European Network of
Transmission System Operators
for Electricity

EUROPEAN MERGING FUNCTION
REQUIREMENTS SPECIFICATION
THIRD EDITION

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CGM OPDE TT
BUILDING PROCESS SUB TEAM (BP ST)

This document is maintained by the Building process Sub Team (BP ST) under ENTSO-E OPDE Task Team (OPDE TT).

NOTE CONCERNING WORDING USED IN THIS DOCUMENT

The force of the following words is modified by the requirement level of the document in which they are used.

MUST: This word, or the terms “REQUIRED” or “SHALL”, means that the definition is an absolute requirement of the specification.

MUST NOT: This phrase, or the phrase “SHALL NOT”, means that the definition is an absolute prohibition of the specification.

SHOULD: This word, or the adjective “RECOMMENDED”, means that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications shall be understood and carefully weighed before choosing a different course.

SHOULD NOT: This phrase, or the phrase “NOT RECOMMENDED”, means that there may exist valid reasons in particular circumstances when the particular behaviour is acceptable or even useful, but the full implications should be understood, and the case carefully weighed before implementing any behaviour described with this label.

MAY: This word, or the adjective “OPTIONAL”, means that an item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product while another vendor may omit the same item. An implementation which does not include a particular option MUST be prepared to interoperate with another implementation which does include the option, though perhaps with reduced functionality. In the same vein an implementation which does include a particular option MUST be prepared to interoperate with another implementation which does not include the option (except, of course, for the feature the option provides).

CHANGE DETAILS

Version 3.0 includes the following main changes:

- Document structure was changed.
- Description of business process was updated.
- Document references to other relevant business documentation were updated and overlaps were removed.
- Reference program validation and replacement strategy was added.
- Model replacement strategy was extended to cover deviations between reference program and model's net position.
- Description of how to handle "partial" CGM-s was added.
- Functional and non-functional requirements tables were updated.

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
2.0	18.11.2016	Second edition after all TSO approval
2.1	23.12.2022	Version for BP ST review
3.0	11.08.2023	Updated version based on Steering Group Regional Coordination comments.

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TABLE OF CONTENT

1. INTRODUCTION

This document defines the specification of a European Merging Function (EMF) which is an essential module used for the creation of the Common Grid Model (CGM). It defines the necessary minimum business requirements for the purpose of CGM service delivery and does not cover the functional specifications of the application. Applications that conform to the EMF requirements are normally operated and hosted by RCC-s to provide ready-to-use CGM covering the whole pan-European power system for every relevant date and time. CGM-s are an input for various business processes.

This document specifies functional and non-functional requirements of an EMF application.

2. NORMATIVE REFERENCES

This section includes the references that are considered as normative for this document. When referring to the references in the document the version of the document is not cited.

[QoCDC]	Quality of CGMES datasets and calculations, version 3.3.1, 26 May 2023
[CGMIG]	CGM Building Process Implementation guide, Edition 2.0, 21 June 2023.
[E2E]	CGM Building Process End-to-End documentation, version 2.0D, 10th of October 2022.
[CGM Rotational]	CGM Rotational Principle, version 3.1, 14 October 2022

3. TERMS AND DEFINITIONS

1.1 Capacity Calculation Region

Capacity Calculation Region (CCR) means the geographic area in which coordinated capacity calculation is applied.

[SOURCE: CACM art.2.3]

1.2 Common Grid Model (CGM)

Common Grid Model (CGM) means a pan-European wide data set agreed between various TSO-s describing the main characteristic of the power system (generation, loads and grid topology) and rules for changing these characteristics during the coordinated capacity calculation process.

[SOURCE: CACM art.2.2]

1.3 Individual Grid Model (IGM)

Individual Grid Model (IGM) means a data set describing power system characteristics (generation, load and grid topology) and related rules to change these characteristics during the coordinated security analysis process, prepared by the responsible TSO-s, to be merged with other individual grid model components in order to create the common grid model.

[SOURCE: CACM art.2.1]

1.4 Regional Coordination Centre (RCC)

Regional Coordination Centre (RCC) means regional coordination centre established pursuant to Article 35 of Regulation (EU) 2019/943.

[SOURCE: Regulation (EU) 2019/943 art. 2]

1.5 Assembled model

Model of a Model Authority Set with internal references resolved.

[SOURCE: IEC 61970-600-1:2021, 3.1.1]

1.6 Boundary point (BP)

Connection point between two Model Authority Sets, that has been agreed on by both relevant Model Authority.

[SOURCE: IEC 61970-600-1:2021, 3.1.2]

1.7 Boundary set

Set containing all boundary points necessary for a merged model.

[SOURCE: IEC 61970-600-1:2021, 3.1.3]

1.8 Common Grid Model Exchange Standard (CGMES)

Collection of standards defined in IEC 61970-600 series that support the exchange of power system models (e.g., individual grid model or common grid model) between model authorities (TSO-s, DSOs, etc.) for the purpose of coordinated set of services to be performed on the same model according to legislation or general data exchanges in the frame of system operation, system development or utilities' projects.

[SOURCE: IEC 61970-600-1:2021, 3.1.6]

1.9 European extensions

Collection of classes, attributes, and associations, which either extend or are defined in the standard IEC CIM model (IEC 61970-300 series, IEC 91968-11 and IEC 62325-300 series). The European extensions aim at satisfying requirements by the European legislation hence not necessarily applicable to other continents. The worldwide adoption of these extensions may not be exactly the same as the defined extension.

[SOURCE: IEC 61970-600-1:2021, 3.1.7]

1.10 External references resolved

No dangling references are present across the models of Model Authority Sets.

[SOURCE: IEC 61970-600-1:2021, 3.1.8]

1.11 Header references resolved

References defined in model header are resolved.

[SOURCE: IEC 61970-600-1:2021, 3.1.9]

1.12 Internal references resolved

No dangling references are present within the model of a Model Authority Set.

[SOURCE: IEC 61970-600-1:2021, 3.1.10]

1.13 Merged model

Model that is a union of different assembled models with external and header references resolved.

[SOURCE: IEC 61970-600-1:2021, 3.1.11]

1.14 Profile

Data model to describe instance file for exchange of CIM data. A profile is a subset of classes, associations and attributes needed to accomplish a specific type of interface and based upon a CIM data model. Profiles may impose stricter rules on original classes and associations. A profile is usually converted to schema (XSD, RDF, OWL, etc.) that can be used to create, read, and validate instance files for data exchange Note 1 to entry: This term may be used to define either the semantic model for an instance data payload or the syntactic schema for an instance data payload. A profile may be expressed in XSD, RDF, and/or OWL files. An instance data conforming to a profile can be tested in exchanges between applications. A profile is necessary in order to "use" the canonical model.

[SOURCE: IEC 61970-600-1:2021, 3.1.12]

1.15 Solved model

Model containing instance of State Variables (SV).

[SOURCE: IEC 61970-600-1:2021, 3.1.13]

1.16 Reporting Information Market Document (RIMD)

Contains both the netted area AC positions and/or aggregated netted external schedules per scheduling area border for each scheduling area 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.

4. ABBREVIATED TERMS

CCR	Capacity Calculation Region
CGM	Common grid model
CGMES	Common Grid Model Exchange Standard
CGMA	Common Grid Model Alignment

CIM	Common Information Model (electricity)
CSA	Coordinated Security Analysis
EIC	Energy Identification Codes
EMF	European Merging Function
ENTSO-E	European Network of Transmission System Operators for Electricity
GCT	Gate Closure Time
GUI	Graphical User Interface
HVDC	High Voltage Direct Current
IEC	The International Electrotechnical Commission
IGM	Individual grid model
MAS	Model Authority Set
OPC	Outage Planning Coordination
OPDE	Operational Planning Data Environment
OWL	Web Ontology Language
PEVF	Pan European Verification function
PCN	Physical Communication Network
RCC	Regional Coordination Centre
RDF	Resource Description Framework
RSC	Regional Security Coordinator
SOC	ENTSO-E System Operations Committee
SOGL	System Operations Guideline
STA	Short Term Adequacy
TSO	Transmission System Operator
URI	Uniform Resource Identifier
XML	Extensible Markup Language
XSD	XML Schema Definition

5. CGM BUILDING PROCESS DESCRIPTION

5.1. HIGH-LEVEL BUSINESS PROCESS DESCRIPTION

The Common Grid Model creation service consists of the generation of a CGM, based on the merging of pan-European Individual Grid Models issued by all TSO-s and exchanged via OPDE to the merging agent (this is a role currently fulfilled by RSCs/RCCs). This CGM is a critical enabler of operational coordination and of security of supply on a Pan-European level, by cancelling certain case assumptions introduced in IGM-s by TSO-s due to a lack of visibility on neighbouring network models. The generated CGM-s are then the input of multiple RSC/RCC services mandated by the Network Codes (CSA, CCC, OPC, STA).

