



BSI Standards Publication

Energy management system application program interface (EMS-API)

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

National foreword

This Published Document is the UK implementation of IEC TS 61970-600-1:2017.

The UK participation in its preparation was entrusted to Technical Committee PEL/57, Power systems management and associated information exchange.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2018

ISBN 978 0 580 97046 7

ICS 33.200

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 May 2018.

Amendments/corrigenda issued since publication

Date	Text affected
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TECHNICAL SPECIFICATION



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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.200

ISBN 978-2-8322-4637-5

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ENERGY MANAGEMENT SYSTEM APPLICATION
PROGRAM INTERFACE (EMS-API) –****Part 600-1: Common Grid Model Exchange Specification
(CGMES) – Structure and rules**

FOREWORD

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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: <ul style="list-style-type: none"> – 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

ID	Specification	Type
GENC14.	In most of the profiles the selection of optional and required attributes is made on this basis so as to ensure a minimum set of required attributes without which the exchange does not fulfil its basic purpose. Business processes governing different exchanges can require mandatory exchange of certain optional attributes or associations. Optional and required attributes and associations shall therefore be supported by applications which claim conformance with certain functionalities of the CGMES. This provides flexibility for the business processes to adapt to different business requirements and base the exchanges on CGMES compliant applications.	Requirement
GENC15.	Breakers represent busbar couplers in a bus-branch model exchange. In this case, breakers are only included if they are to be retained. In case of a node-breaker model exchange the rules defined in IEC 61970-452 and in the CGMES profiles shall be applied.	Requirement
GENC16.	<p>Roles and multiplicity: The direction of the associations in the profiles part of the CGMES is defined in the profiles. All associations are bidirectional, although an association instance is specified only at one end in the instance files.</p> <p>The documentation of the profiles, which is part of the CGMES, describes the association with the end user. It is allowed to include both ends of an association in the XML, although only the end designated by the profile is required. The following two examples present two options which can be seen in the CGMES profiles:</p> <ul style="list-style-type: none"> – Example 1: The names “ConductingEquipment.Terminals” and “Terminal.ConductingEquipment” specify opposite ends of the association between the ConductingEquipment class and the Terminal class. In a one-to-many association, the association reference is included with the data of the “many side” class. Therefore, a ConductingEquipment can be associated with up to two Terminals, although a Terminal must be associated with one and only one ConductingEquipment. Consequently, the XML element corresponding to the ConductingEquipment class is not expected to contain any “ConductingEquipment.Terminals” elements. However, the XML element corresponding to the Terminal class is required to contain appropriate “Terminal.ConductingEquipment” elements. – Example 2: The names “TopologicalIsland.TopologicalNodes” and “TopologicalNode.TopologicalIsland” specify opposite ends of the association between the TopologicalIsland class and the TopologicalNode class. The XML element corresponding to the TopologicalNode class is not required to contain any “TopologicalNode.TopologicalIsland” elements. However, the XML element corresponding to the TopologicalIsland class is expected to contain appropriate “TopologicalIsland.TopologicalNodes” elements. 	Requirement

5.2 Model authority sets (MAS)

The CIM concept of Model Authority Sets is applied to enable the assembly or extraction of TSO models. Model Authority Sets allow an interconnection model to be divided into disjointed sets of objects, which in turn allows different parties to take responsibility for different parts of a common grid model.

