European Network of
Transmission System Operators
for Electricity

COMMON GRID MODEL METHODOLOGY

(CONSULTATION VERSION)

04 FEBRUARY 2016

PROJECT TEAM CGM
PROJECT METHODOLOGIES (WP-1)

DOCUMENT VERSION MANAGEMENT

Version	Date	Changes
4.0	2016-02-04	Version for public consultation

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1 INTRODUCTION

1.1 PURPOSE OF DOCUMENT

As is explained in more detail in section 1.3 below, the present document meets a legal obligation set out in Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (henceforth GL CACM). The legally mandated purpose of the Common Grid Model Methodology (henceforth CGMM) is that it "shall enable a common grid model to be established" [GL CACM Article 17 (2)]. The GL CACM also formulates a number of specific requirements with respect to the CGMM which the European **transmission system operators** (henceforth TSOs) – to whom the obligation to prepare the CGMM is addressed [GL CACM Article 17 (1)] – have incorporated into the present methodology.

The present methodology sets out binding, generally applicable rules so that – in addition to the TSOs themselves – it affects a number of other parties as well. In order to explain the rationale for these rules, the CGMM describes

- the main constituent elements and construction of **individual grid models** (henceforth IGMs),
- how these are merged into **common grid models** (henceforth CGMs),
- the uses to which these are put, and,
- more generally, the principal processes associated therewith

to non-TSO stakeholders with a background in the electricity industry.

Of particular relevance in this respect are those stakeholders obliged to provide the data required by the Generation and Load Data Provision Methodology (henceforth GLDPM), a companion methodology required by GL CACM Article 16 (1) set out in a separate document. While the GL CACM [in Article 16 (1)] formulates an explicit obligation to justify these data requirements only with respect to the GLDPM, the explanations provided in the CGMM provide important context for the need for data from non-TSO stakeholders.

1.2 Geographical coverage and scope of application

Following approval by "all regulatory authorities" [GL CACM Article 9 (6) (c) (GLPDM) and (d) (CGMM))], the present CGMM as well as the accompanying GLDPM will be binding in all jurisdictions in which the GL CACM is in force. Subject to the exception for "transmission systems on islands which are not connected with other transmission systems via interconnections" set out in GL CACM Article 1 (2), that area corresponds to the member states of the European Union (henceforth EU).

However, the geographical coverage of the CGM extends beyond the EU. In other words, the present methodology is expected to also be implemented in a number of jurisdictions outside the EU. For the present methodology to be implemented in a jurisdiction means, in a nutshell, that the TSO (TSOs) in that jurisdiction contributes (contribute) its (their) **individual grid model**(s) to the CGM (which is established by merging IGMs; cf. GL CACM Article 28 (5)). This also entails applying the GLDPM in order to obtain the data required.

The legal definition of an IGM is given by GL CACM Article 2 (1) as "a data set describing power system characteristics (generation, load and grid topology) and related rules to change these characteristics during capacity calculation, prepared by the responsible TSOs, to be merged with other individual grid model components in order to create the common grid model." To a first approximation it is sufficient to think of an IGM as a grid model representing a TSO's **control area**. The distinction between a **control area** and a **bidding zone** (the **bidding zone** being the relevant area concept with respect to many GL CACM provisions) will be discussed below.

Many of the obligations in the GL CACM – including the obligation to develop the CGMM and the GLDPM - are addressed to "all TSOs" or "each TSO". A TSO is any "**certified TSO**"; i.e., any natural or legal person certified as such under Article 3 of Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003. The designation "TSO" notwithstanding, a **certified TSO** does not necessarily have a role in system operation and it is not obliged to be a member of ENTSO-E. The principal categories of TSOs of relevance with respect to the CGM are shown in Figure 1 below:

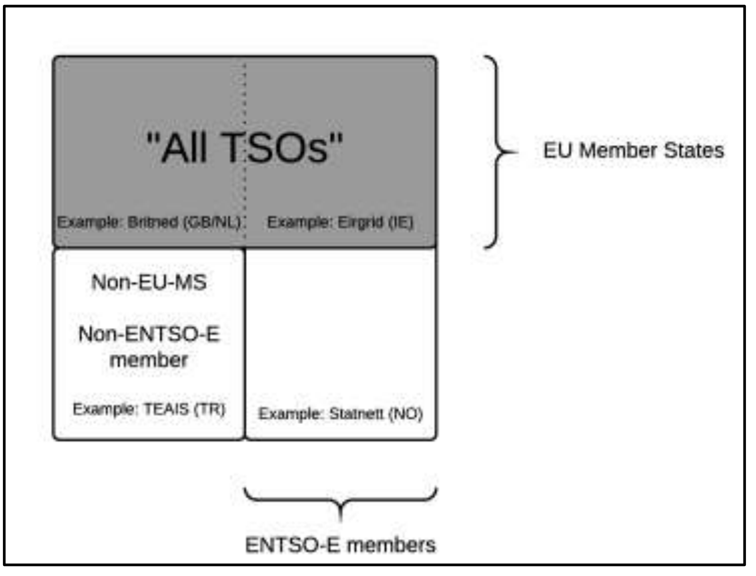

FIGURE 1: TSO TYPES

Guideline or Network Code requirements addressed to "all TSOs" by definition can only apply to **certified TSOs**; i.e., TSOs from EU member states. All EU TSOs that have a system operator role are ENTSO-E members; in addition to these ENTSO-E also has some members that do not have a system operator role. Section 10.1 in the annex contains a table listing all TSOs certified as such at the time of drafting. That table also shows those EU member states in which more than one TSO has been certified.

GL CACM Article 1 (3) stipulates that "[i]n Member States where more than one transmission system operator exists, this Regulation shall apply to all transmission system operators within that Member State. Where a transmission system operator does not have a function relevant to one or more obligations under this Regulation, Member States may provide that the responsibility for complying with those obligations is assigned to one or more different, specific transmission system operators." In other words, in multiple-TSO jurisdictions some of the TSOs certified in that jurisdiction may be exempted from certain GL CACM obligations by a decision of the Member State (typically the National Regulatory Authority). The draft Commission Regulation (EU) .../... of XXX establishing a guideline on forward capacity allocation (henceforth GL FCA) (2015-10-30) Article 1 (3) and the draft Commission Regulation (EU) .../... of XXX establishing a guideline on electricity transmission system operation (henceforth GL SO) (2015-11-27) Article 2 (3) contain equivalent provisions.

Returning to Figure 1, as noted above some non-EU TSOs are expected to contribute their IGM to the CGM. The latter TSOs may be ENTSO-E members (e.g., Statnett of Norway) or they may not be ENTSO-E members (e.g., TEAIŞ of Turkey). For the avoidance of doubt we note that the present methodology is not binding for non-EU TSOs. However, if such non-EU TSOs wish to contribute their IGM to the CGM without a legal obligation to do so, they have to respect the technical, IT, and related requirements set out in the present document. They also have to ensure that the data requirements in the accompanying GLDPM are respected.

GL SO (2015-11-27) Article 13 stipulates that "Where a synchronous area encompasses both Union and third country TSOs, within 18 months from the entry into force of this Regulation all Union TSOs in that synchronous area shall endeavour to conclude with the third country TSOs not bound by this Regulation an agreement setting the basis for their cooperation concerning secure system operation." It is anticipated that adoption of the CGMM as well as the accompanying GLDPM will become part of such a synchronous area agreement.

In summary, while (subject to GL CACM Article 1 (2)) the area in which the present methodology is legally binding corresponds to the European Union, the area covered by the CGM – or "**CGM Area**" – also includes a number of jurisdictions that are not EU members (but which, it is expected, will effectively be implementing the present methodology nonetheless).

Section 10.1 in the annex provides a comprehensive description of the **CGM Area** in terms of the set of (i) **bidding zones** whose TSOs contribute their IGM to the CGM plus (ii) the interconnections linking these **bidding zones** with **bidding zones** that do not contribute an IGM to the CGM (i.e., are not part of the **CGM Area**).

Note that the **CGM Area** is defined in terms of "**bidding zones**" – a **bidding zone** being "the largest geographical area within which market participants are able to exchange energy without capacity allocation" according to Article 2 (3) of Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the European Parliament and of the Council – because this is the area concept around which the definition of IGMs in Article 19 of GL CACM (as well as other requirements set out in that Guideline) revolves. However, a **bidding zone** is by definition not a stable geographical area, so in many places in the present methodology it is more appropriate to use the concept of **control area** (defined as "a coherent part of the interconnected system, operated by a single system operator and shall include connected physical loads and/or generation units if any" in Article 2 (6) of Regulation (EU) No 543/2013). As the table in the annex shows, **bidding zones** in many cases coincide with **control areas** (e.g., The Netherlands), but there are also cases where a single **bidding zone** contains more than one **control area** (e.g., the Ireland / Northern Ireland **bidding zone** is made up of **control areas** Ireland and Northern Ireland) and there are cases where a single **control area** contains more than one **bidding zone** (e.g., Italy).

Finally, the present methodology aims to anticipate and encompass requirements set out in European legislation that has not yet entered into force. It is relevant to note this here in that, for example, many requirements set out in GL SO refer to "**control area**" as opposed to "**bidding zone**". The following section 1.3 describes the legal requirements in more detail.

1.3 LEGAL REQUIREMENTS

The present section outlines the requirements formulated with respect to the CGMM and the GLDPM in various items of European legislation. In the context of the present section, the term "requirement" denotes certain legal provisions on content to be included in the methodologies or on the process by which the methodologies are to be prepared. This section sets out the approach used to ensure that requirements were transposed into the methodologies in full and in an appropriate manner.

The preparation of the CGMM and GLDPM is required by GL CACM Article 17 (1) and GL CACM Article 16 (1), respectively:

- "By 10 months after the entering into force of this Regulation all TSOs shall jointly develop a proposal for a common grid model methodology." (GL CACM Article 17 (1))
- "By 10 months after the entry into force of this Regulation all TSOs shall jointly develop a proposal for a single methodology for the delivery of the generation and load data required to establish the common grid model, (...)." (GL CACM Article 16 (1))

In addition to these obligations set out in the GL CACM (which had already entered into force at the time of drafting), the CGMM is also required by two draft Guidelines expected to enter into force (possibly after some additional revision) during 2016. Thus GL SO (2015-11-27) Article 67 (1) stipulates that "all TSOs shall jointly develop a proposal for the methodology for building the year-ahead common grid models" and Article 70 (1) of the same Guideline requires that "all TSOs shall jointly develop a proposal for the methodology for building the D-1 and intraday common grid models". GL FCA (2015-10-30) Article 18 (1) demands that "all TSOs shall jointly develop a proposal for a common grid model methodology for long-term timeframes". Both the GL SO and the GL FCA requirements acknowledge the present methodology (developed under GL CACM) and demand that the methodologies to be drafted under GL SO and GL FCA, respectively, "take into account and complement" the present methodology.

As for the GLDPM, the companion methodology to the CGMM, GL FCA (2015-10-30) Article 17 (1) requires that "all TSOs shall jointly develop a proposal for a single generation and load data provision methodology for delivering the generation and load data required to establish the common grid model for long-term timeframes." As in the case of the CGMM, the GLDPM to be prepared under GL FCA is to "take into account and complement" the GLDPM being prepared in parallel with the present document (under GL CACM).

Ultimately, i.e., when the obligations set out in all three of the aforementioned Guidelines have been met there should only be a single CGMM and a single GLDPM. In other words, the CGMM will ultimately cover all requirements set out in the GL CACM, the GL SO, and the GL FCA. The accompanying GLDPM will eventually cover all requirements from both the GL CACM and the GL FCA.

As far as the present version of the CGMM (and the accompanying GLDPM) is concerned, this document meets the TSOs' obligations under GL CACM. However, it does cover more ground than would be strictly necessary by consistently including, for example, the year-ahead **time frame**. To the extent that obligations set out in items of legislation other than GL CACM are covered, separate consultation, submission, and approval procedures will, of course, be required. For the avoidance of doubt, requirements set out in legislation that is not yet in force are included and referenced for informational purposes and for the sake of consistency, but for the time being they are not binding. When the other Guidelines have entered into force, the methodologies will be amended accordingly (i.e., based on the definitive version of the legislation as published in the Official Journal) and re-submitted to the competent regulatory authorities for approval.

Aside from the above-mentioned, very general obligation to develop the CGMM and GLDPM, specific requirements with respect to the methodologies are included in a number of articles in the GL CACM as well as the GL SO and GL FCA. To ensure that all requirements contained in the GL CACM (and, eventually, the other two Guidelines) are incorporated into the methodologies in an appropriate manner and to make it easy to check that this has been done, the TSOs have proceeded as follows: As part of a line-by-line review of the three aforementioned Guidelines, all relevant articles from each item of legislation were excerpted. An article was considered relevant if it either describes mandatory requirements (e.g., GL CACM Article 17 (2) setting out minimum content requirements with respect to the CGMM; GL CACM Article 16 (2) setting out minimum content requirements with respect to the GLDPM; requirements formulated with respect to IGMs in GL CACM Article 19 etc.) or it contains material which, while not explicitly mandatory, it is useful to reference in the methodologies (e.g., the provisions on data exchange in GL SO; Article 40 et seq.). Given the amount of material in the three aforementioned Guidelines, these had to be referenced selectively. For example, the articles relating to operational security requirements in Part II, Title 1, of GL SO (2015-11-27) clearly constitute interesting background material, but were not felt to be relevant enough to warrant their being excerpted.

These excerpts have been included in the annex to the present methodology; one sub-section per Guideline; as section 10.2 ("Relevant Legislation"). For each excerpted passage the annex indicates how and where in the methodologies the particular provision was used. This documentation ought to make it possible for a reviewer to check that all relevant requirements in the relevant legislation were transposed in full and in an appropriate manner. The individual requirements are cross-referenced in the body of the methodologies. In so far as possible each requirement set out in the methodologies has been linked individually back to a provision in one of the items of legislation.

Finally material included in an annex to the present methodology is not legally binding and does not, therefore, require approval by the competent regulatory authorities.

Times referred to in the present methodology are not local times, but – following the definition of "**market time**" in GL CACM Article 2 (15) - "central European summer time or central European time, whichever is in effect". Many of the deadlines stated in the present methodology are preliminary in the sense that the processes they relate to have not yet been implemented. Reasonable adjustments to the deadlines proposed by the TSOs in the light of their experience shall not be considered an amendment in the sense of GL CACM Article 9 (12) and shall not require re-submission of the present methodology for approval.

Some TSO tasks set out in GL CACM (and the other GLs) are to be completed on a regional and not pan-European level. GL CACM Article 19 (6) contains an example of such a regional task: "Where appropriate, and upon agreement between all TSOs within a capacity calculation region, each TSO in that capacity calculation region shall exchange data between each other to enable voltage and dynamic stability analyses." As a general rule, such tasks will typically be out of scope of the present methodology (although the TSOs concerned may nevertheless make use of common infrastructure in completing these tasks).

In drafting the present document, the TSOs have generally used the same terminology as the Guidelines (GLs CACM, FCA, SO). One exception to this is the term "**generation shift key**" which is avoided and has been replaced by the term "**power shift key**". GL CACM Article 2 (12) defines a '**generation shift key**' as "a method of translating a net position change of a given **bidding zone** into estimated specific injection increases or decreases in the common grid model". However, reading this definition in conjunction with GL CACM Article 24 (2) ("The generation shift keys shall represent the best forecast of the relation of a change in the net position of a **bidding zone** to a specific change of generation or load in the common grid model.") makes it clear that the term "**generation shift key**" is indeed meant to encompass both generation and load. The term "**power shift key**" makes this clear and substitutes for both "**generation shift key**" and "**load shift key**".

As required by GL CACM Article 12, this methodology is being presented for consultation with stakeholders and the relevant authorities of each Member State. The consultation period will last for one month.

All TSOs shall duly consider the views of stakeholders and relevant authorities resulting from consultation on the methodology. A clear and robust justification for including or not the views resulting from the consultation shall be developed and published in accordance with the requirement specified in GL CACM Article 12 (3).

Following the consultation process outlined above, and after consideration of the views of stakeholders and others following the consultation process, it should be noted that this methodology may change in advance of presentation of the methodology for approval by all regulatory authorities.

The changes that are made to the methodology will be dependent on the views expressed as part of the consultation process and may include changes to technical aspects of the methodology. Changes to the format, structure and wording of this methodology may also be undertaken.

1.4 GLOSSARY / DEFINITIONS

The present document draws on legal definitions of a number of terms as well as definitions developed by the TSOs themselves which have been collected into a Glossary and included in the present section. The following conventions were applied in preparing the glossary:

- Every abbreviation used in the document is spelt out the first time it is used.
- Every abbreviation used in the document has been included in the Glossary.
- Abbreviations are not bolded in the body of the document because they are by default included in the Glossary.
- Terms included in the Glossary that are not abbreviations are bolded each time they are used in the body of the document.

Sub-line	Term	Definition	Source / additional explanations
001	(D-1)	day-ahead	
002	AC/DC net positions	the netted sum of electricity exports and imports of a bidding zone for a given market time unit covering both AC and DC interconnectors	
003	Agreed Measures	remedial actions agreed to be implemented as part of the process of CGM creation	

Sub-line	Term	Definition	Source / additional explanations
004	Balanced AC/DC net positions and consistent flows on DC interconnectors	Standard phrase that describes a key prerequisite for the building of IGMs: --the sum of AC/DC net positions (defined on the level of bidding zones) across all bidding zones of the CGM Area equals the target aggregate AC/DC net position for the entire CGM Area (i.e., the two quantities are in balance) AND --both TSOs connected by an HVDC interconnector are using the same flow value (corrected for losses) for that interconnector in their IGMs (i.e., the flows are consistent)	CGMM, ch. 04 on CGM Alignment
005	Base case	Generally refers to the starting version of a model before modifications are made (the exact nature of which depends on the context). In particular, an IGM prior to merging, implementation of agreed measures etc may be referred to as the base case.	

Sub-line	Term	Definition	Source / additional explanations
006	Bidding Zone	the largest geographical area within which market participants are able to exchange energy without capacity allocation	Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the European Parliament and of the Council; Article 2 (3)
007	Certified TSO	natural or legal person certified as such under Article 3 of the Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003	See additional entry defining a TSO (transmission system operator)
008	CGM	Common Grid Model (see additional entry)	
009	CGMA	CGM Alignment	
010	CGM Area	Area covered by the CGM the set of (i) bidding zones whose TSOs contribute their IGM to the CGM plus (ii) the interconnections linking these bidding zones with bidding zones that do not contribute an IGM to the CGM (i.e., are not part of the CGM Area).	CGMM; section on geographical coverage
011	CGMES	Common Grid Model Exchange Standard	

Sub-line	Term	Definition	Source / additional explanations
012	CGMM	Common Grid Model Methodology	
013	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	GL CACM; Article 2 (2)
014	Contingency	the identified and possible or already occurred fault of an element, including not only the transmission system elements, but also significant grid users and distribution network elements if relevant for the transmission system operational security	GL CACM Article 2 (10)
015	Control Area	a coherent part of the interconnected system, operated by a single system operator and shall include connected physical loads and/or generation units if any	Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the European Parliament and of the Council; Article 2 (6)
016	EMFIP	Electricity Market Fundamental Information Platform	Also known as "Transparency Platform"

Sub-line	Term	Definition	Source / additional explanations
017	ENTSO-E	ENTSO for Electricity or European Network of Transmission System Operators for Electricity	Established in accordance with Article 5 of Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003
018	EU	European Union	
019	External commercial trade schedule	a schedule representing the commercial exchange of electricity between market participants in different scheduling areas	GL SO (2015-11-27) Article 3 (80)
020	Generation Shift Key	See entry "Power shift key"	
021	GL CACM	Abbreviation for: Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management	
022	GL FCA	Abbreviation for: Commission Regulation (EU) …/… of XXX establishing a guideline on forward capacity allocation	
023	GL SO	Abbreviation for: Commission Regulation (EU) …/… of XXX establishing a guideline on transmission system operation	

Sub-line	Term	Definition	Source / additional explanations
024	GLDPM	Generation and Load Data Provision Methodology	
025	GSK	Generation Shift Key (see additional entry)	
026	ID	intraday	
027	IGM	Individual Grid Model (see additional entry)	
028	Individual Grid Model	a data set describing power system characteristics (generation, load and grid topology) and related rules to change these characteristics during capacity calculation, prepared by the responsible TSOs, to be merged with other individual grid model components in order to create the common grid model	GL CACM; Article 2 (1)
029	Interconnected system	'interconnected system' means a number of transmission and distribution systems linked together by means of one or more interconnectors	DIRECTIVE 2009/72/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC; Article 2 (14)
030	Load Shift Key	See entry "Power Shift Key"	
031	LSK	Load Shift Key (see additional entry)	

Sub-line	Term	Definition	Source / additional explanations
032	Market Time	central European summer time or central European time, whichever is in effect	GL CACM Article 2 (15) – note that all times and, in particular, deadlines stated in the CGMM / GLDPM are not stated in terms of local time, but in terms of "market time"
033	NC DC	Abbreviation for: Commission Regulation (EU) …/… of XXX establishing a Network Code on Demand Connection	
034	NC HVDC	Abbreviation for: Commission Regulation (EU) .../... of XXX establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules	
035	NC RfG	Abbreviation for: Commission Regulation (EU) …/… of XXX establishing a network code on requirements for grid connection of generators	
036	Net position	the netted sum of electricity exports and imports for each market time unit for a bidding zone	GL CACM Article 2 (5) – note that the CGMM and GLDPM do not use this term, but use the more precise term **AC/DC net position** (see additional entry)

Sub-line	Term	Definition	Source / additional explanations
037	Network reduction	Modelling a part of the network with an electrical equivalent which, however, has been simplified relative to the original model	CGMM; sub-section on describing the grid
038	NRA	National Regulatory Authority	
039	OPDE	Operational Planning Data Environment (see additional entry)	
040	Operational Planning Data Environment	'ENTSO for Electricity operational planning data environment' means 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	GL SO (2015-11-27) Article 2 (79)
041	Operational security limits	the acceptable operating boundaries for secure grid operation such as thermal limits, voltage limits, short-circuit current limits, frequency and dynamic stability limits	GL CACM Article 2 (7)
042	Physical congestion	any network situation where forecasted or realised power flows violate the thermal limits of the elements of the grid and voltage stability or the angle stability limits of the power system	GL CACM Article 2 (18)

Sub-line	Term	Definition	Source / additional explanations
043	PPD	Pre-processing data (see additional entry)	
044	Pre-processing data	The pre-processing data consist of (i) preliminary aggregate AC/DC net positions, (ii) the feasibility range (i.e., minimum and maximum net positions), (iii) expected flows on HVDC links, and (iv) minimum and maximum flows on HVDC links	CGMM chapter on CGM Alignment
045	Primary data owner	'primary owner of the data' means the entity which creates the data	Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the European Parliament and of the Council; Article 2 (23)

Sub-line	Term	Definition	Source / additional explanations
046	Power Shift Key	The term "Power Shift Key" is meant to substitute for the term "Generation Shift Key" as defined in the GL CACM. GL CACM Article 2 (12) (‘generation shift key’ means a method of translating a net position change of a given bidding zone into estimated specific injection increases or decreases in the common grid model). However, this needs to be read in conjunction with GL CACM Article 24 (2): "The generation shift keys shall represent the best forecast of the relation of a change in the net position of a bidding zone to a specific change of generation or load in the common grid model. That forecast shall notably take into account the information from the generation and load data provision methodology."	The legal definition of the term "Generation Shift Key" makes it clear that this term is meant to designate changes in both generation and load. The alternative term "power shift key" makes it clearer that both generation and load are covered.

Sub-line	Term	Definition	Source / additional explanations
047	Primary owner of the data (= primary data owner)	the entity which creates the data	Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the European Parliament and of the Council; Article 2 (23)
048	Regional Security Coordinator	the entity or entities with the task of managing regional operation in one or more capacity calculation regions	GL SO (2015-11-27); Article 2 (94)
049	Remedial action	any measure applied by a TSO or several TSOs, manually or automatically, in order to maintain operational security	GL CACM Article 2 (13)
050	RSC	Regional Security Coordinator (see additional entry)	
051	Scalability Parameters	The scalability parameters are a subset of the PPD and consist of (i) the feasibility range (i.e., minimum and maximum AC/DC net positions) and (ii) minimum and maximum flows on HVDC links	CGMM chapter on CGM Alignment
052	Scenario	the forecasted status of the power system for a given time-frame	GL CACM Article 2 (4)
053	Scheduled exchange	an electricity transfer scheduled between geographic areas, for each market time unit and for a given direction	GL CACM Article 2 (32)

Sub-line	Term	Definition	Source / additional explanations
054	SGU	Significant grid user	
055	Slack node	Special virtual node that serves to balance active and reactive power in load flow studies	
056	Transmission System Operator	a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity	DIRECTIVE 2009/72/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC; Article 2 (4) See additional entry defining a Certified TSO (transmission system operator)
057	Transparency Regulation	Abbreviation for: Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the European Parliament and of the Council	
058	TSO	Transmission System Operator (see additional entry)	
059	(Y-1)	year-ahead	

1.5 CONFIDENTIALITY

TSOs shall ensure the confidentiality of the data being provided to them pursuant to GL CACM Article 13. The same confidentiality requirement shall apply to ENTSO-E in its role as administrator of the Operational Planning Data Environment (OPDE) explained in more detail in section 5.2. The confidentiality of data in transit to or being stored via the OPDE shall be ensured using industry standards. OPDE users not bound by the GL CACM (i.e., TSOs from jurisdictions where the GL CACM is not or not yet in force) will have to sign suitable confidentiality agreements.

1.6 COST-SHARING

For the sake of completeness, the relevant GL CACM provisions on cost-sharing are restated below. GL CACM Article 78 stipulates that

"1. Each TSO shall individually bear the costs of providing inputs to the capacity calculation process.

2. All TSOs shall bear jointly the costs of merging the individual grid models. (...)

3. Any costs incurred by market participants in meeting the requirements of this Regulation shall be borne by those market participants."

2 HIGH LEVEL PROCESS OVERVIEW

2.1 THE CGM PROCESS

CGMs are used for three purposes:

- capacity calculation (cf., inter alia, GL CACM Article 29 (7) (b) and Article 29 (8) (a))
- operational security analysis (which includes different types of studies / analyses) (cf., inter alia, GL SO (2015-11-27) Article 72 (4))
- outage planning (cf., inter alia, GL SO (2015-11-27) Article 84 (2) (a))

The present section describes the main steps in the process by which CGMs are built and, in doing so, it introduces some important terms. Since the sequence of chapters in the present methodology roughly corresponds to the sequence of steps in the CGM process, the present section can also be read as a summary of the document.

IGMs are the principal buildings blocks of CGMs. The main elements and the creation of IGMs are explained in Chapter 3. The primary owner of the input data may be the TSO itself or the TSO may have to obtain the data from another party. The companion methodology, the GLDPM, describes "the information to be provided by generation units and loads to TSOs" [GL CACM Article 16 (3)].

Once a TSO has prepared its IGM, it needs to make this model available for merging into the CGM. The exchange of IGMs, CGMs, and other data will take place on an IT platform named **Operational Planning Data Environment** (henceforth OPDE). The OPDE will be implemented and administered by ENTSO-E [GL SO (2015-11-27) Article 114 (1)] and is defined as "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." [GL SO (2015-11-27) Article 2 (79)]. (The OPDE is described in more detail in section 5.2.)

Each IGM is prepared for a given **scenario** and it needs to be made available via the OPDE by a certain deadline. The quality of IGMs is checked so that poor-quality IGMs do not impair the overall process. The quality check is performed by service providers for which the term **Regional Security Coordinator** (henceforth RSC) is used in the draft of the GL SO dated 27 November 2015 (and for which the TSOs' preferred designation is "Regional Security Coordination Service Provider" or RSCSP).