The CGM Building Process performed at merging agent level by the European Merging Functions (EMF) requires a multitude of inputs generated by a diversity of applications. Figure 1 displays a high-level representation of the CGM building process, focusing on the tasks performed by the merging agent using the EMF. The figure displays the interaction of the main and back-up RCCs with OPDE, participating in the CGM building process, following the agreed rotational principal procedure (see CGM Rotational reference). More details on the overall CGM building process, with detailed task-split from all participants, is described in the E2E documentation.

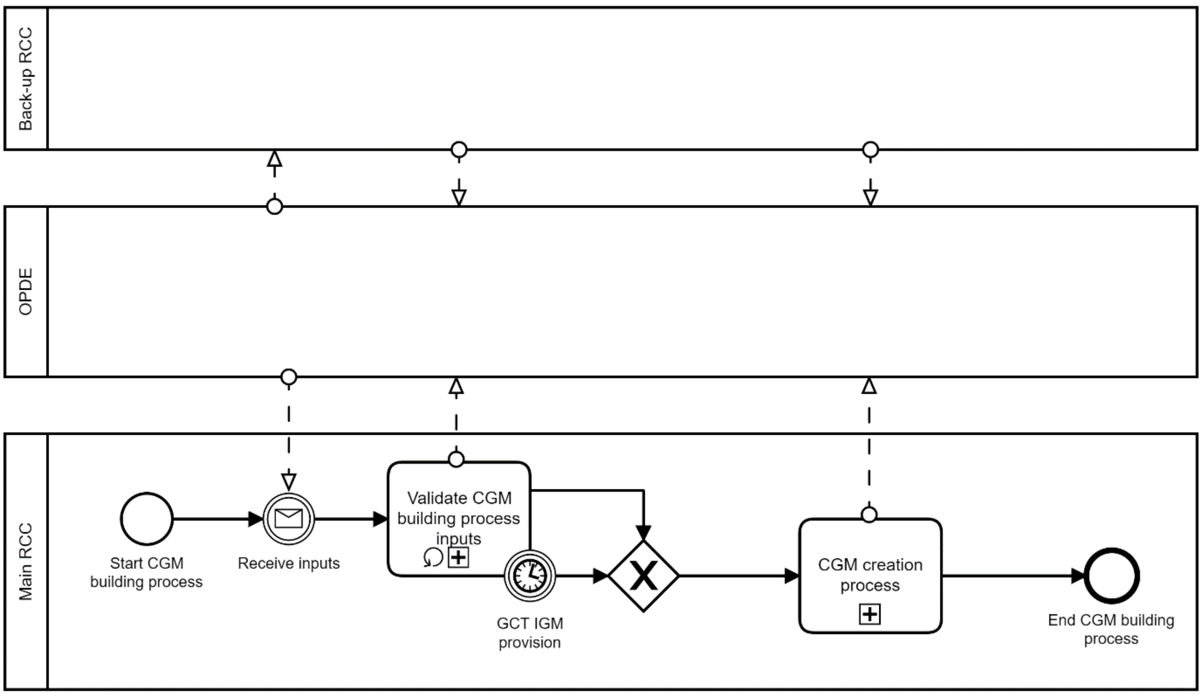

Figure 1 High-Level process description

The merging agent receives, in the happy scenario, all following required inputs:

Reference programs via ECP / EDX through OPDE, generated by either PEVF or CGMA application according to the studied time horizon. They provide respectively the target aggregated (agreed) netted external schedules (PEVF) or aligned net positions (CGMA) for all Control Areas and Synchronous Areas, and the scheduled (PEVF) or aligned (CGMA) DC flows for all interconnectors at pan-European level. These reference programs must be used by TSO-s for the creation of consistent IGM-s, and by the merging agents to guarantee that created CGM-s follow the target schedules or aligned net positions.

Boundary Set (BDS), received via OPDE, includes all the boundary information (AC and DC boundary nodes) and reference data necessary to connect and merge the pan-European IGM-s into a CGM. This BDS is validated within OPDE and is exchanged once per month or more frequently on ad-hoc requests.

IGM-s, received via OPDE and generated by TSO-s for time horizons defined in all-TSO-s approved methodologies. IGM-s shared by TSO-s are validated within OPDE, and merging agents receive through their local OPDM client's storage only the models that fulfil the quality criteria defined by QoCDC document.

The merging agent's EMF tool, through the local OPDM client storage, continuously retrieves for processing all the inputs, validates them according to specific rules described later in the document, and uses the valid inputs to generate the CGM-s. The CGM creation process shall be initiated either manually by a user or automatically by the system at the latest at Gate Opening Time (GOT) for the CGM building process. As timings for the CGM building process are very short, any required manual operation will most probably result in the breach of the CGM publication Gate Closure Time (GCT).

RSC/RCC-s participate in the CGM building process following a rotational principle and are divided in groups defined per time horizon. For each run of the CGM BP in each different group, two RSC/RCC-s are actively participating, by generating and distributing one main and one back-up CGM.

5.2. MERGING AGENT TASKS

This subsection introduces the tasks of the merging agent performed by the EMF within the CGM Building Process. It is assumed that input files are received by the OPDE client.

The detailed process performed within the EMF is described in this document by splitting the different tasks into so-called business sub-functions.

The process within the EMF tool can be split in two parts:

- Continuous input validation: continuous process of input gathering, AC power flow computation for IGM-s, validation of reference programs and EMF IGM validation report generation.
- CGM creation process: scheduled or manually triggered merging of IGM-s, replacement of missing or invalid inputs, AC power flow computation on CGM, adjustment of control areas' netted AC area positions and DC link flows, publication of CGM and EMF quality reports.

5.2.1. INPUT VALIDATION PROCESS

This subsection describes the continuous process of import and validation of IGM-s performed by the EMF before starting the actual merging process.

In this process the following business sub-functions are involved:

- Input / Output
- Power Flow
- Quality assurance

A high-level description of this process is displayed in Figure 2

The EMF continuously retrieves and imports newly available inputs required for the CGM building process.

As shortly introduced in the Section 5.1, IGM created by TSO-s and shared via OPDE are subject to a validation step performed within OPDE. Once available at the merging agent's OPDE Client, these IGM-s are imported into the EMF and are subject to another round of validation proper to the EMF.

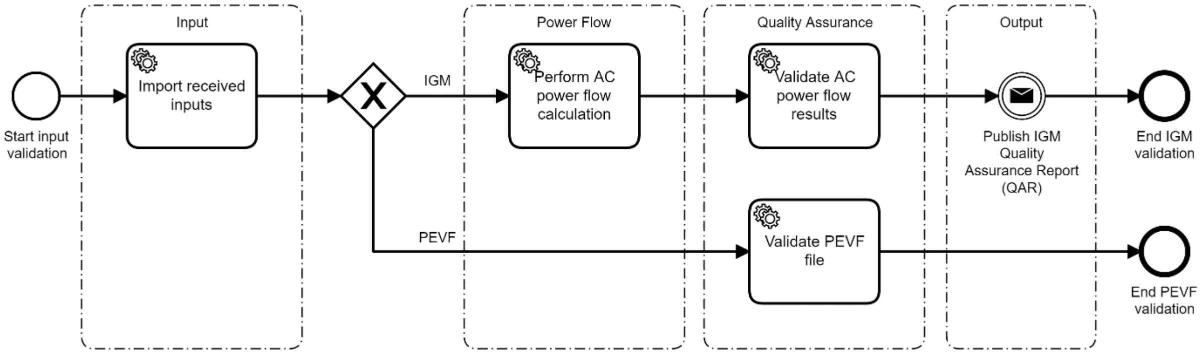

Figure 2 Input validation process

Following steps are performed for the IGM validation process performed by the EMF:

- **Input** / output business sub-function retrieves any newly available input from the connected OPDE Client.
- **Power Flow** business sub-function validates all newly imported IGM-s by performing an AC power flow using the latest official BDS published in OPDE. The AC power flow settings used for the validation of the IGM-s are specified in below subsection 6.6.1.
- **Quality Assurance** business sub-function validates:
  - IGM AC power flow results and generates an EMF Quality Assurance Report (QAR),
  - reference programs, determining if a replacement is necessary in subsequent merging process,
- Input / **output** business sub-function publishes, via the OPDE client, all generated EMF QAR(s) to the OPDE client.

5.2.2. CGM CREATION PROCESS

This subsection describes the CGM creation process that can be triggered either manually by the user or at the latest at the IGM provision GCT. This GCT varies depending on the studied time horizon.

