
Common Grid Model Exchange Standard (CGMES)

Version 2.4

Based on IEC Common Information Model

7 August 2014

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Approval

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Abbreviations

IEC	The International Electrotechnical Commission, headquartered in Geneva.
TSO	Transmission System Operator
ENTSO-E	European Network of Transmission System Operators for Electricity. ENTSO-E has 41 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

1. Scope

The purpose of the Common Grid Model Exchange Standard (CGMES) is to define the interface between ENTSO-E members' software in order to exchange power system modelling information as required by the ENTSO-E and TSO business processes.

The CGMES is based on the following existing or expected IEC CIM standards valid for the CIM UML16v25:

- IEC 61970-552: CIM XML Model Exchange Format
- IEC 61970-301: Common Information Model (CIM) Base
- IEC 61970-302: Common Information Model (CIM) for Dynamics Specification
- IEC 61970-452: CIM Static Transmission Network Model Profiles
- IEC 61970-453: Diagram Layout Profile
- IEC 61970-456: Solved Power System State Profiles
- IEC 61970-457: Common Information Model (CIM) for Dynamics Profile
- IEC 61968-4: Application integration at electric utilities – System interfaces for distribution management - Part 4: Interfaces for records and asset management

The CGMES defines a set of rules and/or requirements which are mandatory for achieving interoperability with the CGMES and for satisfying the business processes. These rules/requirements are marked with [R....] in the document.

1.1. Major updates applied in version 2.4 of the CGMES

The CGMES is a superset of the ENTSO-E CIM Profile 1 which is based on UML14v02 and has been used for certain network models exchanges since 2009. The CGMES reflects current TSO requirements 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. It includes the following major updates in comparison with the ENTSO-E CIM Profile 1:

- Equipment, topology and state variables profiles are modified to fit the latest IEC CIM draft standards (corresponding to CIM16 – UML16v25). All classes, attributes and associations which are necessary for the exchange of a detailed operational model (node-breaker model) and short-circuit data are marked with stereotype "Operation" and "ShortCircuit" respectively.
- Modelling of the power system model's elements is improved, i.e. new transformer model, new shunt compensator model, HVDC equipment, etc.
- Steady State Hypothesis profile is added.
- Dynamics profile is added.
- Diagram Layout profile is added.
- Geographical Location profile is added.

2. Definitions

ENTSO-E defines the following terms in order to avoid confusion during implementation of the CGMES. For definitions which are not specified in the CGMES the definitions in the IEC CIM related standards should be applied.

[D.1.] Common Grid Model Exchange Standard (CGMES) – this is an ENTSO-E standard 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. It 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.

- [D.2.] Profile – this refers to the uniquely named subset of classes, associations and attributes needed to accomplish a specific type of interface and based upon a canonical model. The term profile 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.
- [D.3.] CIM Extension - a 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.
- [D.4.] ENTSO-E Extension – a specific for ENTSO-E CIM Extension [D.3].
- [D.5.] Boundary set – A boundary set contains all boundary points necessary for a given grid model exchange. 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.
- [D.6.] Boundary point (BP) – Boundary point is a connection point between two Model Authority Sets (MAS). 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. Exchange process

There are various levels in 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 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 prepared 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 standard describes what is needed to create an assembly of multiple TSOs Individual Common Grid Model (ICGM) 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 a node-breaker and a 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.

[R.3.1.] 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.

The following specific differences apply to bus-branch and node-breaker model exchanges:

[R.3.2.] Bus-branch model exchanges:

- TopologicalNodes must be persistent;
- If a contingency list is to be exchanged it should refer to ConductingEquipment (TopologicalNode, branches, etc.). This results in a constraint on interoperability between planning and operation processes.

[R.3.3.] 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.
- A topology instance file is not exchanged using a difference file.

- mRID (rdfIDs in serialisation) of the TopologicalNodes are not persistent.
- If a contingency list must be exchanged it should refer to ConductingEquipment (ConnectivityNode, which is not artificial, Busbar, etc.).

[R.3.4.] 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.

4. Specifications and functionalities

4.1. 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.

[R.4.1.1.] 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.

[R.4.1.2.] All objects must have a persistent and globally unique identifier (it is the mRID - see Section 4.2). In the ENTSO-E data exchange process this unique identifier will be exchanged as rdf:ID. The following rules apply to rdf:IDs:

[R.4.1.2.1.] The rdf:ID defined within a data exchange process is the only globally unique and persistent identifier.

[R.4.1.2.2.] IEC 61970-552 defines the rdf:ID as UUID and its syntax. UUID algorithm ensures global uniqueness of the identifier.

[R.4.1.2.3.] 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.

[R.4.1.2.4.] Applications which conform to the CGMES shall support IEC 61970-552 and rdf:ID expressed as a string.

[R.4.1.2.5.] 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 [R.4.1.2.2.] and [R.4.1.2.3.].

[R.4.1.2.6.] rdf:IDs must be kept persistent for all profiles except for State Variable and Diagram layout profiles:

- i. For the State Variable profile the rdf:IDs for state variable classes (SvPowerFlow, SvVoltage, etc.) are not kept persistent.
- ii. For the Diagram layout profile the rdf:IDs of DiagramObjectPoint and DiagramObject classes may not be kept persistent.

[R.4.1.3.] 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”.

- [R.4.1.4.] UTF-8 is the standard for file encoding. UTF-16 is not supported.
- [R.4.1.5.] 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.
- [R.4.1.6.] Optional and required attributes and associations must be imported and exported if they are in the model file prior to import.
- [R.4.1.7.] 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.
- [R.4.1.8.] 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 must 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.
- [R.4.1.9.] 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 the IEC 61970-452 and in the CGMES profiles shall be applied.
- [R.4.1.10.] 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. 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:
 - 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.

4.2. 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.

[R.4.2.1.] In any model exchange governed by the CGMES, each model object has an mRID.

[R.4.2.1.1.] Across all models, the model object instance which represents a given real world asset (line, transformer, etc.) shall always have the same mRID.

[R.4.2.1.2.] 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.

[R.4.2.1.3.] The mRID shall be persistent for the same given functional representation inside a given version of CIM.

[R.4.2.1.4.] 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.

[R.4.2.1.5.] mRIDs are only generated for concrete classes in a given profile. In most cases there is no overlap of functionality between different concrete classes.

[R.4.2.1.6.] 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.

[R.4.2.1.7.] Only one representation (the main class or its specialisation) should be present in a given instance file.

[R.4.2.2.] Each object instance is assigned to one and only one Model Authority Set. There are two types of Model Authority Sets:

[R.4.2.2.1.] 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.

[R.4.2.2.2.] 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.

[R.4.2.3.] 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.

[R.4.2.3.1.] 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.

4.3. File header

[R.4.3.1.] The definition of file header is specified in IEC 61970-552. The CGMES applies the same definition.

[R.4.3.2.] Each type of instance file (full and difference) shall have a file header.

[R.4.3.3.] The file header is declared at the top of the instance file i.e. at the beginning of the file.

[R.4.3.4.] The following rules are applied to the model ID (rdf:about) in the file header:

[R.4.3.4.1.] 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.

[R.4.3.4.2.] Dependent IDs refer to IDs of the dependent instance files at the time of the export;

[R.4.3.4.3.] If all dependencies are resolved then there should not be unresolved references within the data;

[R.4.3.4.4.] 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 should be reported to the user. In general, users are free to combine files on an ad-hoc basis and tooling should identify and optionally resolve all unresolved references.

[R.4.3.4.5.] Model ID shall be the same if a re-export of a model contains the same objects and attributes.

- i. If the information exchanged with the instance file is the same then the re-export is considered identical.
- ii. Rearrangements of classes and attributes in the instance file are allowed.

4.4. File body

[R.4.4.1.] 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.

[R.4.4.2.] 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.

[R.4.4.3.] 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.

[R.4.4.4.] 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).

4.5. Profiles and instance file types

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

4.5.1. CGMES profiles' properties

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

[R.4.5.1.1.] 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.

[R.4.5.1.2.] 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.

[R.4.5.1.3.] Only instances of concrete classes are used in actual exchanges (instance files). Those concrete classes may inherit attributes or associations from abstract classes.

[R.4.5.1.4.] 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:

[R.4.5.1.4.1.] 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.

[R.4.5.1.4.2.] EQ operation: includes all classes/attributes/associations stereotyped with "Operation". These elements are only necessary if a node-breaker model representation is exchanged.

[R.4.5.1.4.3.] 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.

[R.4.5.1.5.] 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".

[R.4.5.1.6.] Classes/attributes/associations which were introduced by ENTSO-E and therefore considered as CIM extensions are marked with a stereotype "Entsoe".

[R.4.5.1.7.] 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.

[R.4.5.1.8.] All profiles which are part of the CGMES are documented as follows:

- 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.
- Pdf, which contains detail description of the CGMES profiles.

