IEC 61850 Part 7-420
DER Logical Nodes

Final Draft International Standard (FDIS)

Communication Networks and Systems for Power Utility Automation for Distributed Energy Resources (DER)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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International Standard IEC 61850-7-420 has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this standard is based on the following documents:

FDIS	Report on voting
57/XX/FDIS	57/XX/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

In clauses 5-8 of this document, each subclause contains an initial informative clause, followed by normative clauses. Specifically, any subclause identified as informative is informative; any clause with no identification is considered normative.

A list of all parts of the IEC 61850 series, under the general title: *Communication networks and systems for power utility automation*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date[1)] indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

1) The National Committees are requested to note that for this publication the maintenance result date is 2011.

INTRODUCTION

Increasing numbers of DER (distributed energy resources) systems are being interconnected to electric power systems throughout the world. As DER technology evolves and as the impact of dispersed generation on distribution power systems becomes a growing challenge - and opportunity, nations worldwide are recognizing the economic, social, and environmental benefits of integrating DER technology within their electric infrastructure.

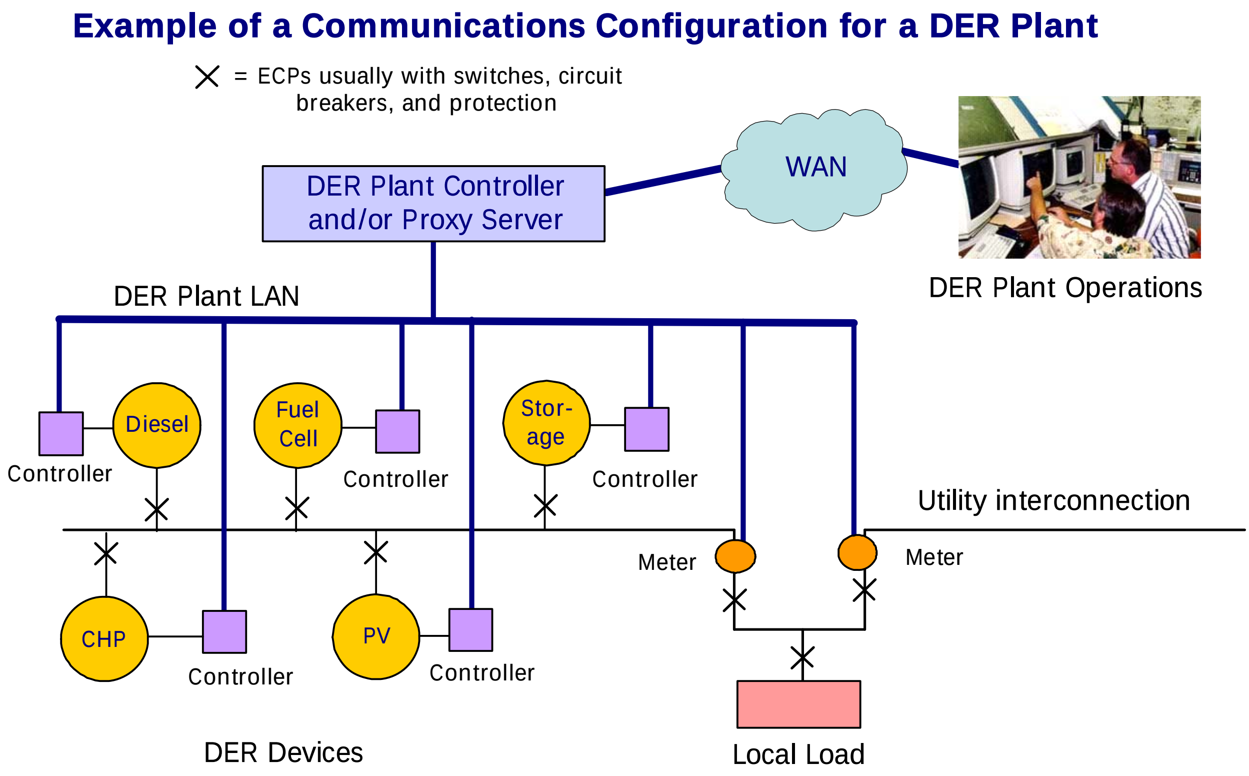
The manufacturers of DER devices are facing the age-old issues of what communication standards and protocols to provide to their customers for monitoring and controlling DER devices, in particular when they are interconnected with the electric utility system. In the past, DER manufacturers developed their own proprietary communication technology. However, as utilities, aggregators, and other energy service providers start to manage DER devices which are interconnected with the utility power system, they are finding that coping with these different communication technologies present major technical difficulties, implementation costs, and maintenance costs. Therefore, utilities and DER manufacturers recognize the growing need to have one international standard that defines the communication and control interfaces for all DER devices. Such standards, along with associated guidelines and uniform procedures would simplify implementation, reduce installation costs, reduce maintenance costs, and improve reliability of power system operations.

The logical nodes in this document are intended for use with DER, but may also be applicable to central-station generation installations that are comprised of groupings of multiple units of the same types of energy conversion systems that are represented by the DER logical nodes in this document. This applicability to central-station generation is strongest for photovoltaics and fuel cells, due to their modular nature.

Communications for DER plants involve not only local communications between DER units and the plant management system, but also between the DER plant and the operators or aggregators who manage the DER plant as a virtual source of energy and/or ancillary services. This is illustrated in **Key**

WAN wide area network

Figure 1.



Key

WAN wide area network

Figure 1 – Example of a communications configuration for a DER plant

In basic terms, "communications" can be separated into four parts:

- information modelling (the types of data to be exchanged – nouns),
- services modelling (the read, write, or other actions to take on the data – verbs),
- communication protocols (mapping the noun and verb models to actual bits and bytes),
- telecommunication media (fibre optics, radio systems, wireless systems, and other physical equipment).

This document addresses only the IEC 61850 information modelling for DER. Other IEC 61850 documents address the services modelling (IEC 61850-7-2) and the mapping to communication protocols (IEC 61850-8-x). In addition, a systems configuration language (SCL) for DER (IEC 61850-6-x) would address the configuration of DER plants.

The general technology for information modelling has developed to become well-established as the most effective method for managing information exchanges. In particular, the IEC 61850-7-x information models for the exchange of information within substations have become International Standard. Many of the components of this standard can be reused for information models of other types of devices.

In addition to the IEC 61850 standards, IEC TC 57 has developed the common information model (CIM) that models the relationships among power system elements and other information elements so that these relationships can be communicated across systems. Although this standard does not address these CIM relationships for DER, it is fully compatible with the CIM concepts.

The interrelationship between IEC TC 57 modelling standards is illustrated in Figure 2.This illustration shows as horizontal layers the three components to an information exchange model for retrieving data from the field, namely, the communication protocol profiles, the service models, and the information models. Above these layers is the information model of utility-specific data, termed the common information model (CIM), as well as all the applications and databases needed in utility operations. Vertically, different information models are shown:

- substation automation (IEC 61850-7-4),
- large hydro plants (IEC 61850-7-410),
- distributed energy resources (DER) (IEC 61850-7-420),
- distribution automation (under development),
- advanced metering infrastructure (as pertinent to utility operations) (pending).

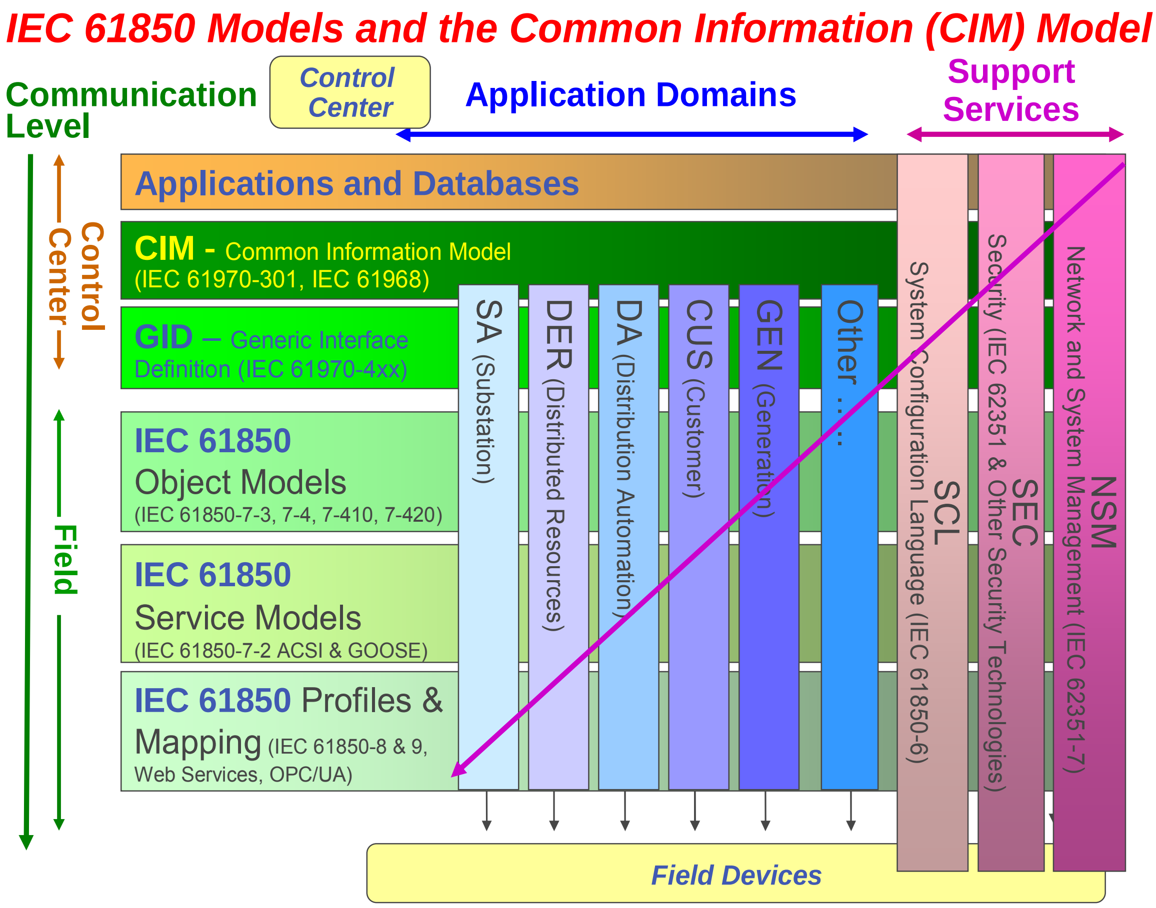


Figure 2 – IEC 61850 modelling and connections with CIM and other IEC TC 57 models

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 7-420: Basic communication structure – Distributed energy resources logical nodes

1 Scope

This International Standard defines the IEC 61850 information models to be used in the exchange of information with distributed energy resources (DER), which comprise dispersed generation devices and dispersed storage devices, including reciprocating engines, fuel cells, microturbines, photovoltaics, combined heat and power, and energy storage.

The IEC 61850 DER information model standard utilizes existing IEC 61850-7-4 logical nodes where possible, but also defines DER-specific logical nodes where needed.

2 Normative references

The following referenced documents are indispensable for the application 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 61850-7-2:2003, *Communication networks and systems in substations – Part 7-2: Basic communication structure for substations and feeder equipment – Abstract communication service interface (ACSI)* [2)]

IEC 61850-7-3:2003, *Communication networks and systems in substations – Part 7-3: Basic communication structure for substations and feeder equipment – Common data classes* [2)]

IEC 61850-7-4:2003, *Communication networks and systems in substations – Part 7-4: Basic communication structure for substations and feeder equipment – Compatible logical node classes and data classes* [2)]

IEC 61850-7-410, *Communication networks and systems for power utility automation – Part 7-410: Hydroelectric power plants – Communication for monitoring and control*

ISO 4217, *Codes for the representation of currencies and funds*

[2)] A new edition of this document is in preparation.

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1
electrical connection point
ECP
point of electrical connection between the DER source of energy (generation or storage) and any electric power system (EPS)

Each DER (generation or storage) unit has an ECP connecting it to its local power system; groups of DER units have an ECP where they interconnect to the power system at a specific site or plant; a group of DER units plus local loads have an ECP where they are interconnected to the utility power system.

NOTE For those ECPs between a utility EPS and a plant or site EPS, this point is identical to the point of common coupling (PCC) in the IEEE 1547 "*Standard for Interconnecting Distributed Resources with Electric Power Systems*".

3.1.2
information exchange
communication process between two or more computer-based systems in order to transmit and receive information

NOTE The exchange of information between systems requires interoperable communication services.

3.1.3
prime mover
equipment acting as the energy source for the generation of electricity

NOTE Examples include diesel engine, solar panels, gas turbines, wind turbines, hydro turbines, battery storage, water storage, air storage, etc.

3.1.4
ambient temperature
temperature of the medium in the immediate vicinity of a device

3.1.5
common data class
CDC
classes of commonly used data structures which are defined in IEC 61850-7-3

3.1.6
combined heat and power (CHP) co-generation
production of heat which is used for non-electrical purposes and also for the generation of electric energy

NOTE Conventional power plants emit the heat produced as a useless byproduct of the generation of electric energy into the environment. With combined heat and power, the excess heat is captured for domestic or industrial heating purposes or – in form of steam – is used for driving a steam turbine connected to an air-conditioner compressor. Alternatively, the production of heat may be the primary purpose of combined heat and power, whereas excess heat is used for the generation of electric energy.

3.1.7
device
material element or assembly of such elements intended to perform a required function

NOTE A device may form part of a larger device.

3.1.8
event
event information

a) something that happens in time

b) monitored information on the change of state of operational equipment

NOTE In power system operations, an event is typically state information and/or state transition (status, alarm, or command) reflecting power system conditions.

3.1.9
fuel cell

a) generator of electricity using chemical energy directly by ionisation and oxidation of the fuel;

b) cell that can change chemical energy from continuously supplied reactants to electric energy by an electrochemical process

3.1.10
fuel cell stack
individual fuel cells connected in series

NOTE Fuel cells are stacked to increase voltage.

3.1.11
function
a computer subroutine; specifically: one that performs a calculation with variables provided by a program and supplies the program with a single result

NOTE This term is very general and can often be used to mean different ideas in different contexts. However, in the context of computer-based technologies, it is used to imply software or computer hardware tasks.

3.1.12
generator

a) energy transducer that transforms non-electric energy into electric energy;

b) device that converts kinetic energy to electrical energy, generally using electromagnetic induction

   The reverse conversion of electrical energy into mechanical energy is done by an electric motor, and motors and generators have many similarities. The prime mover source of mechanical energy may be a reciprocating or turbine steam engine, water falling through a hydropower turbine or waterwheel, an internal combustion engine, a wind turbine, a hand crank, or any other source of mechanical energy.

3.1.13
information

a) intelligence or knowledge capable of being represented in forms suitable for communication, storage or processing;

b) knowledge concerning objects, such as facts, events, things, processes, or ideas, including concepts, that within a certain context has a particular meaning

NOTE Information may be represented for example by signs, symbols, pictures, or sounds.

3.1.14
insolation
solar radiation that has been received

3.1.15
inverter

a) static power converter (SPC);

b) device that converts DC electricity into AC electricity, equipment that converts direct current from the array field to alternating current, the electric equipment used to convert electrical power into a form or forms of electrical power suitable for subsequent use by the electric utility

NOTE Any static power converter with control, protection, and filtering functions used to interface an electric energy source with an electric utility system. Sometimes referred to as power conditioning subsystems, power conversion systems, solid-state converters, or power conditioning units.

3.1.16
irradiance
density of radiation incident on a given surface usually expressed in watts per square centimeter or square meter

NOTE "Irradiance" is used when the electromagnetic radiation is incident on the surface. "Radiant excitance" or "radiant emittance" is used when the radiation is emerging from the surface. The SI units for all of these quantities are watts per square metre (W·m-2), while the cgs units are ergs per square centimeter per second (erg·cm-2·s-1, often used in astronomy). These quantities are sometimes called intensity, but this usage leads to confusion with radiant intensity, which has different units.

3.1.17
measured value
physical or electrical quantity, property or condition that is to be measured [IEC 61850-7-4]

NOTE 1 Measured values are usually monitored, but may be calculated from other values. They are also usually considered to be analogue values.

NOTE 2 The result of a sampling of an analogue magnitude of a particular quantity.

3.1.18
membrane
the separating layer in a fuel cell that acts as electrolyte (a ion-exchanger) as well as a barrier film separating the gases in the anode and cathode compartments of the fuel cell

3.1.19
photovoltaic cell
device in which the photovoltaic effect is utilized

3.1.20
photovoltaic system

a) a complete set of components for converting sunlight into electricity by the photovoltaic process, including the array and balance of system components;

b) a system comprises all inverters (one or multiple) and associated BOS (balance-of-system components) and arrays with one point of common coupling, described in IEC 61836 as PV power plant

NOTE The component list and system configuration of a photovoltaic system varies according to the application, and can also include the following sub-systems: power conditioning, energy storage, system monitoring and control and utility grid interface.

3.1.21
photovoltaics
PV
of, relating to, or utilizing the generation of a voltage when radiant energy falls on the boundary between dissimilar substances (as two different semiconductors)

3.1.22
point of common coupling
PCC
point of a power supply network, electrically nearest to a particular load, at which other loads are, or may be, connected

NOTE 1 These loads can be either devices, equipment or systems, or distinct customer's installations.

NOTE 2 In some applications, the term "point of common coupling" is restricted to public networks.

NOTE 3 The point where a local EPS is connected to an area EPS. The local EPS may include distributed energy resources as well as load (see IEV definition which only includes load).

3.1.23
power conversion
power conversion is the process of converting power from one form into another

This could include electromechanical or electrochemical processes.

In electrical engineering, power conversion has a more specific meaning, namely converting electric power from one form to another. This could be as simple as a transformer to change the voltage of AC power, but also includes far more complex systems. The term can also refer to a class of electrical machinery that is used to convert one frequency of electrical power into another frequency.

One way of classifying power conversion systems is according to whether the input and output are alternating current (AC) or direct current (DC), thus:

DC to DC

- DC to DC converter
- Voltage stabiliser
- Linear regulator

AC to DC

- Rectifier
- Mains power supply unit (PSU)
- Switched-mode power supply

DC to AC

- Inverter

AC to AC

- Transformer/autotransformer
- Voltage regulator

3.1.24
PV module
the smallest complete environmentally protected assembly of interconnected cells

NOTE Colloquially referred to as a "solar module".

3.1.25
PV string
a circuit of series-connected modules

3.1.26
reciprocating engine
piston engine
an engine in which the to-and-fro motion of one or more pistons is transformed into the rotary motion of a crankshaft

NOTE The most common form of reciprocating engines is the internal combustion engine using the burning of gasoline, diesel fuel, oil or natural gas to provide pressure. In DER systems, the most common form is the diesel engine.

3.1.27
reformate
hydrocarbon fuel that has been processed into hydrogen and other products for use in fuel cells

3.1.28
set point

the level or point at which a variable physiological state (as body temperature or weight) tends to stabilize [Merriam-Webster Dictionary]

3.1.29
set point command
command in which the value for the required state of operational equipment is transmitted to a controlled station where it is stored *[IEV 371-03-11]*

NOTE A setpoint is usually an analogue value which sets the controllable target for a process or sets limits or other parameters used for managing the process.

3.1.30
SI
International System of units

3.1.31
standard test conditions
STC
a standard set of reference conditions used for the testing and rating of photovoltaic cells and modules

The standard test conditions are:

a) PV cell temperature of 25 °C;

b) irradiance in the plane of the PV cell or module of 1 000 W/m2;

c) light spectrum corresponding to an atmospheric air mass of 1,5

3.1.32
turbine
machine for generating rotary mechanical power from the energy in a stream of fluid

The energy, originally in the form of head or pressure energy, is converted to velocity energy by passing through a system of stationary and moving blades in the turbine.

3.2 DER abbreviated terms

Clause 4 of IEC 61850-7-4 defines abbreviated terms for building concatenated data names. The following DER abbreviated terms are proposed as additional terms for building concatenated data names.

Term	Description	Term	Description
Abs	Absorbing	Bck	Backup
Acc	Accumulated	Bnd	Band
Act	Active, activated	Cal	Calorie, caloric
Algn	Alignment	Cct	Circuit
Alt	Altitude	Cmpl	Complete, completed
Amb	Ambient	Cmut	Commute, commutator
Arr	Array	Cnfg	Configuration
Aval	Available	Cntt	Contractual
Azi	Azimuth	Con	Constant
Bas	Base	Conn	Connected, connections

Term	Description	Term	Description
Conv	Conversion, converted	Inf	Information
Cool	Coolant	Insol	Insolation
Cost	Cost	Isld	Islanded
Csmp	Consumption, consumed	Iso	Isolation
Day	Day	Maint	Maintenance
Db	Deadband	Man	Manual
Dc	Direct current	Mat	Material
Dct	Direct	Mdul	Module
DCV	DC voltage	Mgt	Management
Deg	Degrees	Mrk	Market
Dep	Dependent	Obl	Obligation
DER	Distributed energy resource	Off	Off
Dff	Diffuse	On	On
Drt	Derate	Ox	Oxidant, oxygen
Drv	Drive	Pan	Panel
ECP	Electrical connection point	PCC	Point of common coupling
Efc	Efficiency	Perm	Permission
El	Elevation	Pk	Peak
Em	Emission	Plnt	Plant, facility
Emg	Emergency	Proc	Process
Encl	Enclosure	Pv	Photovoltaics
Eng	Engine	Qud	Quad
Est	Estimated	Rad	Radiation
ExIm	Export/import	Ramp	Ramp
Exp	Export	Rdy	Ready
Forc	Forced	Reg	Regulation
Fuel	Fuel	Rng	Range
Fx	Fixed	Rsv	Reserve
Gov	Governor	Schd	Schedule
Heat	Heat	Self	Self
Hor	Horizontal	Ser	Series, serial
Hr	Hour	Slp	Sleep
Hyd	Hydrogen (suggested in addition to H_2)	Snw	Snow
Id	Identity	Srt	Short
Imp	Import	Stab	Stabilizer
Ind	Independent	Stp	Step
Inert	Inertia	Thrm	Thermal

Term	Description	Term	Description
Tilt	Tilt	Vbr	Vibration
Tm	Timing	Ver	Vertical
Trk	Track	Volm	Volume
Tur	Turbine	Wtr	Water (suggested in addition to H_2O)
Unld	Unload	Wup	Wake up
Util	Utility	Xsec	Cross-section

4 Conformance

Claiming conformance to this specification shall require the provision of a model implementation conformance statement (MICS) document identifying the standard data object model elements supported by the system or device, as specified in IEC 61850-10.

5 Logical nodes for DER management systems

5.1 Overview of information modelling (informative)

5.1.1 Data information modelling constructs

Data information models provide standardized names and structures to the data that is exchanged among different devices and systems. Figure 3 illustrates the object hierarchy used for developing IEC 61850 information models.