Each IGM is characterised by an estimate of the corresponding export (or import) of electricity from (or into) the area being modeled. These estimates are referred to as **AC/DC net positions**. In order to be able to merge the IGMs from all TSOs into a CGM, these estimates of **AC/DC net positions** have to be consistent with each other. On the level of the overall **interconnected system**, consistency requires all exports and imports to net to zero. When this consistency requirement is met, the **AC/DC net positions** are referred to as "balanced." Establishing balanced **AC/DC net positions** is, in principle, straightforward for those time horizons for which schedule data are available (i.e., day-ahead and intraday). However, for time horizons for which schedules are not available (i.e., the (D-2) and more distant time horizons up to year-ahead), balanced **AC/DC net positions** have to be established via a process known as "Common Grid Model Alignment" (henceforth CGMA). The CGMA process is described in more detail in chapter 4. Note that when the balanced **AC/DC net position** differs from the initial estimate of the **AC/DC net position**, the IGM has to be adapted accordingly. TSOs can make this adjustment themselves or they may delegate that task to an RSC. Thus, in a nutshell, the CGMA process ensures that exports and imports in the CGM are aligned and net out to zero.

The next step in the process is the merging of IGMs into the CGM proper. Chapter 5 explains the merging process and the role of RSCs therein and it also gives some essential background on the IT aspects of CGM construction.

As IGMs are merged into a CGM, constraints – defined as "a situation in which there is a need to prepare and activate a remedial action in order to respect operational security limits" in GL SO (2015-11-27) Article 2 (2) – may be encountered. In order to maintain operational security, TSOs will then implement **remedial actions** such as redispatch. Such **remedial actions** – referred to as "**agreed measures**" - may require updating the IGMs originally provided by one or more TSOs and are addressed in a chapter of their own (chapter 6). Once these **agreed measures** have been successfully implemented, the CGM is validated by the RSCs and available via the OPDE.

The deadlines to be respected for each of the steps in the CGM process are described in greater detail in chapter 7. Given the importance of working with accurate data, quality assurance is an important concern for the TSOs and is discussed in chapter 8. Finally, the GL CACM requires that the methodology provide a timescale for implementation [Article 9 (9)] which is included as chapter 9. The annexes have been collected into chapter 10.

In the remainder of the present chapter, it is first explained in how far the present methodology advances the objectives of the GL CACM (section 2.2). Section 2.3 explains the purposes for which the CGM is used in more detail. Every CGM is prepared for a given **scenario** [GL CACM Article 28 (5)] so section 2.4 explains what a **scenario** is and which **scenarios** are defined by the TSOs.

2.2 OBJECTIVES OF THE GL CACM AND IMPACT OF THE CGMM THEREON

GL CACM Art. 9 (9) requires that the CGMM and the GLDPM each contain "a description of their expected impact on the objectives of [the GL CACM]" (which are formulated in GL CACM Article 3). As for the specific objectives, the CGMM primarily advances the objectives of

(b) ensuring optimal use of the transmission infrastructure;
(c) ensuring operational security; and
(d) optimising the calculation and allocation of cross-zonal capacity.

In outage planning, TSOs need a common reference framework for assessing operational security throughout outages. That common reference framework is provided by the CGM. By establishing the methodology by which the CGM is established, the CGMM helps ensure the optimum availability of the transmission grid and thus the optimal use of the transmission infrastructure.

As far as operational security is concerned, the CGMM makes it possible to more accurately identify operational risks ("constraints") and that in turn enables TSOs to put in place the **remedial actions** that reestablish operational security.

With respect to the calculation and allocation of cross-zonal capacity, the CGMM helps to ensure a higher quality of inputs to the capacity calculation process which leads to more reliable / accurate results. These make it possible for TSOs to reduce reliability margins and allows them to make more capacity available to the market than would otherwise be the case. Standardised and harmonised procedures (such as those described, for example, in sub-section 3.1.1) also further the objective of

(e) ensuring fair and non-discriminatory treatment of TSOs, NEMOs, the Agency, regulatory authorities and market participants.

2.3 OBJECTIVES OF THE CGM

The content of the document describes a methodology which is technical. This section aims at providing the basis that is required to understand the methodology and its implications. This section will therefore not provide any standard or requirement as its only goal is to provide context to the methodology.

2.3.1 CALCULATIONS

The decisions that are taken on the power network are based on numerical simulations. They enable the TSO to assess the behaviour of the grid. In this section we will describe some principles on the numerical calculations and draw the outline of the needs.

2.3.1.1 CALCULATIONS OVERVIEW

The simulation may have different objectives, and therefore different kinds of calculation can be implemented. The most important kinds of such calculations are:

- *Load flow* calculation (or *power flow* calculation): its aim is to assess the steady state flows and voltages in all the components of the grid. This is the most frequently used type of calculation and it will be described in more detail below. The main goal of the CGM is to make it possible to run load flow calculations on an area covered by many TSOs up to pan-European level: GL CACM Art. 19 (5) requires TSOs to "provide all necessary data in the individual grid model to allow active and reactive power flow and voltage analyses in steady state".
  One very usual way of instancing this calculation is the ***contingency*** *analysis* that aims at running successive load flow calculations introducing **contingencies** that are predefined in a list. This enables to assess the robustness of the situation, and identify the **contingency** that would require **remedial actions**, and test their effectiveness.
- *Short-circuit* calculation: its aim is to simulate short-circuits and evaluate the resulting current in the grid, especially close to the failure point. This makes it possible to assess if the protection devices will be accurate enough to work properly, or if the power devices will be sufficiently dimensioned to support it in case of a failure occurrence.
- *Dynamic* calculation: these simulations introduce the time dimension and aim at having an understanding of the transient phenomena. Depending on the time granularity considered, these calculations allow TSOs to assess the risks of voltage collapses due to automatic tap changing on transformers (time range up to few minutes), the stability of the generation units (time range up to a few seconds), or high frequency phenomena.

The GL CACM does not make it mandatory to provide the data required to perform the latter two types of calculation (although GL CACM Article 19 (6) requires that 'where appropriate' and only 'upon agreement between all TSOs within a capacity calculation region', TSOs "shall exchange data between each other to enable voltage and dynamic stability analyses" on the level of capacity calculation regions). However, the CGM can be used as the basis for these kinds of simulations.

The GL SO stipulates that

- "[e]ach TSO shall perform coordinated operational security analyses for at least the following timeframes: (a) year-ahead; (b) week-ahead (...); (c) (D-1); and (d) intraday." (GL SO (2015-11-28) Article 72 (1))
- for these timeframes, the TSO shall use "at least the CGMs established (...)" (GL SO (2015-11-27) Article 72 (4))
- in order "[t]o perform operational security analyses, each TSO shall, in the N-Situation, simulate each **contingency** from its **contingency** list (...) and verify that

the operational security limits defined (...) in the (N-1)-situation are not exceeded in its **control area**" (GL SO Article (2015-11-27) 72 (3))

- GL SO (2015-11-27) Article 25 (1) stipulates that "Each TSO shall establish the operational security limits for each element of its transmission system, taking into account at least the following physical characteristics: (a) voltage limits (...); (b) short-circuit current limits (...); and (c) current limits in terms of thermal rating including the transitory admissible overloads."

These requirements underline the central role of the CGM as the tool supporting the operational security analyses referred to above.

Some of these calculations are extremely demanding in terms of quality of the data, and computing power.

2.3.1.2 Target calculation algorithm used with CGM: the load flow

The most important kind of calculation that is based upon the CGM is the load flow which aims at simulating the steady state behaviour of the grid. The purpose of this algorithm is to determine the voltages, voltage angles, real power and reactive power everywhere in the grid considering the location of load and the generation units and topology (switching configuration) of the network. The load flow is an algorithm that runs within a synchronous area. The synchronous areas are linked together by DC-links, and when running load flow over a CGM, consistency of the balancing of the modelled synchronous areas with the inter-synchronous area DC-flows shall be ensured.[1]

2.3.1.2.1 Inputs

The simplest load flow takes as input a description of the grid as nodes that hold load and generation, and connection devices (lines, transformers) to transmit the power. These elements have the following characteristics:

- *Nodes*:
    - The *PQ node* is described by its active and reactive power values that are fixed, whatever the voltage of the node may be: this is a relevant hypothesis as the voltage shall remain in a narrow range, and the end-user load is commonly connected through transformers equipped with automatic regulation on tap changers to maintain the voltage at the regulated winding level (if the calculations are done with the option "voltage regulation of the transformer enabled").
    - The *PV node* is described by its active power, and a voltage setpoint value. The voltage on the node remains steady during the calculation, implying a

[1] Note that some DC-links are implemented inside a single synchronous area. They shall be modeled within the synchronous area in an appropriate manner to run an AC load flow.

generation unit[2] shall provide or absorb the necessary reactive power to maintain the voltage on the node.[3]

- *Connection devices*:

  They are represented with the physical characteristics of the lines, transformers, or cables (impedances).

2.3.1.2.2 OUTPUT

The load flow algorithm – as a steady state model – simulates the steady state of the power system. This means that it determines the states of the physical variables (voltage magnitudes and angles, active and reactive power flows) that fit the inputs abstracting from transient phenomena.
The output of the calculation is the value of the voltage and the phase angle for each node of the model. This makes it possible to fully deduce all state variables of the model especially:

- The reactive power provided by the generation units to maintain the voltage setpoint
- The flows in connecting devices and therefore the active and reactive power that are transited
- Voltages in load nodes.

These are the basic principles of the load flow. Operational implementations of the algorithm are much more sophisticated. In particular, they take into account the technical limits of third parties such as generation units or can simulate the functioning of automatic tap changing of transformers.

In order to work properly, a load flow requires as input a coherent set of data. This means that

- the system should be close to balance (load – including losses in the grid – is roughly equal to generation),
- the voltage profile (voltage setpoints on generation nodes and tap transfomers) has to be realistic.

2.3.2 DESCRIBING THE GRID

2.3.2.1 DESCRIPTION LAYERS

A common way of describing the grid consists of splitting the model into two parts:

- *Equipment information*: information which changes only very infrequently[4] (if at all) about the behaviour of the equipment such as lines, substations, etc. and its connection to the grid

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[2] Or assets such as Static Var Compensator that control the reactive power to maintain a voltage setpoint

[3] For the completeness of the description, a specialty node (called slack node) is also to be considered bearing additional pseudo generation/load unit that might be needed to bring the model in balance

- *State variables and schedules*: data which describe the system evolution. This corresponds to the variable, frequently changing features of the power system and includes data such as the load (value) on each node, the voltage and phase of a node, the position of the switching devices.

In other words, a grid model typically combines equipment information on structural features that change at a low frequency with highly variable information on schedules and state variables that needs to be updated frequently. This is explained in more detail in chapter 3.

2.3.2.2 Node breaker topology / busbranch topology

The "node" that is used for the algorithm is an abstract concept (mathematical representation) regarding the realm of the power system. Nodes are point holding power inputs or outputs with some characteristics, which are interconnected through impedance equipment.

However, the network in reality is made up of substations which are interconnected through impedance equipment such as transformers, lines and wires. In a substation, a set of items of equipment such as busbars and switching devices make it possible to connect the impedance equipment with other substations in a variety of manners.

The "topology" of the network is the interconnection shape resulting from the switching devices' positions.

Therefore two levels of modelling the topology are possible:

- *The node breaker topology*: that needs a detailed description of all the switching devices and their state
- *The bus branch topology*: that is an abstract description of the network into nodes and connecting devices.

It is possible to calculate the second representation from the first one, and the bus branch representation is needed to provide the information to the simulation algorithms.

The first one on the other hand is more difficult to implement and manipulate, but offers the operator the ability to have an easy understanding of the capabilities of the network in terms of topology.

The modelling of the CGM (regarding Bus Branch vs Node Breaker) depends on the input data provided by TSOs. No restrictions are imposed on TSOs regarding the choice of modelling of IGMs.

2.3.2.3 Need of wide view

Within an **interconnected system**, by definition every change anywhere in the system affects all other parts of the system. However, if the likely impact of a change is small, there is not much interest in studying this particular change in much detail. Therefore two approaches are implemented:

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[4] However, since the CGM covers a very large area with many items of equipment, one should expect frequent modification of the equipment data included in the CGM.

- **NETWORK REDUCTION**: a part of the network is modelled with an electrical equivalent. This has the main advantage of simplicity, but the phenomena inside the equivalent are hidden, and no perturbations coming from it can be simulated. This approach is usually used for part of the DSO grids, or for **control areas** with little influence on the concerned TSOs.
- **AN EXTENDED VIEW** of the power grid: this makes it possible to examine the behaviour of the power grid in detail. The load and generation data are up to date, the network description and topology of a sufficiently large area covering multiple TSO **control areas** are taken into account, and the consequences of **contingencies** can be assessed throughout areas. This approach is clearly the most rigorous, but needs a very strong coordinated methodology and increases the amount of information to be exchanged which is only advisable if the additional grid to be modelled has a significant impact on the network object of the study .

One aim of the CGMM is to determine the use of both approaches in order to enable the European TSOs to coordinate their security management and capacity calculation with relevance :

- **network reduction** that can be applied in line with GL SO (2015-11-27) Article 41 (3) for systems with voltage below 220 kV, and as an option for adjacent systems during the process of creating the IGM
- extended view especially by the merging of IGMs into a CGM that extends the modelling of the adjacent TSOs up to the **CGM Area**.

2.3.2.4 INDIVIDUAL GRID MODEL TO MERGED GRID MODEL

In order to extend the view of the power grid, the Guidelines cited (GL CACM, GL FCA, GL SO) request the TSO to exchange Individual Grid Models (IGM) that describe their grid within their own **control area**. The TSO is responsible for the description of its own area up to its border. Physically, the border is usually an agreed point defined along a line connecting the two areas.
This point shall be substituted by the TSO by a node called boundary point bearing a virtual in-feed (positive or negative) equal to the expected flow.
The process of assembling the IGMs into a CGM consists of joining twin boundary points from IGMs representing 2 different adjacent areas.
Calculations on the resulting merged model can be successful only if the resulting model is balanced (in-feeds cover the load including the losses) and the voltage plans are coherent.

2.3.3 BUSINESS USE OF THE LOAD FLOW

The CGM provides for a given point in time a common view of the European grid and its behaviour. It is a corner stone for any process of coordination either for security assessment, outage planning, or capacity calculation.

- ***Contingency** analysis*: All processes rely on the ability of the TSO to ensure the security of the network. Therefore a fundamental use is the ***contingency** analysis*. It

consists in assessing the consequences of every **contingency** the TSO must be able to cope with.
If for a given **contingency** security limits are exceeded, the TSO must identify **remedial actions** and check their efficiency. It can be preventive **remedial actions** (disposition to be implemented in the **base case**) or curative **remedial actions** (to be implemented when the **contingency** occurs).
Whether they are preventive or curative, they must be elaborated taking into account the whole system – including the neighbouring **control area**. Thus they shall be based on the CGM, coordinated and agreed with the TSOs of the region with the support of RSCs.
Methodologies for coordinating operational security analysis at least per synchronous area are to be developed according to GL SO (2015-11-27) Article 75 (and are out of scope of the CGMM).

- *Outage planning:* the outage planning consists in identifying the relevant period for the maintenance operation or development of the assets of the TSO limiting the impact for the grid users and market participants: assessment of compatibility of planned outage, forecast on the significant grid users schedules, ...
  To this end, based on forecasted situations using the CGM, the impacts of the outages are assessed by running ***contingency*** *analysis* and coordinating **remedial actions**.
  At the outage coordination region level, the TSOs shall develop a regional coordination operational procedures according to GL SO (2015-11-27) Article 83. The details of this procedure are out of scope of the CGMM.
- *Capacity calculation (cf.* GL CACM *Article 29 (7) (b) and 29 (8) (a))*: Having ensured the security of the network and the capability of maintaining and developing the assets in the long term, the TSOs shall identify what are the capacities that shall be put at the disposal of market participants.
  Based on the CGM (including the planned outages) for the time frame under consideration, the TSOs can test various scales of the balance of the **control areas**, run **contingency** analysis and determine in a coordinated manner what are the maximum capacities that can be offered to the market with respect to the security limits.
  The calculation methodologies will be developed at capacity calculation region level as stipulated by GL CACM Article 20 (2) and are out of scope of this methodology.
- *Operational Security Limits definition* as stipulated by GL OS (2015-11-27) Article 25 is out of scope.

2.4 SCENARIO DEFINITION

GL CACM Article 18 (1) defines a **scenario** as a common description of "a specific forecast situation for generation, load and grid topology for the transmission system in the CGM." The legal definition in GL CACM Article 2 (4) is "the forecasted status of the power system for a given time-frame".

GL CACM:

According to Article 17, the CGM methodology shall “contain a definition of the scenarios in accordance with Article 18.”

Article 18 states that the methodology shall describe how the TSOs elaborate “common scenarios” containing “specific forecast situation for generation, load and grid topology”, “per market time unit” for “the day-ahead and intraday capacity calculation timeframes”.

This methodology will also include other timeframes that will be required by the draft Guidelines referred to in section 1.3 in order to ensure a harmonised approach across timeframes.

The description of the **scenario** “shall draw up common rules for determining the net position in each **bidding zone** and for the flow for each direct current line”. To this end – except for the intraday market timeframe, for which the market provides all the results – the CGM Alignment algorithm has been developed; the CGMA process is described in more detail in chapter 4.

GL FCA (2015-10-30):

According to Article 9, "[a]ll TSOs in each capacity calculation region shall ensure that long-term cross-zonal capacity is calculated for each forward capacity allocation and at least on annual and monthly timeframes".

Article 10 (4) stipulates that "the uncertainty associated with long-term capacity calculation timeframes" may be addressed by applying either "(a) a security analysis based on multiple scenarios (...)" or "(b) a statistical approach based on historical cross-zonal capacity for day-ahead or intraday timeframes (...).

If the "security analysis" approach is chosen, Article 22 requires the creation and use of a CGM.

SO (2015-11-27):

Article 79 makes it mandatory to establish a CGM for the year-ahead, (D-1), and intraday time frames.

The **scenarios** will be described per time horizon. Hereafter is a table:

Time horizon of the scenario	Capacity calculation timeframe	Article in GL requiring the scenario	Extent of the requirement
Intraday (ID)	Intraday market	GL CACM Articles 28 (5), 18 (1), 14 (1) GL SO (2015-11-27) Articles 79 (1), 70 (1)	CGM Mandatory at European level
D ahead ((D-1))			
(D-2)	Day ahead market	GL CACM Articles 28 (5), 18 (1), 14 (1)	CGM Mandatory at European level
Week ahead (W-1)		GL SO (2015-11-27) Article 69 (1)	To be agreed among concerned TSOs ("Where two or more TSOs consider it necessary (...)")
Month ahead (M-1)	Monthly market	GL FCA (2015-10-30) Articles 22, 9	To be defined at Regional level (Capacity Calculation Region)
Year ahead ((Y-1)**)**	Yearly market	GL FCA (2015-10-30) Articles 22, 9 GL SO (2015-11-27) Articles 79 (1), 67 (1)	CGM Mandatory at European level

2.4.1 END USE OF THE SCENARIOS

The **scenarios** describe forecasted situations of the grid. This makes it possible to build CGMs for the following goals:

1. *Assess the influence of equipment evolutions*. It shall at first reflect its forecasted structure. Based on as-built situation, it is completed with evolutions (insertion, removal, change of characteristics) on the relevant assets that change its shape and therefore its ground behaviour that must be commonly assessed.
2. *Ensure the security at the considered time horizon*. With a common view of the network, **contingency** analysis can be performed, and strategies involving preventive or curative **remedial actions** to cope with any likely disturbances can be elaborated and their efficiency be checked.
   Beyond the **contingency** analysis, transient stability criteria can be assessed to complete the security assessment of the situation.
   This serves to prepare and activate **remedial actions** in coordination with affected TSOs.
3. *Outage planning*: Having the ability to achieve the two previous objectives, the TSOs can coordinate themselves to plan outages. The security of situations resulting from changes in the grid due to maintenance or development work can be guaranteed. During this process, the TSOs can check the compatibility of concomitant outages,

and take decisions accordingly, shifting the planning of operations or elaborating a suitable set of **remedial actions**.

The information related to the outage planning shall be exchanged through the OPDE as required by GL SO (2015-11-27) Article 116.

4. *Capacity calculation*: based on the results of the previous goals, the TSOs can assess the capacities that can be offered to the market by scaling the load or generation of the **bidding zones** to assess the availability of secure cross-border exchanges.

Security margins are necessary since forecasted situations are inherently uncertain. That is also why it is necessary to update the **scenarios** and calculations for each timeframe. Thus, the longer the time-frame being considered, the wider the security margins that are necessary. Closer to real time the uncertainty of the **scenarios** lessens and smaller security margins are required. Specifically, it might then be possible to release additional transmission capacity to the market.

Considering this, each **scenario** time frame has its own main objectives.

- Year ahead **scenarios**:
    - It is the first operational timeframe[5] that enables the TSO to assess the impact of evolutions of the structure of the grid.
    - Based on these **scenarios**, the TSOs elaborate the skeleton of the outage planning of relevant assets[6]
    - The capacities to offer to the yearly market are then calculated.
- Month ahead **scenarios**:
    - These **scenarios** are used to update capacities for the monthly market in regions where the "security analysis" approach is chosen.
    - At this timeframe, the organisation of the work on the assets is well known, and the outage planning can be refined accordingly.
- Week ahead **scenarios**:
    - These **scenarios** offer a better knowledge of the actual state of the operation (climate, lasting failures, unexpected outages and environmental hypotheses...).
- (D-2) **scenarios**:
    - They incorporate updates on the forecasted operational situation.
    - These mandatory **scenarios** make it possible to elaborate the inputs needed for the calculation of capacity for the day-ahead market

[5] The TSOs are organised for coordinating the development of the network and have a common view of the future of the infrastructure, but that is not considered here as operational activity.

[6] GL SO (2015-11-27) Art 2. (89) defines a "relevant asset" as "any relevant demand facility, relevant power generating module, or relevant grid element partaking in the outage coordination"

- (D-1) / **ID** ->
    - These **scenarios** are based on results of the (D-1) market and intraday results. The operational assumptions are reliable.
    - For the ID time horizons, the provision of an updated IGM by a TSO is triggered at least in case of a significant deviation from the forecasts, or **contingency** situations influencing the grid of other TSOs.

Each of the considered **scenarios** is intended to allow for a **contingency** assessment, and coordinated elaboration and check of **remedial actions**.

2.4.2 SPECIFIC SCENARIOS

Some **scenarios** are mandatory for all TSOs, some are only required at a regional level. The **scenario** definitions therefore describe the expected content for each of them when they are to be implemented (Europe-wide or regionally).

Please note the following principles that are common to all the **scenarios**:

- *Targeted period*: the **scenarios** shall identify the precise period (starting date and ending date) they focus on
- *Net Position and DC-Flows when no market data are available*. The requirement of the methodology is based on the CGMA algorithm described in chapter 4. For some regions, the results of the CGMA algorithm may be computed to divide the cross-border DC-flow results into per-cable DC-flows. The methodology allows the implementation of such an algorithm but will not describe it. In any case, the results of these algorithms shall be at the disposal of all the TSOs on the OPDE.
- *Structural information*: if a change occurs in the structure during the considered period, the following rules shall apply:
    - New equipment: it shall be implemented in the **scenario** as it can be topologically removed during the beginning of the period
    - Removal of equipment : it shall not be removed from the **scenario** – as it may be used until its removal, and could be topologically removed during the end of the period
    - Change in the characteristics: the most constraining characteristics shall be kept – it is up to the TSO to decide what these are.
- *Topological situation*:
    - outages (planned or not) shall not be implemented except if the equipment is expected to be out of service for the entire duration of the **scenario**
      This implies that the shorter the duration of a **scenario** is, the more outages are implemented.
    - The grid components that support voltage control shall be available (although they could be switched off for operational reasons).
    - The topology shall reflect the operational situation and include already known topological **remedial actions**.

- *Operational limits*: Each TSO shall apply the appropriate limits corresponding to the target season of the **scenario** to each grid element. For thermal limits this includes permanent admissible values and transitory admissible (overload) values.
- *Generation infeed*: the principle described above with respect to the handling of outages in describing the topological situation applies equally; generation units shall only be removed if they are expected to be unavailable for the entire duration of the **scenario**.
  According to SO GL (2015-11-27) Article 41 (3) (d), TSOs shall provide "a realistic and accurate forecasted aggregate amount of injection and withdrawal, per primary energy source, at each node of the transmission system for different timeframes."
  Known internal redispatching or countertrading even if not yet reflected in market orders shall be implemented.
- *RES infeed*: "for power generating facilities connected to distribution systems, aggregated active power output differentiated on the basis of the type of primary energy source" shall be included in the model [see GL SO (2015-11-27) Article 70 (3) (d)].

2.4.2.1 Year ahead for Yearly market:

GL SO (2015-11-27) Article 65 (4) states that “ENTSO for Electricity shall publish every year by 15 July the common list of scenarios established for the following year, including the description of these scenarios.” GL SO (2015-11-27) Article 65 (3) describes eight default **scenarios** for the year-ahead time frame to be used in case TSOs cannot agree on a set of alternative **scenarios**.

Initial net position of the TSOs and DC links

The default **scenarios** are listed hereafter and shall be used in order to establish **balanced AC/DC net positions and consistent flows on DC interconnectors**.

	Winter	**Spring**	**Summer**	**Autumn**
Peak (10:30CET)	3^{rd} Wednesday of January current year	3^{rd} Wednesday of April current year	3^{rd} Wednesday of July previous year	3^{rd} Wednesday of October previous year,
Valley (3:30 CET)	2^{nd} Sunday of January current year, 03:30 CET	2^{nd} Sunday of April current year, 03:30 CET	2^{nd} Sunday of July previous year	2^{nd} Sunday of October previous year
Indicative targeted period[7]	January 1^{st} to march 31^{st}	April 1^{st} to June 30^{th}	July 1^{st} to September 30^{th}	October 1^{st} to December 30^{th}

Possible reasons for using **scenarios** other than the default **scenarios** are, for example:

[7] The "indicative targeted periods" have not been excerpted from the GL SO (2015-11-27).

- an unusual operational situation during one of the default time-stamps such as abnormal climatic conditions in a wide area, 3 or more TSOs declaring an alert state (or worse) etc.
- the need to have more time-stamps available in common

The present methodology proposes a more robust approach for defining the initial **balanced AC/DC net positions and consistent flows on DC interconnectors**. Since the **AC/DC net positions** of **control areas** are becoming increasingly volatile (largely because of the effect of an increasing share of electricity being generated from RES), using a snapshot of the operational situation may not be the best approach as far as the requirements of the CGM are concerned. In order to be able to prevent the consequences of volatility as embodied in historical data from unduly skewing the results of the CGM, ENTSO-E developed the CGMA algorithm for computing **balanced AC/DC net positions and consistent flows on DC interconnectors** when no market data are available. The CGMA algorithm is discussed in more detail in chapter 4.

Load pattern

The load pattern and voltage profile shall be based on the realized situation chosen to define the grid condition (state estimator solution) or statistical data, and adjusted to the best estimated value corresponding to the **scenario**.

RES infeed

The grid condition for each **scenario** shall contain realistic infeed of RES for the date and time of the **scenario**. This may be assessed based on historical statistics, taking into account the forecasted implementation of new RES assets.

Generation infeed

GL SO (2015-11-27) Article 65 (1) (d) obliges all TSOs to assume "a fully available production park". This means that the generation schedule shall be updated with realistic values, based on the assumption that all the conventional generators are available, to meet **AC/DC net position** values that have been agreed, as well as agreed power flows on DC interconnector, RES infeed, demand and grid losses. This could thus mean that some generators are switched off in order to meet the minimum generation output requirements. The net generator positions shall be balanced (within their physical limits) to meet agreed net positions of the **scenario**.

2.4.2.2 Month ahead for monthly market and Week ahead

These **scenarios** are not mandatory at pan-European level. In order to have grid models for TSOs who may choose not to provide these models themselves, the year-ahead **scenarios** and corresponding IGMs are used and the substitution rules applied (cf. detailed discussion in sub-section 5.3.4).

The **scenarios** must be agreed among the TSOs concerned. Following the recommendations provided below would ensure that the handling of these time frames is consistent with that of the other **scenarios**.

Targeted period

Month ahead: The target period shall cover the whole month for a peak situation and a valley situation.

Week ahead: The target period shall cover the whole week for a peak situation and a valley situation.

Initial AC/DC net position of the TSOs and flows on DC interconnectors

The present methodology proposes to define the initial **balanced AC/DC net positions and consistent flows on DC interconnectors** using the CGMA algorithm described in chapter 4.

