European Network of
Transmission System Operators
for Electricity

entsoe

Data exchange standards and formats for system operation - An overview of TSOs current practices

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From: ENTSO-E

ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the association for the cooperation of the European transmission system operators (TSOs). The 39 member TSOs, representing 35 countries, are responsible for the secure and coordinated operation of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E brings together the unique expertise of TSOs for the benefit of European citizens by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the security of the inter-connected power system in all time frames at pan-European level and the optimal functioning and development of the European interconnected electricity markets, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first climate-neutral continent by 2050 by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires sector integration and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources. ENTSO-E acts to ensure that this energy system keeps consumers at its centre and is operated and developed with climate objectives and social welfare in mind.

ENTSO-E is committed to use its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

ENTSO-E acts in solidarity as a community of TSOs united by a shared responsibility.

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by optimising social welfare in its dimensions of safety, economy, environment, and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and innovative responses to prepare for the future and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with transparency and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its legally mandated tasks, ENTSO-E's key responsibilities include the following:

› Development and implementation of standards, network codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;

› Assessment of the adequacy of the system in different timeframes;

› Coordination of the planning and development of infrastructures at the European level (Ten-Year Network Development Plans, TYNDPs);

› Coordination of research, development and innovation activities of TSOs;

› Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the implementation and monitoring of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

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EXECUTIVE SUMMARY

KORRR stands for “Key Organisational Requirements, Roles and Responsibilities” related to data exchange in accordance with Article 40(6) of System Operation Guideline (SO GL). The current version that is in force was approved in October 2018 and is found at the ENTSO-E website. It serves as an umbrella framework for all the SO GL data exchange requirements and focuses on TSO communication needs and therefore does not address all levels of communication. It harmonizes practices wherever applicable, while at the same time allowing for national peculiarities.

The KORRR methodology establishes the rights and responsibilities on data exchange and describes: Who has to exchange the information, how the information shall be exchanged, when the information has to be exchanged, and which information has to be exchanged.

To allow for local conditions and national characteristics and needs, the KORRR methodology intentionally does not set the specific rules on defining the amount and resolution of the information required to be exchanged between Significant Grid Users (SGUs) and TSOs/DSOs at national level. In other words, KORRR methodology is a pan-European framework that needs to be specified at national level.

In the past, different European stakeholders have provided their views on the KORRR methodology. These views concern areas such as interoperability, amount/resolution of exchanged information, exchange requirements in different countries, as well as harmonisation of exchange standards for the integration of renewables. While the paper is not exhaustive in addressing these areas, it is intended to bring light to the current practice and challenges of TSOs related to data exchange.

The paper is based on the responses given in the TSO surveys on practices of data exchange within the scope of the KORRR methodology. In terms of the implementation scenarios for SGUs connected to the distribution grid, TSOs apply the data exchange scenarios for the specific type of data based on the national practices. There are also cases in which individual TSOs would apply different scenarios subject to the applications for the same type of data.

Concerning current practices, there are some discrepancies between the recommended standards and the standards being used, in particular, for structural and scheduled data. There are various reasons for these discrepancies. One important reason is the diversity of data objects, communication links or platforms for the data exchange between TSOs, DSOs and SGUs. Additionally, a wide set of formats have been available for a long time for these data types, therefore a wide-scale transition to new standards would impose high investment costs which may not be justified with the benefits this could bring about. Another difficulty to employ recommended standards for schedule and structural data is that they were not deemed exhaustive or sufficiently mature to represent all the possible data exchanges in operational planning currently realized between TSOs, DSOs, SGUs, market parties and other affected parties. Nevertheless, the encouragement to use recommended standards is strong but may require a long-term path and specific roadmap depending on the national status, because of new regulations and operational needs.