ID	Specification	Type
MAS_1.	In any model exchange governed by the CGMES, each model object has an mRID.	Requirement
MAS_2.	Across all models, the model object instance which represents a given real world asset (line, transformer, etc.) shall always have the same mRID.	Requirement
MAS_3.	A CIM functional representation is given by CIM classes defined in CGMES UML. Within any one model, object mRIDs are unique, since the same element shall not be represented twice.	Requirement
MAS_4.	The mRID shall be persistent for the same given functional representation inside a given version of CIM.	Requirement
MAS_5.	In the case of upgrading from one version of CIM to another the mRID shall be kept persistent for the same functional representation in the new CIM given by a new CIM class. For instance, the change from CIM 15 to CIM 16 allows for a functional representation identified by the mRID for a ShuntCompensator which is changed to the newly introduced class NonLinearShuntCompensator with the same mRID.	Requirement
MAS_6.	mRIDs are only generated for concrete classes in a given profile. In most cases there is no overlap of functionality between different concrete classes.	Requirement
MAS_7.	A new mRID is generated in case there is a need to change the class (e.g. GeneratingUnit is changed to ThermalGeneratingUnit). If a physical unit given by mRID in the asset part of the CIM needs to be represented simultaneously as GeneratingUnit and ThermalGeneratingUnit (a given specialisation) it must have different mRIDs for GeneratingUnit and ThermalGeneratingUnit. If different business processes are required to support both types (GeneratingUnit and ThermalGeneratingUnit) the applications should maintain two mRIDs and in both cases support difference file exchange.	Requirement
MAS_8.	Only one representation (the main class or its specialisation) should be present in a given instance file.	Requirement
MAS_9.	Each object instance is assigned to one and only one Model Authority Set. There are two types of Model Authority Sets: <ul style="list-style-type: none"> – Boundary Sets – TSO sets 	Requirement
MAS_10.	Boundary Sets which contain Boundary points marking the boundary between individual models. Boundary Sets are managed by one authority (ENTSO-E) but have been defined by TSOs as a result of mutual agreement.	Requirement
MAS_11.	TSO sets contain individual TSO instance files. Objects in the TSO sets have internal associations and have associations to Boundary sets. A TSO set shall never have associations with objects in other TSO sets. This allows TSO modelling to be carried out independently of other TSOs	Requirement
MAS_12.	Each TSO in ENTSO-E is a Model Authority and manages a Model Authority Set in its area of responsibility. The TSO as Model Authority is also responsible for assigning and maintaining object mRIDs in its area set.	Requirement
MAS_13.	The territory that a TSO model represents may not be exactly the same as the territory managed by a TSO. In the CGMES, "TSO territory" always refers to the model responsibility territory.	Requirement

5.3 File header

The following rules apply to all headers:

ID	Specification	Type
HGEN1.	The definition of file header is specified in IEC 61970-552. The CGMES applies the same definition in any model exchange governed by the CGMES, each model object has an mRID.	Requirement
HGEN2.	Each type of instance file (full and difference) shall have a file header.	Requirement
HGEN3.	The file header is declared at the top of the instance file i.e. at the beginning of the file.	Requirement

The following rules are applied to the model ID (rdf:about) in the file header:

ID	Specification	Type
HREF1.	New ID is generated for new instance files only when the context of instance data changes. An export done on the imported instance data without any changes should have the same model ID reference in the header.	Requirement
HREF2.	Dependent IDs refer to IDs of the dependent instance files at the time of the export.	Requirement
HREF3.	If all dependencies are resolved then there shall not be any unresolved references within the data.	Requirement
HREF4.	The dependency reference in the header shall be used as guidance and shall not restrict the possibility of importing profiles which are exported based on a previous version of a depending profile instance file. The standard does not prevent the tools from exchanging files where the file reference does not match. Unresolved or missing references shall be reported to the user. In general, users are free to combine files on an ad-hoc basis and tooling shall identify and optionally resolve all unresolved references.	Requirement
HREF5.	Model ID shall be the same if a re-export of a model contains the same objects and attributes. <ul style="list-style-type: none"> – If the information exchanged with the instance file is the same then the re-export is considered identical. – Rearrangements of classes and attributes in the instance file are allowed. 	Requirement

5.4 File body

ID	Specification	Type
FBOD1.	The IEC 61970-552 specification is used to format a file, although the instance file shall contain only the objects from one Model Authority Set.	Requirement
FBOD2.	An instance file could contain instance data of more than one profile from the CGMES only if all profile URIs are defined in the file header and as long as the instance data belongs to one MAS. All profile URIs are defined in the file header even if one profile is a superset of another, i.e. both URIs should be included.	Requirement
FBOD3.	Instance files may contain objects with associations to objects which will be packaged in a different instance file. This situation means that the instance file by itself is 'incomplete' – it may have dangling references and cannot be used except when combined with one or more other instance file as specified in the file header dependencies. When this occurs, validation for completeness can only be performed when all the parts are present.	Requirement
FBOD4.	The CGMES requires that at the receiving end of the exchange all references in the instance files pointing to instance files from other profiles which are part of the exchange should be satisfied. Therefore, the complete set of instance files necessary for the grid model must have fulfilled references (no dangling references are allowed).	Requirement
FBOD5.	A difference model should not be created in case of very small numeric differences as these types of difference models are meaningless.	Requirement

5.5 Profiles and instance file types

5.5.1 General

There are nine different profiles in the CGMES. This subclause defines some specific rules for the profiles and their instance files so that the model exchange can be performed correctly.

