IEC TR 61850-90-27

Edition 1.0 2023-08

TECHNICAL REPORT

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Communication networks and systems for power utility automation – Part 90-27: Use of IEC 61850 for thermal energy systems connected to electric power grid

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COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

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IEC TR 61850-90-27 has been prepared by IEC technical committee 57: Power systems management and associated information exchange. It is a Technical Report.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
57/2571/DTR	57/2584/RVDTR

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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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

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INTRODUCTION

The world-wide need to reduce greenhouse gas emissions considerably in order to further reduce detrimental effects on the climate requires that all sectors – power generation, industry, transport, buildings construction and agriculture – contribute to the low-carbon transition.

The power sector has been identified as having the biggest potential for cutting emissions and measures. Ways to accomplish that have also been identified: more renewable energy generation. As some renewable energy sources are intermittent, their integration into the electrical grid calls for adequate measures in order not to endanger system stability and reliability. To accomplish the increased renewable energy integration, there are several measures at hand, one of them being the conversion of excess electrical energy into another energy carrier such as gas or heat and hence to couple the electrical grid with the heat network and the gas network.

In order to allow for future sector coupling activities using the IEC 61850 series, the IEC is aware that the scope of the IEC 61850 series of standards needs to be enhanced. This is true especially for IEC 61850-7-420 tackling distributed energy resources. Hence this report is a crucial first step towards introducing relevant non-electric energy sectors such as gas and heat as cross sectors to the electric energy system.

COMMUNICATION NETWORKS AND SYSTEMS FOR POWER UTILITY AUTOMATION –

Part 90-27: Use of IEC 61850 for thermal energy systems connected to an electric power grid

1 Scope

1.1 General

The scope of this part of IEC 61850, which is a Technical Report, is to provide basic aspects that need to be considered when using IEC 61850 for information exchange between systems and components to support applications for thermal systems connected to electric power networks. Thermal systems isolated from electric power networks are outside the scope of this document.

From the perspective of category, this document considers thermal systems that provide thermal energy services for residential and/or commercial buildings and districts. In other words, industrial thermal systems are outside the scope of this document.

From the perspective of energy transformation, this document deals with ones between electricity and thermal energy. Other types of energy such as gas will be documented in a future report.

From the perspective of resource, this document considers generic aspects of thermal energy generators, storage, and loads that may contribute to the operations and management of electric power networks. It also deals with specific types of resources that have electric parts such as power to heat (P2H) that is a kind of electric load, and combined heat and power (CHP) that is an electric generator. This document models the characteristics for such specific units of resources including alarms and ratings. On the other hand, it does not deal with other types of specific units according to the scope of this document. For example, gas boilers, thermal energy tanks, heat exchangers, HVAC, auxiliary devices for thermal systems are not modelled as logical nodes in this document.

As a summary, this document

– gives an overview of thermal energy resources connected to electric power networks.
– provides use cases for typical operations of thermal system and deducts exchanged information necessary for information modelling.
– provides mapping of requirements on LNs based on the use cases.
– defines generic logical nodes for resources in thermal systems.
– defines logical nodes for specific unit types of P2H and CHP.
– defines logical nodes for operations that may contribute to the operations of electric power networks.

1.2 Data model Namespace name and version

Table 1 shows all tracking information of (Tr)IEC 61850-90-27:2023A namespace.

Table 1 – Tracking information of (Tr)IEC 61850-90-27:2023A namespace

Attribute	Content
Namespace IEC specific information	
Version of the UML model used for generating the document (informative)	WG17build10
Date of the UML model used for generating the document (informative)	2023-07-11
Autogeneration software name and version(informative)	j61850DocBuilder 02.02 based on jCleanCim noNS beta9.2 (derived from jCleanCim 02-02)

Table 2 shows all attributes of the (Tr)IEC 61850-90-27:2023A namespace.

Table 2 – Attributes of (Tr)IEC 61850-90-27:2023A namespace

Attribute	Content
Namespace nameplate	
Namespace Identifier	(Tr)IEC 61850-90-27
Version	2023
Revision	A
Release	1
Full Namespace Name	(Tr)IEC 61850-90-27:2023A
Full Code Component Name	IEC_TR_61850-90-27.NSD.2023A.Full
Light Code Component Name	IEC_TR_61850-90-27.NSD.2023A.Light
Namespace Type	transitional
Namespace dependencies	
extends	IEC 61850-7-4:2007B version:2007 revision:B
extends	IEC 61850-7-420:2019A version:2019 revision:A
Namespace transitional status	
Future handling of namespace content	The name space (Tr)IEC 61850-90-27:2023A is considered as "transitional" since the models are expected to be included in further editions IEC 61850-7-4xx. Potential extensions/modifications may happen if/when the models are moved to the International Standard status

1.3 Data model Namespace Code Component distribution

This document is associated with Code components. Each Code Component is a ZIP package containing at least the electronic representation of the Code Component itself and a file describing the content of the package (IECManifest.xml).

The life cycle of a code component is not restricted to the life cycle of this document. The publication life cycle goes through two stages, "Version" (corresponding to an edition) and "Revision" (corresponding to an amendment). A third publication stage (Release) allows publication of Code Component in case of urgent fixes of Inter-operability Tissues, thus without need to publish an amendment.

Consequently, new release(s) of the Code Component(s) may be released, which supersede(s) the previous release, and will be distributed through the IEC web site at: http://www.iec.ch/tc57/supportdocuments.

The latest version/release of the document will be found by selecting the file for the code component with the highest value for VersionStateInfo, e.g. *IEC_TR_61850-90-27.NSD.{VersionStateInfo}.Light*.

The Code Components associated with this document are reflecting the data model specified in this document formatted in NSD files as described in IEC 61850-7-7. They are available in light and full version:

- The full version is named: *IEC_TR_61850-90-27.NSD.2023A.Full*. It contains definition of the whole data model defined in this document with the documentation associated and access is restricted to purchaser of this document.
- The light version is named: *IEC_TR_61850-90-27.NSD.2023A.Light*. It does not contain any documentation but contains the whole data model as per full version.

The light version is freely accessible on the IEC website for download at: http://www.iec.ch/tc57/supportdocuments but its usage remains under the licensing conditions.

In case of any differences between the downloadable code and the IEC pdf published content, the downloadable code(s) is(are) the valid one; it may be subject to updates. See included history files.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61850-7-4:2010/AMD1:2020, *Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes*

IEC 61850-7-420:2021, *Communication networks and systems for power utility automation - Part 7-420: Basic communication structure - Distributed energy resources and distribution automation logical nodes*

IEC SRD 62913-2-3:2019, *Generic smart grid requirements – Part 2-3: Resources connected to the grid domains*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
aggregator
party who contracts with a number of other network users (e.g. energy consumers) in order to combine the effect of smaller loads or distributed energy resources for actions such as demand response or for ancillary services

[SOURCE: IEC 60050-617:2009, 617-02-18]

3.2
circulation pump
pump which moves a heat transfer medium by mechanical action to transfer thermal energy

3.3
combined heat and power (CHP)
DER system whose primary purpose is creation of heat but can also provide electrical energy from the heat creation capability

Note 1 to entry: In some circumstances, electrical energy is the primary purpose with heat as a secondary purpose.

[SOURCE: IEC SRD 62913-2-3:2019, Table 7]

3.4
demand response (DR)
action resulting from management of the electricity demand in response to supply conditions

[SOURCE: IEC 60050-617:2009, 617-04-16]

3.5
distributed energy resource (DER)
energy resource comprised of generation and/or storage and/or controllable load connected at the low or medium voltage distribution level

Note 1 to entry: DER may include associated protection, control, and monitoring capabilities, and may consist of aggregated DER units.

Note 2 to entry: DER may interact with the area and/or local electric power systems (EPS) by providing energy through the EPSs, by adapting their behaviour based on EPS conditions, and/or by providing other EPS-related services for regulatory, contractual, or market reasons.

[SOURCE: IEC 61850-7-420:2021, 3.2.11]

3.6
district heating (DH)
system that produces hot thermal energy to maintain thermal conditions in a certain area

Note 1 to entry: It is composed of one or several plants for thermal energy production and pipe networks to transfer the produced energy to end use.

3.7
district heating provider (DHP)
party which manages a district heating network of a specific geographical area, including heat generation, system operation and retailing

[SOURCE: PLANET Project]

3.8
electric power network
particular installations, substations, lines or cables for the transmission and distribution of electricity

Note 1 to entry: The boundaries of the different parts of this network are defined by appropriate criteria, such as geographical situation, ownership, voltage, etc.

[SOURCE: IEC 60050-601:1985, 601-01-02]

3.9
electric power system
all installations and plant provided for the purpose of generating, transmitting and distributing electricity

[SOURCE: IEC 60050-601:1985, 601-01-01]

3.10
electricity distribution system operator (DSOe)
system operating low and medium voltage electric power systems

3.11
facility DER energy management system (FDEMS)
system that manages the settings and dispatch of DER systems within a facility

Note 1 to entry: This facility could be a residence, a building, a commercial site, an industrial site, or any other high-level location.

[SOURCE: IEC SRD 62913-2-3:2019, Table 8]

3.12
heat exchanger
component intended to transfer heat from one medium to another while keeping the two media separate

[SOURCE: IEC 60050-411:1996, 411-44-10, modified (replacing the word *coolant* by the word *medium*)]

3.13
heat source
kind of thermal energy generator to supply thermal energy to thermal energy load such as HVAC or thermal energy storages

3.14
heat transfer medium
medium which may be present in the solid, liquid and/or vapor phase; it can be used to store heat in a reversible form and can be circulate within the installation, e.g., in pipes

[SOURCE: DOI: 10.1615/AtoZ.h.heat_transfer_media, http://www.thermopedia.com/content/842/]

3.15
heating, ventilation, and air conditioning (HVAC)
system providing thermal comfort and acceptable indoor air quality by using thermal energy provided by hot/cool thermal energy sources and/or heat exchangers

3.16
refrigeration (RFG, or &R)
process to make the temperature of an object or space cooler than the ambient conditions

3.17
thermal energy controller
controller which gathers data from one or more resources in a thermal system and dispatch commands to them to control the temperature of objects

3.18
thermal energy resource
distributed energy resource from the perspective of electric power system operations

Note 1 to entry: Examples of the resource include thermal energy generators, storage, and loads.

3.19
thermal energy storage (TES)
resource to store thermal energy including heat and cold

Note 1 to entry: The thermal energy to be stored is provided by thermal energy generator such as heat pump and supplied to thermal energy load such as HVAC.

3.20
thermal energy load
resource consuming thermal energy such as a heating unit or a chemical process chain relying on heat for the process

3.21
thermal energy generator
resource generating thermal energy

Note 1 to entry: Examples are Combined Heat and Power units (CHP) (which is also an electric energy generator as it also generates electrical energy) and heat pumps generating thermal energy by conversion of electric energy.

3.22
thermal inertia
product of the density, thermal conductivity and specific thermal capacity of material

[SOURCE: IEC Guide 117:2010, 3.8]

3.23
thermal storage tank
device categorized into thermal energy storage

Note 1 to entry: It usually contains a medium such as water, ice or a chemical to store thermal energy (hot or cold).

3.24
thermal system
system usually composed of resources including thermal energy generators and loads, which, in addition, also includes TES to facilitate operations of resources without lack of comfort or violation of end-use requirements

3.25
transmission system operator (TSO)
transmission system operator is a part operating a transmission system

[SOURCE: IEC 60050-617:2009, 617-02-11]

4 Abbreviated terms

4.1 General purpose abbreviated terms

CHP	Combined heat and power
DER	Distributed energy resource
DR	Demand response
DSOe	Electrical distribution system operator
EMS	Energy management system
P2H	Power to gas
RES	Renewable energy source
TER	Thermal energy resource
TES	Thermal energy storage
TSO	Transmission system operator
VES	Virtual energy storage
VPP	Virtual power plant
UC	Use case

4.2 Abbreviated terms used in data object names

These terms are expected to be added to the lists of abbreviations in future editions of IEC 61850-7-4 or IEC 61850-7-420.

Table 3 shows normative terms that are combined to create data object names.

Table 3 – Normative abbreviations for data object names

Term	Description
Chld	Chilled
Cmft	Comfort, Comfortable
Cmpr	Compressor, Compression
Cmsp	Consumption
Crtl	Curtail, Curtailment
Cvt	Converting, Converter
Ecnm	Economizer
Etg	Electric and thermal generation
Eth	Electricity to thermal energy
Evp	Evaporation, evaporator
Fcl	Fuel cell
Fin	Fin
Hgbp	Hot gas bypass
Hot	Hot
Intk	Intake
Mdm	Medium
Mid	Mid
Rcv	Recovery, Recover
Rnb	Renewable
Tcp	Thermal energy connection point
Tes	Thermal Energy System
Virt	Virtual
Wire	Wire

5 Overview of thermal systems

5.1 General

Thermal systems connected to electric power networks have been identified to provide a relevant contribution in this transition process by offering flexibility to the electric power grid through cross-sector coupling.

Many commercial services with thermal systems have already been rolled out and advanced use of thermal systems for the purpose are to be implemented in pilot sites by national and international research projects.

5.2 System structure

A thermal system basically consists of the following devices.

- Hot or cold thermal energy generators
- Thermal energy storage
- Circulation networks with heat exchangers, valves, and/or circulation pumps
- Thermal energy loads (i.e. end use devices)

Hot or cold thermal energy generators including heat pumps, boilers and refrigerators gives the heat or cold to a medium such as water for HVAC as thermal energy load. The heat or cold produced by the thermal energy generator can be is stored in thermal energy storage such as thermal storage tank. In a circulation network, one or more heat exchangers may be used to transfer the heat or cold without mixing of media.

Figure 1 illustrates a typical structure of thermal system in mid-latitude countries. The air conditioning of buildings requires cooling in summer and heating in winter. The thermal energy generators are connected to the secondary systems installed in the room illustrated on the top of the figure. The blue and green lines in the Figure show water piping. In countries where there are time-of-use tariffs for electricity, thermal energy storage systems store chilled heat for cooling or heat for heating in the case where the price of electricity is cheap; and release the stored thermal energy in the case where the price is expensive.

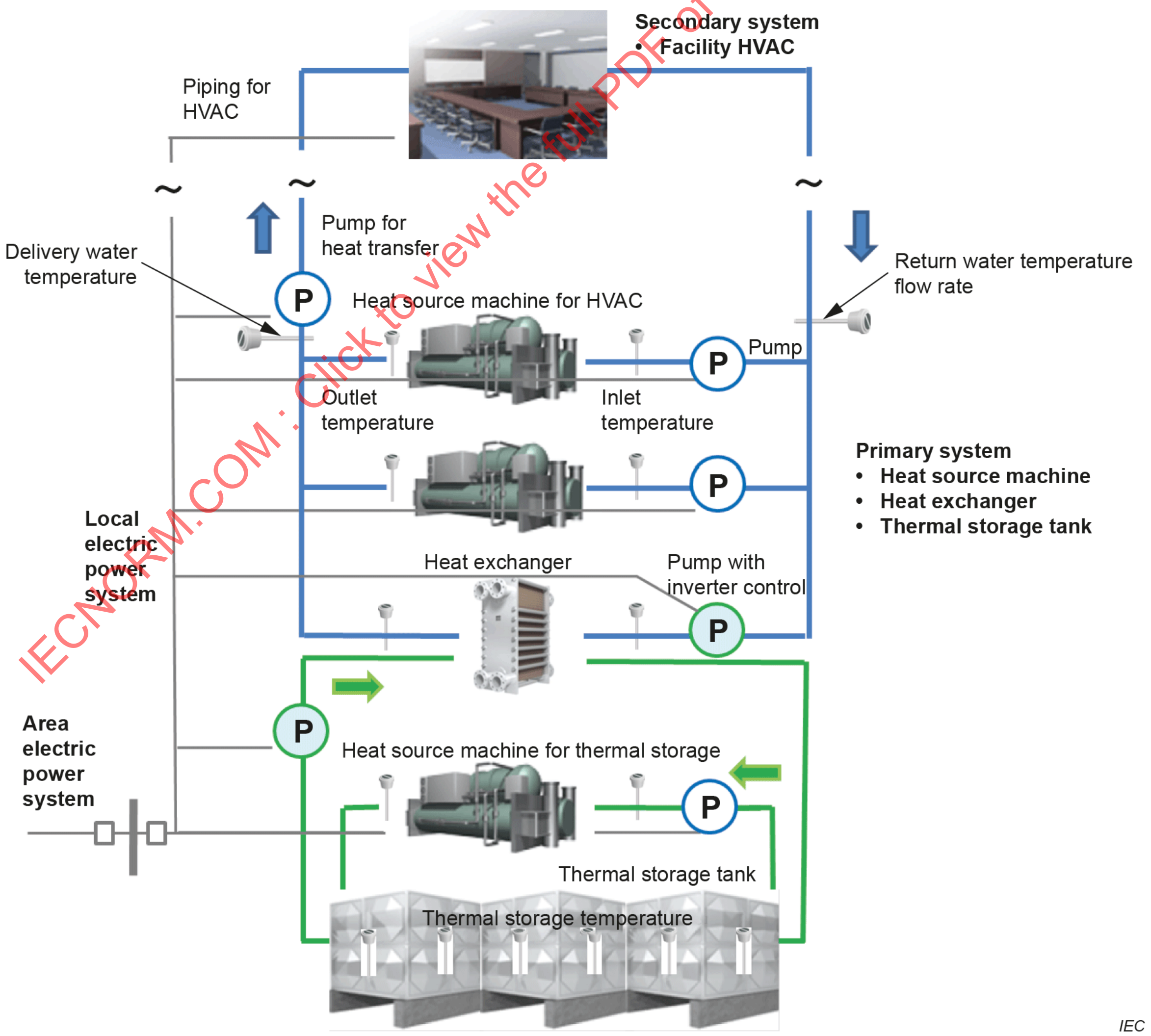

Figure 1 – A typical structure of thermal system

5.3 Energy transformation

5.3.1 General

This subclause describes energy transformation and related information about some specific devices such as compressors and heat pumps. This subclause explains the kinds of devices that are used in the use cases in this document and design of logical nodes for specific resource units.

5.3.2 Transformation from electricity to thermal energy

Transformation from electricity to thermal energy is used for heating or cooling a physical object, liquid, air etc. There are several categories according to the methodologies for use of electricity. This document focuses on electric resistance heating and electric heat pump because other types of electro heating such as induction heating and infrared heating are usually used in factories that hardly provide flexibility. In terms of cooling, freezers and refrigerators usually employ a kind of electric heat pump, so this subclause omits the descriptions of them. Note that non-electric heat pumps (e.g., gas heat pumps) are not modelled in this document.

An electric resistance heating provides heat through the process of Joule heating. There are several types of resistance heating elements including metal, ceramic and semiconductor, and PTC (Positive Temperature Coefficient) rubber. The heating generation can be controlled by changing the electric current flowing through a resistance heating element.

An electric heat pump is typically composed of several parts as illustrated in Figure 2. Refrigerant is a kind of heat transfer medium fluid that circulates through the heat pump. It absorbs thermal energy from the heat source such as air or sea water in an evaporator where the phase of refrigerant changes from liquid to vapor. A compressor driven by electric power compresses the refrigerant to increase its temperature. A condenser releases thermal energy to a heat sink such as air in a room or building. The refrigerant changes its phase from vapor to liquid in the condenser. An expansion valve controls the amount of refrigerant released into the evaporator. The temperature of the refrigerant goes down after release from the expansion valve by decreasing its pressure rapidly.

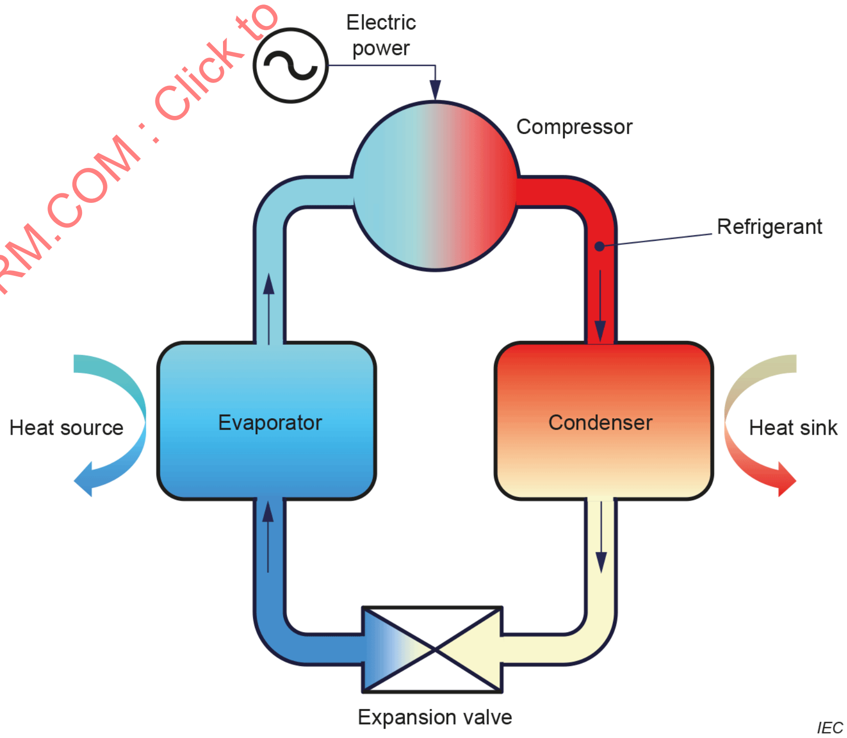

Figure 2 – A configuration of heat pump

5.3.3 Transformation from thermal energy to electricity

Transformation from thermal energy to electricity is a major stream in bulk power generation such as fossil fuel power generation. However, few types of DER make use of the transformation from thermal energy to electricity. In addition, the use cases described in Clause 6 do not consider the use of DER that generates electric power from thermal energy. Therefore, resources transforming thermal energy to electricity are outside the scope of this document. A future edition of this document could consider such resources.

5.3.4 CHP device

CHP devices produce electricity and thermal energy simultaneously. A CHP device is typically composed of prime mover, electric generator, heat recovery equipment and associated equipment such as pipework and valve, as illustrated in Figure 3. Micro gas turbines, gas engines, diesel engines and fuel cells are major prime movers used in CHP devices.

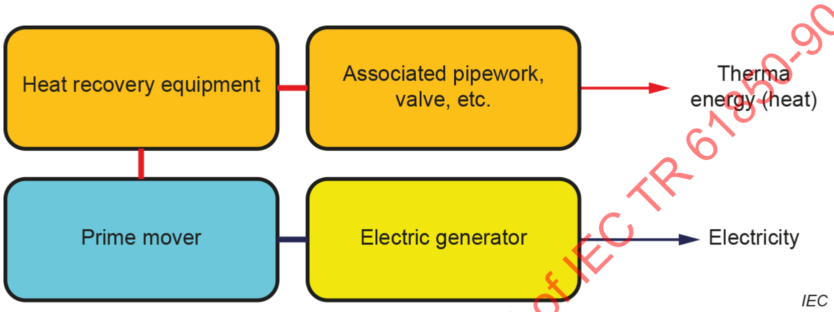

Figure 3 – A typical configuration of a CHP device

A micro gas turbine is a type of continuous and internal combustion engine in which expansion due to combustion of gaseous fuel rotates a turbine. The process of micro gas turbine also includes intake of air, compression, combustion of gaseous fuel and exhaust. For the process, it is typically composed of an upstream rotating gas compressor, a combustor, and a downstream turbine on the shaft connecting the compressor. Micro gas turbines are adopted by energy consumers that need a large amount of thermal energy because its heat recovery is efficient.

A gas engine is a reciprocating engine that transforms the energy produced by gas combustion to rotational motion through a piston mechanism. Its process includes intake of air, compression, combustion of gaseous fuel and exhaust. It is more efficient than gas turbine because the combustion temperature is higher.

A diesel engine is another type of reciprocating engine in which the elevated temperature of the air in the cylinder due to the mechanical compression causes the ignition of the fuel. The ignition control is not easy due to its mechanism even though it is efficient. The shortcomings of diesel engine are noise and vibration.

Fuel cells transform chemical energy of fuel directly to electricity without transformation to thermal energy or kinetic energy so that they are more efficient and silent than heat engines. Several types of fuel cells are used in CHP devices.

A PEFC (polymer electrolyte fuel cell), one of the representative fuel cells, is composed of a fuel electrode (anode), a solid polymer membrane (electrolyte), and an air electrode (cathode). Figure 4 illustrates the configuration and behaviour of PEFC. In the first step of behaviour, a hydrogen molecule is decomposed into two hydrogen ions and two electrons by using catalyst in the fuel electrode. The electrons move along with the electric circuit and this current of electrons produces electric power. The hydrogen ions move to the air electrode through the solid polymer membrane. The solid polymer membrane prevents other materials from moving through itself. The electrons and hydrogen ions react with an oxygen molecule when they reach the air electrode.

An SOFC (solid oxide fuel cell) is another representative fuel cell type. It is also composed of an anode, electrolyte, and cathode. The main difference between SOFC and PEFC is the material of electrolyte and behaviour. The electrolyte of SOFC is usually made of ceramics based on Zirconium or Cerium and oxygen ions move from cathode to anode through it.

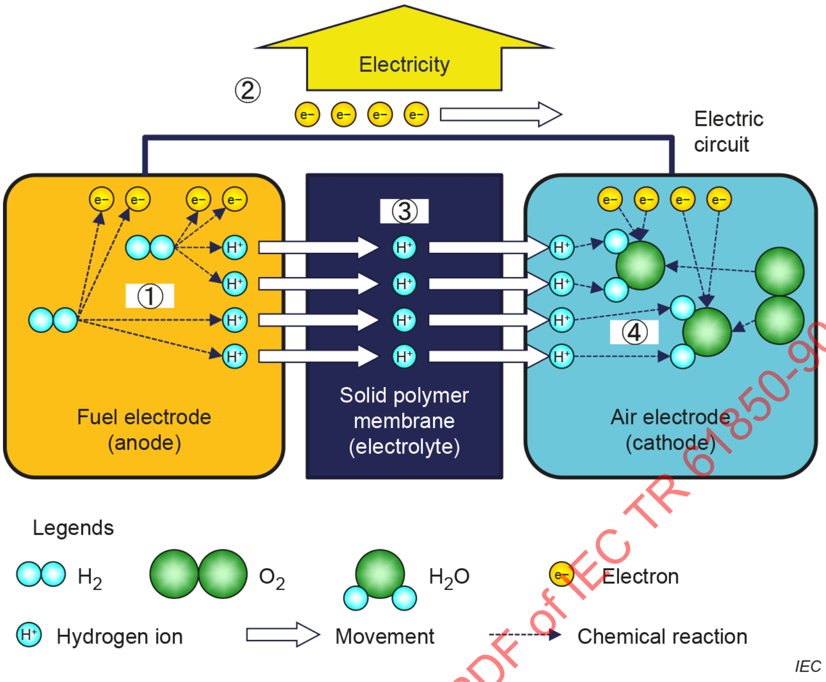

Figure 4 – Configuration and behaviour of a polymer electrolyte fuel cell

6 Use cases

6.1 General

This clause shows common actors and summaries of use cases used for logical node class modelling related to thermal systems. Detailed descriptions of the use cases can be found in Annex A.

6.2 Common actors

6.2.1 General

Common actors for the use cases in this clause can be categorized into two types; one is those from IEC SRD 62913-2-3, and the other is those newly defined for the use cases in this document. IEC SRD 62913-2-3 is an IEC technical specification that defines resources connected to the electric power system domains including system roles. This document uses the system roles defined in IEC SRD 62913-2-3 as much as possible in order to facilitate readers' understanding of the actors across the border between the electric power domain and the thermal energy one. However, some use cases need actors that are not defined in IEC SRD 62913-2-3 so this document defines additional actors that originate with the thermal energy domain.

6.2.2 Actors from IEC 62913-2-3

Table 4 lists the common actors coming from Table 4 or Table 7 of IEC SRD 62319-2-3:2019. The types of actors listed in this table are roles because substantial actors are different among countries and/or regions.

The left column of Table 4 indicates one of the levels defined in the DER hierarchical model (refer to 4.1.2 of IEC 61850-7-420:2021). The levels are as follows:

- Level 1: DER
- Level 2: Facility DER Management
- Level 3: Third Parties: Retail Energy Provider or Aggregator
- Level 4: Utility Operational Grid Management
- Level 5: Market Operations

Table 4 – Common actors from IEC SRD 62913-2-3

Level	Role	Definition
2	Building DER EMS (BDEMS)	System that manages the settings and dispatch of DER systems within a building. [SOURCE: IEC SRD 62913-2-3:2019, Table 7]
2	Distributed energy resource (DER) (high level)	A distributed set of one or more energy service resources, including generators, energy storage, controllable load, and ancillary services. [SOURCE: IEC SRD 62913-2-3:2019, Table 7]
2	Facility DER EMS (FDEMS)	System that manages the settings and dispatch of DER systems within a facility. This facility could be a residence, a building, a commercial site, an industrial site, or any other high-level location. [SOURCE: IEC SRD 62913-2-3:2019, Table 7]
3	Aggregator	A party which aggregates flexibilities for its customers. May activate flexibility sites. [SOURCE: IEC SRD 62913-2-3:2019, Table 4, eliminated the following sentence: "Equivalent to retail energy provider (REP) in this document."]
4	Electricity DSO (DSOe)	Entity responsible for the planning, operation, maintenance, and the development in given areas of the electricity distribution network (LV, MV, and potentially HV), the quality of electricity supply (power delivery, voltage, etc.) and for customer access to energy supply retail market through his or her system under regulated conditions. Equivalent to MV/LV system operators. [SOURCE: IEC SRD 62913-2-3:2019, Table 4]
4	Transmission System Operator (TSO)	Entity responsible for the planning, operation, maintenance, and the development in given areas of the electricity transmission network (HV), the quality of electricity supply (frequency and voltage), and access to the bulk market system for DER systems capable of participating Equivalent to HV system operators. [SOURCE IEC SRD 62913-2-3:2019, Table 4] According to Article 2.4 of the Electricity Directive 2009/72/EC (Directive): "a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity". Moreover, the TSO is responsible for connection of all grid users at the transmission level and connection of the DSOs within the TSO control area. [SOURCE: EU Commission Task Force for smart grids, EG3]
5	Transmission Energy Market (high level)	Operator of a market, example markets include the wholesale electricity or gas market, ancillary service markets, etc. [SOURCE: PLANET project] ("market operator" of the UC in Clause A.1 is equivalent to this role.)

6.2.3 Actors originating with the thermal energy domain

The use cases in this document include other types of roles specific to thermal systems. Table 5 lists the actors that originate with the thermal energy domain.

Table 5 – Actors originating with thermal energy domain

Level	Actor	Definition
2	Building manager	Entity who is in charge of operating/ managing the building plants (both electrical and thermal) which has the knowledge and follow-up of the electrical and heat needs. The actions needed for the operation could be either manual or automatic. It may play the role of BDEMS defined in 6.2.2.
	Cogeneration plant operator (CPO)	Entity that manages a thermal plant based on CHP unit(s) for heat production." It could be a person or a DER EMS. However, CPO has a broader scope than facility DER EMS. It may play the role of FDEMS defined in clause 6.2.2.
	District Heating Provider (DHP)	Refer to 3.7.
	Heat source	Refer to 3.13
	Heat exchanger	Refer to 3.12.
	Heating, Ventilation, and Air Conditioning (HVAC)	Refer to 3.15.
	P2H plant operator	Entity that operates one or more power to heat units. It may play the role of FDEMS.
	Thermal energy storage	Refer to 3.19.
	Thermal storage tank	Refer to 3.23.
5	Distribution energy market	Operator who is responsible for purchasing and billing energy to the user (building manager).

6.3 Use case 1: "Aggregated energy storage in buildings for electricity grid congestion management via electricity demand shifting"

6.3.1 Motivation

A quarter of the primary energy in Europe is consumed for building heating and cooling. Currently the conversion of energy to heat/cool is performed either on user demand or for optimal performance of the heating/cooling equipment locally, without considerations about the impact of the demand profile on the energy networks.

The aim of this use case is to demonstrate the potential available through shifting the operation time and/or power regulation (increase or decrease of power) of such devices for balancing the grid or managing congestion points. The building thermal mass/inertia and/or water tanks for hot water storage provide opportunities for shifting the actual energy consumption while maintaining indoor conditions at acceptable levels.

6.3.2 Solution

If the aggregated electricity demand is lower than electricity generation, management strategies for electrical devices connected to the building heat generation system (e.g. heat pumps) are applied in order to maximise the use of excess electricity by charging heat storages (hot water tanks) and/or using building mass inertia (request by the system operator to consume more at building level). Figure 5 illustrates energy flows in such operations.

Case 1:
Excess electrical energy of the electricity grid is used to feed a heat pump which transforms the electrical energy into thermal energy (heat). This thermal energy can then be stored in the heat storage (heating system and domestic hot water) and/or in the building acting as a Virtual Energy Storage (VES) due its thermal inertia. If the thermal energy provided by the heat pump and the heat storage is not sufficient for satisfying the building's thermal need, the gas boiler is switched on the provide the remaining thermal energy. So, the building serves as a bridge between the electrical distribution network and the distribution gas grid, due to the fact that the heating demand of the building represents a possible combination of electricity and gas consumption.

