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TECHNICAL SPECIFICATION

colour inside

Energy management system application program interface (EMS-API) – Part 600-1: Common Grid Model Exchange Specification (CGMES) – Structure and rules

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 61970-600-1, which is a technical specification, has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
57/1815/DTS	57/1871/RVDTS

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

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

A list of all parts in the IEC 61970 series, published under the general title *Energy management system application program interface (EMS-API)*, can be found on the IEC website.

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

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

The purpose of the Common Grid Model Exchange Specification (CGMES) is to define the interface between Transmission System Operators (TSO) software in order to exchange power system modelling information as required by the European Network of Transmission System Operators for Electricity (ENTSO-E) and TSO business processes.

The CGMES is used as a baseline exchange specification for the implementation of the Common Grid Model (CGM) methodologies in accordance with the requirements for the implementation of various European network codes and guidelines. The CGMES applies to applications dealing with power system data management, as well as applications supporting the following analyses:

- load flow and contingency analyses,
- short circuit calculations,
- market information and transparency,
- capacity calculation for capacity allocation and congestion management, and
- dynamic security assessment.

The conformity of the applications used for operational and system development exchanges with the CGMES is crucial for the needed interoperability of these applications. ENTSO-E therefore developed and approved the CGMES Conformity Assessment Framework as the guiding principles for assessing applications' CGMES conformity. This technical specification relies on the CGMES Conformity Assessment Process operated by ENTSO-E in order to ensure that the CGMES is properly implemented by suppliers of the applications used by TSOs.

The CGMES is a superset of the former ENTSO-E CIM based data exchange standard (Profile 1) which was based on CIM14 (UML14v02) and has been used for certain network models exchanges since 2009. The CGMES reflects TSO requirements (as known by 2014) for accurate modelling of the ENTSO-E area for power flow, short circuit, and dynamics applications whilst also allowing for the exchange of any diagram layouts including GIS data of a grid model.

ENERGY MANAGEMENT SYSTEM APPLICATION PROGRAM INTERFACE (EMS-API) –

Part 600-1: Common Grid Model Exchange Specification (CGMES) – Structure and rules

1 Scope

This technical specification on the CGMES defines the main rules and requirements related to the CGMES which are mandatory for achieving interoperability with the CGMES and for satisfying business processes. In this document requirements are indicated as such in a tabular format. Some descriptions are merely used for clarification and are marked "Informational".

The profiles which belong to CGMES are defined in IEC 61970-600-2:2017. The related technical information and documentation (i.e. RDFS, OCL, XMI and HTML) needed for the implementation of the CGMES, which is not copyrighted by either IEC or CENELEC, is available at the ENTSO-E web site.

The CGMES is defined using information on the Common Information Model (CIM) available in the public domain.

Future editions of this technical specification will be released to describe following CGMES versions which will reflect additional requirements due to European network codes or guidelines.

2 Normative references

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

IEC 61970-452, *Energy management system application program interface (EMS-API) – Part 452: CIM model exchange specification*

IEC 61970-453, *Energy management system application program interface (EMS-API) – Part 453: Diagram layout profile*

IEC 61970-456, *Energy management system application program interface (EMS-API) – Part 456: Solved power system state profiles*

IEC 61970-552, *Energy management system application program interface (EMS-API) – Part 552: CIMXML Model exchange format*

IEC 61968-4, *Application integration at electric utilities – System interfaces for distribution management – Part 4: Interfaces for records and asset management*

3 Terms, definitions and abbreviated terms

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

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

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

NOTE For definitions which are not specified in the CGMES the definitions in the IEC 61970 standards shall be applied.

3.1 Terms and definitions

3.1.1
Common Grid Model Exchange Specification
CGMES
ENTSO-E specification used for the exchange of power system models between TSOs for the purpose of performing bilateral, regional or pan-European studies in the frame of TYNDP or TSOs' projects

Note 1 to entry: This is based on IEC CIM Standards and further extended to meet Network Codes' and projects' requirements. The standard defines a set of data model exchange profiles.

3.1.2
profile
uniquely named subset of classes, associations and attributes needed to accomplish a specific type of interface and based upon a canonical model

Note 1 to entry: This term may be used to define either the semantic model for an instance data payload or the syntactic schema for an instance data payload. A profile may be expressed in XSD, RDF, and/or OWL files. An instance data conforming to a profile can be tested in exchanges between applications. A profile is necessary in order to “use” the canonical model.

3.1.3
CIM Extension
collection of classes, attributes and associations, which extend the standard IEC CIM model in order to cover use cases not currently supported by IEC standards, and which are not considered to be international use cases or are covered by a later version of the standard which is not yet supported

3.1.4
ENTSO-E Extension
CIM Extension, specifically managed by ENTSO-E

3.1.5
boundary set
set containing all boundary points necessary for a given grid model exchange

Note 1 to entry: A Boundary set can have different coverage depending on the requirements of the common grid model exchange. A complete boundary set is necessary to assemble a pan-European power system model.

