Explanation</th> </tr> </thead> <tbody> <tr> <td>True</td> <td>Automatic</td> </tr> <tr> <td>False</td> <td>Manual</td> </tr> </tbody> </table>	Value	Explanation	True	Automatic	False	Manual		M
Value	Explanation									
True	Automatic									
False	Manual									
Loc	SPS	<b>Remote or Local mode:</b> <table border="1"> <thead> <tr> <th>Value</th> <th>Explanation</th> </tr> </thead> <tbody> <tr> <td>True</td> <td>Local</td> </tr> <tr> <td>False</td> <td>Remote is allowed</td> </tr> </tbody> </table>	Value	Explanation	True	Local	False	Remote is allowed		M
Value	Explanation									
True	Local									
False	Remote is allowed									
ModOnConn	SPS	Operational mode - True: On and connected		M						
ModOnAval	SPS	Operational mode - True: On and available for connection		M						
ModOnUnav	SPS	Operational mode - True: On but not available for connection		O						
ModOffAval	SPS	Operational mode - True: Off but available to start		M						
ModOffUnav	SPS	Operational mode - True: Off and not available to start		M						
ModTest	SPS	Operational mode - True: Test mode		O						
ModStr	SPS	Operational mode - True: Starting up		O						
ModStop	SPS	Operational mode - True: Stopping/shutting down		O						
SeqSt	INS	Status of the sequencer		O						
SeqPos	INS	Sequence active position or step		O						
LodModBase	SPS	Load mode – True: Base load		O						
LodModFol	SPS	Load mode – True: Load following		O						
LodModFxExp	SPS	Load mode – True: Fixed export		O						
LodModAval	SPS	Load mode – True: Available		O						
DCPowStat	SPS	DC power status: <table border="1"> <thead> <tr> <th>Value</th> <th>Explanation</th> </tr> </thead> <tbody> <tr> <td>True</td> <td>Power on</td> </tr> <tr> <td>False</td> <td>Power not on</td> </tr> </tbody> </table>	Value	Explanation	True	Power on	False	Power not on		O
Value	Explanation									
True	Power on									
False	Power not on									
<b>Measured values</b>										
FltRate	MV	Fault rates of flexibility asset: Percent		O						
SelfServWh	MV	Actual self service watt-hours		O						

flexibility asset Controller Status

Name: DRCS (modified from CHPCOM project)

DRCS (modified)				
Data object name	Common data class	T	Explanation	M-O-C nds/ds
<b>Status</b>				
AutoMan	SPS		Automatic or manual mode; True = Automatic, False = Manual	O / F
ModOnConn	SPS		Operational mode - True: On and connected	O / F
ModOnAvl	SPS		Operational mode - True: On and available for connection	O / F
ModOffAvl	SPS		Operational mode - True: Off but available to start	O / F
ModOffUnav	SPS		Operational mode - True: Off and not available to start	O / F
LodShrModSt	SPS		Load Mode – True: Load Sharing mode	O / F
RemOpTms	INS		Remaining operational run time	O / F
AlmSt	SPS		Motor alarm which results in operational constraints	O / F
<b>OpSt</b>	<b>SPS</b>		<b>Operational Status – True: in service</b>	O / F
<b>Measurement</b>				
ProdRsvDn	MV		Available output power for down regulation	O / F
ProdRsvUp	MV		Available output power for up regulation	O / F
CsmpRsvDn	MV		Input power (consumption) available for down regulation	O / F
CsmpRsvUp	MV		Input power (consumption) available for up regulation	O / F

### Single point status (SPS)

This common data class shall be used to represent single point status values.

