Use of IEC 61400-25 to secure access to key O&M data

Anders Johnsson
Vattenfall Research and Development AB
anders.johnsson@vattenfall.com

Lars Eeg Højholt
Vattenfall Thermal Power
lars.eeg.hojholt@vattenfall.com

Abstract:

The IEC standard series 61400-25 provides a solution for access to wind power information with standardized data names and semantic. It gives possibilities to procure monitoring and control solutions as separate parts, and to use a single system to store, analyze and present wind power information. Vattenfall has been involved in the development of the international standard from the very beginning. This paper gives an introduction to the IEC 61400-25 series of standards and presents an overview of the different parts. Furthermore it describes how Vattenfall and other wind power owners and operators can benefit from the standard.

Keywords: Communication, IEC 61400-25, monitoring, control, operation, maintenance, wind power plants

1 Introduction

1.1 Background and overview of trends

The wind power business is young compared to the hydropower business, which started more than a century ago, but it is gradually becoming a mature industry. Power companies are now entering the market. Large utilities and independent power producers have, in terms of cumulative capacity, increased their share within a year from some 30 % to 40 % of the total installations in the world by end 2006 [1]. These companies typically have a mix of generation units. Wind power is a complement to other resources, which in turn can be used to compensate for the variations in the wind. The combination of wind and hydro with storage capacity is especially interesting in both the overall long term and the short term production planning.

Wind turbine manufacturers typically provide the maintenance of the turbine for a number of years. In other industrial businesses such as hydropower it is very common that third-party companies offers services for fault-corrective and preventive maintenance. Many owners of wind power now move in a direction where they increase their responsibility for the operation and maintenance of the turbines. Proven and reliable design and well-established processes for operation and maintenance are some of the key success factors.

Vattenfall has close to 100 years experience in operating and maintaining power plants. Methods, tools and processes have developed during these years and have been adjusted to changes in technology, market requirements and stakeholder requirements. The power companies can use their experience from other areas to improve the operation and maintenance of wind power plants. The detailed knowledge of the technology is with the manufacturers. The manufacturers know most about the strengths and weaknesses of their products. Their knowledge is based on the experience gained from the many hours of supervision and evaluation of wind turbines. It would be beneficial to all parties if the manufacturers knowledge of technology could be combined with the customer's knowledge regarding operation and maintenance.

Today Vattenfall owns around 500 wind turbines in the Nordic countries. Vattenfall's goal for Sweden is to increase the production by 7-8 TWh wind power by the year 2016. Vattenfall's wind power initiative

is both land and offshore based. Vattenfall has already launched several offshore wind power projects and is now intensively engaged in identifying suitable sites throughout Sweden for onshore wind power. In Denmark Vattenfall is evaluating suitable sites for new wind turbines and is in parallel to this working to make existing wind farms more efficient.

Access to online and historical wind turbine data is a prerequisite for efficient and effective operation and maintenance. This is where the IEC standard series 61400-25 *WIND TURBINES – Communications for Monitoring and Control of Wind Power Plants* comes in.

2 IEC 61400-25

2.1 Overview

The focus of IEC 61400-25 is on the communications between wind power plant components such as wind turbines and SCADA systems. The application area of IEC 61400-25 covers all components required for the operation of wind power plants, not only the wind turbine but also the meteorological system, the electrical system, and the wind power plant management system. IEC 61400-25 defines all details required to connect wind power plant components in a multi-vendor environment and to exchange the information made available by a component. This is done by definitions made in the document or by reference to other commonly used standards, such as IEC 61850. IEC 61400-25 supports the integration of wind power plants into the power system [2]. For information associated with feeders and substations, the IEC 61400-25 series of standards refers to the standard series IEC 61850 (Communication networks and systems in substation). IEC 61400-25 relies on IEC 61850 – it mainly extends the information models for wind power applications.

The different parts in the IEC61400-25 series include a standardized information model and standardized protocols for communication interfaces to wind turbines and other wind power plant components. The information model specifies standardized names and definitions on process (state and analogue) information, control information and derived (statistical and historical) information. The protocol suite in IEC 61400-25-4 provides solutions for different wind turbine applications. And finally, the conformance test standard IEC61400-25-5 provides a framework to verify that different components are in conformance with the standard.

IEC 61400-25 consists of six parts as presented in Table 1.

