57/818/CDV

COMMITTEE DRAFT FOR VOTE (CDV)
PROJET DE COMITÉ POUR VOTE (CDV)

	Project number Numéro de projet	IEC 61850-7-420 Ed.1
	IEC/TC or SC: **TC57** CEI/CE ou SC:	Secretariat / Secrétariat **Germany**
☒ Submitted for parallel voting in CENELEC Soumis au vote parallèle au CENELEC	Date of circulation Date de diffusion **2006-04-28**	Closing date for voting (Voting mandatory for P-members) Date de clôture du vote (Vote obligatoire pour les membres (P)) **2006-09-29**

Also of interest to the following committees Intéresse également les comités suivants TC 4/TC 8/TC 65/TC 82/TC 88/TC 95/TC 105 and ISO/TC 184/SC 5	Supersedes document Remplace le document 57/750/CD & 57/817/CC

Functions concerned
Fonctions concernées

☐ Safety / Sécurité ☐ EMC / CEM ☐ Environment / Environnement ☐ Quality assurance / Assurance qualité

Title : Communication networks and systems in substations – Part 7-420: Communications systems for distributed energy resources (DER) - Logical nodes

Introductory note

The project number has been changed from 62350 to 61850-7-420, and the title has been adjusted in accordance.

The French National Committee will not provide a French translation for this project.

ATTENTION
VOTE PARALLÈLE
CEI – CENELEC

L'attention des Comités nationaux de la CEI, membres du CENELEC, est attirée sur le fait que ce projet de comité pour vote (CDV) de Norme internationale est soumis au vote parallèle.
Un bulletin de vote séparé pour le vote CENELEC leur sera envoyé par le Secrétariat Central du CENELEC.

ATTENTION
IEC – CENELEC
PARALLEL VOTING

The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) for an International Standard is submitted for parallel voting.
A separate form for CENELEC voting will be sent to them by the CENELEC Central Secretariat.

Draft IEC 62350 *{Tentatively to be renumbered as IEC 61850 Part 7-420}*

Committee Draft for Vote (CDV1)

April 2006

Communications Systems for Distributed Energy Resources (DER)

Part IEC 61850 Part 7-420 DER Logical Nodes

Notes to this first Committee Draft for Vote (CDV1)

This is the first CDV for these DER object models, and reflects the many discussions with IEC TC57 WG10 and WG18 members over the last year. This draft was reviewed in the March 2006 meeting in Mérida, Mexico. As agreed there, this document will be issued as a CDV.

Additional versions will definitely follow this first CDV in order to model additional DER devices and subsystems or to make generally agreed upon corrections. In particular, no implementations or pilot projects have actually used the objects other than in two mapping laboratory tests. Therefore, these object models are not yet field-validated. However, this document does present IEC 61850 object models for DER devices that have been reviewed by a number of IEC and vendor groups, and are therefore considered as ready for review by a larger community.

In this first CDV, DER systems as a whole, and the "energy conversion" technologies of reciprocating engines (piston engines), fuel cells, and photovoltaic systems have been addressed in full. Combined heat and power (CHP) has been tentatively addressed, but requires significant review by CHP experts.

A number of Logical Nodes for metering and physical measurements are being proposed, but these will be reviewed in a larger context since they are not DER-specific. Additional CDCs have also been proposed.

A number of DER technologies have not been addressed at all yet. The decision was made not to wait on these other DER technologies before submitting the document for review, in order to get this basic information out to reviewers. Additional sections or possibly separate documents may be sent in the future as "domain experts" become available to discuss and provide the key data items that can be used to create the object models of these other DER technologies … Any support on these will be greeted with enthusiasm.

The working group would like to get substantive feedback on these object models: all comments and suggestions are welcome, from the editorial, to those related to modeling techniques, and to technical DER device issues.

The informative Annex A provides more information on the context of these object models.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

Distributed Energy Resources (DER) Logical Nodes –

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organisation for standardisation comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardisation in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organisations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organisation for Standardisation (ISO) in accordance with conditions determined by agreement between the two organisations.
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6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

This working draft of the International Standard IEC 61850 Part 7-xxx has been prepared by IEC technical committee 57: Working Group 17 on Distributed Energy Resources Object Modeling.

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

INTRODUCTION

1 Scope (Informative)

The scope of this document is the specification of the object models of DER information that can be exchanged between DER devices and any systems which monitor, control, maintain, audit, and generally operate the DER devices. An informative Annex A titled "*Communications Systems for Distributed Energy Resources (DER) – Informative Annex on DER Modeling*" provides the background, identification of DER functions that will use these normative DER object model standards, and discussions as to how these object model standards will be used by different types of DER devices.

Simply put, "object models" are standardized formats or templates for exchanging data between different equipment or systems. Standard object models, combined with standard service models (methods for sending the data, e.g. report-by-exception, periodic, control commands) and standard protocols (the bits and bytes actually send over the communication channel), permit different systems to interact with minimal customization and greater interoperability. The combination of object model, service model, and protocol profiles can be termed the "information model".

These DER information models are based on open-system language, semantics, services, protocols, and architecture, which have been standardized by IEC 61850, but they include some extensions to IEC 61850. The DER object models will eventually be provided to the IEC as a draft set of object models for international standardization. In order to ensure the standardization process is simplified, these DER information models are compatible with IEC 61850, IEC61970 (CIM), IEC60870-5 (telecontrol protocol, which also formed the base for DNP), and IEC60870-6 (ICCP/TASE.2) standards.

The object models in this draft document are ready for trial use by vendors in order to provide feedback and updates. However, it must be understood that these are still draft object models and are subject to change.

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 who manage both the plant and the individual DER units. This is illustrated in Figure 1-1.

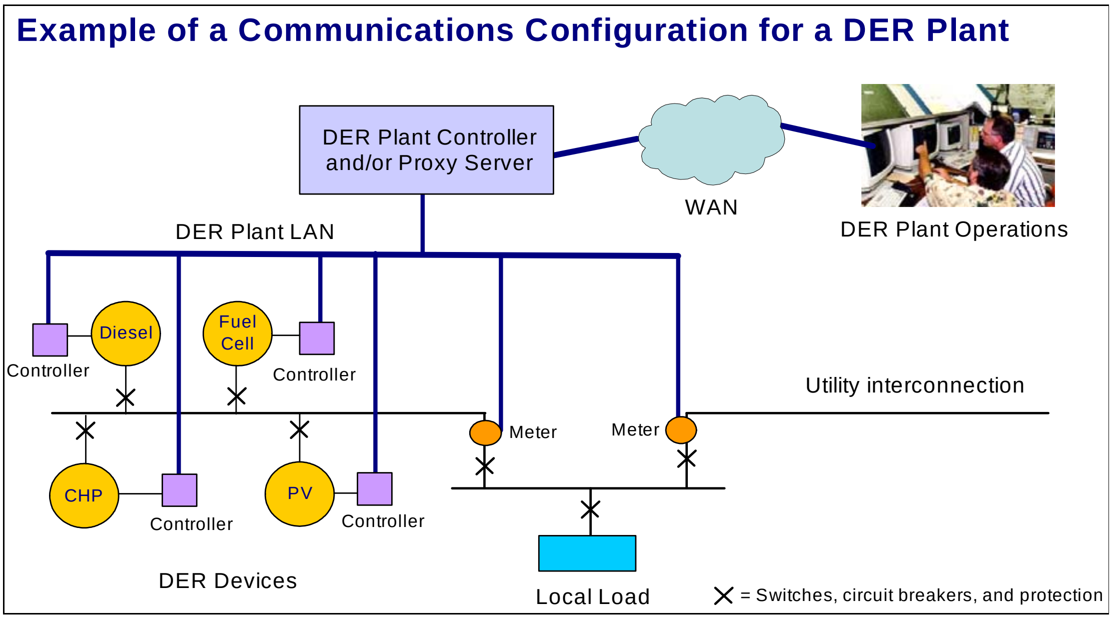


Figure 1-1: Example of a Communications Configuration for a DER Plant

There is a growing interest in implementing DER devices throughout the world. As the DER technology evolves, nations recognize 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 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, DER manufacturers, and the customers they serve are increasingly interested in having one international standard that would define 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.

At the same time, the object modeling technology has developed within the last few years to become well-established as the most effective method for managing information exchanges. In particular, the IEC 61850 object models for the exchange of information within substations have moved through the standardization process, and are now formally designated as the IEC 61850 International Standard. Many of the components of this standard can be reused for object models of other types of devices. Some new components are also needed, but these can follow the rules for creating these new components, thus making them compatible with the existing IEC 61850 standards.

The interrelationship between IEC TC57 modeling standards is illustrated in Figure 1-2.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 object 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 areas are shown: substation automation, DER, distribution automation, customer services, generation (including large hydro plants), etc.

Although this document addresses only the IEC 61850 object models, additional modeling efforts will be needed for DER (and other domain areas) in the CIM/CFL areas.

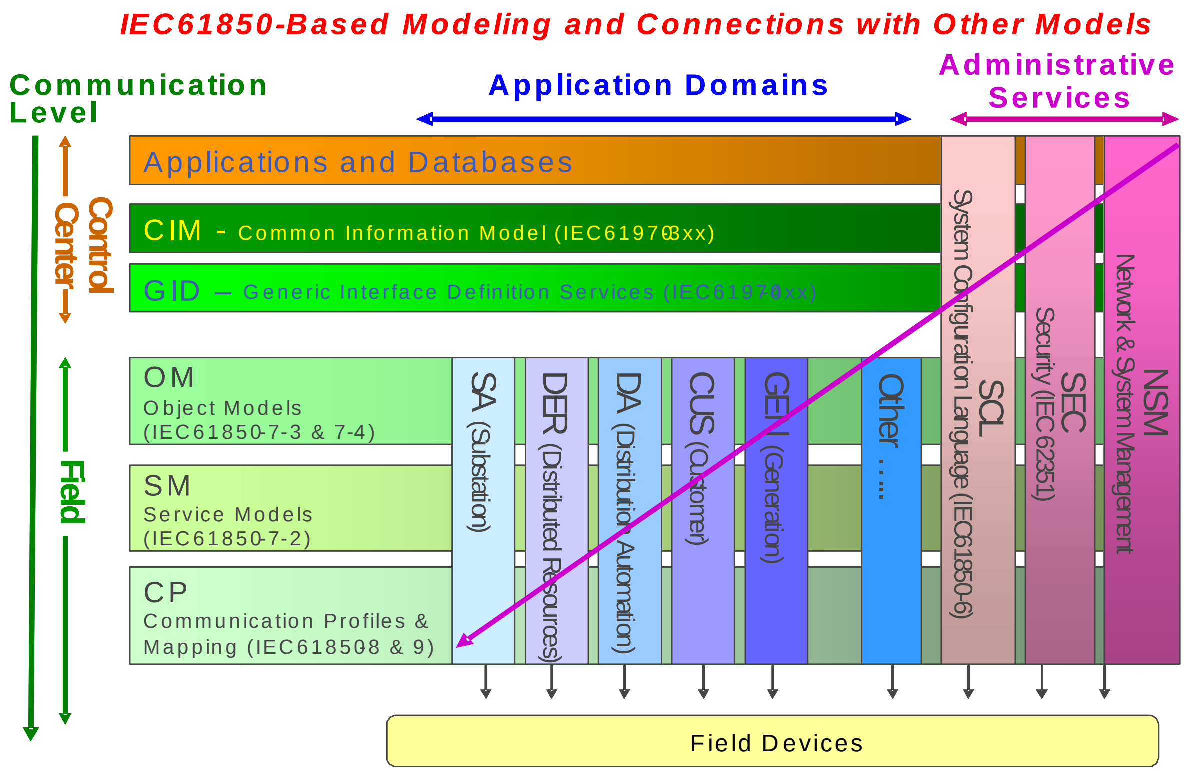


Figure 1-2: IEC 61850 Modeling and Connections with Other IEC TC57 Models

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.

ISO/IEC 7498-1:1994, *Information technology -- Open Systems Interconnection – Basic Reference Model: The Basic Model*

IEC 61850-7-1, *Communication networks and systems in substations – Part 7-1: Basic communication structure for substations and feeder equipment – Principles and models*

IEC 61850-7-2, *Communication networks and systems in substations – Part 7-2: Basic communication structure for substations and feeder equipment – Abstract communication service interface (ACSI)*

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

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

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*

Specific normative references for mapping of IEC 61850 object models to protocols

IEC 61850-8-1, *Communication networks and systems in substations – Part 8-1: Specific Communication Service Mapping (SCSM) – Mapping to MMS (ISO/IEC 9506 Part 1 and Part 2) and to ISO 8802-3*

Specific normative references for IEC 61850 Objects

IEC 61850-7-2:2003, *Communication networks and systems in substations – Part 7-2: Basic communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*

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

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

IEC 61850-6:2004, *Communication networks and systems in substations – Part 6: Substation automation system configuration description language*

IEC 60870-5-101 Ed. 2:2002, *Telecontrol equipment and systems - Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks*

IEC 60870-5-104:2000, *Telecontrol equipment and systems – Part 5-104: Transmission protocols – Network access for IEC 60870-5-101 using standard transport profiles*

Specific normative references for Web Services

OPC *XML-DA Specification Version 1.0; Release Candidate 2.1; June 11, 2003*

W3C, *Extensible Markup Language (XML) 1.0, http://www.w3.org/TR/2000/REC-xml-20001006*

W3C, *Name spaces in XML, http://www.w3.org/TR/1999/REC-xml-names-19990114*

W3C, *XML Schema Part 0: Primer, http://www.w3.org/TR/2001/REC-xmlschema-0-20010502*

W3C, *XML Schema Part 1: Structures, http://www.w3.org/TR/2001/REC-xmlschema-1-20010502*

W3C, *XML Schema Part 2: Data Types,* http://www.w3.org/TR/2001/REC-xmlschema-2-20010502/

3 Terms and definitions

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

Term	Definition
Co-generation	Another term for combined heat and power
Combined Heat and Power (CHP)	CHP is the use of a power station to simultaneously generate both heat and electricity. Multiple alternatives exist: **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 chilling water sent to the air handler units in a different building. **Heat as primary, electricity as secondary**. Alternatively, 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. **Use of available heat.** Inexpensive fuel is available (e.g. produced by landfill or biomass) which can then be burned to generate electricity and/or heat.
Electric Power System (EPS)	System of electrical wires and equipment which transports electrical energy from one location to another. A local EPS transports electrical energy within a defined area, such as a campus, building, or industrial plant, and may or may not be interconnected with the utility EPS.
Electrical Connection Point (ECP)	The point of electrical connection between the DER plant and **any** electric power system (EPS). For those ECPs between a utility EPS and a customer EPS, this point is also defined as the Point of Common Coupling (PCC) in the IEEE 1547 “*Standard for Interconnecting Distributed Resources with Electric Power Systems*”.
Energy Converter	The equipment and process for converting one form of energy into another form. In the context of DER systems, energy converters convert other forms of energy into electrical energy.
Event	State information and/or state transition (status, alarm, command).
Fuel Cell	A fuel cell is an electrochemical energy conversion device similar to a battery, but differing from the latter in that it is designed for continuous replenishment of the reactants consumed; i.e. it produces electricity from an external supply of fuel and oxygen as opposed to the limited internal energy storage capacity of a battery. Additionally, the electrodes within a battery react and change as a battery is charged or discharged, whereas a fuel cell's electrodes are catalytic and relatively stable.

Term	Definition
Function	A function is a task that is performed in the control centre or the distributed energy resource. Generally, a function consists of sub-functions that exchange data with each other. Functions may also exchange data with other functions.
Generator	A device which converts some other type of energy (e.g. rotating energy) into electric energy.
IED	Intelligent Electronic Device - e.g. a device controller. An IED may have connections as a client, or as a server, or both, with other IED. 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.
Information	Information is defined as both the data itself and the metadata describing the data.
information Exchange	Communication process between two systems, such as wind power component and actor, with the goal to provide and to get relevant information. Requires specific communication functions (services).
Log	Historical information of events, actions, and states, typically listed chronologically.
Logging and Reporting	Operational function used for analysing, reporting, and evaluating events and values.
Mandatory	Information shall be provided by an implementation of this standard.
Measured Value	Distributed energy resource analogue information. Sampled value of a process quantity.
Meteorological System	Component of a distributed energy resource responsible for the measuring of the wind conditions, e.g. the wind speed. It is installed at a reference location and supplies the data required to correlate the produced power output of individual wind turbines to the useable wind potential.
Monitoring	Operational function used for local or remote observing of the status and changes of states (indications) for distributed energy resources.
Operational Function	Used by actors for the normal daily operation of distributed energy resources to obtain information on distributed energy resources and to send instructions to it. Types: monitoring, logging and reporting, data retrieval, control.
Optional	Information may be provided by an implementation of this standard.
Parameter	Distributed energy resource analogue information. Controllable value for system behaviour (adjustment).
Photovoltaic System	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.
Prime Mover	Entity providing the force for the generation of electricity. Examples include diesel engine, solar panels, gas turbines, wind turbines, hydro turbines, battery storage, water storage, air storage, etc.

Term	Definition
Processed Value	Measured value which has been processed through calculations.
Reciprocating Engine	A reciprocating engine, also often known as a piston engine, is an engine that utilizes one or more pistons in order to convert pressure into a rotating motion. The reciprocating engine was introduced with the now obsolete steam engine, but today 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.
Report	In information technologies, a report is an event-driven or periodical transmission of information from a server to a client.
Setpoint	An analogue value which sets the controllable target for a process.
Status	State information, which can be the condition of a component or system as well as an alarm condition.

4 Abbreviated terms

IEC 61850-7-4, Clause 4, defines Abbreviated Terms for building concatenated Data Names. The following abbreviated terms are proposed as additional terms for building concatenated Data Names.

Term	Description
Abs	Absorbing
Acc	Accumulated
Alt	Altitude
Amb	Ambient
Arr	Array
Avail	Available
Azi	Azimuth
Bas	Base
Bckup	Backup
Cal	Calorie, Caloric
Circ	Circuit
Cmut	Commute, Commutator
Cntct	Contractual
Con	Constant
Conn	Connected, connections
Conv	Conversion, converted
Cool	Coolant
Cost	Cost
Csump	Consumption, consumed
DCV	DC voltage
Deg	Degrees
Dep	Dependent
DER	Distributed Energy Resource
ECP	Electrical Connection Point
Efc	Efficiency
El	Elevation
Em	Emission
Emrg	Emergency
Encl	Enclosure
Eng	Engine
ExIm	Export/Import
Exp	Export
Forc	Forced
Fuel	Fuel
Fx	Fixed
Gov	Governor
Heat	Heat
Hor	Horizontal
Hr	Hour
Hyd	Hydrogen (suggested in addition to H_2)
Id	Identity
Imp	Import
Ind	Independent
Iso	Isolation
Maint	Maintenance
Man	Manual
Mat	Material
Mdul	Module
Mgt	Management
Mrk	Market
Obl	Obligation
Off	Off
On	On
Ox	Oxidant, oxygen
PCC	Point of Common Coupling
Perm	Permission
Pk	Peak
Plnt	Plant, Facility

Term	Description	Term	Description
Pv	Photovoltaics	Tim	Timing
Ramp	Ramp	Track	Track
Rng	Range	Tur	Turbine
Sched	Schedule	Util	Utility
Self	Self	Ver	Vertical
Ser	Series, Serial	Volm	Volume
Srt	Short	Wtr	Water (suggested in addition to H_2O)
Stab	Stabilizer	Xsec	Cross-section
Tilt	Tilt		

5 Logical Nodes for DER Systems and Equipment

5.1 Overview of DER Logical Nodes and Logical Devices (Informative)

In the following tables, the Logical Nodes (LNs) for DER devices are defined. For each LN implemented, all Mandatory items must be included (those indicated as an M in the M/O 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 object models is illustrated in Figure 5-1. This illustration does not include all LNs that might be implemented, nor all possible configurations, but exemplifies the approach taken to create object models.

Each subclause contains an initial informative clause, followed by normative clauses. Specifically, any clause identified as informative, is informative; any clause with no identification is considered normative.

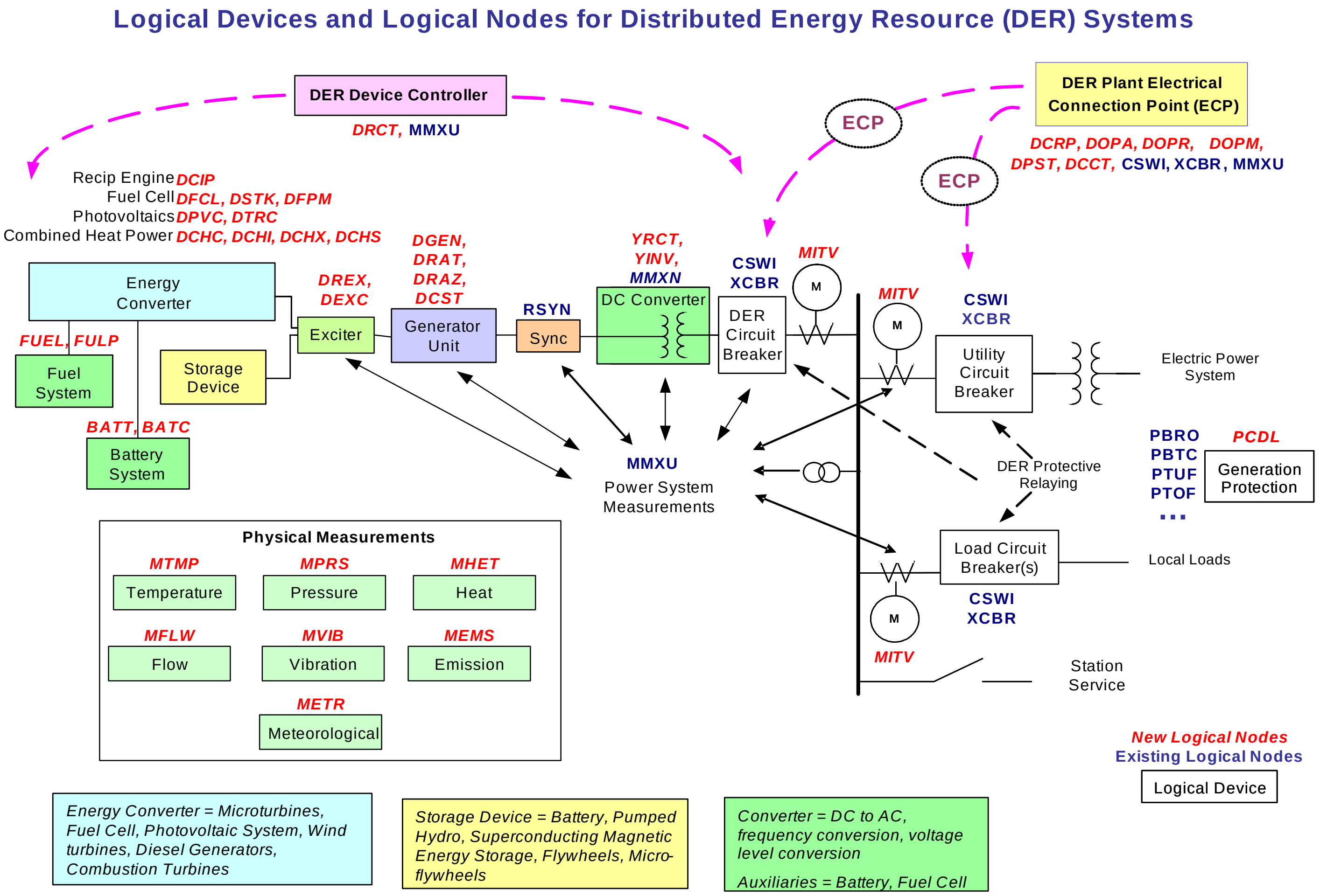


Figure 5-1: Conceptual Organization of DER Logical Devices and Logical Nodes

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.

In a simple DER configuration, there is one ECP between a single DER unit and the utility power system. However, as shown in Figure 5-2, 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

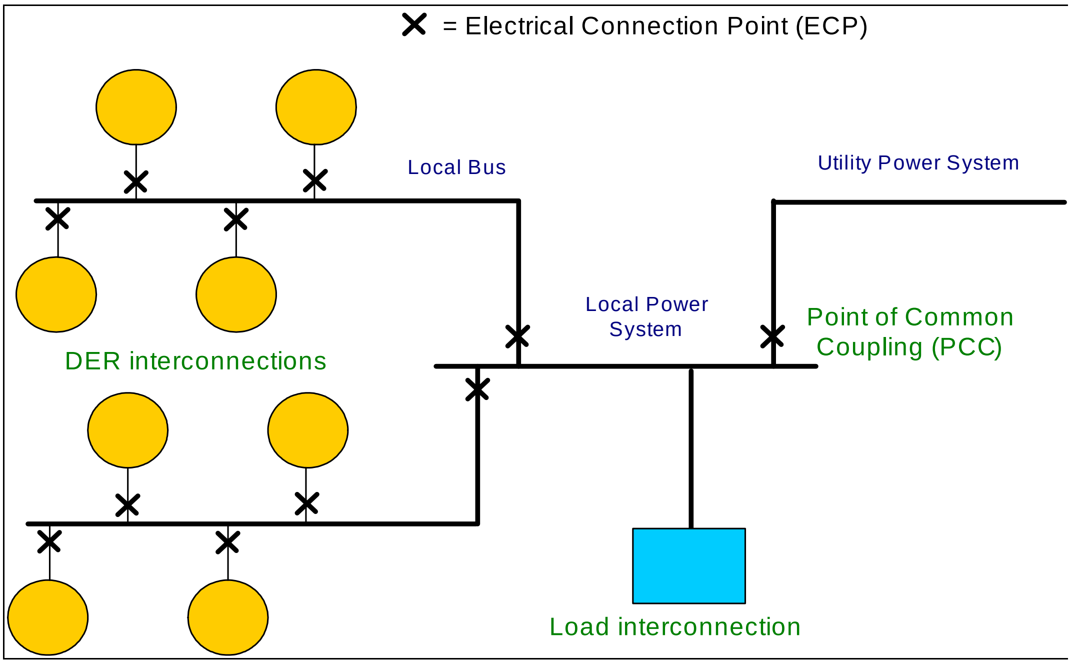


Figure 5-2: Illustration of Electrical Connection Points (ECP) in a DER Plant

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:

- 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 the ECP, including ownership, operating authority, contractual obligations and permissions, location, and identities of all DER devices connected directly or indirectly at the ECP
- **DOPA**: DER operational control authorities at the 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.
- **DOPR**: DER plant operational characteristics at the 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
- **DOPM**: DER operating mode at the ECP. This LN can be used to set available operating modes as well as actual operating modes.
- **DPST**: Actual status at the ECP, including DER Plant connection status, alarms
- **DCCT**: Economic dispatch parameters for DER operations
- **XCBR, CSWI**: Switch or breaker at the ECP and/or at the load connection point (see IEC 61850-7-4)
- **MMXU**: Actual power system measurements at the 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)
- **MITV**: Interval metering information at the ECP, including interval lengths, readings per interval (see section 7.1.2) *{Although an interval revenue metering LN is needed for DER, it is expected that this metering LN will be required and expanded upon in other efforts, and should not be necessarily associated with DER. Therefore, it is recommended that eventually the Metering LNs be handled separately.}*

Recommendations on historical and statistical logging are not standard, but could be included as informative.