#### Attributes of SPS

cdcid = SPS, UML class name = SPS					
Attribute name	Attribute type	FC	TrgOp	(Value/Value range) Description	PresCond
<b>DataAttribute for status</b>					
<b>stVal</b>	<b>BOOLEAN</b>	<b>ST</b>	<b>dchg</b>	<b>Value of the data.</b>	<b>M</b>
q	Quality	ST	qchg	Quality of the value in 'stVal'.	M
t	Timestamp	ST		Timestamp of the last change of the value in any of 'stVal' or 'q'.	M
<b>DataAttribute for substitution and blocked</b>					
subEna	BOOLEAN	SV		inherited from: <a href="#">SubstitutionCDC</a>	<a href="#">MFsubst</a>
subVal	BOOLEAN	SV		Value used to substitute 'stVal'.	<a href="#">MFsubst</a>
subQ	Quality	SV		inherited from: <a href="#">SubstitutionCDC</a>	<a href="#">MFsubst</a>
subID	VisString64	SV		inherited from: <a href="#">SubstitutionCDC</a>	<a href="#">MFsubst</a>
blkEna	BOOLEAN	BL		inherited from: <a href="#">SubstitutionCDC</a>	O
<b>DataAttribute for configuration, description and extension</b>					

cdcId = SPS, UML class name = SPS					
Attribute name	Attribute type	FC	TrgOp	(Value/Value range) Description	PresCond
d	VisString255	DC		inherited from: <a href="#">BasePrimitiveCDC</a>	O
dU	Unicode255	DC		inherited from: <a href="#">BasePrimitiveCDC</a>	O
cdcName	VisString255	EX		inherited from: <a href="#">BasePrimitiveCDC</a>	O
dataNs	VisString255	EX		inherited from: <a href="#">BasePrimitiveCDC</a>	<a href="#">MOdataNs</a>

### 4.3 Total real power consumption (electrical boiler and heat pumps)

MMXU is a measure value signal for a real power consumption from FlexHeat

What is shown in red is the Logical Node and data objects, which is explained in the tables below.

- HD1EB1/**MMXU1.TotW.mag.f**

#### LN: Measurement Name: MMXU

This logical node is used for calculation of currents, voltages, powers and impedances in a three-phase system. The main use is for operative applications.

#### Data objects of **MMXU**

MMXU				
Data object name	Common data class	T	Explanation	PresConds/ds
<b>Descriptions</b>				
NamPlt	LPL		inherited from: <a href="#">DomainLN</a>	O / O
<b>Status information</b>				
Blk	SPS		inherited from: <a href="#">FunctionLN</a>	O / F
ClcExp	SPS	T	inherited from: <a href="#">StatisticsLN</a>	O / O
Beh	ENS ( <a href="#">BehaviourModeKind</a> )		inherited from: <a href="#">DomainLN</a>	M / M
Health	ENS ( <a href="#">Health Kind</a> )		inherited from: <a href="#">DomainLN</a>	O / O
Mir	SPS		inherited from: <a href="#">DomainLN</a>	<a href="#">MOcond(1)</a> / <a href="#">MOcond(1)</a>
<b>Measured and metered values</b>				
<b>TotW</b>	<b>MV</b>		<b>Total real power in a three-phase circuit [W].</b>	<b>O / O</b>
TotVAr	MV		Total reactive power in a three-phase circuit [VAr].	O / O
TotVA	MV		The total apparent power in a three-phase circuit [VA].	O / O
TotPF	MV		Average power factor in a three-phase circuit.	O / O
Hz	MV		Frequency [Hz].	O / O
PPV	DEL		Phase to phase voltages.	O / O
PNV	WYE		Phase to neutral voltages.	O / O
PhV	WYE		Phase to ground (line) voltages.	O / O
A	WYE		Phase to ground/phase to neutral three phase currents.	O / O
W	WYE		Phase to ground/phase to neutral real powers P.	O / O
VAr	WYE		Phase to ground/phase to neutral reactive powers Q.	O / O