Load pattern

The load pattern and voltage profile shall be based on the realized situation chosen to define the grid condition (state estimator solution) or statistical data, and adjusted to the best estimated value corresponding to the **scenario**.

RES infeed

The grid condition for each **scenario** shall contain realistic infeed of RES for the date and time of the **scenario**. This may be assessed based on historical statistics, taking into account the forecasted implementation of new RES assets.

Generation infeed

To be consistent with the annual **scenarios** the production park should be considered to be fully available. This means that the generation schedule shall be updated with realistic values, based on the assumption that all the conventional generators are available, to meet **AC/DC net position** values as agreed as well as agreed flows on DC interconnectors, RES infeed, demand and grid losses. This could thus mean that some generators are switched off in order to meet the minimum generation output requirements. The net generator positions shall be balanced (within their physical limits) to meet the agreed **AC/DC net positions** of the **scenario**.

2.4.2.3(D-2) FOR DAY AHEAD MARKET

Targeted period

Pursuant to GL CACM Article 18 (2), "[o]ne scenario per market time unit shall be developed both for the day-ahead and the intraday capacity calculation time-frames."

The length of one market time unit may not be the same everywhere. The maximum market time unit is 1 hour. For some regions this may be reduced down to 30 minutes or 15 minutes.

The reference time for the IGM is defined as the middle of the time span. For the hour beginning at hh:00 and ending at hh:59, this should be hh:30 in case the IGM is prepared on an hourly basis.

A table in sub-sub-section 5.3.4.3 explains how the consistency of grid models using different market time units as their basis is ensured.

Initial AC/DC net position of the TSOs and flows on DC interconnectors

The CGMA algorithm and process described in chapter 4 shall be used to establish **balanced AC/DC net positions and consistent flows on DC interconnectors**. As the deadlines for this timeframe are very tight, a backup solution is needed. The "reference day" rules described in the table below constitute that backup solution with the data relating to the "reference day" being used as the initial **AC/DC net position** and flows on DC interconnectors.

Target day	Preparation day	Reference day *Previous ...*
Monday	Saturday	Friday
Tuesday	Sunday	Monday
Wednesday	Monday	Tuesday
Thursday	Tuesday	Wednesday
Friday	Wednesday	Thursday
Saturday	Thursday	Saturday
Sunday	Friday	Sunday

Load pattern

At this time horizon, the TSO is able to forecast or gather forecasts from third parties for the target day. If no forecast is available, the TSO shall use its best estimate.

RES infeed

At this time horizon, the TSO is able to forecast or gather forecasts from third parties for the target day, based on actual weather forecasts. Models shall be updated with the most recent forecast for the RES infeed.

Generation infeed

Taking into account the planned generator outages for the target day, generator infeed shall be updated with realistic values to meet the **AC/DC net position** values agreed as well as agreed flows on DC interconnectors, RES infeed, demand and grid losses. The net generator positions shall be balanced (within their physical limits) to meet the agreed **AC/DC net positions** of the **scenario**.

Topology:

Planned outages and relevant topological situation shall be implemented for each hour of the target day.

2.4.2.4 D-1 AND INTRADAY FOR INTRADAY MARKET

Targeted period

The provision of the D-1 IGM is mandatory for all market time units of the day. Therefore at least one set of IGMs corresponding to 24 time slots shall be provided by all TSOs – and one for each market time unit where necessary.

GL CACM Article 14 (4) further stipulates that "[a]ll TSOs in each capacity calculation region shall ensure that cross-zonal capacity is recalculated within the intraday market time-frame based on the latest available information. The frequency of this recalculation shall take into consideration efficiency and operational security."

Explanations above on non-harmonised market time units and reference times and IGMs that do not use the same market time unit as a basis apply.

Initial AC/DC net position of the TSOs and flows on DC interconnectors

For this **scenario** market data are available. To perform capacity calculation for the intraday market:

- For the day ahead timeframe, the model is based on the results of the day ahead market
- For the intraday timeframe, the model is based on the latest intraday market results.

Load pattern

At this time horizon, the TSO is able to forecast or gather forecasts from third parties for the target day. If no forecast is available, the TSO shall use its best estimate.

RES infeed

At this time horizon, the TSO is able to forecast or gather forecasts from third parties for the target day, based on actual weather forecasts. Models shall be updated with the latest forecast for the RES infeed.

Generation infeed

Generator schedules for the target day are used.

Topology:

Planned outages and the relevant topological situation for each hour of the target day are used.

3 IGM CREATION

Individual grid models (IGMs) are the basic building blocks of the CGM. The present chapter describes the principal components of IGMs and how these are combined into a grid model by TSOs.

By way of background, note that GL CACM Article 19 (1) requires IGMs "for each **bidding zone** and for each scenario". The article provides for two basic approaches to the preparation of IGMs. Either "(a) all TSOs in the **bidding zone** (...) jointly provide a single individual grid model which complies with Article 18(3)" or "(b) each TSO in the **bidding zone** (...) provide[s] an individual grid model for its **control area**, including interconnections, provided that the sum of net positions in the **control areas**, including interconnections, covering the **bidding zone** complies with Article 18(3)". The requirements related to GL CACM Article 18 (3) are covered in detail in chapter 4 and the relationship between **bidding zones** and **control areas** was discussed in section 1.2. For the avoidance of doubt it should be noted that the formulation "for each **bidding zone**" does not mean that one IGM has to be prepared per **bidding zone**; it means that each **bidding zone** has to be included in an IGM.

The general obligation to provide IGMs is formulated in GL CACM Article 28 (3) and 28 (4) and is restated below:
"(3) For each capacity calculation time-frame, each TSO shall establish the individual grid model for each scenario (...), in order to merge individual grid models into a common grid model."
(4) Each TSO shall deliver to the TSOs responsible for merging the individual grid models into a common grid model the most reliable set of estimations practicable for each individual grid model."

3.1 IGM DEFINITION

An IGM is defined as "a data set describing power system characteristics (generation, load and grid topology) and related rules to change these characteristics during capacity calculation, prepared by the responsible TSOs, to be merged with other individual grid model components in order to create the CGM" (GL CACM Article 2 (1)). In accordance with GL CACM Article 19 (3), an IGM "shall cover all network elements of the transmission system that are used in regional operational security analysis for the concerned time-frame" and the IGM "shall provide all necessary data (...) to allow active and reactive power flow and voltage analyses in steady state." (GL CACM Article 19 (5))

In practical terms IGMs have three main constituent elements. The first of these is the baseline equipment model for the **bidding zone** or **control area**, which changes relatively infrequently. Section 3.2 specifies requirements on TSOs in relation to the modelling of baseline equipment within each IGM, focusing on the following (each of which corresponds to a dedicated sub-section):

- TSOs' assets;
- Boundary points;
- Generation;
- Load;
- DSOs;
- HVDC equipment;
- Representation of adjacent TSOs (which also covers grid reduction);
- Structural changes (planned changes to the equipment model - e.g., transmission line upratings, decommissioning of plant, etc.).

The second main constituent element comprises the variable information referred to as operating assumptions, which vary depending on the applicable **scenario**. Section 3.3 specifies detailed requirements on TSOs in relation to the definition of IGM operating assumptions subdivided into:

- Topology;
- Energy Injections and Loads;
- Monitoring (technical operating limits of modeled equipment);
- Control Settings;
- Adjacent Grids.

The third main constituent element is included in the legal definition of (both individual and common) grid models as "rules" for changing the power system characteristics. These rules are neither structural nor variable data, but "associated" information and they have been summarised into section 3.4.

3.1.1 HARMONISATION

GL CACM Article 19 (4) stipulates that "[a]ll TSOs shall harmonise to the maximum possible extent the way in which individual grid models are built." In terms of access to cross-zonal capacity, this ensures that market participants are not subject to undue or unfair discrimination based on their location within the interconnected European transmission system. Consistency of approach to IGM creation across all TSOs ensures that cross-zonal capacity calculations are as consistent, repeatable and non-discriminatory as possible. In the interests of both non-discrimination and operational security it is also important that all TSOs create IGMs that are as realistic and accurate as possible, reflecting "the best possible forecast of transmission system conditions for each scenario specified by the TSO(s) at the time when the individual grid model is created" as required by GL CACM Article 19 (2).

Harmonisation of the manner in which IGMs are created is ensured through mandatory TSO adherence to the general principles, rules and detailed requirements for IGM creation specified in the CGMM and sections 3.1.2, 3.2., and 3.3 in particular. IGM quality and accuracy will be ensured through the quality assurance processes described in chapter 8.

Harmonisation of approach to IGM creation is further ensured through the CGM Alignment (CGMA) methodology described in chapter 4 which all TSOs implementing the CGMM are obliged to apply. This methodology constitutes the common rules used to determine the **balanced AC/DC net positions and consistent flows on DC interconnectors** for each **scenario** for which an IGM must be created. The provisions in chapter 4 satisfy the requirements set out in GL CACM Article 18 (3), namely that "all TSOs shall jointly draw up common rules for determining the net position in each **bidding zone** and the flow for each direct current line."

TSOs and RSCs across Europe currently use a variety of different network modelling and operational security analysis tools. As such, there is a practical requirement for harmonisation of the format in which IGMs and CGMs are created and exchanged.

To this end, the CGM Exchange Standard (CGMES) has been developed. All TSOs shall adopt the CGM Exchange Standard (CGMES) as the standardized format for the exchange of IGMs and CGMs as required under GL SO (2015-11-27) Article 114 (2).

The format facilitates the interoperability of the above-mentioned network modelling and operational security analysis tools and is based on the Common Information Model (CIM) international standard.

3.1.2 IGM Creation Process

The IGM creation process is based upon assumptions and forecasts of future system conditions. As such, the manner in which IGMs are created varies depending on the applicable time horizon. At longer term time horizons, such as at year-ahead and month-ahead, there is a relatively high degree of uncertainty over the timing and details of planned outages (the grid topology) and structural changes to the transmission system. Forecasts of renewable generation are unavailable and demand forecasts and assumptions regarding the electricity market are less reliable. At these time horizons, the operating assumptions applied during IGM creation are less dependent on market results and forecasting tools, but rather on the inter-TSO agreement of assumptions as part of **scenario** definition. In contrast, at day-ahead and during intraday, TSOs are in receipt of scheduled interchange programs and market participant schedules and nominations. There is also far greater certainty over planned structural changes to the grid, the grid topology (planned and forced outages), demand and renewable generation forecasts and the necessity for preventive **remedial actions**. The situation at two-days ahead is similar, the main differences being the need to coordinate assumptions regarding scheduled interchanges with all other TSOs and the need to forecast market activity given the unavailability of market schedules. At these shorter time horizons, the operating assumptions applied during IGM creation are derived from market data, forecasting tools and reasonably certain data on planned/forced outages and grid structural changes.

Notwithstanding the differences in the IGM creation process that apply at different time horizons it is possible to outline the general steps that each TSO must take when creating an IGM. The order in which the steps are taken may vary depending on the specific requirements of each TSO. For a given **scenario**, each TSO responsible for the creation of an IGM shall:

a) Create a baseline equipment model (in accordance with section 3.2);
b) Determine relevant structural changes and apply these to the equipment model (cf. sub-section 3.2.9);
c) Apply the relevant operating assumptions to the model (in accordance with section 3.3);
d) Ensure the IGM is consistent with the balanced **AC/DC net positions** and that flows on DC interconnectors are consistent in accordance with the provisions of chapter 4;
e) Perform a load flow solution, and if necessary **contingency** analysis, in order to verify:
    a. **Base case** solution convergence;
    b. Plausibility of nodal voltages and active and reactive power flows on grid elements;
    c. Plausibility of the active and reactive power outputs of each generator;
    d. Plausibility of the reactive power output/consumption of shunt-connected reactive devices;
    e. Compliance with applicable operational security standards.
f) If necessary, modify the equipment model and/or operating assumptions and repeat step e);
g) Carry out **network reduction**, if necessary (cf. sub-section 3.2.8);
h) Export the model in the standardised format for data exchange as per GL SO (2015-11-27) Article 114 (2) (i.e., the CGMES format);
i) Make the IGM available via the Operational Planning Data Environment (OPDE);
j) Repeat relevant steps above as necessary if the IGM fails external quality assurance tests (as explained in more detail in chapter 8) or upon the request of the relevant RSC (as explained in more detail in chapter 5).

3.1.3 Data provision by certified TSOs without system operator role

As was noted in section 1.2, not all "**certified TSOs**" have a system operator role. Data from such "**certified TSOs**" without a system operator role will nevertheless be required in order to build the IGM for the corresponding **control area**. Such TSOs shall therefore provide these data to the TSO building the IGM for the corresponding **control area**. When providing the data they shall follow the instructions from the TSO building the IGM for the corresponding **control area** with respect to, for example, deadlines, data formats to be used etc.

3.2 GRID DESCRIPTION

The present section provides an overview of the various items of equipment that need to be included in grid models as (quasi-) structural information. The first sub-section below explains the focus of coverage of IGMs (and thus CGMs) in terms of voltage levels.

3.2.1 FOCUS OF COVERAGE IN TERMS OF VOLTAGE LEVELS

The present section aims to provide a general explanation with respect to which voltage levels are to be modelled with which degree of detail.

GL SO (2015-11-27), Article 41 (3) (a) which refers to "the topology of the 220 kV and higher voltage transmission system within its **control area**" makes it clear that the grid elements (including SGUs) connected at or included in the 220 kV and higher voltage levels need to be modelled in detail.

Grid elements (including SGUs) connected at or included in voltage levels lower than 220 kV need to be modelled if they have a "significant impact" upon the TSO's own transmission system [GL SO (2015-11-27), Article 41 (3) (b), "a model or an equivalent of the transmission system with voltage below 220 kV with significant impact to its own transmission system"]. In addition to the code provision, the TSOs propose that such grid elements should be modelled in detail if they have cross-border impact.

If grid elements (including SGUs) connected at or included in voltage levels lower than 220 kV do not have cross-border impact, it is sufficient to include them in electrical equivalents in the IGM (such that their relevant electrical characteristics are retained and represented in the model; this will typically entail aggregating generation units by primary energy source as required by GL SO (2015-11-27) Article 41 (3) (d) which reads "a realistic and accurate forecasted aggregate amount of injection and withdrawal, per primary energy source, at each node of the transmission system for different timeframes.") How the aggregation is to be done is out of scope of the methodologies.

There is no lower limit in terms of voltage levels which may be included in the IGM. It is in principle at each TSO's discretion to decide which degree of granularity to implement in its IGM. However, since more granular / detailed modelling increases the computational burden at later steps of the CGM process, TSOs are encouraged to include in their IGM only the degree of detail that is required for the purpose for which the model is being established.

3.2.2 TSOs' ASSETS

This sub-section provides a very general introduction and a simplied description of the basic elements of a transmission system.

Although the title refers to the ‘TSOs’ assets’ , it’s necessary to specify that this sub-section does not discuss "relevant assets"; defined as "any relevant demand facility, relevant power generating module, or relevant grid element partaking in the outage coordination" in GL SO Article 3 (89).

Figure 2 below schematically illustrates a transmission system that is connected to an adjacent transmission system as well as a distribution system.

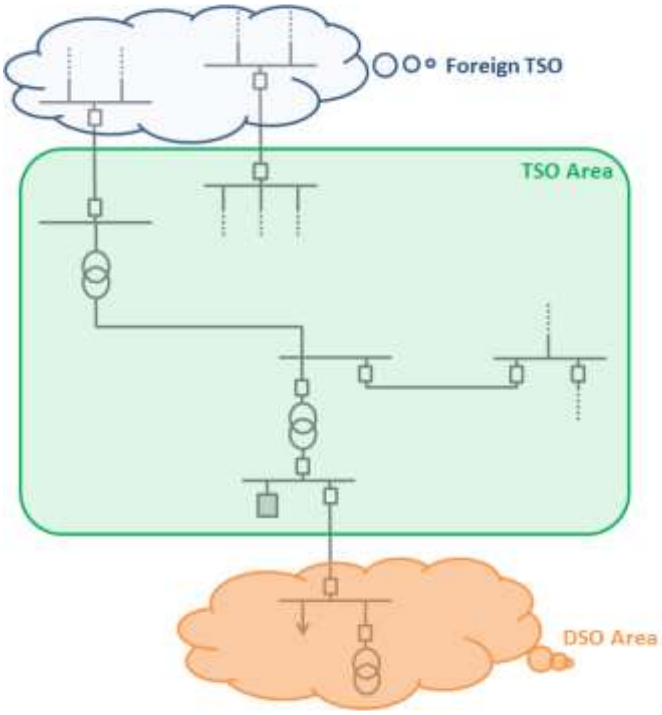


FIGURE 2: SCHEMATIC REPRESENTATION OF TRANSMISSION SYSTEM

The electricity system consists of three parts: generation, transmission, and distribution of electricity.
Transmitting electricity means transferring the power produced in the plants to consumer areas. In order for this to occur, lines, power and transformation plants are necessary.
The last part of the electricity generation process is represented by distribution, that is the delivery of medium and low voltage electricity to users (loads).
The principal elements of the grid are: EHV transformers (Extra High Voltage) that withdraw electricity from national power plants (or from border points if electricity is imported); EHV and HV (High Voltage) lines that carry electricity; and, lastly, substations that feed electricity to distribution companies that in turn (through retail companies) deliver electricity to homes and factories.

Besides the above mentioned principal elements, it should be noted that there are systems in which the generation is not directly connected to the transmission system, but they are related to the area of a DSO (thus, the generation will be transformed through lower voltage levels than EHV transformers).
The transmission system is the set of power lines and substations that form the meshed structure for transferring electricity from the sites where it is produced (power plants) to the sites where it is distributed (users and distribution grids). Transmission facilities are individual installations (lines, busbars, transformers, cables, breakers, isolators etc) which form the transmission network. This includes protective, monitoring and control equipment.
A line is the system that connects two junctions of the grid. It is formed by the power conductors that transfer electricity, by guard wires that protect the conductors against voltage surges having atmospheric origins and by the pylons supporting conductors and guard wires or underground cables.
A substation is the plant where the connection between lines and energy transformation occurs among the different voltage levels. Through the transformer, two or more power junctions are connected to different grid segments. The station contains all the equipment necessary for carrying out opening, closing and sectioning the converging lines in order to manage energy flows.
A transformer allows connecting and transferring electricity between two or more grids having a different voltage.
The busbar is a structure that forms the junction where lines having the same voltage converge. A system of bars with a certain voltage is connected through the transformer to another system of bars having a different voltage.
In order to keep the network in secure operating condition to guarantee a suitable level of security and market access, it is necessary to regularly carry out maintenance work which requires outages of assets.
A demand unit is an indivisible set of installations which can be actively controlled by a demand facility owner or distribution network operator or TSO, in general, to moderate its electrical energy demand. This is so called demand side response. Demand side response can involve actually curtailing power used or by starting on-site generation which may or may not be connected in parallel with the grid.
In order to create CGMs, system technical parameters and attributes are needed because they describe the grid characteristics in mathematical parameters and in connectivity description, independent of the time horizon.

3.2.3 BOUNDARY POINTS

At their border, the two involved TSOs agree on the position of their respective portions of responsibility. It can be located at the border between countries, a midpoint or any other agreed point. Thus, the TSOs are responsible for modelling their network to the agreed point. This point is then referred to as a Boundary Point.

All the agreed boundary points with their validity periods are referenced in a database accessible through OPDE to ensure their continuous availability and consistent use through the different merging processes.
In an IGM, the Boundary Point carries a fictitious injection that takes a plausible value of the flow on the interconnection line. The sum of the fictitious injections for an IGM represents the scheduled/target net interchange. The value on an individual Boundary Point is merely a fraction of this value that makes it possible to calculate an initial load flow on the IGM by balancing production / consumption of the TSO system. Only in the case of HVDC interconnectors does it represent the set point for that HVDC interconnector. TSOs have to include injection data in their IGMs.
A boundary set contains all boundary points necessary for a given grid model. A boundary set can have different coverage depending on the perimeter of the grid model. A complete boundary set is necessary to assemble a pan-European power system model into a **Common Grid Model**.
During the merging of IGMs, TSO Boundary Points will be matched to determine the interconnector, and fictitious injections will be deleted. Then the flows on the AC interconnections will be a result of the load flow calculation for the overall merged system.
The availability of interconnections must be consistent between two **individual grid models**.
Each TSO must apply the appropriate thermal limits corresponding to the target season of the **scenario** to each grid element.

3.2.4 GENERATION

This section describes what structural information of generation units is needed in order to run load-flow calculations. The list of structural data needed from generation facilities of type D and types B or C is contained in GL SO (2015-11-27) Article 45 (1) and (2), respectively.

In accordance with GL SO (2015-11-27) Article 70 (3) (d), (D-1) and intraday IGMs shall include "for power generating facilities connected to distribution systems, aggregated active power output differentiated on the basis of the type of primary energy source (...)"

The generation-related data required for the models are described in GL SO (2015-11-27) Article 41 (4). According to GL SO (2015-11-27) Article 41 (3) (a) all power generating modules connected to the transmission network at 220 kV and above shall be modelled separately. Power generating modules connected at less than 220 kV need to be modelled at least as an aggregated active power output differentiated according to the type of primary energy source.

The individual modeling of units requires that step-up transformers be modelled separately. This is also required by GL SO (2015-11-27) Article 41 (4) (a) (iv). For the aggregate generation the modeling of step-up transformers is optional. Concerning tap changers, description of existing on load tap changers, step up and network transformers, the TSO shall provide the necessary data on:

a) type of regulation; and

b) voltage regulation range

If aplicable, the wind farms or PV shall be considered as a single power generating module. RES shall be modelled separately from load. The aggregated active power output shall be differentiated according to the type of primary energy source. Realistic infeed of RES requires modelling these power-generating modules as generators connected to the distribution or transmission grids.

Optional aggregated models are allowed, depending on the type of generation module. Generation type C and B could be modelled, separately for each fuel type, as: a equivalent generator, equivalent transformer and equivalent line to the connection point at transmission level. Generation module type D must be modelled individually.

For generation model TSO shall provide a unique identifier for each power generating module within its **control area**. Any change of power generating module identifiers should be notified in advance to concerned parties (TSO/RSCs).

For generation model TSO shall provide the type of fuel.

For generation model the outage flag must be provided for all modelled power generating modules. All details concerning the actual value will be provided in the section on operating assumptions in section 3.3.

For generation model TSO shall specify the type of control mode. The following types are defined: “Disabled”, “Voltage Control”, “Power Factor Control”, “Reactive Power Control”. For voltage controlled units regulated buses (where the scheduled voltage is set up) have to be provided.

For each power generating module, each TSO shall provide the active power and minimum and maximum values of active power injection to the grid connection point. These values shall be the ones the power generating module can regulate to. In case of hydro pumped storage units, two cycles shall be modelled and two records have to be provided (generation and pumping mode).

For each power generating module, TSOs shall provide the active / reactive power characteristic and reactive power value. Values depend on whether step-up transformer is modelled or not. As a minimum the following parameters shall be included for each generation unit: minimum and maximum values of reactive power when the minimum and the maximum active power is delivered.

For generation mode, if modeled, the auxiliary load, which represent the internal demand of plant machinery, could be modelled in each connection point of power plant as non-conforming load, if necessary.

For each IGM one specific node, which has the voltage and angle constant, has to be provided. Power generating modules to be used as a slack generator can be identified with slack generator flag.

In addition, if necessary the pseudo-flag shall be delivered. The value "true" indicates that the generator is a fictitious one (a pseudo generator) modeled only for the purpose of balancing the model in unrealistic cases (due to the use of fixed reference days to determine net positions and DC schedules values, there could be some cases where the required generation shift is not feasible (e.g. in case of large deviations in RES infeed or reduced transfer capacity). After merging the pseudo - generator is deleted.

For each generation unit it shall be indicated to which **bidding zone** the unit belongs.

3.2.5 LOAD

Each TSO shall provide all information from SGUs necessary for security analysis. Among others the connected demand facilities and significant demand facilities are listed as significant.

According to GL SO (2015-11-27) Article 70 (3) (c), each TSO shall provide in operation planning consumption schedules. Therefore in the IGM the load shall be properly represented. The following paragraph describes the parameters to be delivered.

The list of structural data to be provided by transmission-connected demand facilities to TSOs is provided in GL SO (2015-11-27) Article 52.

Typically load is represented as flows over a transformer connecting the grid and demand facilities. Load is modelled as a constant consumption of MW and Mvar. Active and reactive power must be provided for all modelled loads. A detailed description of this requirement is provided in section 3.3.

Aditionally, for the demand side response facilities the minimum and maximum value of active load shall be provided. The power factor represents the change of reactive power as a function of the active power which is set up.

The load shall be separated from the active power injection of generating facilities connected to the grids of the distribution companies (DSO or DNO). In this case it is recommended to provide active and reactive power values for a load at the low-voltage side of the transformer (high-voltage side values might also be provided as typically lumped values or one set of values per transformer). A description of the modelling of distribution grids is provided in sub-section 3.2.6.

Each TSO shall provide an identifier (real code of the element) for loads within its **control area**. If applicable, load can be split between regular and price-dependent parts.

The outage flag must be provided for all modelled loads.

The conforming flag shall be provided for each load. The value "true" means that the load is to be scaled (conforming load).

Active power load injections, marked as conforming loads may be scaled to match the net positions, the sum of generation and the grid losses. Non-conforming loads have to have constant P and Q values.

The reactive power of the load injections marked as conforming loads shall retain their power factor after scaling.

3.2.6 Voltage levels below 220 kV

This sub-section describes the part of the IGM which represents the topology needed to model SGUs connected to the distribution part of the system and the representation of this grid in the model.

In view of the explanations in sub-section 3.2.1, the TSO has the right to choose if it provides a model with the lower voltage levels modelled in detail or not.

In case the non-detailed modelling is chosen, it is suggested to set up the model in two steps. In the first step a detailed description of the IGM is needed for the proper representation of the load, generation and lower voltage topology which influences the transmission system. In the second step, the TSO could decide to reduce the lower voltage grid.

Reducing the model is recommended because that reduces not only the size of the IGM but also the volume of data to be exchanged which is important for the exchange of large volumes of data (as among ENTSO-E members). The resulting CGM would also be smaller which would be beneficial from an IT point of view.

However, it is up to each TSO to decide whether such a reduction is useful or not. It is important that the reduced, less detailed model has to represent the real behavior of the transmission system including the response of the lower voltage grids.

Due to the fact that the IGM shall represent realistic system conditions, all necessary data have to be considered. This also means that TSOs are allowed to provide a model of the grid with voltage below 220 kV that has an impact on post-**contingency** load-flow (n-1) on its own transmission system. This happens in unique maintenance cases and n-1 analysis. In most situations those elements belong to the distribution companies (DSO) and work in parallel with the high voltage network (meshed area network). In those cases the representation of the DSO network makes it possible to detect possible constraints and agree on **remedial actions**.

During the IGM creation process, each TSO shall decide which lower voltage connections have to be taken into account for the proper modelling of generation. The reason is that RES have to be differentiated from the other aggregated active power output according to the type of primary energy source and modelled separately from load. Additionally, the lower voltage network should be properly represented because of the fact that most of the loads are physically connected to the lower voltage network. The appropriate modelling of the load in a meshed distribution system makes it possible to calculate plausible flows on transformers or the constant load connected to the buses of the transmission network. That fact is most important in meshed systems when both networks operate in parallel. In radially operated lower voltage grids, however, it could be aggregated into one value which represents the flow over the transformer.

For each transformer and line in a lower voltage network which - according to the rules described in sub-section 3.2.1 above - it is necessary to model, the TSO shall deliver: Operational Security Limits, status of the branch (in bus – branch model). Each TSO shall provide an identifier for lines and transformers.

For each bus in a distribution network modelled, TSO shall provide an identifier, nominal voltage, voltage ranges and scheduled voltage (if necessary) and elements connected to this bus.

For each switch element modelled TSOs shall indicate the type. The following types are defined: breaker, disconnector, load break switch. Jumpers, clamps and fuses in the distribution grids can be modelled using disconnectors. Each TSO shall provide for each switching device the status of the breakers (node – breaker model only).

After the proper modelling of the topology of DSO networks and connected generation and load the distribution networks may be finally reduced as: a load, a generation and equivalent branches connected to the transmission level. This is a less detailed representation of those parts of the system. The process of reduction is optional, as noted above each TSO shall decide if it is needed. DSO networks in IGMs may also be included in full detail.

