

INTERNATIONAL STANDARD



Wind **turbines** energy generation systems –
Part 25-1: Communications for monitoring and control of wind power plants –
Overall description of principles and models

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND ~~TURBINES~~ ENERGY GENERATION SYSTEMS –

Part 25-1: Communications for monitoring and control of wind power plants – Overall description of principles and models

FOREWORD

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International Standard IEC 61400-25-1 has been prepared by IEC technical committee 88: Wind energy generation systems.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) general harmonization of text and overview models with the other parts of the IEC 61400-25 series,
- b) harmonization of definitions in other related standards.

The text of this International Standard is based on the following documents:

CDV	Report on voting
88/587/CDV	88/622/RVC

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

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

The title of TC 88 was changed in 2015 from *Wind turbines* to *Wind energy generation systems*.

A list of all parts in the IEC 61400 series, published under the general titles *Wind turbines* and *Wind energy generation systems* can be found on the IEC website.

The users of IEC 61400-25 have formed a community, USE61400-25. For further information see <http://www.use61400-25.com>.

Attached to the release of the IEC 61400-25 standard series and in addition to the standard IEC maintenance process, a specific maintenance process is set up to handle technical issues raised after publication. Here are the main principles:

- Technical issues (called TISSUES) are collected from the release of the new document in cooperation with the user group for the IEC 61400-25 standard series USE61400-25.
- The collected TISSUES can be categorized in two groups:
 - TISSUES that can threaten interoperability between implementations of the standard and that need either corrections or clarifications (“IntOp” TISSUES),
 - TISSUES that propose new features that will be implemented in future versions of the standard (“next edition” TISSUES).
- IntOp TISSUES require immediate clarification and are following a transparent fixing process handled by the user group for the IEC 61400-25 standard series together with the editors of the IEC 61400-25 standard series.
- The detailed specification of this process, the list of TISSUES, associated fix, their status and impact on implementation and certification are accessible through the USE61400-25 web site <http://www.use61400-25.com>.
- IEC recommends implementing the proposed fixes to IntOp TISSUES, as soon as they have reached the “green” status. The list of TISSUES which are implemented in an intelligent electronic device (IED) should be transparently stated by its manufacturer.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

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INTRODUCTION

IEC 61400-25 (all parts) ~~addresses~~ is intended for vendors (manufacturers, suppliers), operators, owners, planners, and designers of wind power plants as well as system integrators and utility companies operating in the wind energy market. IEC 61400-25 (all parts) is intended to be accepted and to be used world-wide as the international standard for communications in the domain of wind power plants.

IEC 61400-25 (all parts) has been developed in order to provide a uniform communications basis for the monitoring and control of wind power plants. It defines wind power plant specific information, the mechanisms for information exchange and the mapping to communication protocols. In this regard, IEC 61400-25 (all parts) defines details required to exchange the available information with wind power plant components in a manufacturer-independent environment. This is done by definitions made in this part of IEC 61400-25 or by reference to other standards.

The wind power plant specific information describes the crucial and common process and configuration information. The information is hierarchically structured and covers for example common information found in the rotor, generator, converter, grid connection and the like. The information may be simple data (including timestamp and quality) and configuration values or more comprehensive attributes and descriptive information, for example engineering unit, scale, description, reference, statistical or historical information. All information of a wind power plant defined in IEC 61400-25 (all parts) is name tagged. A concise meaning of each data is given. The standardized wind power plant information can be extended by means of a name space extension rule. All data, attributes and descriptive information can be exchanged by corresponding services.

The implementation of IEC 61400-25 (all parts) allows SCADA systems (supervisory control and data acquisition) to communicate with wind turbines from multiple vendors. The standardized self-description (contained either in an XML file or retrieved online from a device) can be used to configure SCADA applications. Standardization of SCADA applications are excluded in IEC 61400-25 (all parts) but standardized common wind turbine information provides means for re-use of applications and operator screens for wind turbines from different vendors. From a utility perspective, unified definitions of common data minimize conversion and re-calculation of data values for evaluation and comparison of all their wind power plants.

IEC 61400-25 (all parts) can be applied to any wind power plant operation concept, i.e. both individual wind turbines, clusters and more integrated groups of wind turbines. The application area of IEC 61400-25 (all parts) covers components required for the operation of wind power plants, i.e. not only the wind turbine generator, but also the meteorological system, the electrical system, and the wind power plant management system. The wind power plant specific information in IEC 61400-25 (all parts) excludes information associated with feeders and substations. Substation communication is covered within IEC 61850 (all parts).

The intention of IEC 61400-25 (all parts) is to enable components from different vendors to communicate with other components, at any location. Object-oriented data structures can make the engineering and handling of large amounts of information provided by wind power plants less time-consuming and more efficient. IEC 61400-25 (all parts) supports scalability, connectivity, and interoperability.

IEC 61400-25 (all parts) is a basis for simplifying the contracting of the roles the wind turbine and SCADA systems have to play. The crucial part of the wind power plant information, the information exchange methods, and the communication stacks are standardized. They build a basis to which procurement specifications and contracts could easily refer.

IEC 61400-25 is organized in several parts.

- IEC 61400-25-1 offers an introductory orientation, crucial requirements, and a modelling guide.
- IEC 61400-25-2 and IEC61400-25-6 contain the description of the information model, a uniform, component-oriented view of the wind power plant data, including extensions for condition monitoring.
- IEC 61400-25-3 describes the information exchange model. It reflects the functionality of the server.
- IEC 61400-25-4 presents five alternative mappings of the information model and information exchange model to a standard communication profile. The choice depends on the application and the functionality and performance needed.
- IEC 61400-25-5 describes test cases for conformance testing of implementations.

NOTE 1 Performance of IEC 61400-25 (all parts) implementations are application specific. IEC 61400-25 (all parts) does not guarantee a certain level of performance. This is beyond the scope of IEC 61400-25 (all parts). However, there is no underlying limitation in the communications technology to prevent high speed application (millisecond level responses).

~~NOTE 2 IEC 61400-25-4 is, at the time of the publication of IEC 61400-25-1 (this part), still to be published. With IEC 61400-25-4 the mapping of the information and information exchange models to a specific communication profile will be described/defined in detail. IEC 61400-25-4 may consist of more than one normative mapping but at least one of the optional mappings has to be selected in order to be in conformance with the IEC 61400-25 series. IEC 61400-25-4 is expected to include the following mappings:~~

~~Webservices~~

~~IEC 61850-8-1 MMS~~

~~OPC XML DA~~

~~IEC 60870-5-104~~

~~DNP3~~

~~Each of the different mappings specifies individually which and how information models (IEC 61400-25-2) and information exchange models (IEC 61400-25-3) will be supported. The mapping will only reflect the information model and the information exchange services given in IEC 61400-25-2 and IEC 61400-25-3. The individual selected mapping will as a minimum support the mandatory data and data attributes, and the associated services. A specific mapping may, for implementation reasons or due to underlying properties of the communication protocol used, need to extend and clarify individual information or individual services in IEC 61400-25-2 and IEC 61400-25-3. IEC 61400-25-4 will in this sense have the highest priority of the ranking order in regards of implementation.~~

WIND ~~TURBINES~~ ENERGY GENERATION SYSTEMS –

Part 25-1: Communications for monitoring and control of wind power plants – Overall description of principles and models

1 Scope

The focus of IEC 61400-25 (all parts) is on the communications between wind power plant components such as wind turbines and actors such as SCADA systems. Internal communication within wind power plant components is beyond the scope of IEC 61400-25 (all parts).

IEC 61400-25 (all parts) is designed for a communication environment supported by a client-server model. Three areas are defined, that are modelled separately to ensure the scalability of implementations:

- 1) wind power plant information models,
- 2) information exchange model, and
- 3) mapping of these two models to a standard communication profile.

The wind power plant information model and the information exchange model, viewed together, constitute an interface between client and server. In this conjunction, the wind power plant information model serves as an interpretation frame for accessible wind power plant data. The wind power plant information model is used by the server to offer the client a uniform, component-oriented view of the wind power plant data. The information exchange model reflects the whole active functionality of the server. IEC 61400-25 (all parts) enables connectivity between a heterogeneous combination of client and servers from different manufacturers and suppliers.

As depicted in Figure 1, IEC 61400-25 (all parts) defines a server with the following aspects:

- information provided by a wind power plant component, for example, 'wind turbine rotor speed' or 'total power production of a certain time interval' is modelled and made available for access. The information modelled in IEC 61400-25 (all parts) is defined in IEC 61400-25-2 and IEC 61400-25-6,
- services to exchange values of the modelled information defined in IEC 61400-25-3,
- mapping to a communication profile, providing a protocol stack to carry the exchanged values from the modelled information (IEC 61400-25-4).

IEC 61400-25 (all parts) only defines how to model the information, information exchange and mapping to specific communication protocols. IEC 61400-25 (all parts) excludes a definition of how and where to implement the communication interface, the application program interface and implementation recommendations. However, the objective of IEC 61400-25 (all parts) is that the information associated with a single wind power plant component (such as a wind turbine) is accessible through a corresponding logical device.

This part of IEC 61400-25 gives an overall description of the principles and models used in IEC 61400-25 (all parts).

NOTE IEC 61400-25 (all parts) focuses on the common, non-vendor-specific information. Those information items that tend to vary greatly between vendor-specific implementations can for example be specified in bilateral agreements, in user groups, or in amendments to IEC 61400-25 (all parts).

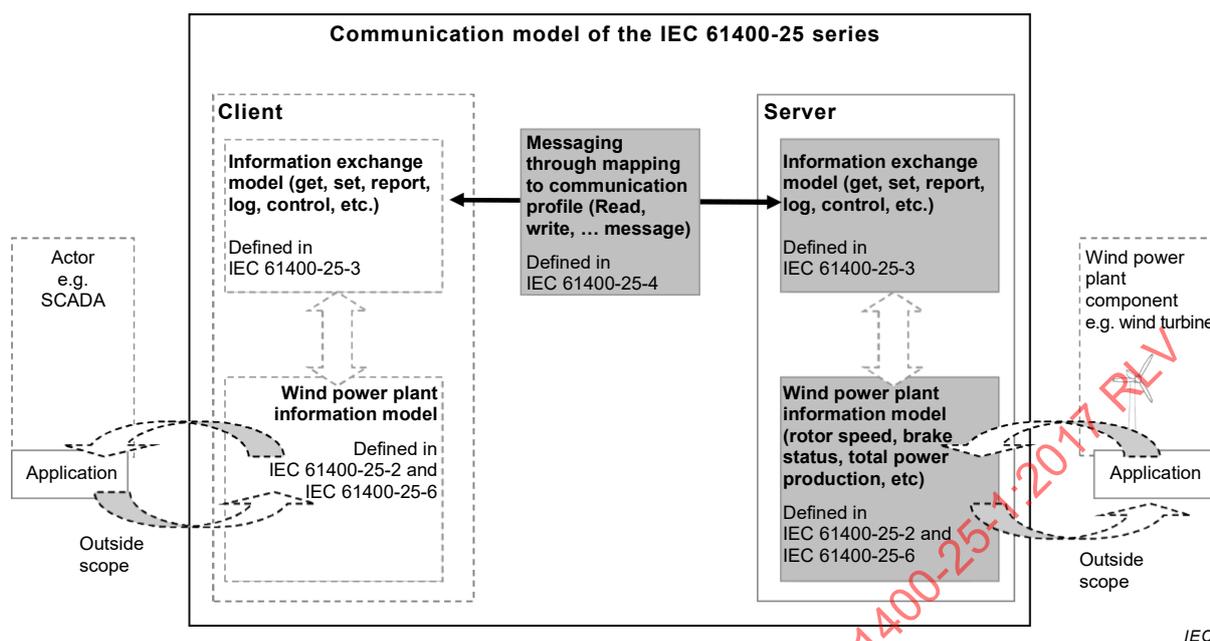


Figure 1 – Conceptual communication model of the IEC 61400-25 series

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 61400-12-1, Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines~~

IEC 61400-25 (all parts), *Wind turbines – Part 25: Communications for monitoring and control of wind power plants*

IEC 61400-25-2:2015, *Wind turbines – Part 25-2: Communications for monitoring and control of wind power plants – Information models*

IEC 61400-25-3:2015, *Wind turbines – Part 25-3: Communications for monitoring and control of wind power plants – Information exchange models*

IEC 61400-25-4, *Wind energy generation systems – Part 25-4: Communications for monitoring and control of wind power plants – Mapping to communication profile*

IEC 61400-25-6, *Wind energy generation systems – Part 25-6: Communications for monitoring and control of wind power plants – Logical node classes and data classes for condition monitoring*

IEC 61850-7-1:2003 2011, *Communication networks and systems in substations for power utility automation – Part 7-1: Basic communication structure for substation and feeder equipment – Principles and models*

IEC 61850-7-2:2003 2010, *Communication networks and systems in substations for power utility automation – Part 7-2: Basic information and communication structure for substation and feeder equipment – Abstract communication service interface (ACSI)*

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

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

~~IEC 61850-8-1:2004, Communication networks and systems in substations — Part 8-1: Specific Communication Service Mapping (SCSM) — Mappings to MMS (ISO 9506-1 and ISO 9506-2) and to ISO/IEC 8802-3~~

~~ISO 7498-1:1994, Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model~~

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

actor

role a system plays in the context of monitoring and control, while it is not directly involved in wind power plant operation, such as supervisory control and data acquisition system (SCADA)

Note 1 to entry: There are many other designations for example central management system, monitoring and control system, remote control system

3.2

alarm

wind power plant state information
statement of safety intervention by the wind turbine control system (i.e. on/off)

3.3

characteristic values

properties of analogue information (min., max., avg, dev, etc.)

3.4

command

controllable data for system behaviour

EXAMPLE Enable/disable, activate/deactivate.

3.5

communication function

function used by an actor to configure, perform and monitor the information exchange with wind power plants

EXAMPLE Operational function, management function.

3.6

control

operational function used for changing and modifying, intervening, switching, controlling, parameterization and optimizing of wind power plants

**3.7
counting value**

total number of occurrences of a specific event

**3.8
data retrieval**

operational function used for collecting of wind power plant data

**3.9
diagnostics**

management function used to set up and provide for self-monitoring of the communication system

**3.10
electrical system**

~~component of a wind power plant responsible for collecting and transmitting the energy produced in wind turbines~~

set of electrical components working together as parts of a wind turbine or wind farm for collecting and transmitting the produced electricity in a wind power plant

**3.11
event**

state transition (status, alarm, command)

**3.12
intelligent electronic device
IED**

any device incorporating one or more processors, with the capability to receive data from an external sender or to send data to an external receiver

EXAMPLE Wind turbine controller.

Note 1 to entry: An IED may have connections as a client, or as a server, or both, with other IEDs.

Note 2 to entry: This note only applies to the French language.

**3.13
information**

content of communication

Note 1 to entry: The basic element is raw data from the wind power plant components, which shall be processed into specified information according to IEC 61400-25 (all parts).

Note 2 to entry: Wind power plant information categories are: source information (analogue and state information), derived information (statistical and historical information). Information is defined as data (usually processed and derived data, and information describing other data).

**3.14
information exchange**

communication process between two systems, such as wind power component and actor, with the goal to provide and to get relevant information

Note 1 to entry: Information exchange requires specific communication functions, consisting of one or more services.

**3.15
information model**

model representing knowledge concerning functions and devices in which the functions are implemented

Note 1 to entry: This knowledge is made visible and accessible through the means of IEC 61400-25 (all parts). The model describes in an abstract way a communication oriented representation of a real function or device.

3.16

log

~~wind power plant~~ historical information

Note 1 to entry: Log is a chronological list of source information for a period of time.

3.17

logging

operational function

Note 1 to entry: Logging is the praxis of recording sequential data, often chronologically. The result of logging is a log.

3.18

logical device

entity that represents a set of typical wind power plant functions

3.19

management function

function required for the administration of the information exchange in a certain level

Note 1 to entry: Management functions are user/access management, time synchronization, diagnostics, and configuration.

3.20

mandatory

~~defined content shall be~~ provided in compliance to IEC 61400-25 (all parts)

3.21

measured data

sampled value of a process quantity with associated data attributes such as time stamp and quality

3.22

meteorological system

component of a wind power plant responsible for the monitoring of the ambient conditions, for example the wind speed, wind direction, pressure, temperature, ~~etc.~~

Note 1 to entry: It supplies data for various purposes for example to correlate the meteorological data to the electrical energy output by individual wind turbines to the potentially usable wind energy.

3.23

monitoring

operational function used for local or remote observation of a system or a process for any changes which may occur over time

Note 1 to entry: The term can also be used for observation of the behaviour of a data value or a group of data values.

3.24

operational function

function to obtain information and to send instructions for the normal daily operation of wind power plants

Note 1 to entry: Types of operational function are: monitoring, logging, reporting, data retrieval, control.

3.25

optional

~~defined content can be~~ optionally provided in compliance with IEC 61400-25 (all parts)

3.26

parameter

controllable information intended for obtaining or correcting a system behaviour

3.27

processed data

measured value, with the associated data attributes such as time stamp and quality, which has been processed according to the calculation method attribute

3.28

profile(s)

format(s) used by a particular protocol to transmit data objects or commands, etc.

3.29

protocol stack

particular software implementation of a computer networking protocol suite

Note 1 to entry The terms are often used interchangeably. Strictly speaking, the suite is the definition of the protocols and the stack is the software implementation of them.

3.30

report

actual information sent by the function reporting

Note 1 to entry: A report can contain all kinds of information defined in IEC 61400-25-2.

3.31

reporting

operational function to transfer data from a server to a client, initiated by a server application process

3.32

supervisory control and data acquisition

SCADA

system based on a processor unit which receives information from IEDs, determines the control requirements and sends commands to IEDs

Note 1 to entry: SCADA is a computer system that for example dispatchers use to monitor the power distribution throughout a service or control area.

Note 2 to entry: This note only applies to the French language.

3.33

status

state condition of a component or system (st1/st2/..stn)

3.34

statistical information

result of applying a statistical algorithm to a set of data in order to get, for example, minimum, maximum, mean standard deviation

3.35

timing data

time duration of a specific state

3.36

time synchronization

coordination of occurrences to operate in unison with respect to time

Note 1 to entry: This process can be a premeditated arrangement set forth on a parallel time scape, or it can be an observable coincidence in eventuality.

3.37

three phase data

measured value in a three phase electrical circuit with associated data attributes such as time stamp, quality and calculation method

3.38

transient log

event triggered chronological list of high resolution information for a short period of time (event driven report)

3.39

user/access management

management function used for setting up, modifying, deleting users (administratively), assigning access rights (administratively) and monitoring access

Note 1 to entry: A management function does not necessarily include communication services.

3.40

wind power plant

complete system consisting of any number of technical subsystems referred to in IEC 61400-25 (all parts) as wind power plant components, for example one or more wind turbines

Note 1 to entry: The main objective of a wind power plant is to generate electrical energy from the wind.

3.41

wind power plant analogue information

continuous information concerning the actual condition or behaviour of a component or system

NOTE EXAMPLE Measured value, processed value, three phase value, setpoint, parameter.

3.42

wind power plant component

technical system employed in the operation of wind power plants, such as wind turbine, meteorological, electrical and wind power plant management system

3.43

wind power plant management system

component of a wind power plant, which is responsible for ensuring that the complete system adapts itself to the static and dynamic conditions and requirements of the electrical power connection (i.e., interoperation of the WTs with substation and other power network related devices)

Note 1 to entry: A wind power plant management system may include other functions (e.g. Shadow control functionality, noise or sound reduction, ice warning, lightning protection) not modelled in IEC 61400-25 (all parts).

3.44

wind turbine

main component of a wind power plant

Note 1 to entry: It is responsible for generating energy and meets the task of using the wind potential of a certain location that converts kinetic wind energy into electric energy.

4 Abbreviated terms

ACSI	abstract communication service interface (defined e.g. in IEC 61850-7-2)
CDC	common data class
CMS	condition monitoring system
DC	data class
DNP3	distributed network protocol version 3
IED	intelligent electronic device
IEM	information exchange model
LCB	log control block
LD	logical device
LN	logical node
O&M	operation and maintenance
OSI	open systems interconnection
RCB	report control block
SCADA	supervisory control and data acquisition
SCSM	specific communication service mapping (defined e.g. in IEC 61850-8-1)
WPP	wind power plant
WT	wind turbine
XML	extensible mark-up language

5 Overall description of IEC 61400-25 (all parts)

5.1 General

The main objective of IEC 61400-25 (all parts) is to create a standard basis for manufacturer-independent communications for monitoring and control. Manufacturers and suppliers of wind power plant components shall implement IEC 61400-25 (all parts) in their devices and systems.

Clause 5 provides a general overview of the context, models, modelling approach, and application possibilities of IEC 61400-25 (all parts).

Subclause 5.2 provides a top-down view on wind power plants and shows the areas where IEC 61400-25 (all parts) can be applied. It explains what is to be understood under the term 'wind power plant', which operation concepts are distinguished and which components are used to run wind power plants.

Subclause 5.3 describes the demands made with reference to the communication taking place within the framework of the monitoring and control of wind power plants. It explains which general communication capabilities wind power plants shall possess and which contents and functions are required for communication.

Subclause 5.4 provides an overview of the communication model defined by IEC 61400-25 (all parts). The server-client communication environment that served as the basis when developing IEC 61400-25 (all parts) is introduced briefly. Next, three server-client application topologies are introduced, illustrating the communication architectures that are possible by way of an example. Finally, the three areas defined by IEC 61400-25 (all parts) to be implemented as the standard for the monitoring and control of wind power plants will be introduced on a generally understandable level.

5.2 Top-down view on wind power plants

5.2.1 Definition of wind power plants

Wind power plants constitute complete systems consisting of any number of technical subsystems with clearly separated tasks. The subsystems are referred to ~~in the further discourse~~ as wind power plant components and will be described in 5.2.2.