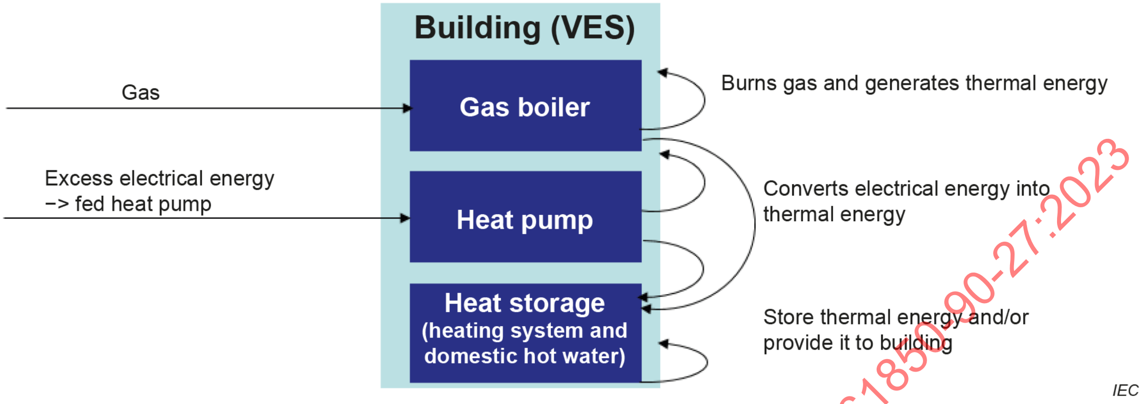

Figure 5 – UC1 Case 1: The aggregated electricity demand is lower than electricity generation

If the aggregated electricity demand is higher than electricity generation, management strategies to the electrical devices connected to the building heating system (e.g. heat pumps) are applied in order to reduce the consumption exploiting heat storages/building mass inertia (request by the system operator to consume less at the building level). Figure 6 illustrates energy flows in such operations.

Case 2:
Lack of electrical energy of the electricity grid results in a reduction of the feeding of the heat pump. To satisfy the building requirements in terms of hot water and heat, the thermal energy stored in the heat storage and the building are used. If this is not enough, the gas boiler is switched on to provide the remaining thermal energy required.

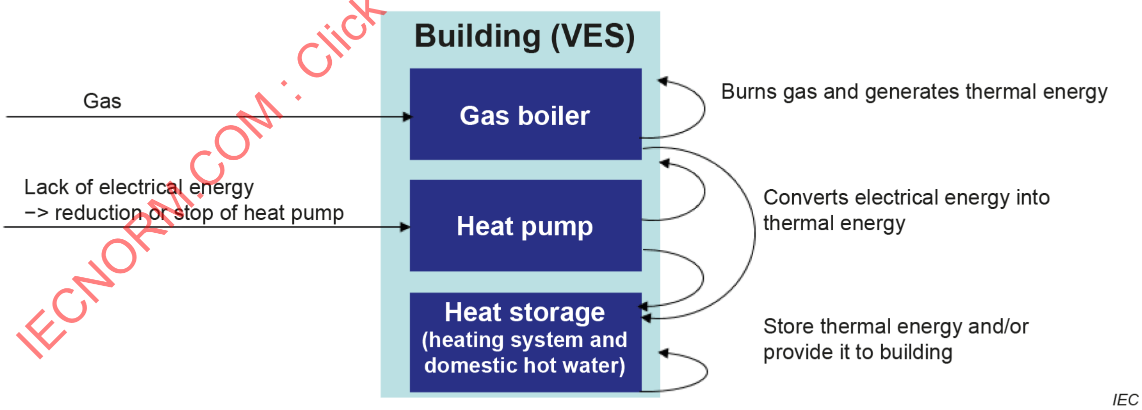

Figure 6 – UC1 Case 2: The aggregated electricity demand is higher than electricity generation

6.3.3 Benefit

In the near future, due to a revision of the market regulation, the power system operator could be engaged as a balance service provider. This condition should allow direct solution of problems such as grid congestion, not only at transmission network level but also on the electrical distribution networks.

The full use case description is provided in Clause A.1. It includes the use case diagram featuring the sub use cases as well as the sequence diagram followed by a step-by-step description of the sub use cases. Furthermore, the required information objects are identified.

6.4 Use case 2: Small-scale cogeneration for e-grid stabilisation and heat generation for use in building or injection

6.4.1 Motivation

The aim of this UC is to support the electricity grid in times when RES generation drops abruptly and unexpectedly leading to an imbalance between demand and generation. This can be accomplished by electricity-driven CHPs which can ramp up their generation and supply the generated electricity to the e-grid.

6.4.2 Solution

The use case involves the exploitation (or installation) of cogeneration units both in large buildings (office buildings, shopping malls, etc.) as well as central CHPs (e.g. P_{el} <100 kW) supplying energy to residential areas.

When there is a lack of electrical energy due to an unexpected RES generation drop the power system operator searches for an aggregator covering his lack of electrical energy on mutually acceptable conditions (price and service delivery). The aggregator checks for available CHPs able to satisfy the requested electricity demand and – based on the information received –sends back their service delivery and price conditions to the power system operator. If a contract is established, the aggregator sends an activation or ramp-up command to the CHP operator at the time the power system operator needs additional electric energy. The surplus thermal energy generated by the requested electricity provision is used to heat up the building(s) in the first place. The remaining thermal energy is then fed into the district heating network and/or stored in the thermal storage of the CHP.

6.4.3 Benefits

CHP units are already known to provide financials benefits when their operation is optimised for the needs of the building. Offering ancillary services to the electricity grid could become another revenue source for them, and under specific conditions it can make sense for building managers to optimise their operation towards an objective function combining building and grid needs. In addition to the above, the injection of heat in the district heating grid can provide further financial benefits to the CHP operator. But even more importantly, it may drastically alter the optimal operational schedule of the cogeneration units especially if it is possible to control the amount of heat for building use and for grid injection in real-time during operation.

The optimal scheduling will then depend on a number of parameters, such as the gas prices (natural gas, synthetic gas and biogas) the reimbursement they can obtain from ancillary services to the e-grid, the feed-in tariff from the heating network, whether building and grid requirements conflict or can be addressed independently, the limits for heat injection, the effect of changing the operating state of CHPs on their life expectancy, etc.

Their ramping capabilities make CHPs suitable for provision of the most lucrative services (e.g. frequency regulation), so the cost-benefit analysis of this use case could lead to interesting results.

The full use case description is provided in Clause A.2. It includes the use case diagram featuring the sub use cases as well as the sequence diagram followed by a step-by-step description of the sub use cases. Furthermore, the required information objects are identified.

6.5 Use case 3: Centralised heat-pumps for hot water storage in DH plant facilities

6.5.1 Motivation

CHP plants connected to the district heating have inherent energy demand flexibility due to their regulation capacity and large storage capacities for hot water. Currently they mostly use gas as their primary fuel though, which give a possible regulation based on the technical features of the system installed. Moreover, new expansion of the DH network in terms of number of buildings connected to the network, and/or new parts of town served by DH, could lead to a need for more thermal units for heating production. This need could be satisfied by the utilization of technology which exploit renewable electricity sources for production of heat.

This use case advocates the installation of large heat-pumps to heat water for district heating purposes to leverage the demand flexibility potential to the benefit of the electricity grid. This effectively alters the fuel mix for DH providers, adding electricity as a main energy source.

6.5.2 Solution

Depending on the operational conditions of each DH network, the heat pump requirements will have to be adapted accordingly. High-temperature heat pumps will be required for DH networks operated at high temperatures, such as the IREN network in Turin. For low-temperature operated networks (e.g. T < 60 °C), regular heat pumps (feeding water with temperature up to 60 °C) will suffice. In the case of HP connected to CHP plant, one of the main aspects to be explored is the relative use of electricity and gas for water heating. One scenario – probably the shorter-term one – is to use the electricity-powered heat pumps as peaking units. In this sense they can be used to alleviate peak load problems in the usual DH activities, but also be used to offer balancing services and at those times support the available co-generation units. If ancillary service timing coincides with heat peak demand, multiplicative benefits can be expected.

6.5.3 Benefit

Facilitate technology for heating production, in particular for DH network, alleviating peak load problem due to the heat demand behaviour and meanwhile offering balancing services to the electricity network.

The full use case description is provided in Clause A.3. It includes the use case diagram featuring the sub use cases as well as the sequence diagram followed by a step-by-step description of the sub use cases. Furthermore, the required information objects are identified.

6.6 Use case 4: Providing tertiary reserve to electric power systems by demand response using thermal energy storage

6.6.1 General

This use case considers an aggregator provide tertiary reserve to electric power systems by demand response using thermal energy storage. Subclauses 6.6.2 to 6.6.4 mention the motivation, solution, and benefits of the use case.

Note that Clause A.4 has the full description of this use case. It includes the use case diagram featuring the sub use cases as well as the sequence diagram followed by a step-by-step description of the sub use cases. Furthermore, the required information objects are identified.

6.6.2 Motivation

To realize a sustainable society, the electric power industry is required to achieve three goals: (1) increasing electric power generations using renewable energy, (2) the supply and demand adjustment functions with the participation of consumers, and (3) stable power supply.

Until now, the electrical power industry rarely collaborates with the thermal energy industry that is in the electric power consumer side. From now on, systems managing electric power and thermal energy facilitate the collaborations between the two industries.

In particular, the thermal energy industry may provide balancing reserve to electric power systems for which quick response is not required. This is because operations of thermal energy storage are slower than those for electric devices such as inverters. On the other hand, the amount of energy that may be stored as thermal energy are so huge that tertiary reserve provided to electric power systems is a promising and reasonable market product for thermal energy industry.

In some countries, thermal energy storage for air conditioning is used for both cooling and heating. So thermal energy industry may provide tertiary reserve especially in summer and winter.

6.6.3 Solution

This use case assumes seven actors: TSO, aggregator, FDEMS & manager, thermal system controller, and resources. The resources include heat source machine, circulation pump, heat exchanger, and thermal system tank/piping. Figure 7 shows how these actors interact with each other.

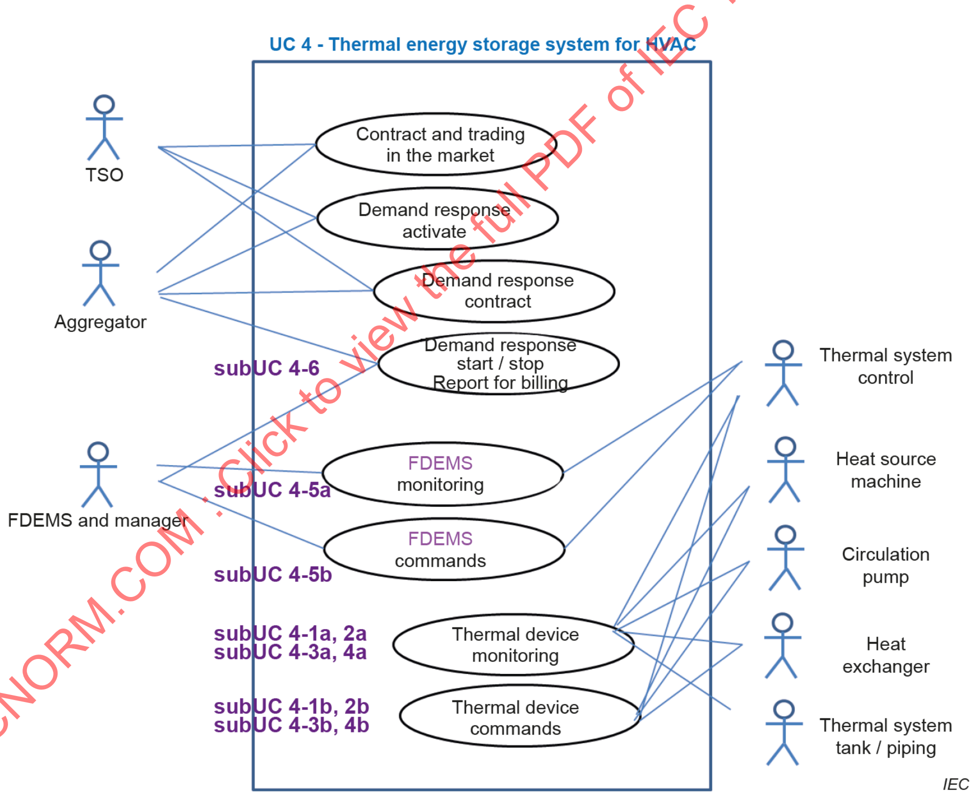

Figure 7 – Main use case diagram of UC4: Providing tertiary reserve to electric power systems by demand response using thermal energy storage

The TSO and aggregator make a contract for tertiary reserve in a market or bilateral way for demand response before operations. At the operation phase, the TSO sends a request to the aggregator to activate demand response. The request contains the upward or downward volume, start time and duration of electric power provided by the aggregator. In addition, the aggregator sends reports to the TSO in which status and measurement values are conveyed. The data items identified in the interactions between TSO and aggregator would be modelled as data objects in logical nodes categorized in operational functions, resources or measurement.

The aggregator makes operational plans for each FDEMS and manager by referring to the request from TSO. The decided plans are delivered to the FDEMS and manager. The FDEMS and manager interacts with the thermal system controller that monitors and controls the resources. The data items identified in such interactions would be modelled as data objects in logical nodes categorized in resources or measurement.

6.6.4 Benefits

This use case would bring benefits to the various stakeholders mentioned below.

(1) For electric power grids and societies: Electric power grids will become more unsuable due to the increase in VRE (Variable Renewable Energy). The function described in this use case contributes to grid stabilization.

(2) For electric power grids: Since this use case already has equipment/human-resources assigned for air conditioning applications, a balancing authority can achieve power adjustment at reasonable cost.

(3) For societies: CO2 can be reduced by shutting down aged fossil fuel power plants

(4) For customers: Costs can be reduced by incentive compensation by demand curtailment (nega-watt).

(5) For customers: An aggregator helps customers to purchase power with lower CO2 (coefficient) with lower tax payment in case where CO2 tax is charged.

7 Information model requirements

7.1 General

Based on the identified information related to the resource specifications described in Clause 5 and one required for the four use cases described in Clause 6, this clause provides mappings between data items of all needed information and logical nodes and data objects in a tabular format. The mappings are categorized into three levels: resource, operational functions, and reference point of thermal system.

If existing logical nodes do not represent the data required in the use cases, the columns of LN and DO show candidates of logical nodes with underline. Details of these candidate logical nodes are described in Clause 8.

The references to UC in Table 6, Table 7, Table 8, Table 9, Table 10 and Table 11 indicate information defined in the use cases described in Clause 6 and Annex A.

7.2 Mappings of requirements on LN classes at the resource level

This subclause includes several tables to show the mappings between data items needed in one or more use cases and logical nodes/data objects for the following four categories:

- DER system and coupling point
- Distributed P2H resource
- Distributed aggregated energy storage resource
- Distributed CHP resource

Logical nodes and data objects defined in this report are marked with an underline in each table.

Table 6 – Mappings of requirements and IEC 61850 for DER system and coupling point

Req Id	Short descriptions	LN	DO (+DA)	Reference in UC
1-1	Identification of the DH (District Heating) coupling point in electric grid	DECP	ElcRefId	DH Coupling Point ID (UC1,2,3,4)
1-2	Identification of the thermal storage unit	DSTH	EEName. name	Unit ID (UC 1,2,3,4)
1-3	The amount of heat the storage unit can accommodate	DSTH	ThmCapRtg	Thermal Power Storage Capacity (UC 1,2,3,4)
1-4	Reference to the corresponding CHP unit ID	DGTH	EEName. name	CHP Unit ID Ref (UC 1,2,3)
		DCHCExt	EEName. name	
1-5	Reference to the corresponding DER unit ID (energy interconnected distributed energy resource)	DETG	EqGn	Electric DER Unit Ref (UC 1,2,3)
		DETH	EqLod	
1-6	Voltage measurement from meters installed in grid nodes	MMXU	PPV	Measured Volts (UC 1,2,3)
1-7	Power measurement from meters installed in grid nodes	MMXU	TotW	Measured P_{el} (UC 1,2,3,4)
1-8	Capacity of thermal energy acceptance [kWh]	DSTH	ThmCapTot	(UC 2,4)

Table 7 – Mappings of requirements and IEC 61850 for P2H resource

Req Id	Short descriptions	LN	DO (+ DA)	Reference in UC
2-1	A reference to the corresponding P2H (power to heat) energy resource ID	DETH	EqThmGn EqLod	P2H ER Ref in Thermal GEN ER / Electrical LD ER (UC 1,2,3,4)
2-2	Identification of the P2H energy resource	DETH	EEName. name	Resource ID in P2H ER (UC 1,2,3,4)
2-3	Geographical coordinates (longitude, latitude) of a P2H ER (degree)	DETH	EEName. longitude / latitude	geoCoordinates in P2H ER (UC 1,2,3,4)
2-4	Rated value of thermal efficiency of an electric boiler; η = (Thermal energy output (water, steam, ...))/(Electric Energy input) × 100 [p.u.]	DETH	EfcRtg	N_boiler in Electric Boiler UC 1,2,3,4)
2-5	A control setpoint for temperature of the electric boiler/the local or DH heat pump [°C] For DH heat pumps, the temperature setpoint is the supply water temperature	DGTH	TmpSpt TmpSptAct	Temp setpoint in Electric Boiler, Local Heat Pump, Electric Radiator and DH heat pump (UC 1,2,3)
2-6	The dead band around the setpoint of the electric boiler/the local heat	DGTH	TmpBndWid	Temp band in Electric Boiler, Local Heat Pump, and Electric Radiator (UC 1,2,3)
2-7	The capacity of the water storage tank [m^3]	DSTH	MatCapRtg	Tank volume in Electric Boiler (UC 1,2,3,4)
2-8	A measurement value of water mass flow [kg/s]	MFLW	FlwRte	Mass Flow in DH Heat Pump (UC 1,2,3,4)
2-9	A measurement value of temperature of the heat source used by heat pump [°C]	DGTH	TmpSrcIn	Heat source temperature in DH Heat Pump (UC 1,2,3,4)

Req Id	Short descriptions	LN	DO (+ DA)	Reference in UC
2-10	A measurement value of heat output temperature [°C]	DGTH	TmpSinkOut	Heat output temperature in DH Heat Pump (UC 1,2,3,4)
2-11	Type of heat source (ambient air, underground source, sea or river, exhaust air, waste heat, wastewater) (Enumeration)	DHPM	HeatSrcTyp	Heat source in DH Heat Pump (UC 1,2,3,4)
2-12	A measurement value of coefficient of performance of a Heat Pump (efficiency of a heat pump at any given set of conditions). The coefficient of performance (COP) of a heat pump (also referred to as the instantaneous efficiency) is defined as the ratio of the thermal power delivered to a thermal zone by the heat pump ($\dot{Q}hp$) to the electrical power consumed (Pel): $\boldsymbol{COP=\dot{Q}hp/Pel}$ To put it in other words: COP = Thermal energy output (water, steam, ...)/(Electric Energy input) *) see also COP definition in the explanation	DETH	Efc	COP in Heat Pump (UC 1,2,3,4)
2-13	Identification of the unit	Specific unit LN	EEName. name	Unit ID in P2H Unit (UC 1,2,3,4)
2-14	Rated active power of a P2H unit [W]	DLOD Ext	WNomRtg	Rated active power in P2H Unit (UC 1,2,3,4)
2-15	Nominal voltage of a P2H unit [V]	DLOD	VMaxRtg	Nominal Voltage in P2H Unit (UC 1,2,3,4)
2-16	A rating of minimum active power of a P2H Unit [W]	DLOD	WMinRtg	Min active power of P2H Unit (UC 1,2,3,4)
2-17	A rating of maximum active power of a P2H Unit [W]	DLOD	WMaxRtg	Max active power of P2H Unit (UC 1,2,3,4)
2-18	ON/OFF status and control of a P2H unit. (Boolean)	DETH	OpCtl	Equipment status of P2H Unit (UC 1,2,3,4)
2-19	Measured active power input of a P2H unit [W]	MMXU	TotW	Measured Active Power of P2H Unit (UC 1,2,3,4)
2-20	Measured reactive power input of a P2H unit [var]	MMXU	TotVAr	Measured Reactive Power of P2H Unit (UC 1,2,3,4)
2-21	Measured Thermal Energy provided from a P2H unit given the electrical consumption for a specified time period Δt [Wh]	DGTH	GnEn	Measured Thermal Energy of P2H Unit (UC 1,2,3,4)
2-22	Measured electrical energy consumption of a P2H unit for a specified time period Δt [Wh]	DLOD Ext	CmspEn	Measured Energy Cons of P2H Unit (UC 1,2,3,4)
2-23	Starting current (inrush current)	DLOD Ext	InrsA	Starting current of P2H Unit (UC 1,2,3,4)
2-24	Maximum flow temperature of heat pump [°C]	DGTH	TmpMaxRtg	Maximum flow temperature (UC 1,3,4)
2-25	Consumed power range of heat pump [kW]	DLOD	WMaxRtg	Power range of heat pump (UC 1,3,4)
2-26	Provided power range of heat pump [kW]	MTHM	ThmW	Power range of heat pump (UC 1,3,4)
2-27	Connection voltage [V]	DLOD	VMaxRtg VMinRtg	Connection voltage (UC 1,3,4)

Req Id	Short descriptions	LN	DO (+ DA)	Reference in UC
2-28	P2H unit failure	DETH	EEhealth	Health kind (UC4)
2-29	On/off status	DGTH	PwrSt	Power status (UC4)
2-30	Generated calories	DGTH	GnEnTot	Generated energy total (UC4)
2-31	Operation mode status	DGTH	ThmGnOpMod	Thermal generator operation mode status (UC4)
2-32	Operation mode control	DGTH	ThmGnOpMod	Thermal generator operation mode control (UC4)
2-33	Machine control type [on/off, variable]	DGTH	OpCtl or TmpSpt	Control type (UC4)
2-34	Electric heat source machine control value	DLOD Ext	WSptPct	Active power setpoint setting (UC4)
2-35	Emergency withdrawal application	DTHP	CmftSt	Comfort status (UC4)
2-36	Monitoring circulating water temperature	STMP	Tmp	Circulating water temperature, (UC4)
2-37	Thermal flow operation mode control (sequential or rotation)	Not covered	Not covered	Operation mode control (UC4)
2-38	Reference to thermal energy resources and pump	Not covered	Not covered	Thermal energy resources reference (UC4)

Table 8 – Mappings of requirements and IEC 61850 for aggregated energy storage resource

Req Id	Short descriptions	LN	DO (+ DA)	Reference in UC
3-1	Profile ID reference of thermal zone.	DSTH DLTH	EEName. name	Profile ID Ref of Thermal Zone (UC 1)
3-2	Identification of thermal mass in a building that is part of an aggregated thermal energy storage.	DSTH	EEName. name	Building ID of Thermal Zone (UC 1)
3-3	Identification of the space thermal zone is part of an aggregated thermal energy storage.	DSTH	EEName. name	Zone ID of Thermal Zone (UC 1)
3-4	Parameter of the space thermal model (RC-Model) [°C/W]	DSTH	ThmRis	Resistance of Thermal Zone (UC 1)
3-5	Parameter of the space thermal model (RC-Model) [J/°C]	DSTH	Capac	Capacitance of Thermal Zone (UC 1)
3-6	Thermal energy provided from a P2H unit given the electrical consumption for a specified time period Δt [Wh]	DETH DGTH	EqThmGn GnEn	Thermal Energy of Thermal Zone (UC 1)
3-7	Identification of aggregated thermal energy storage	DSTH	NamPlt. name	Resource ID of VES ER (UC 1,4)
3-8	Geographical coordinates (longitude, latitude) of thermal energy storage	DSTH	NamPlt. longitude & latitude	geoCoordinates of VES ER (UC 1,4)
3-9	Identification of the unit	DSTH	EEName. name	VES Unit ID of VES Unit (UC 1,4)
3-10	Reference to the corresponding building ID	DSTH	EEName. name	Building ID Ref of VES Unit (UC 1,4)
3-11	Reference to the corresponding space thermal zone ID	DSTH	EEName. name	Thermal zone ID Ref of VES Unit (UC 1,4)
3-12	Demand of a building space / zone for heat	MMXU	TotW	Head Demand of VES Unit (UC1,4)

Req Id	Short descriptions	LN	DO (+ DA)	Reference in UC
3-13	Electrical output of a VES Unit that corresponds to the required electrical energy consumed for heating/cooling	MMXU	TotW	Electrical Response of VES Unit (UC 1,4)
3-14	Insufficient thermal storage Soc	DSTH	SocLoArm	Soc low alarm (UC4)
3-15	Insufficient thermal storage Soc	DSTH	SocHiArm	Soc high alarm (UC4)
3-16	Storing/releasing status of thermal storage	DSTH	StoSt RelSt	Thermal storage operation status (UC4)
3-17	Thermal storage tank inlet temperature	DSTH	TmpSrcIn	Temperature source inlet (UC4)
3-18	Thermal storage tank outlet temperature	DSTH	TmpSinkOut	Temperature sink outlet (UC4)
3-19	Thermal storage tank temperature	DSTH	Tmp	Temperature (UC4)
3-20	Current thermal storage capacity	DSTH	ThmCapTot	Thermal capacity total (UC4)
3-21	Residual thermal generation	DSTH	ThmCapPct	Residual thermal capacity in % (UC4)
3-22	Thermal releasing completion estimated time	DSTH	RelEstTm	Releasing estimated time (UC4)
3-23	Thermal storing completion estimated time	DSTH	StoEstTm	Storing estimated time (UC4)
3-24	Start / Stop releasing of thermal storage	DSTH	ThmStoOpCtl	Thermal storage operation control (UC4)
3-25	Threshold for lower limit alarm of thermal storage	DSTH	SocLoAlsPct	Soc low alarm threshold in % (UC4)
3-26	Threshold for upper limit alarm of thermal storage	DSTH	SocHiAlsPct	Soc high alarm threshold in % (UC4)

Table 9 – Mappings of requirements and IEC 61850 for CHP resource

Req Id	Short descriptions	LN	DO	Reference in UC
4-1	Identification of the CHP Energy Resource	DETG	EEName.name	Resource ID of CHP ER (UC 1,2,3)
4-2	Geographical coordinates (longitude, latitude) of the CHP ER	DETG	EEName. longitude / latitude	geoCoordinates of CHP ER (UC 1,2,3)
4-3	Reference to the corresponding CHP energy resource ID	DETG	EqThmGn EqGn	CHP ER Ref of CHP ER (UC 1,2,3)
4-4	Identification of the generating unit of the CHP	DGEN	EEName.name	GU Unit ID (UC 1,2,3)
4-5	Identification of the CHP unit	DCHC Ext	EEName.name	CHP Unit ID (UC 1,2,3)
4-6	Maximum rated active power output of a CHP unit	DGEN	WMaxRtg	Maximum rated power (UC 1,2,3)
4-7	Minimum rated active power output of a CHP unit	DGEN	WMinRtg	Minimum rated power (UC 1,2,3)
4-8	Maximum rated heat output of a CHP unit	DGTH	MaxThmGnRtg	Maximum rated heat capacity (UC 1,2,3)
4-9	Minimum rated thermal energy output of a CHP unit	DGTH	MinThmGnRtg	Minimum rated heat capacity (UC 1,2,3)
4-10	Rated ratio of the electrical energy produced to the energy consumed (fuel) in a CHP unit	DGEN	EfcRtgPct	e-efficiency, n_{el} (UC 1,2,3)
4-11	Rated ratio of the thermal energy produced to the energy consumed (fuel) in a CHP unit	DGTH	EfcRtg	th-efficiency, n_{th} (UC 1,2,3)

Req Id	Short descriptions	LN	DO	Reference in UC
4-12	Rated ratio of the electrical energy produced to the thermal energy produced in a CHP unit (rated value)	DETG	WThmRtgRat	Power to heat ratio (UC 1,2,3)
4-13	Power factor of the electric output	MMXU	TotPF	Cosphy (UC 1,2,3)
4-14	Measured ratio of the total energy produced (electricity and thermal energy) to the energy consumed (fuel) in a CHP unit	DETG	TotEfc	CHP total efficiency (UC 1,2,3)
4-15	ON/OFF status of a CHP unit	DETG	OpClt	Equipment Status (UC 1,2,3)
4-16	Thermal power generated by a CHP unit. The unit of measurement is [W]	MTHM	ThmW	Thermal power output (UC 1,2,3)
4-17	Active power produced by a CHP unit also described as net useful electric output The gross electric output of the generator minus any parasitic electric losses. In other words, the net useful electric output is the total electric output from the CHP system that is put to a useful purpose. The unit of measurement is [W] • Gross electric output is the total electric output of the generator • Parasitic electric losses are the electrical power consumed by the CHP system; for example, the electricity used to compress natural gas before it is used as fuel in a combustion turbine	MMXU	TotW	Active Electrical Power Output (UC 2)
4-18	Actual total fuel/energy input. The unit of measurement is [W] The total fuel input is the sum of all the fuel used by the CHP system. The total fuel energy input is often determined by multiplying the quantity of fuel consumed by the heating value of the fuel	KFLV	InFuelRte	Actual Energy Cons (UC 1,2,3)
4-19	Operating mode of a CHP unit (heat-production driven, electrical generation driven, combined heat and generation driven)	DCHC Ext	OpModCHP	Operation Mode (UC 1,2,3)
4-20	Type of fuel used for operating a CHP unit	KFUL	FuelTyp	Fuel type (UC 1,2,3)
4-21	Thermal energy medium to transfer energy from CHP to end use or thermal energy storage	DCHC Ext	MdmTyp	Thermal energy medium (UC 1,2,3)
4-22	Active power setpoint	DGEN	WSpt	(UC 2)

7.3 Mappings of requirements on LN classes at the operational function level

This subclause includes one table (Table 10) to show the mappings between data items needed in one or more use cases and logical nodes/data objects at the operational function level.

Table 10 – Mappings of requirements and IEC 61850 for operational function level

Req Id	Short descriptions	LN	DO (+ DA)	Reference in UC
5-1	Identification of the thermal comfort profile	DTHP	NamPlt. name	Profile ID of Thermal Comfort Profile (UC 1)
5-2	Forecasted imbalances [kW/timeframe]	FCSD	Crv	Forecasted imbalance (UC 1,3)
5-3	Available flexibility [kW/timeframe]	FCSD	Crv	Building/P2H available flexibility (UC 1,3)
5-4	Aggregated demand flexibility [kW/timeframe]	FCSD	Crv	Aggregated demand flexibility (UC 1,3)
5-5	Operation setpoints [kW]	DWGC	WSpt	(UC 1,3)
5-6	Operation schedule [kW/timeframe]	FSCH	ValASG	(UC 1,3,4)
5-7	Required active power for balancing [kW]	MMXU	TotW	(UC 2)
5-8	Forecasted demand [kW/timeframes]	FCSD	Crv	(UC 2)
5-9	Maximum comfortable temperature at end use [°C]	DTHP	MaxCmftTmp	Max Temp Comfort of Thermal Comfort Profile (UC 1)
5-10	Minimum comfortable temperature at end use [°C]	DTHP	MinCmftTmp	Min Temp Comfort of Thermal Comfort Profile (UC 1)
5-11	Maximum hours of electric generation curtailment per year [hour]	DWGC Ext	MaxCurtlTmh	Max. Curtailment Hours (UC 1,2,3)
5-12	Start time to provide balancing service (used as a parameter for control or setting)	FSCH	StrTm	Start time of DR (UC 4)
5-13	Duration of balancing service (used as a parameter for control or setting)	FSCH	SchdIntv	Duration of DR (UC 4)
5-14	Time difference between actual activation time and ordered start time (measurement) [second]	DGTH/ DLTH	ActDl	

7.4 Mappings of requirements on LN classes at the reference point level in thermal energy network

This subclause includes one table (Table 11) to show the mappings between data items needed in one or more use cases and logical nodes/data objects at the reference point level.

