European Network of
Transmission System Operators
for Electricity

# EUROPEAN MERGING FUNCTION
# **REQUIREMENTS SPECIFICATION**

24 OCTOBER 2016

PROGRAMME CGM – WP4 (EMF)

# DOCUMENT VERSION MANAGEMENT

| Version | Date | Changes |
|---|---|---|
| 1.0 | 05.11.2015 | Approved in SOC meeting of 05.11.2015 |
| 1.1 | 06.09.2016 | Include addendum and clean up (new structure) |
| 1.2 | 24.10.2016 | Last modifications in line with Quality of CGMES Datasets document, and discussed in SPOC physical meeting |

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# 1. USED TERMINOLOGY

The following definitions are used in this document (ordered alphabetically):

[D.1.] **ATOM** – The all TSO Operational and Market-Operations network for non-real-time data exchanges.

[D.2.] **Boundary point (BP)** – as defined in the CGMES a 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 Modelling Authority Set (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.

[D.3.] **Boundary set** – as defined in the CGMES it is a boundary set that 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.4.] **Canonical model** - a design pattern used to communicate between different data formats. As a form of enterprise application integration, it is intended to reduce costs and standardize on agreed data definitions associated with integrating business systems. A canonical model is any model that is canonical in nature, i.e. a model which is in the simplest form possible based on a standard, application integration solution. The Common Information Model is such a canonical model.

[D.5.] **Case** - It represents a particular set of operating assumption that may occur within the framework of a Long term planning scenario, featuring:

- *one specific point-in-time* (e.g. winter / summer, peak hours / low demand conditions, horizon), with its corresponding demand and environmental conditions;
- *a particular realization of random phenomena*, generally linked to climatic conditions (such as wind conditions, hydro inflows, temperature, etc.) or availability of power plants (forced and planned);
- *power exchange forecasts* with regions surrounding the studied region;

The generation dispatch should be outcome of a market model or at least a merit order dispatch. Usually a Case has the following attributes:

- Name of the case (e.g. Case 1)
- Description (e.g. Specific Wind Conditions, Nuclear Shutdown, etc…)
- Season (e.g. Winter, Summer)
- Condition (e.g. Peak, off-peak)
- Point in Time / Date & Time (e.g. 2015/01/05 18h30; derived from Season + Condition for formal collection)

[D.6.] **CGMA –** Common Grid Model Alignment

[D.7.] **Common Grid Model** - a Union-wide data set agreed between various TSOs describing the main characteristic of the power system (generation, loads and grid topology) and rules for changing these characteristics during the capacity calculation process (definition in GL CACM). In terms of CGMES this means:

- The Equipment model data (EQ) for each MA
- The Steady State Hypothesis (Operating assumptions) data (SSH) for each MA and timestamp
- The Topology profile (TP) for each MA
- The State Variables Profile (SV) for each MA
- The Boundary points for the time horizon
- The agreed methodology set forth in this document

The information that is exchanged is the solved system state (e.g. the complex voltages and active/reactive power flows, expressed in SV instances for all synchronous areas). These SV files refer to the EQ models and TP files already available on the Operational Planning Data Environment. These solved system states can be used to initialize a power flow tool to recreate the European system state of any cross section of the European Grid, enabling regional studies.

[D.8.] **Common Grid Model Exchange Specification (CGMES)** – this is an 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 the Ten Year Network Development Plan, (Regional) Capacity Calculations, (Regional) Outage Coordination and Coordinated Security Assessment. It is based on IEC Common Information Model (CIM) Standards and further extended to meet Network Codes' and projects' requirements. The standard defines a set of data model exchange profiles, of which the details are provided on the ENTSO-E website: https://www.entsoe.eu/major-projects/common-information-model-cim/cim-for-grid-models-exchange/standards/Pages/default.aspx

[D.9.] **ENTSO for Electricity operational planning data environment (OPDE)** – the set of application programs and equipment developed in order to allow the storage, exchange and management of the data used for operational planning processes between TSOs.

[D.10.] **GUI** – Graphical User Interface.

[D.11.] **Individual Grid Model (IGM)** - a data set describing power system characteristics (generation, load and grid topology) prepared by the responsible TSOs, to be merged with other Individual Grid Model components in order to create the Common Grid Model.

[D.12.] **Model – or power system model (PSM)** - A representation of a network that is covering one or more MAS and that can be used as input to a power system analyses tool. Power system models are built up in accordance with load scenario, generation capacity scenarios agreed within the preparation process and based on the information exchanged among involved parties.

[D.13.] **Modelling Authority (MA)** - A business entity, which has the responsibility for making changes to the Model in a particular region of the Model. Modelling Authority is a TSO for its Network Model and supplementary documentation.



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[D.14.] **Model Authority Set (MAS)** - Each collection of objects under a given Modelling Authority. The MAS that make up a model are disjoint.

[D.15.] **Observability area** - a TSO's own transmission system and the relevant parts of distribution systems and neighbouring TSOs' transmission systems, on which the TSO implements real-time monitoring and modelling to maintain operational security in its control area including interconnectors.

[D.16.] **OPDM** – Operational Planning Data Management, i.e. the software needed to manage and store operational planning data and transfer it over the OPDE.

[D.17.] **PEVF –** Pan European Verification function

[D.18.] **Profile** – as defined in the CGMES 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[1], RDF[2], and/or OWL[3] 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.19.] **Regional Security Coordinator (RSC)** - the entity or entities, owned or controlled by TSOs, in one or more capacity calculation regions performing tasks related to TSO regional coordination.

[D.20.] **Scenario** - the forecasted status of the power system for a given time-frame.

[D.21.] **Scheduling Area** - the Bidding Zone except if there is more than one Responsibility Area within this Bidding Zone. In the latter case, the Scheduling Area equals Responsibility Area or a group of Responsibility Areas. Note that a Responsibility Area may have multiple Bidding Zones.

[D.22.] **Short term Planning Model** – A Model representing the Network within a timeframe of less than 5 years.

[D.23.] **Sub Control block** – A sub control block is a group of Scheduling Areas that work together under the supervision of a Scheduling Area Operator. Currently the following sub control blocks have been defined:

- SMM - Serbia, Montenegro and FYROM, Scheduling Area Operator is EMS (Serbia)
- SHB – Slovenia, Croatia en Bosnia/Herzegovina, Scheduling Area Operator is ELES (Slovenia)

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1 XML Schema Definition, a way of describing the structure of an XML document (eXtendible Markup Language)

2 Resource Description Framework, a general method for conceptual description or modeling of information that is implemented in web resources, using a variety of syntax notations and data serialization formats

3 Web Ontology Language, a way of defining the structure of knowledge for various domains using object oriented structures



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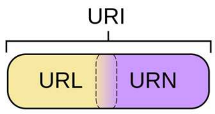
[D.24.] **URN** – In computing, a Uniform Resource Name (URN) is part of the Uniform Resource Identifier (URI), a string of characters to identify a name of a web source:




[D.25.] **Vulcanus data** - Vulcanus is a web platform, developed for RG CE used to visualize matched data on control block level like Inadvertent Exchanges, Day Ahead Control Programs and schedules, Intraday Control Programs and schedules, Realized Control Programs and schedules, Physical Flow, Measured Load flows, frequencies and grid time deviations. Data supplier are Amprion for the northern part, Swissgrid for the southern part and REE. Its successor is called “Verification Platform”

[D.26.] **XSD file** – XML Schema Definition file. These files are used for validation purposes.

# 2. CONTEXT

The European Merging Function (EMF) is operated and hosted by RSCs and provides the solved power flow solution (i.e. the system state) of the whole pan-European grid for every relevant date and time, as input for subsequent business functions.

The EMF is part of a continuous cycle of updates that starts a year before energy delivery:

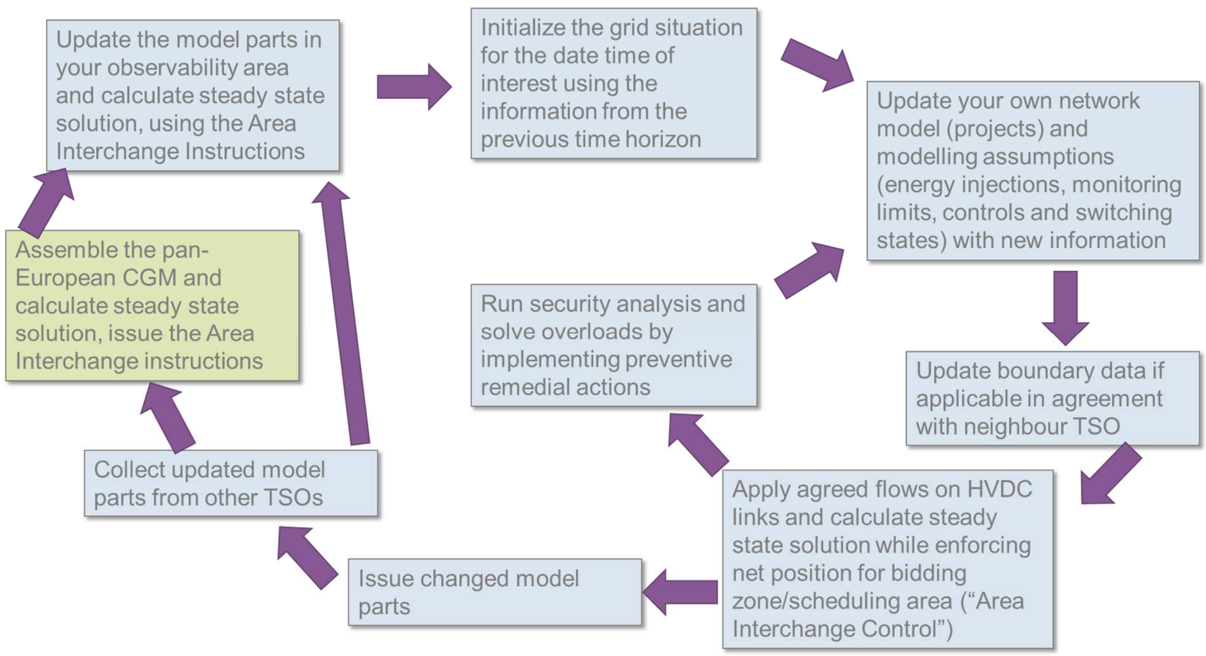



Figure 1 Merging as part of a continuous cycle

In the above figure, the EMF is marked in green. The blue boxes are TSO activities that take place on domestic tools and/or on common tools.

The concept of a closed loop for the IGM/CGM process is based on the following principles:

1. Instead of TSOs maintaining network models and case assumptions for their neighbours, it is more reliable to use the network models their neighbours maintain themselves and to use their case assumptions from the previous time horizon;
2. When starting with a case year ahead, in which planned projects and planned unavailability are included and for which assumptions are used to forecast load and generation, refinement (i.e. model improvement and more accurate forecasts) can be achieved by updating these views with more recent and more up-to-date information.
3. This way the situation is known for any given hour in time ("datetime") already from year ahead until two hours ahead. And it will always be based on the best available information.