With all the factors considered, for already established data exchange between TSOs, DSOs and SGUs, the recommendation is to allow the partner to maintain the current method, in order to avoid additional investment efforts, but it should also be possible for each partner to decide to switch to one of the recommended standards, if so desired. To allow the transition to a harmonised approach at regional and European level, it is advisable for vendors to ensure backward compatibility and support multiple versions of the standards. For new actors, or for existing actors for which additional data exchange has to be established, it is instead suggested to use the recommended standard from the onset if technically feasible, effective and efficient. This allows for gradual implementation and helps avoid additional costs for actors that have already done investments in previously used formats.

Whichever standards and protocols actors ultimately decide to implement, the current target of the European authorities to facilitate interaction and data exchanges across and between data systems in member states and other concerned European countries should be considered, together with other important elements such as cost-benefit evaluation, cyber security, data validation and the ICT strategy of the respective actors.

Introduction and Background

KORRR stands for "Key Organisational Requirements, Roles and Responsibilities" related to data exchange in accordance with Article 40(6) of SO GL. The current version that is in force was approved in October 2018 and is found at the ENTSO-E public website. It serves as an umbrella framework for all the SO GL data exchange requirements and focuses on TSO communication needs and therefore does not address all levels of communication. It harmonizes practices wherever applicable, while at the same time leaving space for national peculiarities.

The KORRR methodology establishes the rights and responsibilities on data exchange and describes: **Who** has to exchange the information, **How** the information shall be exchanged, **When** the information has to be exchanged, and **Which** information has to be exchanged.

The types of data involved are real-time, scheduled, and structural data, and the concerned parties are Transmission System Operators (TSOs), Distribution System Operators (DSOs) and Significant Grid Users (SGUs).

Harmonisation efforts

To allow for local conditions and national characteristics and needs, the KORRR methodology intentionally does not set the specific rules on defining the amount and resolution of the information required to be exchanged between Significant Grid Users and TSOs/DSOs at national level. In other words, KORRR methodology is a pan-European framework that needs to be specified at national level.

The points which are left open on purpose for national approval by the National Regulatory Authority (NRA) or other entities designated by the Member State are:

- data exchange scheme for SGUs connected to the distribution grid; installation, maintenance, and settings of communication channels; validation criteria for data quality (Article 3).
- frequency of scheduled data exchange with the TSO (Article 12 and 16).
- agreement between TSO and DSO on the format of SGUs' structural data exchange (Article 7).

Feedback from industry

In the past, different European stakeholders have provided their views on the KORRR methodology. They concern areas such as interoperability, amount/resolution of exchanged information, exchange requirements in different countries, as well as harmonisation of exchange standards for the integration of renewables. While the paper is not exhaustive in addressing these areas, it is intended to bring light to the current practice and challenges of TSOs related to data exchange. In addition, the paper also serves as the follow-up of the task on standardisation as presented in System Operation European Stakeholders Committee (SO ESC) meeting in September 2022.

Investigation into the use of standards

Considering the feedback from stakeholders as given in a forum such as the SO ESC, ENTSO-E has got the mandate to investigate the use of standards for data exchange as stipulated in KORRR and beyond when deemed applicable. The investigation began in Q2 2023.

Methodology

Objectives and approach

The objective of the paper is to report the current practice on data format used in TSOs' operational processes and if applicable to promote the use of operational standards to facilitate data exchange as stipulated in the SO GL KORRR methodology and beyond between TSO-DSO and TSO-SGU.

Upon review of the network codes (CACM and SO GL) for the identification of specific data items, relevant use cases were built with the use of the Harmonised Electricity Market Role Model. The definitions given in the role model are not binding in nature and serve only to facilitate understanding the context. These use cases served as a basis for the creation of a survey for the investigation of the KORRR implementation scenarios and the currently used standards amongst TSOs. The ENTSO-E recommended standards for the identified data exchanges were also recognized and listed a guidance for the completion of the survey.

