Making wind farms and the power system more interoperable

Focus on data exchange

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Executive summary

Wind and solar will play a major role in the EU energy system as shown in all long-term decarbonisation scenarios. Operating a system and market with high shares of variable renewables requires maximum flexibility. This needs maximum interoperability between all network elements, connected devices and market players which depends very much on the exchange of information between them. To enable the expected volumes of renewables and ensure a cost-effective management of the energy system, policymakers must prioritise the implementation of secure, reliable, and cost-effective practices for data exchange.

The increasing digitalisation of wind farms and of the power system combined with current technologies can technically enable maximum interoperability. Still policies must improve to fully exploit this potential. This paper explores the state of play of data exchange between wind farms and the power system in Europe, identifies major challenges for the wind industry and recommends actions to enable interoperability and flexibility.

The first recommendation is about harmonising data communication obligations across different System Operators and different countries. The ongoing national implementation of Network Code requirements for data exchange needs clear and concrete guidance at EU level to achieve in-depth harmonisation among countries and lower system integration costs for renewables.

To achieve this, **WindEurope recommends that System Operators coordinate with relevant stakeholders (Significant Grid Users such as renewables and demand facilities) at EU level to develop centralized and unified datasets for information exchange – based on existing standards – providing all national authorities with guidance towards harmonisation, efficiency, and security**. This process should be established formally at EU level (for example by ENTSO-E or the European Commission) similarly to other technical groups tackling specific Network Code requirements and their national implementation. The current Network Code leaves much flexibility for national implementation - which helps address country-specific needs – but technical guidance at EU level is necessary. National implementation is at an early stage making it right moment to prioritise this exercise.

WindEurope is also calling for a closer collaboration among relevant stakeholders at EU and national level to ensure wide and harmonised adoption of the same standards as the default requirement.

Finally, **any requirements must acknowledge that legacy systems with different data and control functionalities are still in operation in wind farms across Europe**. Such cases need to be addressed separately from new systems – so that they can continue operating until the end of their lifetime in line with the sector's commitment to sustainability.

1 Context

Wind and solar will play a major role in the EU energy system as shown in all long-term decarbonisation scenarios. The “Impact Assessment” report[1] envisages 439GW of total installed wind capacity by 2030 and 1300GW by 2050. This is more than six times the existing installed capacity (204GW in 2020)[2]. It also envisages more than 1000GW of total installed solar capacity by the same time.

Operating a system and market with high shares of variable renewables requires maximum flexibility. This needs maximum interoperability between all network elements, connected devices and market players which depends very much on the exchange of information between them. To enable the expected volumes of renewables and reduce system integration costs, policymakers must prioritise the implementation of secure, reliable, and cost-effective practices for data exchange. This is the only way to enable on time the EU vision for renewables-based energy system and electricity markets.

The increasing digitalisation of wind farms and of the power system combined with current technologies can technically enable maximum interoperability. But policies must improve to fully exploit this potential. This paper explores the state of play of data exchange between wind farms and the power system in Europe, identifies major challenges for the wind industry and recommends actions to enable interoperability and flexibility.

2 Data flows in wind operation

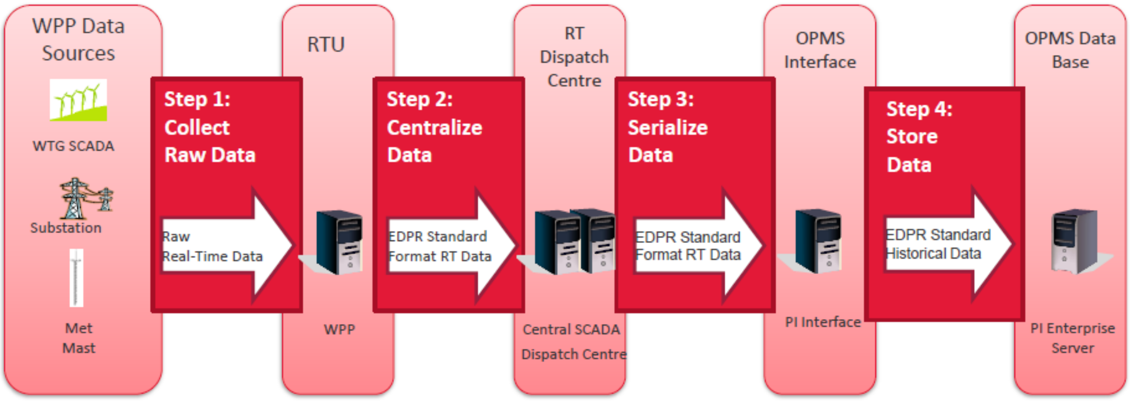
Data exchange is crucial for the operation of wind farms and for the secure and reliable operation of the power system with high shares of wind energy. Such exchange includes data flows between the multiple layers and components of the wind farms but also between the wind farms and the power transmission and distribution systems. **Figure 1** shows the discrete data flow steps that are constantly deployed by the wind energy management system (WEMS) of a wind farm operator managing multiple assets worldwide.

The first step is about **collecting raw real-time data** from the different wind farm data sources; the Remote Terminal Unit (RTU) collects real-time data through the different interfaces provided by the OEMs of the wind turbines and the Supervisory Control and Data Acquisition (SCADA) systems. Considering the great diversity of manufacturers and their multiple models, the effort to harmonise and standardise the respective databases – both for real-time operation and for reporting - is mandatory for ensuring interoperability and effectiveness already in this first step. **Figure 2** shows the Object Model convention suggested by the IEC 61400-25 standard (see **paragraph 3.2**) to determine data normalisation formulas and to create a uniform database for WT and other wind farm data.