The CGM creation process, once triggered, considers only the IGM-s successfully fulfilling the EMF power flow validation described in subsection 5.2.1, while the unavailable IGM-s or the IGM-s failing the validation are replaced according to substitution rules defined in section 6.7.

In this process the following business sub-functions are involved:

- Input / output
- Model replacement
- Model merge
- Model scaling
- Power Flow
- Quality Assurance

A high-level description of this process is displayed in Figure 3.

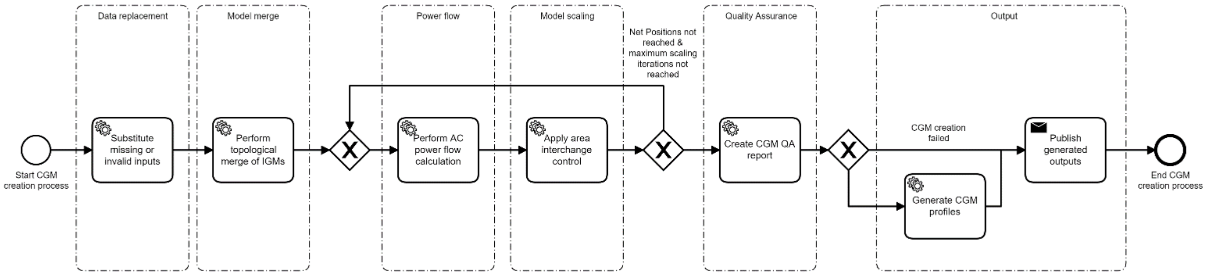

Figure 3 CGM Creation Process (happy flow)

The following steps are performed by the EMF tool during the CGM creation process:

- **Process scheduler** business sub-function allows the user to configure an automatic execution of the merging processes for each time horizon and timestamp.
- **Manual trigger** business sub-function allows the user a manual start of the merging processes for selected time horizons and timestamps.
- **Data replacement** business sub-function replaces the invalid or missing input data, according to specific rules defined per time horizon and described in section 6.7
- **Model merge** business sub-function performs the topological merge of all the considered IGM-s and solves inconsistencies at tie-lines according to specific rules defined in section 6.9.
- **Model scaling** business sub-function, by extracting the relevant values from the reference programs, enforces the DC link exchanges within the CGM and adjusts conform loads in the different control areas to guarantee that the created CGM is aligned with the target values.
- **Power Flow** business sub-function runs the AC power flow analysis on the CGM according to defined power flow settings (default and fallbacks).
- **Quality Assurance** business sub-function verifies the AC power flow results and generates an EMF Quality Assurance Report (QAR) summarizing the validation's result, references to merged models and the EMF's assumptions used for the creation of the CGM (i.e., used power flow settings).
- Input / **output** business sub-function publishes via the OPDE Client the following outputs:
    - CGM EMF QAR
    - In case of successful CGM creation process, the CGM SV and updated SSH CIMXML profiles

6. BUSINESS SUB-FUNCTIONS

The EMF implementation includes all the necessary functionalities for the purpose of performing the CGM building process. The implementation of these different functionalities might be designed following different concepts and regional requirements. Although system architecture practices recommend modular implementation, this document does not impose requirements on the design of the system. This section defines a set of business sub-functions which an EMF shall contain to successfully create CGM-s. One of the main objectives of describing business sub-functions the way they are presented in this document is to describe the EMF requirements in a more structured way.

6.1. INPUT/OUTPUT

The Input/Output sub-function includes all necessary elements to interface other systems. It is interfaced with the OPDE Client, in accordance with the Security Plan, to retrieve or publish the following data/reports:

- OPDE Client integration
    - Retrieve and import latest official BDS
    - Retrieve and import IGM-s
    - Export and publish CGM-s
    - Retrieve latest rotational calendar [Optional]
    - Retrieve CGM publication report [Optional]
    - Retrieve and import reference programs (PEVF, CGMA)
    - Export and publish EMF Quality Assurance Reports (IGM, CGM)
    - Retrieve IGM Quality Assurance Reports [Optional]

6.1.1. CONNECTION TO THE OPDE

The EMF is interfaced to the Operational Data Management Environment (OPDE), consisting of a Physical Communication Network (PCN) using communication layer (ECP/EDX) to exchange data between a set of applications responsible for generating the input data necessary to perform the CGM creation service. The EMF is interfaced to OPDE via the OPDE client, as described in Figure 4, following the requirement defined in the Security Plan.

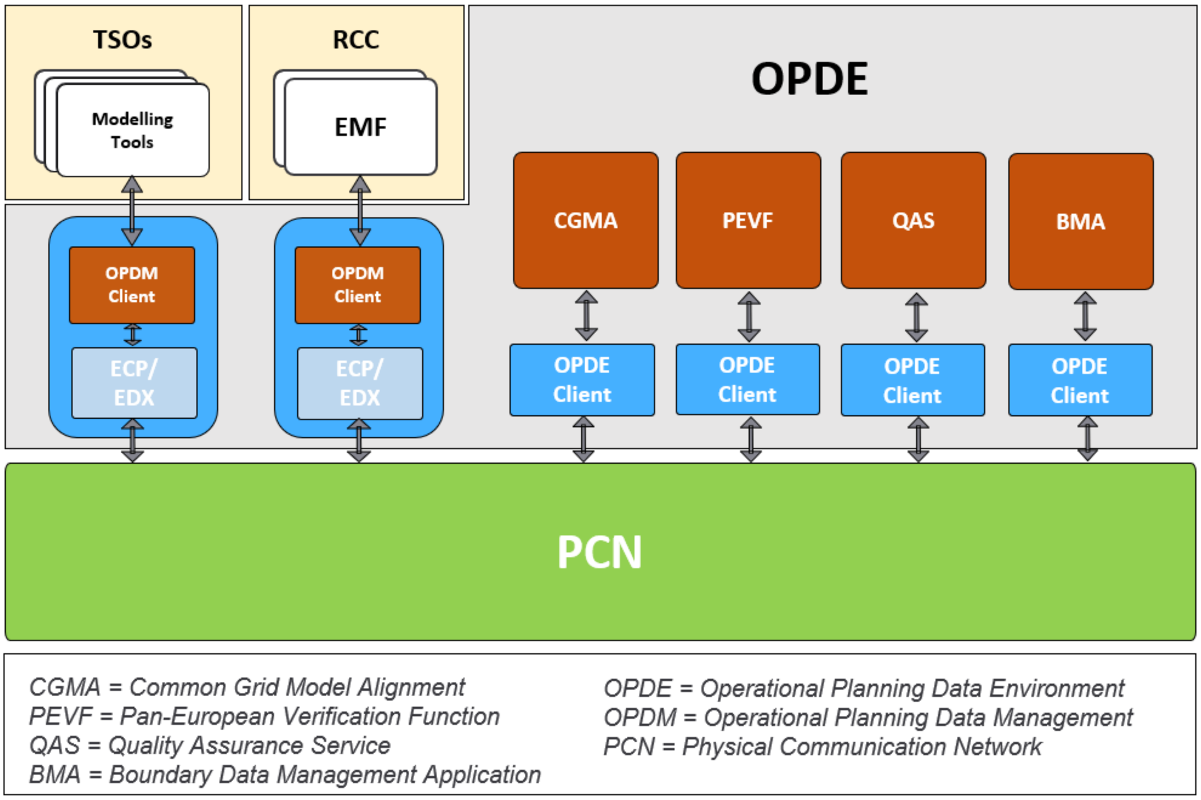

Figure 4 Conceptual diagram of the OPDE

The OPDE Client constitutes the entry point for OPDE for users and external applications. Users and specific applications (e.g., modelling tools from TSO-s, merging applications) will interact with OPDE clients through specific endpoints and/or GUIs to publish, subscribe to or download any OPDE data that are required in business operations.

The communication between OPDE clients and OPDE service providers is handled by the generic EDX / ECP communication layer (through specific messages) using the PCN infrastructure.

6.2. METADATA AND STORAGE

Metadata and storage sub-function is recommended for the storing of data as follows:

- Store reference programs (PEVF, CGMA) information and relevant metadata
- Store BDS information and relevant metadata
- Store IGM-s information and relevant metadata
- Store CGM-s information and relevant metadata
- Store data items consistency and validity status in metadata

EMF data retention time shall be defined at least in accordance with the OPDM client retention rules defined within the E2E document but can extend the retention time.

The sub-function should have data query functionality to enable finding relevant input data for a process. For information, examples of the reference data structure that should eventually be used by the EMF is available on http://energy.referencedata.eu.