Table 11 – Mappings of requirements and IEC 61850 for reference point

Req Id	Short descriptions	LN	DO	Reference in UC
6-1	Identification of the DH network zone	DVTR	ThmRefId	DH Network ID (UC 1,2,3)
6-2	Geographical coordinates (longitude, latitude) of an electric network node (degree)	DSTH	EEName. longitude / latitude	geoCoordinates (UC 1,2,3)
6-3	The amount of heat that the DHP could accept per second in their network [W]	MTHM	ThmW	Network thermal power capacity (UC 1,2,3)
6-4	DH energy loss in the DH grid of the district [Wh]	DSTH	ThmLos	DH Energy Loss (UC 1,2,3)
6-5	Y/N signal to verify if electric network constraints are respected during P2H units' output injection (Boolean). The value is false if no constraints are violated. An example of the constraints Is maximum capacity of distribution line	PXXX (e.g. PTOC)	Op.general	Constr.Verified (UC 1,2,3,4)
6-6	Identification of a node of the DH network	DTCP	ThmRefId	DH Node ID (UC 1,2,3)

Req Id	Short descriptions	LN	DO	Reference in UC
6-7	Supply temperature from thermal energy substation in customer site [°C]	STMP	Tmp	Node.Temp_DH Supply (UC 1,2,3)
6-8	Return temperature to thermal energy substation in customer site [°C]	STMP	Tmp	Node.Temp_DH Return (UC 1,2,3)
6-9	Water mass flow [kg/s]	MFLW	FlwRte	DH Grid Mass Flow (UC 1,2,3)
6-10	Identification of the electrical area network	DPCC	AreaEpsEcpId	EL Network ID (UC 1,2,3,4)
6-12	Total electrical energy losses in a grid zone [Wh]	MMTR	TotWh	E_{loss}
6-13	Total electrical consumption from residential, commercial and industrial loads on a grid zone [W]	MMXU	TotW	Passive Load (UC 1,2,3,4)
6-14	The percentage of RES production that is used for supplying the loads to the energy of the loads [p.u.]	MLPS	RnbGnPct	Grid self-sufficiency
6-15	The ratio between the RES production used for supplying the loads and the total RES production [p.u.]	MLPS	RnbCmspRat	Grid self-consumption
6-16	Y/N signal to verify that line thermal constraints are respected (Boolean)	PTTR	Op	Constr.Verified-Thermal
6-17	Y/N signal to verify that node voltage constraints are respected (Boolean)	PTOV PTUV	Op Op	Constr.Verified-Voltage
6-18	Operation setpoints for each time frame for the controllable loads in order to comply with the requested flexibility [W]	FSCH	ValASG	Active Power Schedule
6-19	Identification of electrical node of the MV distribution grid (could be an MV/LV substation)	DECP	ElcRefId	EL Node ID in Electrical Node (UC 1,2,3,4)
6-20	Nominal Voltage of an electrical node. Voltage deviations w.r.t the minimum and maximum limits may create problems to the customers' end devices. [V]	DECP	VRtg	Nominal Voltage in Electrical Node (UC 1,2,3,4)
6-21	Minimum electrical node voltage as part of operational constraints of the electrical network. [V]	DECP	VMin	Minimum Voltage in Electrical Node (UC 1,3,4)
6-22	Maximum electrical node voltage as part of operational constraints of the electrical network. [V]	DECP	VMax	Maximum Voltage in Electrical Node (UC 1,2,3,4)
6-23	Actual voltage of an electrical node as calculated as a result of offtake active and reactive power. [V]	MMXU	PPV	Volts in Electrical Node (UC 1,2,3,4)
6-24	Identification of electrical line connecting two nodes of the MV distribution grid.	DPCC	ElcRefId	EL Line ID in Electrical Line (UC 1,2,3,4)
6-25	A rated value of maximum electrical line loading [A]	ZLINExt	MaxARtg	Loading_max in Electrical Line (UC 1,2,3,4)
6-26	Ratio of over-utilisation of a line above its maximum loading [p.u.]	ZLINExt ZCABExt	MaxAFact / DynAFact MaxAFact / DynAFact	Over-utilisation in Electrical Line (UC 1,2,3,4)
6-27	A measurement value of actual electrical line loading [A]	MMXU	A /AvAPhs	Line Loading in Electrical Line (UC 1,2,3,4)

Req Id	Short descriptions	LN	DO	Reference in UC
6-28	Ratio of utilisation of a line with respect to its maximum loading [p.u.]	ZLINExt	MaxAFact / DynAFact	Line Utilisation in Electrical Line (UC 1,2,3,4)
		ZCABExt	MaxAFact / DynAFact	

8 Logical node classes and data objects modelling

8.1 General

8.1.1 General

This clause describes major characteristics of the LN classes proposed in this document. It categorizes the LN classes into four groups that are generic resource, specific types of units, operational functions, and reference points in thermal systems.

The complete definitions of the LN classes for thermal systems are listed in Clause 9.

8.1.2 Modelling principles of logical nodes considering sector coupling

This subclause shows how the modelling principles of IEC 61850-7-420 can be used and enhanced in order to also model the interaction of the electric power system with thermal systems including the provision of energy services.

In its current version (edition 2:2021) IEC 61850-7-420 considers only electric distributed energy resources (DER) as laid out in Figure 8. The top node in this hierarchy *DEResourceLN* is composed of an LN for electric generators (*DER_GeneratorLN*), an LN for electrical storage (*DER_StorageLN*) and an LN for electrical load (*DER_LoadLN*).

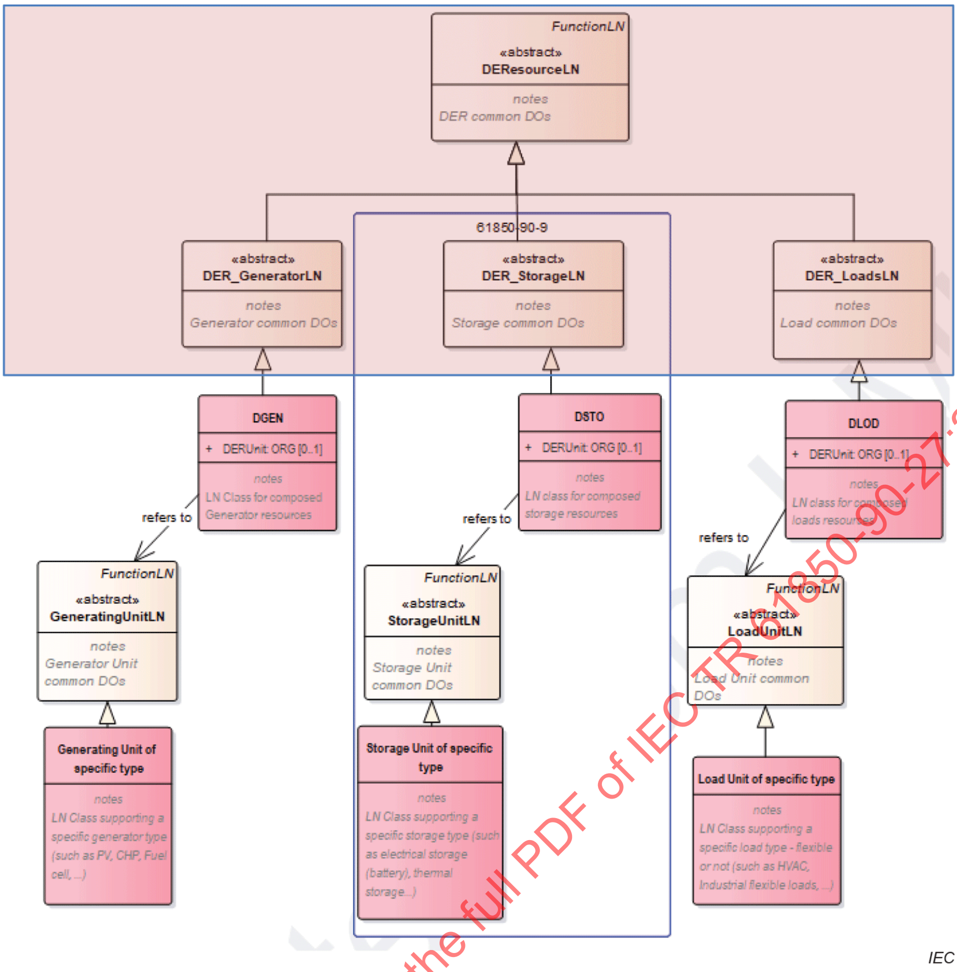

Figure 8 – Hierarchical class model of DER resources – basic principles

Driven by the use cases in Clause 6 to consider also thermal systems, the following schema has already been developed to open the purely electrical world of the current IEC 61850 standard series to address multiple types of energies and associated energy transformation.

Figure 9 has already been included in IEC 61850-7-420:2021 to show that the standard series will open up to other energy systems than electric ones and to guide task forces tackling for example heat and gas systems in IEC 61850 modelling.

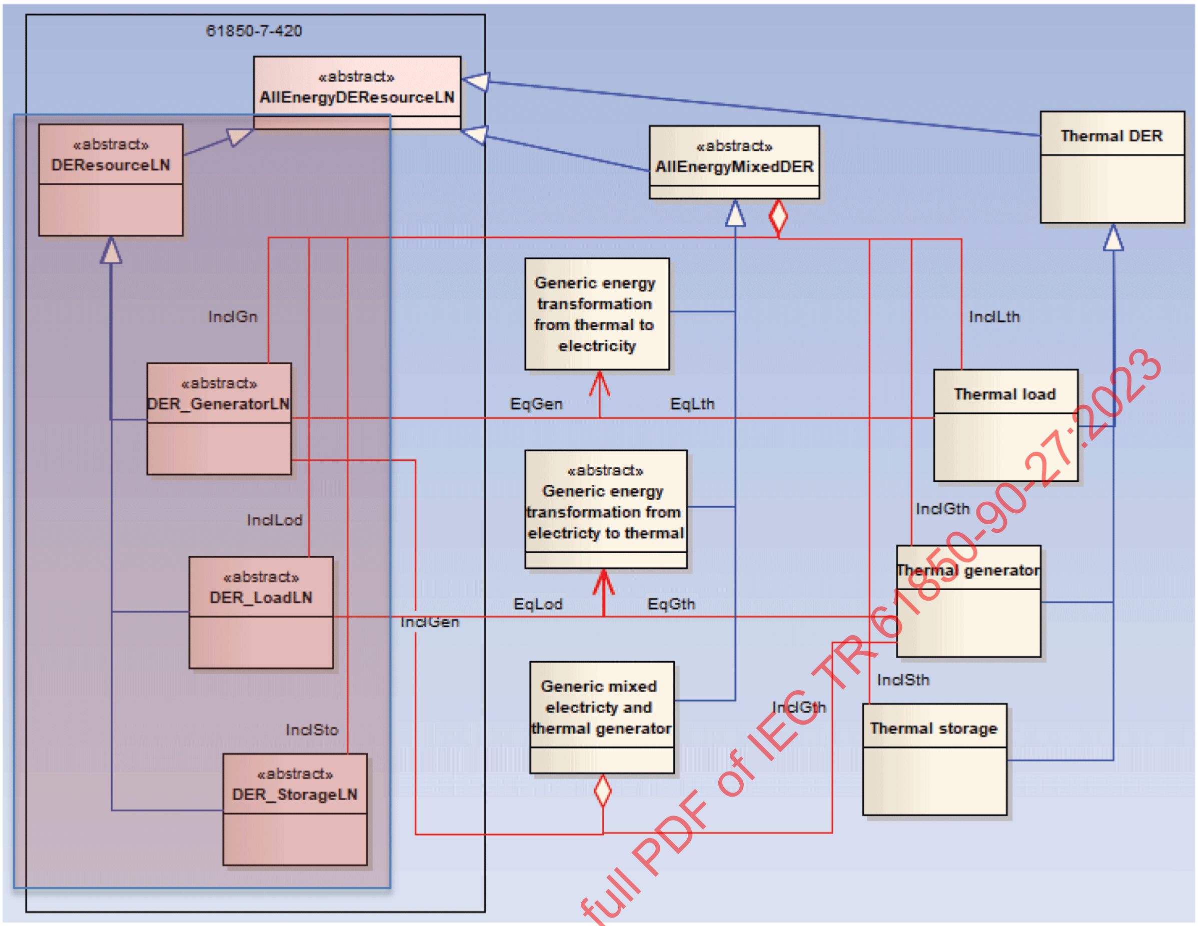

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Figure 9 – Principles to guide the extension of IEC 61850-7-420 for supporting other types of energies

In order to reflect other DER resources than electric ones, the new Logical Node (LN) *AllEnergyDERResourceLN* has been introduced to IEC 61850-7-420. It has the following LNs as its children:

- an LN for electric DER resource (LN *DERResourceLN*),
- an LN for thermal DER (LN *Thermal DER*) and
- an LN for mixed DER (LN *AllEnergyMixedDER*).

NOTE 1 *AllEnergyDERResourceLN* could be enhanced with a child for gas DER in order to model gas DERs in analogy to thermal DERs.

A short description of the three Logical Nodes listed above is as follows:

- LN *DEResourceLN* is for electric DER resources and includes
  – electric generation (LN *DER_GeneratorLN),* e.g., a PV unit,
  – electric load (*DER_LoadLN),* e.g., a heat pump consuming electrical energy and
  – electric storage (*DER_StorageLN),* e.g., an electrochemical battery.

NOTE 2 This part of the tree structure framed in red in Figure 9 is identical to the framed part in Figure 8.

- LN *Thermal* DER is for thermal DER and includes
  - thermal generation (LN *Thermal generator)*, e.g., a heat pump generating heat,
  - thermal load (LN *Thermal load)* and
  - thermal storage (*LN Thermal storage)*, e.g., a storage for warm water or a building having a thermal inertia.
- LN *AllEnergyMixedDER* aggregates the Logical Nodes
  - DER_GeneratorLN,
  - DER_LoadLN,
  - DER_StorageLN,
  - Thermal generator,
  - Thermal storage and
  - Thermal load.

  It has as children the following Logical Nodes:
  - *LN Generic energy transformation from thermal to electricity* describing a transformation process that uses thermal energy as input to generate electrical energy as output, e.g., a steam-driven generator producing electricity from thermal energy,
  - *Generic energy transformation from electricity to thermal* describing a transformation process that uses electrical energy as input and generates thermal energy as output, e.g., a P2H unit producing thermal energy (heat) from electricity, and
  - Generic *mixed electricity and thermal generator* describing a mixed DER system that generates both electrical energy and thermal energy, e.g., a Combined Heat and Power (CHP) unit producing electricity and heat.

8.2 Generic resource LN

8.2.1 Generic LN classes related to electrical DERs (DGEN, DSTO and DLOD)

To date IEC 61850-7-420 is focussed on the electrical aspects. That is, the LNs *DGEN*, *DLOD* and *DSTO* have been defined for electricity specific characteristics. Therefore, it has been decided to allow for a new set of Logical Nodes referring to characteristics that are related to thermal energy and leave the characteristics related to electric energy to the Logical Nodes *DGEN*, *DSTO* and *DLOD*.

The use cases identified in Clause 6 refer to more data objects than the generic LN classes related to electrical DERs. This document therefore defines extended LN classes to have additional data objects to show the data required in the use cases. The extended LN classes are tentatively named *DGENExt* and *DLODExt*. The use cases do not identify new data objects for *DSTO*, so this document does not define *DSTOExt*.

8.2.2 Generic LN classes related to thermal energy resources (DGTH, DSTH and DLTH)

In parallel to DGEN, DLOD and DSTO, a new set of thermal related LNs is introduced to the DER class model as shown in Figure 8. These new Logical Nodes are:

- DGTH: Generation of thermal energy
- DSTH: Storage of thermal energy
- DLTH: Load of thermal energy

Their definitions follow the principles shown in 8.1.2 so they represent generic characteristics of thermal energy generation, storage and load, respectively. The LN classes may represent an aggregated resource in the same way of the generic LN classes related to electrical DERs. In addition, they may refer to a specific type of thermal energy unit that is physically installed to generate, store or consume thermal energy.

The role of the three LN classes is to represent data specific to thermal energy resources, so measurement of energy flow and temperature for themselves are modelled as data objects of the logical nodes. On the other hand, measurement at other points are modelled by other logical nodes such as *MTHM* and *STMP*. The measurement points in this case is represented by a thermal reference point. Figure 10 illustrates an example of logical nodes to representing data related to thermal system according to the boundary of the role. *DGTH*, *DSTH* and *DLTH* represent data for designated resources such as capacity or ratings of resources, temperature measured in the resources. These logical nodes\ do not have data objects to show temperature or energy conveyed via medium that are measured outside the designated resources. Instances of *STMP* would be used to show such temperature and those of *MTHM* would be used to show energy conveyed via medium. Some mechanical devices such as pump and valve may be associated to a thermal connection point.

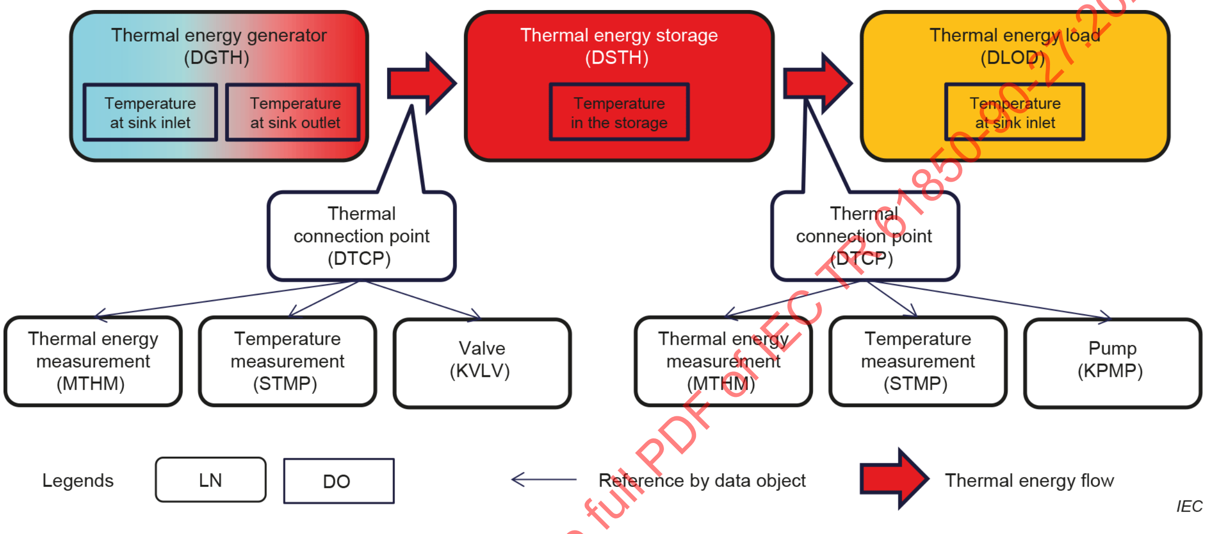

Figure 10 – Logical nodes representing data related to thermal system

According to the UC 3 in this document, the ON/OFF status of heat pump is needed to operate centralized heat pumps hot water storage in DH plant facilities. Therefore, the model of *DGTH* includes a data object named PwrSt typed SPS to indicate whether the unit is ON or OFF.

If another use case identifies other states of thermal generating units, the model of *DGTH* will be revised to represent the additional states and the CDC might be changed to ENS.

8.2.3 Generic LN classes related to both electrical DERs and thermal energy resources (DETH and DETG)

In addition to the three generic LN classes related to thermal energy resource (*DGTH*, *DSTH* and *DLTH*), this document defines two more generic LN classes that are related to both electrical DERs and thermal energy resources. They are named *DETH* and *DETG* respectively.

DETH shows a resource generating thermal energy from electricity. An electric boiler is an example that this LN class represents.

DETG shows a resource generating both electric power and thermal energy. A CHP (Combined Heat and Power) system is a typical resource shown by this LN, and be designed as or inherits from this LN.

8.3 LN classes related to specific type of units

8.3.1 General

This document defines LN classes related to specific types of units. For example, *DHPM* is a new LN class to show the characteristics specific to a heat pump.

This document also extends some LN classes that are defined in IEC 61850-7-420 because such classes have some aspects in terms of thermal energy and are required to follow the modelling principle described in 8.1.2. One of such LN classes is DCHCExt that shows the characteristics of CHP controller.

8.3.2 Modelling P2H units

8.3.2.1 General

P2H (Power to Heat) units transform electric energy into thermal energy (sector coupling). After having defined the transformation as such with the UML model depicted in Figure 9 the next step was to think about how to model concrete P2H units (e.g. heat pumps).

8.3.2.2 Basic modelling principles originating from IEC 61850-7-420:2021

Based on the example of a simple DER resource model of a PV generating unit (see Figure 11) a modelling proposal for heat pumps and CHP units has been worked out. To understand the basic modelling principles of IEC 61850-7-420:2021, Figure 11 is quickly described.

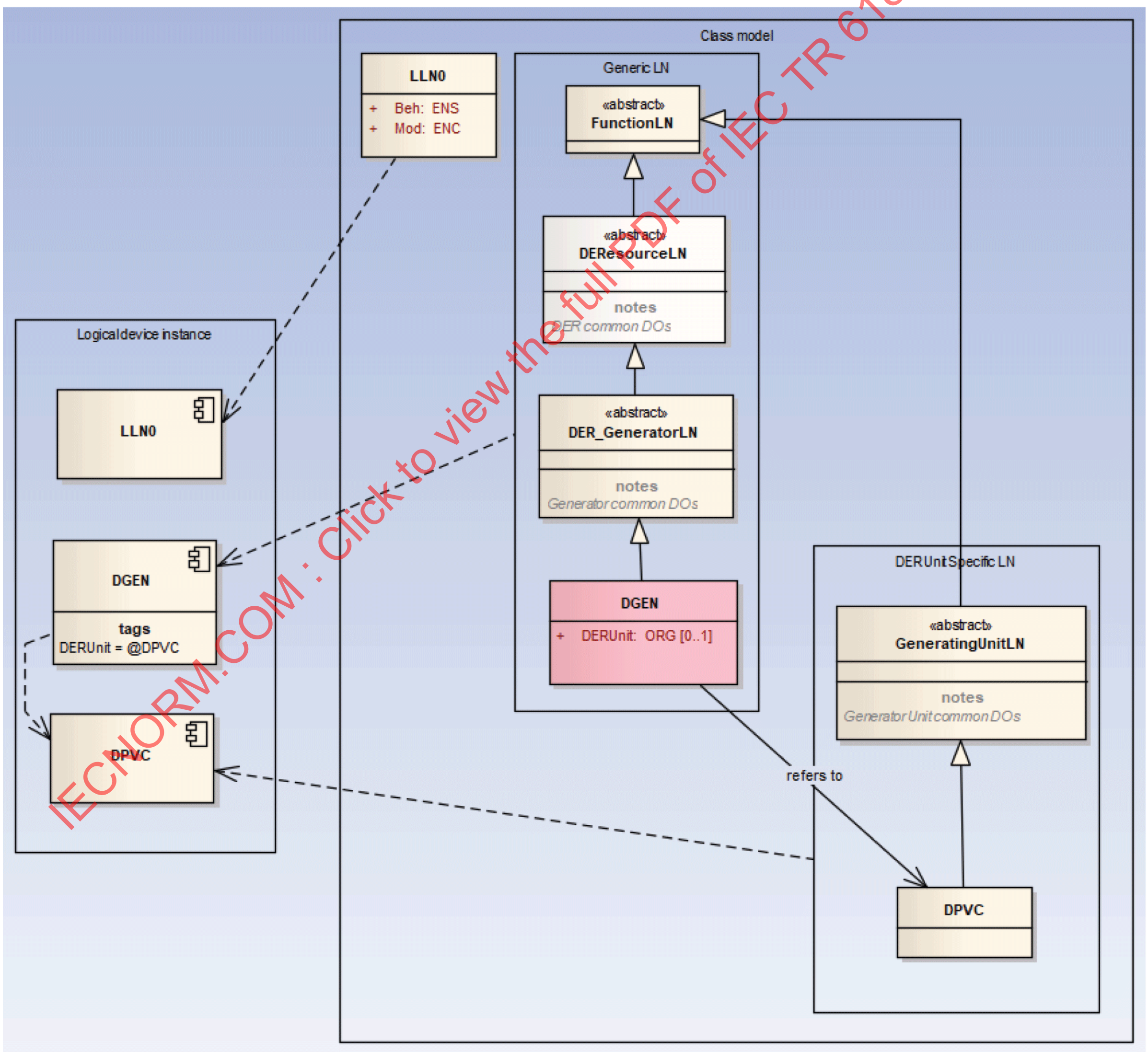

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Figure 11 – An example of a simple DER resource model of a PV generating unit

As a resource, a generation DER unit like a photovoltaic system is composed of:

- Information common to all DER types (generation, load or storage), typically an identifier. This information is contained in *DEResourceLN*.
- Information common to all generators but not applying to loads or storage (e.g. nameplate, operational data on what are its operational characteristics). This information is contained in *DER_GeneratorLN* and *DGEN*. *DGEN* contains a reference to the DER Unit LN which is technology specific (here: *DPVC*).
- Information related to a specific type/technology of generating unit. This information is contained in *GeneratingUnitLN* and the type/technology-specific generating unit (here: *DPVC*).

Such a structure is reflected in Figure 11 which depicts two aspects: the "instantiation view" (left hand side) and the class view (right hand side). An instantiation is the set of LNs that may be selected for a specific implementation, while the class model shows all possible LNs from which an instantiation can select the appropriate LNs for its purpose.

The class structure is subdivided into abstract classes, which have the purpose to favour the re-use of data objects between the different DER types, by sharing the abstract class and thus avoiding possible mistakes and, additionally, to make the reading of the long list of data easier.

8.3.2.3 Structure and associations in the P2H unit modelling

For modelling heat pumps as an example of P2H unit modelling, the approach shown in Figure 12 is adopted.

Figure 12 shows the LNs such as *DGTH* and *DETH* are derived from those depicted in Figure 9. The lower part framed and titled with "Heat Pump LD" contains the instantiable LNs relevant for the modelling of heat pumps.

A heat pump transforms electricity to thermal energy (heat) and is therefore modelled with LN *DETH* as a child of the Logical Node *Generic energy transformation from electricity to thermal.*

As a heat pump is on the one hand side an electric load as it consumes electric energy and on the other hand side is a thermal generator as it produces thermal energy (heat), LN *DETH* aggregates LN *DLOD* (electric load) and *DGTH* (thermal generator), herewith modelling the electric and thermal characteristics of a heat pump.

LN *DETH* has data objects associated to resources transforming electricity to thermal energy. Besides, it contains references such as the reference to the DERUnit (ORG) depicted also with the arrow pointing from LN *DETH* to LN *DHPM*.

LN *DHPM* contains technology specific data objects of heat pump and inherits from LN *ElectricityToThermalUnitLN which* contains data objects common to units transforming electricity to thermal energy.

Note that *DLODExt* in Figure 12 is a logical node derived from *DLOD* defined in IEC 61850-7-420:2021 to add several data objects to monitor and control electric load resource. This technical report suggests merging the data objects into *DLOD* in the next edition of IEC 61850-7-420.

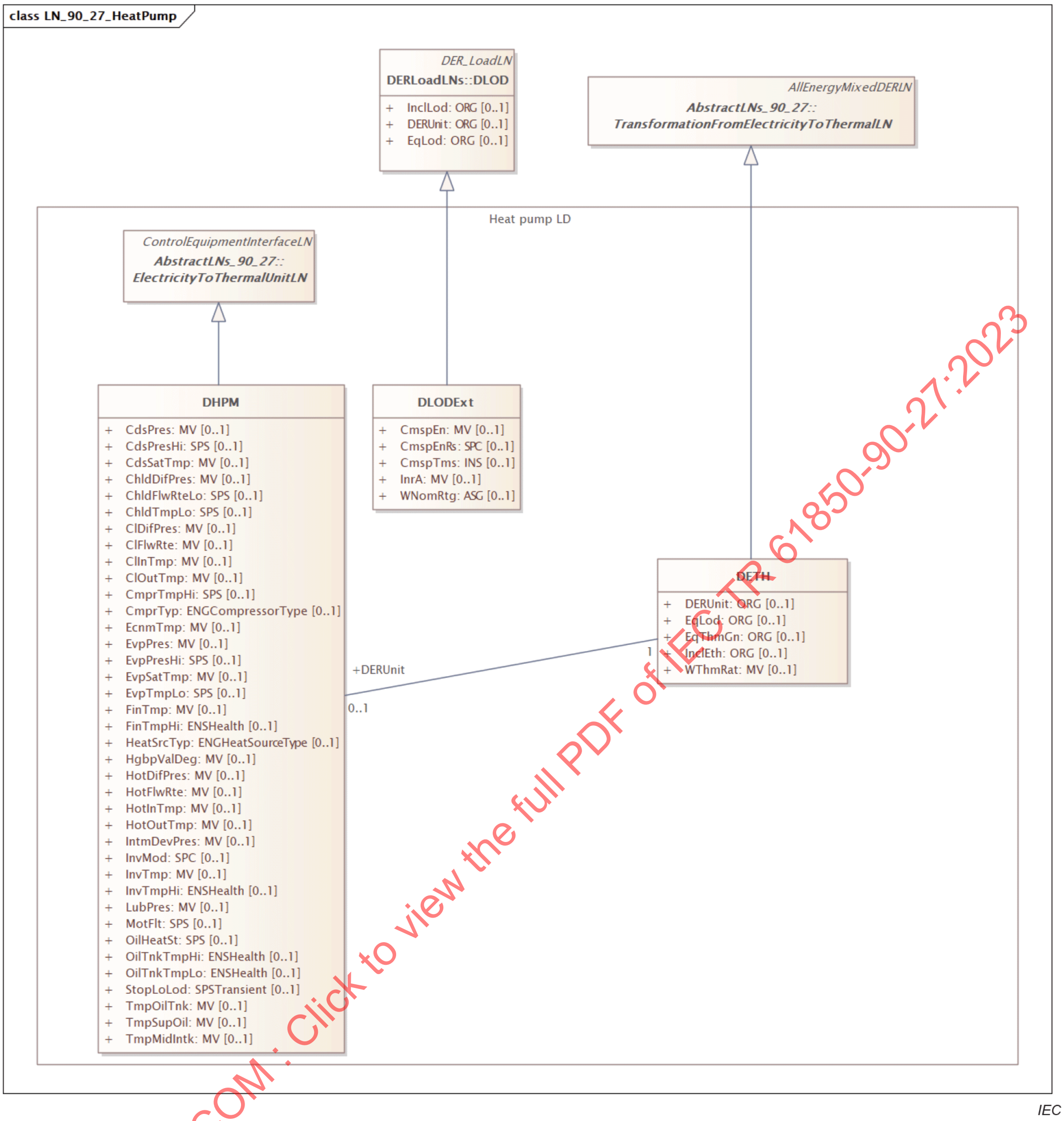


Figure 12 – Modelling of a heat pump

8.3.2.4 Data objects in the P2H unit modelling

DETH has associations to *DLOD* and *DGTH* as shown in Figure 12. *DLOD* includes data objects for monitoring and control a controllable electric load unit whether it produces thermal energy or not. In the same manner, *DGTH* has data objects for monitoring and control a thermal generating unit without the source of energy. Therefore, *DETH* has only data objects specific to the transformation from electricity to thermal energy.

Figure 13 shows data objects that are included in *DLOD*, *DGTH* and *DETH* respectively. As an example, *DLOD* (and *DLODExt*, an extended LN of *DLOD* in this document) has CmspEn meaning Energy consumed since last reset so *DETH* does not have this data as data object. If an application accesses the data, it can trace the association from *DETH* to *DLOD* (*DLODExt*) to identify which LN instance has the data and access the data object in *DLOD* (*DLODExt*). In another example, *MTHM* has ThmW meaning instantaneous thermal power generated [W] so *DETH* does not have this data as data object. If an application accesses the data, it can trace the association from *DETH* to *DGTH* to identify which LN instance has the data and access the data object in *DGTH*.

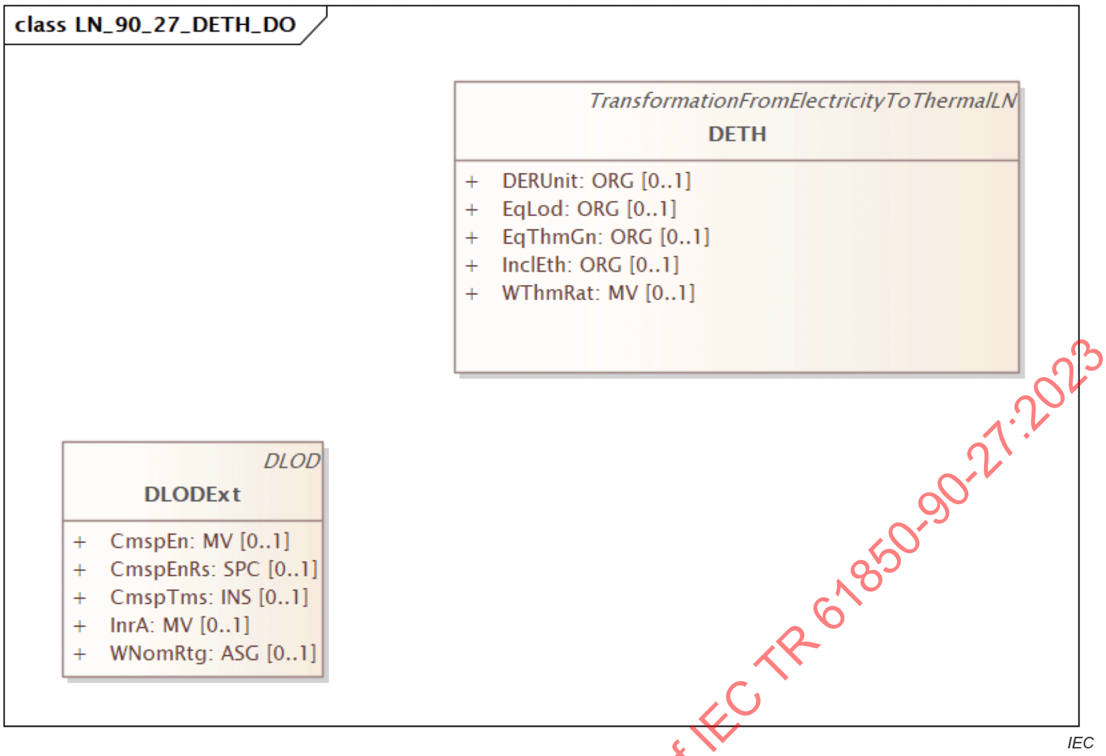


Figure 13 – Data objects in DLOD and DETH

8.3.3 Modelling of CHP

For modelling CHP units, the approach shown in Figure 14 is proposed.