The equivalent model of the non-radial lower than 220 kV networks shall be provided in case this part of the network is considered by the TSO as important for the transmission system network (when a certain level of the power flow in congestion cases flows over these lines). Each TSO shall define the threshold of the power flow which is recognized as having a significant impact.

Radial connections below 220 kV, except generators and condensers connected by step-up transformers, should be aggregated and represent at its EHV or HV network connection point. Generation units of type C and B must be modelled separately for each primary energy source. If applicable, the embedded generation should be represented explicitly as: an aggregated model represented by standard type generator, equivalent transformer and line to the connection point at transmission level. All mentioned elements could be summarized and presented as a single equivalent model of a generation unit.

If applicable, aggregation of generation shall be made in a consistent way with the generation type (fuel type). Indication of the connection node and type of voltage regulation is necessary.

The aggregated loads would be represented at the closest extra-high voltage (EHV) node and show the actual loading on the connection point. The aggregated loads represents the load and losses in the originally connected network (such as losses on step-up transformers of generation type C, B). Aggregation levels shall be consistent with geographical distribution.

3.2.7 HVDC INTERCONNECTORS

The present sub-section covers schedulable HVDC interconnectors. How HVDC interconnectors are modelled depends on the functions that the corresponding **HVDC link** is intended to be used for.

As HVDC interconnectors are becoming more common, the purposes for which these are used should be coordinated and modelled. HVDC interconnectors (converter stations) provide many different functionalities from voltage to frequency control, thus their effect on the grid must be assessed in security analyses and capacity calculations.

Flows on HVDC interconnectors for IGM purposes are provided by market schedules or by the CGM alignment methodology (cf. chapter 4).

SO GL (2015-11-27) Article 45 (4) and Article 46 (2) ensure that TSOs have the right to obtain all data necessary for detailed HVDC modelling. The dedicated draft Commission Regulation (EU) .../... of XXX establishing a network code on requirements for grid connection of high voltage direct current systems and direct current-connected power park modules (henceforth NC HVDC (2015-09-11)) contains additional provisions.

3.2.7.1 HVDC MODELLING

There are two ways of modelling HVDC interconnectors for IGM purposes:

- Detailed
- Simplified

Which option is chosen depends on which functions are used on a given HVDC interconnector and on what kind of calculations the corresponding IGM is to be used for. This must be agreed on by the TSOs concerned.

For the purpose of dynamic simulations, NC HVDC (2015-09-11) Article 54 (2) stipulates that "the models provided shall contain at least, but not limited to the following sub-models, depending on the existence of the mentioned components:

(a) HVDC converter unit models;
(b) AC component models;
(c) DC grid models;
(d) Voltage and power control;
(e) Special control features if applicable e.g. power oscillation damping (POD) function, subsynchronous torsional interaction (SSTI) control;
(f) Multi terminal control, if applicable;
(g) HVDC system protection models as agreed between the relevant TSO and the HVDC system owner."

3.2.7.1.1 SIMPLIFIED

The AC/DC part of the HVDC interconnector is not exchanged. In this case the net interchange is represented by equivalent injections referring to each boundary point. This option is used if the functions used on the HVDC interconnector do not require more detail than injections for defined business processes.

3.2.7.1.2 DETAILED

The AC/DC part of the HVDC interconnector is exchanged. The HVDC model can be exchanged as a separate model or as part of one TSO's IGM. The TSOs concerned will decide which TSO is to be responsible; that TSO is to include the detailed model in its IGM or send it as a separate model. The HVDC model shall refer to the boundary points included in the boundary set. This option is used whenever there is a need for a more detailed model than simple injections. Level of detail is to be agreed between relevant TSOs.

3.2.7.1.3 HVDC CONNECTED TO NON-CGM AREA

If the HVDC interconnector links a **bidding zone** that is part of the **CGM Area** with another **bidding zone** that is not, the HVDC model will be included in the IGM of the TSO that is part of the **CGM Area**.

In this case the within-**CGM Area** TSO shall endeavour to implement an agreement to ensure that the owners of HVDC interconnectors with no legal obligation to comply with EU legislation also cooperate to fulfil the requirements.

3.2.8 REPRESENTATION OF ADJACENT GRIDS (INCL. GRID REDUCTION)

This sub-section describes how to manage adjacent grids (i.e., neighbouring TSOs) within an IGM.

3.2.8.1ADJACENT GRID

In the case of IGMs: "adjacent grid" is the grid outside one's **control area** / **bidding zone**.

In the case of CGMs: "adjacent grid" is the grid outside the **CGM Area**

.
Adjacent grids are represented as injections on tielines. Dedicated rules apply to HVDC interconnectors. The injections will be assigned to defined Boundary Points, so that TSOs' IGMs only represent their own **control area** or **bidding zone**. The concept of Boundary Points is explained in sub-section 3.2.3 in more detail.

3.2.8.2USE OF ADJACENT GRIDS

Adjacent grids are used (where applicable) in the IGM creation process in order to ensure the quality of the IGM, to find injections on Boundary Points with the non-**CGM Area**, to simulate the behaviour on the tie-lines, HVDC links, and on the coupling transformers.

The need for taking into account adjacent grids derives from TSOs' obligation to model the IGMs with high quality [GL CACM Article 19 (2), (3)]. This, in turn, requires that operational security analyses incorporating all defined **contingencies** affecting the corresponding **control area** must be run on an IGM**.** A TSO creating its IGMs shall endeavour to apply **remedial actions** (topology changes, redispatch ...) needed to avoid N-1 constraints taking into account the adjacent grid, but it is the responsibility of RSCs to propose additional

remedial actions based on the CGM merging process and the coordinated security analysis results (cf. GL SO (2015-11-27) Article 78 (2) (a)).

3.2.8.3 STRUCTURAL DATA OF ADJACENT GRIDS

In the process of creating IGMs, when modelling the adjacent grid, the best available data have to be used, the source can be either the CGM from a previous timeframe covering the adjacent grid or the observability area which is maintained and provided by each TSO's SCADA system. The use of these data is only necessary if the adjacent grid is needed in the IGM creation process. This is the case when outages in the adjacent grid have a significant impact on the grid of the TSO preparing the IGM (e.g., because of loop flows, overloading of internal overhead lines or tielines etc). If outages in the adjacent grid do not have a significant impact on the grid of the TSO preparing the IGM, such outages can be represented accurately enough as an outage of a grid element within the TSO's **control area** (e.g., as the outage of an AC tie-line or HVDC interconnector, respectively).

3.2.8.4GRID REDUCTION

After operational security analyses have been run on a grid model combining the IGM as well as the adjacent grid and once preventive measures have been added to the model and **remedial actions** have been defined, the adjacent grid is reduced to injections before exchanging the IGM among TSOs.

3.2.9 STRUCTURAL CHANGES

Structural changes can consist of grid elements being added, modified, or removed. Such structural changes generally have a long term impact and are known several months to even several years in advance. Structural changes constitute a break with respect to the modelling of the grid and require corresponding changes to the IGM building process. For each time horizon under consideration, a TSO needs to assess which changes to the structure of its grid are likely and then adjust its hypotheses as the information (e.g., about the date of commissioning or details of technical characteristics) is updated. Any of the grid elements described in the preceding sub-sections can lead to structural changes in the grid model.

The longer the time horizon of the **scenario** being considered, the more likely it is that structural changes will occur.

The following cases need to be considered:

(a) New equipment: the new item of equipment shall be added to the IGM beginning with the first **scenario** during which the item is expected to be operational (even if it is not for the entire duration of the **scenario**). An outage shall be declared (as associated information) as long as the equipment is not yet in operation; i.e., for the period until it enters into operation.

(b) Removal of an item of equipment: the item of equipment shall be removed from the IGM beginning with the first **scenario** during which the item is expected no longer to be operational at all. In the last **scenario** during which the item of equipment is still operational at least some of the time, an outage shall be declared (as associated information) whenever the equipment is no longer in operation.

(c) Modification of an item of equipment: the most constrained characteristics with regards to security assessment shall be implemented for the full duration of the first **scenario** in which the change occurs.

Structural changes affecting more than one TSO (e.g., relating to interconnectors) need to be implemented in a coordinated manner by all TSOs concerned in order to ensure that IGMs are consistent with each other.

Transient situations in the grid description can occur resulting in many changes in a short period. The TSO provides its best representation of the equipment according to the previous principles, and ensures that the submitted IGMs represent in all circumstances the most constrained situation with regards to security.

3.3 OPERATING ASSUMPTIONS

The present section provides an overview of the various kinds of "operating assumptions" that need to be included in grid models as variable information. In addition to the structural data described in the preceding section 3.2, this is the second main constituent element for IGMs.

In order to fully model a transmission system for the purposes of performing a load flow calculation, short-circuit current calculation or stability assessment, it is necessary to specify the operating assumptions applicable to the relevant **scenario**. Operating assumptions refer to the following:

- Topology
- Energy injections and loads
- Monitoring
- Control settings
- Assumptions on adjacent grids

In conjunction with the equipment model (the elements of which were described in the preceding section 3.2), which represents the electrical and thermal characteristics of the transmission system, the operating assumptions allow a load flow solution to be performed in order to determine the active and reactive power flows across the system and the voltage magnitude and phase angle at each node. The operating assumptions also determine transformer tap positions (where tapping is enabled), the reactive power contribution from generators and reactive devices and how imbalances between generation and demand are handled in the model. While the equipment model should be derived from structural data and will change infrequently, the operating assumptions will differ according to the particular **scenario** or type of study being performed.

The relevant categories of operating assumptions are described below:

The *Topology* of the IGM is a description of how all equipment within the model is expected to be electrically connected as per the relevant **scenario**. The topology describes the switched status (opened or closed) of all switching devices on the system. It reflects the known or expected availability and operational ("in service" / "out of service") status of all modelled transmission lines, cables, transformers, generators, loads, reactive devices and DC equipment. The topology also reflects the assumed initial status of transformer tap positions (cf. the discussion on control settings in sub-section 3.3.4).

Energy Injections and Loads in the IGM pertain to the expected injections and withdrawals of active and reactive power at each node on the system. Energy injections and loads reflect the scheduled or forecast nodal infeed from generators (including renewable energy sources) and distribution networks and the scheduled or forecast nodal outflow to distribution networks, demand facilities, pumps, generator auxiliary supplies and any other significant grid users. They may also reflect the scheduled or forecast aggregate nodal infeed/outflow. Fictitious energy injections and loads at model boundary nodes ("Boundary Points"; cf. sub-section 3.2.3) are used to reflect the scheduled or forecast flows on interconnectors and on tie-lines between TSOs.

Monitoring pertains to information describing the known, expected or forecast operational limits of items of modelled equipment according to the relevant **scenario**. This includes maximum admissible thermal loadings on transmission lines, cables, transformers and DC equipment (in Amps, MVA or MW) and maximum and minimum acceptable voltages. Such operational limits may vary seasonally or may be dependent on environmental or meteorological factors (e.g., temperature, wind speed, wind direction, etc.).

Control Settings in the IGM specify the targets and ranges within which controllable items of equipment can regulate active and reactive power flows, DC flows and nodal voltages. During the performance of a load flow solution these settings influence transformer tap positions, DC equipment settings and the reactive power contribution from generators and reactive devices. Control settings are also used to designate slack generators and their respective proportional contributions towards balancing total modelled generation and total demand.

As described in sub-section 3.2.8, it may be necessary for some TSOs to model portions of neighbouring systems, “adjacent grids”, in order to accurately simulate active and reactive power flows and voltages at or near boundary nodes. *Assumptions on Adjacent Grids* are assumptions the TSO must make regarding the *Topology*, *Energy Injections and Loads*, *Monitoring* and *Control Settings* in those portions of neighbouring systems that the TSO elects to model. All “adjacent grids” are ultimately reduced to fictitious equivalent energy injections or loads at model boundary nodes during the ‘**network reduction**’ step of the IGM creation process, where applicable.

The following sections 3.3.1 to 3.3.5 specify requirements on TSOs in relation to each of the above categories of operating assumptions, ensuring that the manner in which IGMs are built is harmonised to the maximum possible extent as required by GL CACM Article 19 (4). Consistency of approach to IGM creation, insofar as this is possible given regional specificities, guarantees the interoperability, consistency and repeatability of operational security analyses and cross-zonal capacity calculations. This in turn ensures that market participants across the **CGM Area** are treated in a fair and non-discriminatory way.

3.3.1 TOPOLOGY

3.3.1.1 YEAR-AHEAD / MONTH-AHEAD / WEEK-AHEAD REQUIREMENTS

This section specifies requirements on TSOs in relation to the topology of IGMs created for the purposes of year-ahead, month-ahead and week-ahead operational security analyses and cross-zonal capacity calculations.

For a given **scenario**, each TSO responsible for the creation of an IGM shall ensure that:

a) The IGM indicates the switched state (open or closed) of all modelled switching devices (circuit breakers, disconnectors, switches, etc.).
b) The IGM indicates the tap position of all modelled power transformers including phase shift transformers.
c) The topology of the IGM reflects the best forecast operational situation where all modelled items of equipment are assumed to be fully available, notwithstanding points d) and e).
d) The topology of the IGM reflects the planned or forced unavailability of relevant modelled items of equipment that are known or expected to be unavailable throughout the entire period covered by the model (i.e., year, month or week).
e) The topology of the IGM is updated to reflect at least those preventive **remedial actions** that are relevant to coordinated security analyses and cross-zonal capacity calculation, which are required to maintain the system within applicable **operational security limits**. This includes topology changes required to address physical and structural congestion and those required for voltage management, fault level management and system stability management. With respect to voltage management, this includes accurately reflecting the switched status of discretely switchable reactive power compensation devices such as capacitor and reactor banks.
f) The connectivity status of interconnectors and tie-lines to other TSOs is consistent with the IGMs of the relevant neighbouring TSOs.

Topology modifications associated with point b) shall reflect:

- Actual tap positions corresponding to the historical timestamp upon which the **scenario** is based;
- Historical SCADA data or state estimated data for system conditions that are reflective of the applicable **scenario**; and/or
- Tap position optimisation based on load flow calculations and the application of preventive **remedial actions**.

Where relevant in the context of points d) and f), topology modifications shall be consistent with:

- Structural, scheduled and forecast data exchanged between TSOs, DSOs, power generating modules, demand facilities, other significant grid users and owners of interconnectors or other lines in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq.
- Final availability plans for the applicable outage coordination region, as agreed in accordance with GL SO (2015-11-27), Part III (Operational Planning), Title 3 (Outage coordination), Article 82 et seq.

- Information on the planned and forced unavailability of modelled items of equipment as published on the ENTSO-E Transparency Platform in accordance with Commission Regulation (EU) No 543/2013 of 14 June 2013 on submission and publication of data in electricity markets and amending Annex I to Regulation (EC) No 714/2009 of the European Parliament and of the Council (henceforth **Transparency Regulation**)

Year-ahead availability plan proposals, final availability plans and availability plan updates, as referred to in GL SO (2015-11-27), Part III, Title 3, Chapter 2 (Development and update of availability plans of relevant assets), Article 91 et seq., shall be exchanged between TSOs and RSCs separate to the IGMs. Topology modifications associated with these plans may be applied to the **base case** IGMs and CGMs by the relevant TSOs and RSCs for the purposes of coordinated operational security analyses, regional outage coordination and cross-zonal capacity calculations, as necessary.

3.3.1.2 Two-Days Ahead / Day-Ahead / Intraday Requirements

This section specifies requirements on TSOs in relation to the topology of IGMs created for the purposes of two-days ahead, day-ahead or intraday operational security analyses and cross-zonal capacity calculations.
For a given **scenario** (market time unit), each TSO responsible for the creation of an IGM shall ensure that:

a) The IGM indicates the switched state (open or closed) of all modelled switching devices (circuit breakers, disconnectors, switches, etc.).
b) The IGM indicates the tap position of all modelled power transformers including phase shift transformers.
c) The topology of the IGM reflects the planned or forced unavailability of relevant modelled items of equipment that are known or expected to be unavailable during the relevant market time unit. The modelled topology shall reflect relevant local outage plans and be consistent with the following:
    i. Latest final availability plans for the relevant outage coordination region, as agreed in accordance with GL SO (2015-11-27), Part III, Title 3, Chapter 1, Article 82 et seq.;
    ii. Information published on the ENTSO-E Transparency Platform in accordance with the **Transparency Regulation**;
    iii. Structural, scheduled and forecast data exchanged between TSOs, DSOs, power generating modules, demand facilities, other significant grid users and owners of interconnectors or other lines in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq.
    iv. Where a TSO receives short notice information regarding a change in the planned or forced unavailability of a relevant item of modelled equipment, as compared against the exchanged and published data above, the TSO shall

reflect these changes in the model topology. Instances where such actions might be necessary include the short notice cancellation of a planned outage or the tripping of a relevant item of equipment in real time, close to the deadline for submission of the IGMs and where there is insufficient time to update the data above.

d) The topology of the IGM is updated to reflect at least those preventive **remedial actions** that are relevant to coordinated security analyses and cross-zonal capacity calculation required to maintain the system within applicable **operational security limits**. This includes topology changes required to address physical and structural congestion and those required for voltage management, fault level management and, if applicable, system stability management. With respect to voltage management, this includes accurately reflecting the switched status of discretely switchable reactive power compensation devices such as capacitor and reactor banks.

e) The connectivity status of interconnectors and tie-lines to other TSOs is consistent with the IGMs of the relevant neighbouring TSOs.

Topology modifications associated with point b) shall reflect:

- Actual tap positions corresponding to the historical timestamp upon which the **scenario** is based, if applicable;
- Historical SCADA data or state estimated data for system conditions that are reflective of the applicable **scenario**; and/or
- Tap position optimisation based on load flow calculations and the application of **remedial actions**.

The topology of all IGMs created for intraday purposes shall reflect the real-time forced unavailability of modelled items of equipment. This is due to the uncertainty over whether the affected item(s) of equipment will be reconnected (worst case **scenario**).

3.3.2 ENERGY INJECTIONS AND LOADS

3.3.2.1 GENERAL PRINCIPLES

This section specifies general requirements on TSOs in relation to the modelling of energy injections and loads in IGMs created for the purposes of operational security analyses and cross-zonal capacity calculations. For a given **scenario**, each TSO responsible for the creation of an IGM shall ensure that:

- The IGM specifies an active and reactive power injection for each modelled in-service generator;
- The IGM specifies a reactive power injection for each modelled in-service synchronous condenser;
- The specified active and reactive power injection for each modelled in-service generator, synchronous condenser and pump is consistent with the specified maximum and minimum active and reactive power limits and/or applicable reactive capability curve;

- The IGM specifies an active and reactive power withdrawal for each modelled in-service load and pump;
- Following the reduction of all modelled "adjacent grids", if applicable (see sub-section 3.3.5), the sum of the fictitious (equivalent) active power injections and withdrawals at boundary nodes is consistent with the agreed **AC/DC net position** for the relevant **control area** or **bidding zone** and flows on DC interconnectors are also consistent.

For a given **scenario**, active power injections associated with generation within the IGM shall be consistent with the following:

- Information published on the ENTSO-E Transparency Platform in accordance with the **Transparency Regulation**;
- Relevant **remedial actions** required to maintain the system within applicable **operational security limits** on a preventive basis, including but not limited to:
    - Provision of sufficient upward and downward active power reserves (e.g., Frequency Containment Reserve, Frequency Restoration Reserve, etc.) required for the purposes of frequency management;
    - Generation redispatch aimed at resolving internal physical and structural congestion;
    - Generation redispatch for the purposes of voltage management;
    - Generation redispatch for the purposes of ensuring voltage stability and/or dynamic stability.

Specification of the reactive power injections associated with generators, synchronous condensers and pumps shall be based upon one or more of the following:

- Load flow calculations (e.g., to determine reactive power injections based on generator voltage regulation targets/ranges, etc.);
- Historical power factor data.

Where a TSO has not received items of information required from third parties within specified deadlines as per GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq. or as per the GLDPM, that TSO shall use alternative best estimates to determine relevant nodal active and reactive power injections and withdrawals in the IGM.

3.3.2.2 Year-Ahead Requirements

This section specifies requirements on TSOs in relation to the modelling of energy injections and loads in IGMs created for the purposes of operational security analyses and cross-zonal capacity calculations at year-ahead. For a given **scenario**, each TSO responsible for the creation of an IGM shall:

- Scale or otherwise modify the nodal active and reactive power withdrawals associated with modelled in-service loads and pumps such that, in aggregate, they match the total electricity demand agreed in accordance with GL SO (2015-11-27) Article 65 (1), less expected/calculated transmission losses.

- Scale or otherwise modify the nodal active power injections of modelled in-service generators such that, in aggregate, they match the sum of the following:
  - Total electricity demand [cf. GL SO (2015-11-27) Article 65 (1) (a)]
  - Exchanges with other TSOs and/or **bidding zones**, as agreed in accordance with GL SO (2015-11-27) Article 65 (1) (c)

For the relevant **scenario**, the scaling or modification of active and reactive power withdrawals associated with load shall be based upon a selection of the following:

- Representative historical reference data (for the relevant season/day/time, etc.);
- SCADA and/or metered data;
- State estimated data;
- Statistical analysis or forecast data;
- Distinctions between variable load and explicitly modelled non-variable load (e.g., industrial load);
- Forecast demand reduction from demand units;
- Structural, scheduled and forecast data exchanged between TSOs, DSOs, demand facilities and other significant grid users in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq
- Data provided to the TSO in accordance with the GLDPM.

For the relevant **scenario**, the scaling or modification of active power injections associated with generation shall assume a fully available production park in accordance with GL SO 2015-11-27) Article 65 (1) (d) and shall be based upon the following:

- Scheduled and forecast data exchanged between TSOs, DSOs, power generating modules and other significant grid users in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq;
- Data provided to the TSO in accordance with the GLDPM;
- Applicable priority dispatch policies and agreements;
- Conditions relating to the contribution of renewable energy sources as agreed in accordance with GL SO (2015-11-27) Article 65 (1) (b);
- Best forecast dispatch pattern for non-renewable generation taking into account:
  - Relevant current, historical or forecast commercial/market data;
  - Distinctions between base load generation and marginal generation;
  - Established **power shift keys** ("**generation shift keys**"), merit orders or participation factors (e.g., based on fuel type).

3.3.2.3 Month-Ahead / Week-Ahead Requirements

This section specifies requirements on TSOs in relation to the modelling of energy injections and loads in IGMs created for the purposes of operational security analyses and cross-zonal capacity calculations at month-ahead and week-ahead, where such activities have been agreed regionally under GL FCA (2015-10-30) Article 9 and/or GL SO (2015-11-27) Article 69 (1), respectively. For a given **scenario**, each TSO responsible for the creation of an IGM shall:

- Scale or otherwise modify the nodal active and reactive power withdrawals associated with modelled in-service loads and pumps such that, in aggregate, they match the agreed total electricity demand specified during **scenario** definition, less expected/calculated transmission losses.
- Scale or otherwise modify the nodal active power injections of modelled in-service generators such that, in aggregate, they match the sum of the following:
  - Total electricity demand;
  - Exchanges with other TSOs and/or **bidding zones**, as agreed during **scenario** definition.

For the relevant **scenario**, the scaling or modification of active and reactive power withdrawals associated with load shall be based upon a selection of the following:

- Representative historical reference data (for the relevant season/day/time, etc.);
- SCADA and/or metered data;
- State estimated data;
- Statistical analysis or forecast data;
- Distinctions between variable load and explicitly modelled non-variable load (e.g., industrial load);
- Forecast demand reduction from demand units;
- Structural, scheduled and forecast data exchanged between TSOs, DSOs, demand facilities and other significant grid users in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq;
- Data provided to the TSO in accordance with the GLDPM.

For the relevant **scenario**, the scaling or modification of active power injections associated with generation shall be based upon a selection of the following:

- Scheduled and forecast data exchanged between TSOs, DSOs, power generating modules and other significant grid users in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq;
- Data provided to the TSO in accordance with the GLDPM;
- Applicable priority dispatch policies and agreements;
- Contribution from renewable energy sources as agreed during **scenario** definition;
- Best forecast dispatch pattern for non-renewable generation taking into account:
  - Relevant current, historical or forecast commercial/market data;
  - Distinctions between base load generation and marginal generation;
  - Established **power shift keys** ("**generation shift keys**"), merit orders or participation factors (e.g., based on fuel type).

For the relevant **scenario**, active power injections associated with generation within the IGM shall be consistent with the following:

- Latest final availability plans for the relevant outage coordination region, as agreed in accordance with GL SO (2015-11-27), Part III, Title 3, Chapter 1, Article 82 et seq.;
- Relevant local generation outage plans and testing profiles.

3.3.2.4 Two-Days Ahead Requirements

This section specifies requirements on TSOs in relation to the modelling of energy injections and loads in IGMs created for the purposes of cross-zonal capacity calculations at two-days ahead. For a given **scenario** (market time unit), each TSO responsible for the creation of an IGM shall:

- Scale or otherwise modify the nodal active and reactive power withdrawals associated with modelled in-service loads and pumps such that, in aggregate, they match the sum of the following:
  - Total forecast load, exclusive of transmission losses;
  - Total auxiliary supplies to power generating modules ("house load"), if modelled;
  - Total forecast demand reduction from demand units.
- Scale or otherwise modify the nodal active power injections of modelled in-service generators such that, in aggregate, they match the sum of the following:
  - Total forecast load;
  - Total auxiliary supplies to power generating modules ("house load"), if modelled;
  - Total forecast demand reduction from demand units;
  - Transmission losses;
  - Exchanges with other TSOs and/or **bidding zones**.

For the relevant **scenario**, the scaling or modification of active and reactive power withdrawals associated with load shall be based upon a selection of the following:

- Representative historical reference data (for the relevant day/time, etc.);
- SCADA and/or metered data;
- State estimated data;
- Statistical analysis or forecast data;
- Distinctions between variable load and explicitly modelled non-variable load (e.g., industrial load);
- Forecast demand reduction from demand units;
- Structural, scheduled and forecast data exchanged between TSOs, DSOs, demand facilities and other significant grid users in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq;
- Data provided to the TSO in accordance with the GLDPM.

For the relevant **scenario**, the scaling or modification of active power injections associated with generation shall be based upon a selection of the following:

- Scheduled and forecast data exchanged between TSOs, DSOs, power generating modules and other significant grid users in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq;
- Data provided to the TSO in accordance with the GLDPM;
- Applicable priority dispatch policies and agreements;

- Best forecast of generation from renewable energy sources derived from meteorological forecasts, updated no earlier than 15:00 CET at two-days ahead in accordance with GL CACM Article 14 (3);
- Best forecast dispatch pattern for non-renewable generation taking into account:
  - Relevant current or historical commercial/market data;
  - Distinctions between base load generation and marginal generation;
  - Established **power shift keys** ("**generation shift keys**"), merit orders or participation factors (e.g., based on fuel type).

For the relevant **scenario**, active power injections associated with generation within the IGM shall be consistent of the following:

- Latest final availability plans for the relevant outage coordination region, as agreed in accordance with GL SO (2015-11-27), Part III, Title 3, Chapter 1, Article 82 et seq.;
- Relevant local generation outage plans and testing profiles.

Where a TSO receives short notice information involving a change in the planned or forced unavailability of a relevant generator, as compared against the exchanged and published data above, the TSO shall reflect these changes in the relevant IGMs. Instances where such actions might be necessary include the short notice cancellation of a planned generator outage or the tripping of a generator in real time close to the deadline for submission of the IGMs and where there is insufficient time to update the data exchanged/published.

Notwithstanding the requirements above, each TSO responsible for the creation of an IGM shall include energy injections and loads representative of the best possible forecast of transmission system conditions at the time when the IGM is created, in accordance with GL CACM Article 19 (2).