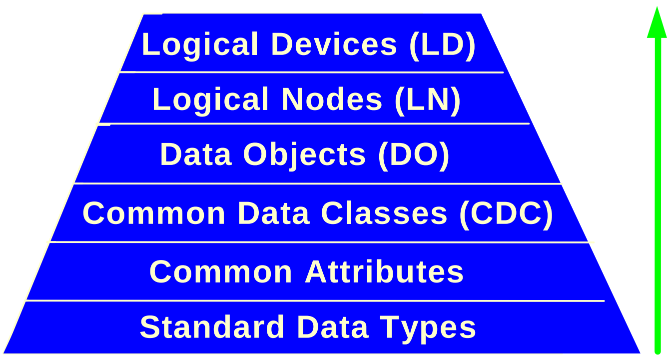


Figure 3 – Information model hierarchy

The process from the bottom up is described below:

a) Standard data types: common digital formats such as Boolean, integer, and floating point.

b) Common attributes: predefined common attributes that can be reused by many different objects, such as the quality attribute. These common attributes are defined in Clause 6 of IEC 61850-7-3.

c) Common data classes (CDCs): predefined groupings building on the standard data types and predefined common attributes, such as the single point status (SPS), the measured value (MV), and the controllable double point (DPC). In essence, these CDCs are used to define the type or format of data objects. These CDCs are defined in IEC 61850-7-3 or in Clause 9 of this document. All units defined in the CDCs shall conform to the SI units (international system of units) listed in IEC 61850-7-3.

d) Data objects (DO): predefined names of objects associated with one or more logical nodes. Their type or format is defined by one of the CDCs. They are listed only within the logical nodes. An example of a DO is “Auto” defined as CDC type SPS. It can be found in a number of logical nodes. Another example of a DO is “RHz” defined as a SPC (controllable single point), which is found only in the RSYN logical node.

e) Logical nodes (LN): predefined groupings of data objects that serve specific functions and can be used as “bricks” to build the complete device. Examples of LNs include MMXU which provides all electrical measurements in 3-phase systems (voltage, current, watts, vars, power factor, etc.); PTUV for the model of the voltage portion of under voltage protection; and XCBR for the short circuit breaking capability of a circuit breaker. These LNs are described in Clause 5 of IEC 61850-7-4.

f) Logical devices (LD): the device model composed of the relevant logical nodes for providing the information needed for a particular device. For instance, a circuit breaker could be composed of the logical nodes: XCBR, XSWI, CPOW, CSWI, and SMIG. Logical devices are not directly defined in any of the documents, since different products and different implementations can use different combinations of logical nodes for the same logical device.

5.1.2 Logical devices concepts

Controllers or servers contain the IEC 61850 logical device models needed for managing the associated device. These logical device models consist of one or more physical device models as well as all of the logical nodes needed for the device.

Therefore a logical device server can be diagrammed as shown in Figure 4.

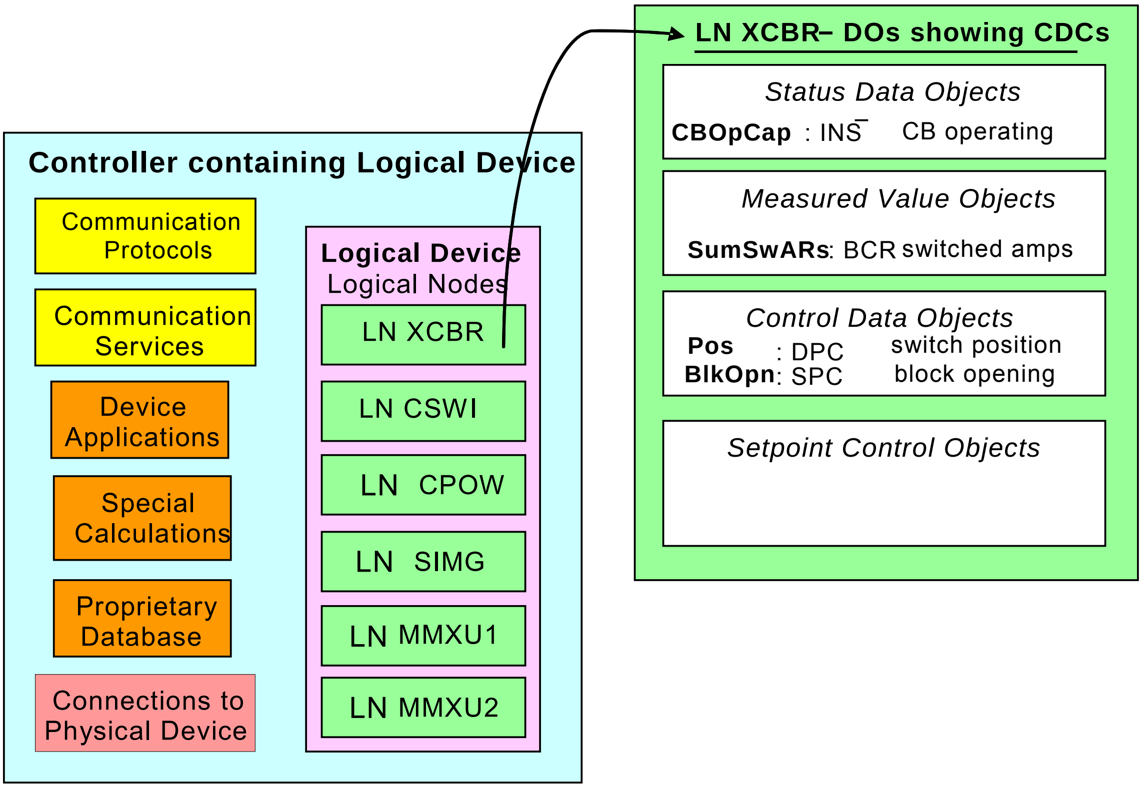


Figure 4 – Example of relationship of logical device, logical nodes, data objects, and common data classes

5.1.3 Logical nodes structure

The logical nodes (LNs) for DER devices are defined in the tables found in Clauses 5 to 8. For each LN implemented, all mandatory items shall be included (those indicated as an M in the M/O/C column). For clarity, these LNs are organized by typical logical devices that they may be a part of, but they may be used or not used as needed. The organization of IEC 61850

DER information models is illustrated in Figure 5. This illustration does not include all LNs that might be implemented, nor all possible configurations, but exemplifies the approach taken to create information models.

5.1.4 Naming structure

NOTE This is extracted from IEC 61850-7-2 Edition 2 (to be published) for informative purposes only – if any conflict is found, the original must be considered the definitive source.

The ObjectReference the various paths through a data object shall be:

```
LDName/LNName.
DataObjectName[.SubDataObjectName[. ...]].
DataAttributeName[(NumArrayElement)][.SubDataAttributeName[. ...]]
```

The following naming conventions (structure, lengths and character set) for object names and object references shall apply:

- LDName ≤ 64 characters, application specific
- LNName = [LN-Prefix] LN class name [LN-Instance-ID]
  - — LN-Prefix = m characters (application specific); it may start with any character
  - — LN class name = 4 characters (for example, compatible logical node name as defined in IEC 61850-7-4)
  - — LN-Instance-ID = n numeric characters (application specific),
    - o m+n ≤ 7 characters
- DataObjectClassName ≤ 10 characters (as, for example, used in IEC 61850-7-4); no DataObjectClassName shall end with a numeric character
- DataObjectName = DataObjectClassName[Data-Instance-ID]
- Data-Instance-ID = n numeric characters, optional; n shall be equal for all instances of the same data class
- FCD ≤ 61 characters including all separators "." (without the value of the FC)
- FCDA ≤ 61 characters including all separators "." (without the value of the FC)
- DataSetName ≤ 52 characters
- CBName = [CB-Prefix] CB class name [CB-Instance-ID]
  - — CB-Prefix = m characters (application specific)
  - — CB class name = 4 characters (as defined in this part of the standard)
  - — CB-Instance-ID = n numeric characters (application specific)
    - o m+n ≤ 7 characters

5.1.5 Interpretation of logical node tables

NOTE This is extracted from IEC 61850-7-4 Edition 2 (to be published) for informative purposes only – if any conflict is found, the original must be considered the definitive source.

The interpretation of the headings for the logical node tables is presented in Table 1.

Table 1 – Interpretation of logical node tables

Column heading	Description
Data object name	Name of the data object
Common data class	Common data class that defines the structure of the data object. See IEC 61850-7-3. For common data classes regarding the service tracking logical node (LTRK), see IEC 61850-7-2.

Column heading	Description
Explanation	Short explanation of the data object and how it is used.
T	Transient data objects – the status of data objects with this designation is momentary and must be logged or reported to provide evidence of their momentary state. Some T may be only valid on a modelling level. The TRANSIENT property of DATA OBJECTS only applies to BOOLEAN process data attributes (FC=ST) of that DATA OBJECTS. Transient DATA OBJECT is identical to normal DATA OBJECT, except that for the process state change from TRUE to FALSE no event may be generated for reporting and for logging. For transient data objects, the falling edge shall not be reported if the transient attribute is set to true in the SCL-ICD file. It is recommended to report both states (TRUE to FALSE, and FALSE to TRUE), i.e. not to set the transient attribute in the SCL-ICD file for those DOs, and that the client filter the transitions that are not "desired".
M/O/C	This column defines whether data objects are mandatory (M) or optional (O) or conditional (C) for the instantiation of a specific logical node. NOTE The attributes for data objects that are instantiated may also be mandatory or optional based on the CDC (attribute type) definition in IEC 61850-7-3. The entry C is an indication that a condition exists for this data object, given in a note under the LN table. The condition decides what conditional data objects get mandatory. C may have an index to handle multiple conditions.

The LN type and the LNName attribute are inherited from logical-node class (see IEC 61850-7-2). The LN class names are individually given in the logical node tables. The LN instance name shall be composed of the class name, the LN-Prefix and LN-Instance-ID according to Clause 19 of IEC 61850-7-2.

All data object names are listed alphabetically in Clause 6 [*applies to IEC 61850-7 only*]. Despite some overlapping, the data objects in the logical nodes classes are grouped for the convenience of the reader into some of the following categories.

a) Data objects without category (Common information)

Data objects without category (Common information) is information independent of the dedicated function represented by the LN class. Mandatory data objects (M) are common to all LN classes i.e. shall be used for all LN classes dedicated for functions. Optional data objects (O) may be used for all LN classes dedicated for functions. These dedicated LN classes show if optional data objects of the common logical node class are mandatory in the LN.

b) Measured 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.

c) Controls

Controls are 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.

d) Metered values

Metered values are analogue data objects representing quantities measured over time, e.g. energy. This information is produced locally and cannot be changed remotely unless substitution is applicable.

e) Status information

Status information is a data object, which shows either the status of the process or of the function allocated to the LN class. This information is produced locally and cannot be changed remotely unless substitution is applicable. Data objects such as “start” or “trip” are listed in this category. Most of these data objects are mandatory.

f) Settings

Settings are data objects which are needed for the function to operate. Since many settings are dependent on the implementation of the function, only a commonly agreed minimum is standardised. They may be changed remotely, but normally not very often.

5.1.6 System logical nodes LN Group: L (informative)

NOTE This is extracted from IEC 61850-7-4 Edition 2 (to be published) for informative purposes only – if any conflict is found, the original must be considered the definitive source.

5.1.6.1 General

In this subclause, the system specific information is defined. This includes system logical node data (for example logical node behaviour, nameplate information, operation counters) as well as information related to the physical device (LPHD) implementing the logical devices and logical nodes. These logical nodes (LPHD and common LN) are independent of the application domain. All other logical nodes are domain specific, but inherit mandatory and optional data from the common logical node.

5.1.6.2 LN: Physical device information Name: LPHD

This LN is introduced in this part to model common issues for physical devices. See Table 2.

Table 2 – LPHD class

LPHD Class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
PhyNam	DPL	Physical device name plate		M
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
RsStat	SPC	Reset device statistics		O
Data sets (see IEC 61850-7-2)				
Control blocks (see IEC 61850-7-2)				
Services (see IEC 61850-7-2)				

5.1.6.3 LN: Common logical node Name: Common LN

The common logical node class provides data which are mandatory or conditional to all dedicated LN classes. It also contains data which may be used in all dedicated logical node classes like input references and data for the statistical calculation methods. See Table 3.

Table 3 – Common LN class

Common LN Class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
Mandatory logical node information (Shall be inherited by ALL LN except LPHD)				
Mod	ENC	Mode		C
Beh	ENS	Behaviour		M
Health	ENS	Health		C1
NamPlt	LPL	Name plate		C1
Optional logical node information (May be inherited)				
InRef1	ORG	General input		O
BlkRef1	ORG	Block reference show the receiving of dynamically blocking signal		O
Blk	SPS	Dynamically blocking of function described by the LN		O
CmdBlk	SPC	Blocking of control sequences of controllable data objects		C2
ClcExp	SPS	Calculation period expired	T	O
ClcStr	SPC	Start calculation at time operTmh (if set) or immediately		O
ClcMth	ENG	Calculation Method of statistical data. Allowed values PRES | MIN | MAX |AVG | SDV |TREND | RATE		C3
ClCMod	ENG	Calculation mode. Allowed values: TOTAL | PERIOD | SLIDING		O
CLCIntvTyp	ENG	Calculation interval type. Allowed values: ANYTIME | CYCLE | PER_CYCLE | HOUR | DAY | WEEK		O
ClcPerms	ING	Calculation period in milliseconds. If ClcIntvTyp is equal ANYTIME Calculation Period shall be defined.		O
ClcSrc	ORG	Object reference to source logical node		O
ClcTyp	ENS	Calculation type		C
GrRef	ORG	Reference to a higher level logical device		O
Data sets (see IEC 61850-7-2)				
Control blocks (see IEC 61850-7-2)				
Services (see IEC 61850-7-2)				

5.1.6.4 LN: Logical node zero Name: LLN0

This LN shall be used to address common issues for Logical Devices. See Table 4.

Table 4 – LLN0 class

LLN0 Class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
LocKey	SPS	Local operation for complete logical device		O
RemCtlBlk	SPC	SPC remote control blocked		O
LocCtlBeh	SPS	SPS Local control behaviour		O
OpTmh	INS	Operation time		O
Controls				
Diag	SPC	Run diagnostics		O
LEDRs	SPC	LED reset	T	O
Settings				
MltLev	SPG	Select mode of authority for local control (True – control from multiple levels above the selected one is allowed, False – no other control level above allowed)		O

5.1.7 Overview of DER management system LNs

Figure 5 shows a conceptual view of the logical nodes which could be used for different parts of DER management systems.

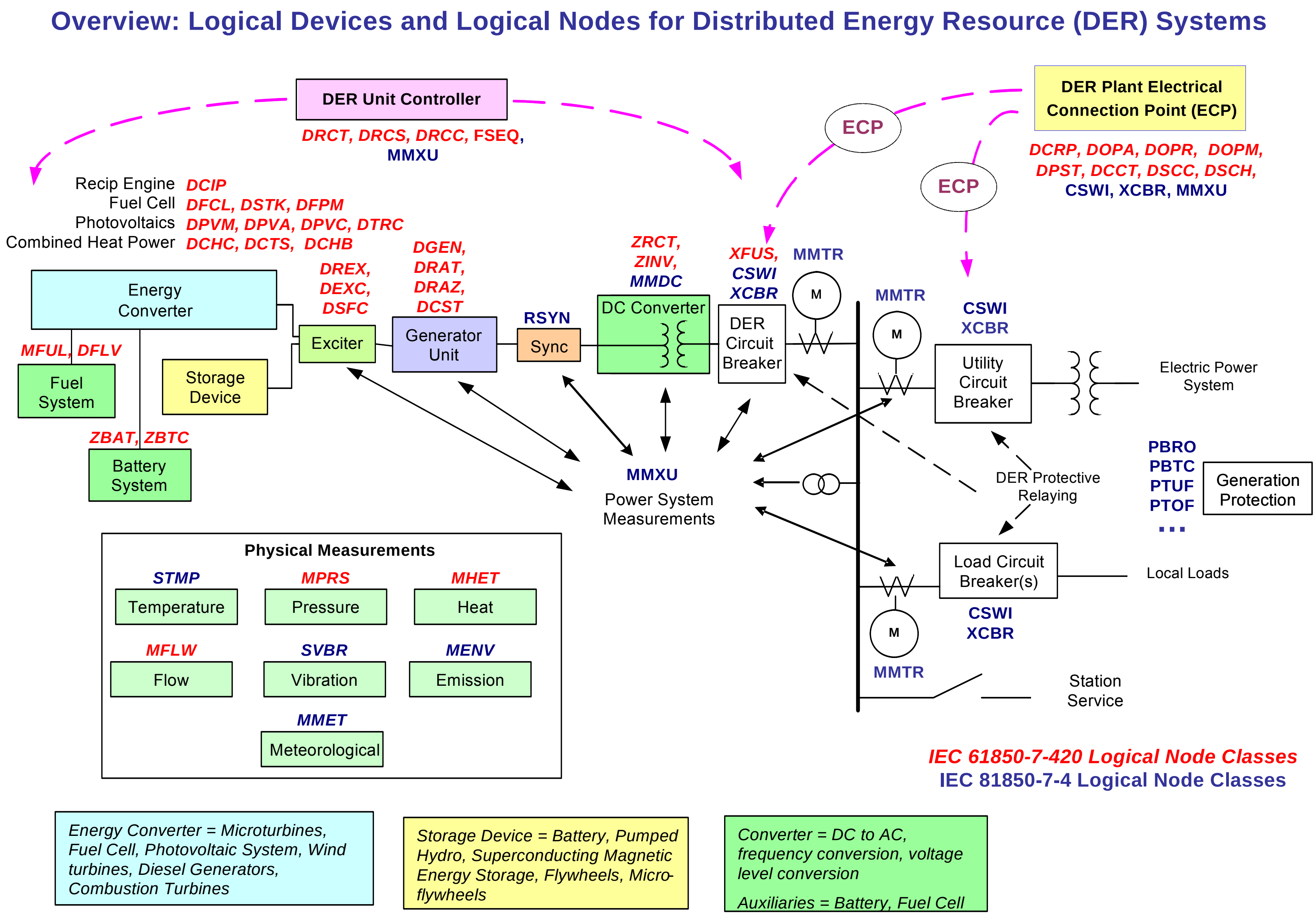


Figure 5 – Overview: Conceptual organization of DER logical devices and logical nodes

5.2 Logical nodes for the DER plant ECP logical device

5.2.1 DER plant electrical connection point (ECP) logical device (informative)

The DER plant electrical connection point (ECP) logical device defines the characteristics of the DER plant at the point of electrical connection between one or more DER units and any electric power system (EPS), including isolated loads, microgrids, and the utility power system. Usually there is a switch or circuit breaker at this point of connection.

ECPs can be hierarchical. Each DER (generation or storage) unit has an ECP connecting it to its local power system; groups of DER units have an ECP where they interconnect to the power system at a specific site or plant; a group of DER units plus local loads have an ECP where they are interconnected to the utility power system.

In a simple DER configuration, there is one ECP between a single DER unit and the utility power system. However, as shown in Figure 6, there may be more ECPs in a more complex DER plant installation. In this figure, ECPs exist between:

- each single DER unit and the local bus;
- each group of DER units and a local power system (with load);
- multiple groups of DER units and the utility power system.

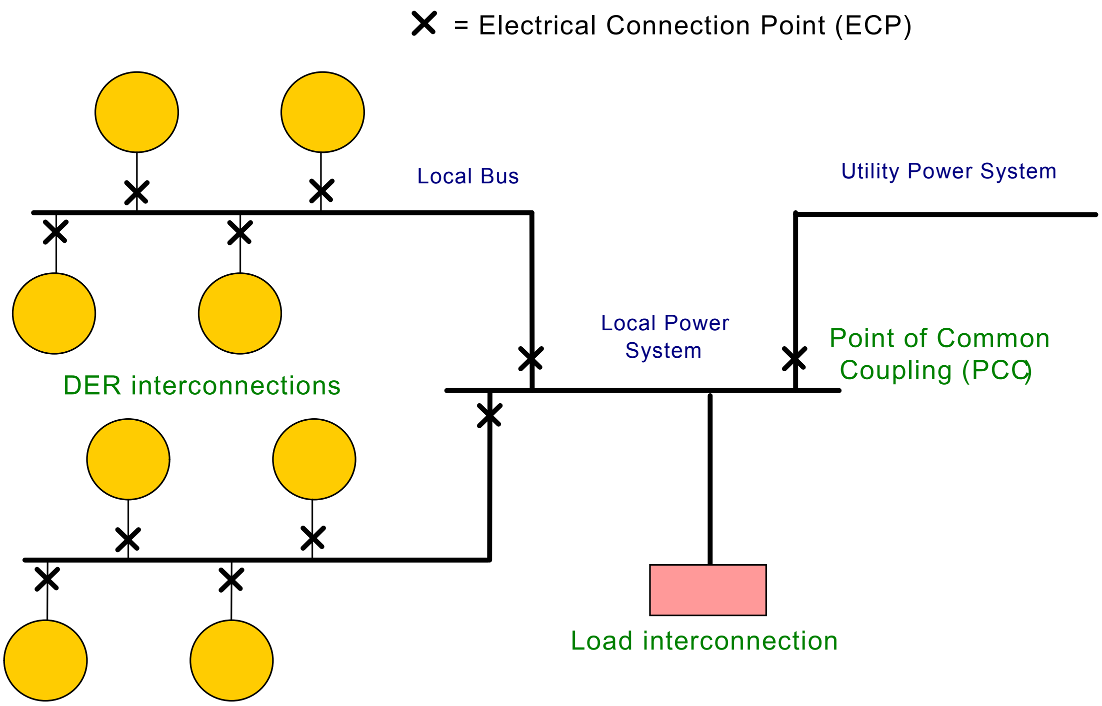


Figure 6 – Illustration of electrical connection points (ECP) in a DER plant

The ECP between a local DER power system and a utility power system is defined as the point of common coupling (PCC) in the IEEE 1547 "*Standard for Interconnecting Distributed Resources with Electric Power Systems*". Although typically the PCC is the electrical connection between a utility and a non-utility DER plant, this is not always true: the DER plant may be owned/operated by a utility, and/or the EPS may be owned/operated by a non-utility entity, such as a campus power system or building complex.

DER systems have economic dispatch parameters related to their operations which are important for efficient operations, and will increasingly be used directly or indirectly in market operations, including demand response, real-time pricing, advanced distribution automation, and bidding into the auxiliary services energy marketplace.

Examples of installations with multiple ECPs include the following.

- One DER device is connected only to a local load through a switch. The connection point is the ECP.
- Groups of similar DER devices are connected to a bus which feeds a local load. If the group is always going to be treated as a single generator, then just one ECP is needed where the group is connected to the bus. If there is a switch between the bus and the load, then the bus has an ECP at that connection point.
- Multiple DER devices (or groups of similar DER devices) are each connected to a bus. That bus is connected to a local load. In this case, each DER device/group has an ECP at its connection to the bus. If there is a switch between the bus and the load, then the bus has an ECP at that connection point.
- Multiple DER devices are each connected to a bus. That bus is connected to a local load. It is also connected to the utility power system. In this case, each DER device has an ECP at its connection to the bus. The bus has an ECP at its connection to the local load. The bus also has an ECP at its connection to the utility power system. This last ECP is identical to the IEEE 1547 PCC.

ECP logical devices would include the following logical nodes as necessary for a particular installation. These LNs may or may not actually be implemented in an ECP logical device, depending upon the unique needs and conditions of the implementation. However, these LNs handle the ECP issues:

- DCRP: DER plant corporate characteristics at each ECP, including ownership, operating authority, contractual obligations and permissions, location, and identities of all DER devices connected directly or indirectly at the ECP.
- DOPR: DER plant operational characteristics at each ECP, including types of DER devices, types of connection, modes of operation, combined ratings of all DERs at the ECP, power system operating limits at the ECP.
- DOPA: DER operational control authorities at each ECP, including the authority to open the ECP switch, close the ECP switch, change operating modes, start DER units, stop DER units. This LN could also be used to indicate what permissions are currently in effect.
- DOPM: DER operating mode at each ECP. This LN can be used to set available operating modes as well as actual operating modes.
- DPST: Actual status at each ECP, including DER plant connection status, alarms.
- DCCT: Economic dispatch parameters for DER operations.
- DSCC: Control of energy and ancillary services schedules.
- DSCH: Schedule for DER plant to provide energy and/or ancillary services.
- XFUS, XCBR, CSWI: Switch or breaker at each ECP and/or at the load connection point (see IEC 61850-7-4).
- MMXU: Actual power system measurements at each ECP, including (as options) active power, reactive power, frequency, voltages, amps, power factor, and impedance as total and per phase (see IEC 61850-7-4).
- MMTR: Interval metering information at each ECP (as needed), including interval lengths, readings per interval (see IEC 61850-7-4, including statistical and historical statistical values).

5.2.2 LN: DER plant corporate characteristics at the ECP Name: DCRP

This logical node defines the corporate and contractual characteristics of a DER plant. A DER plant in this context is defined as one DER unit and/or a group of DER units which are connected at an electrical connection point (ECP). The DCRP LN can be associated with each ECP (e.g. with each DER unit and a group of DER units) or just those ECPs where it is appropriate.