IEC 61400-25 – WIND TURBINES – Communications for Monitoring and Control of Wind Power Plants
Part -1: Overall description of principles and models Introductory orientation, overview of crucial requirements and basic principles, and a modelling guide.
Part -2: Information model Hierarchical model of wind power plant specific name tagged information that describes common process data, meta-data (e.g. scale factor or engineering unit), and configuration data.
Part -3: Information exchange model Model with services to get, set, and subscribe to wind power plant information. Access to the meta data (including configuration information) provides self-description of a device.
Part -4: Mapping to communication profiles Mappings for Web Services, MMS (defined in IEC 61850-8-1), OPC XML DA, IEC 60870-5-104 and DNP3. (Will be published January 2008)
Part -5: Conformance testing Specifies techniques for testing of implementation conformance plus measurement techniques to be applied when declaring performance parameters.
Part -6: LN classes and Data classes for Condition Monitoring Defines additional information models for use in condition monitoring systems. (To be released)

Table 1 – List of the parts in the IEC 61400-25 series

2.2 Modelling of wind power plant information

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 must be processed into specified information. Besides source data, wind turbine controllers usually derive a huge amount of additional information (10 minutes averages, alarms, logs, counters, timers, etc.). This valuable information is locally stored and available for future use or analysis.

The modelling method of IEC 61400-25 can be used to describe wind turbine units from different manufacturers in the same information model. The standard also describes additional devices, components and functions in a wind power plant, such as meteorological information, alarm logs, event logs, active and reactive power control [2]. Figure 1 shows logical nodes of the information model. The logical nodes represent different components of a wind power plant. Mandatory logical nodes are expected to be available and optional logical nodes may be available depending on the type of wind turbine. When applicable the IEC 61400-25 standard re-uses information models of IEC 61850-7-3 and IEC 61850-7-4.

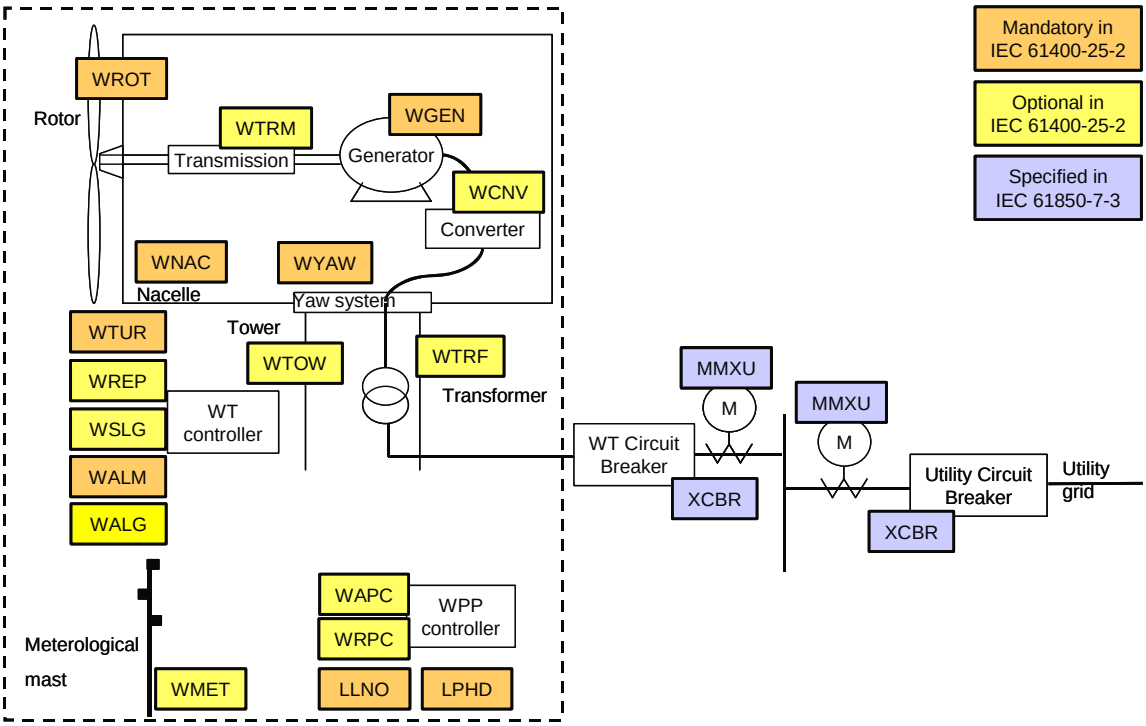


Figure 1 – Modelling of wind power plant components

Five types of information that can be differentiated:

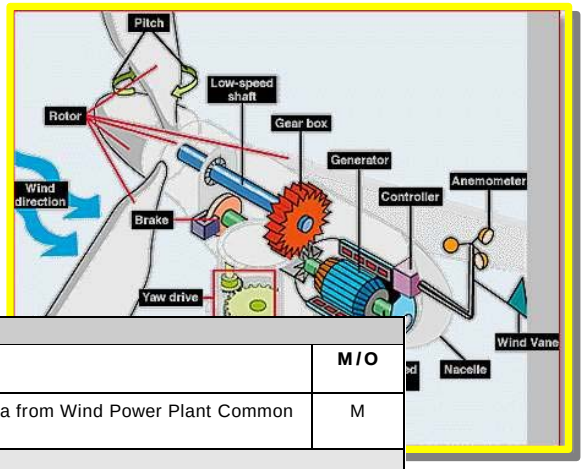
– Process information,
– Statistical information,
– Historical information,
– Control information,
– Descriptive information.

Process, statistical and historical information provide the contents required for the monitoring, control and evaluation of wind power plants; this information must 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 must first be communicated to wind power plants by certain actors. Wind power plants must 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.

Each component or function is represented by a logical node that contains a set of data with standardised names. A number of standard data types have been defined, to be used for the different data. Figure 2 shows an example with the logical node for a generator, WGEN. As can be seen in the figure the speed of the generator is available as a measured value (MV) under the standardised name Spd. An M in the M/O column indicates that this is a mandatory data. Every implementation according IEC 61400-25 shall have this data and all other mandatory data. The operation mode of the generator may be available as a status value (STV) under the standardised name GnOpMod, in case the vendor has made this optional data available.
NOTE Not all standardised data are shown in this example.



WGEN class			
Attribute name	**Attribute type**	**Explanation**	**M/O**
		LN shall inherit all Mandatory Data from Wind Power Plant Common Logical Node Class	M
Data			
Common information			
OpTmRs	TMS	Generator operation time	O
Status information			
GnOpMod	STV	Operation mode of generator	O
ClSt	STV	Status of generator cooling system	O
Analogue information			
Spd	MV	Generator speed	M
W	WYE	Generator active power	O
VAr	WYE	Generator reactive power	O
GnTmpSta	MV	Temperature measurements for generator stator	O

Figure 2 – WGEN - Model of wind power plant generator

3 Benefits

Vattenfall and other wind power operators can benefit from the IEC61400-25 series of international standards. It provides solutions to several challenges. To begin with, it can be used to provide access to data without expensive converters or extra communication equipment. It also gives the possibility to compare and analyze key data from different turbine makes without having to pre-process and translate the data due to

different semantics. The data set used for comparisons are common to most wind turbines but have so far typically had different vendor-specific names and have been calculated in different ways. IEC 61400-25-2 standardizes these common data and at the same time provides a method for the vendors to describe data unique to a vendor-specific turbine in a standardized way. One possibility with IEC 61400-25, which is so far very seldom used, is to procure the wind power plant monitoring and control solution as different parts, i.e. to choose best-of-breed systems. On supervision level there is a possibility to use a single system to process and present wind power information.

Vattenfall has been involved in the development of the IEC61400-25 standard from the very beginning. The fact that more than 10 countries have been involved in the work shows the importance of the standard. With the publication of the IEC61400-25 series of standards there is now a complete solution to the earlier problems to get easy access to relevant data.

The benefits listed so far focus very much on the customer but the standard is not only of value for the customer but also for the supplier. The standard is not intended to provide a standardized communication interface on top of the vendor-specific solution. The protocols defined in IEC 61400-25-4 can replace the vendor-specific solutions. Thus, the vendors do not have to spend time and money to develop communication solutions and can instead focus on developing the monitoring and control applications that give real value to the customer.