[1] EC, “Commission Staff Working Document: Impact Assessment” accompanying the document “Stepping up Europe’s 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people”, September 2020

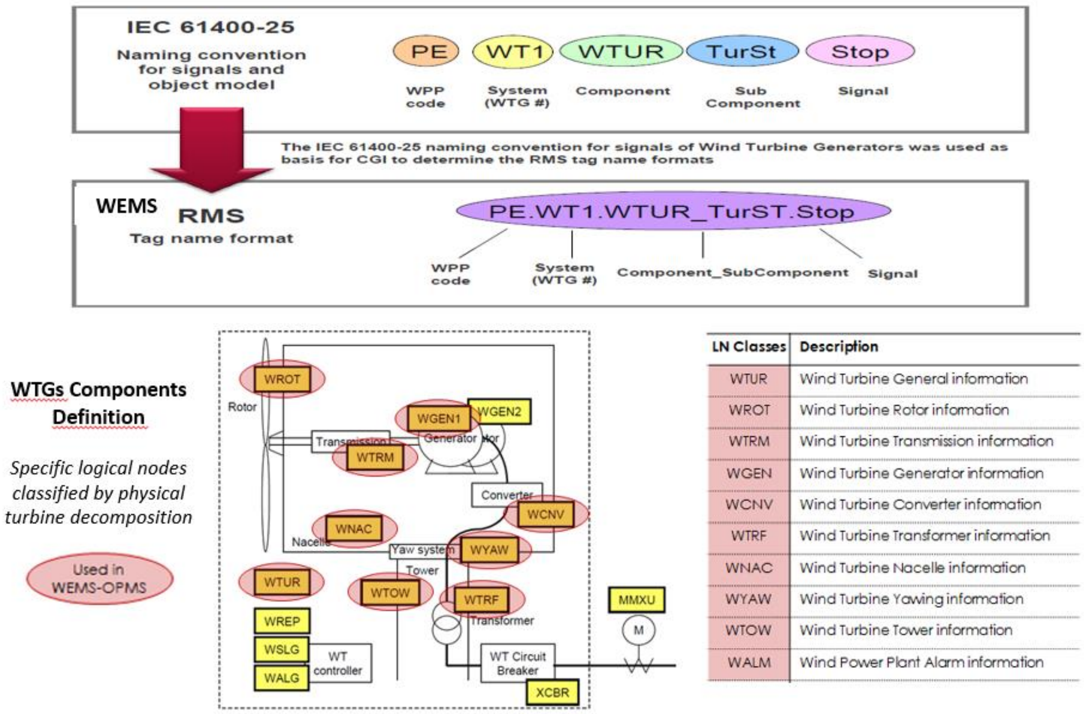
[2] WindEurope, “Wind energy in Europe in 2019 - Trends and statistics, February 2020

Figure 1 Data flow process in wind farm operation



Source: EDP Renewables

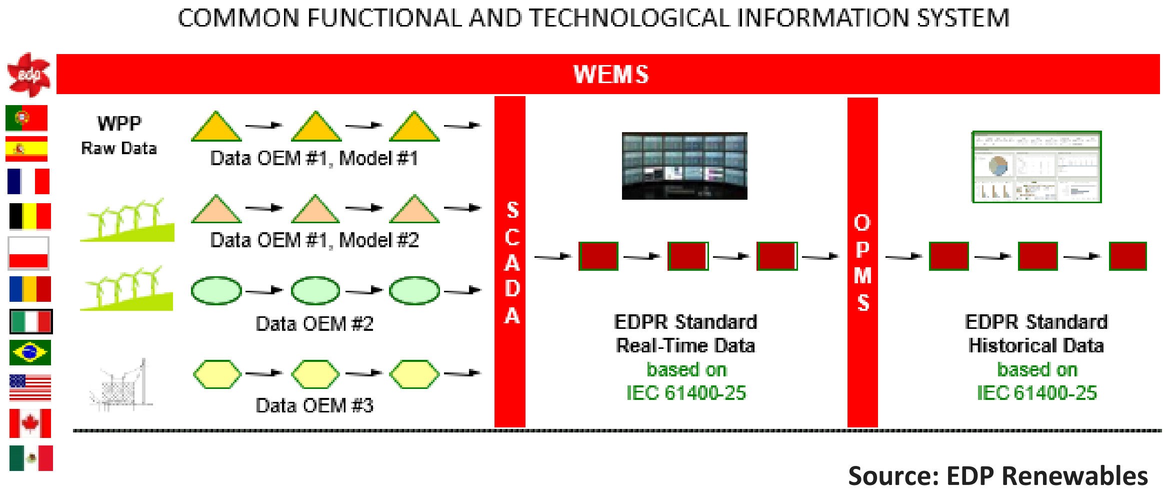
Figure 2 The IEC 61400-25 standard naming convention for object and signals' model in wind farms



Source: EDP Renewables

The second data flow step is about **centralising data**: the real-time dispatch centre collects data from each RTU into the central SCADA dispatch centre of the operator. As a third step, the Process Information (PI) interface collects the centralised real-time data and **transforms it into historical data**. Finally, the PI server of the operator collects this serialised data and stores it in its historical database. **Harmonisation of parameters and standardisation of the data exchange is crucial also in these steps as it can significantly increase the cost-effectiveness of remote control and performance management of the wind farms.** **Figure 3** graphically represents the benefit of standardising information exchange in the wind farm energy management system (WEMS) of the same wind farm operator. Information on different technical and economical parameters, availability and performance status, capabilities, faults, alarms, and other parameters can be communicated with the same indicators no matter what the brand or the model of the operating equipment is.