[R.4.5.1.9.] Appendix 6.5 provides references to the CGMES documentation related to a specific version of the profiles.

4.5.2. CGMES' extensions

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

[R.4.5.2.1.] 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.

[R.4.5.2.2.] All extension should be an addition to an existing standard (CGMES or 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.

[R.4.5.2.3.] 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 your CIM/XML file along with CIM and other URI.

Example (URI of the ENTSO-E CIM extension and the alias):

```
<?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>
```

[R.4.5.2.4.] Using Extension URI Alias to Declare the Extended Data.

[R.4.5.2.4.1.] In the example below the attribute IdentifiedObject.shortName is declared as an extended attribute and prefixed with the extension alias “entsoe”.

Example (declaring an extended attribute):

```
<cim:ACLineSegment rdf:ID="_f732688e-bace-4ece-bc2b-5d9792608092">
  <cim:IdentifiedObject.name>DFG-THY 1</cim:IdentifiedObject.name>
  <entsoe:IdentifiedObject.shortName>Brussels</entsoe:IdentifiedObject.shortName>
  <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>
```

[R.4.5.2.4.2.] In the example below, 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):

```
<entsoe:ExtendedClass rdf:ID="_21d3bbfb-0aec-4e44-8db0-ae2e064b22e2">
  <cim:IdentifiedObject.name>EX11</cim:IdentifiedObject.name>
  <entsoe:ExtendedClass.extendedAttribute >20</entsoe:ExtendedClass.extendedAttribute >
  ....
</entsoe:ExtendedClass >
```

[R.4.5.2.4.3.] The example below illustrates the addition of an association, namely ENTSO-E extension.

Example (declaring an extended association):

```
<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>BIX3</cim:IdentifiedObject.name>
</cim:ACLineSegment>
```

[R.4.5.2.5.] 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.

[R.4.5.2.6.] 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.

[R.4.5.2.7.] 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.

4.5.3. Equipment profile and instance file

[R.4.5.3.1.] 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:

- 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.

[R.4.5.3.2.] An equipment instance file describes the equipment in the power system model covered by a MAS.

[R.4.5.3.3.] An equipment instance file would not normally change in case of frequent data exchange process. It can be updated with difference file exchange.

4.5.4. Topology profile and instance file

[R.4.5.4.1.] A topology instance file contains all topology objects for a MAS. These topology objects reference the corresponding equipment describing how equipment is electrically connected.

[R.4.5.4.2.] 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.

[R.4.5.4.3.] Depending on the data exchange process a topology instance file may or may not change frequently. A topology instance file can be updated using difference file exchange.

4.5.5. Steady state hypothesis profile and instance file

[R.4.5.5.1.] A steady state hypothesis instance file contains all objects required to exchange input parameters to be able to perform load flow simulations.

[R.4.5.5.2.] 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 should have persistent mRIDs and rdf:IDs.

4.5.6. State variables profile and instance file

[R.4.5.6.1.] A state variable instance file contains all objects required to complete the specification of a steady-state solution.

[R.4.5.6.2.] A state variables instance file is always exchanged in full.

[R.4.5.6.3.] 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.

4.5.7. Boundary equipment profile and instance file

- [R.4.5.7.1.] 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.
- [R.4.5.7.2.] 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 EnergySchedulingType-s and BaseVoltage-s. 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.
- [R.4.5.7.3.] Boundary equipment instance files can be updated using difference file exchange.

4.5.8. Boundary topology profile and instance file

- [R.4.5.8.1.] 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.
- [R.4.5.8.2.] A boundary topology instance file can be updated using difference file exchange.

4.5.9. Dynamics profile and instance file

A dynamics instance file represents the parameters necessary to model dynamic behaviour of the power system, e.g. transient and subtransient reactances of synchronous machines, parameters of the control block diagrams of excitation systems, turbine, governors, power system stabilisers, etc.

- [R.4.5.9.1.] A dynamics instance file would not normally change in case of frequent data exchange processes. It can be updated using difference file exchange.

4.5.10. 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.

- [R.4.5.10.1.] A diagram layout instance file is always exchanged in full.
- [R.4.5.10.2.] 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.
- [R.4.5.10.3.] The objects in the equipment are identified by the DiagramObject.IdentifiedObject.
- [R.4.5.10.4.] 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.

4.5.11. Geographical location profile and instance file

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.

[R.4.5.11.1.] A geographical data instance file is exchanged in full, although it could be updated using difference file exchange.

4.6. File exchange

[R.4.6.1.] A given exchange consists of multiple files. The CGMES defines that all files in a given logical exchange must be zipped together. The tools use zip files directly when importing and exporting in order to minimise users' effort.

[R.4.6.2.] There is 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.

[R.4.6.3.] One zip file can only contain the following types of files:

[R.4.6.3.1.] 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).

[R.4.6.3.2.] 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.

[R.4.6.3.3.] Difference files of one MAS only when exchanging a TSO model.

[R.4.6.3.4.] Equipment, topology, steady state hypothesis, state variables, dynamics, diagram and geographical files per MAS for an assembled model.

[R.4.6.3.5.] Difference files per MAS for an assembled model.

[R.4.6.3.6.] 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.

[R.4.6.4.] The zip file must not contain folders. It is only a container of *.xml files.

[R.4.6.5.] The hierarchy and model dependency should 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:

- 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.

[R.4.6.6.] It is not valid 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.

[R.4.6.7.] In case difference files are exchanged, the same dependences as for full model exchange are followed. The difference file (e.g. equipment, topology, 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.

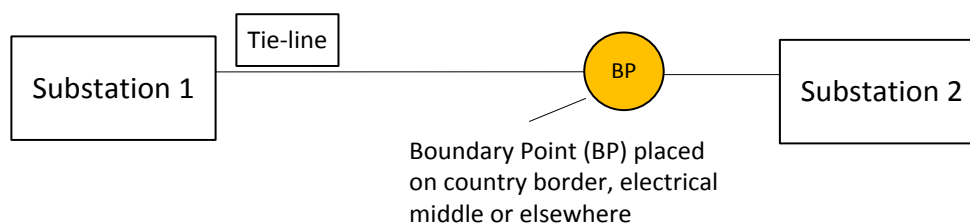
4.7. Boundary point – properties and location

[R.4.7.1.] EquivalentInjection classes are used to represent the power flow exchanges through Boundary points. These classes are included in the individual model MAS (TSO MAS) and refer to the Boundary points in the Boundary set. A SvInjection class is not used for this purpose.

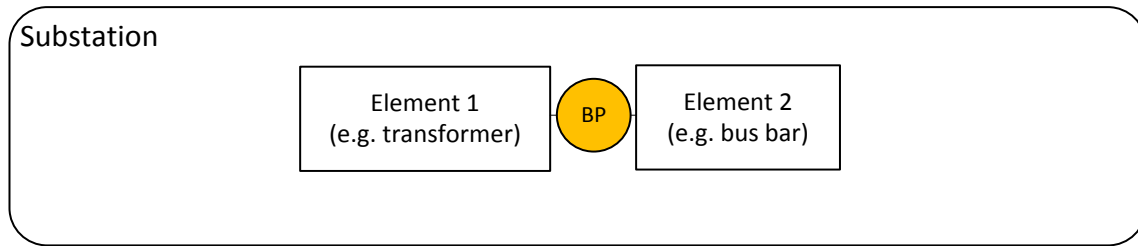
[R.4.7.2.] In case the use cases require the exchange of multiple SSH, TP, SV, etc. instance files which are dependent on an EQ instance file, this EQ shall always include an instance of EquivalentInjection per Boundary point. Therefore, in a multi TSO exchange a Boundary point will always have two EquivalentInjections per Boundary point contained in different TSO MAS. Rdf:IDs of those EquivalentInjections are kept persistent.