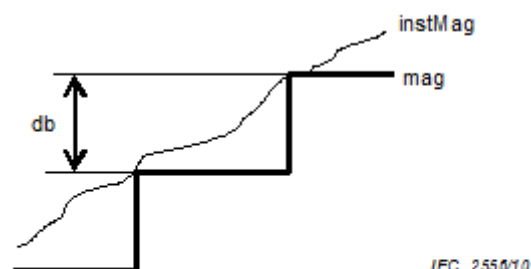


MMXU				
Data object name	Common data class	T	Explanation	PresConds/ds
VA	WYE		Phase to ground/phase to neutral apparent powers S.	0 / 0
PF	WYE		Phase to ground/phase to neutral power factors. The power factor is defined as P (active power) / S (apparent power), so the value range is 0...1. If current (I) and voltage (U) are sinusoidal and displaced by the angle phi, then the power factor is  cos phi , again with the value range 0...1. Therefore, for the power factor per phase, value is contained in 'mag' and 'ang' is not used.	0 / 0
Z	WYE		Phase to ground/phase to neutral impedances in a three-phase system.	0 / 0
AvAPhs	MV		Arithmetic average of the magnitude of current of the 3 phases: average(Ia,Ib,Ic).	0 / 0
AvPPVPhs	MV		Arithmetic average of the magnitude of phase to phase voltage of the 3 phases: average(PPVa, PPVb, PPVc).	0 / 0
AvPhVPhs	MV		Arithmetic average of the magnitude of phase to reference voltage of the 3 phases: average(PhVa, PhVb, PhVc).	0 / 0
AvWPhs	MV		Arithmetic average of the magnitude of active power of the 3 phases: average(Wa, Wb, Wc).	0 / 0
AvVAPhs	MV		Arithmetic average of the magnitude of apparent power of the 3 phases: average(VAa, VAb, VAc).	0 / 0
AvVArPhs	MV		Arithmetic average of the magnitude of reactive power of the 3 phases: average(VAra, VARb, VArc).	0 / 0
AvPFPhs	MV		Arithmetic average of the magnitude of power factor of the 3 phases: average(PFa, PFb, PFc).	0 / 0
AvZPhs	MV		Arithmetic average of the magnitude of impedance of the 3 phases: average(Za, Zb, Zc).	0 / 0
MaxAPhs	MV		Maximum magnitude of current of the 3 phases: max(Ia,Ib,Ic).	0 / 0
MaxPPVPhs	MV		Maximum magnitude of phase to phase voltage of the 3 phases: max(PPVa, PPVb, PPVc).	0 / 0
MaxPhVPhs	MV		Maximum magnitude of phase to reference voltage of the 3 phases: max(PhVa, PhVb, PhVc).	0 / 0
MaxWPhs	MV		Maximum magnitude of active power of the 3 phases: max(Wa, Wb, Wc).	0 / 0
MaxVAPhs	MV		Maximum magnitude of apparent power of the 3 phases: max(VAa, VAb, VAc).	0 / 0
MaxVArPhs	MV		Maximum magnitude of reactive power of the 3 phases: max(VAra, VARb, VArc).	0 / 0
MaxPFPhs	MV		Maximum magnitude of power factor of the 3 phases: max(PFa, PFb, PFc).	0 / 0
MaxZPhs	MV		Maximum magnitude of impedance of the 3 phases: max(Za, Zb, Zc).	0 / 0
MinAPhs	MV		Minimum magnitude of current of the 3 phases: min(Ia,Ib,Ic).	0 / 0
MinPPVPhs	MV		Minimum magnitude of phase to phase voltage of the 3 phases: min(PPVa, PPVb, PPVc).	0 / 0
MinPhVPhs	MV		Minimum magnitude of phase to reference voltage of the 3 phases: min(PhVa, PhVb, PhVc).	0 / 0
MinWPhs	MV		Minimum magnitude of active power of the 3 phases: min(Wa, Wb, Wc).	0 / 0
MinVAPhs	MV		Minimum magnitude of apparent power of the 3 phases: min(VAa, VAb, VAc).	0 / 0