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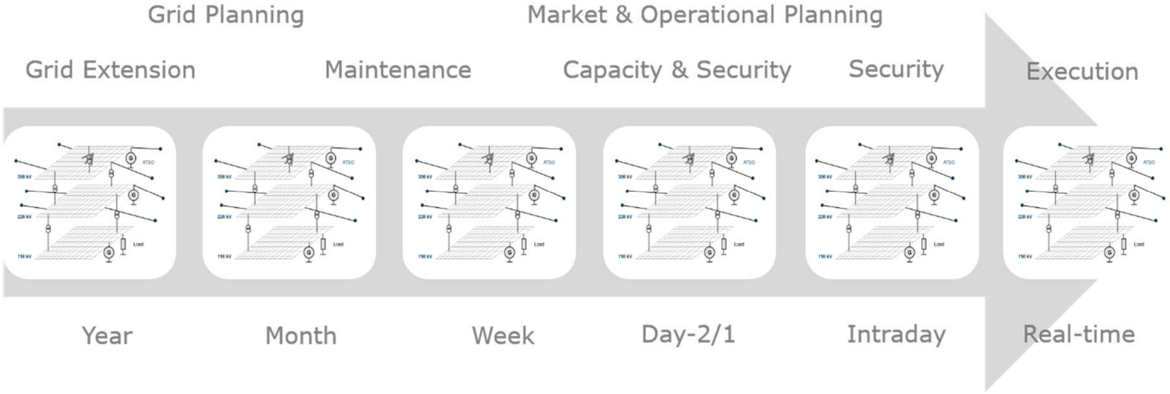


Figure 2 Improving the common view on the system state by adding information

In this philosophy certain model assembly is done by all parties involved, so that:

- each TSO has sufficient information for its observability area[4] and
- each RSC has the pan-European view

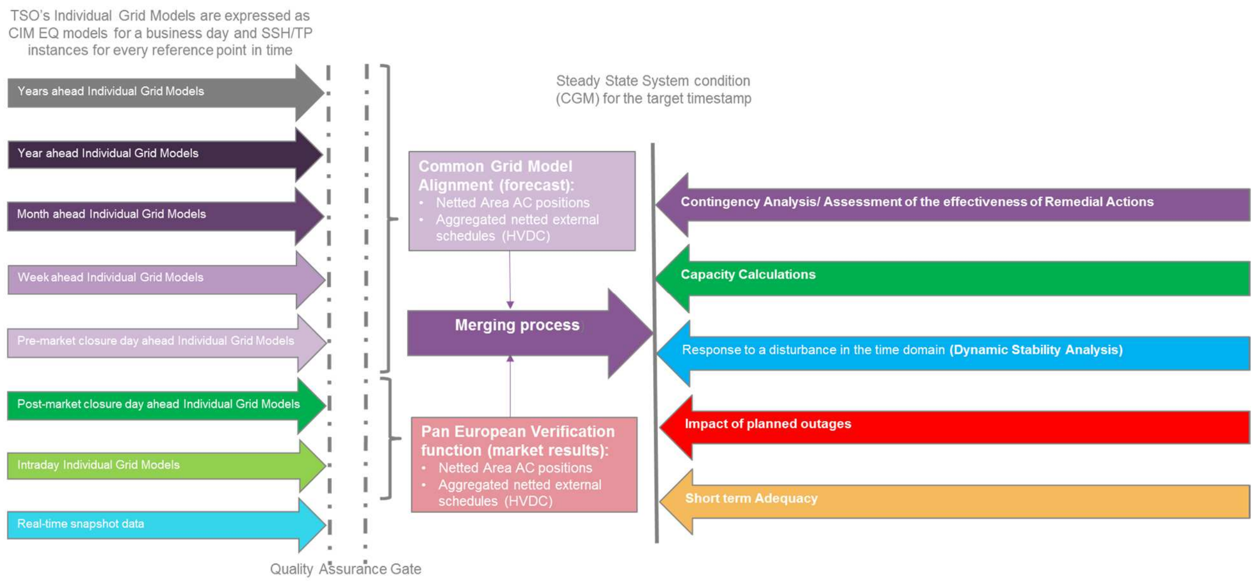


Figure 3 EMF with providers of input data and users of the CGM

This document defines the business rules, the functional and non-functional requirements and the interface requirements for tools that need to be certified as EMF tool.

4 Note that it's up to the TSO if it performs its analysis on the common tool of its RSC (using the pan-European view) or in its domestic tool (using a view on its observability area)

# 3. Interfaces

## 3.1 Connection to the OPDE

The EMF is connected to the ENTSO for Electricity operational planning data environment (OPDE). OPDE consists of a physical layer (ATOM), application programming interfaces for communication (ECP/EDX) and software needed to manage and store operational planning data and transfer it over the OPDE (OPDM).

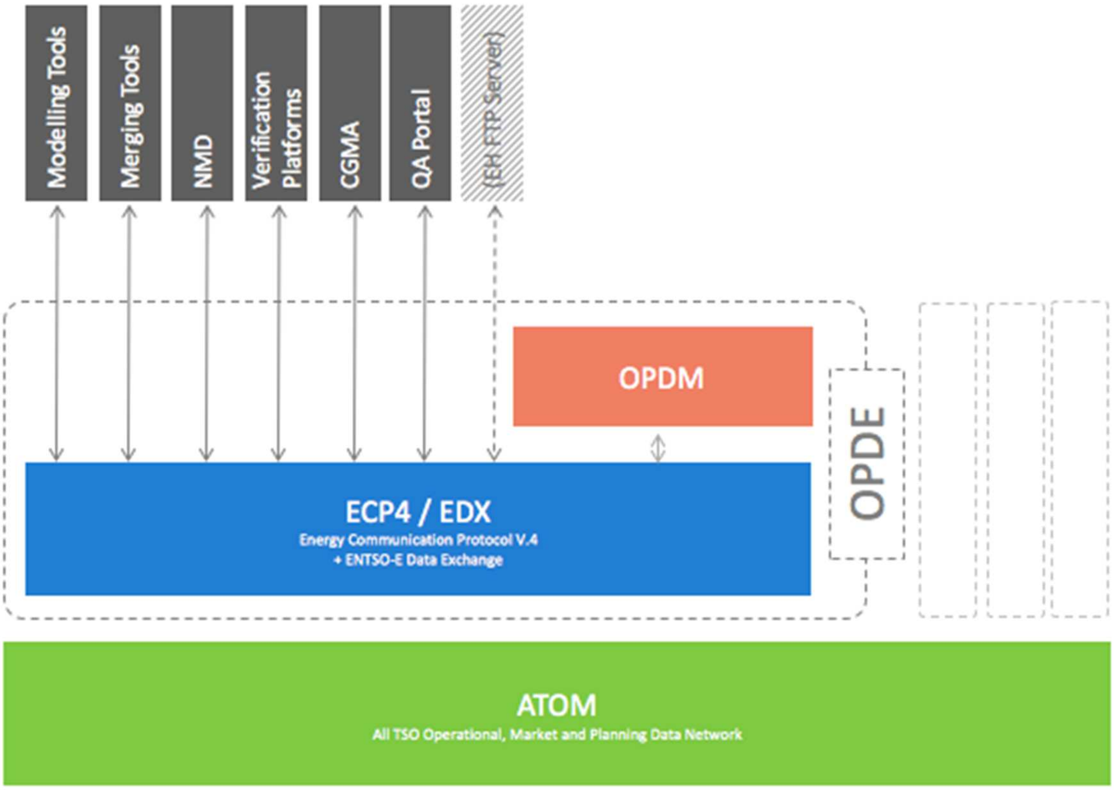


Figure 4 Conceptual diagram of the OPDE

As stated before, the **OPDM constitutes the entry point for OPDE** for users and external applications. Users and specific applications (e.g. modelling tools from TSOs, merging applications) will interact with OPDM through specific endpoints and/or GUIs in order to publish, subscribe to or download any OPDM data that are required in business operations i.e. mainly CGMES-based models but in the future could be extended to cover other data types if needed.

OPDM shall be a **distributed application** between a set of “service providers” (server-side) which store the data and allows a set of “consumers” (client-side) to communicate with the service providers to publish data and/or receive automatically or not specific available content.

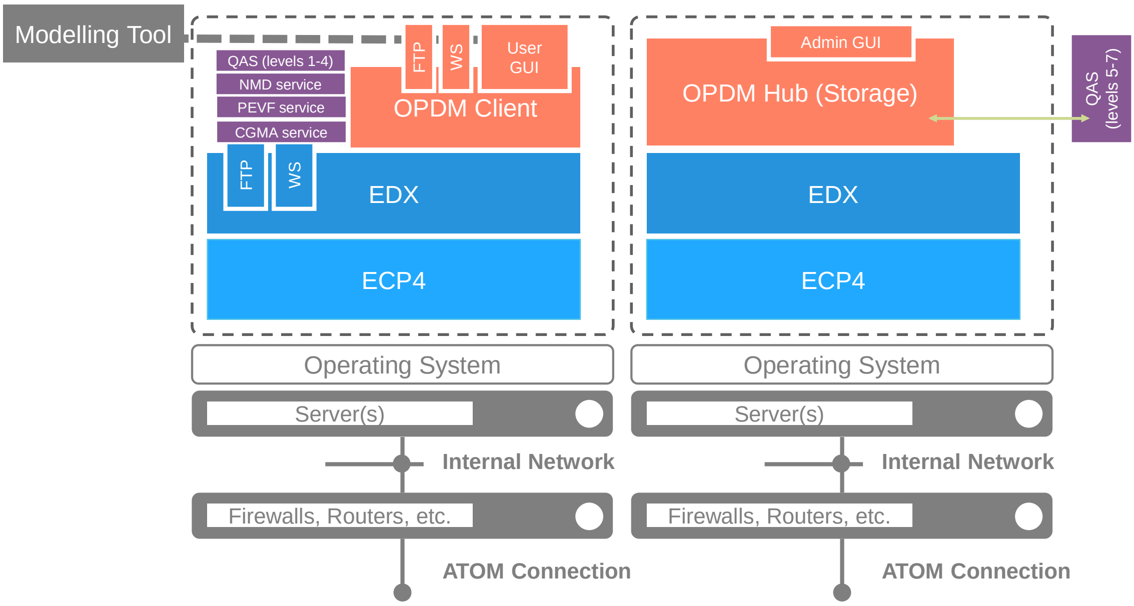


Figure 5 OPDM in the ecosystem of the OPDE

OPDM service providers shall **store the data** within the OPDM application, with **configurable retention policies** that will depend on the data type and the business processes they are used for. For redundancy reasons, each data item shall be available on at least two service providers. The **replication of data items** shall be ensured at message level.

The OPDM client communicates with other local services and applications through a set of APIs in order to easily integrate for example with TSOs automated delivery processes or with other central applications (for example NMD, PEVF, CGMA, QAS services).

Each OPDM client provides a **user interface** to allow authenticated users to directly interact with the system on their site.

The management of data stored in OPDM is done through **metadata** that describes both the data itself and the context in which it is used (e.g. the operational business process). This allows OPDM to store any kind of data.