Figure 3 Integration and harmonization of the real-time remote control and performance management of EDPR wind energy assets worldwide[3]



Source: EDP Renewables

However, often in case of legacy assets, standardized nomenclature is not compatible with the respective equipment which makes the commonly used standards inapplicable. Data provision recommendations or requirements and the use of certain interfaces might not be possible or economically viable in the case of legacy assets. For example, today in Europe 10-20 years old wind farms with no communication interface to external parties are in operation and should continue to generate until the end of their lifetime. There have already been examples where requirements for installing new SCADA system, internet connection or other interfaces led the wind farm owner to decommissioning decision as such investments were not viable. It is important to ensure that the sustainability of the industry is not compromised by new regulations.

Another important parameter is bidirectionality. The previous paragraphs describe how the data flow from the source (wind turbine) flow to the upper control levels. This process also includes data flows between the wind farms or the central control systems of the wind farm operator and the transmission or distribution system operator (TSO or DSO). **Bidirectionality in these exchanges is one of the most critical issues in terms of wind integration.**

Efficient data flow from the system operator to the wind farm management tools and from there to the wind turbine level is also difficult to implement and time-consuming to validate. In case of distribution-connected wind farms the efficiency of the process also very much depends on the efficiency of the data exchange between the TSO and the connecting DSO. The use of harmonised standardised processes also in this direction is a prerequisite for the complete system and market integration of wind farms. This

[3] EDP Renewables, 2020

includes their interoperability with the power system, the secure and reliable operation of both sides but also the participation of wind assets in different market layers.

3 Data exchange with the power system: state of play

Today data exchange between wind farms and the power system is done differently across Europe. The requirements about the content, the format of exchanged data and the way they must be communicated differs from country to country or from system operator to system operator. This does not concern only real-time operational information but also information that is necessary for long-term system planning studies and for grid connection (e.g., wind turbine simulation models, their static and dynamic behaviour…), for system operation and short-term planning as well as for power plant participation in ancillary service markets.

The EU Network Code on System Operation (System Operation Guideline, SO GL[4]) regulates the Key Organisational Requirements, Roles and Responsibilities of grid users and System Operators for the exchange of operation data (known as the KORRR approach[5]). The lack of a harmonised approach implementing the EU regulation leaves space for many different interpretations and flexibility for customisation at national level. System Operators need to specify their own requirements. Certain System Operators have put significant efforts to design data exchange processes for maximising interoperability with power plants, but these efforts do not always result in operational efficiency. For example, in many cases, email or the telephone are still used for interaction, despite the highly technical deployed interfaces. Moreover, information exchange for system operation is often decoupled from the one for market participation.

Most importantly, so far, there has been little harmonisation effort between countries and between TSOs and DSOs. Wind technology is called to comply with many different specifications so that it can be eligible in different countries and for different transmission or distribution systems. And TSOs face technical difficulties to increase the exchange of data across borders. **Data exchange requires better high-level coordination of system and market operation needs together - from the highest asset management levels to the very end of the communication chains. This can reduce currently devoted resources both from power plant operators and from System Operators, and renewables' integration costs overall.**

Leaving flexibility for national implementation is good for addressing country-specific needs. Still technical guidance at EU level is necessary and should support the ongoing national implementation. To achieve this **WindEurope recommends a collaborative exercise involving TSOs, DSOs and Significant Grid Users such as renewables' and demand facilities at EU level. The aim should be to develop centralized and**

[4] EC, Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation.

[5] ENTSO-E, All TSOs' proposal for the Key Organisational Requirements, Roles and Responsibilities (KORRR) relating to Data Exchange in accordance with Article 40(6) of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a Guideline on Electricity Transmission System Operation

unified datasets for real-time and scheduled information providing all national authorities with guidance towards harmonisation, efficiency, and security. This can accelerate interoperability and unlock the envisioned flexibility of the system. This process should be established formally at EU level (for example by ENTSO-E or the European Commission) similarly to other stakeholder and technical groups tackling different Network Code requirements and national implementation guidance.

The discussion could initially focus on a dataset valid for the next decade, to ensure stability in the design of communication infrastructure, with the objective to be updated later so that it can reflect new needs and technology developments. Outcomes of such an exercise should be based on existing standards and in line with current Network Code requirements. They should also acknowledge that legacy systems with different data and control functionalities are still in operation across Europe and should continue until the end of their lifetime. The sustainability of the sector should not be compromised due to inflexible requirements that do not consider country-specific needs or technology/fleet-specific capabilities.

3.1 Overview of data exchange requirements in system operation

The KORRR approach[6] sets the framework for all data exchange provisions of the SO GL thus all data exchange between parties involved in the security of the electric system. The approach focuses on the elements presented in Table 1.

Table 1 Information exchanges in the KORRR document

Information exchange elements in the KORRR document*		
(a)	System Operators	Communication obligations for TSOs towards neighbouring TSOs
(b)		Communication obligations for DSOs towards their connecting TSO
(c)		Communication obligations for DSOs towards downstream and upstream DSOs
(d)	Significant Grid Users	Communication obligations for **Significant Grid Users** towards their connecting TSO or DSO
(e)		Detailed contents of data exchange (main principles, type of data, communication means, format and standards to be applied, timing and responsibilities
(f)		The time stamping and frequency of data delivery (provided by DSOs and Significant Grid Users, to be used by TSOs)
(g)		The format for the reporting of the information

*The elements that are highlighted in green may generate obligations for wind operators.