5.5.2 CGMES profiles' properties

The profiles which are part of the CGMES are based on IEC CIM UML and maintained in a UML environment.

ID	Specification	Type
PROF1.	The UML namespace, namespaces of the profiles, ENTSO-E extensions, profiles versions as well as the identification of the versions of the UML and profiles are defined in a Version class for each profile of the CGMES. These properties shall be used as a primary source for file header information.	Requirement
PROF2.	Profile specific notes have been added to various classes and attributes in the UML in order to further clarify different profiles and define specific rules. These notes are considered mandatory and shall be satisfied by the applications	Requirement
PROF3.	Only instances of concrete classes are used in actual exchanges (instance files). Those concrete classes may inherit attributes or associations from abstract classes.	Requirement
PROF4.	The CGMES uses UML stereotypes to categorise classes, attributes and associations used for different exchanges. This is mainly valid for the EQ (equipment) profile where the following categorisation is applied and defines the three different types of equipment instance files supported by CGMES: <ul style="list-style-type: none"> – EQ core: includes all classes/attributes/associations which are not stereotyped. These elements are part of both node-breaker and bus-branch types of model exchange. – EQ operation: includes all classes/attributes/associations stereotyped with "Operation". These elements are only necessary if a node-breaker model representation is exchanged. – EQ short circuit: includes all classes/attributes/associations stereotyped with "ShortCircuit". These elements are only necessary if a node-breaker or a bus-branch model representation is exchanged for the purpose of performing short circuit calculations 	Requirement
PROF5.	The cardinality of given classes/attributes/associations stereotyped with "Operation" or "ShortCircuit" shall be respected if the exchange requires the inclusion of "Operation" or "ShortCircuit". The respective profile URI shall be declared in the file header. If the profile URI is not included in the header, all classes/attributes/associations part of the undeclared profile are considered optional.	Requirement
PROF6.	Classes/attributes/associations which were introduced by ENTSO-E and therefore considered as CIM extensions are marked with a stereotype "Entsoe".	Requirement
PROF7.	Any classes/attributes/associations which are defined by the CGMES profiles can be used in grid model exchanges. The authority governing a given business process and related data exchange process shall specify all required attributes/classes/associations to be exchanged. An optional attribute can be required, while a required attribute as defined in the CGMES cannot be changed to optional without modification of the version of the profile. Applications and tools should be able to deal with this complexity and support all classes and attributes depending on the tools' functionalities, i.e. they should at least be able to host the data and transfer with no change in case the tool is not able to use the data.	Requirement
PROF8.	All profiles which are part of the CGMES are documented as follows: <ul style="list-style-type: none"> – UML (XMI), which contains packages "CommonGridModelExchangeStandard" and "Extension". These packages contain all definitions related to the profiles in the CGMES and are a source of other ways in which to document the CGMES. – RDFS, which contains RDF schema files for each profile of the CGMES. The files are generated by the application CimConteXtor. – HTML, which contains HTML documentation for each profile of the CGMES. The files are generated by the application CimConteXtor. – HTML_EA, which contains the HTML native Enterprise Architect export of the "CommonGridModelExchangeStandard" package. 	Information
PROF9.	Annex F provides references to the CGMES documentation related to a specific version of the profiles.	Information

ID	Specification	Type
PROF10.	<p>The dependencies between the profiles belonging to CGMES are defined in the following figure</p> <p>Figure 1 – Dependencies between the profiles belonging to CGMES</p> <p>Figure 1 defines the “ref” relations that show a dependency between two profiles. Profile schemas (RDFS) shall not be merged to create a new joint merged profile definitions. Profile instance files shall list in the file header all profiles that describe the instance data so that an application can load all the profile schemas needed to validate the instance data. The “ref” relation may be added to the profile schemas such that an application working with instance data can use this information to load all needed profile schemas. The “ref” and “opt.ref” (optional reference) are used to indicate possible dependencies at instance data level. These dependencies are provided in the file header.</p> <p>The blue profiles are invariant, whereas the yellow ones are variant (meaning that the instance files may be different for every other scenario).</p>	Requirement
PROF11.	<p>The profile references in the file header specify which profiles validation the instance file data is valid for. The instance data file can contain data from multiple profiles (such as ShortCircuit or Operation) without being declared in the header profile references. However, the data belonging to non-declared profiles does not need to be imported and re-exported as the profiles are not defined in the file header. The user shall be informed if the data is not imported.</p>	Requirement

5.5.3 CGMES' extensions

Due the complexity and specificity of the ENTSO-Es' and TSOs's business processes, the CIM version used to create the profiles of the CGMES has been extended.