The DCRP LN includes the DPL (device nameplate) information of ownership, operating authorities, and location of the ECP, and also provides contractual information about the ECP: plant purpose, contractual obligations, and contractual permissions. It is expected that only yes/no contractual information needed for operations will be available in this LN. See Table 5.

Table 5 – DER plant corporate characteristics at the ECP, LN (DCRP)

DCRP class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Settings				
PlntOblSelf	SPG	Plant purpose/obligations at the ECP – run passively or whenever possible (e.g. photovoltaics, wind)		O
PlntOblBck	SPG	Plant purpose/obligations at the ECP – for backup		O
PlntOblMan	SPG	Plant purpose/obligations at the ECP – manual operations		O
PlntOblMrk	SPG	Plant purpose/obligations at the ECP – market-driven		O
PlntOblUtil	SPG	Plant purpose/obligations at the ECP – utility operated		O
PlntOblEm	SPG	Plant purpose/obligations at the ECP – emission-limited		O

5.2.3 LN: Operational characteristics at ECP Name: DOPR

This logical node contains the operational characteristics of the combined group of DER units connected at the ECP, including the list of physically connected DER units, the status of their electrical connectivity at this ECP, the type of ECP, the modes of ECP operation, combined ratings of all DERs at ECP, and power system operating limits at ECP. See Table 6.

Table 6 – Operational characteristics at the ECP, LN (DOPR)

DOPR class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O

DOPR class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
Status				
ECPType	ENS	Type of ECP Value | Explanation 0 | Not applicable / Unknown 1 | Connection of one DER to local load 2 | Connection of group of DERs to local EPS serving local load 3 | Connection of local EPS with local load to area EPS (PCC) 4 | Connection of local EPS without local load to area EPS (PCC) 99 | Other		M
InCctID	ING	Circuit Id of generation source at ECP		O
OutCctID	ING	Circuit Id of non-generation (load) at ECP		O
CctPhs	ENS	Type of circuit phases: Value | Explanation 0 | Not applicable / Unknown 1 | single phase 2 | 3 phase 3 | Delta 4 | Wye 5 | Wye-grounded 99 | Other		O
Settings				
ECPWRtg	ASG	Nominal, min, and max aggregated DER W rating at ECP		O
ECPVarRtg	ASG	Nominal, min, and max aggregated DER var rating at ECP		O
ECPVLev	ASG	Nominal, min, and max voltage level at ECP		O
ECPHz	ASG	Nominal, min, and max frequency at ECP		O

5.2.4 LN: DER operational authority at the ECP Name: DOPA

This Logical Node is associated with role based access control (RBAC) and indicates the authorized control actions that are permitted for each “role”, including authority to disconnect the ECP from the power system, connect the ECP to the power system, change operating modes, start DER units, and stop DER units. This LN could also be used to indicate what permissions are in effect. One instantiation of this LN should be established for each “role” that could have operational control. The possible types of roles are outside the scope of this standard. See Table 7.

Table 7 – DER operational authority at the ECP, LN (DOPA)

DOPA class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The Data from LLN0 may optionally be used		O

DOPA class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
Settings				
DERAuth	VRY	List of the MRIDs of the DER units at this ECP which are covered by this authorization		M
ECPOpnAuth	SPG	Authorized to disconnect the ECP from power system		O
ECPClsAuth	SPG	Authorized to connect the ECP to the power system		O
ECPModAuth	SPG	Authorized to change operating mode of DER plant connected to ECP		O
DERStrAuth	SPG	Authorized to start DER units connected to this ECP		O
DERStpAuth	SPG	Authorized to stop DER units connected to the ECP		O
DEROpMode	ERY	List of authorized operational modes: Value – Explanation 0 – Not applicable / Unknown 1 – Driven by energy source 2 – Constant W 3 – Constant voltage 4 – Constant vars 5 – Constant PF 6 – Constant Export / Import 7 – Maximum vars 99 – Other		O

5.2.5 LN: Operating mode at ECP Name: DOPM

This logical node provides settings for the operating mode at the ECP. This LN can be used to set available operating modes as well as to set actual operating modes. More than one mode can be set simultaneously for certain logical combinations. For example:

- PV designates both constant W and constant voltage modes;
- PQ designates both constant var and constant voltage modes;
- PF with voltage override mode designates both constant PF and constant voltage modes;
- Constant W and vars mode designates both constant W and constant vars modes.

It is assumed that a DER management system will then take whatever actions are necessary to set the DER units appropriately so that the ECP maintains the operating mode that has been set. See Table 8.

Table 8 – Operating mode at the ECP, LN (DOPM)

DOPM class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node information				
		LN shall inherit all mandatory data from common logical node class		M

DOPM class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
		The data from LLN0 may optionally be used		O
Controls				
OpModPM	SPC	Mode of operation – driven by energy source (e.g. solar, water flow)		O
OpModConW	SPC	Mode of operation – constant W		O
OpModConV	SPC	Mode of operation – constant voltage		O
OpModConVar	SPC	Mode of operation – constant vars		O
OpModConPF	SPC	Mode of operation – constant PF		O
OpModExIm	SPC	Mode of operation – constant export/import		O
OpModMaxVar	SPC	Mode of operation – maximum vars		O
OpModVOv	SPC	Mode of operation – voltage override		O
OpModPk	SPC	Mode of operation – peak load shaving		O
OpModIsld	SPC	Mode of operation – islanded at the ECP		O

5.2.6 LN: Status information at the ECP Name: DPST

This logical node provides the real-time status and measurements at the ECP, including connection status of ECP and accumulated watt-hours.

The active modes of operation are handled by the LN DOPM, the actual power system measurements at the ECP are handled by the LN MMXU, and control of connectivity at ECP is either a manual action or handled by LNs XCBR and CSWI. See Table 9.

Table 9 – Status at the ECP, LN (DPST)

DPST class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node information				
		LN shall inherit all mandatory data from common logical node class		M
OpTms	INS	Operational time since commissioning		M
		Other data from LLN0 may optionally be used		O
Status information				
ECPConn	SPS	Connection of DER plant at ECP Value / Explanation: True – Electrically connected at ECP False – Not electrically connected at ECP		M
Measured values				
TotWh	BCR	Total watt-hours at ECP since last reset		O

5.2.7 LN: DER economic dispatch parameters Name: DCCT

The following logical node defines the DER economic dispatch parameters. Each DCCT is associated with one or more ECPs. See Table 10.

Table 10 – DER Economic dispatch parameters, LN (DCCT)

DCCT class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Settings				
Currency	CUG	ISO 4217 currency 3-character code		M
CnttExpWLim	ASG	Contractual limit on export energy		O
CnttImpWLim	ASG	Contractual limit on import energy		O
CnttPF	ASG	Contractual power factor to be provided by DER		O
CnttHiV	ASG	Contractual voltage high limit		O
CnttLoV	ASG	Contractual voltage low limit		O
CnttAncil	ING	Ability to provide ancillary services Value – Explanation 0 – Not applicable / Unknown 1 – Load following 2 – Immediate reserve 3 – Operational reserve 4 – Base load 5 – Black start 99 – Other		O
OpCost	CUG	Marginal operational cost per hour		M
OpWCost	CUG	Marginal operational cost per kWh		M
StrCost	CUG	Cost to start up DER		M
StopCost	CUG	Cost to stop DER		M
RampCost	CUG	Cost to ramp DER per kW per minute		O
HeatRteCost	SCR	Incremental heat rate piecewise linear curve costs		O
CarbRteCost	SCR	Incremental carbon emission curve costs		O

5.2.8 LN: DER energy and/or ancillary services schedule control Name: DSCC

The following logical node controls the use of DER energy and ancillary services schedules. Each DSCC is associated with one or more ECPs. Time activated control shall be used to establish the start time for schedules using relative time and if the start time is in the future. See Table 11.

Table 11 – DER energy schedule control, LN (DSCC)

DSCC class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Status information				
ActWSchdSt	INS	Indication of which energy schedule is active – schedule 0 indicates no schedule		M
ActAncSchdSt	INS	Indication of which ancillary services schedule is active – schedule 0 indicates no schedule		M
Controls				
ActWSchd	SPC	Activate specific energy schedule, using TimeActivatedOperate to establish start time for schedules using relative time and if start time is in the future. ctrVal: 0 = deactivate, 1 = activate		M
ActAncSchd	SPC	Activate specific ancillary services schedule, using TimeActivatedOperate to establish start time for schedules using relative time and if start time is in the future. ctrVal: 0 = deactivate, 1 = activate		M

5.2.9 LN: DER energy and/or ancillary services schedule Name: DSCH

The following logical node defines a DER energy and/or ancillary services schedule. Multiple schedules can be defined, using DSCC LN to control which ones are active. Each DSCH is associated with one or more ECPs. See Table 12.

Table 12 – DER Energy and ancillary services schedule, LN (DSCH)

<table>
<tr><th colspan="5">DSCH class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>LNName</td><td></td><td>Shall be inherited from logical-node class (see IEC 61850-7-2)</td><td></td><td></td></tr>
<tr><td colspan="5">Data</td></tr>
<tr><td colspan="5">System logical node data</td></tr>
<tr><td></td><td></td><td>LN shall inherit all mandatory data from common logical node class</td><td></td><td>M</td></tr>
<tr><td></td><td></td><td>Data from LLN0 may optionally be used</td><td></td><td>O</td></tr>
<tr><td colspan="5">Status information</td></tr>
<tr><td>SchdSt</td><td>INS</td><td>Indication that this schedule has been activated</td><td></td><td>M</td></tr>
<tr><td colspan="5">Settings</td></tr>
<tr><td>SchdId</td><td>ING</td><td>Non-zero identity of the schedule</td><td></td><td>M</td></tr>
<tr><td>SchdCat</td><td>ING</td><td>Category of schedule:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Regular</td></tr><tr><td>2</td><td>Backup</td></tr><tr><td>3</td><td>Emergency</td></tr><tr><td>4</td><td>Maintenance</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>M</td></tr>
</table>

<table>
<tr><th colspan="5">DSCH class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>SchdTyp</td><td>ING</td><td>Type of schedule, identifying the operating mode under which the schedule will be used:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Energy</td></tr>
<tr><td>2</td><td>Contingency reserve “spinning”</td></tr>
<tr><td>3</td><td>Contingency reserve supplemental</td></tr>
<tr><td>4</td><td>Emergency reserve</td></tr>
<tr><td>5</td><td>Emission reserve</td></tr>
<tr><td>6</td><td>Energy balancing</td></tr>
<tr><td>7</td><td>Reactive power</td></tr>
<tr><td>8</td><td>Black start</td></tr>
<tr><td>9</td><td>Emergency islanding</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>M</td></tr>
<tr><td>SchdAbsTm</td><td>SCA</td><td>Array of energy targets for each schedule period using absolute time, starting at zero (UTC epoch)</td><td></td><td>C1</td></tr>
<tr><td>SchdRelTm</td><td>SCR</td><td>Array of energy targets for each schedule period using relative time offsets</td><td></td><td>C2</td></tr>
<tr><td>SchdVal</td><td>ING</td><td>Meaning of the val parameter in the SCA or SCR:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Active power</td></tr>
<tr><td>2</td><td>Reactive power</td></tr>
<tr><td>3</td><td>Power factor</td></tr>
<tr><td>4</td><td>Voltage</td></tr>
<tr><td>5</td><td>Price for active power</td></tr>
<tr><td>6</td><td>Price for reactive power</td></tr>
<tr><td>7</td><td>Heat</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td></td></tr>
<tr><td colspan="5">Either C1 or C2 shall be used but not both</td></tr>
</table>

5.3 Logical nodes for the DER unit controller logical device

5.3.1 DER device controller logical device (informative)

The DER device controller logical device defines the operational characteristics of a single DER device, regardless of the type of generator or prime mover.

This DER device can contain the following logical nodes:

- DRCT: DER unit controller characteristics, including what type of DER, electrical characteristics, etc.,
- DRCS: DER unit status,
- DRCC: DER unit control actions,
- MMXU: DER self serve active and reactive power measurements,
- CSWI: switch opening and closing between DER unit and power system.

5.3.2 LN: DER controller characteristics Name: DRCT

The DER controller logical node defines the control characteristics and capabilities of one DER unit or aggregations of one type of DER device with a single controller. See Table 13.

Table 13 – DER controller characteristics, LN DRCT

DRCT class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Settings				
DERNum	ING	Number of DER units connected to controller		M
DERtyp	ING	Type of DER unit: Value – Explanation 0 – Not applicable / Unknown 1 – Virtual or mixed DER 2 – Reciprocating engine 3 – Fuel cell 4 – Photovoltaic system 5 – Combined heat and power 99 – Other		M
MaxWLim	ASG	Nominal max output power		M
MaxVarLim	ASG	Nominal max output reactive power		M
StrDlTms	ING	Nominal time delay before starting or restarting		M
StopDlTms	ING	Nominal time delay before stopping		M
LodRampRte	ING	Nominal ramp load or unload rate, power versus time		M

5.3.3 LN: DER controller status Name: DRCS

The DER controller logical node defines the control status of one DER unit or aggregations of one type of DER device with a single controller. See Table 14.

Table 14 – DER 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)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
OpTmh	INS	Operation time		M
		Other data from LLN0 may optionally be used		O
Status information				
ECPConn	SPS	Electrically connected to the ECP that it is physically connected to: Value – Explanation True – Electrically connected False – Not connected		M

<table>
<tr><th colspan="5">DRCS class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>AutoMan</td><td>SPS</td><td>Automatic or manual mode:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>True</td><td>Automatic</td></tr><tr><td>False</td><td>Manual</td></tr></table></td><td></td><td>M</td></tr>
<tr><td>Loc</td><td>SPS</td><td>Remote or local mode:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>False</td><td>Local</td></tr><tr><td>True</td><td>Remote is allowed</td></tr></table></td><td></td><td>M</td></tr>
<tr><td>ModOnConn</td><td>SPS</td><td>Operational mode - True: On and connected</td><td></td><td>M</td></tr>
<tr><td>ModOnAval</td><td>SPS</td><td>Operational mode - True: On and available for connection</td><td></td><td>M</td></tr>
<tr><td>ModOnUnav</td><td>SPS</td><td>Operational mode - True: On but not available for connection</td><td></td><td>O</td></tr>
<tr><td>ModOffAval</td><td>SPS</td><td>Operational mode - True: Off but available to start</td><td></td><td>M</td></tr>
<tr><td>ModOffUnav</td><td>SPS</td><td>Operational mode - True: Off and not available to start</td><td></td><td>M</td></tr>
<tr><td>ModTest</td><td>SPS</td><td>Operational mode - True: Test mode</td><td></td><td>O</td></tr>
<tr><td>ModStr</td><td>SPS</td><td>Operational mode - True: Starting up</td><td></td><td>O</td></tr>
<tr><td>ModStop</td><td>SPS</td><td>Operational mode - True: Stopping/shutting down</td><td></td><td>O</td></tr>
<tr><td>SeqSt</td><td>INS</td><td>Status of the sequencer</td><td></td><td>O</td></tr>
<tr><td>SeqPos</td><td>INS</td><td>Sequence active position or step</td><td></td><td>O</td></tr>
<tr><td>LodModBase</td><td>SPS</td><td>Load mode – True: Base load</td><td></td><td>O</td></tr>
<tr><td>LodModFol</td><td>SPS</td><td>Load mode – True: Load following</td><td></td><td>O</td></tr>
<tr><td>LodModFxExp</td><td>SPS</td><td>Load mode – True: Fixed export</td><td></td><td>O</td></tr>
<tr><td>LodModAval</td><td>SPS</td><td>Load mode – True: Available</td><td></td><td>O</td></tr>
<tr><td>DCPowStat</td><td>SPS</td><td>DC power status:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>True</td><td>Power on</td></tr><tr><td>False</td><td>Power not on</td></tr></table></td><td></td><td>O</td></tr>
<tr><td colspan="5">Measured values</td></tr>
<tr><td>FltRatePct</td><td>MV</td><td>Fault rates of DER as percent</td><td></td><td>O</td></tr>
<tr><td>SelfServWh</td><td>MV</td><td>Actual self service energy used</td><td></td><td>O</td></tr>
</table>

5.3.4 LN: DER supervisory control Name: DRCC

The DER supervisory control logical node defines the control actions for one DER unit or aggregations of one type of DER device with a single controller. See Table 15.

Table 15 – DER supervisory control, LN DRCC

DRCC class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Controls				
DeRtePct	APC	Derated load target as percent		O
OutWSet	APC	Output target power setpoint		O
OutVarSet	APC	Output target reactive power setpoint		O
ImExSet	APC	Setpoint for maintaining constant import/export energy at ECP		O
OutPFSet	APC	Setpoint for maintaining fixed power factor: negative PF is leading and positive PF is lagging		O
OutHzSet	APC	Setpoint for maintaining fixed frequency offset		O
OutVSet	APC	Voltage setpoint for maintaining fixed voltage level in percent offset		O
StrDlTms	ING	Time delay before starting		O
StopDlTms	ING	Time delay before stopping		O
MaxVarLim	APC	Derated max output reactive power		O
LodRamp	APC	Ramp load or unload rate		O
LodShutDown	APC	Load shut down: Stop/Don't stop		O
LodSharRamp	APC	Load share/Don't share		O
LodWPct	APC	Percent load power		O
DERStr	SPC	Start DER unit or sequencer		M
DERStop	SPC	Stop DER unit or sequencer		M
GnSync	SPC	Starts synchronizing generator to EPS		O
EmgStop	DPC	Remote emergency stop		O
FltAck	SPC	Acknowledge fault clearing		O
AutoManCtl	SPC	Sets operations mode to automatic or manual: Value / Explanation On / Automatic Off / Manual		M
LocRemCtl	SPC	Sets operations mode to remote or local: Value / Explanation 0 / Remote 1 / Local		M
OpModAval	SPC	Sets operational mode: is or is not available		O
OpModOff	SPC	Sets operational mode: off-line		O

DRCC class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
OpModTest	SPC	Sets operational mode: test mode		O
LodModBase	SPC	Sets “base load” load mode		O
LodModFol	SPC	Sets “load following” load mode		O
LodModFxExp	SPC	Sets “fixed export” load mode		O
LodModAval	SPC	Sets “available” for connection to load		O
DCPowStat	SPC	DC power control		O
OpTmRs	SPC	Reset operational time		O

6 Logical nodes for DER generation systems

6.1 Logical nodes for DER generation logical device

6.1.1 DER generator logical device (informative)

Each non-storage DER unit has a generator. Although each type of DER unit provides different prime movers for its generator, thus requiring different prime mover logical nodes, the general operational characteristics of these generators are the same across all DER types. Therefore, only one DER generator model is required.

The DER generator logical device describes the generator characteristics of the DER unit. These generator characteristics can vary significantly, depending upon the type of DER device.

The LNs in the DER generator logical device could include:

- DGEN: DER generator operations,
- DRAT: DER basic generator ratings,
- DRAZ: DER advanced generator features,
- DCST: Costs associated with generator operations,
- RSYN: Synchronization (see IEC 61850-7-4 with expected enhancements),
- FPID: PID regulator (see IEC 61850-7-410).

6.1.2 LN: DER unit generator Name: DGEN

The DER unit generator logical node defines the actual state of DER generator. See Table 16.

Table 16 – DER unit generator, LN (DGEN)

DGEN class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class. The following optional data may be used		M
OpTmh	INS	Operation time		M
		Other data from LLN0 may optionally be used		O

<table>
<tr><th colspan="5">DGEN class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td colspan="5">Status information</td></tr>
<tr><td>GnOpSt</td><td>ENS</td><td>Generation operational state:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Not operating</td></tr>
<tr><td>2</td><td>Operating</td></tr>
<tr><td>3</td><td>Starting up</td></tr>
<tr><td>4</td><td>Shutting down</td></tr>
<tr><td>5</td><td>At disconnect level</td></tr>
<tr><td>6</td><td>Ramping (power)</td></tr>
<tr><td>7</td><td>Ramping (reactive power)</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>M</td></tr>
<tr><td>GnSync</td><td>SPS</td><td>Generator is synchronized to EPS, or not
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>True</td><td>Synchronized</td></tr>
<tr><td>False</td><td>Not synchronized</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>ParlSt</td><td>SPS</td><td>Paralleling status:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>True</td><td>Paralleling</td></tr>
<tr><td>False</td><td>Standby</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>RampLodSw</td><td>SPS</td><td>Ramp Load/Unload Switch:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>True</td><td>Ramp load</td></tr>
<tr><td>False</td><td>Ramp unload</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>DCPowSt</td><td>SPS</td><td>DC Power On/Off Status:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>True</td><td>DC power on</td></tr>
<tr><td>False</td><td>DC power off</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>OpTmsRs</td><td>INS</td><td>Total time generator has operated – re-settable: accumulated time since the last time the counter was reset</td><td></td><td>M</td></tr>
<tr><td>GnOnCnt</td><td>INS</td><td>The number of times that the generator has been turned on: count of “generator on” times, since the last time the counter was reset</td><td></td><td>O</td></tr>
<tr><td colspan="5">Measured values</td></tr>
<tr><td>TotWh</td><td>MV</td><td>Total energy delivered</td><td></td><td>M</td></tr>
<tr><td>PerWh</td><td>MV</td><td>Energy in period since last reset</td><td></td><td>O</td></tr>
<tr><td>TotStrCnt</td><td>BCR</td><td>Count of total number of starts</td><td></td><td>O</td></tr>
<tr><td>PerStrCnt</td><td>BCR</td><td>Count of starts in period since reset</td><td></td><td>O</td></tr>
<tr><td>GnOpTm</td><td>MV</td><td>Elapsed time as the generator becomes ready after the GenOnOff command was issued
max = maximum time before issuing a start-failure alarm</td><td></td><td>O</td></tr>
<tr><td>GnStbTm</td><td>MV</td><td>Timer for stabilization time; max = maximum time before issuing a stabilization-failure alarm</td><td></td><td>O</td></tr>
<tr><td>GnCoolDnTm</td><td>MV</td><td>Timer for generator to cool down; min = minimum time for cool down</td><td></td><td>O</td></tr>
<tr><td>AVR</td><td>MV</td><td>Automatic voltage regulator percent duty cycle</td><td></td><td>O</td></tr>
</table>

DGEN class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
GnH	HMV	Generator harmonics		O
Controls				
GnCtl	DPC	Starts or stops the generator: Start = True, Stop = False		O
GnRL	DPC	Raises or lowers the generation level by steps: Raise = True, Lower = False		O
GnBlk	SPC	Set generator as blocked from being turned on		O

6.1.3 LN: DER generator ratings Name: DRAT

The following logical node defines the DER basic generator ratings. These are established as status objects since they are not expected to be remotely updated except through the use of the system configuration language or other direct intervention. See Table 17.