Use Cases

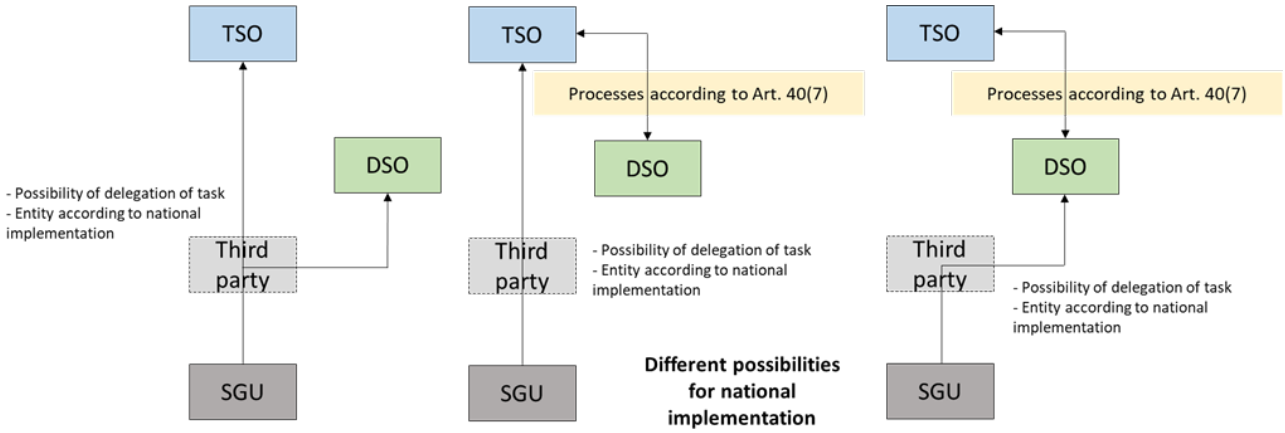
Specific use cases were developed to facilitate the completion of the survey. For this purpose, the data exchanges and actors involved have been elaborated based on existing legal requirements. The cases cover the main applications as stipulated in the SO GL, such as Electricity Balancing, Capacity Allocation and Congestion Management (cross-border), Voltage Control and Reactive Power Management.

The survey was sent to ENTSO-E members for the completion from each TSO. The summary of the survey outcome is found in the next chapter.

KORRR implementation scenarios

The KORRR methodology allows for different data exchange schemes to be used by the distribution connected SGUs to provide data to the TSO and the DSO. In the following figures such scenarios are shown. In the first scenario, the data is delivered independently by the SGU to the TSO and the DSO; in the second one, the data is delivered to the TSO that in turn distributes it to the DSO; in the third one, the data is delivered to the DSO who then provides it to the TSO. The SGU can delegate the task

to a third-party actor. As it is also shown in the figure, Article 3(7) of KORRR allows SGUs to delegate data exchange tasks assigned to them under the SO GL to one or more third parties, which are the ones responsible to ensure the links, as well as secure and standardised SGU-aggregated information exchange with TSOs or DSOs.



For various technical and historical reasons, different countries have different practices. These reasons were beyond the scope of the investigation. However, different practices could then have an impact on the choice of the data format and standards which are used for the data exchange.

ENTSO-E recommended standards

In this section, the list of standards/formats recommended by ENTSO-E and its members for the different data flows is presented.

Real-time data: IEC 60870-6 (ICCP TASE.2), IEC 60870-5-101/-104, IEC 61850, IEEE C37.118[1]

Scheduled data: IEC 62325-451, IEC 62325-351, IEC 61970-600 (CGMES), IEC 61970-45x series, ENTSO-E Network Code Profiles Specifications

Depending on the type of scheduled data, several standard formats are recommended:

- IEC 62325-451-2 (Schedule Market Document) for scheduled active power consumption, forecasted reactive power consumption, scheduled active power output, scheduled active power restrictions and unavailability.

- IEC 62325-451-7 (Reserve Bid Market Document) for amount of active power output and reserves.

[1] *IEEE C37.118 is used for PMU data and not applicable for real time exchange with SGU. It is mentioned for completeness reasons, as it is commonly used for communication between TSOs*

It is important to note that IEC 62325-451-7, which has been created following the requirements of EBGL, could also be recommended for other types of scheduled data related to the balancing process.

