European Network of
Transmission System Operators
for Electricity

INTEROPERABILITY TEST “CIM FOR SYSTEM DEVELOPMENT AND OPERATIONS” 2016

15 July 2016

Foreword

ENTSO-E conducted, along with European and American vendors and Transmission System Operators (TSOs), a common information model (CIM) interoperability test (IOP) — ENTSO-E IOP "CIM for System Development and Operations" 2016. The test was organised and directed by ENTSO-E from 11 to 15 July 2016 at ENTSO-E's premises, in Brussels.

The future ENTSO-E CIM-based data exchange format, ENTSO-E Common Grid Model Exchange Specification (CGMES), which is based on the International Electrotechnical Commission (IEC) CIM standards 61970 (parts 301, 302, 452, 453, 456, 457, 552), was tested in this IOP on a large number of products. The test is a part of the development process of the ENTSO-E Common Grid Model Exchange Standard.

Key goals were to test and validate the latest IEC draft CIM standards on which ENTSO-E bases the new version of the ENTSO-E CGMES.

The following companies participated with their tools in the testing: ABB, CESI, DIgSILENT, EDF, FGH, Neplan, Nexant, Open Grid Systems, RTE/Tractebel, Siemens, and Simtec.

The results achieved during the test are in line with the expectations of the participants. The test results are summarised and presented in detail in this report showing the specific tests successfully completed by each vendor and the test case files that they have exchanged.

Issues recorded during the testing and proposed resolutions are included in this report, along with some guidelines on how to implement the CIM standards within the TSO/utility enterprise. Details on the products tested and the test procedures are included in the report appendices.

The IOP participants have approved the report, making it a basis for further discussions in the ENTSO-E Committees as well as in the IEC TC57/WG13. The implementation schedule for the CGMES 2.5 is subject to an ENTSO-E decision later this year.

Acknowledgements

ENTSO-E would like to thank the many people who worked hard to make the ENTSO-E Interoperability Test "CIM for System Development and Operations" 2016 a success. Not all people who contributed can be named here. However, ENTSO-E would like to give special recognition to the following utilities and vendors:

- ENTSO-E – Chavdar Ivanov, Dario Frazzetta for directing the IOP, for assistance in witnessing the IOP, for preparation of test data and procedures, ENTSO-E CGMES documentation, and the final report.
- Miloš Bunda – for supporting the preparation of the IOP including the development of CGMES 2.5 profiles.
- Statnett – Svein Olsen for supporting the preparation of the IOP including the development of CGMES 2.5 profiles and preparation of the test data.
- Project Team Common Grid Model (Work Package 2 on CGMES) – for their active support to the preparation of the IOP and CGMES 2.5.
- PowerInfo – Jun Zhu for providing version of CIMdesk, which validates CGMES 2.5.
- All participating TSOs as test witnesses for CGMES and discussion of various issues.
- All participating vendors (ABB, CESI, DIgSILENT, EDF, FGH, GE, Neplan, Nexant, Open Grid Systems, PSE Innowacje, RTE/Tractebel, Siemens, Simtec), for the hard work in a very short time to develop the necessary software for the testing of the CGMES and for providing inputs to the issues discussed during the preparatory work as well as during the IOP.

In addition, ENTSO-E acknowledges IEC TC57/WG13 and CIM user group members that provided assistance and supported ENTSO-E IOP in various ways.

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1 Introduction

1.1 Background information

The CIM for grid model exchange enables exchanges for the data necessary for regional or pan-European grid development studies, and for future processes related to network codes.

Grid model exchange is a complex process covering a variety of use cases, which include the exchange of

- equipment information, i.e. power system equipment data characteristics and connectivity;
- steady state hypothesis data, i.e. information that define the starting conditions for a particular situation or study;
- topology information, i.e. the result of topology processing;
- information on power system state variables, which contains the results from initial power flow simulation of the system.

In addition, grid model exchange can benefit from information related to dynamics, diagram layout and geographical location for elements in the power system. Supported by IEC TC 57 WG13, ENTSO-E developed these features in the latest drafts of the ENTSO-E CIM specifications to cover the specific business requirements of TSO grid model exchanges. ENTSO-E CIM specifications for grid models exchange are based on the following existing or expected IEC CIM standards:

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

The Common Grid Model Exchange Specification (CGMES) – version 2.4 is a superset of the IEC Common Information Model (CIM) standard. ENTSO-E developed the specification to meet necessary requirements for TSO data exchanges in the areas of system development and system operation (e.g. TYNDP and network codes) and initially published the specification in December 2013.

TSOs have to use the CGMES as the baseline exchange standard for the implementation of the Common Grid Model (CGM) methodologies. Applications dealing with data management for power systems, as well as applications supporting the following analyses shall exchange their models in accordance with CGMES:

- power flow and contingency analysis,
- short circuit calculations,
- market information and transparency,
- (flow based) capacity calculation for capacity allocation and congestion management, and
- dynamic stability assessment.

The conformity with the CGMES of the applications used for operational and system development exchanges is crucial for the required interoperability of these applications. ENTSO-E therefore developed and approved the CGMES Conformity Assessment Framework as the guiding principles for assessing applications'

CGMES conformity. Based on those principles, ENTSO-E operates a CGMES Conformity Assessment Process in order to ensure that suppliers of the applications used by TSOs properly implement the CGMES.

1.2 Objectives

The IEC is publishing international standards based on the CIM as a generalised abstract information model and is progressing data interface specifications based on the CIM to exchange power system models. The ENTSO-E CGMES IOP is an important step in validating these standards as well as the new draft of the ENTSO-E CGMES (currently version 2.5), which specifies those parts of the CIM needed to support the ENTSO-E business processes.

This ENTSO-E IOP is a stage in the development process of the ENTSO-E CGMES version 2.5, which will become an official data exchange format once endorsed by the ENTSO-E committees responsible for the data exchanges.

The specific objectives of the ENTSO-E IOP 2016 were to:

1. Validate the resolution of all issues recorded in previous interoperability tests and CGMES implementation efforts.

2. Validate the ENTSO-E CGMES 2.5 profiles and documentation. The goal was to ensure it is correct, complete and ready to be used in ENTSO-E data exchanges or identify issues to be corrected before the release of the final document.

2 Summary of the testing and discussions

During the CGMES Interoperability assessment of 2016, which ENTSO-E organised from the 11th to the 15th of July at ENTSO-E in Brussels, 43 participants from different TSOs, vendors and Universities actively participated in the development of CGMES 2.5. ENTSO-E held different presentations on the necessary extensions that are mainly driven by new obligations and business processes from a European network code perspective. The participants actively discussed proposals and agreed on making the necessary changes into the UML of CGMES 2.5. An overview of agreed decisions can be found in Appendix A: Summary of issues' agreements from IOP 2016
ENTSO-E made the following main extensions to CGMES:

- Operational limits in the SSH profile
- Power Electronics
- Manifest
- Network model project
- System Integrity Protection Scheme (SIPS)
- Availability planning
- Frames
- Renewable Energy Sources (RES)
- Energy Area
- Interarea Exchange
- Power System Corridors (PTC)

Apart from the efforts on CGMES 2.5, participants presented their efforts and developments with respect to CDPSM, Modelica and CIM for Dynamics.
Additionally EDF has made efforts to validate CGMES 2.4.15 with its tools RiseClipse, and Disnetsimpl and provided an presentation about Distribution datasets, please see references [3] and [4].

3 Next steps on CGMES 2.5

The intended planning for approval of CGMES 2.5 and development of test configurations is the following:

- Sep 2016: ENTSO-E will publish the IOP report including all CGMES 2.5 documentation
- End of 2016: approval by ENTSO-E
- Q1/2017: start IEC process on CGMES 2.5 technical specification
- Q1/2017: start to develop test configurations for CGMES 2.5
- Q2/2017: organize a workshop with vendors to validate the test configurations that will be used for the CGMES 2.5 conformity assessment process
- Before end of 2017: Launch the conformity process on the CGMES 2.5
- 2018: run conformity process and plan the implementation of the CGMES 2.5 by TSOs.

4 Conclusions and recommendations

Various vendors that provide tools for a “system operational” environment as well as for a “system planning” environment attended ENTSO-E IOP and validated the draft version 2.5 of the CGMES.
The CGMES has a wide scope, is based on the latest IEC draft standards, and fully covers all classes and definitions described in IEC 61970-452, 61970-456, 61970-453, 61970-301, 61970-302, 61970-552, and 61970-457. ENTSO-E created the profiles part of the CGMES in a UML environment, which facilitates the maintenance process.

The main conclusions of the ENTSO-E Interoperability test “CIM for System Development and Operations” 2016 can be summarised as follows:

- The IOP/workshop discussed the example files illustrating the most important features of the ENTSO-E CGMES v2.5. The participants extensively reviewed the UML and the documentation of the CGMES v2.5.

- The outcome of the discussions and the final post-IOP version of the CGMES v2.5 are a solid basis for further ENTSO-E discussions towards the approval of the CGMES v2.5.

- During the IOP, the participants identified and discussed important issues that IEC/WG13 needs to address, as well as CGMES-related implementation issues. ENTSO-E IOP participants agreed on the resolution of these issues.

- ENTSO-E IOP participants are confident that issues identified since the approval of CGMES v2.4 are sufficiently covered in the CGMES v2.5.

- Some vendors demonstrated that the transformation between distribution network and CGMES is possible. This is a first step towards the efforts to have closer integration between CGMES and profiles for exchanging distribution data (CDPSM).

The following recommendations were agreed:

- ENTSO-E should organise a process to prepare test models (the so-called test configurations) for different functionalities and equipment in the CGMES v2.5. Vendors shall use these test configurations for validation of the production releases of their tools that support CGMES v2.5. The process related to conformity of applications with CGMES v2.5 can only be triggered after the approval of the CGMES v2.5 and finalization of the test configurations.

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- ENTSO-E needs to develop supportive documentation on some of the CGMES profiles to facilitate the implementation of these profiles and to clarify the use cases.
- ENTSO-E needs to modify CGMES 2.4 OCL rules or develop new rules for CGMES 2.5 based on the outcome of the IOP.
- Continuous maintenance of the ENTSO-E CGMES v2.5 is necessary in order to facilitate future development work and implementation of the CGMES.
- IEC CIM standards should ensure backwards compatibility with respect to both IT and network modelling.

5 References

[1] CGMES 2.5 main document (61970-600 part 1, edition 2)
[2] OPDE and related planning: http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/Reference%20Documents/20160331_IEC_WG13_OPDE-in-a-nutshell.pdf
[3] Validation report of CGMES with EDF tools: http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/Test%20data/VariousTests/EDF_RD_ENTSOE_July2016IOP_CGMES-2-4-15-RiseClipseDisNetSimpl_Final.pdf
[4] Distribution Datasets and associated report and presentation: http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/Forms/AllItems.aspx?RootFolder=%2fGroups%2fENTSO%2dE%5fIOP%2f2016%2fShared%20Documents%2fTest%20data%2fTSO%2dDSO%2dCDPSM&FolderCTID=&View=%7bCC9311C1%2d793D%2d463A%2d8760%2d698E03DBCF55%7d

6 Appendix A: Summary of issues' agreements from IOP 2016

All participants had discussions on CIM-related topics during the IOP. Issues related to the CIM UML and the CGMES were identified and mostly resolved. More than 50 people participated in the discussion (either present in the ENTSO-E premises or joining remotely via webinar). The outcome of these discussions and the agreements are summarised in this Appendix as issues to be addressed to IEC, CGMES' profiles issues, and recommendations.

6.1 CGMES 2.5 namespace – backwards compatibility

- **Description**

CGMES requirement VERS2, VERS3, VERS4, VERS7 and VERS are describing requirement for backwards compatibility.
The objective is to be fully backwards compatible which is possible with Option 1.

<u>Option 1</u>: Two namespaces for the UML and two namespaces for the profile
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:cim="http://iec.ch/TC57/2013/CIM-schema-cim16#"
xmlns:entsoe="http://entsoe.eu/CIM/SchemaExtension/3/1#"

```
xmlns:entsoe2="http://entsoe.eu/CIM/SchemaExtension/3/2#" xmlns:md="http://iec.ch/TC57/61970-552/ModelDescription/1#" xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<md:FullModel rdf:about="urn:uuid:d400c631-75a0-4c30-8aed-832b0d282e73">
<md:Model.created>2014-10-24T11:56:40</md:Model.created>
<md:Model.scenarioTime>2014-06-01T10:30:00</md:Model.scenarioTime>
<md:Model.version>2</md:Model.version>
<md:Model.DependentOn rdf:resource="urn:uuid:2399cbd0-9a39-11e0-aa80-0800200c9a66"/>
<md:Model.description>CGMES Conformity Assessment... </md:Model.description>
<md:Model.modelingAuthoritySet>http://elia.be/CGMES/2.4.15</md:Model.modelingAuthoritySet>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentCore/3/1</md:Model.profile>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentCore/3/2</md:Model.profile>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentShortCircuit/3/1</md:Model.profile>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentShortCircuit/3/2</md:Model.profile>
</md:FullModel>
```


<u>Option 2</u>: Replace namespace for the UML and replace namespaces for the profile


```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF  xmlns:cim="http://iec.ch/TC57/2013/CIM-schema-cim16#"
xmlns:entsoe="http://entsoe.eu/CIM/SchemaExtension/3/2#"
xmlns:md="http://iec.ch/TC57/61970-552/ModelDescription/1#"
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<md:FullModel rdf:about="urn:uuid:d400c631-75a0-4c30-8aed-832b0d282e73">
<md:Model.created>2014-10-24T11:56:40</md:Model.created>
<md:Model.scenarioTime>2014-06-01T10:30:00</md:Model.scenarioTime>
<md:Model.version>2</md:Model.version>
<md:Model.DependentOn rdf:resource="urn:uuid:2399cbd0-9a39-11e0-aa80-0800200c9a66"/>
<md:Model.description>CGMES Conformity Assessment... </md:Model.description>
<md:Model.modelingAuthoritySet>http://elia.be/CGMES/2.4.15</md:Model.modelingAuthoritySet>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentCore/3/2</md:Model.profile>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentShortCircuit/3/2</md:Model.profile>
</md:FullModel>
```


IEC decided to increase the number of the CIM namespace every time UML is released (for the 61970-301 and 61968 etc…).
The objective is to ensure interoperability and enable application which supports CGMES 2.4 to be able to consume CGMES 2.5 without modification of the application.

After the discussion on 29 Feb vendors were requested to express (by 4 Mar) their preference on the different options.
The summary of the preferences is:

- For option 1: 4
- For option 2: 5
- Both problematic – 1

So there is no clear preference.
It shall also be noted that the plan is to have CGMES 2.5 build on CIM16 and as backwards compatible as possible.

Perhaps an option 3 can be defined in which the users will be allowed to manage the content of the URIs in the header. In this way depending on the situation the parties in an exchange could agree what to use. However, this means that all tools currently supporting CGMES 2.4 also need modification.

<u>New option discussed in the call</u>

<u>Option 3</u>: One namespace for the UML and two namespaces for the profile

```
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF  xmlns:cim="http://iec.ch/TC57/2013/CIM-schema-cim16#"
xmlns:entsoe="http://entsoe.eu/CIM/SchemaExtension/3/1#"
xmlns:md="http://iec.ch/TC57/61970-552/ModelDescription/1#"
xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
<md:FullModel rdf:about="urn:uuid:d400c631-75a0-4c30-8aed-832b0d282e73">
<md:Model.created>2014-10-24T11:56:40</md:Model.created>
<md:Model.scenarioTime>2014-06-01T10:30:00</md:Model.scenarioTime>
<md:Model.version>2</md:Model.version>
<md:Model.DependentOn rdf:resource="urn:uuid:2399cbd0-9a39-11e0-aa80-0800200c9a66"/>
<md:Model.description>CGMES Conformity Assessment... </md:Model.description>
<md:Model.modelingAuthoritySet>http://elia.be/CGMES/2.4.15</md:Model.modelingAuthoritySet>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentCore/3/1</md:Model.profile>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentCore/3/2</md:Model.profile>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentShortCircuit/3/1</md:Model.profile>
<md:Model.profile>http://entsoe.eu/CIM/EquipmentShortCircuit/3/2</md:Model.profile>
</md:FullModel>
```

- **Agreement**

Option 1 is selected, i.e. include explanation in the Implementation guide for CGEMS 2.5 related to the power electronics classes, DisconnectingCircuitBreaker and the dynamics profile. The implementation guide should define business rules to ensure backwards compatibility. The dynamics profile is not an issue for backwards compatibility as no exchanges were performed and no ENTSO-E conformity attestation was issued on applications. The 61970-302 standard will be 1:1 with CGMES 2.5 DY profile. Deadline for commenting of 61970-302 is end of July 2016.
The following actions needs to be performed:

- UML of CGMES 2.5 should be modified
  - tag all CGMES 2.5 extension in the UML information model with Entsoe2
  - tag all CGMES 2.5 extension in the UML profile model with entsoe2 and associate it with the namespace http://entsoe.eu/CIM/SchemaExtension/3/2#
  - tag the CIM informative part, SIPS, in the UML profile model with icim and use the namespace http://iec.ch/TC57/2013/CIM-schema-cim16-info#.
- Implementation guide to be prepared when CGMES 2.5 is approved for implementation
- Use entsoe2 as the namespace tag in the test file for the CGMES 2.5 extension

6.2 Filename convention for operational planning

- **Description**

ENTSO-E approved file naming convention for operational planning. The document is available here: http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/CGMES%202.5%20documentation/File%20name%20convention%20operational%20data%20exchanges.pdf