4 Development of operations and maintenance centers

4.1 O&M related applications

The systems, functions and applications for operation and maintenance are continuously developing in the wind power area, when the experience from wind turbine development and operation is mixed with the experience to operate and maintain power plants, together with demands from power system operators, etc. Well-established monitoring and control applications for the wind power plant now include conventional remote monitoring and control, local automation and protection, power quality monitoring, measurement systems, condition monitoring, and control system condition monitoring. Some of the new application areas include the following:

- Asset management (collection of asset information, control of changes)
- Maintenance management (supervision of maintenance process, review and improvement of tasks, achievement of an efficient maintenance cost)
- Operational management (calculation of energy lost, identification of main causes to no production)
- Operation experience feedback (analysis of incidents and identification of root causes, definition of WT design modifications to increase reliability)
- Information access control and cyber-security

Human-interfaces to the systems include local, remote (centralized/distributed) and mobile interfaces.

4.2 Vattenfall Wind power data center

Vattenfall has developed a system infrastructure for overall wind power plant management. Vattenfall Wind Power Data Center is part of this infrastructure with application servers, clients, database servers, communication networks and firewalls on several levels. Figure 3 shows the infrastructure with the different levels. The SCADA level contains several different vendor-specific SCADA servers, one system for each family or generation of wind turbines. The servers are for maintenance reasons typically located at Vattenfall control centre In Esbjerg. A separate communication network is implemented for the wind power area. Actors outside the area of Vattenfall operations and maintenance, for example turbine manufacturers, access the network in a secure manner through firewalls or virtual private networks.

The Vattenfall Wind Power Data Center supports mainly analysis, maintenance and

operational feedback. The objectives from an O&M standpoint is to reduce O&M costs, to get an overview of wind turbine operation, minimize outage times due to faults, increase production, and optimize the service planning. Key components include a process information (PI) management system and a central condition monitoring system. The process information system collects the data from Vattenfall wind power plants in Denmark, Sweden, and some additional places. The data is collected in a common database. This data is then made available to different users and systems through reporting, specific applications in the PI system, and communication interfaces. Combined reporting of production and availability, and quick detection of deviating wind turbines in wind farms are two important support applications. Output to forecasting and overall energy control can be combined with input of overall generation limits and power setpoints for control of wind power plants.