At the top of Figure 14 the LNs depicted in Figure 9 are shown. The lower part framed and titled with "CHP logical device" contains the LNs relevant for the modelling of CHPs.

A CHP generates electricity and thermal energy and is therefore modelled with LN *DETG* as a child of the Logical Node *Generic energy transformation from electricity to thermal* (not shown) which in turn is a child of LN *AllEnergyMixedDER*.

As a CHP is an electric generator and a thermal generator, LN *DETG* aggregates LN *DGEN* (electric generator) and *DGTH* (thermal generator), herewith modelling the electric and thermal characteristics of a CHP.

LN *DETG* has data objects associated to resources generating electricity and thermal energy. Besides, it contains references such as the reference to the *DERUnit* (ORG) depicted also with the arrow pointing from LN *DETG* to LN *DCHCExt*. Furthermore, LN *DETG* may refer to other generating technology LNs: *DCIP* (reciprocating engine) and *DFCL* (fuel cell). This allows consideration of different drive unit technologies for CHPs.

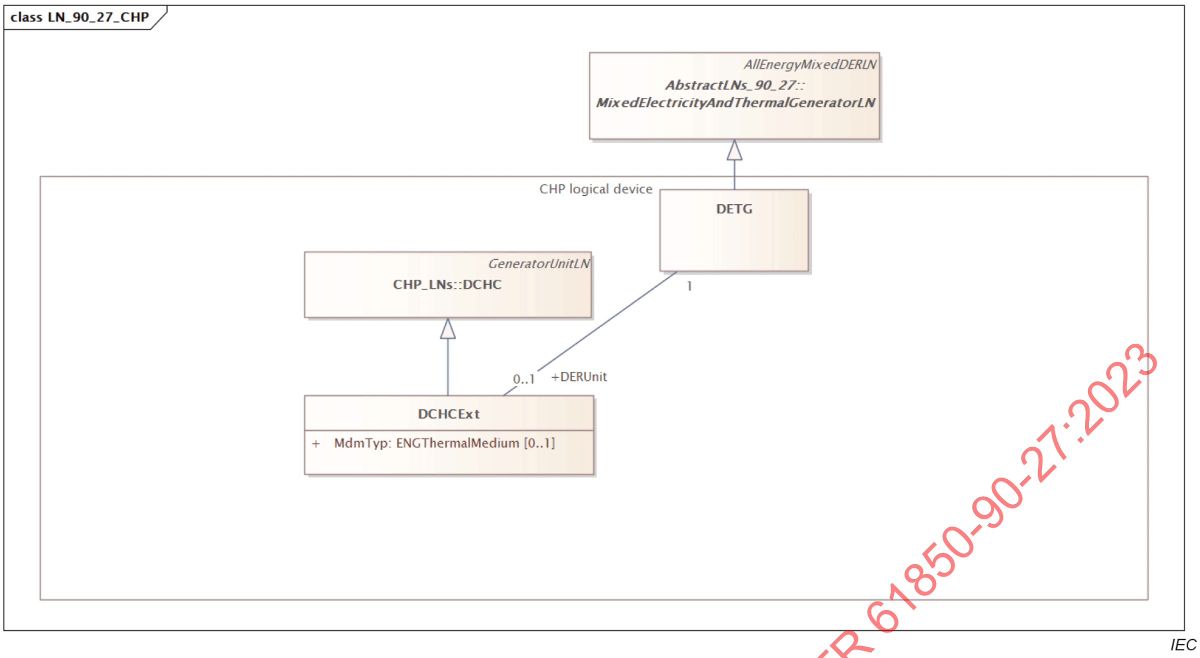


Figure 14 – Modelling of a CHP

LN *DCHC* (DCHCExt in the figure) contains technology specific data objects of CHP. The inheritance of *DCHC* is the same as one defined in IEC 61850-7-420:2021 since no data objects common to units are not identified.

According to the modelling principle, this document proposes that *DCHB* and *DCTS* in IEC 61850-7-420 will be deprecated and the data objects supported by *DCHB* or *DCTS* will be moved to other LN classes. In the case of *DCHB* representing a CHP boiler, most of the data object in the LN class will move to *DGTH* because *DGTH* models generic characteristics of boilers. The remaining data object will be moved to corresponding LN classes for specific unit types. In the case of *DCTS* representing a CHP thermal storage, *DSTH* will have most of the data objects that are generic to any kinds of thermal storage. LN classes for specific types of thermal storage may have the remaining data object of *DCTS*. Note that *DCHC* continues to be used to model a CHP controller, but it is redefined in this document.

8.3.4 Modelling of thermal storage units

Thermal storage units are not modelled in this document according to several reasons mentioned as follows. The first reason is that any types of thermal storage units do not generate or consume electric power. Therefore, the modelling of thermal storage units are outside the scope of this document described in Clause 1. The second reason is that DSTH includes all the generic information of thermal storage. They may be used for operations of thermal systems, so they are enough for generation and/or consumption of electricity in thermal systems. Therefore, this document does not define any logical nodes for thermal storage units such as sensible, latent, and thermo-chemical heat storage units.

To assist readers to understand how to use LN instances without LN classes specific to thermal storage units, this subclause explains how to assign LN instances to real thermal resources in the use case 1.

The use case 1 in 6.3 identifies an aggregation of resources that includes gas boiler, heat pump, heat storage, and thermal mass in a building. This aggregation can be modelled by using the aggregation scheme provided by the logical nodes for generic logical nodes for resources.

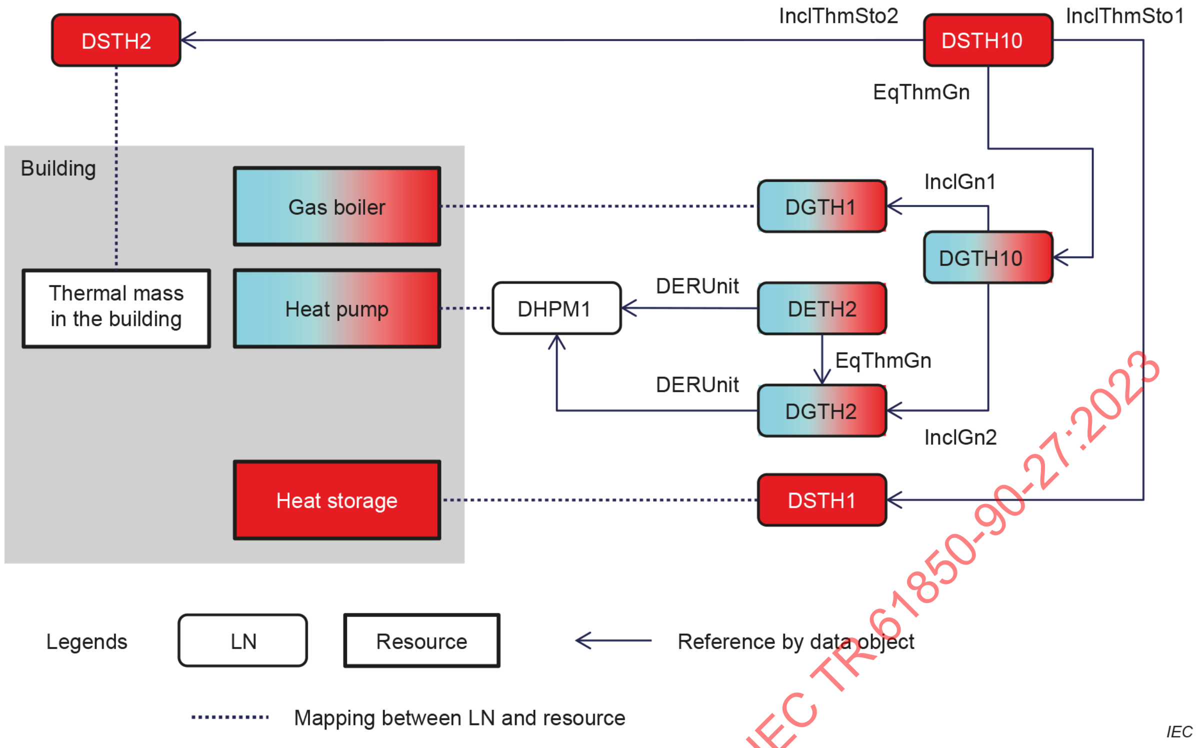


Figure 15 – An example of thermal storage resources including thermal mass in a building with mappings to logical nodes

Figure 15 shows thermal energy resources including thermal mass in a building described in 6.3 and mappings between the resources and logical nodes. In this example, a gas boiler and a heat pump are thermal generation. A gas boiler does not have aspects directly related to electricity so that only an instance named *DGTH1* is used to represent the generic characteristics for thermal energy management. This document does not define a logical node class for gas boiler as a specific unit because it is outside the scope of this document. On the other hand, a heat pump has aspects as electric load so its characteristics including alarms and ratings are modelled as a logical node named *DHPM*. An instance of *DHPM* may be used to handle such data and referred to by *DETH* and/or *DGTH* that are generic logical nodes for thermal resources. A heat storage and thermal mass in the building are represented by instances of *DSTH* and no other instances specific to units are used according to the scope. The aggregation of resources may be represented by *DSTH10* that has references to *DGTH10*, *DSTH1*, and *DSTH2* respectively. Note that *DSTH10* provides data to power management function for the flexibility described in the use case in 6.3.

8.4 Modelling of operational functions for energy services

P2H units and CHP units can be used to provide energy services to electric power systems. It is therefore essential to be able to model these energy services in IEC 61850-7-420.

Energy services offered by P2H and CHP units to support electric power grid are modelled as additional operational functions to the currently existing ones depicted in Figure 16 such as:

- Electric power grid connection requirement related to functions, that already form a substantial part of IEC 61850-7-420:2021,
- market related functions, that will include energy services in a future edition of IEC 61850-7-420, and
- functions related to operations of thermal systems.

Figure 16 gives an overview of the DER generic model defined in IEC 61850-7-420:2021. The concept is similar to the OS4ES approach suggested in deliverable D6.5 of the OS4ES project [OS4ES Deliverable D6.5] in which an energy service is associated with a DER System which in turn had 1 point of common coupling.

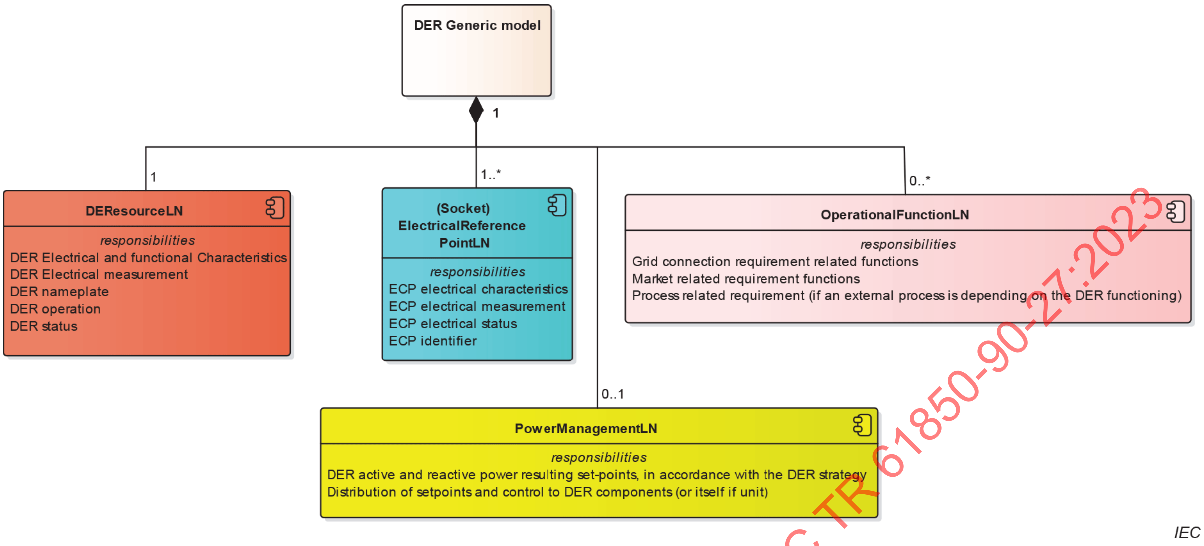


Figure 16 – DER Generic model

Figure 17 shows two types of operational function logical node classes for thermal systems.

The first type of the operational functions is used for operations of electric aspects of thermal systems such as P2H and CHP units. From the perspectives of thermal systems, additional data are needed in the existing operational functions defined in IEC 61850-7-420:2021 so the logical node classes categorized into this type are defined as classed derived from one of the operational function LNs defined in IEC 61850-7-420:2021. The diagram on the left side in Figure 17 shows *DWGCExt* as an example of the logical node class that is derived from *DWGC* in IEC 61850-7-420:2021.

The second type of the operational functions is used for general operations of thermal systems. It means that such functions are not related to electricity. For those classes, this document defines an abstract class named *ThermalOperationalFunctionLN* to define data objects common to any kinds of operational functions in this type. The diagram on the right side in Figure 17 shows DTHP to maintain a profile for thermal comfort as an example of the logical node classes to inherit *ThermalOperationalFunctionLN.*

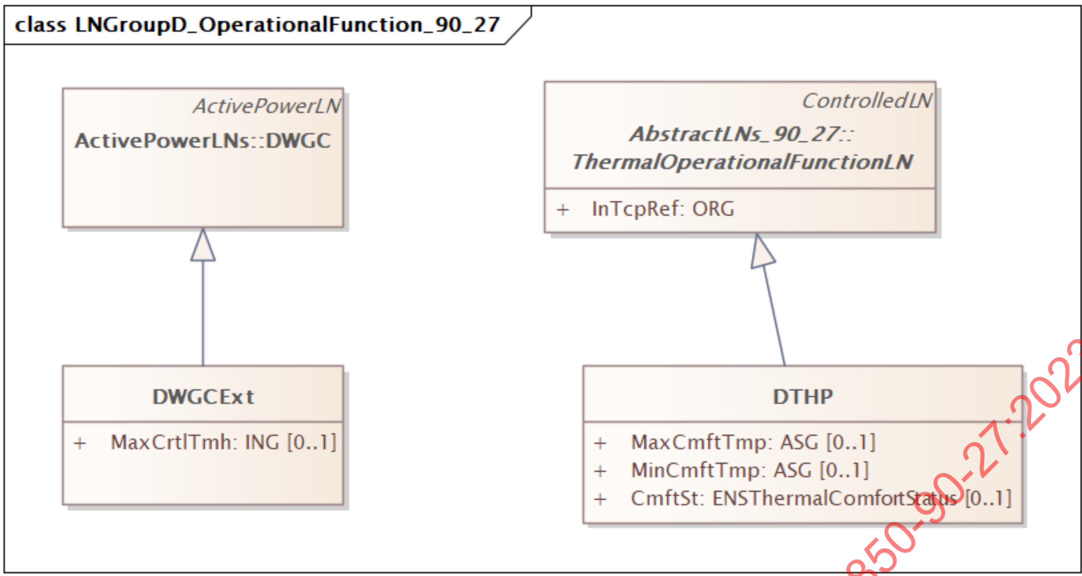


Figure 17 – Modelling of operational functions for thermal systems

8.5 Modelling of reference points in thermal systems

The next essential question to solve is how to model references from thermal units to a thermal energy network such as district heating grid/heating system.

IEC 61850-7-420:2021 models electric connection points (ECP) to any electric power system as depicted in Figure 18.

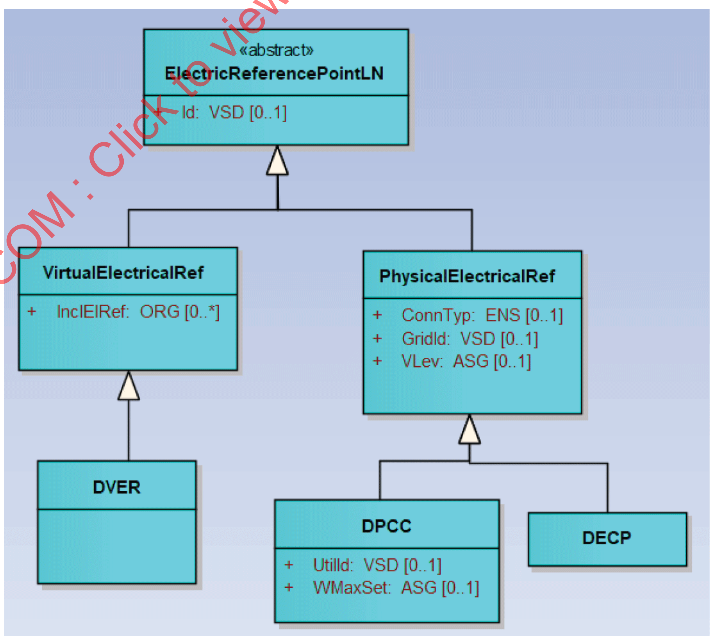


Figure 18 – Class model of an Electric Reference Point

The ECP class model has been extended to also consider connections to heat systems as illustrated in Figure 19. On the left-hand side of Figure 19, the existing classes for electric reference points are presented as they form part of the ECP class model shown in Figure 18. In the middle of the Figure the classes for thermal reference points are depicted. And, on the right-hand side the classes for gas reference points are presented. All of them have the new common parent class *ReferenceLN*. Note that reference classes for gas and oil systems are out of scope of this document. They appear in Figure 19 to show the inheritance from the *ReferenceLN*.

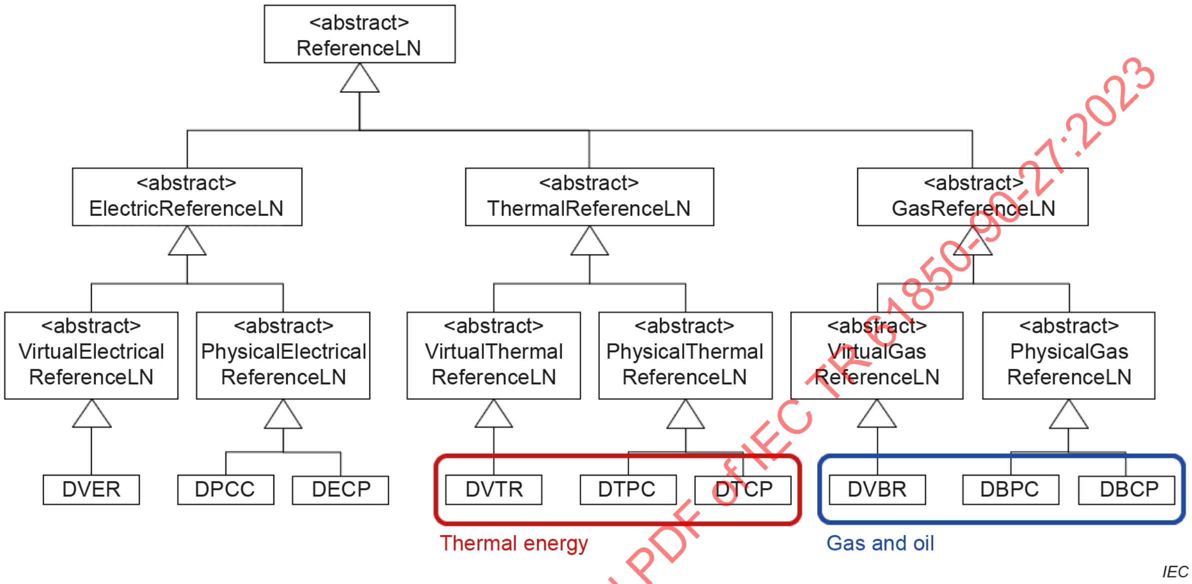


Figure 19 – Proposed extension of the class model of an Electric Reference Point

9 LN class definitions

9.1 General

This clause proposes new or extended logical nodes to support resources, operational functions, and reference points in thermal systems.

Some of the data objects listed in the data tables are reproduced from IEC 61850-7-4:2010+AMD1:2020 and IEC 61850-7-420:2021, and therefore their descriptions may include the word "shall".

9.2 Abstract logical nodes for thermal systems (AbstractLNs_90_27)

9.2.1 General

This subclause specifies abstract logical nodes defined in IEC 61850-90-27 to support resources, operational functions, and reference points in thermal systems. Figure 20 depicts abstract logical nodes for resources related to thermal systems, Figure 21 depicts abstract logical nodes for unit types of resources related to thermal systems, and Figure 22 depicts abstract logical nodes for operational functions related to thermal systems, respectively.

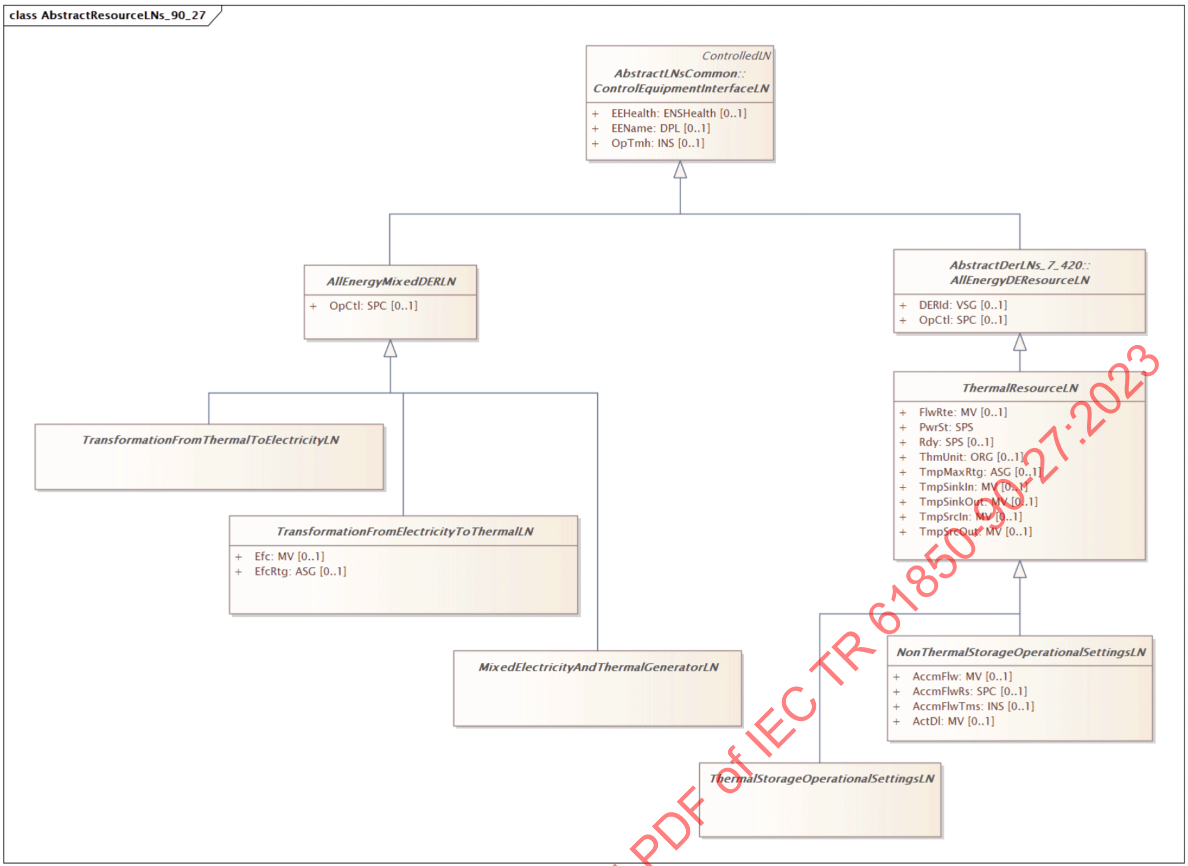


Figure 20 – Class diagram AbstractResourceLNs

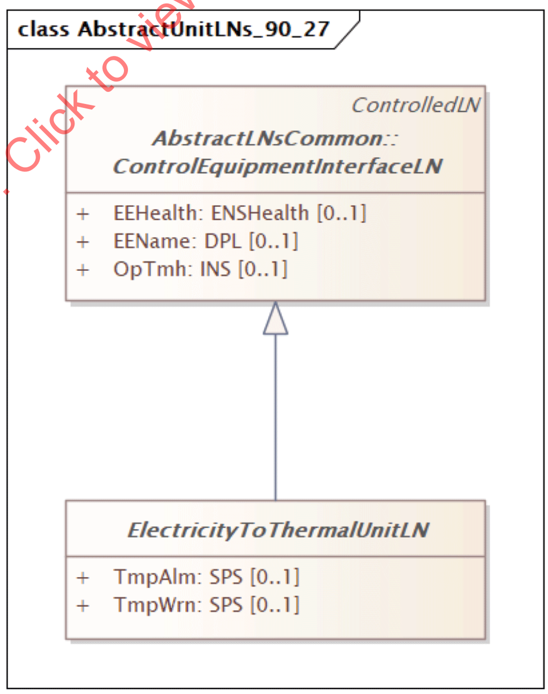


Figure 21 – Class diagram AbstractUnitLNs

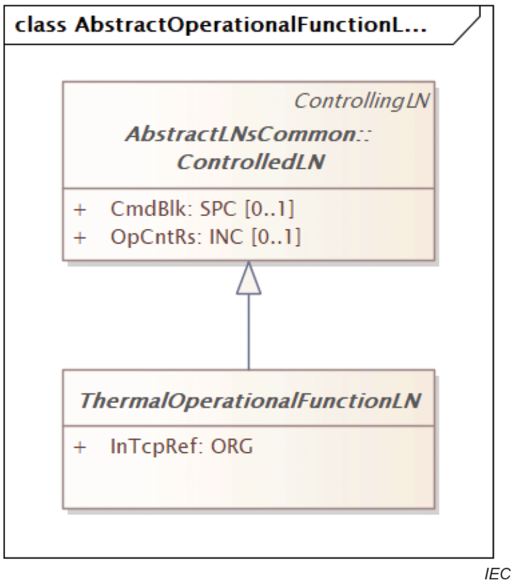


Figure 22 – Class diagram AbstractOperationalFunctionLNs

9.2.2 <<abstract>> LN: All energy (electricity, thermal energy, and gas) mixed DER Name: AllEnergyMixedDERLN

The abstract logical node defines data objects common to any kind of distributed energy resources including electric resources and thermal ones.

Table 12 shows all data objects of AllEnergyMixedDERLN.

This class has as parent: ControlEquipmentInterfaceLN.

Table 12 – Data objects of AllEnergyMixedDERLN

AllEnergyMixedDERLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Controls				
OpCtl	SPC		(Controllable) Start/stop control of the DER. The DER is running if the stVal of this DO is TRUE, and it is off if the stVal is FALSE.	O / F

9.2.3 <<abstract>> LN: Transformation from electricity to thermal Name: TransformationFromElectricityToThermalLN

This abstract logical node defines common data objects for transformation from electrical energy to thermal energy.

Table 13 shows all data objects of TransformationFromElectricityToThermalLN.

This class has as parent: AllEnergyMixedDERLN.

Table 13 – Data objects of TransformationFromElectricityToThermalLN

TransformationFromElectricityToThermalLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Measured and metered values				
Efc	MV		Measured or calculated efficiency from electricity to thermal energy. This value is represented as per unit.	O / O
Settings				
EfcRtg	ASG		The rated thermal efficiency of the electricity to thermal transformer unit. ƒÅ = (Thermal energy output (water, steam, …)) / (Electric energy input) x 100	O / F

9.2.4 <<abstract>> LN: Transformation from thermal energy to electricity Name: TransformationFromThermalToElectricityLN

The abstract logical node supports the data management common to resources that transform electricity into thermal energy.

9.2.5 <<abstract>> LN: Mixed electricity and thermal generator Name: MixedElectricityAndThermalGeneratorLN

This abstract logical node defines common data objects for mixed electrical and thermal generators.

9.2.6 <<abstract>> LN: Thermal resource Name: ThermalResourceLN

This abstract logical node defines common data objects for any kind of thermal resources including thermal generators, storage, and loads.

Table 14 shows all data objects of ThermalResourceLN.

This class has as parent: AllEnergyDEResourceLN.

Table 14 – Data objects of ThermalResourceLN

ThermalResourceLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Status information				
PwrSt	SPS		If true, power for operations is supplied to the resource.	M / F
Rdy	SPS		If true, the resource is ready for operation.	O / F

ThermalResourceLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Measured and metered values				
FlwRte	MV		Flow rate of the material to convey thermal energy. The measurement unit is [m3/h].	O / O
TmpSinkIn	MV		Temperature measured at the sink inlet of the thermal resource unit.	O / O
TmpSinkOut	MV		Temperature measured at the sink outlet of the thermal resource unit.	O / O
TmpSrcIn	MV		Temperature measured at the source inlet of the thermal resource unit.	O / O
TmpSrcOut	MV		Temperature measured at the source outlet of the thermal resource unit.	O / O
Settings				
ThmUnit	ORG		Reference to the thermal unit LN which is associated with this generic model LN.	O / F
TmpMaxRtg	ASG		Maximum flow temperature (in °C).	O / F

9.2.7 <<abstract>> LN: Non thermal storage operational settings Name: NonThermalStorageOperationalSettingsLN

This abstract logical node defines common data objects, such as operational ratings, for thermal generators and thermal loads.

Table 15 shows all data objects of NonThermalStorageOperationalSettingsLN.

This class has as parent: ThermalResourceLN.

Table 15 – Data objects of NonThermalStorageOperationalSettingsLN

NonThermalStorageOperationalSettingsLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Status information				
AccmFlwTms	INS		Time in seconds for accumulation of medium flow since reset.	O / O
Measured and metered values				
AccmFlw	MV		Accumulated medium flow since last reset. The value (mag) is reset by AccmFlwRs. The time since reset is expressed by AccmFlwTms.	O / O
ActDl	MV		Time difference between actual activation time and ordered start time. This is a measurement value, which is usually in seconds.	O / O
Controls				
AccmFlwRs	SPC		(controllable) Operating with value true resets the value of AccmFlw; operating with value false is ignored. The change of its status value is a local issue.	O / F

9.2.8 <<abstract>> LN: Thermal storage operational settings Name: ThermalStorageOperationalSettingsLN

This abstract logical node defines common data objects of operational settings for thermal energy storage.

9.2.9 <<abstract>> LN: Electricity to thermal energy unit Name: ElectricityToThermalUnitLN

This abstract logical node defines data objects that are common to all kinds of electrical to thermal energy conversion.

Table 16 shows all data objects of ElectricityToThermalUnitLN.

This class has as parent: ControlEquipmentInterfaceLN.

Table 16 – Data objects of ElectricityToThermalUnitLN

ElectricityToThermalUnitLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Status information				
TmpAlm	SPS		An alarm indicating the temperature exceeds the threshold.	O / F
TmpWrn	SPS		A warning indicating the temperature exceeds the threshold.	O / F

9.2.10 <<abstract>> LN: Thermal operation function Name: ThermalOperationalFunctionLN

The abstract logical node supports the data management for thermal operational functions.

Table 17 shows all data objects of ThermalOperationalFunctionLN.

This class has as parent: ControlledLN.

Table 17 – Data objects of ThermalOperationalFunctionLN

ThermalOperationalFunctionLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Settings				
InTcpRef	ORG		Reference to an instance of thermal connection point LN which is the source of the measurement used by thermal operational function.	M / F

9.2.11 <<abstract>> LN: Thermal reference point Name: ThermalReferenceLN

This abstract logical node class is the root for any LN depicting a thermal reference point in a given thermal network/system.

Table 18 shows all data objects of ThermalReferenceLN.

This class has as parent: FunctionLN.

Table 18 – Data objects of ThermalReferenceLN

ThermalReferenceLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Settings				
ThmMeasRef	ORG		Reference to a measurement function for temperature STMP, energy flow MTHM, or medium flow MFLW LN instance.	Omulti / F
ThmRefId	VSG		Identification of thermal reference point as a Visible String.	O / F
ThmStCtlRef	ORG		Reference to status (and control) function associated to the thermal reference point, typically KVLV or KPMP LN instances.	Omulti / F

9.2.12 <<abstract>> LN: Physical thermal reference Name: PhysicalThermalReferenceLN

This abstract logical node class contains the physical characteristics of the thermal connection point (TCP).

It contains its operational characteristics, including "nameplate" or static information (identity, type), settings (typical nominal temperature) and measurement (pointers to STMP logical node).

Table 19 shows all data objects of PhysicalThermalReferenceLN.

This class has as parent: ThermalReferenceLN.

Table 19 – Data objects of PhysicalThermalReferenceLN

PhysicalThermalReferenceLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Status information				
TcpIsldSt	ENS (TCPIslandStateKind)		Thermal connection point (TCP) state.	O / F
Settings				
TmpRtg	ASG		Temperature rating at the thermal connection point designated by this logical node.	O / F
FlwRtg	ASG		Medium flow rating at the thermal connection point designated by this logical node.	O / F

9.2.13 <<abstract>> LN: Virtual Thermal Reference Point Name: VirtualThermalReferenceLN

The abstract logical node contains the operational characteristics of virtual thermal reference point.