5.2.2 Wind power plant components

Wind power plant components are technical systems employed in the operation of wind power plants. They consist of various sub-components, ~~which will not be differentiated in the following~~. All wind power plant components fall within the application area of IEC 61400-25 (all parts).

The information modelled in IEC 61400-25 (all parts) covers the following corresponding components:

Wind turbine

- rotor,
- transmission,
- generator,
- converter,
- nacelle,
- yaw system,
- tower,
- alarm system.

Meteorological system

- meteorological conditions of the wind power plant.

Wind power plant management system

- wind power plant control.

Electrical system

- wind power plant grid connection.

Condition monitoring system (CMS)

- ~~process with the purpose of observing components or structures of a wind turbine or wind power plant for a period of time.~~

The wind turbine (with its many sub-components) is the main component of a wind power plant. The wind turbine is responsible for generating energy and meets the task of using the wind potential of a certain location to convert wind into electrical energy.

Vendors of wind turbines usually guarantee their customers a certain power curve and technical availability in terms of energy production. To enable both the operators and owners to verify the guaranteed performance of the wind turbines used, well-founded data providing information on the wind conditions at the particular location shall be available.

~~According to the standard IEC 61400-12-1,~~ A separate wind power plant component, the reference met mast, referred to ~~in the further discourse~~ as a meteorological system, should be used for the measuring of the wind conditions, for example the wind speed, at a particular location. The meteorological system supplies the data that may be required to correlate the

produced power output of individual wind turbines to the useable wind potential. On this basis, it is possible to draw well-founded conclusions as to the real performance of a certain wind turbine.

In addition to several wind turbines, integrated operation requires further components; the energy produced in decentralized feeder and/or substations shall be collected and transported to the final user via suitable power networks. This task is covered by the electrical system.

NOTE All electrical system issues concerning substations are targeted in the scope of IEC 61850 (all parts).

Another component, the wind power plant management system, ensures that the complete system adapts itself to the static and dynamic conditions and requirements of the electrical power connection (substation, utility network).

5.3 Generic requirements on communication

5.3.1 Communication capability

Wind power plants are monitored and controlled by various external actors, such as local or remote SCADA systems, local real time build-in control systems, energy dispatch centres.

The objective of the monitoring of wind power plants is to provide the actors with information on the complete system and the installed components. This information is deemed to be an important knowledge basis for the control of wind power plants. For example, a SCADA system which wants to stop the operation of a certain wind turbine in an integrated operation, shall know how this component can be identified within the complete system and in which status it is currently operating. The SCADA system shall, however, also know to which device within the integrated operation it shall send which commands to make sure that the relevant component is controlled as intended. To be able to check whether or not the command has been executed, the SCADA system additionally requires a feedback from the wind power plant.

Thus, wind power plants and external actors shall meet an essential prerequisite to be able to exchange information within the framework of monitoring and control: they shall be able to communicate with the outside world.

Typically, any wind power plant component, which needs to exchange information with other components and actors, is therefore equipped with a so-called intelligent electronic device (IED), which can send data to external receivers and receive data from external senders. A wind turbine usually possesses a wind turbine controller, which is primarily responsible for the internal monitoring and control of the wind power plant component, but also allows external monitoring and control.

5.3.2 Communication content

Information is the content of the communication that takes place within the framework of monitoring and control. The basic elements are raw data from the wind power plant component, which shall be processed into specified information according to IEC 61400-25 (all parts). There are five types of information that can be differentiated and are important for the monitoring and control of wind power plants:

- process information,
- statistical information,
- historical information,
- control information,
- descriptive information.

Process, statistical and historical information provide the contents required for the monitoring and control of wind power plants; this information shall be communicated by the wind power

plants. Process information provides information on the behaviour of certain complete systems and their components, on their current states. Statistical information is often useful to evaluate the operation of a wind power plant. By using historical information, it might be possible to track the operational trends in logs and reports.

Control information is intended to transmit the contents required for the control of wind power plants, such as access profiles, set points, parameters and commands; this information shall first be communicated to wind power plants by certain actors. Wind power plants shall store control information and provide this for further communication to sub-processes.

Descriptive information is the type and the accuracy of the information, as well as the time and the data description.

5.3.3 Communication functions

The actors communication for monitoring and controlling the wind power plants require special functions to configure, perform and monitor the information exchange with wind power plants. These functions can be divided into the following two main categories:

- operational functions,
- management functions.

While operational functions are within the scope of IEC 61400-25 (all parts), the management functions are outside the scope of IEC 61400-25 (all parts) because they are implementation specific.

Operational functions (manual or automatic) are used by the actors to obtain information on wind power plants and to send control instructions to wind power plants. The operational functions include:

- monitoring,
- control,
- data retrieval,
- logging,
- reporting.

Table 1 provides an overview of the ranges of application of the operational functions.

Table 1 – Operational functions

Operational functions	Range of application (practical use)
Monitoring	Operational function used for local or remote observation of a system or a process for any changes which may occur over time. The term can also be used for observation of the behaviour of a data value or a group of data values.
Control	Changing and modifying, intervening, switching, controlling, parameterization, optimizing of wind power plants.
Data retrieval	Collecting of wind power plant data.
Logging	Logging is a function intended for sequential recording of data and events in chronological order. The result of the logging is a log.
Reporting	The reporting is a function intended to transfer data from a server to a client, initiated by a server application process.

Management functions are required for the higher-level management of the information exchange. They are used by actors to secure integrity of the monitoring and control process. The management functions included are as follows:

- user/access management,
- time synchronization,
- diagnostics (self-monitoring),
- system setup.

Table 2 provides an overview of the ranges of application of the management functions.

Table 2 – Management functions

Management functions	Range of application (practical use)
User/access management	Setting up, modifying, deleting users (administratively), assigning access rights (administratively), monitoring access
Time synchronization	Synchronization of devices within a communication system.
Diagnostics (self-monitoring)	This function is used to set up and provide for self-monitoring of the communication system.
System setup functions	Defining how the information exchange will take place; setting, changing and receiving (retrieval) of system setup data.
NOTE Time synchronization is covered in IEC 61400-25-4.	

5.4 Communication model of IEC 61400-25 (all parts)

5.4.1 General

IEC 61400-25 (all parts) defines a communication model for the monitoring and control of wind power plants, taking into account all requirements made with reference to the communication, on an abstract level. The communication model comprises three separately defined areas:

- information model,
- information exchange model,
- mapping of the information model and the information exchange model to standard communication profiles.

The communication model is embedded in an abstract environment where two entities may communicate via a common communication channel. These two entities are referred to ~~in the further discourse~~ as server and client (see Figure 1). The server assumes the role of an information and service provider supplying the client with the contents and functions required for the communication. The client assumes the role of a user who possesses certain rights to use and manage the server.

IEC 61400-25 (all parts) leaves it open how and in which physical device the server is to be implemented in practice. The objective of IEC 61400-25 (all parts) is that the information associated with a single wind power plant component (such as the wind turbine) is accessible through a corresponding logical device. Also, IEC 61400-25 (all parts) does not specify how objects in the wind power plant information model are distributed among the servers.

5.4.2 Information model

The wind power plant information model (see Figure 2) provides the contents required for the information exchange that takes place within the framework of the monitoring and control between client and server.

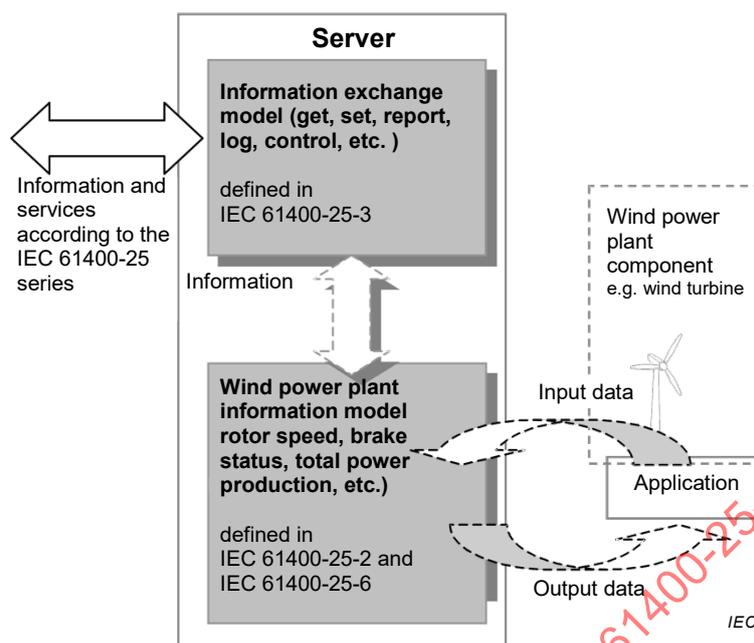


Figure 2 – Data processing by the server (conceptual)

The model is deemed to be a standard frame of interpretation via which the server may process all data, which is provided by wind power plants for the external monitoring and control, into relevant and semantically standardized information, and may grant the client access to these data in a component-oriented view.

When developing the wind power plant information model, the paradigm of object orientation has been taken into account. This approach allows wind power plants to be viewed as information objects and modelling of an appropriate information architecture.

IEC 61400-25 (all parts) utilizes the concept of object modelling to represent the systems and components of a wind power plant to communicate with. This means that all of the components in the real world are identified as objects that have data such as analogue values, binary status, commands and set points and these objects and data are mapped into generic, logical representations of the real world components as a wind power plant information model.

Breaking a real world component down into objects to produce a model of that object involves identifying all of the data and functionality of each component object. Each data has a name and a simple or complex type (a class) and represents data in the device to be read or updated.

Instead of dealing with lists of numbered quantities, an object-modelling approach lets us organize and define standard names for standard things, independent of the manufacturer of the equipment. If the equipment has a shaft for which the rotational speed is available for reading, it has the same name regardless of the vendor of that equipment and can be read by any client programme that knows the information model.

In addition to reading and updating process information, other functionalities of the device may include things such as historical logs of information, report by exception capabilities, and actions within the device that are initiated by internal or external command and control inputs. All of these items imply some type of information exchange between the outside world and the real world device represented by the wind power plant information model.

Clause 6 describes in more detail the logical structure of the wind power plant information model and the method by which wind power plants shall be modelled as information objects.

5.4.3 Information exchange model and relation to wind power plant information models

The information exchange mechanisms rely on standardized wind power information models. These information models and the modelling methods are the core of IEC 61400-25 (all parts). IEC 61400-25 (all parts) uses the approach to model the information found in real components as depicted in the conceptual overview in Figure 3. All information made available to be exchanged with other components is defined in IEC 61400-25 (all parts). The model provides for the wind power plant automation system an image of the real world (power system process, generator, etc.).

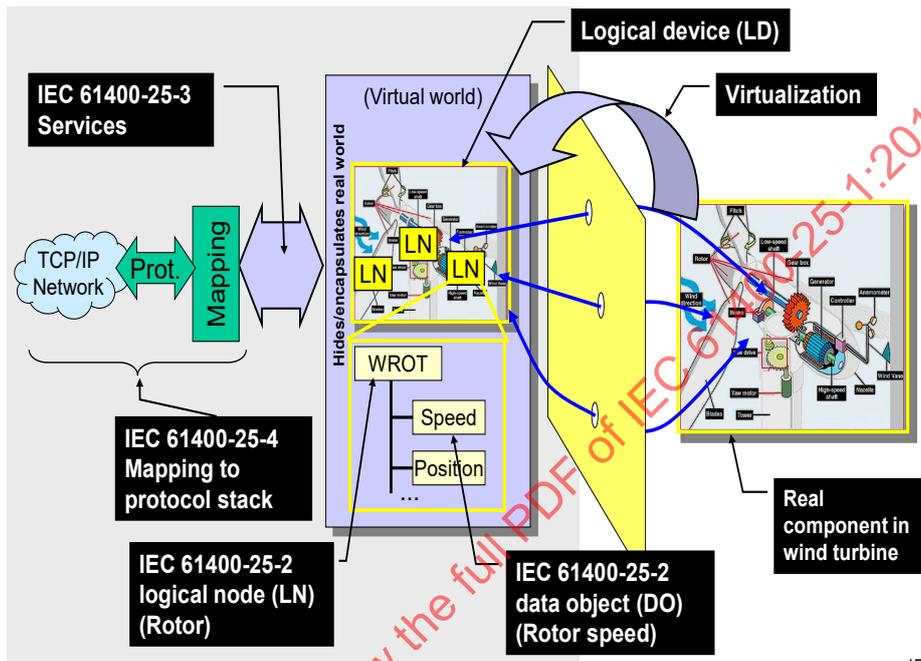


Figure 3 – Modelling approach (conceptual)

IEC 61400-25 (all parts) defines the information and information exchange in a way that is independent of a concrete implementation (i.e., it uses abstract models). IEC 61400-25 (all parts) also uses the concept of virtualization. Virtualization provides a view of those aspects of a real device that are of interest for the information exchange with other devices. Only those details that are required to provide interoperability of devices are defined in IEC 61400-25 (all parts).

The approach of IEC 61400-25 (all parts) is to decompose the functions components into the smallest entities, which are used to exchange information. The granularity is given by a reasonable distributed allocation of these entities to dedicated devices (IEDs). These entities are called logical nodes (e.g. a virtual representation of a rotor class, with the standardized class name WROT). The logical nodes are modelled and defined from the conceptual application point of view. Logical nodes are collected in a logical device representing for example a complete wind turbine.

Real components on the right hand side of Figure 3 are modelled into a virtual model in the middle of the figure. The logical nodes correspond to functions in the real physical devices. In this example, the logical node WROT represents a specific rotor of the turbine to the right.

Based on their functionality, a logical node contains a list of data (e.g. rotor speed) with dedicated information. The data have a structure and a well-defined semantic (meaning in the context of wind power plant systems). The information represented by the data is exchanged by the services according to the information exchange services defined.

The logical nodes and the data contained are crucial for the information model and the information exchange services for wind turbines to reach interoperability.

The logical nodes and the data contained are configured by the control information, for example parameters, commands to be accepted, set point ranges.

5.4.4 Mapping to communication profile

The information exchange between server and client requires a uniform communication protocol on both sides. A specific mapping to a communication profile defines how the objects in the wind power plant information model and the functions and services defined in the information exchange model are implemented using a specific protocol stack, i.e. a complete communication protocol. IEC 61400-25-4 specifies in detail the communication protocols applied in IEC 61400-25 (all parts).

The mapping to protocol stacks specified in IEC 61400-25-4 is oriented in its structure towards the OSI reference model (ISO/IEC 7498-1:1994). According to the OSI reference model, the communication realized between client and server is divided into seven layers. Whereas layer 7, 6 and 5 are concerned with application issues (often named as the A-Profile), the lower four layers are concerned with data transport issues (often named as the T-Profile).

6 Wind power plant information model

6.1 General

Clause 6 provides a detailed description regarding the wind power plant information model. Common wind power plant relevant information is defined, structured and described unambiguously from the viewpoint of object orientation.

Subclause 6.2 describes the modelling methodology used to represent and structure relevant information.

~~IEC 61400-25-2 defines logical nodes to group related information. It also defines common data classes as building blocks that contain wind power plant specific properties of the information. This part also comprises the common data classes inherited from IEC 61850-7-3.~~

6.2 Information modelling methodology

6.2.1 Wind power plant information

~~For modelling purposes, information could be LNs, data or data attributes. Data consists of data attributes that can be for example the value (of a measurand, state, setpoint etc.), accompanying name, time, quality, accuracy, unit etc.~~

A wind power plant comprises different types of information. Besides source data, wind turbine controllers power plant components usually derive a huge amount of additional information (10 min-averages, alarms, logs, counters, timers, etc.). This valuable information is locally stored and available for future use or analysis. In Table 3, the relations between different information categories are shown and their definition will be used in IEC 61400-25 (all parts).

Table 3 – Wind power plant information categories

Category	Description
Process information	
State information	Discrete information concerning the current condition or behaviour of a component or system
Status	Condition of a component or system (st1/st2/..stn)
Alarm	Statement of safety intervention by, for example, the turbine control system
Event	State transition (status, alarm, command)
Analogue information	Continuous information concerning the current condition or behaviour of a component or system
Measured data	(Sampled) value of a process quantity
Processed data	Measured value, which has been processed (10 min-average/...)
Three phase data	Measured value of a three phase electric power quantity
Control information	
Control information	Discrete information concerning the current condition or behaviour of a component or system
Command	Controllable status for system behaviour (enable/disable, activate/deactivate, etc)
Set point	Reference value for a process quantity
Parameter	Controllable value for system behaviour (adjustment)
Derived information	
Statistical information	The result of applying a statistical algorithm to a set of data
Timing data	Total time duration of a specific state
Counting data	Total number of occurrences of a specific event
Characteristic data	Properties of information or data observed (min., max., average, standard deviation, etc.)
Historical information	Information about the time passed
Log	Chronological list of events for a specific period of time
Transient log	Event triggered chronological list of high resolution source information for a short period of time
Report	Periodical notification comprising the information that represent the state and data requested in the report control block

6.2.2 Modelling approach

Because all the information categories as listed in Table 3 comprise their own formats and properties, IEC 61400-25 (all parts) has to define a general wind power plant information model. The structure of this top-down view model is hierarchical and based on the modelling approach as defined in IEC 61850-7-1:2011, Clause 6 (~~Modelling approach of the IEC 61850 series~~) where the basis is described in IEC 61850-7-2:2003 2010, Clause 5. Hierarchical means that different levels of common information are distinguished and grouped together into classes. Lower level classes will automatically inherit properties as specified by upper level classes. The structure of the wind power plant information model is concisely given in Figure 4. Each level will be discussed separately in more detail.

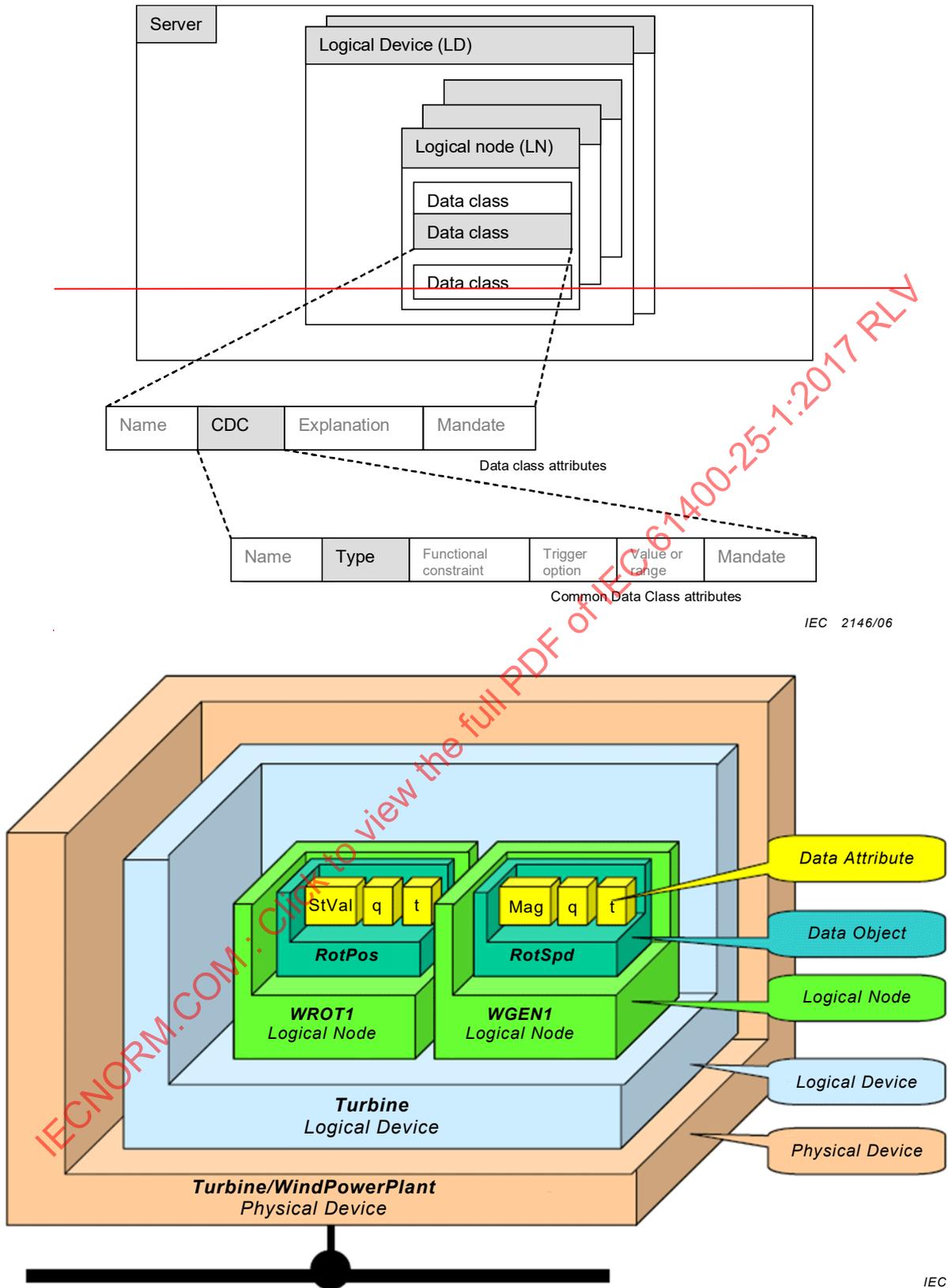


Figure 4 – Structure of wind power plant information model

~~The highest level is called Logical Device (LD), which is decomposed into Logical Nodes (LN). A logical node consists of a collection of related data, called data classes (DC). Each data class inherit a collection of properties, as defined by a so-called Common Data Class (CDC) to which it is assigned. A common data class consists of a collection of data records. The most basic detail of data can be found in the type definition of a common data class.~~

The highest level of modeling within a physical device is called logical device (LD) and aggregates one or more logical nodes (LN). A logical node itself aggregates one or more data objects (DO). Data objects aggregate then again one or more data attributes (DA). The definition, which data attributes are aggregated by a data object, is determined by a common data class (CDC) of which a data object is a type of. Both, data objects and data attributes can be nested as given in Figure 5.