ID	Specification	Type
EEXT1.	ENTSO-E extensions defined in the frame of the CGMES and part of its profiles shall be equally supported in the same way as the IEC CIM.	Requirement
EEXT2.	All extension shall be an addition to an existing standard (CGMES of IEC CIM standards). ENTSO-E extensions which are part of the CGMES are extensions of the IEC CIM. When extending the CGMES it is permitted to create a restriction which does not prevent the validity of the CGMES. While an optional attribute or association can be made required as a part of the profiling work, a required attribute or association cannot be made optional as part of an extension.	Requirement
EEXT3.	<p>Declaring the ENTSO-E Extension URI and the Corresponding Alias: The ENTSO-E extension URI and the corresponding alias shall be declared at the topmost element of the CIM/XML file along with CIM and other URI.</p> <p>EXAMPLE (URI of the ENTSO-E CIM extension and the alias):</p> <pre><?xml version="1.0" encoding="utf-8"?> <rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#" xmlns:cim="http://iec.ch/TC57/2013/CIM-schema-cim16# xmlns:entsoe="http://entsoe.eu/CIM/SchemaExtension/3/1#"> </rdf:RDF></pre>	Requirement

ID	Specification	Type
EEXT4.	<p>Using Extension URI Alias to Declare the Extended Data is illustrated in the following examples. In the first example the attribute IdentifiedObject.shortName is declared as an extended attribute and prefixed with the extension alias "entsoe". EXAMPLE (declaring an extended attribute):</p> <pre> <cim:ACLineSegment rdf:ID="_ f732688e-bace-4ece-bc2b-5d9792608092"> <cim:IdentifiedObject.name>DFG-THY 1</cim:IdentifiedObject.name> <entsoe:IdentifiedObject.shortName>Brussels</entsoe:IdentifiedObject.sh ortName> <cim:ACLineSegment.bch>4.61157E-05</cim:ACLineSegment.bch> <cim:ACLineSegment.r>1.06601</cim:ACLineSegment.r> <cim:ACLineSegment.x>34.28535</cim:ACLineSegment.x> <cim:Conductor.length>45</cim:Conductor.length> <cim:Equipment.aggregate>false</cim:Equipment.aggregate> <cim:ConductingEquipment.BaseVoltage rdf:resource= "#_ 4852044a-e072-441b-bc3c-dc7b00de7e5e" /> </cim:ACLineSegment> </pre> <p>In the second example, if an instance of the extended class is declared as extension, then the extended class, i.e. ExtendedClass, and the extended attribute ExtendedClass.extendedAttribute must be prefixed with the extension alias "entsoe". EXAMPLE (declaring an extended instance or object):</p> <pre> <entsoe:ExtendedClass rdf:ID="_ 21d3bbfb-0aec-4e44-8db0- ae2e064b22e2"> <cim:IdentifiedObject.name>EX11</cim:IdentifiedObject.name> <entsoe:ExtendedClass.extendedAttribute>20</entsoe:ExtendedClass.ext endedAttribute > </entsoe:ExtendedClass > </pre> <p>The third example illustrates the addition of an association, namely ENTSO-E extension. EXAMPLE (declaring an extended association):</p> <pre> <cim:ACLineSegment rdf:ID="_ 9cdc68b4-3953-c88a-24de-820873445a59"> <cim:ACLineSegment.bch>0.000157</cim:ACLineSegment.bch> <cim:ACLineSegment.gch>0</cim:ACLineSegment.gch> <cim:ACLineSegment.r>1.04001</cim:ACLineSegment.r> <cim:ACLineSegment.x>12</cim:ACLineSegment.x> <entsoe:ConductingEquipment.ExtendedClass rdf:resource="#_9cf549dc- 2453-d994-976a-c2ea44773145" /> <cim:Conductor.length>30</cim:Conductor.length> <cim:IdentifiedObject.name>B1X3</cim:IdentifiedObject.name> </cim:ACLineSegment> </pre>	Requirement
EEXT5.	The same principle related to extensions applies to any other extensions. Therefore, if an instance file produced by a given application/software contains some extensions specific to vendors' internal applications, the same method to declare such extended data shall be used.	Requirement
EEXT6.	An instant file which contains classes, associations and attributes not defined in the CGMES shall be processed by the receiving application which would ignore the extensions left undefined by the CGMES and make use of the rest of the data.	Requirement
EEXT7.	Extending an enumerator has to be done by adding a new enumerator which includes the additional values. Both the extended and the standard enumerator have to comply with the profile, i.e. if the standard enumerator is mandatory, it shall be included in addition to the new (extended) enumerator.	Requirement