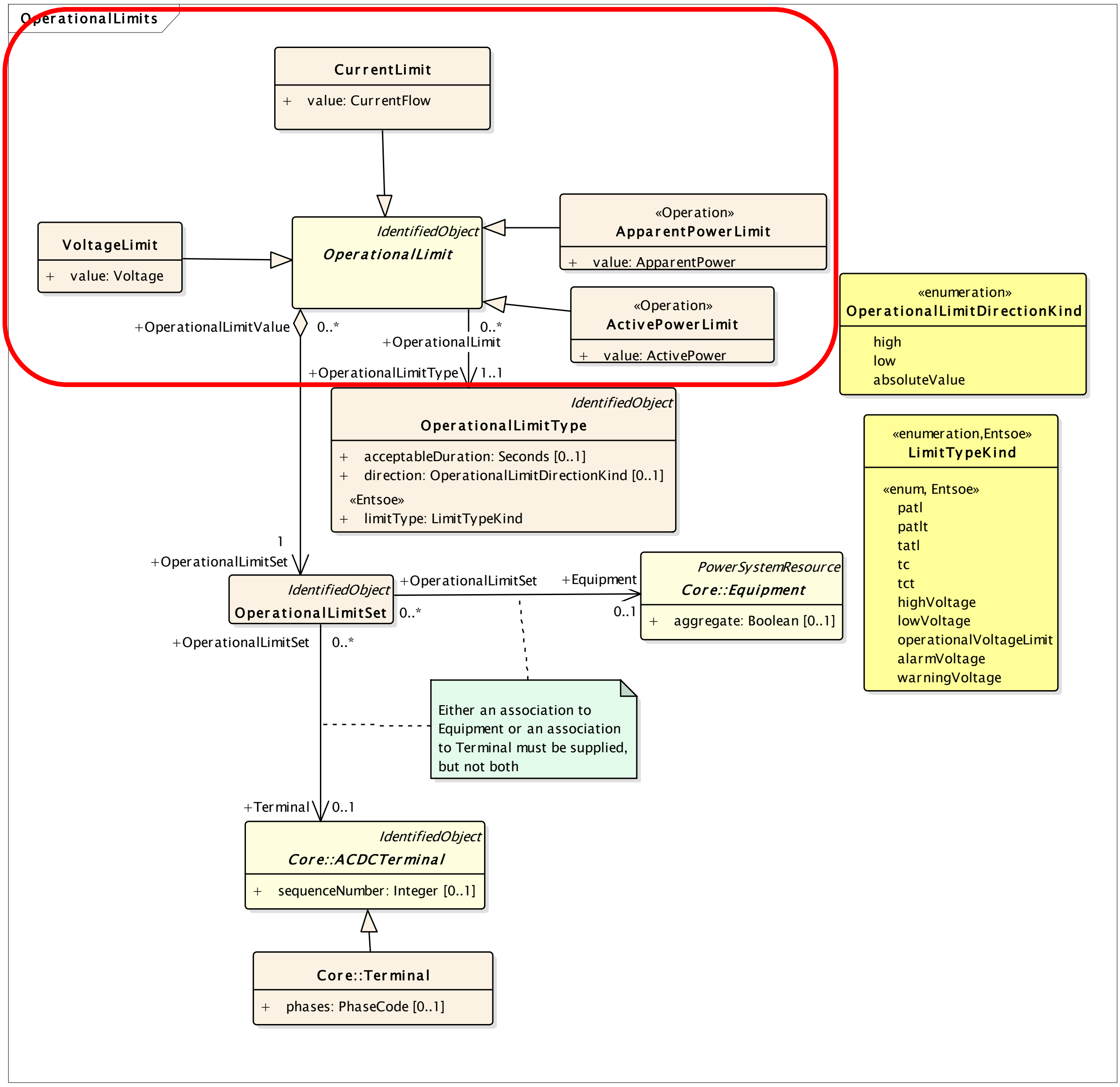
- **Agreement**

IOP participants acknowledge the existence of the document. No comments were expressed.

6.3 Operational limits in the SSH

- **Description**

For the purpose of operational planning i.e. exchanging temporary operational limits, some EQ classes needs to be duplicated in the SSH.



The value in the SSH does not change the value of the EQ, e.g. the operational in SSH are only valid for the time period of the SSH. The operational limits in SSH are not exchanged in case the value of the limits is the same as in the EQ.

Timestamp	EQ	SSH	Used value
00:30	CurrentLimit.value =100		**100**
01:30	CurrentLimit.value =100	CurrentLimit.value =150	**150**
02:30		CurrentLimit.value =100	**Not a valid option**
03:30	CurrentLimit.value =100		**100**

- **Agreement**

  - The classes that are circled in red will included in the SSH as it is. The attributes value in SSH will replace the value in the EQ.
  - The normalValue attributes will be added to the EQ as ENTSO-E extensions to retain the value before it is substituted by the value of SSH. The value attributes will be kept as it is.
  - The SSH contains the full set of operational limits.

The UML was reviewed in the IOP. No additional changes are necessary.

6.4 Association PowerElectronicsConnection.PowerElectronicsUnit

- **Description**

N/A.

- **Agreement**

The association remains as it is in the draft CGMES 2.5, i.e. 1 (PowerElectronicsConnection) to 0..1 (PowerElectronicsUnit). The direction is from PowerElectronicsConnection to PowerElectronicsUnit.

6.5 Short circuit related attributes on PowerElectronicsConnection class

- **Description**

Short circuit attributes should be adapted/extended to match the IEC 60909-0 standard (chapter 3.9), in particular the ratios ILR/IrM and RM/Xm should be introduced.

Attribute	Description
iaIrRatio	Ratio of maximum short circuit current to the rated current of the motor. Used for short circuit data exchange according to IEC 60909 [ILR/IrM]
rxRatio	Ratio (R/X) used for short circuit data exchange according to IEC 60909 [RM/Xm]

It could also be useful to check with IEC if a revision of this standard is scheduled for short/medium term. Moreover, maybe also for HVDC these short circuit parameters should be included.

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3.9 Static converters

Reversible static converter-fed drives (for example, rolling mill drives) are considered for three-phase short circuits only, if the rotational masses of the motors and the static equipment provide reverse transfer of energy for deceleration (a transient inverter operation) at the time of short circuit. Then they contribute only to the initial symmetrical short-circuit current I_k'' and to the peak short-circuit current i_p. They do not contribute to the symmetrical short-circuit breaking current I_b and the steady-state short-circuit current I_k.

As a result, reversible static converter-fed drives are treated for the calculation of short-circuit currents in a similar way as asynchronous motors. The following applies:

Z_M is the impedance according to equation (26);

U_{rM} is the rated voltage of the static converter transformer on the network side or rated voltage of the static converter, if no transformer is present;

I_{rM} is the rated current of the static converter transformer on the network side or rated current of the static converter, if no transformer is present;

$I_{LR}/I_{rM} = 3$;

$R_M/X_M = 0{,}10$ with $X_M = 0{,}995\, Z_M$.

All other static converters are disregarded for the short-circuit current calculation according to this standard.

Srm is the apparent power.

$$Z_M = \frac{1}{I_{LR}/I_{rM}} \cdot \frac{U_{rM}}{\sqrt{3}\, I_{rM}} = \frac{1}{I_{LR}/I_{rM}} \cdot \frac{U_{rM}^2}{S_{rM}} \qquad (26)$$

$$X_M = \frac{Z_M}{\sqrt{1 + (R_M/X_M)^2}} \qquad (27)$$

- **Agreement**
  - No additional attributes are necessary for the PowerElectronicsConnection.
  - WG13 will need to revise short circuit attributes in the PowerElectronicsConnection and fix in CIM17.

6.6 DisconnectingCircuitBreaker

- **Description**

N\A.

- **Agreement**
  - DisconnectingCircuitBreaker should inherit from Breaker
  - Both DisconnectingCircuitBreaker and Breaker should be concrete classes.

6.7 Boundary profiles (EQ and TP)

- **Description**

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Junction class was added to the boundary profiles in order to resolve an issue related to the ability to declare GIS coordinated for the boundary points. It looks like the association from terminal to ConnectivityNode and TopologicalNode are missing which makes the connectivity implicit relying on the containership of Junction, ConnectivityNode and TopologicalNode.

- **Agreement**
  - Add the associations from Terminal to ConnectivityNode in the EQ-BD profile
  - Add the associations from Terminal to TopologicalNode in the TP-BD profile.

6.8 Association RegulatingControl.Terminal

- **Description**

Inconsistency with 61970-452 was found.

- **Agreement**
  - The association RegulatingControl.Terminal should be 0..* at the side of RegulatingControl. The 61970-452 is already having this cardinality.

6.9 Name related attributes of the IdentifiedObject

- **Description**

The CGMES v2.4 has the following rules and cardinalities related to the IdentifiedObject attributes.

• **IdentifiedObject**	**String length, characters**	**Equipment profile**	**Topology profile**	**Study State Hypothesis profile**	**State variables profile**	**Diagram layout profile**	**Geographical location profile**	**Dynamics profile**
.name	32 maximum	✓r	✓o	✓o	✓r	✓r	×	✓o
.description	256 maximum	✓o	✓o	×	×	×	×	✓o
.energyIdentCodeEic	16 exactly	✓o	✓o	×	×	×	×	×
.shortName	12 maximum	✓o	✓o	×	×	×	×	×

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

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

The current UML and profiling tooling does not allow to define specific rules for the name attribute for each class due to the inheritance principle i.e. if IdentifiedObject.name is set required then it is required for all classes which inherit from IdentifiedObject. Please pay attention that .name is required in 61970-452 since the beginning.
There are the following option that could be applied to clarify:

1) **Do not apply any change on the cardinalities**. This means that e.g. for EQ profile all classes that inherit from IdentifiedObject must have name. A tool that receives data can reject the data if required attribute is missing
2) **Do not apply any change on the cardinalities, but specify that required attribute of identifiedObject can be exchanged as null** i.e. <IdentifiedObject.name>< IdentifiedObject.name >
3) **Do not apply any change on the cardinalities, but create a table which would specify for which classes it is not required**
4) **Change the cardinality to optional and define OCL rules to specify where it is required for each class**

Decision IOP calls:

- The issue needs some further discussion. Option 2 seems the most easy to implement and does not require changes. It also has the advantages to support specific use cases in which names are not exchanged at all.

After the call Jun Zhu summarized the principles and practices related to naming. The discussion will continue in the next call on 23 May.

Problem Statement

Naming is complex issue. Vendor's systems have inconsistent and sometimes conflicting naming conventions. But naming is important. Despite the fact that most analytical functions don't require names to be specified for modeling entities, naming is critical for information presentation, such as reporting, visualization, etc.
The existing CIM profiles are lack of detailed guidance for naming. This issue is further complicated by the UML and profiling tools, which lack a capability of customizing the cardinality specification at the concrete class level. Consequently, vendors implemented the naming rules inconsistently.

Objective

The objective of this note is to propose

- ✓ principles for naming in CIM profiles
- ✓ an initial draft of naming rules

CIM Naming Principles

- ✓ Names are mainly for humans. They shall not be used for any purposes object identification. Restrictions, such as, "Equipments of a Substation shall maintain a unique name", shall be avoided.
- ✓ Naming rules shall be driven by the use cases (mainly information presentation), not restricted by limitations of vendors systems and UML/profiling tools.
- ✓ Names are important in many cases. But restrictive requirements on naming may result in the interoperability issues. For example, the dynamically-created names may not be storable in the underlying data source, resulting in information loss.
- ✓ In general,

- Physical modeling entities, such as Substation, Equipment, etc., require a name to be specified, while naming is optional for the components that make up a physical modeling entity, such as Terminal, RatioTapChanger, etc.
- Conceptual modeling entities may or may not require a name to be specified depending on whether these modeling entities shall be presented to end-users. DiagramObjects, for example, are meaningless for human audiences. Names shall not be enforced. TopologicalIsland, on the other hand, may require a name to be provided, since they could be shown in the power flow reports.
- Name of conceptual modeling entities shall be optional whenever possible. For example, if the conceptual modeling can be characterized by one or a combination of its attributes, then naming shall be optional. As an example, name for BaseVoltage shall not be required, since it is characterized by attribute BaseVoltage.nominalVoltage, which could optionally serve as name. By the same token, if a conceptual modeling entity is uniquely associated with a physical modeling entity, then its name can be derived from the associated physical modeling entity if needed.

- **Proposal**:

The proposal is to:

- Describe the above principles in the CGMES 2.5
- And apply the option - 2) Do not apply any change on the cardinalities, but specify that required attribute of identifiedObject can be exchanged as null i.e. <IdentifiedObject.name>< IdentifiedObject.name >
- Add a note in the SSH profile that the optional attribute name is not used for classes marked with description stereotype

- **Agreement**
  - Keep the empty string as defined in the documentation
  - Ask IEC WG13 to delete name attribute where this is not needed. Possible approach is to require names for classes inheriting from PowerSystemResource.

6.10 Review of CGMES 2.5 documentation

- **Description**

The IOP participants reviewed the track changes applied in the documentation of the CGMES 2.5.

- **Agreement**
  - A few modifications were agreed and directly inserted in the document.
  - The diagram on dependencies needs to be fixed to include the following optional links: DL to TP, DL to DY, GL to EQ-BD and SV to TP-BD. This resolved issue (CGMES-115).

6.11 Issue CGMES-117 (PowerTransformer.isPartOfGeneratingUnit)

- **Description**

In CIM16 version, PowerTransformer has an attribute ‘isPartOfGeneratingUnit’ which indicates whether it is a station transformer or not. It is useful when calculating generator and transformer impedances as per IEC 60909 standard for Fault Analysis. However, such transformer has no association with corresponding station Generator/s. Some background on why the decision was made to not include this association while adding ‘isPartOfGeneratingUnit’ attribute to Transformer is needed?

- **Agreement**

The issue will be closed by adding the following note to the PowerTransformer “PowerTransformer.isPartOfGeneratingUnit is related to the IEC 60909. It has an impact on how the correction factors are calculated for transformers, since the transformer is not necessarily part of a generating unit, while a generator typically is. It is not always possible to derive this information from the model. This is why the attribute is necessary.".

6.12 Issues related to dynamics profile

- **Description**

The 61970-302 is now in commenting phase in IEC with deadline 29 July 2016. All changes that needs to be implemented as country comments should be reviewed.

- **Agreement**
    - xls table with constrains is accepted. It will be added to the country comments for 61970-302. It will be a leaving document. If implementation efforts find issues in the future the table will be updated.
    - A proposal for country comments for 61970-302 was reviewed
    - SVC dynamics – the UML and the profile is updated to be able to exchange user defined SVC models.
    - HVDCdynamics - the UML and the profile is updated to be able to exchange user defined SVC models. Proposed standard models will be kept in Inf package for future development. Vendors will review these including the documentation by Sep 2016.
    - Modify the descriptions of the following attributes to change units from m to km and correct the typical value:
        - GovHydroFrancis.h1, h2, hn, zsfc
        - GovHydroPelton.h1, h2, hn, zsfc
    - A number of changes were agreed and documented as country comments to 61970-302.

6.13 Support for IEC 61970-552 Ed2

- **Description**

61970-552 ed2 will be used for all the new profiles in CGMES 2.5. First conclusion for part 2 of the new profiles, we only allow urn:uuid types. The proposal is to use one RDFID format for all profiles. The proposal is to use only one type of RDFID format during the serialisation. The tools can either select which type of serialisation needs to be applied during the export

Some vendors do not make use of serialization routines but have implemented parsers, which make it time consuming to implement changes in the code.

There is a question why WG13 did 552 ed.2? the reason was - improvements were made with regard to clarity of specs written in previous documents.

CGMES 2.5 should be able make use of RDFID format described in ed1 and ed2 of the 61970-552.

Some TSOs need a long time to implement new versions. Reaction ENTSO-E TSOs rely on CGMES version 2.5 for the business processes they need to implement.

- **Agreement**
    - Use of IEC 61970-552 Ed2 for all profiles that are created in CGMES 2.5
        - rdf:ID is replaced with rdf:about "urn:uuid:"+mRID;
        - rdf:about that refers to rdf:ID shall also be replaced with rdf:about "urn:uuid:"+mRID reference.
    - The existing profiles from CGMES 2.4 could be serialised using IEC 61970-552 Ed1 for processes that needs backwards compatibility. However, for conformity it is allowed that a system only can serialise using IEC 61970-552 Ed2. A CGMES 2.4 importer can also support IEC 61970-552 Ed2.
    - If a file is imported as IEC 61970-552 Ed1 with rdf:ID, and then exported according to IEC 61970-552 Ed2, the application needs to use rdf:about "urn:uuid:"+mRID if it is an UUID. If it not an UUID it should be left as is.
    - The preferred serialization for CGMES 2.5 is IEC 61970-552 Ed2.

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6.14 Issue CGMES-169 - GeneratingUnit.startupTime

- **Description**

In order to address the requirement "TSOs shall provide the redispatch potential in both directions for generators that can be started within two hours for the D-1 scenarios" there is a need to add GeneratingUnit.startupTime to the EQ and SSH profile.

- **Agreement**

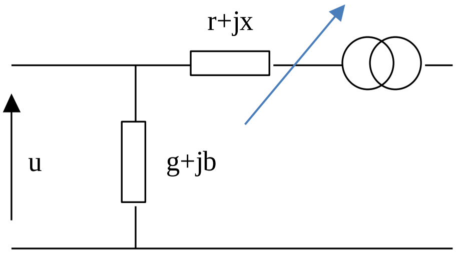
Need to add GeneratingUnit.startupTime to the EQ only.