The **communication between OPDM clients and OPDM service providers is handled by the generic EDX communication layer** (through specific messages) using the ATOM infrastructure.

The OPDM software shall be delivered by ENTSO-E.

## 3.2 APPLICATION INTERFACES

### 3.2.1 INPUT DATA

The EMF requires various input data in order to calculate the pan-European system state for a given point in time. The following input data is required:

- Boundary agreements, specified in CGMES 2.4 profiles EQ-BD and TP-BD
- Individual grid models, specified in CGMES 2.4 profiles EQ, SSH, TP and SV.
- Individual grid models from TSOs in the synchronous area of Continental Europe, specified in UCTE DEF 2.0 files[5]
- Area Interchange targets, specified in the Reporting Information Market Document:
  - netted area AC position per scheduling area (not provided for synchronous areas consisting of only a single scheduling area)
  - aggregated netted external schedules per scheduling area border (not provided for synchronous areas consisting of only a single scheduling area)
  - aggregated netted external schedule for each boundary point of a HVDC link within the synchronous area

The input data is delivered via the OPDM software in EDX/ECP messages that contain Metadata. The following table provides an overview of the Meta Data is used for Individual Grid Models and boundary data.

| Metadata name | Metadata type | Description |
|---|---|---|
| **TimeHorizon** | Enumerated string | Derived from file name. Reference to business process type[6]. The following values are allowed:<br><br>YR, MO, WK, 2D, 1D, 23, …, 01, RT |
| **ScenarioTime** | UTC datetime | The energy delivery day, expressed in UTC datetime. Obtained from file header (md:Model.scenarioTime). |
| **ValidFrom** | UTC datetime | The *from* date time validity of EQ and boundary data is derived from the file name. |
| **ValidTo** | UTC datetime | The *to* date time validity of EQ and boundary data is derived from ValidFrom metadata. For year ahead, the validity is ValidFrom + 3 months, for month ahead, the validity is until the end of the month, for week ahead until the end of the week. D-2, D-1, intraday and RTSN models are only valid for the energy delivery day, unless |

[5] Only during the migration from the existing UCTE DEF based exchanges in ENTSO-E Regional Group Continental Europe towards full CGMES based exchanges for all ENTSO-E TSOs.

[6] Note that time horizon only applies for SSH, TP and SV instances

| Metadata name | Metadata type | Description |
|---|---|---|
| | | the specified hour deviates from 00:30 UTC time. In that case it's only valid for the given timestamp. |
| **ModelAuthority** | String | A model authority is an entity responsible for supplying and maintaining the data defining a specific set of objects in a network model. It is obtained from the file header (md:Model.modelingAuthoritySet) |
| **ModelPartReference** | String | The TSO name or name of the HVDC link obtained from the file name |
| **EMFReference** | String | The name of the RSC that created the CGM, obtained from the file header (md:Model.description) |
| **CGMType** | Enumerated string | Obtained from the file name. The CGM State Variables files are prepared per synchronous region (CGMCE, CGMNO, CGMBA, CGMUK, CGMIN) and one which contains all synchronous regions (CGMEU) |
| **FullModel_ID** | String | Unique identifier of the file, obtained from the file header (md.FullModel rdf:about) |
| **DifferenceModel_ID** | String | Unique identifier of the file, obtained from the file header (md:DifferenceModel rdf:about) |
| **ModelProfile** | Array of string | Obtained from file header (md:Model.profile) to determine the type of validation:<br>• http://entsoe.eu/CIM/EquipmentBoundary/3/1<br>• http://entsoe.eu/CIM/TopologyBoundary/3/1<br>• http://entsoe.eu/CIM/EquipmentCore/3/1<br>• http://entsoe.eu/CIM/EquipmentOperation/3/1<br>• http://entsoe.eu/CIM/EquipmentShortCircuit/3/1<br>• http://entsoe.eu/CIM/SteadyStateHypothesis/1/1<br>• http://entsoe.eu/CIM/Topology/4/1<br>• http://entsoe.eu/CIM/StateVariables/4/1<br>• http://entsoe.eu/CIM/DiagramLayout/3/1<br>• http://entsoe.eu/CIM/GeographicalLocation/2/1<br>• http://entsoe.eu/CIM/Dynamics/3/1 |
| **VersionNumber** | String | Obtained from file header (md.Model.version) |
| **Updated_ID** | String | Obtained from file header (md:Model.Supersedes rdf:resource). Must be provided by a merging entity when updates are done in SSH files and when model corrections are applied (relevant profile instances) |
| **DependentFile** | Array of string | Obtained from file header (md:Model.DependentOn rdf:resource). The following hierarchy applies:<br>• SSH depends on EQ |

| Metadata name | Metadata type | Description |
|---|---|---|
| | | • TP depends on EQ<br>• EQ depends on EQ-BD<br>• TP-BD depends on EQ-BD<br>• SV depends on SSH, TP and TP-BD<br>• GL depends on EQ<br>• DL depends on EQ<br>• DY depends on EQ |
| **FileStatus** | Enumerated string | Indicates the subscribe status. It is set to "Private" if **QA_indicatorL** equals "Processible". It is set to "Public" if **QA_indicatorC** equals "Valid", "Warning" or "Diagnostics" |
| **IGM** | Array of string | Listing of the FullModel_ID and, if applicable, DifferenceModel_ID of all associated model parts of an IGM: SV, SSH, TP, EQ, EQ-BD and TP-DB |
| **QA_indicatorL** | Enumerated string | Result of the validation of instance data (local validation). Allowed values are:<br>• Processible<br>• Rejected – Invalid file type<br>• Rejected – Invalid file name<br>• Rejected – File cannot be parsed<br>• Rejected – Invalid CGMES file<br>• Rejected – OCL rule violation(s) |
| **QA_indicatorC** | Enumerated string | Result of the validation of IGM data (after model assembly of an IGM, which is done centrally). Allowed values are:<br>• Valid<br>• Diagnostics<br>• Warning – non fatal inconsistencies<br>• Invalid – dangling references<br>• Invalid – inconsistent data<br>• Invalid – preconditions PF |
| **QA_indicatorM** | Enumerated string | Result of the validation of IGM data (in the merging process). Allowed values are:<br>• Plausible<br>• Unlikely<br>• Substituted<br>• Unavailable |

Table 1 Metadata associated with CGMES instance files for IGMs and Boundary Data

The following table provides an overview of the Meta Data is used for the Reporting Information Market Document.

| Metadata name | Metadata type | Description |
|---|---|---|
| **type** | Code | B19 = Reporting Information Market Document |
| **process.processType** | Code | A01 = Day Ahead<br>A18 = Intraday |
| **sender_MarketParticipant.marketRole.type** | Code | A32 = Market Information Integrator |
| **receiver_MarketParticipant.marketRole.type** | Code | A04 = System Operator<br>A14 = Load-frequency control area operator<br>A15 = Load-frequency control block operator<br>A16 = Coordination center zone operator<br>A33 = Information receiver |
| **domain.mRID** | EIC Y code | Used if no dataset_MarketDocument information provided. Identified with an EIC Y code (codingScheme is A01). |
| **time_Period.timeInterval** | ESMP_DateTimeInterval | e.g. 2016-01-20T23:00Z/2016-01-21T23:00Z |
| **Doc_Status** | Code | A01 = intermediate<br>A02 = final |

### 3.2.2 OUTPUT DATA

The EMF exports various output data for further processing by TSOs and for Quality Assurance purposes:

- The solved system state, specified in CGMES profile SV for each synchronous area and for the whole pan-European region
- The updated operating assumptions in a TSO granularity, specified in CGMES 2.4 profile SSH
- Quality assurance reports, specified in this document

# 4. BUSINESS RULES

In this section the different steps in the merging process are detailed.

## 4.1 ASSEMBLING INDIVIDUAL GRID MODELS

Using the "DependentFile" Metadata attributes first from the SV instance file that defines an IGM, the associated model parts are collected: EQ-BD, TP-BD, EQ, SSH and TP. The model assembly process combines the information in order to solve all the references, so the data can be mapped to internal EMF tables for further processing.

## 4.2 QUALITY ASSURANCE I

The first step of quality assurance take place prior to the actual merge. It aims to detect the following quality issues:

- EMF Power flow engine cannot solve the IGM, given predefined settings
- Solved power flow balance deviates too much from target Netted Area AC Position
- Inconsistency in the connected status of a tie-line between two neighbouring TSOs
- Inconsistency in the applicable limits of a tie-line between two neighbouring TSOs

The following rules apply:

1. When calculating the steady state solution, a full Newton Raphson power flow algorithm is to be used, using the following settings:
   - Q limits shall be respected (also for slack node/swing bus)
   - Transformer tap adjustment is set to enabled[7]
   - Switched shunt adjustment is set to enabled
   - If Area interchange control has been implemented, it is set to enabled using conforming loads to meet the constraints, if it has not been implemented, distributed load slack is set to enabled in order to respect the applicable Area AC Net Position for each area
   - Solution tolerance is set to 0.5 MW and 0.5 MVAr
2. It shall be possible to calculate the power flow of an IGM[8] with the above power flow settings. Non-convergence of the largest electrical island is considered a fatal error.

[7] Note: Transformer tap and switch shunt control is used during power flow calculation to enable regulating control during contingency analysis (where the solved system state is used for the base case). In case of non-convergence, switched shunt and transformer tap regulation is disabled and power flow calculation is started again.

[8] A consistent set of EQ, SSH, TP, BDEQ and BDTP profiles



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3. The sum of the EquivalentInjection.p values for all AC Boundary Points is not allowed to deviate from the Netted Area AC position[9] by more than 500 MW. Exceeding this threshold is considered a fatal error.
4. The sum of the EquivalentInjection.p values for all AC Boundary Points shall not deviate from the Netted Area AC Position[10] by more than 50 MW. Exceeding this threshold is triggers a warning message.
5. If ***a*** TopologicalNode is associated with the terminal of the remote end of an ACLineSegment of which the other terminal is associated with a BoundaryPoint for one IGM, it is expected that this is also the case for the second IGM with the same BoundaryPoint[11]. Violating this rule triggers a diagnostic message
6. If ***no*** TopologicalNode is associated with the terminal of the remote end of an ACLineSegment of which the other terminal is associated with a BoundaryPoint for one IGM, it is expected that this is also the case for the second IGM with the same BoundaryPoint. Violating this rule triggers a diagnostic message.
7. The value of CurrentLimit.value is expected to be the same on both sides of a tie-line. Violating this rule triggers a diagnostic message.