6.3. PROCESS SCHEDULER

The process scheduler business sub-function enables users of the EMF to configure an automatic execution of the merging process at a configured time for:

- given time horizon.
- given business day and timestamp.

Configuration of automatic execution of the merging process is recommended due to very short timing for this process for any time horizon.

6.4. MANUAL TRIGGER

The manual trigger business sub-function enables users of the EMF to manually start the execution of a merging process for:

- given time horizon.
- given business day and timestamp.

6.5. QUALITY ASSURANCE

The quality assurance sub-function includes one or more validation engines to validate the different inputs required to perform the CGM service creation. The validation follows requirements by the data exchange standards and business requirements on quality checks. This sub-function can be seen as an additional quality gate to the ones already in OPDE.

IGM-s and CGM-s validation sub-functions may rely on the information included in Quality Assurance Reports published to OPDE for visualization purposes or to determine if prerequisites for the model merge are fulfilled. EMF implementations may repeat prior validations to confirm results.

Quality assurance is performed by the EMF at different stages as follows:

- After PEVF is retrieved from the OPDE (mandatory)
- After boundary set is retrieved from the OPDE (optional);
- After IGM is retrieved from the OPDE (optional);
- After an import of an IGM (optional);

- After power flow calculation of an IGM (mandatory level 8 QoCDC validation in scope of EMF, which includes load flow feasibility check);
- After the merge of a CGM (mandatory level 8 QoCDC validation in scope of EMF, which includes load flow feasibility check);
- After an export of a CGM (optional).

To perform the quality assurance verification, the EMF requires the following inputs:

- IGM-s;
- Boundary Data Set (latest official);
- PEVF output (for Day-Ahead and Intra-day processes);
- CGMA output (for all time horizons prior to Day-Ahead).

Quality assurance aims at checking:

- If PEVF is balanced, as defined in CGM IG
- If an IGM is suitable for model merge, e.g., has the expected quality, power flow converges. Optionally, additional verifications might be implemented aiming at improving the CGM power flow results, e.g., comparison of computed power flow results with provided SV information from the IGM. Any optionally added validation checks should not result in IGM-s or CGM-s being excluded in the process, nor change any of their content.
- If a CGM converges and if power flow solution calculated by the EMF are plausible and computed net positions are within defined thresholds compared to reference programs.

The results of the mandatory level 8 EMF load flow feasibility verifications on IGM-s and CGM-s shall be reported to all parties via the Quality Assurance Reports (QAR-s) exported by the I/O business sub-functions to the OPDE client. These QAR-s shall report any eventual violations of some QoCDC level 8 rules not validated within the OPDE client. The QAR-s are XML files that shall be created in accordance with defined XSD.

The results of the IGM quality assurance are input for the model replacement process, and any eventual performed replacement shall be reported in the exported CGM QAR-s to enable simpler reporting of the used models in the merging process.

The same is valid for PEVF files. The sum of scheduling area’s AC net positions within a synchronous area shall be equal to zero (inside a threshold of ±2MW per synchronous area), i.e., AC net positions are balanced. Balanced AC net positions are the main requirement that enables the merge of IGM-s into the CGM. The balance of AC net positions for every synchronous area is to be validated for every time stamp. PEVF is considered valid if all synchronous areas are balanced. The results of the PEVF quality assurance is input for PEVF replacement process, that can as well be triggered if PEVF is missing as an input.

6.6. POWER FLOW

Depending on the modelling style used in the exchanged models for power flow calculation, the power flow may require topology processing. Topology processing algorithm uses the information on model connectivity, switching device statuses and bus section information to determine the network connectivity and to develop a bus-branch model representation eliminating zero impedance branches. This model forms the basis for the power flow calculation algorithm. Topology processing can also be done “by proxy”, i.e., the data from the TP instance file is used instead of performing complete topology processing.

To increase the feasibility of power flow convergence as well as to keep a sufficient performance of the calculations, a defined set of power flow settings for power flow calculation shall be used on either IGM or CGM. These settings include consideration of regulation of transformers and of switched shunts, consideration of active and/or reactive power limits, conditions related to active power slack and necessary power flow algorithm tolerances. Details on the conditions are provided in QoCDC and in the definition of the power flow settings.

6.6.1. POWER FLOW SETTINGS

The information on power flow settings used to calculate power flow on an IGM or on a CGM is important for the preparation of the quality reports and CGM creation process. Earlier versions of the CGMES do not include the capability to exchange this information. However, edition 2 of IEC 61970-457[1] includes Simulation settings profile, which can be used for exchange of power flow calculation settings together with IGM and CGM as well as for defining reference data on the power flow settings. The upgraded version of the document header enables reference to the calculation settings, and this can be used to refer to the set of power flow settings to be used to calculate a model. Examples of the reference data structure for the power flow settings can be found on http://energy.referencedata.eu. Nevertheless, the minimum power flow settings to be supported by the EMF shall be aligned with the IGM and CGM power flow level 8 plausibility rules from QoCDC document.

6.7. DATA REPLACEMENT

In this chapter, the data replacement rules define a set of fallback choices in case of missing or invalid mandatory inputs (IGM-s, RIMD file output from PEVF/CGMA). It shall be noted that when applying any of the defined fallbacks, replaced data will have an impact on the quality of the produced CGM-s and will introduce potential inconsistencies between models and/or used RIMD file. The rules to solve such inconsistencies are present in chapter 6.9.1.

[1] IEC 61970-457:Ed2 expected to be published early 2024

6.7.1. MODEL REPLACEMENT

Model replacement sub-function shall be triggered when one or more pan-European IGM-s are unavailable for the merging, either due to not received IGM-s, or in case received IGM-s are considered invalid according to the EMF mandatory quality assurance verifications.

The replacement rules aim at selecting valid IGM-s from the already available models according to a defined logic, presented below. These replacement rules shall be applied at the latest at the time horizon's specific GCT for IGM provision.

An additional logic is applied in case an inconsistency between the computed IGM AC net position and target AC net position from RIMD file is identified in chapter 6.9.1.

6.7.1.1. REPLACEMENT OF MISSING OR DIVERGING IGM

The general principles of the model replacement steps are the following:

- 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.

In details follow the steps described below[2]:

										Load increase		Beginning of outages												End of outages / winter peak				
CE(S)T	UTC (during CEST)	UTC (during CET)	CE(S)T	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
			UTC (during CEST)	22:30	23:30	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
			UTC (during CET)	23:30	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
00:30	22:30	23:30	Replaced by ->	1	2	3	4	5	6																		
01:30	23:30	00:30	Replaced by ->	5	1	2	3	4	6																		
02:30	00:30	01:30	Replaced by ->	5	3	1	2	4	6																		
03:30	01:30	02:30	Replaced by ->	6	4	2	1	3	5																		
04:30	02:30	03:30	Replaced by ->	6	4	3	2	1	5																		
05:30	03:30	04:30	Replaced by ->			5	4	2	1	3																	
06:30	04:30	05:30	Replaced by ->							1	2	3	4	5	6	7											
07:30	05:30	06:30	Replaced by ->								1	2	3	4	5	6											
08:30	06:30	07:30	Replaced by ->									1	2	3	4	5											
09:30	07:30	08:30	Replaced by ->									3	1	2	4	5											
10:30	08:30	09:30	Replaced by ->									3	2	1	4	5											
11:30	09:30	10:30	Replaced by ->										5	2	1	3	4										
12:30	10:30	11:30	Replaced by ->										5	3	2	1	4										
13:30	11:30	12:30	Replaced by ->											5	4	2	1	3									
14:30	12:30	13:30	Replaced by ->											7	6	5	4	1	2	3							
15:30	13:30	14:30	Replaced by ->													6	5	4	1	2	3						
16:30	14:30	15:30	Replaced by ->													6	5	4	3	1	2						
17:30	15:30	16:30	Replaced by ->													7	6	5	4	3	1	2					
18:30	16:30	17:30	Replaced by ->													7	6	5	4	3	2	1	8				
19:30	17:30	18:30	Replaced by ->																			3	1	2	4	5	
20:30	18:30	19:30	Replaced by ->																				2	1	3	4	5
21:30	19:30	20:30	Replaced by ->																				4	2	1	3	5
22:30	20:30	21:30	Replaced by ->																				5	4	2	1	3
23:30	21:30	22:30	Replaced by ->																				5	4	3	2	1

Priorities:	1	2	3	4	5	6	7	8
Accuracy:	Highest							Lowest

Table 1 Model replacement priority rules[3]

[2] Substitution rules must follow the OPDE retention period rules in terms of availability of data.

[3] Previous valid version must be used for priority 1 (if any) and only in step 1 of replacement strategy, for subsequent steps only latest valid version shall be considered.