Table 20 shows all data objects of VirtualThermalReferenceLN.

This class has as parent: ThermalReferenceLN.

Table 20 – Data objects of VirtualThermalReferenceLN

VirtualThermalReferenceLN				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Settings				
InclThmRef	ORG		Reference(s) to the set of physical or virtual thermal reference points that are included in this virtual reference.	Mmulti / F

9.3 Generic logical nodes for thermal resource (LNGroupD)

9.3.1 General

This subclause specifies generic logical nodes defined in IEC 61850-90-27 to support resources in thermal systems. These logical nodes represent generic characteristics of thermal generators, storage, or loads. In addition, resources transforming electricity to thermal energy and those of combined heat and power are modelled from the perspective of generic characteristics. Figure 23 shows a UML class diagram in which the LN classes support resources in thermal systems.

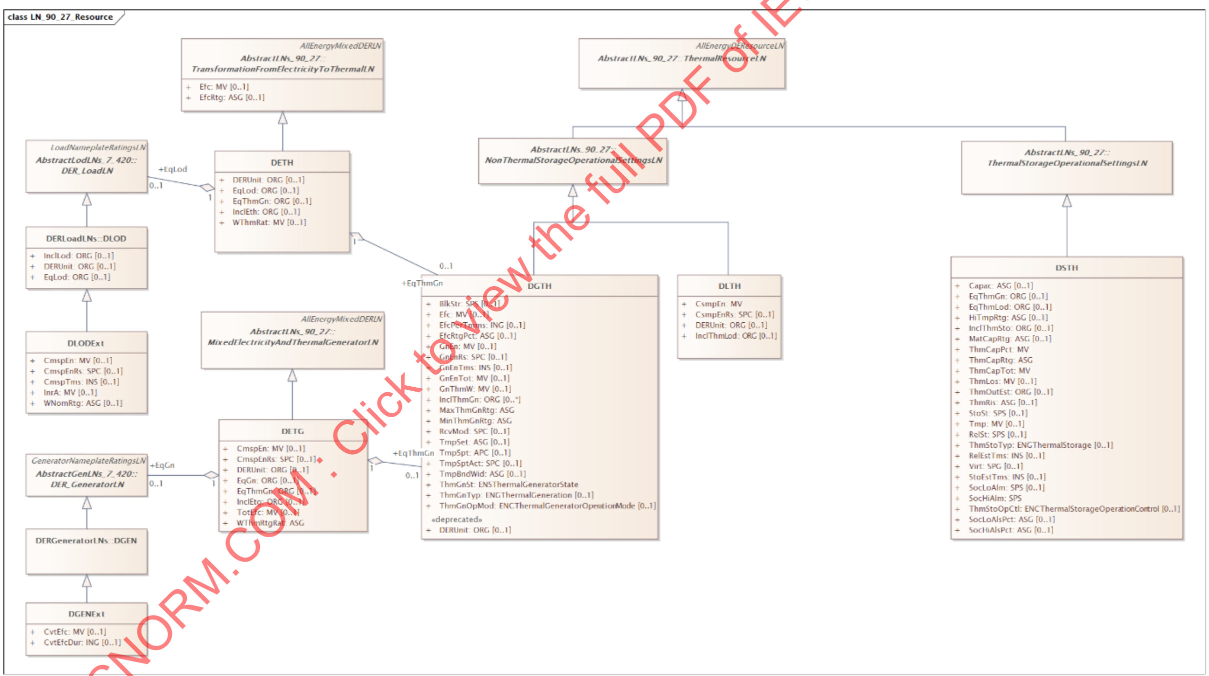


Figure 23 – Class diagram for resources

9.3.2 LN: Thermal generating resource Name: DGTH

The DGTH logical node defines the actual connected and operational state of a thermal generating unit, including aggregations of thermal generating units. It inherits nameplate and operational characteristics and includes the commands that cause it to change state. It also reflects the thermal generating unit's responses to external events that cause a change of state (DERState).

Table 21 shows all data objects of DGTH.

Table 21 – Data objects of DGTH

DGTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
BlkStr	SPS		if true, the thermal generator is blocked so it may not start.	O / F
GnEnTms	INS		Time in seconds for accumulation of thermal energy generated since reset.	O / O
ThmGnSt	ENS (ThermalGeneratorStateKind)		Current operating state.	M / F
AccmFlwTms	INS		(inherited from: NonThermalStorageOperationalSettingsLN) Time in seconds for accumulation of medium flow since reset.	O / O
PwrSt	SPS		(inherited from: ThermalResourceLN) If true, power for operations is supplied to the resource.	M / F
Rdy	SPS		(inherited from: ThermalResourceLN) If true, the resource is ready for operation.	O / F
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M

DGTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresConds/ds**
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
Efc	MV		Ratio of the thermal energy produced to the energy consumed (e.g., fuel and electric energy). This is a measured or calculated value. This DO is used to represent COP (Coefficient Of Performance).	O / O
GnEn	MV		Total thermal energy generated since last reset. The value (mag) is reset by GnEnRs. The time since reset is expressed by GnEnTms. The unit of value be Wh or Joule.	O / O
GnEnTot	MV		Total thermal energy generated. The unit be Wh or Joule.	O / O
GnThmW	MV		Instantaneous thermal energy generated. The unit is Watt [W] that may be with an SI suffix such as k and M. Need to consider whether is good to use this DO or define another LN to show measured values about thermal energy. This is because DGEN in 7-420 does not have a DO for measurement of generated power. The measured value of generated power will be represented by TotW or other DOs in MMXU.	O / O
AccmFlw	MV		(inherited from: NonThermalStorageOperationalSettingsLN) Accumulated medium flow since last reset. The value (mag) is reset by AccmFlwRs. The time since reset is expressed by AccmFlwTms.	O / O
ActDl	MV		(inherited from: NonThermalStorageOperationalSettingsLN) Time difference between actual activation time and ordered start time. This is a measurement value, which is usually in seconds.	O / O
FlwRte	MV		(inherited from: ThermalResourceLN) Flow rate of the material to convey thermal energy. The measurement unit is [m3/h].	O / O
TmpSinkIn	MV		(inherited from: ThermalResourceLN) Temperature measured at the sink inlet of the thermal resource unit.	O / O
TmpSinkOut	MV		(inherited from: ThermalResourceLN) Temperature measured at the sink outlet of the thermal resource unit.	O / O
TmpSrcIn	MV		(inherited from: ThermalResourceLN) Temperature measured at the source inlet of the thermal resource unit.	O / O
TmpSrcOut	MV		(inherited from: ThermalResourceLN) Temperature measured at the source outlet of the thermal resource unit.	O / O

DGTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresConds nds/ds**
Controls				
GnEnRs	SPC		(controllable) Operating with value true resets the value of GnEn; operating with value false is ignored. The change of its status value is a local issue.	O / F
RcvMod	SPC		(controllable) if true, the thermal generator is running in the recovery mode in which the exhausted heat is recovered for another use.	O / F
TmpSpt	APC		Control setpoint for temperature of medium at outlet. In case no value is received by the client or TmpSptAct is set to false, its mxVal should be a copy of the default value TmpSet with quality.	O / O
TmpSptAct	SPC		If false, the value stored in TmpSpt of the same instance is considered as quality=invalid (do not pay attention to TmpSpt) otherwise the corresponding TmpSpt of the same instance is active (follow the TmpSpt value).	O / F
ThmGnOpMod	ENC (ThermalGeneratorOperationModeType)		(controllable) Operation mode of thermal generating resource that may be changed by operator. If the resource provides only fixed mode, the ctlModel shall be set to "status-only"	O / F
AccmFlwRs	SPC		(inherited from: NonThermalStorageOperationalSettingsLN) (controllable) Operating with value true resets the value of AccmFlw; operating with value false is ignored. The change of its status value is a local issue.	O / F
OpCtl	SPC		(inherited from: AllEnergyDEResourceLN) (Controllable) Start/stop control of the DER. The DER is running if the stVal of this DO is TRUE, and it is off if the stVal is FALSE.	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
DERUnit	ORG		(deprecated) Reference to the thermal generating unit LN which may be associated to this generic model LN.	O / F
EfcPerTmms	ING		The period in milliseconds to calculate the value of EfcPct.	O / F
EfcRtgPct	ASG		Efficiency at rated capacity as percent	O / F
InclThmGn	ORG		Included thermal generators	Omulti / F

DGTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
MaxThmGnRtg	ASG		Maximum thermal generation rating [J/s].	M / F
MinThmGnRtg	ASG		Minimum thermal generation rating [J/s].	M / F
TmpSet	ASG		Default value of TmpSpt, setpoint for temperature of medium at outlet.	O / F
TmpBndWid	ASG		Control temperature bandwidth at outlet (i.e., range) given by temperature value. It is also recognized as the dead band around the setpoint of the temperature at outlet of the electricity to thermal transforming unit. So, no control is activated as long as the temperature is within the bandwidth.	O / F
ThmGnTyp	ENG (ThermalGenerationKind)		Thermal generation type in terms of output (heating, cooling, freezing).	O / F
ThmUnit	ORG		(inherited from: ThermalResourceLN) Reference to the thermal unit LN which is associated with this generic model LN.	O / F
TmpMaxRtg	ASG		(inherited from: ThermalResourceLN) Maximum flow temperature (in °C).	O / F
DERId	VSG		(inherited from: AllEnergyDEResourceLN) Internal identifier of the resource within a system which is using that resource. It complements the mRID defined as part of the EEname DO. Different DERIds may be defined for different system users.	Omulti / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if ‘TRUE_RMS’ and ‘RMS_FUNDAMENTAL’). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O

DGTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.3.3 LN: Thermal storage resource Name: DSTH

The DSTH logical node defines the actual operational state of a thermal load resource, a thermal storage unit or aggregations of them. It includes nameplate and operational characteristics as well as the commands that cause it to change state.

Table 22 shows all data objects of DSTH.

Table 22 – Data objects of DSTH

DSTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
StoSt	SPS		If true, the thermal storage is storing thermal energy (e.g. heat, chilled heat).	O / F
RelSt	SPS		If true, the thermal storage is releasing thermal energy (e.g. heat, chilled heat).	O / F
RelEstTms	INS		Estimated time in seconds to release all the thermal energy currently stored.	O / O
StoEstTms	INS		Estimated time in seconds to store the thermal energy to fill the thermal storage.	O / O
SocLoAlm	SPS		Alarm trigger status: If true, the thermal energy storage level is lower than the minimum threshold (SocLoAlsPct).	O / F
SocHiAlm	SPS		Alarm trigger status: If true, the thermal energy storage level exceeds the maximum threshold (SocHiAlsPct).	M / F
PwrSt	SPS		(inherited from: ThermalResourceLN) If true, power for operations is supplied to the resource.	M / F
Rdy	SPS		(inherited from: ThermalResourceLN) If true, the resource is ready for operation.	O / F
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F

DSTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
ThmCapPct	MV		Remaining actual thermal energy capacity as percent of total available capacity.	M / O
ThmCapTot	MV		Total available thermal energy capacity.	M / O
Tmp	MV		Temperature in the storage. The measurement point (e.g., surface, bottom) is outside the scope of this report.	O / O
ThmLos	MV		Thermal energy lost or dumped.	O / O
FlwRte	MV		(inherited from: ThermalResourceLN) Flow rate of the material to convey thermal energy. The measurement unit is [m3/h].	O / O
TmpSinkIn	MV		(inherited from: ThermalResourceLN) Temperature measured at the sink inlet of the thermal resource unit.	O / O
TmpSinkOut	MV		(inherited from: ThermalResourceLN) Temperature measured at the sink outlet of the thermal resource unit.	O / O
TmpSrcIn	MV		(inherited from: ThermalResourceLN) Temperature measured at the source inlet of the thermal resource unit.	O / O

DSTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
TmpSrcOut	MV		(inherited from: ThermalResourceLN) Temperature measured at the source outlet of the thermal resource unit.	O / O
Controls				
ThmStoOpCtl	ENC (ThermalStorageOperationControlKind)		(controllable) Operating with the value expressed in ctlVal (selected among the list specified in ThermalStorageOperationControlKind) initiates the appropriate transition request. The attribute stVal represents the received control value that may not be consistent to the current status of the thermal storage. The resulting state of the thermal storage shall be observed in the StoSt and RelSt DOs.	O / F
OpCtl	SPC		(inherited from: AllEnergyDEResourceLN) (Controllable) Start/stop control of the DER. The DER is running if the stVal of this DO is TRUE, and it is off if the stVal is FALSE.	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
ThmStoTyp	ENG (ThermalStorageKind)		Thermal storage type in terms of output (heating, cooling, freezing). Note that this data object is proposed to replace the definition of ThmStoTyp in IEC 61850-7-420.	O / F
SocLoAlsPct	ASG		Threshold alarm setting of the usable lower limit of the thermal storage resource (in % of the usable capacity of the resource element (in Joule)).	O / F
SocHiAlsPct	ASG		Threshold alarm setting of the usable upper limit of the thermal storage resource (in % of the usable capacity of the resource element (in Joule)).	O / F
MatCapRtg	ASG		Capacity rating for material in the storage. The unit is m3.	O / F
EqThmGn	ORG		Reference to the DGTH instance reflecting the thermal energy generation aspects of the DER.	O / F
EqThmLod	ORG		Reference to the DLTH instance reflecting the thermal energy load aspects of the DER	O / F
InclThmSto	ORG		Reference to thermal storage resources	Omulti / F
HiTmpRtg	ASG		The highest temperature rating of the storage	O / F

DSTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ThmCapRtg	ASG		Capacity rating for thermal energy in the storage. The unit is Wh or Joule.	M / F
Virt	SPG		If true, the LN represents a virtual thermal energy storage. If false, it is recommended to omit the data object Virt.	O / F
ThmRis	ASG		Thermal resistance. A parameter of the space thermal model (RC-Model). The unit of value is [°C/W].	O / F
Capac	ASG		A parameter of the space thermal model (RC-Model). The unit of value is [J/°C].	O / F
ThmOutEst	ORG		Reference to the LN holding the estimated instantaneous thermal energy output over time (using time offsets).	O / F
ThmUnit	ORG		(inherited from: ThermalResourceLN) Reference to the thermal unit LN which is associated with this generic model LN.	O / F
TmpMaxRtg	ASG		(inherited from: ThermalResourceLN) Maximum flow temperature (in °C).	O / F
DERId	VSG		(inherited from: AllEnergyDEResourceLN) Internal identifier of the resource within a system which is using that resource. It complements the mRID defined as part of the EEname DO. Different DERIds may be defined for different system users.	Omulti / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to	F / M

DSTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			calculate the values contained in this logical node instance.	
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.3.4 LN: Thermal load resource Name: DLTH

The DLTH logical node defines the actual operational state of a thermal load unit, including aggregations of thermal load units. It includes nameplate and operational characteristics as well as the commands that cause it to change state.

Table 23 shows all data objects of DLTH.

Table 23 – Data objects of DLTH

DLTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
AccmFlwTms	INS		(inherited from: NonThermalStorageOperationalSettingsLN) Time in seconds for accumulation of medium flow since reset.	O / O
PwrSt	SPS		(inherited from: ThermalResourceLN) If true, power for operations is supplied to the resource.	M / F
Rdy	SPS		(inherited from: ThermalResourceLN) If true, the resource is ready for operation.	O / F
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F

DLTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
CsmpEn	MV		Energy consumed since last reset (This is designed based on the approach of GnEnPer in DER_GenerationLN)	M / O
AccmFlw	MV		(inherited from: NonThermalStorageOperationalSettingsLN) Accumulated medium flow since last reset. The value (mag) is reset by AccmFlwRs. The time since reset is expressed by AccmFlwTms.	O / O
ActDl	MV		(inherited from: NonThermalStorageOperationalSettingsLN) Time difference between actual activation time and ordered start time. This is a measurement value, which is usually in seconds.	O / O
FlwRte	MV		(inherited from: ThermalResourceLN) Flow rate of the material to convey thermal energy. The measurement unit is [m3/h].	O / O
TmpSinkIn	MV		(inherited from: ThermalResourceLN) Temperature measured at the sink inlet of the thermal resource unit.	O / O
TmpSinkOut	MV		(inherited from: ThermalResourceLN) Temperature measured at the sink outlet of the thermal resource unit.	O / O
TmpSrcIn	MV		(inherited from: ThermalResourceLN) Temperature measured at the source inlet of the thermal resource unit.	O / O
TmpSrcOut	MV		(inherited from: ThermalResourceLN) Temperature measured at the source outlet of the thermal resource unit.	O / O
Controls				
CsmpEnRs	SPC		(controllable) Operating with value true resets the value of Energy consumed represented by	O / F

DLTH				
Data object name	Common data class	T	Explanation	PresCond nds/ds
			CmspEn. The change of its status value and return to false are local issues.	
AccmFlwRs	SPC		(inherited from: NonThermalStorageOperationalSettingsLN) (controllable) Operating with value true resets the value of AccmFlw; operating with value false is ignored. The change of its status value is a local issue.	O / F
OpCtl	SPC		(inherited from: AllEnergyDEResourceLN) (Controllable) Start/stop control of the DER. The DER is running if the stVal of this DO is TRUE, and it is off if the stVal is FALSE.	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
DERUnit	ORG		Reference to the thermal load Unit LN which may be associated to this generic model LN.	O / F
InclThmLod	ORG		Reference to included thermal loads	Omulti / F
ThmUnit	ORG		(inherited from: ThermalResourceLN) Reference to the thermal unit LN which is associated with this generic model LN.	O / F
TmpMaxRtg	ASG		(inherited from: ThermalResourceLN) Maximum flow temperature (in °C).	O / F
DERId	VSG		(inherited from: AllEnergyDEResourceLN) Internal identifier of the resource within a system which is using that resource. It complements the mRID defined as part of the EEname DO. Different DERIds may be defined for different system users.	Omulti / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if ‘TRUE_RMS’ and ‘RMS_FUNDAMENTAL’).	O / M

DLTH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			If the value is 'unspecified', the dependent data objects may be meaningless.	
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.3.5 LN: Mixed electricity and thermal generating unit Name: DETG

The DETG logical node defines the ratings, operational state and measurement of a resource that generates both electricity and thermal energy.

Table 24 shows all data objects of DETG.

Table 24 – Data objects of DETG

DETG				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O

DETG				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
CmspEn	MV		Energy consumed since last reset (This is designed based on the approach of GnEnPer in DER_GenerationLN) The unit be Joule or Wh.	O / O
TotEfc	MV		Ratio of the electrical and thermal energy produced to the energy consumed (fuel). This is a measured value.	O / O
Controls				
CmspEnRs	SPC		(controllable) Operating with value true resets the value of Energy consumed during the period represented by CmspEn. The change of its status value and return to false are local issues.	O / F
OpCtl	SPC		(inherited from: AllEnergyMixedDERLN) (Controllable) Start/stop control of the DER. The DER is running if the stVal of this DO is TRUE, and it is off if the stVal is FALSE.	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and	OF(Loc) / F

DETG				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			control from remote is disabled; otherwise control from remote is allowed.	
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
DERUnit	ORG		This data object refers to a concrete unit of MixedElectricityAndThermalGeneratingUnit LN such as DCHC. If a client tries to set a reference to another LN class other than one derived from MixedElectricityAndThermalGeneratingUnit as the DERUnit, the LN class refuses it.	O / F
EqGn	ORG		Reference to the equivalent DGEN instance reflecting the electrical generation aspects of the DER.	O / F
EqThmGn	ORG		Reference to the DGTH instance reflecting the thermal generation aspects of the DER	O / F
InclEtg	ORG		References to included mixed electricity and thermal generators.	Omulti / F
WThmRtgRat	ASG		Rated ratio of the electrical energy produced to the thermal energy produced in a CHP.	M / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to	F / M

DETG				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			calculate the values contained in this logical node instance.	
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

Table 25 shows all relations of DETG with other classes.

Table 25 – Relations of DETG with other classes

Name	Mult	Type	Description
DERUnit	0..1	DCHCExt	
EqGn	0..1	DER_GeneratorLN	
EqThmGn	0..1	DGTH	

9.3.6 LN: Electricity to thermal transforming unit Name: DETH

The DETH logical node defines the ratings, operational state and measurement of a resource that transforms electricity to thermal energy.

Table 26 shows all data objects of DETH.

Table 26 – Data objects of DETH

DETH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may	OF(Loc) / F

DETH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			have a set of contacts from which the position can be read.	
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
WThmRat	MV		Ratio of the thermal energy produced to the electrical energy consumed.	O / O
Efc	MV		(inherited from: TransformationFromElectricityToThermalLN) Measured or calculated efficiency from electricity to thermal energy. This value is represented as per unit.	O / O
Controls				
OpCtl	SPC		(inherited from: AllEnergyMixedDERLN) (Controllable) Start/stop control of the DER. The DER is running if the stVal of this DO is TRUE, and it is off if the stVal is FALSE.	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O

DETH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Settings				
DERUnit	ORG		This data object refers to a concrete unit of ElectricityToThermalUnit LN such as DHPM. If a client tries to set a reference to another LN class other than one derived from ElectricityToThermalUnitLN as the DERUnit, the LN class should refuse it.	O / F
EqLod	ORG		Reference to the DLOD instance reflecting the electric load aspects of the DER.	O / F
EqThmGn	ORG		Reference to the DGTH instance reflecting the thermal generation aspects of the DER.	O / F
InclEth	ORG		If this LN is an aggregation, this data object is a reference to the instances to included DETH logical nodes.	Omulti / F
EfcRtg	ASG		(inherited from: TransformationFromElectricityToThermalLN) The rated thermal efficiency of the electricity to thermal transformer unit. ƒÅ = (Thermal energy output (water, steam, ...)) / (Electric energy input) x 100	O / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O

DETH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

Table 27 shows all relations of DETH with other classes.

Table 27 – Relations of DETH with other classes

Name	Mult	Type	Description
DERUnit	0..1	DHPM	
EqLod	0..1	DER_LoadLN	
EqThmGn	0..1	DGTH	

9.4 Extended logical nodes for distributed energy resources (LNGroupD)

9.4.1 General

The LN group D in this document includes resources related to electricity and/or thermal energy. It also has reference points in thermal systems and an operational function. The LN class definitions are depicted in Figure 23.

9.4.2 LN: DER generating unit extended in 90-27 Name: DGENExt

This LN class is an extension of the DGEN logical node defined in IEC 61850-7-420.

The "Ext" suffix attached to the LN name is only there for editorial purpose and is not present in the real model.

Table 28 shows all data objects of DGENExt.

Table 28 – Data objects of DGENExt

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
GnOpSt	ENS (DERGeneratorStateKind)		(deprecated) (inherited from: DGEN) Generation operational state	M / F
OpTmsRs	INS		(deprecated) (inherited from: DGEN) Total time generator has operated – re-settable: accumulated time since the last time the counter was reset	M / O

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
GnSynSt	ENS (DERSynchronizationKind)		(inherited from: DER_GeneratorLN) Synchronization status of the DER generator unit.	O / F
RmpLodSw	SPS		(inherited from: DER_GeneratorLN) Ramp Load/Unload Switch; True = Ramp load, False = Ramp unload	O / F
TotStrCnt	INS		(inherited from: DER_GeneratorLN) Count of total number of starts	O / O
RemExpcOpTms	INS		(inherited from: DER_GeneratorLN) Expected remaining operational run time (in seconds) before the unit is required to end exporting energy (get out from the state "Connected and Generating" state) due to external factors (e.g. lack of fuel, limits on emissions, limits on heat storage, limits on energy storage) if operating as planned. If not used, quality shall be set to invalid.	O / O
DEROpSt	ENS (DERStateKind)		(inherited from: DER_StateAbstractLN) Current state of operation of the distributed energy resource.	M / F
TestRsl	SPS		(inherited from: DER_StateAbstractLN) Set to true at the end of the test procedure (just before Test.stVal goes from true to false to notify the end of the test) if all tests successful, otherwise set to false. Its value remains unchanged until a new test procedure is launched. Set systematically to false at warm or cold start of the equipment, and at the time a new test is initiated (when the Test.stVal goes from false to true).	O / F
TestAddRsl	ENS (EquipmentTestResultKind)		(inherited from: DER_StateAbstractLN) Reflects the equipment test additional results at the end of the test procedure (just before Test.stVal goes from true to false to notify the end of the test). Set systematically to value 'test running' at the time a new test is initiated (when the Test.stVal goes from false to true).	O / F
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
CvtEfc	MV		Ratio of the electric energy produced to the energy consumed (fuel). This is a measured value.	O / O
GnH	HMV		(deprecated) (inherited from: DGEN) Generator harmonics	O / O
CnstWMax	MV		(inherited from: DER_GeneratorLN) The calculation of the maximum power that the generator could output, based on constraining environmental conditions (e.g. solar insolation or wind speed or constraints from heat or vibrations). The delta between this calculation and the actual power being output indicates how much additional power could be output.	O / O
GnOpTm	MV		(inherited from: DER_GeneratorLN) Elapsed time as the generator becomes ready after the start command was issued; max = maximum time before issuing a start-failure alarm	O / O
GnStabTm	MV		(inherited from: DER_GeneratorLN) Timer for stabilization time; max = maximum time before issuing a stabilization-failure alarm	O / O
GnClDnTm	MV		(inherited from: DER_GeneratorLN) Timer for generator unit to cool down; min = minimum time for cool down	O / O
AutoVRegPct	MV		(inherited from: DER_GeneratorLN) Automatic voltage regulator percent duty cycle	O / O
GnEnTot	MV		(inherited from: DER_GeneratorLN) Total energy generated	O / O
GnEnPer	MV		(inherited from: DER_GeneratorLN) Energy generated during the period since last reset	O / O
RenWPct	MV		(inherited from: DER_GeneratorLN) Percentage of the active power currently generated which results from renewable energy resource. What is considered as renewable is a local definition.	O / O
RenVArPct	MV		(inherited from: DER_GeneratorLN) Percentage of the reactive power currently generated which results from renewable energy resource. What is considered as renewable is a local definition.	O / O
VArTot	MV		(inherited from: NonStorageOperationalSettingsLN) The total	O / O

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			amount of reactive power without impacting active power output if the distinction between absorbing and injecting reactive power is not significant (the use of this DO is mutually exclusive with the use of AvarTot and IvarTot)	
AvarTot	MV		(inherited from: NonStorageOperationalSettingsLN) The total amount of reactive power available for absorbing even if possibly impacting active power output (the use of this DO is mutually exclusive with the use of VArTot)	O / O
IvarTot	MV		(inherited from: NonStorageOperationalSettingsLN) The total amount of reactive power available for injecting even if possibly impacting active power output (the use of this DO is mutually exclusive with the use of VArTot)	O / O
VArAvl	MV		(inherited from: NonStorageOperationalSettingsLN) The amount of reactive power available without impacting active power output if the distinction between absorbing and injecting reactive power is not significant (the use of this DO is mutually exclusive with the use of AvarAvl and IvarAvl)	O / O
AvarAvl	MV		(inherited from: NonStorageOperationalSettingsLN) The amount of reactive power available for absorbing without impacting active power output (the use of this DO is mutually exclusive with the use of VArAvl)	O / O
IvarAvl	MV		(inherited from: NonStorageOperationalSettingsLN) The amount of reactive power available for injecting without impacting active power output (the use of this DO is mutually exclusive with the use of VArAvl)	O / O
SelfSvcWh	MV		(inherited from: DER_ActualPowerInformationLN) Actual self service energy used	O / O
VAPct	MV		(inherited from: DER_ActualPowerInformationLN) Actual percentage of apparent power output based on VAMax	O / O
AvlUpW	MV		(inherited from: DER_ActualPowerInformationLN) Available capability (measured or calculated) for increasing active output, including increasing generation of active power, even if currently consuming power.	O / O
AvlDnW	MV		(inherited from: DER_ActualPowerInformationLN) Available capability (measured or calculated) for decreasing active power, including increasing the consumption of active power, even if currently generating power.	O / O
Controls				
GnCtl	DPC		(deprecated) (inherited from: DGEN) Starts or stops the generator: Start = True, Stop = False, other states indicate error condition	O / F
GnRL	DPC		(deprecated) (inherited from: DGEN) Raises or lowers the generation level by steps: Raise = True, Lower = False, other states indicate error condition	O / F
GnBlk	SPC		(deprecated) (inherited from: DGEN) Set generator as blocked: True = blocked from being turned on	O / F

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
GnOnCntRs	SPC		(deprecated) (inherited from: DGEN) Reset the number of times that the generator has been turned on.	O / F
PerStrCntRs	SPC		(deprecated) (inherited from: DGEN) Reset the count of starts in period.	O / F
GnOnCnt	INC		(inherited from: DER_GeneratorLN) The number of times that the DER unit has been turned on or returned to service: count of "DER unit on" times, since the last time the counter was reset	O / O
PerStrCnt	INC		(inherited from: DER_GeneratorLN) Count of starts in period since reset	O / O
OpTms	INC		(inherited from: DER_GeneratorLN) Total time DER unit has operated – resettable: accumulated time since the last time the time was reset	O / O
GnEnPerRs	SPC		(inherited from: DER_GeneratorLN) Reset the generated energy in period.	O / F
AuthConn	SPC		(inherited from: DER_StateAbstractLN) (controllable) if true, the DER is authorized to connect, otherwise it has to remain (or become) disconnected. Authorization may come from an external source or may be a default setting.	O / F
DEROpStCtl	ENC (DERStateTransitionKind)		(inherited from: DER_StateAbstractLN) (controllable) Operating with the value expressed in ctlVal (selected among the list specified in DERStateControlKind) initiates the appropriate transition request. The reading of its attribute stVal is meaningless. The resulting state of the DER shall be observed in the DEROpSt DO.	O / F
CeaEgzCtl	SPC		(inherited from: DER_StateAbstractLN) (controllable) Operating with value true initiates the cease to energize state of the DER (see definition of "cease to energize"); operating with value false initiates the return to service (get back to Idle, then reflect the settings of any or all default settings, enabled operational functions, and/or schedules) of the DER.	O / F
WSpt	APC		(inherited from: DER_StateAbstractLN) Active power setpoint. Its mxVal attribute reflects the value of the setpoint that is requested.	O / O
VArSpt	APC		(inherited from: DER_StateAbstractLN) Reactive power setpoint. Its mxVal attribute reflects the value of the setpoint that is requested.	O / O
EmgMod	SPC		(inherited from: DER_StateAbstractLN) (controllable) if true the DER shall operate in emergency mode, otherwise shall operate in normal mode. In emergency mode, emergency settings, emergency limits, and other emergency-related setpoints will be in effect.	O / F
AuthDscon	SPC		(inherited from: DER_StateAbstractLN) (controllable) if true, the DER is authorized to disconnect, otherwise shall remain connected (if possible)	O / F
TestEna	SPC		(inherited from: DER_StateAbstractLN) (controllable) If set to true, entering into test mode for the DER is allowed, otherwise forbidden	O / F
Test	SPC		(inherited from: DER_StateAbstractLN) (controllable) Operating with value true initiates starting a test of the DER equipment and resets the values of TestRsl.stVal (set to 'false') and TestAddRsl.stVal (set to 'test running'); operating	O / F

DGENExt				
Data object name	Common data class	T	Explanation	PresCond nds/ds
			with value false aborts the test. The reading of the status indicates whether the equipment is under test or not. The content of such test is implementation dependant.	
OpCtl	SPC		(inherited from: AllEnergyDEResourceLN) (Controllable) Start/stop control of the DER. The DER is running if the stVal of this DO is TRUE, and it is off if the stVal is FALSE.	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
CvtEfcDur	ING		The period in milliseconds to calculate the value of CvtEfc.	O / F
InclGn	ORG		(inherited from: DGEN) Included generator. This DO points to an instance of DGEN	Omulti / F
DERUnit	ORG		(inherited from: DGEN) Reference to the DER Unit LN which may be associated to this generic model LN	O / F
EqGn	ORG		(inherited from: DGEN) Reference to the equivalent DGEN instance reflecting the generation aspects of the DER	Omulti / F
WMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Nameplate maximum active generation power rating at unity power factor	M / F
WOvPFRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Nameplate active power generation rating at specified over-excited power factor, OvPFRtg	O / F
WUnPFRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Nameplate active power generation rating at specified under-excited power factor, UnPFRtg	O / F
VAMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Nameplate maximum apparent power generation rating	O / F
VArMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Setpoint for maximum reactive power if the distinction between absorbing and injecting reactive power is not significant	O / F
AvarMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Rating for maximum absorbing reactive power	O / F
IvarMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Rating for maximum supply (injection) reactive power	O / F