5.2.2 *LN: DER Plant Corporate Characteristics at the ECP Name: DCRP*

This Logical Node defines the corporate and contractual characteristics of DER plant (DER plant is defined as one or more DER devices) at the Electrical Connection Point (ECP), including ownership, operating authorities, identities of all DER devices, location of the ECP, contractual obligations, and contractual permissions. It is expected that only key provisions of the contractual information needed for operations will be available in the LN; many additional provisions may be available through alternate means.

Table 5-1: DER Plant Corporate Characteristics at the ECP, LN (DCRP)

		DCRP Class	
Attribute Name	CDC	Explanation	M/O
LNName		Shall be inherited from Logical-Node Class (see IEC 61850-7-2)	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
PlntOwn	DOO[1]	Owner of plant	M
PlntOpr	DOO	Operator of plant	M
PlntDER	LIST[2]	List of DER identities connected to ECP – possibly MRIDs[3]	O
PlntOblSelf	SPS	Plant purpose/obligations – run whenever possible (e.g. photovoltaics, wind)	O
PlntOblBckup	SPS	Plant purpose/obligations – for backup	O
PlntOblMan	SPS	Plant purpose/obligations – manual operations	O
PlntOblMrk	SPS	Plant purpose/obligations – market-driven	O
PlntOblUtil	SPS	Plant purpose/obligations – utility operated	O
PlntOblEm	SPS	Plant purpose/obligations – emission-limited	O

5.2.3 *LN: DER Operational Authority at the ECP Name: DOPA*

This Logical Node indicates the authorized control actions that are permitted for each entity, including 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 in effect. One instantiation of this LN should be established for each entity that could have operational control.

1 DOO is a new CDC that may be integrated into DPL. If/when WG10 makes this change, this data item will be removed.

2 LIST is a new CDC for containing MRIDs if these are accepted as needed in IEC 61850.

3 Master Resource Identities (MRID) should be used to identify specific DER units, as well as components within DER units (e.g. generator, prime mover, battery, etc.). This will make 61850 more conformant with CIM concepts. It might be integrated into DPL.

Table 5-2: DER Operational Authority at the ECP, LN (DOPA)

		DOPA Class	
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
ECPAuth	MRID	Identity of Entity whose authorizations are being set	M
ECPId	MRID	Identity of the ECP	M
DERAuth	LIST	List of the MRIDs of the DERs covered by this authorization	M
ECPSwOpnAuth	SPS	Authorized to open the ECP switch	O
ECPSwClsAuth	SPS	Authorized to close the ECP switch	O
ECPOpModeAuth	SPS	Authorized to change operating mode of DER plant	O
DERStrAuth	SPS	Authorized to start DER units	O

5.2.4 LN: Operational Characteristics at ECP Name: DOPR

This Logical Node contains the aggregated operational characteristics of all DERs connected at the ECP, including types of DER devices, types of connection, modes of operation, combined ratings of all DERs at PCC, power system operating limits at ECP.

Table 5-3: Operational Characteristics at the ECP, LN (DOPR)

		DOPR Class	
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
ECPType	INS	Type of ECP: • Connection of one DER to local load • Connection of group of DERs to local EPS serving local load • Connection of local EPS with local load to area EPS (PCC) • Connection of local EPS without local load to area EPS (PCC)	M
PlntDER	LIST	List of DER MRIDs connected to the ECP	M
CktID	ING	Circuit Id at ECP	O
CktPhs	INS	Type of Circuit phases: 3 phase or single phase: A, B, C, Delta, Wye, Wye-grounded, Other	O
ECPWRtg	ASG	Nominal aggregated DER W rating at ECP	O
ECPVArRtg	ASG	Nominal aggregated DER VAr rating at ECP	O
ECPVLev	ASG	Nominal voltage level at ECP	O

		DOPR Class	
Attribute Name	**CDC**	**Explanation**	**M/O**
ECPHz	ASG	Nominal frequency at ECP	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. Specifically:

- PV mode sets both constant W and constant voltage
- PQ mode sets both constant VAr and constant voltage
- PF with voltage override mode sets both constant PF and constant voltage
- Constant W and VArs mode sets both constant W and constant VArs

Table 5-4: Operating Mode at the ECP, LN (DOPM)

		DOPM Class	
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
OpModPM	SPG	Mode of operation – driven by energy source (e.g. wind, solar, water flow)	O
OpModConW	SPG	Mode of operation – constant W	O
OpModConV	SPG	Mode of operation – constant voltage	O
OpModConVAr	SPG	Mode of operation – constant VArs	O
OpModConPF	SPG	Mode of operation – constant PF	O
OpModConExIm	SPG	Mode of operation – constant export/import	O
OpModConMaxVAr	SPG	Mode of operation – maximum VArs	O
OpModConVOv	SPG	Mode of operation – voltage override	O
OpModConPk	SPG	Mode of operation – peak load shaving	O

5.2.6 LN: Status Information at the ECP Name: DPST

This Logical Node provides the actual, real-time status and measurements at the ECP, including connection status of ECP, list of electrically connected DER units, 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.

Table 5-5: Status at the PCC, LN (DPST)

DPST Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
ECPConn	SPS	DER plant is or is not electrically connected at ECP	M
PlntDERConn	LIST	List of DER units currently electrically connected at this ECP	M
Measured Values			
TotWh	BCR	Total Watt-hours 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 DGEN LNs and/or DRCTs.

Table 5-6: DER Economic Dispatch Parameters, LN (DCCT)

DCCT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
HeatRteSt	CSD	Active heat rate curve characteristic	O
Settings			
CntctExpWLim	ASG	Contractual limit on export energy: W	O
CntctImpWLim	ASG	Contractual limit on import energy: W	O
CntctPF	ASG	Contractual power factor to be provided by DER	O
CntctHiV	ASG	Contractual voltage high limit	O
CntctLoV	ASG	Contractual voltage low limit	O
CntctAncil	ING	Ability to provide ancillary services • Load following • “Spinning” reserve • Operational reserve • Base load • Black start • Other	O
CntctPenalties	ASG	Penalties for violation of contractual agreements.	O

DCCT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
WSched	ARY[4]	Energy schedules	O
HeatRte	CURVE	Incremental heat rate curves	O
FuelCost	ARY	Table of fuel costs	O
MaintCost	ARY	Table of maintenance costs	O
StrCost	ASG	Cost to start up DER	O
StopCost	ASG	Cost to stop DER	O
RampCost	ASG	Cost to ramp DER	O
MaintSched	ARY	Table of maintenance schedules	O
AncSerSched	ARY	Ancillary Services schedule	O

[4] ARY is a new CDC for an array.

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, ratings, etc
- **MMXU**: DER self serve active and reactive power measurements

5.3.2 LN: DER Controller Characteristics Name: DRCT

The DER Controller Logical Node defines the characteristics of the environment of one DER device or aggregations of one type of DER device with a single controller.

Table 5-7: DER Unit Controller, LN DRCT

DRCT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
ECPConn	SPS	Connected to the ECP	O
AutoMan	SPS	Automatic or Manual mode: Automatic; Manual	M
OpModOnConn	SPS	Operational mode: On and connected	M
OpModOnAvail	SPS	Operational mode: On and available for connection	M
OpModOnUnav	SPS	Operational mode: On but not available for connection	O
OpModOffAvail	SPS	Operational mode: Off but available to start	O
OpModOffUnav	SPS	Operational mode: Off and not available to start	M
OpModTest	SPS	Operational mode: Test mode	O
OpModStr	SPS	Operational mode: Starting up	O
OpModStop	SPS	Operational mode: Stopping/shutting down	O
SeqSt	INS	Status of the sequencer	O
SeqPos	INS	Sequence active position or step	O
LodModBase	SPS	Base load	O
LodModLodFol	SPS	Load following	O
LodModFxExp	SPS	Fixed export	O
LodModAvail	SPS	Available	O

DRCT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
DCPowStat	SPS	DC power status: Power not on; Power on	O
Measured Values			
FltRate	MV	Fault rates of DER: Percent	O
SelfServWh	MV	Actual self service watt-hours	O
Controls			
GnSync	SPC	Starts synchronizing generator to EPS	O
EmgStop	DPC	Remote emergency stop	O
FltAck	SPC	Acknowledge fault clearing	O
ECPConnCtl	DPC	Connects DER to the ECP, or disconnects DER from the ECP	O
AutoManCtl	SPC	Sets operations mode to automatic or manual	M
OpModAvailCtl	SPC	Sets operational mode: is or is not available	M
OpModOffCtl	SPC	Sets operational mode: off-line	O
DERStr	SPC	Start DER device or sequencer	O
DERStop	SPC	Stop DER device or sequencer	O
OpModTestCtl	SPC	Sets operational mode: test mode	O
LodModBaseCtl	SPC	Sets “base load” load mode	O
LodModLodFolCtl	SPC	Sets “load following” load mode	O
LodModFxExpCtl	SPC	Sets “fixed export” load mode	O
LodModAvailCtl	SPC	Sets “available” for connection to load	O
DCPowStatCtl	SPC	DC power control	O
OpTimRs	SPC	Reset operational time	O
Control Settings			
DeRteTarg	ASG	Derated load target %	O
OutWSet	ASG	Output target watts setpoint	O
OutVArSet	ASG	Output VAr target setpoint	O
ImExSet	ASG	Setpoint for maintaining constant import/export at ECP	O
OutPFSet	ASG	Setpoint for maintaining fixed power factor	O
OutHzSet	ASG	Setpoint for maintaining fixed frequency: Frequency value {offset}	O
OutVSet	ASG	Voltage setpoint for maintaining fixed voltage level: Voltage value {% offset}	O
StrDlTms	ASG	Time delay before starting: Seconds	O
StopDlTms	ASG	Time delay before stopping: Seconds	O
MaxVArLim	ASG	Max output VAr	O
LodRamp	ASG	Ramp load or unload rate	O
LodShutDown	ASG	Load Shut Down: Stop/Don’t Stop	O
LodShareRamp	ASG	Load Share/Don’t share	O
LodWPct	ASG	% load watts	O
Settings			
DERId	MRID	Master Resource Id of DER device	M

5.4 Logical Nodes for DER Generation Logical Device

5.4.1 DER Generator Logical Device (Informative)

Each DER unit has a generator. Although each type of DER 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
- **DREX**: DER excitation ratings
- **DEXC**: Excitation component of generator
- **RSYN**: Synchronization (See IEC 61850-7-4 with expected enhancements)
- **DCST**: Costs associated with generator operations

5.4.2 LN: DER Unit Generator Name: DGEN

The DER unit generator Logical Node defines the actual state of DER generator.

Table 5-8: DER Unit Generator, LN (DGEN)

DGEN Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	SPS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment name plate	M
OpTmh	INS	Operation time	O
Status Information			
GnSt	SPS	Generator is on or is off	M

DGEN Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
GnOpSt	INS	Generation operational state: starting up, shutting down, ramping, at disconnect level: 1 = Starting up 2 = Shutting down 3 = At disconnect level 4 = kW ramping 5 = kVar ramping	O
GnSync	INS	Generator is synchronized to EPS, or not	O
ParlSt	SPS	Paralleling status: Standby; Paralleling	O
GnAlm	ALM	Generation alarms: high/low voltage, high/low current, high/low frequency, emergency trip, etc: 1 = High voltage alarm 2 = Low voltage alarm 3 = High current alarm 4 = Low current alarm 5 = High frequency alarm 6 = Low frequency alarm 7 = Emergency trip alarm 8 = Generator invalidly moved by prime mover	M
DroopV	SPS	Voltage droop status: Droop not enabled; Droop enabled	O
RampLodSw	SPS	Ramp Load/Unload Switch	
DCPowSt	SPS	DC Power On/Off Status	O
OpTms	INS	Total time generator has operated: Accumulated time in seconds since the last time the counter was reset	O
GnOnCnt	INS	The number of times that the generator has been turned on: Count of “generator on” times, since the last time the counter was reset	O
Measured Values			
TotWh	MV	Total Watt hours delivered	O
PerWh	MV	Watt hours in period since last reset	
TotStrCnt	CTE	Count of total number of starts	O
PerStrCnt	CTE	Count of starts in period since reset	O
GnOpTmms	MV	Elapsed time in msec as the generator becomes ready after the GenOnOff command was issued: Value = Elapsed milliseconds max = maximum time before issuing a start-failure alarm	O
GnStbTmms	MV	Timer for stabilization time: Value = Elapsed milliseconds max = maximum time before issuing a stabilization-failure alarm	O
GnCoolDnTmms	MV	Timer for generator to cool down: Value = Elapsed milliseconds min = minimum time for cool down	O
AVR	MV	Automatic voltage regulator % duty cycle	O
GnH	HMV	Generator harmonics	O
Controls			
GnCtl	DPC	Starts or stops the generator	O
GnRL	DPC	Raises or lowers the generation level by steps	O

DGEN Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
GnBlk	SPC	Set generator as blocked from being turned on	O
Settings			
DEROwn	DOO	Owner and operator of device	O

5.4.3 LN: DER Generator Ratings Name: DRAT

The following Logical Node defines the DER basic generator ratings.

Table 5-9: DER Basic Generator Ratings, LN (DRAT)

DRAT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
DEROwn	DOO	Owner and operator of device	O
DERId	MRID	Master Resource Id of DER device	M
DERTyp	INS	Type of DER device	M
ConnTyp	INS	Type of connection: 3-phase or single phase, Delta, Wye	M
VRtg	MV	Voltage level rating	M
ARtg	MV	Current rating under nominal voltage under nominal power factor	M
HzRtg	MV	Nominal frequency	M
TmpRtg	MV	Max temperature rating: Kelvin	O
FltRtg	MV	Exposure to fault rates – nominal percent	O
FltARtg	MV	Max fault current rating: Amps	O
FltDurRtg	INS	Max fault duration rating: Seconds	O
ArmFltRat	MV	Max armature short circuit rating ratio	O
VARtg	MV	Max volt-amps rating	O
WRtg	MV	Max watt rating	O
VAVArRtg	MV	Max var rating	O
MaxLodRampRtg	INS	Max load ramp rate: Watts per second	O
MaxUnlodRampRtg	INS	Max unload ramp rate: Watts per second	O
EmgRampRtg	INS	Emergency ramp rate: Watts per second	O
MaxWOut	MV	Max Watt output	O
WRtg	MV	Rated Watts	O
MinWOut	MV	Min Watt output	O

DRAT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
MaxVArOut	MV	Max VAr output	O
RotDir	INS	Rotation direction: ABC or CBA	O
GnDisconnLevW	INS	Generator disconnect level: Watts	O
GnLodDrpV	INS	Generator load droop setting: Volts per amp (ohms)	O
GnLodDrpHz	INS	Generator load droop setting: Hz per Watt	O
RBasLodSetRtg	INS	Raise baseload setpoint rate: Watts	O
LBasLodSetRtg	INS	Lower baseload setpoint rate: Watts	O
GndZ	CMV	Grounding impedance: Z	O
PowStab	INS	Power System stabilizer present: Value = yes, no	M
SelfV	MV	Self-service voltage;	O
SelfW	MV	Self-service nominal kW;	O
SelfPF	MV	Self-service nominal PF;	O
SelfVRng	MV	Self-service acceptable voltage range.	O

5.4.4 LN: DER Advanced Generator Ratings Name: DRAZ

The following Logical Node defines the DER advanced generator ratings.

Table 5-10: DER Advanced Generator Ratings, LN (DRAZ)

DRAZ Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
PQVLimCrvSt	CSD	Active curve characteristics for PQV curve	O
ALimCrvSt	CSD	Active curve characteristics for Amp limit curve	O
Settings			
PFRtgGn	MV	Power factor rating generating: Cosθ	O
PFRtgAbs	MV	Power factor rating absorbing: Cosθ	O
SynZ	CMV	Synchronous Impedance; Z	O
TransZ	CMV	Transient impedance; Z	O
SubTransZ	CMV	Subtransient Direct Axis impedance; Z	O
SubTransQuadZ	CMV	Subtransient Quadrature Axis impedance: Z	O
NegSeqZ	CMV	Negative Sequence Impedance: Z	O
ZerSeqZ	CMV	Zero Sequence Impedance: Z	O

DRAZ Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
OpCirTransDirAxisTms	MV	Open Circuit Transient Direct Axis Time constants: Seconds	O
ShCirTransTms	MV	Short Circuit Subtransient Direct Axis Time constants: Seconds	O
OpCirTransQuadTms	MV	Open Circuit Subtransient Quadrature Axis Time constants: Seconds	O
ShCirTransQuadTms	MV	Short Circuit Subtransient Quadrature Axis Time constants: Seconds	O
InertiaTms	MV	Time for response to fault current (MW * seconds / MVA): Seconds	O
PQVLimCrv	Curve	Real Power-Reactive Power-Voltage dependency curve	O
ALimCrv	Curve	Table 10 x 10 - may only be for fuel cells, but will see	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
THD	THD	DER THD: From IEEE 1547 - voltage THD, current THD, different harmonics	O
ImpactHzPct	MV	Frequency impact on the DER output: Percentage	O
HACrv	HMV	Table of current harmonics dependencies on DER operations: Ranges of harmonics and percentage of electrical pollution	O
HVCrv	HMV	Table of voltage harmonics dependencies on DER operations: Ranges of harmonics and percentage of electrical pollution	O
GnPID	PID	Proportional, integral, and derivative gain parameters for automatic voltage regulator (AVR):	O
ChgLimV	MV	Rapid voltage changes: Limits on % of voltage	O
ChgLimAng	MV	Rapid angle changes: Limits on degrees	O
ChgLimRatAng	MV	Rate of angle change: Limits on degrees per second	O

5.4.5 LN: Generator Costs Name: DCST

The generator costs Logical Node provides the related cost 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.

Table 5-11: Generator Costs, LN DCST

DCST Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
HeatRteCostSt	CSD	Active curve characteristics for the incremental heat rate curve	O
Settings			
HeatRteCost	CURVE	Costs associated with each segment in an incremental heat rate curve	O
CostRamp	MV	$ for ramping	O
CostStart	MV	$ for starting generator	O
CostStop	MV	$ for stopping generator	O

5.5 Logical Nodes for DER Excitation Logical Device

5.5.1 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

5.5.2 LN: Excitation Ratings Name: DREX

The following Logical Node defines the DER excitation ratings.

Table 5-12: Excitation Ratings, LN (DREX)

DREX Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	SPS	Local operation	O
EEHealth	INS	External equipment health	M

DREX Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
EEName	DPL	External equipment name plate	M
OpTmh	INS	Operation time	O
Settings			
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
ExtForc	ING	Forced excitation: Yes/no	O
ExtANoLod	MV	Excitation current no load;	O
ExtAatPF	MV	Excitation current at rated PF;	O
ExtInertia	MV	Excitation inertia constant: Seconds	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

5.5.3 LN: Excitation Name: DEXC

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

Table 5-13: Excitation, LN (DEXC)

DEXC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
GenExcit	SPS	Excitation state: **Excitation off; Excitation on**	M
FlshAlm	SPS	Field flashing failure	O
PwrSupAlm	SPS	Power system failure	O
DCAlm	SPS	DC system failure	O
ACAlm	SPS	AC system failure	O
UPSAlm	SPS	UPS failure	O
BlkA	SPS	Operation blocked due to current	O
BlkV	SPS	Operation blocked due to voltage	O

DEXC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
MaxHiVLim	SPS	Maximum allowed voltage set-point reached	
MaxLoVLim	SPS	Minimum allowed voltage set-point reached	
Control Settings			
PIDVCtr	PID	Configuration parameters for voltage control algorithm	
SetV	ASG	Voltage set-point	
ExtGain	ASG	Power stabilizer exciter gain setting	O
PhaseLeadComp	ASG	Power system stabilizer phase lead compensation	O
StabSigWash	ASG	Power system stabilizer signal washout	O
StabGain	ASG	Power system stabilizer gain	O
ExtCeilV	ASG	Forced excitation ceiling voltage	O
ExtCeilA	ASG	Forced excitation ceiling amps	O
ExtVTms	ASG	Forced excitation voltage time response: Seconds	O
ExtVDurTms	ASG	Forced excitation duration of ceiling voltage: Seconds	O
Settings			
DEROwn	DOO	Owner and operator of device	O
DERLoc	GPS	GPS location of device	O

{fmc Review data object names to see if they can be made the same as WG18}

5.6 Logical Nodes for DER Inverter/Converter Logical Device

5.6.1 Inverter/Converter Logical Device (Informative)

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:

- **YRCT**: Rectifier for converting alternating current to continuous, direct current (AC -> DC)
- **YINV**: Inverter for converting direct current to alternating current (DC -> AC)
- **MMXN**: Measurement of intermediate DC
- **MMXU**: Measurements of input AC (See IEC 61850-7-4)
- **MMXU**: Measurements of output AC (See IEC 61850-7-4)

5.6.2 LN: Rectifier Name: YRCT

The YRCT logical node defines the characteristics of the rectifier, which converts generator output AC to intermediate DC. {The different data items in the rectifier versus the inverter needs to be reviewed by an expert}

Table 5-14: Rectifier, LN (YRCT)

YRCT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	SPS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment name plate	M
OpTmh	INS	Operation time	O
Settings			
CmutTyp	ING	Type of commutation: Line commutated or self commutated	O
IsoTyp	ING	Type of isolation: • Low frequency transformer isolated • Hi frequency transformer isolated • Non-isolated, grounded • Non-isolated, isolated DC source • Other	O
Control Settings			
OutWSet	ASG	Output power setpoint	O
InALim	ASG	Input current limit	O
InVLim	ASG	Input voltage limit	O

5.6.3 LN: Inverter Name: YINV

The YINV 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.

Table 5-15: Inverter, LN (YINV)

YINV Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	SPS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment name plate	M
OpTmh	INS	Operation time	O

YINV Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
Status Information			
PQVLimSt	CSD	Active curve characteristic for PQV Limit	O
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
Control Settings			
OutWSet	ASG	Output power setpoint	O
OutVArSet	ASG	Output reactive power setpoint	O
OutPFSet	ASG	Power factor setpoint: Cosθ	O
OutHzSet	ASG	Frequency setpoint	O
InALim	ASG	Input current limit	O
InVLim	ASG	Input voltage limit	O
Settings			
CmutTyp	ING	Type of commutation: • Line commutated • Self commutated	O
IsoTyp	ING	Type of isolation: • Low frequency transformer isolated • Hi frequency transformer isolated • Non-isolated, grounded • Non-isolated, isolated DC source • Other	O
SwPer	ASG	Periodicity of switching	M
SwTyp	ING	Switch type: • Field Effect Transistor • Insulated Gate Bipolar Transistor • Thyristor • Gate Turn Off Thyristor • Other ….	M
GriMod	ING	Power system connect modes: • Current control (Norton model) • Voltage droop control (Thevenin model) • Combined	O
FanSpdSet	MV	Fan speed setting	O
PQVLim	CURVE	P-Q-V Limiting Curve	O

6 Logical Nodes for Specific Types of DER

6.1 Logical Nodes for Reciprocating Engine Logical Device

6.1.1 Reciprocating Engine Description (Informative)

A reciprocating engine is an engine that utilizes one or more pistons in order to convert pressure into a rotating motion.

Today 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 (see Figure 6-1). This figure illustrates the components of a typical, four stroke cycle, DOHC reciprocating engine: (E) Exhaust camshaft, (I) Intake camshaft, (S) Spark plug, (V) Valves, (P) Piston, (R) Connecting rod, (C) Crankshaft, (W) Water jacket for coolant flow.

There may be one or more pistons. Each piston is located inside a cylinder, into which a fuel and air mixture is introduced, and then ignited. The now hot gases expand, pushing the piston away. The linear movement of the piston is converted to a circular movement via a connecting rod and a crankshaft. The more cylinders a piston engine has, the more power it is capable of producing, so it is common for such engines to be classified by the number and alignment of cylinders. Single- and two-cylinder engines are common in smaller vehicles such as motorcycles; automobiles, locomotives, and ships may have a dozen cylinders or more. These engines are known collectively as internal-combustion engines, although internal-combustion engines do not necessarily contain pistons.

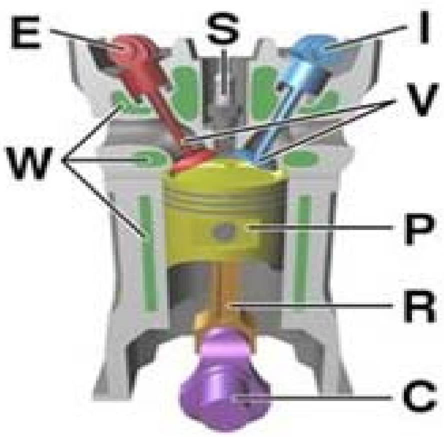


Figure 6-1: Reciprocating engine *(Wikipedia)*

6.1.2 Reciprocating Engine Logical Device (Informative)

The LNs in this section cover the object models for the reciprocating engine energy converter. Figure 6-2 illustrates the LNs in a reciprocating engine system.

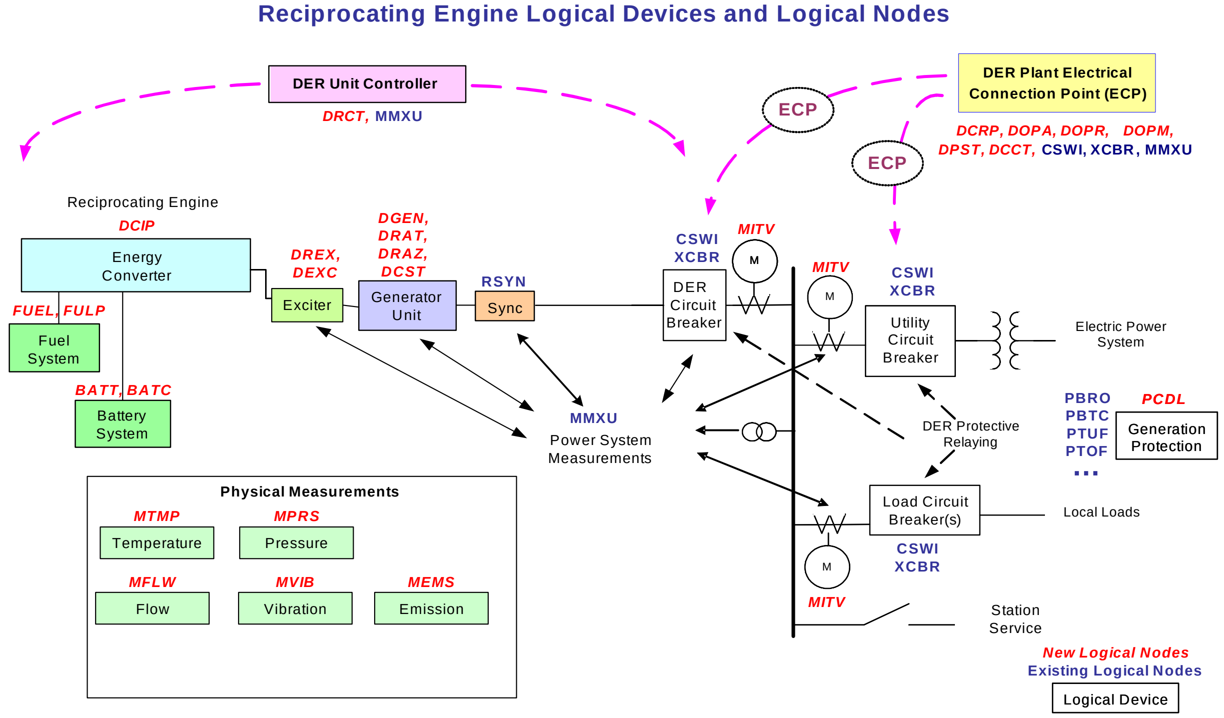


Figure 6-2: LNs in a Reciprocating Engine System (e.g. Diesel Gen-Set)

The Logical Nodes in the reciprocating engine logical device include:

- **DCIP**: Reciprocating engine characteristics, measured values, and controls
- **DRCT**: DER general controller characteristics (see Clause 5.3.2)
- **MITV**: Metering information (see Clause 7.1.2)
- **FUEL**: Fuel characteristics (see Clause 7.2.2)
- **BATT**: Auxiliary battery (see Clause 7.3.2)
- **BATC**: Auxiliary battery charger (see Clause 7.3.3)
- **MTMP**: Temperature characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, lubrication (oil), after-cooler, etc. (see Clause 7.4.2)
- **MPRS**: Pressure characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (see Clause 7.4.3)
- **MFLW**: Flow characteristics, including coolant, lubrication, etc. (see Clause 7.4.5)
- **MEMS**: Emissions characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (see Clause 7.4.6)
- **MVIB**: Vibration characteristics (See Clause 7.4.6)

6.1.3 LN: Reciprocating Engine Name: DCIP

The reciprocating engine characteristics covered in the DCIP logical node reflect those required for remote monitoring of critical reciprocating engine functions and states. The DCIP LN attributes contain strictly non-electrical objects, even though typically a diesel genset consists of a combined diesel engine and generator.