6.15 Transformer issues – CGMES-146, 148, 157, 158, 170

- **Description**
  - The equations for symmetrical and asymmetrical PST included in the ENTSOE_CGMES_v2.4_28May2014_PSTmodelling.pdf could be optimized. These equations are also included in the CENELEC technical specification and in edition 6 of the 61970-301.
  - There is a problem with the sign of the WindingConnection Angle and its interpretation. What is the difference between +60 and -120 (+30 and -150,.+90and -90) or -60 and +120. There is a strong need to precisely describe those otherwise we won't get interoperability at all.
  - Is it allowed for the value of the field voltageStepIncrement of the object PhaseTapChangerNonLinear to be negative?
  - Is it allowed to have negative values for parameters of transformers and perhaps lines in case these are not equivalents? How this is to be validated?
  - May a RatioTapChanger have a negative StepVoltage Increment?
  - What is the correct interpretation of the B,G parameters of the PowerTransformerEnd model in CGMES?
- **Agreement**

Add the following notes to the CGMES 2.5 documentation:

  - Angle sign convention: Positive value indicates a positive phase shift from the winding where the tap is located to the other winding (for a two-winding transformer).
  - RatioTapChanger.stepVoltageIncrement: Both positive and negative values are allowed.
  - PhaseTapChangerNonLinear.voltageStepIncrement: Both positive and negative values are allowed.
  - PhaseTapChangerAsymmetrical.windingConnectionAngle: Both positive and negative values are allowed.
  - The following note will be added to the PowerTransformerEnd and ACLineSegment:
    - "Negative reactance values are valid for transformers." - to be added to the PowerTransformerEnd
    - "Negative reactance values are not allowed for ACLineSegments. Instead it is recommended to model series compensators explicitly." - to be added to the ACLineSegment
  - Interpretation of parameters of PowerTransformerEnd



  - A two winding PowerTransformer has two PowerTransformerEnds. This gives the option to specify the impedance values for the equivalent pi-model completely at one end or split them between the two ends. The impedances shall be specified at the primary voltage side.
  - Left side is the “primary” (high voltage) voltage side.
- PowerTransformerEnd.x shall be consistent with PhaseTapChangerLinear.xMin and PhaseTapChangerNonLinear.xMin. In case of inconsistency, PowerTransformerEnd.x shall be used. PhaseTapChangerLinear.xMin and PhaseTapChangerNonLinear.xMin will be removed in future versions of CIM.

6.16 Issue CGMES-60 - RegulatingControl

- **Description**

IOP 2014 agreed to add the extensions (RegulatingControl.minAllowedTargetValue and RegulatingControl.maxAllowedTargetValue) as proposed in the CGMES v2.5.xx. Due to Network code requirement GEN5, which is "For a power Generating Module in Power Factor control mode, each TSO shall specify maximum and minimum power factor values".. The comment on the requirement is "Only if power factor control is set, e.g. at wind farms"

The following note was inserted to RegulatingControl in order to specify the usage of the attributes.
“RegulatingControl.minAllowedTargetValue and RegulatingControl.maxAllowedTargetValue are required for the following cases:
- For a power generating module operated in power factor control mode, each TSO shall specify maximum and minimum power factor values;
- Whenever it is necessary to have an off center target voltage for the tap changer regulator. For instance, due to long cables to off shore wind farms and the need to have a simpler setup at the off shore transformer platform, the voltage is controlled from land at the connection point for the off shore wind farm. Since there usually is a voltage rise along the cable, there is typical and overvoltage of up 3-4 kV compared to the on shore station. Thus in normal operation the tap changer on the on shore station is operated with a target set point, which is in the lower parts of the dead band.".

- **Agreement**

The following note should be added to the RegulatingControl:
RegulatingControl.minAllowedTargetValue and RegulatingControl.maxAllowedTargetValue are required for the following cases:
- For a power generating module operated in power factor control mode, each TSO shall specify maximum and minimum power factor values;
- Whenever it is necessary to have an off center target voltage for the tap changer regulator. For instance, due to long cables to off shore wind farms and the need to have a simpler setup at the off shore transformer platform, the voltage is controlled from land at the connection point for the off shore wind farm. Since there usually is a voltage rise along the cable, there is typical and overvoltage of up 3-4 kV compared to the on shore station. Thus in normal

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operation the tap changer on the on shore station is operated with a target set point, which is in the lower parts of the dead band.".

RegulatingControl.minAllowedTargetValue and RegulatingControl.maxAllowedTargetValue define the min and max allowed RegulatingControl.targetValues. RegulatingControl.minAllowedTargetValue and RegulatingControl.maxAllowedTargetValue are not related to RegulatingControl.targetDeadband and thus they are not treated as an alternative of the RegulatingControl.targetDeadband.

The RegulatingControl.minAllowedTargetValue and RegulatingControl.maxAllowedTargetValue values are needed due to limitations in the local substation controller. The RegulatingControl.targetDeadband is used to prevent the power flow from move the tap position in circles (hunting) that is to be used regardless of the RegulatingControl.minAllowedTargetValue and RegulatingControl.maxAllowedTargetValue values.

6.17 Issue CGMES-159 - HVDC

- **Description**

Are there any rules or expectations about transformers being in series with DC equipment? It seems our implementers expect and have seen only models with transformers in series with DC converters. This has to do with the converter angle limits being fairly narrow and transformers are normally needed to tap in order to control DC voltages. We would need to do a workaround in one of our systems if there are to be models with no transformers in series, though we certainly could do this if it is needed. What other implementations expect in this regard, and if it is worth discussion time?

- **Agreement**

For CSC HVDC the transformer must be modelled explicitly. The way to validate this is not resolved.
Add note to the CsConverter.

6.18 OperationalLimitSet.active in the EQ profile

- **Description**

N/A

- **Agreement**

The attribute should be in the SSH as required attribute.

6.19 Issue file header

- **Description**

CGMES 2.4 does not define clear rules related to the EQ profiles and file header content.

- **Agreement**

The CGMES 2.5 documentation should include the following rules:

  - The profile references in the file header specifies for which profiles' validation the instance file data is valid for.
  - The instance data file can contain data from multiple profiles (such as ShortCircuit or Operation) without being declared in the header profile references. However, the data belonging to non-declared profiles does not need to be imported and re-exported as the profiles are not defined in the file header. The user shall be informed if the data is not imported.
  - Modify the rule from "[R.4.5.1.5.] The cardinality of given classes/attributes/associations stereotyped with "Operation" or "ShortCircuit" shall be respected if the exchange requires the inclusion of "Operation" or "ShortCircuit"." To "[R.4.5.1.5.] The cardinality of given classes/attributes/associations stereotyped with "Operation" or "ShortCircuit" shall be respected if the exchange requires the inclusion of "Operation" or "ShortCircuit". The respective profile URI shall be declared in the file header.

If the profile URI is not included in the header all classes/attributes/associations part of the undeclared profile are considered optional."

6.20 Issue CGMES-119

- **Description**

CGMES states that the following attributes of EnergySource: "voltageMagnitude" and "voltageAngle" parameters should be interpreted as an "open circuit" voltage and not as a "closed circuit" voltage. Some vendors are on the opinion that a change of the meaning of those two parameters is necessary so that the voltage source uses the "voltageAngle" and "voltageMagnitude" parameters to control the voltage at the corresponding connected busbar (closed circuit voltage). This way is found much more logical and useful. Current description of internal voltage of energy source and open circuit angle (phase angle of the independent device while it is disconnected from the network?). Connecting such device to the network would result in results difficult to predict. On a mid/high voltage all devices are controlling voltage and angle on busbars.

- **Agreement**
    - EnergySource.activePower and EnergySource.reactivePower in the SSH are defining PQ generation. EnergySource.voltageAngle and EnergySource.voltageMagnitude are not exchanged in the EQ.
    - Add this in the CGMES 2.4.15 Implementation guide.
    - EnergySource.voltageAngle and EnergySource.voltageMagnitude are specified as voltage characteristics imposed on the node (at the Terminal).
    - EnergySource.voltageAngle and EnergySource.voltageMagnitude are moved to SSH.
    - The following use case needs to be documented.
        - This is understood such that a transmission high voltage solution exists and the consequences of that solution is studied on a connected distribution network. The voltages and angles from the solved transmission level solution is then used as input to the distribution network.
        - The solution from the transmission level may have used and equivalent of the distribution network so it is difficult to tell whether that transmission level solution is based on an open or closed circuit representation of the distribution network.

6.21 Issue CGMES-140

- **Description**

The CGMES should state if the association Terminal.TopologicalNode should be exported for non-retained Breakers in case of node-breaker model exchange. CGMES issue should be recorded. In addition, this leads to:

- an error in CIMdesk "The two Terminals of the Breaker are connected to the same node". CIMdesk behaviour should be checked when the CGMES is specified.
- A warning in CIMdesk "The two nodes that the Breaker are connected to are not in the same VoltageLevel".

- **Agreement**

Include the following in the documentation:

There are two different use cases related to the association Terminal.TopologicalNode:
- reduction away of the Switching details to create bus-branch style model intended for traditional planning only.
- keep the detailed model including the Switches and provide topology results also about the Switches.

- In cases of creation of a bus-branch model from a node-breaker model non-retained Switches are of no interest and their Terminal.TopologocalNode references shall not be included.
- If instead the model is intended to stay node-breaker it is of interest to know

- - ▪ if a Switch has been reduced away indicated by the two Switch Terminal.TopologocalNodes referring the same TopologicalNode.
    ▪ if an open Switch connect two different TopologicalNodes that is useful when studying the consequences of closing the switch.

    In this case Terminal.TopologocalNode shall be included for all Switches.
  - If the two sides of a Switch are connected to the same ConnectivityNode this should be considered an error.
  - A Switch with the two sides connected to the same TopologicalNode is valid and normal situation, if not retained.
  - A Switch connecting BusbarSections at different VoltageLevels is an error.

6.22 Changes related to Manifest, Frame, network Model Project, Study, Availability Plan

- **Description**

N/A

- **Agreement**
  - The DateTimeInterval compound in IEC61970/Base/Domain needs to be added to the DomainProfile and linked to all the attributes used in Availability Profile.
  - The following note is added to the DateTimeInterval:
    The note for the class DateTimeInterval shall be understood as: "Interval between two date and time points, where the interval include the start time but excludes end time, start <= interval defined < end."
    DateTimeInterval.start has the description: "Start date and time included in the in the defined interval."
    DateTimeInterval.end has the description: "End date and time where the interval is defined up to, but excluded.".
  - It was agreed to include Compound, including 0..n, in the serialization support as defined in IEC 61970-552 Ed2.
  - Add extension ModelSpecification.type of String with the description "The type of model that is specified, e.g. planning, operation etc. It could also include reference on the profiling version it supports, e.g. CGMES 2.5, CIM16 etc.". The attributes is included in the Manifest profile.
  - Rename AvailabilitySchedule.daytimeRestitutionDuration to AvailabilitySchedule.daytimeReinstatementDuration
  - Rename AvailabilitySchedule.eveningRestitutionDuration to AvailabilitySchedule. eveningReinstatementDuration
  - Rename AvailabilitySchedule.maxRestitutionDuration to AvailabilitySchedule. maxReinstatementDuration
  - Rename AvailabilitySchedule.weekendRestitutionDuration to AvailabilitySchedule. weekendReinstatementDuration
  - Change the association AvailabilitySchedule.AvailabilityPlan from [0..1] to [1..1] in the Availability Plan profile
  - Change the reverse association AvailablityPlan.AvailabilitySchedule from [0..n] to [1..n] in the Availability Plan profile
  - Change the association name between AvailabilitySchedule.Schedule and AvailabilitySchedule.DependentOnSchedule so that the cardinality and direction becomes correct. (notes needs to be swapped as well)
  - Change the association Manifest.ManifestSpecification to Manifest.Specification so that the naming as similar to the other classes in the package.
  - Change the association NetworkModelProject.ProjectSpecification to NetworkModelProject.Specification so that the naming as similar to the other classes in the package.

- Change the association name between NetworkModelProject.Project and NetworkModelProject.DependentOnProject so that the cardinality and direction becomes correct. (notes needs to be swapped as well)
- Change the association name between NetworkModelProject.ShadowProject and NetworkModelProject.SilhouetteProjectProject so that the cardinality and direction becomes correct. (notes needs to be swapped as well)
- Change NetworkModelSpecification.OutageSpecification to NetworkModelSpecification.AvailabilityPlan.
- Change PowerFlowOperation.algorithm from String to a new enumerator, PowerFlowAlgorithmKind, with the following types [fullNewtonRaphson; fixedSlopeNewtonRaphson; fastDecoupled; gaussSeidel; modifiedGaussSeidel, dcPowerFlow]
- Add attribute PowerFlowOperation.enableTransformerTapControl as Boolean with the following note "True means transformer tap adjustment is set to enabled."
- Add attribute PowerFlowOperation.enableSwitchShuntControl as Boolean with the following note "True means switched shunt adjustment is set to enabled"
- Add attribute PowerFlowOperation.enableStaticVarCompensatorControl as Boolean with the following note "True means switched shunt adjustment is set to enabled"
- Change the association AvailabilityPlan.ProjectSpecification to AvailabilityPlan.Specification
- Add attribute PowerFlowOperation.slackDistributionKind as new enumerator, SlackDistributionKind, [LoadDistribution, GenerationDistribution]
- Add attribute PowerFlowOperation.enableInterchangeControl as Boolean with the following note "True means area interchange control is enabled."
- Change PowerFlowOperation.tolerance to PowerFlowOperation.pTolerance as ActivePower with the following note "The active power tolerance for the given power flow solution."
- Add PowerFlowOperation.qTolerance ReactivePower with the following note "The reactive power tolerance for the given power flow solution."
- Add attribute PowerFlowOperation.voltageLimitAngle as «CIMDatatype» AngleDegrees with the following note "The maximum allowed voltage angle between two buses for the given power flow solution"
- A lot of the classes, attributes and associations are missing notes. It was agreed to add items that are missing notes before the release.
- It were agreed to add the following example to the test model:
  - Project that are linked with Availability plan.
  - Project that are linked between two TSO (MAS).
- DCSwitch is deleted from the Availability Plan profile and the association with AvailabilitySwitchAction.
- The association AvailabilitySwitchAction.Switch is changed from 0..1 to 1.
- AvailabilitySchedule.AvailabilityPlan should be 1 in the extension package. The proifle is already restricted.
- Add attribute AvailabilitySchedule.priority, integer. Description: 0 means ignore priority, 1 means the highest priority, 2 is the second highest priority.

6.23 Issue - OperationalLimitSet

- **Description**

N/A

- **Agreement**

The attribute OperationalLimitSet.active in the EQ profile should be in the SSH as required attribute.

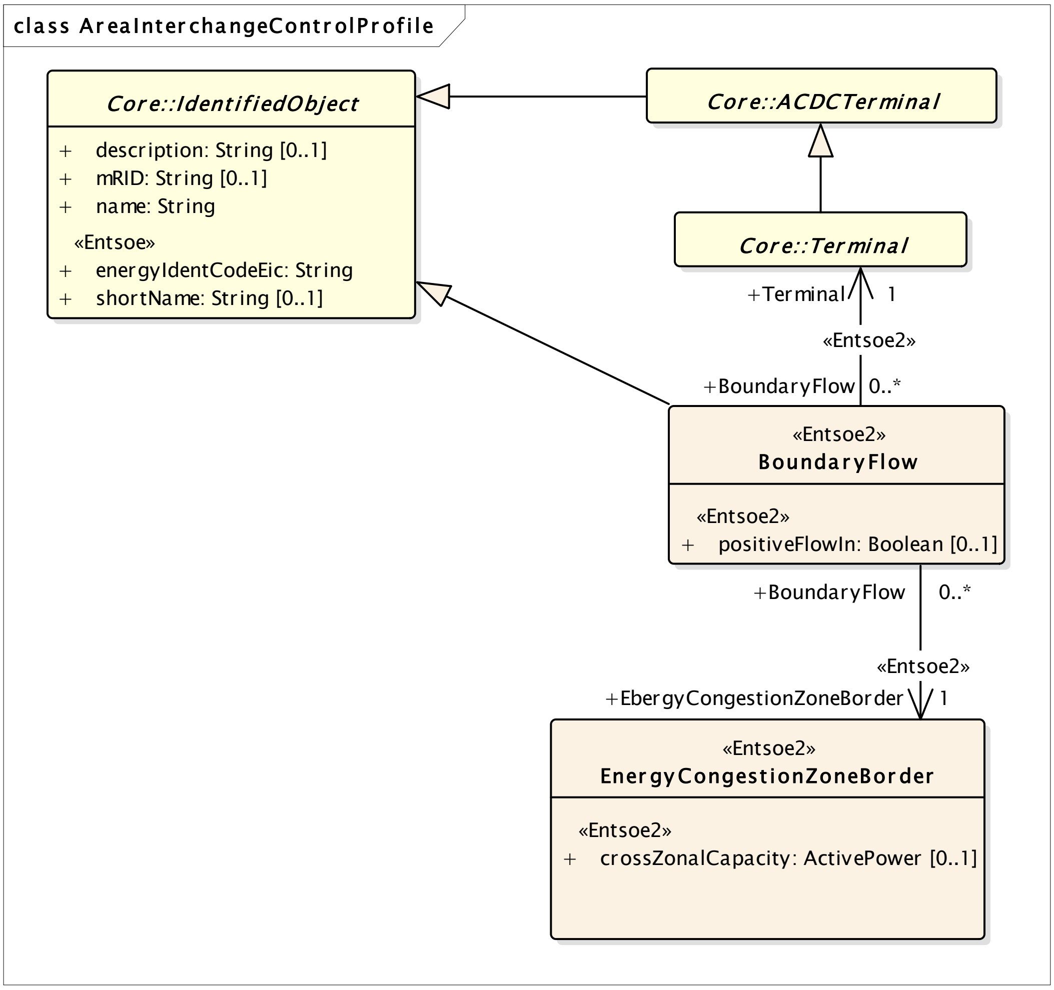
6.24 Discussion Area Interchange Control and Energy Area

- **Description**

Presentation was given by ENTSO-E mainly focussing on Area Interchange control and the EnergyArea extension in the UML.