- IEC 61970-600 (CGMES) and ENTSO-E Regional Coordination Processes Data Exchange Specification as well as ENTSO-E Network Codes Profiles Specifications: these IEC standards and ENTSO-E specifications are concurrently recommended for exchanging scheduled data related to availability, unavailability or restrictions: availability of active power output and reserves, scheduled active power restrictions and unavailability, generation units dispatch.

  It is important to mention that standards and specifications have been initially designed for TSO-TSO data exchange or TSO-RSC/RCC data exchange. They rely heavily on the consistency of structural data in order to reconstitute a common consolidated view of the grid.

Structural data: IEC 61970-600 (CGMES) and ENTSO-E Regional Coordination Processes Data Exchange Specification as well as ENTSO-E Network Codes Profiles Specifications

- Structural data concern all detailed information for a resource, whether generation or consumption unit: electrotechnical information, installed capacity, structural minimum and maximum power available for demand response or balancing reserves (FCR, aFRR, mFRR, RR). For this category of structural data, the TSO experts recommend the use of IEC 61970-600 (CGMES) standard.

- Structural data also provide useful information for determining cost of remedial actions, which is essential for coordinated security analysis and other coordinated processes. For this category of structural data, the TSO Experts recommends the use of ENTSO-E Regional Coordination Processes Data Exchange Specifications and related ENTSO-E Network Codes Profiles Specifications.

Used formats vs recommended standards

Real-time data

For real-time data exchange with SGUs, almost all surveyed TSOs use telecontrol protocols defined in IEC 60870 set of standards. Most commonly used are:

- IEC 60870 part 5 (104 or 101)
- IEC 60870 part 6 (TASE.2)

IEC 60870-5-104 (IP-based) represents an extension of IEC 60870-5-101 (serial access) standard for enabling network access. Protocols are identical at the application layer, with some of the data types omitted within IEC 104 specification.

TSOs quote IEC 60870-6 (Inter-Control Center Communications Protocol) mostly in the context of TSO-TSO and TSO-DSO exchange of SGU data.

IEC 61850 is used exclusively in substation automation according to the TSOs surveyed.

Scheduled data

Scheduled data fall into two main categories:

- **Schedules,** for exchange of scheduled or forecasted data, relative to active or reactive power input or to active or reactive power consumption. It also applies to unavailability and restrictions of power input or power consumption.

  The SGU is supposed to send those schedules for each of its resources (load unit or generation unit) or pools of resources.

- **Reserve information,** for the amount of reserves and availability of reserves (upward or downward), for Balancing or for Demand response purposes.

Schedules:

Depending on national implementation, some TSOs use 62325-2 Schedule Market Document for exchanging Schedules, but this standard only allows schedules to be defined at a Market Point level. It may not be sufficient to meet certain SOGL or CACM requirements, where the information should be defined at the resource level.

Similarly, some TSOs use Resource Planning Market Document from ERRP format (ENTSO-E Reserve Resource Process). This common format is dedicated to the exchange of the planned production or consumption data of a resource and also to the exchange of its reserve plans. In this case, it is possible not only to transfer the information about planned/scheduled production of the SGU but also other information used in the operation planning process (e.g. planned production, redispatchable power, power contracted and reserved for balancing issues, already activated redispatch measures, etc.).

In addition, some TSOs use EDIfact DELFOR messages (DELivery FORmat), which follow the EDI message format UN/EDIFACT and EDI-type data exchanges functionalities.

Some TSOs have defined their own national format, CIM-based or not, which can be exchanged though xml files or using web-services. This approach allows them to define arrangements which are locally suitable (at nation level or NRA).

Reserve information:

Subject to national implementation, some TSOs use 62325-451-7 standard for specific reserves (e.g., aFRR products exchanged on European Balancing platforms), while some TSOs also use this standard format for all kind of reserves.