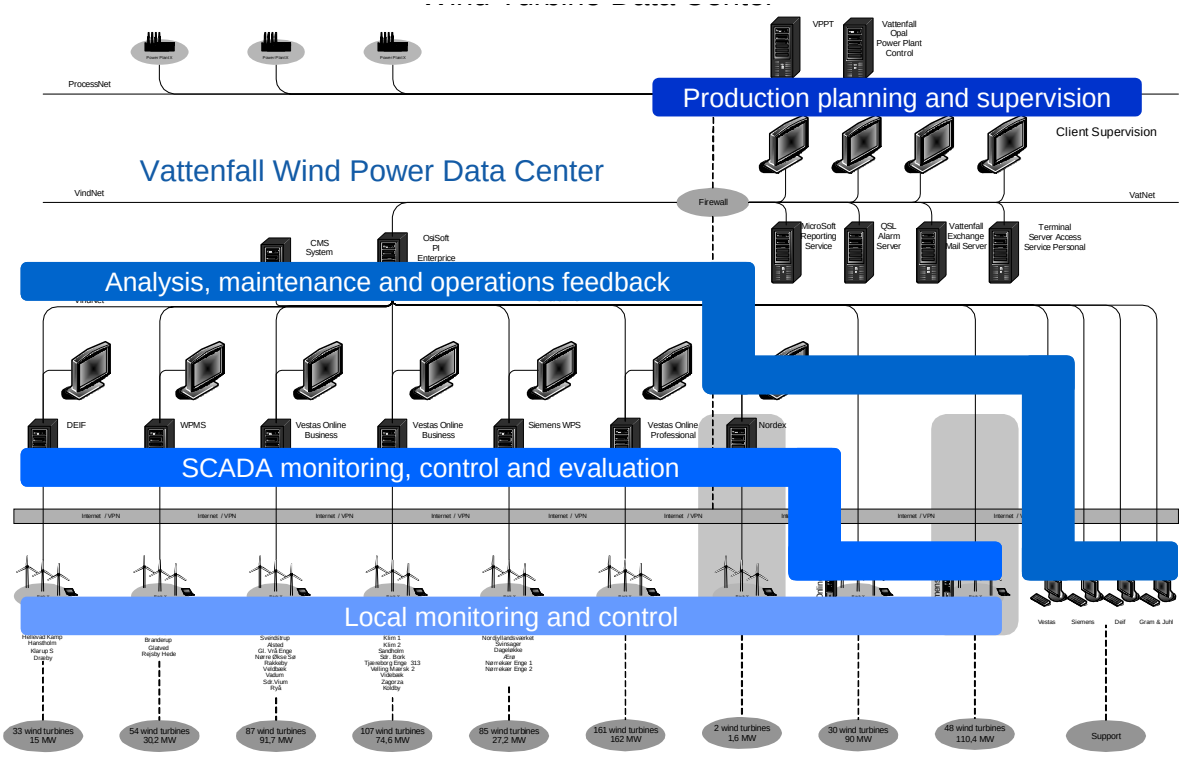


Figure 3 – Modelling of wind power plant components

4.3 Use of information models and reference systems

Vattenfall is introducing the RDS-PP (Reference Designation System for Power Plants) for the wind power assets. The system is a development of the KKS. The German standard DIN 6779-10 entitled "Structuring principles for technical products and technical product documentation – Part 10: Power plants" is expected to be published in early 2008 as an international standard under the number ISO TS 16952-10. The RDS-PP will be the basis for structuring and naming of components for maintenance purposes. The wind power plant information model defined in IEC 61400-25 has to work together with information models defined for this and other applications. The following is a short comparison of the two reference systems.

Both standards provide a way to identify and reference wind power plant components but the two systems have

different scope and purpose. Thus, they are not competing solutions.

RDS-PP is a top-down system for complete structured referencing, identification and categorization down to the level of (physical) components. IEC 61400-25-2 describes more of a bottom-up system. It specifies a method for structured naming and identification of data that is typically accessible in a wind power plant instrumentation and control system for the purpose of monitoring, control and evaluation. The IEC 61400-25-2 model therefore covers only a part of what is included in RDS-PP but is specifically designed to handle online and historical data. The strength of IEC 61400-25-2 lies in its ability to describe and give access to different attributes of data inside a component, such as time stamp, quality, scaling, unit, range etc. It is developed to provide necessary information to process and analyze data. There is a direct connection between the data reference and its properties.

5 Implementation of IEC 61400-25

5.1 Development of process information management systems

A system such as the PI-system, used in Vattenfall Wind power data center, needs to handle wind power plant information with different origin. It needs both a way to store detailed process values according to the IEC 61400-25-2 information model as well as a way to link these data to the general reference system RDS-PP. Since both systems have the same basic structure it should be possible to set up a table with translation from IEC 61400-25-2 naming references to RDS-PP references. Both identification systems have a hierarchical structure with several levels. IEC 61400-25-2 focus on RDS-PP function groups C - I&C equipment and M - Main machinery to identify non-physical and physical functions/parts. To a large extent these systems use the same grouping (rotor, nacelle, transmission etc) so the names should in many cases be similar, at least on the function level. Due to the fact that IEC 61400-25-2 is much more detailed about data attributes there will be a many-to-one relationship on the lowest level in the hierarchy.

5.2 Integration of SCADA systems

The communication standard IEC 61400-25 facilitates a unified operational platform. While the present Wind Power Data Center solution relies on vendor-specific front-end systems to interface to wind power plants, the introduction of standardised communication profiles according to IEC 61400-25-4 opens up for a direct connection to the wind power plants. On the SCADA level different wind power plants could be managed independently of all the vendor specific SCADA systems. The number of SCADA servers as shown in Figure 3, which is typical for a power company with many wind turbines, can be decreased. Operation from one SCADA system facilitates efficient, secure and reliable operation.

5.3 Migration on power plant level

IEC 61400-25 only defines how to model the information, information exchange and mapping to specific communication protocols. The standard excludes a definition of how and where to implement the communication interface. However, the objective of the standard is that information associated with a single wind power plant component (such as the wind turbine) is accessible through standard means. For migration reasons, when the standard interface is not yet available at the wind turbine level, the interface can be implemented at the wind power plant level. Figure 4 shows these two alternative levels. Thus, IEC 61400-25 supports the full range of wind power plant topologies. This enables adaptation of existing wind power plants, through use of a gateway or proxy.