There are three main categories of information to be exchanged:

[6] ENTSO-E, All TSOs' proposal for the Key Organisational Requirements, Roles and Responsibilities (KORRR) relating to Data Exchange in accordance with Article 40(6) of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a Guideline on Electricity Transmission System Operation

1. **Structural information**: general and permanent characteristics and attributes of the facilities, all the capabilities of the equipment, static and dynamic models of the facilities.
2. **Scheduled information**: expected behaviour of the facilities in the scheduled time frame and near future (up to one year) and information on outage planning and generation and consumption schedules; and
3. **Real-time information**: the present behaviour of the facilities. Real-time exchanges for TSOs include telemetry measurements or estimated values for the following non-exhaustive parameters: active and reactive powers (line flows, interchange power, generation, load, reserves), bus bar voltages, frequency, and frequency restoration control error, set points (load-frequency controller), tap changer positions of transformers and compensating equipment, open/close position of switching equipment.

Significant Grid Users in the System Operation Guideline and the KORRR methodology include most wind farms that are connected to the EU power system today (all power generating modules classified as type B, C and D in the Network Code on Requirements for Generators[7])**.** The KORRR methodology addresses how the exchange of information should be and which entity defines the relevant details at national level. It does not set clear rules on defining the amount and resolution of the information that is required to be exchanged between Significant Grid Users and System Operators at national level. Moreover, it does not recommend any harmonisation effort among Member States and System Operators (apart from recommending the use of international standards).

As a result, **the data exchange requirements are very different from country to country or among System Operators of the same country which makes the system and market integration of renewables less cost-effective.** Asset owners and operators need to dedicate significant resources in designing and adapting their data logistics and communication systems to varying national requirements. **Paragraph 3.3** outlines some national practices of data exchange requirements.

Finally, regarding implementation, TSOs shall apply the KORRR approach as soon as all National Regulatory Authorities have approved it (19 December 2018). **ENTSO-E has been monitoring[8] the implementation process and today very few TSOs have already implemented the respective System Operation Guideline articles (Art. 40.5, Art. 40.6, Art. 40.7). One third of TSOs have not yet implemented any of these. Therefore, setting up an EU level collaborative exercise among relevant stakeholders - TSOs, DSOs and Significant Grid Users – to develop technical guidance for national implementation would be very meaningful at this stage.**

3.1.1 What is relevant for wind?

The KORRR document proposes the matrix* in **Figure 4** to facilitate the navigation among the different regulation requirements for Significant Grid Users and System Operators. **Figure 5** and **Figure 6** link these

[7] The European Commission, Commission Regulation (EU) 2016/631 of 14 April 2016 establishing a network code on requirements for grid connection of generators.

[8] ENTSO-E stakeholder workshop "National implementation of KORRR", December 2020.

requirements to specific data flows that take place between Significant Grid Users and System Operators. Among these, the requirements that are relevant to wind are analysed in the following paragraphs.

General responsibilities include the following principal provisions:

- Significant Grid Users shall provide data to the TSO or the connecting DSO, or to both, depending on the national KORRR approach implementation. Significant Grid Users providing scheduled and real-time data are responsible for the installation, configuration, security, and maintenance of the communication links up to the communication interface point with the system operator. Significant Grid Users can delegate such tasks to one or more third parties, but they remain responsible for ensuring compliance with System Operation Guideline obligations.

- For distribution connected Significant Grid Users the process may be different for each type of information (structural, scheduled, real-time) and for each Significant Grid User. DSOs shall be responsible for the installation, configuration, security, and maintenance of communication links for data exchange with the TSO up to the communication interface point agreed with the TSO.

  For the distribution level, KORRR presents the option in Figure 6 as the default one. For facilitating the exchange, the KORRR document gives the possibility that Significant Grid Users provide data only to one system operator (TSO or DSO). In such cases, the latter are responsible for exchanging the necessary data between them. Thus, apart from the default case (Figure 6), the KORRR approach mentions supplementary possibilities (Figure 6(b), 6(c)). However, national implementation does not need to be reduced to these three possibilities. Further cases are applicable. For instance, Significant Grid Users could enter the data on a common platform to which both TSO and DSO have access, as presented in the KORRR supporting document (Figure 6(d)).

Figure 4 Aspects covered by each article of the KORRR approach[9]

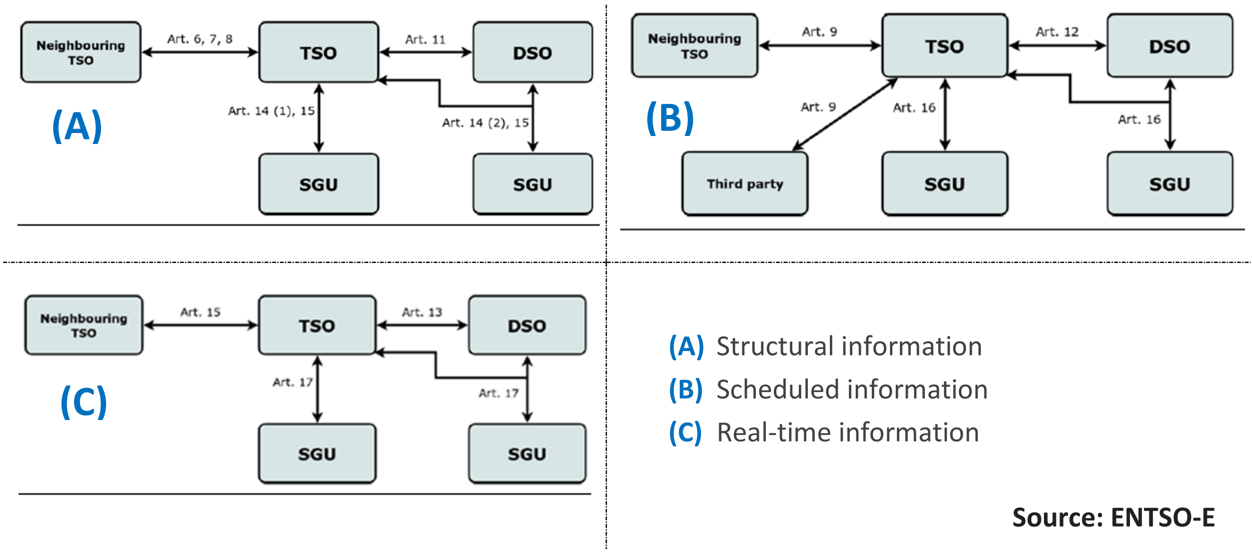
	General	Structural Data	Scheduled Data	Real Time data
Responsibilities of TSOs	Chapter 1			
	Art. 6	*Art. 7, 8*	*Art. 9*	*Art. 10*
Responsibilities of DSOs	Chapter 2			
	-	*Art. 11*	*Art. 12*	*Art. 13*
Responsibilities of SGUs	Chapter 3			
	-	*Art. 14, 15*	*Art. 16*	*Art. 17*