Some TSOs use 62325-451-2 to exchange detailed information on reserves.

Structural data

Most TSOs have indicated that they do not use CGMES for structural data exchange with SGUs and DSOs. CGMES is widely used at EU level for the TSO-TSO data exchange on Individual Grid Models. Additionally, TSOs use data formats, defined at national level. The structural data is often collected either by a manual process or through file transfers or through web-based platforms.

According to some TSOs, the data model used for collecting structural data has been defined according to their NRA specifications.

Reasons mentioned not to move to the recommended standards

All of the TSOs participating in the survey already use one of the recommended standards for real-time data exchange, with IEC 60870-5-101, IEC 60870-5-104 and IEC 60870-6 ICCP TASE.2 being predominantly used.

No operational difficulties are reported by the TSOs regarding the use of these standards. Real-time data exchange is considered to be efficient and reliable. Standards are widely supported by vendors so there is little if any interoperability issues between partner systems. TSOs benefit from employing skilled personnel for implementation, maintenance, and diagnostic purposes.

TSOs however use a wide set of other formats for structural and scheduled data, some of which are very specific for each system or area, which has been used and integrated in TSOs' internal system over a long time. This means that wide-scale transition to a new standard may incur high costs, and that any new standard must offer significant enhancements compared to existing formats to justify such a big engineering effort and risk of potential service disruptions. In addition, the recommended standards for structural data have been subjectively perceived by the sector as complex to implement and only relevant for exchange between TSO-TSO, and the cost and effort for transitioning for data exchange also for SGUs and DSOs has been deemed disproportionate compared with the potential benefits that the introduction of the new standards would have, although this perception has not been confirmed by reality, and most of the issues are in practice associated with processes, data governance and data quality.

For already established data exchange, where standards and formats used do not match those recommended by ENTSO-E, the suggested strategy is to:

- Allow the partner to maintain the current method, in order to avoid additional investment efforts.

- Assess (TSOs and DSOs and/or other entities as applicable) the possibility to additionally offer an interface for exchanging schedule and structural data through one of the recommended standards. The assessment shall take into account if the data exchange functionalities are fulfilled by the existing standards. When applicable, TSOs (in the case of balancing), or TSOs and DSOs, where applicable, shall propose to NRAs a roadmap to implement additional new standards.

Reasons to encourage to move to the recommended standards

The general opinion of experts from ENTSO-E and its members is to broaden the use of IEC standards for data exchange.

ICCP and IEC 104 provide sufficient functionality, fulfill all operational and reliability needs for real time data exchange and are widely available in the market, and with the addition of IEC 61850 for substation communication, cover all needs of real time data exchange between TSOs, DSOs and SGUs.

The same cannot be said for structural data and scheduled data, where the case for transition to recommended standards is much stronger, given that at least for structured data it is already used for TSO-TSO exchange. As new European and regional regulations, as well as new operational needs, require for more extensive, comprehensive, and timely data exchange, the need for standardized solutions is becoming stronger. The building rate of the electrical system, as well as the emergence of new actors with operations in several countries, also play in favour of common standards, to enable centralized modelling and coherent data governance, which in turn contains costs and enable scaling.

For new actors, or for existing actors for which additional data exchange has to be established, it is suggested to assess the feasibility and cost effectiveness for a multiple interface that allows the use of the recommended standard(s) from the outset.

For structural data, it is particularly advantageous to collect data using recommended standards, this will permit all actors to exchange, use and benefit from well-structured information with high level of quality, consistency, and reliability.

In addition, whichever standards and protocols actors ultimately decide to implement, the current target of the European Authorities through European regulation to facilitate interaction and data exchanges across and between data systems in member states and other concerned European countries should be considered accordingly. New European regulation is already developed with an implementation based on standards from the onset.

Data exchange for future system operations

The European grid relies heavily on data exchange, it is therefore important to ensure availability, integrity and confidentiality.