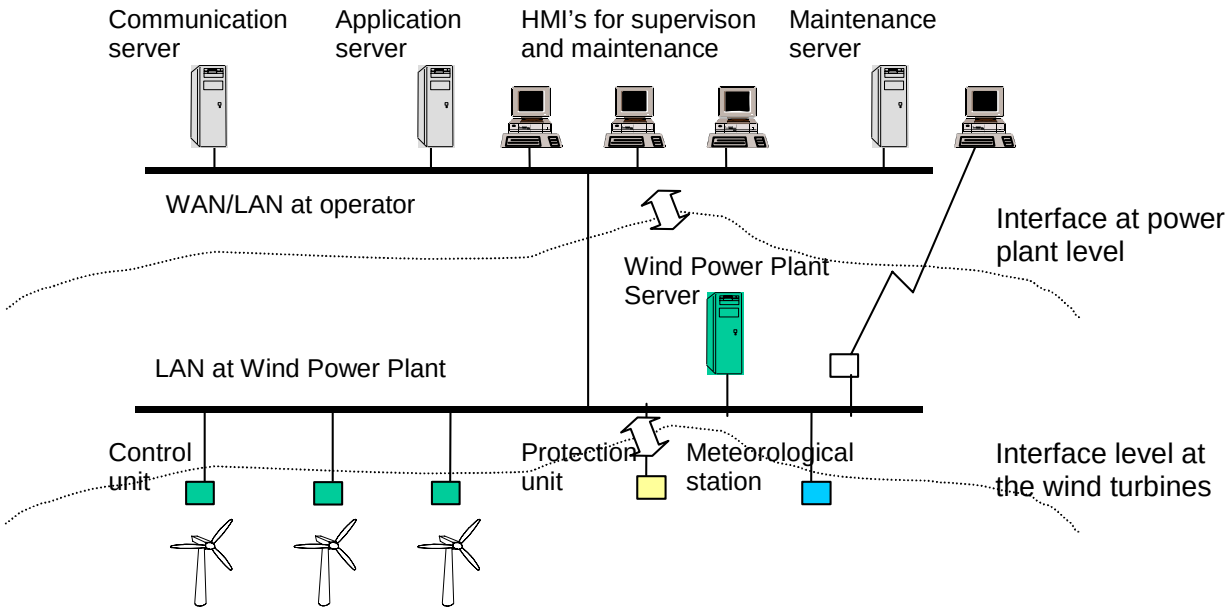


Figure 4 – Alternative interface levels

6 Conclusions

The IEC 61400-25 series of standards provides the means to get open and easy access to key O&M data. This data is a necessity for making the evaluations and analysis needed to improve operation and maintenance of the wind power plants. The paper has shown how the standard can be implemented and what benefits are associated with its use.

The standard does not restrict nor mandate specific customer-supplier roles, but provides a solution that supports the whole range of business cases where the different actors can cooperate. Both the customer and the supplier can benefit from IEC 61400-25 through decreased costs for data access and system integration. Time and money can instead be put on the development of applications, functions and methods that increase the performance of the wind turbines.

Vattenfall considers standards such as IEC 61400-25 to be an important part in the development of the wind power business. The IEC 61400-25 series of standards is therefore part of Vattenfall technical requirements for future procurements.

References

[1] *International Wind Energy Development - World Market Update 2006*, BTM Consult ApS, 2007.

[2] San Telmo, E., Canales, I., Villate, J.L., Robles, E. and Apiñaniz, S., "The use of IEC 61400-25 standard to integrate wind power plants into the control of power system stability", European Wind Energy Conference (EWEC2007), 7-10 May 2007.

About the authors

Anders Johnsson is a Senior Research Engineer at Vattenfall Research and Development AB, Sweden. His professional experience includes power plant monitoring and control with special focus on IT and communication. More recently, Johnsson has been responsible for the SCADA part of the Lillgrund project and project leader for the IEC 61400-25 standardization project. He earned his MSEE degree from the Royal Institute of Technology (Stockholm, Sweden).
anders.johnsson@vattenfall.com

Lars Eeg Højholt is an Engineer at Vattenfall Thermal Power in Denmark. His professional experience includes Wind power plant monitoring, and Enterprise systems. Højholt is responsible for the development of Vattenfall Wind Power Data Center solution. He has also worked with the SCADA systems in several wind power plant projects, most recently Kentish Flats and Lillgrund. He earned his BSEE degree from Odense Teknikum in Denmark.
lars.eeg.hojholt@vattenfall.com