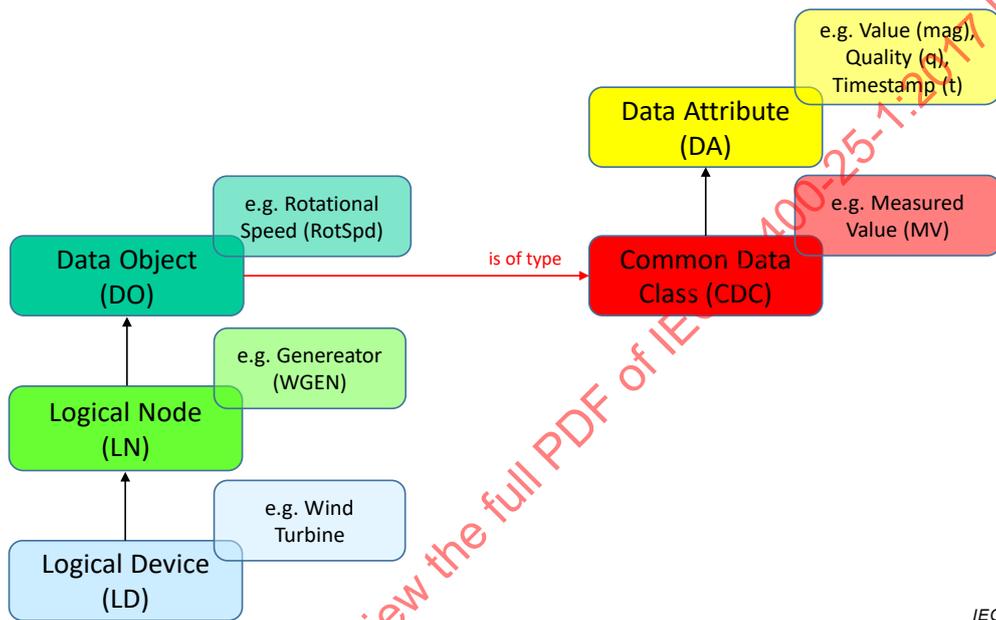


Figure 5 – Role of common data classes (CDC) in WPP information model

6.2.3 Logical devices

A server hosts at least one logical device. IEC 61400-25 (all parts) could for example be used to assign a logical device to a specific wind turbine of a wind power plant. Thus a logical device contains a collection of specific logical nodes belonging to this wind turbine. The logical node zero (LLN0) is destined to provide common information about the logical device (e.g. logical device nameplate and health) and the logical node physical device (LPHD) represents common data of the physical device that is hosting the logical device (e.g. physical device nameplate and health).

6.2.4 Logical nodes

Within a logical device, all wind turbine information will be distributed in different 'containers', called logical nodes. In IEC 61400-25 (all parts) a set of specific logical node classes for wind power plants have been specified (IEC 61400-25-2), some of these shall be mandatory (indicated with an 'M' in tables) and others optional (indicated with an 'O' in tables). The basic rules for the use of logical nodes and data ~~classes~~ objects and their extensions are defined in ~~Annex A of IEC 61850-7-4 and~~ Clause 14 of 61850-7-1:2011. The specific LNs are originated by a physical turbine break down into ~~functional systems~~ components (e.g. rotor, transmission, generator, yaw system), but collections of common information can also be represented in a specific LN (e.g. alarm log, event log). The names of wind power plant specific logical nodes shall be unique and always begin with 'W', followed by three capitals representing the content.

The logical node data is represented by named attributes that can have simple or complex types (a 32 bit integer or a complex structure variable made up of a collection of named simple and complex component types). ~~In the first generation of wind power plant communications, this data would have been represented as a linear, memory mapped address space with all data having the same type.~~ In this model, this data is named and has whatever types are appropriate to represent the underlying data. The specific internal organization and implementation of the data storage and management scheme are independent of the outside world view.

Inside a LN, information is specified by data ~~classes~~ objects. All logical nodes have a standardized and similar table structure as shown in Table 4. The table represents and visualizes the different data ~~class attributes~~ objects in a logical node.

Table 4 – General table structure of a logical node (LN)

Wxxx class			
Attribute Data Object Name	Attribute type Common Data Class	Explanation	M/O
Data Objects			
<i>Common information</i>			
Data Object class name	CDC	Description and range	
<i>Status information</i>			
Data Object class name	CDC	Description and range	
<i>Analogue Information Measured and metered values</i>			
Data Object class name	CDC	Description and range	
<i>Control Information Controls</i>			
Data Object class name	CDC	Description and range	

For the sake of convenience, all information in a logical node is categorized in compliance with the wind power plant information decomposition of Table 3.

In Table 5 all data class attributes inside a logical node are explained briefly.

Table 5 – Data class attributes in a logical node

Data class attribute	Description
Attribute Data Object Name	Name of the data class object
Attribute Type Common Data Class	Common data class that defines common data properties. The CDCs are defined in IEC 61400-25-3
Explanation	Short explanation of the content of the data class
Mandate	M: Mandatory, O: Optional

If an optional logical node is used, its mandatory (M) data class attributes shall also be used. Optional (O) defined data class attributes are instantiated as needed by the user.

7 Wind power plant information exchange model

7.1 General

Clause 7 provides an overview of the information exchange models that can be applied by a client and a server to access the content and structure of the wind power plant information model defined in Clause 6.

7.2 Information exchange modelling methodology

7.2.1 Wind power plant information exchange

The primary objective of the wind power plant information exchange model defined in IEC 61400-25-3 is to exchange information provided by the instantiated information model of the various classes, such as logical nodes, data objects, data attributes or control blocks. The IEM defines a server that provides:

- an instance of the wind power plant information model, and
- required functions including the associated services (Get, Set, Control, Query, Report, etc.) which enable a client to access the instantiated information model.

IEC 61400-25 (all parts) defines the server role only. A client issues service requests to the server, by sending request messages, and receives response messages or reports from the server.

A server provides access to its wind power plant information model instance for multiple clients, as illustrated in Figure 6. Each client can, independently of other clients, communicate with the server.

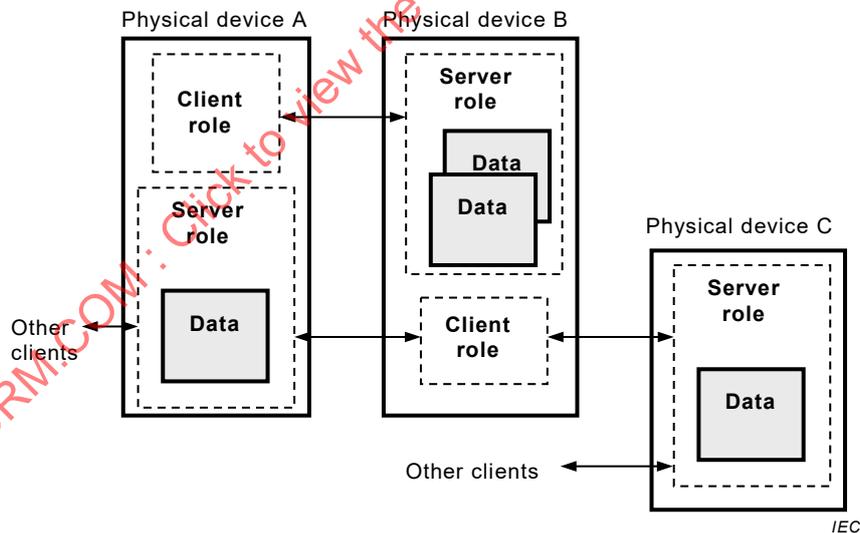


Figure 6 – Client and server role

As shown in Figure 6, physical devices may implement the client, the server role, or both roles.

The client plays the complementary role of the server with regard to the services.

NOTE IEC 61400-25 (all parts) does not define any application program interface – neither in the server nor in the client. It defines the externally visible view of the information contained in the server and how this information can be sent and received.

7.2.2 Service models

The wind power plant information model in the server supports the access services as depicted in Figure 7.

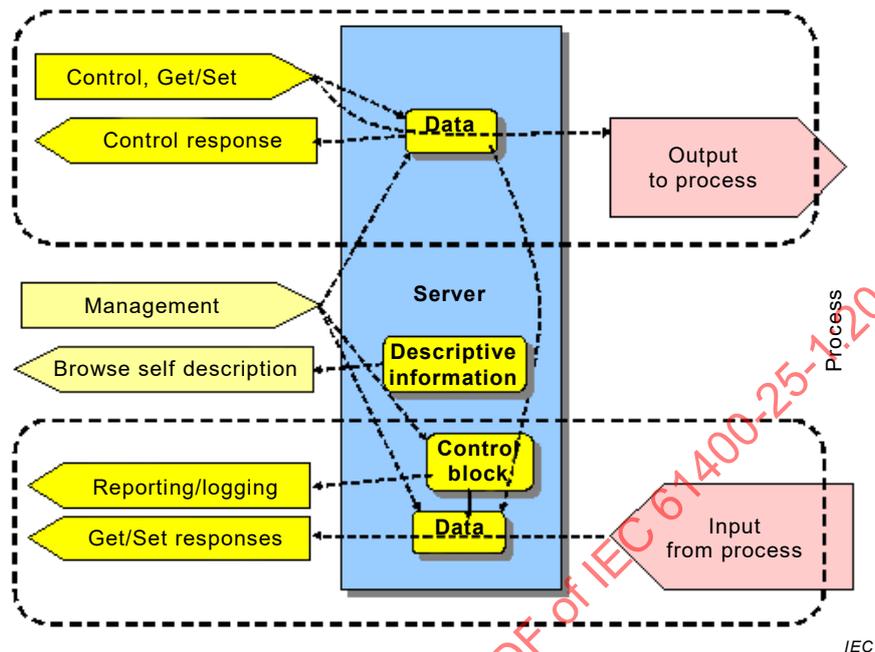


Figure 7 – IEM service models

The focus of the server is to provide data that make up the wind power plant information model. The data attributes contain the values used for the information exchange. The IEM provides services for:

- control of external operational devices or internal device functions,
- monitoring of both process and processed data, and
- management of devices as well as retrieving the wind power plant information model.

The wind power plant information model data instances contained in the server can be accessed by the services Get, Set, Control for immediate action (return information, set values to data, control device or function).

Reporting and logging provide the means to autonomously and spontaneously send information from the server to the client issued by a server-internal event (reporting) or to store this information in the server for later retrieval (logging).

7.2.3 Abstract communication service interface

The set of basic services that the communications interface uses to accomplish the information exchange between the outside world and various components of the real world device are referred to as the abstract communication service interface (ACSI). The basic methodology of these services is described in detail in IEC 61850-7-1 and IEC 61850-7-2. Table 6 of IEC 61850-7-1:2011 describes the ACSI models and services. The following describes the services in the specific wind power plant context.

Figure 8 graphically illustrates the various components of the ACSI models. This figure is used to provide a narrative description of how a typical device interacts with the outside world using these services.

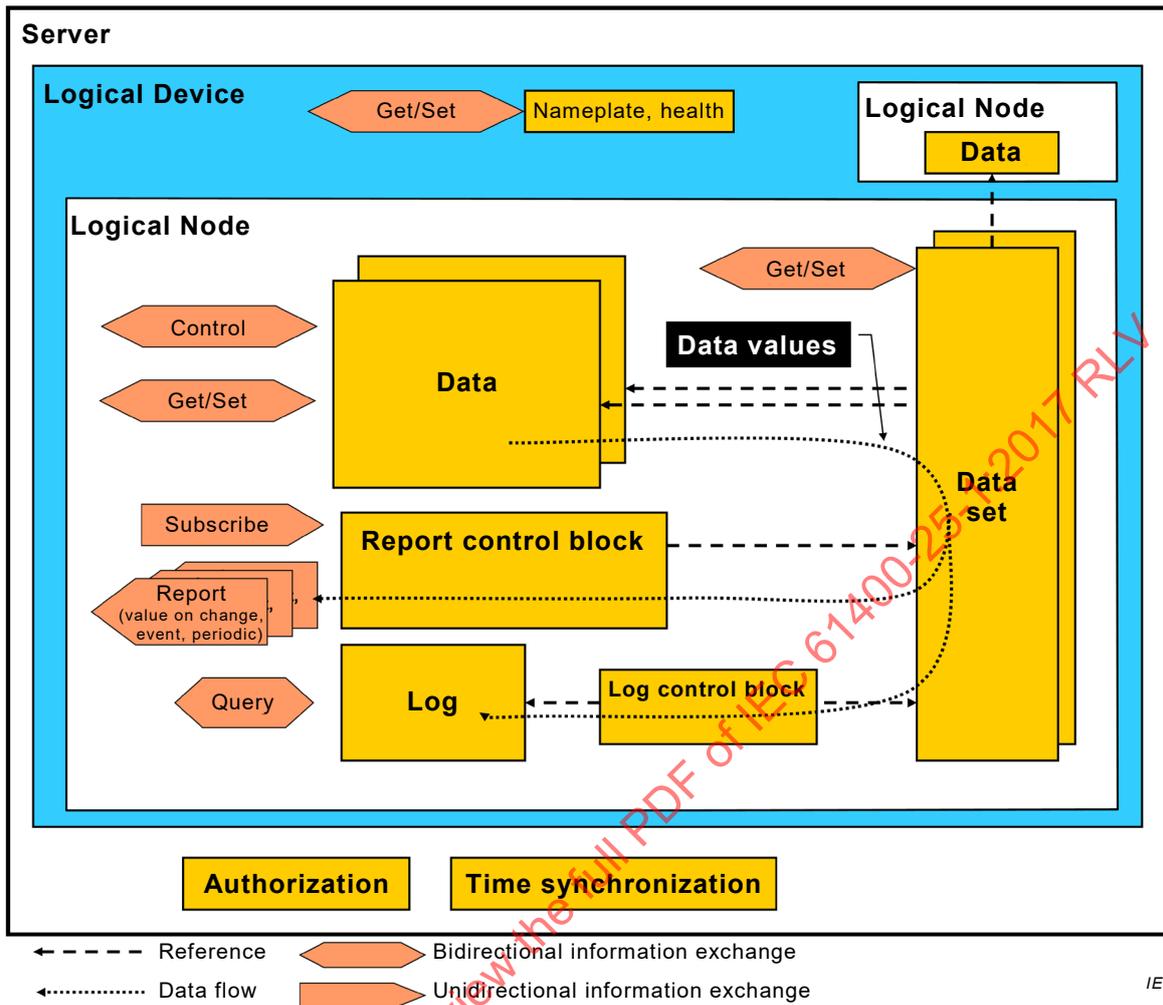


Figure 8 – Conceptual information exchange model for a wind power plant

A physical device with a communications interface is represented as a server. It has a communication network address and is accessible over a network by an external client. The server can accept a connection from one or more external clients, authenticate that connection, and support services to provide information to the client. This server contains one or more logical devices, which contains one or more logical nodes that represent the basic building blocks (objects) that represent various functionalities of the logical device. The logical node contains data that can be written to or read individually and in groups (data sets), responds to control inputs, provides solicited and unsolicited reports, and contains logs that can be queried. This representation is generic, but quite powerful in terms of the services it provides and can be used to represent any real world physical device with a communications interface.

Get/Set and Control services are provided to read (get) and write (set) the data in the logical node. Analogue information and status information are normally read only. Control and configuration information are generally read and write. Services are provided to facilitate concepts such as select before operate for control applications.

In addition to individually named data, collections of data (a Data Set) can be defined and given a name. Services are provided to create, delete and list Data Sets, and to get and set values of Data Sets. This arbitrary grouping capability lets client applications define collections of data attributes that are commonly needed and retrieve them with a single get operation using a single name.

Data Sets are the key to two information exchange mechanisms in a logical node – reporting and logging. Most physical devices have some kind of internal logging mechanism. These logs may contain periodic recordings of data values, recordings of data values when the value changed by some amount, exceeded a threshold, or some other triggering mechanism. Similarly, physical devices often have the means to send some kind of report directly to a subscribed client under circumstances similar to those just described for logging. In the ACSI models, the information that gets reported or logged is represented by a Data Set. This approach permits specifying the rules for logging and reporting to be defined in a more compact and efficient fashion.

The rules for logging and reporting are defined in the log control block (LCB) and report control block (RCB) respectively. Each log has an associated LCB and each report has an associated RCB that defines the rules for what goes into the logs and reports. These rules determine which Data Set(s) are to be included and under what conditions. This approach provides a very powerful and flexible means of logging and reporting information.

Logs are often a very important aspect of a physical device. The generation of these logs may be the core function of the physical device (a condition monitoring device for example) or may be utilized for diagnostic information. Logs are time ordered collections of data grouped into defined Data Sets. Services are provided to permit an external client to retrieve information from the log either in whole or in part. This is accomplished by providing the means to query the log with filters that specify a time range of interest and which named attributes are to be retrieved.

Services are also provided to permit a client to subscribe to reports that have been defined in the device. These reports can be buffered so that if communications are temporarily disrupted, all of the reports are still sent to the client when communications are re-established.

This overview illustrates the core information exchange capabilities of a physical device using the ACSI approach. For more detailed description of the ACSI, refer to IEC 61850-7-1 and IEC 61850-7-2.

7.2.4 Service modelling convention

The services are generally defined by:

- a set of rules for the definition of messages so that receivers can unambiguously understand messages sent from a peer,
- the service request parameters as well as results and errors that may be returned to the service caller, and
- an agreed-on action to be executed by the service (which may or may not have an impact on process).

This basic concept of the IEM is depicted in Figure 9.

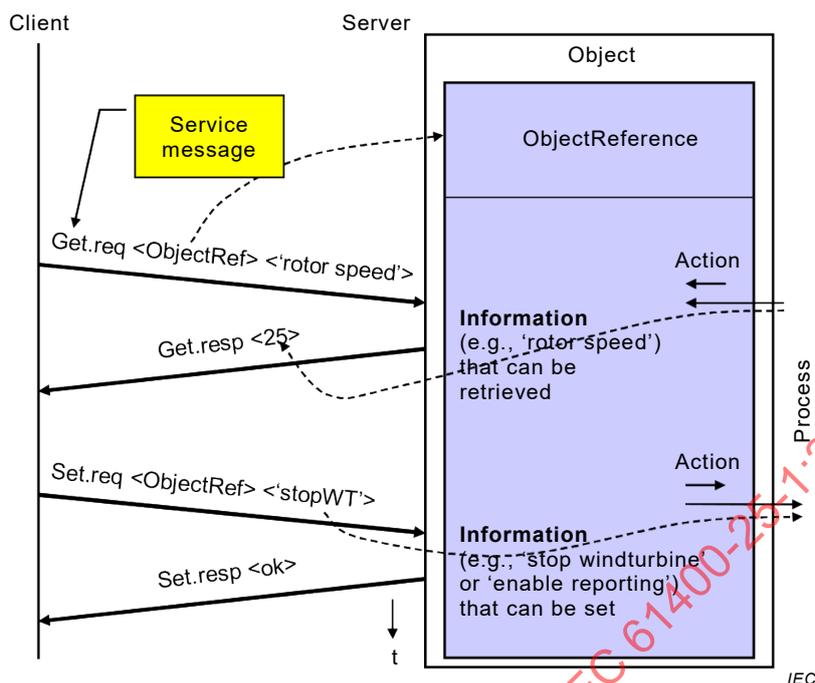


Figure 9 – IEM service model with examples

All services are based on three message primitives: request, positive response and negative response. The request primitive is used by the client to issue a service call to the server and the response primitives allow the server to return information to the client. A positive response primitive indicates that the service agreed-on action was or will be executed whereas a negative response indicates the action failed to execute or will not be executed. A message primitive may have a number of parameters, called results and errors in case of response primitives.

Each specific service is defined by one or more service tables that summarize the parameters that are required for the processing of a particular primitive as shown in Table 6.

Table 6 – Service table

Parameter name
Request
Parameter 1...
Parameter <i>n</i>
Response+
Parameter 1...
Parameter <i>n</i>
Response-
Parameter 1...
Parameter <i>n</i>

NOTE 1 The service tables of the services defined in IEC 61400-25-3 do not show all parameters required in concrete interface implementations; for example, the parameter 'association' or 'retransmission time' are not depicted in the service tables. These tables are abstract – local issues and concrete protocol issues are not shown. These specific issues are not required to understand the semantic and behaviour of the service.

Each parameter and the effect this parameter has on the processing of the service are abstractly described in this document.

The sequences of the request/response primitives (messages) for the services are depicted in Figure 10.

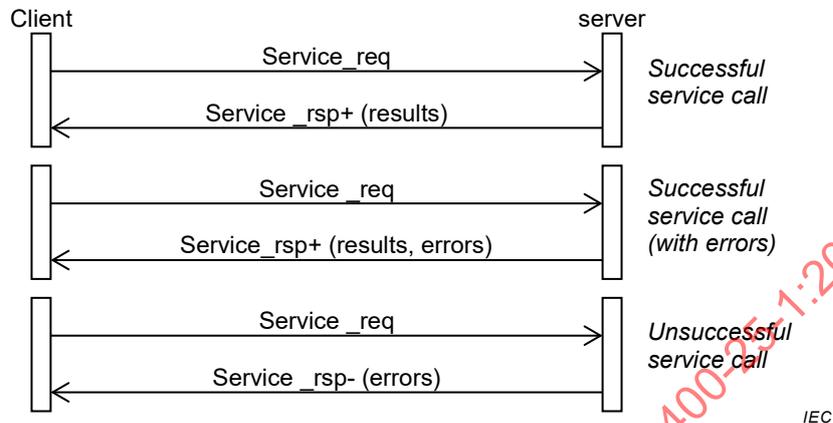


Figure 10 – Sequence diagram

The messages operate on the (attributes of) information objects. There are two kinds of classes that can be instantiated to objects:

- 1) The wind power plant information model classes such as logical devices, logical nodes, data **objects**, and data attributes as defined in Clause 6 (mainly representing process data, e.g. 'rotor speed' or 'stop wind turbine'), and
- 2) Various (common) control blocks, for example, for reporting and logging. The reporting control block may, for example, be accessed to start or stop reporting values by setting a specific attribute.