[R.4.7.3.] There are two options related to the location of the Boundary point (BP) in a network model representing the AC grid only:

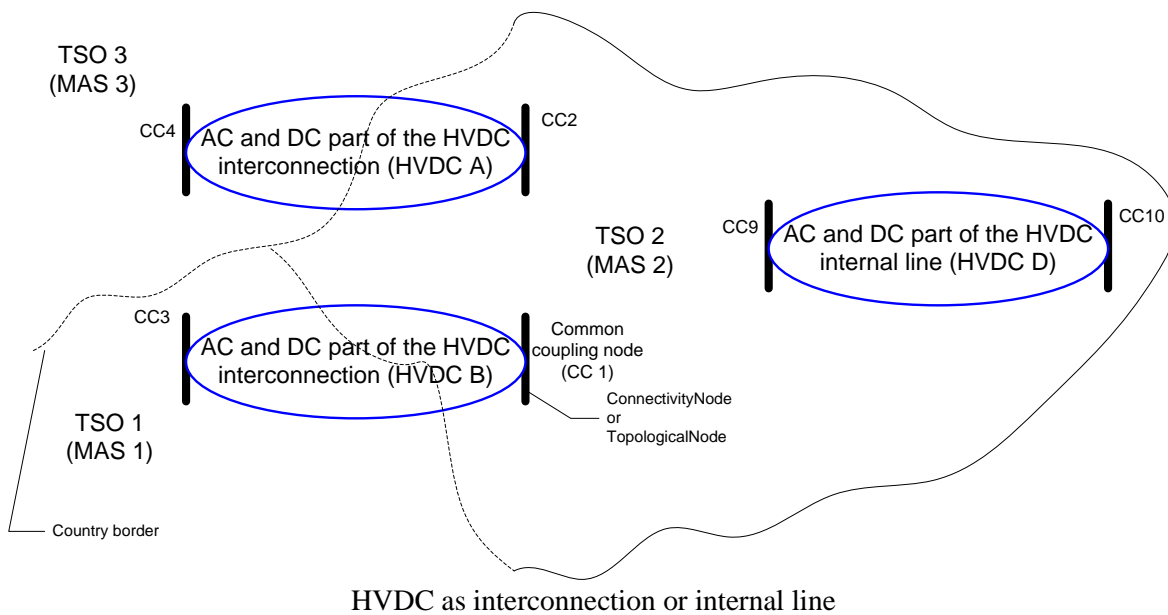
[R.4.7.3.1.] Boundary point placed on a tie-line: The CGMES does not fix the position of the Boundary point on a tie-line. The Boundary point can be placed on a country border, at the electrical middle of the tie-line, or elsewhere based on mutual agreement between the two neighbouring MAS.



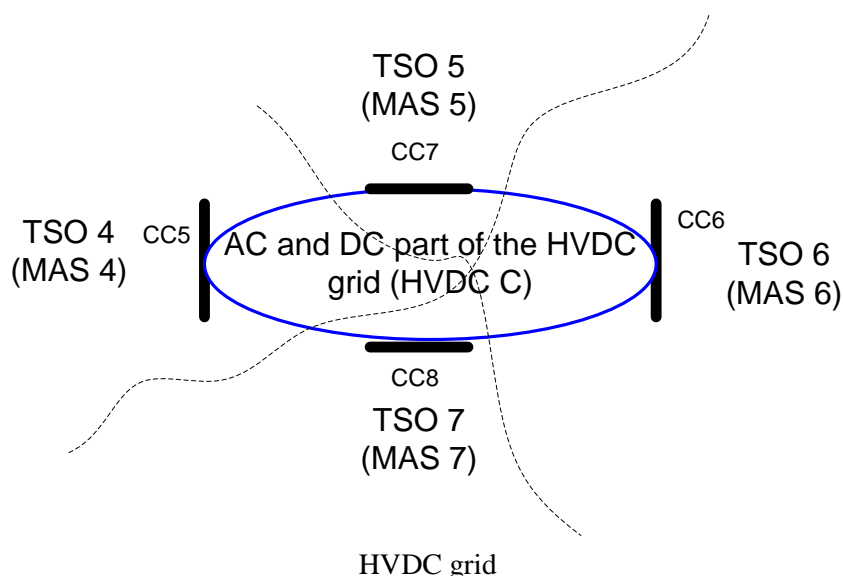
[R.4.7.3.2.] Boundary point placed in a substation: The CGMES allows a Boundary point to be placed in a substation. The two neighbouring MAS shall agree between which two elements in a substation the Boundary point is placed.



[R.4.7.4.] The CGMES supports HVDC modelling for a detailed representation of HVDC interconnections, TSO internal HVDC links and HVDC grid. The figures below illustrate different cases.



HVDC as interconnection or internal line



HVDC grid

[R.4.7.5.] There are two main representations/exchanges of a HVDC link which are supported by the CGMES:

[R.4.7.5.1.] Simplified exchange – no exchange of the AC/DC part of the HVDC interconnections. A HVDC link is represented with two radial AC lines.

- In this case the net interchange between the MAS is represented by EquivalentInjection classes referring to each common coupling node (CC).
- This exchange could be applied to internal HVDC links (systems) as well as to HVDC interconnections.

[R.4.7.5.2.] Detail exchange - AC/DC part of HVDC links is exchanged

- HVDC can be exchanged as a MAS:
 - Separate instance files (EQ, TP, SSH, SV) are included in this MAS.
 - In case one TSO is responsible for the HVDC, the HVDC model is included in the TSO MAS (EQ, TP, SSH, SV).
- HVDC MAS shall refer to the common coupling points (ConnectivityNode or to TopologicalNode) included in the Boundary set.
- In case of more than one HVDC interconnection (including interconnections with different TSOs) the TSO can include them in a single HVDC MAS or in its own MAS.

[R.4.7.6.] In particular cases a Boundary point can be placed on a DCLineSegment and could possibly represent a different authority. The CGMES does not allow for the separation of the HVDC model at this specific Boundary point. It only makes sense to add a Boundary point with a location to identify certain responsibilities.

4.8. Model assembling process

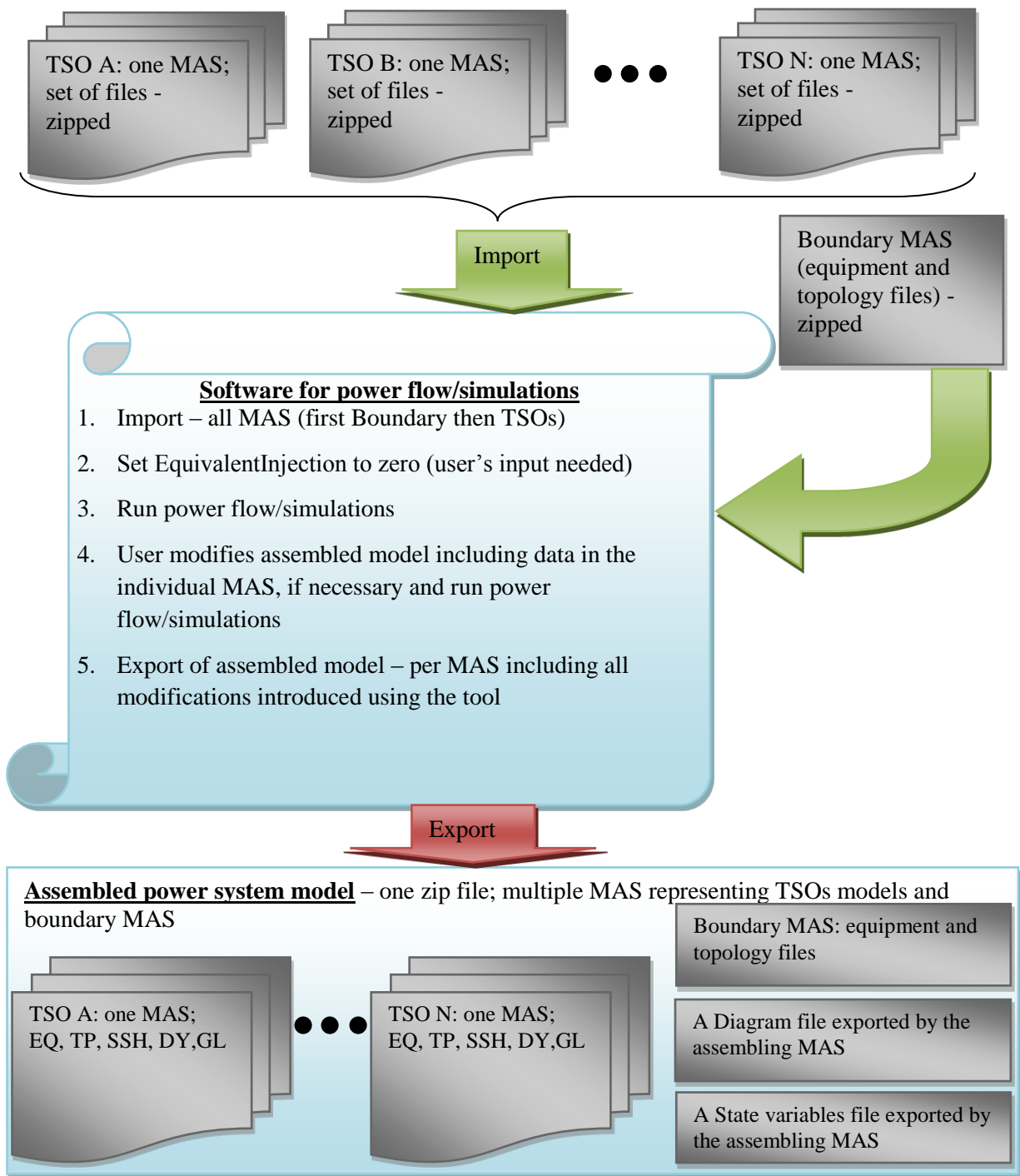
[R.4.8.1.] A complete (assembled) common grid model (solved or unsolved power system model) contains information from more than one model authority set. Part of the reason for the division into files per MAS is to create better flexibility when it comes to how complete assembled models for different purposes are formed from base parts. Model management systems can be designed based on this capability.