## 4.3 GENERATE VALIDATION REPORT I

If the consistency and robustness checks have been performed and an error has been detected (violation of rules 2 or 3), the process is stopped by returning the following:

| Attribute Name | Type | Value |
|---|---|---|
| **QA_indicatorM** | string | Substituted |
| **TimeHorizon** | Enumerated string | Defined by SV |
| **ScenarioTime** | UTC datetime | Defined by SV |
| **QAReport** | XML | Listing of issues found for the following error types, if applicable:<br>• **ERROR: IGM for <md:ModelingAuthoritySet>***value***</md:ModelingAuthoritySet> didn't converge**<br>• **ERROR: Sum of the AC tie-line flows (***value***) deviates more than 500 MW from Netted Area AC Position (***value***)** |

[9] Note that losses are expected to be compensated inside the IGM (sum of Production = -(sum of consumption and losses) – Netted Area AC Position

[10] Note that losses are expected to be compensated inside the IGM (sum of Production = -(sum of consumption and losses) – Netted Area AC Position

[11] Note: the receiving application shall always interpret the terminal.connected for the terminal associated with the BoundaryPoints as true

If the consistency and robustness checks have been completed without errors, but with one or more consistency warnings or diagnostics (violation of one or more rules from 4-7), the process is stopped by returning the following:

| Attribute Name | Type | Value |
|---|---|---|
| **QA_indicatorM** | string | Unlikely |
| **TimeHorizon** | Enumerated string | Defined by SV |
| **ScenarioTime** | UTC datetime | Defined by SV |
| **QAReport** | XML | Listing of issues found for the following consistency warning types, if applicable:<br>• **WARNING: Sum of the AC tie-line flows (*value*) deviates more than 50 MW from Netted Area AC Position (*value*)**<br><br>Listing of issues found for the following diagnostics, if applicable:<br>• **INFO: Tie-line <*IdentifiedObject.description*> opened at one side**<br>• **INFO: Inconsistent monitoring values on the Tie-line <*IdentifiedObject.description*>**[12] |

## 4.4 COLLECTING MODELS FOR A PARTICULAR TIME HORIZON

The EMF shall be used for the following time horizons:

- Year ahead
- Month ahead
- Week ahead
- Before closing of the day ahead markets (“two days ahead”)
- After closing of the day ahead markets up to one hour before energy delivery
- After the fact (based on real-time snapshots)

The following rules apply:

1. The EMF shall subscribe to all IGMs for the above mentioned time horizons, using the Metadata attribute “TimeHorizon”.
2. The EMF shall subscribe to all EQ-BD and TP-BD instances.
3. The EMF shall subscribe to all Reporting Information Market Documents (issued by the Common Grid Model Alignment function and by the Pan-European Verification function)

[12] Note: the receiving application shall use the lowest value



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4. Operating assumptions (SSH) that didn't pass the EMF quality gate (Metadata attribute "QA_indicatorM" has been set to "Substituted") shall not be used for further processing.
5. An energy delivery datetime that already exists in the EMF shall preferably be reused (i.e. not built up from scratch), **unless** the associated EQ data has been changed.
6. The EMF shall build an internal interconnected Equipment model for each time horizon by assembling the EQ instances from all TSOs with the EQ-BD file that is applicable for that particular time horizon.

## 4.5 UPDATING THE EQUIPMENT MODEL

The following triggers can initiate reloading the EQ data of a particular TSO into the internal memory of the EMF[13]:

- A boundary point has been added, removed or modified
- An EQ file header contains the md:Model.Supersedes statement
- An EQ file header contains the dm:DifferenceModel statement
- The "ValidTo" Metadata value of the data in memory has expired

Updating means reloading the relevant EQ model data into the internal tables, taking into account the reference to the boundary data (as defined in the EQ-BD instance data). The mapping information for matching the Netted Area AC position is retrieved from the IdentifiedObject.energyIdentCodeEic attribute associated with the ControlArea class in the EQ model.

The mapping information for matching the HVDC target flows is retrieved from the IdentifiedObject.energyIdentCodeEic attribute associated with the Line classes in the boundary set (EQ-BD instance). Note that the EIC code is for the (HVDC) line, but the values from the Reporting Information Market Document (RIMD) are different at both end of the HVDC line (due to the losses). The value from the RIMD document is to be compared with the EquivalentInjection.p value associated with the topological node that is connecting the HVDC line referred to in the RIMD document.

## 4.6 UPDATING OPERATING ASSUMPTIONS

The operating assumptions, defined in SSH (always exchanged in full), provide the scenario specific values for a given point in time (defined in the "ScenarioTime" Metadata attribute). The applicability of the data is defined by the process (time horizon), the version number (the highest one is to be used) and the "Supersedes" statement (indicating that an update was produced). In general the most recent data for a given time horizon is to be used. If no valid data is available, the data from the previous run is to be used.

[13] It is up to the vendor to reload every EQ model instance or to do it only in case of changes

If this data is also not available for a calculation that is considered to be time critical, data substitution of missing data is performed only in case the responsible TSO is not able to provide valid data in due time. Updating of the operating assumptions is done according to the time horizon is performed in the following order:

STEP 1. Use the IGM of the same timeframe of the same day following the priority defined in the next table :

| | | | | | | | Load increase | | Begining of outages | | | | | | | | | | | End of outages / winter peak | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replaced by-> | 00:30 | 01:30 | 02:30 | 03:30 | 04:30 | 05:30 | 06:30 | 07:30 | 08:30 | 09:30 | 10:30 | 11:30 | 12:30 | 13:30 | 14:30 | 15:30 | 16:30 | 17:30 | 18:30 | 19:30 | 20:30 | 21:30 | 22:30 | 23:30 |
| 00:30 | 1 | 2 | 3 | 4 | 5 | 6 | | | | | | | | | | | | | | | | | | |
| 01:30 | 5 | 1 | 2 | 3 | 4 | 6 | | | | | | | | | | | | | | | | | | |
| 02:30 | 5 | 3 | 1 | 2 | 4 | 6 | | | | | | | | | | | | | | | | | | |
| 03:30 | 6 | 4 | 2 | 1 | 3 | 5 | | | | | | | | | | | | | | | | | | |
| 04:30 | 6 | 4 | 3 | 2 | 1 | 5 | | | | | | | | | | | | | | | | | | |
| 05:30 | | | 5 | 4 | 2 | 1 | 3 | | | | | | | | | | | | | | | | | |
| 06:30 | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | | | | | |
| 07:30 | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | | | | | | | | | | | |
| 08:30 | | | | | | | | | 1 | 2 | 3 | 4 | 5 | | | | | | | | | | | |
| 09:30 | | | | | | | | | 3 | 1 | 2 | 4 | 5 | | | | | | | | | | | |
| 10:30 | | | | | | | | | 3 | 2 | 1 | 4 | 5 | | | | | | | | | | | |
| 11:30 | | | | | | | | | | 5 | 2 | 1 | 3 | 4 | | | | | | | | | | |
| 12:30 | | | | | | | | | | 5 | 3 | 2 | 1 | 4 | | | | | | | | | | |
| 13:30 | | | | | | | | | | | 5 | 4 | 2 | 1 | 3 | | | | | | | | | |
| 14:30 | | | | | | | | | | | 7 | 6 | 5 | 4 | 1 | 2 | 3 | | | | | | | |
| 15:30 | | | | | | | | | | | | | 6 | 5 | 4 | 1 | 2 | 3 | | | | | | |
| 16:30 | | | | | | | | | | | | | 6 | 5 | 4 | 3 | 1 | 2 | | | | | | |
| 17:30 | | | | | | | | | | | | | 7 | 6 | 5 | 4 | 3 | 1 | 2 | | | | | |
| 18:30 | | | | | | | | | | | | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 8 | | | | |
| 19:30 | | | | | | | | | | | | | | | | | | | 3 | 1 | 2 | 4 | 5 | |
| 20:30 | | | | | | | | | | | | | | | | | | | | 2 | 1 | 3 | 4 | 5 |
| 21:30 | | | | | | | | | | | | | | | | | | | | 4 | 2 | 1 | 3 | 5 |
| 22:30 | | | | | | | | | | | | | | | | | | | | 5 | 4 | 2 | 1 | 3 |
| 23:30 | | | | | | | | | | | | | | | | | | | | 5 | 4 | 3 | 2 | 1 |

STEP 2. If not available, use the IGM from the same timeframe of older files of the same day type (Working Day, Saturday, Sunday, Bank holiday)
STEP 3. If not available, use the IGM from the same day (other time frame)
STEP 4. If not available, use older files of a different day type

The quality of the substituted data decreases with every step (highest accuracy in step 1, lowest in step 4. Substitution of data implies the introduction of inconsistencies, which should be corrected according to the following rules:

| **Type of inconsistency** | **Correction** |
|---|---|
| Inconsistent status of interconnector | Use the status of the neighbouring TSO for this timestamp |
| Inconsistent DC exchange value on interconnector | Use the DC exchange value of the connecting TSO for this timestamp |

## 4.7 TOPOLOGY PROCESSING

Topology processing uses switching device statuses and bus section information to determine the network connectivity and to develop a bus-oriented model that forms the basis for all of the power system analysis calculations.

The following steps are executed:

- Check whether or not new input data has been read and whether or not any switching devices have operated[14]. If either of these conditions is true, Topology Processing builds a new model for the affected substations. Each set of connected bus sections ("ConnectivityNode") becomes an electrical bus in the model ("TopologicalNode")
- Assign each electrical bus ("TopologicalNode") a name by giving it the name of the substation in which the bus is located ("BusNameMarker"). Each TopologicalNode will also have a particular bus-section ("ConnectivityNode") associated with it.
- Form into electrical islands all of the TopologicalNodes connected together by branches (e.g. transmission lines, transformers). Determine whether an existing island is active or inactive. An active island must contain both generation and load.
- Assign to each active electrical island one generating unit to serve as the swing unit for that island.

Topology processing can also be done "by proxy", i.e. the data from the TP instance file is used instead to build the pointers in the internal EMF model for the scenario that is defined by the SV instance.

## 4.8 CALCULATING THE POWER FLOW

As soon as the topological nodes and topological island have been defined, the power flow can be calculated. The following rules apply:

1. If two equivalent injections, belonging to two different Geographical Regions, are associated with the same topological node, their injection value shall be set to zero (EquivalentInjection.p)
2. When calculating the steady state solution, a full Newton Raphson power flow algorithm is to be used, using the following settings:
   - Q limits shall be respected (also for slack node/swing bus)
   - Transformer tap adjustment is set to enabled[15]
   - Switched shunt adjustment is set to enabled
   - If Area interchange control has been implemented, it is set to enabled using conforming loads to meet the constraints, if it has not been implemented, distributed load slack is set to enabled in order to respect the applicable Area AC Net Position for each area
   - Solution tolerance is set to 0.5 MW and 0.5 MVAr
3. When obtaining a solution, the target flows for HVDC connections are to be respected

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[14] If a switch is closed, but the Terminal.connected attribute (SSH) is false for the terminal of equipment associated with the same ConnectivityNode as the terminal of the switch, both terminals of said switch will be associated with a different TopologicalNode.

[15] Note: Transformer tap and switch shunt control is used during power flow calculation to enable regulating control during contingency analysis (where the solved system state is used for the base case). In case of non-convergence, switched shunt and transformer tap regulation is disabled and power flow calculation is started again.



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4. When obtaining a solution, the Netted Area AC Positions for each control area need to be respected, using either embedded Area Interchange Control or Distributed load slack. Both options are explained hereunder.