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
AMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Maximum current rating under nominal voltage under nominal power factor	O / F
VMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Maximum voltage rating	M / F
VMinRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Minimum voltage rating	O / F
ConsWMinRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Minimum continuous active power generation rating	O / F
ConsWMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Maximum continuous active power generation rating	O / F
EmgWMinRtg	CSG		(inherited from: GeneratorNameplateRatingsLN) Minimum active power generation ratings curve of emergency limits for different minutes	O / F
EmgWMaxRtg	CSG		(inherited from: GeneratorNameplateRatingsLN) Maximum active power generation ratings curve of emergency limits for different minutes	O / F
DsconWMinRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Minimum active power generation level that generator should be able to disconnect without harm	O / F
WRpuMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Maximum generation active power ramp up rating	O / F
WRpdMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Maximum generation active power ramp down rating	O / F
CtbWMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Max rated active power (WMaxRtg) which may result from controllable resource, .i.e whose level can be potentially controlled/set under the request of an entity external to the given DER.	O / F
CtbVArMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Max rated reactive power VArMaxRtg, which may result from controllable resource, .i.e whose level can be potentially controlled/set under the request of an entity external to the given DER.	O / F
WCtb	SPG		(inherited from: GeneratorNameplateRatingsLN) If true, the active power currently generated which results from controllable resource is fully controllable (up to CtbWMaxRtg), .i.e its level can be potentially controlled/set under the request of an entity external to the given DER. Otherwise the generated active power is not controllable.	O / F
VArCtb	SPG		(inherited from: GeneratorNameplateRatingsLN) If true, the reactive power currently generated which results from controllable resource is fully controllable (up to CtbVArMaxRtg), .i.e its level can be potentially controlled/set under the request of an entity external to the given DER. Otherwise the reactive power is not controllable.	O / F
RenWMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Max rated active power (WMaxRtg) which may result from renewable energy resource. What is considered as renewable is a local definition.	O / F
RenVArMaxRtg	ASG		(inherited from: GeneratorNameplateRatingsLN) Max rated reactive power VArMaxRtg, which may	O / F

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			result from renewable energy resource. What is considered as renewable is a local definition.	
WMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum active power	M / F
WOvPFMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum active power at specified over-excited power factor, OvPF	O / F
WUnPFMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum active power at specified under-excited power factor, UnPF	O / F
WRmp	ASG		(inherited from: NonStorageOperationalSettingsLN) Default ramp rate for changes in active power: percentage of WMax per second	M / F
VArMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum reactive power if the distinction between absorbing and injecting reactive power is not significant (the use of this DO is mutually exclusive with the use of AvarMax and IvarMax)	O / F
AvarMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum absorbing reactive power (the use of this DO is mutually exclusive with the use of VArMax)	O / F
IvarMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum supply (injection) reactive power (the use of this DO is mutually exclusive with the use of VArMax)	O / F
VMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum voltage operational rating	M / F
VMin	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for minimum voltage operational rating	O / F
AMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum operational current rating under nominal voltage under nominal power factor	O / F
VAMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum apparent power while generating (the use of this DO is mutually exclusive with the use of AvaMax and IvaMax)	O / F
AvaMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum absorbing apparent power (the use of this DO is mutually exclusive with the use of VAMax)	O / F
IvaMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum injecting apparent power (the use of this DO is mutually exclusive with the use of VAMax)	O / F
VArSptRef	ENG (ReactivePowerRefParamKind)		(inherited from: NonStorageOperationalSettingsLN) Reference	O / F

DGENExt				
Data object name	Common data class	T	Explanation	PresCond nds/ds
			for reactive power setpoints. Selects which setpoint is active.	
StrMaxTms	ING		(inherited from: DER_StateAbstractLN) Maximum time from starting to connect to the grid until achieving grid connection	O / F
OffMinTms	ING		(inherited from: DER_StateAbstractLN) Minimal time the DER needs to stay off after being switched off	O / F
OnMinTms	ING		(inherited from: DER_StateAbstractLN) Minimal time the DER needs to stay on after being switched on	O / F
StopDlMinTms	ING		(inherited from: DER_StateAbstractLN) Minimal time delay before stopping and/or disconnecting after a disconnect command received	O / F
StopMaxTms	ING		(inherited from: DER_StateAbstractLN) Maximum time from starting to disconnect from the grid until achieving grid disconnection	O / F
StrDlMinTms	ING		(inherited from: DER_StateAbstractLN) Minimal time delay before starting or restarting after a connect command has been received	O / F
AutoStr	SPG		(inherited from: DER_StateAbstractLN) if true, the DER can automatically initate its starting up	O / F
AutoConn	SPG		(inherited from: DER_StateAbstractLN) if true, the DER can automatically initiate its connection to the grid	O / F
PFSign	ENG (PFSignKind)		(inherited from: DER_OperationalSettingsLN) Power factor convention: IEC or EEI	O / F
OplPct	ING		(inherited from: DER_OperationalSettingsLN) Percentage of the changed value that must be reached in response to a step change in an open loop response time context (normally equals 90 % or 95 %)	O / F
OvPF	ASG		(inherited from: DER_OperationalSettingsLN) Specified Over-Excited Power Factor setting	O / F
PFExtSet	SPG		(inherited from: DER_OperationalSettingsLN) True = overexcited; False = underexcited	O / F
IsldCtlFol	SPG		(inherited from: DER_OperationalSettingsLN) DER behaviour in Islanded Mode. Determines how the DER behaves when in an Islanded configuration. False = Controlling Isochronous Mode. DER attempts to control voltage and frequency independent of configured curves and settings up to the limits of the machine's capabilities in order to achieve the Reference Voltage and nominal frequency. True = Following Droop Mode. DER acts as a follower using Volt/VAR and Freq/Watt curves.	O / F
ClcTotVA	ENG (STotalCalcMethodKind)		(inherited from: DER_OperationalSettingsLN) Calculation method used for total apparent power calculation: Vector or Arithmetic	O / F
FllBckTmExp	ING		(inherited from: DER_OperationalSettingsLN) Timeout period after which the fallback behavior must apply	O / F
AvarZerWMax	ASG		(inherited from: DER_OperationalSettingsLN) Maximum reactive power absorbed in case of zero active power	O / F

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
IvarZerWMax	ASG		(inherited from: DER_OperationalSettingsLN) Maximum reactive power injected in case of zero active power	O / F
OutEcpRef	ORG		(inherited from: DER_NameplateRatingsLN) Reference to ECP directly connected at the output of the DER, the "plug" part. Note: The power management function ECP associated to this same resource will refer to the "socket" part.	M / F
EcpConnTyp	ENG (ECPConnKind)		(inherited from: DER_NameplateRatingsLN) Connection type of ECP: connection to DER (Point of Connection (PoC)), to load, within Local Electric Power System (Local EPS), Point of Common Coupling (PCC), or directly to Area EPS	O / F
PhsConnTyp	ENG (PhaseKind)		(inherited from: DER_NameplateRatingsLN) Phase type of electrical connection of the DER	M / F
DERTyp	ENG (DERUnitKind)		(inherited from: DER_NameplateRatingsLN) Type of DER	M / F
OvPFRtg	ASG		(inherited from: DER_NameplateRatingsLN) Specified Over-Excited Power Factor Rating	O / F
UnPFRtg	ASG		(inherited from: DER_NameplateRatingsLN) Specified Under-Excited Power Factor	O / F
TmpMaxRtg	ASG		(inherited from: DER_NameplateRatingsLN) Maximum temperature rating	O / F
FltRtgPct	ASG		(inherited from: DER_NameplateRatingsLN) Exposure to fault rates as percent of ??	O / F
GndReactRtg	ASG		(inherited from: DER_NameplateRatingsLN) Grounding reactance	O / F
FltAMaxRtg	ASG		(inherited from: DER_NameplateRatingsLN) Max fault current rating	O / F
SelfVRtg	ASG		(inherited from: DER_NameplateRatingsLN) Self-service voltage	O / F
FltDurMaxTms	ING		(inherited from: DER_NameplateRatingsLN) Max fault duration rating	O / F
SelfWRtg	ASG		(inherited from: DER_NameplateRatingsLN) Self-service nominal power	O / F
SelfPFRtg	ASG		(inherited from: DER_NameplateRatingsLN) Self-service nominal power factor	O / F
RvSeq	SPG		(inherited from: DER_NameplateRatingsLN) Sequence (direction) reversed: False = ABC, true = CBA	O / F
SelfVRngRtg	ASG		(inherited from: DER_NameplateRatingsLN) Self-service acceptable voltage range	O / F
EfcRtgPct	ASG		(inherited from: DER_NameplateRatingsLN) Efficiency at rated capacity as percent	O / F
GndRisRtg	ASG		(inherited from: DER_NameplateRatingsLN) Grounding resistance	O / F
SuscRtg	ASG		(inherited from: DER_NameplateRatingsLN) Susceptance rating in siemens	O / F
RegClas	VSG		(inherited from: DER_NameplateRatingsLN) Regulatory classification, using text strings which may have pre-specified values. For example, for IEEE 1547:2018, the specified text is "IEEE 1547:2018 Normal Category A (B) & Abnormal Category I (II,III)", where either "A" or "B" is stated for the Normal Category and either "I", "II", or "III" is stated for the Abnormal Category	Omulti / F

DGENExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
HzNomRtg	ASG		(inherited from: DER_NameplateRatingsLN) Rated Nominal frequency of usage of the DER	Omulti / F
HzMinRtg	ASG		(inherited from: DER_NameplateRatingsLN) Rated minimal frequency of usage of the DER	O / F
HzMaxRtg	ASG		(inherited from: DER_NameplateRatingsLN) Rated maximum frequency of usage of the DER	O / F
DERId	VSG		(inherited from: AllEnergyDEResourceLN) Internal identifier of the resource within a system which is using that resource. It complements the mRID defined as part of the EEname DO. Different DERIds may be defined for different system users.	Omulti / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.4.3 LN: DER load unit extended in 90-27 Name: DLODExt

This LN class is an extension of the DLOD logical node as defined in IEC 61850-7-420.

The "Ext" suffix attached to the LN name is only there for editorial purposes and is not present in the real model.

Table 29 shows all data objects of DLODExt.

Table 29 – Data objects of DLODExt

DLODExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
CmspTms	INS		Time in seconds for accumulation of electric energy consumed since reset.	O / O
DEROpSt	ENS (DERStateKind)		(inherited from: DER_StateAbstractLN) Current state of operation of the distributed energy resource.	M / F
TestRsl	SPS		(inherited from: DER_StateAbstractLN) Set to true at the end of the test procedure (just before Test.stVal goes from true to false to notify the end of the test) if all tests successful, otherwise set to false. Its value remains unchanged until a new test procedure is launched. Set systematically to false at warm or cold start of the equipment, and at the time a new test is initiated (when the Test.stVal goes from false to true).	O / F
TestAddRsl	ENS (EquipmentTestResultKind)		(inherited from: DER_StateAbstractLN) Reflects the equipment test additional results at the end of the test procedure (just before Test.stVal goes from true to false to notify the end of the test). Set systematically to value 'test running' at the time a new test is initiated (when the Test.stVal goes from false to true).	O / F
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F

DLODExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
CmspEn	MV		Energy consumed since last reset (This is designed based on the approach of GnEnPer in DER_GenerationLN)	O / O
InrA	MV		Measurement value of starting current (inrush current) at the latest start-up of the load. The unit of value is [A].	O / O
VArTot	MV		(inherited from: NonStorageOperationalSettingsLN) The total amount of reactive power without impacting active power output if the distinction between absorbing and injecting reactive power is not significant (the use of this DO is mutually exclusive with the use of AvarTot and IvarTot)	O / O
AvarTot	MV		(inherited from: NonStorageOperationalSettingsLN) The total amount of reactive power available for absorbing even if possibly impacting active power output (the use of this DO is mutually exclusive with the use of VArTot)	O / O
IvarTot	MV		(inherited from: NonStorageOperationalSettingsLN) The total amount of reactive power available for injecting even if possibly impacting active power output (the use of this DO is mutually exclusive with the use of VArTot)	O / O
VArAvl	MV		(inherited from: NonStorageOperationalSettingsLN) The amount of reactive power available without impacting active power output if the distinction between absorbing and injecting reactive power is not significant (the use of this DO is mutually exclusive with the use of AvarAvl and IvarAvl)	O / O
AvarAvl	MV		(inherited from: NonStorageOperationalSettingsLN) The amount of reactive power available for absorbing without impacting active power output (the use of this DO is mutually exclusive with the use of VArAvl)	O / O
IvarAvl	MV		(inherited from: NonStorageOperationalSettingsLN) The amount	O / O

DLODExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			of reactive power available for injecting without impacting active power output (the use of this DO is mutually exclusive with the use of VArAvl)	
SelfSvcWh	MV		(inherited from: DER_ActualPowerInformationLN) Actual self service energy used	O / O
VAPct	MV		(inherited from: DER_ActualPowerInformationLN) Actual percentage of apparent power output based on VAMax	O / O
AvlUpW	MV		(inherited from: DER_ActualPowerInformationLN) Available capability (measured or calculated) for increasing active output, including increasing generation of active power, even if currently consuming power.	O / O
AvlDnW	MV		(inherited from: DER_ActualPowerInformationLN) Available capability (measured or calculated) for decreasing active power, including increasing the consumption of active power, even if currently generating power.	O / O
Controls				
CmspEnRs	SPC		(controllable) Operating with value true resets the value of Energy consumed during the period represented by CmspEn. The change of its status value and return to false are local issues.	O / F
AuthConn	SPC		(inherited from: DER_StateAbstractLN) (controllable) if true, the DER is authorized to connect, otherwise it has to remain (or become) disconnected. Authorization may come from an external source or may be a default setting.	O / F
DEROpStCtl	ENC (DERStateTransitionKind)		(inherited from: DER_StateAbstractLN) (controllable) Operating with the value expressed in ctlVal (selected among the list specified in DERStateControlKind) initiates the appropriate transition request. The reading of its attribute stVal is meaningless. The resulting state of the DER shall be observed in the DEROpSt DO.	O / F
CeaEgzCtl	SPC		(inherited from: DER_StateAbstractLN) (controllable) Operating with value true initiates the cease to energize state of the DER (see definition of "cease to energize"); operating with value false initiates the return to service (get back to Idle, then reflect the settings of any or all default settings, enabled operational functions, and/or schedules) of the DER.	O / F
WSpt	APC		(inherited from: DER_StateAbstractLN) Active power setpoint. Its mxVal attribute reflects the value of the setpoint that is requested.	O / O
VArSpt	APC		(inherited from: DER_StateAbstractLN) Reactive power setpoint. Its mxVal attribute reflects the value of the setpoint that is requested.	O / O
EmgMod	SPC		(inherited from: DER_StateAbstractLN) (controllable) if true the DER shall operate in emergency mode, otherwise shall operate in normal mode. In emergency mode, emergency settings, emergency limits, and other emergency-related setpoints will be in effect.	O / F
AuthDscon	SPC		(inherited from: DER_StateAbstractLN) (controllable) if true, the DER is authorized to disconnect, otherwise shall remain connected (if possible)	O / F
TestEna	SPC		(inherited from: DER_StateAbstractLN) (controllable) If set to true, entering into test	O / F

DLODExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			mode for the DER is allowed, otherwise forbidden	
Test	SPC		(inherited from: DER_StateAbstractLN) (controllable) Operating with value true initiates starting a test of the DER equipment and resets the values of TestRsl.stVal (set to 'false') and TestAddRsl.stVal (set to 'test running'); operating with value false aborts the test. The reading of the status indicates whether the equipment is under test or not. The content of such test is implementation dependant.	O / F
OpCtl	SPC		(inherited from: AllEnergyDEResourceLN) (Controllable) Start/stop control of the DER. The DER is running if the stVal of this DO is TRUE, and it is off if the stVal is FALSE.	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
WNomRtg	ASG		Nominal rated active power.	O / F
InclLod	ORG		(inherited from: DLOD) Included load resource. This DO points to an instance of DLOD.	Omulti / F
DERUnit	ORG		(inherited from: DLOD) Reference to the DER Unit LN which may be associated to this generic model LN	O / F
EqLod	ORG		(inherited from: DLOD) Reference to the equivalent DLOD instance reflecting the load aspects of the DER	O / F
WMaxRtg	ASG		(inherited from: LoadNameplateRatingsLN) Nameplate maximum Load active power rating at unity power factor	M / F
WOvPFRtg	ASG		(inherited from: LoadNameplateRatingsLN) Nameplate active charging power rating at specified over-excited power factor	M / F
WUnPFRtg	ASG		(inherited from: LoadNameplateRatingsLN) Nameplate active charging power rating at specified under-excited power factor	M / F
VMaxRtg	ASG		(inherited from: LoadNameplateRatingsLN) Maximum voltage rating	M / F
VMinRtg	ASG		(inherited from: LoadNameplateRatingsLN) Minimum voltage rating	M / F
AMaxRtg	ASG		(inherited from: LoadNameplateRatingsLN) Maximum current rating under nominal voltage under nominal power factor while charging	O / F

DLODExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
VAMaxRtg	ASG		(inherited from: LoadNameplateRatingsLN) Nameplate maximum apparent charging power rating	O / F
WRpuMaxRtg	ASG		(inherited from: LoadNameplateRatingsLN) Maximum nameplate charging ramp up rating	O / F
WRpdMaxRtg	ASG		(inherited from: LoadNameplateRatingsLN) Maximum nameplate charging ramp down rating	O / F
WMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum active power	M / F
WOvPFMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum active power at specified over-excited power factor, OvPF	O / F
WUnPFMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum active power at specified under-excited power factor, UnPF	O / F
WRmp	ASG		(inherited from: NonStorageOperationalSettingsLN) Default ramp rate for changes in active power: percentage of WMax per second	M / F
VArMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum reactive power if the distinction between absorbing and injecting reactive power is not significant (the use of this DO is mutually exclusive with the use of AvarMax and IvarMax)	O / F
AvarMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum absorbing reactive power (the use of this DO is mutually exclusive with the use of VArMax)	O / F
IvarMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum supply (injection) reactive power (the use of this DO is mutually exclusive with the use of VArMax)	O / F
VMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum voltage operational rating	M / F
VMin	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for minimum voltage operational rating	O / F
AMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum operational current rating under nominal voltage under nominal power factor	O / F
VAMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum apparent power while generating (the use of this DO is mutually exclusive with the use of AvaMax and IvaMax)	O / F
AvaMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum absorbing apparent power (the use of this DO is mutually exclusive with the use of VAMax)	O / F

DLODExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
IvaMax	ASG		(inherited from: NonStorageOperationalSettingsLN) Setting for maximum injecting apparent power (the use of this DO is mutually exclusive with the use of VAMax)	O / F
VArSptRef	ENG (ReactivePowerRefParamKind)		(inherited from: NonStorageOperationalSettingsLN) Reference for reactive power setpoints. Selects which setpoint is active.	O / F
StrMaxTms	ING		(inherited from: DER_StateAbstractLN) Maximum time from starting to connect to the grid until achieving grid connection	O / F
OffMinTms	ING		(inherited from: DER_StateAbstractLN) Minimal time the DER needs to stay off after being switched off	O / F
OnMinTms	ING		(inherited from: DER_StateAbstractLN) Minimal time the DER needs to stay on after being switched on	O / F
StopDlMinTms	ING		(inherited from: DER_StateAbstractLN) Minimal time delay before stopping and/or disconnecting after a disconnect command received	O / F
StopMaxTms	ING		(inherited from: DER_StateAbstractLN) Maximum time from starting to disconnect from the grid until achieving grid disconnection	O / F
StrDlMinTms	ING		(inherited from: DER_StateAbstractLN) Minimal time delay before starting or restarting after a connect command has been received	O / F
AutoStr	SPG		(inherited from: DER_StateAbstractLN) if true, the DER can automatically initate its starting up	O / F
AutoConn	SPG		(inherited from: DER_StateAbstractLN) if true, the DER can automatically initiate its connection to the grid	O / F
PFSign	ENG (PFSignKind)		(inherited from: DER_OperationalSettingsLN) Power factor convention: IEC or EEI	O / F
OplPct	ING		(inherited from: DER_OperationalSettingsLN) Percentage of the changed value that must be reached in response to a step change in an open loop response time context (normally equals 90 % or 95 %)	O / F
OvPF	ASG		(inherited from: DER_OperationalSettingsLN) Specified Over-Excited Power Factor setting	O / F
PFExtSet	SPG		(inherited from: DER_OperationalSettingsLN) True = overexcited; False = underexcited	O / F
IsldCtlFol	SPG		(inherited from: DER_OperationalSettingsLN) DER behaviour in Islanded Mode. Determines how the DER behaves when in an Islanded configuration. False = Controlling Isochronous Mode. DER attempts to control voltage and frequency independent of configured curves and settings up to the limits of the machine's capabilities in order to achieve the Reference Voltage and nominal frequency. True = Following Droop Mode. DER acts as a follower using Volt/VAR and Freq/Watt curves.	O / F
ClcTotVA	ENG (STotalCalcMethodKind)		(inherited from: DER_OperationalSettingsLN) Calculation method used for total apparent power calculation: Vector or Arithmetic	O / F

DLODExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
FllBckTmExp	ING		(inherited from: DER_OperationalSettingsLN) Timeout period after which the fallback behavior must apply	O / F
AvarZerWMax	ASG		(inherited from: DER_OperationalSettingsLN) Maximum reactive power absorbed in case of zero active power	O / F
IvarZerWMax	ASG		(inherited from: DER_OperationalSettingsLN) Maximum reactive power injected in case of zero active power	O / F
OutEcpRef	ORG		(inherited from: DER_NameplateRatingsLN) Reference to ECP directly connected at the output of the DER, the "plug" part. Note: The power management function ECP associated to this same resource will refer to the "socket" part.	M / F
EcpConnTyp	ENG (ECPConnKind)		(inherited from: DER_NameplateRatingsLN) Connection type of ECP: connection to DER (Point of Connection (PoC)), to load, within Local Electric Power System (Local EPS), Point of Common Coupling (PCC), or directly to Area EPS	O / F
PhsConnTyp	ENG (PhaseKind)		(inherited from: DER_NameplateRatingsLN) Phase type of electrical connection of the DER	M / F
DERTyp	ENG (DERUnitKind)		(inherited from: DER_NameplateRatingsLN) Type of DER	M / F
OvPFRtg	ASG		(inherited from: DER_NameplateRatingsLN) Specified Over-Excited Power Factor Rating	O / F
UnPFRtg	ASG		(inherited from: DER_NameplateRatingsLN) Specified Under-Excited Power Factor	O / F
TmpMaxRtg	ASG		(inherited from: DER_NameplateRatingsLN) Maximum temperature rating	O / F
FltRtgPct	ASG		(inherited from: DER_NameplateRatingsLN) Exposure to fault rates as percent of ??	O / F
GndReactRtg	ASG		(inherited from: DER_NameplateRatingsLN) Grounding reactance	O / F
FltAMaxRtg	ASG		(inherited from: DER_NameplateRatingsLN) Max fault current rating	O / F
SelfVRtg	ASG		(inherited from: DER_NameplateRatingsLN) Self-service voltage	O / F
FltDurMaxTms	ING		(inherited from: DER_NameplateRatingsLN) Max fault duration rating	O / F
SelfWRtg	ASG		(inherited from: DER_NameplateRatingsLN) Self-service nominal power	O / F
SelfPFRtg	ASG		(inherited from: DER_NameplateRatingsLN) Self-service nominal power factor	O / F
RvSeq	SPG		(inherited from: DER_NameplateRatingsLN) Sequence (direction) reversed: False = ABC, true = CBA	O / F
SelfVRngRtg	ASG		(inherited from: DER_NameplateRatingsLN) Self-service acceptable voltage range	O / F
EfcRtgPct	ASG		(inherited from: DER_NameplateRatingsLN) Efficiency at rated capacity as percent	O / F
GndRisRtg	ASG		(inherited from: DER_NameplateRatingsLN) Grounding resistance	O / F
SuscRtg	ASG		(inherited from: DER_NameplateRatingsLN) Susceptance rating in siemens	O / F
RegClas	VSG		(inherited from: DER_NameplateRatingsLN) Regulatory classification, using text strings which	Omulti / F

DLODExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			may have pre-specified values. For example, for IEEE 1547:2018, the specified text is "IEEE 1547:2018 Normal Category A (B) & Abnormal Category I (II,III)", where either "A" or "B" is stated for the Normal Category and either "I", "II", or "III" is stated for the Abnormal Category	
HzNomRtg	ASG		(inherited from: DER_NameplateRatingsLN) Rated Nominal frequency of usage of the DER	Omulti / F
HzMinRtg	ASG		(inherited from: DER_NameplateRatingsLN) Rated minimal frequency of usage of the DER	O / F
HzMaxRtg	ASG		(inherited from: DER_NameplateRatingsLN) Rated maximum frequency of usage of the DER	O / F
DERId	VSG		(inherited from: AllEnergyDEResourceLN) Internal identifier of the resource within a system which is using that resource. It complements the mRID defined as part of the EEname DO. Different DERIds may be defined for different system users.	Omulti / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.5 Unit type logical nodes for thermal resources (LNGroupD)

9.5.1 General

This subclause specifies logical nodes defined in IEC 61850-90-27 to support resource unit types in thermal systems. These logical nodes represent characteristics specific to unit types and provide data objects that are not modelled in the generic logical nodes for thermal resources. Figure 24 provides an overview of LN class definitions to support resource unit types.

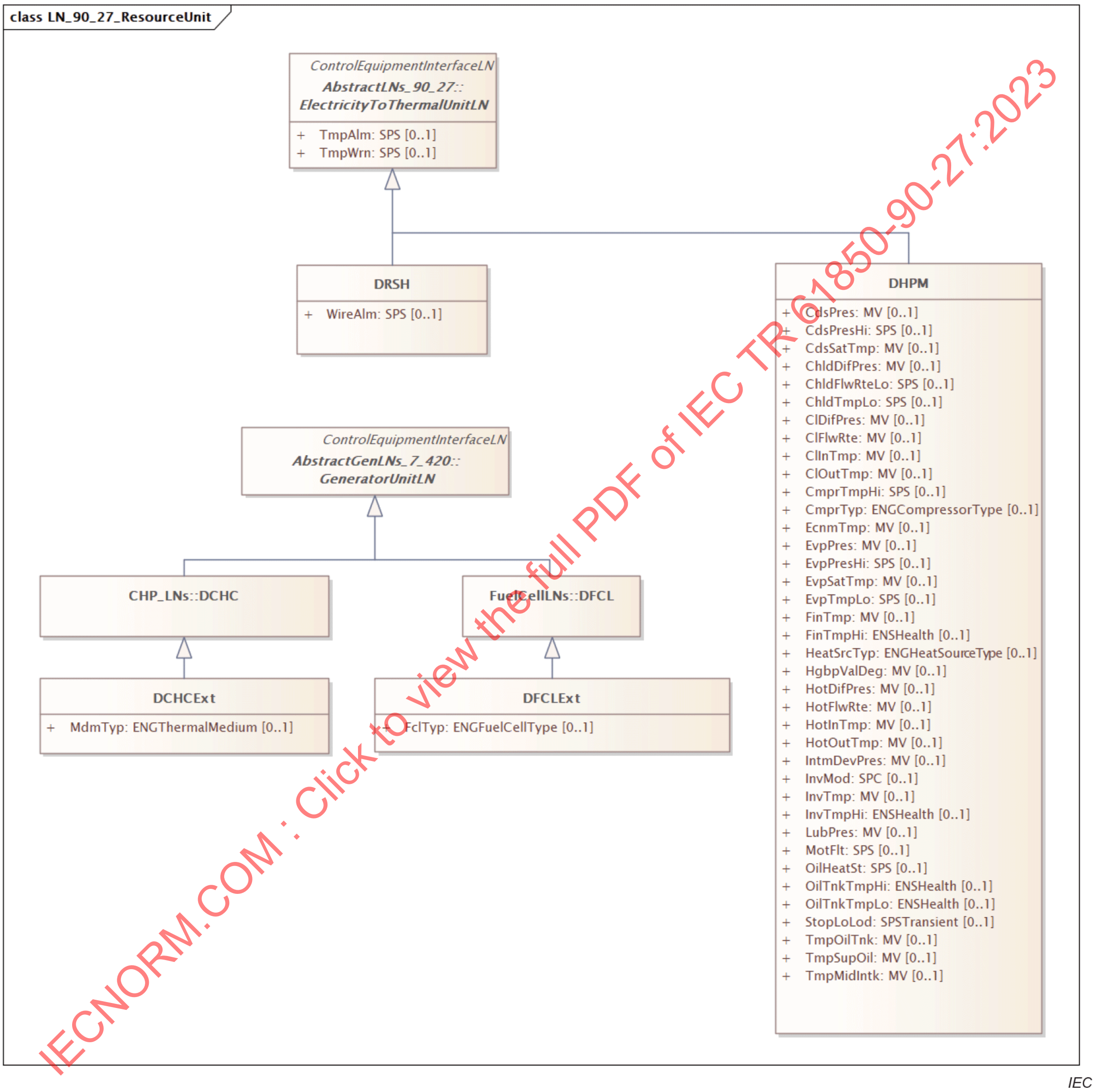


Figure 24 – Class diagram for resource units

9.5.2 LN: CHP system controller Name: DCHCExt

The DCHC logical node supports the CHP controller. The CHP controller provides overall system 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.

The "Ext" suffix attached to the LN name is only there for editorial purposes and is not present in the real model.

Table 30 shows all data objects of DCHCExt.

Table 30 – Data objects of DCHCExt

DCHCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
MaintTms	INS		(inherited from: DCHC) Time until next maintenance: seconds	O / O
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
HtPwrEfc	MV		(inherited from: DCHC) Heat to power efficiency	O / O

DCHCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Controls				
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
MdmTyp	ENG (ThermalMediumKind)		Type of thermal energy medium	O / F
HtTyp	ENG (ThermalEnergyMediumKind)		(inherited from: DCHC) Type of heating medium	M / F
MaxHtCap	ASG		(inherited from: DCHC) Maximum heat capacity	O / F
HtEfcPct	ASG		(inherited from: DCHC) Efficiency of heat production in percentage	O / F
ClTyp	ENG (ThermalEnergyMediumKind)		(inherited from: DCHC) Type of cooling medium	O / F
EnCnvTyp	ENG (CHPEnergyConverterKind)		(inherited from: DCHC) Type of energy converter	M / F
GnTyp	ENG (CHPGeneratorKind)		(inherited from: DCHC) Type of generator	O / F
FuelTyp	ENG (FuelKind)		(inherited from: DCHC) Type of fuel	O / F
OpModCHP	ENG (CHPOperatingModeKind)		(inherited from: DCHC) Operating modes of CHP	O / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M

DCHCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.5.3 LN: Fuel cell controller Name: DFCLExt

The DFCL logical node provides the fuel cell characteristics required for remote monitoring of critical functions and states of the fuel cell itself.

The "Ext" suffix attached to the LN name is only there for editorial purpose and is not present in the real model

Table 31 shows all data objects of DFCLExt.

Table 31 – Data objects of DFCLExt

DFCLExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
ConnGriCnt	INS		(inherited from: DFCL) Count of reconnections to power system	O / O
LifeEfcPct	INS		(inherited from: DFCL) Efficiency estimate (lifetime) as percent	M / O

DFCLExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
InstEfcPct	INS		(inherited from: DFCL) Instantaneous efficiency estimate as percent	O / O
MaintTms	INS		(inherited from: DFCL) Time until next maintenance: seconds	O / O
StrCnt	INS		(deprecated) (inherited from: DFCL) Count of system starts since last reset	M / O
LifeTms	INS		(deprecated) (inherited from: DFCL) Lifetime system run time	M / O
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
FuelCsmp	MV		(inherited from: DFCL) Input fuel consumption (lifetime)	O / O
WtrCsmp	MV		(inherited from: DFCL) Input water consumption (lifetime)	O / O
InOxFlwRte	MV		(inherited from: DFCL) Input air or oxygen flow rate for the fuel cell chemical process	O / O
WtrLev	MV		(inherited from: DFCL) Water level remaining	O / O
OutH2Rte	MV		(inherited from: DFCL) Output hydrogen flow rate	O / O

DFCLExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
OutH2Lev	MV		(inherited from: DFCL) Output hydrogen level	O / O
WtrCndct	MV		(inherited from: DFCL) Water conductivity	O / O
LifeWh	MV		(deprecated) (inherited from: DFCL) Lifetime system run energy	M / O
Controls				
FuelStop	SPC		(inherited from: DFCL) True = open; False = close fuel valve driver command	M / F
StrCntRs	SPC		(deprecated) (inherited from: DFCL) Reset the count of system starts.	O / F
EmgCtl	SPC		(deprecated) (inherited from: DFCL) True = start; False = stop emergency stop fuel cell	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
FclTyp	ENG (FuelCellKind)		Fuel cell type (e.g. MCFC, SOFC).	O / F
GriIndpWRtg	ASG		(inherited from: DFCL) System power system independent output power rating	O / F
GriDepRtg	ASG		(inherited from: DFCL) System power system dependent output power rating	O / F
HzRtg	ASG		(inherited from: DFCL) System output frequency rating	O / F
FuelTyp	ENG (FuelKind)		(inherited from: DFCL) System input fuel type	O / F
EfcPct	ASG		(inherited from: DFCL) System average efficiency as percent	O / F
ALim	ASG		(inherited from: DFCL) Input current limit	M / F
VLim	ASG		(inherited from: DFCL) Input voltage limit	O / F
VRtg	ASG		(deprecated) (inherited from: DFCL) System output voltage rating	O / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F

DFCLExt				
Data object name	Common data class	T	Explanation	PresCond nds/ds
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if ‘TRUE_RMS’ and ‘RMS_FUNDAMENTAL’). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.5.4 LN: Electric heat pump Name: DHPM

The DHPM logical node supports electric heat pumps and reflects the information required for remote monitoring of critical functions and states of heat pumps.