3.3.2.5 Day-Ahead / Intraday Requirements

This section specifies requirements on TSOs in relation to the modelling of energy injections and loads in IGMs created for the purposes of operational security analyses and cross-zonal capacity calculations at day-ahead and intraday. For a given **scenario** (market time unit), each TSO responsible for the creation of an IGM shall:

- Adjust the nodal active and reactive power withdrawals associated with modelled in-service loads and pumps such that, in aggregate, they match the sum of the following:
  - Total forecast load, exclusive of transmission losses;
  - Total auxiliary supplies to power generating modules (“house load”), if modelled;
  - Total scheduled demand reduction from demand units.
- Adjust the nodal active power injections of modelled in-service generators such that, in aggregate, they match the sum of the following:
  - Total forecast load;
  - Total auxiliary supplies to power generating modules (“house load”), if modelled;
  - Total scheduled demand reduction from demand units;

  - Transmission losses;
  - Exchanges with other TSOs and/or **bidding zones**.

For the relevant **scenario**, the adjustment of active and reactive power withdrawals associated with load shall be based upon a selection of the following:

- Scheduled demand reduction from demand units;
- Representative historical reference data (for the relevant day/time, etc.);
- SCADA and/or metered data;
- State estimated data;
- Statistical analysis or forecast data;
- Distinctions between variable load and explicitly modelled non-variable load (e.g., industrial load);
- Structural, scheduled and forecast data exchanged between TSOs, DSOs, demand facilities and other significant grid users in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq;
- Data provided to the TSO in accordance with the GLDPM.

For the relevant **scenario**, the adjustment of active power injections associated with generation shall be based upon the following:

- Latest available market schedules for non-renewable generation;
- Best forecast of generation from renewable energy sources as derived from meteorological forecasts and latest available market schedules for renewable generation;
- Applicable priority dispatch policies and agreements;
- Scheduled and forecast data exchanged between TSOs, DSOs, power generating modules and other significant grid users in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq;
- Data provided to the TSO in accordance with the GLDPM;

For the relevant **scenario**, active power injections associated with generation within the IGM shall be consistent of the following:

- Latest final availability plans for the relevant outage coordination region, as agreed in accordance with GL SO (2015-11-27), Part III, Title 3, Chapter 1, Article 82 et seq.;
- Relevant local generation outage plans and testing profiles.

Where a TSO receives short notice information involving a change in the planned or forced unavailability of a relevant generator, as compared against the exchanged and published data above, the TSO shall reflect these changes in the relevant IGMs. Instances where such actions might be necessary include the short notice cancellation of a planned generator outage or the tripping of a generator in real time close to the deadline for submission of the IGMs and where there is insufficient time to update the data exchanged/published.

Notwithstanding the requirements above, each TSO responsible for the creation of an IGM shall include energy injections and loads representative of the best possible forecast of transmission system conditions at the time when the IGM is created, in accordance with GL CACM Article 19 (2).

3.3.3 MONITORING

This section specifies requirements on TSOs in relation to the operational monitoring limits of modelled items of transmission equipment in IGMs. Monitoring limits pertain to the following:

- Permanent Admissible Transmission Loading (PATL) – the maximum loading in Amps, MW or MVA that can be sustained on a transmission line, cable or transformer for an unlimited duration without risk to the equipment;
- Temporary Admissible Transmission Loading (TATL) – the maximum loading in Amps, MW or MVA that can be sustained for a limited duration without risk to the equipment (multiple different TATLs may apply for a particular item of equipment);
- Maximum Permissible TATL Duration – the maximum period of time that a loading in excess of the PATL and less than or equal to the TATL can be sustained without risk to the equipment;
- Tripping Current – the maximum current threshold above which a transmission line, cable or transformer will trip without delay (i.e., before any curative **remedial actions** can be applied);
- Substation Voltage Limits – the maximum and minimum acceptable voltages for modelled substations at each nominal voltage level as per the locally applicable power quality and system security standards.

Operational monitoring limits associated with the loading of transmission lines, cables and transformers may vary seasonally, may otherwise be dependent on environmental or meteorological factors (e.g., in the case of Dynamic Line Rating schemes) and/or may be dependent on the pre-fault loading. For a given **scenario** it is particularly important that the limits in the **individual grid models** accurately reflect those which will apply in reality, in order to ensure the accuracy of cross-zonal capacity calculations and operational security analyses.

For a given **scenario**, each TSO responsible for the creation of an IGM shall ensure that:

a) The IGM specifies a PATL reflecting the nominal rating for the corresponding season (i.e., summer, autumn, winter, etc.), for each explicitly modelled transmission line, cable, transformer and relevant item of DC equipment;
b) The IGM specifies one or more TATLs, reflective of the corresponding season and based on the applicable PATL, for each explicitly modelled transmission line, cable, transformer and relevant item of DC equipment;
c) The IGM specifies a TATL duration for all items of transmission equipment for which a TATL is specified, for each TATL specified;
d) The IGM specifies a tripping current for each relevant item of explicitly modelled transmission equipment, if applicable;
e) The IGM appropriately reflects the maximum and minimum acceptable voltages at each nominal voltage level, as per relevant locally applicable codes, standards, licences, policies and agreements;
f) Operational monitoring limits that apply to interconnectors and tie-lines to other TSOs are consistent with those specified in the IGMs of the relevant neighbouring TSOs;
g) Operational monitoring limits specified in the IGM are consistent with the following:

i. Current limits specified as per the provisions of GL SO (2015-11-27) Article 25 (1) (c) and (4);
ii. Voltage ranges specified as per the provisions of GL SO (2015-11-27) Article 25 (1) (a) and Article 27;
iii. Structural, scheduled and forecast data exchanged between TSOs, DSOs, power generating modules, demand facilities, other significant grid users and owners of interconnectors or other lines in accordance with GL SO (2015-11-27), Part II (Operational Security), Title 2 (Data exchange), Article 40 et seq;
iv. **Operational security limits** specified in the capacity calculation methodology for the applicable capacity calculation region, where relevant in the context of GL CACM Article 23 (2).

At the two-days ahead, day-ahead and intraday timeframes the following extension to point a) above shall apply:

- For each explicitly modelled transmission line, cable, transformer and relevant item of DC equipment, each **individual grid model** must specify a PATL reflecting the nominal rating for the corresponding season (i.e., summer, autumn, winter, etc.) or the best forecast rating if dependent on meteorological conditions or pre-fault loading.

In order to reflect local transmission constraints that are not associated with steady state thermal or voltage security (e.g., constraints associated with transient or voltage stability), each TSO may specify artificial PATL and TATL limits on relevant individual items of modelled transmission equipment (or groups of items) within the IGM.

For implicitly modelled items of transmission equipment (i.e., equivalent models) and for modelled items of equipment that do not fall under the jurisdiction of the TSO (e.g., distribution networks), default or artificial limits may be specified such that they are ignored for the purposes of cross-zonal capacity calculations and operational security analyses. If the implicitly modelled items of transmission equipment influence cross-zonal capacity calculations or operational security analyses then appropriate equivalent operating limits must be specified.

3.3.4 Control Settings

This section specifies requirements on TSOs in relation to the specification of control settings in IGMs. Control settings dictate how transformer tap positions, voltages, active power flows, reactive power flows and DC power flows are regulated in the model. Control settings also determine how mismatches between total generation and demand are reconciled in the model when performing a load flow solution.

Appropriate control settings shall be specified for at least the following items of regulating equipment, where modelled and relevant:

a) Power transformers and associated tap changers;

b) Phase shift transformers and associated tap changers;

c) Reactive compensation devices, including but not limited to:

   a. Shunt compensators (shunt capacitors or reactors or discretely switchable banks of shunt capacitors or reactors);
   b. Static VAR compensators;
   c. Synchronous condensers;
   d. STATCOMs[8] and other FACTS[9] devices.

d) Generators (with respect to voltage regulation);

e) DC equipment.

In the case of the items of equipment referred to in points a), b), c) and d) each IGM shall include the following information, where relevant:

- Regulation status (enabled/disabled);
- Regulation mode (voltage, active power, reactive power, power factor, current, etc.);
- Regulation target or target range (in kV, MW, Mvar, p.u., etc.);
- Regulation target deadband;
- Regulation participation factor;
- Regulated node.

In the case of items of DC equipment each **individual grid model** shall include all relevant information regarding the following, where relevant:

- Operating mode (inverter/rectifier);
- Control mode (voltage, active power, reactive power, power factor, current, etc.);
- Active power targets;
- Voltage targets;
- Regulated nodes.

Where a modelled item of DC equipment forms part of an interconnector each TSO shall ensure that the resultant flows on the interconnector are consistent with the agreed DC flows for the relevant **scenario** as described in chapter 4.

Each TSO shall ensure that target voltages and target voltage ranges are reflective of the relevant **scenario** (e.g., day time, night time) and are reflective of applicable voltage control policies and **operational security limits**. At a minimum, target voltages and target voltage ranges shall be consistent with the provisions of GL SO (2015-11-27) Article 27.

For the purposes of managing mismatches between total generation and demand when performing a load flow solution, at least one **slack node** shall be specified in each IGM.

3.3.5 ASSUMPTIONS ON ADJACENT GRIDS

[8] Static Synchronous Compensator

[9] Flexible AC Transmission System

This section describes which variable data should be used for representing adjacent grids (neighbouring TSOs) within an IGM. Sub-section 3.2.8 provides a description of how structural data relating to adjacent grids are to be used.

3.3.5.1 VARIABLE DATA OF ADJACENT GRIDS

Best available data are to be used. In the case of variable data the latest available is usually the best.
In the IGM the adjacent grid will ultimately be represented as injections on boundary points. As described in sub-section 3.2.8 depending on the TSO's requirements for IGM creation the adjacent grid can be modelled in different degrees of detail.
If the adjacent grid is represented as injections, all necessary data (**balanced AC/DC net positions and consistent flows on DC interconnectors**) can be obtained from the OPDE or depending on the time-frame under consideration directly from market schedules. This is explained in more detail in chapters 4 and 5.
If the adjacent grid is represented with a more detailed model, the following data sources can be used:

- Topology - from OPDE (planned outages) or coordinated/bilaterally agreed outages
- Energy injections and load – scaled to match forecasts, schedules, and/or data provided by the OPDE (depending on the time-frame)
- Monitoring – from previous CGM or coordinated values
- Control Settings - from previous CGM, SCADA data or coordinated values

Thus previous CGM or SCADA visible area covering adjacent grid can be used, by scaling the models to match planned injections and topology changed to match planned topology.

Where the adjacent grid is not part of the **CGM Area**, all the same conditions apply but the data are not available on the OPDE platform. It is then the responsibility of the TSO concerned to make sure that flows between the non-**CGM Area** and the **CGM Area** are represented as accurately as possible in its IGM. This will typically require including the latest bilaterally agreed information in the IGM.

3.4 Associated Information

The present section describes the third main constituent element of IGMs, "associated information". "Associated information" refers to the rules that are applied in order to change power system characteristics (i.e., the information described in the preceding sections) – cf. the definition of an IGM as "a data set describing power system characteristics (generation, load and grid topology) and related rules to change these characteristics during capacity calculation, prepared by the responsible TSOs, to be merged with other individual grid model components in order to create the common grid model" in GL CACM Article 2 (1)..

The legal definition relates these rules to the capacity calculation process, but they are, in fact, applicable to other CGM use cases; i.e., outage planning and operational security assessments.

This "associated information" is discussed in the present chapter on IGMs, but – as is explained below – these rules in large part relate to how various IGMs are combined and made consistent with each other, so there are important linkages with the topic of merging (covered in more detail in chapter 5).

By way of introduction, note that some "associated information" is relevant at the level of the **CGM Area**; i.e., at pan-European level. This is not always the case: where "associated information" is used for the capacity calculation process at the level of a capacity calculation region (CCR), it will be specific to the corresponding CCR and will be agreed upon by the TSOs concerned. This latter type of CCR-specific "associated information" is out of scope of the present Methodology.

"Associated information" may be constant across different **scenarios** or it may vary with the **scenario**. This implies that in the latter situation the "associated information" needs to be updated in parallel with the IGMs being prepared, whereas in the former situation ("associated information" constant across **scenarios**) it does not change.

In all cases, "associated information" is stored in the OPDE described in more detail in section 5.2.

The following sets of "associated information" are relevant at the level of the **CGM Area**:

1. Rules to balance the system for merging

The IGMs provided by individual TSOs have **balanced AC/DC net positions and consistent flows on DC interconnectors**. The set of all IGMs together is therefore by definition balanced as well (as is implicitly required by GL CACM Article 18 (3)).

However, there are also those **scenarios** for which a CGM at the level of the **CGM Area** is not mandatory. For example, capacity may be made available for the month-ahead time-frame at the level of a capacity calculation region (CCR), but the TSOs who are not members of that particular CCR are under no obligation to participate in the capacity calculation process and prepare a matching (month-ahead) IGM. The workaround for the TSOs within the CCR is to re-use the corresponding year-ahead IGMs prepared by the non-concerned TSOs. That approach is referred to as "substitution" and is explained in more detail in chapter 5. However, combining IGMs prepared for different **scenarios** (i.e., both month-ahead and year-ahead) virtually ensures that the system overall is not in balance as the sub-scenario (month-ahead for year ahead) is supposed to include more up-to-date assumptions regarding the **AC/DC net positions** of the specific time horizon and also covers a shorter time frame thus reducing the likely range for generation and load. A set of rules is therefore needed that ensures that individual **AC/DC net positions** are adjusted in such a way as to ensure that the system overall is returned to balance.

This illustration related to the question of how an imbalance at the level of the **CGM Area** should be corrected by adjusting individual **AC/DC net positions**. However, an adjustment of individual **AC/DC net positions** requires explaining just how exactly that adjustment is to be implemented in the corresponding IGM. One approach might be to send the IGM back to the corresponding TSO and ask the TSO to make the necessary changes. That is theoretically an option, but not in operational practice: at least in the "shorter" time-frames, there is not enough time for that. Instead, one solution is to enable the RSCs (who will ensure the merging of the IGMs) to adjust the IGMs as needed which requires translating a change in **AC/DC net positions** into a change in generation and/or load. The essential tool that makes this adjustment possible is the Power Shift Key (referred to as "Generation Shift Key" in GL CACM; cf. explanation at the end of section 1.3 on why that term is not used in the present document). The Power Shift Key is thus one important type of "associated information".

2. Operational security management:

Operational security shall be ensured at all times (whatever process: capacity calculation, outage planning, operational security), meaning the consequences shall be assessed acceptable for all the **contingencies** that are to be taken into account. Therefore, the list of **contingencies** to consider shall be shared for each TSO, and for each situation if a constraint occurs, the curative **remedial action** shall be available to assess its effectiveness. Therefore the following associated information shall be exchanged:

- ***Contingencies** list*
- ***Remedial actions***

The approach to be used in developing these items of "associated information" shall be developed in the “methodology for coordinating operational security analysis” pursuant to GL SO (2015-11-27) Article 75.

3. Operational planning management:

The **scenarios** (from year ahead to week ahead) are supposed to take into account only the outages expected to persist throughout the entire time span of the **scenario**. For outage planning management, the TSOs shall provide to the OPDE the **outage planning**, and, for each of them, the consequences in the CGM: the outage itself (of course), and the means at the TSO's disposal to reestablish operational security (preventive **remedial actions**). Therefore the following associated information is to be exchanged: *Planned Outages* (with start and end dates / times).

4 CGM ALIGNMENT

It is a basic consistency requirement for any CGM that the sum of aggregate **AC/DC net positions** must equal the target aggregate **AC/DC net position** at the level of the **CGM Area**. In addition, flows on DC interconnectors linking different synchronous areas must be consistent with each other. When these requirements are met, the CGM is said to be "aligned".

The obligation to ensure this alignment is formulated in GL CACM Article 18 (3) which stipulates that "[f]or each scenario, all TSOs shall jointly draw up common rules for determining the net position in each **bidding zone** and the flow for each direct current line. These common rules shall be based on the best forecast of the net position for each **bidding zone** and on the best forecast of the flows on each direct current line for each scenario and shall include the overall balance between load and generation for the transmission system in the Union." Consistent with this provision addressed to "all TSOs", GL SO (2015-11-27) Article 66 (2) obliges each TSO to ensure an analogous alignment on the level of ((Y-1)) IGMs.

Several configurations can exist for a given **bidding zone** as far as the preparation of IGMs by individual TSOs is concerned:

- A **bidding zone** covering only one **control area**,
- A **bidding zone** covering several **control areas**, in this case TSOs within this **bidding zone** shall coordinate so that the overall balance of their **control areas**, which defines the net position, is aligned,
- A **bidding zone** included in a **control area** with other **bidding zones**, in this case the TSO shall ensure that the overall balance of its **control area**, which is defined by the overall balance of these **bidding zones**, is aligned.

For time horizons for which market schedules are available ((D-1) and Intraday), aligned **AC/DC net positions** and consistent flows on DC interconnectors are derived from **external commercial trade schedules** (see section 4.2). However, since no agreed schedules are available for the (D-2) and previous horizons, the alignment of **AC/DC net positions** and flows on DC interconnectors is ensured via a specific methodology known as the “CGM Alignment” (CGMA) Methodology. The CGMA methodology is explained in more detail in section 4.1.

For the avoidance of doubt, the CGMA methodology is about a group of TSOs jointly developing a common starting point for a given purpose (such as capacity calculation). Therefore the results obtained by applying the CGMA methodology are not end points and, in particular, they are not the equivalent of a certain allocation of transmission capacity.

The table hereafter summarizes the **AC/DC net positions** and flows on DC interconnectors to be used per model time horizon:

Model Horizon	**AC/DC net positions / flows on DC interconnectors to be used**	**Comments**
Year ahead	Based on CGMA Module	Forecasts (referred to as "pre-processing data" (PPD) and explained in more detail below) provided as input data to the CGMA Module by the TSOs are based on a set of eight default scenarios
Month ahead	Methodology to be defined by TSOs concerned	
Week ahead	Methodology to be defined by TSOs concerned	
(D-2)	Based on CGMA Module	Forecasts (referred to as "pre-processing data" (PPD) and explained in more detail below) provided as input data to the CGMA Module by the TSOs reflect the expected outcome of the day ahead market
(D-1)	Based on agreed external commercial trade schedules	Values for flows on DC interconnectors may need a specific calculation to be agreed between concerned TSOs
Intraday	Based on agreed external commercial trade schedules	Values for flows on DC interconnectors may need a specific calculation to be agreed between concerned TSOs

4.1 FROM (Y-1) TO (D-2) (WHEN NO MARKET DATA ARE AVAILABLE)

The CGMA methodology is applied for timeframes when no agreed commercial trade schedules are available. The concerned model horizons are year ahead ((Y-1)) and two days ahead ((D-2)). Definition of **scenarios** for month ahead and week ahead horizons is done only by concerned TSOs and therefore the present document does not address these horizons.

In order to be able to build grid models for the (Y-1) and (D-2) horizons, substitutes for agreed commercial trade schedules are required. These substitutes are provided by the output of the CGMA Algorithm and consist of the following elements:

- balanced **AC/DC net positions** (one per **bidding zone**), and
- consistent flows on DC interconnectors (one figure per DC tie-line connecting to another synchronous area, more generally, for interconnections only composed of several DC tie-lines).

Such elements are provided to the TSOs according to the applicable timeline so that the balanced **AC/DC net positions** and values for consistent flows on DC interconnectors can be implemented in the IGMs.

The CGMA methodology is primarily concerned with processes and their harmonization on the level of the **CGM Area**. As for requirements with respect to individual TSOs, it primarily defines the data that individual TSOs will need to contribute and sets quality standards in this respect.

Figure 3 shows that the CGM alignment process is divided into three phases:

i. the pre-processing phase,
ii. the processing phase,
iii. the post-processing phase.

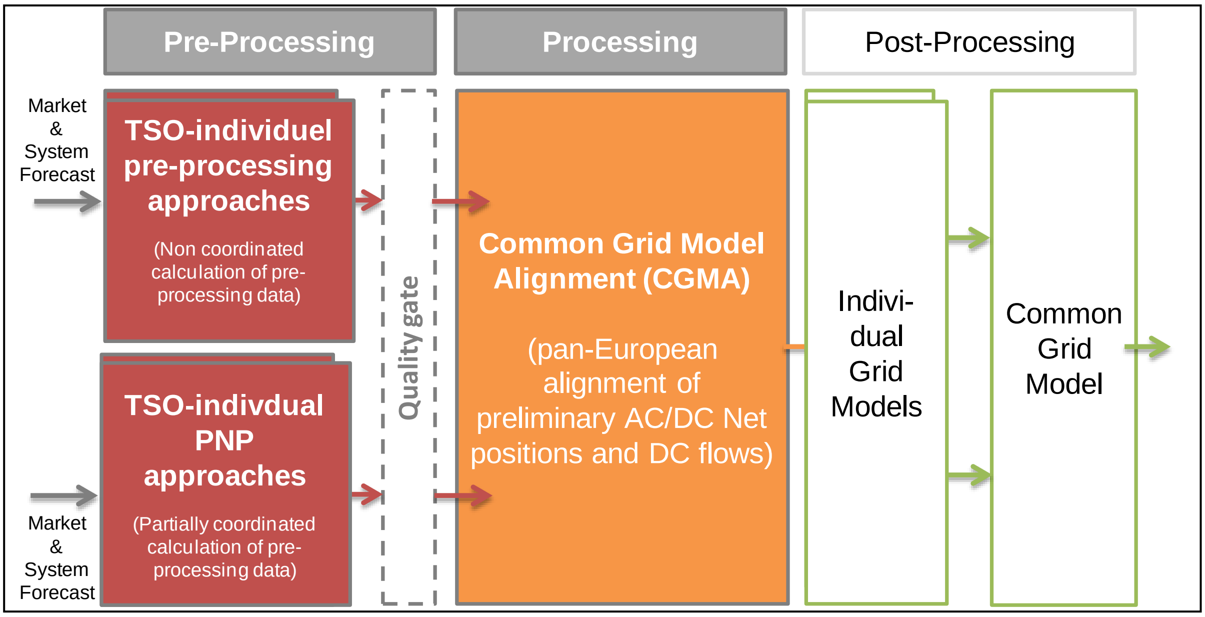


FIGURE 3: CGM ALIGNMENT PROCESS

As outlined in the diagram, and explained in more detail below, the CGMA methodology relies on a bottom-up rule-based process where individual TSOs provide their input (**pre-processing data**, based on coordinated or individual best forecasts) to the central CGMA Algorithm which ensures an overall alignment on the level of the **CGM Area**.

4.1.1 PRE-PROCESSING PHASE

In the pre-processing phase TSOs must provide a standard set of Pre-Processing Data (henceforth PPD) per relevant **bidding zone** whose objectives are to:

- reflect best forecasts of **AC/DC net positions** and (if applicable) flows on DC interconnection/s based on specific input data. These values (identified as "preliminary" **AC/DC net positions** and DC flows) are meant to describe the expected state of cross-border flows in the horizon targeted by the model.
- specify how flexible these forecasted values can be considered in the alignment process run during the processing step (i.e. the "CGMA Algorithm"). This subset of PPD is referred to as "**scalability parameters**".

To be specific, for the (Y-1) horizon (and in line with GL SO (2015-11-27) Article 66) TSOs must define their best estimate for **AC/DC net positions** and flows on DC interconnectors to reflect the operation of the grid during the coming year, with the possibility to use eight default **scenarios** as a fallback solution (as stipulated in GL SO (2015-11-27) Article 65 (3)). For the (D-2) timeframe a CGM needs to be prepared for each of the day-ahead market time units (cf. GL CACM Articles 14 (1) (a), 18 (1) and 18 (2)), which implies effectively twentyfour separate CGMs. Thus, TSOs must define their best estimate for **AC/DC net positions** and flows on DC interconnectors (cf. GL CACM Article 18 (3)) to reflect the expected outcome of the day ahead market.

Even if the PPD are to be provided on an individual basis, TSOs are advised to coordinate their pre-processing processes at least on the adjacent **bidding zone** “borders” and move gradually to a regional level. Coordinated approaches should be expected to lead to more accurate forecasts of PPD because interactions with neighbours are taken into account at the pre-processing stage. This should lead to some netting of **AC/DC net positions** and should thus reduce the volume of adjustments required at the processing stage.

Throughout the pre-processing phase, the prohibition against undue discrimination between internal and cross-zonal exchanges set out in GL CACM Article 18 (3) shall be respected by the TSOs when providing the set of PPD.

Two options are possible for a given TSO to provide their PPD to the processing phase. In **Option 1** the TSO makes its IGM available earlier in the process based on forecasted **AC/DC net positions** and flows on DC interconnectors; i.e., PPD must be implicitly and explicitly stated in the IGM. In this case the TSO has to provide its IGM and PPD at the same time (and according to the PPD provision deadlines set out in chapter 7 on timelines / deadlines) to the relevant RSC who will adjust the IGM to the **balanced AC/DC net positions and consistent flows on DC interconnectors** as part of the merging process. This is explained in more detail in chapter 5. Providing the IGM earlier makes it possible for the TSO to delegate the alignment of its IGM to the relevant RSC, instead of doing it itself: this allows combining the CGMA processing phase and CGM relevant post-processing phase. In **Option 2** the TSOs provide only their PPD for the CGMA and make necessary adjustments of their IGM in the post-processing phase themselves. In other words, the relevant TSO will wait for the outcome of the processing phase before finalizing its IGM.

In any case, the PPD must be made available by each TSO to the CGMA Module for each (Y-1) or (D-2) scenario via the OPDE. The PPD have to meet the “best forecast” requirement that is checked via a ”Quality Gate”.

One crucial quality criterion checked by the Quality Gate is that each TSO provides **scalability parameters** of a meaningful magnitude allowing at least a minimum adjustment possibility of their **AC/DC net positions** and flows on DC interconnectors by the CGMA Algorithm. The range of possible adjustments of the CGMA Algorithm is indeed limited by the minimum and maximum values allowed for the **AC/DC net position** and for the flows on DC interconnectors, respectively, which are defined by the TSOs in their **scalability parameters** (defined as “feasibility range” and minimum and maximum DC flows). If the scope for adjustments is insufficient, it might not be possible to obtain **balanced AC/DC net positions and consistent flows on DC interconnectors**. In this special case the CGMA will (to the extent necessary) adjust the **scalability parameters** taking into account the dimension of the **bidding zones**.

The Quality Gate ensures that the following criteria (among others) are also met:

- PPD are provided in a standard format
- the PPD data set is complete; i.e., all required data are available for all TSOs.
- PPD are made available by the TSOs within the deadlines of the CGMA processing phase (see chapter 7 where these deadlines are explained in more detail); i.e., before 16:30h on (D-2) for (D-2) models and by 15 July minus 18 business days for (Y-1) models.

TSO are informed about quality problems (if any) and requested to re-submit their PPD if necessary and possible within the process timeline.

4.1.2 Processing phase (or "CGMA Algorithm")

In the processing phase the CGMA Algorithm aligns the PPD to be used as a common starting point for IGM creation and CGM merging.

To this end the CGMA Algorithm provides an overall alignment of the **AC/DC net positions** and (if applicable) flows on DC interconnectors while ensuring that the results remain as close as possible to the TSO-individual preliminary values, by taking into account the **scalability parameters** defined by each TSO.

In general terms the CGMA Algorithm applies (if needed) an integrated optimization at least on a **CGM Area** level: aggregated deviations from preliminary **AC/DC net positions** and DC flows provided as part of the PPD are minimized.

The CGMA Algorithm is operated as a central IT System which connects to the OPDE environment for downloading and uploading data and is operated by the RSCs. The OPDE is the platform that connects the TSOs / RSCs to the CGMA Module. The CGMA output data are made available to all TSOs via the OPDE according to the applicable timeline per concerned horizon. In terms of the standard CGM process steps and associated deadlines described in chapter 7, this is before step 03 "**Balanced AC/DC net positions and consistent flows on DC interconnectors** available to TSOs via OPDE" no later than 17:15h (D-2) for the (D-2) process and 10 business days before 15 July for the (Y-1) process.

The CGMA methodology provides the TSOs with some flexibility to define the configuration: for example, all the DC interconnectors between two **bidding zones** of two different synchronous areas can be modelled in the CGMA Algorithm, or only one DC interconnector. In this latter case, the relevant TSOs have to define the process ending with an agreed value per DC cable, starting from the output of the CGMA Algorithm. If all DC interconnectors are modelled individually, the CGMA Algorithm will provide one value per interconnector. If a single DC interconnector is modelled, the CGMA Algorithm will provide a single value as an output. The granularity of the forecasted data provided as part of the PPD as an input for the CGMA Algorithm is thus the same as the output following the processing phase.