### 4.8.1 EMBEDDED AREA INTERCHANGE CONTROL

Embedded area interchange control involves including area control equations in Newton's method power flow, which leads to the same convergence rate as without area interchange control. No slack adjustments need to be done between iterations. The following needs to be done:

1. In the Jacobian, every bus (including the system reference), have both P and Q equations explicitly. The following area constraints are added:
2. area swing equations in the Jacobian by $S_k = \sum_{i=1}^{l_k}\left(\frac{\partial S_k}{\partial \delta p_i}\Delta\delta p_i + \frac{\partial S_k}{\partial Ep_i}Ep_i\frac{\Delta Ep_i}{Ep_i} + \frac{\partial S_k}{\partial \delta q_i}\Delta\delta q_i + \frac{\partial S_k}{\partial Eq_i}Eq_i\frac{\Delta Eq_i}{Eq_i}\right)$, where:
   $p_i$ represents the terminal in area *k* for tie line *i*
   $q_i$ represents the terminal outside area *k* for tie line *i*
   $l_k$ represents the total number of tie lines emanating from area *k*
3. In equation (2), $\frac{\partial S_k}{\partial \delta q_i} = Ep_i Eq_i(-Bp_iq_i\cos(\delta p_i - \delta q_i) + Gp_iq_i\sin(\delta p_i - \delta q_i))$
4. In equation (2), $\frac{\partial S_k}{\partial Eq_i}Eq_i = Ep_i Eq_i(Gp_iq_i\cos(\delta p_i - \delta q_i) + Bp_iq_i\sin(\delta p_i - \delta q_i))$
5. In equation (2), $\frac{\partial S_k}{\partial \delta p_i} = -\frac{\partial S_k}{\partial \delta q_i}$
6. In equation (2), $\frac{\partial S_k}{\partial Ep_i}Ep_i = \frac{\partial S_k}{\partial Eq_i}Eq_i - 2Ep_i^2 Gp_iq_i$
7. $\Delta S_k$ = Netted Area AC position – $S_k$ (calculated)
8. To make this work, slack variables are paired up as follows:
   - System slack real power paired with reference bus P equation
   - Area slack real power paired with area interchange equations
   - Reactive slack paired with Q equations at fixed voltage buses

The use of slack variables makes it very easy to set up proportionate participation in slacks. For example, if you want all loads in an area to participate in a slack, then the Jacobian column for the slack variable will have non-zero terms at each bus P equation where a load exists**.**

### 4.8.2 "CLASSIC" AREA INTERCHANGE CONTROL

In the "classic" approach, corrections to conforming load withdrawals are applied between iterations in the solution. In other words, they vary the system during the solution. Obviously, no numerical procedure can converge as quickly on a varying system as it can on a static system. The number of iterations can easily triple in comparison with power flow calculations without intermediate adjustments. In case of the "classical" approach the following procedure is to be followed:

1. Compare the target values for AC net positions and DC links with the values recorded after calculating the power flow on the pan-European model.
2. The recorded flow on DC links shall be equal to the target value of the scenario.
3. The recorded AC net position shall be equal to the reference value of the scenario.
4. If discrepancy exists for one or more scheduling areas, between the two values, then a balance adjustment by adjusting the loads has to be done.
5. The discrepancy thresholds are defined as follows:
6. $\left|\sum AC\ tieline\ flows - \ Netted\ Area\ AC\ position_{Scheduling\ Area}\right| < 2\ MW, \forall\ (Scheduling\ Areas)$
7. If the discrepancy occurs as defined in the previous step, the conforming loads of each scheduling area are modified proportionally in order to match the netted Area AC position, while maintaining the power factor of the loads.
8. The Jacobian is built for the new power flow iteration and new values for the AC tie line flows are calculated, in order to check if the conforming loads in the scheduling area have to be adjusted again.
9. If the power injection in the global slack bus exceeds a configurable threshold, this power injection shall be redistributed on all generation units in the synchronous area proportional to the reserve margin.
10. This loop ends:
    - When all the differences between the recorded and target values of net positions of scheduling areas are below the discrepancy thresholds, as defined previously;
    - In any case after the 15th iteration[16] (adjustments take place within the iterations).

## 4.9 QUALITY ASSURANCE II

The second step of quality assurance take place after the actual merge. It aims to detect the following quality issues:

- EMF Power flow engine cannot solve the CGM, given predefined settings
- The calculated system state is not plausible locally

The following rules apply:

1. When calculating the steady state solution, a full Newton Raphson power flow algorithm is to be used, using the following settings:
    - Q limits shall be respected (also for slack node/swing bus)
    - Transformer tap adjustment is set to enabled[17]
    - Switched shunt adjustment is set to enabled

[16] This is a configurable parameter

[17] Note: Transformer tap and switch shunt control is used during power flow calculation to enable regulating control during contingency analysis (where the solved system state is used for the base case). In case of non-convergence, switched shunt and transformer tap regulation is disabled and power flow calculation is started again.



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  - If Area interchange control has been implemented, it is set to enabled using conforming loads to meet the constraints, if it has not been implemented, distributed load slack is set to enabled in order to respect the applicable Area AC Net Position for each area
  - Solution tolerance is set to 0.5 MW and 0.5 MVAr
2. It shall be possible to calculate the power flow for each synchronous area with the above power flow settings. In case of non-convergence of a synchronous area first transformer tap and switched shunt regulation is disabled and a new calculation is initiated. In such case a warning message is issued.
3. In case of non-convergence of a synchronous area without transformer tap and switched shunt regulation, the reactive power limits for this synchronous area are relaxed and a new calculation is initiated. In such case a second warning message is issued.
4. In case of non-convergence after rules 2 and 3 have been tried, an error message shall be issued.
5. No substitute data is to be used as it impacts credibility of results. If substitute data is used (i.e. in accordance with the steps, described in 4.6), a warning message shall be issued.
6. For all TopologicalNodes, the value of SvVoltage.v shall be smaller than or equal to the VoltageLimit.value for OperationalLimitType.limitType=highVoltage. Violation of this rule will trigger a warning message.
7. For all TopologicalNodes, the value of SvVoltage.v shall be greater than or equal to the VoltageLimit.value for OperationalLimitType.limitType=lowVoltage. Violation of this rule will trigger a warning message.
8. There shall be no base case violations with respect to PATL. Violation of this rule will trigger a warning message.
9. For all TopologicalNodes, associated with synchronous machines (including slack generator), the negated value of SvInjection.qInjection value must be greater than or equal to the minimum of (SynchronousMachine.minQ and ReactiveCapabilityCurve.y1value at ReactiveCapabilityCurve.xvalue[18]). Violation of this rule will trigger a warning message.
10. For all TopologicalNodes, associated with synchronous machines (including slack generator), the negated value of SvInjection.qInjection value must be smaller than or equal to the maximum of (SynchronousMachine.maxQ and ReactiveCapabilityCurve.y2value at ReactiveCapabilityCurve.xvalue[19]). Violation of this rule will trigger a warning message.

---

[18] The xvalue here is equal to the value of RotatingMachine.p

[19] The xvalue here is equal to the value of RotatingMachine.p

## 4.10 GENERATE VALIDATION REPORT II

If the consistency and robustness checks have been performed and an error has been detected (violation of rule 4), the process is stopped by returning the following:

| Attribute Name | Type | Value |
|---|---|---|
| **QA_indicatorM** | string | Unavailable |
| **TimeHorizon** | Enumerated string | Defined by SV |
| **ScenarioTime** | UTC datetime | Defined by SV |
| **QAReport** | XML | Listing of issues found for the following error types, if applicable:<br>• **ERROR: CGM didn't converge for synchronous area <*Synchronous area*> with relaxed power flow settings, calculation results not available** |

If the consistency and robustness checks have been completed without errors, but with one or more consistency warnings (violation of one or more rules except 4), the process is stopped by returning the following:

| Attribute Name | Type | Value |
|---|---|---|
| **QA_indicatorM** | string | Unlikely |
| **TimeHorizon** | Enumerated string | Defined by SV |
| **ScenarioTime** | UTC datetime | Defined by SV |
| **QAReport** | XML | Listing of issues found for the following consistency warning types, if applicable:<br>• **WARNING: CGM didn't converge for synchronous area <*Synchronous area*> with default power flow settings, calculation results may not be realistic**<br>• **WARNING: CGM didn't converge for synchronous area <*Synchronous area*> without transformer tap and shunt controls, calculation results may not be realistic**<br>• **WARNING: IGM for <md:ModelingAuthoritySet>*value*</md:ModelingAuthoritySet> has been substituted**<br>• **WARNING: Calculated voltage at TopologicalNode <*IdentifiedObject.name*> is too high**<br>• **WARNING: Calculated voltage at TopologicalNode <*IdentifiedObject.name*> is too low**<br>• **WARNING: Base case violation detected for monitored element <*IdentifiedObject.name*>** |

| | | |
|---|---|---|
| | | • **WARNING: SvInjection.qInjection bound for SynchronousMachine <*IdentifiedObject.name*> (low Qlimit has been reached)**<br>• **WARNING: SvInjection.qInjection bound for SynchronousMachine <*IdentifiedObject.name*> (high Qlimit has been reached)** |

## 4.11 EXPORTING RESULTS

### 4.11.1 EXPORTING THE SOLVED SYSTEM STATE

For each CGM, the EMF shall export to the OPDM the SV file for the Pan-European grid and for each synchronous area, using the following naming convention:

<YYYYMMDD>T<hhmm>Z_<Time horizon>_<CGM type>_SV_<version number>.zip or .cimx

Where

| | |
|---|---|
| <YYYYMMDD>T<hhmm>Z | is the date time of the scenario, expressed in UTC |
| <Time horizon> | is the time horizon, allowed values are: YR, MO, WK, 2D, 1D, 23, 22, 21, 20, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 09, 08, 07, 06, 05, 04, 03, 02, 01, RT |
| <CGM type> | is the geographical scope of the solution. Allowed values are: CGMEU (Pan-European), CGMCE (Continental Europe), CGMNO (Nordic area), CGMBA (Baltic area, i.e. Estonia, Latvia and Lithuania), CGMUK (UK area), CGMIN (Ireland and Northern Ireland) |
| <version number> | is the three digit version number (every time a new merge is run by one EMF for one time horizon and one dedicated scenario date and time, this number is incremented by one) |

Note that the file extension is either zip or cimx (both are zipped xml file).

The following rules apply:

1. The SV files contain all calculation results
2. The tie-line flows are included as Equivalent Injection values, so they can be displayed without having to run a new load flow
3. In the file header of the SV files the EMF shall identify which tool and version number was used, using the md:Model.description statement
4. In the file header of the SV files the EMF shall identify which RSC issued the CGM, using the md:Model.description statement



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5. In the file header of the SV files the EMF shall identify which source data was used (SSH, TP and TP-BD), using md:Model.DependentOn statements

### 4.11.2 EXPORTING THE UPDATED OPERATING ASSUMPTIONS

For each CGM, the EMF shall export to the OPDM updates of the SSH files for all TSOs, derived from the solved system state. These file will use the following naming convention:

| |
|---|
| <YYYYMMDD>T<hhmm>Z_<Time horizon>_<Model part reference>_SSH_<version number>.zip or .cimx |

Where

| | |
|---|---|
| <YYYYMMDD>T<hhmm>Z | is the date time of the scenario, expressed in UTC |
| <Time horizon> | is the time horizon, allowed values are: YR, MO, WK, 2D, 1D, 23, 22, 21, 20, 19, 18, 17, 16, 15, 14, 13, 12, 11, 10, 09, 08, 07, 06, 05, 04, 03, 02, 01, RT |
| <Model part reference> | is the geographical scope of the solution. Model part references have no predefined restrictions other than allowed characters[20], but the use of TSO names or HVDC link names is recommended[21] |
| <version number> | is the three digit version number (this version number will equal the SV version number provided by EMF of one RSC) |

Note that the file extension is either zip or cimx (both are zipped xml file).