Source: ENTSO-E

[9] ENTSO-E, All TSOs' proposal for the Key Organisational Requirements, Roles and Responsibilities (KORRR) relating to Data Exchange in accordance with Article 40(6) of Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a Guideline on Electricity Transmission System Operation

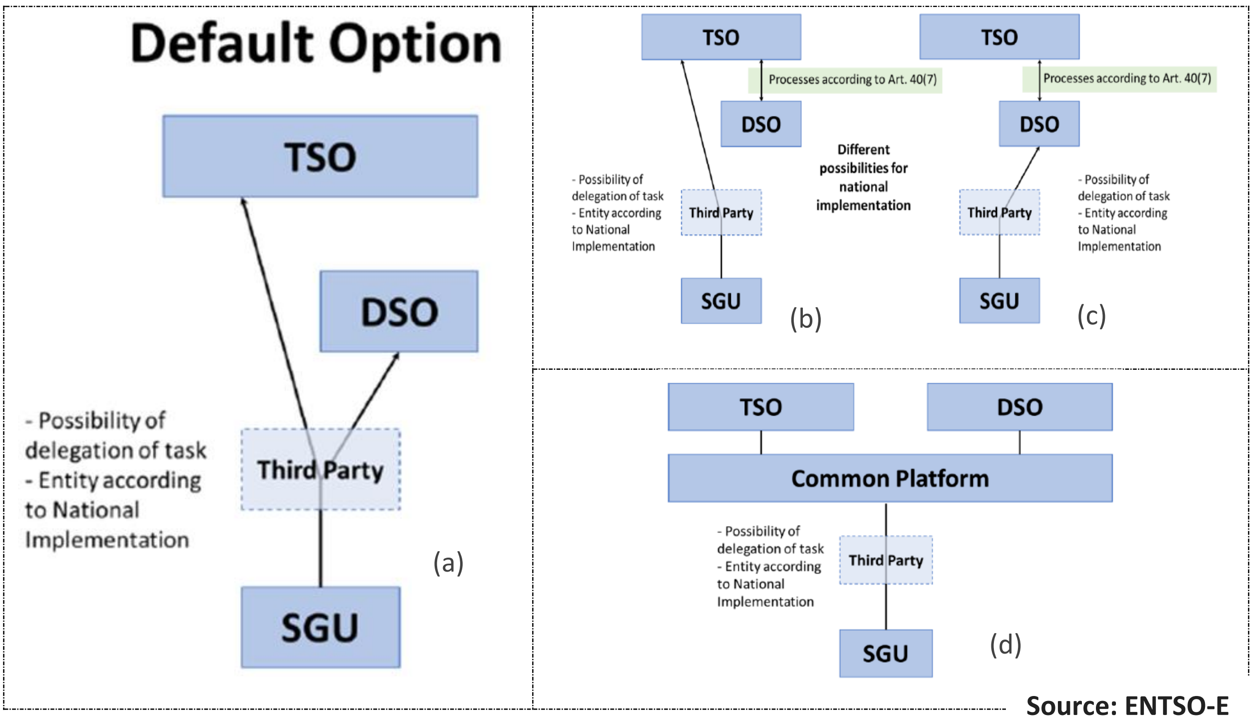
* “Chapters” and “Articles” refer to the ones in the KORRR document.

Figure 5 Structural, scheduled, and real-time information data flows and KORRR provisions



Source: ENTSO-E

Figure 6 The System Operation Guideline default case (a) for data exchange between System Operators and distribution connected Significant Grid Users and other suggested possibilities



Source: ENTSO-E

These provisions leave indeed much flexibility for the national implementation however the national authorities should consider the following risk when further specifying requirements; TSOs are responsible for specifying requirements for the direct communication link between the Significant Grid User and the defined interface point. Significant Grid Users are flexible to choose the design and type of communication chain within their facilities. Nevertheless, cybercrime incidents have been reported with initial access points within the facility's communication network which finally affected the TSO control area. Such incidents have led to service contract breaches or permission issues between Significant Grid Users and the respective TSO. **TSOs and DSOs should coordinate with Significant Grid Users when defining security specifications and requirements** (including any discussions for the upcoming Network Code for Cyber Security).

Responsibilities for System Operators, relevant for wind

Regarding **structural data**, each TSO shall specify the format and templates for information exchange, inform at least 6 months before any planned commissioning, final removal, significant modification of a power generating module and store all gathered data in updated and maintained data storage. DSOs and SIGNIFICANT GRID USERs should have access to the information referred to their own facilities.