The messages described in this clause are conceptual – to understand the IEM.

NOTE 2 The concrete messages **may** **can** be defined by some well known notation, for example, tables or XML. Concrete messages can be found in the mappings to specific application layer protocols (see IEC 61400-25-4).

The agreed-on action or actions to be processed on the receipt of a message may be simple, as in the case of the service 'Get', or more complex, as in the case of controlling the behaviour of a real physical device. The later case requires precise description of how the control acts, for example, the server could immediately invoke the process control system to distribute the necessary internal commands to stop the wind turbine or it may first have to check if another client is operating the wind turbine, thus requiring the use of a semaphore (often called Select-before-Operate).

The dynamical behaviour of the reporting and logging models is controlled by common control blocks. The actions of a certain control block object are described by multiple attributes like number of entries/array-elements, which values to be reported or logged, period of periodic reporting/logging, or events to buffer in case the communication link is down. The dynamic behaviour is also influenced by the nature of the buffer, for example, circular buffer that wraps.

Actions usually produce results that have to be transmitted back to the client. In case of error occurrence, error messages are sent back. The actions are usually defined by various attributes, formal state machines and plain text.

8 Mapping to communication protocols

8.1 General

The specific communication service mapping (SCSM) defines how the services and the models (server, logical devices, logical nodes, data objects, data sets, report controls, log controls, setting groups, etc.) are mapped to specific communication stacks, i.e. to a complete profile. The mappings and the used application layer define the syntax (concrete encoding) for the data exchanged over the network.

NOTE The concept of the SCSM has been introduced to be independent from communication stacks including application protocols.

According to Figure 11, the SCSM maps the abstract communication services, objects and parameters to the specific application layers. These application layers provide the concrete coding. Depending on the technology of the communication network, these mappings may have different complexities, and some ACSI services may not be supported in all mappings but where a service is provided in a mapping, that service shall be equivalent in its meaning to the same service in the benchmark mapping. An application layer may use one or more stacks (layers 1 to 6).

EXAMPLE The mapping of the service 'GetDataSetValues' (reading many values in one chunk) may can have different mappings for AL1 to ALn. For example, a specific AL may can support this service directly while another AL supports Get of single values or many values of the same type only. In this case, the mapping has to issue issues several Gets.

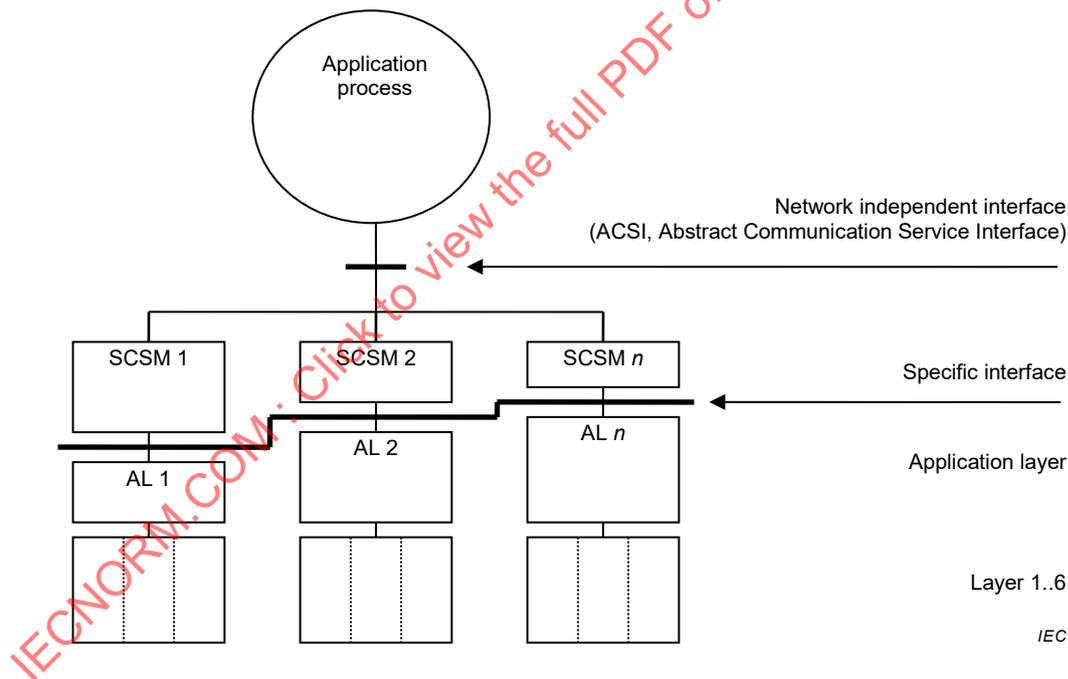


Figure 11 – ACSI mapping to communication stacks/profiles

8.2 Architecture of the mappings

Multiple mappings may be supported by IEC 61400-25 (all parts). The conceptual architecture of the mappings is shown in Figure 12.

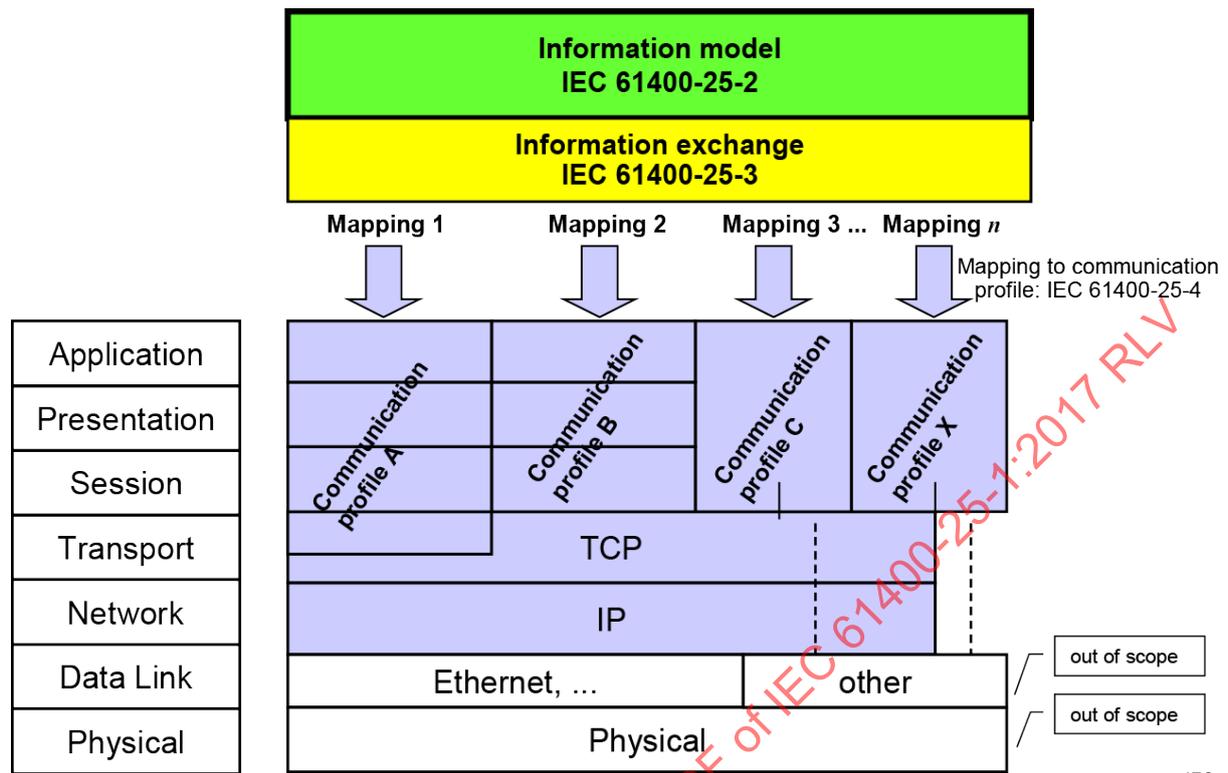


Figure 12 – Communication profiles

The information models and the information exchange models need to be mapped to appropriate protocols. Mapping requirements are defined in IEC 61400-25-4. The protocols TCP and IP shall be the basic lower layer protocols provided by all mappings. Specific data link and physical layers are beyond the scope of IEC 61400-25 (all parts).

8.3 Mapping of the wind power plant information model

The mapping of the wind power plant information models to a hierarchical structure as defined in Clause 6 and Clause 7 of IEC 61400-25-2:2015, shall be applied for all SCSMs of IEC 61400-25 (all parts).

Bibliography

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

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

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INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Wind energy generation systems –
Part 25-1: Communications for monitoring and control of wind power plants –
Overall description of principles and models**

**Systèmes de génération d'énergie éolienne –
Partie 25-1: Communications pour la surveillance et la commande des centrales
éoliennes – Description globale des principes et des modèles**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

WIND ENERGY GENERATION SYSTEMS –**Part 25-1: Communications for monitoring and control of
wind power plants – Overall description of principles and models**

FOREWORD

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International Standard IEC 61400-25-1 has been prepared by IEC technical committee 88: Wind energy generation systems.

This second edition cancels and replaces the first edition published in 2006. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) general harmonization of text and overview models with the other parts of the IEC 61400-25 series,
- b) harmonization of definitions in other related standards.

The text of this International Standard is based on the following documents:

CDV	Report on voting
88/587/CDV	88/622/RVC

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

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

The title of TC 88 was changed in 2015 from *Wind turbines* to *Wind energy generation systems*.

A list of all parts in the IEC 61400 series, published under the general titles *Wind turbines* and *Wind energy generation systems* can be found on the IEC website.

The users of IEC 61400-25 have formed a community, USE61400-25. For further information see <http://www.use61400-25.com>.

Attached to the release of the IEC 61400-25 standard series and in addition to the standard IEC maintenance process, a specific maintenance process is set up to handle technical issues raised after publication. Here are the main principles:

- Technical issues (called TISSUES) are collected from the release of the new document in cooperation with the user group for the IEC 61400-25 standard series USE61400-25.
- The collected TISSUES can be categorized in two groups:
 - TISSUES that can threaten interoperability between implementations of the standard and that need either corrections or clarifications (“IntOp” TISSUES),
 - TISSUES that propose new features that will be implemented in future versions of the standard (“next edition” TISSUES).
- IntOp TISSUES require immediate clarification and are following a transparent fixing process handled by the user group for the IEC 61400-25 standard series together with the editors of the IEC 61400-25 standard series.
- The detailed specification of this process, the list of TISSUES, associated fix, their status and impact on implementation and certification are accessible through the USE61400-25 web site <http://www.use61400-25.com>.
- IEC recommends implementing the proposed fixes to IntOp TISSUES, as soon as they have reached the “green” status. The list of TISSUES which are implemented in an intelligent electronic device (IED) should be transparently stated by its manufacturer.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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INTRODUCTION

IEC 61400-25 (all parts) is intended for vendors (manufacturers, suppliers), operators, owners, planners, and designers of wind power plants as well as system integrators and utility companies operating in the wind energy market. IEC 61400-25 (all parts) is intended to be accepted and to be used world-wide as the international standard for communications in the domain of wind power plants.

IEC 61400-25 (all parts) has been developed in order to provide a uniform communications basis for the monitoring and control of wind power plants. It defines wind power plant specific information, the mechanisms for information exchange and the mapping to communication protocols. In this regard, IEC 61400-25 (all parts) defines details required to exchange the available information with wind power plant components in a manufacturer-independent environment. This is done by definitions made in this part of IEC 61400-25 or by reference to other standards.

The wind power plant specific information describes the crucial and common process and configuration information. The information is hierarchically structured and covers for example common information found in the rotor, generator, converter, grid connection and the like. The information may be simple data (including timestamp and quality) and configuration values or more comprehensive attributes and descriptive information, for example engineering unit, scale, description, reference, statistical or historical information. All information of a wind power plant defined in IEC 61400-25 (all parts) is name tagged. A concise meaning of each data is given. The standardized wind power plant information can be extended by means of a name space extension rule. All data, attributes and descriptive information can be exchanged by corresponding services.

The implementation of IEC 61400-25 (all parts) allows SCADA systems (supervisory control and data acquisition) to communicate with wind turbines from multiple vendors. The standardized self-description (contained either in an XML file or retrieved online from a device) can be used to configure SCADA applications. Standardization of SCADA applications are excluded in IEC 61400-25 (all parts) but standardized common wind turbine information provides means for re-use of applications and operator screens for wind turbines from different vendors. From a utility perspective, unified definitions of common data minimize conversion and re-calculation of data values for evaluation and comparison of all their wind power plants.

IEC 61400-25 (all parts) can be applied to any wind power plant operation concept, i.e. both individual wind turbines, clusters and more integrated groups of wind turbines. The application area of IEC 61400-25 (all parts) covers components required for the operation of wind power plants, i.e. not only the wind turbine generator, but also the meteorological system, the electrical system, and the wind power plant management system. The wind power plant specific information in IEC 61400-25 (all parts) excludes information associated with feeders and substations. Substation communication is covered within IEC 61850 (all parts).

The intention of IEC 61400-25 (all parts) is to enable components from different vendors to communicate with other components, at any location. Object-oriented data structures can make the engineering and handling of large amounts of information provided by wind power plants less time-consuming and more efficient. IEC 61400-25 (all parts) supports scalability, connectivity, and interoperability.

IEC 61400-25 (all parts) is a basis for simplifying the contracting of the roles the wind turbine and SCADA systems have to play. The crucial part of the wind power plant information, the information exchange methods, and the communication stacks are standardized. They build a basis to which procurement specifications and contracts could easily refer.

IEC 61400-25 is organized in several parts.

- IEC 61400-25-1 offers an introductory orientation, crucial requirements, and a modelling guide.
- IEC 61400-25-2 and IEC61400-25-6 contain the description of the information model, a uniform, component-oriented view of the wind power plant data, including extensions for condition monitoring.
- IEC 61400-25-3 describes the information exchange model. It reflects the functionality of the server.
- IEC 61400-25-4 presents five alternative mappings of the information model and information exchange model to a standard communication profile. The choice depends on the application and the functionality and performance needed.
- IEC 61400-25-5 describes test cases for conformance testing of implementations.

NOTE Performance of IEC 61400-25 (all parts) implementations are application specific. IEC 61400-25 (all parts) does not guarantee a certain level of performance. This is beyond the scope of IEC 61400-25 (all parts). However, there is no underlying limitation in the communications technology to prevent high speed application (millisecond level responses).

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WIND ENERGY GENERATION SYSTEMS –

Part 25-1: Communications for monitoring and control of wind power plants – Overall description of principles and models

1 Scope

The focus of IEC 61400-25 (all parts) is on the communications between wind power plant components such as wind turbines and actors such as SCADA systems. Internal communication within wind power plant components is beyond the scope of IEC 61400-25 (all parts).

IEC 61400-25 (all parts) is designed for a communication environment supported by a client-server model. Three areas are defined, that are modelled separately to ensure the scalability of implementations:

- 1) wind power plant information models,
- 2) information exchange model, and
- 3) mapping of these two models to a standard communication profile.

The wind power plant information model and the information exchange model, viewed together, constitute an interface between client and server. In this conjunction, the wind power plant information model serves as an interpretation frame for accessible wind power plant data. The wind power plant information model is used by the server to offer the client a uniform, component-oriented view of the wind power plant data. The information exchange model reflects the whole active functionality of the server. IEC 61400-25 (all parts) enables connectivity between a heterogeneous combination of client and servers from different manufacturers and suppliers.

As depicted in Figure 1, IEC 61400-25 (all parts) defines a server with the following aspects:

- information provided by a wind power plant component, for example, 'wind turbine rotor speed' or 'total power production of a certain time interval' is modelled and made available for access. The information modelled in IEC 61400-25 (all parts) is defined in IEC 61400-25-2 and IEC 61400-25-6,
- services to exchange values of the modelled information defined in IEC 61400-25-3,
- mapping to a communication profile, providing a protocol stack to carry the exchanged values from the modelled information (IEC 61400-25-4).

IEC 61400-25 (all parts) only defines how to model the information, information exchange and mapping to specific communication protocols. IEC 61400-25 (all parts) excludes a definition of how and where to implement the communication interface, the application program interface and implementation recommendations. However, the objective of IEC 61400-25 (all parts) is that the information associated with a single wind power plant component (such as a wind turbine) is accessible through a corresponding logical device.

This part of IEC 61400-25 gives an overall description of the principles and models used in IEC 61400-25 (all parts).

NOTE IEC 61400-25 (all parts) focuses on the common, non-vendor-specific information. Those information items that tend to vary greatly between vendor-specific implementations can for example be specified in bilateral agreements, in user groups, or in amendments to IEC 61400-25 (all parts).

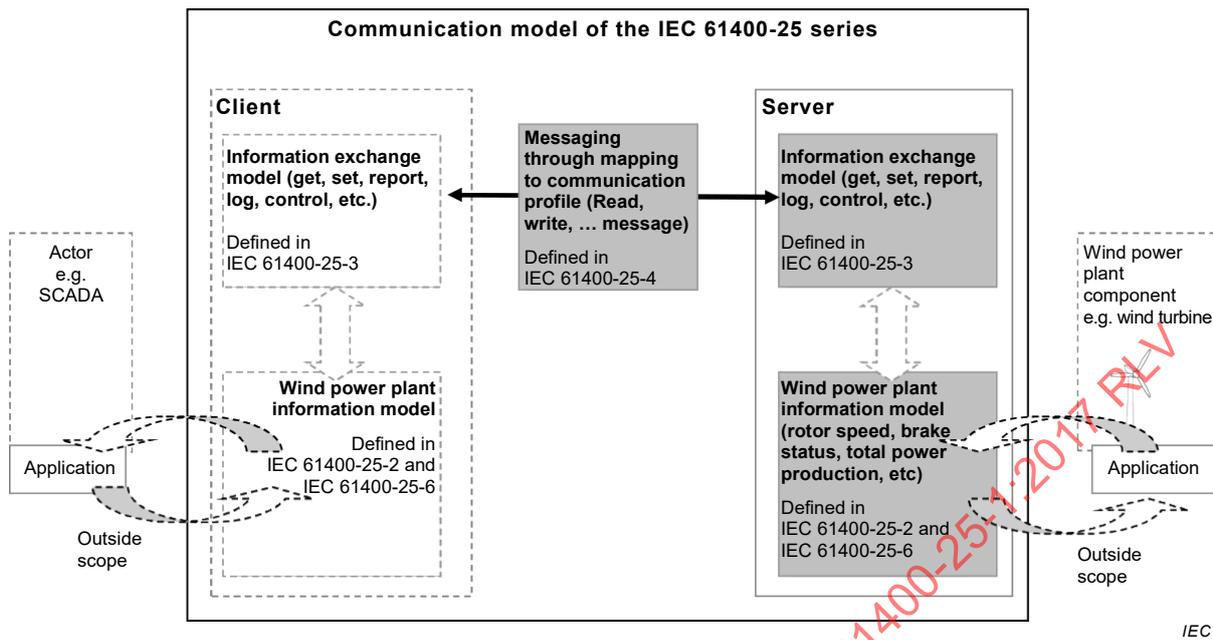


Figure 1 – Conceptual communication model of the IEC 61400-25 series

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 61400-25 (all parts), *Wind turbines – Part 25: Communications for monitoring and control of wind power plants*

IEC 61400-25-2:2015, *Wind turbines – Part 25-2: Communications for monitoring and control of wind power plants – Information models*

IEC 61400-25-3:2015, *Wind turbines – Part 25-3: Communications for monitoring and control of wind power plants – Information exchange models*

IEC 61400-25-4, *Wind energy generation systems – Part 25-4: Communications for monitoring and control of wind power plants – Mapping to communication profile*

IEC 61400-25-6, *Wind energy generation systems – Part 25-6: Communications for monitoring and control of wind power plants – Logical node classes and data classes for condition monitoring*

IEC 61850-7-1:2011, *Communication networks and systems for power utility automation – Part 7-1: Basic communication structure – Principles and models*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract communication service interface (ACSI)*

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

actor

role a system plays in the context of monitoring and control, while it is not directly involved in wind power plant operation, such as supervisory control and data acquisition system (SCADA)

Note 1 to entry: There are many other designations for example central management system, monitoring and control system, remote control system

3.2

alarm

wind power plant state information

statement of safety intervention by the wind turbine control system (i.e. on/off)

3.3

characteristic values

properties of analogue information (min., max., avg, dev, etc.)

3.4

command

controllable data for system behaviour

EXAMPLE Enable/disable, activate/deactivate

3.5

communication function

function used by an actor to configure, perform and monitor the information exchange with wind power plants

EXAMPLE Operational function, management function.

3.6

control

operational function used for changing and modifying, intervening, switching, controlling, parameterization and optimizing of wind power plants

3.7

counting value

total number of occurrences of a specific event

3.8

data retrieval

operational function used for collecting of wind power plant data

3.9

diagnostics

management function used to set up and provide for self-monitoring of the communication system

**3.10
electrical system**

set of electrical components working together as parts of a wind turbine or wind farm for collecting and transmitting the produced electricity in a wind power plant

**3.11
event**

state transition (status, alarm, command)

**3.12
intelligent electronic device
IED**

any device incorporating one or more processors, with the capability to receive data from an external sender or to send data to an external receiver

EXAMPLE Wind turbine controller.