Table 6-1: Reciprocating Engine, LN (DCIP)

DCIP Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	SPS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment name plate	M
OpCntRs	INC	Operation counter resettable	O
OpCnt	INS	Operation counter	O
OpTmh	INS	Operation time	O
Status Information			
EngOnOff	SPS	Engine is on or is off	M
SpdDroop	SPS	Speed droop status: Disabled; enabled	O
HeatRteCrvSt	CSD	Active characteristic of heat rate curve	O
Measured Values			
EngRPM	ANV	Engine speed: Speed in revolutions per minute	O
EngTrq	MV	Engine torque: Newton-meters	O
EngTimDeg	MV	Engine timing: Degrees BTDC (before top dead center)	O
BlowFlow	MV	Blowby flow: m/s	O
Controls			
EngCtl	DPC	Start / stop engine	M
CrankCtl	DPC	On / Off Crank relay driver command	O
EmrgCtl	DPC	Emergency start / stop diesel engine	O
DiagEna	DPC	Diagnostic mode enable	O
Control Setpoints			
TrgSpd	SPV	Final target engine speed: rpm	O
EngTrqSet	APC	Desired engine torque: Newton-meter	O
DrpAdj	APC	Droop adjustment: %	O
Settings			
DERId	MRID	Identity of reciprocating engine	M
MinSpd	ASG	Min speed	O
MaxSpd	ASG	Max speed	O
HeatRteCrv	CURVE	Heat rate curves	O

6.2 Logical Nodes for Fuel Cell Logical Device

6.2.1 Fuel Cell Description (Informative)

A fuel cell is an electrochemical energy conversion device similar to a battery, but differing from the latter in that it is designed for continuous replenishment of the reactants consumed; i.e. it produces electricity from an external supply of fuel and oxygen as opposed to the limited internal energy storage capacity of a battery. Additionally, the electrodes within a battery react and change as a battery is charged or discharged, whereas a fuel cell's electrodes are catalytic and relatively stable. A diagram of a fuel cell is shown in Figure 6-3.

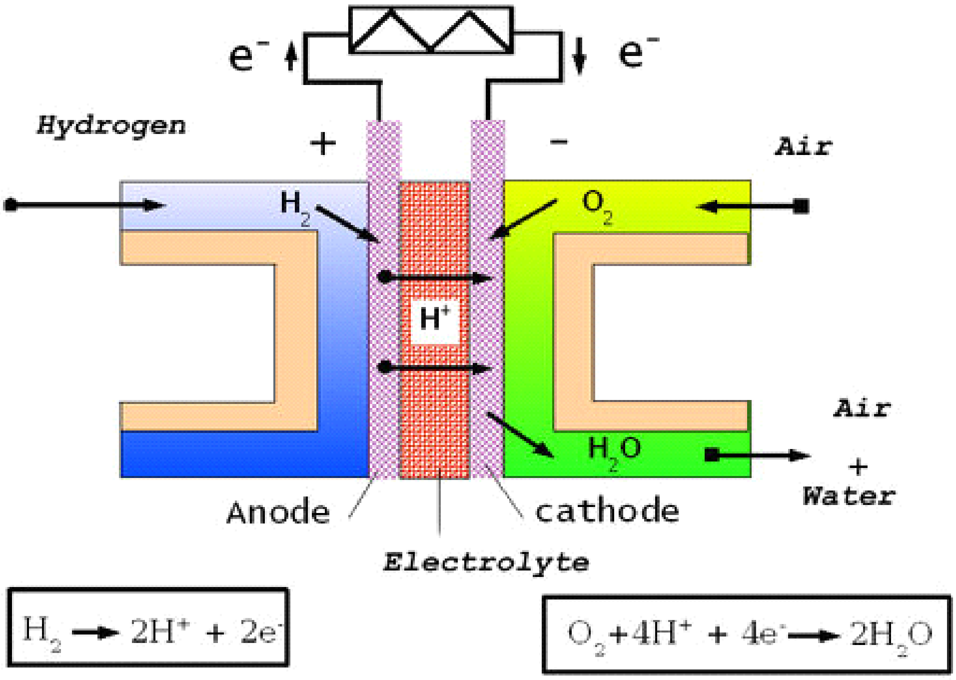


Figure 6-3: Fuel cell – Hydrogen/oxygen proton-exchange membrane fuel cell (PEMFC) (*Wikipedia)*

A typical fuel cell produces about 0.8 volts. 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 6-4). The number of cells used is usually greater than 45 and varies with design. The theoretical voltage of a fuel cell is 1.23 volts, at a temperature of 25°C. This voltage depends on the fuel used, quality and temperature of the cell.

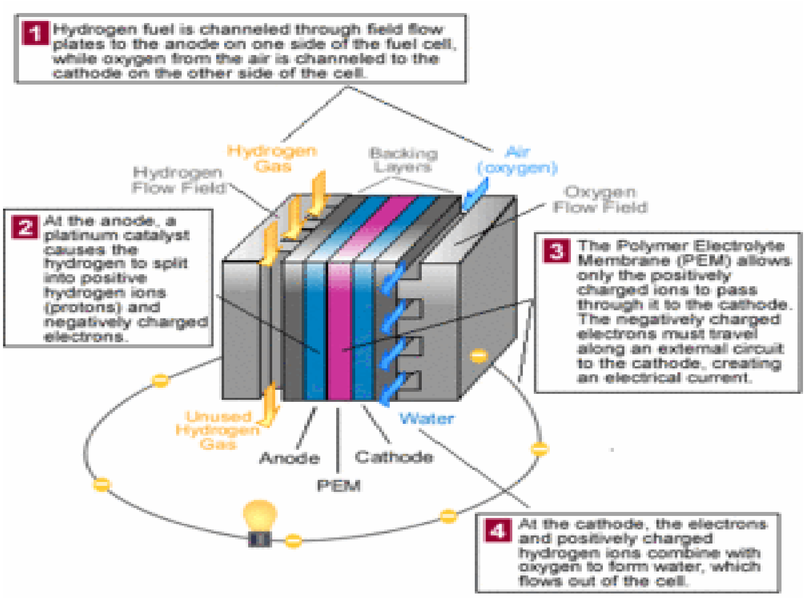


Figure 6-4: Fuel Cell Stack

6.2.2 *Fuel Cell Logical Device (Informative)*

The LNs in this section describe the object models for the fuel cell as a prime mover. Figure 6-5 illustrates the LNs used in a Fuel Cell system.

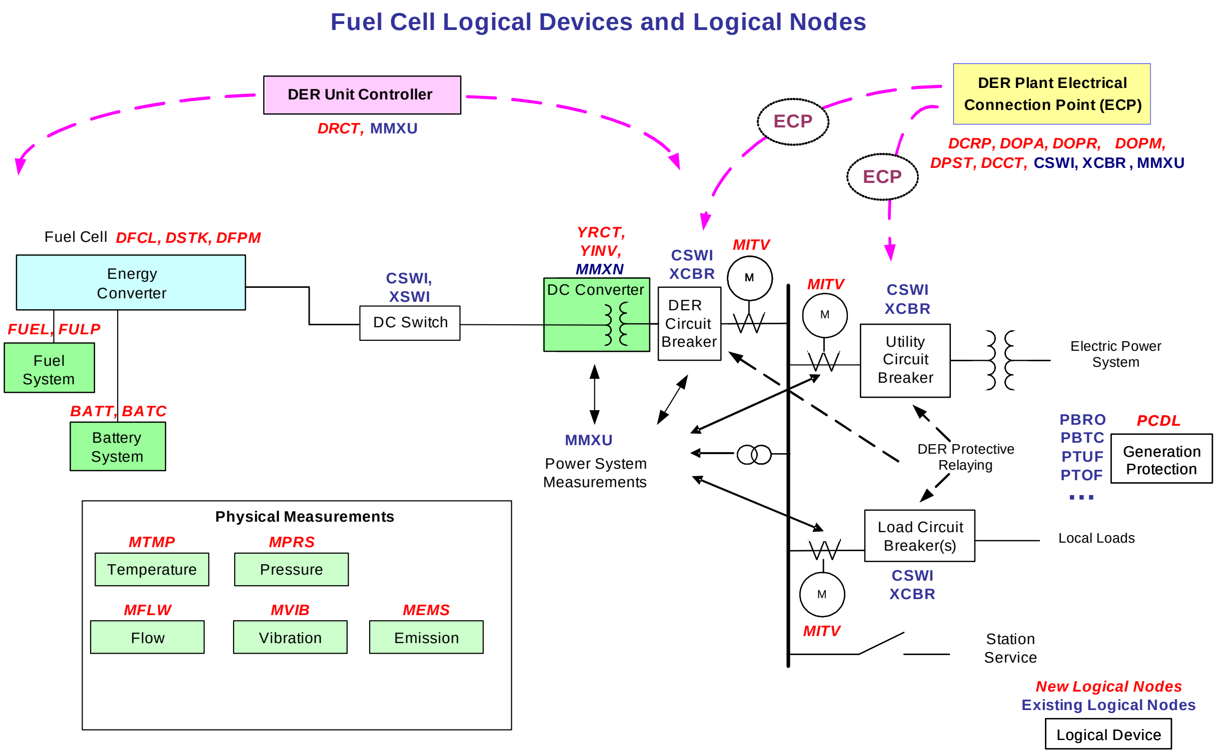


Figure 6-5: LNs Used in a Fuel Cell System

The fuel cell logical device would include the following LNs:

- **DFCL**: Fuel cell controller characteristics. These are the fuel cell specific characteristics which are not in DRCT
- **DSTK**: Fuel cell stack
- **DFPM**: Fuel processing module
- **CSWI**: Switch between fuel cell and inverter (see IEC 61850-7-4)
- **YINV**: Inverter (see Clause 5.6.3)
- **MMXU**: Output electrical measurements (see IEC 61850-7-4)
- **MMXN**: Measurement of intermediate DC
- **DRCT**: DER general controller characteristics (see Clause 5.3.2)
- **MITV**: Metering information (see Clause 7.1.2)
- **FUEL**: Fuel characteristics (See Clause 7.2.2)
- **BATT**: Auxiliary battery (See Clause 7.3.2)
- **BATC**: Auxiliary battery charger (See Clause 7.3.3)
- **MTMP**: Temperature characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), etc. (See Clause 7.4.2)
- **MPRS**: Pressure characteristics, including intake (e.g. air, oxygen, water), exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (See Clause 7.4.3)
- **MEMS**: Emissions characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), after-cooler, etc. (See Clause 7.4.6)
- **MVIB**: Vibration characteristics (See Clause 7.4.6)

6.2.3 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.

Table 6-2: Fuel Cell Controller, LN (DFCL)

DFCL Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	
Loc	SPS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment name plate	M
OpTmh	INS	Operation time	O
Status Information			
StrCnt	INS	Count of system starts since last reset	O

DFCL Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
ConnGriCnt	INS	Count of reconnections to power system	O
Measured Values			
LifeRunTms	MV	Lifetime system run time: seconds	O
LifeWh	MV	Lifetime system run energy: W-hrs	O
FuelCsump	MV	Input fuel consumption (lifetime): Liters	
WtrCsump	MV	Input water consumption (lifetime): Liters	O
MaintTms	MV	Time until next maintenance: Seconds	O
LifeEfcPct	MV	Efficiency Estimate (lifetime): %	O
InstEfcPct	MV	Instantaneous Efficiency Estimate: %	O
InOxFlwRte	MV	Input air or oxygen flow rate: cubic meters/ second	O
WtrLev	MV	Water level remaining: Liters or Meters (?)	O
OutHydFlwRte	MV	Output Hydrogen flow rate: liters/sec^2	O
OutHydLev	MV	Output Hydrogen level: Liters	
WtrCndv	MV	Water conductivity: {?}	O
Controls			
FuelShut	DPC	Open / Close fuel valve driver command	O
EmrgCtl	DPC	Start / Stop emergency stop fuel cell	O
Control Setpoints			
ALim	ASG	Input current limit	O
VLim	ASG	Input voltage limit	O
Settings			
DerId	MRID	Identity of the fuel cell	M
GriIndWRtg	ASG	System power system independent output power rating: Watt	M
GriDepRtg	ASG	System power system dependent output power rating: Watt	O
VRtg	ASG	System output voltage rating	O
HzRtg	ASG	System output frequency rating	O
PhRtg	ING	System output phase rating: Single phase or 3 phase	O
FuelTyp	ING	System input fuel type	O
FuelCsumpRte	ASG	System maximum fuel consumption rate: Liters per second	O
EfcPct	ASG	System average efficiency: %	O

6.2.4 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.

Table 6-3: Fuel Cell Stack, LN (DSTK)

DSTK Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	
Status Information			
StkSt	SPS	On / Off stack state	M
CellVTrCnt	INS	Count of cell low voltage trips	O
Measured Values			
StkLodTms	MV	Accumulated stack load time: Seconds	O
StkWh	MV	Accumulated stack energy: W-secs	O
MaintTms	MV	Time until next maintenance: Seconds	O
InstStkEfcPct	MV	Instantaneous stack efficiency: %	O
OutDCV	MV	Stack voltage: DC volts	M
OutDCA	MV	Stack direct current	M
InCoolTmp	MV	Stack Inlet Coolant temperature: C	O
OutCoolTmp	MV	Stack Outlet Coolant temperature: C	O
CoolFlwRte	MV	Coolant Flow Rate: cubic meters/second	O
CoolPres	MV	Coolant Inlet Pressure: Pascal, Bar, or mBar(?)	O
HydFlwRte	MV	Hydrogen (or reformate) flow rate: cubic meters/ second	O
InHydPres	MV	Inlet hydrogen pressure: Pascal, Bar, or mBar(?)	O
InOxFlwRte	MV	Input air or oxygen flow rate: cubic meters/ second	O
InOxPres	MV	Inlet oxidant pressure: Pascal, Bar, or mBar(?)	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

6.2.5 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 DFUL 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

Table 6-4: Fuel Cell Processing Module, LN (DFPM)

DFPM Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	
Status Information			
FPMSt	SPS	FPM state	M
Measured Values			
InAccWh	MV	Accumulated input energy: W-seconds	O
OutAccWh	MV	Accumulated output energy: W-seconds	O
ConvEfc	MV	Conversion efficiency	O
Settings			
ThmRtg	ASG	FPM output power rating (thermal)	O
InFuelTyp	ING	FPM input fuel type	O
OutFuelTyp	ING	FPM output fuel type: e.g. Hydrogen, Reformate	O

6.3 Logical Nodes for Photovoltaic System (PV) Logical Device

6.3.1 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.

The basic unit of photovoltaic conversion is a semiconductor device called the PV cell. A PV module is the smallest complete environmentally protected assembly of interconnected cells. These modules are themselves assembled to form a PV array. Basically, the PV array is considered to be a DC power supply unit. Modules can be connected in series (PV string), in parallel, or in a combination of series-parallel. In a large system, PV arrays are often divided into 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 interconnected with the power system. Therefore, there is no obligation to provide additional energy storage (e.g. battery system), although this may be included.

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 system have the added task of adjusting the current and voltage levels (DC) to maximize efficiency during changing solar irradiance and temperature condition. The optimal combination for a PV module is defined by a point called *maximum power point* (MPP) on the I-V curve. The temperature of the module is another important element that affects the power output.

Figure 6-6 illustrates a small interconnected PV system using multiple inverters. In this example, the PV arrays are composed of two modules.

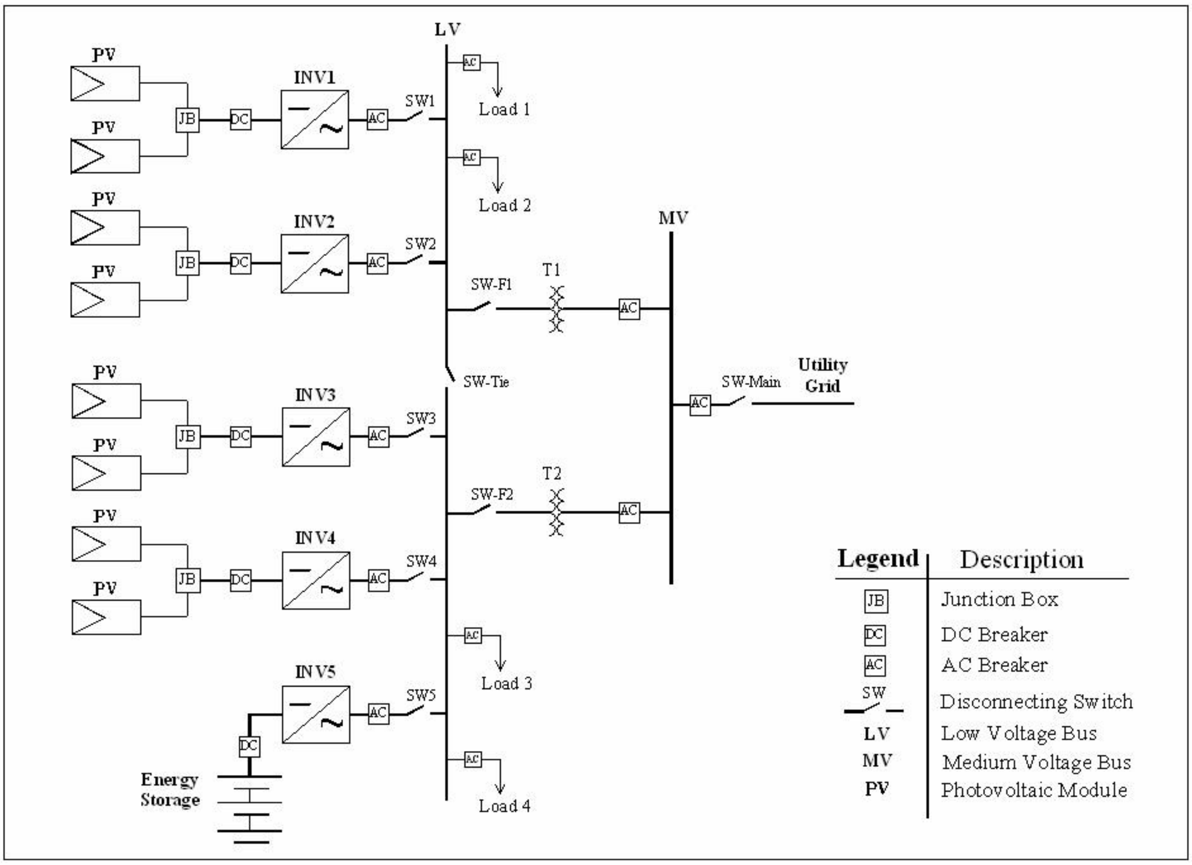


Figure 6-6: One line diagram of an interconnected PV system

A larger and more complex PV array can be used in a larger system. Figure 6-7 gives an illustration of such a PV system.

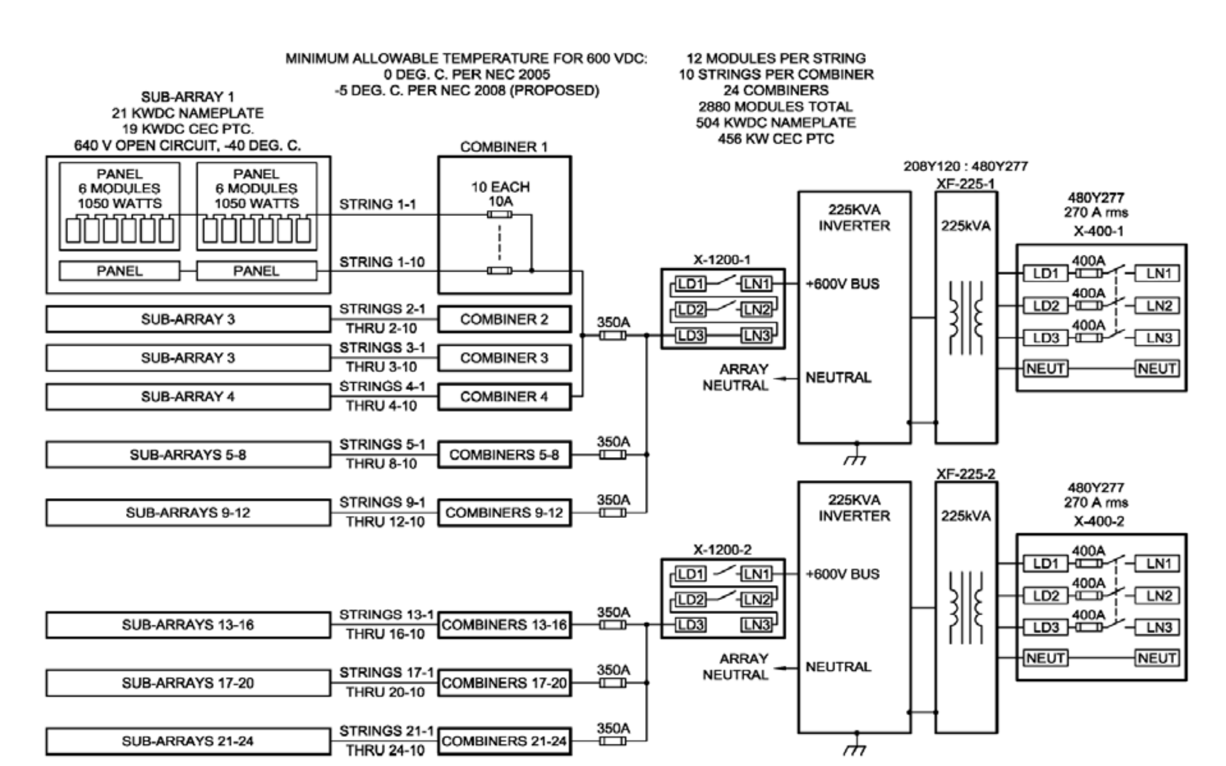


Figure 6-7: PV array diagram - large array divided in sub arrays

6.3.2 Photovoltaics System Logical Device (Informative)

The LNs in this section describe the object models for the photovoltaics system as a prime mover. Figure 6-8 illustrates these Logical Nodes associated with one configuration of a photovoltaics system, although actual implementations may vary, depending upon the system requirements.

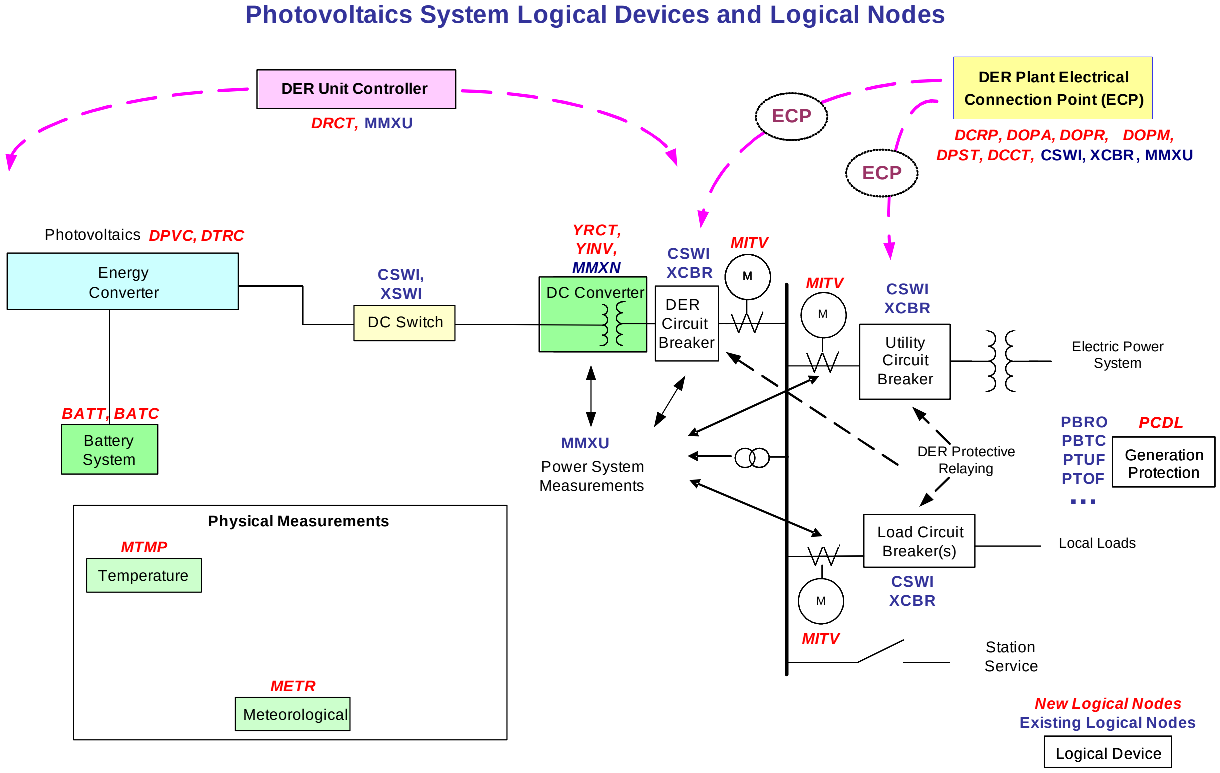


Figure 6-8: LNs Associated with a Photovoltaics System

Building a logical device to automate the operation of a PV system would require these functions:

- **Switchgear operation:** functions for the control and monitoring of breakers and disconnect devices. This is already covered in 61850-7-4 (XCBR, XSWI, CSWI…).
- **Protection:** functions required to protect the electrical equipment and personnel in case of a malfunction. Already covered in 61850-7-4 (PTOC, PTOV, PTTR…).
- **Measuring and metering:** functions required to obtain electrical measurements like voltage and current. AC measurements are already covered in 61850-7-4 (MMXU). DC measurements are covered as MMXN.
- **DC to AC conversion:** functions for the control and monitoring of the inverter. Covered in this standard (YINV).
- **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.
- **Cooling:** functions to control the temperature of the PV arrays. Covered in this standard (MTMP).
- **Islanding:** functions required to synchronize the PV system to the power system. Covered in this standard (DRCT, DROP). RSYN covered in IEC 61850-7-4
- **Energy storage:** functions required to store excess energy produced by the system. Energy storage in a PV system is usually done with batteries. Covered in this standard (BATT, BATC).
- **Environment monitoring:** functions required to obtain environmental measurement like solar irradiation and ambient temperature. Covered in this standard (METR).