Table 17 – DER Basic Generator ratings, LN (DRAT)

<table>
<tr><th colspan="5">DRAT class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>LNName</td><td></td><td>Shall be inherited from logical-node class (see IEC 61850-7-2)</td><td></td><td></td></tr>
<tr><td colspan="5">Data</td></tr>
<tr><td colspan="5">System logical node data</td></tr>
<tr><td></td><td></td><td>LN shall inherit all mandatory data from common logical node class</td><td></td><td>M</td></tr>
<tr><td></td><td></td><td>Data from LLN0 may optionally be used</td><td></td><td>O</td></tr>
<tr><td colspan="5">Status</td></tr>
<tr><td>DERTyp</td><td>ENS</td><td>Type of DER generator:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Diesel/gas engine</td></tr>
<tr><td>2</td><td>Turbine engine</td></tr>
<tr><td>3</td><td>Stirling engine</td></tr>
<tr><td>4</td><td>Storage</td></tr>
<tr><td>5</td><td>PV</td></tr>
<tr><td>6</td><td>Fuel cell</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>M</td></tr>
<tr><td>ConnTyp</td><td>ENS</td><td>Type of connection: 3-phase or single phase, delta, wye
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Single phase</td></tr>
<tr><td>2</td><td>Split phase</td></tr>
<tr><td>3</td><td>2-phase</td></tr>
<tr><td>4</td><td>3-phase delta</td></tr>
<tr><td>5</td><td>3-phase wye</td></tr>
<tr><td>6</td><td>3-phase wye grounded</td></tr>
<tr><td>7</td><td>3-phase / 3-wire (inverter type)</td></tr>
<tr><td>8</td><td>3-phase / 4-wire (inverter type)</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>M</td></tr>
<tr><td>VRtg</td><td>ASG</td><td>Voltage level rating</td><td></td><td>M</td></tr>
<tr><td>ARtg</td><td>ASG</td><td>Current rating under nominal voltage under nominal power factor</td><td></td><td>O</td></tr>
</table>

DRAT class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
HzRtg	ASG	Nominal frequency		O
TmpRtg	ASG	Max temperature rating		O
FltRtgPct	ASG	Exposure to fault rates as percent		O
FltARtg	ASG	Max fault current rating		O
FltDurTms	INS	Max fault duration rating		O
MaxFltRtg	ASG	Max short circuit rating		O
VARtg	ASG	Max volt-amps rating		O
WRtg	ASG	Max watt rating		O
VarRtg	ASG	Max var rating		O
MaxLodRamp	INS	Max load ramp rate		O
MaxUnldRamp	INS	Max unload ramp rate		O
EmgRampRtg	INS	Emergency ramp rate		O
MaxWOut	ASG	Max watt output – continuous		O
EmgMaxWOut	CSG	Max watt output – emergency limits for different minutes		O
WRtg	ASG	Rated watts		O
MinWOut	ASG	Min watt output – continuous		O
EmgMinWOut	CSG	Min watt output – emergency limits for different minutes		O
MaxVarOut	ASG	Max var output		O
SeqDir	ENS	Sequence (direction): ABC or CBA Value / Explanation: 0 – ABC 1 – CBA		O
DisconnLevW	ASG	Generator disconnect level		O
RLodSetRte	INS	Raise baseload setpoint rate		O
LLodSetR	INS	Lower baseload setpoint rate		O
GndZ	CMV	Grounding impedance		O
SelfV	ASG	Self-service voltage		O
SelfW	ASG	Self-service nominal power		O
SelfPF	ASG	Self-service nominal PF		O
SelfVRng	ASG	Self-service acceptable voltage range.		O
EffRtgPct	ASG	Efficiency at rated capacity as percent		O

6.1.4 LN: DER advanced generator ratings Name: DRAZ

The following logical node defines the DER advanced generator ratings. These are established as status objects since they are not expected to be remotely updated except through the use of the system configuration language or other direct intervention. See Table 18.

Table 18 – DER advanced generator ratings, LN (DRAZ)

DRAZ class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Status information				
PFGnRtg	MV	Power factor rating generating as angle		O
PFAbsRtg	MV	Power factor rating absorbing as angle		O
SynZ	CMV	Synchronous impedance		O
TransZ	CMV	Transient impedance		O
SubTransZ	CMV	Subtransient direct axis impedance		O
SubTransQuadZ	CMV	Subtransient quadrature axis impedance		O
NegSeqZ	CMV	Negative sequence impedance		O
ZerSeqZ	CMV	Zero sequence impedance		O
OpCctDirTms	INS	Open circuit transient direct axis time constants		O
ShCctDirTms	INS	Short circuit subtransient direct axis time constants		O
OpCctQudTms	INS	Open circuit subtransient quadrature axis time constants		O
ShCctQudTms	INS	Short circuit subtransient quadrature axis time constants		O
InertTms	INS	Time for response to fault current (MW * seconds / MVA)		O
PQVLimCrv	CSG	Real power-reactive power-voltage dependency curve		O
PMaxQCrv	CSG	PQ operating region of apparent power for max Q		O
PMinQCrv	CSG	PQ operating region of apparent power for min Q		O
AlimCrv	CSG	Table 10 × 10		O
TransVLim	MV	Transient voltage limits: Volts – Surge – mostly by magnitude		O
ImbALim	MV	DER current imbalance limit		O
ImbVLim	MV	DER voltage imbalance limit		O
ThdWPct	MV	Total harmonic distortion for power as percent of fundamental power		O
ImpactHzPct	MV	Frequency impact on the DER output as percent		O
HACrvPct	HMV	Table of current harmonics dependencies on DER operations		O
HVCrvPct	HMV	Table of voltage harmonics dependencies on DER operations		O
ChgLimVPct	MV	Rapid voltage changes as percent of voltage		O
ChgLimAng	MV	Rapid angle changes as limits on degrees		O
ChgLimRatAng	MV	Rate of angle change as limits on degrees over time		O

6.1.5 LN: Generator cost Name: DCST

The generator cost logical node provides the related economic information on generator operating characteristics. In some implementations, it is expected that multiple DCST LNs will be used for different seasons or for different operational conditions. See Table 19.

Table 19 – Generator cost, LN DCST

DCST class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Status information				
HeatRteCstSt	CSG	Active curve characteristics for the incremental heat rate curve		M
Settings				
Currency	CUG	ISO 4217 currency 3-character code		O
HeatRteCst	CSG	Costs associated with each segment in an incremental heat rate curve		O
CstRamp	CSG	Cost for ramping associated with each segment		O
CstStart	ASG	Cost for starting generator		O
CstStop	ASG	Cost for stopping generator		O

6.2 Logical nodes for DER excitation logical device

6.2.1 DER excitation logical device (informative)

DER excitation comprises the components of a DER that handles the excitation systems used to start the generator. The LNs include:

- DREX: Excitation ratings,
- DEXC: Excitation operations.

6.2.2 LN: Excitation ratings Name: DREX

The following logical node defines the DER excitation ratings. These are established as status objects since they are not expected to be remotely updated except through the use of the system configuration language or other direct intervention. See Table 20.

Table 20 – Excitation ratings, LN (DREX)

DREX class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node Class		M
		Data from LLN0 may optionally be used		O
Status information				
ExtTyp	INS	Type of exciter: DC: permanent magnet or motor-generator; AC: static		M
ExtVNoLod	MV	Excitation voltage at no load		O
ExtVatPF	MV	Excitation voltage at rated PF		O

DREX class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
ExtForc	ING	Forced excitation: Yes/no		O
ExtANoLod	MV	Excitation current no load		O
ExtAatPF	MV	Excitation current at rated PF		O
ExtInertTms	INS	Excitation inertia constant		O
CtrHzHiLim	ASG	Hard high frequency control limit. This is for normal, islanded generation, as setpoint for the upper level of Hz allowed for the generator.		O
CtrHzLoLim	ASG	Hard low frequency control limit. This is for normal, islanded generation, as setpoint for the lower level of Hz allowed for the generator.		O
CtrHzHiAlm	ASG	Hard high frequency alarm limit		O
CtrHzLoAlm	ASG	Hard low frequency alarm limit		O

6.2.3 LN: Excitation Name: DEXC

The DEXC logical node provides settings and status of the excitation components of DER devices. See Table 21.

Table 21 – Excitation, LN (DEXC)

DEXC class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Status information				
GenExcit	SPS	Excitation state: <table><tr><th>Value</th><th>Explanation</th></tr><tr><td>True</td><td>Excitation on</td></tr><tr><td>False</td><td>Excitation off</td></tr></table>		M
FlshAlm	SPS	Field flashing failure – True = failure		O
PwrSupAlm	SPS	Power system failure – True = failure		O
DCAlm	SPS	DC system failure – True = failure		O
ACAlm	SPS	AC system failure – True = failure		O
UPSAlm	SPS	UPS failure – True = failure		O
BlkA	SPS	Operation blocked due to current – True = blocked		O
BlkV	SPS	Operation blocked due to voltage – True = blocked		O
MaxHiVLim	SPS	Maximum allowed voltage set-point reached – True = max		O
MaxLoVLim	SPS	Minimum allowed voltage set-point reached – True = min		O
DroopV	SPS	Voltage droop status: <table><tr><th>Value</th><th>Explanation</th></tr><tr><td>True</td><td>Droop enabled</td></tr><tr><td>False</td><td>Droop not enabled</td></tr></table>		O

DEXC class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
PowStab	SPS	Power system stabilizer present <table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>No</td></tr><tr><td>1</td><td>Yes</td></tr></table>		O
Controls				
SetV	APC	Voltage set-point		O
ExtGain	APC	Power stabilizer exciter gain setting		O
PhLeadComp	APC	Power system stabilizer phase lead compensation		O
StabSigWash	APC	Power system stabilizer signal washout		O
StabGain	APC	Power system stabilizer gain		O
ExtCeilV	APC	Forced excitation ceiling voltage		O
ExtCeilA	APC	Forced excitation ceiling amps		O
ExtVTms	INC	Forced excitation voltage time response		O
ExtVDurTms	INC	Forced excitation duration of ceiling voltage		O

6.3 Logical nodes for DER speed/frequency controller

6.3.1 Speed/frequency logical device (informative)

Some DER generators can have their speed or frequency controlled to affect their energy output. The LNs for the speed or frequency logical device could include:

- DSFC: Speed or frequency controller.

6.3.2 LN: Speed/Frequency controller Name: DSFC

The DSFC logical node defines the characteristics of the speed or frequency controller. See Table 22.

Table 22 – Speed/frequency controller, LN (DSFC)

DSFC class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Status information				
HzActSt	SPS	Frequency (speed) droop status: Disabled; enabled <table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Disabled (fixed frequency)</td></tr><tr><td>1</td><td>Enabled</td></tr></table>		O
Settings				
Droop	ASG	Power droop in energy per frequency		M
RefHz	ASG	Reference frequency		M

DSFC class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
RegBndOvHz	ASG	Regulation band for over-frequency (frequency deviation at which the control response is 100 percent activated)		M
RegDbOvHz	ASG	Deadband for over-frequency (frequency deviation where no control action is taken)		M
PwrRsvOvHz	ASG	Power reserved for over-frequency for frequency control		O
RegBndUnHz	ASG	Regulation band for under-frequency (frequency deviation at which the control response is 100 percent activated)		M
RegDbUnHz	ASG	Deadband for under-frequency (frequency deviation where no control action is taken)		M
PwrRsvUnHz	ASG	Power reserved for under-frequency for frequency control		O
Controls				
HzAct	SPC	Frequency control activate (1=activate, 0=deactivate)		O
Measured values				
HzPwr	MV	Power currently activated for frequency control		O

6.4 Logical nodes for DER inverter/converter logical device

6.4.1 Inverter/converter logical device (informative)

The diagram in Figure 7 provides a generalized schematic of an inverter / converter.

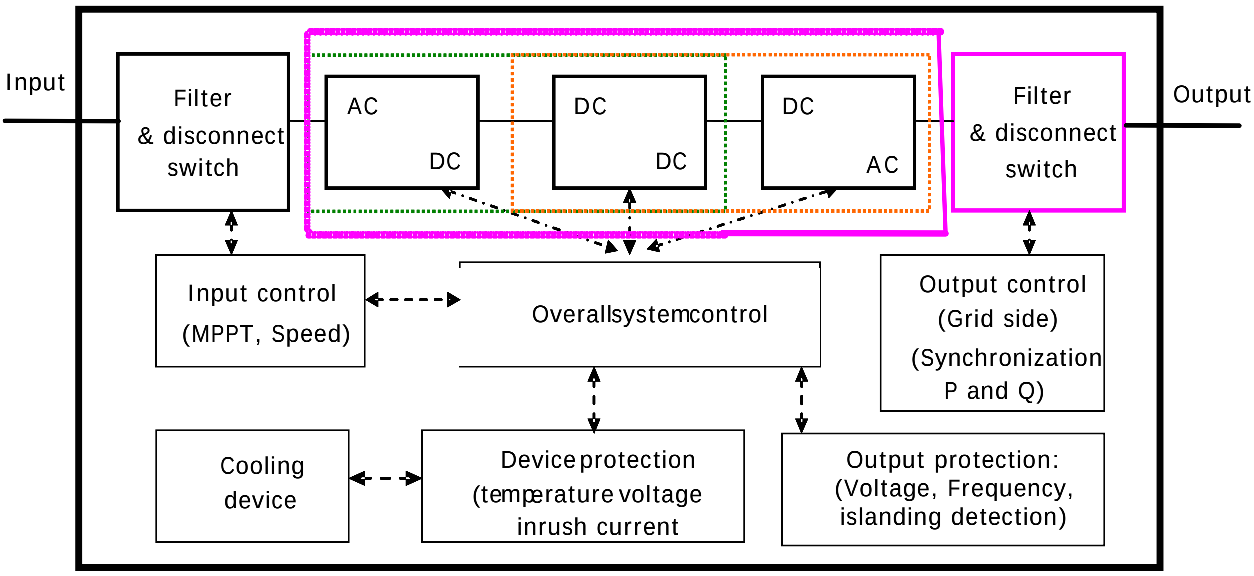


Figure 7 – Inverter / converter configuration

Some DER generators require rectifiers, inverters, and other types of converters to change their electrical output into end-user AC. The LNs for the inverter/converter logical device could include:

- ZRCT: Rectifier for converting alternating current to continuous, direct current (AC -> DC),
- ZINV: Inverter for converting direct current to alternating current (DC -> AC),
- DRAT: Inverter nameplate data,
- MMDC: Measurement of intermediate DC (see IEC 61850-7-4),
- MMXU: Measurements of input AC (see IEC 61850-7-4),

- MMXU: Measurements of output AC (see IEC 61850-7-4),
- CCGR: Cooling group control for cooling fans (see IEC 61850-7-4).

6.4.2 LN: Rectifier Name: ZRCT

The ZRCT logical node defines the characteristics of the rectifier, which converts generator output AC to intermediate DC. See Table 23.

Table 23 – Rectifier, LN (ZRCT)

<table>
<tr><th colspan="5">ZRCT class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>LNName</td><td></td><td>Shall be inherited from logical-node class (see IEC 61850-7-2)</td><td></td><td></td></tr>
<tr><td colspan="5">Data</td></tr>
<tr><td colspan="5">System logical node data</td></tr>
<tr><td></td><td></td><td>LN shall inherit all mandatory data from common logical node class</td><td></td><td>M</td></tr>
<tr><td></td><td></td><td>Data from LLN0 may optionally be used</td><td></td><td>O</td></tr>
<tr><td>CmutTyp</td><td>ENG</td><td>Type of commutation:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Line commutated</td></tr><tr><td>1</td><td>Self commutated</td></tr></table></td><td></td><td>M</td></tr>
<tr><td>IsoTyp</td><td>ENG</td><td>Type of isolation:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Power frequency transformer isolated</td></tr><tr><td>2</td><td>Hi frequency transformer isolated</td></tr><tr><td>3</td><td>Non-isolated, grounded</td></tr><tr><td>4</td><td>Non-isolated, isolated DC source</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>M</td></tr>
<tr><td>VRegTyp</td><td>ENG</td><td>Type of voltage regulation:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Regulated output: fixed voltage</td></tr><tr><td>2</td><td>Regulated output: variable voltage</td></tr><tr><td>3</td><td>Filtered output: load dependent</td></tr><tr><td>4</td><td>Unregulated and unfiltered</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>M</td></tr>
<tr><td>ConvTyp</td><td>ENG</td><td>Conversion type:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>AC to DC</td></tr><tr><td>2</td><td>AC to AC to DC</td></tr><tr><td>3</td><td>AC to DC to DC</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>O</td></tr>
</table>

<table>
<tr><th colspan="5">ZRCT class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>CoolTyp</td><td>ENG</td><td>Type of cooling method:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Passive air cooling (heatsink)</td></tr><tr><td>2</td><td>Forced air cooling (fan + heatsink)</td></tr><tr><td>3</td><td>Fluid cooling (water)</td></tr><tr><td>4</td><td>Heat pipe</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>O</td></tr>
<tr><td colspan="5">Status information</td></tr>
<tr><td>ACTyp</td><td>ENG</td><td>AC system type:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>1</td><td>Single phase</td></tr><tr><td>2</td><td>Two phase</td></tr><tr><td>3</td><td>Three phase</td></tr></table></td><td></td><td>M</td></tr>
<tr><td>OutFilTyp</td><td>ENG</td><td>Output filter type:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>None</td></tr><tr><td>2</td><td>Series filter (L)</td></tr><tr><td>3</td><td>Parallel filter (LC)</td></tr><tr><td>4</td><td>Series-Parallel (LCL)</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>O</td></tr>
<tr><td>InWavTyp</td><td>ENG</td><td>Input waveform conditioning type:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>None</td></tr><tr><td>2</td><td>EMI filter</td></tr><tr><td>3</td><td>Line filter</td></tr><tr><td>4</td><td>EMI/Line filter</td></tr><tr><td>5</td><td>Unified power factor</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>O</td></tr>
<tr><td colspan="5">Settings</td></tr>
<tr><td>OutWSet</td><td>ASG</td><td>Output power setpoint</td><td></td><td>O</td></tr>
<tr><td>InALim</td><td>ASG</td><td>Input current limit</td><td></td><td>O</td></tr>
<tr><td>OutVSet</td><td>ASG</td><td>Output voltage setpoint</td><td></td><td>O</td></tr>
<tr><td>OutALim</td><td>ASG</td><td>Output current limit</td><td></td><td>O</td></tr>
<tr><td>InVLim</td><td>ASG</td><td>Input voltage limit</td><td></td><td>O</td></tr>
</table>

6.4.3 LN: Inverter Name: ZINV

The ZINV logical node defines the characteristics of the inverter, which converts DC to AC. The DC may be the output of the generator or may be the intermediate energy form after a generator's AC output has been rectified. See Table 24.

Table 24 – Inverter, LN (ZINV)

<table>
<tr><th colspan="5">ZINV class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>LNName</td><td></td><td>Shall be inherited from logical-node class (see IEC 61850-7-2)</td><td></td><td></td></tr>
<tr><td colspan="5">Data</td></tr>
<tr><td colspan="5">System logical node data</td></tr>
<tr><td></td><td></td><td>LN shall inherit all mandatory data from common logical node class</td><td></td><td>M</td></tr>
<tr><td></td><td></td><td>Data from LLN0 may optionally be used</td><td></td><td>O</td></tr>
<tr><td>WRtg</td><td>ASG</td><td>Maximum power rating</td><td></td><td>M</td></tr>
<tr><td>VarRtg</td><td>ASG</td><td>Maximum var rating: var</td><td></td><td>O</td></tr>
<tr><td>SwTyp</td><td>ENG</td><td>Switch type:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Field effect transistor</td></tr>
<tr><td>2</td><td>Insulated gate bipolar transistor</td></tr>
<tr><td>3</td><td>Thyristor</td></tr>
<tr><td>4</td><td>Gate turn off thyristor</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>CoolTyp</td><td>ENG</td><td>Type of cooling method:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Passive air cooling (heatsink)</td></tr>
<tr><td>2</td><td>Forced air cooling (fan + heatsink)</td></tr>
<tr><td>3</td><td>Fluid cooling (water)</td></tr>
<tr><td>4</td><td>Heat pipe</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>PQVLim</td><td>CSG</td><td>P-Q-V set of limiting curves</td><td></td><td>O</td></tr>
<tr><td colspan="5">Status information</td></tr>
<tr><td>GridModSt</td><td>ENS</td><td>Current connect mode:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Disconnected</td></tr>
<tr><td>2</td><td>Power not delivered</td></tr>
<tr><td>3</td><td>Power delivered</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>Stdby</td><td>SPS</td><td>Inverter stand-by status – True: stand-by active</td><td></td><td>O</td></tr>
<tr><td>CurLev</td><td>SPS</td><td>DC current level available for operation – True: sufficient current</td><td></td><td>O</td></tr>
<tr><td>CmutTyp</td><td>ENG</td><td>Type of commutation:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Line commutated</td></tr>
<tr><td>1</td><td>Self commutated</td></tr>
</table></td><td></td><td>O</td></tr>
</table>

<table>
<tr><th colspan="5">ZINV class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>IsoTyp</td><td>ENG</td><td>Type of isolation:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Low frequency transformer isolated</td></tr>
<tr><td>2</td><td>Hi frequency transformer isolated</td></tr>
<tr><td>3</td><td>Non-isolated, grounded</td></tr>
<tr><td>4</td><td>Non-isolated, isolated DC source</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>SwHz</td><td>ASG</td><td>Nominal frequency of switching</td><td></td><td>O</td></tr>
<tr><td>GridMod</td><td>ENG</td><td>Power system connect modes to the power grid:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Current-source inverter (CSI)</td></tr>
<tr><td>2</td><td>Voltage-controlled voltage-source inverter (VC-VSI)</td></tr>
<tr><td>3</td><td>Current-controlled voltage-source inverter (CC-VSI)</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td colspan="5">Settings</td></tr>
<tr><td>ACTyp</td><td>ENG</td><td>AC System Type:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>1</td><td>Single phase</td></tr>
<tr><td>2</td><td>Two phase</td></tr>
<tr><td>3</td><td>Three phase</td></tr>
</table></td><td></td><td>M</td></tr>
<tr><td>PQVLimSet</td><td>CSG</td><td>Active curve characteristic curve for PQV limit</td><td></td><td>M</td></tr>
<tr><td>OutWSet</td><td>ASG</td><td>Output power setpoint</td><td></td><td>M</td></tr>
<tr><td>OutVarSet</td><td>ASG</td><td>Output reactive power setpoint</td><td></td><td>O</td></tr>
<tr><td>OutPFSet</td><td>ASG</td><td>Power factor setpoint as angle</td><td></td><td>O</td></tr>
<tr><td>OutHzSet</td><td>ASG</td><td>Frequency setpoint</td><td></td><td>O</td></tr>
<tr><td>InALim</td><td>ASG</td><td>Input current limit</td><td></td><td>O</td></tr>
<tr><td>InVLim</td><td>ASG</td><td>Input voltage limit</td><td></td><td>O</td></tr>
<tr><td>PhACnfg</td><td>ENG</td><td>Inverter phase A feed configuration:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Feeding from N to A</td></tr>
<tr><td>2</td><td>Feeding from N to B</td></tr>
<tr><td>3</td><td>Feeding from N to C</td></tr>
<tr><td>4</td><td>Feeding from A to B</td></tr>
<tr><td>5</td><td>Feeding from A to C</td></tr>
<tr><td>6</td><td>Feeding from B to A</td></tr>
<tr><td>7</td><td>Feeding from B to C</td></tr>
<tr><td>8</td><td>Feeding from C to A</td></tr>
<tr><td>9</td><td>Feeding from C to B</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>PhBCnfg</td><td>ENG</td><td>Inverter Phase B feed configuration: see PhACnfg for enumerated values</td><td></td><td>O</td></tr>
<tr><td>PhCCnfg</td><td>ENG</td><td>Inverter Phase C feed configuration: see PhACnfg for enumerated values</td><td></td><td>O</td></tr>
</table>

ZINV class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
Measured values				
HeatSinkTmp	MV	Heat sink temperature: Alarm if over max		O
EnclTmp	MV	Enclosure temperature		O
AmbAirTemp	MV	Ambient outside air temperature		O
FanSpdVal	MV	Measured fan speed: Tach or vane		O

7 Logical nodes for specific types of DER

7.1 Logical nodes for reciprocating engine logical device

7.1.1 Reciprocating engine description (informative)

A reciprocating engine is an engine that utilizes one or more pressure-driven pistons in order to convert back-and-forth motion into a rotating motion. The most common form of reciprocating engine used to generate electricity is the diesel engine, which is used in combination with an electric generator to form a diesel generator.

Small portable diesel generators range from about 1 kVA to 10 kVA, usually designed for backup home use. Larger commercial generators can range from 8 kVA to 30 kVA for home-offices, small shops and individual offices, while industrial generators up to 2 000 kVA can be used for large office complexes, factories, and power stations.

Diesel generators can be used as off-grid sources of electricity or as emergency power-supplies if the grid fails. The larger commercial and industrial generators may also be used to sell excess energy or other ancillary services back to utility grids.

7.1.2 Reciprocating engine logical device (informative)

The LNs in this subclause cover the information models for the reciprocating engine energy converter. See Figure 8. Figure 9 illustrates some of the LNs that could be included in a diesel generation system.