Chillers with compressors are also modelled by this LN because the principle and mechanical structure for producing chilled material are the same.

This LN does not cover gas heat pumps because it is derived from the ElectricityToThermalUnitLN.

Table 32 shows all data objects of DHPM.

Table 32 – Data objects of DHPM

DHPM				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
CdsPresHi	SPS		if true, the pressure in the condenser exceeds alarm trigger level setting.	O / F
ChldFlwRteLo	SPS		If true, the flow rate of chilled medium is lower than alarm trigger level setting.	O / F
ChldTmpLo	SPS		if true, the temperature of chilled medium at outlet is lower than alarm trigger level setting.	O / F
CmprTmpHi	SPS		if true, the temperature at outlet of the compressor exceeds alarm trigger level setting.	O / F
EvpPresHi	SPS		if true, the pressure in the evaporator exceeds alarm trigger level setting.	O / F
EvpTmpLo	SPS		if true, the temperature in the evaporator is lower than alarm trigger level setting.	O / F
FinTmpHi	ENS (HealthKind)		An alarm or a warning related to high temperature of the fins for cooling inverters.	O / F
InvTmpHi	ENS (HealthKind)		An alarm or a warning related to high temperature of the inverter or in the cubicle including it.	O / F
MotFlt	SPS		If true, a fault occurs in the interlock panel for motor.	O / F
OilHeatSt	SPS		If true, the designated oil heater of the heat pump is heating the oil.	O / F
OilTnkTmpHi	ENS (HealthKind)		An alarm or a warning indicating high temperature in the oil tank of the heat pump.	O / F
OilTnkTmpLo	ENS (HealthKind)		An alarm or a warning indicating low temperature in the oil tank of the heat pump.	O / F
StopLoLod	SPS	T	If true, the given heat pump is stopped by low load.	O / F
TmpAlm	SPS		(inherited from: ElectricityToThermalUnitLN) An alarm indicating the temperature exceeds the threshold.	O / F
TmpWrn	SPS		(inherited from: ElectricityToThermalUnitLN) A warning indicating the temperature exceeds the threshold.	O / F
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F

DHPM				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
CdsPres	MV		Pressure in the condenser of the heat pump.	O / O
CdsSatTmp	MV		Saturation temperature for condensation.	O / O
ChldDifPres	MV		Differential pressure of chilled medium flow rate measured in [Pa].	O / O
ClDifPres	MV		Differential pressure of cooling medium flow rate measured in [Pa].	O / O
ClFlwRte	MV		Flow rate of the cooling medium measured in [m3/h].	O / O
ClInTmp	MV		Temperature of cooling medium at inlet.	O / O
ClOutTmp	MV		Temperature of cooling medium at outlet.	O / O
EcnmTmp	MV		Temperature at outlet of economizer.	O / O
EvpPres	MV		Pressure in the evaporator of the heat pump.	O / O
EvpSatTmp	MV		Saturation temperature for evaporation.	O / O
FinTmp	MV		Temperature of the fins for cooling one or more inverters.	O / O
HgbpValDeg	MV		HGBP valve opening degree in [%]. HGBP is the abbreviation of "Hot Gas Bypass".	O / O
HotDifPres	MV		Differential pressure of hot medium flow rate measured in [Pa].	O / O
HotFlwRte	MV		Flow rate of hot medium measured in [m3/h].	O / O
HotInTmp	MV		Temperature of hot medium at inlet.	O / O
HotOutTmp	MV		Temperature of hot medium at outlet.	O / O

DHPM				
Data object name	Common data class	T	Explanation	PresCond nds/ds
IntmDevPres	MV		Pressure in the intermediate device of the heat pump.	O / O
InvTmp	MV		Temperature in the inverter panel of the heat pump.	O / O
LubPres	MV		Pressure of lubricant.	O / O
TmpOilTnk	MV		Temperature of oil tank	O / O
TmpSupOil	MV		Temperature of supplied oil measured in [□deg C].	O / O
TmpMidIntk	MV		Temperature at mid-intake	O / O
Controls				
InvMod	SPC		(controllable) if true, the electric power is supplied to the heat pump through the inverter, otherwise, it is supplied directly from a feeder in an area distribution network.	O / F
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
CmprTyp	ENG (CompressorKind)		Compressor type.	O / F
HeatSrcTyp	ENG (HeatSourceKind)		Type of heat source (e.g. ambient air, underground source, sea, river, exhaust air, waste heat, and waste water)	O / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O

DHPM				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.5.5 LN: Electric resistance heater Name: DRSH

The DRSH logical node supports an electric resistance heater and reflects the information required for remote monitoring of critical functions and states.

Table 33 shows all data objects of DRSH.

Table 33 – Data objects of DRSH

DRSH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: ControlEquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
WireAlm	SPS		An alarm indicating that a heating wire is broken.	O / F
TmpAlm	SPS		(inherited from: ElectricityToThermalUnitLN) An alarm indicating the temperature exceeds the threshold.	O / F
TmpWrn	SPS		(inherited from: ElectricityToThermalUnitLN) A warning indicating the temperature exceeds the threshold.	O / F
EEHealth	ENS (HealthKind)		(inherited from: ControlEquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F

DRSH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
OpTmh	INS		(inherited from: ControlEquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Controls				
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O

DRSH				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Settings				
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if ‘TRUE_RMS’ and ‘RMS_FUNDAMENTAL’). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.6 Logical nodes for operational functions related to thermal systems (LNGroupD)

9.6.1 General

This subclause specifies a new logical node and extended logical node for operational functions related to thermal systems. Figure 17 provides an overview of LN class definitions to support operational functions.

9.6.2 LN: Thermal comfort profile Name: DTHP

LN DTHP defines a comfort profile for the end use of thermal energy. A thermal energy management logical node refers to this LN to provide thermal energy service to the end use.

Table 34 shows all data objects of DTHP.

Table 34 – Data objects of DTHP

DTHP				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
CmftSt	ENS (ThermalComfortStatusKind)		The status of thermal comfort at the end use location.	O / F
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Controls				
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the	O / O

DTHP				
Data object name	Common data class	T	Explanation	PresCond nds/ds
			quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	
Settings				
MaxCmftTmp	ASG		A setting value of maximum comfortable temperature at end use (in °C).	O / F
MinCmftTmp	ASG		A setting value of maximum comfortable temperature at end use (in °C).	O / F
InTcpRef	ORG		(inherited from: ThermalOperationalFunctionLN) Reference to an instance of thermal connection point LN which is the source of the measurement used by thermal operational function.	M / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.6.3 LN: Mode to cause DER to set active power Name: DWGCExt

This LN class is derived from the original DWGC in IEC 61850-7-420 to add a setting for maximum curtailment time.

The "Ext" suffix attached to the LN name is only there for editorial purpose and is not present in the real model

Table 35 shows all data objects of DWGCExt.

Table 35 – Data objects of DWGCExt

DWGCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
SocExpcTms	INS		(inherited from: ActivePowerLN) Time in seconds from now, associated with the expected State of Charge (SOC) and/or State of Energy (SOE), assuming persistence of the current command	O / O
RvrtTmExp	SPS	T	(inherited from: OperationalFunctionLN) If set to true, the revert timeout duration has been reached. Setting it back to false is a local issue.	O / F
Loc	SPS		(inherited from: ControllingLN) If true, the control behaviour is allowed at this level.	O / F
LocKey	SPS		(inherited from: ControllingLN) If true, the operation has been switched (from remote) to local. This changeover is always done locally with a physical key or toggle switch, which may have a set of contacts from which the position can be read.	OF(Loc) / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
ReqW	MV		(inherited from: ActivePowerLN) Requested active power resulting from the function. Quality attribute shall be invalid when function is not active.	M / O

DWGCExt				
Data object name	Common data class	T	Explanation	PresCond nds/ds
SocExpc	MV		(inherited from: ActivePowerLN) Expected State of Charge (SOC) at SocExpcTms time from now, assuming persistence of the current command	O / O
SocWhExpc	MV		(inherited from: ActivePowerLN) Expected State of Charge expressed in Wh at SocExpcTms time from now, assuming persistence of the current command	O / O
Controls				
WSpt	APC		(inherited from: ActivePowerLN) Active power setpoint. Its mxVal attribute reflects the value of the setpoint that is requested.	AllOnlyOneGroup(2) / O
WSptPct	APC		(inherited from: ActivePowerLN) Active power setpoint setting as a percentage of Maximum Active Power capability, WMax at the Referenced ECP, and in the case of signed setpoint (typically for storage systems) as a percentage of Maximum Active Power charging (consuming) capability for values related to the charging phase. Its mxVal attribute reflects the value of the setpoint that is requested.	AllOnlyOneGroup(1) / O
ModPrio	INC		(inherited from: OperationalFunctionLN) Priority relation of this mode (0..n) with higher numbers superseding lower numbers shall be a positive value, with the default as 0.	O / O
CmdBlk	SPC		(inherited from: ControlledLN) (controllable) If true, control commands and action triggers of all controllable data objects in this function (except CmdBlk, Mod) have been blocked.	O / F
OpCntRs	INC		(inherited from: ControlledLN) (controllable) Operations count, can be reset to a value different than 0.	O / O
LocSta	SPC		(inherited from: ControllingLN) (controllable) If true, control authority is at station level and control from remote is disabled; otherwise control from remote is allowed.	OF(Loc) / F
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
MaxCrtlTmh	ING		Maximum hours of electric generation curtailment per year [hour]	O / F
RmpRteUse	SPG		(inherited from: RampRatesLN) Use ramp rates limit. True = limited to ramp rates; False = Not limited to ramp rates	M / F
RpuMax	ASG		(inherited from: RampRatesLN) Maximum ramp up rate during generating (discharging)/injecting. Ramp rate as percentage of WMax or VArMax or AMax per second, depending on the output of the operational function. In case the output of the operational function is PF, the ramp rate is expressed dimensionless.	O / F
RpdMax	ASG		(inherited from: RampRatesLN) Maximum ramp down rate during generating (discharging)/injecting . Ramp rate as percentage of WMax or VArMax or AMax per	O / F

DWGCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresConds/ds**
			second, depending on the output of the operational function	
ChaRpuMax	ASG		(inherited from: RampRatesLN) Maximum ramp up rate during consuming (charging) / absorbing. Ramp rate is expressed as percentage of ChaWMax or ChaVArMax or AMax per second, depending on the output of the operational function.	O / F
ChaRpdMax	ASG		(inherited from: RampRatesLN) Maximum active power ramp down rate during consuming (charging) / absorbing. Ramp rate is expressed as percentage of ChaWMax or ChaVArMax or AMax per second, depending on the output of the operational function.	O / F
EmgRpuMax	ASG		(inherited from: RampRatesLN) Maximum emergency ramp up rate. Ramp rate as percentage of WMax or VArMax or AMax per second, depending on the output of the operational function.	O / F
EmgRpdMax	ASG		(inherited from: RampRatesLN) Maximum emergency ramp down rate. Ramp rate as percentage of WMax or VArMax or AMax per second, depending on the output of the operational function.	O / F
ChaEmgRpuMax	ASG		(inherited from: RampRatesLN) Maximum emergency ramp up rate during consuming (charging) / absorbing. Ramp rate is expressed as percentage of ChaWMax or ChaVArMax or AMax per second, depending on the output of the operational function.	O / F
ChaEmgRpdMax	ASG		(inherited from: RampRatesLN) Maximum ramp down rate during consuming (charging) / absorbing. Ramp rate is expressed as percentage of ChaWMax or ChaVArMax or AMax per second, depending on the output of the operational function.	O / F
RpuMin	ASG		(inherited from: RampRatesLN) Minimum up ramp rate	O / F
RpdMin	ASG		(inherited from: RampRatesLN) Minimum down ramp rate	O / F
OutFilByp	SPG		(inherited from: LowPassFilterOnFunctionOutputLN) Set to true, the LP filter is by-passed otherwise is active	O / F
OplTmsMax	ING		(inherited from: LowPassFilterOnFunctionOutputLN) Maximum (Fast-as-possible) open loop response time in seconds. The DER should reach OplPct (e.g. 90 % or 95 %) of the delta between its current value and the requested value by the end of this time period. It may go as fast as it can, while still respecting any limiting ramp rates. Is equivalent to 3 tau in case of a first order low pass filter and the target percentage is equal to 95 %.	O / F
OplTmsMin	ING		(inherited from: LowPassFilterOnFunctionOutputLN) Minimum (no-faster-than-this time) open loop response time in seconds. The DER should reach OplPct (e.g. 90 % or 95 %) of the delta between its current value and the requested value by the end of this time period. It should not go faster than this time. Is equivalent to 3 tau in case of a first order low pass filter and the target percentage is equal to 95 %.	O / F

DWGCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
InFilByp	SPG		(inherited from: LowPassFilterOnFunctionInputLN) Set to true, the LP input filter is by-passed otherwise is active	O / F
RspTmms	ING		(inherited from: LowPassFilterOnFunctionInputLN) Value of the response time (in ms) used by the low-pass filter applying to the input signal of the considered operational function. Is equivalent to 3 tau in case of a first order low pass filter and the target percentage is equal to 95 %.	O / F
ActDlTmms	ING		(inherited from: OperationalFunctionLN) Intentional delay in ms before operational function enabling	O / F
WinTms	ING		(inherited from: OperationalFunctionLN) Time window within which to randomly initiate the actions specified by the enabled mode. If the time window is zero, the mode will be initiated immediately.	O / F
RvrtTms	ING		(inherited from: OperationalFunctionLN) Timeout period (in seconds), after which the device will revert to its default status, such as returning to service or allowing maximum active power output, in case communications are lost or mitigating messages are not received.	O / F
RmpTms	ING		(inherited from: OperationalFunctionLN) Ramp time for moving from current operational mode settings to new operational mode settings upon enabling of the mode	O / F
ModPsAcc	ASG		(inherited from: OperationalFunctionLN) Average accuracy with which the function will follow the stated values of the dependent curve, in plus units from the stated curve value.	O / F
ModNgAcc	ASG		(inherited from: OperationalFunctionLN) Average accuracy with which the function will follow the stated values of the dependent curve, in minus units from the stated curve value.	O / F
SocUseMaxPct	ASG		(inherited from: OperationalFunctionLN) Maximum percent of SOC to use for the function	O / F
SocUseMinPct	ASG		(inherited from: OperationalFunctionLN) Minimum percent of SOC to use for the function	O / F
InEcpRef	ORG		(inherited from: ElectricalContextReferenceLN) Referenced ECP which is the source of the measurement used by the DER mode. It consists of the index or address of the appropriate LN DECP. This address may be within the DER, or within a proxy of ECP, or within a device at the ECP.	M / F
EcpConnTyp	ENG (ECPConnKind)		(inherited from: ElectricalContextReferenceLN) Connection type of ECP: connection to DER (Point of Connection (PoC)), to load, within Local Electric Power System (Local EPS), Point of Common Coupling (PCC), or directly to Area EPS	O / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F

DWGCExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if ‘TRUE_RMS’ and ‘RMS_FUNDAMENTAL’). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.7 Logical nodes for thermal reference points (LNGroupD)

9.7.1 General

This subclause specifies new logical nodes for thermal reference points in thermal systems. Figure 25 provides an overview of LN class definitions to support reference points.

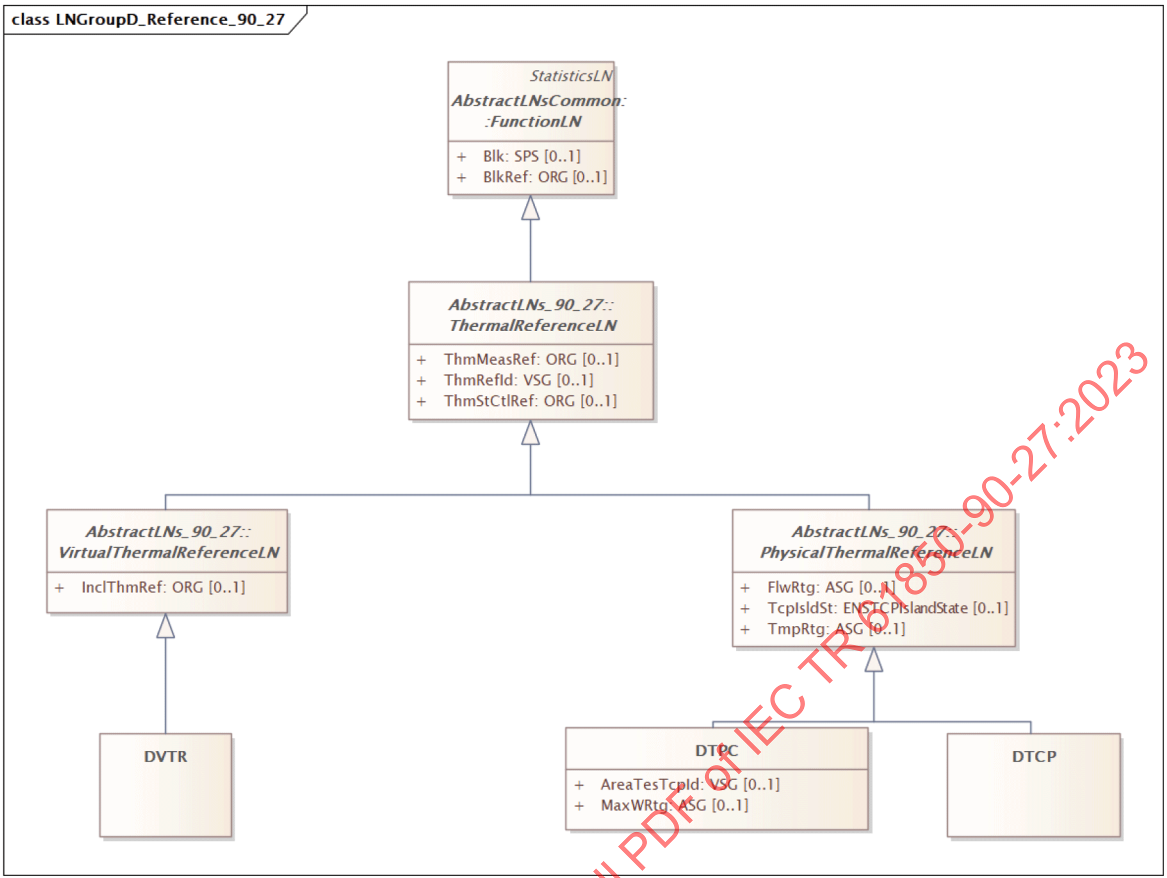


Figure 25 – Class diagram for thermal reference points

9.7.2 LN: Thermal Connection Point Name: DTCP

The DTCP logical node contains the operational characteristics of the Thermal Connection Point (TCP), to be used in all other classes than the Thermal Point of Common Coupling (refer to DTPC).

Table 36 shows all data objects of DTCP.

Table 36 – Data objects of DTCP

DTCP				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
TcpIsldSt	ENS (TCPIslandStateKind)		(inherited from: PhysicalThermalReferenceLN) Thermal connection point (TCP) state.	O / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O

DTCP				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Controls				
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
TmpRtg	ASG		(inherited from: PhysicalThermalReferenceLN) Temperature rating at the thermal connection point designated by this logical node.	O / F
FlwRtg	ASG		(inherited from: PhysicalThermalReferenceLN) Medium flow rating at the thermal connection point designated by this logical node.	O / F
ThmMeasRef	ORG		(inherited from: ThermalReferenceLN) Reference to a measurement function for temperature STMP, energy flow MTHM, or medium flow MFLW LN instance.	Omulti / F
ThmRefId	VSG		(inherited from: ThermalReferenceLN) Identification of thermal reference point as a Visible String.	O / F
ThmStCtlRef	ORG		(inherited from: ThermalReferenceLN) Reference to status (and control) function associated to the thermal reference point, typically KVLV or KPMP LN instances.	Omulti / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F

DTCP				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if ‘TRUE_RMS’ and ‘RMS_FUNDAMENTAL’). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.7.3 LN: Thermal Point of Common Coupling Name: DTPC

The DTPC logical node contains the operational characteristics of a specific Thermal Connection Point (TCP) located between the local Thermal Energy System (TES) and the area TES, called Thermal Point of Common Coupling.

Table 37 shows all data objects of DTPC.

Table 37 – Data objects of DTPC

DTPC				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
TcpIsldSt	ENS (TCPIslandStateKind)		(inherited from: PhysicalThermalReferenceLN) Thermal connection point (TCP) state.	O / F
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Controls				
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
AreaTesTcpId	VSG		Identification of the TCP (thermal energy connection point) from the Area Thermal Energy System.	O / F
MaxWRtg	ASG		Maximum injectable thermal energy per second (in W).	O / F
TmpRtg	ASG		(inherited from: PhysicalThermalReferenceLN) Temperature rating at the thermal connection point designated by this logical node.	O / F
FlwRtg	ASG		(inherited from: PhysicalThermalReferenceLN) Medium flow rating at the thermal connection point designated by this logical node.	O / F
ThmMeasRef	ORG		(inherited from: ThermalReferenceLN) Reference to a measurement function for	Omulti / F

DTPC				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			temperature STMP, energy flow MTHM, or medium flow MFLW LN instance.	
ThmRefId	VSG		(inherited from: ThermalReferenceLN) Identification of thermal reference point as a Visible String.	O / F
ThmStCtlRef	ORG		(inherited from: ThermalReferenceLN) Reference to status (and control) function associated to the thermal reference point, typically KVLV or KPMP LN instances.	Omulti / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.7.4 LN: Virtual Thermal Connection Point Name: DVTR

The DVTR logical node represents a virtual connection point that can be used with a set of aggregated thermal energy resources which are not connected to the same physical Thermal Connection Point (TCP).

Table 38 shows all data objects of DVTR.

Table 38 – Data objects of DVTR

DVTR				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Controls				
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
InclThmRef	ORG		(inherited from: VirtualThermalReferenceLN) Reference(s) to the set of physical or virtual thermal reference points that are included in this virtual reference.	Mmulti / F
ThmMeasRef	ORG		(inherited from: ThermalReferenceLN) Reference to a measurement function for temperature STMP, energy flow MTHM, or medium flow MFLW LN instance.	Omulti / F
ThmRefId	VSG		(inherited from: ThermalReferenceLN) Identification of thermal reference point as a Visible String.	O / F
ThmStCtlRef	ORG		(inherited from: ThermalReferenceLN) Reference to status (and control) function associated to the thermal reference point, typically KVLV or KPMP LN instances.	Omulti / F

DVTR				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.8 Logical nodes for metering and measurement (LNGroupM)

9.8.1 General

This subclause specifies extended logical nodes in the group M to support measurement values needed for energy operations of thermal systems. Figure 26 provides an overview of LN class definitions to support the measurement values.

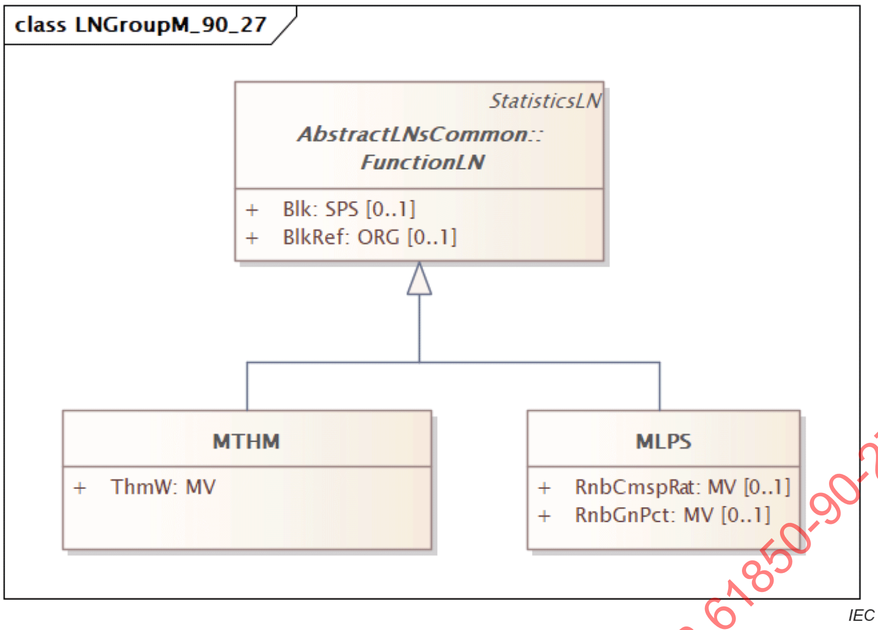


Figure 26 – Class diagram for measurements

9.8.2 LN: Local electric power system measurement Name: MLPS

This logical node is used for measurement or calculation of various aspects of local electric power system.

This logical node may be used and possibly extended by IEC 61850-90-23 that will describe use cases and logical node classes for microgrids.

Table 39 shows all data objects of MLPS.

Table 39 – Data objects of MLPS

MLPS				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M

MLPS				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
RnbCmspRat	MV		The ratio between the RES (Renewable Energy System) production used for supplying the loads and the total RES production [p.u.]	O / O
RnbGnPct	MV		The percentage of renewable energy used for supplying the loads to the energy of the loads [p.u.]	O / O
Controls				
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if ‘TRUE_RMS’ and ‘RMS_FUNDAMENTAL’). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O

MLPS				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.8.3 LN: Thermal energy measurement Name: MTHM

This logical node is used for calculation of thermal energy. The main use is for applications to operate thermal energy systems.

Table 40 shows all data objects of MTHM.

Table 40 – Data objects of MTHM

MTHM				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
ThmW	MV		Instantaneous thermal energy current (in W)	M / O

MTHM				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Controls				
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.9 Logical nodes for further power system equipment (LNGroupZ)

9.9.1 General

This subclause specifies extended logical nodes in the group Z to support some characteristics of lines and cables needed for energy operations of thermal systems. Figure 27 specifies extensions to logical nodes for lines and cables that are monitored as part of an electrical and thermal energy management system.

This document shows the simple approach of adding additional data objects to the ZLIN and ZCAB logical nodes that represent the physical lines. An alternative modelling approach is to define new logical nodes for line and cable supervision.

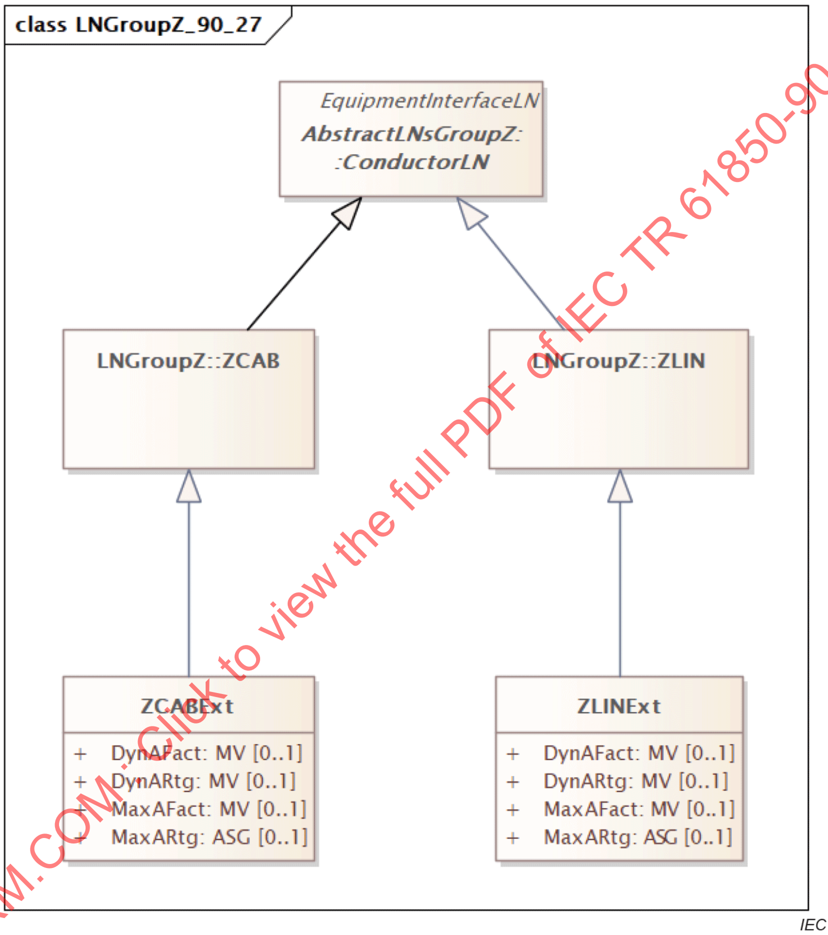


Figure 27 – Class diagram for lines and cables

9.9.2 LN: Power cable Name: ZCABExt

This logical node models a power cable. It is an extension of ZCAB defined in IEC 61850-7-4.

The "Ext" suffix is for editorial purposes only and is not used in a real model.

Table 41 shows all data objects of ZCABExt.

Table 41 – Data objects of ZCABExt

ZCABExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: EquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
EEHealth	ENS (HealthKind)		(inherited from: EquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: EquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
DynAFact	MV		Capacity factor (ratio) of the actual current to the dynamic current rating DynARtg.(in p.u.) A cable might be used under an overload condition so the value might be over 1.0. If possible, this data object should be moved into ConductorLN because it is included in both ZLINExt and ZCABExt.	O / O
DynARtg	MV		Dynamic current rating of overhead line expressed as a percentage of the maximum current rating of the line MaxARtg (%) (calculated output) This DO is the same defined in ZLINExt in 90-3. If possible, this data object should be moved	O / O

ZCABExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
			into ConductorLN because it is included in both ZLINExt and ZCABExt.	
MaxAFact	MV		Capacity factor (ratio) of the actual current to maximum current rating MaxARtg. (in p.u.) A cable might be used under an overload condition so the value might be over 1.0. If possible, this data object should be moved into ConductorLN because it is included in both ZLINExt and ZCABExt.	O / O
Controls				
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
MaxARtg	ASG		Designed static maximum current rating (A) This DO is the same defined in ZLINExt in 90-3. If possible, this data object should be moved into ConductorLN because it is included in both ZLINExt and ZCABExt.	O / F
LinLenkm	ASG		(inherited from: ConductorLN) Line length [km].	O / F
RPs	ASG		(inherited from: ConductorLN) Positive sequence line resistance.	O / F
XPs	ASG		(inherited from: ConductorLN) Positive sequence line (reach) reactance.	O / F
ZPsMag	ASG		(inherited from: ConductorLN) Magnitude of positive sequence line impedance.	O / F
ZPsAng	ASG		(inherited from: ConductorLN) Angle of positive sequence line impedance.	O / F
RZer	ASG		(inherited from: ConductorLN) Zero sequence line resistance.	O / F
XZer	ASG		(inherited from: ConductorLN) Zero sequence line reactance.	O / F
ZZerMag	ASG		(inherited from: ConductorLN) Magnitude of zero sequence line impedance.	O / F
ZZerAng	ASG		(inherited from: ConductorLN) Angle of zero sequence line impedance.	O / F
RmZer	ASG		(inherited from: ConductorLN) Mutual resistance coupling from parallel line.	O / F
XmZer	ASG		(inherited from: ConductorLN) Mutual reactance coupling from parallel line.	O / F
ZmZerMag	ASG		(inherited from: ConductorLN) Magnitude of mutual impedance coupling from parallel line.	O / F
ZmZerAng	ASG		(inherited from: ConductorLN) Angle of mutual impedance coupling from parallel line.	O / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F

ZCABExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.9.3 LN: Power overhead line Name: ZLINExt

This logical node models an overhead power line. It is an extension of ZLIN defined in IEC 61850-7-4.

The "Ext" suffix attached to the LN name is only there for editorial purpose and is not present in the real model

Table 42 shows all data objects of ZLINExt.