  - The presentation and IEEE document describing the Area Interchange Control were uploaded to the folder: http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/Forms/AllItems.aspx?RootFolder=%2fGroups%2fENTSO%2dE%5fIOP%2f2016%2fShared%20Documents%2fReference%20Documents&FolderCTID=&SortField=Modified&SortDir=Asc&View=%7bCC9311C1%2d793D%2d463A%2d8760%2d698E03DBCF55%7d
    - Presentation http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/Reference%20Documents/DAY1_SPOC_TOP06%20CGMES%20related%20topics.pdf
    - Algorithm http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/Reference%20Documents/Improved%20Area%20Interchange%20Control%20for%20Newton%27s%20Method%20Load%20Flows.pdf
  - Some vendors already have implemented the principles of Area Interchange control in their tools; some have not yet implemented this type of functionality.
  - It was pointed out that there is a need for having both generation slack (part of the D-2 process) and load slack (D-1) in the Area Interchange control.
  - Some vendors raised the question that additional documentation is needed on the proposed extension in the UML. This request is being acknowledged by ENTSO-E, there will be additional context given in the description field of the UML, however precise process descriptions cannot be given at this stage.
- **Agreement**
  - EnergyGroup.p and BlockDispatchorder.p should follow load convention were production is tagged as negative and consumption is positive.
  - The need of having a separate profile for exchanging the Energy Area (or setup of the power flow) was discussed. It was agreed to use EQ and SSH for the items related to given MAS and use the new profile AreaInterchangeControl (AIC) for the control setting that may in some cases be outside a given MAS control.
  - It was discussed if AIC profile need to reflect both the definition of the area that should be controlled and another for the set points. Since this is a very small profile content, it was decided to keep it as one profile.
  - The minimum requirement for the EnergyArea is that it should handle the same use cases as the current Load Model distribution, but also include generation.
  - The IOP recommended to get more example on the use of the model in regards to the different processes, D-2, D-1 and ID (intra-day). One of the items to clarify is the use of isSlack in particularly regards to the area interchange tolerance. This will be done when CGMES 2.5 is approved.
  - Add attribute EnergyGroup.normalP as ActivePower – Normal active power for the energy group. The attribute is part of the EQ profile.
  - Change ProportionalDistributionComponent.distributionFactor of type Float to ActivePower so that the representation are clearly defined. The factor is given by the distributionFactor as ActivePower (MW) over EnergyGroup.normalP in ActivePower. The attribute ProportionalDistributionComponent.distributionFactor is moved to SSH.
  - Add ProportionalDistributionComponent.normalDistributionFactor as ActivePower optional field in EQ.
  - Move EnergyGroup.isSlack to the SSH profile and make it mandatory, so that is can change between time interval.

- Add EnergyGroup.isNormalSlack as Boolean optional attribute in EQ.
- Move BlockDispatchOrder.p from SSH to EQ
- Change EnergyGroup.p from Mandatory to optional [1..1] to [0..1].
- The possibility to connect the following classes to the SeasonDayType pattern was discussed: EnergyGroup, ProportionalDistributionComponent and BlockDispatchInstruction. It was decided to wait with this until CIM is updated with improved SeasonDay pattern that will work for operational and long-term planning.
- Change SchedulingArea to EnergySchedulingArea to achieve consistency with IEC CIM 17.
- Move the EnergyGroup.BlockDisptachInstruction from EnergyGroup to EnergySchedulingArea.
- Add an additional association between EnergySchedulingArea.BlockDispatchInstruction to indicate the active BlockDispatchInsruction. This association should be in SSH.
- Additional documentation and information is requested by vendors that support the modelling decisions that have been made in the UML extensions
- Adding ControlArea in the AIC profile was discussed, but agreed to leave it in EQ for backward compatibility.
- BlockDisparchInstruction.BlockDispatchOrder is changed from 0..* to 1..*
- Add new class: BoundaryFlow between EnergyCongestionZoneBorder and Terminal.



6.25 Market Schedule Profile

- **Description**

Market Schedule Profile - IEC 62325-451-2 Scheduling business process and contextual model for CIM European market:

  - ENTSO-E presented the existing standard that needs to be purchased from IEC, https://webstore.iec.ch/publication/6843
  - ENTSO-E presented the XSD that is uploaded into folder: http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/Forms/AllItems.aspx?RootFolder=%2fGroups%2fENTSO%2dE%5fIOP%2f2016%2fShared%20Documents%2fXSD%5fMarket&FolderCTID=&SortField=Modified&SortDir=Asc&View=%7bCC9311C1%2d793D%2d463A%2d8760%2d698E03DBCF55%7d

Alternative 0: PT CGM WP-2 does not provide any guidance or recommendation. Leave this up to individual agreement between TSOs and vendors.
Alternative 1: PT CGM WP-2 recommend the use of IEC 62325-451-2 Schedule. Sub alternative would be if we should include it in IOP. This is developed by CIM for Market and European Market.
Alternative 2: Developed a CIM/XML based format that include this information.

The production units in the market does not always map one-to-one with the units defined in the operation, CGM.
Alternative 1 is the one to start with.

- **Agreement**

The IOP recommended that ENTSO-E provide guidelines and example on how to use IEC 62325-451-2 together with CGMES 2.5 to generate the necessary IGM for the CGM process.

6.26 Discussion on Power Transfer Corridor, SIPS, Contingency model and remedial actions

- **Description**

The presentation is added to the IOP SharePoint under Reference Document: http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/Reference%20Documents/20160714_CGMES_IOP_SIPS.pdf
The challenge with creating a SIPS model that would work for long-term planning using bus-branch, operational planning using node-breaker and operation using real-time measurement was discussed.

- **Agreement**
  - Add a note to CircuitShare: CircuitShare.contributionFactor is only informative for the user. The system should use contingency analysis to calculate the real contribution based on the available network model if needed for other calculation.
  - It was pointed out that the SIPS allows for sharing of Protective Actions among different triggering conditions.
  - The IOP agreement that SIPS should, when possible, have multiple trigger condition and/or Protective Action that would make it work in all different environments. However, it was agreed to exclude classes and reference to measurement in the profile CGMES 2.5.
  - If a generator is taken out by disconnecting switch it should be also be a protective action that take generator out of service, i.e. Equipment.inService = false.
  - It was discussed if there is a need to create a ProtectiveActionTerminal that are instructing the terminal connected. This could save the need for duplicating Protective Action between node-breaker and bus-branch. Since TSO business processes are moving in the direction of node-breaker it was decided to not add this class.

- Decided to keep inService flag as this allows simply changing matrices during the calculations instead of having to running topology processes during contingency analysis.
- The current Gate logic model is not necessary well suited for future SIPS configuration that is using more programmable logic rather than just gate logic. WG13 together with ENTSO-E will be looking into the possibility to support PLC language or other logic description languages. Linked to IEC 61850 could also be relevant. If possible it would be good to have the same "code" in the control centre" as used in the field. IOP recommendation is that vendors are looking at PLC language or other scripting languages that could replace the CIM UML based exchange.
- It was agreed to make the following changes to SIPS:
  - Add Entsoe2 extension ProtectiveActionAdjustement.value as Float with the following note "The value that should be used for adjustment. The type is defined by kind attribute. byPrecentage means the value new value = existing value * attribute value, for 10% reduction the value would be 90, for a 15% increase the attribute value would be 115.
  - The following existing attribute be taken out of the profile:
    - ⇨ ProtectiveActionAdjustement.byPrecentage
    - ⇨ ProtectiveActionAdjustement.byValue
    - ⇨ ProtectiveActionAdjustement.setValue
  - The enumerator is kept unchanged even if it includes the Measurement value that is not supported in the profile.
- It was discussed if there is any need to add DCCondutionEquipment as ProtectiveActionEquipment. It was decided not to add it. It can be added later, if needed.
- It was discussed how Circuit and PowerTransferCorridor that are shared between TSOs (or MAS) should be handled. IOP agreed to add the following to the BoundaryEquipmentProfile:
  - LineCircuit
  - PowerTransferCorridor
  - There is no need to add any attributes or associations to them.
- IOP agreed to add a new element in the LimitTypeKind enumerator called Stability
- The need to be able to model preventive remedial action using the SIPS model was discussed. One proposal was to just add a flag on RemedialActionScheme to state that these were preventive remedial actions. However, these are changes that do not have any triggering. They are actions that are valid for a given time. They cannot be exchanged in the EQ. So it was discussed to add a new profile. This will need to be done in an upcoming profile version. It will however, be investigated the possibility to use project and study from the Manifest profile to achieve the same.
- IOP agreed to do the following changes in the Circuit model to make it more in-line with CIM17 model of Feeder :
  - Add association Circuit.Identifier to Terminal [0..1] and the reverse Terminal.TerminalCircuit [0..1]. The direction should be from Circuit to Terminal.
  - Remove association between PowerTransformerEnd to PowerTransformerCircuit
  - Remove association Circuit.Identifier to Equipment
- CDPSM tests were performed during the IOP 2016 and were presented
  - IOP discussed if ENTSO-E should make changes to the StateVariableProfile to accommodate the needs from CDPSM. It was decided not to make any changes.
- ENTSO-E asked vendors if they would like ENTSO-E to follow up with support for CDPSM as part of IOP and Conformity. Vendors stated that this is of interest as long as it is possible to separate the need for conformity between CGMES (Transmission's need) and CDPSM (Distribution needs). Everyone agreed that it would be really good to have systems that support both.
- Contingency profile (issue CGMES-175) – It is agreed to add IdentifiedObject.description in the contingency profile as optional attribute.

- Rename DifferentialModel to DifferenceModel
- Change FrameworkIdentifiedObject.modelAuthority from optional [0..1] to mandatory [1..1]

6.27 Issue related to limits discussion

- **Description**

There is a need to add the classes Sensor (and its specialisations), Wavetrap, SurgeArrestor and FaultIndicator to the CGMES 2.5 Equipment profile since they have limits which may affect the transfer capacity of a branch. This is a real use case currently at TenneT TSO.

- **Agreement**

Add in the EQ profile the following classes that are under AuxiliaryEquipment in the 61970: AuxiliaryEquipment, Sensor, CurrentTransformer, WaveTrap. The association AuxiliaryEquipment.Terminal should be added as well.

6.28 Issue CGMES-80

- **Description**

Detailed explanation of the proposal for extension is available here: http://cimug.ucaiug.org/Groups/ENTSO-E_IOP/2016/Shared%20Documents/IssueList/Issue_80_TERNA%20HVDC%20MODELS%20FOR%20CGMES%20EXTENSION_v5.docx .

- **Agreement**
    - Converter reactive power consumption related extension: It needs more discussion and eventually a formula could be included in order to also match with the concept that will be used for dynamics. The issue is postponed to CGMES 2.6.
    - Filters: The issue is postponed to CGMES 2.6. It is advised that ACDCConverterShuntCompensator is associated with LinearShuntCompensator instead of ShuntCompensator
    - The upgrade of the HVDC model should include the connection between converter transformers and DC systems and allow transformers to control DC voltage and firing angle.

6.29 Issue CGMES-171

- **Description**

The PerLengthDCLineParameter are not consistent with the parameter of the DCLineSegment in Ohm in respect to its line length. There is no rule on which parameters would have priority in case of inconsistency. Furthermore, the PerLengthDCLineParameter as well as both version of the impedances are optional, which means that you might end up with two worst case scenarios:

1. Having no impedances at all
2. Having both impedance versions which are inconsistent.

There is a need to agree on two rules:

1. Even though both impedances are optional, there should be a rule which forces at least one version
2. In case of inconsistencies, which parameters should have higher priority.

- **Agreement**
    - Make DCLineSegment.capacitance, DCLineSegment.inductance and DCLineSegment.resistance required attributes.
    - Add a note: PerLengthDCLineParameter is optional. The calculations are based on the data in DCLineSegment.

6.30 Issue CGMES-172

- **Description**

There are some issues related to the usage of the class 'Curve':

  - xUnit, y1Unit and y2Unit type is 'UnitSymbol': is it possible to specify also the UnitMultiplier? For example, Reactive Capability curve parameters use W and VAr as UnitSymbol but the values are entered as MW and MVAr and this is a bit confusing for me,
  - Is it possible to add in the 'UnitSymbol' enumeration also 'per unit' and 'percentage' ?.

- **Agreement**
  - UnitMultiplier is not exchanged. It is defined that the multiplier is:
    - M for W, VA, VAh, Wh, VArh and Var
    - k for volt
    - 1 for all the rest of UnitSymbol values.

6.31 Issue – DC switching devices

- **Description**

There is no „open" parameter for any DC switching devices (DCSwitch, DCBreaker, DCDisconnector). This kind of makes them unusefull, since they do not really have any kind of meaning. If there is no specific reason they have been modelled like that, it is needed to add the parameter in the CGMES 2.5.

- **Agreement**

It will be considered for future versions of the CGMES that would support DC grid. Perhaps DCSwitch.open should be added in the SSH and DCSwitch.normalOpen in the EQ.
DCSwitch should be ignored if included in the instance data.

6.32 Issue CGMES-160

- **Description**

The main issue is the difference between exchanging a solved state, which we don't need to change, and exchanging a model to be used for studies with significant changes in power flow conditions after exchange. A solved state can always be manipulated to fit CGMES allowed regulating control schemes with only one active regulating control bus and the rest of the controlling element locked at its current position based on station control distribution. However, this control will only be valid for this solved state and not for other power flow situations – which is insufficient for studies on our system.

The idea of a common target value requires rules for MVAr distribution on different components. If we used voltage control, SVCs and generators will take priority over tap changer controlled/switched elements like capacitor banks and shunt reactors. Dynamic reactive reserves will then be used first, static reactive reserve will first be used after dynamic reserves are fully utilized. This is the wrong way around, and will lead to erroneous capacity limits for us.

At least some additional priority between multiple control elements must be added if control of a component MVAr isn't allowed.

- **Agreement**
  - Rename PowerFlowOperation.enableStaticVarCompensatorControl to PowerFlowOperation.staticVarCompensatorControlPriority, type Integer. Description: 0 means not used, 1 means highest priority.
  - Rename PowerFlowOperation.enableSwitchShuntControl to PowerFlowOperation.switchShuntControlPriority, type Integer. Description: 0 means not used, 1 means highest priority.

- Rename PowerFlowOperation.enableTransformerTapControl to PowerFlowOperation. transformerTapControlPriority, type Integer. Description: 0 means not used, 1 means highest priority.
- Rename PowerFlowOperation.varLimit to PowerFlowOperation.respectQlimits. type Boolean, Description: True means that VAr limits are respected during power flow calculation.

6.33 Issue CGMES-165

- **Description**

There is inconsistence between OCL rules and notes.

- **Agreement**
    - The OCL rules need to be developed on the basis of the note attached to the DCConverterUnit
    - The OCL script on the ConductingEquipment should be updated to exclude PowerTransformer. The updated rule is the following:

```
inv conductingEquipmentVoltage: (
(
        (self.oclIsKindOf(PowerTransformer))
) or
(
        (self.BaseVoltage =null) and
        (self.EquipmentContainer <> null) and
        (self.EquipmentContainer.oclIsKindOf(VoltageLevel))
) or
(
        (self.BaseVoltage <>null) and
        (
                (self.EquipmentContainer = null) or
                (
                        (self.EquipmentContainer <> null) and
                        (self.EquipmentContainer.oclIsKindOf(VoltageLevel)) and
                        (self.EquipmentContainer.oclAsType(VoltageLevel).BaseVoltage =
self.BaseVoltage)
                ) or
                (
                        (self.EquipmentContainer <> null) and
                        (not self.EquipmentContainer.oclIsKindOf(VoltageLevel))
                )
        )
)
)
```

- It is confirmed that the OCL rule on the EquivalentBranch is correct. It is possible to have only 2 Terminals.

6.34 Issue zip

- **Description**

N/A

- **Agreement**

- CGMES rule should be added to CGMES 2.5: In the future applications shall support cimx file extension, which is a zip file.

6.35 Issue CGMES-166

- **Description**

There is a need to define clear rules for sign convention of attributes in SSH, SV and EQ profiles.

- **Agreement**
  - Load sign convention for SSH and SV is used for attributes where the sign convention is not specified. For reactive power (e.g. on RotatingMachine, StaticVarCompensator, etc.) positive means inductive.
  - For EQ ratings the equipment is used as a reference rather than the node.

6.36 Issues CGMES-173 and CGMES-174

- **Description**

The grounding model is changes in CGMES 2.4. Ground and GroundDisconnector are new classes. GroundDisconnector is now a two terminal device. There is a need to clarify how grounding should be modelled using CGMES 2.4 in regards to BaseVoltage, VoltageLevel, GroundDisconnector and Ground.
Relevant questions are: Should we have one or more BaseVoltage for Ground? Should grounding equipment be located in a "ground" VoltageLevel or be spread in relevant Bay?.

- **Agreement**

Add the following CGMES rule:

  - CGMES rule: There shall not be any ground voltage level. The ConnectivityNode connected to the Ground instance belongs to the same containment instance as the grounding device. This means that the Ground instances are contained in the same voltage level where other switching devices are contained with a non-zero BaseVoltage.