Connections to **bidding zones** outside the **CGM Area** are modelled as equivalent injections in the corresponding **bidding zone** within the **CGM Area**. This means that the target aggregate **AC/DC net position** for the **CGM Area** is not necessarily zero.

4.1.3 POST-PROCESSING PHASE

In the post-processing phase TSOs build or update IGMs based on the output data of the CGMA methodology: IGMs must then be made available via the OPDE by each TSO for all relevant **scenarios** according to the deadlines set for step 05 of the CGM timeline (cf. chapter 7 on timelines): before 19:00 on (D-2) for (D-2) models and by 01 September plus five business days for (Y-1) models.

In case a TSO submits a preliminary IGM to be aligned by RSCs, RSCs will only update the IGM, but not build the IGM themselves. In this case, IGMs must be made available via the OPDE by each TSO for all relevant **scenarios** according to the deadlines set for step 02 of the CGM process (see chapter 7 on timelines): before 16:30h on (D-2) for (D-2) models and by 15 July minus 18 business days for (Y-1) models. Consistent IGMs are merged into CGMs in the final step.

4.2 DAY AHEAD / ID (WHEN MARKET DATA ARE AVAILABLE)

For these horizons, TSOs will rely on effective market schedules to define the **balanced AC/DC net positions and consistent flows on DC interconnectors** to be used in the IGM. The relevant schedules are the **external commercial trade schedules**.

The prohibition against undue discrimination between internal and cross-zonal exchanges set out in GL CACM Article 18 (3) is respected by the TSOs by using effective market schedules.

The requirement is to ensure that the same **external commercial trade schedules** values are used by all TSOs, meaning that these values have to be agreed by all TSOs and balanced across the entire perimeter of the CGM (within each synchronous area and between synchronous areas): this is firstly ensured by the scheduling process where

external commercial trade schedules are agreed among relevant TSOs as stipulated in GL SO (2015-11-27) Article 112 and, more generally, GL SO (2015-11-27) Part III (Operational Planning), Title 6 (Scheduling).

Secondly, it is required that all TSOs use the same version of the data:

- For the day ahead horizon, the **external commercial trade schedules** values to use are the final ones
- For the intraday horizon, the **external commercial trade schedules** values to use are the ones agreed between the relevant TSOs (in the meaning of GL SO (2015-11-27) Article 112) at a defined point in time, which is defined as the agreed values as of [H-n-1]:30 before the creation time of the IGM, [H-n]:00 being defined as the next round hour after the moment the IGM is updated (cf. section 7.7 on timelines, step 04 of the intraday time horizon).

This defines the agreed **external commercial trade schedules**.

Based on the agreed **external commercial trade schedules** values, all TSOs will determine a set of **balanced AC/DC net positions and consistent flows on DC interconnectors**:

- Balanced **AC/DC net positions** can be simply derived from **external commercial trade schedules** by adding all agreed **external commercial trade schedules** concerning the same synchronous area.
- Consistent flows on DC interconnectors have to be defined per DC interconnector to another synchronous area, more generally, for interconnectors only composed of several DC tie-lines and thus in need of a a specific calculation. The issue to address by relevant TSOs is how to define the process ending with a common value, since the market schedules are not defined per DC cable. To that end, TSOs may implement their own algorithm, but it is necessary that the DC flows per DC cable in both TSOs' IGMs must be equal in order to be able to assemble the IGMs into a CGM.

The resulting set of **balanced AC/DC net positions and consistent flows on DC interconnectors** has to be made accessible through the OPDE before the deadline of step 03 of the CGM timeline "**Balanced AC/DC net positions and consistent flows on DC interconnectors** available to TSOs via OPDE" (cf. chapter 7 on timelines). It is a requirement for the CGM process that **balanced AC/DC net positions and consistent flows on DC interconnectors** are made available via the OPDE in order to guarantee access to these by all RSCs.

The process applicable for the (D-1) and intraday horizons can thus be summarized as follows:

- TSOs use agreed **external commercial trade schedules** to define **balanced AC/DC net positions and consistent flows on DC interconnectors**
- For DC flows, a specific step is needed to derive values per DC cable from the **external commercial trade schedules** that are only agreed by the relevant TSOs

- The resulting set of balanced **AC/DC net positions** and consistent DC flows is made accessible through the OPDE before the deadline of step 04 of the CGM timeline

This is illustrated in Figure 4 below:

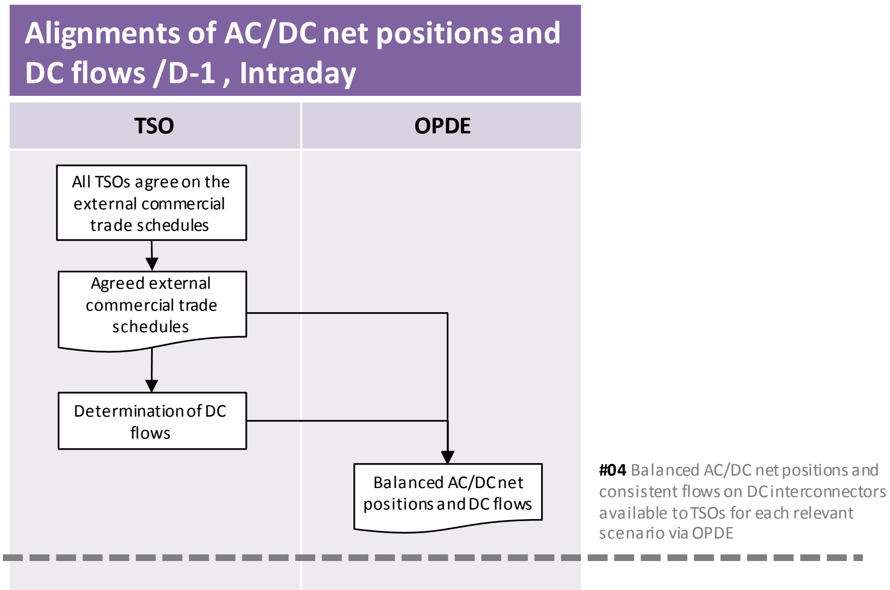


FIGURE 4: CGM ALIGNMENT (D-1; INTRADAY)

In the following steps of the CGM process:

- Each TSO implements the **balanced AC/DC net positions and consistent flows on DC interconnectors** in its IGM (when applicable, bearing in mind that update and creation of intraday models are not done on a systematic basis, but on an event basis)
- Each RSC uses the **balanced AC/DC net positions and consistent flows on DC interconnectors** in the merging process (for quality checks and merging).

5 MERGING

The merging process aims to uniquely and unequivocally define the system state of the **CGM Area** transmission grid for a given point in time, taking into account the expected grid configuration for that point in time, as well as the planned switching configuration and the forecast/scheduled energy injections and withdrawals.

This information has to be collected from a large number of parties. One could say that each TSO holds a piece of the puzzle: the Individual Grid Models and **scenarios**. Only after merging does the interaction between these “TSO model parts” become clear via loop flows and transit flows.

Before any coordinated assessment of available capacity, coordinated assessment of the impact of remedial measures to solve congestion or coordination of planned unavailability can be done, the system state of the pan European grid must be determined, so that each involved TSO has the same view on the expected system state for the referenced point in time.

This merging process is performed by the RSCs who have implemented the requirements specification for the European merging function, so that they all use the same input data and follow the same procedures (as stipulated in GL SO (2015-11-27) Article 79).

The collection of data from third parties by TSOs has been discussed already in the previous chapters. This chapter will focus on the merging process as implemented by the RSCs.

The chapter first explains the role of **Regional Security Coordinators** (RSCs) in section 5.1. The subsequent section 5.2 gives an overview of the architecture of the IT systems used by TSOs to perform various CGM-related tasks. These systems are collectively referred to as the **Operational Planning Data Environment** (OPDE) or linked to the OPDE. The remaining section 5.3 provides a detailed description of the merging process.

For the sake of completeness, note that the general obligation to provide CGMs is formulated in GL CACM Article 28 (5) as follows: "For each capacity calculation time-frame a single, Union-wide common grid model shall be created for each scenario (...) by merging inputs from all TSOs applying the capacity calculation process (...)."

5.1 ROLE OF REGIONAL SECURITY COORDINATORS (RSCS)

RSCs are referred to numerous times in the present document. This section provides an overview of the tasks assigned to RSCs that are relevant in the context of the CGMM.

According to GL SO (2015-11-27) Article 77 (1), "all TSOs of each capacity calculation region shall jointly set-up a regional security coordinator and establish rules governing its operations (...)". GL SO (2015-11-27) Article 77 (2) stipulates that "[t]he regional security coordinator shall perform the following tasks:

(a) regional operational security coordination in accordance with Article 78 in order to support TSOs fulfil their obligations for the D-1 and intraday timeframes in Articles 34(3), 72 and 74;
(b) building of **common grid models** in accordance with Article 79;
(c) regional outage coordination in accordance with Article 80 in order to support TSOs fulfil their obligations in Articles 99 and 103; and
(d) regional adequacy assessment in accordance with Article 81 in order to support TSOs fulfil their obligations under Article 107."

GL SO (2015-11-27) Article 79 (1) requires each RSC to "check the individual grid models quality and (...) build the common grid models in accordance with the methodologies referred to in Article 67(1) and Article 70(1) for all the mentioned timeframes."

GL SO (2015-11-27) Article 79 (3) further stipulates that "Where necessary, each regional security coordinator shall request the TSOs concerned to correct their individual grid models in order to achieve their conformity with the quality controls and for their improvement."

Finally, pursuant to GL SO (2015-11-27) Article 79 (5) "[e]ach regional security coordinator shall make available the common grid models on the ENTSO for Electricity operational planning data environment as soon as possible (...)."

5.2 Operational Planning Data Environment

5.2.1 Data required in order for the CGM to be stored in the OPDE

GL SO (2015-11-27) Part III (Operational Planning), Title 7 (ENTSO for Electricity operational planning data environment), Articles 114 et seq. sets out the legal requirements with respect to the **Operational Planning Data Environment** (OPDE). The specific requirements related to IGMs and CGMS in GL SO (2015-11-27) Article 115 are as follows:

"1. The ENTSO for Electricity operational planning data environment shall store all individual grid models and related relevant information for all the relevant timeframes set out in this Regulation and in Article 14 (1) of Commission Regulation (EU) No 2015/1222.
2. The information on individual grid models contained on the ENTSO for Electricity operational planning data environment shall allow for their merging into common grid models.
3. All common grid models shall be made available on the ENTSO for Electricity operational planning data environment.
4. For the year-ahead timeframe, the following information shall be available on the ENTSO for Electricity operational planning data environment:
(a) year-ahead individual grid model per TSO and per scenario determined in accordance with Article 65; and
(b) year-ahead common grid model per scenario defined in accordance with Article 66.
5. For the D-1 and intraday timeframes, the following information shall be available on the ENTSO for Electricity operational planning data environment:

(a) D-1 and intraday individual grid models per TSO and according to the time resolution defined pursuant to Article 70;
(b) **scheduled exchanges** at the relevant time instances per scheduling area or per scheduling area border, whichever is deemed relevant by the TSOs, and per HVDC system linking scheduling areas;
(c) D-1 and intraday common grid models according to the time resolution defined pursuant to Article 70; and
(d) a list of the prepared and agreed remedial actions identified to cope with constraints having cross-border relevance."

For the need of the merging function, the OPDE shall provide access to the data of:

- The quality portal (which ensures that basic data quality requirements are met): overview of the quality state of available IGMs and CGMs
- Verification service (ensuring consistency of **external commercial trade schedules** as defined in GL SO (2015-11-27) Article 3 (80)) that provides all the net market results for each **bidding zone**. This information shall be consistent. In case multiple verification platforms for the different regions are implemented, cross-platform consistency of the data provided by the different platforms absolutely must be ensured for otherwise it would not be possible to build a CGM.
- Boundary point reference repository
- Any other information that shall be shared to work on the CGM at a regional or **CGM Area** level (outage planning, Power Shift Keys, **contingency** lists, **remedial actions**)

5.2.2 OVERVIEW OF THE OPDE

As far as the IT implementation of the process of CGM creation is concerned, the central tool is a virtual data repository called **Operational Planning Data Environment** (OPDE) which allows various sub-systems to retrieve and collect data. The following Figure 5 provides an overall view of the **Operational Planning Data Environment** (OPDE) and its components. The present methodology does not aim to explain the construction and functioning of the OPDE in detail, but merely outlines those features of relevance to the creation of CGMs.

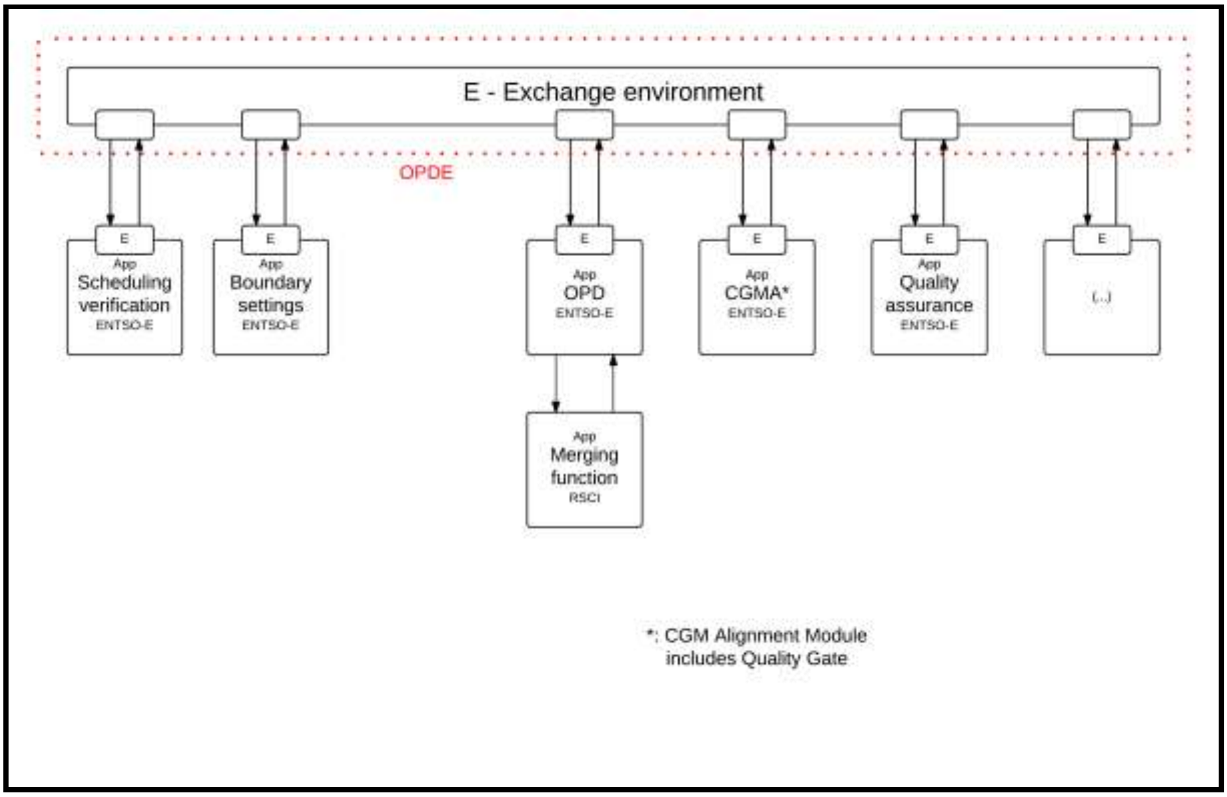


FIGURE 5: OPDE

5.2.3 CONFIDENTIALITY

The confidentiality obligations set out in GL CACM Article 13 apply to the OPDE, too, of course: Further to, in particular, GL CACM Article 13 (4) access to the data to be exchanged via the OPDE is restricted to those parties that require the data in order to perform their lawful duties as set out in the GL CACM and other legislation.

5.2.4 MINIMUM STORAGE REQUIREMENTS

To enable the CGM process to run, a minimum in terms of storage is required. This minimum is driven by this methodology to enable the substitution rules, to provide to the TSOs and RSCs a minimum level of ex-post analysis, but limiting its amount. The storage requirements could be increased to cover needs resulting from other methodologies or processes or specific additional national requirements and shall be contracted between the RSCs and the TSOs they serve.

5.3 MERGING PROCESS

The first step of the merging process entails the collection, verification and storing of input data in the local merging environment.

The tool that is used for the merging of IGMs into CGMs shall be certified to create European merging function compatible models. Thus it shall have passed the normal and extended European merging function conformity assessment.

5.3.1 INPUT DATA FOR SCENARIOS BASED ON MARKET RESULTS

The merging function automatically obtains both the hourly scheduled AC net interchange programmes for all **control areas** and the hourly scheduled DC programmes for all HVDC links once these data have been made available by the scheduling tools. These data are available once the day-ahead markets have closed and all transactions have been cleared. Updates of these values become available after closure and clearing of the intraday markets.

5.3.2 INPUT DATA FOR SCENARIOS NOT BASED ON MARKET RESULTS

For the **scenarios** that are not based on market results the uncertainties are bigger:

- Details of structural changes (e.g., commissioning dates of new items of equipment) are the more uncertain the further we look into the future;
- Not all plans for maintenance may have been coordinated yet;
- Weather forecasts are the less accurate the further we look into the future;
- Load forecast becomes more difficult due to the impact of dispersed generation;
- Generation schedules are not available, so market models may have to be used to predict a plausible unit commitment and dispatch;
- External commercial trade schedules have not been matched because no transactions have taken place yet.

In order to prepare the IGMs for the target **scenarios**, each TSO uses its best judgement to take into account structural changes, to include the already agreed upon planned unavailabilities, a reasonable load forecast and a plausible generation dispatch such that the target AC interchange schedules are respected.

5.3.3 INPUT DATA PROCESSING

Once the IGMs have been submitted by a TSO, the RSC responsible automatically downloads a copy. The data are checked against ENTSO-E validation rules in order to check if the data have been provided in the correct exchange format (and can be processed correctly). Also the plausibility of the data is checked and the system state for the TSO models is calculated in order to check convergence and the deviation from the target AC net interchange values. If the validation fails, the model will be rejected. If the calculated **AC/DC net position** deviates from the target interchange value within a reasonable tolerance, the energy balance in the model is adjusted automatically by proportionally scaling the energy withdrawals. If the deviation is too large, the model will be rejected, because it would impact the plausibility of the calculation results too much.

As soon as the IGMs of two adjacent TSOs have become available, consistency of the interconnector switching states is verified. In case of inconsistency, the respective TSOs are notified.

A quality assurance portal is used to inform the TSOs about availability and quality of the models for the various time horizons.

5.3.4 SUBSTITUTION OF MISSING MODEL PARTS

The need for substitution of IGMs emerges when time is of the essence, i.e. for the time horizons (D-1) and intraday. In the longer time-frames, a coordination between RSC and responsible TSO takes place to make sure all IGMs are available and of good quality before the model assembly is initiated.

For year ahead, no substitution rules are allowed as the provision of the IGM is mandatory at the Europe level, and the operators have time to organise themselves to provide the IGMs in due time.

5.3.4.1 MONTH AHEAD / WEEK AHEAD

These **scenarios** are not mandatory. Therefore the principle of the substitution rules is to reuse the IGM that is available for the same period in the previous time horizon, for the same configuration of load (peak / valley).

5.3.4.2 (D-2) DAY AHEAD / INTRADAY RULES

For the time critical processes, an automated process is applied. Because every substitution potentially compromises plausibility, the general approach is to use data intended for the same energy delivery day (so that the same topology is applied) and to try and find **scenarios** that are close to the target point in time (so that the deviation in load and generation is minimized). The final step is to adjust the load proportionally in order to match the scheduled ((D-1) and intraday) interchange values.

In order to be robust enough the following priorities are applied:

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

							Load increase		Beginning 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

FIGURE 6: SUBSTITUION MATRIX

(e.g. for 11:30: the substitution order would be:
1 – 11:30 (no substitution)
2 – 10:30
3 – 12:30
4 – 13:30
5 – 9:30)

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)
(e.g. for a Tuesday 11:30, use of Monday 11:30)

STEP 3. If not available, use the IGM from the same day (other time frame)
(e.g. for 11:30, use 19:30 of the same day)

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.

5.3.4.3 MARKET TIME UNIT CORRESPONDANCE

The table hereafter shows the time unit correspondance for CGMs that are built with IGMs prepared on the basis of a market time unit strictly less than one hour.

The substitution rules for the use of IGMs that are based on a longer market time unit are as follows:

<table>
<tr><th>15-minute</th><th>30-minute</th><th>1 hour</th></tr>
<tr><td>hh:07</td><td rowspan="2">hh:15</td><td rowspan="4">hh:30</td></tr>
<tr><td>hh:22</td></tr>
<tr><td>hh:37</td><td rowspan="2">hh:45</td></tr>
<tr><td>hh:52</td></tr>
</table>

For example, the TSO building an IGM for the hh:37 timestamp would base this IGM on the IGM for the hh:45 timestamp in case of TSOs making use of a 30-minute market time unit and on the IGM for the 00:30 timestamp in case of TSOs making use of a one-hour market time unit, respectively.

Conversely, the substitution rules for the use of IGMs that are based on a shorter market time unit are as follows:

- For 30-minute based CGM:

15-minute IGM	**30-minute** CGM
hh:07	hh:15
hh:37	hh:45

- For 1-hour based CGM

15-minute IGM	**30-minute** IGM	**1 hour** CGM
hh:37	hh:45	hh:30

5.3.5 THE ASSEMBLY OF MODEL PARTS

The next step in the merging process is the assembly of all model parts in order to obtain the **CGM Area** view. In this step the assumptions of all TSOs for the target point in time (typically the date and time for which the energy delivery is planned) are interpreted and processed. These so-called “Steady State Hypotheses” (operating assumptions) include:

- The switching states, tap positions of transformers and discrete voltage regulating equipment, step positions of phase shifting transformers as well as the consecutive topology of the grid;
- The energy injections and withdrawals;
- The operating limits;
- The target values for controlling voltage and power flows;

These operating assumptions contain sufficient information about which equipment models (i.e. sets of equations to describe the physics of the grid) are to be used to interpret and process the said operating assumptions.

The boundary points are then removed to assemble the **individual grid models**.

- For AC lines the virtual injections are removed. It is irrelevant to check if twin virtual injections are coherent, as their use was only to reflect the state of the **AC/DC net position** of the IGMs as stand-alone models.
- For DC-link between synchronous areas, the injection shall match taking into account the losses between energy scheduling point and IGM boundary point
- For DC-link within a synchronous area, the necessity of matching of the injections depends on the kind of control that is implemented. For AC simulation control, the matching is not required, for fixed flows, it is required.

For the Baltic Region, Russia and Belarus are not merged into the CGM for reason of confidentiality. The way the TSOs of the region merge its representation will be described in the regional procedures (outage pursuant to GL SO (2015-11-27) Part III, Title 3) and methodologies (operational security analysis pursuant to GL SO (2015-11-27) Part III, Title 2, and capacity calculation pursuant to GL CACM, Title II, Chapter 1) they have to establish.

5.3.6 SOLVING THE SYSTEM STATE

The steady state situation (the “system state”) for the referenced point in time can be calculated by solving the equations that are provided in the IGMs. The pan European grid can be seen as a collection of five topological islands that match the five European areas in which the frequency is kept synchronously. These synchronous areas are:

- Continental Europe
- Nordic countries
- Baltic (Estonia, Lithuania and Latvia)
- Great-Britain
- Ireland/Northern-Ireland

For each topological island/synchronous area a reference bus is assigned (the voltage angle is zero in this bus, hence the designation “reference”), so that each node in the network has an angle difference compared to this reference bus. When determining the voltage magnitude and angle at each node of the network (these are called the state variables), the power flows in the network can be derived.
The RSCs are using essentially the same algorithm and settings when solving the system state.

The system state is provided by all RSCs in the form of a general solution for the pan European grid. This is what we refer to as the “CGM”. Every TSO and RSC can initialize its local tools with the solved system state for its synchronous area in order to perform consecutive calculations, such as:

- Determining the impact and effectiveness of **remedial actions**
- Determining the critical network elements and calculating the domain that can be used for cross-border exchanges without overloading the critical network elements
- Determining the behaviour of the grid shortly after a step response (dynamic stability assessment)
- Coordination of planned unavailabilities

6 IMPLEMENTATION OF AGREED MEASURES

On a regional basis the load flow results of the CGM shall be analyzed in order to check the plausibility of the flows and voltages during the relevant business processes based on the CGM: coordinated security analyses, outage planning coordination, coordinated capacity calculation. If deemed necessary, RSCs shall coordinate adjustments of the models in order to compensate for implausible results, e.g. by coordinating flows over phase shifting transformers, improving topology or by providing feedback to individual TSOs. Once TSOs agree on modifications of the models following the coordination with RSCs and other TSOs, TSOs are then obliged to update their IGMs accordingly and provide a new version of the respective IGMs, if the grid situation described in the IGM requires it: this update constitutes the ”**Agreed measures**” pursuant to GL SO (2015-11-27) Article 70 (4).

Agreed measures are resulting from a loop between an RSC and the TSO composed of the following steps which the RSC and the TSO shall follow:

1- The TSO submits an IGM,

2- TSOs agree on modifications to bring to the IGM following the coordination with RSCs and other TSOs : this step can require multiple loops/discussions between the TSO and the RSC, and also between RSCs.
   For this step a security analysis is performed on a CGM which can occur in the course of a given business process (especially the Coordinated Security Analysis).

3- The TSO submits an IGM in which the agreed improvements are implemented, if any (the TSO remains responsible for updating the IGM).

The key point of **agreed measures** is that agreed modifications are implemented by TSOs in their next versions of IGMs when the grid situation requires it, so that the next CGM is kept up-to-date with the last decisions agreed, e.g. implementation of **remedial action** or redispatching.

Thus, the CGM created in timeframe X is used as a support for assessment of **agreed measures** during relevant business processes (operational security analysis, capacity calculation, outage planning) the results of which are implemented in the IGM to be used for creating the CGM in timeframe X+1 when the grid situation requires it. This can be summarized by the following scheme:

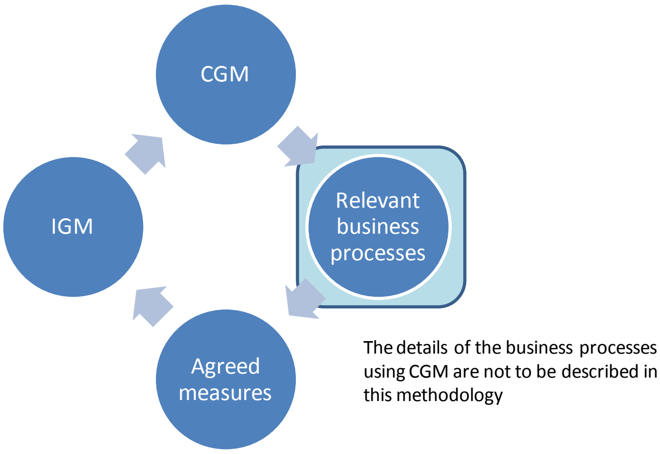


FIGURE 7: UPDATE LOOP FOR AGREED MEASURES

Agreed measures yielding an update of the IGM are defined in the next table:

Model Horizon	Possible agreed measures	Implemented in horizon
Year ahead	• change of topology, phase shifter tap position, or automatic devices operation that could have an influence on the neighbouring grid, • modeling of new grid elements to be commissioned	Year ahead and after
Month ahead	Defined at CCR level	Defined at CCR level
Week ahead		
(D-2)	• preventive **remedial actions**, including cross-border and internal redispatching, countertrading • change of topology, phase shifter tap position, or automatic devices operation that could have an influence on the neighbouring grid, • change of switch position of reactive components or voltage reference on PV nodes that can have influence on reactive power flows on the neighboring grid, • updated market results (cross-border schedules, generation schedules), or significant change of weather forecast having a significant impact on RES generation or load, • updated generation availabilities.	(D-1)
(D-1)		Intraday
Intraday		Intraday

7 TIMELINES / DEADLINES

The present chapter looks at the CGM process more closely, providing detailed descriptions of the various steps and the associated deadlines which TSOs and RSCs shall respect.