When it comes to **scheduled** and **real-time data**, TSOs should, **in coordination with DSOs and Significant Grid Users**, **define the Significant Grid Users in its control area that will provide real-time data**. They should also specify the detailed content and technical requirements and publish the format for the respective data exchange, including time stamping. TSOs shall also define the refresh rate for the real-time data exchange which cannot be longer than 1 minute. **Currently these requirements are very different from country to country while the KORRR provisions do not include clear recommendations for harmonising such parameters in the future.**

Responsibilities for Significant Grid Users

Regarding **structural data**, transmission connected Significant Grid Users shall provide their structural data to the TSO, in the specified – by the TSO - format. Similarly, distribution connected Significant Grid Users shall provide their data to the TSO or to the DSO, or to both, depending on the national implementation. The Significant Grid User needs to review the data at least every 6 months and to inform about any planned commissioning, final removal from service, significant modifications, at least 6 months in advance, or as soon as an error is detected in the information. The parameters that need to be transmitted as part of the structural data are set in Art.45 of the System Operation Guideline.

Regarding **scheduled data**, the receiving entity (TSO, DSO, or both) and the format are also to be specified at national level. All transmission connected Significant Grid Users shall provide **real-time data** directly to the TSO while the respective entity for distribution connected Significant Grid Users shall be defined at national level. Each Significant Grid User providing real-time data to the TSO or DSO shall fulfil the requirements defined by the TSO in terms of logical connections between parties and protocols used, network architecture including redundancy, network security rules, identification code and/or naming convention and data quality, data transmission parameters and performance, rules of contact in case of planned outages and disturbances of communication equipment.

3.2 Standards for data exchange in system operation

The EU M/490 Smart Grid Mandate[10] is an EC standardization mandate to European Standardisation Organisations (ESOs) to support EU smart grid deployment. The M/490 identified 6 core standards to be

[10] The European Commission, "Smart Grid Mandate. Standardization Mandate to European Standardisation Organisations (ESOs) to support European Smart Grid deployment", March 2011

used for power system data exchange (Table 2). Among these, three standards were to be implemented in accordance with the SO GL and Capacity Allocation and Capacity Management (CACM):

- IEC 61850 for Distributed Energy Resources (DER) with IEC 62351-4 cyber security
- IEC 62325 for Market Actors with IEC 62325-503 cyber security
- IEC 60870-6 (TASE.2) for Control Centre-to-Control Centre with IEC 62351-4 cyber security

Table 2 Six core standards to be used for power system information exchange[9]

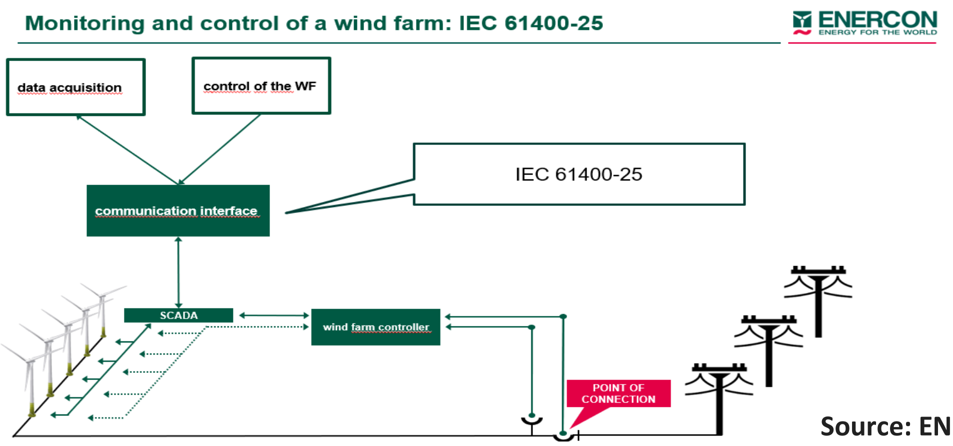
Core standards and series	Comments
IEC 61970 / IEC 61968	Common Information Model (CIM) / Energy Management. Relevant Application: EMS, DMS, DA, SA, DER, AMI, DR, Storage. / Distribution Management. Relevant Application: DMS, DER, AMI, DR. CIM applied for system related information exchange.
IEC 62325	CIM applied in market information exchange
IEC 61850 / IEC 61400-25	Power Utility Automation. Relevant Application: EMS, DMS, DA, SA, DER, AMI, Storage, EV / Information exchange with wind turbine systems and wind power plants. Information exchange with generation/demand units, grid devices and substations
IEC 62056	Data exchange for meter reading, tariff and load control.
IEC 62351	Security related aspects. Relevant Application: EMS, DMS, DA, SA, DER, AMI, DR, Smart Home, Storage, EV.
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems.

Regarding data exchange between renewables and the power system, the data model defined in IEC 61400-25 is intended to be protocol agnostic, supporting the IEC 60870 as the standard wind farm protocol series (such as -5-104) and the IEC 61850 as the standard substation protocol. Additionally, future enhancements to IEC 61850, including OPC-UA, can also benefit from the IEC 61400-25 as the unifying data model for communication over these existing real-time protocols.