Note 1 to entry: An IED may have connections as a client, or as a server, or both, with other IEDs.

Note 2 to entry: This note only applies to the French language.

**3.13
information**

content of communication

Note 1 to entry: The basic element is raw data from the wind power plant components, which shall be processed into specified information according to IEC 61400-25 (all parts).

Note 2 to entry: Wind power plant information categories are: source information (analogue and state information), derived information (statistical and historical information). Information is defined as data (usually processed and derived data, and information describing other data).

**3.14
information exchange**

communication process between two systems, such as wind power component and actor, with the goal to provide and to get relevant information

Note 1 to entry: Information exchange requires specific communication functions, consisting of one or more services.

**3.15
information model**

model representing knowledge concerning functions and devices in which the functions are implemented

Note 1 to entry: This knowledge is made visible and accessible through the means of IEC 61400-25 (all parts). The model describes in an abstract way a communication oriented representation of a real function or device.

**3.16
log**

historical information

Note 1 to entry: Log is a chronological list of source information for a period of time.

**3.17
logging**

operational function

Note 1 to entry: Logging is the praxis of recording sequential data, often chronologically. The result of logging is a log.

3.18**logical device**

entity that represents a set of typical wind power plant functions

3.19**management function**

function required for the administration of the information exchange in a certain level

Note 1 to entry: Management functions are user/access management, time synchronization, diagnostics, and configuration.

3.20**mandatory**

provided in compliance to IEC 61400-25 (all parts)

3.21**measured data**

sampled value of a process quantity with associated data attributes such as time stamp and quality

3.22**meteorological system**

component of a wind power plant responsible for the monitoring of the ambient conditions, for example the wind speed, wind direction, pressure, temperature

Note 1 to entry: It supplies data for various purposes for example to correlate the meteorological data to the electrical energy output by individual wind turbines to the potentially usable wind energy.

3.23**monitoring**

operational function used for local or remote observation of a system or a process for any changes which may occur over time

Note 1 to entry: The term can also be used for observation of the behaviour of a data value or a group of data values.

3.24**operational function**

function to obtain information and to send instructions for the normal daily operation of wind power plants

Note 1 to entry: Types of operational function are: monitoring, logging, reporting, data retrieval, control.

3.25**optional**

optionally provided in compliance with IEC 61400-25 (all parts)

3.26**parameter**

controllable information intended for obtaining or correcting a system behaviour

3.27**processed data**

measured value, with the associated data attributes such as time stamp and quality, which has been processed according to the calculation method attribute

3.28**profile(s)**

format(s) used by a particular protocol to transmit data objects or commands, etc.

3.29

protocol stack

particular software implementation of a computer networking protocol suite

Note 1 to entry: The terms are often used interchangeably. Strictly speaking, the suite is the definition of the protocols and the stack is the software implementation of them.

3.30

report

actual information sent by the function reporting

Note 1 to entry: A report can contain all kinds of information defined in IEC 61400-25-2.

3.31

reporting

operational function to transfer data from a server to a client, initiated by a server application process

3.32

supervisory control and data acquisition SCADA

system based on a processor unit which receives information from IEDs, determines the control requirements and sends commands to IEDs

Note 1 to entry: SCADA is a computer system that for example dispatchers use to monitor the power distribution throughout a service or control area.

Note 2 to entry: This note only applies to the French language.

3.33

status

state condition of a component or system (st1/st2/..stn)

3.34

statistical information

result of applying a statistical algorithm to a set of data in order to get, for example, minimum, maximum, mean standard deviation

3.35

timing data

time duration of a specific state

3.36

time synchronization

coordination of occurrences to operate in unison with respect to time

Note 1 to entry: This process can be a premeditated arrangement set forth on a parallel time scape, or it can be an observable coincidence in eventuality.

3.37

three phase data

measured value in a three phase electrical circuit with associated data attributes such as time stamp, quality and calculation method

3.38

transient log

event triggered chronological list of high resolution information for a short period of time (event driven report)

3.39**user/access management**

management function used for setting up, modifying, deleting users (administratively), assigning access rights (administratively) and monitoring access

Note 1 to entry: A management function does not necessarily include communication services.

3.40**wind power plant**

complete system consisting of any number of technical subsystems referred to in IEC 61400-25 (all parts) as wind power plant components, for example one or more wind turbines

Note 1 to entry: The main objective of a wind power plant is to generate electrical energy from the wind.

3.41**wind power plant analogue information**

continuous information concerning the actual condition or behaviour of a component or system

EXAMPLE Measured value, processed value, three phase value, setpoint, parameter.

3.42**wind power plant component**

technical system employed in the operation of wind power plants, such as wind turbine, meteorological, electrical and wind power plant management system

3.43**wind power plant management system**

component of a wind power plant, which is responsible for ensuring that the complete system adapts itself to the static and dynamic conditions and requirements of the electrical power connection (i.e., interoperation of the WTs with substation and other power network related devices)

Note 1 to entry: A wind power plant management system may include other functions (e.g. Shadow control functionality, noise or sound reduction, ice warning, lightning protection) not modelled in IEC 61400-25 (all parts).

3.44**wind turbine**

main component of a wind power plant

Note 1 to entry: It is responsible for generating energy and meets the task of using the wind potential of a certain location that converts kinetic wind energy into electric energy.

4 Abbreviated terms

ACSI	abstract communication service interface
CDC	common data class
CMS	condition monitoring system
DC	data class
DNP3	distributed network protocol version 3
IED	intelligent electronic device
IEM	information exchange model
LCB	log control block
LD	logical device
LN	logical node
O&M	operation and maintenance

OSI	open systems interconnection
RCB	report control block
SCADA	supervisory control and data acquisition
SCSM	specific communication service mapping
WPP	wind power plant
WT	wind turbine
XML	extensible mark-up language

5 Overall description of IEC 61400-25 (all parts)

5.1 General

The main objective of IEC 61400-25 (all parts) is to create a standard basis for manufacturer-independent communications for monitoring and control. Manufacturers and suppliers of wind power plant components shall implement IEC 61400-25 (all parts) in their devices and systems.

Clause 5 provides a general overview of the context, models, modelling approach, and application possibilities of IEC 61400-25 (all parts).

Subclause 5.2 provides a top-down view on wind power plants and shows the areas where IEC 61400-25 (all parts) can be applied. It explains what is to be understood under the term 'wind power plant', which operation concepts are distinguished and which components are used to run wind power plants.

Subclause 5.3 describes the demands made with reference to the communication taking place within the framework of the monitoring and control of wind power plants. It explains which general communication capabilities wind power plants shall possess and which contents and functions are required for communication.

Subclause 5.4 provides an overview of the communication model defined by IEC 61400-25 (all parts). The server-client communication environment that served as the basis when developing IEC 61400-25 (all parts) is introduced briefly. Next, three server-client application topologies are introduced, illustrating the communication architectures that are possible by way of an example. Finally, the three areas defined by IEC 61400-25 (all parts) to be implemented as the standard for the monitoring and control of wind power plants will be introduced on a generally understandable level.

5.2 Top-down view on wind power plants

5.2.1 Definition of wind power plants

Wind power plants constitute complete systems consisting of any number of technical subsystems with clearly separated tasks. The subsystems are referred to as wind power plant components and will be described in 5.2.2.

5.2.2 Wind power plant components

Wind power plant components are technical systems employed in the operation of wind power plants. They consist of various sub-components. All wind power plant components fall within the application area of IEC 61400-25 (all parts).

The information modelled in IEC 61400-25 (all parts) covers the following corresponding components:

Wind turbine

- rotor,
- transmission,
- generator,
- converter,
- nacelle,
- yaw system,
- tower,
- alarm system.

Meteorological system

- meteorological conditions of the wind power plant.

Wind power plant management system

- wind power plant control.

Electrical system

- wind power plant grid connection.

Condition monitoring system (CMS)

- process with the purpose of observing components or structures of a wind turbine or wind power plant for a period of time.

The wind turbine (with its many sub-components) is the main component of a wind power plant. The wind turbine is responsible for generating energy and meets the task of using the wind potential of a certain location to convert wind into electrical energy.

Vendors of wind turbines usually guarantee their customers a certain power curve and technical availability in terms of energy production. To enable both the operators and owners to verify the guaranteed performance of the wind turbines used, well-founded data providing information on the wind conditions at the particular location shall be available.

A separate wind power plant component, the reference met mast, referred to as a meteorological system, should be used for the measuring of the wind conditions, for example the wind speed, at a particular location. The meteorological system supplies the data that may be required to correlate the produced power output of individual wind turbines to the useable wind potential. On this basis, it is possible to draw well-founded conclusions as to the real performance of a certain wind turbine.

In addition to several wind turbines, integrated operation requires further components; the energy produced in decentralized feeder and/or substations shall be collected and transported to the final user via suitable power networks. This task is covered by the electrical system.

NOTE All electrical system issues concerning substations are targeted in the scope of IEC 61850 (all parts).

Another component, the wind power plant management system, ensures that the complete system adapts itself to the static and dynamic conditions and requirements of the electrical power connection (substation, utility network).

5.3 Generic requirements on communication

5.3.1 Communication capability

Wind power plants are monitored and controlled by various external actors, such as local or remote SCADA systems, local real time build-in control systems, energy dispatch centres.

The objective of the monitoring of wind power plants is to provide the actors with information on the complete system and the installed components. This information is deemed to be an important knowledge basis for the control of wind power plants. For example, a SCADA system which wants to stop the operation of a certain wind turbine in an integrated operation, shall know how this component can be identified within the complete system and in which status it is currently operating. The SCADA system shall, however, also know to which device within the integrated operation it shall send which commands to make sure that the relevant component is controlled as intended. To be able to check whether or not the command has been executed, the SCADA system additionally requires a feedback from the wind power plant.

Thus, wind power plants and external actors shall meet an essential prerequisite to be able to exchange information within the framework of monitoring and control: they shall be able to communicate with the outside world.

Typically, any wind power plant component, which needs to exchange information with other components and actors, is therefore equipped with a so-called intelligent electronic device (IED), which can send data to external receivers and receive data from external senders. A wind turbine usually possesses a wind turbine controller, which is primarily responsible for the internal monitoring and control of the wind power plant component, but also allows external monitoring and control.

5.3.2 Communication content

Information is the content of the communication that takes place within the framework of monitoring and control. The basic elements are raw data from the wind power plant component, which shall be processed into specified information according to IEC 61400-25 (all parts). There are five types of information that can be differentiated and are important for the monitoring and control of wind power plants:

- process information,
- statistical information,
- historical information,
- control information,
- descriptive information.

Process, statistical and historical information provide the contents required for the monitoring and control of wind power plants; this information shall be communicated by the wind power plants. Process information provides information on the behaviour of certain complete systems and their components, on their current states. Statistical information is often useful to evaluate the operation of a wind power plant. By using historical information, it might be possible to track the operational trends in logs and reports.

Control information is intended to transmit the contents required for the control of wind power plants, such as access profiles, set points, parameters and commands; this information shall first be communicated to wind power plants by certain actors. Wind power plants shall store control information and provide this for further communication to sub-processes.

Descriptive information is the type and the accuracy of the information, as well as the time and the data description.

5.3.3 Communication functions

The actors communication for monitoring and controlling the wind power plants require special functions to configure, perform and monitor the information exchange with wind power plants. These functions can be divided into the following two main categories:

- operational functions,
- management functions.

While operational functions are within the scope of IEC 61400-25 (all parts), the management functions are outside the scope of IEC 61400-25 (all parts) because they are implementation specific.

Operational functions (manual or automatic) are used by the actors to obtain information on wind power plants and to send control instructions to wind power plants. The operational functions include:

- monitoring,
- control,
- data retrieval,
- logging,
- reporting.

Table 1 provides an overview of the ranges of application of the operational functions.

Table 1 – Operational functions

Operational functions	Range of application (practical use)
Monitoring	Operational function used for local or remote observation of a system or a process for any changes which may occur over time. The term can also be used for observation of the behaviour of a data value or a group of data values.
Control	Changing and modifying, intervening, switching, controlling, parameterization, optimizing of wind power plants.
Data retrieval	Collecting of wind power plant data.
Logging	Logging is a function intended for sequential recording of data and events in chronological order. The result of the logging is a log.
Reporting	The reporting is a function intended to transfer data from a server to a client, initiated by a server application process.

Management functions are required for the higher-level management of the information exchange. They are used by actors to secure integrity of the monitoring and control process. The management functions included are as follows:

- user/access management,
- time synchronization,
- diagnostics (self-monitoring),
- system setup.

Table 2 provides an overview of the ranges of application of the management functions.

Table 2 – Management functions

Management functions	Range of application (practical use)
User/access management	Setting up, modifying, deleting users (administratively), assigning access rights (administratively), monitoring access
Time synchronization	Synchronization of devices within a communication system.
Diagnostics (self-monitoring)	This function is used to set up and provide for self-monitoring of the communication system.
System setup functions	Defining how the information exchange will take place; setting, changing and receiving (retrieval) of system setup data.
NOTE Time synchronization is covered in IEC 61400-25-4.	

5.4 Communication model of IEC 61400-25 (all parts)

5.4.1 General

IEC 61400-25 (all parts) defines a communication model for the monitoring and control of wind power plants, taking into account all requirements made with reference to the communication, on an abstract level. The communication model comprises three separately defined areas:

- information model,
- information exchange model,
- mapping of the information model and the information exchange model to standard communication profiles.

The communication model is embedded in an abstract environment where two entities may communicate via a common communication channel. These two entities are referred to as server and client (see Figure 1). The server assumes the role of an information and service provider supplying the client with the contents and functions required for the communication. The client assumes the role of a user who possesses certain rights to use and manage the server.

IEC 61400-25 (all parts) leaves it open how and in which physical device the server is to be implemented in practice. The objective of IEC 61400-25 (all parts) is that the information associated with a single wind power plant component (such as the wind turbine) is accessible through a corresponding logical device. Also, IEC 61400-25 (all parts) does not specify how objects in the wind power plant information model are distributed among the servers.

5.4.2 Information model

The wind power plant information model (see Figure 2) provides the contents required for the information exchange that takes place within the framework of the monitoring and control between client and server.

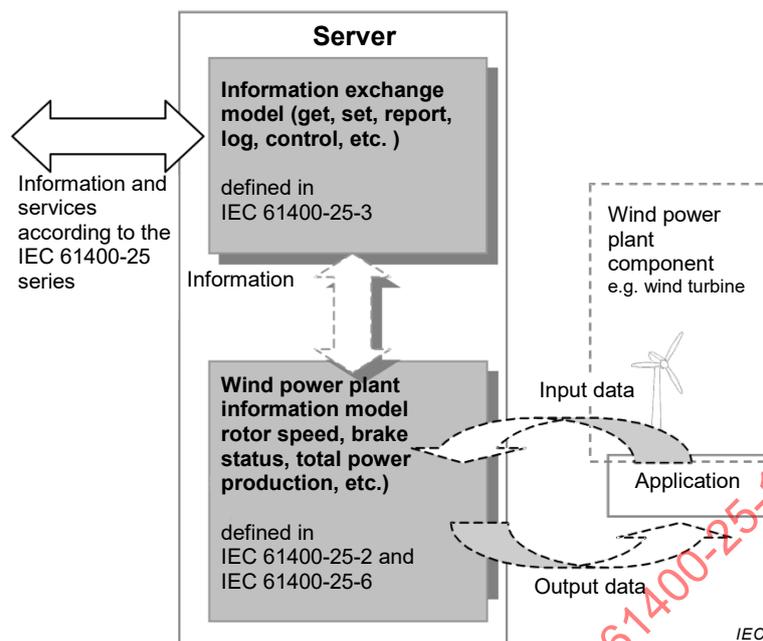


Figure 2 – Data processing by the server (conceptual)

The model is deemed to be a standard frame of interpretation via which the server may process all data, which is provided by wind power plants for the external monitoring and control, into relevant and semantically standardized information, and may grant the client access to these data in a component-oriented view.

When developing the wind power plant information model, the paradigm of object orientation has been taken into account. This approach allows wind power plants to be viewed as information objects and modelling of an appropriate information architecture.

IEC 61400-25 (all parts) utilizes the concept of object modelling to represent the systems and components of a wind power plant to communicate with. This means that all of the components in the real world are identified as objects that have data such as analogue values, binary status, commands and set points and these objects and data are mapped into generic, logical representations of the real world components as a wind power plant information model.

Breaking a real world component down into objects to produce a model of that object involves identifying all of the data and functionality of each component object. Each data has a name and a simple or complex type (a class) and represents data in the device to be read or updated.

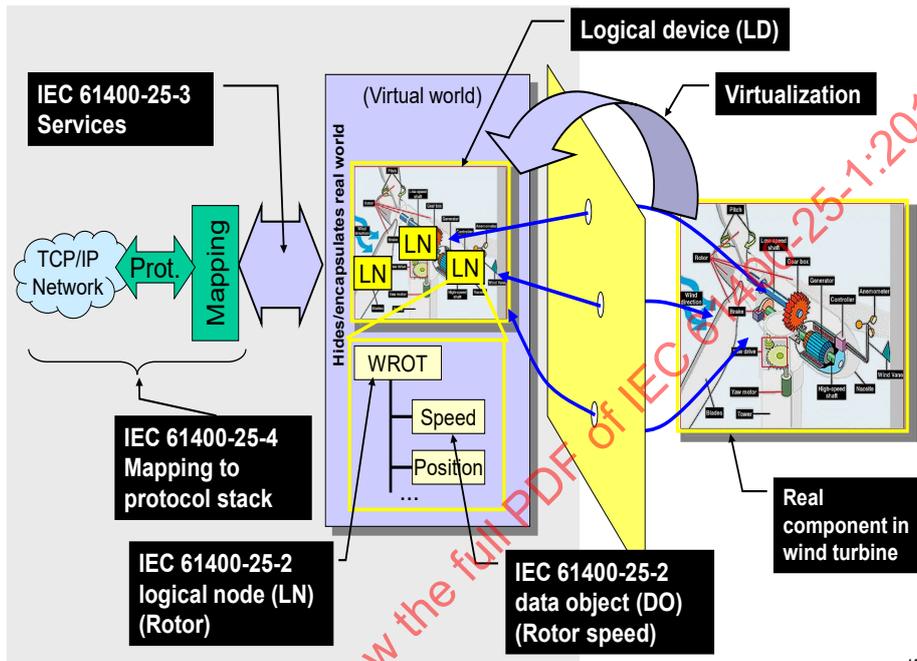
Instead of dealing with lists of numbered quantities, an object-modelling approach lets us organize and define standard names for standard things, independent of the manufacturer of the equipment. If the equipment has a shaft for which the rotational speed is available for reading, it has the same name regardless of the vendor of that equipment and can be read by any client programme that knows the information model.

In addition to reading and updating process information, other functionalities of the device may include things such as historical logs of information, report by exception capabilities, and actions within the device that are initiated by internal or external command and control inputs. All of these items imply some type of information exchange between the outside world and the real world device represented by the wind power plant information model.

Clause 6 describes in more detail the logical structure of the wind power plant information model and the method by which wind power plants shall be modelled as information objects.

5.4.3 Information exchange model and relation to wind power plant information models

The information exchange mechanisms rely on standardized wind power information models. These information models and the modelling methods are the core of IEC 61400-25 (all parts). IEC 61400-25 (all parts) uses the approach to model the information found in real components as depicted in the conceptual overview in Figure 3. All information made available to be exchanged with other components is defined in IEC 61400-25 (all parts). The model provides for the wind power plant automation system an image of the real world (power system process, generator, etc.).



IEC

Figure 3 – Modelling approach (conceptual)

IEC 61400-25 (all parts) defines the information and information exchange in a way that is independent of a concrete implementation (i.e., it uses abstract models). IEC 61400-25 (all parts) also uses the concept of virtualization. Virtualization provides a view of those aspects of a real device that are of interest for the information exchange with other devices. Only those details that are required to provide interoperability of devices are defined in IEC 61400-25 (all parts).

The approach of IEC 61400-25 (all parts) is to decompose the components into the smallest entities, which are used to exchange information. The granularity is given by a reasonable distributed allocation of these entities to dedicated devices (IEDs). These entities are called logical nodes (e.g. a virtual representation of a rotor class, with the standardized class name WROT). The logical nodes are modelled and defined from the conceptual application point of view. Logical nodes are collected in a logical device representing for example a complete wind turbine.

Real components on the right hand side of Figure 3 are modelled into a virtual model in the middle of the figure. The logical nodes correspond to functions in the real physical devices. In this example, the logical node WROT represents a specific rotor of the turbine to the right.

Based on their functionality, a logical node contains a list of data (e.g. rotor speed) with dedicated information. The data have a structure and a well-defined semantic (meaning in the context of wind power plant systems). The information represented by the data is exchanged by the services according to the information exchange services defined.

The logical nodes and the data contained are crucial for the information model and the information exchange services for wind turbines to reach interoperability.

The logical nodes and the data contained are configured by the control information, for example parameters, commands to be accepted, set point ranges.

5.4.4 Mapping to communication profile

The information exchange between server and client requires a uniform communication protocol on both sides. A specific mapping to a communication profile defines how the objects in the wind power plant information model and the functions and services defined in the information exchange model are implemented using a specific protocol stack, i.e. a complete communication protocol. IEC 61400-25-4 specifies in detail the communication protocols applied in IEC 61400-25 (all parts).

The mapping to protocol stacks specified in IEC 61400-25-4 is oriented in its structure towards the OSI reference model (ISO/IEC 7498-1). According to the OSI reference model, the communication realized between client and server is divided into seven layers. Whereas layer 7, 6 and 5 are concerned with application issues (often named as the A-Profile), the lower four layers are concerned with data transport issues (often named as the T-Profile).

6 Wind power plant information model

6.1 General

Clause 6 provides a detailed description regarding the wind power plant information model. Common wind power plant relevant information is defined, structured and described unambiguously from the viewpoint of object orientation.