The photovoltaics system logical device could include the following logical nodes:

- **DPVE**: PV Array engineering. Able to maximize the power output of the array. One instance of the logical node per array (or sub-array) in the PV system.
- **DPVC**: PV Array controller. Able to maximize the power output of the array. One instance of the logical node per array (or sub-array) in the PV system.
- **DTRC**: Tracking controller. Able to follow the sun movement. One instance of the logical node per PV system.
- **CSWI**: Switch between the PV system and the inverter (see IEC 61850-7-4)
- **YINV**: Inverter (see Clause 5.6.3)
- **MMXN**: Measurement of intermediate DC (see IEC 61850-7-4)
- **DRCT**: DER general controller characteristics (see Clause 5.3.2)
- **MMXU**: Electrical measurements (see IEC 61850-7-4)
- **MITV**: Metering information (see Clause 7.1.2)
- **BATT**: Battery if needed for energy storage (see Clause 7.3.2)
- **BATC**: Battery charger if needed for energy storage (see Clause 7.3.3)
- **MTMP**: Temperature characteristics (see Clause 7.4.2)
- **METR**: Meteorological measurements (see Clause 7.4.8)

6.3.3 LN: Photovoltaics Array Characteristics Name: DPVE

The photovoltaics array characteristics covered in the DPVE logical node describe the type and configuration of the PV array. For PV arrays without active tracking, the tilt of the array is a setting in this LN.

Table 6-5: Photovoltaic Array Characteristics, LN (DPVE)

DPVE Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	
Loc	SPS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment name plate	M
OpTmh	INS	Operation time	O
Status Information			
FuseSt	INS	Fuse status	O
ArrStow	INS	Array in stowed position	O
AVCrvSt	CSD	Active characteristic of AV curve	O
Settings			

DPVE Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
DERId	MRID	Master Resource Id of DER device	M
PvRtg	ASG	Ratings of the photovoltaic system: W-seconds	O
PvArrArea	ASG	Array area: meters^2	O
PvArrWRtg	ASG	Array power rating: W (W peak – W p)	O
PvArrTilt	MV	Array tilt: Degrees from horizontal	O
PvArrAziShade	ARY	Array of obstruction elevations vs azimuth: TBD	O
PvMat	ING	PV module material: • Silicon • Cadmium Telluride • Copper Indium Diselenide	O
PvTyp	ING	PV module type: • Single crystal • Amorphous • Other….	O
PvCfgTyp	ING	PV module configuration type: • Flat plate • Concentrating	O
MdulSerCnt	ING	Number of modules per series string	O
MdulParCnt	ING	Number of parallel strings of modules	O
AVCrv	CURVE	Amp-Volt curve	O
MdulWRtg	ASG	Module rated power: W peak; W	O
MaxMdulV	ASG	Module voltage at max power	O
MaxMdulA	ASG	Module current at max power	O
MdulOpnCircV	ASG	Module open circuit voltage	O
MdulSrtCircA	ASG	Module short circuit current	O
MdulTmpDerate	ASG	Module temperature/power derate: %/DegC above 25C	O
MdulFuseRtg	ASG	Module series fuse rating	O

6.3.4 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.

Table 6-6: Photovoltaic Array Controller, LN (DPVC)

DPVC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	
Loc	SPS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment name plate	M
OpTmh	INS	Operation time	O
Status Information			
FuseSt	INS	Fuse status	O
Controls			
ArrModCtr	INC	Mode selected to control the power output of the array. **Array Operating Mode** **Value** Series controller 1 Shunt controller 2 Maximum power point tracking (MPPT) 3 Automatic 4	O
Settings			
DERId	MRID	Master Resource Id of DER device	M
MdulFuseRtg	ASG	Module series fuse rating	O

6.3.5 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 orientations even if no active tracking is included.

Table 6-7: Tracking Controller, LN (DTRC)

DTRC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	INS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment nameplate	M

DTRC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
OpTmh	INS	Operation time	O
Status Information			
TrackAlm	SPS	Tracking alarm	O
Measured Values			
PvArrAziDegVal	MV	Array azimuth degrees from true north	O
PvArrElDegVal	MV	Array elevation degrees from horizontal	O
Controls			
TrackStow	INC	Go to stow position	O
Settings			
DERId	MRID	Master Resource Id of DER device	M
TrackTyp	ING	Tracking type (single axis or two axis)	M
PvArrAziDeg	ING	Array azimuth degrees from true north	O
PvArrElDeg	ING	Array azimuth elevation from horizontal	O
StowArrAziDeg	ING	Stow array azimuth degrees from true north	O
StowArrElDeg	ING	Stow array azimuth elevation from horizontal	O

6.4 Logical Nodes for Combined Heat and Power (CHP) Logical Device

6.4.1 Combined Heat and Power Description (Informative)

Combined Heat and Power (CHP) covers multiple types of generation systems involving heat. Different CHP purposes include:

- Heat is produced through an industrial process. 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.
- Fuel is burned in order to create heat (e.g. for heating buildings), and this heat is also used to generate electrical energy (e.g. gas /combustion turbine).
- Inexpensive 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 (ownership of different equipment, market interactions with respect to heat and energy, constraints on heat or electrical production, etc.). Figure 6-9 illustrates two configurations.

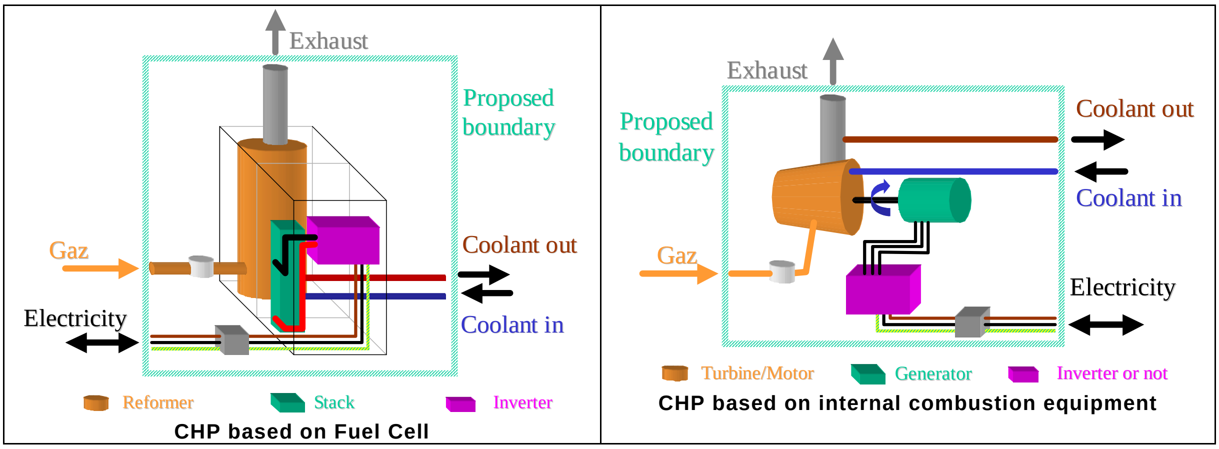


Figure 6-9: Two Examples of CHP Configurations

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. Object models of each of these different parts can then be created.

Figure 6-10, Figure 6-11, and Figure 6-12 below show three simple thermal facility scheme examples:

- In the first figure, heated water/steam from the heating system is used directly for the electricity generation system.
- In the second and third figures, 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 the third figure, 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.

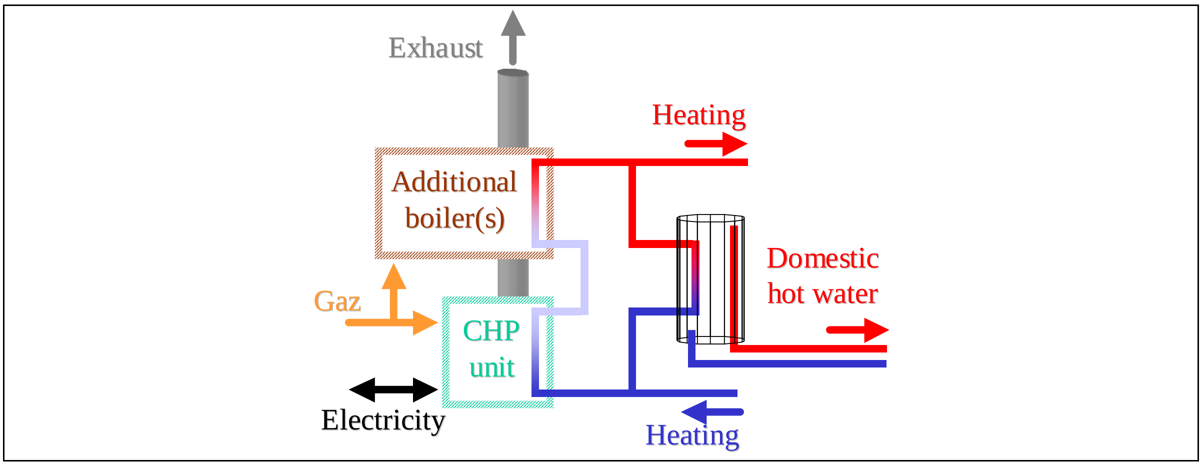
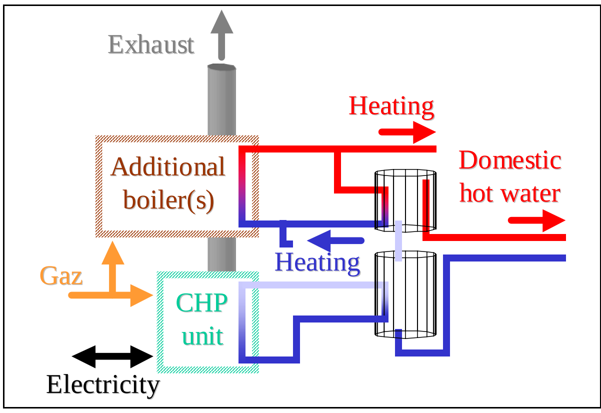


Figure 6-10: CHP unit includes both domestic hot water and heating loops



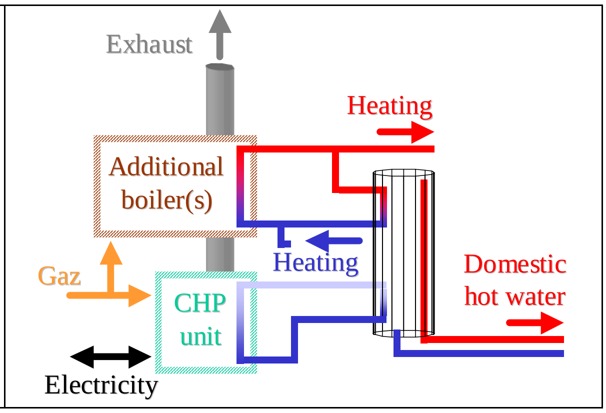


Figure 6-11: CHP unit includes domestic hot water with hybrid storage

Figure 6-12: 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, microturbine, and diesel engines). Some of these combinations are in different phases of development (from commercial to prototypes). 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 different Logical Nodes could be used in a CHP system, most of which are already existing or proposed for other DER systems. The LNs that may be unique to CHP are those which handle the “combined” aspect of CHP, along with the characteristics of the individual parts of the CHP system:

- Combined operations management
- Heat production and boiler systems
- Heat exchange systems
- Chimney and exhaust systems
- Cooling systems

6.4.2 *Combined Heat and Power Logical Device (Informative)*

The LNs in this section 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 6-13 illustrates the CHP Logical Nodes.

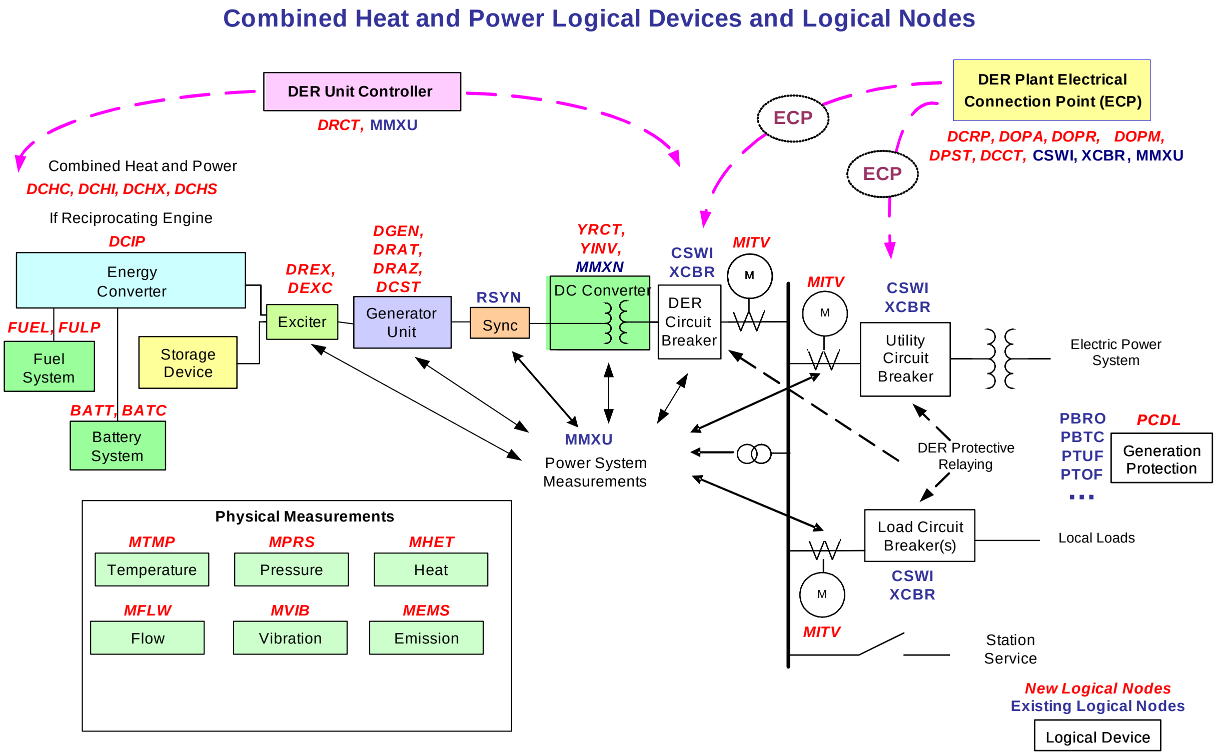


Figure 6-13: LNs Associated with a Combined Heat and Power (CHP) System

The Logical Devices probably used with a CHP Logical Device include:

- **DER Plant ECP:** electrical connection point of the DER plant to an electric power system, which could be local or interconnected to the power system.
- **DER Unit Controller**: general capabilities of the controller for any type of DER unit
- **DER Generation**: generator characteristics
- **DER Excitation**: exciter characteristics
- **DER *Energy Converter***, such as reciprocating engine, steam turbine, or fuel cell. (The Logical Nodes for a turbine have not been developed yet.)
- **DER Fuel System**: fuel system characteristics, including fuel pumps and costs

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
- **DCHI**: CHP chimney and exhaust

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[5] IEC 61850 object models for steam turbines, gas turbines, and microturbines have not yet been developed

- **DCHX**: CHP heat exchanger
- **DCHP**: CHP heat production
- **DCHC**: CHP coolant system
- **MMXU**: electrical measurements (see IEC 61850-7-4)
- **MITV**: Metering information (see Clause 7.1.2)
- **MTMP**: Temperature characteristics (see Clause 7.4.2)
- **MPRS**: Pressure measurements (see Clause 7.4.3)
- **MHET**: Heat and cooling measurements (see Clause 7.4.4)
- **MFLW**: Flow measurements (see Clause 7.4.5)
- **MVIB**: Vibration measurements (see Clause 7.4.6)
- **MEMS**: Emission measurements (see Clause 7.4.7)

6.4.3 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.

Table 6-8: CHP System Controller, LN (DCHC)

DCHC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Measured values			
HeatPwrEfc	MV	Heat to power efficiency	O
Settings			
DERId	MRID	Master Resource Id of DER device	M
HeatTyp	ING	Type of heating system • Water • Steam • Air	M
CoolTyp	ING	Type of cooling system	O
EnrgyConvTyp	ING	Type of energy converter • Gas turbine • Fuel cell • Reciprocating engine	M
GnTyp	ING	Type of generator • Rotating • Inverter	M

DCHC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
FuelTyp	ING	Type of fuel (see Table 7-2)	M
MaxHeatCap	ASG	Maximum heat capacity	O
CHPOpMod	ING	Operating modes of CHP • Heat-production driven • Electrical generation driven • Other	O

6.4.4 LN: Chimney and Exhaust Name: DCHI

This Logical Node describes the characteristics of the CHP chimney and exhaust systems.

Table 6-9: CHP Chimney, LN (DCHI)

DCHI Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
ChmTyp	ING	Type of chimney	M

What else belongs in DCHI that is not covered in MTMP, MPRS, MHET, MFLW, and MEMS? Alternatively, should additional objects be added to those LNs to cover items needed by DCHI?

6.4.5 LN: Heat Exchanger Name: DCHX

This Logical Node describes the characteristics of the CHP heat exchanger.

Table 6-10: CHP Heat Exchanger, LN (DCHX)

DCHX Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
HeatExTyp	ING	Type of heat exchanger	M

What else belongs in DCHX that is not covered in MTMP, MPRS, MHET, MFLW, and MEMS? Alternatively, should additional objects be added to those LNs to cover items needed by DCHX?

6.4.6 LN: Heat Storage Name: DCHS

This Logical Node describes the characteristics of the CHP heat storage.

Table 6-11: CHP Heat Storage, LN (DCHS)

DCHS Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
HeatStoTyp	ING	Type of heat storage	M

What else belongs in DCHS that is not covered in MTMP, MPRS, MHET, MFLW, and MEMS? Alternatively, should additional objects be added to those LNs to cover items needed by DCHS?

6.4.7 LN: Coolant System Name: DCHC

This Logical Node describes the characteristics of the CHP coolant system.

Table 6-12: CHP Coolant System, LN (DCHC)

DCHC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Settings			
CoolTyp	ING	Type of coolant system	M

What else belongs in DCHC that is not covered in MTMP, MPRS, MHET, MFLW, and MEMS? Alternatively, should additional objects be added to those LNs to cover items needed by DCHC?

7 Logical Nodes for Auxiliary Systems

7.1 Logical Nodes for Interval Metering Logical Device

7.1.1 Interval Metering Logical Device (Informative)

7.1.2 LN: Interval Revenue Metering Name: MITV

This Logical Node provides interval revenue metering information at the PCC, including interval lengths, readings per interval, etc. It is derived directly from the ANSI C12.19 metering specifications, but uses only the tables necessary for revenue metering. If any discrepancy in the meaning of objects is found, then the ANSI C12.19 meanings should be taken as correct.

{The following LN was derived from the Ashrae Research Project 1011-RP, but modified to be more IEC 61850 conformant. Although an interval revenue metering LN is needed for DER, it is expected that this metering LN will be required and expanded upon in other efforts, and should not be necessarily associated with DER. Therefore, it is recommended that eventually the Metering LNs be handled separately.}

Table 7-1: Interval Revenue Metering, LN (MITV)

		MITV Class	
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	INS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment nameplate	M
OpTmh	INS	Operation time	O
Status Information			
MtrEna	SPS	Meter is enabled or disabled	M
Measured Values			
MtrVal	MTV	Array of interval metered values	M
Settings			
Extents	MTG	Maximums for programmable meters, including maximum number of intervals per day, number of saved measurements, …	M
Cfg	MTG	Meter configuration, including number of intervals per day	M
CnfClass	ING	Conformance class	M

7.2 Logical Nodes for Fuel System Logical Device

7.2.1 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:

- **FUEL**: fuel characteristics
- **FULP**: delivery system for the fuel, including the rail system, pump, and valves

The following table shows the different types of fuel[6]:

Table 7-2: Fuel types

Type of Energy Source	Energy Source Code	Unit Label	AER (Aggregated) Fuel Code	Energy Source Description
Fossil and Nuclear Fuels				
Coal and Syncoal	BIT	tons	COL	Anthracite Coal and Bituminous Coal
	LIG	tons	COL	Lignite Coal
	SUB	tons	COL	Sub-bituminous Coal
	WC	tons	WOC	Waste/Other Coal (includes anthracite culm, bituminous gob, fine coal, lignite waste, waste coal)
	SC	tons	COL	Coal-based Synfuel, including briquettes, pellets, or extrusions, which are formed by binding materials or processes that recycle materials
Petroleum Products	DFO	barrels	DFO	Distillate Fuel Oil (Diesel, No. 1, No. 2, and No. 4 Fuel Oils)
	JF	barrels	WOO	Jet Fuel
	KER	barrels	WOO	Kerosene
	PC	tons	PC	Petroleum Coke
	RFO	barrels	RFO	Residual Fuel Oil (No. 5, No. 6 Fuel Oils, and Bunker C Fuel Oil)
	WO	barrels	WOO	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	Mcf	NG	Natural Gas
	BFG	Mcf	OOG	Blast Furnace Gas
	OG	Mcf	OOG	Other Gas
	PG	Mcf	OOG	Gaseous Propane
Nuclear	NUC	N/A	NUC	Nuclear Fission (Uranium, Plutonium, Thorium)
Renewable Fuels				
Solid Renewable Fuels (Biomass)	AB	tons	ORW	Agricultural Crop Byproducts/Straw/Energy Crops
	MSW	tons	MLG	Municipal Solid Waste
	OBS	tons	ORW	Other Biomass Solids
	TDF	tons	ORW	Tire-derived Fuels
	WDS	tons	WWW	Wood/Wood Waste Solids (paper pellets, railroad ties, utility poles, wood chips, bark, an other wood waste solids)
Liquid Renewable (Biomass) Fuels	OBL	barrels	ORW	Other Biomass Liquids (specify in Comments)
	BLQ	tons	WWW	Black Liquor
	SLW	tons	ORW	Sludge Waste
	WDL	barrels	WWW	Wood Waste Liquids excluding Black Liquor (BLQ) (Includes red liquor, sludge wood, spent sulfite liquor, and other wood-based liquids)
Gaseous	LFG	Mcf	MLG	Landfill Gas

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

Type of Energy Source	Energy Source Code	Unit Label	AER (Aggregated) Fuel Code	Energy Source Description
Renewable (Biomass) Fuels	OBG	Mcf	ORW	Other Biomass Gas(includes digester gas, methane, and other biomass gases)
All Other Renewable Fuels			GEO	
	GEO	N/A		Geothermal
	WAT	N/A	HYC	Water at a Conventional Hydroelectric Turbine
	SUN	N/A	SUN	Solar
	WND	N/A	WND	Wind
All Other Fuels				
	HPS	N/A	HPS	
	PUR	N/A	OTH	Purchased Steam
	WH	N/A	OTH	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	Other

7.2.2 LN: Fuel Systems Name: FUEL

The fuel characteristics covered in the FUEL logical node describe the type and nature of the fuel.

Table 7-3: Fuel Systems, LN (FUEL)

FUEL Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	INS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment nameplate	M
OpTmh	INS	Operation time	O
Measured Values			
FuelLev1	MV	Fuel level in tank #1	O
FuelLev2	MV	Fuel level in tank #2	O
FuelPres	MV	Fuel pressure	O
FuelCostAv	MV	Running average cost of fuel	O
FuelEfcCoefPct	MV	Fuel efficiency coefficient measured: percent	O
AccTotFuel	MV	Accumulated fuel consumption: liters	O
AccFuel	MV	Accumulated fuel consumption since reset	O
FuelRte	MV	Fuel usage rate	O

FUEL Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
AccOpTms	MV	Accumulated operational time since reset	O
FuelCalAv	MV	Running calorie content of fuel	O
Controls			
AccFuelRs	DCP	Reset cumulative fuel accumulation	O
AccOpTimRs	DCP	Reset accumulated operational time	O
Settings			
FuelTyp	ING	Type of fuel (see Table 7-2)	O
FuelCost	ASG	Base cost of fuel	O
GrossCalVal	ASG	Gross calorific value for the fuel	O
FuelEffCoef	ASG	Rated fuel efficiency coefficient: percent	O

7.2.3 LN: Fuel Delivery System Name: FULP

The fuel delivery system covered in the FULP logical node describe the delivery system for the fuel.

Table 7-4: Fuel Systems, LN (FULP)

FULP Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	INS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment nameplate	M
OpTmh	INS	Operation time	O
Status Information			
FuelSt	SPS	Fuel system is on or is off	O
Measured Values			
InFuelFlwRte	MV	Input fuel flow rate	O
OutFuelFlwRte	MV	Output fuel flow rate	O
InFuelTmp	MV	Input fuel temperature	O
OutFuelTmp	MV	Output fuel temperature	O
FuelRailActA	MV	Fuel rail actuator current	O
FuelRailPres	MV	Fuel rail pressure	O
EngFuel	MV	Engine fuelling: m^3s	O
TimPres	MV	Timing rail pressure	O
TimRailActA1	MV	Timing rail actuator current	O

FULP Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
TimRailActA2	MV	Timing rail actuator current	O
PumpActA	MV	Fuel pump actuator current	O
Controls			
FuelStr	DPC	Fuel start	O
FuelShut	DPC	Fuel shutoff valve driver command	O
Settings			
FuelDelTyp	ING	Type of fuel delivery system • Passive • Pump • Other	O

7.3 Logical Nodes for Battery System Logical Device

7.3.1 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 the prime mover for generating electricity.

The LNs could include:

- **BATT**: battery system characteristics
- **BATC**: charger for the battery system

7.3.2 LN: Battery Systems Name: BATT

The battery system characteristics covered in the BATT 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. *{The comment was made that ZBAT could be used, but it does not contain all needed parameters. Also, the "Z" class of LNs is really a catch-all, so battery should not be in the Z class.}*

Table 7-5: Battery Systems, LN (BATT)

BATT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	INS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment nameplate	M

BATT Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
OpTmh	INS	Operation time	O
Status Information			
BatSt	SPS	Battery system is on or is off	M
BatTestRsl	SPS	Battery test results	O
BatVHi	SPS	Battery voltage high or overcharged	O
BatVLo	SPS	Battery voltage low or undercharged	O
DisChaCrvSt	CSD	Active characteristics of discharge curve	O
Measured Values			
InBatV	MV	Internal battery voltage	M
InBatA	MV	Internal battery current	M
InBatTmp	MV	Internal battery temperature	O
OutBatV	MV	External battery voltage	O
OutBatVChg	MV	Rate of output battery voltage change	O
Controls			
BatSt	SPC	Turn on battery	O
BatTest	SPC	Start battery test	O
Settings			
BatTyp	ING	Type of battery	M
AHrRtg	ASG	Amp-hour capacity rating	M
BatVNom	ASG	Nominal voltage of battery	M
BatCelSerCnt	ING	Number of cells in series	O
BatCelParCnt	ING	Number of cells in parallel	O
DisChaCrv	CURVE	Discharge curve	O
MaxBatA	ASG	Maximum battery discharge current	O
SelfDisChaRte	ASG	Self discharge rate	O
LoBatVAlm	ASG	Low battery voltage alarm level	O
HiBatVAlm	ASG	High battery voltage alarm level	O

7.3.3 LN: Battery Charger Name: BATC

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

Table 7-6: Battery Charger, LN (BATC)

BATC Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Loc	INS	Local operation	O
EEHealth	INS	External equipment health	M
EEName	DPL	External equipment nameplate	M
OpTmh	INS	Operation time	O
Status Information			
BatChaSt	SPS	Battery charger is on or is off	M
ChaTms	INS	Charging time since last off/reset	O
ChaCrvSt	CSD	Active characteristic of charge curve	O
Measured Values			
ChaV	MV	Charging voltage	M
ChaA	MV	Charging current	M
Settings			
BatChaTyp	ING	Type of battery charger: constant voltage or constant current	M
ChaCrv	CURVE	Charge curve	O
ReChaRte	ASG	Recharge rate	O

7.4 Logical Nodes for Physical Measurements

7.4.1 Physical Measurements (Informative)

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

The WG10, 17, and 18 meeting in September 2006 will have a workshop will discuss these LNs.