Figure 8 – Example of a reciprocating engine system (e.g. Diesel Gen-Set)

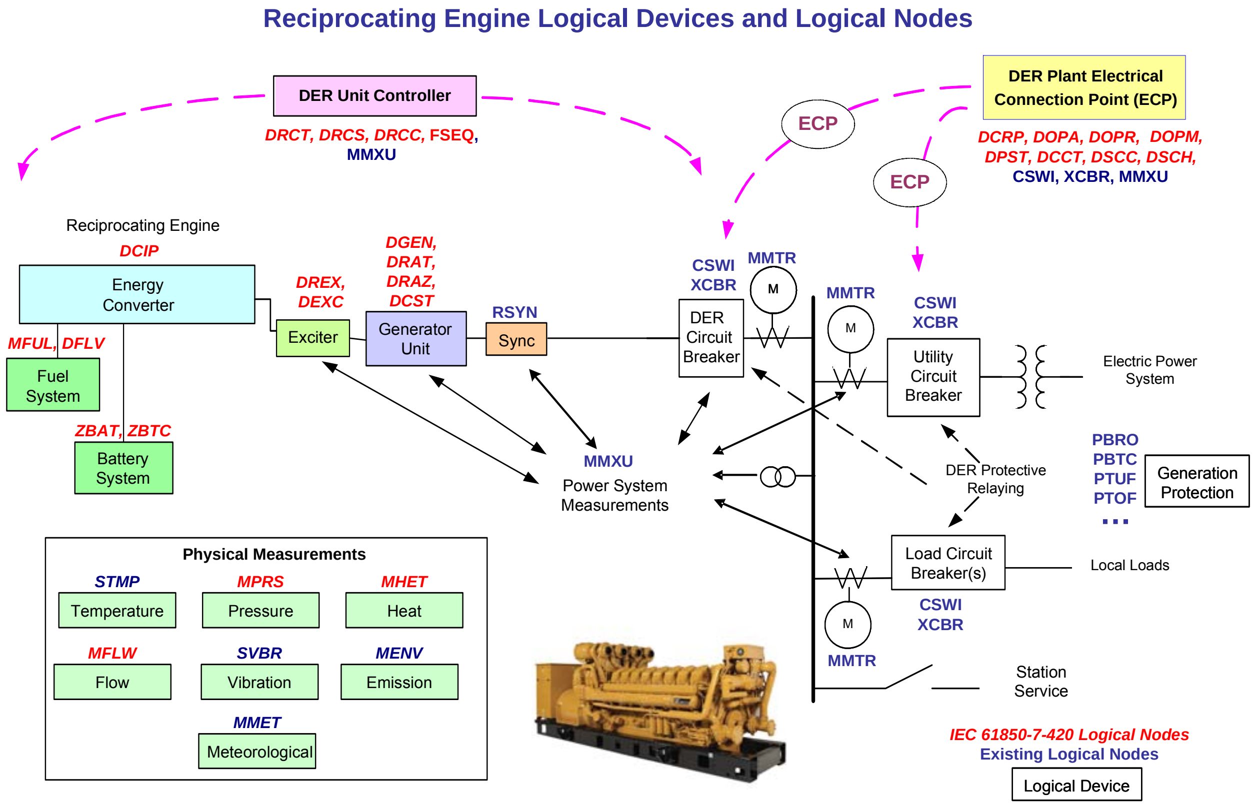


Figure 9 – Example of LNs in a reciprocating engine system

In addition to the LNs needed for the DER management (see Clause 5) and the DER generator (see Clause 6), the LNs in the reciprocating engine logical device could include:

- DCIP: Reciprocating engine characteristics, measured values, and controls (see 7.1.3),
- MFUL: Fuel characteristics (see 0),
- DFLV: Fuel delivery system (see 8.1.3),
- ZBAT: Auxiliary battery (see 8.2.2),
- ZBTC: Auxiliary battery charger (see 8.2.3),
- STMP: Temperature characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, lubrication (oil), after-cooler, etc. (see 8.5.2),
- MPRS: Pressure characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (see 8.5.3),
- MFLW: Flow characteristics, including coolant, lubrication, etc. (see 8.5.5),
- SVBR: Vibration characteristics (see 8.5.6),
- MENV: Emissions characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (see 8.5.7).

7.1.3 LN: Reciprocating engine Name: DCIP

The reciprocating engine characteristics covered in the DCIP logical node reflect those required for remote monitoring and control of reciprocating engine functions and states. See Table 25.

Table 25 – Reciprocating engine, LN (DCIP)

<table>
<tr><th colspan="5">DCIP class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>LNName</td><td></td><td>Shall be inherited from logical-node class (see IEC 61850-7-2)</td><td></td><td></td></tr>
<tr><td colspan="5">Data</td></tr>
<tr><td colspan="5">System logical node data</td></tr>
<tr><td></td><td></td><td>LN shall inherit all mandatory data from common logical node class</td><td></td><td>M</td></tr>
<tr><td></td><td></td><td>Data from LLN0 may optionally be used</td><td></td><td>O</td></tr>
<tr><td colspan="5">Status information</td></tr>
<tr><td>EngOnOff</td><td>SPS</td><td>Engine status:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>True</td><td>On</td></tr><tr><td>False</td><td>Off</td></tr></table></td><td></td><td>M</td></tr>
<tr><td colspan="5">Settings</td></tr>
<tr><td>MinSpd</td><td>ASG</td><td>Minimum speed</td><td></td><td>O</td></tr>
<tr><td>MaxSpd</td><td>ASG</td><td>Maximum speed</td><td></td><td>O</td></tr>
<tr><td>HeatRteCrv</td><td>CSG</td><td>Heat rate curves</td><td></td><td>O</td></tr>
<tr><td colspan="5">Controls</td></tr>
<tr><td>TrgSpd</td><td>APC</td><td>Final target engine speed</td><td></td><td>O</td></tr>
<tr><td>EngTrqSet</td><td>APC</td><td>Desired engine torque</td><td></td><td>O</td></tr>
<tr><td>EngCtl</td><td>DPC</td><td>Start / stop engine</td><td></td><td>O</td></tr>
<tr><td>CrankCtl</td><td>DPC</td><td>On / Off crank relay driver command</td><td></td><td>O</td></tr>
<tr><td>EmgCtl</td><td>DPC</td><td>Emergency start / stop diesel engine</td><td></td><td>O</td></tr>
<tr><td>DiagEna</td><td>DPC</td><td>Diagnostic mode enable</td><td></td><td>O</td></tr>
<tr><td colspan="5">Measured values</td></tr>
<tr><td>EngRPM</td><td>MV</td><td>Engine speed</td><td></td><td>O</td></tr>
<tr><td>EngTrq</td><td>MV</td><td>Engine torque</td><td></td><td>O</td></tr>
<tr><td>EngTmDeg</td><td>MV</td><td>Engine timing as degrees BTDC (before top dead centre)</td><td></td><td>O</td></tr>
<tr><td>BlowFlow</td><td>MV</td><td>Blowby flow</td><td></td><td>O</td></tr>
</table>

7.2 Logical nodes for fuel cell logical device

7.2.1 Fuel cell description (informative)

A fuel cell is an electrochemical energy conversion device. It produces electricity from external supplies of fuel (on the anode side) and oxidant (on the cathode side). These react in the presence of an electrolyte. Generally, the reactants flow in and reaction products flow out while the electrolyte remains in the cell. Fuel cells can operate virtually continuously as long as the necessary flows are maintained. Over 20 different types of fuel cells have been developed. A diagram of a generic proton exchange membrane (PEM) fuel cell is shown in Figure 10.

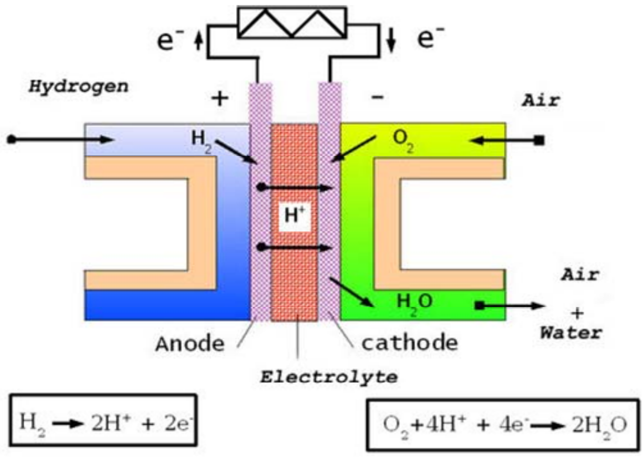


Figure 10 – Fuel cell – Hydrogen/oxygen proton-exchange membrane fuel cell (PEM)

A typical fuel cell produces about 0,8 V. To create enough voltage for the many applications requiring higher voltage levels, the cells are layered and combined in series and parallel into a “fuel cell stack” (see Figure 11). The number of cells used is usually greater than 45 and varies with design. The theoretical voltage of a fuel cell is 1,23 V, at a temperature of 25 °C. This voltage depends on the fuel used, quality and temperature of the cell.

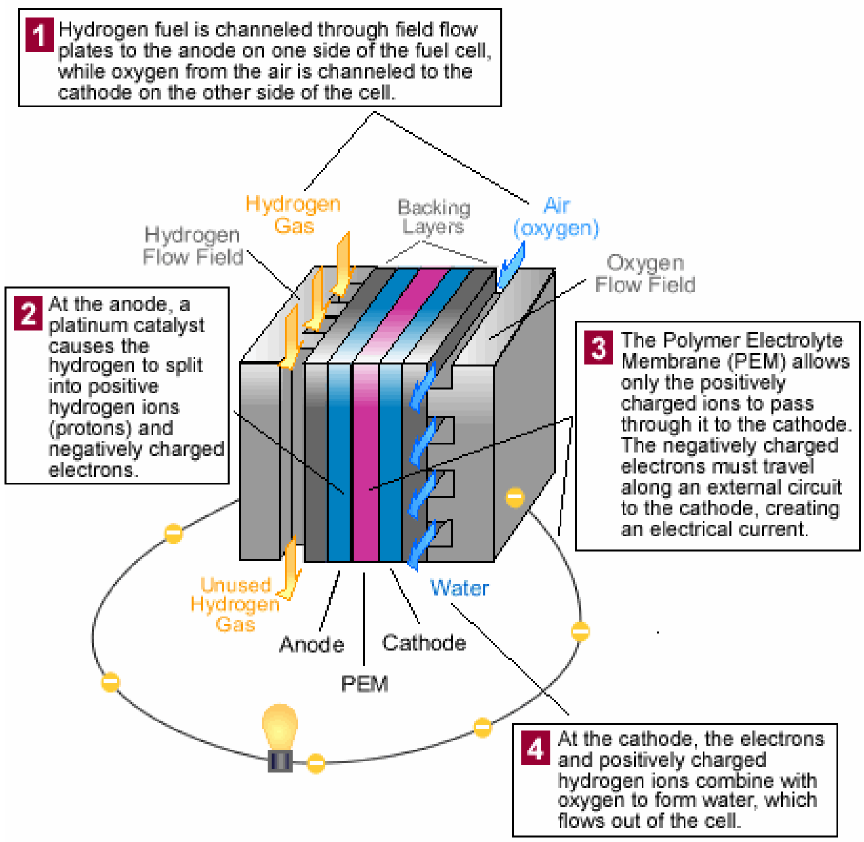


Figure 11 – PEM fuel cell operation

7.2.2 Fuel cell logical device (informative)

The LNs in this subclause describe the information models for the fuel cell as a prime mover. Figure 12 illustrates the LNs used in a fuel cell system.

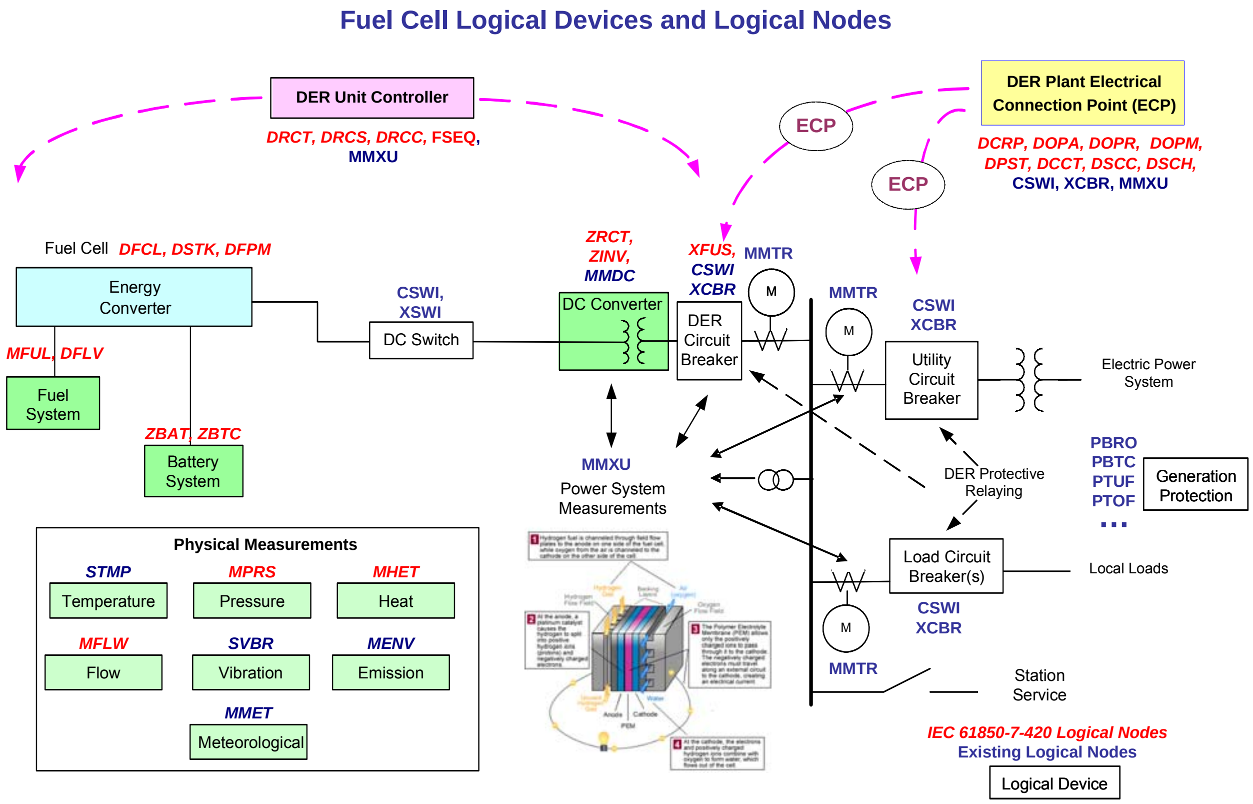


Figure 12 – Example of LNs used in a fuel cell system

In addition to the LNs needed for the DER management (see Clause 5) and the DER generator (see Clause 6), the fuel cell logical device could include the following LNs:

- DFCL: Fuel cell controller characteristics (see 7.2.3). These are the fuel cell specific characteristics which are not in DRCT,
- DSTK: Fuel cell stack (see 7.2.4),
- DFPM: Fuel processing module (see 7.2.5),
- CSWI: Switch between fuel cell and inverter (see IEC 61850-7-4),
- ZRCT: Rectifier (see 6.4.2),
- ZINV: Inverter (see 6.4.3),
- MMXU: Output electrical measurements (see IEC 61850-7-4),
- MMDC: Measurement of intermediate DC (see IEC 61850-7-4),
- MFUL: Fuel characteristics (see 0),
- DFLV: Fuel delivery system (see 8.1.3),
- MFLW: Flow characteristics, including air, oxygen, water, hydrogen, and/or other gasses or liquids used for fuel and for the fuel cell processes (see 8.5.5),
- ZBAT: Auxiliary battery (see 8.2.2),
- ZBTC: Auxiliary battery charger (see 8.2.3),
- STMP: Temperature characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, lubrication (oil), after-cooler, etc. (see 8.5.2),
- MPRS: Pressure characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (see 8.5.3),
- SVBR: Vibration characteristics (see 8.5.6),

- MENV: Emissions characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (see 8.5.7).

7.2.3 LN: Fuel cell controller Name: DFCL

The fuel cell characteristics covered in the DFCL logical node reflect those required for remote monitoring of critical functions and states of the fuel cell itself. See Table 26.

Table 26 – Fuel Cell controller, LN (DFCL)

DFCL class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Status information				
StrCnt	INS	Count of system starts since last reset		M
ConnGriCnt	INS	Count of reconnections to power system		
OpTms	INS	Lifetime system run time		M
LifeEfcPct	INS	Efficiency estimate (lifetime) as percent		M
InstEfcPct	INS	Instantaneous efficiency estimate as percent		O
MaintTms	INS	Time until next maintenance: seconds		O
Settings				
GriIndWRtg	ASG	System power system independent output power rating		O
GriDepRtg	ASG	System power system dependent output power rating		O
VRtg	ASG	System output voltage rating		O
HzRtg	ASG	System output frequency rating		O
FuelTyp	ENG	System input fuel type (see # in Table 36)		O
FuelCsmpRte	ASG	System maximum fuel consumption rate		O
EfcPct	ASG	System average efficiency as percent		O
Alim	ASG	Input current limit		M
Vlim	ASG	Input voltage limit		O
Controls				
FuelShut	DPC	Open / Close fuel valve driver command		M
EmgCtl	DPC	Start / Stop emergency stop fuel cell		O
Measured values				
LifeWh	MV	Lifetime system run energy		M
FuelCsmp	MV	Input fuel consumption (lifetime)		O
WtrCsmp	MV	Input water consumption (lifetime)		O
InOxFlwRte	MV	Input air or oxygen flow rate		O
WtrLev	MV	Water level remaining		O
OutHydRte	MV	Output hydrogen flow rate		O
OutHydLev	MV	Output hydrogen level		O
WtrCndv	MV	Water conductivity		O

7.2.4 LN: Fuel cell stack Name: DSTK

Fuel cells are stacked together to provide the desired voltage level. The characteristics of a fuel cell stack that are included in the DSTK logical node are those required for remote monitoring of the fuel cell stack. See Table 27.

Table 27 – Fuel cell stack, LN (DSTK)

DSTK class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Status information				
StkSt	SPS	Stack state: Value – Explanation True – On False – Off		M
CellVTrCnt	INS	Count of cell low voltage trips		O
StkLodTms	INS	Accumulated stack load time		O
MaintTms	INS	Time until next maintenance		O
Settings				
StkWRtg	ASG	Stack power rating		O
StkVRtg	ASG	Stack voltage rating		O
StkARtg	ASG	Stack current rating		O
StkFuelTyp	ASG	Stack input fuel type		O
CellCnt	ING	Count of cells in stack		O
Measured values				
StkWh	MV	Accumulated stack energy		O
StkEfcPct	MV	Instantaneous stack efficiency		O
OutDCV	MV	Stack voltage in DC volts		O
OutDCA	MV	Stack direct current		O
InCoolTmp	MV	Stack inlet coolant temperature		O
OutCoolTmp	MV	Stack outlet coolant temperature		O
CoolFlwRte	MV	Coolant flow rate		O
CoolPres	MV	Coolant inlet pressure		O
HydFlwRte	MV	Hydrogen (or reformate) flow rate		O
InHydPres	MV	Inlet hydrogen pressure		O
InOxFlwRte	MV	Input air or oxygen flow rate		O
InOxPres	MV	Inlet oxidant pressure		O

7.2.5 LN: Fuel processing module Name: DFPM

The fuel processing module of the fuel cell is used to extract hydrogen from other types of fuels. The hydrogen can then be used in the fuel cell to make electricity. This LN can be combined with one or two MFUL LNs for a complete picture of fuel processing. The data included in the DFPM logical node are those required for remote monitoring of the fuel processing module. See Table 28.

Table 28 – Fuel cell processing module, LN (DFPM)

<table>
<tr><th colspan="5">DFPM class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>LNName</td><td></td><td>Shall be inherited from logical-node class (see IEC 61850-7-2)</td><td></td><td></td></tr>
<tr><td colspan="5">Data</td></tr>
<tr><td colspan="5">System logical node data</td></tr>
<tr><td></td><td></td><td>LN shall inherit all mandatory data from common logical node class</td><td></td><td>M</td></tr>
<tr><td></td><td></td><td>Data from LLN0 may optionally be used</td><td></td><td>O</td></tr>
<tr><td>ProcTyp</td><td>ENG</td><td>FPM processing type:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Steam reforming</td></tr>
<tr><td>2</td><td>Partial oxidation</td></tr>
<tr><td>3</td><td>Autothermal reforming</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>ThmRtg</td><td>ASG</td><td>FPM output power rating (thermal)</td><td></td><td>M</td></tr>
<tr><td colspan="5">Status information</td></tr>
<tr><td>FPMSt</td><td>SPS</td><td>FPM state:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>True</td><td>On</td></tr>
<tr><td>False</td><td>Off</td></tr>
</table></td><td></td><td>M</td></tr>
<tr><td colspan="5">Settings</td></tr>
<tr><td>InFuelTyp</td><td>ENG</td><td>FPM input fuel type
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Hydrogen plus pure oxygen</td></tr>
<tr><td>2</td><td>Hydrogen</td></tr>
<tr><td>3</td><td>Methanol</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td>OutFuelTyp</td><td>ENG</td><td>FPM output fuel type: e.g. Hydrogen, Reformate
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Hydrogen</td></tr>
<tr><td>2</td><td>Reformate</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>O</td></tr>
<tr><td colspan="5">Measured values</td></tr>
<tr><td>InAccWh</td><td>MV</td><td>Accumulated input energy</td><td></td><td>O</td></tr>
<tr><td>OutAccWh</td><td>MV</td><td>Accumulated output energy</td><td></td><td>O</td></tr>
<tr><td>ConvEfc</td><td>MV</td><td>Conversion efficiency</td><td></td><td>O</td></tr>
</table>

7.3 Logical nodes for photovoltaic system (PV) logical device

7.3.1 Photovoltaic system description (informative)

A photovoltaic power system, commonly referred to as a PV system, directly converts solar energy into electricity. This process does not use heat to generate electricity and therefore no turbine or generator is involved. In fact, a PV module has no moving part.

PV systems are modular – the building blocks (modules) come in a wide range of power capabilities. These modules can be connected in various configurations to build power systems capable of providing several megawatts of power. However, most installed PV systems are much smaller. One categorization, which can impact how many characteristics and status items need to be monitored and which LNs are needed, is as follows:

- small PV system (up to 10 kW) – monitor totals such as power, voltage, current, ambient temperature, and irradiation on panels;
- medium PV system (10 kW to 200 kW) – monitor some individual values;
- large PV system (above 200 kW) – monitor individual PV strings and ancillary equipment such as fuses.

The basic unit of photovoltaic conversion is a semiconductor device called the solar cell. Many individual solar cells can be interconnected into a PV module. A PV module is the smallest complete environmentally protected assembly of interconnected solar cells; this standard will use this term “module” to describe the equipment for which individual ratings are provided.[3)]

These PV modules are interconnected using combinations of parallel and series connections to form a PV array. The components of a typical PV array are structured as illustrated in Figure 13: first several PV modules are connected in series to form PV strings, and then several PV strings are combined together in parallel using combiners (or junction boxes (JB)) to construct PV arrays. In a large system, PV arrays are often divided into groups of individually controlled sub-arrays composed of series-connected PV modules and parallel-connected PV strings as shown in Figure 14.

A single PV array is considered to be a single DC power supply unit. Two or more PV array assemblies which are not interconnected in parallel on the generation side of the power conditioning unit are considered as independent PV arrays.

Since the power system requires AC power for interconnected generation, a power conditioning unit (PCU) or inverter is required to transform the DC output of the PV array into AC. Inverters used in PV systems have the added task of adjusting the current and voltage levels (DC) to maximize efficiency during changing solar irradiance and temperature conditions, both of which affect the output power. The optimal combination for a PV module is defined by a point called the *maximum power point* (MPP) on the I-V curve.

Figure 13 illustrates the main building blocks for a small interconnected PV system. In this example, two PV sub-arrays, each of which composed of several series PV modules and parallel strings, are connected to a single grid-tie inverter.

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3) Commonly one or more PV modules can be packaged as a solar panel, which is typically a rectangular glass-covered pre-assembled plate that is ready for installation. Conversely, some PV installations consist of multiple panels which are treated as one module. Therefore, to avoid confusion, the term “panel” is not used in this standard.