MMXU				
Data object name	Common data class	T	Explanation	PresConds/ds
MinVARPhs	MV		Minimum magnitude of reactive power of the 3 phases: min(VAra, VArb, VArc).	O / O
MinPFPhs	MV		Minimum magnitude of power factor of the 3 phases: min(PFa, PFb, PFc).	O / O
MinZPhs	MV		Minimum magnitude of impedance of the 3 phases: min(Za, Zb, Zc).	O / O
HzRte	MV		Rate of change of frequency [Hz/s].	O / O
Controls				
ClcStr	SPC		inherited from: <a href="#">StatisticsLN</a>	O / O
Mod	ENC ( <a href="#">BehaviourModeKind</a> )		inherited from: <a href="#">DomainLN</a>	O / O
Settings				
ClcTotVA	ENG ( <a href="#">STotalCalcMethodKind</a> )		Calculation method used for total apparent power 'TotVA'.	O / F
PFSign	ENG ( <a href="#">PFSignKind</a> )		Sign convention for power factor 'PF' (and reactive power 'VAR').	O / F
BlkRef	ORG		inherited from: <a href="#">FunctionLN</a>	<a href="#">Omulti</a> / F
ClcMth	ENG ( <a href="#">CalcMethodKind</a> )		inherited from: <a href="#">StatisticsLN</a>	O / M
ClcMod	ENG ( <a href="#">CalcModeKind</a> )		inherited from: <a href="#">StatisticsLN</a>	O / O
ClcIntvTyp	ENG ( <a href="#">CalcIntervalKind</a> )		inherited from: <a href="#">StatisticsLN</a>	O / O
ClcIntvPer	ING		inherited from: <a href="#">StatisticsLN</a>	O / O
NumSubIntv	ING		inherited from: <a href="#">StatisticsLN</a>	O / O
ClcRfTyp	ENG ( <a href="#">CalcIntervalKind</a> )		inherited from: <a href="#">StatisticsLN</a>	O / O
ClcRfPer	ING		inherited from: <a href="#">StatisticsLN</a>	O / O
ClcSrc	ORG		inherited from: <a href="#">StatisticsLN</a>	<a href="#">E</a> / M
ClcNxtTmms	ING		inherited from: <a href="#">StatisticsLN</a>	O / O
InSyn	ORG		inherited from: <a href="#">StatisticsLN</a>	O / O
InRef	ORG		inherited from: <a href="#">DomainLN</a>	<a href="#">Omulti</a> / <a href="#">Omulti</a>

## Measured value (MV)

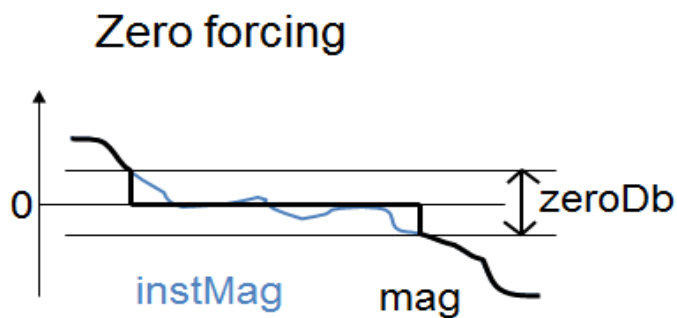
This common data class shall be used to represent measured values.



## Deadbanded value

This diagram illustrates the relationship of attributes 'instMag', 'mag' and 'db' (used for deadband calculation).

NOTE The figure above is an example. There may be other algorithms providing a comparable result; for example as an alternate solution, the deadband calculation may use the integral of the change of 'instMag'. The algorithm used is a local issue.



### Zero deadband

This diagram illustrates the relationship of attributes 'instMag', 'mag' and 'zeroDb' (used for zero forcing).

### Attributes of MV

cdcid = MV, UML class name = MV					
Attribute name	Attribute type	FC	TrgOp	(Value/Value range) Description	PresCond
<b>DataAttribute for measured attributes</b>					
instMag	<a href="#">AnalogueValue</a>	MX		Instantaneous value of the magnitude. NOTE 'instMag' is optional from the perspective of the visibility of that value to the communication. The instantaneous value may be required for the internal behaviour of the function, e.g. to perform the deadband calculation for 'mag'.	O
<b>mag</b>	<b><a href="#">AnalogueValue</a></b>	<b>MX</b>	<b>dchg, dupd</b>	<b>Value of the magnitude based on a deadband calculation from the instantaneous value 'instMag'. The value of 'mag' shall be updated to the current instantaneous value 'instMag' when the value has changed according to the configuration parameter 'db'. If 'db'=0, 'mag'='instMag'.</b> <b>NOTE 1 This value is typically used to create reports for analogue values. Such a report sent "by exception" is not comparable to the transfer of sampled measured values as supported by the CDC SAV.</b> <b>NOTE 2 This 'mag' is not the same as 'mag' of the constructed attribute class 'Vector'.</b>	<b>M</b>
range	<a href="#">RangeKind</a>	MX	dchg	Range in which the current instantaneous value 'instMag' is. A transition of 'instMag' to another range generates a change in this attribute that may be used to trigger a report with trigger option 'data-change' (see RangeConfig). 'instMag' can be a local value, i.e. does not need to be visible over the communication for implementing the range attribute.  NOTE The use of algorithms to filter events based on transition from one range to another is a local issue. Depending on the update rate of the 'instMag', a fast change of the value may result in non-consecutive values of this 'range'; e.g. 'range' can be reported as 'low-low' and 'high-high' in two consecutive updates.	O
q	Quality	MX	qchg	Quality of the values in 'instMag', 'mag', 'range'.	M
t	Timestamp	MX		Timestamp of the last refresh of the value in 'mag' or of the last change of the value in any of 'range' or 'q'.	M
<b>DataAttribute for substitution and blocked</b>					