The following rules apply:

1. The SSH files contain all values from the original SSH files, but updated with calculation results
2. The tie-line flows are included as Equivalent Injection values, so they can be displayed without having to run a new load flow
3. In the file header of the SSH files the EMF shall identify which tool and version number was used, using the md:Model.description statement
4. In the file header of the SSH files the EMF shall identify which RSC issued the CGM, using the md:Model.description statement
5. In the file header of the SSH files the EMF shall identify which equipment model was used (EQ), using the md:Model.DependentOn statement

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[20] Note that for the Model part reference only US ASCII characters are allowed

[21] Note that Denmark has two model parts, one for each Synchronous area

6. In the file header of the SSH files the EMF shall identify which source data was used (SSH), using the md:Model.Supersedes statement

### 4.11.3 EXPORTING THE QA REPORTS

QA reports are exported as XML documents, in accordance with 4.3 and 4.10.



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# 5. CLASSIFICATION AND COMPLIANCE DEFINITION

## 5.1 CLASSIFICATION

The requirements are structured in following classes:

| Class | Type of requirement | Description |
|---|---|---|
| F | Must have final | Describes a requirement that must be satisfied in the final solution for the solution to be considered a success (to be implemented by 14.06.2017) |
| M | Must have migration | Describes a requirement that must be satisfied in order to support the minimum viable solution (to be implemented by 14.12.2016) |
| H | Hybrid merge | Describes a requirement that must be satisfied in order to support the migration from UCTE DEF to CGMES for RG CE TSOs (to be implemented by 14.12.2016 until the parallel run ends) |
| W | Would have | Not mandatory, but highly recommended |
| I | Information | No requirement, only for informational purpose. |

## 5.2 COMPLIANCE DEFINITION

The following compliance is used to monitor progress of the implementation:

| Code | Description | Score |
|---|---|---|
| P | Available in Service Providers' proven technology | 5 |
| X | Will be provided by Service Provider (development) | 3 |
| N | Non-compliant: this functionality cannot be provided by the Service Provider | 0 |

The Service Provider shall use these categories for filling out the tables of compliance (empty compliance will be considered as non-compliant). If there are several items in a requirement, Service Provider shall give compliance to each of the sub-items.

**For all must have requirements (Class "M", "F") a compliance declaration "N" is not allowed.**



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# 6. FUNCTIONAL REQUIREMENTS

## 6.1 GRAPHICAL USER INTERFACE (EMF GUI)

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| GUI1. | Selection of functional modules and scripts through displays shall trigger only local execution of processes | F | | |
| GUI2. | The request data function of the EMF GUI allows the user to retrieve the relative data from OPDE when it is not available in local storage | F | | |
| GUI3. | For initiating a manual model assembly, it shall be possible to select input data, based on the following criteria:<br>❑ Date and time to be studied<br>❑ Type of data to be used (MAS, Boundary Set and/or Net Positions/HVDC flows)<br>❑ MA (in case of MAS data)<br>❑ Scope of data to be used (time horizon)<br>❑ Version of data to be used (creation time) | F | | |
| GUI4. | When retrieving a historical CGM case, it shall be possible to display the following characteristics of the CGM:<br>❑ Target date and time of the CGM<br>❑ Merging entity that created the CGM<br>❑ Creation date and time<br>❑ Type of CGM (i.e. time horizon)<br>❑ Version number of the CGM<br>❑ Specification of the input data that was used:<br>o For each MAS: TSO, creation date and time, version number<br>o For Net positions and HVDC flows: creation date and time, version number | F | | |

## 6.2 INTERFACES (INPUT DATA)

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| ITF1. | For all relevant time horizons the IGM files of all TSOs are imported automatically from the Operational Planning Data Environment (event driven) | F | | |
| ITF2. | It shall be possible to import IGM data manually | M | | |
| ITF3. | Concurrent handling of different data formats is required (UCTE DEF, CGMES, CIM XML documents, EXCEL files) | H | | |
| ITF4. | The ***merging application*** shall be responsible to map the EIC codes for scheduling areas[22] (as used by the Pan European Verification Function and the Common Grid Model Alignment Function) to the control areas defined in the CGMES datasets (attribute energyIdentCodeEic for Class ControlArea in EQ profile). | F | | |
| ITF5. | The AC and HVDC exchanges to non-ENTSO-E areas (such as Morocco, Belarus, Russia, Moldavia) are modelled as Equivalent Injections, connected to the relative Boundary Points. | F | | |

[22] Note: the existing control area codes will be used for the Scheduling Areas. For HVDC links there are either EIC codes available or they have to be issued by the responsible TSOs at the EIO. TSOs will deliver the energyIdentCodeEic for Class ControlArea in EQ profile. Mapping tables need to be created by the EMF tool provider, as some control areas contain multiple scheduling areas (Italy, Sweden and Norway).

## 6.3 INTERFACES (OUTPUT DATA)

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| ITF6. | For every synchronous area (i.e. Topological Island), all calculation results (base case power flow) shall be made available in a separate SV file on the local OPDE node, and with corresponding individual updated profiles (SSH) after merging. All profiles except SV profile will be delivered individually, at a TSO granularity, taking into account the details specified in 4.11.1 and 4.11.2. | F | | |
| ITF7. | For the complete ENTSO-E area (i.e. all topological Islands), all calculation results (base case power flow) shall be made available in a separate SV file on the local OPDE node | F | | |
| ITF8. | For the synchronous area of Continental Europe, all calculation results (base case power flow) shall be made available in a UCTE DEF merged model, in accordance with the data exchange format description provided in the document “Quality of Datasets and Calculations”: (https://www.entsoe.eu/Documents/Publications/SOC/Continental_Europe/150420_quality_of_datasets_and_calculations_3rd_edition.pdf) , maintaining the original node names and equipment model characteristics of the input models. | H | | |
| ITF9. | State variable instance files for the common grid model include SvPowerFlow for injections of all 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[23] | M | | |
| ITF10. | IGM data in UCTE-format shall be internally converted to CGMES format (so-called pseudo CGMES data) in order to enable the exchange of a full CGMES based Common Grid Model solution in accordance with the CGMES requirements | H | | |

[23] See also [R.4.8.5.] of the CGMES 2.4.15 specifications document.

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| ITF11. | The rdf:IDs of the pseudo CGMES EQ data shall be persistent for the target day among different processes in a row (as long as UCTE naming is stable) | M | | |
| ITF12. | For all pseudo CGMES datasets, the EQ model for the target day is included in the base case power flow solution that is exported to the local OPDE node[24] | H | | |
| ITF13. | The results of the consecutive validation steps shall be made available in XML format on the local OPDE node for representation purposes on the ENTSO-E Quality Assurance Portal, according to the detailed specification in 4.3 and 4.10. | F | | |
| ITF14. | For every MAS, the adjustments made during the merging process in terms of active/reactive power infeed or withdrawal, TapChanger.step, voltage control (bound synchronous machines) and boundary flows (Equivalent Injections) shall be expressed as updated SSH instances[25] that are derived from the input SSH[26] and include an “md:Model.Supersedes” statement in the file header that refers to the original input file. | F | | |
| ITF15. | All exported instance files shall comply to the validation rules, set forth in https://extra.entsoe.eu/SOC/IT/Key%20Documents/QUALITY%20OF%20CGMES%20DATASETS%20AND%20CALCULATIONS%201st%20edition.pdf?Web=1 | F | | |

[24] This is necessary as all merging entities will generate their own rdf:IDs for the EQ data of pseudo CGMES instances. This way all the references from TP and SSH can be found.

[25] Full instances. The updated SSH profile instances shall be exported each time when the SV is exported.

[26] In case of substitution the reference to the substituted file is made in the md:Model.Supersedes statement

## 6.4 INTERFACES (DETAILS)

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| ITF16. | For each synchronous area the set of schedules shall be available on the OPDE in the Reporting Information Market Document[27] per timeframe | I | | |
| ITF17. | This Reporting Information Market Document contains both the netted area AC positions and/or aggregated netted external schedules per scheduling area border for each scheduling area[28] in the synchronous area as well as all the aggregated netted external schedules for each boundary point of each HVDC interconnector and all corresponding QA flags[29] | I | | |

27 The final specification/implementation guide shall be provided in August 2016

28 Note: for control areas that contain multiple scheduling areas (Italy, Sweden and Norway) aggregation is to be done for CGMES 2.4. Mapping is a responsibility for the EMF tool provider (see also ITF4)

29 Allowed status values are: “Unverified”, “Verified”, “Matched”, “Unbalanced”, “Substituted”

## 6.5 INPUT DATA VALIDATION

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| IDV1. | The ***merging application*** validates the CGMES data against the validation rules[30], set forth in https://extra.entsoe.eu/SOC/IT/Key%20Documents/QUALITY%20OF%20CGMES%20DATASETS%20AND%20CALCULATIONS%201st%20edition.pdf?Web=1. | F | | |
| IDV2. | The ***merging application*** validates the UCTE DEF data against the rules set forth in the document "Quality of Datasets and Calculations": (https://www.entsoe.eu/Documents/Publications/SOC/Continental_Europe/150420_quality_of_datasets_and_calculations_3rd_edition.pdf) | H | | |
| IDV3. | The ***merging application*** validates the CIM XML data against the applicable XSD file | F | | |
| IDV4. | Intentionally left blank | | | |
| IDV5. | Intentionally left blank | | | |
| IDV6. | The ***merging application*** performs a checksum for all referenced timestamps in Vulcanus.xls files, taking into account a 5 MW threshold | H | | |
| IDV7. | The ***merging application*** performs a checksum for all referenced timestamps in PEVF xml files, taking into account a 5 MW threshold | M | | |

30 Note: Validation for levels 1-4 will be done on the OPDM client (also for RSCs publishing data), validation levels 5-7 will be done at the OPDM Central server. Level 8 (plausibility) is to be done by the EMF. Results of this last step need to be published via the QAS portal. Internal validation should not be in conflict with the official rules

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| IDV8. | Only data that has passed the validation process of IDV1, IDV2, IDV3, IDV4 and IDV6 without fatal issues, shall be used for further processing | F | | |
| IDV9. | Both Bus-Branch and Node Breakers models shall be handled by EMF Tools[31] | F | | |
| IDV10. | The EMF tool shall be able to import EQ difference files. | F | | |

[31] During transition phase it should be expected that some TSOs still issue bus branch models (EQ Core). Some net parts (DSO grids) may contain no switches due to lack of information. Inclusion of such grid may be considered as “mixed modelling”, but if breakers and disconnectors are included in the HV parts, the EQ Operation stereotype is to be used in the file header. As long as at least one TSO still uses a bus branch tool, all TSOs (and RSCs) must exchange TP instances.