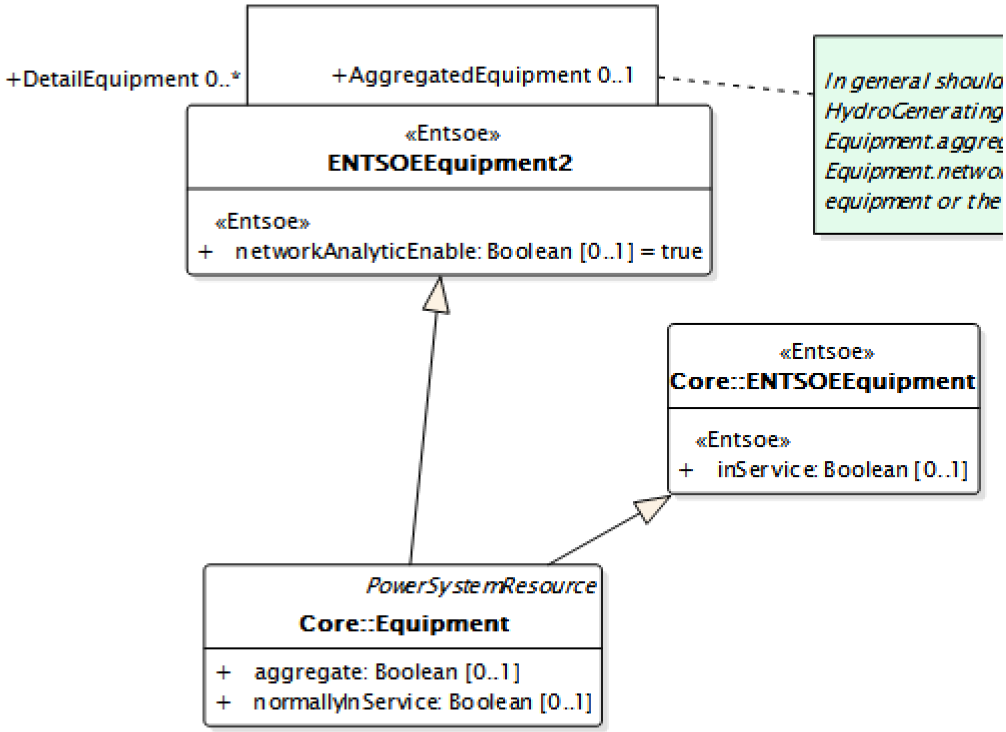
6.37 Issue CGMES-8

- **Description**

In some TSOs, planning and operation models have different detailing on the equipment. In principle, are all the generators in operation "real" generators (not an aggregation of underlying production). However, that is not always the case. Particularly with small embedded generators, Distributed Energy Resource (DER) is very difficult to get a model without using equivalent aggregates. In some cases, the dynamic and short-circuit data are only available on the aggregated units.
It is suggested to add an association from Equipment to Equipment with the following note: "Only Unit of the same type, e.g. HydroGeneratingUnit, can be aggregated to the same type where Equipment.aggregate = true. Equipment.networkAnalysisEnable can only be true on the aggregated equipment or the detail equipment."
WG13 has agreed to add Equipment.networkAnalysisEnable to CIM17.
This will only affect the EQ profile.

- **Proposal**:

See InfoCore in the UML. Check also the descriptions of the attributes/classes



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- **Agreement**
  - The issue is postponed for future versions of CGMES. The use cases need to be described.

6.38 Issue CGMES-145

- **Description**

Related to the CGMES GL profile - xPosition, yPosition and zPosition attributes in the Position class are defined as string types. Shouldn't these be floats? If they are floats, then the US numbering system must be enforced. If they are strings, then import software must determine if decimals or commas are used in the number. For that matter, there is no limitation to what alpha/numeric string is put into the attribute..

- **Agreement**

Add a note to PositionPoint in the GL: The attributes xPosition, yPosition and zPosition are treated as float and follow regional settings. Decimal degrees are used.

6.39 Issue stereotypes in SSH

- **Description**

There are wrong stereotypes in the SSH.

- **Agreement**
  - Remove Operation and ShortCircuit from GroundDisconnector
  - Remove Operation from StationSupply.

7 Appendix B: Framework for model exchange – use cases and requirements – for information (2014)

7.1 Context

7.1.1 Introduction

This document was originally created within the scope of the ENTSO-E PROFI project but will become an extension to CGMES (probably version 2.5) from ENTSO-E as well as becoming an IEC standard. It will also make reference to other documents in progress, e.g. a glossary.
Network Code Operational Security Article 17 states that TSOs shall exchange network model (structural) data and Article 19 states that TSOs and DSOs shall exchange power grid model (structural) data.
This document addresses these requirements by specifying how network models that represent a partial power networks are described and how the partial network models fit together to form composite network model that represent a larger network. The standard also specifies how boundaries for the partial networks are described and how partial network models are merged to form larger models suitable for network applications.
The purpose of describing network parts like this is to enable automated processes for exchange and merger of these parts into complete network models that can be used in network calculations.
The description of the equipment and components within network model as well as the power system state are not described in this standard but in other specifications as CGMES from ENTSO-E and IEC 61970-452, IEC 61970-456 from IEC.
The resulting standards, Framework for Model exchange FRM, consist of an extension of the canonical CIM model as well as a profile derived from it. The exact document structure is yet to be decided.

7.1.2 Requirements

The need to operate the power system closer to its limits is increasing and as a consequence system security needs to be evaluated more frequently. As a result system operators need for accurate network models and power system state data are increasing. System operators also need to consider the neighbouring power grids to a larger extent than before. Hence the exchange of network models and power system states are increasing both in terms of size of the exchanged power grid models and exchange frequency.
Network models for operational planning and operations have traditionally been managed by separate organizations within a system operator. As a result two different models of the same network have been managed in parallel which is a source of errors and extra work. To avoid redundancy it is expected that the same network model will be used for both operation and planning.
Planning models has traditionally been bus-branch and operational models node-breaker. CIM support both, hence using the CIM as basis enables mixing bus-branch and node-breaker models.
Increasing and more frequent network model exchanges require tracking and identification of the exchanged data.
In addition to model their own network a TSO or DSO also model their neighbours networks. This create duplicate work where a network is modelled multiple times for each TSO/DSO. The duplication also introduce errors and inaccurate or outdated representations of networks. By sharing a model once created by its responsible TSO/DSO with other TSOs/DSOs will reduce duplicate work and improve data quality.

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7.2 Scope

This standard specify how regional or partial network models are described and how they fit together to form a larger composite models that is used in network related calculations.
This specification is intended to support network model exchange use cases including but not limited to

- Congestion forecast processes (IDCF, DACF…)
- Capacity allocation process (2DCA…)
- Outage planning coordination
- Creation and maintenance of operational models across TSOs/DSOs
- Consolidation of power system projects in base models
- Long term extension planning (TYNDP projects)
- Exchange of grid study cases

The purpose of the data models provided by the Framework for Model exchange FRM standard is to describe

- the actor/organization roles responsible for a power grid model that is an elaboration on the existing CIM ModelingAuthority concept.
- the power networks that is related to the existing CIM ModelingAuthoritySet concept.
- audit trails needed to track the power grids that build up a composite power gird model.
- the work flows used to assemble composite power gird model from regional power grid models.
- how ModelingAuthoritySet data is used as input to functions that process the data, e.g. merge of power grids, running power flow etc.

Not covered by this profile is the description of power networks themselves. Data models for this already exist and are

- equipment data and basic topology is described in the in the CGMES equipment EQ profile as well as IEC 61970-452.
- power flow initial conditions is described in the CGMES steady state hypothesis SSH profile and IEC 61970-456.
- power flow resulting topology is described in CGMES topology TP profile and IEC 61970-456.
- power flow results described in the CGMES state variables SV profiles and IEC 61970-456.
- display layout described in the CGMES display layout DL profile and IEC 61970-453
- dynamic data described in the CGMES dynamic data DY profile and IEC 61970-457

Data according to these standards as well as this standard appear as CIM Dataset documents. CIM Datasets can have different formats, a commonly used format both for the ENTSO-E CGMES and the above IEC standards is CIMXML described in IEC 61970-552.
The header in IEC 61970-552 has a reference to the CIM ModelingAuthoritySet that identifies the model data in a CIMXML document. As stated above the CIM ModelingAuthoritySet is elaborated in this specification to distinguish the different types of network models.

7.3 Use cases

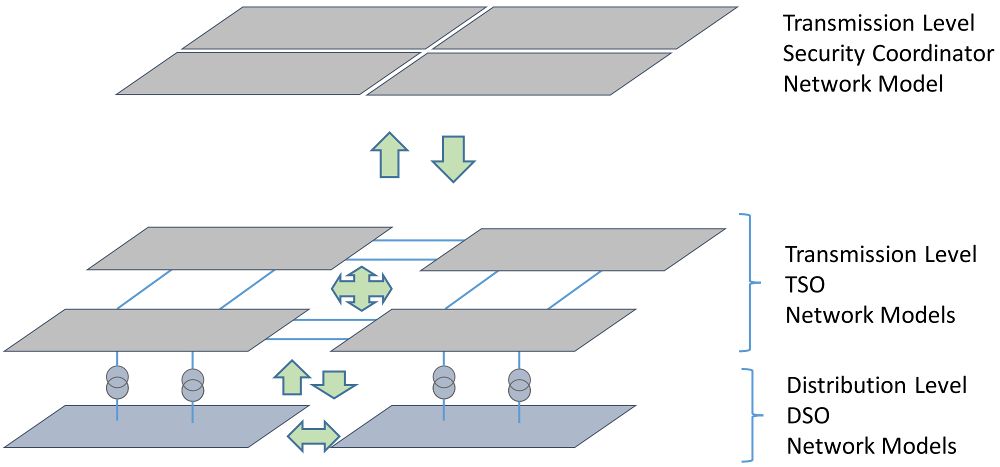
7.3.1 Actors

Large interconnected power grids typically span over continents covering many different countries, states or regions. To monitor and control the power grid, system operators have evolved e.g.

- Distribution System Owner (DSO)
- Transmission System Owner (TSO)
- Regional Transmission System Owner (RTO)

- Independent Transmission System Owner (ISO)
- Security Coordinator (SCI)
- ENTSO-E

A system operator (SO) is typically responsible for the power grid in a country, state or region, these are PowerGridRegions.
In large power grids, system operators have the responsibility for a part of the power grid. To avoid duplication of work and increase quality of data the system operators share their data with each other and exchange power grid models.
Larger consumers or producers connected to a network may also have to exchange data with the system operators.



Arrows indicate model (EQ profile) exchanges between actors

- TSO <-> Security Coordinator
- TSO <-> TSO
- DSO <-> TSO
- DSO <-> DSO

Figure 1 Overview on Actors and Their Data Exchange

In Figure 1 The TSOs and DSOs may share the grid models with each other. The TSOs will also make their network models available to a Security Coordinator that builds a complete model for a larger region.

7.3.2 Network Model Framework Parts

7.3.2.1 Network Regions And Boundaries

Figure 2 shows an example with four TSOs and two DSOs used to explain how their network is divided into parts.

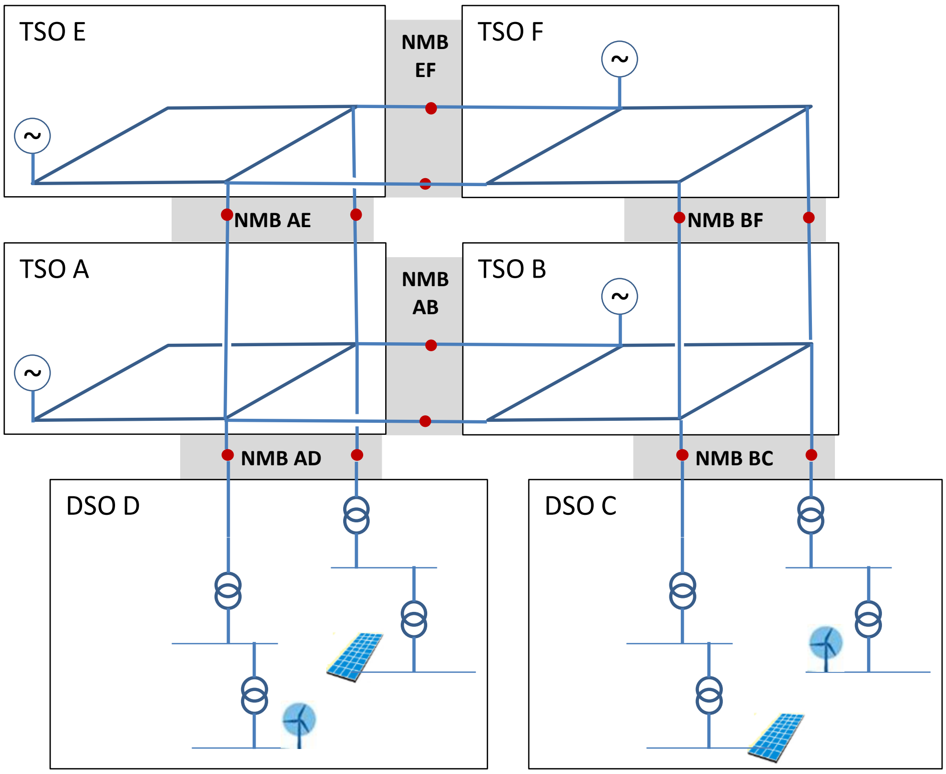


Figure 2 network model example

Power networks operated by system operators TSO A, TSO B, TSO E, TSO F, DSO C and DSO D are connected with tie lines and transformers. Each of the networks are described by a region indicated with frames in Figure 2.
The tie lines between the TSOs have one boundary point each. They are red in Figure 2 and are also called x-nodes. The grey shaded areas where the boundary points are located are boundaries. Note that a boundary appear between two parties and hence are bilateral.
TSO A is connected through transformers to a distribution network run by DSO D and TSO B is connected through other transformers to a distribution network run by DSO C. Both DSOs have both wind and solar power. The distribution networks are also regional networks. The boundary between the TSOs and the DSOs are also defined by boundary points at the transformers, red in Figure 2.
In CIM the boundary points correspond to ConnectivityNodes. Figure 3 shows a more detailed example of a boundary with CIM objects.

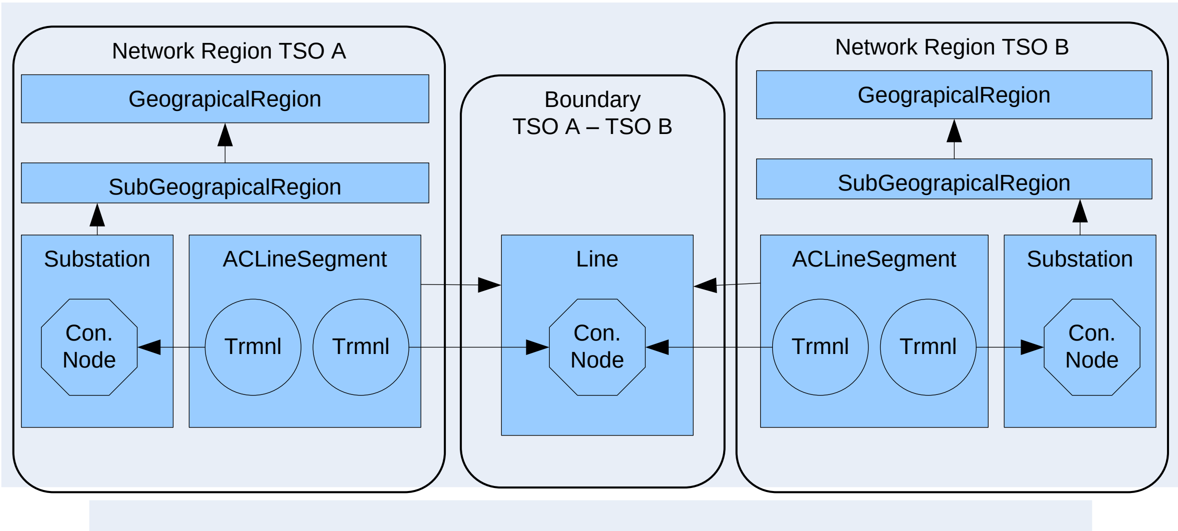


Figure 3 Detailed CIM data diagram for the tie line between tso a and tso b

The cim:ConnetivityNodes at the tie lines are contained by cim:Lines while the cim:ConnetivityNodes at transformers are contained by cim:Substations. The cim:Lines and cim:Substations are in the boundary. Note that the tie line cim:ACLineSegments is contained by the cim:Line in the boundary but is defined within the scope of the TSO network regions.

Also note that the references from the TSO A and TSO B network regions points into the boundary. Hence they will be “dangling” until merged with the boundary. There are two use cases that manages this differently

- The boundaries are already implemented demarcating an existing network model region.
- The boundaries are not implemented and need to be imported.

A TSO that models its own network will do so way before any boundaries has been defined. Hence the TSO will have a description of the boundary and it will be used in the negotiation on what the explicit boundary description will look like. Once the boundary is defined the TSOs will have to adjust their boundary models to fit with the agreed boundary definition. After this a TSO may decide to replace its own built model for the external networks outside the boundary with models imported from the neighbouring TSOs or DSOs. Note that the boundary definition in this case will not be imported.

A TSO or security coordinator that want to import models separated by boundaries they don’t already have implemented will import also the boundary definitions.

7.3.2.2 Network Edges

In the ENTSO-E congestion forecast processes (IDCF, DACF, D2CF…) the TSO that solve the congestion forecast will use scheduled power flow exchange values at the boundaries. This means that network regions need an injection at the boundary points holding the scheduled power flow exchange values.