Subclause 6.2 describes the modelling methodology used to represent and structure relevant information.

6.2 Information modelling methodology

6.2.1 Wind power plant information

A wind power plant comprises different types of information. Besides source data, wind power plant components usually derive a huge amount of additional information (10 min-averages, alarms, logs, counters, timers, etc.). This valuable information is locally stored and available for future use or analysis. In Table 3, the relations between different information categories are shown and their definition will be used in IEC 61400-25 (all parts).

Table 3 – Wind power plant information categories

Category	Description
Process information	
State information	Discrete information concerning the current condition or behaviour of a component or system
Status	Condition of a component or system (st1/st2/..stn)
Alarm	Statement of safety intervention by, for example, the turbine control system
Event	State transition (status, alarm, command)
Analogue information	Continuous information concerning the current condition or behaviour of a component or system
Measured data	(Sampled) value of a process quantity
Processed data	Measured value, which has been processed (10 min-average/...)
Three phase data	Measured value of a three phase electric power quantity
Control information	
Control information	Discrete information concerning the current condition or behaviour of a component or system
Command	Controllable status for system behaviour (enable/disable, activate/deactivate, etc)
Set point	Reference value for a process quantity
Parameter	Controllable value for system behaviour (adjustment)
Derived information	
Statistical information	The result of applying a statistical algorithm to a set of data
Timing data	Total time duration of a specific state
Counting data	Total number of occurrences of a specific event
Characteristic data	Properties of information or data observed (min., max., average, standard deviation, etc.)
Historical information	Information about the time passed
Log	Chronological list of events for a specific period of time
Transient log	Event triggered chronological list of high resolution source information for a short period of time
Report	Periodical notification comprising the information that represent the state and data requested in the report control block

6.2.2 Modelling approach

Because all the information categories as listed in Table 3 comprise their own formats and properties, IEC 61400-25 (all parts) has to define a general wind power plant information model. The structure of this top-down view model is hierarchical and based on the modelling approach as defined in IEC 61850-7-1:2011, Clause 6 where the basis is described in IEC 61850-7-2:2010, Clause 5. Hierarchical means that different levels of common information are distinguished and grouped together into classes. Lower level classes will automatically inherit properties as specified by upper level classes. The structure of the wind power plant information model is concisely given in Figure 4. Each level will be discussed separately in more detail.

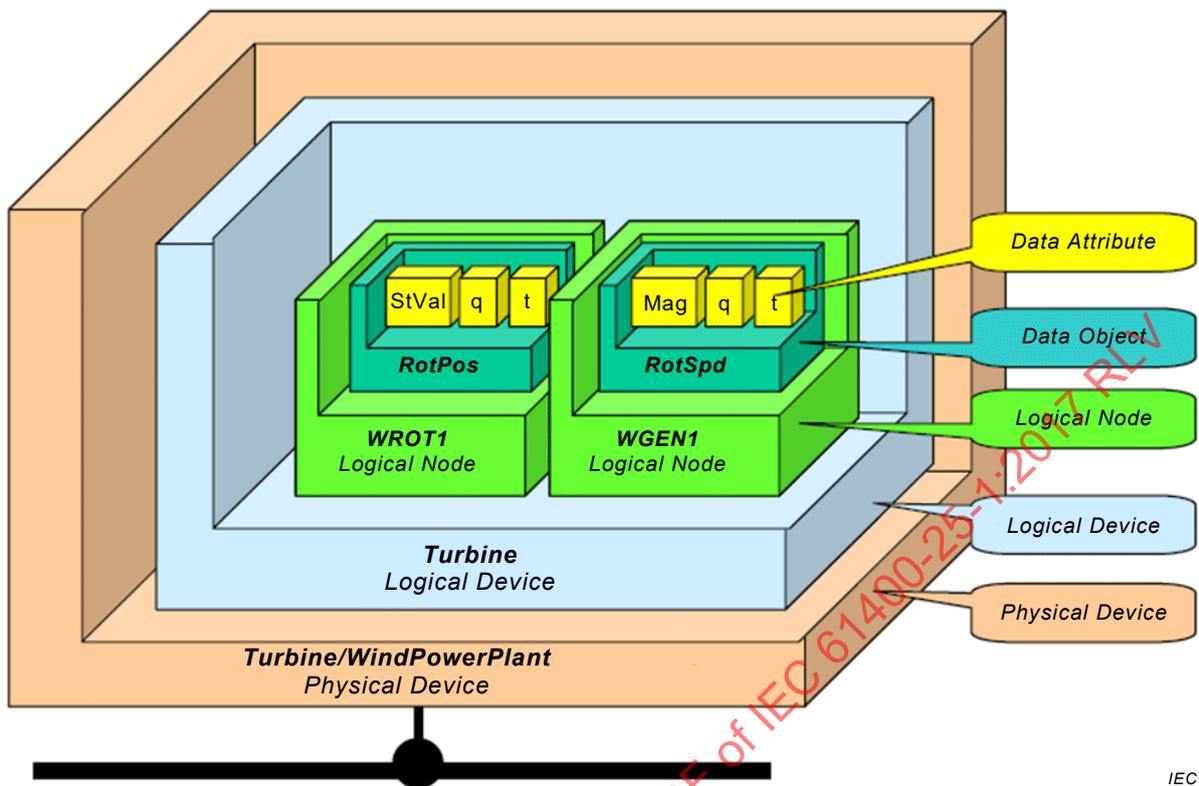


Figure 4 – Structure of wind power plant information model

The highest level of modeling within a physical device is called logical device (LD) and aggregates one or more logical nodes (LN). A logical node itself aggregates one or more data objects (DO). Data objects aggregate then again one or more data attributes (DA). The definition, which data attributes are aggregated by a data object, is determined by a common data class (CDC) of which a data object is a type of. Both, data objects and data attributes can be nested as given in Figure 5.

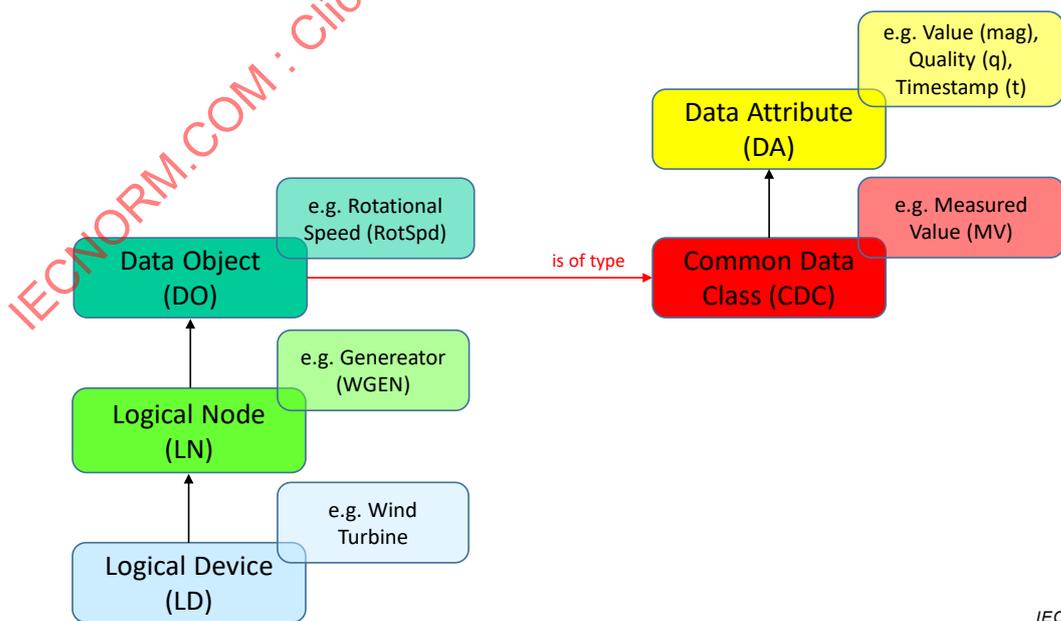


Figure 5 – Role of common data classes (CDC) in WPP information model

6.2.3 Logical devices

A server hosts at least one logical device. IEC 61400-25 (all parts) could for example be used to assign a logical device to a specific wind turbine of a wind power plant. Thus a logical device contains a collection of specific logical nodes belonging to this wind turbine. The logical node zero (LLN0) is destined to provide common information about the logical device (e.g. logical device nameplate and health) and the logical node physical device (LPHD) represents common data of the physical device that is hosting the logical device (e.g. physical device nameplate and health).

6.2.4 Logical nodes

Within a logical device, all wind turbine information will be distributed in different 'containers', called logical nodes. In IEC 61400-25 (all parts) a set of specific logical node classes for wind power plants have been specified (IEC 61400-25-2), some of these shall be mandatory (indicated with an 'M' in tables) and others optional (indicated with an 'O' in tables). The basic rules for the use of logical nodes and data objects and their extensions are defined in Clause 14 of 61850-7-1:2011. The specific LNs are originated by a physical turbine break down into components (e.g. rotor, transmission, generator, yaw system), but collections of common information can also be represented in a specific LN (e.g. alarm log, event log). The names of wind power plant specific logical nodes shall be unique and always begin with 'W', followed by three capitals representing the content.

The logical node data is represented by named attributes that can have simple or complex types (a 32 bit integer or a complex structure variable made up of a collection of named simple and complex component types). In this model, this data is named and has whatever types are appropriate to represent the underlying data. The specific internal organization and implementation of the data storage and management scheme are independent of the outside world view.

Inside a LN, information is specified by data objects. All logical nodes have a standardized and similar table structure as shown in Table 4. The table represents and visualizes the different data objects in a logical node.

Table 4 – General table structure of a logical node (LN)

Wxxx class			
Data Object Name	Common Data Class	Explanation	M/O
Data Objects			
<i>Common information</i>			
Data Object class name	CDC	Description and range	
<i>Status information</i>			
Data Object class name	CDC	Description and range	
<i>Measured and metered values</i>			
Data Object class name	CDC	Description and range	
<i>Controls</i>			
Data Object class name	CDC	Description and range	

For the sake of convenience, all information in a logical node is categorized in compliance with the wind power plant information decomposition of Table 3.

In Table 5 all data class attributes inside a logical node are explained briefly.

Table 5 – Data class attributes in a logical node

Data class attribute	Description
Data Object Name	Name of the data object
Common Data Class	Common data class that defines common data properties. The CDCs are defined in IEC 61400-25-3
Explanation	Short explanation of the content of the data class
Mandate	M: Mandatory, O: Optional

If an optional logical node is used, its mandatory (M) data class attributes shall also be used. Optional (O) defined data class attributes are instantiated as needed by the user.

7 Wind power plant information exchange model

7.1 General

Clause 7 provides an overview of the information exchange models that can be applied by a client and a server to access the content and structure of the wind power plant information model defined in Clause 6.

7.2 Information exchange modelling methodology

7.2.1 Wind power plant information exchange

The primary objective of the wind power plant information exchange model defined in IEC 61400-25-3 is to exchange information provided by the instantiated information model of the various classes, such as logical nodes, data objects, data attributes or control blocks. The IEM defines a server that provides:

- an instance of the wind power plant information model, and
- required functions including the associated services (Get, Set, Control, Query, Report, etc.) which enable a client to access the instantiated information model.

IEC 61400-25 (all parts) defines the server role only. A client issues service requests to the server, by sending request messages, and receives response messages or reports from the server.

A server provides access to its wind power plant information model instance for multiple clients, as illustrated in Figure 6. Each client can, independently of other clients, communicate with the server.

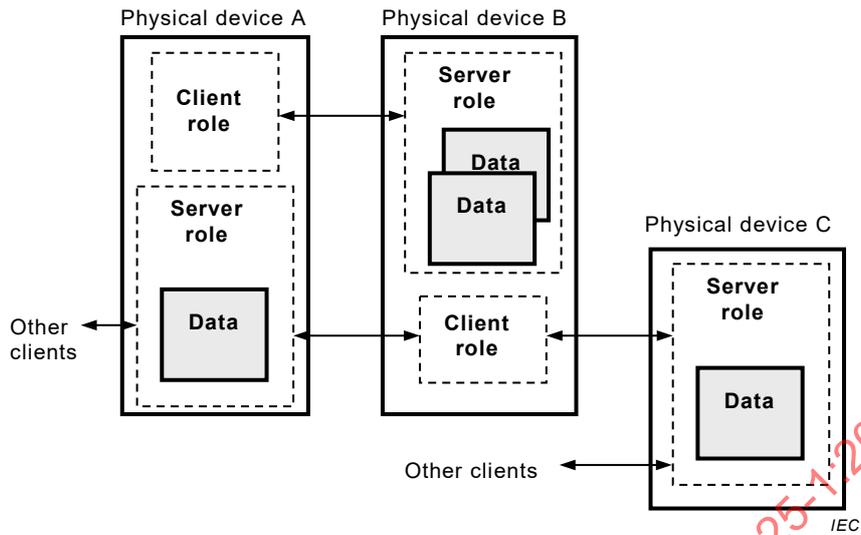


Figure 6 – Client and server role

As shown in Figure 6, physical devices may implement the client, the server role, or both roles.

The client plays the complementary role of the server with regard to the services.

NOTE IEC 61400-25 (all parts) does not define any application program interface – neither in the server nor in the client. It defines the externally visible view of the information contained in the server and how this information can be sent and received.

7.2.2 Service models

The wind power plant information model in the server supports the access services as depicted in Figure 7.

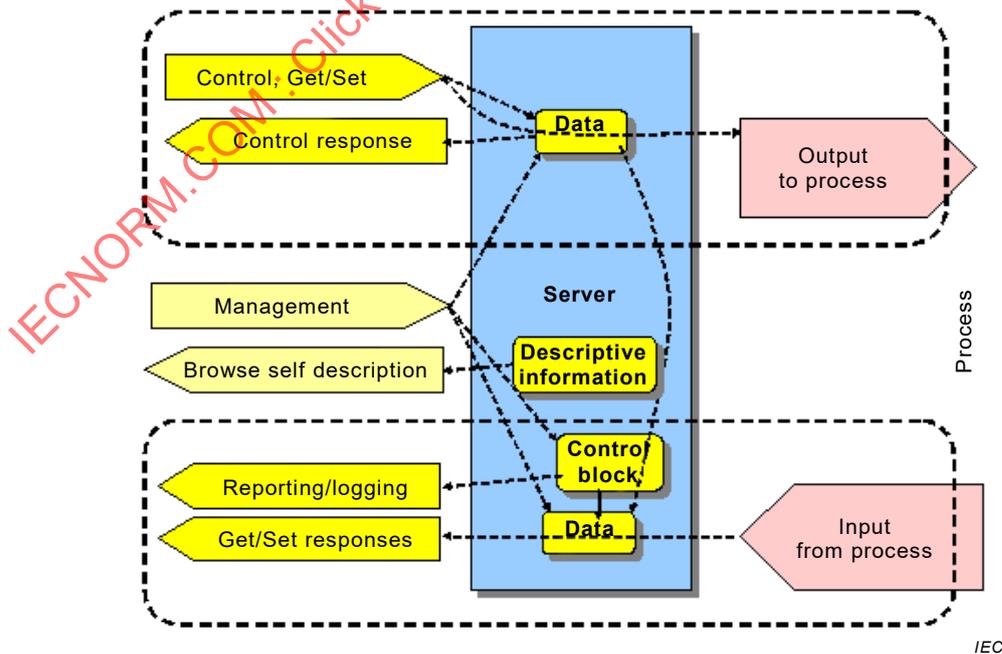


Figure 7 – IEM service models

The focus of the server is to provide data that make up the wind power plant information model. The data attributes contain the values used for the information exchange. The IEM provides services for:

- control of external operational devices or internal device functions,
- monitoring of both process and processed data, and
- management of devices as well as retrieving the wind power plant information model.

The wind power plant information model data instances contained in the server can be accessed by the services Get, Set, Control for immediate action (return information, set values to data, control device or function).

Reporting and logging provide the means to autonomously and spontaneously send information from the server to the client issued by a server-internal event (reporting) or to store this information in the server for later retrieval (logging).

7.2.3 Abstract communication service interface

The set of basic services that the communications interface uses to accomplish the information exchange between the outside world and various components of the real world device are referred to as the abstract communication service interface (ACSI). The basic methodology of these services is described in detail in IEC 61850-7-1 and IEC 61850-7-2. Table 6 of IEC 61850-7-1:2011 describes the ACSI models and services. The following describes the services in the specific wind power plant context.

Figure 8 graphically illustrates the various components of the ACSI models. This figure is used to provide a narrative description of how a typical device interacts with the outside world using these services.

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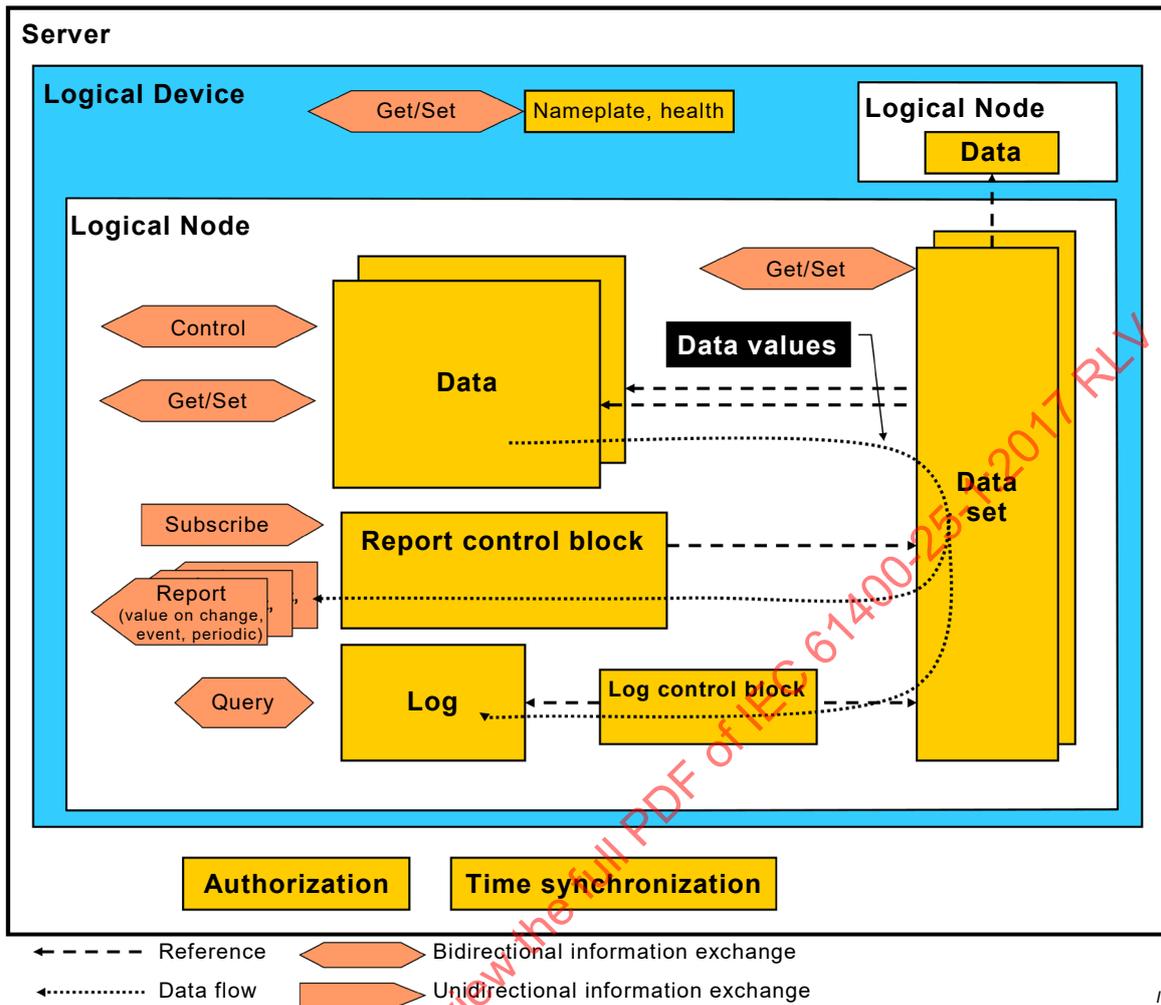


Figure 8 – Conceptual information exchange model for a wind power plant

A physical device with a communications interface is represented as a server. It has a communication network address and is accessible over a network by an external client. The server can accept a connection from one or more external clients, authenticate that connection, and support services to provide information to the client. This server contains one or more logical devices, which contains one or more logical nodes that represent the basic building blocks (objects) that represent various functionalities of the logical device. The logical node contains data that can be written to or read individually and in groups (data sets), responds to control inputs, provides solicited and unsolicited reports, and contains logs that can be queried. This representation is generic, but quite powerful in terms of the services it provides and can be used to represent any real world physical device with a communications interface.

Get/Set and Control services are provided to read (get) and write (set) the data in the logical node. Analogue information and status information are normally read only. Control and configuration information are generally read and write. Services are provided to facilitate concepts such as select before operate for control applications.

In addition to individually named data, collections of data (a Data Set) can be defined and given a name. Services are provided to create, delete and list Data Sets, and to get and set values of Data Sets. This arbitrary grouping capability lets client applications define collections of data attributes that are commonly needed and retrieve them with a single get operation using a single name.

Data Sets are the key to two information exchange mechanisms in a logical node – reporting and logging. Most physical devices have some kind of internal logging mechanism. These logs may contain periodic recordings of data values, recordings of data values when the value changed by some amount, exceeded a threshold, or some other triggering mechanism. Similarly, physical devices often have the means to send some kind of report directly to a subscribed client under circumstances similar to those just described for logging. In the ACSI models, the information that gets reported or logged is represented by a Data Set. This approach permits specifying the rules for logging and reporting to be defined in a more compact and efficient fashion.