With the exception of IEC 60870-5-101, recommended protocols use an access to a standard TCP/IP network. To prevent potential unwanted influence on data exchange, underlying network must be secured using various mechanisms.

Cybersecurity enhancements are available for protocols or data exchange formats of IEC 60870-5, IEC 60870-6, IEC 61850, IEC 61970 and IEC 61968 series in the form of IEC 62351 standard, which defines a set of security mechanism to ensure authenticated access and data transfer for different profiles. These include enabling transport layer security (TLS) and role-based access control (RBAC). In case of TLS, both a client and a server are required to use a valid certificate and a private key, this could mitigate the risk of data being modified by an intermediate node (application level), without being noticed by the final receivers.

Even though encryption is nowadays implemented for the data transport layer, the data itself is often not sufficiently validated. This could lead to compromise or disruption of the receiving applications and their underlying infrastructure. Especially the protocol or file format parsers, e.g., XML, can have vulnerabilities which could be exploited in this way.

A common approach for application-side data validation and digital signature to address this risk would increase the overall security posture of the European Grid and market integration.

CONCLUSION

The paper is based on the responses given in the TSO surveys on practices of data exchange within the scope of the KORRR methodology. In terms of the implementation scenarios for SGUs connected to the distribution grid, TSOs apply the data exchange scenarios for the specific type of data based on the national practices. There are also cases in which individual TSOs would apply different scenarios subject to the applications for the same type of data.

Concerning current practices, there are some discrepancies between the recommended standards and the standards being used, in particular, for structural and scheduled data. There are various reasons for these discrepancies. One important reason is the diversity of data objects, communication links or platforms for the data exchange between TSOs, DSOs and SGUs. Additionally, a wide set of formats have been available for a long time for these data types, therefore a wide-scale transition to new standards would impose high investment costs which may not be justified with the benefits this could bring about. Another difficulty to employ recommended standards for schedule and structural data is that they were not deemed exhaustive or sufficiently mature to represent all the possible data exchanges in operational planning currently realized between TSOs, DSOs, SGUs, market parties and other affected parties. Nevertheless, the push to use recommended standards is strong but may require a long-term path and specific roadmap depending on the national status, because of new regulations and operational needs.

With all the factors considered, for already established data exchange, the recommendation is to allow the partner to maintain the current method, in order to avoid additional investment efforts, but it should also be possible for each partner to decide to switch to one of the recommended standards if so desired. To allow transition to harmonised approach at regional and European level, it is advisable for vendors to ensure backward compatibility and support multiple versions of the standards. For new actors, or for existing actors for which additional data exchange has to be established, it is instead suggested to use the recommended standard from the onset if technically feasible, effective and efficient. This allows for gradual implementation and avoid additional costs for actors that already have done investments in previously used formats.

Whichever standards and protocols actors ultimately decide to implement, the current target of the European authorities to facilitate interaction and data exchanges across and between data systems in member states and other concerned European countries should be considered, together with other important elements such as cost-benefit evaluation, cyber security, data validation and the ICT strategy of the respective actors.

Glossary

BRP	Balance Responsible Party
BSP	Balancing Service Provider
CACM	Capacity Allocation and Congestion Management, Commission Regulation (EU) 2015/1222 24 July 2015
CGMES	Common Grid Model Exchange Standard, described in IEC 61970-600
CIM	Common Information Model, described in IEC 61970 (Grid), IEC 61968 (Support) and IEC 62325 (Market).
CSA	Coordinated Security Analysis
DSO	Distribution System Operator
EBGL	Electricity Balancing Guideline Commission Regulation (EU) 2017/2195 of 28.11.2017
IEC	International Electrotechnical Commission
KORRR	Key Organisational Requirements, Roles, and Responsibilities
LFC	Load Frequency Control
NRA	National Regulatory Authority
SGU	Significant Grid User
SOC	ENTSO-E System Operations Committee
SO GL	System Operation Guideline Commission Regulation (EU) 2017/1485 of 02.08.2017
TSO	Transmission System Operator