3.2.1 Standardisation of wind data objects: the IEC 61400-25 standard series

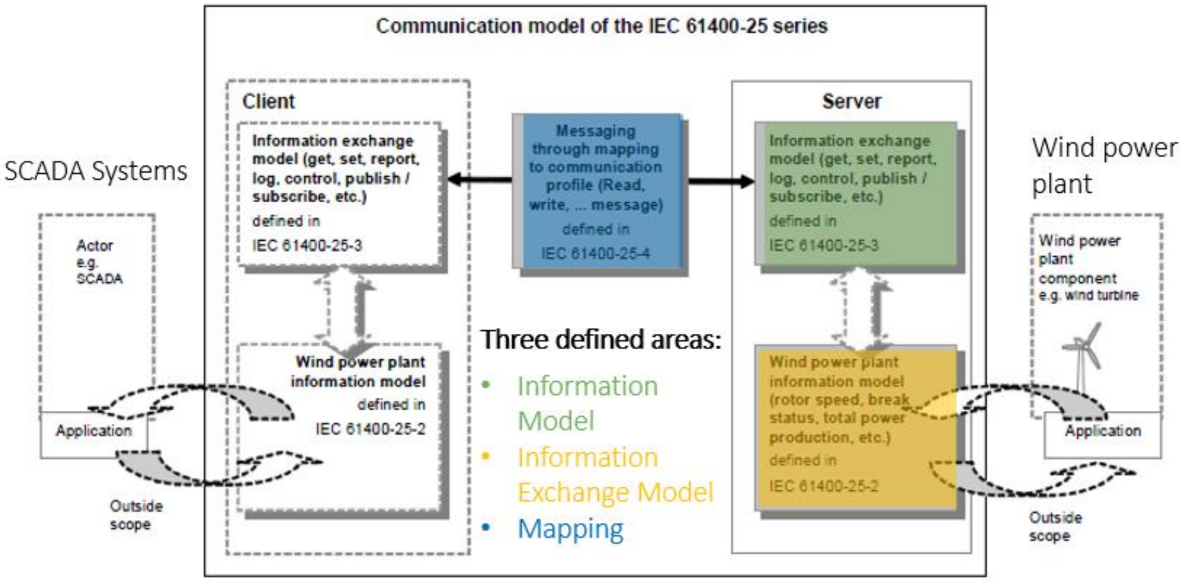
The International Electrotechnical Committee (IEC) has made a big effort to develop the IEC 61400-25 standard series and so to streamline communications for monitoring and control in wind farms. The focus is on communications between wind power plant components and SCADA systems (**Figure 7**). **Figure 8** presents the conceptual communication model that is considered in the IEC 61400-25 standard series.

Figure 7 The IEC 61400-25 standard series is used in the communication interface between the wind farm components and the SCADA system



Source: ENERCON

Figure 8 Conceptual communication model of the IEC 61400-25 standard series[11]



Most wind OEMs and wind farm operators support the use of this standard as it can offer several benefits:

- Better connectivity for the wind farms
- Lower installation costs
- Reduced number of different interfaces
- Interoperability between devices and systems from different vendors
- Re-usable data models for future technologies
- Standardized way to define system extensions
- Independent applications on hardware solutions/Vendor independent configuration
- Future-proof applications: configuration withstands changes in communication systems
- Comprehensive approach for cyber risk assessment

[11] Knud Johansen, Energinet, «IEC 61400-25 standard series brief presentation; standardised information exchange with wind power plants », WindEurope Interoperability workshop, September 2019

Today each wind farm integrated into a remote monitoring and control system carries heavy engineering work due to lack of unified information model among wind manufacturers and even different turbine models of the same manufacturer. Any updates on manufacturer software requires a thorough re-check of data mapping and testing in the remote system. Cyber aspects are different for every manufacturer, but also different practices are applied to setup the automation system inside the WTs and farms. Any new wind farm requires a repetition of such engineering processes. All these processes mean continuous data management, checking and testing tasks that add costs to wind power integration.

Today wind technology manufacturers and operators agree that adopting the IEC 61400-25 standard series can significantly reduce their costs for data exchange and system integration costs for renewables overall. Manufacturers claim that they would invest significant resources to make their technologies fully compliant in case this standard becomes the default requirement in national legislations. Today they do not make this effort as they still need to be compliant with many other specifications that may vary from country to country. The System Operation Guideline (KORRR methodology) supports the use of the IEC 61400-25 standard series only in a soft manner - as a suggestion for considering in national implementations. The following paragraph outlines some national practices for data exchange requirements between wind farms and System Operators.

3.3 National implementation of data exchange requirements

Today there is very little harmonisation among data exchange practices and requirements across Europe both in data definition and required functionalities. Moreover, there is big diversity of required communication protocols and applied interfaces e.g., IEC104/DNP3, IEC101 (RS232), wired information to TSO/DSO-owned devices installed onsite.

Certain System Operators have put significant efforts to design efficient data exchange processes. In some cases, the efforts have indeed been fruitful. For example, Spain has defined a small and standard dataset easy to implement and leading to fluid validation processes. The TSO can control the assets, through the established and validated channels, only for limited functionalities (mainly active power limitation) and this feature has been effectively used.

However, there are still examples where operational efficiency has not been achieved even if System Operators have put significant efforts in the process design or invested in highly technical interfaces. This might be due to excessive and complex requirements for exchanged datasets (e.g., too many parameters required which are finally not valorised) or even to complex commissioning processes. The implementation might also be too complex and based on highly bureaucratic validations with several stakeholders involved. In such cases, it might take years after the energisation of a wind farm to finally close the implementation and validation of the TSO/DSO capabilities to operate the asset. As a result, the TSO can control the assets through the established and validated channels for an extended set of functionalities (active power limitation, reactive power regulation, power factor regulation, voltage regulation, static curve, power/frequency response …) but it barely uses these capabilities when operating generation assets.

Overall obligations for the provision of real-time and scheduled data may add extra costs to the operation of wind farms which must be considered in the regulatory process. Some of these costs may be justified and monetised thanks to a better system integration of the wind farms but relevant authorities must look for trade-offs between nice-to-have and must-have capabilities of wind farms, and costs and sustainability of the wind industry.

Figure 9 outlines currently deployed data exchange practices between System Operators and Significant Grid Users in a set of EU countries.