The rules for logging and reporting are defined in the log control block (LCB) and report control block (RCB) respectively. Each log has an associated LCB and each report has an associated RCB that defines the rules for what goes into the logs and reports. These rules determine which Data Set(s) are to be included and under what conditions. This approach provides a very powerful and flexible means of logging and reporting information.

Logs are often a very important aspect of a physical device. The generation of these logs may be the core function of the physical device (a condition monitoring device for example) or may be utilized for diagnostic information. Logs are time ordered collections of data grouped into defined Data Sets. Services are provided to permit an external client to retrieve information from the log either in whole or in part. This is accomplished by providing the means to query the log with filters that specify a time range of interest and which named attributes are to be retrieved.

Services are also provided to permit a client to subscribe to reports that have been defined in the device. These reports can be buffered so that if communications are temporarily disrupted, all of the reports are still sent to the client when communications are re-established.

This overview illustrates the core information exchange capabilities of a physical device using the ACSI approach. For more detailed description of the ACSI, refer to IEC 61850-7-1 and IEC 61850-7-2.

7.2.4 Service modelling convention

The services are generally defined by:

- a set of rules for the definition of messages so that receivers can unambiguously understand messages sent from a peer,
- the service request parameters as well as results and errors that may be returned to the service caller, and
- an agreed-on action to be executed by the service (which may or may not have an impact on process).

This basic concept of the IEM is depicted in Figure 9.

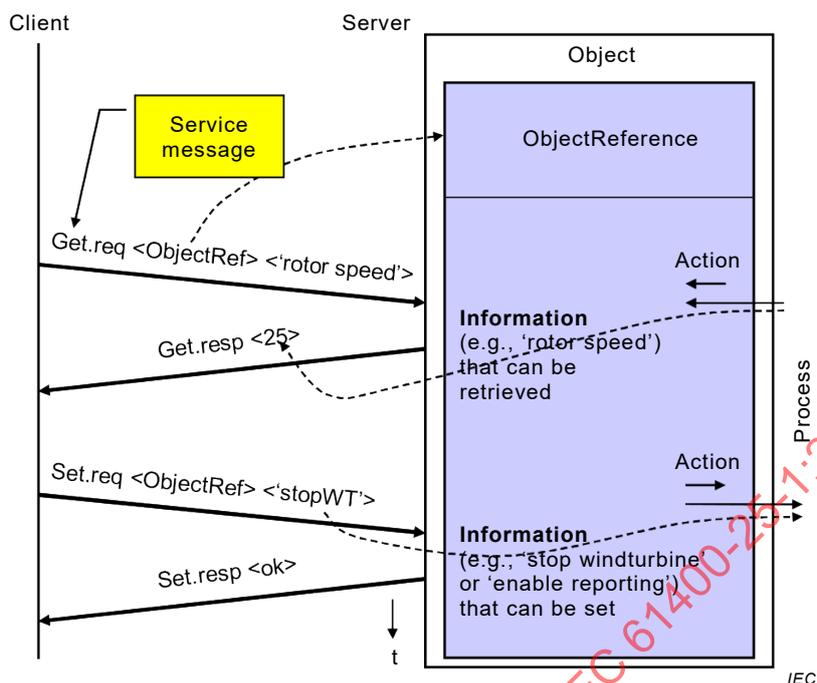


Figure 9 – IEM service model with examples

All services are based on three message primitives: request, positive response and negative response. The request primitive is used by the client to issue a service call to the server and the response primitives allow the server to return information to the client. A positive response primitive indicates that the service agreed-on action was or will be executed whereas a negative response indicates the action failed to execute or will not be executed. A message primitive may have a number of parameters, called results and errors in case of response primitives.

Each specific service is defined by one or more service tables that summarize the parameters that are required for the processing of a particular primitive as shown in Table 6.

Table 6 – Service table

Parameter name
Request
Parameter 1...
Parameter <i>n</i>
Response+
Parameter 1...
Parameter <i>n</i>
Response-
Parameter 1...
Parameter <i>n</i>

NOTE 1 The service tables of the services defined in IEC 61400-25-3 do not show all parameters required in concrete interface implementations; for example, the parameter 'association' or 'retransmission time' are not depicted in the service tables. These tables are abstract – local issues and concrete protocol issues are not shown. These specific issues are not required to understand the semantic and behaviour of the service.

Each parameter and the effect this parameter has on the processing of the service are abstractly described in this document.

The sequences of the request/response primitives (messages) for the services are depicted in Figure 10.

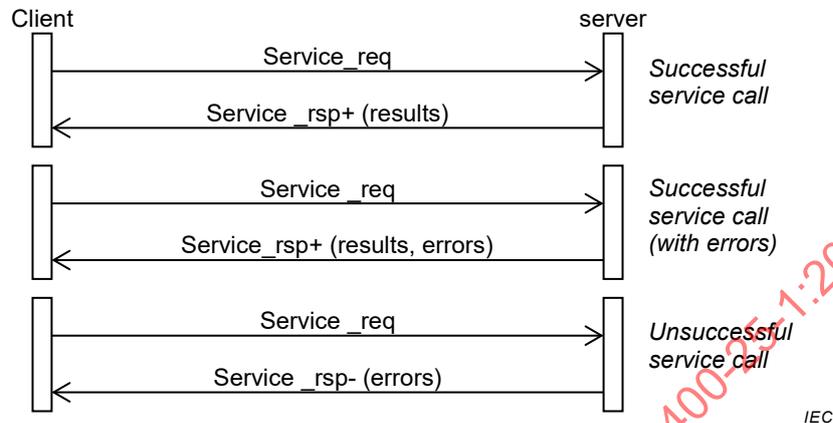


Figure 10 – Sequence diagram

The messages operate on the (attributes of) information objects. There are two kinds of classes that can be instantiated to objects:

- 1) The wind power plant information model classes such as logical devices, logical nodes, data objects, and data attributes as defined in Clause 6 (mainly representing process data, e.g. 'rotor speed' or 'stop wind turbine'), and
- 2) Various (common) control blocks, for example, for reporting and logging. The reporting control block may, for example, be accessed to start or stop reporting values by setting a specific attribute.

The messages described in this clause are conceptual – to understand the IEM.

NOTE 2 The concrete messages can be defined by some well known notation, for example, tables or XML. Concrete messages can be found in the mappings to specific application layer protocols (see IEC 61400-25-4).

The agreed-on action or actions to be processed on the receipt of a message may be simple, as in the case of the service 'Get', or more complex, as in the case of controlling the behaviour of a real physical device. The later case requires precise description of how the control acts, for example, the server could immediately invoke the process control system to distribute the necessary internal commands to stop the wind turbine or it may first have to check if another client is operating the wind turbine, thus requiring the use of a semaphore (often called Select-before-Operate).

The dynamical behaviour of the reporting and logging models is controlled by common control blocks. The actions of a certain control block object are described by multiple attributes like number of entries/array-elements, which values to be reported or logged, period of periodic reporting/logging, or events to buffer in case the communication link is down. The dynamic behaviour is also influenced by the nature of the buffer, for example, circular buffer that wraps.

Actions usually produce results that have to be transmitted back to the client. In case of error occurrence, error messages are sent back. The actions are usually defined by various attributes, formal state machines and plain text.

8 Mapping to communication protocols

8.1 General

The specific communication service mapping (SCSM) defines how the services and the models (server, logical devices, logical nodes, data objects, data sets, report controls, log controls, setting groups, etc.) are mapped to specific communication stacks, i.e. to a complete profile. The mappings and the used application layer define the syntax (concrete encoding) for the data exchanged over the network.

NOTE The concept of the SCSM has been introduced to be independent from communication stacks including application protocols.

According to Figure 11, the SCSM maps the abstract communication services, objects and parameters to the specific application layers. These application layers provide the concrete coding. Depending on the technology of the communication network, these mappings may have different complexities, and some ACSI services may not be supported in all mappings but where a service is provided in a mapping, that service shall be equivalent in its meaning to the same service in the benchmark mapping. An application layer may use one or more stacks (layers 1 to 6).

EXAMPLE The mapping of the service 'GetDataSetValues' (reading many values in one chunk) can have different mappings for AL1 to ALn. For example, a specific AL can support this service directly while another AL supports Get of single values or many values of the same type only. In this case, the mapping issues several Gets.

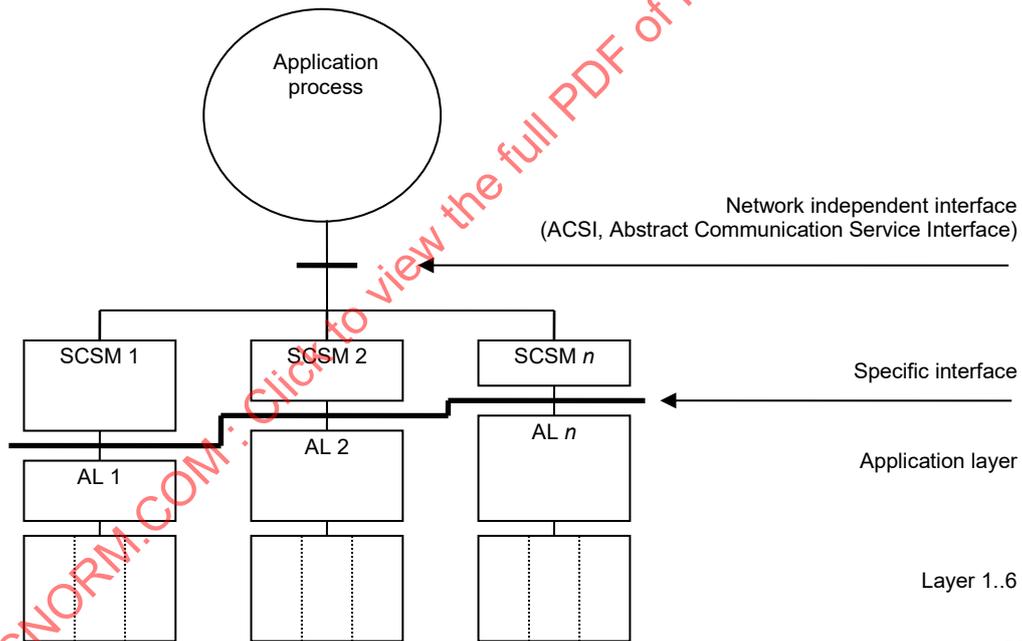


Figure 11 – ACSI mapping to communication stacks/profiles

8.2 Architecture of the mappings

Multiple mappings may be supported by IEC 61400-25 (all parts). The conceptual architecture of the mappings is shown in Figure 12.

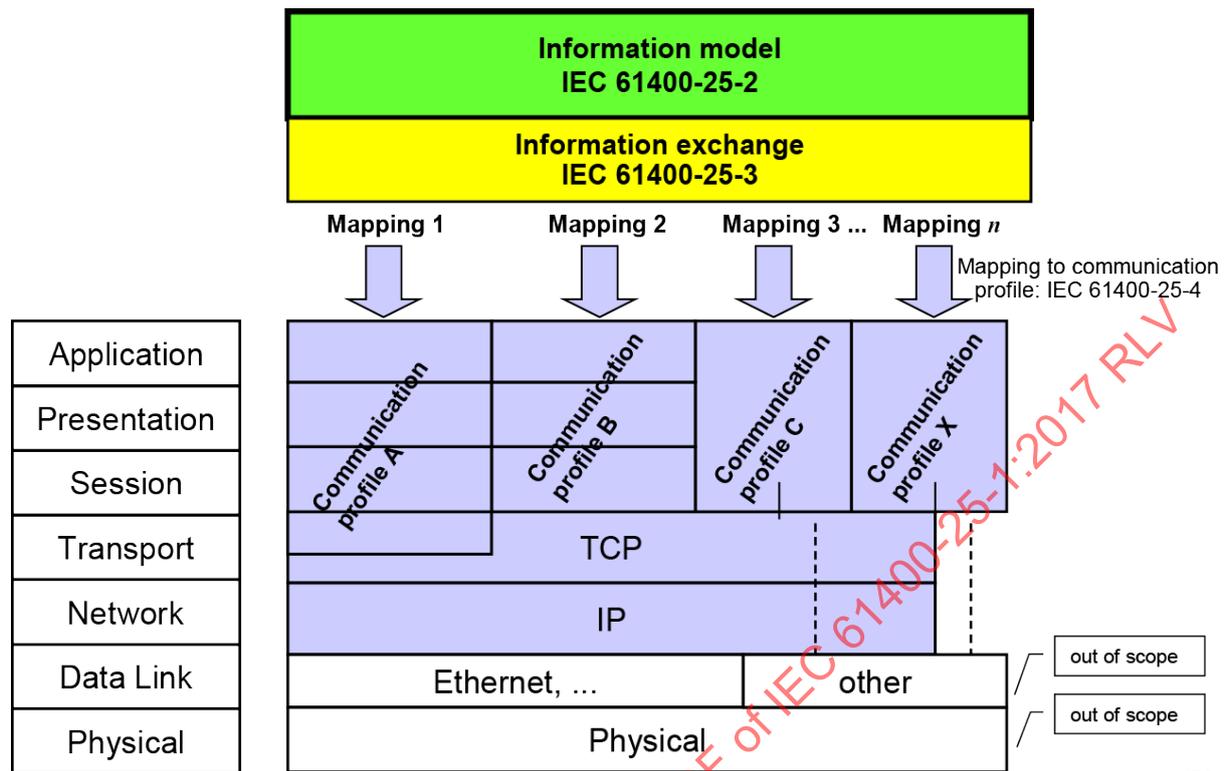


Figure 12 – Communication profiles

The information models and the information exchange models need to be mapped to appropriate protocols. Mapping requirements are defined in IEC 61400-25-4. The protocols TCP and IP shall be the basic lower layer protocols provided by all mappings. Specific data link and physical layers are beyond the scope of IEC 61400-25 (all parts).

8.3 Mapping of the wind power plant information model

The mapping of the wind power plant information models to a hierarchical structure as defined in Clause 6 and Clause 7 of IEC 61400-25-2:2015, shall be applied for all SCSMs of IEC 61400-25 (all parts).

Bibliography

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

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

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

SYSTÈMES DE GÉNÉRATION D'ÉNERGIE ÉOLIENNE –

Partie 25-1: Communications pour la surveillance et la commande des centrales éoliennes – Description globale des principes et des modèles

AVANT-PROPOS

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Cette deuxième édition annule et remplace la première édition parue en 2006. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) harmonisation générale du texte et des modèles présentés avec les autres parties de la série IEC 61400-25,
- b) harmonisation des définitions des autres normes connexes.

Le texte de cette Norme internationale est issu des documents suivants:

CDV	Rapport de vote
88/587/CDV	88/622/RVC

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Le titre du comité d'études 88 qui était *Éoliennes* est devenu *Systèmes de génération d'énergie éolienne* en 2015.

Une liste de toutes les parties de la série IEC 61400, publiées sous les titres généraux *Éoliennes et Systèmes de génération d'énergie éolienne*, peut être consultée sur le site web de l'IEC.

Les utilisateurs de l'IEC 61400-25 forment une communauté, appelée USE61400-25. Pour de plus amples informations, voir <http://www.use61400-25.com>.

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- Les TISSUES rassemblés peuvent être classés en deux groupes:
 - TISSUES pouvant compromettre l'interopérabilité entre les mises en œuvre de la norme et nécessitant des corrections ou des clarifications (TISSUES «IntOp»),
 - TISSUES proposant de nouvelles caractéristiques qui seront mises en œuvre dans les versions futures de la norme (TISSUES «next edition»).
- Les TISSUES IntOp exigent une clarification immédiate et suivent un processus de résolution de problème transparent géré par le groupe d'utilisateurs de la série IEC 61400-25 avec les éditeurs de la série IEC 61400-25.
- La spécification détaillée de ce processus, la liste des TISSUES, la solution associée, leur statut et leur impact sur la mise en œuvre et la certification sont accessibles via le site web de l'USE61400-25, sous <http://www.use61400-25.com>.
- L'IEC recommande la mise en œuvre des solutions proposées pour les TISSUES IntOp dès qu'ils ont atteint l'état «green» (vert). Il convient que la liste des TISSUES mis en œuvre dans un dispositif électronique intelligent (IED) soit indiquée en toute transparence par son constructeur.

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INTRODUCTION

L'IEC 61400-25 (toutes les parties) s'adresse aux fournisseurs (constructeurs, fournisseurs), opérateurs, propriétaires, planificateurs et concepteurs de centrales éoliennes ainsi qu'aux intégrateurs système et aux entreprises publiques opérant sur le marché de l'énergie éolienne. L'IEC 61400-25 (toutes les parties) est destinée à être reconnue et utilisée dans le monde entier comme norme internationale relative aux communications dans le domaine des centrales éoliennes.

L'IEC 61400-25 (toutes les parties) a été élaborée afin de fournir des principes de communication uniformes servant de base pour la surveillance et le contrôle des centrales éoliennes. Elle spécifie des informations spécifiques aux centrales éoliennes ainsi que les mécanismes d'échange d'information et le mapping aux protocoles de communication. À cet égard, l'IEC 61400-25 (toutes les parties) définit les détails exigés pour l'échange des informations disponibles avec les composants de centrales éoliennes dans un environnement indépendant du constructeur. Cela est réalisé par les définitions données dans la présente partie de l'IEC 61400-25 ou par des références à d'autres normes.

Les informations spécifiques aux centrales éoliennes décrivent le processus essentiel et commun ainsi que les informations relatives à la configuration des centrales. Les informations sont structurées de manière hiérarchique et couvrent, par exemple, les informations communes relatives au rotor, au générateur, au convertisseur, à la connexion réseau et aux éléments similaires. Les informations peuvent être de simples données (y compris l'horodatage et la qualité) et des valeurs de configuration ou des attributs plus complets et des informations descriptives, par exemple l'unité d'ingénierie, l'échelle, la description, la référence et les informations statistiques ou historiques. Le nom de toutes les informations d'une centrale éolienne définies dans l'IEC 61400-25 (toutes les parties) est renseigné. Une brève description de la signification de chaque donnée est fournie. Les informations normalisées relatives aux centrales éoliennes peuvent être étendues au moyen d'une règle d'extension d'espace de noms. Toutes les données, tous les attributs et toutes les informations descriptives peuvent être échangés par le biais de services correspondants.

La mise en œuvre de l'IEC 61400-25 (toutes les parties) permet aux systèmes SCADA (systèmes de supervision, contrôle et acquisition de données) de communiquer avec les éoliennes de plusieurs fournisseurs. L'autodescription normalisée (contenue dans un fichier XML ou récupérée en ligne à l'aide d'un dispositif adapté) peut être utilisée pour configurer les applications SCADA. La normalisation des applications SCADA est exclue de l'IEC 61400-25 (toutes les parties), mais les informations normalisées communes relatives aux éoliennes fournissent des moyens de réutiliser les applications et les écrans opérateur des éoliennes de plusieurs fournisseurs. Du point de vue des entreprises publiques, les définitions unifiées des données communes réduisent de manière notable la conversion et le recalcul des valeurs des données pour l'évaluation et la comparaison de toutes leurs centrales éoliennes.

L'IEC 61400-25 (toutes les parties) peut être appliquée à tout concept de fonctionnement de centrale éolienne, c'est-à-dire à des éoliennes individuelles, à des parcs éoliens et à d'autres groupes intégrés d'éoliennes. Le domaine d'application de l'IEC 61400-25 (toutes les parties) couvre les composants exigés pour le fonctionnement des centrales éoliennes, c'est-à-dire non seulement le générateur éolien mais également le système météorologique, le système électrique et le système de gestion des centrales éoliennes. Les informations spécifiques aux centrales éoliennes de l'IEC 61400-25 (toutes les parties) ne comprennent pas les informations associées aux artères et aux postes. La communication des postes est traitée dans l'IEC 61850 (toutes les parties).

L'IEC 61400-25 (toutes les parties) a pour objet de permettre aux composants provenant de différents fournisseurs de communiquer avec d'autres composants, quel que soit leur emplacement. Les structures de données orientées objet peuvent rendre moins chronophages et plus efficaces l'ingénierie et la manipulation de grandes quantités d'informations fournies par les centrales éoliennes. L'IEC 61400-25 (toutes les parties) prend en charge l'extensibilité, la connectivité et l'interopérabilité.

L'IEC 61400-25 (toutes les parties) sert de base à la simplification de la mise en œuvre des rôles que les éoliennes et les systèmes SCADA doivent jouer. La partie cruciale des informations des centrales éoliennes, les méthodes d'échange d'information et les piles de communication sont normalisées. Elles constituent une base à laquelle il est facile de se référer pour la rédaction des spécifications et des contrats relatifs aux marchés publics.

L'IEC 61400-25 est organisée en plusieurs parties.

- L'IEC 61400-25-1 a une portée introductive, comporte des exigences cruciales et un guide de modélisation.
- L'IEC 61400-25-2 et l'IEC 61400-25-6 contiennent la description du modèle d'information, une vue uniforme, orientée composant, des données relatives aux centrales éoliennes, y compris les extensions pour la surveillance de l'état.
- L'IEC 61400-25-3 décrit les modèles d'échange d'information. Elle reflète la fonctionnalité du serveur.
- L'IEC 61400-25-4 présente cinq options de mapping du modèle d'information et du modèle d'échange d'information à un profil de communication normalisé. Le choix s'effectue en fonction de l'application et de la fonctionnalité et des performances nécessaires.
- L'IEC 61400-25-5 décrit les cas d'essai pour les essais de conformité des mises en œuvre.

NOTE Les performances liées à la mise en œuvre de l'IEC 61400-25 (toutes les parties) sont spécifiques à l'application. L'IEC 61400-25 (toutes les parties) ne garantit pas un certain niveau de performances. Ce type de garantie ne fait pas partie du domaine d'application de l'IEC 61400-25 (toutes les parties). Toutefois, il n'y a pas de limitation sous-jacente à la technologie de communication qui interdirait des applications à haut débit (réponses de l'ordre de la milliseconde).