3.1.6
boundary point
BP
connection point between two Model Authority Sets (MAS)

Note 1 to entry: A Boundary point could be a ConnectivityNode or a TopologicalNode placed on a tie-line or in a substation. A Boundary point must be contained in a Boundary Set and must not be contained in the MAS of a TSO. A Boundary point is referenced by Terminals in the MAS of a TSO. ConnectivityNode and TopologicalNode are terms specified in IEC CIM standards. If a Boundary point is placed on a tie-line, the term X-Node is often used instead of Boundary point. X-Node is therefore a specific type of Boundary point.

3.2 Abbreviated terms

IEC The International Electrotechnical Commission, headquartered in Geneva

DSO	Distribution System Operator
TSO	Transmission System Operator
ENTSO-E	European Network of Transmission System Operators for Electricity (ENTSO-E has 43 TSO members)
MRID	CIM Master Resource Identifier
CIM	Common Information Model (electricity)
CGMES	Common Grid Model Exchange Standard
MAS	Model Authority Set
IOP	Interoperability Test
RDF	Resource Description Framework
EQ_BD	Boundary equipment profile or instance file
TP_BD	Boundary topology profile or instance file
EQ	Equipment profile or instance file
TP	Topology profile or instance file
SSH	Steady State Hypothesis profile or instance file
SV	State Variables profile or instance file
DL	Diagram Layout profile or instance file
GL	Geographical Location profile or instance file
DY	Dynamics profile or instance file
BP	Boundary point

4 Exchange process

There are various levels at which the exchange of power system data/models is necessary. A pan-European model exchange level covers the territory of all TSOs. Regional model exchanges can be realised between different TSOs in one or more synchronous areas. A model exchange on the national level includes interfaces between TSOs and DSOs, as well as between different DSOs.

The purpose of model exchanges is not only to exchange the data from one authority to another but also to satisfy the ultimate goal, namely to perform common studies using shared data. All parties involved in the process should be able to perform the same types of studies and be able to share project tasks between different parties which are using different power system analysis applications. Indeed, the interoperability between different applications used in the exchange process is therefore crucial in both reaching seamless data exchange and obtaining comparable study results when using this data.

The CGMES covers these ENTSO-E and TSO business processes by defining the following main types of exchanges valid for a particular study or process:

- Exchange of boundary set: An exchange of a boundary Set is necessary to prepare an exchange of an internal TSO model and to assemble a common grid model. The latest information on Boundary Sets covering the pan-European area is available to TSOs and maintained in the ENTSO-E Network Modelling Database (NMD) where all TSOs negotiate and agree on the boundary information.
- Exchange of an internal TSO model: A number of business processes require each TSO to provide models of its internal territory. To describe its internal territory in a single stand-alone exchange, a TSO is treated as a single model authority set and shall be able to exchange all profiles defined in the CGMES. The TSO prepares its internal model in such a way that it is easily and unambiguously combined with other TSO internal models to make up complete models for analytical purposes. This type of exchange can also be

applied for the interface between a TSO and a DSO, where models covering transmission or distribution parts of the power system can be exchanged based on a mutual agreement between the TSOs and the DSOs. In this case, and if a TSO requests a DSO model, the DSO would provide its model in accordance with CGMES definitions which might be extended by the TSO requesting this type of exchange.

- Exchange of a common grid model: A common grid model refers to the concept of having one model which can be used for multiple purposes. The specification describes what is needed to create an assembly of multiple TSOs' Individual Grid Models (IGM) of their responsible territory into a regional or pan-European model. Different business processes will require specific implementation of the profiles part of the CGMES and the exchange of respective instance files to meet interoperability inside the business process. The Common Grid Model meta-model description will ensure interoperability across the business process.

ENTSO-E and TSO business processes (e.g. system development planning, protection planning, operational planning, operation, fault study/simulation, market operation, etc.) are, of course, more complex than these operations, but what is important to note is that all processes are supported using only these basic kinds of interoperation.

Note that each power system model in CIM normally consists of multiple datasets (instance files) as defined in IEC CIM standards and further specified by CGMES.

The CGMES supports node-breaker and bus-branch model exchanges. Moving forward the procedures of the model exchanges using the CGMES, it is expected that equipment and steady state hypothesis data (EQ and SSH instance files) will be the input source data for all processes. This type of model should be the fully detailed model with all disconnectors/breakers, etc. Any configuration changes are made by changing switch statuses.