Figure 9 National examples of data exchange in system operation[12,13]

Denmark

Denmark has put in place an action plan for the IEC standard concept in power system data exchange. The concept has already been tested and will soon be fully implemented. The IEC 61850/IEC 61400-25 information model and the IEC 61850-8-1 protocol will be used for real-time, scheduled and online available structural data. The national Public Key Infrastructure (PKI) system with X.509 certificates will be used to identify parties (role-based access control on information level according to IEC 62351-8), and to sign and encrypt data (according to IEC 62351-4). The international PKI system with X.509 SSL-certificates will be used for Transport Layer Security (TLS) according to IEC 62351-4. Real-time data from DER will be delivered on a secure IEC 61850 server in PCOM (Point-of-Communication) accessible from the Internet, a MPLS network or an agreed Private Network. Energinet, the Danish TSO, has been developing an informative technical specification which can support the System Operation Guideline and national directives like NGF 'Nationale Gennemførelsesforanstaltninger'.

Germany

The data exchange project started for the four German TSOs in 2017 and is currently in the last implementation phase. The scope covers real-time and scheduled data from DSOs and Significant Grid Users. A centralised approach per TSO will be deployed; the TSO will have to forward the relevant Significant Grid User data to the DSO. Regarding real-time data, Significant Grid Users with installed capacity above 1MW will have to communicate available capacity (not affected by maintenance or failures), possible generation (calculated based on the available capacity, the wind speed at the site and losses) and active power generation at the grid connection point (the actual measured power generation). Scheduled data will be required from all Significant Grid Users above 10MW, all transmission-connected renewables and consumers above 50MW. The IEC60870-5- 101 and 104 standard protocols will be used. Regarding scheduled data, all transmission connected wind farms will have to communicate unavailability and run schedules while distribution-connected wind farms with a higher than 1MW capacity will have to communicate unavailability.

Spain

The implementation of KORRR in Spain was addressed in a way that it could guarantee enough observability and an efficient data exchange between all parties. TSOs and DSOs have access to all data of power generation modules (Significant Grid User) connected to their observability grid area with installed capacity higher than 1MW. Significant Grid Users are free to choose to whom they send their real-time data no matter which parties should finally access it. This excepts Balance Service Providers who must send real-time data directly to the TSO. TSOs and DSOs are responsible for accessing the Significant Grid User's information that they are not directly receiving. Significant Grid Users can send their scheduled data to the TSO platform and DSOs can access that information.

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[12] Knud Johansen, Energinet, "KORRR Implementation in Denmark. Secure and standardised information exchange with SGUs (DER and BRP) and DSOs", WindEurope Interoperability workshop, September 2019

[13] ENTSO-E stakeholder workshop "National implementation of KORRR", December 2020.

3.4 Data exchange for the Common Grid Model

With increase renewables shares, efficient data exchange between System Operators and Significant Grid Users will also be crucial not only for operating the grid but also for modelling it more reliably and for anticipating evolving system needs at EU level. This can be achieved with the implementation of the Common Grid Model (CGM).

The CGM is an EU-wide data set representing the principal elements of the EU power system – grid topology, generation, load- and the rules for modifying these elements in the capacity calculation process. Three EU regulations - the Guideline on Capacity Allocation and Congestion Management (CACM Regulation), the Network Code on Forward Capacity Allocation (FCA Regulation) and the Network Code on System Operation (SOGL) – require TSOs to prepare a CGM methodology. Any regional security evaluation and capacity calculation involving several TSOs requires the CGM. It is also used for market, asset management and grid planning activities like operational security calculations, capacity calculations, and outage coordination.

Each TSO needs to prepare its Individual Grid Model (IGM) to be merged with the IGMs of other TSOs for creating the CGM and to provide it with all necessary data for deploying active and reactive power flow and voltage studies in steady state. TSOs shall harmonise to the maximum possible extent the way IGMs are built. **The provision of such data requires an extensive and continuous information exchange with generators including availability data, schedules for different timeframes, dispatch strategies, generation patterns for year-ahead scenarios, amount of generated power in distribution systems and other**. **As already suggested, closer collaboration between wind farm and power System Operators is required to ensure a widely harmonised exchange of such information.** This will accelerate a common understanding of power system operational and planning needs across countries and regions and improve the interoperability between wind and the power system.

4 WindEurope recommendations to improve data exchange

A successful exchange of static and dynamic information between wind farms and the power system is crucial for interoperability which in turn is a major enabler for flexibility. This means that the design and implementation of secure, reliable, and cost-effective data exchange practices must be prioritised. WindEurope recommends the following actions to improve this data exchange at EU and national level:

- The first recommendation is about harmonising data communication obligations across different System Operators and different countries. **The ongoing national implementation of Network Code requirements for data exchange needs clear and concrete guidance at EU level to achieve in-depth harmonisation among countries and lower system integration costs for renewables.**

- To achieve this, **WindEurope recommends that System Operators coordinate with relevant stakeholders (Significant Grid Users such as renewables and demand facilities) at EU level to develop centralized and unified datasets for information exchange – based on existing**

standards – providing all national authorities with guidance towards harmonisation, efficiency, and security. This process should be established formally at EU level (for example by ENTSO-E or the European Commission) similarly to other technical groups tackling specific Network Code requirements and their national implementation. The current Network Code leaves much flexibility for national implementation - which helps address country-specific needs – but technical guidance at EU level is necessary. National implementation is at an early stage making it right moment to prioritise this exercise.

- **WindEurope is also calling for a closer collaboration among relevant stakeholders at EU and national level to ensure wide and harmonised adoption of the same standards as the default requirement.**

- Finally, **any requirements must acknowledge that legacy systems with different data and control functionalities are still in operation in wind farms across Europe**. Such cases need to be addressed separately from new systems – so that they can continue operating until the end of their lifetime in line with the sector's commitment to sustainability.