SYSTÈMES DE GÉNÉRATION D'ÉNERGIE ÉOLIENNE –

Partie 25-1: Communications pour la surveillance et la commande des centrales éoliennes – Description globale des principes et des modèles

1 Domaine d'application

L'IEC 61400-25 (toutes les parties) concerne essentiellement les communications entre les composants des centrales éoliennes, tels que les éoliennes, et des acteurs, tels que les systèmes SCADA. La communication interne entre les composants des centrales éoliennes ne relève pas du domaine d'application de l'IEC 61400-25 (toutes les parties).

L'IEC 61400-25 (toutes les parties) est conçue pour un environnement de communication fondé sur un modèle client-serveur. Trois domaines sont définis, qui sont modélisés séparément pour assurer l'extensibilité des systèmes mis en œuvre:

- 1) les modèles d'information des centrales éoliennes,
- 2) le modèle d'échange d'information, et
- 3) le mapping des deux modèles précédents à un profil de communication normalisé.

Le modèle d'information de centrale éolienne et le modèle d'échange d'information, considérés ensemble, constituent une interface entre le client et le serveur. Dans cette combinaison, le modèle d'information de centrale éolienne sert de cadre pour interpréter les données accessibles de la centrale éolienne. Le modèle d'information de centrale éolienne est utilisé par le serveur pour fournir au client une vue uniforme, orientée composant, des données de la centrale éolienne. Le modèle d'échange d'information reflète toutes les fonctions actives du serveur. L'IEC 61400-25 (toutes les parties) permet de connecter entre eux une combinaison hétérogène de clients et de serveurs issus de différents constructeurs et fournisseurs.

Comme représenté à la Figure 1, l'IEC 61400-25 (toutes les parties) définit un serveur ayant les aspects suivants:

- les informations fournies par un composant de centrale éolienne, par exemple, «vitesse du rotor de l'éolienne» ou «production électrique totale durant un certain laps de temps», sont modélisées et rendues accessibles. Les informations modélisées dans l'IEC 61400-25 (toutes les parties) sont définies dans l'IEC 61400-25-2 et l'IEC 61400-25-6,
- les services pour échanger les valeurs des informations modélisées, définies dans l'IEC 61400-25-3,
- le mapping à un profil de communication, fournissant une pile de protocoles pour transporter les valeurs échangées provenant des informations modélisées (IEC 61400-25-4).

L'IEC 61400-25 (toutes les parties) se contente de définir comment modéliser les informations, l'échange d'information et le mapping à des protocoles de communication spécifiques. L'IEC 61400-25 (toutes les parties) s'abstient de définir comment et où mettre en œuvre l'interface de communication, l'interface de programmation d'application et les recommandations de mise en œuvre. Toutefois, l'objectif de l'IEC 61400-25 (toutes les parties) est de permettre l'accès aux informations associées à un composant individuel de la centrale éolienne (tel qu'une éolienne) par le biais d'un dispositif logique approprié.

La présente partie de l'IEC 61400-25 fournit une description globale des principes et des modèles utilisés dans l'IEC 61400-25 (toutes les parties).

NOTE L'IEC 61400-25 (toutes les parties) concerne essentiellement les informations communes et non spécifiques au fournisseur. Les éléments d'informations qui tendent à varier considérablement en fonction des mises en œuvre spécifiques au fournisseur peuvent, par exemple, être spécifiés dans des accords bilatéraux, par des groupes d'utilisateurs ou dans les amendements de l'IEC 61400-25 (toutes les parties).

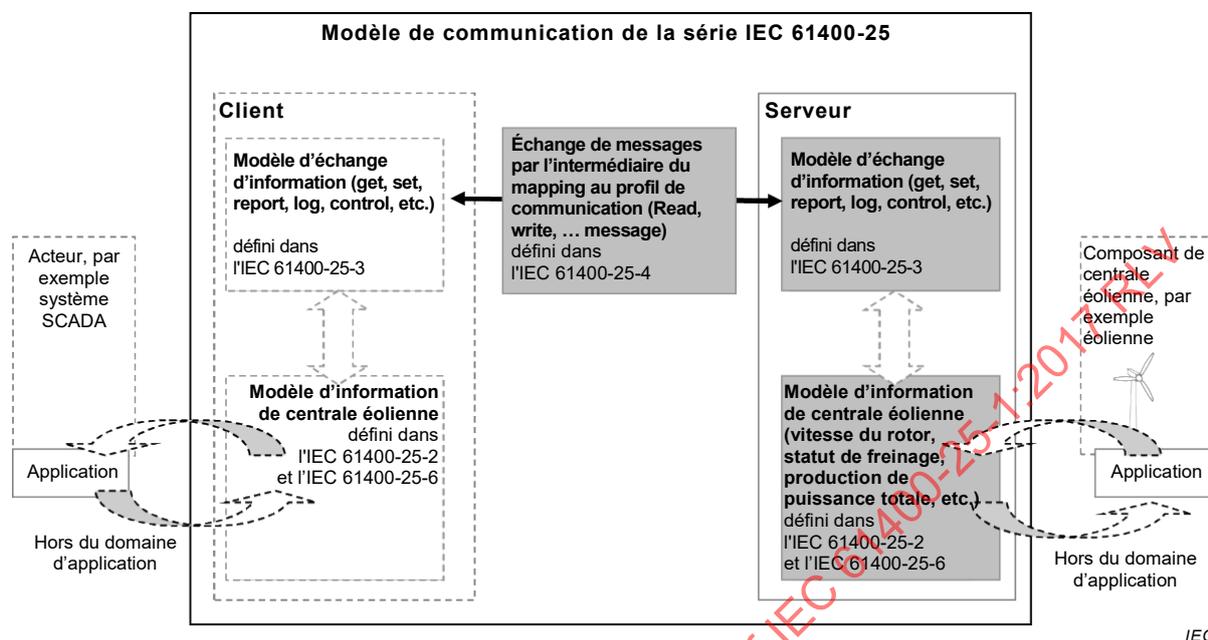


Figure 1 – Modèle conceptuel de communication de la série IEC 61400-25

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 61400-25 (toutes les parties), *Éoliennes – Partie 25: Communications pour la surveillance et la commande des centrales éoliennes*

IEC 61400-25-2:2015, *Eoliennes – Partie 25-2: Communications pour la surveillance et la commande des centrales éoliennes – Modèles d'information*

IEC 61400-25-3:2015, *Eoliennes – Partie 25-3: Communications pour la surveillance et la commande des centrales éoliennes – Modèles d'échange d'information*

IEC 61400-25-4, *Systèmes de génération d'énergie éolienne – Partie 25-4: Communications pour la surveillance et la commande des centrales éoliennes – Mapping pour les profils de communication*

IEC 61400-25-6, *Wind energy generation systems – Part 25-6: Communications for monitoring and control of wind power plants – Logical node classes and data classes for condition monitoring* (disponible en anglais seulement)

IEC 61850-7-1:2011, *Réseaux et systèmes de communication pour l'automatisation des systèmes électriques – Partie 7-1: Structure de communication de base – Principes et modèles*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract communication service interface (ACSI)* (disponible en anglais seulement)

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

3.1

acteur

rôle que joue un système dans le cadre de la surveillance et du contrôle alors qu'il n'est pas directement impliqué dans le fonctionnement des centrales éoliennes, par exemple un système de supervision, contrôle et acquisition de données (SCADA)

Note 1 à l'article: Il existe de nombreuses autres désignations, par exemple système central de gestion, système de surveillance et de contrôle, système de contrôle à distance.

3.2

alarme

information d'état concernant la centrale éolienne
indication relative à l'intervention de sécurité émise par le système de contrôle des éoliennes (c'est-à-dire marche/arrêt)

3.3

valeurs caractéristiques

propriétés des informations analogiques (min, max, moyenne, écart, etc.)

3.4

commande

données contrôlables du comportement du système

EXEMPLE Activer/désactiver, valider/invalider.

3.5

fonction de communication

fonction utilisée par un acteur pour configurer, effectuer et surveiller l'échange d'information avec les centrales éoliennes

EXEMPLE Fonction opérationnelle, fonction de gestion.

3.6

contrôle

fonction opérationnelle utilisée pour le changement, la modification, l'intervention, la commutation, le contrôle, le paramétrage et l'optimisation des centrales éoliennes

3.7

valeur de comptage

nombre total d'apparitions d'un événement particulier

3.8

récupération de données

fonction opérationnelle utilisée pour la récupération de données relatives aux centrales éoliennes

3.9

diagnostic

fonction de gestion utilisée pour configurer et assurer l'autosurveillance du système de communication

3.10

système électrique

ensemble de composants électriques qui fonctionnent les uns avec les autres en tant que parties d'une éolienne ou d'un champ d'éoliennes chargé de la récupération et de la transmission de l'électricité produite dans une centrale éolienne

3.11

événement

transition d'état (statut, alarme, commande)

3.12

dispositif électronique intelligent

IED

tout dispositif comprenant un ou plusieurs processeurs ayant la capacité de recevoir des données d'un émetteur externe ou d'envoyer des données à un récepteur externe

EXEMPLE Contrôleur d'éolienne.

Note 1 à l'article: Un IED peut être raccordé à un autre IED comme client, comme serveur, ou les deux.

Note 2 à l'article: Le terme abrégé «IED» est dérivé du terme anglais développé correspondant «intelligent electronic device».

3.13

information

contenu d'une communication

Note 1 à l'article: L'élément de base est une donnée brute provenant des composants de centrale éolienne, à traiter dans les informations spécifiées, conformément à l'IEC 61400-25 (toutes les parties).

Note 2 à l'article: Les catégories d'informations de centrales éoliennes sont: informations sources (informations analogiques et d'état), informations dérivées (informations statistiques et historiques). Les informations sont définies comme des données (des données généralement traitées et dérivées et des informations décrivant d'autres données).

3.14

échange d'information

processus de communication entre deux systèmes, par exemple un composant et un acteur d'une centrale éolienne, dans le but de fournir et d'obtenir des informations pertinentes

Note 1 à l'article: L'échange d'information exige des fonctions particulières de communication consistant en un ou plusieurs services.

3.15

modèle d'information

modèle représentant les connaissances relatives aux fonctions et aux dispositifs dans lesquels les fonctions sont mises en œuvre

Note 1 à l'article Ces connaissances sont rendues visibles et accessibles par les moyens décrits dans l'IEC 61400-25 (toutes les parties). Le modèle décrit de manière abstraite une représentation orientée communication d'une fonction ou d'un dispositif réel(le).

3.16

journal

informations historiques

Note 1 à l'article: Le journal est une liste chronologique d'informations sources correspondant à une période de temps donnée.

3.17**journalisation**

fonction opérationnelle

Note 1 à l'article: La journalisation est une pratique consistant à enregistrer des données séquentielles, la plupart du temps de manière chronologique. Le journal est le résultat d'une journalisation.

3.18**dispositif logique**

entité qui représente un ensemble de fonctions types de centrales éoliennes

3.19**fonction de gestion**

fonction exigée pour l'administration de l'échange d'information d'un certain niveau

Note 1 à l'article: La gestion utilisateur/accès, la synchronisation temporelle, le diagnostic et la configuration sont les fonctions de gestion.

3.20**obligatoire**

fourni conformément à l'IEC 61400-25 (toutes les parties)

3.21**données mesurées**

valeur échantillon d'une grandeur de processus avec les attributs de données associés tels que l'horodatage et la qualité

3.22**système météorologique**

composant d'une centrale éolienne chargé de la surveillance des conditions ambiantes, par exemple la vitesse du vent, la direction du vent, la pression, la température

Note 1 à l'article: Il fournit des données à des fins différentes, par exemple afin d'établir une corrélation entre les données météorologiques et l'énergie électrique de sortie produite par des éoliennes individuelles, d'une part, et l'énergie éolienne potentiellement utilisable, d'autre part.

3.23**surveillance**

fonction opérationnelle utilisée pour l'observation locale ou à distance d'un système ou d'un processus concernant toute modification pouvant survenir dans le temps

Note 1 à l'article: Ce terme peut également concerner l'observation du comportement d'une valeur de données ou d'un groupe de valeurs de données.

3.24**fonction opérationnelle**

fonction permettant d'obtenir des informations et d'envoyer des instructions pour le fonctionnement quotidien normal des centrales éoliennes

Note 1 à l'article: Les types de fonction opérationnelle sont: surveillance, journalisation, établissement de rapports, récupération de données, contrôle.

3.25**facultatif**

fourni de manière facultative, conformément à l'IEC 61400-25 (toutes les parties)

3.26**paramètre**

informations contrôlables destinées à obtenir ou à corriger un comportement du système

3.27**données traitées**

valeur mesurée, avec les attributs de données associés, tels que l'horodatage et la qualité, qui a été traitée selon l'attribut de méthode de calcul

3.28**profil(s)**

format(s) utilisé(s) par un protocole particulier pour transmettre des objets de données ou des commandes, etc.

3.29**pile de protocoles**

mise en œuvre logicielle particulière d'une suite de protocoles de réseau informatique

Note 1 à l'article: Les termes sont souvent utilisés de manière interchangeable. Au sens strict, la suite est la définition des protocoles et la pile est la mise en œuvre logicielle de ces protocoles.

3.30**rapport**

information réelle envoyée par la fonction d'établissement de rapports

Note 1 à l'article: Un rapport peut contenir toutes les sortes d'informations définies dans l'IEC 61400-25-2.

3.31**établissement de rapports**

fonction opérationnelle permettant de transférer des données d'un serveur à un client, initiée par un processus d'application du serveur

3.32**système de supervision, contrôle et acquisition de données****SCADA**

système fondé sur une unité de processeur qui reçoit des informations provenant d'IED, détermine les exigences de contrôle et envoie des commandes aux IED

Note 1 à l'article: SCADA est un système informatique utilisé, par exemple, par les répartiteurs pour surveiller la distribution de puissance au sein d'un service ou d'une zone de contrôle.

Note 2 à l'article: Le terme abrégé «SCADA» est dérivé du terme anglais développé correspondant «supervisory control and data acquisition».

3.33**statut**

condition de l'état d'un composant ou d'un système (st1/st2/..stn)

3.34**information statistique**

résultat de l'application d'un algorithme statistique à un ensemble de données afin d'obtenir, par exemple, la valeur minimale, la valeur maximale, la moyenne, l'écart-type

3.35**données de durée**

durée d'un état spécifique

3.36**synchronisation temporelle**

coordination permettant d'exploiter des occurrences de façon synchronisée

Note 1 à l'article: Ce processus peut être un ordre délibérément établi sur une échelle de temps parallèle ou une coïncidence éventuellement observable.

3.37**donnée triphasée**

valeur mesurée dans un circuit électrique triphasé avec les attributs de données associés, tels que l'horodatage, la qualité et la méthode de calcul

3.38**journal de transitoire**

liste chronologique déclenchée par des événements d'informations à haute résolution relative à une courte période de temps (rapport déclenché par des événements)

3.39**gestion utilisateur/accès**

fonction de gestion utilisée pour configurer, modifier, supprimer des utilisateurs (de manière administrative), attribuer des droits d'accès (de manière administrative) et surveiller les accès

Note 1 à l'article: Une fonction de gestion n'inclut pas nécessairement de services de communication.

3.40**centrale éolienne**

système complet comprenant un certain nombre de sous-systèmes techniques spécifiés dans l'IEC 61400-25 (toutes les parties) comme composants de centrales éoliennes, par exemple une ou plusieurs éoliennes

Note 1 à l'article: Le principal objectif d'une centrale éolienne est de générer de l'énergie électrique à partir du vent.

3.41**informations analogiques relatives aux centrales éoliennes**

informations continues relatives à l'état ou au comportement réel d'un composant ou d'un système

EXEMPLE Les valeurs mesurées, les valeurs traitées, les valeurs triphasées, le point de consigne, les paramètres sont des types d'informations analogiques relatives aux centrales éoliennes.

3.42**composant de centrale éolienne**

système technique employé pour le fonctionnement des centrales éoliennes, tel que le système de gestion des éoliennes, les systèmes de gestion météorologique et électrique et le système de gestion de centrale éolienne

3.43**système de gestion de centrale éolienne**

composant d'une centrale éolienne servant à assurer que la totalité du système s'adapte aux conditions statiques et dynamiques et aux exigences relatives au raccordement à l'alimentation électrique (c'est-à-dire, l'interopération des éoliennes avec le poste et les autres dispositifs liés au réseau d'alimentation)

Note 1 à l'article: Un système de gestion de centrale éolienne peut inclure d'autres fonctions (par exemple, une fonctionnalité de contrôle Shadow, la réduction de bruit ou de son, l'avertissement de formation de glace, la protection contre la foudre) non modélisées dans l'IEC 61400-25 (toutes les parties).

3.44**éolienne**

principal composant d'une centrale éolienne

Note 1 à l'article: Elle est chargée de la production d'énergie et remplit cette tâche en utilisant le potentiel éolien d'un emplacement donné pour convertir l'énergie cinétique éolienne en énergie électrique.

4 Termes abrégés

ACSI	abstract communication service interface (interface abstraite des services de communication)
CDC	common data class (classe de données communes)
CMS	condition monitoring system (système de surveillance de l'état)
DC	data class (classe de données)
DNP3	distributed network protocol version 3 (protocole de réseau distribué version 3)
IED	intelligent electronic device (dispositif électronique intelligent)
IEM	information exchange model (modèle d'échange d'information)
LCB	log control block (bloc de commande de journal)
LD	logical device (dispositif logique)
LN	logical node (nœud logique)
O&M	operation and maintenance (fonctionnement et maintenance)
OSI	open systems interconnection (interconnexion de systèmes ouverts)
RCB	report control block (bloc de commande de rapport)
SCADA	supervisory control and data acquisition (système de supervision, contrôle et acquisition de données)
SCSM	specific communication service mapping (mapping des services de communication spécifiques)
WPP	wind power plant (centrale éolienne)
WT	wind turbine (éolienne)
XML	extensible mark-up language (langage de balisage extensible)

5 Description globale de l'IEC 61400-25 (toutes les parties)

5.1 Généralités

Le principal objectif de l'IEC 61400-25 (toutes les parties) est de créer une base normative pour les communications de surveillance et de contrôle indépendantes du constructeur. Les constructeurs et les fournisseurs de composants de centrales éoliennes doivent mettre en œuvre l'IEC 61400-25 (toutes les parties) dans leurs dispositifs et systèmes.

L'Article 5 fournit un aperçu général du contexte, des modèles, de l'approche de modélisation et des possibilités d'application de l'IEC 61400-25 (toutes les parties).

Le Paragraphe 5.2 fournit une vue descendante des centrales éoliennes et présente les domaines dans lesquels l'IEC 61400-25 (toutes les parties) peut être appliquée. Il explique ce que le terme «centrale éolienne» doit évoquer, les concepts de fonctionnement distinctifs et les composants utilisés pour faire fonctionner des centrales éoliennes.

Le Paragraphe 5.3 décrit les demandes effectuées concernant la communication établie dans le cadre de la surveillance et du contrôle des centrales éoliennes. Il décrit les capacités générales de communication que doivent avoir les centrales éoliennes et le contenu et les fonctions exigés pour la communication.

Le Paragraphe 5.4 fournit un aperçu du modèle de communication défini dans l'IEC 61400-25 (toutes les parties). L'environnement de communication serveur-client qui a servi de base à l'élaboration de l'IEC 61400-25 (toutes les parties) est brièvement présenté. Ensuite, trois topologies d'applications serveur-client sont présentées avec des exemples d'architectures de communication qu'il est possible d'appliquer. Pour finir, les trois domaines définis dans l'IEC 61400-25 (toutes les parties) et à mettre en œuvre de façon normalisée

pour la surveillance et le contrôle des centrales éoliennes sont présentés de manière généralement compréhensible.

5.2 Vue descendante des centrales éoliennes

5.2.1 Définition des centrales éoliennes

Les centrales éoliennes constituent la totalité des systèmes composés d'un certain nombre de sous-systèmes techniques avec des tâches clairement séparées. Les sous-systèmes sont spécifiés comme étant des composants de centrales éoliennes et sont décrits en 5.2.2.

5.2.2 Composants de centrales éoliennes

Les composants de centrales éoliennes sont des systèmes techniques employés pour le fonctionnement des centrales éoliennes. Ils sont constitués de différents sous-composants. Tous les composants de centrales éoliennes font partie du domaine d'application de l'IEC 61400-25 (toutes les parties).

Les informations modélisées dans l'IEC 61400-25 (toutes les parties) couvrent les composants correspondants suivants:

Éolienne

- rotor,
- transmission,
- générateur,
- convertisseur,
- nacelle,
- système d'orientation,
- mât,
- système d'alarme.

Système météorologique

- conditions météorologiques de la centrale éolienne.

Système de gestion de la centrale éolienne

- contrôle de la centrale éolienne.

Système électrique

- raccordement de la centrale éolienne au réseau.

Système de surveillance de l'état (CMS – Condition monitoring system)

- processus qui a pour objet l'observation des composants ou des structures d'une éolienne ou d'une centrale éolienne au cours d'une période de temps donnée.

L'éolienne (et ses nombreux sous-composants) constitue le principal composant d'une centrale éolienne. L'éolienne est chargée de la production d'énergie et remplit la tâche en utilisant le potentiel éolien d'un emplacement donné pour convertir le vent en énergie électrique.

Les fournisseurs d'éoliennes garantissent généralement à leurs clients une certaine courbe de puissance et une certaine disponibilité technique sur le plan de la production d'énergie. Afin de permettre aux opérateurs et aux propriétaires de vérifier la garantie des performances des éoliennes utilisées, des données justifiées fournissant des informations sur les conditions de vent à un emplacement particulier doivent être disponibles.