Since these LNs are expected to be used by many systems, they may eventually be described in a different part of IEC 61850. In WG18, these are called Sensors and are part of the S class. These M-class LNs may need to be combined/merged with the S Class LNs, which have fewer data objects. Additional discussion needs to take place on whether control capabilities might be added to some of the LNs.

The LNs included are:

- **MTMP**: Temperature measurements
- **MPRS**: Pressure measurements
- **MHET**: Heat measurements
- **MFLW**: Flow measurements

- **MVIB**: Vibration conditions
- **MEMS**: Emission conditions
- **METR**: Meteorological conditions

7.4.2 LN: Temperature Measurements Name: MTMP

This LN provides temperature measurements.

Table 7-7: Temperature measurements, LN (MTMP)

MTMP Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
TmpSt	SPS	Temperature alarm status	O
TmpRteSt	SPS	Temperature rate change alarm status	O
Measured Values			
TmpVal	MV	Temperature measurement	O
TmpRte	MV	Rate of temperature change	O
Settings			
MaxTmp	ASG	Maximum temperature	O
MaxTmpRte	ASG	Maximum temperature change rate	O

7.4.3 LN: Pressure Measurements Name: MPRS

This LN provides pressure measurements.

Table 7-8: Pressure measurements, LN (MPRS)

MPRS Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
PresSt	SPS	Pressure alarm status	O
PresRteSt	SPS	Pressure rate change alarm status	O
Measured Values			
PresVal	MV	Pressure measurement	O

MPRS Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
PresRte	MV	Rate of pressure change	O
Settings			
MaxPres	ASG	Maximum pressure	O
MaxPresRte	ASG	Maximum pressure change rate	O

7.4.4 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.

Table 7-9: Heat Measurement, LN (MHET)

MHET Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Measured values			
MatVolm	MV	Volume of material	O
MatPct	MV	Percentage of container filled with material	O
MatCal	MV	Calories of material	O
HeatOut	MV	Heat output	O
AccHeatOut	MV	Accumulated heat output since last reset	O
Control			
AccHeatOutCtl	SPC	Reset accumulated heat output since last reset	O
Settings			
MatTyp	ING	Type of material • Air • Water • Steam • Oil • Other	M
HeatSpec	ASG	Specific heat of material	O
MaxMatCal	ASG	Maximum calories of material	O
MaxHeatOut	ASG	Maximum heat output of heating system	O

7.4.5 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 functions.

Table 7-10: Flow Measurement, LN (MFLW)

MFLW Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Measured Values			
FlwSpd	MV	Flow speed	O
FlwHorDir	MV	Flow horizontal direction	O
FlwVerDir	MV	Flow vertical direction	O
FlwVlvPct	MV	Flow valve opening percentage	O
Control Settings			
FlwVlvCtr	APC	Set flow valve opening percentage	O
Settings			
MatTyp	ING	Type of material • Air • Water • Steam • Oil • Other	M
MaxFlwSpd	ASG	Maximum flow speed	O
MinFlwSpd	ASG	Minimum flow speed	O
MinXsecArea	ASG	Smallest restriction on flow: area of cross-section of restricted point	O

7.4.6 LN: Vibration Conditions Name: MVIB

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

Table 7-11: Vibration Conditions, LN (MVIB)

MVIB Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Measured values			
VibMag	MV	Vibration magnitude	M
VibPer	MV	Vibration periodicity	O
VibDir	MV	Vibration direction	O
Settings			
MaxVibMag	ASG	Maximum vibration magnitude	O

7.4.7 LN: Emissions Measurements Name: MEMS

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.

Table 7-12: Emissions Measurements, LN (MEMS)

MEMS Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Status Information			
SmokDetect	SPS	Smoke detector alarm	O
FloodAlm	SPS	Flood alarm	O
Measured Values			
CO2Em	MV	CO2 emissions	O
COEm	MV	CO emissions	O
NOxEm	MV	NOx emissions	O
SOxEm	MV	SOx emissions	O
SoundEm	MV	Sound emissions	O
WaterLev	MV	Water level	O
Partic	MV	Particulates	O

MEMS Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
Settings			
CarbTrd	INS	Involved in carbon trading	O
CarbCred	ASG	Carbon production credit value	O
GreenTag	INS	Green tag information	O
PartSens	ASG	Sensitivity to particulates	O

7.4.8 LN: Meteorological Conditions Name: METR

The characteristics of the meteorological conditions of the DER system cover meteorological parameters. Some of these parameters are found in the Wind object models[7].

Table 7-13: Meteorological Conditions, LN (METR)

METR Class			
Attribute Name	**CDC**	**Explanation**	**M/O**
LNName		**Shall be inherited from Logical-Node Class (see IEC 61850-7-2)**	
Data			
Common Logical Node Information			
		LN shall inherit all Mandatory Data from Common Logical Node Class	M
Measured values			
WindDir	MV	Wind direction	O
WindVel	MV	Average wind velocity	O
WindGustVel	MV	Wind gust velocity	O
AmbTemp	MV	Ambient temperature	O
Humidity	MV	Humidity	O
CloudCvr	MV	Cloud cover level	O
Lumin	MV	Luminosity	O
Precip	MV	Precipitation	O
Settings			
Alt	ASG	Altitude of sensor	O
CloudSens	ASG	Sensitivity of DER to cloudiness	O
WindSens	ASG	Sensitivity of DER to wind	O

[7] IEC 61400-25-2, LN WMET in Wind turbines: Communications for monitoring and control of wind power plants – Information models

8 Additional Common Data Attribute Types and Common Data Classes (CDC)

*{**Editorial Note**: if these Common Data Attribute Types and CDCs are accepted, they will be moved to IEC 61850-7-3 when it is next updated.}*

8.1 Proposed New Common Data Attribute Types

8.1.1 Master Resource Identity (MRID)

{It is possible that the MRID will become part of the DPL or LN0 or some other object that will be inherited by domain-specific LNs, but until that time, it is used directly in the DER LNs}.

MRID Type Definition			
Attribute Name	**Attribute Type**	**Value/Value Range**	**M/O/C**
Id	INT32U	Unique identity	M

8.1.2 Array of Points (Arrp)

This Data Attribute type provides a means for defining a one-dimensional array of data points. Although the attributes i, f, and enum are all optional, it is expected that at least one will be used.

Table 8-1: Array of Points (Arrp)

Array Type Definition			
Attribute Name	**Attribute Type**	**Value/Value Range**	**M/O/C**
ArrayLength	INT16U	Length of array: n	M
i[0-n]	INT32U	0 to n integer values	O
f[0-n]	FLOAT32	0 to n floating point values	O
enum[0-n]	INT32U	0 to n enumerated values	O
q[0-n]	Quality	0 to n quality codes	O
t[0-n]	Timestamp	0 to n timestamps	O
d[0-n]	VISIBLESTRING255	0 to n descriptions	O

8.2 Proposed New CDCs

The following are additional Common Data Classes, which are required for DER device models.

8.2.1 Array (ARY)

This Data Attribute type provides a means for defining a one-dimensional array of data elements. Although the attributes i, f, and enum are all optional, it is expected that at least one will be used.

Table 8-2: Array (ARY)

Array Type Definition			
Attribute Name	**Attribute Type**	**Value/Value Range**	**M/O/C**

Array Type Definition			
Attribute Name	**Attribute Type**	**Value/Value Range**	**M/O/C**
ArrayLength	INT16U	Length of array: n	M
i[0-n]	INT32U	0 to n integer values	O
f[0-n]	FLOAT32	0 to n floating point values	O
enum[0-n]	INT32U	0 to n enumerated values	O
q[0-n]	Quality	0 to n quality codes	O
t[0-n]	Timestamp	0 to n timestamps	O
d[0-n]	VISIBLESTRING255	0 to n descriptions	O

8.2.2 List of Identifiers (LIST)

This CDC provides a means for defining a one-dimensional list of MRID identifiers.

Table 8-3: List of Identities (LIST)

List Type Definition				
Attribute Name	**Attribute Type**	**FC**	**Value/Value Range**	**M/O/C**
DataName	Inherited from Data Class (see IEC 61850-7-2)			
DataAttribute				
ListLength	INT16U	MX	Length of list: n	M
Id[0-n]	MRID	MX	0 to n MRIDs	M
q[0-n]	Quality	MX	0 to n quality codes	M
t[0-n]	Timestamp	MX	0 to n timestamps	M
d[0-n]	VISIBLESTRING255	DC	0 to n descriptions	O

8.2.3 Metering Configuration (MTG)

This CDC is based on the metering object models in the Ashrae Research Report RP-1011, but modified to reflect IEC 61850 concepts. *{It is expected that this metering CDC will be required and expanded upon in other efforts, and should not necessarily be associated with DER. Therefore, it is recommended that this CDC and the Metering LNs be handled separately.}*

Table 8-4: Metering Configuration (MTG)

MTG Class				
Attribute Name	**Attribute Type**	**FC**	**Value/Value Range**	**M/O/C**
DataName	Inherited from Data Class (see IEC 61850-7-2)			
DataAttribute				
configuration				
SrcFlgs	INT8U	CF	Source functions for demand control	O
NumUOMEntry	INT8U	CF	Number of unit of measure entries	O
NumDmdCtlEntry	INT8U	CF	Number of demand control entries	O
NumDatCtlEntry	INT8U	CF	Number of data control entries	O
ConstSel	INT8U	CF	Constants selected	O

MTG Class				
Attribute Name	**Attribute Type**	**FC**	**Value/Value Range**	**M/O/C**
NumSrc	INT8U	CF	Number of sources	O
RegFuncs	INT8U	CF	Dimensions of arrays for register functions	O
NumSlfRead	INT8U	CF	Self read support	O
NumSumm	INT8U	CF	Summation table support	O
NumDmd	INT8U	CF	Number of demand registers	O
NumCoin	INT8U	CF	Number of coincident measurements	O
NumOcc	INT8U	CF	Number of demand occurrences	O
NumTiers	INT8U	CF	Number of tiers	O
NumPresDmd	INT8U	CF	Number of present demands	O
NumPresVal	INT8U	CF	Number of present values	O
SummSel	Arrp	CF	Array of summation selections. Identifies sources.	O
DmdSel	Arrp	CF	Array of demand measurement selections.	O
MinOrMaxFlgs	Arrp	CF	Array of flags to show if demand peaks are minimums or maximums.	O
CoinSel	Arrp	CF	Array of coincident measurement selections	O
CoinDmdAssoc	Arrp	CF	Array of coincident demand associations	O

8.2.4 Metering Electric Measured values (MTV)

This CDC is based on the metering object models in the Ashrae Research Report RP-1011, but modified to reflect IEC 61850 concepts. *{It is expected that this metering CDC will be required and expanded upon in other efforts, and should not be necessarily associated with DER. Therefore, it is recommended that this CDC and the Metering LNs be handled separately.}*

Table 8-5: Metering Electric Measurements (MTV)

MTV Class				
Attribute Name	**Attribute Type**	**FC**	**Value/Value Range**	**M/O/C**
DataName				
DataAttribute				
Description				
InstMag	AnalogueValue	MX	Instantaneous demand	M
q	Quality	MX	Quality of instantaneous demand	M
t	Timestamp	MX	Timestamp of instantaneous demand	M
IntvDmd	ARY	MX	Array of interval demands	M
CumDmd	ARY	MX	Cumulative demand per interval	M
ContCumDmd	ARY	MX	Continuous cumulative demand per interval	O
Pks	ARY	MX	Array of peak demands per interval	O

8.2.5 Device Ownership and Operator (DOO)

Clause 7.9.2 of IEC 61850-7-3 defines the device name plate information, including the vendor, the device, and its location. However, for DER devices, the ownership of the device is also important, along with the entity(ies) responsible for operations. This CDC could be used for general information as well as part of access management. *This CDC may be incorporated into the Nameplate information. If so, it will disappear*.

Table 8-6: Device Ownership and Operator (DOO)

DOO Class				
Attribute Name	**Attribute Type**	**FC**	**Value/Value Range**	**M/O/C**
DataName				
DataAttribute				
Description				
Owner	Visible String 255	DC	Owner of device	M
OwnerSite	Visible String 255	DC	Site where device is located	O
EPSName	Visible String 255	DC	Name of Electric Power System device is connected to	O
Role	Visible String 255	DC	Role of device	O
PrimeOperator	Visible String 255	DC	Primary operator of device	O
SecondOperator	Visible String 255	DC	Secondary operator of device	O

8.2.6 Proportional-Integral-Derivative Configuration (PID)

The *Proportional-Integral-Derivative Configuration* class defines the PID response parameters for control actions.

Table 8-7: Proportional-Integral-Derivative Configuration (PID)

PID Class					
Attribute Name	**Attribute Type**	**FC**	**TrgOp**	**Value/Value Range**	**M/O/C**
DataName					
DataAttribute					
Setpoint					
Bias	FLOAT32	SP			
ClampLowr	FLOAT32	SP			
ClampUppr	FLOAT32	SP			
dbLower	FLOAT32	SP			
dbUpper	FLOAT32	SP			
DerivAct	FLOAT32	SP			
ErrorTerm	FLOAT32	SP			
Kgain	FLOAT32	SP			
Krate	FLOAT32	SP			
Ktime	FLOAT32	SP			
MaxRate	FLOAT32	SP			
PIDAlg	ENUM8				

PID Class					
Attribute Name	**Attribute Type**	**FC**	**TrgOp**	**Value/Value Range**	**M/O/C**
PolarFrwd	BOOL				
Override	BOOL				
smpRate	INT16U				

Annex A

A1. Introduction to Distributed Energy Resources (DER) Object Modelling (Informative)

A1.1 Challenge of Integrating DER into the Power System Information Infrastructure

The advent of decentralized electric power production is a reality in the majority of the power systems all over the world, driven by the need for new types of energy converters to replace the heavy reliance on oil, by the increased demand for electrical energy, by the development of new technologies of small power production, by the deregulation of the energy market, and by the increasing environmental constraints. These pressures have greatly increased the demand for Distributed Energy Resources (DER) systems which are interconnected with the distribution power systems.

Distribution power systems are and will continue to be the most impacted by DER, but transmission and the management of generation operations are also impacted. A number of studies on the wide-spread interconnection of DER systems have shown significant effects and impacts on operation of the entire electrical system.

As a result not only of DER systems, but also the need for greater efficiency and reliability of the power system, automation of the distribution systems is becoming a major requirement. This distribution automation implies new remote control functions, modified distribution configurations, increasingly intelligent protection systems, and the use of significantly more telecommunication and information technologies.

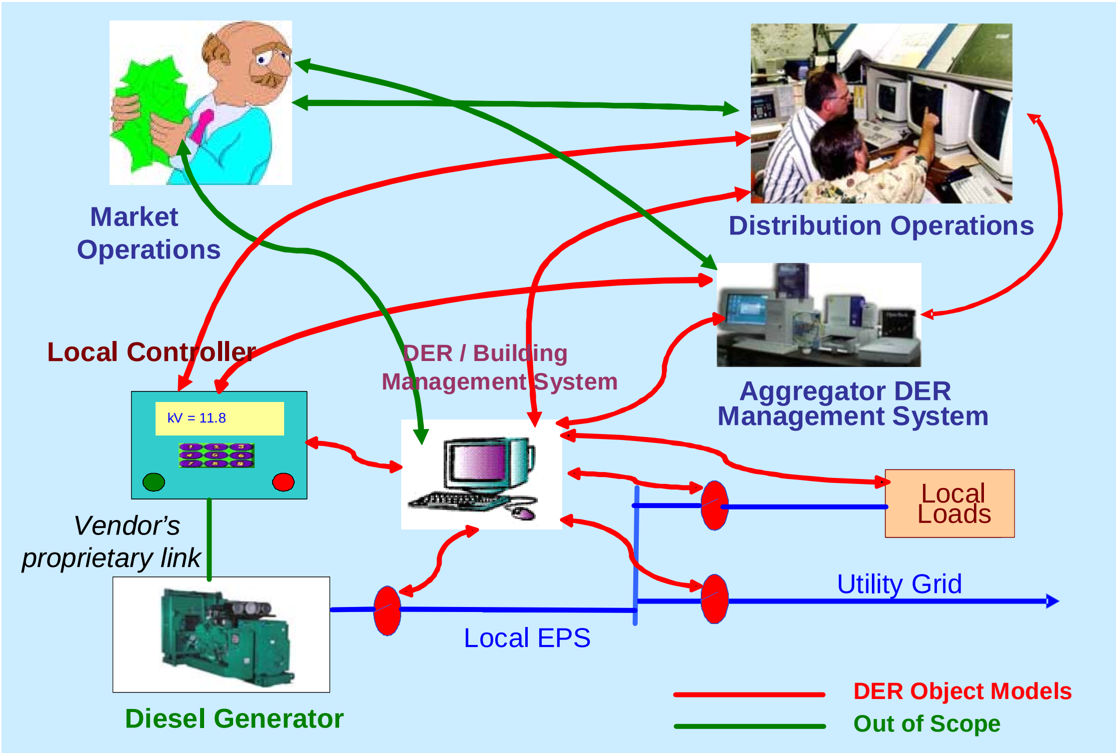
The rapid advances of digital technologies have enabled the automation of electric power operations, providing utilities and customers with both new capabilities and new challenges. The challenge facing utilities, customers, vendors, and the electricity marketplace is: how can the information infrastructure be implemented to meet the expanded needs of the power system, while not becoming part of the problem itself.

Part of that challenge can be met by IEC 61850 object models for DER, as the standardized communications interface for DER devices. Standardized communication interfaces permit the interoperability between different systems from different vendors, thus increasing the cost benefit to all owners, operators, and users of DER systems.

DER systems involve more than just turning a DER unit on and off. DER systems involve the following aspects:

- Management of the interconnection between the DER units and the power systems they connect to, including local power systems, switches and circuit breakers, and protection.
- Monitoring and controlling the DER units as producers of electrical energy
- Monitoring and controlling the individual generators, excitation systems, and inverters/converters
- Monitoring and controlling the energy conversion systems, such as reciprocating engines (e.g. diesel engines), fuel cells, photovoltaic systems, and combined heat and power systems
- Monitoring and controlling the auxiliary systems, such as interval meters, fuel systems, and batteries
- Monitoring the physical characteristics of equipment, such as temperature, pressure, heat, vibration, flow, emissions, and meteorological information

The information requirements for DER systems are illustrated in Annex Figure 1 below. These IEC 61850 DER object models cover all operational aspects of DER systems, but do not address market operations.



Annex Figure 1: Interactions involving Distributed Energy Resources (DER) in Electric Power System Operations

A1.2 Background on the Development of the DER Object Models

IEC TC-57, WG-17 is developing the communication architecture for integrating DER into the IEC 61850 body of communication standards. This document, the first standard to be produced by WG-17, provides standards for object models for exchanging information with DER devices. DER devices are generation and energy storage systems that are connected to a power distribution system. Object models for four specific types of DER are provided in this first document:

1. Photovoltaic systems
2. Reciprocating engines
3. Fuel cells
4. Combined heat and power

Additional standards documents will be developed by this working group in the future.

The approach taken by the working group in developing these models was to seek wide applicability of the models. Accordingly, no assumption was made as to DER ownership. Ownership could reside with a utility or an alternative party. No limitations were placed on type of distribution system (networked or radial) or on where in the distribution system the DER might be located. The requisite distribution design engineering for DER installations must address the distribution system electrical issues and determine where DER can safely be placed in the distribution system and what alterations to the electrical system may be needed. This document focuses specifically on the ability to communicate with the DER and dispatch the services it may be intended to provide for the distribution system operator, such as emergency power and voltage support.

The object models provide the structured, standard identification and naming of the attributes that need to be included in the information exchange with the DER. These object models will become a part of the IEC 61850 body of communication standards for electric power systems. The goal is to achieve interoperability of DER with the power system, including current components and new technologies that are coming in the future. Interoperability of all intelligent electronic devices (IEDs) in the system is desired, and DER is one such IED type. IEC 61850 is the principal body of international communication architecture standards evolving to support real-time automated operation of the power system of the future. As such, it is intended that the DER object models be a part of this communication architecture and not be used as a standalone entity. In other words, if a power system operator specifies that DER should conform to the 61850 family of standards, it is because they are intending to migrate their whole automated system to 61850 conformity.

A1.3 Purpose of this Annex on DER Object Models (DER-OM)

Utilities will need to manage increasing amounts of DER within their distribution systems, and will increasingly use automation to handle the challenges and opportunities posed by DER. The purpose of this annex is to discuss the scope and requirements for DER object models for the exchange of information between DER devices and any systems which monitor, control, maintain, audit, and generally operate the DER devices. This annex explains what object models are and provides guidelines on which objects are associated with specific DER devices and configurations.

Simply put, “object models” are standardized formats or templates for exchanging data between different equipment or systems. Standard object models, combined with standard service models (methods for sending the data) and standard protocols (the bits and bytes actually send over the communication channel), permit different systems to interact with minimal customization. The combination of object model, service model, and protocol profiles can be termed the “information model”.

These DER object models are based on open-system language, semantics, services, protocols, and architecture which have been standardized by IEC 61850. These DER object models re-use components of existing IEC 61850 object models where possible, but also include some extensions to IEC 61850.

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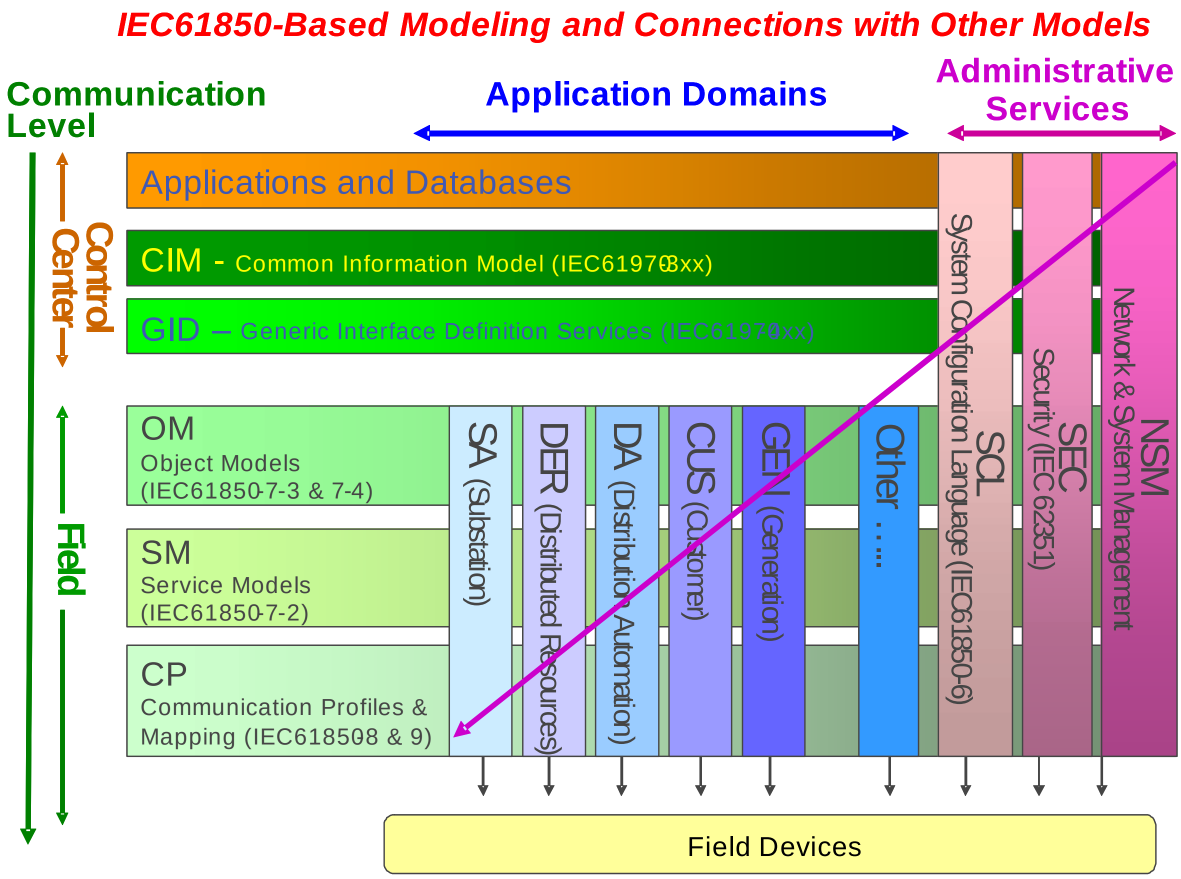


Annex Figure 2: Overview of IEC Object Modeling Constructs

A2. Functional Requirements for DER Information (Informative)

A2.1 Overview of the DER Environment

A2.1.1 Challenges and Opportunities of Integrating DER with Utility Operations

Spurred by the need to increase renewable sources of energy, to decrease the costs of energy usage, and to take advantage of the electricity market, the number and type of Distributed Energy Resources (DER) systems interconnected to power systems has sharply increased worldwide. Some of these DER systems are owned and directly managed by utilities; most, however, are owned by utility customers and often operated by independent energy service providers. This diversity of ownership and operations provides even more challenges to utilities as they try to manage their power system operations efficiently and reliably.

Many utilities, DER owners, and regulators are examining new technologies and exploring new methods for safely, reliably, and effectively implementing and interconnecting DER systems. At the same time, utilities are trying to find ways to cut operational costs without jeopardizing the security of the power system. As a result of this pressure from both sides, the possible benefits of different DER technologies are increasingly being evaluated, and the operational requirements for interconnecting these DER systems are being assessed. Some benefits could be “soft”, such as increased customer satisfaction, while other benefits could be “hard” or quantifiable monetary benefits which either reduce costs or increase revenue.

DER systems can have very different operational characteristics. For instance, some types are strictly driven by their energy source, such as wind and solar energy. Others can be more directly controlled, but may have constraints such as emission limits or availability limits. Many need to balance the production of electrical energy with other requirements, such as heating buildings for CHP units or river water flows for hydro units. In other cases, the variability of some energy sources needs to be balanced by alternate energy sources. For instance, in a wind farm, part of the inconstant wind power electrical energy can be used to charge batteries or pump water into storage basins. These alternate energy sources can then augment the power produced by the wind farm whenever the wind decreases.