A network edge describe an equivalent injection that act as a replacement of a network region at a specific boundary. The network model in Figure 4 is used in the regional congestion forecast done by TSO A.

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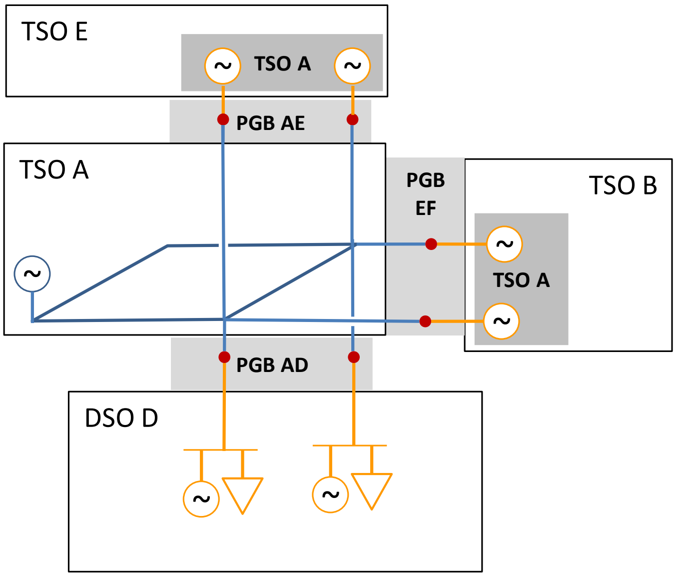

Figure 4 Example where TSO A has replaced TSO B and TSO E with Network Edges

By separating the network edge from the network boundary better modularity is achieved and gives the flexibility to combine and evaluate network models of different types.

7.3.2.3 Network Equivalents

A complete network model is composed by merging network model parts, e.g. regions, boundaries and edges. The resulting model may be larger than needed by a system operator (SO), Security Coordinator, ENTSO-E or other party. Hence there may be a need to remove parts of the network. The removed parts can be replaced by an equivalent derived in different ways

- The simplest is an edge as described in section 7.3.2.2.
- The equivalent can be handmade according to some heuristic method.
- The equivalent can be created by a network reduction program.

An edge works well for grids that spread radially e.g. a distribution grid or the first congestion forecast step where boundary exchanges are kept constant.

A meshed network surrounding a regional network may not be suitable for the simple edge. Instead a system operator (SO) will have to decide on the remote network parts to replace. This include the steps

- identify the boundaries where to place the equivalent.
- decide how to create the equivalent, e.g. heuristically or by network reduction.
- replace the equipment at the far side of the boundary with the equivalent.

It may be the case that multiple equivalents are needed at the boundary due to changing conditions, e.g. winter and summer.

When TSO A from Figure 2 plans and operates its network it needs to model the whole TSO B and DSO D power grids. TSO A also want to model bigger wind parks and solar plants in the DSO C power grid and does that by replacing the DSO C power grid with a load and generating unit at the boundary points.

The TSO A and TSO B in Figure 2 are connected with four tie lines at boundaries AE and BF to TSO E and F. TSO A now want to replace both TSO E and F with an equivalent. Figure 5 show a fully reduced version of the TSO E and F grids in Figure 2.

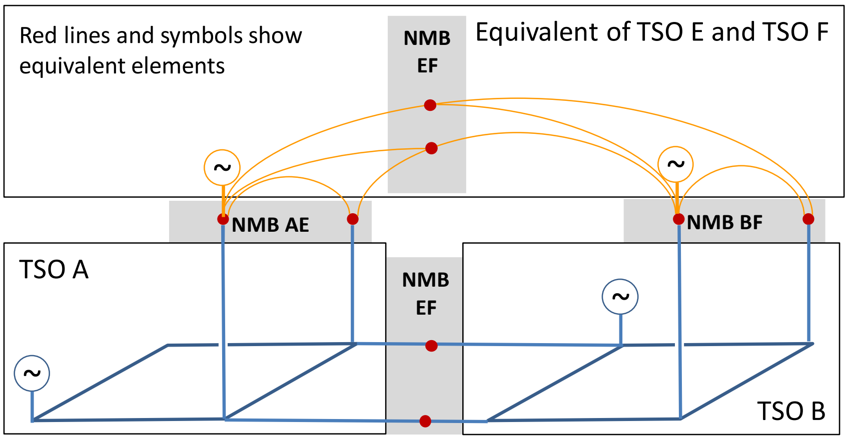

Figure 5 Equivalent from Fully Reduced TSO E and TSO F Networks

The example in Figure 5 show how all equipment is replaced by the equivalent elements (yellow color) including the boundary EF.

When creating the equivalent some real equipment may be kept and while others is replaced creating a network model mixing real equipment with equivalent elements. The resulting equivalent will be treated the same as the example in Figure 5.

Figure 6 show the TSO A power grid with a partially reduced version of the TSO E and TSO F grids as well as an equivalent of the DSO C grid.

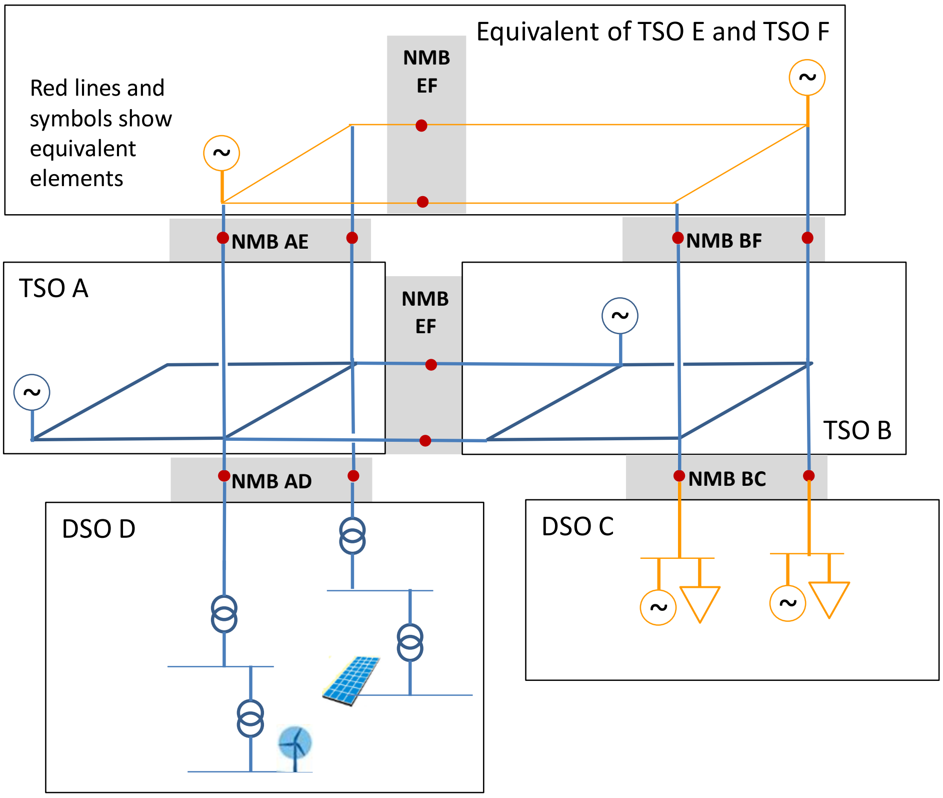

Figure 6 Power grid model as seen from TSO A

In Figure 6 equivalent elements are colored yellow. The DSO C transformers have been replaced by an equivalent load and generating unit. The tie lines between TSO A and TSO E as well as TSO B and TSO F has been kept but the rest of the equipment has been replaced by equivalent elements.

In a meshed network it may be that the equivalent connect with multiple boundaries and that the boundaries are reduced away within the equivalent. The examples in Figure 5 and Figure 6 however show the boundary between TSO E and TSO F has been retained and this is the recommended practice.

7.3.2.4 Framework for Model Exchange

Sections 7.3.2.1, 7.3.2.2 and 7.3.2.3 have defined different types of network models and actors responsible for them. To reason about and describe network models a data model is needed. This data model is named a Framework for Model exchange, FRM. The data model contain the following concepts

- A description of the actors responsible for network models, this already exists in CIM and is the ModelAuthority.
- A description of the network model parts as describe in previous sections. These are frame work parts descriptions.
- A description of network model parts specific to an actor and one or more CIM profiles. These are network model part specifications.
- A description of network model data being exchanged.

A frame work part description contain information as

- Responsible ModelAuthority
- A description of the network region it concerns. Network regions are non-overlapping and there is just one description per region.

The network model part specifications are needed because a TSO or DSO may have their own version of a particular frame work part. Hence multiple network model part specifications may exist for a particular frame work part.

Network model part specifications do not consider the evolution in time. As a network model evolve over time it changes, e.g. due to power system projects. An instance of a partial network model in time is a “model part”. Data describing a model part is

- A data set with the data describing the actual power system objects according to existing profiles, e.g. EQ, SSH, DL etc.
- The point in time for which the data is valid.
- A version of the data set.

7.3.3 Network Models

A network model is a complete network that can be used in network applications e.g. power flow calculations and studies.

Network models are composed from the network parts as defined in section **Error! Reference source not found.**. The composition process require the boundaries to be in place and known before the composition can start. As discussed in section 7.3.2.1 there are two cases on how the boundaries are treated

- The boundaries are already implemented demarcating an existing network model region.
- The boundaries are not implemented and need to be imported.

In the first case the complete network model is created by composing the network model regions outside the boundary with the existing network and its boundaries.

In the second case boundaries and network model regions are composed.

To instruct the composition process on what network components to include a description is needed. The description is a composition or assembly instruction.

Once all network parts has been gathered according to the composition or assembly instruction they can be merged into the complete network model. An assembly manifest record what network model parts that were actually merged. The assembly manifest tells a user of the network model information as

- The identification of the merged network model parts.
- When the network model was composed and by whom.

It may or may not be that case that the individual network model parts are distinguishable. That depends of how the party performing the composition decide to treat the individual network model parts.

7.3.3.1 Data Exchange

7.3.3.2 Overview

The exchange of network models has two phases

- Exchange of data that describe the network model parts to be exchanged.
- Exchange of network model data according to profiles EQ, SSH, DL, DY etc.

This document describe the data model needed to describe the data exchanged in the first phase. Section 7.3.2.4 define the concepts that is used in this section.

The sequence of data exchanges that take place in the first phase are exchange of

- ModelAuthorities. This is probably in the form of a public document issued by an central authority as ENTSO-E.
- Frame work parts including boundary and network model part descriptions. This may also be a public documents issued by the ModelAuthorities or by ENTSO-E.
- Model part specifications is published by each ModelAuthoritiy implementing a network model part for a frame work part.

After this all actors have machine readable information about each other and are now prepared to start the second phase with exchange of model parts including data sets.

7.3.3.3 Operational model Exchange Case

This section describes the exchange of operational models between System Operators. The models are used in SCADA/EMS systems. The network from Figure 2 is used as example.

Each TSO in Figure 2 build a network model by extending its own regional network model with partial models from their neighbouring TSOs, DSOs and larger power grid users. The parts of the neighbouring networks of interest is where measurements are available to support state estimation. Networks further away is normally represented by some an equivalent.

With reference to Figure 2 and TSO A perspective TSO A will receive EQ model parts from its neighbors TSO B, TSO E, TSO F, DSO D and DSO C.

From this TSO A may replace some of the model parts with equivalents and then compose a complete network model. Figure 5 and Figure 6 are examples on what the resulting network models may look like.

7.3.3.4 DACF Exchange Case

7.3.3.4.1 Overview

This section describes the DACF exchange case.

The network that is used as basis is from Figure 2. The TSOs in figure 1 runs DACF for their regional grid and deliver the results to the security coordinator that assembles the DACF case by composing the regional model parts and rerun DACF for the composed network model.

7.3.3.4.2 TSO A

TSO A may have a real time system operating with a network model as described in Figure 6 and running power flows, e.g. with a State Estimator, creating SSH and SV data sets.

The day-ahead congestion forecast (DACF) will run on a smaller model than the real time model described in section 7.3.3.3. The DACF model will include the TSO own power network model part with boundary injections fixed to scheduled values.

For TSO A the DACF network model is shown in Figure 7.

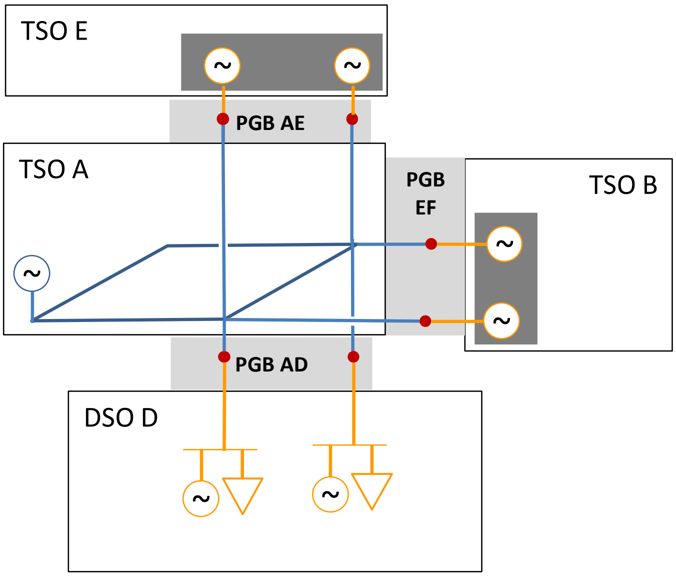

Figure 7 TSO A DACF Network model

The dark grey areas in Figure 7 represent edges with simple boundary injections matching the scheduled tie flows.
TSO A has several options for the DSO D grid

- Reduce the network parts with less impact on TSO A and keep major load and production units
- Completely replace the network parts with injections representing major load and production units
- Keep the boundary with DSO D
- Remove the boundary and integrate the DSO D equivalent into the own network.

In Figure 7 the boundary TSO A and DSO D has been kept, major load and production units have been placed directly at the boundary. Keeping the boundary is the most flexible solution and allows for replacing the equivalent depending on changing conditions in the DSO D network part without impacting the own network model part.
TSO A will deliver the following model parts to the security coordinator assuming that the boundary and edge EQ model parts are exchanged separately

- The TSO A EQ model part.
- The outage schedule for the TSO A model part.
- The SSH data set for the TSO A model part.
- The TSO A version of DSO D EQ model part.
- The SSH data set for DSO D model part.
- The SSH data sets for the edges to TSO B and TSO E.

7.3.3.4.3 The Security Coordinator

For each TSO the security coordinator will receive the EQ model parts and SSH data sets that was used or created by each of the local TSOs. The security coordinator will build a complete network model by composing the model parts. This result in a power grid model as shown in Figure 8.

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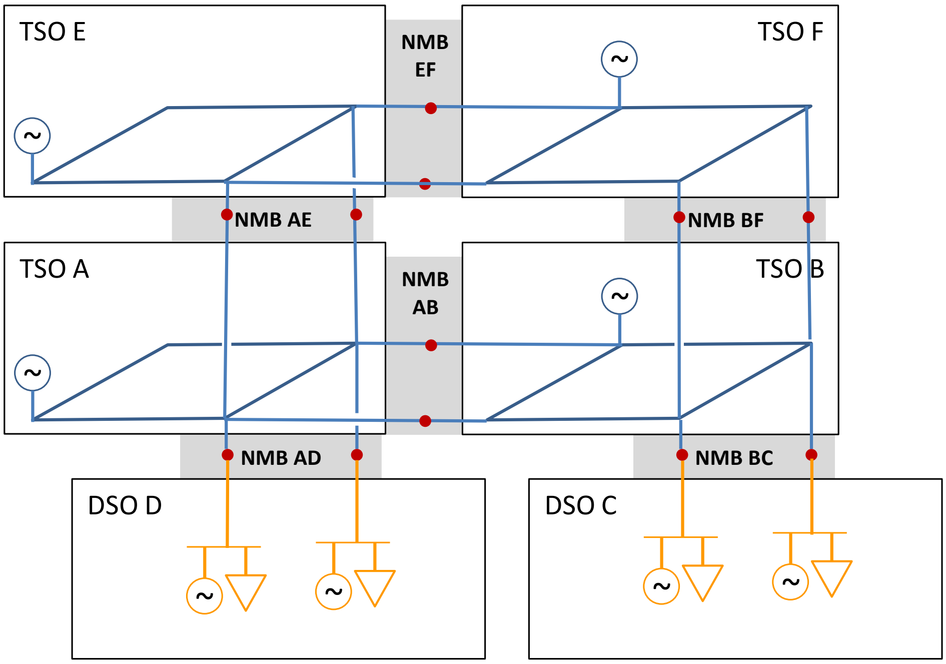


Figure 8 Security Coordinator Network Model

The security coordinator will do the following

- Merge the TSO model parts.
- Check boundary mismatches by comparing injections from the boundary SSH data sets for the edges.
- Merge the TSO SSH data sets to a single set of injections.

8 Appendix C: Power system project – for information (2014)

8.1 Introduction

The document is describing requirement, test configuration, test procedure, information model, profile to support a "paper" based interoperability test of Power System Resource variance as part of the ENTSO-E Common Grid Model Exchange Standard (CGMES).

8.2 Requirement

8.2.1 Information items

CIM incremental are currently defining the changes to the network model. We need to get additional meta-data to describe the content of the changes.
The additional meta-data MUST give information on:

- Date and time the changes will be added to the network model.
- State the realization of the changes is. A minimum would be to separate in planning, in build, cancelled and commissioned changes.
- Date and time the new equipment would be in of service. Updated and deleted equipment will follow standard outage handling.