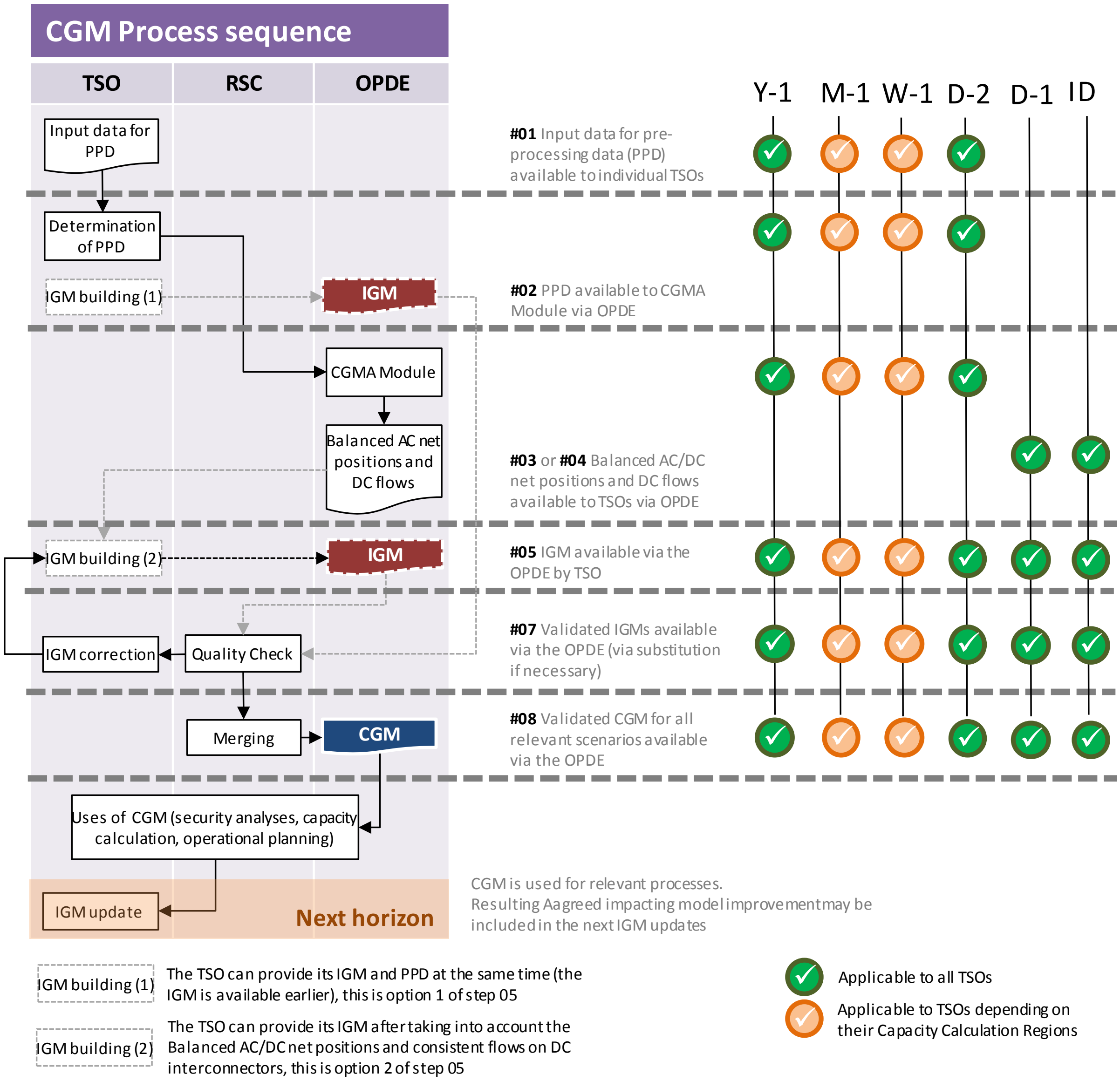
7.1 COMMONALITIES ACROSS SCENARIOS

As outlined in the CGM process description in section 2.1, most steps in the CGM process are the same across all horizons when models are created.

Note that the terminology "horizon" is used in the next part of the chapter to refer to the moment when the model is created. For example, for the "(D-2) horizon" the models for target day D are created in D-2.

The following flowchart gives an overview of these steps, and how they follow each other.

3129



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3131 **FIGURE 8: STANDARD STEPS IN CGM PROCESS**

3132

3133 The following table describes the steps more in detail.

Step	End point	Applicable to (horizon / TSOs)	Description
01	Input data for pre-processing data (PPD) available to individual TSOs for all relevant **scenarios**. *(for time horizon where no market schedules are available)*	((Y-1)): all TSOs (M-1): applicable to TSOs depending on their Capacity Calculation Regions (*); for all other TSOs (i.e., those not members of the concerned CCR and therefore not providing PPD) the CGMA Module would use the corresponding ((Y-1)) PPD (W-1): see (M-1) except that PPD would be provided by concerned TSOs (***); note that GL SO (2015-11-27) Article 69 (1) restricts the building of week-ahead IGMs / CGMs to "two or more TSOs [who] consider [them] necessary". ((D-2)): all TSOs ((D-1)): not applicable because market schedules are available (**ID**): not applicable because market schedules are available	The determination of PPD by each TSO requires input data. Based on these input data, TSOs compute the PPD (see next step). This step represents the moment when each TSO has all needed input data in order to determine its PPD. The determination of this deadline is the responsibility of each TSO, which has to take into account its process for assessment of PPD (this process being possibly defined on a regional level) while ensuring that its PPD are made available to the CGMA module by the deadline defined in the next step. The exact meaning of and need for pre-processing data (PPD) is explained in more detail in chapter 4. **<u>Output</u>:** Input data to be used by each TSO in order to determine its PPD

Step	End point	Applicable to (horizon / TSOs)	Description
02	PPD available to CGM Alignment (CGMA) Module for each relevant **scenario** via OPDE *(for time horizon where no market schedules are available)*	Same as previous step	In order to compute **balanced AC/DC net positions and consistent flows on DC interconnectors** for time horizons where no market schedules are available, the CGM Alignment (CGMA) Module, explained in more detail in section 4.1, needs input data referred to as PPD. In this present process step, TSOs compute and make their pre-processing data (PPD) available to the CGMA Module via the Operational Planning Data Environment (OPDE). TSOs are advised to use coordinated approaches in order to compute the PPD, leading to more accurate forecasts of preliminary net positions. **Input:** Input data to be used by each TSO in order to determine its PPD **Output:** PPD are made available to CGM Alignment (CGMA) Module via OPDE for each relevant **scenario** by individual TSOs. PPD provided are then checked for quality and consistency; TSO are informed about quality problems (if any) and requested to re-submit PPD if necessary.

Step	End point	Applicable to (horizon / TSOs)	Description
03	**Balanced AC/DC net positions and consistent flows on DC interconnectors** made available to TSOs by CGMA Module for each relevant **scenario** via OPDE *(for time horizon where no market schedules are available)*	((Y-1)): all TSOs (M-1): applicable to TSOs depending on their Capacity Calculation Regions (*); not applicable for all other TSOs (W-1): see (M-1) except that PPD would be provided by concerned TSOs (***) ((D-2)): all TSOs ((D-1)): not applicable because market schedules are available (**ID**): not applicable because market schedules are available	For time horizons where no market schedules are available, the CGMA Module computes **balanced AC/DC net positions and consistent flows on DC interconnectors**, which are made available to TSOs for use in their IGM for those TSOs which choose the option 2 of step 05 when sending their IGM. TSOs sending their IGM along with their PPD according to option 1 of step 05 won't need to wait for the output of this step. This is explained in more detail in section 4.1. There is a different set of these values for each **scenario**; TSOs are required to build their IGM using these values as input (see next steps). **Input**: PPD in acceptable quality following previous step available to CGMA Module (by substitution by reference data if necessary) **Output**: **Balanced AC/DC net positions and consistent flows on DC interconnectors** are made available to TSOs by the CGMA Module for each relevant **scenario** via the OPDE
04	**Balanced AC/DC net positions and consistent flows on DC interconnectors** available to TSOs for each relevant **scenario** via OPDE based on information in market schedules *(for time horizon where market schedules are available)*	((Y-1)) / (M-1) / (W-1) / ((D-2)): not applicable, because there are no market schedules ((D-1)): all TSOs (**ID**): all TSOs	Based on the information in the market schedules, TSOs can compute their balanced **AC/DC net position** and consistent flows on DC interconnectors. Involved TSOs may implement their own algorithm in order to compute consistent flows on DC interconnectors (**) but they must provide the agreed results via OPDE. There is a different set of these values for each **scenario**; TSOs are required to build their IGM using these values as input (see next steps). **Input**: Validated market schedules **Output**: **Balanced AC/DC net positions and consistent flows on DC interconnectors** are made available by TSOs for each relevant **scenario** via OPDE

Step	End point	Applicable to (horizon / TSOs)	Description
05	IGM available via the OPDE by TSO for all relevant **scenarios**	((Y-1)): all TSOs (M-1): applicable to TSOs depending on their Capacity Calculation Regions (*); not applicable for all other TSOs (W-1): see (M-1) except that PPD would be provided by concerned TSOs (***) ((D-2)): all TSOs ((D-1)): all TSOs (**ID**): all TSOs	Each TSO creates its IGM following the methodology detailed in chapter 3 before the defined deadline. Two options are possible (described in greater detail in chapter 4): 1. Either the TSO makes its IGM available earlier in the process (and uses its own estimate of its **AC/DC net position** and flows on DC interconnectors as the basis). In this case the TSO has to provide its IGM and PPD at the same time (i.e. at step 02) to the relevant Regional Security Coordinator (RSC) who would adjust the IGM in line with the **balanced AC/DC net positions and consistent flows on DC interconnectors** as part of the merging process (see chapter 5). Note that for the (D-1) and **ID** time horizons (when market data are available), the balanced **AC/DC net position** and consistent flows on DC interconnectors are directly determined by the market and there is no possibility or need to provide an IGM in advance. 2. Or the TSOs take into account in their IGMs the **Balanced AC/DC net positions and consistent flows on DC interconnectors** for each relevant **scenario** by making the necessary adjustments. This approach is optional. **<u>Inputs</u>:** **Balanced AC/DC net positions and consistent flows on DC interconnectors** for each relevant **scenario**, other IGM input data as described in chapter 3 on IGM creation **<u>Output</u>:** IGM available via the OPDE by TSO for all relevant **scenarios** IGM provided are then checked for quality and consistency by RSC; TSOs are informed about quality problems (if any) and requested to re-submit IGM if necessary (cf. chapter 8): if an IGM has passed the quality check it is referred to as a "validated IGM".

Step	End point	Applicable to (horizon / TSOs)	Description
06	Substitute IGM available via the OPDE by RSC for IGM not made available in time by TSOs for all relevant **scenarios**	Same as previous step	If a TSO cannot ensure that its IGMs are available by the deadline of previous step or the IGMs are rejected due to poor data quality and not replaced with one of sufficient quality by the deadline, as a fallback option the RSC makes a substitute IGM available for all relevant **scenarios**, as explained in more detail in chapter 5. While default substitution rules are crucial from an efficiency point of view for short term horizons ((D-2), (D-1), intraday), other horizons may allow for TSOs to coordinate on appropriate substitution rules with RSCs. Moreover, the provision of IGMs is not mandatory for all horizons. Specifically, for the (M-1) and (W-1) horizons it is to be expected that only a subset of TSOs from one or more Capacity (or Outage) Calculation Regions make IGMs available via the OPDE. However, in order to create a CGM, IGMs for the other TSOs are also needed. This requires a process of "substitution" which is handled by the **Regional Security Coordinators** (RSCs) and should be thought to be part of the present process step. Substitution may also be required for cases where the ((D-1) / **ID**) market time unit does not correspond to one hour. The rules that apply to the process of substitution are uniform and explained in chapter 5. **<u>Output</u>:** Substitute IGM available via the OPDE by TSO for all relevant **scenarios**
07	Validated IGMs for all relevant **scenarios** available via the OPDE for all TSOs (via substitution if necessary)	((Y-1)): all TSOs (M-1): applicable to TSOs depending on their Capacity Calculation Regions (*); IGMs for other TSOs that are required are to be provided by substitution (W-1): see (M-1) except that PPD would be provided by concerned TSOs (***) ((D-2)): all TSOs ((D-1)): all TSOs (**ID**): all TSOs	At this step, all validated IGMs, whether resulting from substitution or not, are available. If all TSOs provide IGMs, the present process step would not be a separate step; it would be merely a logical consequence of the previous step. **<u>Output</u>:** Validated IGMs for all relevant **scenarios** available via the OPDE for all TSOs (via substitution if necessary)

Step	End point	Applicable to (horizon / TSOs)	Description
08	Validated CGM for all relevant **scenarios** available via the OPDE	((Y-1)): all TSOs (M-1): all TSOs (possibly involving substitution) (W-1): all TSOs (possibly involving substitution) ((D-2)): all TSOs ((D-1)): all TSOs (**ID**): all TSOs (possibly involving substitution)	RSC merges all IGMs gathered at the previous step and makes adjustments to losses and **AC/DC net positions** as needed (this may require several iterations). Eventually a converging load flow signals that the merged model is consistent; at this point, the merged model is referred to as a “validated CGM”. The merging process is described more in detail in chapter 5. **<u>Input</u>:** Validated IGMs for all relevant **scenarios** available via the OPDE for all TSOs (via substitution if necessary) **<u>Output</u>:** Validated CGMs for all relevant **scenarios** available via the OPDE for all TSOs
After CGM creation	CGM is used for relevant processes. Resulting **agreed measures** may be included in the next IGM updates at the next horizon	((Y-1)): all TSOs (M-1): applicable to TSOs depending on their Capacity Calculation Regions (*); IGMs for other TSOs that are required are to be provided by substitution (W-1): see (M-1) except that PPD would be provided by concerned TSOs (***) ((D-2)): all TSOs ((D-1)): all TSOs (**ID**): all TSOs	During execution of the relevant processes using the CGM, RSCs and the TSO may agree on "**agreed measures**" to take into account in the IGM, as described in chapter 6. **Agreed measures** have to be included in the next IGM updates by the TSO if the grid situation of the time horizons concerned requires it. **<u>Input</u>:** Validated CGM **<u>Output</u>:** If the grid situation of the time horizons concerned requires it, **agreed measures** are included in the next IGM update.

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Detail of the references in the table:
(*) This applies only to TSOs of Capacity Calculation Regions that decide to perform capacity calculations using an NTC-based approach
(**) A calculation is necessary at least to derive consistent flows on DC interconnectors (per DC link) from the information in market schedules (that are exchanged between **bidding zones**)
(***) This applies only to TSOs defining a procedure to merge week-ahead models, which is not necessarily done at Outage Coordination Region (OCR) level.

The specific deadlines relating to each step for each of the horizons are detailed below. As a general reminder, the deadlines given in the next sub-sections always apply to all IGMs (i.e., all the IGMs for all **scenarios**) required for a given horizon. This document doesn't specify any deadlines that are only applicable to a subset of TSOs or regions.

7.2 Models created at Year Ahead Horizon

All TSOs shall deliver IGMs and RSC**s** shall produce validated year ahead CGMs that are used for operational security analyses in order to detect at least the following constraints:

- power flows and voltages exceeding **operational security limits**,
- breaches of stability limits of the transmission system,
- violation of short-circuit thresholds of the transmission system.

Such operational security analyses are mandated by GL SO (2015-11-27) Article 73 (1).

The yearly outage planning coordination process relies on operational security analyses performed on the validated year-ahead CGM.
In capacity calculation regions opting for an NTC-based approach, specific regional CGMs may be used for the year-ahead capacity calculation.
Validated year-ahead CGMs can thus also serve as the starting point for regional CGMs used in capacity calculation process by the concerned CCRs.
On the other hand, regional CGMs won't be used in capacity calculation regions where uncertainties inherent in the long-term timeframes are taken into account by applying a statistical approach.

One validated year-ahead CGM will be created for each year-ahead **scenario**. Year ahead **scenarios** are defined in section 2.4 (with the possibility of using eight default **scenarios** as a fallback solution).
The specific deadlines applicable to the year ahead horizon are detailed hereafter:

Step	End point	Deadline [CET / CEST]	Comments / References
02	PPD available to CGMA Module for each relevant **scenario** via OPDE	15 July minus 18 business days	This deadline has been fixed so that a buffer of eighteen business days is set to allow sufficient time in order to assess the **balanced AC/DC net positions and consistent flows on DC interconnectors**. Compared to other time horizons that are closer to the execution day (cf. (D-2) time horizon), or for which market schedules are available, the assessment of the **balanced AC/DC net positions and consistent flows on DC interconnectors** in year ahead is of higher complexity due to the higher level of uncertainty and consequently needs more time.
03	**Balanced AC/DC net positions and consistent flows on DC interconnectors** available to TSOs for each relevant **scenario** via OPDE by CGMA Module	15 July minus 10 business days	**Balanced AC/DC net positions and consistent flows on DC interconnectors** for year ahead models correspond to year-ahead **scenarios** to be published by ENTSO-E before 15 July as stipulated by GL SO (2015-11-27) Article 65 (4). Thus, this deadline has been fixed so that a buffer of ten business days is set beforehand, ensuring that the 15 July deadline is respected.
05	IGM available via the OPDE by TSO for all relevant **scenarios**	01 September	This deadline has been fixed at the soonest after the **Balanced AC/DC net positions and consistent flows on DC interconnectors** are made available to the TSOs, in order to allow creating the year ahead CGMs at the soonest before deadlines applicable to provision of outage planning for interconnectors as set out in GL SO (2015-11-27) Article 97 (1) (preliminary ((Y-1)) availability plans: deadline of 01 November) and GL SO (2015-11-27) Article 99 (final ((Y-1)) availability plans: deadline of 01 December). This maximizes the time available to TSOs to carry out the corresponding outage coordination processes.
07	Validated IGMs for all relevant **scenarios** available via the OPDE for all TSOs	01 September plus five business days	This deadline has been fixed relative to the deadline for step 05.

Step	End point	Deadline [CET / CEST]	Comments / References
08	Validated CGM for all relevant **scenarios** available via the OPDE	01 September plus ten business days	This deadline has been fixed relative to the deadline for step 07.
After CGM creation	CGM is used for relevant processes. Resulting **agreed measures** may be included in the next IGM updates	During updates of year ahead models	**Agreed measures** have to be included in the next IGM updates by the TSO if relevant in order to keep an up-to-date set of year ahead CGMs. This is in line with the provisions in GL SO (2015-11-27) Article 68 (1) and (2). On the other hand, such updates are only possible until (D-2) horizon, where new **scenarios** are created.

7.3 Models created at Month Ahead Horizon

Year ahead models can be updated after the year ahead horizon until the (D-2) horizon, so that TSOs can use such year ahead up-to-date models in case an update of the outage planning is needed in line with GL SO (2015-11-27) Article 100.

In capacity calculation regions opting for an NTC-based approach, the TSOs concerned may update their IGMs in order to create a CGM to be used for the month-ahead capacity calculation.

Models are thus created in month-ahead horizon for managing the capacity calculation process in the concerned capacity calculation regions, where TSOs who are part of it will prepare month-ahead IGMs. For the other TSOs, the most up-to-date models (meaning the last version of year ahead models) can be re-used when building the CGM by way of substitution.

On the other hand, regional CGMs won't be used in capacity calculation regions where uncertainties inherent in the long-term timeframes are taken into account by applying a statistical approach.

Deadlines for the different steps in the process are defined on the level of CCRs and are therefore not stated in the present document.

Definition of **scenarios** for month ahead horizon is done on the level of CCRs and is therefore not part of the present document.

7.4 Models created at Week Ahead Horizon

Models are created in week-ahead horizon for coordinated security analyses and for managing the outage coordination process by TSOs that agree to define this process for the week-ahead timeframe (cf. GL SO (2015-11-27) Article 69 (1)). Such operational security analyses aim to detect at least the following constraints:

- power flows and voltages exceeding **operational security limits**,
- breaches of stability limits of the transmission system,
- violation of short-circuit thresholds of the transmission system.

Such operational security analyses are mandated by GL SO (2015-11-27) Article 73 (1).

TSOs involved in week-ahead coordinated security analyses will prepare week-ahead IGMs. For other TSOs, the most up-to-date models can be re-used (meaning the last version of year ahead or month ahead models) when building the CGM by way of substitution. Deadlines for the different steps in the process are defined between concerned TSOs and are therefore not stated in the present document.
Definition of **scenarios** for week ahead horizon is done only by concerned TSOs and is therefore not part of the present document.

7.5 Models created at (D-2) Horizon

All TSOs shall deliver IGMs and RSC**s** shall produce validated (D-2) CGMs that are used by the capacity calculators as an input to the capacity calculation process for the day ahead market (as stipulated by GL CACM Article 29 (7) (b) and 29 (8) (a)).

Deadlines are set such as to ensure that each coordinated capacity calculator can meet the deadlines imposed on it by, inter alia, GL CACM Article 46 (1) ("Each coordinated capacity calculator shall ensure that cross-zonal capacity and allocation constraints shall be provided to relevant NEMOs in time to ensure the publication of cross-zonal capacity and of allocation constraints to the market no later than 11.00 market time day-ahead.")

One validated (D-2) CGM will be created for each (D-2) **scenario**, defined per market time unit (i.e. one per hour), as detailed in section 2.4.

GL CACM Article 14 (3) stipulates that "[f]or the day-ahead market time-frame, the capacity calculation shall be based on the latest available information. The information update for the day-ahead market time-frame shall not start before 15:00 market time two days before the day of delivery."

The specific deadlines applicable to the (D-2) horizon are detailed hereafter:

Step	End point	Deadline [CET / CEST]	Comments / References
02	PPD available to CGMA Module for each relevant **scenario** via OPDE	16:30, (D-2)	This deadline takes also into account (D-2) exchanges forecast processes for each TSO that must be based on recent information as stipulated by GL CACM Article 14 (3). The deadline has been set to grant TSOs sufficient time to build their IGM based on the **balanced AC/DC net positions and consistent flows on DC interconnectors** values calculated by the CGMA module at the next step.
03	**Balanced AC/DC net positions and consistent flows on DC interconnectors** available to TSOs for each relevant **scenario** via OPDE by CGMA module	17:15, (D-2)	This deadline has been fixed so that a sufficient buffer is set to allow CGMA Module calculation.
05	IGM available via the OPDE by TSO for all relevant scenarios	19:00, (D-2)	Capacity calculation for the (D-1) market will be done using the CGM as a starting point within each CCR. However, it has to be noted that the capacity calculation process can be quite long and can run from end of (D-2) horizon until (D-1) morning (knowing that exact timing of Capacity Calculation is up to each CCR). This deadline has been set so that provision of validated CGM allows executing coordinated capacity calculation before opening of the day ahead market. On the other hand, this deadline also takes into account the operational constraints of TSOs.
07	Validated IGMs for all relevant **scenarios** available via the OPDE for all TSOs (via substitution if necessary)	19:50, (D-2)	A 50 min delay is introduced after previous step to ensure sufficient time for potential correction loops
08	Validated CGM for all relevant **scenarios** available via the OPDE	20:00, (D-2)	This deadline has been set to harmonize the time when the CGM is available for all CCRs, knowing that some CCRs may start using it later than other CCRs.

Step	End point	Deadline [CET / CEST]	Comments / References
After CGM creation	CGM is used for relevant processes. Resulting **agreed measures** may be included in the next IGM updates	18:00, (D-1)	Following the direction chosen by the market a subset of the coordinated **agreed measures** during capacity calculation in (D-2) horizon shall be available for use in IGMs created in (D-1) horizon. If applicable, these model improvements have then to be included in the (D-1) models, so that they can be checked against the security calculations performed in (D-1) horizon.

7.6 Models created at (D-1) Horizon

All TSOs shall deliver IGMs and RSC**s** shall produce validated CGMs created at the (D-1) horizon that are used for operational security analyses (in line with GL SO (2015-11-27) Article 72).

The validated (D-1) CGM is also used by the capacity calculator as an input for the first capacity calculation process for the intraday market timeframe which takes place before the opening of the intraday market.

One validated (D-1) CGM will be created for each (D-1) **scenario**, defined per market time unit (i.e. one per hour), as detailed in section 2.4.

Deadlines need to be set such as to ensure that each coordinated capacity calculator can meet the obligations and deadlines imposed on it by, inter alia, GL CACM Article 58 (1):
"1. Each coordinated capacity calculator shall ensure that cross-zonal capacity and allocation constraints are provided to the relevant NEMOs no later than 15 minutes before the intraday cross-zonal gate opening time.
GL CACM Article 58 needs to be read in conjunction with the following GL CACM Articles:
Article 14 (1) : cross-zonal capacity shall be calculated for the intraday market.
Article 59: intraday cross-zonal gate opening and intraday cross-zonal gate closure times remain to be specified.

The specific deadlines applicable to the (D-1) horizon are detailed hereafter:

Step	End point	Deadline [CET / CEST]	Comments / References

Step	End point	Deadline [CET / CEST]	Comments / References
04	**Balanced AC/DC net positions and consistent flows on DC interconnectors** available to TSOs for each relevant **scenario** via OPDE based on information in market schedules	16:30, (D-1)	The latest DA market results as known at 16:30, (D-1) are used. This deadline has been set as the soonest after (D-1) market results are available as 16:30h on (D-1) is the latest time for closing of explicit (D-1) markets. These values, coming from market results, are both representative and balanced. This deadline is also compliant with the timing of calculation of the **scheduled exchanges** resulting from day ahead market coupling as set out in GL CACM Article 43 (2).
05	IGM available via the OPDE by TSO for all relevant **scenarios**	18:00, (D-1)	This deadline has been set so that TSOs can update their IGM with information from step 04.
07	Validated IGMs for all relevant **scenarios** available via the OPDE for all TSOs (via substitution if necessary)	18:50, (D-1)	
08	Validated CGM for all relevant **scenarios** available via the OPDE	19:00, (D-1)	
After CGM creation	CGM is used for relevant processes. Resulting **agreed measures** may be included in the next IGM updates	22:15, (D-1)	Following coordinated security analysis performed on (D-1) CGM, **agreed measures** shall be included in the updated IGMs in the intraday horizon whenever such measures have been agreed and the forecast of grid situation at the moment of IGM creation is in line with the hypothesis and reasons leading to agree on this **remedial action**, thus ensuring further coordination. This deadline has been set to ensure that **agreed measures** based on (D-1) models, if any, and if the situation requires it, are taken into account at least in a first update of the models at the very beginning of the intraday horizon.

7.7 MODELS CREATED AT INTRADAY HORIZON

During the intraday horizon, TSOs must update their IGM at the latest one hour after significant changes (compared to previous version of IGMs) influencing the grid of other TSO(s) (specifically influencing these other grids in such a way that the results of the coordinated analysis performed on the previous CGM are not valid anymore) take place, which are the following:

- Change of **AC/DC net position**,
- Change of expected load profiles, production schedules (including RES), DC flows
- Change of expected topology, including: unplanned outages, change of phase shifter transformer tap positions, modification of the standard automatic devices operation
- Updates/change of previously agreed coordinated **remedial actions** (including redispatching and countertrading).

When creating intraday grid models, TSOs use best estimation based on updated schedules from market participants, forecasts on load and generation (including RES), knowing that these can change on a continuous basis. In order to maintain a balanced set of **AC/DC net positions** and consistent flows on DC interconnectors in the intraday CGMs, it is important to coordinate the data exchange and synchronize the time of update, which implies that only validated exchange schedules available on OPDE can be used: it is necessary that the deadlines given in this chapter are always used in all CCRs for a given delivery hour H in order to correctly balance the CGM.
Each IGM update (triggered by at least one significant modification influencing the grid of other TSO(s)) during the intraday horizon implies a CGM update, thus defining an event based model creation process.

The validated intraday CGMs resulting from this process are used for operational security analyses; they are also used by the capacity calculator as an input for the capacity recalculation process for intraday timeframe, the frequency of which is to be assessed by each CCR in line with GL CACM Article 14 (4).