Some of the DER uses include:

1. **Generation capacity**. DER devices have generation capacity that can provide energy to offset load within a customer site, to support local load on a distribution feeder, and/or to provide energy within a substation. Using net metering or other types of tariffs, DER owners can be paid for this generation.
2. **Load following**. DER devices can be used to follow load, not necessarily second by second (as needed by automatic generation control), but over short time frames or to counteract the large non-conforming loads of the DER owner. Utilities could benefit from improved power quality (e.g. more stable voltages, lower voltage spikes) on the feeder serving this load.
3. **Power supply balancing**. For DER units whose energy source can be variable, such as wind farms and solar systems, other DER units, such as batteries and pumped storage, can be used to fill valleys and maintain a more constant power supply.
4. **Peak shaving**. DER systems can be scheduled, manually controlled, or remotely controlled to turn on or provide more power during peak load times. Some DER systems naturally provide additional energy during peak load times, such as photovoltaic systems increasing output on hot sunny days when the air conditioning load increases.
5. **Operating reserve**. DER systems which are on-line or have a short start-up and synchronization time can be counted as “spinning” or operating reserve. Since DER units are normally smaller than units in primary generating plants, this operating reserve would

come in small increments and could be scheduled by utilities to avoid starting up much larger units.

6. **Emergency backup generation**. The same DER devices which could provide operating reserve can also provide emergency power to individual customer sites, substations, and groups of customers.

7. **Voltage support**. Feeders drop in voltage from the source substation to the end of the feeder. Typically voltage regulators along the feeders are installed to boost voltage and prevent low voltage conditions for customers at the end. DER devices could provide the same voltage support. If many DER devices are located along a feeder, voltage support could be achieved with more but smaller increments, thus permitting the feeder voltage at the distribution substation to have a wider range for the load tap changer. This wider range could be translated into lower feeder voltage at the substation during peak loads, and vice versa during low loads.

8. **Var support**. Some DER devices could provide var support in place of capacitor banks with similar benefits as for voltage support.

9. **Intentional islanding**. Sections of distribution feeders with significant amounts of available DER energy could be designed to become self-supporting islands if outages shut off the primary source of electricity. Campuses, isolated developments, or groups of hotels might be candidates.

10. **Pollution credits**. Many DER devices, particularly the renewables (wind, solar, etc.), cause less pollution than the larger coal and oil plants. Utilities which want or need to minimize their pollution levels could purchase more power from these DER devices, while customers concerned with pollution could either purchase or contract to use these DER devices.

11. **Green power**. Either through mandated use of renewable energy or via the electricity marketplace, the need for “Green Power” is growing. Many customers are willing to pay extra for green power. Although most green power today comes from hydro power, DER based on renewables could provide additional support, particularly whenever access to the hydro power (usually far away from most loads) is unavailable or curtailed due to power system problems.

12. **Defer construction of utility facilities**. DER devices which act as negative load, provide peak shaving, and support voltage and vars on the feeder, also implicitly can defer the construction or upgrade of utility facilities. Deferral of these large capital expenditures can significantly off-set the lower costs associated with installing, interconnecting, and operating smaller DER equipment.

13. **DER products for sale**. Utilities could provide DER devices for sale, using utility expertise and equipment for consulting on different DER alternatives, for installing the DER devices, and for testing the monitoring and control facilities.

14. **DER services**. Utilities could provide operation and maintenance services for DER equipment, again using their expertise and facilities as a marketing advantage.

A2.1.2 DER Monitoring and Control Requirements

Installing DER devices presents DER owners and utilities with multiple challenges. The main challenge is the interconnection of the DER system to distribution systems that were not designed for two-way real and reactive power flows. This technical challenge has been complicated by the organizational challenges of the deregulation process in the utility industry. For instance, which utility and non-utility organizations will be permitted to own and operate generation and energy storage devices at the distribution level? Which organizations and/or customers can benefit from DER? How will costs and benefits be allocated to participating organizations and customers?

Whichever organizations do become involved with implementing DER devices, the key for utilities and other organizations to utilize DER effectively will be the timely and efficient exchange of critical and relevant information. For instance, some information may be collected once a month, such as meter reads of DER usage, and maybe perfectly adequate. However, other information, such as the on-off state of a DER device, or its remaining energy generation capacity, or its availability to provide backup power, must be known in "real-time" (seconds) for it to be truly useful. Without the ability to remotely monitor and control the DER devices in real-time, utilities will be blind and inefficient in using these DER resources.

In order to determine what types of communications, control, and management technologies are needed for DER, it is first necessary to determine the information and timing requirements of all of the stakeholders involved with DER. Once the stakeholder requirements are determined, then the flow of information can be assessed. With the information flows understood, then the technology requirements can be addressed.

A2.1.3 DER Stakeholders

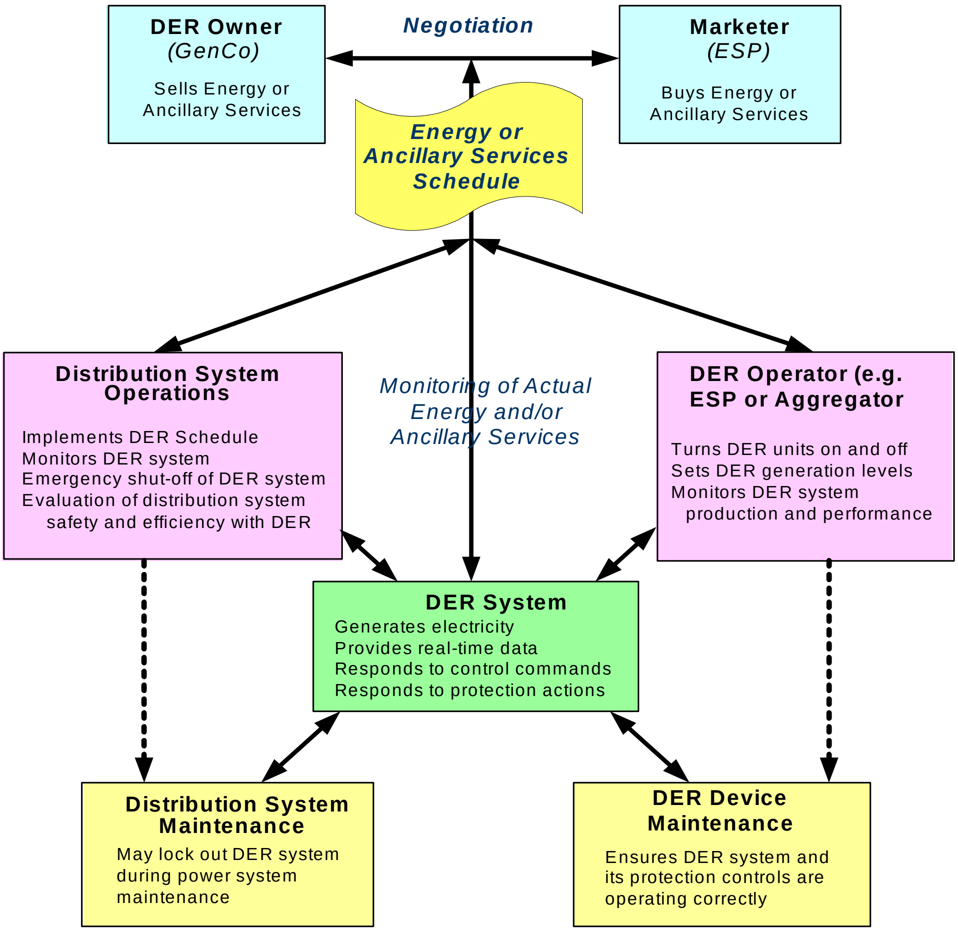
DER Stakeholders are the roles that different people or companies play in relation to each other with respect to the DER systems, both from a power system operational point of view and in the deregulated electricity marketplace. These roles determine what information they have and what information they need. In some cases, the same person or company may actually play two different roles at one time, but conceptually that one person or company is still two different stakeholders.

The stakeholders in the use of DER devices (see Annex Figure 3) consist of the following:

1. **DER Owners:** The DER Owners own the DER systems. These owners could be viewed as a small ***GenCo***: the owners profit from using the DER either for serving their own load or from selling products: energy capacity or ancillary services. These services could be operating reserve, peak shaving, emergency backup, voltage support, var support, etc.
2. **Marketers or Energy Services Providers:** The Marketers wish to purchase energy or other services from the DER device for servicing their customer loads. In the terms of deregulation, they can be viewed as an **Energy Service Provider (ESP)**, if they are providing more services than just energy. They negotiate with the DER Owner for the type of product (e.g. capacity, operating reserve, and voltage support), the schedule of the product (e.g. next hour, on peak for the next month, etc.), and the price. The marketers could be serving only themselves; however, more generally, the marketers will have collected a number of customers for whom they are acting as the broker for purchasing energy and services.
3. **Distribution System Operators:** The distribution system operators are responsible for operating the distribution system safely and efficiently with DER: implementing all DER schedules in their control area, monitoring the DER systems (either directly or indirectly), and ensuring that all DER units have tripped off in an emergency, while in general ensuring the secure and economic operation of the power system. The operators are also, generally, responsible for directing all maintenance and emergency activities on the power system.
4. **DER Operators:** The DER Operators are responsible for turning the DER systems on and off during normal operations, based on the needs of the DER Owners for their own use of the DER system, as well as on the requirements of any contractual DER schedule. Since this is clearly not a complex task, the DER Operators may be a person pushing a button on the DER device, or an automated controller/synchronizer with a built-in scheduler, or the Distribution System Operator with a remote control capability. The DER system will have the built-in capability to shut down or not turn on if it is unsafe for the device to operate.

5. **Distribution System Maintenance:** The field crews responsible for distribution system maintenance (usually under the direction of the distribution system operators) are also usually responsible for ensuring that DER devices are off and/or locked out of connecting to the power system. At other times, these field crews must be aware of the impact of their maintenance activities on DER and vice versa.
6. **DER Device Maintenance:** The personnel responsible for DER maintenance are responsible for ensuring that the DER system and their security shut-offs, are operating correctly.
7. **DER System:** The DER system itself must provide real-time data on its condition when queried, and respond to local and/or remote control commands, as well as protective relaying commands.
8. **Distribution Power System Protection:** If needed for security, the distribution power system protection devices issue long distance protection commands.
9. **Telecommunications Maintenance:** Telecommunications maintenance ensures the reliability and availability of the telecommunications capability. This function may be under utility control or may be the responsibility of a third party.

These DER Stakeholder roles are shown in Annex Figure 3.



Annex Figure 3: DER Stakeholders

A2.2 Functions Requiring Monitoring and Control of DER Systems

A2.2.1 "Use Cases" as Method for Determining Information Exchange Requirements

Many power system functions require information from DER systems, as well as the ability to set parameters and issue control commands to DER units. These functions are the drivers for determining what monitoring and control capabilities are needed for developing a model of the information exchanges.

The best way to ensure that all information exchange requirements are met is to exhaustively analyze all functions that could be implemented. That said, much of the information to be exchanged are the same for different functions, and the availability of different types of information is determined by the equipment capabilities, the installation choices, and the degree of precision that the functions necessitate. Therefore, a more practical approach entails listing all functions (to ensure completeness), and then selecting a few that most likely cover all key information exchange requirements. These selected functions (acting as Use Cases[8]) are then assessed in detail to determine both the minimum, mandatory information exchange requirements, as well as the maximum, optional information exchange requirements.

[8] Use Cases are used by the Unified Modelling Language (UML) and other similar processes to model the interactions and information exchange requirements among different functions, systems, and equipment.

The same function can vary in scope significantly, depending upon the purpose of the DER system in a particular installation. In addition, functions that are barely feasible today could become typical in the future. Therefore Use Cases are *useful* to determine initial and basic requirements, but they are necessarily just a *snapshot* of requirements; any successful model of information exchanges must allow for variable needs as well as future growth and modifications.

For instance, some of the basic monitoring and control functions include:

1. Occasional use for backup for the local EPS (within a customer site). It is never interconnected to the area EPS (utility-owned distribution power system).
2. Occasional use for additional generation for the local EPS. It is never interconnected to the area EPS. This could be for reducing load that is served by the area EPS.
3. Occasional use for additional generation while local EPS is interconnected with the area EPS. This could be for peak shaving or other situation necessitating reduction in load.
4. Full-time use as additional generation interconnected with the area EPS. This generation could be run independently by the DER owner, loosely coordinated with distribution operations, or tightly integrated and controlled by utility operations. The DER generation would typically be larger combined heating and power (CHP) or other co-generation systems.
5. Full-time use as market-driven generation interconnected with the area EPS. This could include responses to real-time pricing signals, requirements of distribution automation scenarios, formation of microgrids, etc.
6. Emergency use as part of an overall plan for prevention of power system outages and blackouts, as well as the recovery from outages and blackouts.

Because of this large range of different purposes, the types of data that are exchanged can vary significantly for the same function. Therefore, careful attention must be paid to what data is mandatory and what data is optional, as well as how the data is organized in the object models.

Some of the key functions are described in the following sections.

A2.2.2 DER Owner/Operator Functions

In these Use Cases, DER owners manage their own DER systems locally. DER owner/operator functions are those functions required by DER owners and/or operators, including commercial customers, industrial customers, residential customers, as well as utilities if they own the DER systems. The DER system can be located at a customer site or at a utility site, such as in a substation. In these functions, the DER owner/operator owns and operates the DER directly: no third party is involved. Therefore, information exchange requirements would primarily involve the DER units, the DER plant system, and the local DER owner/operators.

Possible DER owner/operator functions include:

1. The DER system is driven by the energy source, e.g. photovoltaic systems and wind power systems. The DER owner/operator monitors the system for energy output, performance statistics, and maintenance purposes.
2. The DER owner/operator uses DER as automatic backup for key internal load if main power is lost or may be lost (e.g. diesel generator). The DER system undertakes automatic start of DER device, disconnects from the utility power system, synchronizes and interconnects DER to local power system, and performs generation control to meet changing load requirements.
3. The DER owner/operator sets the DER system at a specific setpoint to provide a set level of generation (e.g. to offset load, to provide local generation for reliability and/or demand-response, to shave peaks).

4. The DER owner/operator establishes an intentional island: a permanent building/campus microgrid (e.g. utility power as backup).
5. The DER system is used exclusively for local load with net zero import/export. However, the utility power system is available for backup power.
6. The DER owner/operator uses the DER system primarily for internal loads, but includes an import/export interconnection to the utility power system. This interconnection is set for a fixed level of import or export of power.
7. The process which generates heat is main purpose of a Combined Heat and Power (CHP) system, so that only excess heat is used to generate power and provide it to the utility power system.
8. The DER owner plans the scheduling/bidding of DER generation in electricity marketplace, for energy, as ancillary services, as contracted, as per real-time pricing, etc. The DER operator then executes the schedules as required.
9. The DER operator manages DER system maintenance, including DER generator, prime mover, local EPS switching and protection, communications system, and the monitoring and control system
10. The DER system collects information, logs, and statistics, including operational information, performance, efficiency, emissions, environmental parameters, green power %, etc. This information may be available in real-time as well as historical.

A2.2.3 Third-Party Remote Operation Functions

In these Use Cases, third parties operate the DER systems from remote locations. The third party remote operation functions include those in which energy service providers (ESPs), aggregators, utilities, or other entity manage the DER system from a remote site. The DER system can be located at a customer site or at a utility site, such as in a substation. Therefore, information exchange requirements would primarily involve the DER units, the DER plant system, DER owner/operators, and the remotely located ESPs, aggregators, and/or utilities.

Possible third party remote operation functions include:

1. The remote operator monitors DER system operational status only (on/off).
2. The remote operator monitors instantaneous metering (status, alarms, kW output, voltage, amps, statistics, etc.).
3. The remote operator monitors the entire DER environment (energy source, weather, emissions, protective relays, switches, etc.)
4. The remote operator dispatches a local operator to manually control the DER units.
5. Make-before-break DER system picks up a local load, then disconnects from the utility power system.
6. The utility issues a pricing signal which causes the DER system to generate at a specific level.
7. The remote operator sets the DER system at a specific setpoint to provide a fixed amount of generation (e.g. to offset load, to provide local generation for reliability and/or demand-response, to shave peaks).
8. The remote operator controls the DER system through automatic control (AGC) to meet specified operational needs and contracts (e.g. power quality, emissions, economic dispatch, energy schedules, ancillary service contracts, real-time pricing, local backup, interconnection with distribution system).
9. The remote operator dispatches field crew to perform manual switching operations on feeders with the DER system interconnected with the utility. Under most current

situations, the DER system would be off or disconnected from the utility, but future situations might allow the DER system to remain on and interconnected.

10. The remote operator performs supervisory control of switching operations on feeders with DER systems connected to these feeders. The impact of this switching on the DER operations would need to be understood and taken into account, as well as the reverse: the impact of DER operations on the switching.
11. The remote operator performs control of load tap changers and/or voltage controllers with DER systems connected to the feeders. Since DER systems can have impacts and responses to changes in voltage, these interactions would need to be taken into account.
12. The remote operator performs control of capacitor bank switches (or other equipment that changes vars) with DER systems connected to the feeders. Since DER systems can have impacts and responses to changes in vars, these interactions would need to be taken into account.
13. The remote operator aggregates information from multiple DER systems for use by utility SCADA systems. This information would need to be collected and collated every few seconds from these widely dispersed DER systems.
14. The remote operator provides DER owners, utilities, and/or market operators with the results and other information on DER operations.
15. The remote operator manages local microgrid operations with DER systems. Since a microgrid must match generation to load, this management would involve some level of unit commitment and automatic generation control (AGC).
16. The ESP or utility reads interval/revenue meters (or metering per other tariff arrangements) for both the DER system and the local loads.
17. The ESP or utility handles settlements and billing for the DER owner.
18. Regulators and auditors monitor compliance of DER operations with contractual and environmental commitments.

A2.2.4 Utility Automated Distribution Operations (ADO) Functions

In these Use Cases, utilities operate both their radial and networked distribution systems with many interconnected DER systems. If significant amounts of DER generation are connected to their distribution systems, these utilities will need additional automation which can monitor, control, and optimize operations. The DER systems could be located at customer sites or at utility sites, such as in substations.

The utility would need to monitor, control, and analyze these multiple DER systems in order to best manage power system reliability, power system efficiency, power quality assessment, outage management, market operations, and maintenance. Once the number of DER systems becomes large enough, this management would require significant automation of distribution operations (ADO), which could be a combination of local automated field equipment and system-wide automated central analysis.

Possible ADO functions include:

1. ADO systems collect and analyze distribution operations with significant DER penetration. These ADO systems including basic SCADA, distribution state estimation and operational analysis, status estimation of controllable devices, load modeling and analysis, reliability assessment, dynamic limit calculations, power quality analysis, etc.
2. ADO systems operate DER systems in a substation or other utility facility for additional local generation and ancillary services.
3. ADO systems provide quality power to customers under normal conditions and/or as a result of predicted adverse conditions, based on coordinated volt-var control, contingency

analysis, multi-level feeder reconfiguration, relay protection re-coordination, and feeder phase load and voltage balancing.

4. ADO systems manage planned outages for DER systems and distribution facilities, covering distribution operations analysis, DER availability analysis, multi-level feeder reconfiguration, coordinated volt-var control, reliability assessment, cold load pickup, and work order creation.
5. ADO systems, support market operations for the utility, through load forecasting of DER availability and dispatchable load analysis, look-ahead distribution system analysis, contract-oriented loss calculations, coordinated volt-var with real-time pricing, etc.
6. ADO systems support distribution and DER maintenance by providing performance and historical statistics of DER systems and distribution equipment, as well as risk assessments based on these statistics.
7. ADO systems coordinate distribution and DER operations with bulk power system operations, including real and reactive load/DER management, load shedding, load/DER transfer to different feeders, etc.
8. ADO systems support customer services through demand response, power quality assessment and management, real-time pricing analysis, and performance analysis.
9. ADO systems directly manage DER systems which are interconnected with the utility power system, through DER forecasting and scheduling, microgrid creation and management, injection and storage management, interconnection design, and performance monitoring.
10. ADO systems support database management through asset management, database consistency management, and database validation management.

A2.2.5 Utility Emergency Operations Functions

In these Use Cases, the DER systems provide support for utility emergency operations (customer emergency operations were covered under DER owner/operator functions). The DER systems can be located at a customer site or at a utility site, such as in a substation, and are operated by utilities specifically to meet their emergency operational needs. These emergency needs could include protection schemes and actions, load shedding, alarm management, disturbance monitoring, emergency switching, and establishment of microgrids (intentional islanding).

Possible emergency operation functions include:

1. Protection equipment performs system protection actions on DER interconnections – fault detection, clearing, and reclosing.
2. Utility operators directly trip or verify the tripping of interconnected DER on loss of feeder power.
3. Utility operators manage emergency alarms from DER devices.
4. The utility SCADA system performs disturbance monitoring analysis, including DER responses.
5. ADO systems manage forced outages of DER and distribution facilities by supporting automated fault clearing (protective devices), fault indication, fault location, fault isolation, dynamic limit calculation, service restoration (manual or closed-loop switching), volt-var adjustment, DER control, microgrid creation, cold load pickup, paralleling check, relay re-coordination, etc.
6. Utility operators dispatch field crews to troubleshoot system and customer power problems, and provide them with real-time information from the DER site.

7. Utility operators dispatch field crews to troubleshoot communication systems and customer communication problems, and provide them with real-time information from the DER site.
8. Utility operators perform substation and feeder switching operations which involve DER interconnections.
9. Utility Operators shed loads and/or DER devices intentionally.
10. Outage management systems collect trouble calls and generate outage information on outages involving DER systems.
11. Microgrids of DER devices matched to loads are formed, operated, and eventually connected back into the distribution system.

A2.2.6 Planning, Installation, Commissioning, and Maintenance Functions

In these Use Cases, DER systems are planned, installed, commissioned, and maintained by DER owners, ESPs, and/or utilities. The planning and implementation of DER systems involve longer term activities, with multiple parties involved in designing, testing, installing, and maintaining these systems. Some of the information exchanges could be non-electronic or through commercial electronic means. However some other information exchanges, particularly for maintenance activities, could require additional types of data and different means of communication (e.g. links to laptops).

Possible planning, installation, commissioning, and maintenance functions include:

1. DER system sizing, technology, configuration, and installation is planned and coordinated with utility, by providing ratings, configurations, planned usage, etc.
2. Distribution planners study the impact of planned DER installations on the distribution system, and integrate these results with other distribution upgrades and additions.
3. The DER implementer installs and tests DER devices in the local power system.
4. The DER operator tests the DER communications system performance and management capabilities.
5. The utility tests the DER installation when it is interconnected with the utility power system.
6. Vendors of different equipment (including DER systems, switches, protection, and communications system) gather real-time data and statistics, and perform troubleshooting of their own equipment.
7. The DER maintenance personnel maintain the DER system, accessing not only real-time measurements, but also historical and statistical information on DER performance, efficiency, emissions, and maintenance requirements.

A2.3 Information Exchanges: What Data Should, Might, or Should Not Be Included in DER Object Models

A2.3.1 Different Configurations Determine Scope of Information Exchanges

As can be deduced from the wide variety of functions described in the previous clause, DER systems can be implemented in many different configurations and can be operated with many different purposes and modes. One size does not fit all; ultimately the information exchanges specified for any specific implementation must reflect the actual requirements for that installation. However, the key is:

> ***If the same type of data is going to be exchanged in multiple implementations, then the same data name and data format should be used, in order for these***

implementations to be interoperable. This is the fundamental reason for developing these IEC 61850 DER object models.

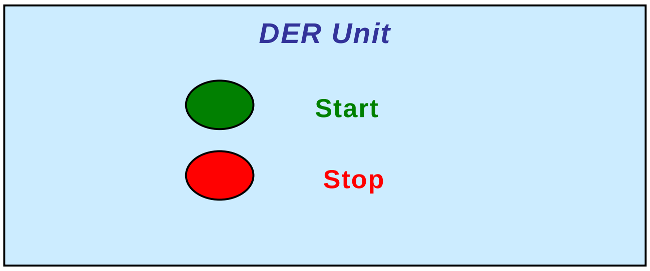
DER system configurations can range from the simple with little or no need for data exchanges, to the very complex with tremendous amounts of data exchanges required to ensure the DER systems are functioning as expected. Examples of the range of configurations are described in the following subclauses.

A2.3.2 Configuration #1 – Single DER Unit with Manual Controls

The simplest configuration is a single DER unit with manual controls. In this configuration, the DER unit can be considered a “black box”, and no standardized communications are required. Any communications internal to such a DER unit may use proprietary data formats, since interoperability is not an issue (see Annex Figure 4).

Examples of such configurations include:

- Small photovoltaic systems that may be manually connected and disconnected at a circuit breaker
- Batteries used as uninterruptible power for a local power system.



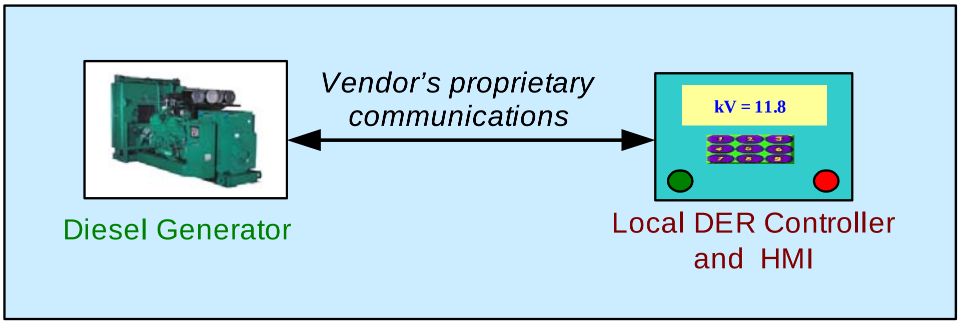
Annex Figure 4: Configuration #1 – Manual DER System

A2.3.3 Configuration #2 – Standalone DER Unit Connected to a Local Controller

A very common configuration is a single, standalone DER unit connected to a local controller that provides a simple HMI (human-machine interface) for local interactions with the DER unit. The communications links between the DER device and the local controller are currently vendor proprietary. Since the HMI and these links are usually packaged as a unit, it may not be necessary or beneficial at this time to standardize the information flows on these links. Therefore, any communications internal to such a DER system may use proprietary data formats, since interoperability is not an issue (see Annex Figure 5).

Examples of such configurations include:

- Diesel generators and their controllers used as customer backup to utility power
- Photovoltaic systems with solar tracking controllers



Annex Figure 5: Configuration #2 – Standalone DER with Local Controller/HMI

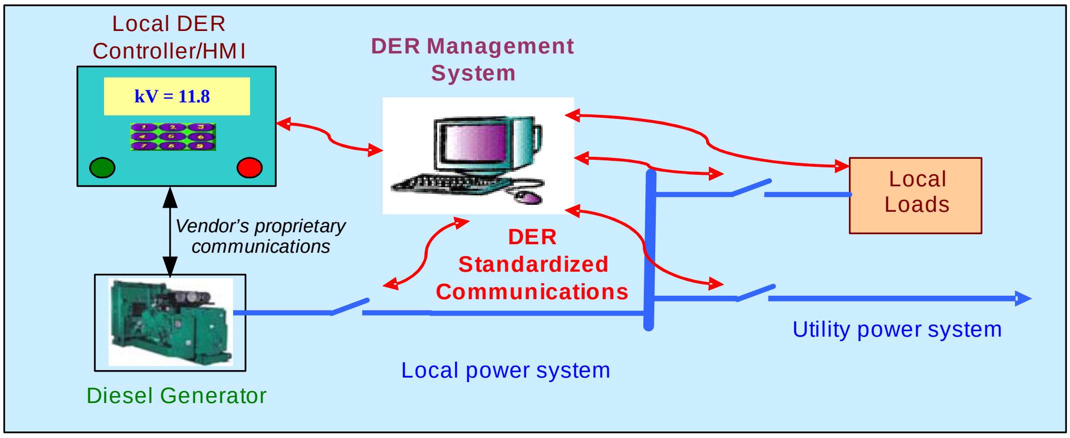
A2.3.4 Configuration #3 – Local DER Management System

Another configuration is a local DER Management System controlling to a single or multiple DER units. The DER Management System also monitors, controls, and maintains the local power system, including the switching operations of DER units and local loads. This DER Management System may be a system that handles the scheduling and running of DER units only or it could be a part of a Building Automation System (BAS). The BAS would combine the scheduling and management of the loads within a customer's site with the scheduling and management of the DER generation (see Annex Figure 6).