[R.4.8.2.] Among instance files which are to be combined to form an assembled model, there is no overlap – each object, association or attribute appears in one and only one of the instance files being combined.

[R.4.8.3.] The model assembling procedure in the CGMES is based on the Model Authority Sets concept. The procedure includes the following steps:

- Model management system (calculation tool/software) imports all MAS (full set of files for MAS for each TSO and Boundary MAS). Depending on the implementation of the import process, the Boundary MAS must be imported first in case other MAS are subsequently imported. The following files/MAS should be available for import.
 - At least two models from TSOs are available and represented in two different MAS. These models have necessary references to the Boundary set.

-
- TSO models which include classes (EquivalentInjection for SSH profile; SvPowerFlow and SvVoltage for SV) represent the flow between the MAS and the voltage of the Boundary points.
 - Boundary MAS: Boundary instance files (equipment and topology) cover, but are not limited to, the area represented in the common grid model.
- SvVoltage classes pointing to the Boundary set are set to the nominal voltage of the Boundary Node with zero angles in case the values for EquivalentInjection pointing to a Boundary Node are different.
 - EquivalentInjection.p and EquivalentInjection.q are set to zero, if a tie-line or a ConnectivityNode is connected. It is not necessary that these parameters be set to zero at the time of the import. Additional functions should be made available for users to cover all necessary use cases when dealing with TSO MAS and Boundary MAS.
 - A power flow can be performed to obtain a solution for the assembled power system model.
- [R.4.8.4.] An update of the assembled power system model is performed via an update of the concerned MAS (i.e. replacing of MAS files). A power flow solution is necessary to update the common state variables file valid for the updated assembled model.
- [R.4.8.5.] State variable instance file for the common grid model include SvPowerFlow for injections of Boundary points. In order to solve an assembled model these injections are set to zero in case a Boundary point successfully connects the two MAS. Some injections (SvPowerFlow) may differ from zero to represent the exchange with other areas not included in the assembled model.
- [R.4.8.6.] The exported assembled model shall have only one instance of SvVoltage per Boundary point.
- [R.4.8.7.] The CGMES does not fix the content of an assembled grid model. Different business processes shall define the type (EQ, SSH, TP, SV, etc.) of data needed in the assembled model depending on the objectives.
- [R.4.8.8.] The CGMES supports export of unsolved assembled model. The model can be a node-breaker or bus-branch model representation type, and shall always include SSH instance files if the purpose of the exchange is to perform (without data additions) a load flow calculation in a different application.
- [R.4.8.9.] The exported assembled model contains multiple MAS. These exported multiple MAS include all changes which are introduced on the assembled model (changes made in the software which is used to assemble the model) per MAS. The following chart illustrates the assembly process.
- [R.4.8.10.] The model authority set of the state variable instance file of the assembled model is not defined in the file header.
- [R.4.8.11.] The model authority set of the diagram layout instance file of the assembled model is not defined in the file header.



4.9. RDF/XML model validity

In order to be considered a valid model, a given combined set of RDF/XML must adhere to the following criteria:

- [R.4.9.1.] The file must be well-formed as defined by the Extensible Markup Language (XML) 1.0 (Second Edition) (<http://www.w3.org/TR/REC-xml>).

[R.4.9.2.] The file must adhere to the rules set forth in the Simplified RDF Syntax for Power System Model Exchange as defined in IEC 61970-552.

[R.4.9.3.] The file must contain CIM entities which are valid according to the CIM RDF Schema file.

4.10. Naming Convention

The naming convention of any profile is important in order to ensure that the information which is part of the data exchange can be understood and used. A power system model without appropriate naming information cannot be readily used for any human analyses and thus loses its meaning.

The CGMES, which uses multiple profiles, serves various business processes. These business processes have different needs in terms of naming information. There is no single set of rules which could be applied to deal with the specificities of different business processes axes such as:

- Bilateral, regional, ENTSO-E – pan-European data exchanges;
- Operational (day ahead and related processes), long term planning data exchanges;
- Node-breaker, bus-branch based data exchanges;
- Voluntary, project oriented, obligatory by an ENTSO-E process, obligatory by law data exchanges.

A restriction related to naming could serve one business process well but may represent a significant constraint for another business process. In addition, actors involved in the exchange are not necessarily the same.

Therefore, the objective of the CGMES naming convention is to define a common framework related to naming rules which could be further restricted by different business processes.

The following rules related to the naming convention are defined:

[R.4.10.1.] A template for further defining constraints related to the naming convention is provided in Appendix 6.1. The template shall be used by experts defining naming convention rules within a business process. The template shall be completed by a profile (EQ, TP, SV, etc.). As soon as a business process is defined and data exchange requirements agreed, the tables related to different profiles should be made available to all parties participating in the data exchange and vendors should be informed. This will allow:

- TSO experts to be aware and respect requirements related to naming in the models.
- Vendors developing tools for power system analyses to ensure that:
 - TSO experts are able to supply the names as required by the business process;
 - An agreement for naming translation between requirements in the business process and the proprietary formats or TSO databases is in place;
 - Export and import functionalities are compliant with the data exchange rules.
 - Vendors developing validation tools to adjust validation rules valid for the business process.

[R.4.10.2.] The restrictions related to the naming convention are considered obligatory for any tool importing or exporting naming data if the tool claims compliance with the CGMES.

-
- [R.4.10.3.] Further restrictions can be applied by different business processes. Business processes restrictions on naming must define required and optional attributes related to naming. These restrictions or rules should not contradict this naming convention and are considered mandatory for all parties participating in a given business process.
- [R.4.10.3.1.] Tools used to validate instance data shall be able to validate against different sets of naming conventions which are applied to exchanges based on the CGMES.
- [R.4.10.3.2.] Tools used for various power system analyses shall provide users with the opportunity to cope with different naming rules. These tools shall be developed to support the full scope of this naming convention.
- [R.4.10.4.] Due to the current inheritance structure of the CIM used for the profile, the naming convention primarily addresses the attributes of the class IdentifiedObject. However, there are certain exceptions, including Boundary profiles whereby some ENTSO-E extensions are applied to ConnectivityNode and TopologicalNode.
- [R.4.10.5.] The name related attributes have an informational character intended for human reading for explanations outside the classes. Software solutions must not count on this information to complete physical links of the power system model. All necessary links between different parts of the CIM XML are expressed by the reference schema which uses rdf:ID.
- [R.4.10.6.] Names shall conform to UTF-8.
- [R.4.10.7.] In cases where tools using instance data (compliant with the CGMES exchanges) need uniqueness rules, this should be handled in the importing function based on requirements defined by the users.
- [R.4.10.8.] It is obligatory that information exchanged in name related attributes is not modified by the tools within an exchange, i.e.
- [R.4.10.8.1.] step 1: Tool A imports data from Tool B and modifies initial information to fit user requirement of tool limitation;
- [R.4.10.8.2.] step 2: Tool A is obliged to export the imported data in the same form and content as the data exported from Tool B.
- One of the main reasons behind this rule is the fact that exchanges in the ENTSO-E are meant to be bi-directional, i.e. there is a sending party and a receiving party which exchange models within studies and do not necessarily consume only the data.
- [R.4.10.9.] It is mandatory that tools shall provide users with the ability to add and maintain naming related information for classes which represent physical equipment as well as classes which represent elements important for business processes (e.g. TopologicalNode). This information is then mapped onto relevant attributes and can be exported for the purpose of the exchange.
- [R.4.10.10.] There is no need for a specific naming convention when it comes to the names of the instance files due to file header information which is defined by IEC CIM standards and the CGMES.
- [R.4.10.11.] The following tables summarise the use of name related attributes in the different profiles. It provides the length of the strings which tools must support for all classes that inherit from IdentifiedObject or on ConnectivityNode and TopologicalNode.

IdentifiedObject	String length, characters	Equipment profile	Topology profile	Study State Hypothesis profile	State variables profile	Diagram layout profile	Geographical location profile	Dynamics profile
.name	32 maximum	✓ _r	✓ _o	✓ _o	✓ _r	✓ _r	✗	✓ _o
.description	256 maximum	✓ _o	✓ _o	✗	✗	✗	✗	✓ _o
.energyIdentCodeEic	16 exactly	✓ _o	✓ _o	✗	✗	✗	✗	✗
.shortName	12 maximum	✓ _o	✓ _o	✗	✗	✗	✗	✗

For ConnectivityNode in Boundary Equipment profile and TopologicalNode in the Boundary Topology profile	String length, characters	Boundary equipment profile	Boundary topology profile
IdentifiedObject.name	32 maximum	✓ _r	✓ _r
IdentifiedObject.description	256 maximum	✓ _r	✓ _r
IdentifiedObject.energyIdentCodeEic	16 exactly	✓ _o	✓ _o
IdentifiedObject.shortName	12 maximum	✓ _r	✓ _r
.fromEndIsoCode	2 exactly	✓ _r	✓ _r
.toEndIsoCode	2 exactly	✓ _r	✓ _r
.fromEndName	32 maximum	✓ _r	✓ _r
.toEndName	32 maximum	✓ _r	✓ _r
.fromEndNameTso	32 maximum	✓ _r	✓ _r
.toEndNameTso	32 maximum	✓ _r	✓ _r

Legend: ✓_r – the attribute is present in the profile and required (required means that it is mandatory that this attribute be present in the instance data); ✓_o - the attribute is present in the profile and optional; ✗ - the attribute is not present in the profile.