The timeline defined for intraday models must address the three main following issues:

- A CGM update (when relevant) shall be possible with the latest possible cross-border exchanges values to reflect the latest activity of the intraday market,
- CGM update (when relevant) shall ensure synchronism for **AC/DC net positions** and flows on DC interconnectors to be used as reference by the TSOs in step 04,
- CGM update (when relevant) shall take into account the timing constraints of the TSOs to make such updates ready for the subsequent operational process

Following steps are defined for a given delivery Hour H:

- After the end of D-1 horizon, TSOs will send an update of their IGM at regionally agreed timestamps and one hour after occurrence of a significant change**.**
  The next round hour after the moment the IGM is updated is defined as [H-n]:00.

The first possible update of the IGM can be sent until 22:00, D-1 when relevant; this does thus allows a first update of the intraday IGM after 22:00, D-1.

- Values of **AC/DC net positions** and flows on DC interconnectors to be included in IGM shall be the validated ones on OPDE at [H-n-1]:30

- In order to ensure a very efficient process, a high level of automation has to be ensured, which means that in case the IGM uploaded on OPDE are not valid, they are replaced applying the appropriate automated replacement strategy within 5 minutes (cf. sub-section 5.3.4). This implies that, in case an IGM is updated, it must be validated on OPDE at [H-n]:05 at the latest,
- In the same way, since the update of IGMs is not systematic for all TSOs, and in order to cope with fallback situations inherent to the tight timeline of the intraday horizon, automatic substitution rules are applied to non-updated IGM (cf. sub-section 5.3.4) so that a consistent validated CGM must always be created.
- Validated versions of CGM updates are created in case at least one IGM has been updated; they must be made available on OPDE at each [H-n]:15, meaning that the last update of the CGM, where relevant, may be created at [H-1]:15 and contains the values of **AC/DC net positions** and flows on DC interconnectors validated on OPDE at [H-2]:30.

This is illustrated hereafter:

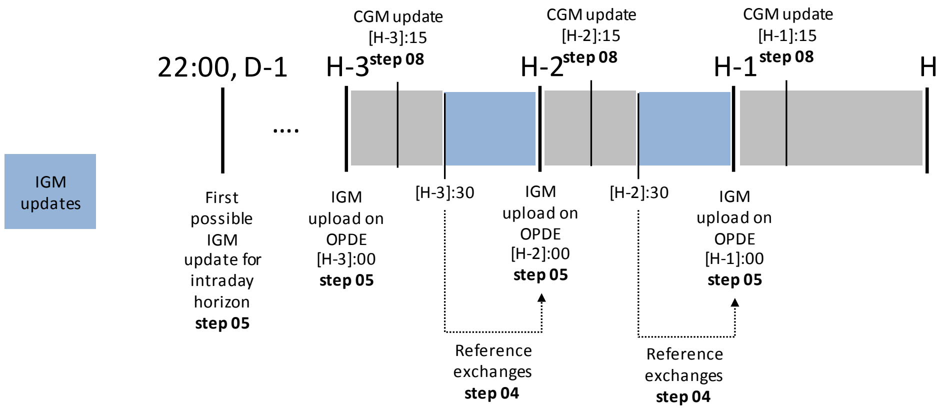

FIGURE 9: INTRADAY UPDATES

It has to be noted that, for each CGM update at [H-n]:15, the overall balance of the CGM is always ensured through the use of the values of **AC/DC net positions** and flows on DC interconnectors validated on OPDE at [H-n-1]:30 that are included in the updated IGM submitted by the TSOs (if applicable), or when applying the substitution strategy for IGMs that have not been updated if applicable (cf. chapter 5).

The substitution principle is illustrated hereafter:

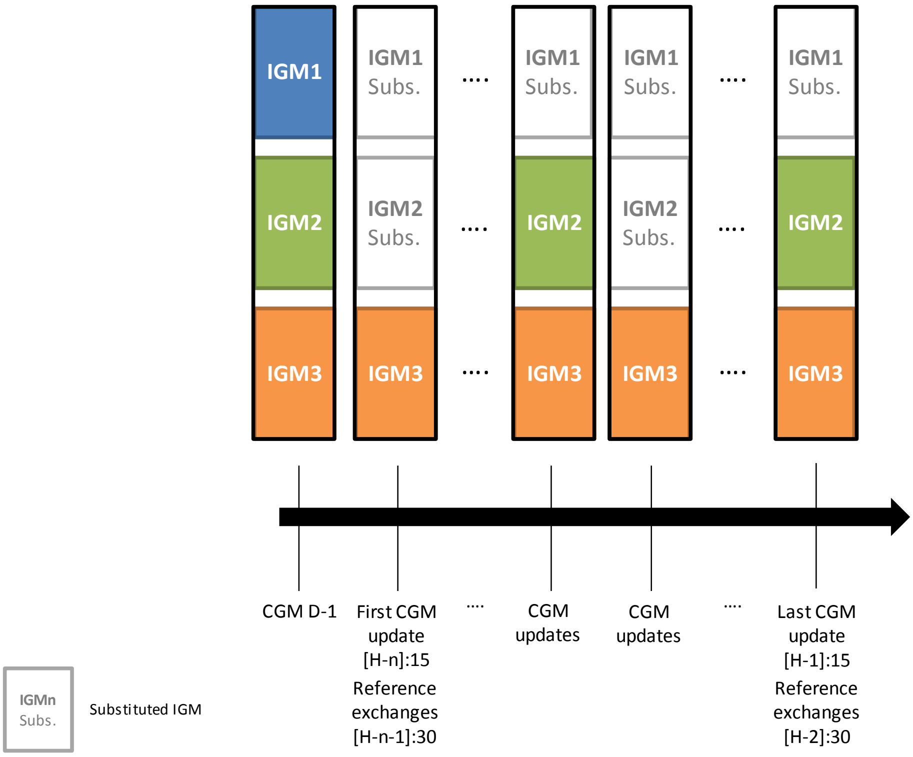

FIGURE 10: IGM SUBSTITUTION IN ID TIMEFRAME FOR THE CGM OF A GIVEN DELIVERY HOUR H

Before the intraday horizon, a CGM is created in (D-1) horizon with a mandatory provision of IGMs from all TSOs. During the intraday horizon, IGMs may be updated on an individual basis, when relevant, thus yielding an update of the CGM: in this case, non-updated IGMs may be replaced by substituted IGMs.

The timeline defined for intraday CGM implies that, for a given delivery hour, the first version of the intraday model, based on the (D-1) validated CGM, is continuously updated during the intraday horizon, when needed (when at least one IGM has been updated), thus creating up-to-date validated intraday models.
This means that for example, agreed model improvements following coordinated security analysis performed on the (D-1) CGM can yield, when applicable, a first update of the intraday CGM at 22:15 in (D-1) horizon (cf. previous section), this update will also include intraday trade realized at this moment.

One validated intraday CGM is created for each intraday **scenario** when applicable, defined per market time unit.

The specific deadlines applicable to the intraday horizon are detailed hereafter for a given delivery hour H :

Sub-line	End point of process step	Deadline [CET / CEST]	Comments / References

Sub-line	End point of process step	Deadline [CET / CEST]	Comments / References
04	**Balanced AC/DC net positions and consistent flows on DC interconnectors** available to TSOs for each relevant **scenario** via OPDE based on information in market schedules	[H-n-1]:30	This allows TSO to use validated data before they begin updating their intraday IGM
05	IGM available via the OPDE by TSO for all relevant **scenarios**	[H-n]:00	Since the intraday CGM process is a continuous update, this ensures that the last version of the intraday CGM contains the most up-to-date information possible (while taking into account timing constraints for TSOs)
07	Validated IGMs for all relevant **scenarios** available via the OPDE for all TSOs (via substitution if necessary)	[H-n]:05	The specificity of the intraday horizon is that automatic (and therefore faster) substitution rules have to be applied to validate IGMs.
08	Validated CGM for all relevant **scenarios** available via the OPDE	[H-n]:15	As for (D-1) and (D-2) horizons, 10min delay is set before first validated version of CGM is available (next deadline). Since the intraday CGM process is a continuous update, this ensure that last version of intraday CGM contains the most up-to-date information possible (while taking into account timing constraints for TSOs).
After CGM creation	CGM is used for relevant processes. Resulting agreed measure may be included in the next IGM updates	As soon as possible, if applicable	Following coordinated security analysis performed during intraday horizon, **agreed measures** may be exchanged through updated IGMs in the intraday horizon, if the situation requires it, to ensure further coordination.

8 QUALITY ASSURANCE

GL SO (2015-11-27) Article 67 (1) (b) (for (Y-1)), Article 70 (1) (c) (for (D-1) and **ID**), and Article 71 establish the need for "all TSOs [to] jointly determine controls aimed at least to check:
(a) the coherence of the connection status of interconnectors;
(b) that voltage values are within the usual operational values for those transmission system elements having influence on other **control areas**;
(c) the coherence of transitory admissible overloads of interconnectors; and
(d) that active power and reactive power injections or withdrawals are compatible with usual operational values."

The same quality controls will be applied to IGMs and CGMs established pursuant to GL CACM and GL FCA (2015-10-30).

The quality checking process allows in all cases to model improvements aimed to facilitate convergence of load flow calculation as well as realistic and accurate results of the analysis and processes the models are built for.

In the following sections a description of the quality check rules to be implemented is shown.

8.1 COMMON QUALITY ISSUES

RSCs check IGMs' quality pursuant to GL SO (2015-11-27) Article 79. Feedback on the quality and consistency of models is provided to TSOs through a common platform, the Quality Assessment Portal. In case strong discrepancies with respect to the quality criteria are detected, TSOs shall adjust the models and take note of the warnings and a new iteration of the process starts by TSOs making available the adjusted model through the OPDE.

Processes aiming to ensure quality of IGMs built for the different purposes shall check:

- IGM for the relevant time stamp and for the relevant periodicity exists;
- data exchange format, data completeness and data consistency;
- existence of a plausible AC load flow solution of IGMs, identifying potential non-convergence of IGMs and CGMs;
- inter-TSO consistency (connection status and operational limits of interconnectors in adjacent IGMs).

IGMs are merged into the necessary CGMs in line with the process described in chapter 5.

The quality of CGMs' load flow is verified. In case discrepancies or inaccuracies are detected, RSCs have to identify the IGMs causing this discrepancy and make available this information through the common quality portal, so that the necessary iteration and improvement of IGMs and CGMs is initiated. If a TSO for whatever reason cannot ensure that IGMs rejected due to poor data quality are replaced with ones of sufficient quality by the deadline, as a fallback option the RSC makes a substitute IGM available for the relevant **scenario** following the fall-back substitution rules described in sub-section 5.3.4.

8.2 Quality assurance of the IGM

For each timeframe in which IGMs are built, the IGMs corresponding to the same time stamp are identified (**scenarios** in the case of IGMs built for year-ahead till month-ahead or even, if applicable, week-ahead processes; hourly representation of the targeted day in the case of (D-2), day-ahead and intraday processes) and the next verifications are undertaken:

1) for each IGM, data completeness and data consistency:

- Time stamping and periodicity for the data and information to be provided.
- Is there an IGM?
- Does it follow the established file naming convention (which all TSOs shall follow)?
- Is the IGM compliant with the data exchange format?
- Are the data in IGM complete and coherent with limits and status?:
  a. are device status data (i.e. in/out of service) in lines and transformers correctly declared?
  b. is there a **slack node**, and PV nodes to support voltage, in the model?
  c. warning if injection in disconnected nodes is not zero;
  d. warning in case of inconsistency with design parameters of:
     i. tap position of phase or angle regulation transformers,
     ii. voltage target to control for phase regulation transformers;
  e. warning in case limits in reactive generation in PV nodes are not defined;
- Are data in IGM plausible?:
  a. are voltage set points for PV nodes realistic?
  b. warning if active or reactive generation in a node is outside operational limits.

2) for each IGM load-flow, the following items will be checked:

- IGM finds full load flow convergence (active and reactive)
- Active imbalances (including losses and net exchanges) with respect to an established maximum threshold.
- Deviation in the arranged net position with respect to an established maximum threshold.
- Bus voltages are within applicable limits for those transmission system elements having influence on other **control areas**.

- Warning if overloaded equipment in N state with respect to an established maximum level of the branch flows.

3) for adjacent IGMs, inter-TSO consistency is checked:
- Do interconnectors have the same connection status and operational limits?
- Have the corresponding established flows on DC interconnectors been considered when modelling the HVDC interconnectors operated with a fixed value of power set point?

8.3 QUALITY ASSURANCE OF THE CGM

After merging IGMs, load-flow verification on CGMs is carried out, in such a way as to detect:
- If CGM does not find full load flow convergence (active and reactive)
- Active imbalances (including losses and net imports) with respect to an established maximum threshold;
- warnings if:
    a. overloaded equipment in N state with respect to an established maximum level of the branch flows
    b. reactive power injections required exceed generators' capabilities,
    c. voltages for those transmission system elements having influence on other **control areas** not within operational limits.

9 TIMESCALE FOR IMPLEMENTATION

The starting point for implementation is the submission of the draft CGMM to the competent regulatory authorities and ACER. Unless there is a request for amendments [GL CACM Article 9 (12)] or the NRAs cannot find a consensus [GL CACM Article 9 (11)], the NRAs have a maximum of six months to make a decision [GL CACM Article 9 (10)].

Once the CGMM has been approved, it shall be published on the internet pursuant to GL CACM Article 9 (14) as well as GL SO (2015-11-27) Article 8.

GL CACM Article 27 (1) stipulates that "[n]o later than six months after the decision on the generation and load data provision methodology referred to in Article 16 and the common grid model methodology referred to in Article 17, all TSOs shall organise the process of merging the individual grid models." This corresponds to a decision on who will merge IGMs into CGMs and on the requirements specification on the basis of which the corresponding IT infrastructure shall be designed. This requirement should be read in conjunction with GL FCA (2015-10-30) Article 21 (1): "1. The process of merging the individual grid models established in accordance with Article 27 of Commission Regulation (EU) 2015/1222 shall apply when merging the individual grid models into a common grid model for each long-term timeframe. No later than six months after the approval of the generation and load data provision methodology for long-term timeframes referred to in Article 17 and the common grid model methodology for long-term timeframes referred to in Article 18, all TSOs in each capacity calculation region shall jointly develop operational rules for long-term capacity calculation timeframes supplementing the rules defined for the operation to merge the individual grid models pursuant to Article 27 of Commission Regulation (EU) 2015/1222."

A separate but related obligation set out in GL SO (2015-11-27) Article 114 (2) ["By 6 months after entry into force of this Regulation, all TSOs shall define a harmonised data format for data exchange, which shall be an integral part of the ENTSO for Electricity operational planning data environment."] is also relevant for tasks under GL CACM. Indeed, as was explained in sub-section 3.1.1 on harmonisation, the joint use of the common data format, the CGM Exchange Standard (CGMES), is firmly envisaged and meets the requirement set out in GL SO (2015-11-27) Article 114 (2). However, the timescale for implementation of CGMES under the present methodology is partially delinked from the deadlines set out in GL SO. The deadline for implementation of CGMES shall be the earlier of either six months after the approval of the CGMM by all regulatory authorities or six months after entry into force of the GL SO.

However, further to GL CACM Article 1 (3), "[w]here a transmission system operator does not have a function relevant to one or more obligations under this Regulation, Member States may provide that the responsibility for complying with those obligations is assigned to one or more different, specific transmission system operators." If the tasks requiring implementation of CGMES are assigned to a different TSO, implementation of CGMES may thus be deferred. CGMES will have to be implemented in a manner timely enough to ensure that when the assignment to another TSO is coming to an end, the TSO that previously was exempted is able to complete these by itself.

The implementation of CGMES is, of course, linked to the development of the OPDE which was referred to several times in the present methodology. While the GL CACM does not explicitly refer to the OPDE, the OPDE is the essential IT platform without which the CGM process cannot be implemented. The OPDE is governed by GL SO (2015-11-27) Article 114 et seq. which defines the following implementation steps:

- GL SO (2015-11-27) Article 114 (1) provides a general mandate to set up the OPDE: "1. By [24 months after entry into force of this Regulation], ENTSO for Electricity shall, pursuant to Articles 114, 115 and 116, implement and administer an ENTSO for Electricity operational planning data environment for the storage, exchange and management of all relevant information for implementation."
- GL SO (2015-11-27) Article 115 contains a number of provisions related to grid models (both IGMs and CGMs) specifically which provide the legal basis for the model storage and sharing arrangements described in the present methodology:
    - "1. The ENTSO for Electricity operational planning data environment shall store all individual grid models and related relevant information for all the relevant timeframes set out in this Regulation and in Article 14(1) of Commission Regulation (EU) No 2015/1222.
    - 2. The information on individual grid models contained on the ENTSO for Electricity operational planning data environment shall allow for their merging into common grid models.
    - 3. All common grid models shall be made available on the ENTSO for Electricity operational planning data environment.
    - 4. For the year-ahead timeframe, the following information shall be available on the ENTSO for Electricity operational planning data environment:
        - (a) year-ahead individual grid model per TSO and per scenario determined in accordance with Article 65; and
        - (b) year-ahead common grid model per scenario defined in accordance with Article 66.
    - 5. For the D-1 and intraday timeframes, the following information shall be available on the ENTSO for Electricity operational planning data environment:
        - (a) D-1 and intraday individual grid models per TSO and according to the time resolution defined pursuant to Article 70;
        - (b) **scheduled exchanges** at the relevant time instances per scheduling area or per scheduling area border, whichever is deemed relevant by the TSOs, and per HVDC system linking scheduling areas;
        - (c) D-1 and intraday common grid models according to the time resolution defined pursuant to Article 70; and

    - (d) a list of the prepared and agreed remedial actions identified to cope with constraints having cross-border relevance."
- GL SO (2015-11-27) Article 116 governs the role of the OPDE in outage coordination (which is one of the three principal uses for the CGM):
  - "1. The ENTSO for Electricity operational planning data environment shall contain a module for the storage and exchange of all relevant information for outage coordination.
  - 2. The information referred to in paragraph 1 shall include at least availability status of relevant assets and the information on availability plans (...)."

A number of obligations set out in GL SO (2015-11-27), while not the focus of the present version of the CGMM and only indirectly related to the CGM Methodology, should be mentioned because these will also have to be incorporated into the TSOs' overall implementation plan:

- GL SO (2015-11-27) Article 65 (4) stipulates that "ENTSO for Electricity shall publish every year by 15 July the common list of scenarios established for the following year, including the description of those scenarios." This will thus be a recurring task to be completed every year.
- According to GL SO (2015-11-27) Article 13 "[w]here a synchronous area encompasses both Union and third country TSOs, within 18 months from the entry into force of this Regulation all Union TSOs in that synchronous area shall endeavour to conclude with the third country TSOs not bound by this Regulation an agreement setting the basis for their cooperation concerning secure system operation."
- GL SO (2015-11-27) Article 24 (3) stipulates that "[w]ithin 18 months from the entry into force of this Regulation], each TSO shall adopt a business continuity plan detailing its responses to a loss of critical tools, means and facilities, containing provisions for their maintenance, replacement and development. Each TSO shall review at least annually its business continuity plan and update it as necessary and in any case following any significant change of the critical tools, means and facilities or of the relevant system operation conditions. The TSO shall share the parts of the business continuity plan which affect DSOs and SGUs with the DSOs and SGUS concerned."
- GL SO (2015-11-27) Article 75 obliges all TSOs to jointly develop a methodology for coordinating operational security analysis by 12 months after entry into force of GL SO. A similar methodology is to be developed on the level of capacity calculation regions [GL SO (2015-11-27) Article 76].
- The accompanying GLDPM builds on the concept of "relevant demand facilities" as defined in GL SO (2015-11-27) Article 3 (88) which will be defined on the basis of the methodology for assessing the relevance of assets for outage coordination. Pursuant to GL SO (2015-11-27) Article 84, that methodology will have to be prepared by 12 months after entry into force of GL SO.

The RSCs who will handle the merging of IGMs into CGMs pursuant to GL SO (2015-11-27) Article 77 (2) (b) will have to be set up within four months of the approval of the methodology for regional operational security coordination pursuant to GL SO (2015-11-27) Article 76 (see above).

Following the implementation of the OPDE, an additional twelve months should be allowed in order to set up the CGM process. Therefore, implementation of the present CGMM and the associated CGM process should be complete by 36 months after entry into force of GL SO.

This completes the overview of the timescale for implementation of the CGMM.

10 ANNEXES

Disclaimer applicable to all annexes included in the present CGMM

The annexes are not meant to be legally binding. They are included in the present version of the document (for public consultation) for the sake of convenience. However, in order to make the non-binding character clear, the annexes will likely be split off into "Supporting Documents" prior to submission of the Methodologies to the competent regulatory authorities.

10.1 CGM AREA IN TERMS OF COVERAGE OF BIDDING ZONES (AS OF 2016-01)

The following table comprehensively describes the geographical coverage of the CGM on the level of **bidding zones**. It should be read in conjunction with the explanations in section 1.2 of the present methodology. Unless noted otherwise, the **bidding zones** listed below are part of the **CGM Area**.

In the case of TSOs managing more than one **bidding zone**, the TSO provides a single IGM for the whole **control area** and the TSO's website provides additional information about the composition of the **bidding zones**. Additional information of interest may also be found in the "All TSOs' proposal for Capacity Calculation Regions (CCRs) in accordance with Article 15(1) of the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a Guideline on Capacity Allocation and Congestion Management" published on the ENTSO-E website.

As explained in section 1.2, only TSOs from an EU member state are considered "**certified TSOs**". In multiple-TSO jurisdictions, Member States may have assigned responsibilities among the TSOs in a particular manner. The present overview table does <u>not</u> aim to provide details on this.

SUB-LINE	**Synch. Area**	**Bidding zone**	TSO**(s)**	**EU member?**	**ENTSO-E member?**	**Comments**
01	CE	AL	Operatori i Sistemit të Transmetimit (OST)	No, but Energy Community member	No	Albania provides its IGM and <u>is</u> part of the **CGM Area.**

SUB-LINE	Synch. Area	Bidding zone	TSO(s)	EU member?	ENTSO-E member?	Comments
02	CE	AT / DE / LU	Austrian Power Grid AG Vorarlberger Übertragungsnetz GmbH Eneco Valcanale S.r.l. 50Hertz Transmission GmbH Amprion GmbH TenneT TSO GmbH TransnetBW GmbH Creos Luxembourg S.A.	Yes	Yes (except Eneco Valcanale S.r.l.)	**Bidding zone** configuration as of 2016-01. Given that splitting up this **bidding zone** into separate "AT" and "DE/LU" **bidding zones** is being envisaged, the present overview table shall be reviewed prior to submission of the methodology to the competent regulatory authorities.
03	CE	BA	Nezavisni operator sustava u Bosni i Hercegovini (NOS BiH)	No, but Energy Community member	Yes	
04	CE	BE	Elia System Operator SA	Yes	Yes	
05	CE	BG	Electroenergien Sistemen Operator EAD (ESO)	Yes	Yes	
06	Baltic	BY	Belenergo Holding / Belarus TSO	No	No	Belarus <u>not</u> part of **CGM Area**; interconnections to Belarus to be incorporated as injections by the TSOs of Lithuania and Poland

SUB-LINE	Synch. Area	Bidding zone	TSO(s)	EU member?	ENTSO-E member?	Comments
07	CE	CH	Swissgrid AG	No	Yes	Switzerland is part of the **CGM Area**; legal questions related to Article 1 (4) and (5) of the GL CACM are out of scope of the present document
08	CE	CZ	ČEPS a.s.	Yes	Yes	
09	CE	DK1	Energinet.dk	Yes	Yes	
10	Nordic	DK2	Energinet.dk	Yes	Yes	
11	Baltic	EE	Elering AS	Yes	Yes	
12	CE	ES	Red Eléctrica de España S.A.	Yes	Yes	
13	Nordic	FI	Fingrid Oyj	Yes	Yes	
14	CE	FR	Réseau de Transport d'Electricité	Yes	Yes	
15	GB	GB	National Grid Electricity Transmission plc Scottish Hydro Electric Transmission plc Scottish Power Transmission plc BritNed National Grid Interconnectors Ltd. Moyle IC Offshore Transmission Owners (OFTOs – not individually listed)	Yes	Yes Yes Yes No No No No	

SUB-LINE	Synch. Area	Bidding zone	TSO(s)	EU member?	ENTSO-E member?	Comments
16	CE	GR	Independent Power Transmission Operator S.A.	Yes	Yes	
17	CE	HR	HOPS d.o.o.	Yes	Yes	
18	CE	HU	MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság	Yes	Yes	
19	IE / NI	IE/NI	EirGrid plc System Operator for Northern Ireland Ltd	Yes	Yes	
20	CE	IT1 (NORD)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	
21	CE	IT2 (CNOR)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	
22	CE	IT3 (CSUD)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	
23	CE	IT4 (SUD)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	
24	CE	IT5 (FOGN)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	
25	CE	IT6 (BRNN)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	
26	CE	IT7 (ROSN)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	
27	CE	IT8 (SICI)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	

SUB-LINE	**Synch. Area**	**Bidding zone**	TSO**(s)**	**EU member?**	**ENTSO-E member?**	**Comments**
28	CE	IT9 (PRGP)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	
29	CE	IT10 (SARD)	Terna - Rete Elettrica Nazionale SpA	Yes	Yes	Not included in CGM according to Terna (not relevant from a technical point of view)
30	Baltic	LT	Litgrid AB	Yes	Yes	
31	Baltic	LV	AS Augstsprieguma tĪkls	Yes	Yes	
32	CE	MA	ONEE	No	No	Morocco <u>not</u> part of **CGM Area**; interconnection to Morocco to be incorporated as injection by the TSO of Spain
33	CE	MD	Moldelectrica	No, but Energy Community member	No	Moldova <u>not</u> part of **CGM Area**
34	CE	ME	Crnogorski elektroprenosni sistem AD	No, but Energy Community member	Yes	
35	CE	MK	Macedonian Transmission System Operator AD	No, but Energy Community member	Yes	

SUB-LINE	**Synch. Area**	**Bidding zone**	TSO**(s)**	**EU member?**	**ENTSO-E member?**	**Comments**
36	CE	MT	Enemalta	Yes	No	Malta is not part of the **CGM Area** as it only has a distribution network, not a transmission network. Following the commissioning of the interconnection linking Malta with Sicily, Malta is incorporated in the IGM of Terna, the Italian TSO, as an injection.
37	CE	NL	TenneT TSO B.V. BritNed	Yes	Yes No	
38	Nordic	NO1	Statnett SF	No	Yes	
39	Nordic	NO2	Statnett SF	No	Yes	
40	Nordic	NO3	Statnett SF	No	Yes	
41	Nordic	NO4	Statnett SF	No	Yes	
42	Nordic	NO5	Statnett SF	No	Yes	
43	CE	PL	Polskie Sieci Elektroenergetyczne S.A.	Yes	Yes	
44	CE	PT	Rede Eléctrica Nacional, S.A.	Yes	Yes	
45	CE	RO	C.N. Transelectrica S.A.	Yes	Yes	
46	CE	RS	JP Elektromreža Srbije	No, but Energy Community member	Yes	
47	Baltic	RU	FGC	No	No	Russia not part of **CGM Area**; interconnections to Russia to be incorporated as injections by the TSOs of Finland, Estonia, Latvia, Lithuania, and Norway.
48	Nordic	SE1	Svenska Kraftnät	Yes	Yes	

SUB-LINE	**Synch. Area**	**Bidding zone**	TSO**(s)**	**EU member?**	**ENTSO-E member?**	**Comments**
49	Nordic	SE2	Svenska Kraftnät	Yes	Yes	
50	Nordic	SE3	Svenska Kraftnät	Yes	Yes	
51	Nordic	SE4	Svenska Kraftnät	Yes	Yes	
52	CE	SI	ELES, d.o.o.	Yes	Yes	
53	CE	SK	Slovenská elektrizačná prenosová sústava, a.s.	Yes	Yes	
54	CE	TR	TEIAS	No	No	Turkey provides its IGM and is part of the **CGM Area.**
55	CE	UA_W	WPS	No, but Energy Community member	No	Western Ukraine provides its IGM (six timestamps) and is part of the **CGM Area**
56	CE	XK	KOSTT	No, but Energy Community member	No	Kosovo provides its IGM and is part of the **CGM Area**

10.2 RELEVANT LEGISLATION

The relevant passages of the three Guidelines referred to in the section on legal requirements have been excerpted into a separate document distributed in parallel with the present Methodology.