Since this configuration requires communications between control systems and power system equipment that are very likely to be manufactured by different vendors, the need for standardization of information exchanges becomes critical. Specifically, these interfaces would be between the DER Management System and the Local Controller/HMI, the local loads, the local switches, and the local protective relays. These interfaces are shown as curved red pointers in the figure.

Examples of such configurations include:

- Combined heat and power (CHP) system used to generate electricity with the heat by-product of an industrial process
- Small hydro plant that manages both electricity production and water flow requirements
- Wind turbines in a wind farm
- Diesel generator used for peak shaving in an industrial plant with a demand-based tariff
- Fuel cell system used in a substation



Annex Figure 6: Configuration #3 – Local DER Management System

A2.3.5 Configuration #4 – Remote DER Master Station for Multiple DER Systems

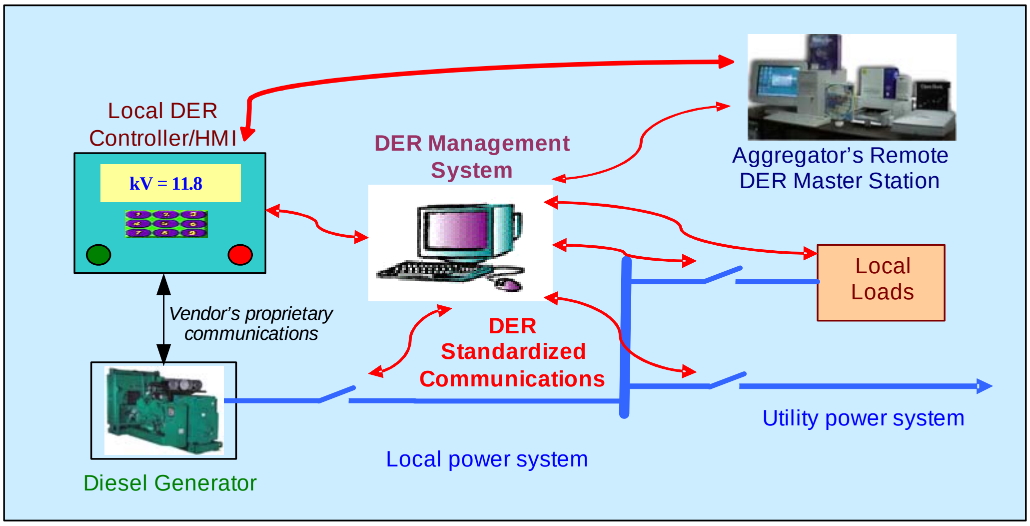
A more complex configuration involves the use of a remote DER master station to monitor and control one or more DER systems. This remote DER master station could be an aggregator's system, a utility's energy management system, or a building management system that handles multiple DER installations, providing different levels of monitoring, control, statistics-gathering, and maintenance support (see Annex Figure 7).

The information exchange requirements for this configuration expand from management of the local power system to the management of multiple power systems with different local environments and different contractual relationships with the remote system. Although the communications would most likely be through the DER management systems, alternative configurations could involve communications directly to the local DER controller/HMI.

Since this configuration requires communications between remote systems and DER management systems that are very likely to be manufactured by different vendors, the need for standardization of information exchanges becomes critical. These interfaces are shown as curved red pointers in the figure.

Examples of such configurations include:

- A commercial company has multiple office sites nation-wide, each with a DER system for backup and for peak shaving. An aggregator has been contracted to manage the DER systems on all sites.
- A university campus has many buildings, each with different CHP systems. An energy service provider has been contracted to manage these CHP systems.
- An energy service provider manages multiple wind farms across state and country borders.



Annex Figure 7: Configuration #4 – Remote DER Master Station

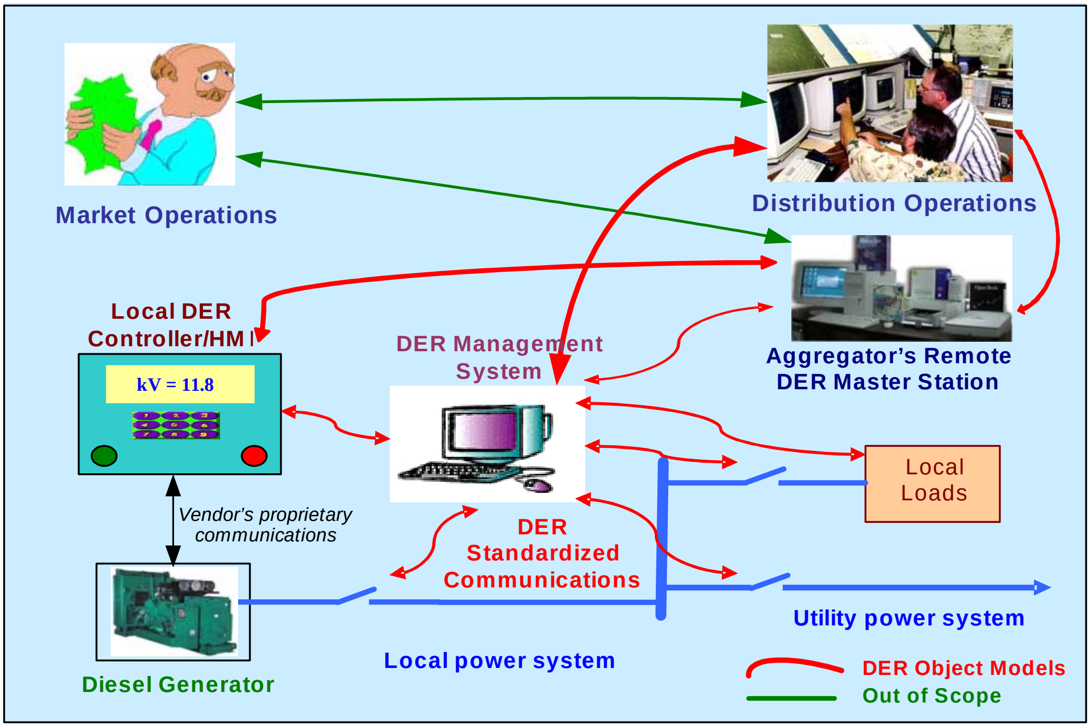
A2.3.6 Configuration #5 – Utility Operations Managing DER Systems

Utility operations can directly manage multiple different DER systems as part of distribution operations, possibly including market operations. At a simple level, the distribution operations could simply monitor these DER systems; while at more complex levels the distribution operations could actively manage the DER systems for volt/var control, schedule the DER systems for energy and ancillary services in the energy marketplace, utilize DER systems for emergency responses, and initiate deliberate islanding of the power system into "microgrids" for economic or emergency reasons (see Annex Figure 8).

The information exchange requirements for this scenario involve many different systems with many variations on what information will be needed by what system, and when and how. Standards are therefore crucial.

Examples of such configurations include:

- A utility manages sets of fuel cells at multiple substations. These are used for voltage support and peak shaving.
- A utility manages a group of hotels which each have DER systems. If utility power is lost, these hotels form a microgrid to provide at least emergency generation for the group.



Annex Figure 8: Configuration #5 – Distribution Operations Managing DER Systems

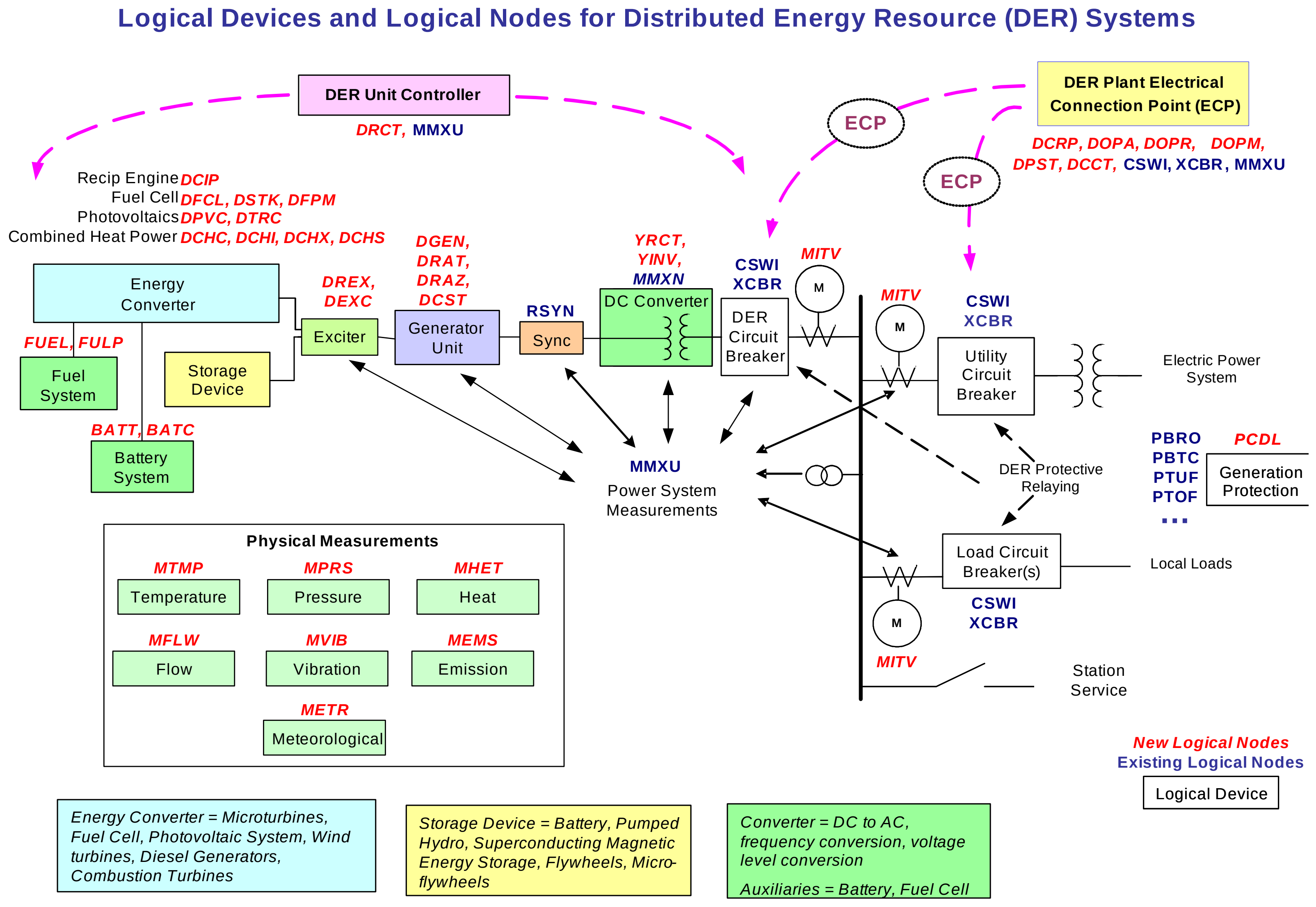
A3. Examples of Using DER Logical Nodes in DER Implementations (Informative)

A3.1 Generic DER Installation Configuration

As can be seen from the different configurations above, DER systems can be implemented in many different ways. In addition, DER systems themselves are made up of different modules, some of which are similar between types of DER and others of which are unique to each DER type. As can be seen in the normative information modeling clauses, this decomposition into modules is very important.

Annex Figure 9 shows a block diagram of a generic DER system in which the relationships between (normative) logical nodes (LNs) and the (informative) DER logical devices (LDs) is illustrated. The Red LNs are new for DER; the Blue LNs already exist. The block diagram illustrates LNs in the following logical devices:

1. DER Systems
    - DER Plant Electrical Connection Point (ECP)
    - DER Unit Controller
    - DER Generation
    - DER Excitation
    - DER Inverter/Converter
2. Specific Types of DER Systems
    - Reciprocating Engine (e.g. diesel engine)
    - Fuel Cell
    - Photovoltaic System
    - Combined Heat and Power
3. Auxiliary Systems
    - Interval Meter
    - Fuel System
    - Battery System
    - Physical Measurements

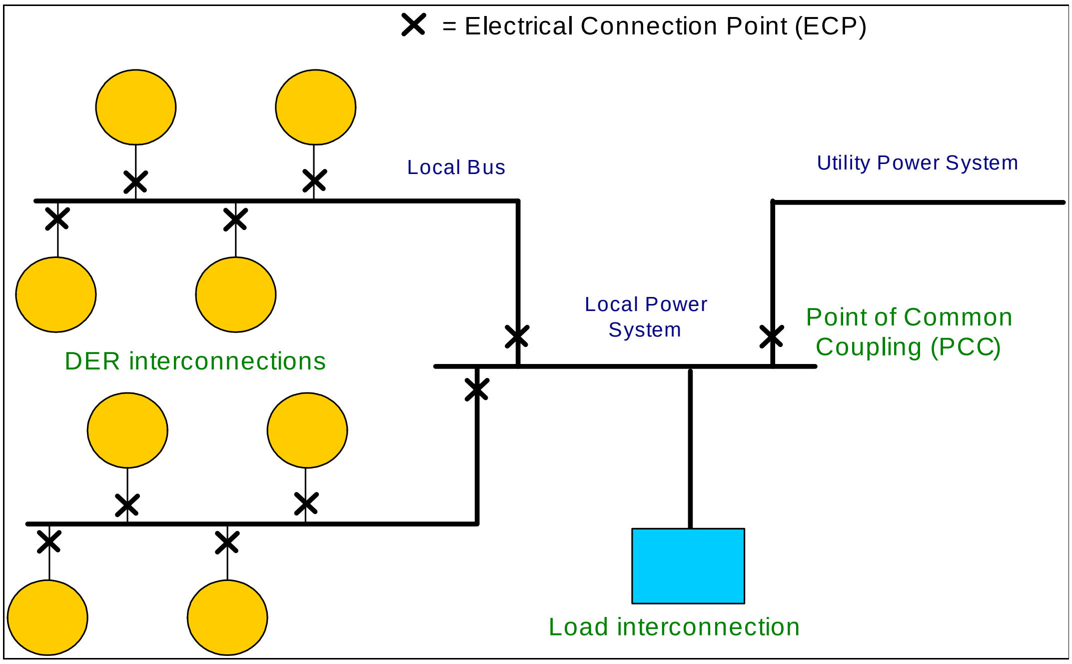


Annex Figure 9: Block Diagram of a Generic Distributed Energy Resources (DER) System

DER Plant Electrical Connection Point (ECP) Logical Device
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.

In a simple DER configuration, there is one ECP between a single DER unit and the utility power system. However, as shown in Annex Figure 10, 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



Annex Figure 10: 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:

- 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 the ECP, including ownership, operating authority, contractual obligations and permissions, location, and identities of all DER devices connected directly or indirectly at the ECP
- **DOPA**: DER operational control authorities at the 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.
- **DOPR**: DER plant operational characteristics at the 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
- **DOPM**: DER operating mode at the ECP. This LN can be used to set available operating modes as well as actual operating modes.
- **DPST**: Actual status at the ECP, including DER Plant connection status, alarms
- **DCCT**: Economic dispatch parameters for DER operations
- **XCBR, CSWI**: Switch or breaker at the ECP and/or at the load connection point (see IEC 61850-7-4)
- **MMXU**: Actual power system measurements at the 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)
- **MITV**: Interval metering information at the ECP, including interval lengths, readings per interval

Recommendations on historical and statistical logging are not standard, but could be included as informative.

A3.1.2 DER Device Controller Logical Device

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, ratings, etc

- **MMXU**: DER self serve active and reactive power measurements

A3.1.3 DER Generator Logical Device

Each DER unit has a generator. Although each type of DER 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
- **DREX**: DER excitation ratings
- **DEXC**: Excitation component of generator
- **RSYN**: Synchronization (See IEC 61850-7-4 with expected enhancements)
- **DCST**: Costs associated with generator operations

A3.1.4 DER Excitation Logical Device

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

A3.1.5 Inverter/Converter Logical Device

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:

- **YRCT**: Rectifier for converting alternating current to continuous, direct current (AC -> DC)
- **YINV**: Inverter for converting direct current to alternating current (DC -> AC)
- **MMXN**: Measurement of intermediate DC
- **MMXU**: Measurements of input AC (See IEC 61850-7-4)
- **MMXU**: Measurements of output AC (See IEC 61850-7-4)

A3.2 Reciprocating Engine (Diesel GenSet) Logical Device

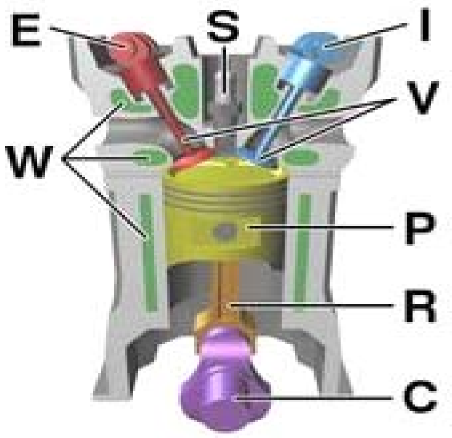
A3.2.1 Reciprocating Engine Description

A reciprocating engine is an engine that utilizes one or more pistons in order to convert pressure into a rotating motion.

Today 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 (see Annex Figure 11).

This figure illustrates the components of a typical, four stroke cycle, DOHC reciprocating engine: (E) Exhaust camshaft, (I) Intake camshaft, (S) Spark plug, (V) Valves, (P) Piston, (R) Connecting rod, (C) Crankshaft, (W) Water jacket for coolant flow.

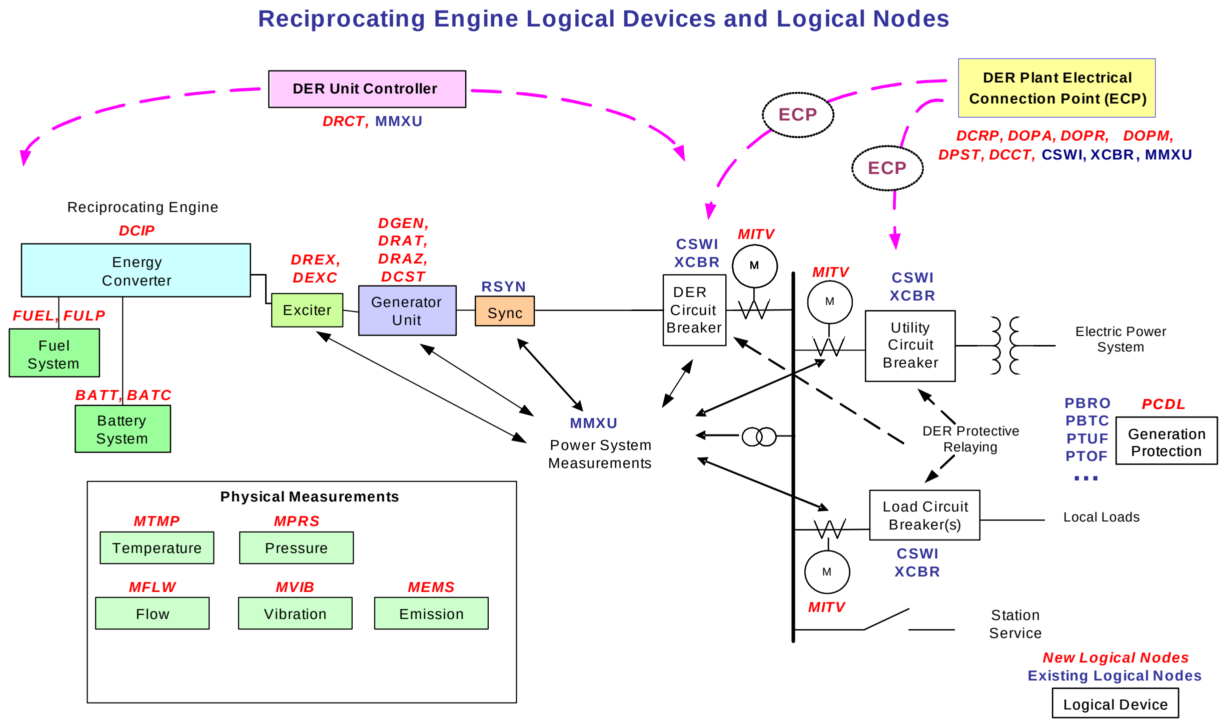
There may be one or more pistons. Each piston is located inside a cylinder, into which a fuel and air mixture is introduced, and then ignited. The now hot gases expand, pushing the piston away. The linear movement of the piston is converted to a circular movement via a connecting rod and a crankshaft. The more cylinders a piston engine has, the more power it is capable of producing, so it is common for such engines to be classified by the number and alignment of cylinders. Single- and two-cylinder engines are common in smaller vehicles such as motorcycles; automobiles, locomotives, and ships may have a dozen cylinders or more. These engines are known collectively as internal-combustion engines, although internal-combustion engines do not necessarily contain pistons.



Annex Figure 11: Reciprocating engine *(Wikipedia)*

A3.2.2 Reciprocating Engine Logical Device

The LNs in this section cover the object models for the reciprocating engine energy converter. Annex Figure 12 illustrates the LNs in a reciprocating engine system.



Annex Figure 12: LNs in a Reciprocating Engine System (e.g. Diesel Gen-Set)

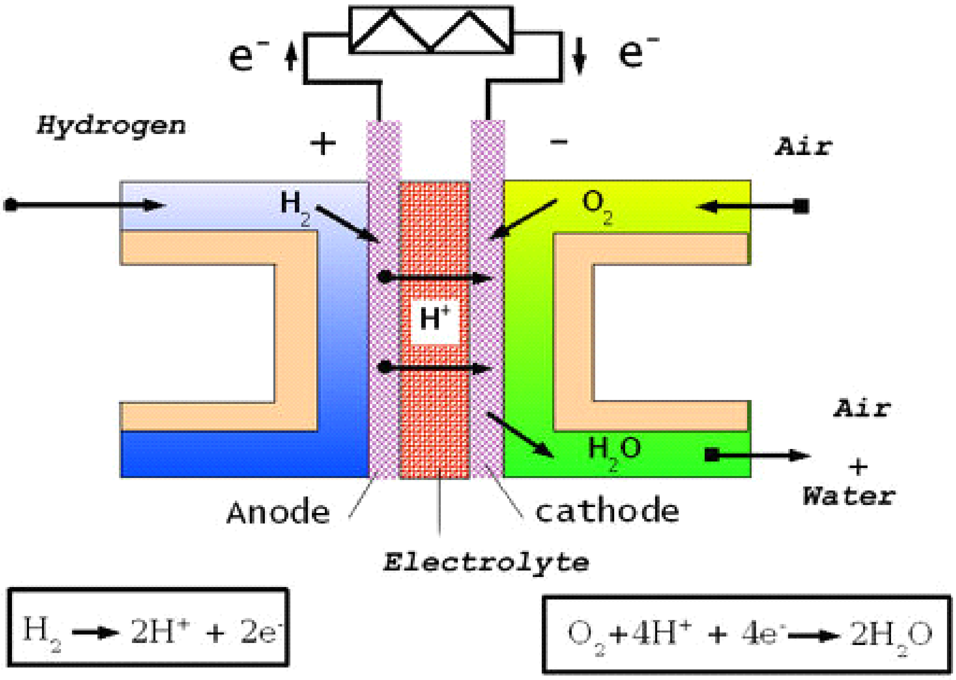
The Logical Nodes in the reciprocating engine logical device include:

- **DCIP**: Reciprocating engine characteristics, measured values, and controls
- **DRCT**: DER general controller characteristics
- **MITV**: Metering information
- **FUEL**: Fuel characteristics
- **BATT**: Auxiliary battery
- **BATC**: Auxiliary battery charger
- **MTMP**: Temperature characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, lubrication (oil), after-cooler, etc.
- **MPRS**: Pressure characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc.
- **MFLW**: Flow characteristics, including coolant, lubrication, etc.
- **MEMS**: Emissions characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (see Clause 7.4.6)
- **MVIB**: Vibration characteristics (See Clause 7.4.6)

A3.3 Fuel Cell Logical Device

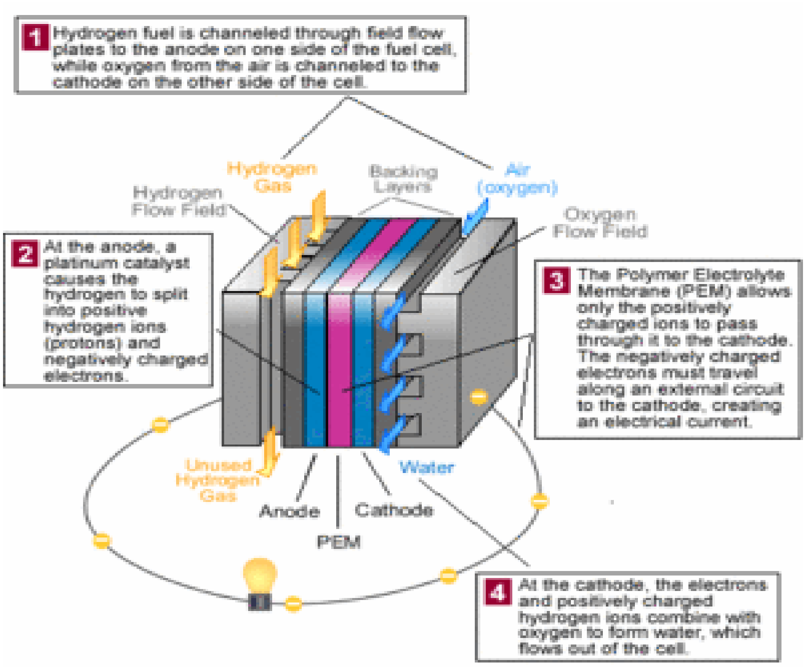
A3.3.1 Fuel Cell Description

A fuel cell is an electrochemical energy conversion device similar to a battery, but differing from the latter in that it is designed for continuous replenishment of the reactants consumed; i.e. it produces electricity from an external supply of fuel and oxygen as opposed to the limited internal energy storage capacity of a battery. Additionally, the electrodes within a battery react and change as a battery is charged or discharged, whereas a fuel cell's electrodes are catalytic and relatively stable. A diagram of a fuel cell is shown in Annex Figure 13.