[R.4.10.12.] Additional specific rules related to the naming attributes are included as notes in the profile specifications. These notes are considered as mandatory rules. The same rules are summarised in Appendix 6.2.

[R.4.10.13.] OCL validation rule in the TP profile defined in which cases the attribute IdentifiedObject.name is required.

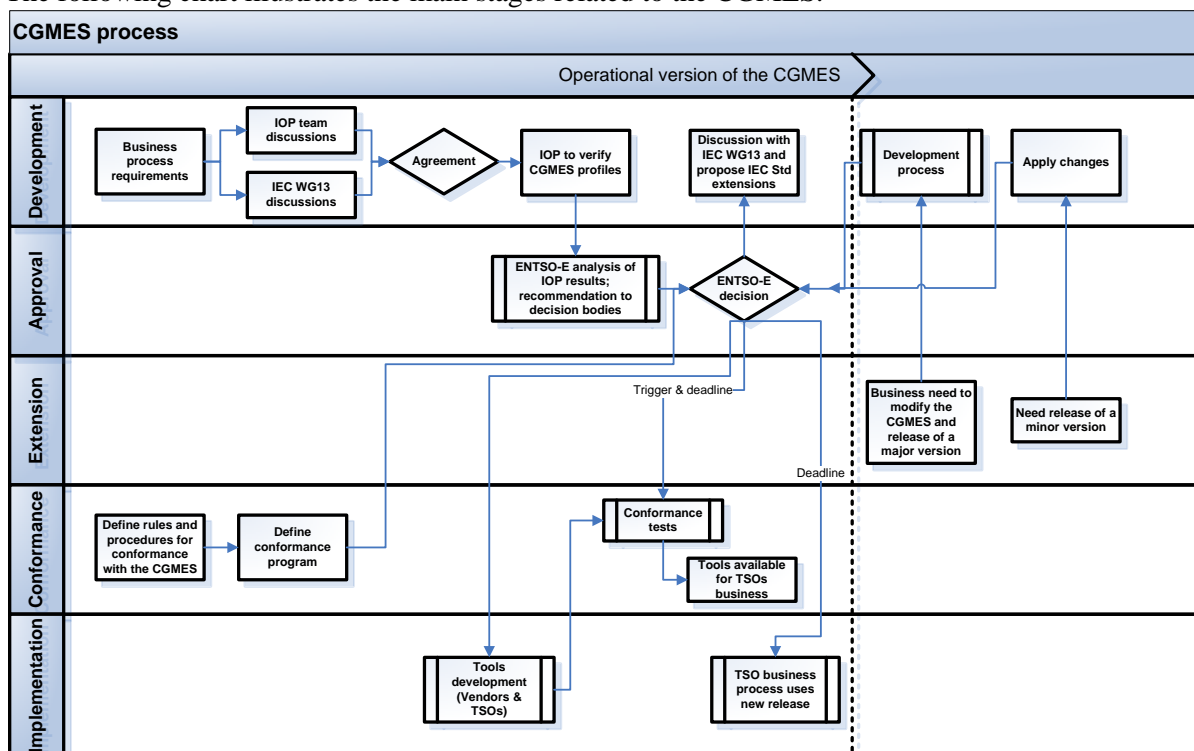
5. CGMES governance

The overall governing process of the CGMES is a complex process and includes the following sub-processes:

- Standardisation process – a process to develop the CGMES, and which relies on the latest IEC CIM related standards.
- Interoperability process – the process to conduct IOPs targeting verification of the CGMES and IEC CIM standards. Feedback to standardisation bodies and organisations involved in the development of different profiles which form part of the CGMES.

- Business process – all business processes which use the CGMES, They define requirements and request additional improvements due to business needs.
- CGMES conformance process – this process ensures that tools used by parties involved in an exchange utilising the CGMES are implementing the CGMES correctly.
- Implementation process – the implementation process is triggered by a business process/need. It aims to apply a certain version of the CGMES to a business process.

The following chart illustrates the main stages related to the CGMES.



5.1. Versions of the CGMES and the profiles

Each version of the CGMES and the profiles part of the CGMES has its unique version identifier. The following rules related to versioning are defined:

[R.5.1.1.] The format of a version of the CGMES is xx.yy.zzz where xx, yy and zzz are non-negative integers, and must not contain leading zeroes, and:

- xx - names the major version of the CGMES;
- yy – names the minor version of the CGMES;
- zzz –names the revision version of the CGMES.

[R.5.1.2.] Each profile part of the CGMES is assigned with a version defined by the profile URI which shall be declared in the file header of the instance files. The profile URI is specified in the UML of the CGMES.

[R.5.1.3.] A profile URI changes every time a minor or a major version of a profile is released.

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- [R.5.1.4.] The namespace URI of the ENTSO-E extensions changes every time a minor or a major version of the extension package is released.
 - [R.5.1.5.] The namespace UML changes every time the CGMES changes the base version of the CIM, e.g. the base UML changes from CIM 16 to CIM 17.
 - [R.5.1.6.] Each of the CGMES profiles is related to a profile defined by the IEC. The ENTSO-E UML lists the base URI of the IEC profiles for information only and to link a specific profile of the CGMES to the closest IEC CIM profile. This information is provided in the baseURI attribute of the version class to each profile of the CGMES.
 - [R.5.1.7.] A minor version is a compatible change to a profile. The minor version must be incremented if new, backwards compatible functionality is introduced to the CGMES. It must be incremented if any functionality is marked as deprecated. It may be incremented if substantial new functionality or improvements are introduced to the CGMES by adding additional profiles and/or ENTSO-E extension. It may include revision level changes. Revision version must be reset to 0 when minor version is incremented.
 - [R.5.1.8.] The number of a major must be incremented if any backwards incompatible changes are introduced to the CGMES, e.g. something is deleted. It may include minor and revision level changes if the amount of changes is significant. The major version will also be incremented if one or more profile is no longer backwards compatible. Minor and revision version numbers must be reset to 0 when major version is incremented
 - [R.5.1.9.] Updates belonging to a minor version update should not break the interoperability for a major profile exchange. This means that a tool which supports a profile version, e.g. 2.4 (2 major version, and 4 minor version) shall be able to import a file which is generated based on profile version 2.5 where all the additional classes, attributes and associations are ignored.
 - [R.5.1.10.] The revision version must be incremented if only backwards compatible error fixes are introduced. A fix is defined as an internal change that fixes incorrect behaviour. Updating documentation or a class, an attribute or a profile to reflect the intended behaviour are considered error fixes.
 - [R.5.1.11.] A pre-release version may be denoted by appending a hyphen and a series of dot separated identifiers immediately following the revision version. Identifiers must comprise only ASCII alphanumeric and hyphen [0-9a-Za-z-]. Identifiers must not be empty. Numeric identifiers must not include leading zeroes. A pre-release version indicates that the version is unstable and might not satisfy the intended compatibility requirements as denoted by its associated normal version. Example: 2.5.0-alpha
 - [R.5.1.12.] Once a versioned package has been released, the contents of that version must not be modified. Any modifications must be released as a new version.
 - [R.5.1.13.] The key words "must", "must not", "required", "shall", "shall not", "should", "should not", "recommended", "may", and "optional" in this section of the CGMES are to be interpreted as described in RFC 2119.

5.2. Standardisation and interoperability processes

The CGMES serves many business processes and covers numerous use cases. In order to rely as much as possible on international standards, the CGMES development process interacts with IEC to ensure that most of the functionalities of the CGMES are accepted and released in the IEC CIM standards. Nevertheless, ENTSO-E and TSOs have some specific requirements which would not be part of the IEC

CIM standards. These requirements are satisfied by ENTSO-E CIM extensions which are part of the CGMES profiles.

[R.5.2.1.] Model exchange requirements change over time with the development of the business processes as well as the implementation of the Network Codes. All these requirements would bring changes to the CGMES and its profiles. In order to structure the process to standardise certain changes in the profiles and the CGMES, all changes shall be implemented either as ENTSO-E extensions or realised during an annual CGMES vetting interoperability test.