STEP 1. Use an IGM of the same time horizon of the same energy delivery day following the priority defined in Table 1.

STEP 2. If not available, use an IGM from the same energy delivery day (other time horizon in consecutive order[4]), following the priority defined in Table 1.

STEP 3. If not available, use an IGM from the same time horizon of older models of the same day type (working day, Saturday, Sunday), season and scenario type (peak, valley), following the priority defined in Table 1. Handling holidays is established based on the per-TSO request and provided via centralized approach, by using either previous day, Saturday, or Sunday data (single option or define prioritization). It is a prerequisite to have the holiday definitions per TSO/IGM and an indication if the substitution strategy should consider previous day, Saturday, or Sunday data and if the prioritization should be set.

STEP 4. If not available, use older files of a different day type, following the priority defined in Table 1, considering the following general principles: for working days prioritize Saturday over Sunday, for Saturday prioritize Sunday over closest working days, and for Sunday prioritize Saturday over closest working days.

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

Below, two examples are provided for the application of the replacement strategy.

[4] Until Week-ahead is established with 24 timestamp delivery, fallback is not foreseen from ID, 1D, and 2D to other time horizons.

- Intraday replacement strategy example scenario:

Merging start time UTC (in CET)	01:05 on 22.02.2023.
Invalid / missing IGM	20230222T**0130Z_01**_TSO_SV_003.zip
Day type	Wednesday

- The choice of the replacement models shall be done following the below priority list:

Intraday replacement example	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Priority 6
STEP 1.	20230222T0130Z_01 Previous valid version if any	20230222T0230Z_02	-	20230222T0330Z_03	-	20230222T0430Z_04
STEP 2. For ID iterate through the previous runs (hours-ahead)	20230222T0130Z_02	20230222T0230Z_03	20230222T0030Z_01	20230222T0330Z_04	-	20230222T0430Z_05
...	20230222T0130Z_03	20230222T0230Z_04	20230222T0030Z_02	20230222T0330Z_05	20230221T2330Z_01	20230222T0430Z_06
…	…	…	…	…	…	…
... until 1D	20230222T0130Z_1D	20230222T0230Z_1D	20230222T0030Z_1D	20230222T0330Z_1D	20230221T2330Z_1D	20230222T0430Z_1D
… until 2D	20230222T0130Z_2D	20230222T0230Z_2D	20230222T0030Z_2D	20230222T0330Z_2D	20230221T2330Z_2D	20230222T0430Z_2D
STEP 3. Same timehorizon, older models of same day type**.**	20230021T0130Z_XX	20230021T0230Z_XX	20230221T0030Z_XX	20230221T0330Z_XX	20230220T2330Z_XX	20230221T0430Z_XX
…	20230220T0130Z_XX	20230220T0230Z_XX	20230220T0030Z_XX	20230220T0330Z_XX	20230219T2330Z_XX	20230220T0430Z_XX
…	20230217T0130Z_XX	20230217T0230Z_XX	20230217T0030Z_XX	20230217T0330Z_XX	20230216T2330Z_XX	20230217T0430Z_XX
…	…	…	…	…	…	…
STEP 4. Same time horizon, older models of different day type.	20230218T0130Z_XX	20230218T0230Z_XX	20230218T0030Z_XX	20230218T0330Z_XX	20230217T2330Z_XX	20230218T0430Z_XX
…	20230219T0130Z_XX	20230219T0230Z_XX	20230219T0030Z_XX	20230219T0330Z_XX	20230218T2330Z_XX	20230219T0430Z_XX
…	…	…	…	…	…	…

Table 2 Example of replacement strategy for Intraday time horizon[5]

[5] *XX* being the latest available valid version of hours-ahead, 01 having highest priority.

- Day-Ahead replacement strategy example scenario:

Merging start time in CET	18:50 on 21.02.2023.
Invalid / missing IGM UTC (during CET)	20230222T0130Z_1D_TSO_003_SV.zip
Day type	Wednesday

- The choice of the replacement models shall be done following the below priority list:

Day-ahead replacement example	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Priority 6
STEP 1.	20230222T0130Z_1D Previous valid version, if any	20230222T0230Z_1D	20230222T0030Z_1D	20230222T0330Z_1D	2023021T2330Z_1D	20230222T0430Z_1D
STEP 2.	20230222T0130Z_2D	20230222T0230Z_2D	20230222T0030Z_2D	20230222T0330Z_2D	20230221T2330Z_2D	20230222T0430Z_2D
STEP 3. Same timehorizon, older models of same day type	20230221T0130Z_1D	20230221T0230Z_1D	20230221T0030Z_1D	20230221T0330Z_1D	20230220T2330Z_1D	20230221T0430Z_1D
	20230220T0130Z_1D	20230220T0230Z_1D	20230220T0030Z_1D	20230220T0330Z_1D	20230219T2330Z_1D	20230220T0430Z_1D
…	20230217T0130Z_1D	20230217T0230Z_1D	20230217T0030Z_1D	20230217T0330Z_1D	20230216T2330Z_1D	20230217T0430Z_1D
…	…	…	…	…	…	…
STEP 4. Same timehorizon, older models of different day type	20230218T0130Z_1D	20230218T0230Z_1D	20230218T0030Z_1D	20230218T0330Z_1D	20230217T2330Z_1D	20230218T0430Z_1D
	20230219T0130Z_1D	20230219T0230Z_1D	20230219T0030Z_1D	20230219T0330Z_1D	20230218T2330Z_1D	20230219T0430Z_1D
…	…	…	…	…	…	…

Table 3 Example of replacement strategy for Day-Ahead time horizon

6.7.1.2. Replacement of an IGM due to AC net position inconsistency

The replacement of valid original IGMs according to mandatory EMF quality assurance verification shall be performed as well in case an inconsistency of the computed IGM AC net position versus target AC net position from used RIMD is raised.

In this situation only the STEP 1 described in 6.7.1.1 replacement rules shall be considered. It is considered that rejecting an IGM due to the AC net position inconsistency and replacing it with an IGM of the same energy delivery day and previous time horizon will introduce more inaccuracy (topology, generation pattern).

If Scalability of an IGM (see chapter 6.9.1) is greater than Scalability threshold, an IGM shall be replaced according to the STEP 1, taking into account the scalability of the IGM used for replacement according to the previously described steps, always compared towards the target net position in the RIMD file for the timestamp of the IGM being replaced.

6.7.2. Reference program replacement

In case reference program, PEVF or CGMA, is missing or not balanced (in case of PEVF) and the gate closure time for a CGM merge approaches, the following replacement steps per time horizons are foreseen.

6.7.2.1. INTRADAY

Thirty (30) versions of preliminary intraday schedules are provided for every intraday market gate, for a given market time unit (MTU), starting from publication to OPDE at 18:30h CE(S)T on the day before intraday process up to the last, 30th version of the intraday PEVF document published at 23:30h CE(S)T on the day of the intraday process.

STEP 1. If PEVF provided at hh-01:30 CE(S)T for the merge of the reference hour hh CE(S)T is not available, use latest balanced PEVF of the previous hours-ahead[6] and the same energy delivery day.

STEP 2. If not available or balanced, for none of the previous hour(s)-ahead, use the PEVF of the final Day-Ahead reference program.

6.7.2.2. DAY-AHEAD

Day-Ahead schedules as PEVF are provided as:

- Preliminary reference program at 16:30h CE(S)T
- Final reference program at 17:50h CE(S)T

The substitution of the reference program for Day-Ahead process will follow as:

STEP 1. If the final reference program is not available or invalid, use the preliminary reference program of the same energy delivery day.

STEP 2. If not available or invalid, use the CGMA final results of the same energy delivery day.

STEP 3. If not available or invalid, use PEVF results from the previous energy delivery day.

6.7.2.3. 2D, WK, MO, YR

For the two days ahead, reference programs are provided by CGMA platform as:

- Initial reference program finalized at 17:15h CE(S)T
- Final CGMA document with PSLC results provided at 17:30h CE(S)T

The substitution of the reference program for two days ahead process will follow as:

STEP 1. If the final reference program is not available, use the initial reference program of the same energy delivery day.

STEP 2. If not available, use the CGMA final results of the same energy delivery day from the previous time horizon.

[6] For intraday time horizon, it represents the previous version of PEVF, generated one hour earlier.

6.7.2.4. Schedules or aligned HVDC flows

Reference programs are expected to contain, next to the net positions per AC scheduling area, the flows for HVDC links, per pole. In case a schedule for an HVDC pole is missing, in PEVF reference program or in initial CGMA used during replacement, IGM-s are to be used as the source of the information for the flows per HVDC pole.