## 6.6 MERGING FUNCTION

### 6.6.1 MODEL ASSEMBLY

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| MAS1. | It shall be possible to start te model assembly process manually through the interface specified in GUI1, GUI2 and GUI3 | M | | |
| MAS2. | It shall be possible to specify for the D-1 time horizon:<br>❑ When to start the automatic process of model assembly and the consecutive power flow calculation | M | | |
| MAS3. | It shall be possible to specify for the Intraday time horizon:<br>❑ The number of hours ahead of the series of calculations<br>❑ The number of timestamps to be calculated as part of a rolling process<br>❑ The delay in minutes after the full clock hour to start the assembly process and the consecutive power flow calculation | M | | |
| MAS4. | It shall be possible to specify for the close after real-time snapshots:<br>❑ The delay in minutes after the full clock hour and every 15 minutes to start the assembly process and the consecutive power flow | M | | |

### 6.6.2 UPDATING MODEL DATA

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| UPD1. | The following triggers can initiate reloading the EQ data of a particular TSO into the internal memory of the EMF[32]:<br>• A boundary point has been added, removed or modified<br>• An EQ file header contains the md:Model.Supersedes statement<br>• An EQ file header contains the dm:DifferenceModel statement<br>• The “ValidTo” Metadata value of the data in memory has expired | W | | |
| UPD2. | Updating means reloading the relevant EQ model data into the internal tables, taking into account the reference to the boundary data (as defined in the EQ-BD instance data). The mapping information for matching the Netted Area AC position is retrieved from the IdentifiedObject.energyIdentCodeEic attribute associated with the ControlArea class in the EQ model. | M | | |
| UPD3. | The applicability of the data is defined by the process (time horizon), the version number (the highest one is to be used) and the “Supersedes” statement (indicating that an update was produced). | I | | |
| UPD4. | In general the most recent data for a given time horizon is to be used. If no valid data is available, the data from the previous run is to be used. | M | | |
| UPD5. | Before a Common Grid Model can be created automatically, the European Merging Function needs to check if all IGMs[33] and associated data that belong to a specific scenario are complete and consistent. Consistency refers to IGM balance versus target balance and to status of interconnectors of neighbouring TSOs. | M | | |

32 It is up to the vendor to reload every EQ model instance or to do it only in case of changes

33 Note: for close after real-time snapshots, only available data sets will be used for the model assembly process. No substitution of data is allowed.

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| UPD6. | The ControlArea.netInterchange value is to be checked against the target Netted Area AC Position only when the merge is done prior to any cross-control-area redispatch modelling. | I | | |
| UPD7. | When cross-load-frequency-control-area redispatch has already been modelled, the total balance of the control areas affected by cross-load-frequency control area redispatching is checked against the sum of the target balances of these control areas. If the check is successful the applicable Netted area AC Position for each of the control areas subject to cross-load-frequency-control-area redispatching shall be the Netted area AC position from the IGM. | M | | |
| UPD8. | In case of model assembly for a calculation process that isn't considered to be time critical, the merging entity shall ensure that all system operators[34] have provided the requested data before the merging is performed. | M | | |
| UPD9. | In case of model assembly for a calculation that is considered to be time critical (D-1 and intraday time horizons), substitution of missing data is performed only in case the responsible TSO is not able to provide valid data in due time. Completion of the set of IGMs according to the time horizon is performed in the following order: | M | | |

[34] At least on a synchronous area level during the migration period, after the migration period all ENTSO-E TSOs

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| | STEP 1. Use the IGM of the same timeframe of the same day following the priority defined in the next table : | | | |

| | | | | | | | Load increase | | Begining of outages | | | | | | | | | | | End of outages / winter peak | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replaced by-> | 00:30 | 01:30 | 02:30 | 03:30 | 04:30 | 05:30 | 06:30 | 07:30 | 08:30 | 09:30 | 10:30 | 11:30 | 12:30 | 13:30 | 14:30 | 15:30 | 16:30 | 17:30 | 18:30 | 19:30 | 20:30 | 21:30 | 22:30 | 23:30 |
| 00:30 | 1 | 2 | 3 | 4 | 5 | 6 | | | | | | | | | | | | | | | | | | |
| 01:30 | 5 | 1 | 2 | 3 | 4 | 6 | | | | | | | | | | | | | | | | | | |
| 02:30 | 5 | 3 | 1 | 2 | 4 | 6 | | | | | | | | | | | | | | | | | | |
| 03:30 | 6 | 4 | 2 | 1 | 3 | 5 | | | | | | | | | | | | | | | | | | |
| 04:30 | 6 | 4 | 3 | 2 | 1 | 5 | | | | | | | | | | | | | | | | | | |
| 05:30 | | | 5 | 4 | 2 | 1 | 3 | | | | | | | | | | | | | | | | | |
| 06:30 | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | | | | | | | | |
| 07:30 | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | | | | | | | | | | | |
| 08:30 | | | | | | | | | 1 | 2 | 3 | 4 | 5 | | | | | | | | | | | |
| 09:30 | | | | | | | | | 3 | 1 | 2 | 4 | 5 | | | | | | | | | | | |
| 10:30 | | | | | | | | | 3 | 2 | 1 | 4 | 5 | | | | | | | | | | | |
| 11:30 | | | | | | | | | | 5 | 2 | 1 | 3 | 4 | | | | | | | | | | |
| 12:30 | | | | | | | | | | 5 | 3 | 2 | 1 | 4 | | | | | | | | | | |
| 13:30 | | | | | | | | | | | 5 | 4 | 2 | 1 | 3 | | | | | | | | | |
| 14:30 | | | | | | | | | | | 7 | 6 | 5 | 4 | 1 | 2 | 3 | | | | | | | |
| 15:30 | | | | | | | | | | | | | 6 | 5 | 4 | 1 | 2 | 3 | | | | | | |
| 16:30 | | | | | | | | | | | | | 6 | 5 | 4 | 3 | 1 | 2 | | | | | | |
| 17:30 | | | | | | | | | | | | | 7 | 6 | 5 | 4 | 3 | 1 | 2 | | | | | |
| 18:30 | | | | | | | | | | | | | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 8 | | | | |
| 19:30 | | | | | | | | | | | | | | | | | | | 3 | 1 | 2 | 4 | 5 | |
| 20:30 | | | | | | | | | | | | | | | | | | | | 2 | 1 | 3 | 4 | 5 |
| 21:30 | | | | | | | | | | | | | | | | | | | | 4 | 2 | 1 | 3 | 5 |
| 22:30 | | | | | | | | | | | | | | | | | | | | 5 | 4 | 2 | 1 | 3 |
| 23:30 | | | | | | | | | | | | | | | | | | | | 5 | 4 | 3 | 2 | 1 |

STEP 2. If not available, use the IGM from the same timeframe of older files of the same day type (Working Day, Saturday, Sunday, Bank holiday)

STEP 3. If not available, use the IGM from the same day (other time frame)

STEP 4. If not available, use older files of a different day type

The quality of the substituted data decreases with every step (highest accuracy in step 1, lowest in step 4.

For intraday coordinated security assessment, missing data shall be replaced by the latest available version of the same timestamp.

Substitution of data implies the introduction of inconsistencies, which should be corrected according to the following rules:

<table>
<tr><th>Number</th><th>Requirement</th><th>Class</th><th>Compliance</th><th>Comments</th></tr>
<tr><td></td><td>
<table>
<tr><th>Type of inconsistency</th><th>Correction</th></tr>
<tr><td>Inconsistent status of interconnector</td><td>Use the status of the neighbouring TSO for this timestamp</td></tr>
<tr><td>Inconsistent DC exchange value on interconnector</td><td>Use the DC exchange value of the connecting TSO for this timestamp</td></tr>
<tr><td>Balance doesn’t fit the aggregated netted AC position</td><td>• Scale the conforming loads proportional to match the difference<br>• run a power flow calculation with voltage regulation (i.e. respecting Q limits)<br>• if this power flow doesn’t converge, try again releasing the Q limits of generators<br>• assign the grid losses to the slack node</td></tr>
</table>
</td><td></td><td></td><td></td></tr>
</table>

### 6.6.3 ENFORCING NETTED AREA AC POSITIONS IN THE IGM

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| BNP1. | For all planning horizons, the ***merging application*** shall first apply the applicable Aggregated Netted External Schedules for each HVDC boundary point and then the applicable Netted area AC position for each control area**.** Area Interchange Control is then applied as follows:<br><br>Option 1 - Adjustment of conforming load values between the power flow calculation iterations:<br>1. Compare the target values for AC net positions and DC links with the values recorded after calculating the power flow on the pan-European model.<br>2. The recorded flow on DC links shall be equal to the target value of the scenario.<br>3. The recorded AC net position shall be equal to the reference value of the scenario.<br>4. If discrepancy exists for one or more scheduling areas, between the two values, then a balance adjustment by adjusting the loads has to be done.<br>5. The discrepancy thresholds are defined as follows:<br>6. $\left\lvert \sum AC\ tieline\ flows - Netted\ Area\ AC\ position_{Scheduling\ Area} \right\rvert < 2\ MW, \forall\ (Scheduling\ Areas)$<br>7. If the discrepancy occurs as defined in the previous step, the conforming loads of each scheduling area are modified proportionally in order to match the netted Area AC position, while maintaining the power factor of the loads.<br>8. The Jacobian is built for the new power flow iteration and new values for the AC tie line flows are calculated, in order to check if the conforming loads in the scheduling area have to be adjusted again.<br>9. If the power injection in the global slack bus exceeds a configurable threshold, this power injection shall be redistributed on all generation units in the synchronous area proportional to the reserve margin.<br>10. This loop ends:<br>o When all the differences between the recorded and target values of net positions of scheduling areas are below the discrepancy thresholds, as defined previously; | F | | |