5.5.4 Equipment profile and instance file

ID	Specification	Type
EQ__1.	The equipment profile is separated by three functional parts: EQ core, EQ operation and EQ short circuit. The following types of equipment instance files and their relation with the EQ profiles can be exchanged: <ul style="list-style-type: none"> – Full EQ: contains all classes/attributes/associations defined in EQ core, EQ operation and EQ short circuit profiles. – EQ operation: contains all classes/attributes/associations defined in EQ core and EQ operation profiles. – EQ short circuit: contains all classes/attributes/associations defined in EQ core and EQ short circuit profiles. It covers a bus-branch model exchange which contains short circuit data. 	Requirement
EQ__2.	An equipment instance file describes the equipment in the power system model covered by a MAS.	Requirement
EQ__3.	An equipment instance file would not normally change in case of frequent data exchange process. It can be updated with difference file exchange.	Requirement

5.5.5 Topology profile and instance file

ID	Specification	Type
TP__1.	A topology instance file contains all topology objects for a MAS. These topology objects reference the corresponding equipment describing how equipment is electrically connected.	Requirement
TP__2.	A topology instance file is the result of a network topology processing analysis. Because of this the topology instance file is considered as an output if the exchange is based on a node-breaker model exchange.	Information
TP__3.	Depending on the data exchange process a topology instance file may or may not change frequently. E.g. a topology instance file can be updated using difference file exchange in case of bus-branch model exchange.	Information

5.5.6 Steady state hypothesis profile and instance file

ID	Specification	Type
SSH_1.	A steady state hypothesis instance file contains all objects required to exchange input parameters to be able to perform load flow simulations.	Requirement
SSH_2.	A steady state hypothesis instance file is always exchanged in full. Due to the nature of the SSH profile, all objects in an steady state hypothesis instance file shall have persistent mRIDs and rdf.IDs.	Requirement

5.5.7 State variables profile and instance file

ID	Specification	Type
SV__1.	A state variable instance file contains all objects required to complete the specification of a steady-state solution.	Requirement
SV__2.	A state variables instance file is always exchanged in full.	Requirement
SV__3.	A state variables instance file of an assembled model contains state variables related objects for all model authority sets being part of the assembled model.	Requirement

5.5.8 Boundary equipment profile and instance file

ID	Specification	Type
EQBD1.	A boundary equipment instance file contains all objects defined in the boundary equipment profile and includes data for boundary information relating to a given exchange.	Requirement
EQBD2.	The boundary equipment profile defines which instance data represents types or voltages which are agreed for the CGMES based exchanges. Therefore, individual grid models shall refer to the boundary equipment instance file to use declared EnergySchedulingTypes and BaseVoltages. This does not limit different model authorities when it comes to defining additional types or voltages in their instance files, although there shall not be an overlap of data values between boundary equipment files and individual grid model instance files. For instance, ENTSO-E boundary equipment file defines base voltages for both 380 kV and 400 kV to which TSOs instance files should refer and not redefine these base voltages in their instance files.	Requirement
EQBD3.	Boundary equipment instance files can be updated using difference file exchange.	Requirement

5.5.9 Boundary topology profile and instance file

ID	Specification	Type
TPBD1.	A boundary topology instance file contains all objects defined in the boundary topology profile and includes data for boundary information relating to a given exchange.	Requirement
TPBD2.	A boundary topology instance file can be updated using difference file exchange.	Requirement

5.5.10 Diagram layout profile and instance file

A diagram instance file is based on the IEC 61970-453 Diagram layout profile standard and contains data necessary for the model diagram.