We can differentiate two cases:

- DC IGM is not provided:
  - Only one AC IGM is provided:
    - Use the value from the provided AC IGM
  - Both AC IGM-s are provided:
    - If the flows are inside configurable (default value 2%[7]) offset, use the values from the AC IGM-s as-is.
    - If the values are outside the configurable offset, use the average value of the two, maintaining the direction of the flow.
- DC IGM is provided:
  - Use the values from DC IGM.

6.8. Model Scaling

Model scaling is applied when the following situations occur:

- When an IGM does not meet the targeted net interchange with the latest information from reference program.
- When an IGM is not available, and a model replacement is used.

It is done upon a topologically merged IGM-s after verification of the alignment with reference program.

There are two area interchange control algorithms that are considered when applying model scaling. They are described in the following subsections.

6.8.1. Embedded area interchange control

Embedded area interchange control includes area control equations that integrate the scaling of the loads in Newton-Raphson's power flow calculation algorithm. Active power slack is not adjusted between iterations. The procedure can be applied to realize embedded area interchange control:

1. P and Q equations are represented explicitly.

[7] Default value capturing power flow losses on HVDC link.

The following area swing equation is added:

$S_k = \sum_{i=1}^{l_k}(\frac{\partial S_k}{\partial \delta p_i}\Delta\delta p_i + \frac{\partial S_k}{\partial Ep_i}Ep_i\frac{\Delta Ep_i}{Ep_i} + \frac{\partial S_k}{\partial \delta q_i}\Delta\delta q_i + \frac{\partial S_k}{\partial Eq_i}Eq_i\frac{\Delta Eq_i}{Eq_i})$, where:

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*

Ep_i represents the voltage magnitude at terminal in area k for tie-line *i*

Eq_i represents the voltage magnitude at terminal outside area k for tie-line *i*

δp_i represents the voltage angle of terminal in area k for tie-line *i*

δq_i represents the voltage angle of terminal outside area k for tie-line *i*

With:

$\frac{\partial S_k}{\partial \delta q_i} = Ep_iEq_i(-Bp_iq_i\cos(\delta p_i - \delta q_i) + Gp_iq_i\sin(\delta p_i - \delta q_i))$

$\frac{\partial S_k}{\partial Eq_i}Eq_i = Ep_iEq_i(Gp_iq_i\cos(\delta p_i - \delta q_i) + Bp_iq_i\sin(\delta p_i - \delta q_i))$

$\frac{\partial S_k}{\partial \delta p_i} = -\frac{\partial S_k}{\partial \delta q_i}$

$\frac{\partial S_k}{\partial Ep_i}Ep_i = \frac{\partial S_k}{\partial Eq_i}Eq_i - 2Ep_i^2Gp_iq_i$, where:

Gp_iq_i represents the conductance of tie-line *i*

Bp_iq_i represents the susceptance of tie-line *i*

2. ΔS_k = Netted Area AC position – S_k (calculated)
3. Slack variables are paired up as follows:
   - System real (active) power slack paired with reference bus P equation.
   - Area real (active) power slack paired with area interchange equations.
   - System reactive power 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.

6.8.2. "CLASSIC" AREA INTERCHANGE CONTROL

In the "classic" area interchange control, corrections to conform load are applied in multiple iterations outside Newton-Raphson power flow algorithm. The following procedure is applied:

1. Perform power flow calculation.
2. Compare the target values for AC net positions and DC links with the values recorded after calculating the power flow on the model.
   - Calculated power flow on DC links shall be equal to the target value of the scenario.
   - Calculated AC net position shall be equal to the reference value of the scenario.
3. The discrepancy threshold is defined as follows:

$$\left|\sum AC\ tieline\ flows - Netted\ Area\ AC\ position_{Scheduling\ Area}\right| < INTERCH\_IMBALANCE\_EMF\ MW, \forall\ (Scheduling\ Areas)$$

where INTERCH_IMBALANCE_EMF is defined in the latest QoCDC document.

4. If the discrepancy occurs, the conform loads of each scheduling area are modified proportionally to match the AC net position, while maintaining the power factor of the loads. This can be realized by applying distributed active power slack by loads.
5. Power flow calculation is performed followed by a check if the conform loads in the scheduling area must be adjusted again.
6. If the active power of the global slack bus exceeds a configurable threshold, this power mismatch shall be redistributed on all generation units in the synchronous area, proportional to their reserve margin. The active power mismatch is the difference between the active power of the IGM active power slack and the active power of the CGM active power slack generator. This can be realized by a distributed active power slack by generators.
7. The procedure is completed when one of the following conditions is fulfilled:
   - All the differences between the computed and target values of the net positions of scheduling areas are below the defined discrepancy threshold.
   - After a predefined number of iterations (the number of iterations is configurable with default value set to 15; the parameter is different than the Newton-Raphson power flow calculation algorithm's iteration limit).

6.9. MODEL MERGE

Model merge sub-function includes functionalities related to:

- resolving tie-line inconsistencies between the models in scope
- perform a topological merge of all the models in scope.

6.9.1. HANDLING OPERATING ASSUMPTIONS/INCONSISTENCIES

The operating assumptions, defined within the IGM, provide the scenario specific values for a given point in time and are depending on the time horizon, scenario time and IGM version. For same timestamp and time horizon, multiple versions of IGM-s could be present, the one with highest version shall be used.

It should be noted that the EMF shall always use the best available information from OPDE. Therefore, updates of boundary sets, of IGM-s and/or RIMD, if applicable, shall be considered in the model merge.

Despite applying this logic, or due to performed data replacement, it is not guaranteed the absence of operating assumption and state variables inconsistencies related to:

- Values of the operational limits defined in the IGM-s of two neighboring TSO-s for the same interconnector.
- Switching status defined in the IGM-s of two neighboring TSO-s for the same interconnector.
- The sum of calculated exchanges provided in the IGM-s should match the value of the external schedule defined in PEVF/CGMA.

QoCDC includes some rules to monitor the quality of the IGM-s but does not recommend rules for resolving the identified inconsistencies. Therefore, only if responsible TSO is not able to provide valid data in due time (GCT for IGM provision), the following general rules shall apply to solve inconsistencies:

Type of inconsistency	**General Correction Rules**
Inconsistent switching status of an interconnector	Consider interconnector open in both IGM-s, to simulate the worst-case scenario
Inconsistent values of operational limits of an interconnector	Use the smaller operational limit value when determining and reporting the congestion on the interconnector as violation of PATL limits, which is performed as part of QoCDC based validation

The third type of inconsistency originates from the offset of the IGM's AC net position compared to RIMD values. To quantify the offset, following definitions are introduced:

- AC net position inconsistency for an IGM: AC net position vs target AC net position deviation, assessed between the computed IGM AC net position and the target AC net position from the relevant RIMD file.
- Scalability of an IGM: ratio between AC net position inconsistency and sum of all cim:ConformLoad-s
- Scalability threshold: maximum allowed Scalability, configurable parameter subject to change, based on operational experience, default value 1/5

If the Scalability of an IGM is less or equal to the Scalability threshold, enforce target net position provided in the RIMD file using area interchange control. If Scalability of an IGM is greater than Scalability threshold, the IGM shall be replaced (see 6.7.1).

6.9.2. TOPOLOGICAL MERGE

According to the definitions from the CGMES, which are also referred to in Section 3 of this document, the topological merge is a process in which:

- Different datasets composing an IGM are assembled according to internal references.

- A union of different assembled IGM are merged, with all header references resolved, i.e., no dangling references are present.

Normally an IGM should have only external references to the boundary data set.

Topological merge uses all relevant data for the CGM, i.e., it includes DC IGM-s modelling TSO internal or cross TSO interconnections as well, if these are available in the OPDE.

Detailed models for HVDC links internal for the TSO-s are exchanged as separate DC IGM-s that are provided by the responsible TSO as a service to other TSO-s and Merging agents.

In cases where a HVDC link connects AC IGM-s from different TSO-s, one of the TSO-s shall take the role of the modelling authority responsible for the HVDC link. Both TSO-s have a bilateral interest in the HVDC link and are supposed to cooperate in the modelling of the DC IGM despite one of them being assigned the modelling responsibility.

6.9.3. PARTIAL CGM

Partial CGM is the ability of the EMF to handle the merging of an incomplete pan-European dataset. This can occur if there are missing IGM-s and the replacement rules do not identify a suitable model to use. When testing a business process, this situation might also occur more frequently.

During creation of a partial CGM, EMF monitors AC net positions and DC schedules as for a complete CGM, but at the places where IGM is missing the interconnections are not complete. Depending on topology, multiple islands could be created. If this is the case the EMF shall ensure that there are slacks available for all islands with energized boundary points.