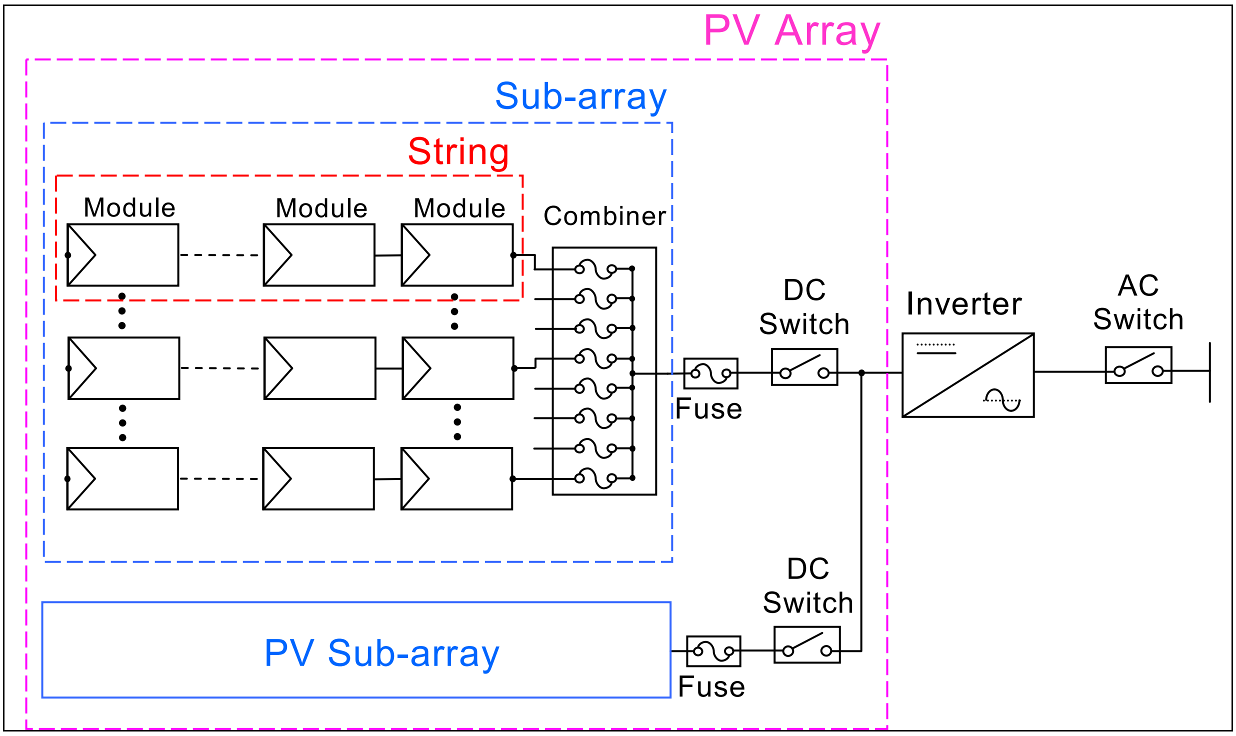


Figure 13 – Example: One line diagram of an interconnected PV system

For larger, more complex PV installations, the PV system can consist of several arrays which are connected to separate inverters. Figure 14 provides an illustration of such a PV system composed of two arrays, each of which consists of twelve sub-arrays. The sub-arrays in turn are constructed from 10 strings in parallel with 12 modules per string.

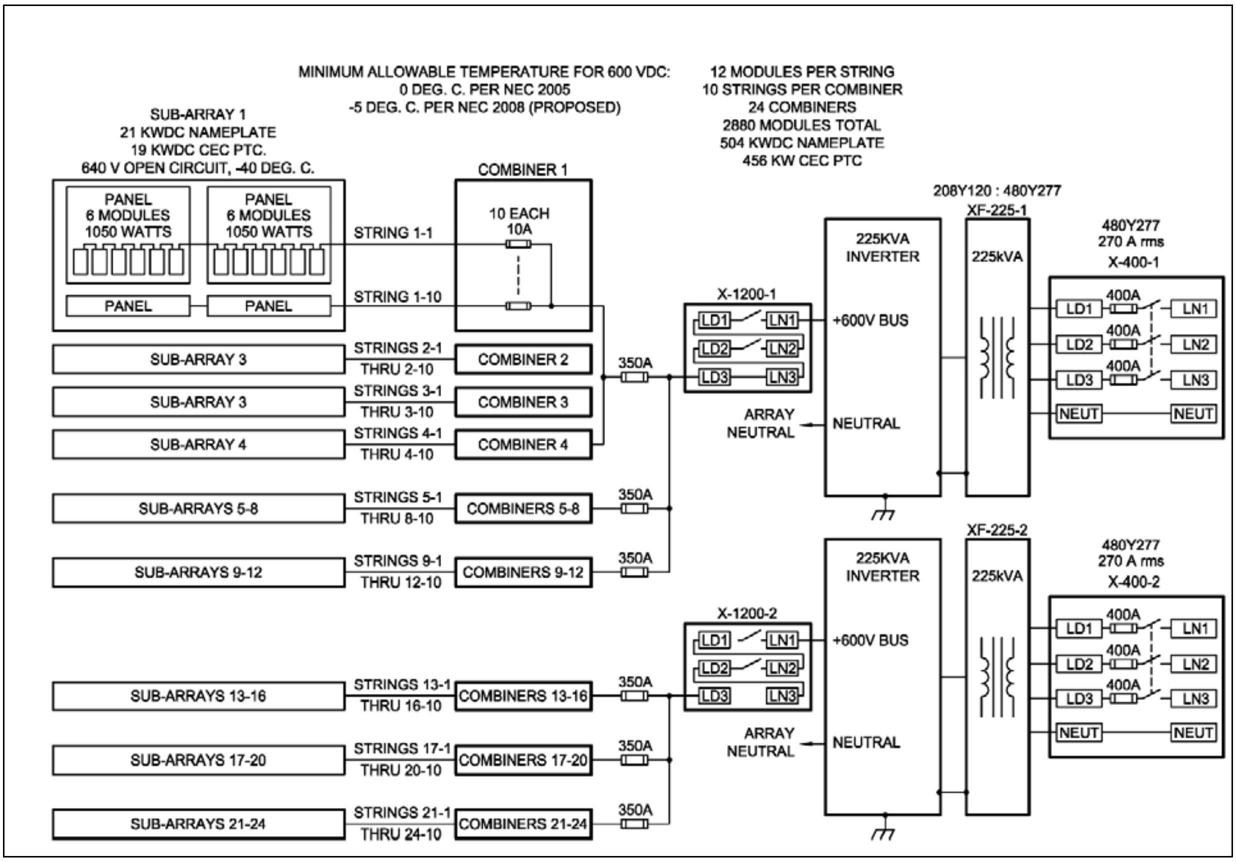


Figure 14 – Schematic diagram of a large PV installation with two arrays of several sub-arrays

PV power systems can be standalone (not connected to the power system), hybrid (combined with another energy source), or interconnected (connected with the power system). The photovoltaic system covered by this standard is assumed to be interconnected with the power system. Therefore, there is no obligation to provide additional energy storage (e.g. battery system), although this may be included.

7.3.2 Photovoltaics system logical device (informative)

The LNs in this subclause describe the information models for the photovoltaics system as a prime source of electric energy. Figure 15 illustrates these logical nodes associated with one configuration of a photovoltaics system, although actual implementations may vary, depending upon the system requirements.

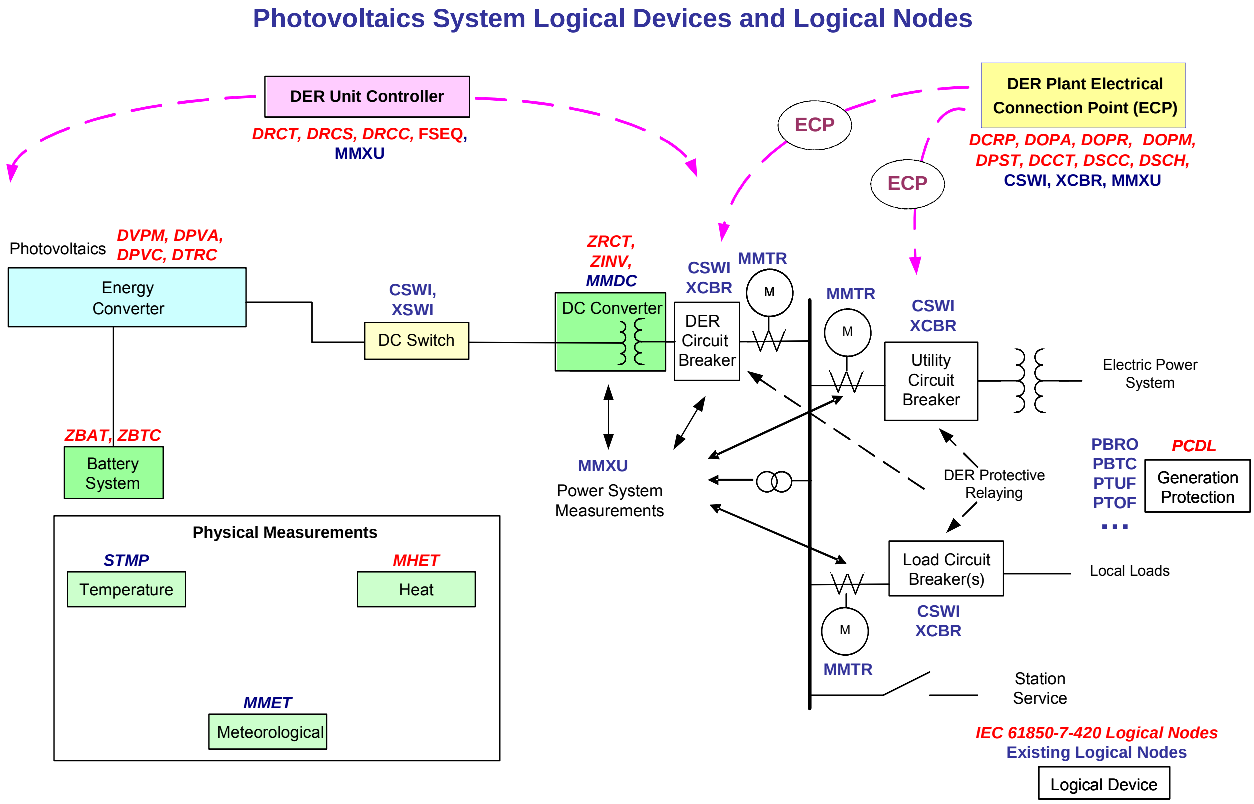


Figure 15 – Example of LNs associated with a photovoltaics system

Building logical devices to automate the operation of a PV system would require the following functions.

- Switchgear operation: functions for the control and monitoring of breakers and disconnect devices. This is already covered in IEC 61850-7-4 (XCBR, XSWI, CSWI, etc).
- Protection: functions required to protect the electrical equipment and personnel in case of a malfunction. Already covered in IEC 61850-7-4 (PTOC, PTOV, PTTR, PHIZ, etc). A PV specific protection is "DC ground fault protection function" that is required in many PV systems to reduce fire hazard and provide electric shock protection. This function is covered by the PHIZ logical node and described in IEC 61850-7-4.
- Measuring and metering: functions required to obtain electrical measurements like voltage and current. AC measurements are covered in MMXU, while DC measurements are covered as MMDC, both in IEC 61850-7-4.
- DC to AC conversion: functions for the control and monitoring of the inverter. These are covered in this standard (ZRCT, ZINV).
- Array operation: functions to maximize the power output of the array. These include adjustment of current and voltage level to obtain the MPP and also the operation of a tracking system to follow the sun movement. Specific to PV and covered in this standard (DPVC, DTRC).
- Islanding: functions required to synchronize the PV system operation with the power system. This includes anti-islanding requirements specified in the interconnection standards. These are covered in this standard as DRCT (see 5.3.2) and DOPR (see 5.2.3). RSYN is covered in IEC 61850-7-4.
- Energy storage: functions required to store excess energy produced by the system. Energy storage in small PV systems is usually done with batteries, while larger PV systems may include compressed air or other mechanisms. The batteries for energy storage are covered in this standard as ZBAT (see 8.2.2) and ZBTC (see 8.2.3). Compressed air has not yet been modelled.

- Meteorological monitoring: functions required to obtain meteorological measurement like solar irradiation and ambient temperature. These are covered in MMET and STMP.

In addition to the LNs needed for the DER management (see Clause 5), the photovoltaics system logical device could include the following logical nodes:

- DPVM: PV Module ratings. Provides the ratings for a module (see 7.3.3),
- DPVA: PV Array characteristics. Provide general information on a PV array or sub-array (see 7.3.4),
- DPVC: PV Array controller. Used to maximize the power output of the array. One instantiation of this LN per array (or sub-array) in the PV system (see 7.3.5),
- DTRC: Tracking controller. Used to follow the sun movement (see 7.3.6),
- CSWI: Describes the controller for operation of the various switches in the PV system (see IEC 61850-7-4). CSWI is always used in conjunction with XSWI or XCBR which identifies whether it is DC or AC,
- XSWI: Describes the DC switch between the PV system and the inverter; also the AC switch that provides physical interconnection point of the inverter to the power system (see IEC 61850-7-4),
- XCBR: Describes breakers used in the protection of the PV array (see IEC 61850-7-4),
- ZINV: Inverter (see 6.4.3),
- MMDC: Measurement of intermediate DC (see IEC 61850-7-4),
- MMXU: Electrical measurements (see IEC 61850-7-4),
- ZBAT: Battery if needed for energy storage (see 8.2.2),
- ZBTC: Battery charger if needed for energy storage (see 8.2.3),
- XFUS: Fuses in the PV systems (see 8.3.1),
- FSEQ: Sequencer status if used in startup or shutdown automated sequences (see 8.4.2),
- STMP: Temperature characteristics (see 8.5.2),
- MMET: Meteorological measurements (see 8.5.8).

7.3.3 LN: Photovoltaics module ratings Name: DPVM

The photovoltaics module ratings covered in the DPVM logical node describes the photovoltaic characteristics of a module. See Table 29.

Table 29 – Photovoltaic module characteristics, LN (DPVM)

DPVM class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
AVCrv	INS	Index into active point of the AV curve		O
Settings				

DPVM class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
MdulCfgTyp	ENG	PV module configuration type: Value / Explanation: 0 – Unknown / Not applicable 1 – Flat plate 2 – Concentrating 99 – Other		O
MdulAVCrv	CSG	Amp-Volt curve of module at STC[4)]		O
MdulWRtg	ASG	Module rated power at W peak STC		O
MdulW200Rtg	ASG	Module rated power as W peak at 200 W/m^2		O
MaxMdulV	ASG	Module voltage at max power at STC		O
MaxMdulA	ASG	Module current at max power at STC		O
MdulOpnCctV	ASG	Module open circuit voltage (Voc at STC)		O
MdulSrtCctA	ASG	Module short circuit current (Isc at STC)		O
MdulWTmpDrt	ASG	Module power/temperature derate as percent of degrees above 25 °C		O
MdulATmpDrt	ASG	Module current/temperature derate as percent of degrees above 25 °C		O
MdulVTmpDrt	ASG	Module voltage/temperature derate as voltage/degrees above 25 °C		O
MdulAgeDrtPct	ASG	Module age derate as percent over time		O

7.3.4 LN: Photovoltaics array characteristics Name: DPVA

The photovoltaics array characteristics covered in the DPVA logical node describe the configuration of the PV array. The logical node may be used to provide configuration information on the number of strings and panels or the number of sub-arrays in parallel. (Note that if the strings are individually controlled, the array characteristic is the same as string. In other word, a string becomes an array by itself). See Table 30.

Table 30 – Photovoltaic array characteristics, LN (DPVA)

DPVA class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O

4) STC: Standard test conditions – see Bibliography.

DPVA class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
Settings				
Typ	ENG	Assembly type: Value / Explanation 0 – Not applicable / Unknown 1 – Array 2 – Sub-array 3 – String 4 – Module 5 – Plant 99 – Other		M
GrndConn	ENG	Type of ground connection: Value / Explanation 0 – Not applicable / Unknown 1 – Positive ground 2 – Negative ground 3 – Not grounded 99 – Other		O
MdulCnt	ING	Number of modules per string		O
StrgCnt	ING	Number of parallel strings per sub-array		O
SubArrCnt	ING	Number of parallel sub-arrays per array		O
ArrArea	ASG	Array area		O
ArrWRtg	ASG	Array power rating (W peak – W p)		O
Tilt	ASG	Assembly fixed tilt – degrees from horizontal (may be seasonally adjusted)		O
Azi	ASG	Assembly azimuth – degrees from true north		O

7.3.5 LN: Photovoltaics array controller Name: DPVC

The photovoltaics array controller covered in the DPVC logical node reflects the information required for remote monitoring of critical photovoltaic functions and states. If the strings are individually controlled, one DPVC per string would be required to describe the controls. This logical node also provides list of the possible control modes that can be applied by the array controller. The control mode may change during the operation. The present status is then given by the array control status attribute. See Table 31.

Table 31 – Photovoltaic array controller, LN (DPVC)

DPVC class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
CtrModSt	INS	Array control mode status		O
Settings				

DPVC class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
TrkRefV	ASG	Peak power tracker reference voltage		O
TrkWupV	ASG	Power tracker wake-up voltage		O
TrkDlWupTms	ING	Time delay for PV wake-up		O
TrkDlSlpTms	ING	Time delay for PV sleep test		O
TrkSlpW	ASG	PV power point to begin sleep test timer		O
TrkRte	ING	Power tracker update rate		O
TrkVStp	ASG	Voltage perturbation step of power tracker		O
Controls				
ArrModCtr	ENC	Mode selected to control the power output of the array: Value | Explanation 0 | Not applicable / Unknown 1 | Maximum power point tracking (MPPT) 2 | Power limiter controller 3 | DC current limit 4 | Array voltage control 99 | Other		O

7.3.6 LN: Tracking controller Name: DTRC

The tracking controller provides overall information on the tracking system to external users. This LN can still be used for defining array or device orientations even if no active tracking is included. See Table 32.

Table 32 – Tracking controller, LN (DTRC)

DTRC class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
TrkTyp	ENG	Tracking type: Value | Explanation 0 | Not applicable / Unknown 1 | Fixed, no tracking 2 | Single axis – vertical axis of rotation 3 | Single axis – inclined axis of rotation (north-south) 4 | Single axis – horizontal axis of rotation (north-south) 5 | Dual axis – horizontal and vertical axis of rotation 6 | Dual axis – two dependent horizontal axes of rotation – main axis north-south 7 | Dual axis – two dependent horizontal axes of rotation – main axis east-west 99 | Other		M

<table>
<tr><th colspan="5">DTRC class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td colspan="5">Status information</td></tr>
<tr><td>TrkAlm</td><td>SPS</td><td>Tracking alarm – True: alarm condition</td><td></td><td>O</td></tr>
<tr><td>TrkSt</td><td>ENS</td><td>Tracking status
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Unknown</td></tr>
<tr><td>1</td><td>Stopped</td></tr>
<tr><td>2</td><td>Automatic tracking in progress</td></tr>
<tr><td>3</td><td>Reference run in progress</td></tr>
<tr><td>4</td><td>Reference run completed</td></tr>
<tr><td>5</td><td>Manual mode</td></tr>
<tr><td>6</td><td>Going to position</td></tr>
<tr><td>7</td><td>In target position</td></tr>
<tr><td>8</td><td>In stow position</td></tr>
<tr><td>9</td><td>In storm position</td></tr>
<tr><td>10</td><td>In snow position</td></tr>
<tr><td>11</td><td>In night position</td></tr>
<tr><td>12</td><td>In maintenance position</td></tr>
</table></td><td>T</td><td>O</td></tr>
<tr><td colspan="5">Settings</td></tr>
<tr><td>TrkTech</td><td>ENG</td><td>Tracking technology:
<table>
<tr><th>Value</th><th>Explanation</th></tr>
<tr><td>0</td><td>Not applicable / Unknown</td></tr>
<tr><td>1</td><td>Sensory tracking</td></tr>
<tr><td>2</td><td>Astronomical tracking</td></tr>
<tr><td>99</td><td>Other</td></tr>
</table></td><td></td><td>M</td></tr>
<tr><td>StowAziDeg</td><td>ASG</td><td>Stow azimuth degrees from true north toward east positive</td><td></td><td>O</td></tr>
<tr><td>StowElDeg</td><td>ASG</td><td>Stow elevation from horizontal</td><td></td><td>O</td></tr>
<tr><td>StormAziDeg</td><td>ASG</td><td>Storm azimuth degrees from true north toward east positive</td><td></td><td>O</td></tr>
<tr><td>StormElDeg</td><td>ASG</td><td>Storm elevation from horizontal</td><td></td><td>O</td></tr>
<tr><td>SnwAziDeg</td><td>ASG</td><td>Snow azimuth degrees from true north toward east positive</td><td></td><td>O</td></tr>
<tr><td>SnwElDeg</td><td>ASG</td><td>Snow elevation from horizontal</td><td></td><td>O</td></tr>
<tr><td>NightAziDeg</td><td>ASG</td><td>Night azimuth degrees from true north toward east positive</td><td></td><td>O</td></tr>
<tr><td>NightElDeg</td><td>ASG</td><td>Night elevation from horizontal</td><td></td><td>O</td></tr>
<tr><td>MaintAziDeg</td><td>ASG</td><td>Maintenance azimuth degrees from true north toward east positive</td><td></td><td>O</td></tr>
<tr><td>MaintElDeg</td><td>ASG</td><td>Maintenance elevation from horizontal</td><td></td><td>O</td></tr>
<tr><td>IntvAzi</td><td>ASG</td><td>Azimuth interval, for sensory tracking. Tracking, if absolute difference between actual tracker position and sun position is a higher interval value.</td><td></td><td>O</td></tr>
<tr><td>IntvEl</td><td>ASG</td><td>Elevation interval, for sensory tracking. Tracking, if absolute difference between actual tracker position and sun position is a higher interval value.</td><td></td><td>O</td></tr>
<tr><td>IntvTm</td><td>ASG</td><td>Time interval, for astronomical tracking. After this time interval tracking operation is done periodically.</td><td></td><td>O</td></tr>
<tr><td colspan="5">Controls</td></tr>
<tr><td>AziDeg</td><td>APC</td><td>Target azimuth degrees from true north toward east positive</td><td></td><td>M</td></tr>
<tr><td>ElDeg</td><td>APC</td><td>Target elevation from horizontal</td><td></td><td>M</td></tr>
</table>

DTRC class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
TrkCtl	ENC	Tracking command Value / Explanation 1 Stop 2 Start tracking 3 Start reference run 4 Go to manual mode 5 Go to stow position 6 Go to storm position 7 Go to snow position 8 Go to night position 9 Go to maintenance position		M
Measured values				
AziDeg	MV	Device azimuth degrees from true north		O
ElDeg	MV	Device elevation degrees from horizontal		O

7.4 Logical nodes for combined heat and power (CHP) logical device

7.4.1 Combined heat and power description (informative)

Combined heat and power (CHP) covers multiple types of generation systems involving heat in the production of electricity. Different CHP purposes include the following.

- Heat as primary, electricity as secondary. An industrial process may generate heat or buildings may be heated with steam. The excess heat from these processes may then be used to generate electricity, often via steam or gas turbines. Rather than using energy to cool the heated medium (typically water or other fluid), the heat is used to run a turbine (e.g. steam turbine) which in turn connects to a generator to produce electrical energy.
- Electricity as primary, heat as secondary. Conventional power plants emit the heat created as a byproduct of electricity generation into the environment through cooling towers, as flue gas, or by other means. CHP captures the excess heat for domestic or industrial heating purposes, either very close to the plant, or – especially in eastern Europe – distributed through steam pipes to heat local housing ("district heating"). This steam can also be used for large air-conditioner units through turning a steam turbine connected to a compressor, which is chilling water sent to the air handler units in a different building.
- Byproduct fuel is available (e.g. produced by landfill or biomass) which can then be burned to generate electricity and/or heat.