ID	Specification	Type
DL__1.	A full Diagram (non-difference instance file) represents a new drawing of the diagram. Data may change from one system drawing to another, e.g. two diagrams with the same mRID of the classes in the instance files do not need to be identical. The purpose of Diagram layout profile is to support the understanding of the equipment data. If a diagram generated by one system is updated by another the file does not need to be identical, with the exception of the edited changes. However, the updated and exported diagram instance file must include all the same relevant information and must have the same layout rendering in the new destination system (old source) as the original, with the exception of the changes. The expected behaviour is that a diagram may have a new layout with the same Diagram mRID as well as DiagramObject mRID. Persistence of Diagram and DiagramObject mRIDs is required if difference updates are supported.	Requirement
DL__2.	The objects in the equipment of the Diagram layout instance are identified by the DiagramObject.IdentifiedObject.	Requirement
DL__3.	The diagram layout profile supports exchange of more than one diagram, e.g. detailed substation diagram, single line diagram, etc. in one instance file of DL profile.	Requirement
DL__4.	A Diagram layout instance file is always exchanged in full.	Requirement

5.5.11 Geographical location profile and instance file

ID	Specification	Type
GL__1.	A geographical data instance file contains GIS data and is constructed based on IEC 61968-4, although it is limited to the classes which cover ENTSO-E needs.	Information
GL__2.	A geographical data instance file is exchanged in full, although it could be updated using difference file exchange.	Requirement

5.6 File exchange

ID	Specification	Type
FILX1.	A given exchange consists of multiple files. The CGMES defines that all files in a given logical exchange must be zipped together ¹ . The tools use zip files directly when importing and exporting in order to minimise users.	Information
FILX2.	The CGMES defines no naming convention applied to the .xml or .zip file names. Although different business processes may define such a file naming convention, the applications shall rely solely on the information provided in the file headers in order to process the instance files.	Information
FILX3.	One zip file may only contain the following types of files: <ul style="list-style-type: none"> – A single instance file of the following types: equipment (EQ), boundary equipment (EQ_BD), topology (TP), boundary topology (TP_BD), steady state hypothesis (SSH), state variables (SV), dynamics (DY), diagram layout (DL), geographical location (GL). – Combinations of equipment, topology, steady state hypothesis, state variables, dynamics, diagram and geographical instance files which are allowed by the CGMES and are related to one MAS only. – Difference files of one MAS only when exchanging a TSO model. – Equipment, topology, steady state hypothesis, state variables, dynamics, diagram and geographical files per MAS for an assembled model. – Difference files per MAS for an assembled model. – Boundary MAS instance files (full or difference or the assembled model is expressed with difference files) shall always be included in the zip file containing an assembled model 	Information
FILX4.	The zip file shall not contain folders. It is only a container of *.xml files.	Requirement
FILX5.	The hierarchy and model dependency shall be respected when exchanging models. The number of files and the type of the files (full or difference) depends on the requirements set by the business process. The following examples show some possible situations: <ul style="list-style-type: none"> – If the equipment file is changed, all files (depending on the requirements of the exchange: equipment, topology, steady state hypothesis, state variables, dynamics, diagram and geographical files) must be sent as part of any exchange. – If only the steady state hypothesis file is changed, only the steady state hypothesis file must be sent as part of any exchange if there is no requirement to exchange the solved power system model. – If only the state variables file is changed, only the state variables file must be sent as part of any exchange. – If only the dynamics file is changed, only the dynamics file must be sent as part of any exchange. – If only the diagram file is changed, only the diagram file must be sent as a part of any exchange. – If only the geographical file is changed, only the geographical file must be sent as a part of any exchange. 	Requirement
FILX6.	It is not permitted to exchange a topology file, a steady state hypothesis file, a state variables file, a dynamics file, a diagram file or a geographical file from one model and an equipment file from another model (or from an entity which has changed the equipment file) and attempt to assemble all files into one assembled model.	Requirement
FILX7.	In case difference files are exchanged, the same dependences as for full model exchange are followed. The difference file (e.g. equipment, topology or dynamics) should refer to the base model which is subject to an update. Dependencies are listed in the file header of each file which is exchanged	Requirement

¹ Note that a given business process may require the instances to be exchanged in individual zip files.