cdcid = MV, UML class name = MV					
Attribute name	Attribute type	FC	TrgOp	(Value/Value range) Description	PresCond
subEna	BOOLEAN	SV		inherited from: <a href="#">SubstitutionCDC</a>	<a href="#">MFsubst</a>
subMag	<a href="#">AnalogueValue</a>	SV		Value used to substitute 'instMag'.	<a href="#">MFsubst</a>
subQ	Quality	SV		inherited from: <a href="#">SubstitutionCDC</a>	<a href="#">MFsubst</a>
subID	VisString64	SV		inherited from: <a href="#">SubstitutionCDC</a>	<a href="#">MFsubst</a>
blkEna	BOOLEAN	BL		inherited from: <a href="#">SubstitutionCDC</a>	O
DataAttribute for configuration, description and extension					
units	<a href="#">Unit</a>	CF	dchg	Unit for: 'instMag', 'mag', 'subMag', 'rangeC'.	O
db	INT32U	CF	dchg	(range=[0...100000]) Deadband is a configuration parameter used to calculate deadbanded value 'mag'. The value of 'db' shall represent the percentage of 'dbRef' in units of 0.001%. Therefore, 'db'=[0, 100'000], corresponding to [0%, 100%], respectively. If an integral calculation is used to determine the deadbanded value, the value of 'db' shall be represented as 0,001% s. Value 0 shall suppress reporting events on the analog value, so that only changes of the 'range' value will lead to events.	O
zeroDb	INT32U	CF	dchg	(range=[0...100000]) Configuration parameter used to calculate the range around zero, where the deadbanded value 'mag' will be forced to zero. The value of 'zeroDb' shall represent the percentage of 'zeroDbRef' in units of 0,001%. Therefore, 'zeroDb'=[0, 100'000], corresponding to [0%, 100%], respectively.	O
sVC	<a href="#">ScaledValueConfig</a>	CF	dchg	Configuration for scaled value representation ('instMag', 'mag', 'subMag', 'rangeC').	<a href="#">MFscaledAV</a>
rangeC	<a href="#">RangeConfig</a>	CF	dchg	Configuration for 'range'.	<a href="#">MO(range)</a>
smpRate	INT32U	CF	dchg	Number of samples per second that has been used to determine instantaneous value 'instMag'. In the case of an ac system, it is number of samples per nominal period.	O
dbRef	INT32U	CF	dchg	Deadband reference used for the calculation of deadband. A value of 0 means that the value db shall represent the percentage of the last transmitted values in units of 0,001 %. A value > 0 means that the value db shall represent the percentage of the deadband reference (dbRef) in units of 0,001 %.	<a href="#">MO(db)</a>
zeroDbRef	INT32U	CF	dchg	Zero deadband reference used for the zero deadband calculation. A value of 0 is not allowed. A value > 0 means that the value zeroDb shall represent the percentage of the zero deadband reference (zeroDbRef) in units of 0,001 %.	<a href="#">MO(zeroDb)</a>
d	VisString255	DC		inherited from: <a href="#">BasePrimitiveCDC</a>	O
dU	Unicode255	DC		inherited from: <a href="#">BasePrimitiveCDC</a>	O
cdcName	VisString255	EX		inherited from: <a href="#">BasePrimitiveCDC</a>	O
dataNs	VisString255	EX		inherited from: <a href="#">BasePrimitiveCDC</a>	<a href="#">MOdataNs</a>

<b>f</b>	<b>Float</b>
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