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| | o In any case after the 15th iteration[35] (adjustments take place within the iterations).<br><br>Option 2 – Improved area interchange control (as part of the PF iterations):<br>9. In the Jacobian, every bus (including the system reference), have both P and Q equations explicitly. The following area constraints added:<br>10. area swing equations in the Jacobian by $S_k = \sum_{i=1}^{l_k}(\frac{\partial S_k}{\partial \delta p_i}\Delta\delta p_i + \frac{\partial S_k}{\partial Ep_i}Ep_i\frac{\Delta Ep_i}{Ep_i} + \frac{\partial S_k}{\partial \delta q_i}\Delta\delta q_i + \frac{\partial S_k}{\partial Eq_i}Eq_i\frac{\Delta Eq_i}{Eq_i})$ , where<br>$p_i$ represents the terminal in area *k* for tie line *i*<br>$q_i$ represents the terminal outside area *k* for tie line *i*<br>$l_k$ represents the total number of tie lines emanating from area *k*<br>11. In equation (2), $\frac{\partial S_k}{\partial \delta q_i} = Ep_iEq_i(-Bp_iq_i\cos(\delta p_i - \delta q_i) + Gp_iq_i\sin(\delta p_i - \delta q_i))$<br>12. In equation (2), $\frac{\partial S_k}{\partial Eq_i}Eq_i = Ep_iEq_i(Gp_iq_i\cos(\delta p_i - \delta q_i) + Bp_iq_i\sin(\delta p_i - \delta q_i))$<br>13. In equation (2), $\frac{\partial S_k}{\partial \delta p_i} = -\frac{\partial S_k}{\partial \delta q_i}$<br>14. In equation (2), $\frac{\partial S_k}{\partial Ep_i}Ep_i = \frac{\partial S_k}{\partial Eq_i}Eq_i - 2Ep_i^2Gp_iq_i$<br>15. $\Delta S_k$ = Netted Area AC position – $S_k$ (calculated)<br>16. To make this work, slack variables are paired up as follows:<br>o System slack real power paired with reference bus P equation<br>o Area slack real power paired with area interchange equations<br>o Reactive slack paired with Q equations at fixed voltage buses<br><br>The use of slack variables makes it very easy to set up proportionate participation in slacks. For example, if you want all loads in an area to participate in a slack, then the Jacobian column for the slack variable will have non-zero terms at each bus P equation where a load exists. | | | |
| BNP2. | Intentionally left blank | | | |

[35] This is a configurable parameter

### 6.6.4 Enforcing netted AREA AC positions in the CGM

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| MNP1. | EquivalentInjection.p and EquivalentInjection.q are set to zero, if a tie-line or a ConnectivityNode is connected[36] | M | | |
| MNP2. | After processing topology for the assembled models, the equivalent injection active power value for every HVDC interconnector boundary point in every IGM is set to the corresponding balanced HVDC position in case of simplified HVDC modelling (i.e. using equivalent injections) | M | | |
| MNP3. | For each CGM the merging application shall assign a slack bus automatically | M | | |
| MNP4. | When calculating the steady state solution, a full Newton Raphson power flow algorithm is to be used, using the following settings:<br>• Q limits shall be respected (also for slack node/swing bus)<br>• Transformer tap adjustment is set to enabled[37]<br>• Switched shunt adjustment is set to enabled<br>• If Area interchange control has been implemented, it is set to enabled using conforming loads to meet the constraints, if it has not been implemented, distributed load slack[38] is set to enabled in order to respect the applicable Area AC Net Position for each area | M | | |

[36] See also [R.4.8.3.] of the CGMES 2.4.15 specifications document

[37] Note: Transformer tap and switch shunt control is used during power flow calculation to enable regulating control during contingency analysis (where the solved system state is used for the base case). In case of non-convergence, switched shunt and transformer tap regulation is disabled and power flow calculation is started again.

[38] See BNP1.

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| | • Solution tolerance is set to 0.5 MW and 0.5 MVAr | | | |
| MNP5. | If the active power injection in the global slack bus exceeds a configurable threshold, this active power injection shall be redistributed on all generation units in the synchronous area proportional to the reserve margin, respecting the reactive power limits of all the Generating Units and the power flow is calculated again. This process is repeated, until the active power slack deviation is lower than a configurable threshold (see detailed description is **Erreur ! Source du renvoi introuvable.**, **Erreur ! Source du renvoi introuvable.**, **Erreur ! Source du renvoi introuvable.** and 8), or the maximum number of iterations has been reached. | M | | |

### 6.6.5 VOLTAGE MANAGEMENT

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| VMA1. | The target voltage of all controlled buses shall be pursued, within the reactive power limits of all Synchronous Machines and control ranges of discrete controls (shunts, transformers)[39] | M | | |
| VMA2. | In case of non-convergence of a synchronous area first transformer tap and switched shunt regulation is disabled and a new calculation is initiated. In such case a warning message is issued. | M | | |

[39] Ideal case of PF solution is that target voltages (assuming that here one fixed value of $U_{initial}$ is meant, not admissible range of U) in PV nodes is achieved, while Qgen is within limits. There is an intermediate level of PF convergence quality - but real and often occurring that PF have to give up from $U_{initial}$ in some nodes, order to respect Qmin-Qmax range. This level could be recognized (before switching from VMA1 to VMA2), just the level of voltage admissible change could be defined as setting (%$U_{initial}$ allowed deviation).

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| VMA3. | In case of non-convergence of a synchronous area without transformer tap and switched shunt regulation, the reactive power limits for this synchronous area are relaxed and a new calculation is initiated. In such case a second warning message is issued. | M | | |
| VMA4. | In case of non-convergence after rules VMA2 and VMA3 have been tried, an error message shall be issued. | | | |

### 6.6.6 POWER FLOW DIAGNOSTICS

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| PFD1. | If the load flow solution cannot be found by the means specified in VMA1 or VMA2, the process shall be aborted and the Operator shall be informed. Such data shall be stored in the merging application and in the QAS portal for detailed convergence analysis[40]. | M | | |
| PFD2. | A calculation report (log-file) is created describing the quality of the merged data sets. This will at least comprise the following:<br>❑ Results of load flow calculation (number of iterations, slack mismatch, voltage range, system losses)<br>❑ List of IGMs used, including their quality assessment (No warnings, Warning issues, Substituted)<br>❑ Base case violations | M | | |

[40] Final solution to bring in case of non convergence remains at Regional level

# 7. NON-FUNCTIONAL REQUIREMENTS

## 7.1 AVAILABILITY

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| AVA1. | The availability shall be at least 99,95% for the fundamental system functionality | F | | |
| AVA2. | The maximum unplanned downtime may not exceed 4 hours per year. Single incidents may last no longer than 2 hours | F | | |
| AVA3. | The merging entity shall propose the procedures to reduce the planned downtime for rollouts and patches | F | | |
| AVA4. | To reach the necessary availability, the system needs to be designed as a redundant system. These systems shall not contain any single point of failure | F | | |

## 7.2 COMMUNICATION INFRASTRUCTURE

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| COM1. | Temporary interruption in communication media shall not interrupt the process of already received complete datasets | M | | |
| COM2. | With admission or return of the connection the data on the local OPDE node shall be updated, interrupted data transmission shall be repeated (restarted). | F | | |
| COM3. | EMF shall implement at least one of the following technical specifications for data exchange between the local OPDE end point and EMF:<br>❑ ftp/scp[41]<br>❑ MADES[42] | M | | |
| COM4. | The IT shall support both data flow with not fixed coded routes and dynamic IP allocation and network operation according to EH rules | M | | |
| COM5. | The IT solution must comply with the current network and host IP addressing Scheme used over EH. Na additional changes in this scheme are allowed. | M | | |
| COM6. | If required an “interface” to "normal" office networks could in principle be realised through a suitable system security with firewall and DMZ considering the EH network and architecture criteria:<br>❑ Direct physical or logical connection between EH and Internet is not allowed. | M | | |

[41] This protocol is expected for Migration phase only

[42] ENTSO-E Market Data Exchange Standard
(see also https://www.entsoe.eu/publications/electronic-data-interchange-edi-library/work%20products/mades/Pages/default.aspx )

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| | ❑ Data exchange between EH and the “outside world” needs to be done under full security procedures. The separation of EH from insecure networks must be guaranteed by use of intermediate gateways. These gateways must be located in a Demilitarized Zone (DMZ) separated by different firewalls from both Internet and EH. Further existing security restrictions (e.g. security policies of the different networks) must be considered for these "interfaces".<br><br>Furthermore, the workstations in the office could be realised, e.g. with a terminal server system. | | | |

## 7.3 TIME SYNCHRONISATION AND DAYLIGHT SAVING TIME

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| TIM1. | The Merging Application shall use the Universal Time Coordinated (UTC) to ensure a single time reference throughout the whole system. However, local time shall be displayed at every system. | F | | |
| TIM2. | To synchronize all system components, the Network Time Protocol (NTP) shall be used. | F | | |
| TIM3. | Time Synchronisation from GPS or equivalent will be provided by the hosting TSO. The Merging Application shall synchronise itself with this time signal. | F | | |
| TIM4. | It shall be possible to disable this time synchronization function and to set the time manually by the Merging Application Administrator for testing purposes. | F | | |
| TIM5. | It shall be possible that each Merging Application has an own time ('time travelling' without change servers system time). | F | | |
| TIM6. | Software functions must consider local time zones with daylight saving time specifics, particularly with regard to the data management. | F | | |

## 7.4 IT-SECURITY

Concerning IT-security the protection objectives of availability, integrity, confidentiality and non-repudiability shall be considered. The following requirements define these (not exhaustively) in more detail.

Sensitive system and user data must be protected against the access and the knowledge of non-beneficiaries.

The integrity and consistency of the data in the Merging Application as well as the data models must be guaranteed at every time or must be recovered in case errors. For the traceability and security check all relevant operating actions and system operations (among other things update of data, configuration updates, communication processes) must be documented (e.g. log data). The logged data must be saved against unauthorized access or change (manipulation) and permit a suitable evaluation. This shall be supported by the used format or a suitable, provided evaluation tool.

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| ITS1. | Regarding the security the vendor has to fulfil the applicable requirements of "BDEW White Paper Requirements for Secure Control and Telecommunication Systems".[43] | F | | |
| ITS2. | The intention is to protect the system and the interfaces against security menaces in the everyday operation appropriately, to minimise the effects of menaces on the operation and to guarantee the maintenance of the business concern also in security incidents or to recover a defined minimum in services or official quality as quickly as possible. | F | | |
| ITS3. | The system must be designed and developed to ensure a safe operation.<br>To the principles of a safe system design belong e.g.:<br>❑ Minimally or need to know principle: Every component and every user receives only the rights which are necessary for the implementation of an operation. Thus | F | | |

[43] http://www.bdew.de/bdew.nsf/id/A975B8333599F9B0C12574B400348E7A/$file/Whitepaper_Secure_Systems_Vedis_1.0final.pdf

| Number | Requirement | Class | Compliance | Comments |
|---|---|---|---|---|
| | are run, e.g., applications and network services not with administrator's privileges, but only with the minimally necessary system rights.<br>❑ Redundancy principle: The system is designed in such a way that the failure of single components does not affect the functions relevant for security. The system design reduces the probability and the effects of problems which originate from unlimited requesting of system resources, as for example main memory or network bandwidth (so called resource consumption or DoS attacks). | | | |
| ITS4. | Sensitive data shall be able to be transmitted and stored in the system encoded. For example, passwords or confidential data can belong to the data to be protected. | F | | |
| ITS5. | Only approved encryption procedures and minimum key lengths may be used which are valid according to state of the art (standard) technologies. | F | | |
| ITS6. | The data integrity must be reached at data and database level among other things by the following properties of the system:<br>❑ Guarantee for the secrecy and the protection of the data against unauthorized accesses.<br>❑ The logging of carried out interventions in the system by administrators and updates of the data by the users must be guaranteed by the system (when, what, who). The kind and the depth of the logging must be configurable. | F | | |
| ITS7. | It shall be possible that system files, applications, configuration files and application parameters will be checked automatically for integrity (e.g. by checksum.) | F | | |
| ITS8. | The traceability of transactions is to be guaranteed by suitable logging. | F | | |