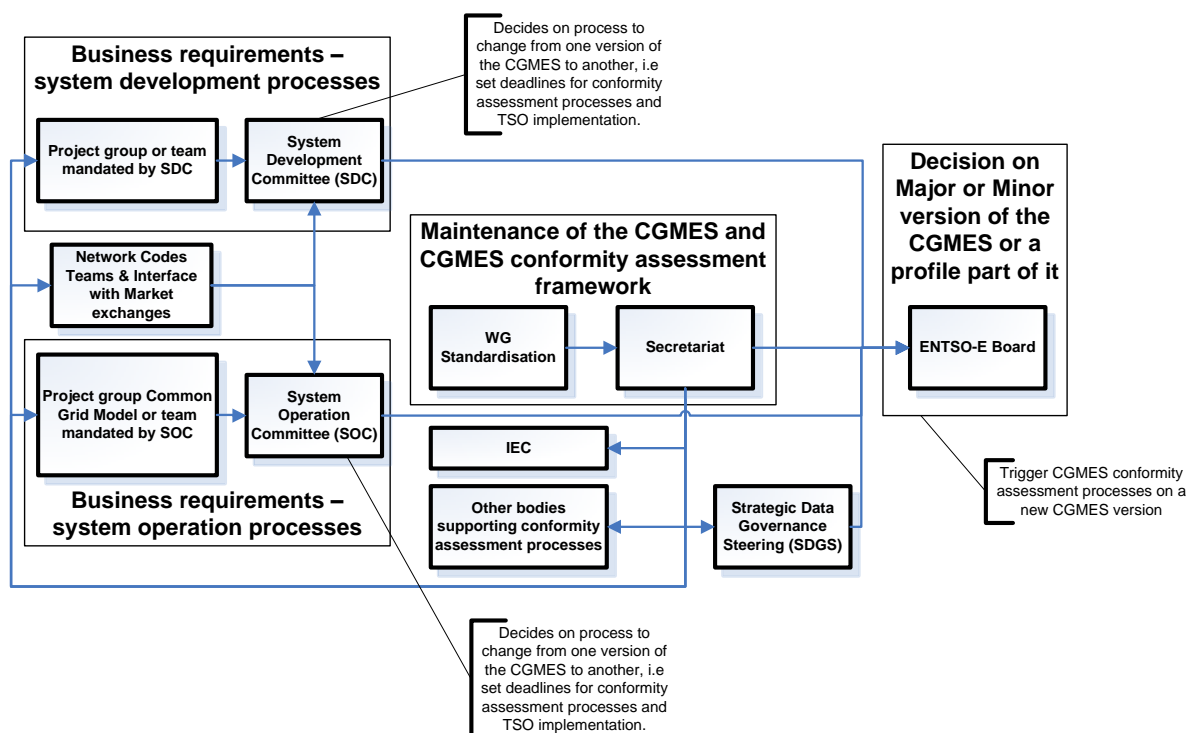
[R.5.2.2.] ENTSO-E organises an annual standard vetting interoperability test related to the CGMES. The test confirms the maturity and the correctness of the implemented changes in the CGMES and allows decision making bodies to approve a version of the CGMES for a conformance assessment process and further implementation.

5.3. Approval process

[R.5.3.1.] The ENTSO-E Board approves major and minor versions of the CGMES and or its profiles. The approval triggers the conformity assessment process of this version. The Board receives recommendations from the following ENTSO-E bodies:

- System Development Committee (SDC) and/or System Operations Committee (SOC): Recommend changes of the CGMES and decide which data exchange process uses which version of the CGMES. The approval of a certain version of the CGMES by the SDC (or SOC) has two main stages:
 - 1) approval to confirm that the development of the CGMES has reached a milestone and could be used for planning exchanges (or operational exchanges in case of SOC), i.e. it is a recommendation to the Board to approve the CGMES. SDC/SOC can set deadlines for the conformity assessment processes if it sees a need to immediately switch to the new version of the CGMES;
 - 2) approval to set a deadline for a certain business process (data exchange) to switch from one version of the CGMES to another. This approval follows the successfully completed conformity assessment processes on a certain version of the CGMES.
- Secretariat: The Secretariat, as a body which maintains and coordinates conformity assessment processes, can directly recommend to the Board changes of the CGMES based on its activities and feedback from vendors'/TSOs' implementation of the CGMES. In this activity the Secretariat receives support from Working Group Standardisation.
- Strategic Data Governance Steering (SDGS) Group: The Strategic Data Governance Steering Group assesses the requests for major changes of the CGMES and gives recommendations to the Board on these changes.

The following chart illustrates the main working groups and bodies involved in the approval process as well as in the development of the CGMES.



5.4. Conformity assessment

Conformity assessment of tools is necessary to confirm that tools comply with a given profile part of the CGMES and can be used for model exchange in a given business process. Conformity assessment is business driven and ensures reliability of the model exchanges by confirming interoperability between applications. The conformity assessment processes that shall be followed is defined in the ENTSΟ-E CGMES Conformity Assessment Framework.

[R.5.4.1.] Each new version of a tool shall be tested for conformity with a particular version of the CGMES used in ENTSΟ-E business processes prior to its usage in the business processes. ENTSΟ-E members are responsible for ensuring that tools which they use in the frame ENTSΟ-E business processes conform to the CGMES.

[R.5.4.2.] Test configurations (models) representing the main functionalities of the profiles of the CGMES shall be publicly available to all interested parties no later than 3 months after the approval of a major or minor release of the CGMES or its profiles. Depending on the complexity of the changes in the profiles the decision body approving the CGMES shall either confirm this deadline or specify another deadline.

[R.5.4.3.] Each new version of the CGMES shall include information on which conformity assessment procedures and test configurations should be updated.

[R.5.4.4.] Conformity assessment shall rely on a machine readable way of defining the validation rules and describing the constraints valid for a certain profile. Object Constraint Language (OCL) is used for this purpose.

5.5. Implementation process

The implementation of a version of the CGMES for use in a business process is launched as soon as the conformance assessment process is finalised. The following rules are defined for the implementation process:

- [R.5.5.1.]The implementation process is triggered by the body responsible for the model exchange. The body defines the deadline when the implementation process shall end and the business process switches to the new version of the CGMES.
- [R.5.5.2.]The implementation process includes a period during which TSOs shall upgrade their tools and a period during which a trial tests running the business process with the new version of the CGMES. This is especially valid for operational exchanges where the exchange shall be reliable and completed more frequently than a planning model exchange process.
- [R.5.5.3.]The CGMES contains various profiles. The implementation of each of them can have a different schedule depending on the business needs.
- [R.5.5.4.]Due to the different requirements of the business processes, different versions of the CGMES profiles can be simultaneously operational. The ENTSO-E Secretariat shall maintain a publicly available list of version of the CGMES used in business processes. Vendors and TSOs shall adapt the implementation process and the support to the model exchange processes and be able to cope with a variety of the CGMES versions used in the exchanges.
- [R.5.5.5.]Business processes shall be adapted in order to allow smooth interfaces between main types of exchange such as planning to planning, operation to operation, operation to planning, interface with distribution, etc. Business processes shall aim to use a limited number of different versions of the CGMES in order to decrease maintenance effort by TSOs and facilitate interoperability of data exchanges between business processes.

5.5.1. Dynamics model exchange implementation

Dynamics models exchange supplies data for one of the most complex analyses of a power system. The requirements of the data exchanges are directly related to the level of detail of the power system modelling applied in a given area. The DY profile supports the exchange of dynamic behaviour models used by software applications which perform analysis of the steady state stability (small-signal stability) or transient stability of a power system as defined by IEEE / CIGRE Standard Terms and Definitions for Power System Stability Analysis.

There are numerous possible drivers which could result in the need for updates to the dynamics standard models, including:

- Interoperability testing identifies issues relating to which resolutions are found following an interactive process between users, vendors and IEC.
- Users acquire new equipment which should be adequately represented in dynamics models.
- Industry organisations develop new or improved standard models.
- New modelling functionalities are required by the business processes.

Appendix 6.3 lists some of the expected extensions of the dynamics profile.

Requests for updates could come from a variety of sources, including utilities, generator owners, manufacturers, standards organisations (like the IEEE or IEC) or industry groups. Updates could take the form of existing model corrections or new model additions.

Dynamics standard models are typically described using both graphics and text. Because of this complexity, a reliable, organised approach is necessary in order to capture and maintain the information needed for each

standard model. The following process is intended to provide this structure as update requests to standard models are processed.

[R.5.5.1.1.] An update request is received by the ENTSO-E Secretariat which further submits to the IEC TC57/WG13 CIM Model Manager, by means of a filled out Dynamics Model Request Form (Appendix 6.4 including attachments).

[R.5.5.1.2.] ENTSO-E Secretariat organises the process to evaluate the request and related update of the CGMES.

[R.5.5.1.3.] ENTSO-E Secretariat interacts with IEC TC57/WG13 which evaluates the proposed update for inclusion in the IEC standards.