- Grouping of set of changes that belongs together but do not have the same commissioned data, e.g. a project that consist of depended subprojects that will be commissioned before the main project (that has been approved by the government).
- Version on the changes. It is not practical to support tacking on changes on changes.
- Necessary references to a particular situation (EQ, SSH, TP, SV). In some cases a project is only commissioned (including in a planning model) in a certain situation.
- Dependency between projects. In case on alternative solutions of a problem.

The additional meta-data SHOULD give information on:

- Date and time the changes was actual added to the network model.
- Date and time the changes was cancelled.
- Mutual excluded changes. Alternative dependent changes that will NOT be implemented together.
- Priority of alternative changes.

The additional meta-data COULD give information on:

- Type of changes. A classification that would help systems on an information bus to identify changes that are relevant for their system without investigating all the detail changes.
- Model responsible. The organization that are primary responsible for the model.

8.3 Use-Case Overview

The use-case for the meta-data for changes are relevant for all the use-cases that changes to the model is included.
A change set or group of change sets will in a given organization be created on one of more of the following cases:

1. Created by the network analysing team (System Development Planning, Protection Planning).
2. Construction project (new or maintenance).
3. External organization.

An organisation could have one or more system that manages change set. A normal minimum would be a System Development Planning tool and an Operation (EMS/DMS). In many organisations the same changes are modelled in parallel for both systems. The CIM standard need to support the possibility to model the change set once and reuses it both for System Development Planning and Operation.
In the planning phase there could be multiple systems that are contributing with analysis and modelling on a given change set. It must be possible to exchange the set and the additional information between the systems. The following exchanges are relevant:

- System Development Planning
- Protection Planning
- Market design and planning
- Asset Construction
- TSO/DSO (DNO), TSO/TSO, DSO (DNO)/DSO (DNO)
- Government, regional/European (ENTSO-E)
- Research projects challenging different solutions (minor impact in terms of exchanges)

As construction is finalising, the “as build” model need to be exchange and in some cases contributes by the following system and business function:

- Outage Management/Scheduling System (OMS/OSS)
- Market Management System (MMS)

- Operation Planning and Operation (EMS/DMS)
- Grid Settlement
- Data Warehouse, measurement historian

8.4 IOP Test Cases

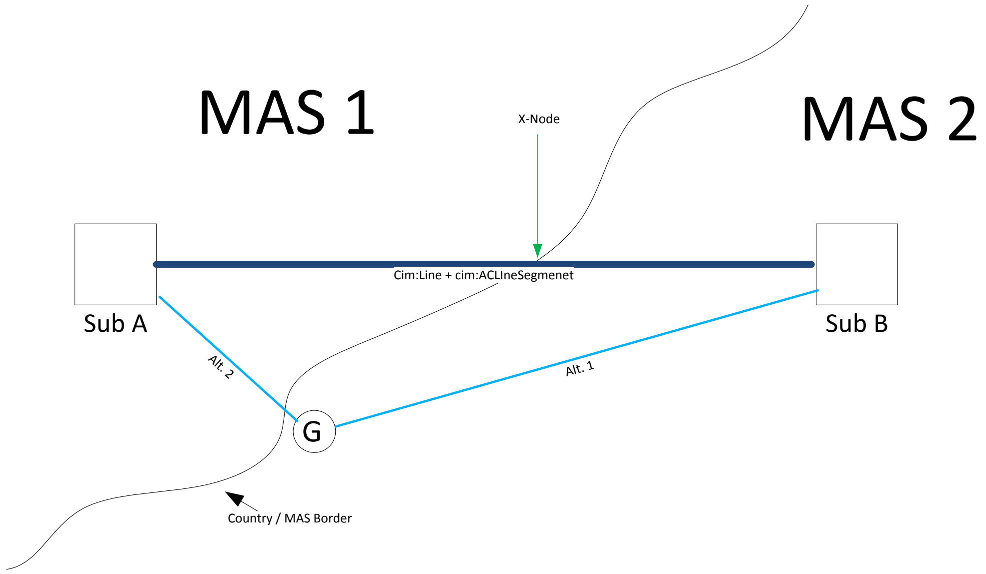
8.4.1 Purpose

The aim of this test is to demonstrate the ability of the tool to administrate Power System Project (PSP). The test will verifying the following functionality:

- Add changes/increment to a Power System Project
- Change attributes including dates on the project
- Change status of a project
- Split a project into two depending projects
- Create competing project
- The following main use cases are covered:
- Cross border MAS projects
- Project Schedule Alternatives
- Project Lifecycle

8.4.2 TU PSP1: Cross border MAS projects

The test handles the exchange of changes to models that represent the construction of a new line between to existing substation that is located in two separate MAS. The Boundary point needs to be defined and to different users should make the construction separate and on a later stage merge. Two alternative connection of a generating unit should be evaluated.

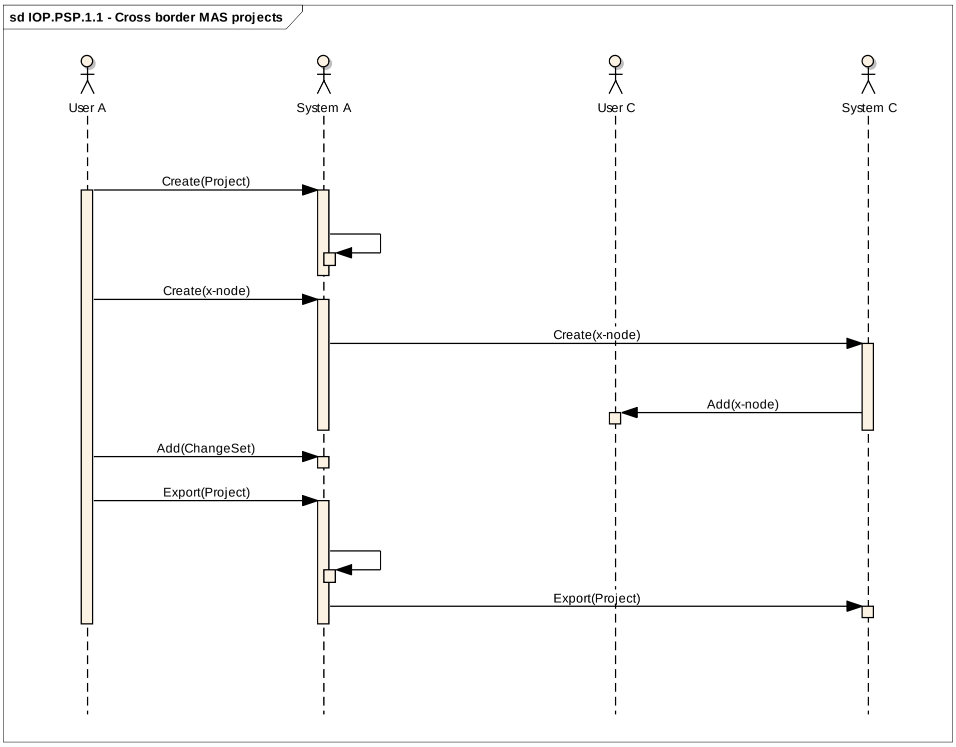


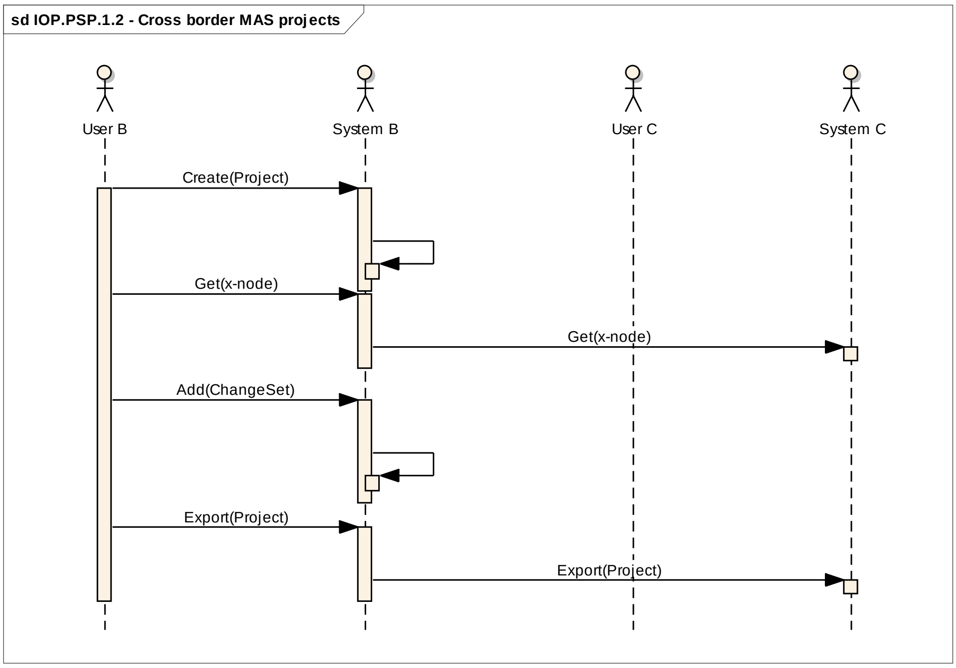
Three actors are involved:

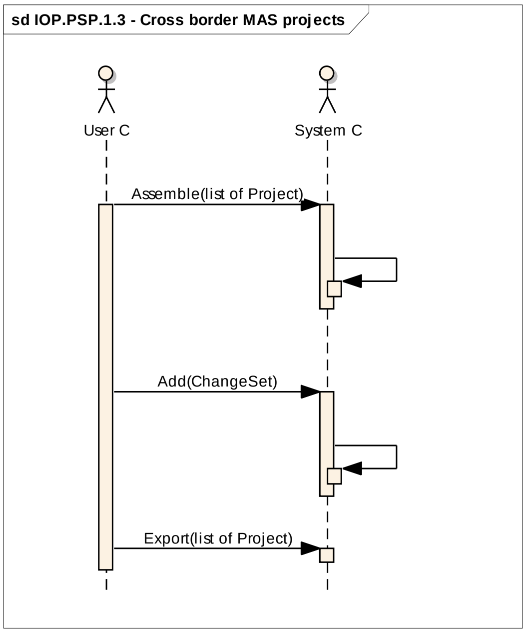
- User U_A with system S_A are updating MAS_1
- User U_B with system S_B are updating MAS_2
- User U_C with system S_C are merging change in MAS_1 with changes in MAS_2 and make dependent change to both MAS.

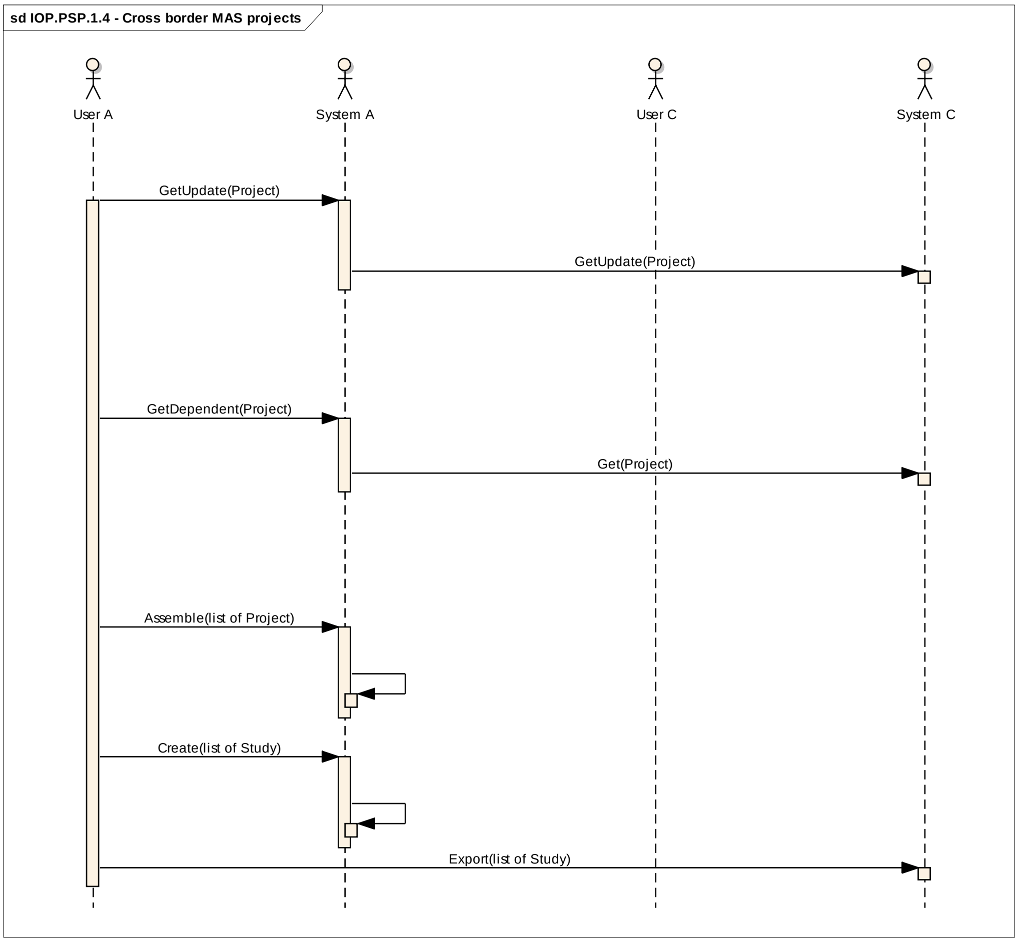
The sequence of steps is the following:

- User U_A through system S_A create (or request) a Boundary point from system S_C
- User U_A through system S_A build the ACLineSegment up to the Boundary Point
- User U_A through system S_A transfer the change set to System S_C
- User U_B using system S_B download the Boundary point information from system S_C
- User U_B build the ACLineSegement from the Boundary point
- User U_B through system S_B transferees the change set to System S_C
- User U_C through system S_C are merging the change set
- User U_C though system S_C are providing power flow study that covers both MAS_1 and MAS_2 including both change set
- User U_C through system S_C are making change two changes, add generator G to substation A in MAS_1, and add generator G to substation B in MAS_2. These changes are mutual excluded. One of the changes should be included in a given study.
- User U_C through system C is transferring all changes to both system S_A and system S_B
- User U_A through system S_A and User U_B through system S_B are calculating two cases for both MAS_1 and MAS_2 including all changes. Each of the case will be based on the mutual excluded changes
- User U_A through system S_A and User B through system S_B are transferring there result to system S_C.




sd IOP.PSP.1.2 - Cross border MAS projects
User B
System B
User C
System C
Create(Project)
Get(x-node)
Get(x-node)
Add(ChangeSet)
Export(Project)
Export(Project)


sd IOP.PSP.1.3 - Cross border MAS projects
User C
System C
Assemble(list of Project)
Add(ChangeSet)
Export(list of Project)



User B with System B does the same.

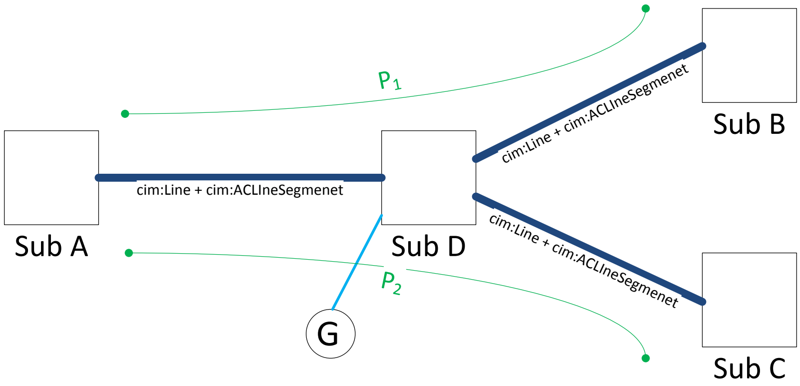
8.4.3 TU PSP02: Project Schedule Alternatives

There is a need to connect a major generating unit, G, to the network. Through analysing studies it is found that it should be connected together with the construction of substation D. However, it not yet decided if this should be done though project P_1 or project P_2.

Project P_1 include the construction of $ACLineSegment_{AD}$, substation D, generating unit G connected to substation D and $ACLineSegment_{DB}$.