Annex Figure 13: Fuel cell – Hydrogen/oxygen proton-exchange membrane fuel cell (PEMFC) (*Wikipedia)*

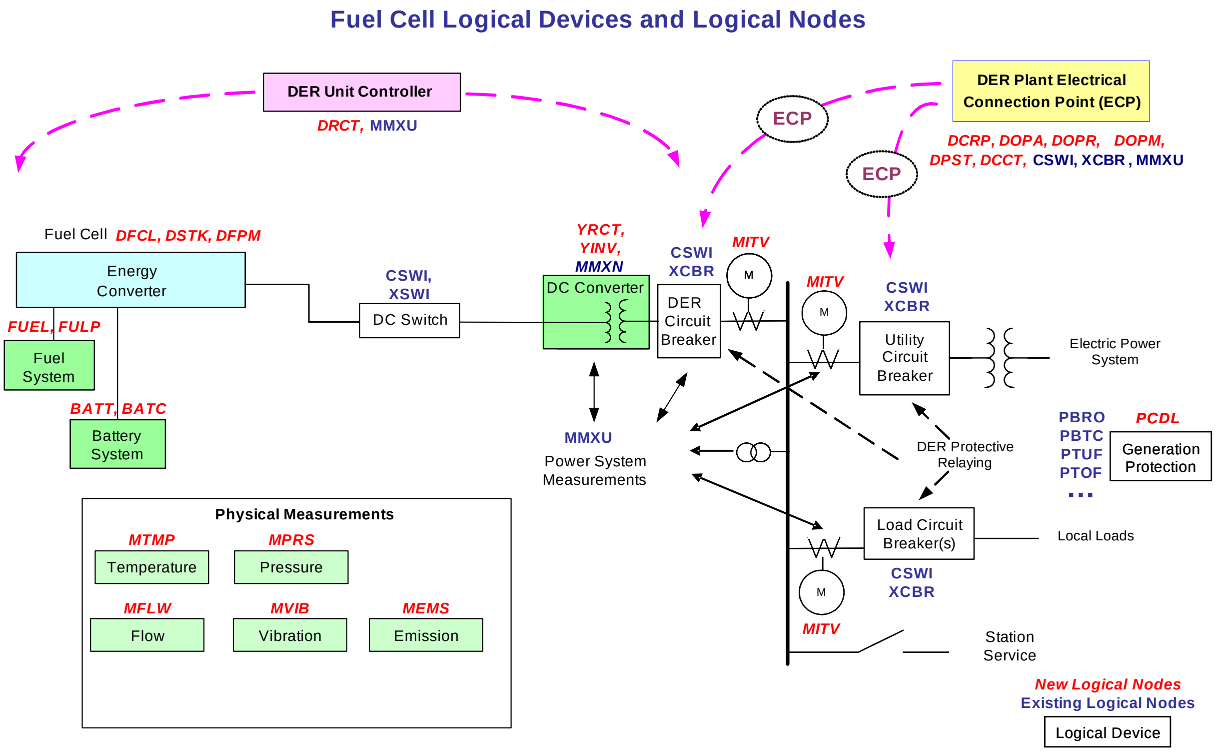
A typical fuel cell produces about 0.8 volts. To create enough voltage for the many applications requiring higher voltage levels, the cells are layered and combined in series and parallel into a "Fuel Cell Stack" (see Annex Figure 14). The number of cells used is usually greater than 45 and varies with design. The theoretical voltage of a fuel cell is 1.23 volts, at a temperature of 25°C. This voltage depends on the fuel used, quality and temperature of the cell.



Annex Figure 14: Fuel Cell Stack

A3.3.2 Fuel Cell Logical Device

The LNs in this section describe the object models for the fuel cell as a prime mover. Annex Figure 15 illustrates the LNs used in a Fuel Cell system.



Annex Figure 15: LNs Used in a Fuel Cell System

The fuel cell logical device would include the following LNs:

- **DFCL**: Fuel cell controller characteristics. These are the fuel cell specific characteristics which are not in DRCT
- **DSTK**: Fuel cell stack
- **DFPM**: Fuel processing module
- **CSWI**: Switch between fuel cell and inverter (see IEC 61850-7-4)
- **YINV**: Inverter (see Clause 5.6.3)
- **MMXU**: Output electrical measurements (see IEC 61850-7-4)
- **MMXN**: Measurement of intermediate DC
- **DRCT**: DER general controller characteristics (see Clause 5.3.2)
- **MITV**: Metering information (see Clause 7.1.2)
- **FUEL**: Fuel characteristics (See Clause 7.2.2)
- **BATT**: Auxiliary battery (See Clause 7.3.2)
- **BATC**: Auxiliary battery charger (See Clause 7.3.3)
- **MTMP**: Temperature characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), etc. (See Clause 7.4.2)
- **MPRS**: Pressure characteristics, including intake (e.g. air, oxygen, water), exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler, etc. (See Clause 7.4.3)

- **MEMS**: Emissions characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), after-cooler, etc. (See Clause 7.4.6)
- **MVIB**: Vibration characteristics (See Clause 7.4.6)

A3.4 Photovoltaic Systems Logical Device

A3.4.1 Photovoltaic System Description

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.

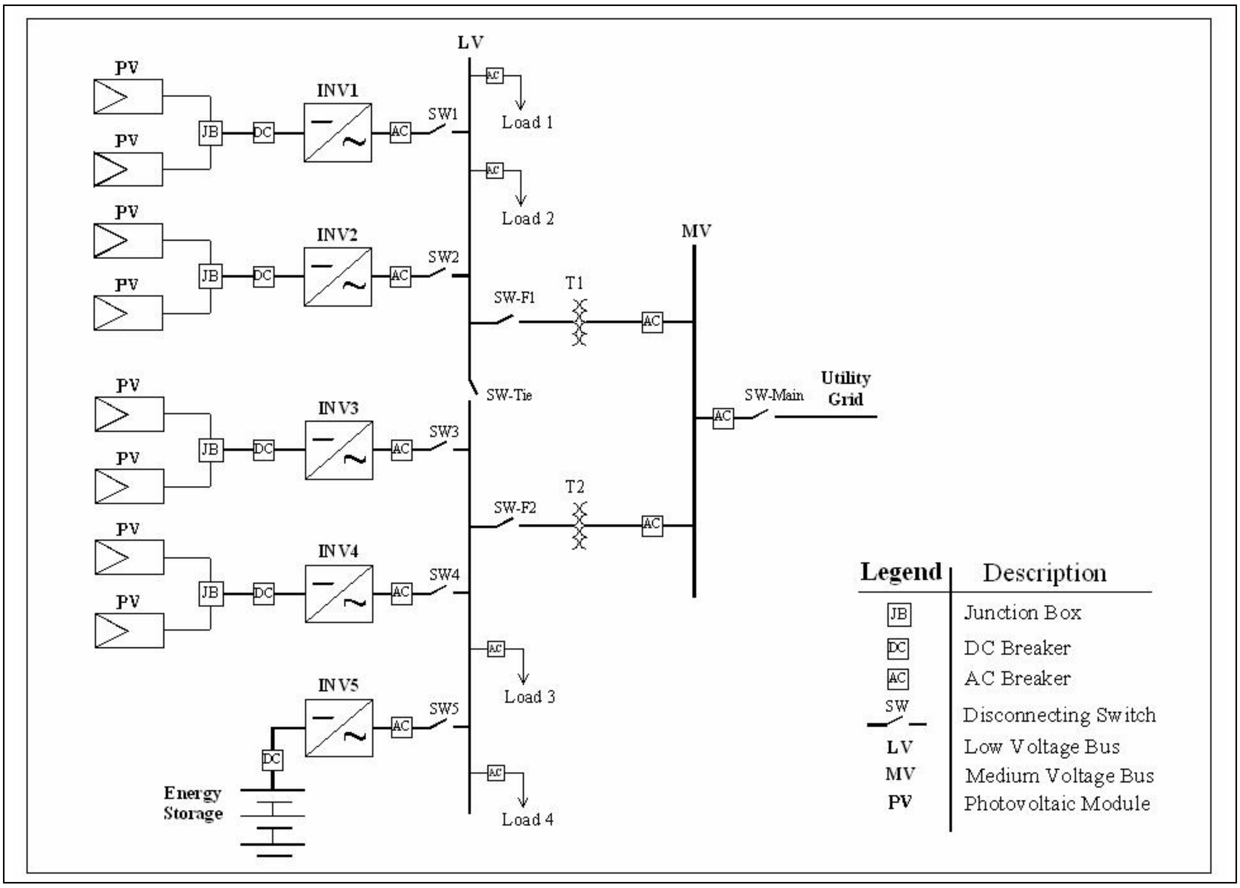
PV systems are modular – the building blocks (modules) come in a wide range of power capabilities. These modules can be connected in various configurations to build power systems capable of providing several megawatts of power. However, most installed PV systems are much smaller.

The basic unit of photovoltaic conversion is a semiconductor device called the PV cell. A PV module is the smallest complete environmentally protected assembly of interconnected cells. These modules are themselves assembled to form a PV array. Basically, the PV array is considered to be a DC power supply unit. Modules can be connected in series (PV string), in parallel, or in a combination of series-parallel. In a large system, PV arrays are often divided into 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 interconnected with the power system. Therefore, there is no obligation to provide additional energy storage (e.g. battery system), although this may be included.

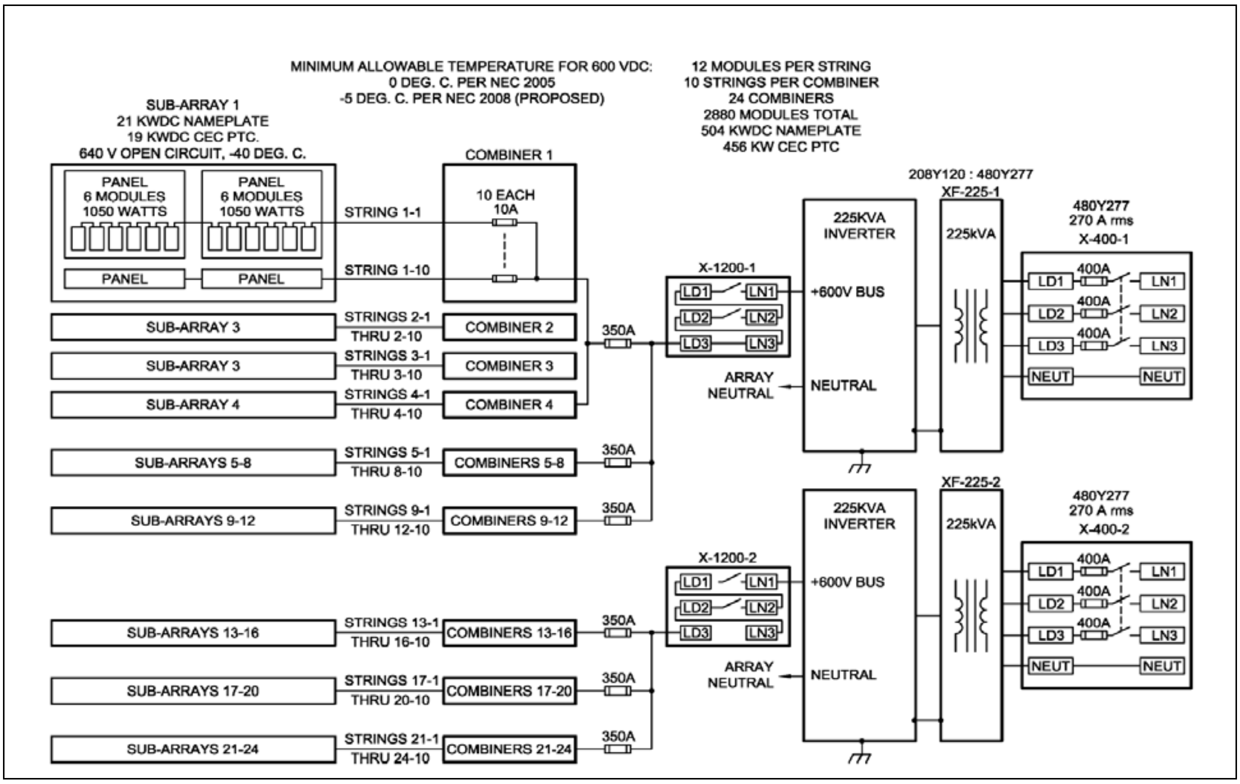
Since the power system requires AC power for interconnected generation, a power conditioning unit (PCU) or inverter is required to transform the DC output of the PV array into AC. Inverters used in PV system have the added task of adjusting the current and voltage levels (DC) to maximize efficiency during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

Annex Figure 16 illustrates a small interconnected PV system using multiple inverters. In this example, the PV arrays are composed of two modules.



Annex Figure 16: One line diagram of an interconnected PV system

A larger and more complex PV array can be used in a larger system. Annex Figure 17 gives an illustration of such a PV system.



Annex Figure 17: PV array diagram - large array divided in sub arrays

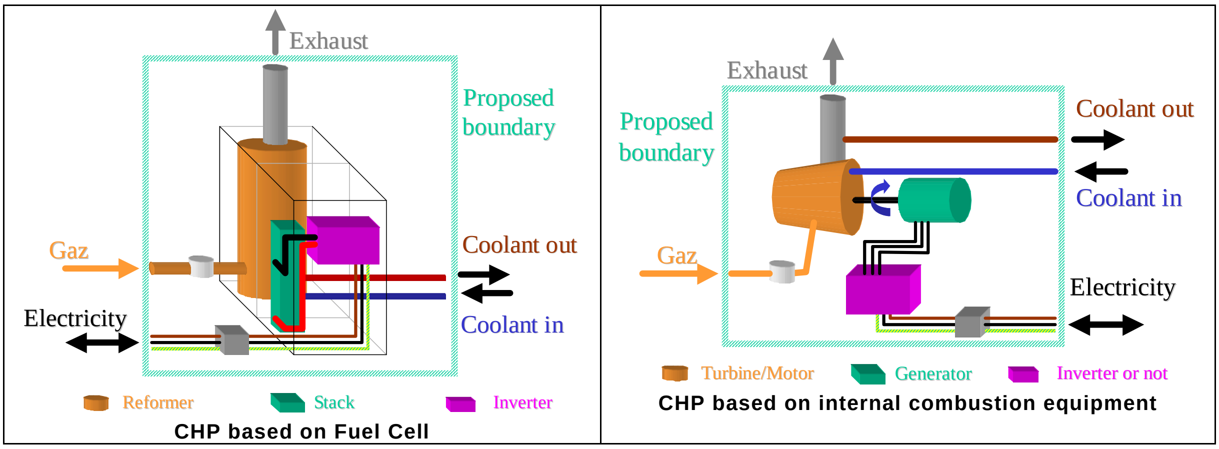
A3.5 Combined Heat and Power Logical Device

A3.5.1 Combined Heat and Power Description

Combined Heat and Power (CHP) covers multiple types of generation systems involving heat. Different CHP purposes include:

- Heat is produced through an industrial process. 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.
- Fuel is burned in order to create heat (e.g. for heating buildings), and this heat is also used to generate electrical energy (e.g. gas /combustion turbine).
- Inexpensive 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 (ownership of different equipment, market interactions with respect to heat and energy, constraints on heat or electrical production, etc.). Annex Figure 18 illustrates two configurations.



Annex Figure 18: Two Examples of CHP Configurations

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

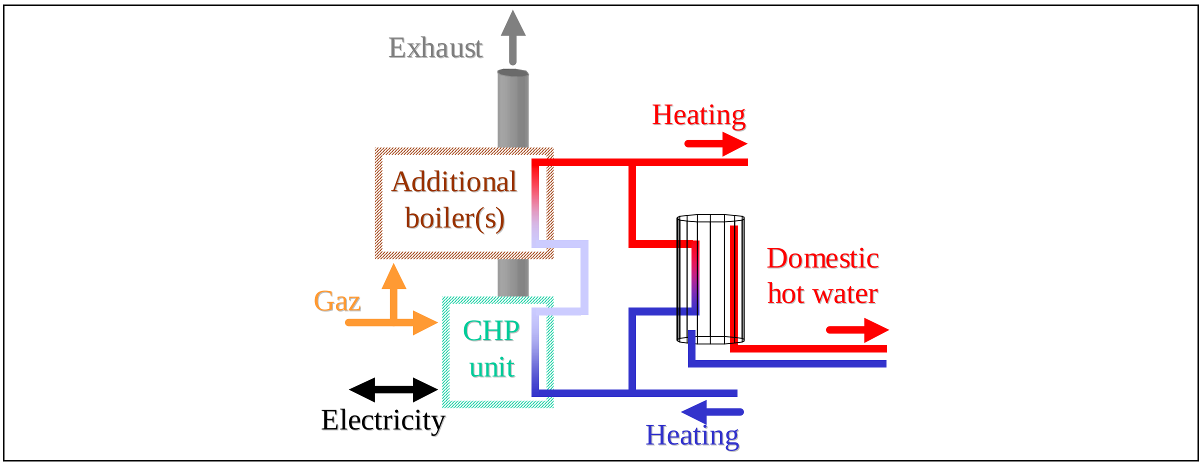
- The large variety of different types, purposes, and operational characteristics of CHP systems
- The heterogeneous maturity of CHP systems

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. Object models of each of these different parts can then be created.

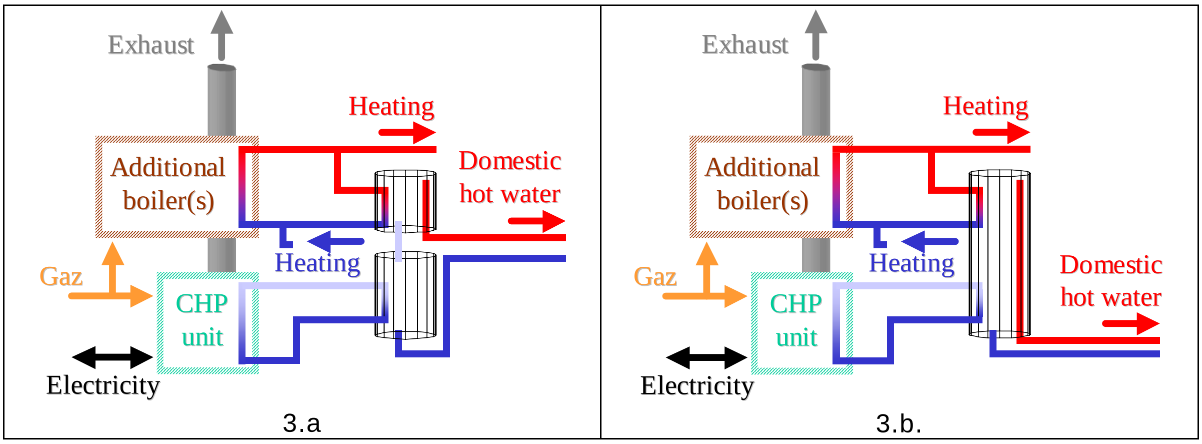
Annex Figure 19, Annex Figure 20, and Annex Figure 21 below show three simple thermal facility scheme examples:

- In the first figure, heated water/steam from the heating system is used directly for the electricity generation system.
- In the second and third figures, 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 the third figure, 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.



Annex Figure 19: CHP unit includes both domestic hot water and heating loops



Annex Figure 20: CHP unit includes domestic hot water with hybrid storage

Annex Figure 21: 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, microturbine, and diesel engines). Some of these combinations are in different phases of development (from commercial to prototypes). Therefore, determining which combined technologies will be used over time will be difficult to determine.

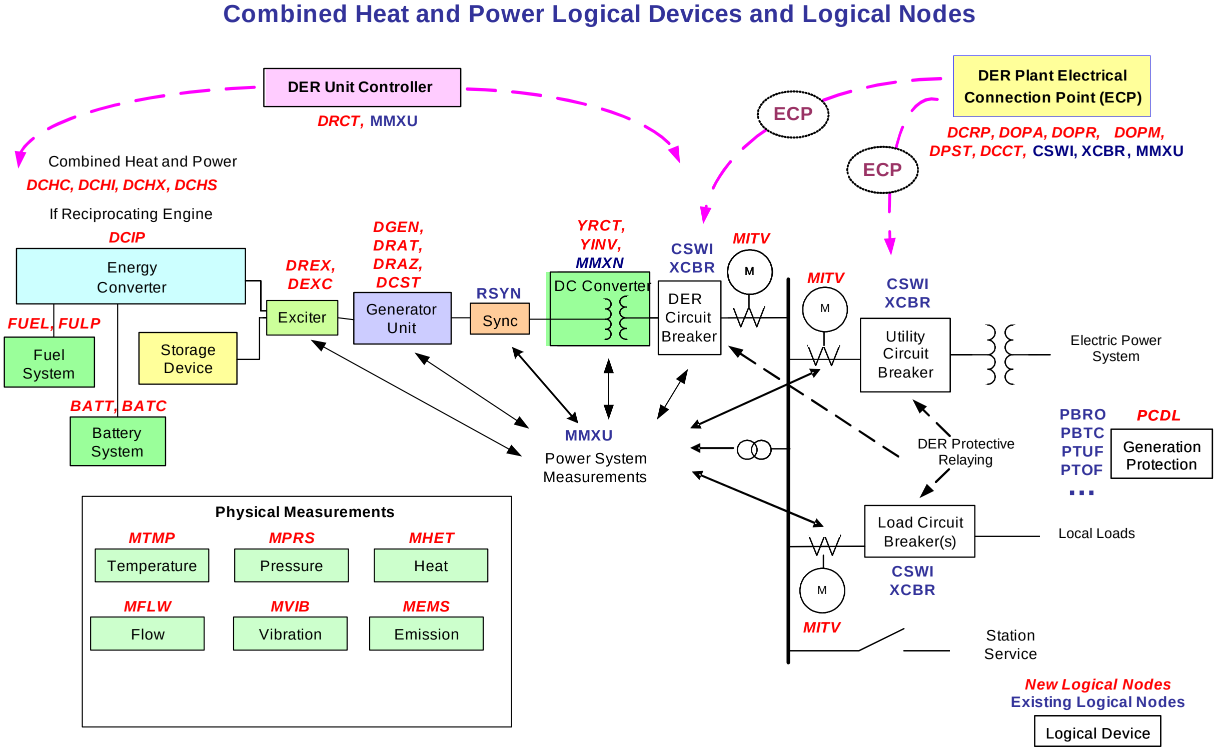
These facts lead again to the conclusion that each part of a CHP system should be separately modelled, with these parts put together as needed by the implementers of different CHP systems. For this reason, many different Logical Nodes could be used in a CHP system, most of which are already existing or proposed for other DER systems. The LNs that may be unique to CHP are those which handle the “combined” aspect of CHP, along with the characteristics of the individual parts of the CHP system:

- Combined operations management
- Heat production and boiler systems
- Heat exchange systems
- Chimney and exhaust systems
- Cooling systems

A3.5.2 Combined Heat and Power Logical Device

The LNs in this section 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[9], etc.).

Annex Figure 22 illustrates the CHP Logical Nodes.



Annex Figure 22: LNs Associated with a Combined Heat and Power (CHP) System

The Logical Devices probably used with a CHP Logical Device include:

- **DER Plant ECP:** electrical connection point of the DER plant to an electric power system, which could be local or interconnected to the power system.
- **DER Unit Controller**: general capabilities of the controller for any type of DER unit
- **DER Generation**: generator characteristics
- **DER Excitation**: exciter characteristics
- **DER *Energy Converter***, such as reciprocating engine, steam turbine, or fuel cell. (The Logical Nodes for a turbine have not been developed yet.)
- **DER Fuel System**: fuel system characteristics, including fuel pumps and costs

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

[9] IEC 61850 object models for steam turbines, gas turbines, and microturbines have not yet been developed

- **DCHI**: CHP chimney and exhaust
- **DCHX**: CHP heat exchanger
- **DCHP**: CHP heat production
- **DCHC**: CHP coolant system
- **MMXU**: electrical measurements (see IEC 61850-7-4)
- **MITV**: Metering information (see Clause 7.1.2)
- **MTMP**: Temperature characteristics (see Clause 7.4.2)
- **MPRS**: Pressure measurements (see Clause 7.4.3)
- **MHET**: Heat and cooling measurements (see Clause 7.4.4)
- **MFLW**: Flow measurements (see Clause 7.4.5)
- **MVIB**: Vibration measurements (see Clause 7.4.6)
- **MEMS**: Emission measurements (see Clause 7.4.7)

A3.6 Auxiliary Logical Devices

A3.6.1 Interval Metering Logical Device

A3.6.2 Fuel System Logical Device

The fuel system logical device describes the characteristics of the system of fuel for different prime movers. The LNs could include:

- **FUEL**: fuel characteristics
- **FULP**: delivery system for the fuel, including the rail system, pump, and valves

The following table shows the different types of fuel[10]:

Annex Table 1: Fuel types

Type of Energy Source	Energy Source Code	Unit Label	AER (Aggregated) Fuel Code	Energy Source Description
Fossil and Nuclear Fuels				
Coal and Syncoal	BIT	tons	COL	Anthracite Coal and Bituminous Coal
	LIG	tons	COL	Lignite Coal
	SUB	tons	COL	Sub-bituminous Coal
	WC	tons	WOC	Waste/Other Coal (includes anthracite culm, bituminous gob, fine coal, lignite waste, waste coal)
	SC	tons	COL	Coal-based Synfuel, including briquettes, pellets, or extrusions, which are formed by binding materials or processes that recycle materials
Petroleum	DFO	barrels	DFO	Distillate Fuel Oil (Diesel, No. 1, No. 2, and No. 4 Fuel Oils)
	JF	barrels	WOO	Jet Fuel
	KER	barrels	WOO	Kerosene
	PC	tons	PC	Petroleum Coke

10 EIA – Energy Information Administration, official energy statistics from the US government

Type of Energy Source	Energy Source Code	Unit Label	AER (Aggregated) Fuel Code	Energy Source Description
Products	RFO	barrels	RFO	Residual Fuel Oil (No. 5, No. 6 Fuel Oils, and Bunker C Fuel Oil)
	WO	barrels	WOO	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	Mcf	NG	Natural Gas
	BFG	Mcf	OOG	Blast Furnace Gas
	OG	Mcf	OOG	Other Gas
	PG	Mcf	OOG	Gaseous Propane
Nuclear	NUC	N/A	NUC	Nuclear Fission (Uranium, Plutonium, Thorium)
Renewable Fuels				
Solid Renewable Fuels (Biomass)	AB	tons	ORW	Agricultural Crop Byproducts/Straw/Energy Crops
	MSW	tons	MLG	Municipal Solid Waste
	OBS	tons	ORW	Other Biomass Solids
	TDF	tons	ORW	Tire-derived Fuels
	WDS	tons	WWW	Wood/Wood Waste Solids (paper pellets, railroad ties, utility poles, wood chips, bark, an other wood waste solids)
Liquid Renewable (Biomass) Fuels	OBL	barrels	ORW	Other Biomass Liquids (specify in Comments)
	BLQ	tons	WWW	Black Liquor
	SLW	tons	ORW	Sludge Waste
	WDL	barrels	WWW	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	Mcf	MLG	Landfill Gas
	OBG	Mcf	ORW	Other Biomass Gas(includes digester gas, methane, and other biomass gases)
All Other Renewable Fuels			GEO	
	GEO	N/A		Geothermal
	WAT	N/A	HYC	Water at a Conventional Hydroelectric Turbine
	SUN	N/A	SUN	Solar
	WND	N/A	WND	Wind
All Other Fuels				
	HPS	N/A	HPS	
	PUR	N/A	OTH	Purchased Steam
	WH	N/A	OTH	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	Other

A3.6.3 Battery System Logical Device

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 the prime mover for generating electricity.

The LNs could include:

- **BATT**: battery system characteristics
- **BATC**: charger for the battery system

A3.6.4 Physical Measurements

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

The LNs included are:

- **MTMP**: Temperature measurements
- **MPRS**: Pressure measurements
- **MHET**: Heat measurements
- **MFLW**: Flow measurements
- **MVIB**: Vibration conditions
- **MEMS**: Emission conditions
- **METR**: Meteorological conditions