There are many variations on these themes (different types of electric generators, different sources of heat, different ownership of equipment, market interactions with respect to heat and energy, constraints on heat or electrical production, etc.). Figure 16 illustrates two configurations.

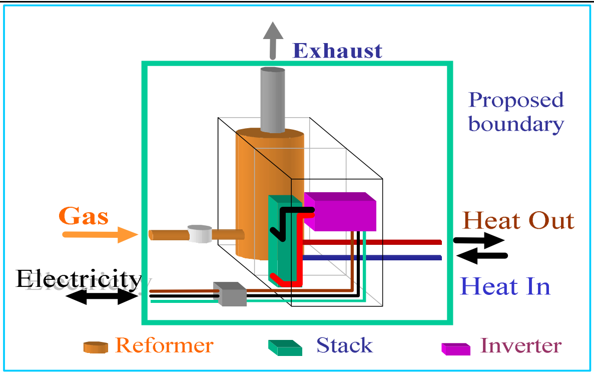


Figure 16a – CHP based on fuel cells

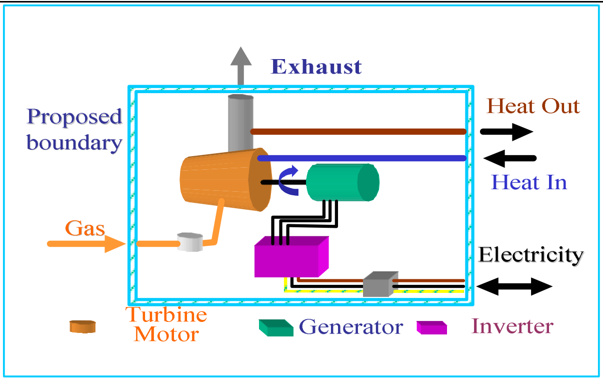


Figure 16b – CHP based on internal combustion units

Figure 16 – Two examples of CHP configurations

The difficulties in defining a generic CHP model come from, among other reasons:

- the large variety of different types, purposes, and operational characteristics of CHP systems,
- the heterogeneous maturity of CHP systems.

Due to the variety of current thermal facility schemes and prime movers used in CHP configurations, it is not possible to develop a unique model of a CHP system. Therefore, rather than attempting to model the complete CHP systems themselves, a more profitable approach is to model individual parts of CHP systems, which can then be used like building blocks to construct a variety of configurations for different types of CHP systems. Information models of each of these different parts can then be created.

Figure 17, Figure 18 and Figure 19 below show three simple thermal facility scheme examples.

- In Figure 17, heated water/steam from the heating system is used directly for the electricity generation system.
- In Figure 18 and Figure 19, the return water from the domestic heating system is used to generate electricity. In one case, pre-heating storage may be needed if the return temperature from the additional boiler and building is too cool for the CHP. Alternately, the return temperature from the heating system may be too high for the CHP unit; therefore, the CHP unit may need to cool this returning water first.
- In Figure 19, hybrid storage may also be used: instead of using two different tanks, the same tank with two heat exchangers may be used. Hybridizing with electric water heating may also add flexibility to the heating facility.

These examples only show some of the many variations. Many other different CHP system architectures may be implemented.

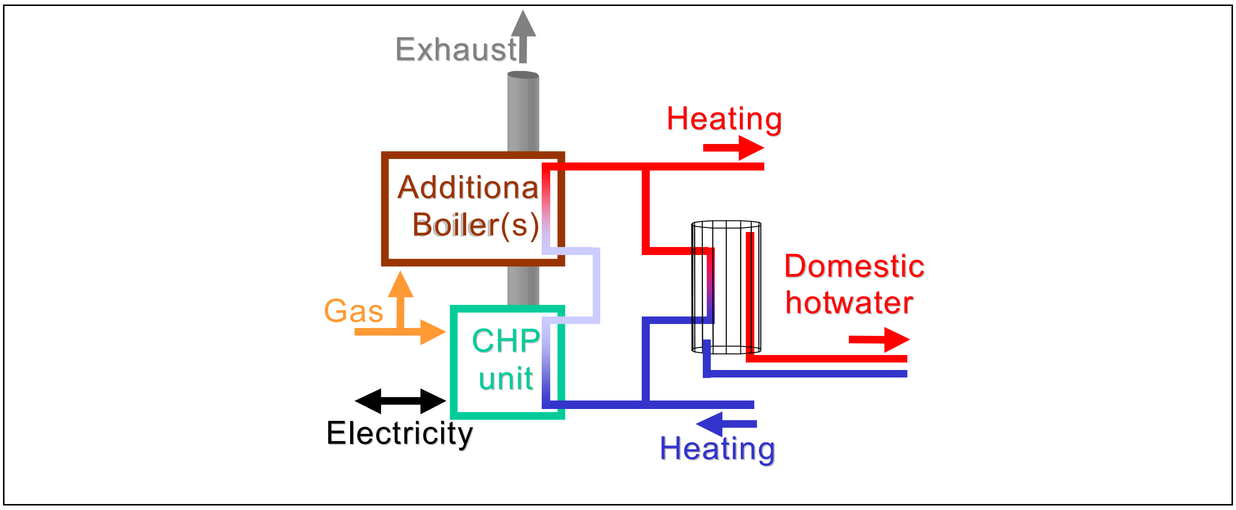
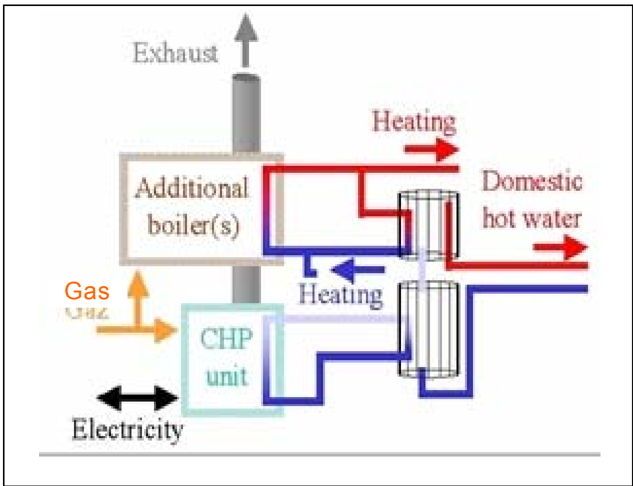


Figure 17 – CHP unit includes both domestic hot water and heating loops



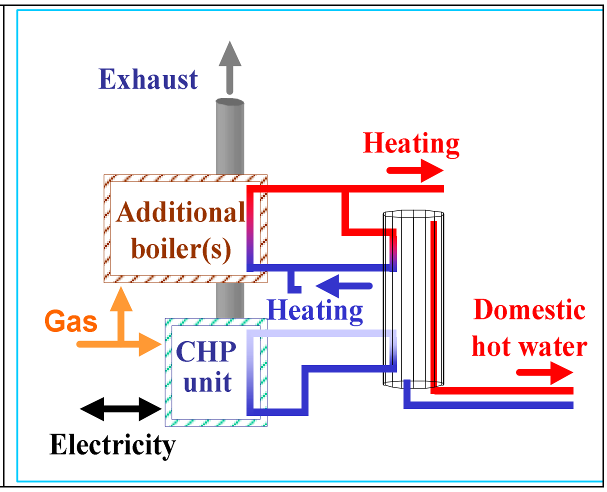


Figure 18 – CHP unit includes domestic hot water with hybrid storage

Figure 19 – CHP unit includes domestic hot water without hybrid storage

In addition to different configurations, CHP systems rely on different prime movers (e.g. gas turbines, fuel cells, microturbines, and diesel engines). Some of these combinations are in different phases of development (from prototypes to commercial off-the-shelf products). Therefore, determining which combined technologies will be used over time will be difficult to determine.

These facts lead again to the conclusion that each part of a CHP system should be separately modelled, with these parts put together as needed by the implementers of different CHP systems. For this reason, many of the different electricity generation LNs could be used in a CHP system, most of which already exist for other DER systems. The LNs that may be unique to CHP are those which handle the heat aspects as well as the “combined” aspects of CHP:

- heat production and boiler systems,
- heat exchange systems,
- chimney and exhaust systems,
- cooling systems,
- combined operations management.

7.4.2 Combined heat and power logical device (informative)

The LNs in this subclause address the non-generator aspects of the CHP system, since the generator types are addressed independently of their use in a CHP system (see reciprocating engines, steam turbines, gas turbines, microturbines[5]), etc.).

Figure 20 illustrates the CHP logical nodes.

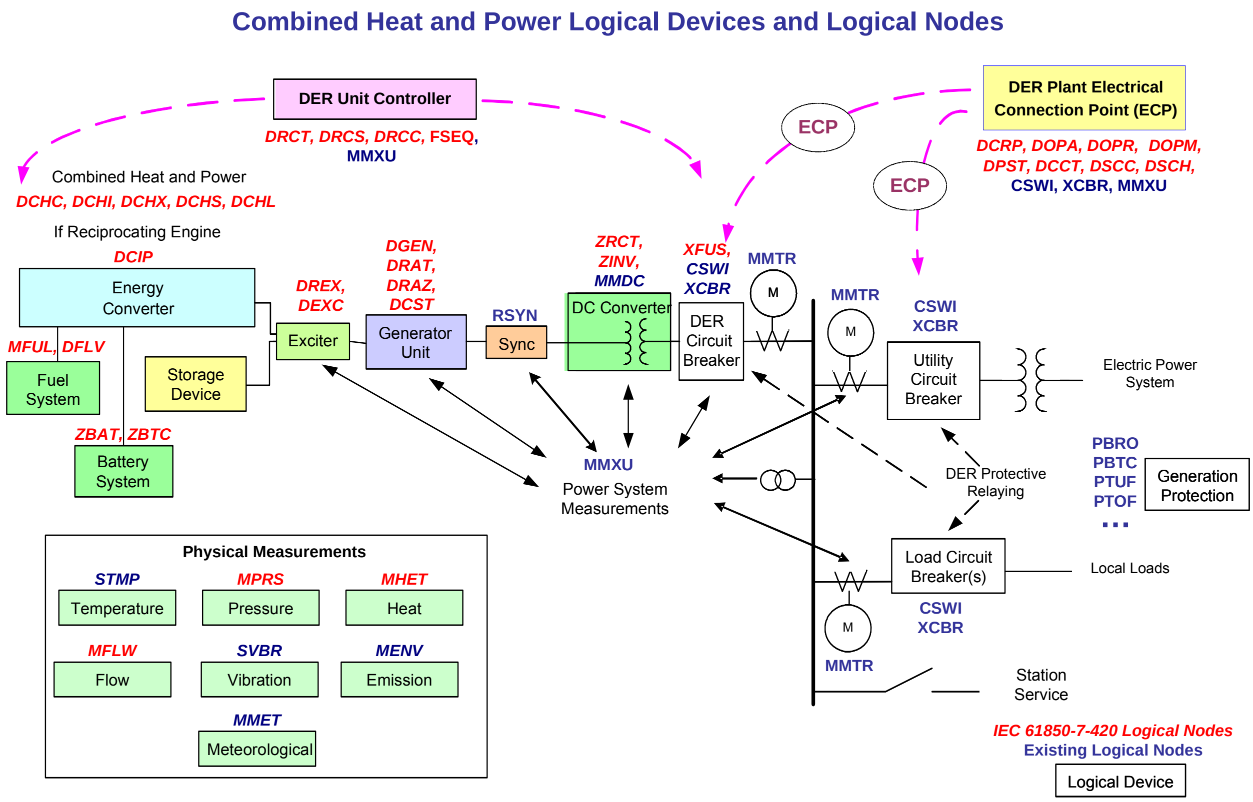


Figure 20 – Example of LNs associated with a combined heat and power (CHP) system

In addition to the LNs needed for the DER management (see Clause 5) and the DER generator (see Clause 6) and the DER prime movers (see other DER equipment in Clause 7), the LNs which could be used within a CHP logical device include:

- DCHC: CHP controller of overall CHP system, covering information not contained in the DER unit controller logical device (see 7.4.3),
- DCTS: CHP thermal storage (see 7.4.4),
- CCGR: Coolant system (see IEC 61850-7-4),
- MMXU: Electrical measurements (see IEC 61850-7-4),
- XSWI: Electrical switch (see IEC 61850-7-4),
- STMP: Temperature characteristics (see 8.5.2),
- MPRS: Pressure measurements (see 8.5.3),
- MHET: Heat and cooling measurements (see 8.5.4),
- MFLW: Flow measurements (see 8.5.5),
- SVBR: Vibration measurements (see 8.5.6),

5) IEC 61850 information models for steam turbines, gas turbines, and microturbines have not yet been developed.

- MENV: Emission measurements (see 8.5.7),
- MMET: Meteorological measurement (see 8.5.8).

7.4.3 LN: CHP system controller Name: DCHC

The CHP system controller provides overall information from the CHP system to external users, including identification of the types of equipment within the CHP system, usage issues, and constraints affecting the overall CHP system, and other parameters associated with the CHP system as a whole. See Table 33.

Table 33 – CHP system controller, LN (DCHC)

<table>
<tr><th colspan="5">DCHC class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>LNName</td><td></td><td>Shall be inherited from logical-node class (see IEC 61850-7-2)</td><td></td><td></td></tr>
<tr><td colspan="5">Data</td></tr>
<tr><td colspan="5">System logical node data</td></tr>
<tr><td></td><td></td><td>LN shall inherit all mandatory data from common logical node class</td><td></td><td>M</td></tr>
<tr><td></td><td></td><td>The data from LLN0 may optionally be used</td><td></td><td>O</td></tr>
<tr><td colspan="5">Settings</td></tr>
<tr><td>HeatTyp</td><td>ENG</td><td>Type of heating medium:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Water</td></tr><tr><td>2</td><td>Steam</td></tr><tr><td>3</td><td>Air</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>M</td></tr>
<tr><td>CoolTyp</td><td>ENG</td><td>Type of cooling medium<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Water</td></tr><tr><td>2</td><td>Steam</td></tr><tr><td>3</td><td>Air</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>O</td></tr>
<tr><td>EngyConvTyp</td><td>ENG</td><td>Type of energy converter<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Gas turbine</td></tr><tr><td>2</td><td>Fuel cell</td></tr><tr><td>3</td><td>Reciprocating engine</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>M</td></tr>
<tr><td>GnTyp</td><td>ENG</td><td>Type of generator:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Rotating</td></tr><tr><td>2</td><td>Inverter</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>O</td></tr>
<tr><td>FuelTyp</td><td>ENG</td><td>Type of fuel (see # in Table 36)</td><td></td><td>O</td></tr>
<tr><td>MaxHeatCap</td><td>ASG</td><td>Maximum heat capacity</td><td></td><td>O</td></tr>
</table>

DCHC class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
CHPOpMod	ENG	Operating modes of CHP: <table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>Heat-production driven</td></tr><tr><td>2</td><td>Electrical generation driven</td></tr><tr><td>3</td><td>Combined heat and generation driven</td></tr><tr><td>99</td><td>Other</td></tr></table>		O
Measured values				
HeatPwrEfc	MV	Heat to power efficiency		O

7.4.4 LN: Thermal storage Name: DCTS

This logical node describes the characteristics of the CHP thermal storage. This LN applies both to heat storage and to coolant storage, and is used for measurements of heat exchanges. See Table 34.

Table 34 – CHP thermal storage, LN (DCTS)

DCTS class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Settings				
ThrmStoTyp	ENG	Type of thermal energy storage <table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>For heating with storage</td></tr><tr><td>2</td><td>For heating without storage</td></tr><tr><td>3</td><td>For cooling with storage</td></tr><tr><td>4</td><td>For cooling without storage</td></tr><tr><td>99</td><td>Other</td></tr></table>		M
ThrmOutEst	SCR	Estimated instantaneous thermal energy output over time (using time offsets)		O
Measured values				
ThrmCapTot	MV	Total available thermal energy capacity		O
ThrmCapPct	MV	Remaining actual thermal energy capacity as percent of total available capacity		O
ThrmIn	MV	Instantaneous thermal energy input into storage		O
ThrmOut	MV	Instantaneous thermal energy output from storage		O
ThrmLos	MV	Thermal energy lost or dumped		O

7.4.5 LN: Boiler Name: DCHB

This logical node describes the characteristics of the CHP boiler system. See Table 35.

Table 35 – CHP Boiler System, LN (DCHB)

DCHB class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
BoilTyp	ENG	Type of boiler: Value – Explanation 0 – Not applicable / Unknown 1 – Regular boiler 2 – Condensing boiler 99 – Other		M
Status information				
BoilRdy	SPS	Boiler ready for operation: True = ready		M
BoilDnReg	SPS	Boiler down regulating warning		O
Control				
BoilCtl	DPC	Boiler start and stop: True = Start; False = Stop		M
Measured values				
BoilWh	MV	Energy being consumed by boiler		O

8 Logical nodes for auxiliary systems

8.1 Logical nodes for fuel system logical device

8.1.1 Fuel system logical device (informative)

The fuel system logical device describes the characteristics of the system of fuel for different prime movers.

The LNs could include:

- MFUL: fuel characteristics,
- DFLV: delivery system for the fuel, including the rail system, pump, and valves,
- STMP,
- MFLW,
- MPRS,
- KTNK: fuel tank characteristics (IEC 61850-7-410).

Table 36 shows the different types of fuel[6]:

[6] EIA – Energy Information Administration, official energy statistics from the US government.

Table 36– Fuel types

Type of energy source	Energy source code	Unit label	AER (Aggr'd) fuel code	#	Energy source description
Fossil and nuclear fuels					
Coal and syncoal	BIT	kg	COL	0	Anthracite coal and bituminous coal
	LIG	kg	COL	1	Lignite coal
	SUB	kg	COL	2	Sub-bituminous coal
	WC	kg	WOC	3	Waste/other coal (includes anthracite culm, bituminous gob, fine coal, lignite waste, waste coal)
	SC	kg	COL	4	Coal-based synfuel, including briquettes, pellets, or extrusions, which are formed by binding materials or processes that recycle materials
Petroleum products	DFO	m^3	DFO	5	Distillate fuel oil (diesel, No. 1, No. 2, and No. 4 fuel oils)
	JF	m^3	WOO	6	Jet fuel
	KER	m^3	WOO	7	Kerosene
	PC	kg	PC	8	Petroleum coke
	RFO	m^3	RFO	9	Residual fuel oil (No. 5, No. 6 fuel oils, and bunker C fuel oil)
	WO	m^3	WOO	10	Waste/other oil (including crude oil, liquid butane, liquid propane, oil waste, re-refined motor oil, sludge oil, tar oil, or other petroleum-based liquid wastes)
Natural gas and other gases	NG	m^3	NG	11	Natural gas
	BFG	m^3	OOG	12	Blast furnace gas
	OG	m^3	OOG	13	Other gas
	PG	m^3	OOG	14	Gaseous propane
Nuclear	NUC	N/A	NUC	15	Nuclear fission (uranium, plutonium, thorium)
Renewable Fuels					
Solid renewable fuels (biomass)	AB	kg	ORW	16	Agricultural crop byproducts/straw/energy crops
	MSW	kg	MLG	17	Municipal solid waste
	OBS	kg	ORW	18	Other biomass solids
	TDF	kg	ORW	19	Tire-derived fuels
	WDS	kg	WWW	20	Wood/wood waste solids (paper pellets, railroad ties, utility poles, wood chips, bark, an other wood waste solids)
Liquid renewable (biomass)	OBL	m^3	ORW	21	Other biomass liquids (specify in comments)
	BLQ	kg	WWW	22	Black liquor
	SLW	kg	ORW	23	Sludge waste

Type of energy source	Energy source code	Unit label	AER (Aggr'd) fuel code	#	Energy source description
fuels	WDL	m^3	WWW	24	Wood waste liquids excluding black liquor (BLQ) (Includes red liquor, sludge wood, spent sulfite liquor, and other wood-based liquids)
Gaseous renewable (biomass) fuels	LFG	m^3	MLG	25	Landfill gas
	OBG	m^3	ORW	26	Other biomass gas(includes digester gas, methane, and other biomass gases)
All other renewable fuels	GEO	N/A	GEO	27	Geothermal
	WAT	N/A	HYC	28	Water at a conventional hydroelectric turbine
	SUN	N/A	SUN	29	Solar
	WND	N/A	WND	30	Wind
All Other Fuels					
	HPS	N/A	HPS	31	
	PUR	N/A	OTH	32	Purchased steam
	WH	N/A	OTH	33	Waste heat not directly attributed to a fuel source. Note that WH should only be reported where the fuel source for the waste heat is undetermined, and for combined cycle steam turbines that are not supplementary fired
	OTH	N/A	OTH	34	Other

8.1.2 LN: Fuel characteristics Name: MFUL

The fuel characteristics covered in the MFUL logical node describe the type and nature of the fuel. See Table 37.

Table 37 – Fuel characteristics, LN (MFUL)

MFUL class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
AccOpTms	INS	Accumulated operational time since reset		O
Settings				
FuelTyp	ENG	Type of fuel (use # in Table 36)		M
Currency	CUG	Currency used for costs		O
FuelCost	ASG	Base cost of fuel		O

MFUL class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
GrossCalVal	ASG	Gross calorific value for the fuel		O
FuelEffCoef	ASG	Rated fuel efficiency coefficient as percent		O
Measured values				
FuelCostAv	MV	Running average cost of fuel		O
FuelEfcPct	MV	Fuel efficiency coefficient measured as percent		O
AccTotFuel	MV	Accumulated fuel consumption		O
AccFuel	MV	Accumulated fuel consumption since reset		O
FuelRte	MV	Fuel usage rate		O
FuelCalAv	MV	Running calorie content of fuel		O
Controls				
AccFuelRs	DCP	Reset cumulative fuel accumulation		M
AccOpTmRs	DCP	Reset accumulated operational time		O

8.1.3 LN: Fuel delivery system Name: DFLV

The fuel delivery system covered in the DFLV logical node describes the delivery system for the fuel. See Table 38.

Table 38 – Fuel systems, LN (DFLV)

DFLV class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
FuelSt	SPS	Fuel system status – True: on		M
Settings				
FuelDelTyp	ENG	Type of fuel delivery system: Value – Explanation 0 – Not applicable / Unknown 1 – Passive 2 – Pump 99 – Other		O
Measured values				
InFuelRte	MV	Input fuel flow rate		O
OutFuelRte	MV	Output fuel flow rate		O
InFuelTmp	MV	Input fuel temperature		O
OutFuelTmp	MV	Output fuel temperature		O
FuelRalA	MV	Fuel rail actuator current		O
FuelRalPres	MV	Fuel rail pressure		O
EngFuelRte	MV	Engine fuelling rate		O

DFLV class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
TmPres	MV	Timing rail pressure		O
TmRalActA1	MV	Timing rail actuator current		O
TmRalActA2	MV	Timing rail actuator current		O
PumpActA	MV	Fuel pump actuator current		O
Controls				
FuelStr	DPC	Fuel start		O
FuelStop	DPC	Fuel shutoff valve driver command		O

8.2 Logical nodes for battery system logical device

8.2.1 Battery system logical device (informative)

The battery system logical device describes the characteristics of batteries. These batteries could be used as backup power, the source of excitation current, or as energy storage.

The LNs could include:

- ZBAT: battery system characteristics,
- ZBTC: charger for the battery system.

8.2.2 LN: Battery systems Name: ZBAT

The battery system characteristics covered in the ZBAT logical node reflect those required for remote monitoring and control of critical auxiliary battery system functions and states. These may vary significantly based on the type of battery. See Table 39.