Table 42 – Data objects of ZLINExt

ZLINExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
Descriptions				
EEName	DPL		(inherited from: EquipmentInterfaceLN) Name plate of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
NamPlt	LPL		(inherited from: DomainLN) Name plate of the logical node.	MONamPlt / MONamPlt
Status information				
EEHealth	ENS (HealthKind)		(inherited from: EquipmentInterfaceLN) State of external (electrical, mechanical or communication) equipment to which the logical node is associated.	O / F
OpTmh	INS		(inherited from: EquipmentInterfaceLN) Operation time of the external (electrical, mechanical or communication) equipment since start of the operation.	O / O
Blk	SPS		(inherited from: FunctionLN) If true, this function has been dynamically blocked by another function.	O / F
ClcExp	SPS	T	(inherited from: StatisticsLN) If true, calculation period of the statistical logical node has expired.	O / O
ClcNxtTmms	INS		(inherited from: StatisticsLN) Remaining time up to the end of the current calculation interval.	O / O
Beh	ENS (BehaviourModeKind)		(inherited from: DomainLN) Read-only value, describing the behaviour of a domain logical node. It depends on the current operating mode of the logical node ('DomainLN.Mod'), and the current operating mode of the logical device that contains it ('LLN0.Mod'). Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of 'DomainLN.Beh'.	M / M
Health	ENS (HealthKind)		(inherited from: DomainLN) Reflects the state of the logical node related hardware and software. More detailed information related to the source of the problem may be provided by specific attribute of the logical node.	O / O
Mir	SPS		(inherited from: DomainLN) If true, the LN is a mirror and represents a LN from another LD that does not reflect this physical device. If false, it is recommended to omit the data object Mir.	MOcond(1) / MOcond(1)
Measured and metered values				
DynAFact	MV		Capacity factor (ratio) of the actual current to the dynamic current rating DynARtg.(in p.u.) A cable might be used under an overload condition so the value might be over 1.0. If possible, this data object should be moved into ConductorLN because it is included in both ZLINExt and ZCABExt.	O / O
DynARtg	MV		Dynamic current rating of overhead line expressed as a percentage of the maximum current rating of the line MaxARtg (%) (calculated output) This DO is the same as one defined in IEC 61850-90-3.	O / O

ZLINExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
MaxAFact	MV		Capacity factor (ratio) of the actual current to maximum current rating MaxARtg. (in p.u.) A cable might be used under an overload condition so the value might be over 1.0. If possible, this data object should be moved into ConductorLN because it is included in both ZLINExt and ZCABExt.	O / O
Controls				
ClcStr	SPC		(inherited from: StatisticsLN) (controllable) If true, statistical data calculation has started.	O / O
Mod	ENC (BehaviourModeKind)		(inherited from: DomainLN) (controllable) Operating mode of the domain logical node that may be changed by operator. Processing of the quality status ('q') of the received data is the prerequisite for correct interpretation of the operating mode.	O / O
Settings				
MaxARtg	ASG		Designed static maximum current rating (A). This DO is the same as one defined in IEC 61850-90-3.	O / F
LinLenkm	ASG		(inherited from: ConductorLN) Line length [km].	O / F
RPs	ASG		(inherited from: ConductorLN) Positive sequence line resistance.	O / F
XPs	ASG		(inherited from: ConductorLN) Positive sequence line (reach) reactance.	O / F
ZPsMag	ASG		(inherited from: ConductorLN) Magnitude of positive sequence line impedance.	O / F
ZPsAng	ASG		(inherited from: ConductorLN) Angle of positive sequence line impedance.	O / F
RZer	ASG		(inherited from: ConductorLN) Zero sequence line resistance.	O / F
XZer	ASG		(inherited from: ConductorLN) Zero sequence line reactance.	O / F
ZZerMag	ASG		(inherited from: ConductorLN) Magnitude of zero sequence line impedance.	O / F
ZZerAng	ASG		(inherited from: ConductorLN) Angle of zero sequence line impedance.	O / F
RmZer	ASG		(inherited from: ConductorLN) Mutual resistance coupling from parallel line.	O / F
XmZer	ASG		(inherited from: ConductorLN) Mutual reactance coupling from parallel line.	O / F
ZmZerMag	ASG		(inherited from: ConductorLN) Magnitude of mutual impedance coupling from parallel line.	O / F
ZmZerAng	ASG		(inherited from: ConductorLN) Angle of mutual impedance coupling from parallel line.	O / F
BlkRef	ORG		(inherited from: FunctionLN) Object reference of data object that sent the dynamically blocking signal n.	Omulti / F

ZLINExt				
Data object name	**Common data class**	**T**	**Explanation**	**PresCond nds/ds**
ClcMth	ENG (CalcMethodKind)		(inherited from: StatisticsLN) Kind of statistical calculation, specifying how the data attributes that represent analogue or counter values have been calculated. The calculation method shall be the same for all data objects of the logical node instance. If the value is 'PEAK_FUNDAMENTAL', angle may be present in a data object of complex measured value type (CMV, such as in WYE, DEL, etc.), otherwise angle is not used (if 'TRUE_RMS' and 'RMS_FUNDAMENTAL'). If the value is 'unspecified', the dependent data objects may be meaningless.	O / M
ClcMod	ENG (CalcModeKind)		(inherited from: StatisticsLN) Calculation mode.	O / O
ClcIntvTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of calculation interval.	O / O
ClcIntvPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the calculation interval duration, in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
NumSubIntv	ING		(inherited from: StatisticsLN) Number of sub-intervals contained in a calculation period interval duration.	O / O
ClcRfTyp	ENG (CalcIntervalKind)		(inherited from: StatisticsLN) Kind of refresh interval.	O / O
ClcRfPer	ING		(inherited from: StatisticsLN) Number of units to consider to calculate the refreshment interval duration in case 'ClcIntvTyp' is not 'EXTERNAL'.	O / O
ClcSrc	ORG		(inherited from: StatisticsLN) Object reference of logical node whose data objects are used to calculate the values contained in this logical node instance.	F / M
InSyn	ORG		(inherited from: StatisticsLN) Object reference of source of the external synchronization signal for the calculation interval.	O / O
InRef	ORG		(inherited from: DomainLN) Object reference of data object bound to the input n.	Omulti / Omulti

9.10 Enumerated data attribute types

9.10.1 General

This subclause contains explicit definition of enumerated types used in data objects of logical nodes for distributes energy resources.

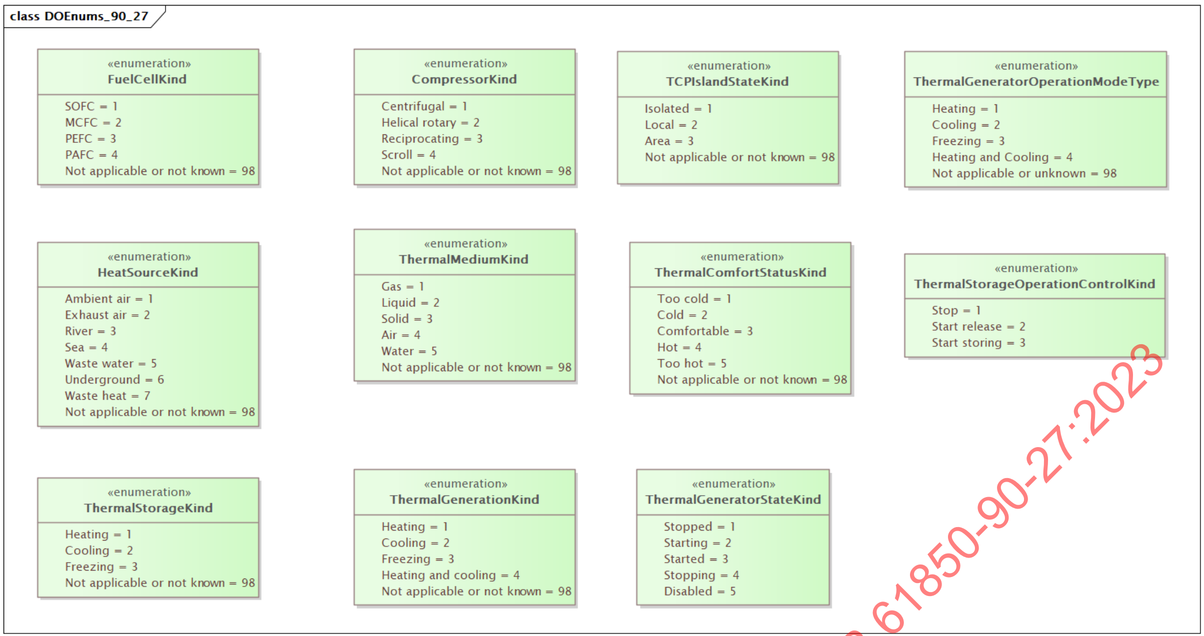


Figure 28 – Class diagram DOEnums_90_27::DOEnums_90_27

Figure 28 shows enumerations defined by the IEC 61850-90-27 namespace.

9.10.2 Classes list

Table 43 shows all classes defined in the DOEnums_90_27 package.

Table 43 – List of classes defined in DOEnums_90_27 package

Name	Description
CompressorKind	Describes the type of compressor.
FuelCellKind	Describes the type of fuel cell.
HeatSourceKind	Describes common sources of heat energy.
TCPIslandStateKind	Describes the type of thermal connection point island states.
ThermalComfortStatusKind	Describes types of thermal comfort.
ThermalGenerationKind	Describes the type of thermal generation.
ThermalGeneratorOperationModeType	Describes the thermal generator operation mode.
ThermalGeneratorStateKind	Describes the type of thermal generator operating state.
ThermalMediumKind	Describes the kinds of medium used to transfer thermal energy.
ThermalStorageKind	Describes the type of thermal storage.
ThermalStorageOperationControlKind	Describes the types of thermal storage operation control.

9.10.3 ThermalGeneratorStateKind enumeration

Describes the type of thermal generator operating state.

Table 44 shows all enumeration items of ThermalGeneratorStateKind.

Table 44 – Literals of ThermalGeneratorStateKind

ThermalGeneratorStateKind		
enumeration item	**value**	**description**
Stopped	1	
Starting	2	
Started	3	
Stopping	4	
Disabled	5	

9.10.4 ThermalGeneratorOperationModeType enumeration

Describes the thermal generator operation mode.

Table 45 shows all enumeration items of ThermalGeneratorOperationModeType.

Table 45 – Literals of ThermalGeneratorOperationModeType

ThermalGeneratorOperationModeType		
enumeration item	**value**	**description**
Heating	1	
Cooling	2	
Freezing	3	
Heating and Cooling	4	
Not applicable or unknown	98	

9.10.5 ThermalStorageOperationControlKind enumeration

Describes the types of thermal storage operation control.

Table 46 shows all enumeration items of ThermalStorageOperationControlKind.

Table 46 – Literals of ThermalStorageOperationControlKind

ThermalStorageOperationControlKind		
enumeration item	**value**	**description**
Stop	1	
Start release	2	
Start storing	3	

9.10.6 HeatSourceKind enumeration

Describes common sources of heat energy.

Table 47 shows all enumeration items of HeatSourceKind.

Table 47 – Literals of HeatSourceKind

HeatSourceKind		
enumeration item	**value**	**description**
Ambient air	1	
Exhaust air	2	
River	3	
Sea	4	
Waste water	5	
Underground	6	
Waste heat	7	
Not applicable or not known	98	

9.10.7 CompressorKind enumeration

Describes the type of compressor.

Table 48 shows all enumeration items of CompressorKind.

Table 48 – Literals of CompressorKind

CompressorKind		
enumeration item	**value**	**description**
Centrifugal	1	
Helical rotary	2	
Reciprocating	3	
Scroll	4	
Not applicable or not known	98	

9.10.8 ThermalComfortStatusKind enumeration

Describes types of thermal comfort.

Table 49 shows all enumeration items of ThermalComfortStatusKind.

Table 49 – Literals of ThermalComfortStatusKind

ThermalComfortStatusKind		
enumeration item	**value**	**description**
Too cold	1	
Cold	2	
Comfortable	3	
Hot	4	
Too hot	5	
Not applicable or not known	98	

9.10.9 ThermalStorageKind enumeration

Describes the type of thermal storage.

Table 50 shows all enumeration items of ThermalStorageKind.

Table 50 – Literals of ThermalStorageKind

ThermalStorageKind		
enumeration item	**value**	**description**
Heating	1	Energy is stored in a medium at a temperature higher than ambient.
Cooling	2	Energy is stored in a medium at a temperature lower than ambient.
Freezing	3	Energy is stored in a medium at a temperature lower than ambient, and has passed from liquid state to a solid state.
Not applicable or not known	98	

9.10.10 ThermalMediumKind enumeration

Describes the kinds of medium used to transfer thermal energy.

Table 51 shows all enumeration items of ThermalMediumKind.

Table 51 – Literals of ThermalMediumKind

ThermalMediumKind		
enumeration item	**value**	**description**
Gas	1	Any type of gas medium other than air
Liquid	2	Any type of liquid medium other than water
Solid	3	Any type of solid medium
Air	4	
Water	5	
Not applicable or not known	98	

9.10.11 FuelCellKind enumeration

Describes the type of fuel cell.

Table 52 shows all enumeration items of FuelCellKind.

Table 52 – Literals of FuelCellKind

FuelCellKind		
enumeration item	**value**	**description**
SOFC	1	Solid oxide fuel cell
MCFC	2	Molten carbonate fuel cell
PEFC	3	Polymer electrolyte fuel cell
PAFC	4	Phosphoric acid fuel cell
Not applicable or not known	98	

9.10.12 TCPIslandStateKind enumeration

Describes the type of thermal connection point island states.

Table 53 shows all enumeration items of TCPIslandStateKind.

Table 53 – Literals of TCPIslandStateKind

TCPIslandStateKind		
enumeration item	**value**	**description**
Isolated	1	The thermal connection point is not part of a thermal grid.
Local	2	A small thermal grid for example within a building.
Area	3	Part of an area or district thermal grid.
Not applicable or not known	98	

9.10.13 ThermalGenerationKind enumeration

Describes the type of thermal generation.

Table 54 shows all enumeration items of ThermalGenerationKind.

Table 54 – Literals of ThermalGenerationKind

ThermalGenerationKind		
enumeration item	**value**	**description**
Heating	1	
Cooling	2	
Freezing	3	
Heating and cooling	4	
Not applicable or not known	98	

Annex A
(informative)

Complete descriptions of use cases

A.1 Aggregated energy storage in buildings for electricity grid congestion management via electricity demand shifting

A.1.1 Description of the use case

A.1.1.1 Name of use case

Use case identification		
ID	**Area domain(s) / Zone(s)**	**Name of use case**
UC1	Area: Consumption management at local electricity grid Domains: Electrical Distribution, DER Zones: Building	Thermal mass in buildings for electricity grid congestion management via electricity demand shifting

A.1.1.2 Version management

Version management				
Version No.	**Date**		**Changes**	**Approval status**
0.1	06.09.19		Creation	Draft

A.1.1.3 Scope and objectives of use case

Scope and objectives of use case	
Scope	Identify and apply time shiftable electrical load profiles for heating purposes to VES systems (buildings) and hence making use of their flexibility (inherent thermal inertia of the building and the possible availability of small heat pumps, i.e., P_{el}< 100 kW, for supplying hydronic heating system).
Objective(s)	The main objective of this use case is to enhance the time flexibility of electricity demand. This flexibility can be used for multiple purposes, for example for grid balancing by aligning demand with generation through dynamic pricing schemes and for grid congestion management via provision of balancing services. This use case supports the ancillary service system control with the focus on congestion management and feed-in management.
Related business case(s)	

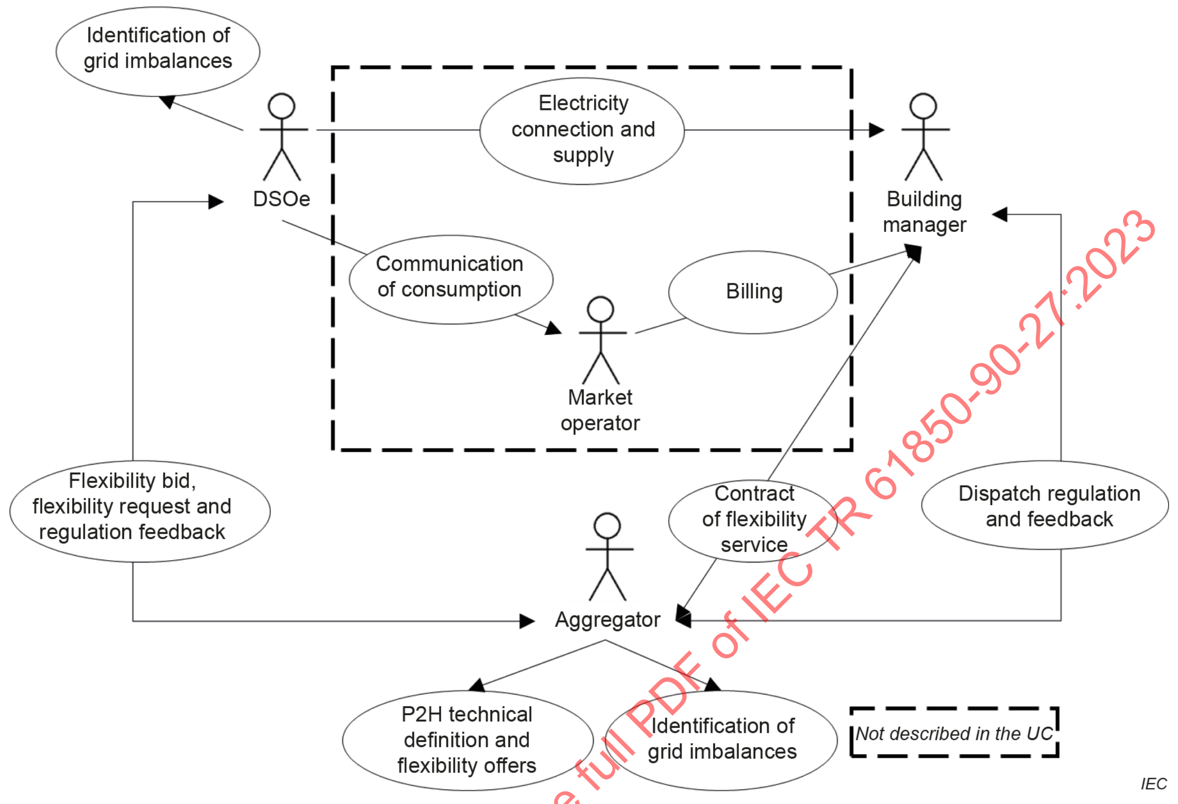
A.1.1.4 Narrative of use case

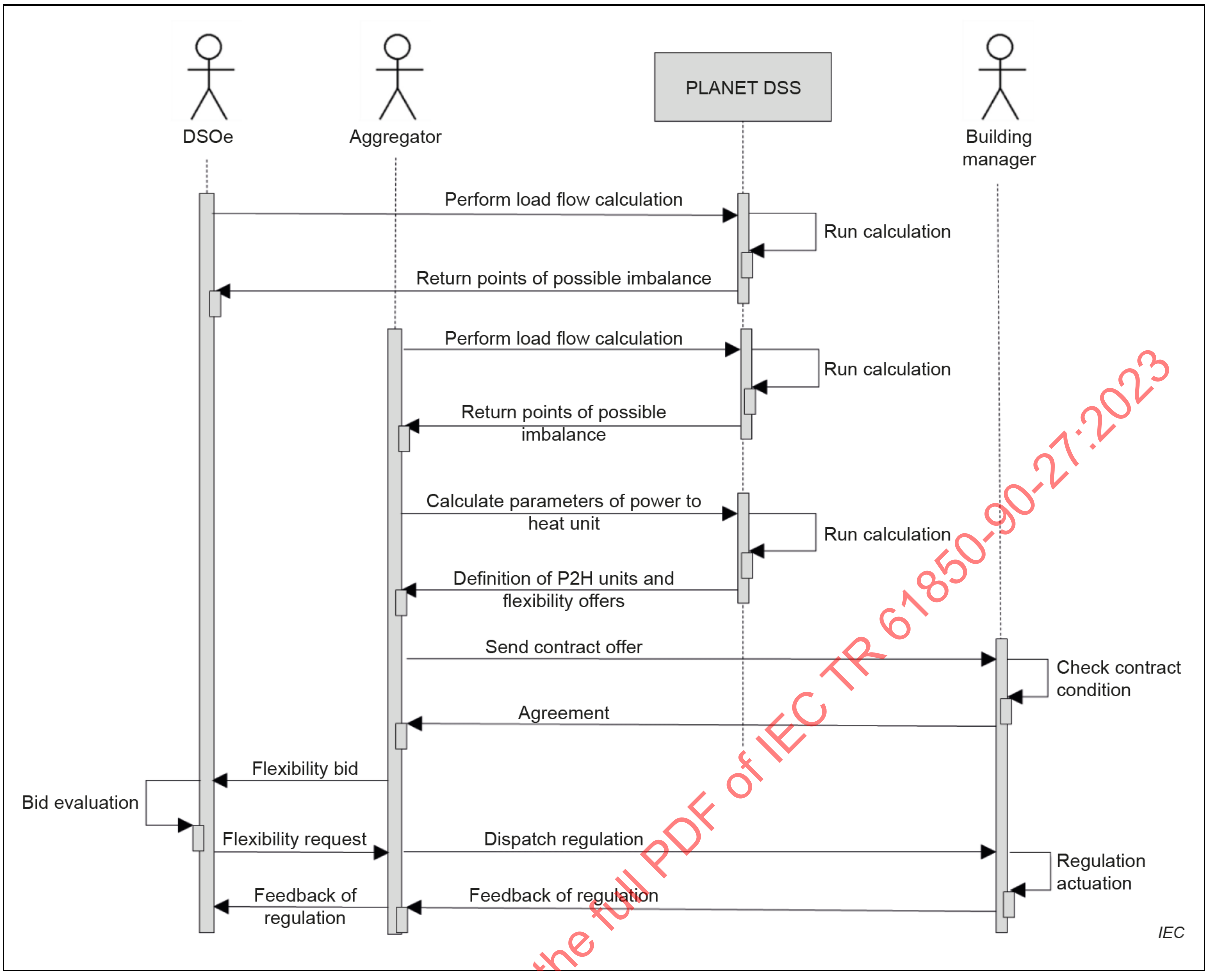
Narrative of use case
Short description
This use case deals with the experimentation of an advanced management of the electrical user demand for heating purposes and domestic hot water provision (if the building setup allows for it) at building level, providing a possible benefit for system operation. In this use case the present electrical consumption of the building will be analysed, assessing some possible future scenarios of consumption, and evaluating electricity demand shifting. It will be assured at all times that building residents won't be affected by this advanced management. The use case will show how the building could be used as an aggregated energy storage. This use case will also show the possible synergy between the electrical distribution network and distribution gas network exploiting the building as a bridge between the grids, due to the fact that the heating demand of the building represents a possible combination of electricity and gas consumption.
Complete description
Problem and proposed solution: A quarter of primary energy in Europe is consumed for building heating and cooling. Currently conversion of energy to heat/cool is performed either on user demand or for optimal performance of the heating/cooling equipment locally, without considerations about the impact of the demand profile on the energy networks. The aim of this use case is to demonstrate the potential available through shifting the operation time and/or power regulation (increase or decrease of power) of such devices for balancing the grid or managing congestion points. The building thermal mass/inertia and/or water tanks for hot water storage provide opportunities for shifting the actual energy consumption while maintaining indoor conditions at acceptable levels. Solution steps: In Italy, at the moment ancillary services are managed and requested by TSO. If the aggregated electricity demand is lower than electricity generation, management strategies for electrical devices connected to the building heat generation system are applied in order to maximise the use of excess electricity by charging heat storages (hot water tank) and/or using building mass inertia (request by the TSO to consume more electric power at building level). If the aggregated electricity demand is higher than electricity generation, management strategies to the electrical devices connected to the building heating system are applied in order to reduce the consumption exploiting heat storages/building mass inertia (request by the TSO to consume less electric power at the building level). In the near future, due to a revision of the market regulation, the DSOe could be engaged as a balance service provider. This condition should allow to directly solve the problems such as grid congestion, not only at transmission network level, but also on the electrical distribution networks.
Benefit: Via intelligent control of building heating/cooling systems – transforming electricity to heat for final use – their demand profile can be shaped according to the grid needs in a human-centric manner that constantly respects the comfort preferences of building residents. This requires the understanding of comfort preferences on individual residents and the monitoring of indoor conditions, as well as the necessary intelligence to identify opportunities for satisfying the grid (TSO at the moment and maybe in the next future DSOe) requirements in a manner that minimally affects comfort. Such intelligent tools can be the foundation for aggregator toolsets that manage devices of many buildings in a coordinated manner in order to provide ancillary services to the grid.

A.1.1.5 General remarks

General remarks
In this context feed-in management means to tackle excess RES generation in such a way that voltage violations in the electricity grid can be avoided.

A.1.2 Diagrams of use case

Use case diagram
UC diagram for the possible future scenario in Italy and other European countries

Sequence diagram for the possible future scenario



A.1.3 Technical details

A.1.3.1 Actors

Actors			
Actor name see actor list	**Actor type see actor list**	**Actor description see actor list**	**Further information specific to this use case**
BM – Building Manager	Role	Physical person or legal entity that manages the energy assets of buildings of various types (e.g. residential, commercial, shopping malls, office buildings, etc.) or groups thereof.	Entity who is in charge to operate/ manage the buildings plants (both electrical and thermal) and has the knowledge and follow-up of the electrical and heat needs. The actions needed for the operation could be either manual or automatic
DSOe – Electricity DSO	Role	The electricity Distribution System Operator managing the low and medium voltage electricity grids.	Entity that operates the distribution network, which is entitled to operate the electric energy network and to supply electrical energy to the user (building manager)
MO – Market Operator	Role	Operator of a market, example markets include the wholesale electricity or gas market, ancillary service markets, etc.	Market operator in charge for electrical energy and gas purchasing and billing to the building manager

Actors			
Actor name see actor list	**Actor type see actor list**	**Actor description see actor list**	**Further information specific to this use case**
Aggr – Aggregator	Role	Operator of a market, example markets include the wholesale electricity or gas market, ancillary service markets, etc.	Aggregator manages the electrical flexibility of its customers (Balance service provider) Aggregator and electricity/gas seller could be the same operator
TSO – Transmission System Operator	Role	Entity entrusted with transporting energy in the form of natural gas or electrical power on a national or regional level, using fixed infrastructure.	Responsible for operating the transmission electricity network, and entitled of dispatching the electricity at national level

A.1.3.2 Triggering events, preconditions, assumptions

Use case conditions			
Actor/System/ Information/Contract	**Triggering event**	**Pre-conditions**	**Assumption**
DSOe	Given a certain electrical network scheme and a level of consumption at each node, a power flow calculation estimates the maximum electrical flexibility given at each consumption node.	High amount of renewables in the grid.	Installation of P2H unit at the consumption node where the maximum electrical flexibility is estimated.
System	Additional P2H devices connected to the electrical network		
Information	Possible deviation in electrical consumption (reduction or increase) for each node between the actual consumption and the one estimated, due to P2H installation	Data for handling with the issues are provided through the power flow calculation and estimation on P2H consumption	Deployment of P2H units at nodes with the maximum estimated flexibility gives the possibility to module the electrical consumption for better utilization of RES
Contract between BM and Aggregator	Agreement between building manager and aggregator for flexibility service.		P2H devices connected to the electrical network and to the building facilities (heating system)
Contract between DSOe and Aggregator	Evaluation and acceptance by the DSOe among different flexibility bids received on the marketplace settled for flexibility regulation.	Aggregator has to be compliant to the rules of flexibility market. Proposition by Aggregator of flexibility bids.	Definition of future flexibility market rules for DSOe.

A.1.3.3 References

References						
No.	**References type**	**Reference**	**Status**	**Impact on use case**	**Originator / Organisation**	**Link**
1	Project deliverable	D1.1 – – End-user Requirements and Specifications for the PLANET system	Final	Defines list of relevant roles for the PLANET project roles (Table 2)	PLANET consortium	
2	Project deliverable	D1.3 – Definition of requirements and specifications for communication & grid interfaces	Final	Identified this UC as one of the five major UCs to be considered in the PLANET project	PLANET consortium	
3	Project deliverable	D2.2 – Target context and requirements for conversion module deployment in the smart grid	Final	Defines business cases for P2G	PLANET consortium	

A.1.3.4 Further information to the use case for classification / mapping

Classification information
Relation to other use cases
Power-to-Heat integration at local large scale close to the buildings
Level of depth
Detailed
Prioritization
High
Generic, regional or national relation
Regional
Viewpoint
Technical
Further keywords for classification
Deployment of P2H units, grid flexibility, in-feed management, avoiding curtailment of renewables

A.1.4 Step by step analysis of use case

A.1.4.1 Overview of scenarios

Scenario conditions					
No.	**Scenario name**	**Primary actor**	**Triggering event**	**Pre-condition**	**Post-condition**
1	Identification of grid imbalances by DSOe	DSOe	Imbalance and congestion forecast	Electricity grid is expected to be in balance within the forecast time frame.	Imbalance reduction or elimination
2	Identification of grid imbalances by Aggregator	Aggr	Imbalance and congestion forecast	Electricity grid is expected to be in balance within the forecast time frame.	Imbalance reduction or elimination
3	P2H technical definition and flexibility offers	Aggr	Definition of technical parameters of P2H based on Imbalance and congestion forecast. Definition of flexibility offers.	Definition of the electrical node where to set P2H units	Definition of aggregated flexibility offer
4	Contract of flexibility service	Aggr BM	Flexibility contract offer.	P2H installed closed to the buildings	Agreement with the building manager for the actuation of regulation
5	Regulation actuation (comprises "Flexibility bid, flexibility request and regulation feedback" & "Dispatch regulation and feedback".	Aggreg. DSOe BM	Dispatch regulation	Flexibility bid proposed by aggregator and flexibility request sent by DSOe	Feedback on regulation to Aggregator and DSOe

A.1.4.2 Steps – Scenarios

Scenario								
Scenario name:	**S01- "Identification of grid imbalances by DSOe"**							
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged**	**Requirements, R-ID**
1	Daily forecast of supply and demand	Perform load flow calculation	The DSOe makes a daily forecast of supply and demand based on weather models, RES production, conventional generation capacity and wholesale contracts as well as demand forecast models.		DSOe	PLANET DSS	Electrical Network topology and all relevant grid parameters	All relevant grid parameters are available for running the PF calculation and PF settings are set

Scenario								
Scenario name:		**S01- "Identification of grid imbalances by DSOe"**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged**	**Requirements, R-ID**
2	Initiation of PF calculation	Run PF calculation	The network planning tool runs the PF calculation		PLANET DSS	PLANET DSS	Electrical consumption at final nodes and electricity supply	-
3	Power flow calculation performed	Return points of possible imbalances and congestions	Identification of grid nodes with forecasted congestions or imbalances		PLANET DSS	DSOe	Nodes of the electrical network with their active power flows and utilization of lines/cables	Power flow has iterated

Scenario								
Scenario name:		**S02- "Identification of grid imbalances by Aggregator"**						
Step No.	**Event**	**Name of process/ activity**	**Description of process/ activity**	**Service**	**Information producer (actor)**	**Information receiver (actor)**	**Information exchanged**	**Requirements, R-ID**
1	Forecast of supply and demand	Perform load flow calculation	The Aggregator makes a forecast of supply and demand based on weather models, RES production, conventional generation capacity and wholesale contracts as well as demand forecast models.		Aggregator	PLANET DSS	Electrical Network topology and all relevant grid parameters (same as step 1, S01)	All relevant grid parameters are available for running the PF calculation and PF settings are set
2	Initiation of PF calculation	Run PF calculation	The network planning tool runs the PF calculation		PLANET DSS	PLANET DSS	Electrical consumption at final nodes and electricity supply.	-
3	Power flow calculation performed	Return points of possible imbalances and congestions	Identification of nodes od the network where is forecasted congestion		PLANET DSS	Aggregator	Nodes of the electrical network closed to the buildings where to install P2H.	Power flow has iterated

Scenario								
Scenario name:		**S03- "P2H technical definition and flexibility offers"**						
Step No.	**Event**	**Name of process/ activity**	**Descrip-tion of process/ activity**	**Service**	**Informa-tion producer (actor)**	**Informa-tion receiver (actor)**	**Information exchanged**	**Requirements, R-ID**
1	Points of imbalances and congestions have been identified	Calculate parameters of Power to Heat units	The Aggregator request a definition of the technical parameter for each P2H which could maximize the flexibility offer.		Aggregator	PLANET DSS	Electrical Network topology. Table of nodes of the electrical network close to the buildings where to install P2H	
2	Parameters of P2H units have been calculated	Run calculation	Calculation of the technical parameters for each P2H unit		PLANET DSS	PLANET DSS	Definitions of P2H unit parameters and range of possible values	
3	Calculation has been run	Definition of P2H units and flexibility offers	Identification of nodes of the network where is forecasted congestion		PLANET DSS	Aggregator	Nodes of the electrical network closed to the buildings where to install P2H. Available flexibility (seen as integrated flexibility of building HP also utilizing flexibility in buildings heating/cooling demand) for each building	

Scenario								
Scenario name:		**S04- "Contract of flexibility service"**						
Step No.	**Event**	**Name of process/ activity**	**Descrip-tion of process/ activity**	**Service**	**Informa-tion producer (actor)**	**Informa-tion receiver (actor)**	**Information exchanged**	**Requirements, R-ID**
1	P2H units and flexibility offers have been defined	Send contract offer	The Aggregator proposes a contract to the building manager where the following is defined: the installation of the P2H and the availability to operate P2H for flexibility purposes		Aggregator	Building Manager	P2H design for integration in the plants of the building and contract	Information on BM is available. Contract request is complete.
2	Contract has been received	Check contract condition	Evaluation of the contract		Building Manager	Building Manager	-	-
3	Contract has checked	Agreement	Acceptance of the contract		Building Manager	Aggregator	Acceptance or rejection	In case of acceptance: Contract contains all necessary data and does not have formal errors In case of rejection: Reason for rejection is provided.

Scenario								
Scenario name:		**S05- "Regulation actuation"**						
Step No.	**Event**	**Name of process/ activity**	**Descrip-tion of process/ activity**	**Service**	**Informa-tion producer (actor)**	**Informa-tion receiver (actor)**	**Information exchanged**	**Requirements R-ID**
1	Contract between Aggregator and BM established	Flexibility bid	The Aggregator bids the aggregated available demand flexibility – within his portfolio – in order to address the need for balancing,		Aggregator	DSOe	Flexibility offer composed by: setpoint commands (increase or decrease of electric power) for each timeframe	