There are three ways in which the current version of the dynamics profile is designed to support as follows:

- **Standard models exchange** – a simplified approach to exchange, where models are contained in packages in predefined libraries of classes which represent dynamic behaviours of elements of the power system interconnected in a standard manner. Block diagrams and other information are also defined. The current profile supports a set of standard models.
- **User-defined models exchange** - a more flexible approach which permits users to exchange the definitions of a model by defining elementary control blocks and interconnections between these blocks in an explicit manner in the instance data. It is a way in which to exchange full information on user defined models. The profile does not fully support this type of exchange.
- **Proprietary models exchange** - an exchange which provides users with the ability to exchange the parameters of a model representing a vendor-proprietary device where an explicit public description of the model is not desired. It is a way in which to exchange proprietary models, and the models' "black box" (dll, etc.). All parties participating in the exchange should have the model (dll, etc.). Only parameters of models are exchanged. The profile supports this approach. It allows for the exchange of model name and description as well as an unlimited number of parameters per model.

A step by step approach to the implementation of the dynamics profile is proposed. Indeed, this is due to the fact that the dynamics profile part of the CGMES contains many standard models and it is not possible to achieve interoperability using a complete set of standard models before approval of the profile. It takes a lot of time and effort to implement all models and conduct complex tests to prove interoperability between different tools. The following requirements define the step by step approach to the implementation of the dynamics profile:

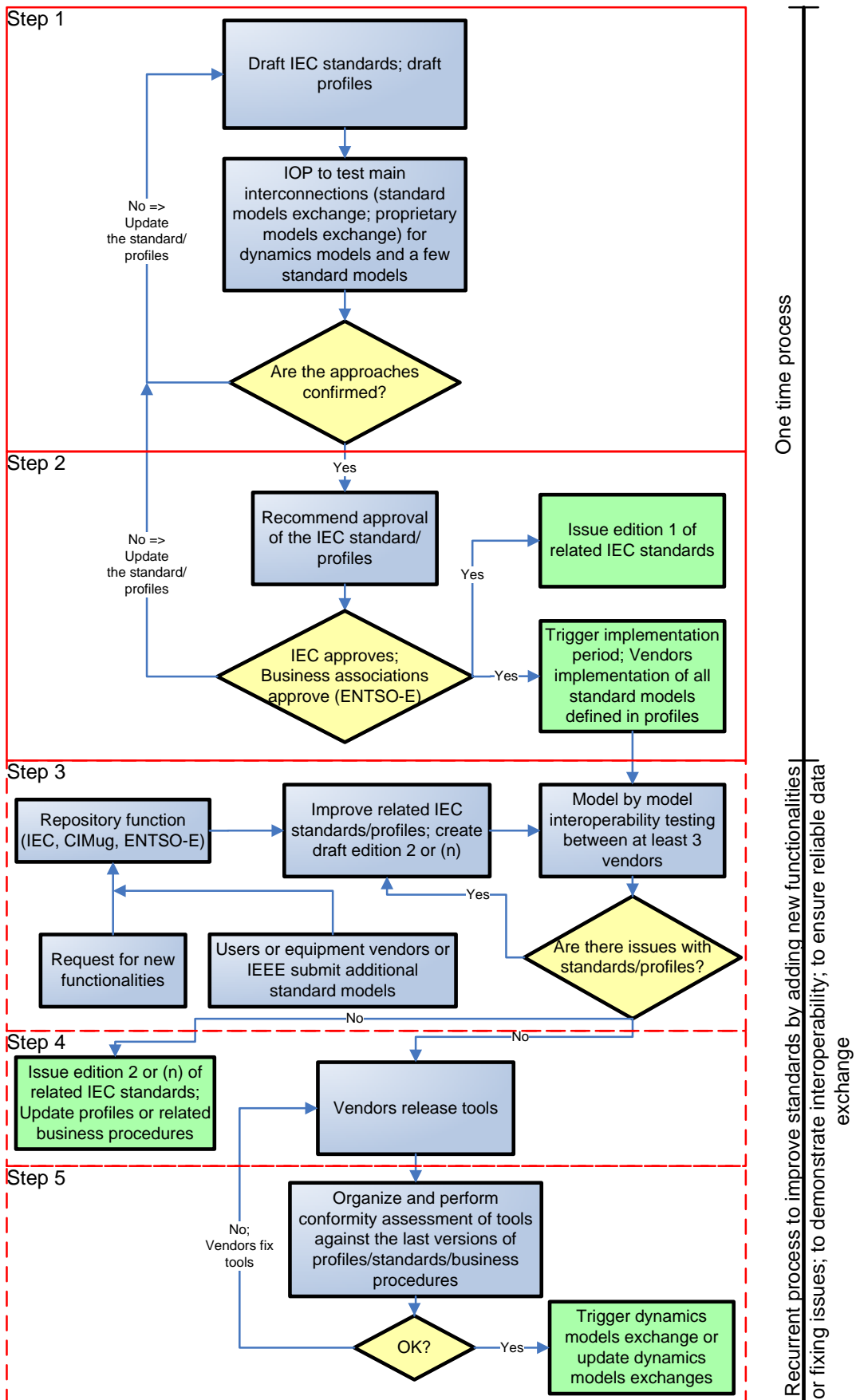
[R.5.5.1.4.] The implementation of tools shall start following the approval of the profile.

[R.5.5.1.5.] Vendors shall implement different standard models from the dynamics library in an agreed order, and hence interoperability between tools using the current description of the standard models shall be checked. The ENTSO-E Secretariat will equally distribute all standard models for a period of 10 months after the approval of the profile when all tools which can perform dynamics simulations shall support all standard models defined in the CGMES. Due to this process, corrections of clarification character, standards model improvements or fixes could be applied to the profile. The latest versions of documents such as IEC standard on wind IEC 61400-27-1, the latest IEEE Std. 421.5 (expected in 2014), the IEEE Special Publication TP538 "Dynamic Models for Turbine-Governors in Power System Studies", etc. shall be considered.

[R.5.5.1.6.] During vendors' implementation a technical guide on dynamics standard models implementation shall be prepared. This technical document will be a reference to the CGMES and will be updated any time a new standard model is added to the dynamics library.

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- [R.5.5.1.7.] Vendors shall support proprietary model exchange which shall be used for an exchange of user defined models if all parties involved in the exchange have modelled the user defined models in their tools, i.e. documentation (in the form of Dynamics Model Request Form - Appendix 6.4 including appended additional documentation) shall be exchanged in advance. This is necessary since field implementations and interoperability testing activities will expose dynamics standard model requirements which result in update requests. There will clearly be cases where standards updates lag behind real-world needs. Although the aim is for the IEC standard and associated CGMES profiles to be sufficiently flexible and cover various use cases, the timing of processes related to standardisation cannot be regulated and fully in line with the business processes. In addition, there will be periods of time during which users will need to rely on adapted modelling in order to accomplish their goals and realise the exchange with no impact on tools. One example of this is if a party is lacking a standard model in the CIM standard library. In this case, the use of proprietary user-defined models is a strategy which will temporarily meet the needs of users in such situations. In this case different parties in the exchange shall represent this model as a user-defined model in their tools and exchange the information for the parameters of the model as proprietary exchange. Thus, any control equipment associated to a synchronous machine or an asynchronous machine can be modelled.
- [R.5.5.1.8.] In most of the cases the dynamic data is not owned by users (TSOs, utilities, etc.) which are part of the dynamics models exchange. A legal framework shall be put in place in order to allow for the smooth exchange of data necessary for the dynamics models. ENTSO-E Legal and Regulatory Group (LRG) is responsible for coordinating various actions to allow for dynamics exchange on a pan-European level.

The following chart illustrates the step by step approach.



6. Appendices

6.1. Template for further restrictions on naming

Class name	IdentifiedObject							
	.name		.description		.energyIdentCodeEic		.shortName	
	Status [✓r, ✓o, ✕]	Required content/rules	Status [✓r, ✓o, ✕]	Required content/rules	Status [✓r, ✓o, ✕]	Required content/rules	Status [✓r, ✓o, ✕]	Required content/rules

Legend: ✓r – the attribute is required; ✓o - the attribute is optional; ✕ - users do not need to have the ability to add name to the attribute.

6.2. Summary of specific rules for naming convention

6.2.1. IdentifiedObject.name

Human readable name with a maximum string length of 32 characters. The length restriction is defined in the IEC 61970-452.

IdentifiedObject.name is a required attribute for the Boundary Equipment and Boundary Topology profiles. The IdentifiedObject.name shall be consistent with the name of the object used in companies, in daily operation (e. g. in SCADA systems), in planning processes or in asset related systems.

The IdentifiedObject.name should allow for inter-communicating of TSO, using general names.

6.2.2. IdentifiedObject.description

Human readable description with maximum string length of 256 characters. The length restriction is defined in the IEC 61970-452.