For each topological island created during the partial merge process, EMF shall ensure that the sum of the net positions in RIMD for identified topological island is equal to the sum of equivalent injections modeled on unpaired borders, by distributing the difference (if any) across unpaired borders proportionally to absolute value of equivalent injection's initial active power, while always maintaining a constant power factor.

It shall be considered if the topological island contains unpaired borders that are not connected, like the case shown in Figure 5. Such borders will be scaled separately, in order to maintain the direction of the flows, in the provided example – from east to west and the flow in/from central area.

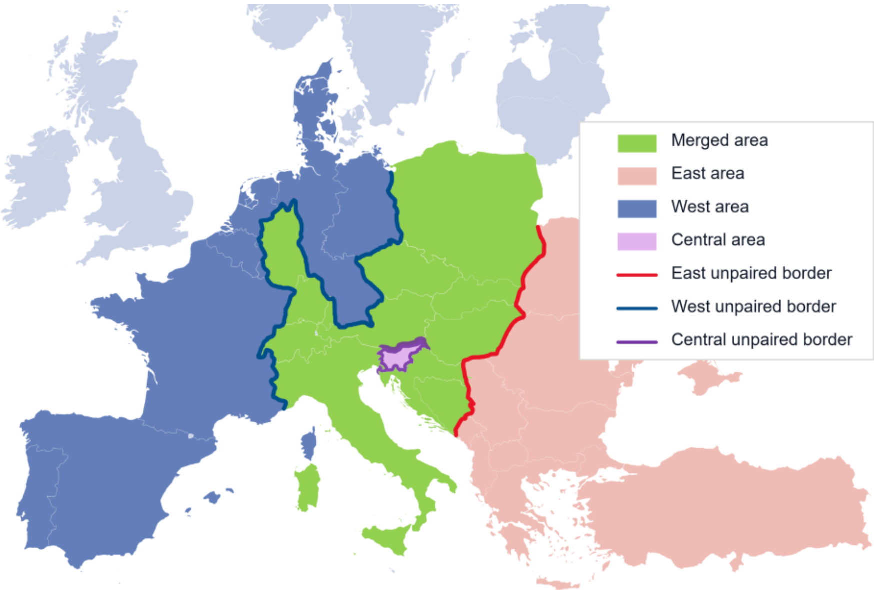

Figure 5 Borders of partially merged area

7. FUNCTIONAL AND NON-FUNCTIONAL REQUIREMENTS

7.1. REQUIREMENTS CLASSIFICATION

The requirements are structured in following classes:

Class	Type of requirement	Description
M	Must have	Mandatory requirement
R	Recommendation	Recommendation on requirement or implementation
I	Information	No requirement, only for informational purpose.

7.2. NON-FUNCTIONAL REQUIREMENTS

7.2.1. COMMUNICATION INFRASTRUCTURE

Number	Requirement	Class
COM1.	Temporary interruption in communication media shall not interrupt the process of already received complete datasets.	M
COM2.	As ECP/EDX and OPDM have different APIs, it is recommended to use the available AMQP API which is in line with the security plan.	R

7.2.2. TIME SYNCHRONISATION AND DAYLIGHT-SAVING TIME

Number	Requirement	Class
TIM1.	The EMF shall use the Universal Time Coordinated (UTC) to ensure a single time reference and compliance with data exchange standard throughout the whole system.	M
TIM2.	The system should be able to display local time on users' request.	R
TIM3.	The system shall support time synchronization for all system components.	M
TIM4.	The EMF should be able to display Central Europe Time (CET) to ensure the merging process complies with the expected timeline described in the CGM Methodology.	R

Number	Requirement	Class
TIM5.	It should be possible to disable this time synchronization function and to set the time manually by the Merging Application Administrator for testing purposes in a testing environment.	R
TIM6.	It should be possible that each Merging Application has an own time ('time travelling' without change servers' system time).	R
TIM7.	Software functions shall consider local time zones with daylight saving time specifics, particularly with regard to the data management.	M

7.2.3. IT-SECURITY AND CONFIDENTIALITY

Number	Requirement	Class
ITS1.	EMF shall implement all requirements specified in the OPDE PCN Agreement for the Minimum Viable Solution.	M

7.2.4. EMF APPLICATION GRAPHICAL USER INTERFACE (GUI)

Number	Requirement	Class
GUI1.	The GUI shall allow the user to trigger the I/O sub-function to retrieve inputs and provide outputs required for the CGM service delivery, as allowed by the security plan.	M
GUI2.	For initiating a model merge, it shall be possible to select input data, based on the following minimum criteria: ❑ Date and time to be studied ❑ Type of data to be used (MAS, Boundary Data Set, and/or AC Net Positions and HVDC flows from reference program) ❑ MA (in case of MAS data) ❑ Scope of data to be used (time horizon) ❑ Version of data to be used (based on IGM SV)	M
GUI3.	When retrieving a historical CGM case, it shall be possible to display the following characteristics of the CGM: ❑ Target date and time of the CGM ❑ Merging entity that created the CGM ❑ Creation date and time ❑ Type of CGM (time horizon) ❑ Version number of the CGM (based on the CGM SV)	M

Number	Requirement	Class
	❑ Specification of the input data that was used: ○ For each MAS: TSO, creation date and time, version number (based on IGM SV) ○ For reference program: creation date and time, version number	
GUI4.	The GUI shall allow users to view the file history of inputs imported, uploaded, and validated by the system related to the CGM process.	M
GUI5.	The GUI shall allow users to view a map with all the TSO-s, their delivered IGM-s and validation statuses including boundary point inconsistencies. It shall be possible to distinguish new versions of IGM-s received.	M
GUI6.	The GUI shall display the EMF specific quality assurance verifications results.	M
GUI7.	The GUI should display validation results (retrieved QAR received via OPDE or validation results performed by EMF).	R
GUI8.	The GUI should allow the users to filter the quality assurance results per severity type (error, warning).	R

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7.2.5. CONFIGURATION AND PERFORMANCE

Number	Requirement	Class
CON1.	Different workflows supported by the EMF should be configurable via user interface.	R
CON2.	Search options supported by the EMF should be configurable to enable customizable assembled IGM/CGM selection when retrieving data. This functionality should extend to other data related to CGM service delivery (i.e., BDS, RIMD).	R
CON3.	The EMF shall complete the CGM creation, including submission to OPDE, in 15min starting from triggering of the process. This also includes the time needed for submission of validation reports to OPDE.	M
CON4.	The EMF shall support parallel merging executions for multiple timestamps. Each individual CGM creation shall comply with CON3 requirement.	M
CON5.	The EMF shall allow manual upload of files required for the CGM build process by users.	M
CON6.	The EMF should allow to set, load, update the parameters and rules to use for the CGM process per time horizon, including replacement strategy, scenario times, quality assurance and input/output execution.	R
CON7.	The EMF should allow to configure data replacement rules as defined in Data Replacement functional requirements and be able to reconfigure/change the logic, if necessary.	R

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7.3. FUNCTIONAL REQUIREMENTS

7.3.1. INPUT/OUTPUT

7.3.1.1. APPLICATION INTERFACES

Number	Requirement	Class
INT1.	Input/output sub-function shall enable to import the data received from OPDE and identify the data based on the information in the file headers.	M
INT2.	The following serialization standards shall be supported: - CIM/XML that conforms to the version agreed to be used for the operational planning processes. - QAR scheme - RIMD – reference schedules scheme	M
INT3.	Input/output sub-function shall be able to export CGMES based models that conform to the standard enforced for the operational planning processes.	M
INT4.	Model import and export functions should have flexible implementation to enable fast transition from one version of the data exchange standard to another. This requirement propagates to the flexibility of the whole system and not only to this specific subfunction.	R

7.3.1.2. INPUT DATA INTERFACES

Number	Requirement	Class
IO1.	For all relevant time horizons, the IGM-s related data of all TSO-s, boundary data set, RIMD from CGMA and PEVF, shall be retrieved and imported automatically.	M
IO2.	For all relevant time horizons, the validation reports (QAR-s) can be retrieved and imported automatically.	R
IO3.	It shall be possible to retrieve and import IGM-s and CGMA/PEVF files manually.	M
IO4.	Concurrent handling of different versions of CGMES, additional profiles and other data exchange formats should be supported in a flexible manner.	R
IO5.	The EMF shall support different modelling styles e.g., node-breaker and bus-branch model representation.	M