ID	Specification	Type
EXCH1.	The CGMES defines equipment and steady state hypothesis profiles as an input, meaning that all results, whether topology or state variables profiles data, must refer to the equipment and steady state hypothesis objects. Therefore, in the case that both equipment and steady state hypothesis instance files are available, there is no need to exchange topology or state variables instance files in order to obtain a load flow.	Requirement
EXCH2.	For node-breaker model exchanges the TopologicalNodes represent the output from a topology processing on the detailed input source operational data. These can be optionally exchanged to be used by tools which have an interest in the computed buses.	Information
EXCH3.	For node-breaker model exchanges mRID (rdfIDs in serialisation) of the TopologicalNodes are not persistent.	Information
EXCH4.	For node-breaker model exchanges a topology instance file is not exchanged using a difference file.	Requirement
EXCH5.	For bus-branch model exchanges the TopologicalNodes must be persistent.	Requirement
EXCH6.	If a contingency list is exchanged belonging to the model exchanged in bus-branch detail, it shall refer to ConductingEquipment (TopologicalNode, branches, etc.). This results in a constraint on interoperability between planning and operation processes.	Requirement
EXCH7.	If a contingency list is exchanged belonging to the model exchanged in node-breaker detail, it shall refer to ConductingEquipment (ConnectivityNode, which is not artificial, Busbar, etc.).	Requirement
EXCH8.	If a model has mixed representation (node-breaker and bus-branch) then the profile URI in the header related to the Equipment Operation is not included as only part of the network will include classes stereotyped with Operation.	Requirement

5 Specifications and functionalities

5.1 General constraints

The following rules are general in nature or involve multiple classes. Additional rules are defined in the notes to the individual classes in the profiles part of the CGMES.

ID	Specification	Type
GENC1.	All objects must have a persistent and globally unique identifier (it is the mRID – see 5.2). In the ENTSO-E data exchange process this unique identifier will be exchanged as rdf:ID.	Requirement
GENC2.	Software solutions shall not use “name” related attributes (name, short name, description, etc. inherited by many classes from the abstract class IdentifiedObject) to link the power system model. Only mRID (exchanged as rdf:ID) is used for this purpose.	Requirement
GENC3.	The rdf:ID defined within a data exchange process is the only globally unique and persistent identifier.	Requirement
GENC4.	IEC 61970-552 defines the rdf:ID as UUID and its syntax (i.e. lower case and number of characters for the different groups part of the UUID). UUID algorithm ensures global uniqueness of the identifier. Example UUID: f81d4fae-7dec-11d0-a765-00a0c91e6bf6	Requirement
GENC5.	The CGMES defines the identifier as a case sensitive string which conforms to W3C (ISO 8859/1 8-bit single-byte coded graphic character set known as Latin Alphabet No. 1; http://www.w3.org/MarkUp/html3/specialchars.html) with a maximum character limit of 60 characters. A prefix could be added, if necessary, to ensure global uniqueness. The rdf:ID is the mRID plus an underscore “_” added in the beginning of the string.	Requirement
GENC6.	Applications which conform to the CGMES shall support IEC 61970-552 and rdf:ID expressed as a string.	Requirement
GENC7.	Each TSO is responsible for ensuring that the rdf:ID is globally unique. ENTSO-E role in ensuring global uniqueness of the rdf:ID is limited to coordination and harmonisation of the approaches used in different data exchanges and which shall conform to GENC4 and GENC5.	Requirement
GENC8.	rdf:IDs must be kept persistent for all profiles except for State Variable and Diagram layout profiles: – For the State Variable profile the rdf:IDs for state variable classes (SvPowerFlow, SvVoltage, etc.) are not kept persistent. – For the Diagram layout profile the rdf:IDs of DiagramObjectPoint and DiagramObject classes may not be kept persistent	Requirement
GENC9.	rdf:about expression is used for objects which are exchanged in an instance file for a given profile but defined in a different profile (i.e. exchanged in a different instance file). A stereotype “Description” is introduced to facilitate the implementation of this rule. All classes which shall be expressed by rdf:about are stereotyped with “Description”.	Requirement
GENC10.	UTF-8 is the standard for file encoding. UTF-16 is not supported.	Requirement
GENC11.	Instance data to be exchanged must make use of the most detailed class possible within a profile, i.e. using sub-typed classes rather than general classes e.g. NuclearGeneratingUnit instead of GeneratingUnit.	Requirement
GENC12.	Optional and required attributes and associations must be imported and exported if they are in the model file prior to import.	Requirement
GENC13.	If an optional attribute does not exist in the imported file, it does not have to be exported in case exactly the same data set is exported, i.e. the tool is not obliged to automatically provide this attribute. This is not valid if the user is able to process the data, update the model and perform another export.	Requirement