IdentifiedObject.description is a required attribute for the Boundary Equipment and Boundary Topology profiles.

6.2.3. IdentifiedObject.energyIdentCodeEic

It is an ENTSO-E extension of the IEC CIM. The following description was given in the UML for this attribute: “The attribute is used for an exchange of the EIC code (Energy identification Code). The length of the string is 16 characters as defined by the EIC code.

References:

- Local issuing offices for EIC: <https://www.entsoe.eu/publications/electronic-data-interchange-edilibrary/links-to-eic-websites/>

- EIC description: <https://www.entsoe.eu/index.php?id=73&libCat=eic>

6.2.4. IdentifiedObject.shortName

It is an ENTSO-E extension of the IEC CIM. The following description was given in the UML for this attribute: “The attribute is used for an exchange of a human readable short name with length of the string 12 characters maximum.”

6.2.5. ConnectivityNode and TopologicalNode .fromEndIsoCode

It is an ENTSO-E extension of the IEC CIM. The following description was given in the UML for this attribute: “The attribute is used for an exchange of the ISO code of the region to which the “from” side of the Boundary point belongs to or is connected to.

The ISO code is a two character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum.”

The attribute is required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

6.2.6. ConnectivityNode and TopologicalNode .toEndIsoCode

It is an ENTSO-E extension of the IEC CIM. The following description was given in the UML for this attribute: “The attribute is used for an exchange of the ISO code of the region to which the “to” side of the Boundary point belongs to or is connected to.

The ISO code is a two character country code as defined by ISO 3166 (http://www.iso.org/iso/country_codes). The length of the string is 2 characters maximum.”

The attribute is a required for the Boundary Model Authority Set where this attribute is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

6.2.7. ConnectivityNode and TopologicalNode .fromEndName

It is an ENTSO-E extension of the IEC CIM. The following description was given in the UML for this attribute: “The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases:

- if the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation to which the “from” side of the tie-line is connected.
- if the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc) to which the “from” side of the Boundary point is connected.”

The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

6.2.8. ConnectivityNode and TopologicalNode .toEndName

It is an ENTSO-E extension of the CIM. The following description was given in the UML for this attribute: “The attribute is used for an exchange of a human readable name with length of the string 32 characters maximum. The attribute covers two cases:

- if the Boundary point is placed on a tie-line the attribute is used for exchange of the geographical name of the substation to which the “to” side of the tie-line is connected.
- if the Boundary point is placed in a substation the attribute is used for exchange of the name of the element (e.g. PowerTransformer, ACLineSegment, Switch, etc) to which the “to” side of the Boundary point is connected.”

The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.

6.2.9. ConnectivityNode and TopologicalNode .fromEndNameTso

It is an ENTSO-E extension of the IEC CIM. The following description was given in the UML for this attribute: “The attribute is used for an exchange of the name of the TSO to which the “from” side of the Boundary point belongs or is connected to. The length of the string is 32 characters maximum.

The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.”

6.2.10. ConnectivityNode and TopologicalNode .toEndNameTso

It is an ENTSO-E extension of the IEC CIM. The following description was given in the UML for this attribute: “The attribute is used for an exchange of the name of the TSO to which the “to” side of the Boundary point belongs or it is connected. The length of the string is 32 characters maximum.

The attribute is required for the Boundary Model Authority Set where it is used only for the TopologicalNode in the Boundary Topology profile and ConnectivityNode in the Boundary Equipment profile.”

6.3. Future developments on CIM for dynamics

The following gaps and needs for future development are currently identified. Discussion regarding these topics is expected to:

- Extend user-defined models approach of the dynamics profile.
- The class StaticVarcompensator is present in the equipment model, but is not represented in the dynamic model. The class could probably be used to represent different FACTS components, although it should be possible to define type of SVC (TCR,TCR/TSC, STATCOM) as this is of importance when it comes to how dynamic response is modelled.
- There are no models representing branch quantities (like line relays and models which measure line flow). It is critical that this type of model should be tested at the IOP, since the input and behaviour is very different from unit models (topology dependency).

- Clarification regarding wind farms modelling is necessary. There is a need to verify that the models are compliant with the last IEC standard on wind modelling. There is also the need for adequate modelling of the wind power plants/parks.
- There are no relay models at all, whether for lines or for loads/units. Frequency dependent load relays are important.
- Models to represent dynamics behaviour of HVDC are necessary.

6.4. CIM Dynamics Model Request Form

The aim of this template is to provide both the requesting party and the vendor with the possibility to exchange necessary information for accurate CIM representation of the supplied equipment. It also provides sufficient information to the ENTSO-E Secretariat and IEC TC57/WG13 to allow the requested dynamic standard model addition/change to be reviewed and incorporated into the CIM or to update the CGMES.

I. Information about the requestor

1. Name of the requestor:
2. Requestor company name:
3. Requestor contact information:
 - a. Address
.....
 - b. Phone:
 - c. Fax:
 - d. E-mail:

II. Type of change

- a. Existing CIM dynamics standard model update/correction
CIM model name:
- b. New standard model addition

III. Existing standard model update/correction

- a. Please describe the requested update or correction (use fields in **Section IV New standard model addition** below if applicable to assist in describing request):

IV. New standard model addition - equipment information

1. Type
 - a. Excitation system
 - b. Automatic Voltage Regulator (AVR)
 - c. Exciter
 - d. Power system stabiliser (PSS)
 - e. Governor
 - f. Turbine
 - g. FACTS device

h. Other
If other, please specify here:

2. Description, use of model

a. Name of model (what requestor calls model):

b. Is the model included in other international or national publicly available standards? Yes No
If yes, please specify the standard and the model reference here:

c. Is it a simplified model? Yes No

d. Is it a detailed model? Yes No

e. Does the model adequately represent the equipment in case of assessment of overall power system behaviour (system stability studies)? Yes No

f. Does the model adequately represent the equipment in case of assessment of power plant behaviour?: Yes No

g. The model is for general use. Yes No

h. Please describe the recommended usage of the model:

3. Block diagrams (*needed if model is not described by a diagram in a publicly available standard*)

a. Main block diagram - Attach a hardcopy or electronic copy (PowerPoint, Word, Visio, .jpg) diagram of the equipment.

b. Block diagram for initialisation - Attach a block diagram (hardcopy or electronic copy) describing initialisation.

c. Interface description (information on inputs/outputs)

Inputs			
Name	Units	Description	Source
Outputs			
Name	Units	Description	Source

d. Equations –Attach hardcopy or electronic copy of any specific equations needed to fully describe model functionality

4. Parameters (*Typical Value and Typical Range needed if not described in a publicly available standard*)

Please use the table below to describe all parameters used in the main block diagram:

Parameter Name	Usual Units ¹	CIM Units ²	Typical Value	Typical Range	Description

¹ In general “usual units” have to be in accordance with the standard on SI units. Other standards can also be applied depending on the usage of this template.

² “CIM units” are the units to be defined in the IEC Std. 61070-302.

- 5. Step response at typical values *(needed if not described in a publicly available standard)*.
In an attachment, please provide step response at typical values as supplementary documentation.
- 6. Relation between parameters in the model and real parameters of the equipment.
In an attachment, please provide information regarding the relationship (direct - 1:1 or indirect - using equations) for all parameters which can be an object of change (parameters of control equipment, etc.) as supplementary documentation.

Attachments

- 1. Main block diagram *(only if not public standard model)*
- 2. Block diagram for initialisation *(only if not public standard model)*
- 3. Equations *(only if not public standard model and if necessary)*
- 4. Step response at typical values *(only if not public standard model)*
- 5. Relation between parameters in the model and real parameters of the equipment

Other attachments, please specify here:

- 6.
- 7.
- 8.
- 9.
- 10.

Signature:
Date (mm/dd/yyyy):

6.5. CGMES profiles versions

The CGMES version 2.4.15 uses the following profiles and extensions:

- XMI: ENTSOE_CGMES_v2.4.15_7Aug2014_XML.zip
- HTML: ENTSOE_CGMES_v2.4.15_7Aug2014_HTML.zip
- RDFS: ENTSOE_CGMES_v2.4.15_7Aug2014_RDFS.zip
- HTML_EA: ENTSOE_CGMES_v2.4.15_7Aug2014_HTML_EA.zip
- PDF: ENTSOE_CGMES_v2.4.15_7Aug2014_PDF.pdf
- OCL: ENTSOE_CGMES_v2.4.15_7Aug2014_OCL.zip
- ENTSOE_CGMES_v2.4_28May2014_PSTmodelling.pdf
- EQ_BD profile version: 3.1
- TP_BD profile version: 3.1
- EQ profile version: 3.1
- TP profile version: 4.1
- SSH profile version: 1.1
- SV profile version: 4.1
- DL profile version: 3.1
- DY profile version: 3.1
- GL profile version: 2.1