7.3.1.3. Output Data Interfaces

Number	Requirement	Class
IO6.	The CGM shall be a solved power system model and shall be exported according to CGMES and CGM business process rules and guidelines. This relates to pan-European CGMES SV and updated SSH profiles for each pan-European merged IGM-s.	M
IO7.	The pan-European CGM SV and the updated SSH instance files shall be made available to the OPDE client.	M
IO8.	For all merging executions for the same scenario date, time and time horizon, if any of the used data and/or configuration are changed compared to previous execution, exported CGM version should be incremented, i.e., version of new CGM = version of previous CGM + 1.	M
IO9.	The EMF validation report generated by the Quality Assurance sub-function shall be made available in specified format to the OPDE Client for representation purpose in ENTSO-E Quality Assurance Portal. The serialization is according to QAR scheme.	M
IO10.	Reports on the level of balance deviation in grid model for both AC and DC positions should be available up to a month.	R

7.3.2. Metadata and Storage

Number	Requirement	Class
MET1.	The EMF should be able to extract metadata and store it in relation to a CGM so that it can be used for further processes.	R
MET2.	The EMF should be able to map to grid models all EIC codes in reporting information market document (for scheduling areas, DC links, interconnectors, controlled links).	R
MET3.	The EMF should update all metadata information as soon as a change of reference data occurs. Examples of the reference data structure can be found on http://energy.referencedata.eu.	R

7.3.3. Process Scheduler

Number	Requirement	Class
PS1.	The EMF shall be able to define, for each business process (e.g. 1D, 2D, ID…), when to start the merging process automatically.	M

Number	Requirement	Class
PS2.	The EMF shall be able to launch manually, for any business process (e.g. 1D, 2D, ID...), the merging process.	M
PS3.	The EMF shall allow the users to interrupt any execution of a merging process.	M

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811 ### 7.3.4. Quality Assurance

812 #### 7.3.4.1. Data Validation

Number	Requirement	Class
QA1.	The quality assurance sub-function should have the functionality to validate all input data for conformance with CGMES and business constraints.	R
QA2.	The quality assurance sub-function shall report which models did not pass the mandatory EMF quality assurance verification, triggering at the merging process execution time a model replacement based on defined replacement rules.	M
QA3.	The EMF shall validate PEVF RIMD and verify if the provided schedules are balanced. In case of unbalanced net positions, the RIMD shall be replaced as defined by the reference program replacement rules.	M

813 #### 7.3.4.2. Validation Report

Number	Requirement	Class
QA4.	Validation report for IGM shall conform to QAR scheme and shall include the following min requirements: - Merging entity name - TSO name - Time horizon - Scenario time - IGM version - IGM SV identification reference - IGM EMF specific QoCDC Level 8 triggered rules	M
QA5.	Validation report for CGM shall conform to QAR scheme and shall include the following min requirements: - Merging entity name - CGM time horizon - CGM scenario time - CGM version - CGM SV identification reference	M

Number	Requirement	Class
	- List of merged IGM-s with each following information: o TSO name o IGM time horizon o IGM scenario time o IGM version o IGM SV identification reference - CGM EMF specific QoCDC Level 8 triggered rules	

7.3.5. DATA REPLACEMENT

Number	Requirement	Class
DR1.	The EMF shall be able to handle multiple versions of provided IGM-s so that the latest version imported before the start of the merging process shall be used.	M
DR2.	The EMF shall execute a replacement strategy for missing or invalid IGM-s according to mandatory EMF quality assurance validation, to get the full dataset of expected IGM-s for the merging process. Replacement rules shall be defined per time horizon.	M
DR3.	The EMF shall execute the first step of the defined replacement strategy in case the IGM scalability exceeds the configurable scalability threshold.	M
DR4.	The EMF shall be able to execute a replacement strategy for missing or invalid RIMD (PEVF and CGMA) resulting from the dedicated quality assurance validation. RIMD replacement is defined specifically per time horizon and according to a configurable threshold.	M
DR5.	Configured data replacement strategies shall be triggered either manually by the user or automatically at the configured merging process execution time.	M

7.3.6. MODEL MERGE

Number	Requirement	Class
MM1.	Model merge sub-function shall receive the following input data for the purpose of the merging process: - Latest BDS. - IGM-s containing the EQ, SSH, TP and SV CGMES profiles. - Area Interchange targets, specified in the Reporting Information Market Document.	M
MM2.	Model merge sub-function shall be able to receive information from the Input/Output sub-function if any of the following occurs: - BDS is updated.	M

Number	Requirement	Class
	Requirements in the following documents are respected in terms of procedures and understanding of the metadata: OPDM, QoCDC, CGMA IG, CGM IG, PEVF IG.	
MM3.	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
MM4.	The most recent data for a given time horizon is to be used. If no valid data is available, the data model replacement rules apply.	M
MM5.	The model merge sub-function shall be able to create merged model including all IGM-s.	M
MM6.	In case, data replacement sub-function does not find a suitable model for missing or invalid IGM-s, the model merge sub-function shall be able to create a partial merged model containing unpaired borders.	M
MM7.	The model merge sub-function shall be able to detect and solve all inconsistencies between interconnectors, prior to the CGM creation. The interconnector inconsistencies shall be corrected according to the following logic: - For inconsistent switching status of an interconnector, it shall be considered as open on both IGM-s. - For inconsistent values of operational limits, use the smaller operation limit value when determining and reporting the congestion on the interconnector as violation of PATL limits.	M
MM8.	The model merge sub-function shall be able to assess, prior to the CGM creation, inconsistencies between computed IGM balance and reference program’s aggregated netted AC position. In case of deviation, following assessment shall be performed: - IGM scalability shall be assessed as the ration between AC net position inconsistency and sum of all IGM’s cim:ConformLoad-s. In case the IGM scalability exceeds the configurable scalability threshold, the corresponding model replacement rules shall be applied, otherwise the reference program’s target net position shall be enforced during the model scaling step.	M
MM9.	Model merge sub-function shall provide the following output to the Power flow sub-function as a result from the merging process: - Topologically merged IGM-s using the latest BDS, with all solved tie-lines inconsistencies according to defined logic. - Merged IGM-s shall be scalable, meaning the IGM scalability shall not exceed the scalability threshold.	M

7.3.7. POWER FLOW

Number	Requirement	Class
PF1.	For an IGM power flow calculation, the slack bus shall be assigned based on settings provided within IGM.	M
PF2.	For each CGM, the merging application shall be able to automatically assign a slack bus.	M
PF3.	Power flow sub-function shall support, as minimum, the following power flow calculation algorithms and parameters[7] and shall be configurable: - full Newton Raphson power flow algorithm - respecting/ignoring active power limits during calculation iterations - respecting/ignoring reactive power limits during calculation iterations - enable/disable tap changing during calculation iterations - enable/disable switch shunt adjustment during calculation iterations - respecting/ignoring area net interchange during calculation iterations - selection of active power slack: load distribution, generation distribution participation factor, generation distribution active power and voltage nodes only, single reference machine - enable/disable flat start - active power tolerance - reactive power tolerance - voltage tolerance - voltage angle limit - zero impedance threshold (if implemented) - load voltage dependency - transformer ratio tap control priority - transformer phase tap control priority - switched shunt control priority - static var compensator control priority - shift kind: conform load shift, all load shift, generation shift, generation and load shift key - number of maximum iterations	M
PF4.	The power flow sub-function shall be able to issue a calculation report (log-file) describing the quality of the power flow calculation with used dataset. This will include at least: - list of data (IGM, BDS, RIMD) included in merged model including their eventual quality assessment - power flow settings used - result of power flow calculation (number of iterations, slack mismatch, voltage range, system losses)	M
PF5.	The power flow sub-function shall be able to generate a report including power flow results and settings used.	M

[7] For details about the parameters please see IEC 61970-457:Ed2, expected to be published early 2024.

Number	Requirement	Class
PF6.	Be able to relax some of the power flow settings (tap regulation, switched shunts regulation, enable/disable reactive power limits) during the power flow algorithm to increase the feasibility of power flow algorithm's convergence. This option should be configurable.	R
PF7.	The Power flow sub-function shall abort the power flow calculation in case a solution is not found and shall inform the users. This information shall be reported to the Quality assurance sub-function to report accordingly in the QAR to be delivered to the OPDE client.	M

7.3.8. MODEL SCALING

Number	Requirement	Class
MS1.	The EMF shall support at least one of the embedded or classic variants of area interchange control.	M
MS2.	In the merged model the DC links' equivalent injections shall be set to the corresponding target DC position extracted from the relevant reference program, while maintaining the power factor.	M
MS3.	The AC and HVDC exchanges to CGM neighboring areas (such as Morocco, Belarus, Russia, Moldavia) are modelled as Equivalent Injections, connected to the respective Boundary Points. Note that these are unpaired connections.	I
MS4.	The EMF shall be able to compare the computed scheduling areas AC net position and DC flows, based on solved power flow, and target net positions from reference program.	M