Table 39 – Battery systems, LN (ZBAT)

<table>
<tr><th colspan="5">ZBAT class</th></tr>
<tr><th>Data name</th><th>CDC</th><th>Explanation</th><th>T</th><th>M/O/C</th></tr>
<tr><td>LNName</td><td></td><td>Shall be inherited from logical-node class (see IEC 61850-7-2)</td><td></td><td></td></tr>
<tr><td colspan="5">Data</td></tr>
<tr><td colspan="5">System logical node data</td></tr>
<tr><td></td><td></td><td>LN shall inherit all mandatory data from common logical node class</td><td></td><td>M</td></tr>
<tr><td></td><td></td><td>The data from LLN0 may optionally be used</td><td></td><td>O</td></tr>
<tr><td colspan="5">Status information</td></tr>
<tr><td>BatSt</td><td>SPS</td><td>Battery system status – True: on</td><td></td><td>M</td></tr>
<tr><td>BatTestRsl</td><td>SPS</td><td>Battery test results:<table><tr><th>Value</th><th>Explanation</th></tr><tr><td>0</td><td>Not applicable / Unknown</td></tr><tr><td>1</td><td>All good</td></tr><tr><td>2</td><td>Bad</td></tr><tr><td>99</td><td>Other</td></tr></table></td><td></td><td>O</td></tr>
<tr><td>BatVHi</td><td>SPS</td><td>Battery voltage high or overcharged – True: high or overcharged</td><td></td><td>O</td></tr>
<tr><td>BatVLo</td><td>SPS</td><td>Battery voltage low or undercharged – True: low or undercharged</td><td></td><td>O</td></tr>
<tr><td colspan="5">Settings</td></tr>
</table>

ZBAT class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
BatTyp	ENG	Type of battery: Value – Explanation 0 – Not applicable / Unknown 1 – Lead-acid 2 – Nickel-metal hydrate (NiMH) 3 – Nickel-cadmium (NiCad) 4 – Lithium 5 – Carbon zinc 6 – Zinc chloride 7 – Alkaline 8 – Rechargeable alkaline 9 – Sodium sulphur (NaS) 10 – Flow 99 – Other		M
AhrRtg	ASG	Amp-hour capacity rating		O
MinAhrRtg	ASG	Minimum resting amp-hour capacity rating allowed		O
BatVNom	ASG	Nominal voltage of battery		O
BatSerCnt	ING	Number of cells in series		O
BatParCnt	ING	Number of cells in parallel		O
DisChaCrv	CSG	Discharge curve		O
DisChaTim	SCH	Discharge curve by time		O
DisChaRte	ASG	Self discharge rate		O
MaxBatA	ASG	Maximum battery discharge current		O
MaxChaV	ASG	Maximum battery charge voltage		O
HiBatVAlm	ASG	High battery voltage alarm level		O
LoBatVAlm	ASG	Low battery voltage alarm level		O
Measured values				
Vol	MV	External battery voltage		M
VolChgRte	MV	Rate of output battery voltage change		O
InBatV	MV	Internal battery voltage		O
Amp	MV	Battery drain current		O
InBatA	MV	Internal battery current		O
InBatTmp	MV	Internal battery temperature		O
Controls				
BatSt	SPC	Turn on battery		O
BatTest	SPC	Start battery test		O

8.2.3 LN: Battery charger Name: ZBTC

The battery charger characteristics covered in the ZBTC logical node reflect those required for remote monitoring and control of critical auxiliary battery charger. See Table 40.

Table 40 – Battery charger, LN (ZBTC)

ZBTC class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
BatChaSt	ENG	Battery charger charging mode status Value – Explanation 0 – Not applicable / Unknown 1 – Off 2 – Operational mode 3 – Test mode 99 – Other		M
ChaTms	INS	Charging time since last off/reset		O
Settings				
BatChaTyp	ENG	Type of battery charger: Value – Explanation 0 – Not applicable / Unknown 1 – Constant voltage 2 – Constant current 99 – Other		O
ChaCrv	CSG	Charge curve		O
ChaCrvTim	SCH	Charge curve as time schedule		O
ReChaRte	ASG	Recharge rate		O
BatChaPwr	ASG	Battery charging power required		O
BatChaMod	ENG	Battery charger mode setting Value – Explanation 0 – Not applicable / Unknown 1 – Off 2 – Operational mode 3 – Test mode 99 – Other		M
Measured values				
ChaV	MV	Charging voltage		O
ChaA	MV	Charging current		O

8.3 Logical node for fuse device

8.3.1 Fuse logical device (informative)

Fuses are used to limit current. Although often fuses are not monitored, in some DER devices such as photovoltaic systems, so many fuses are used that it is critical to monitor them so that they may be replaced in a timely manner. Different types of fuses can be used:

- Explosion fuses: (time-delay fuse): slow-blow, fast-blow,

- Fast acting (current limiting fuse),
- Very fast acting (high speed fuse), normally for semiconductors protection.

8.3.2 LN: Fuse Name: XFUS

The XFUS logical node is used to model a fuse which can be described as a switch that is normally closed but can only open once. This equipment cannot be controlled. See Table 41.

Table 41 – Fuse, LN (XFUS)

XFUS class				
Data name	**CDC**	**Explanation**	**T**	**M/O/C**
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
TypFus	ENS	Type of fuse: Value – Explanation 0 – Not applicable / Unknown 1 – Time-delay fuse: slow-blow explosion fuse 2 – Time-delay fuse: fast-blow explosion fuse 3 – Fast acting (current limiting fuse) 4 – Very fast acting (high speed fuse), normally for semiconductors protection 99 – Other		M
FusA	ASG	Fuse current rating		M
FusV	ASG	Voltage rating		O
TmACrv	CSG	Time-current curve		O
PkLetA	ASG	Peak let-thru current or Interrupting capacity		M
Status information				
TypV	SPG	Application voltage: True = DC; False = AC		M
AlmSt	SPS	Fuse alarm: True = alarm state		O

8.4 Logical node for sequencer

8.4.1 Sequencer logical device

Some DER devices require a sequence of steps for starting up or shutting down. This logical node provides the sequence of steps that the DER device controller will use for those functions.

8.4.2 LN: Sequencer Name: FSEQ

The role of this logical node is to provide information regarding sequences of actions during startup or stopping of a DER device. See Table 42.

Table 42 – Sequencer, LN (FSEQ)

FSEQ class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		Data from LLN0 may optionally be used		O
Status information				
SeqStat	INS	Status of the sequencer		M
StepPos	SPS	Active step		M
StrCmpl	SPS	Start sequence completed – True = completed		M
StopCmpl	SPS	Stop sequence completed – True = completed		M
Controls				
Auto	SPC	Automatic or Manual: Value – Explanation True – Automatic False – Manual		M
Start	SPC	Start order of the sequence		M
Stop	SPC	Stop order of the sequence		M

8.5 Logical nodes for physical measurements

8.5.1 Physical measurements (informative)

NOTE Since these LNs are expected to be used by many systems, IEC TC57 WG10 will develop the final versions of these physical measurements. In the meantime, other WGs have also developed many of these LNs, describing them as supervisory LNs, as sensors, or as measurements, but none are "complete" in that they cover all requirements. When IEC TC57 WG10 eventually develops complete LNs, this clause will then point to those LNs.

These LNs cover physical measurements, including temperature, pressure, heat, flow, vibration, environmental, and meteorological conditions.

The LNs included are:

- STMP: Temperature measurements,
- MPRS: Pressure measurements,
- MHET: Heat measurements,
- MFLW: Flow measurements,
- SVBR: Vibration conditions,
- MENV: Emission conditions,
- MMET: Meteorological conditions (see IEC 61850-7-4).

8.5.2 LN: Temperature measurements Name: STMP

This LN provides temperature measurements. See Table 43.

Table 43 – Temperature measurements, LN (STMP)

STMP class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
TmpSt	SPS	Temperature alarm status		O
TmpRteSt	SPS	Temperature rate change alarm status		O
Settings				
MaxTmp	ASG	Maximum temperature		O
MinTmp	ASG	Minimum temperature		O
MaxTmpRte	ASG	Maximum temperature change rate		O
Measured values				
Tmp	MV	Temperature measurement		M
TmpRte	MV	Rate of temperature change		O

8.5.3 LN: Pressure measurements Name: MPRS

This LN provides pressure measurements. See Table 44.

Table 44 – Pressure measurements, LN (MPRS)

MPRS class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
PresSt	SPS	Pressure alarm status		O
PresRteSt	SPS	Pressure rate change alarm status		O
Settings				
MaxPres	ASG	Maximum pressure		O
MinPres	ASG	Minimum pressure		O
MaxPresRte	ASG	Maximum pressure change rate		O
Measured values				
Pres	MV	Pressure measurement		M
PresRte	MV	Rate of pressure change		O

8.5.4 LN: Heat measured values Name: MHET

This LN describes the measurement of heat in the material (air, water, steam, etc.) used for heating and cooling. See Table 45.

Table 45 – Heat measurement, LN (MHET)

MHET class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Settings				
MatTyp	ENG	Type of material: Value – Explanation 0 – Not applicable / Unknown 1 – Air 2 – Water 3 – Steam 4 – Oil 5 – Hydrogen 6 – Natural gas 7 – Butane 8 – Propane 99 – Other		M
HeatSpec	ASG	Specific heat of material		O
MaxMatCal	ASG	Maximum heat content of material		O
MaxHeatOut	ASG	Maximum heat output of heating system		O
Measured values				
MatVolm	MV	Volume of material		O
MatPct	MV	Percent of container filled with material		O
MatCal	MV	Heat of material		O
HeatOut	MV	Instantaneous heat output		O
AccHeatOut	MV	Accumulated heat output since last reset		O
Controls				
AccHeatCtl	SPC	Reset accumulated heat output since last reset		O

8.5.5 LN: Flow measurements Name: MFLW

This LN describes the measurement of flows of liquid or gas materials (air, water, steam, oil, etc.) used for heating, cooling, lubrication, and other auxiliary functions. See Table 46.

Table 46 – Flow measurement, LN (MFLW)

MFLW class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Settings				
MatTyp	ENG	Type of material: Value – Explanation 0 – Not applicable / Unknown 1 – Air 2 – Water 3 – Steam 4 – Oil 5 – Hydrogen 6 – Natural gas 7 – Butane 8 – Propane 99 – Other		M
MatStat	ENG	State of material: Value – Explanation 0 – Not applicable / Unknown 1 – Gaseous 2 – Liquid 3 – Solid 99 – Other		M
MaxFlwRte	ASG	Maximum volume flow rate		O
MinFlwRte	ASG	Minimum volume flow rate		O
MinXsecArea	ASG	Smallest restriction on flow: area of cross-section of restricted point		O
Measured values				
FlwRte	MV	Volume flow rate		C1
FanSpd	MV	Fan or other fluid driver speed		O
FlwHorDir	MV	Flow horizontal direction		O
FlwVerDir	MV	Flow vertical direction		O
MatDen	MV	Material density		O
MatCndv	MV	Material thermal conductivity		O
MatLev	MV	Material level as percent of full		O
FlwVlvPct	MV	Flow valve opening percent		O
Controls				
FlwVlvCtr	APC	Set flow valve opening percent		O
FanSpdSet	APC	Set fan (or other fluid driver) speed		O
Metered values				
MtrVol	BCR	Metered volume of fluid since last reset		C2
NOTE Either C1 or C2 or both must be available.				

8.5.6 LN: Vibration conditions Name: SVBR

This LN describes the vibration of material, including rotating plant objects as well as vibrations from liquid or gas flows (e.g. cavitation). See Table 47.

Table 47 – Vibration conditions, LN (SVBR)

SVBR class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
Alm	SPS	Vibration alarm level reached		M
Trip	SPS	Vibration trip level reached		O
Settings				
VbrAlmSpt	ASG	Maximum vibration magnitude setpoint		O
VbrTrSpt	ASG	Vibration trip level setpoint		O
AxDspAlmSpt	ASG	Axial displacement alarm level setpoint		O
AxDspTrpSpt	ASG	Axial displacement trip level setpoint		O
Measured values				
VibMag	MV	Vibration magnitude		M
VibPer	MV	Vibration periodicity		O
VibDir	MV	Vibration direction		O
AxDsp	MV	Total axial displacement		O

8.5.7 LN: Emissions measurements Name: MENV

The characteristics of the emissions of the DER system cover emissions, sensitivity of DER unit to external conditions, and other key environmental items. In addition, many of the environmental sensors may be located remotely from the instantiated logical node. This logical node may therefore represent a collection of environmental information from many sources. The need for different objects may vary significantly based on the type of DER. See Table 48.

Table 48 – Emissions measurements, LN (MENV)

MENV class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
LNName		Shall be inherited from logical-node class (see IEC 61850-7-2)		
Data				
System logical node data				
		LN shall inherit all mandatory data from common logical node class		M
		The data from LLN0 may optionally be used		O
Status information				
SmokAlm	SPS	Smoke alarm		O

MENV class				
Data name	**CDC**	**Explanation**	**T**	M/O/C
FloodAlm	SPS	Flood alarm		O
Settings				
CTrade	INS	Involved in carbon trading		O
CCredit	ASG	Carbon production credit value		O
GreenTag	INS	Green tag information		O
PartSens	ASG	Sensitivity to particulates		O
FloodLev	ASG	Flood level		O
Measured values				
CO2	MV	CO2 emissions		O
CO	MV	CO emissions		O
NOx	MV	NOx emissions		O
SOx	MV	SOx emissions		O
Dust	MV	Smoke/dust particulates suspended in air		O
Snd	MV	Sound emissions		O
O2	MV	Oxygen		O
O3	MV	Ozone		O

8.5.8 LN: Meteorological conditions Name: MMET

The characteristics of the meteorological conditions of the DER system cover meteorological parameters.

8.6 Logical nodes for metering

8.6.1 Electric metering (informative)

Metering of usage of materials, such as electricity, liquids, and gas, may or may not be handled by the same systems that manage DER devices, essentially because metering usually involves payments for metered amounts. In electric metering, IEC 62056 and ANSI C12.19 are the standards used for revenue metering of customers, while similar standards are used for water, gas, and other liquids and gases. Nonetheless, energy usage, liquid usage, and gas usage can often be needed for other purposes than payments, such as calculations on how much fuel is available or emissions assessments or water flow evaluations. Therefore, IEC 61850 LNs could provide this usage metering information, but currently only include a basic electric metering capability.

Metering LNs include:

- MMTR for electricity metering (see IEC 61850-7-4).

9 DER common data classes (CDC)

9.1 Array CDCs

The following are additional common data classes, which are required for DER device models.

9.1.1 E-Array (ERY) enumerated common data class specification

The ERY CDC provides a means for defining an array of set points. This CDC is similar to HST (histogram), but expands it to enumerated and provides both quality and timestamp for each element in the array. See Table 49.

Table 49 – E-Array (ERY) common data class specification

ARY class					
Data name	**Attribute type**	**FC**	**TrgOp**	**Value/value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
			setting		
numPts	INT16U	SP		Length of array >= 1	M
eAry	ARRAY 0..numPts-1 OF ENUMERATED	SP	dchg	1 to numPts values	M
qAry	ARRAY 0..numPts-1 OF Quality	SP	qchg	1 to numPts quality codes	O
tAry	ARRAY 0..numPts-1 OF TimeStamp	SP		1 to numPts timestamps	O
			configuration, description and extension		
dAry	ARRAY 1..numPts of VISIBLE STRING255	DC		0 to numPts descriptions	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

9.1.2 V-Array (VRY) visible string common data class specification

The VRY CDC provides a means for defining an array of enumerated points. This CDC is similar to HST (histogram), but changes the type to VISIBLE STRING and provides both quality and timestamp for each element in the array. See Table 50.

Table 50 – V-Array (VRY) common data class specification

ARY class					
Data name	**Attribute type**	**FC**	**TrgOp**	**Value/value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
			setting		
numPts	INT16U	SP		Length of array >= 1	M
vAry	ARRAY 0..numPts-1 OF VISIBLE STRING255	SP	dchg	1 to numPts enumerated values	M
qAry	ARRAY 0..numPts-1 OF Quality	SP	qchg	1 to numPts quality codes	O
tAry	ARRAY 0..numPts-1 OF TimeStamp	SP		1 to numPts timestamps	O
			configuration, description and extension		
dAry	ARRAY 0..numPts-1 of VISIBLE STRING255	DC		0 to numPts descriptions	O
d	VISIBLE STRING255	DC			O
dU	UNICODE STRING255	DC			O

ARY class					
Data name	**Attribute type**	**FC**	**TrgOp**	**Value/value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
cdcNs	VISIBLE STRING255	EX			AC_DLNDA_M
cdcName	VISIBLE STRING255	EX			AC_DLNDA_M
dataNs	VISIBLE STRING255	EX			AC_DLN_M

9.2 Schedule CDCs

9.2.1 Absolute time schedule (SCA) settings common data class specification

The SCA CDC provides a means for defining an absolute time array of setting values, such as schedules. The time intervals between points may be variable. See Table 51.

Table 51 – Schedule (SCA) common data class specification

SCA class					
Data name	**Attribute type**	**FC**	**TrgOp**	**Value/value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
			setting		
numPts	INT16U	SP		Length of array >= 1	AC_NSG_M
val	ARRAY 1..numPts OF FLOAT32	SP	dchg	1 to numPts values	AC_NSG_M
rmpTyp	ARRAY 1..numPts OF ENUMERATED	SP	dchg	1 to numPts values: 1=Fixed, 2=Ramp, 3=Average	AC_NSG_C
time	ARRAY 1..numPts OF TimeStamp	SP	dchg	1 to numPts date/time values	AC_NSG_M
numPts	INT16U	SG, SE		Length of array >= 1	AC_SG_M
val	ARRAY 1..numPts OF FLOAT32	SG, SE	dchg	1 to numPts point values	AC_SG_M
rmpTyp	ARRAY 1..numPts OF ENUMERATED	SG, SE	dchg	1 to numPts values: 1=Fixed, 2=Ramp, 3=Average	AC_SG_C
time	ARRAY 1..numPts OF TimeStamp	SG, SE	dchg	1 to numPts date/time values	AC_SG_M
			configuration, description and extension		
cur	VISIBLE STRING3	CF		Currency as 3-character string as per ISO 4217	O
valUnits	Unit	CF		Units of val	O
valEq	ENUMERATED	CF		Equation for val: 1 = SI units, 2 = Currency as per ISO 4217 per SI unit, 3 = SI unit per currency	O
valD	VISIBLE STRING255	DC		Description of val	O
valDU	UNICODE STRING255	DC		Description of val in Unicode	O
d	VISIBLE STRING255	DC		Description of instance of data	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

SCA class					
Data name	**Attribute type**	**FC**	**TrgOp**	**Value/value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
rmpTyp is conditionally mandatory or optional: if val is a power-related type, then rmpTyp is mandatory; if val is currency, then rmpTyp is not necessary.					

9.2.2 Relative time schedule (SCR) settings common data class specification

The SCR CDC provides a means for defining a relative time array of setting values, such as schedules. The time intervals between points may be variable. See Table 52.

Table 52 – Schedule (SCR) common data class specification

SCR Class					
Data name	**Attribute type**	**FC**	**TrgOp**	**Value/value range**	**M/O/C**
DataName	Inherited from data class (see IEC 61850-7-2)				
DataAttribute					
setting					
numPts	INT16U	SP		Length of array >= 1	AC_NSG_M
val	ARRAY 1..numPts OF FLOAT32	SP	dchg	1 to numPts values	AC_NSG_M
rmpTyp	ARRAY 1..numPts OF ENUMERATED	SP	dchg	1 to numPts values: 1=Fixed, 2=Ramp, 3=Average	AC_NSG_C
tmOffset	ARRAY 1..numPts OF UINT24	SP	dchg	1 to numPts of time offsets in seconds	AC_NSG_M
numPts	INT16U	SG, SE		Length of array >= 1	AC_SG_M
val	ARRAY 1..numPts OF FLOAT32	SG, SE	dchg	1 to numPts point values	AC_SG_M
rmpTyp	ARRAY 1..numPts OF ENUMERATED	SG, SE	dchg	1 to numPts values: 1=Fixed, 2=Ramp, 3=Average	AC_SG_C
tmOffset	ARRAY 1..numPts OF UINT24	SG, SE	dchg	1 to numPts of time offsets in seconds	AC_SG_M
configuration, description and extension					
cur	VISIBLE STRING3	CF		Currency as 3-character string as per ISO 4217	O
valUnits	Unit	CF		Units of val	O
valEq	ENUMERATED	CF		Equation for val: 1 = SI units, 2 = Currency as per ISO 4217 per SI unit, 3 = SI unit per currency	O
valD	VISIBLE STRING255	DC		Description of val	O
valDU	UNICODE STRING255	DC		Description of val in Unicode	O
d	VISIBLE STRING255	DC		Description of instance of data	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
rmpTyp is conditionally mandatory or optional: if val is a power-related type, then rmpTyp is mandatory; if val is currency, then rmpTyp is not necessary.					

Annex A

(informative)

Glossary

For the purpose of this document, the following additional definitions apply.

A.1
area electric power system area EPS
an EPS that serves local EPSs

A.2
catalyst
a chemical substance that increases the rate of a reaction without being consumed; after the reaction it can potentially be recovered from the reaction mixture chemically unchanged

The catalyst lowers the activation energy required, allowing the reaction to proceed more quickly or at a lower temperature. In a fuel cell, the catalyst facilitates the reaction of oxygen and hydrogen. It is usually made of platinum powder very thinly coated onto carbon paper or cloth. The catalyst is rough and porous so that the maximum surface area of the platinum can be exposed to the hydrogen or oxygen. The platinum-coated side of the catalyst faces the membrane in the fuel cell.

A.3
electric power network
entity consisting of particular installations, substations, lines or cables for the transmission and distribution of electric energy

NOTE The boundaries of the different parts of an electric power network are defined by appropriate criteria, such as geographical situation, ownership, voltage, etc.

A.4
electricity supply system
entity consisting of all installations and plant provided for the purpose of generating, transmitting and distributing electric energy

A.5
fuel processor
device used to generate hydrogen from fuels such as natural gas, propane, gasoline, methanol, and ethanol, for use in fuel cells

A.6
illuminance
the luminous flux received by an elementary surface divided by the area of this surface

NOTE In the SI system of units, illuminance is expressed in lux (lx) or lumens per square metre (lm/m2).

A.7
intelligent electronic device
IED
microprocessor-based controller of power system equipment, such as circuit breakers, transformers, and capacitor banks

NOTE In addition to controlling a device, an IED may have connections as a client, or as a server, or both, with computer-based systems including other IEDs. An IED is, therefore, any device incorporating one or more processors, with the capability to receive data from an external sender or to send data to an external receiver.

A.x
international system of units (SI)

International System of Units, universally abbreviated as SI, is the modern metric system of measurement. *[NIST SP330]*

A.8
Local area network
LAN

A.8
local electric power system
A.9
local EPS
an EPS contained entirely with in a single premise or group of premises

A.10
log
to reproduce spontaneously, cyclically or by polling a recording in a readable way for human operators

NOTE As a noun, a log is historical information of events, actions, and states, typically listed chronologically.

A.11
luminous efficacy (lm/W)
quotient of the luminous flux emitted by the power consumed by the source

A.12
normal operating cell temperature
NOCT
temperature of a photovoltaic module when subjected to 800 W/m2 illumination, 20 °C ambient temperature, wind speed < 1 m/s and spectral distribution AM 1.5

NOTE The temperature at which the cells in a solar module operate under standard operating conditions (SOC), with the cell or module in an electrically open circuit state, the wind oriented parallel to the plane of the array, and all sides of the array fully exposed to the wind.

A.13
power conversion efficiency
the efficiency, ηC, of the power conversion is the ratio of the power delivered by the converter to the total power drawn from the input power supplies feeding lines, including the converter auxiliaries, and is usually expressed as a percentage

A.14
PVUSA test condition
PTC
test conditions for photovoltaic modules in which they are subjected to 1 000 W/m2 illumination, 20 °C ambient temperature, wind speed < 1 m/s

A.15
radiance
the flux density of radiant energy per unit solid angle and per unit projected area of radiating surface

A.xx
WAN

Wide area network

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- IEEE 1547, *Standard for Interconnecting Distributed Resources with Electric Power Systems*
- [NIST] United States National Institute of Standards and Technology
- [US DOE] United States Department of Energy – Energy Efficiency and Renewable Energy Glossary of Terms at http://www1.eere.energy.gov/solar/solar_glossary.html and http://www1.eere.energy.gov/hydrogenandfuelcells/glossary.html
- [Photovoltaic industry] Agreements by the photovoltaic industry
- [Merriam-Webster dictionary] Standard English dictionary