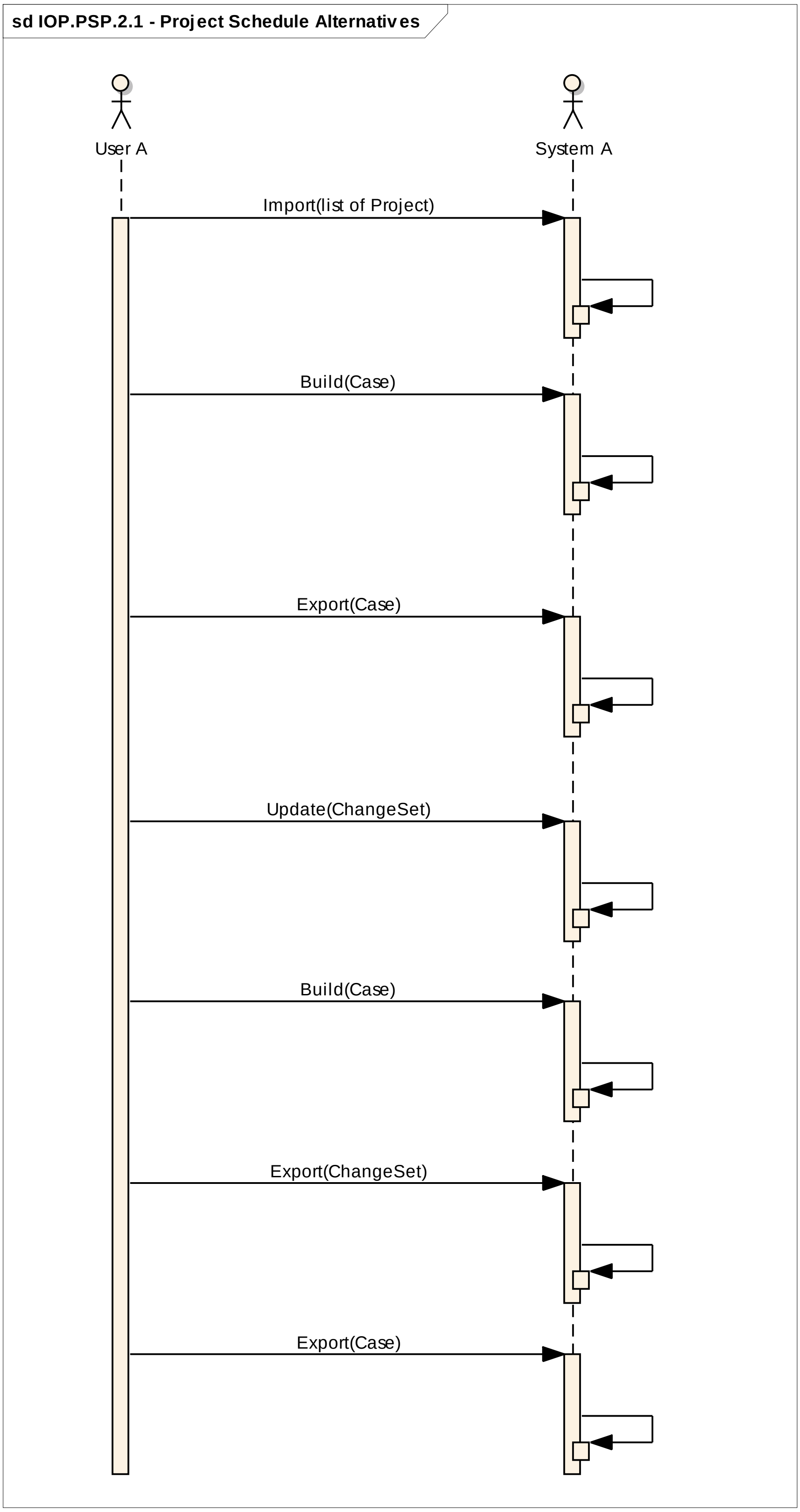
Project P_2 include the construction of $ACLineSegment_{AD}$, substation D, generating unit G connected to substation D and $ACLineSegment_{DC}$.

Project P_1 and project P_2 are competing project (mutually excluded). Both projects include the construction of $ACLineSegment_{AD}$, substation D and generating unit G connected to substation D. However, in project P_1 are the construction of $ACLineSegment_{AD}$ required before energising the generator. In project P_2 are this construction scheduled after the energising.



The sequence of steps is the following:

- User U_A through system S_A imports project P_1 and P_2
- User U_A through system S_A build and calculate a case including P_1 and export the results
- User U_A through system S_A build and calculate two case based on P_2 and export the results. One case does not include the $ACLineSegment_{AD}$
- User U_A through system S_A change one parameters $ACLineSegment_{AD}$. This one change should be reflected in both project P_1 and P_2.
- User U_A through system S_A build and calculate cases C_1 including P_1 and case C_2 including P_2.
- User U_A through system S_A exports the change and the result from the case C_1 and case C_2.
- User U_B through system S_B imports project P_1 and P_2
- User U_B through system S_B imports the change done by user U_A through system S_A and calculate the case C_1 and case C_2.



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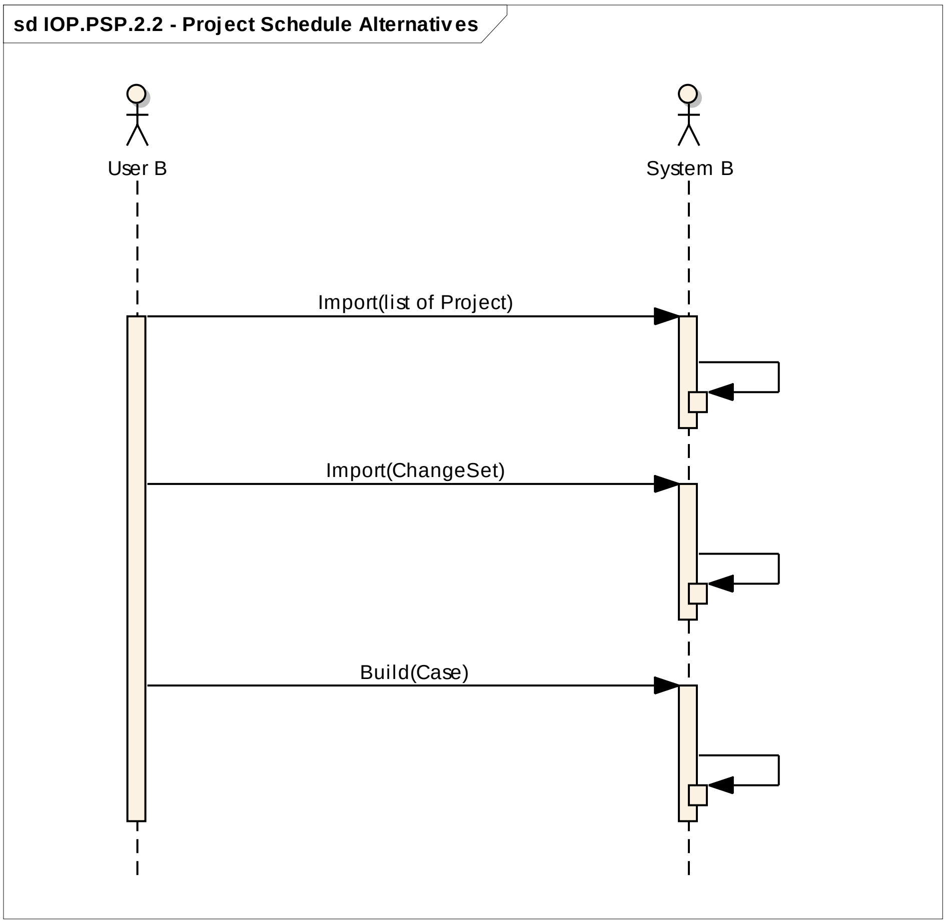
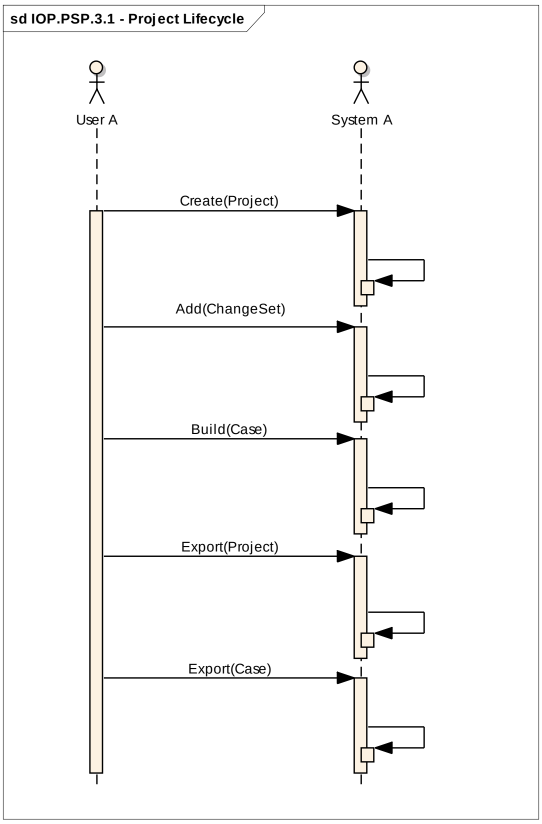
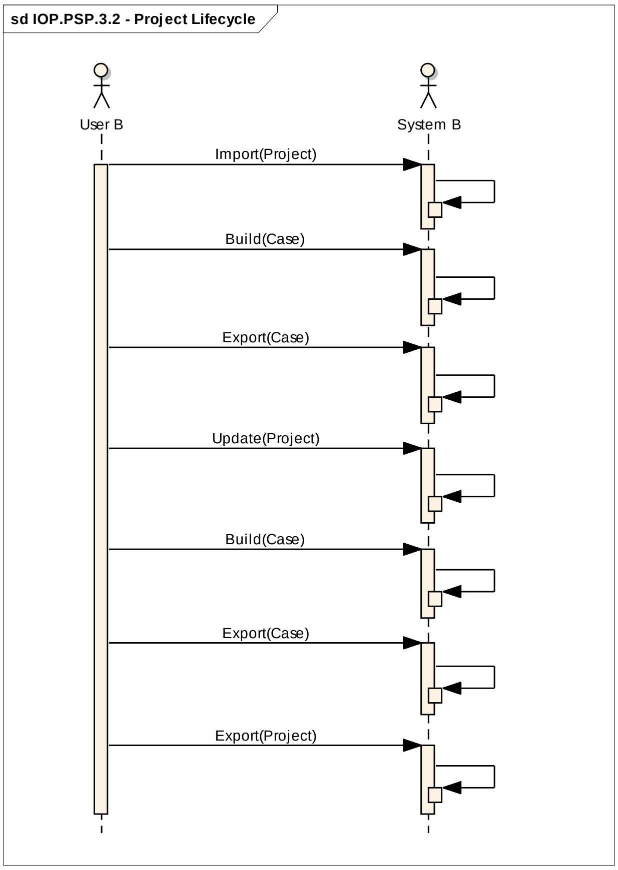


8.4.4 TU PSP03: Project Lifecycle

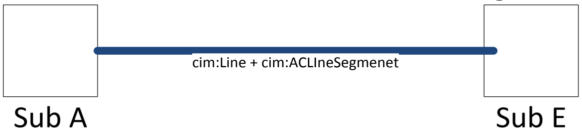
The developments of a project lifecycle from an analytic case to a commission the changes. The project evolution is starting with one project that is split into subproject with more detail in the change set. The update to the project is alternating between two users and with two different systems.


sd IOP.PSP.3.1 - Project Lifecycle
User A
System A
Create(Project)
Add(ChangeSet)
Build(Case)
Export(Project)
Export(Case)


sd IOP.PSP.3.2 - Project Lifecycle
User B
System B
Import(Project)
Build(Case)
Export(Case)
Update(Project)
Build(Case)
Export(Case)
Export(Project)

Stage 1. Early Analysis Stage

This stage is focused on low detailing and many alternative projects or solutions to a given problem. Exchanges of alternative project are covered in another test use case. The project is created with a change set including the addition of an ACLineSegment, ca. 150 km duplex parrot, between two existing substation, Sub A and Sub E. Add Transformer of 300 MVA to substation Sub E.
The attributes are taken as standard catalogue values.

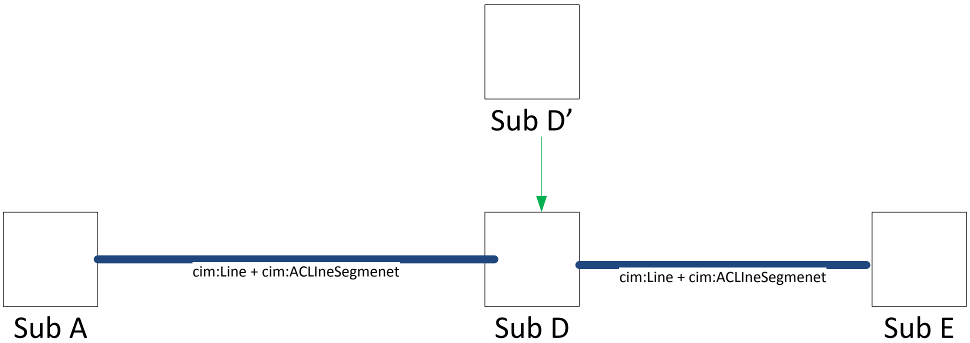


The following analysis/operation should be able to be done:

- Power Flow solution including the new line segment
- Short-circuit level (balanced 3 phase)
- Display diagram including the new line segment
- Rough geographical location information
- Positive system model adequate (including dynamic model)

Stage 2. First Public Analysis Stage

The alternatives are limited, but existing. The key point is to find out as much as possible to evaluate the "best" alternative from the previous stage. The output of this stage can be used as requirement for Request for Proposal (RFP) for the project and the equipment acquisition.
Exchanges of alternative project are covered in another test use case.
It is now clear that an existing substation, Sub D', needs to be "moved" and enhanced to become Sub D. The exact schedule does not need to be defined, but sufficient staging with use of temporarily configuration needs to be defined so that a reasonable confidence of the approached will work.



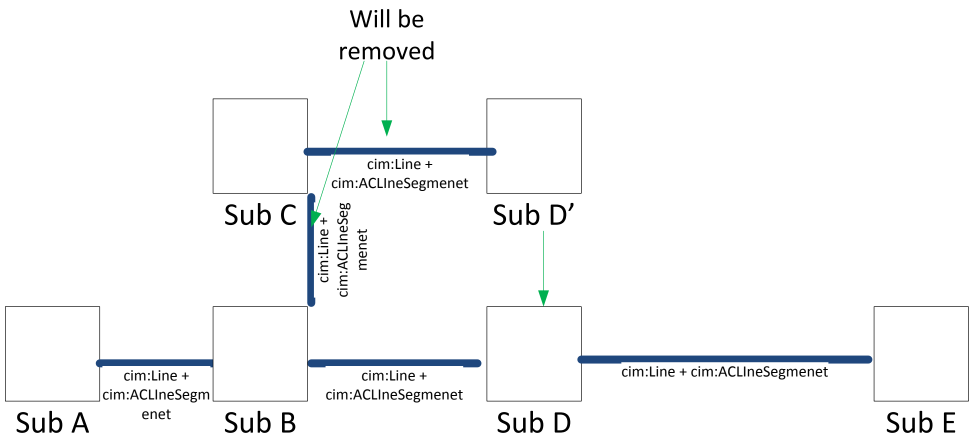
The following analysis/operation should be able to be done:

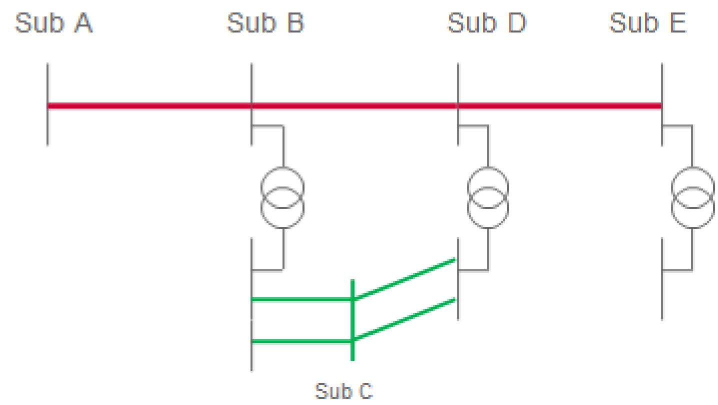
- Power Flow solution including the new line segment
- Short-circuit level (balanced 3 phase)
- Earth fault /Single phase short circuit calculations (1-phase faults)
- Display diagram including the new line segment
- Rough geographical location information
- Positive and zero sequence system model necessary (including dynamic model)

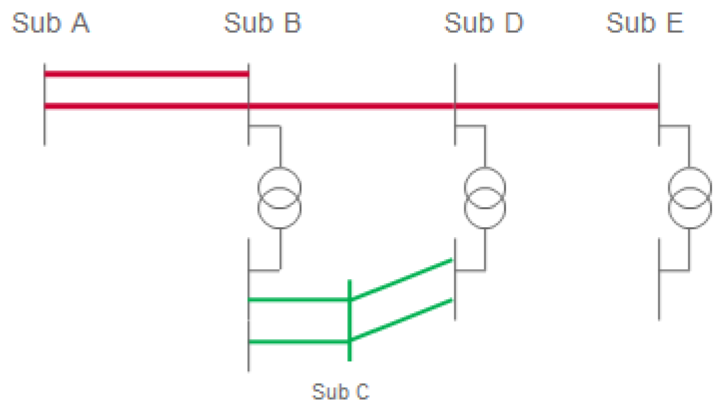
Stage.3. Application of License Stage

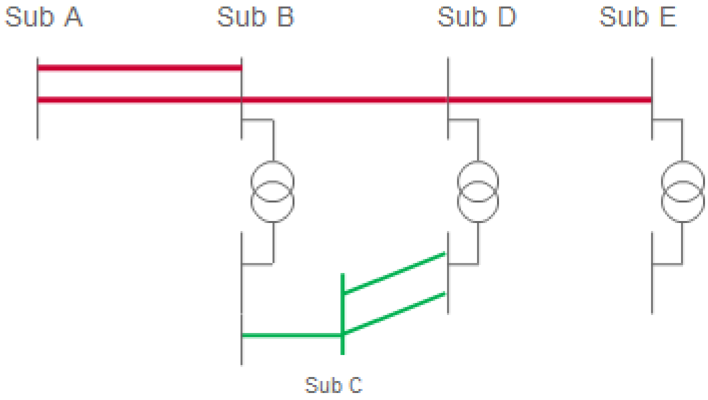
At this stage there is normally only one alternative. This model is updated to reflect the chosen project vendor and equipment. The detail needs to be so that each operating stage can be analyzed in detail. Standard catalogue values are replaced with vendor catalogue values.

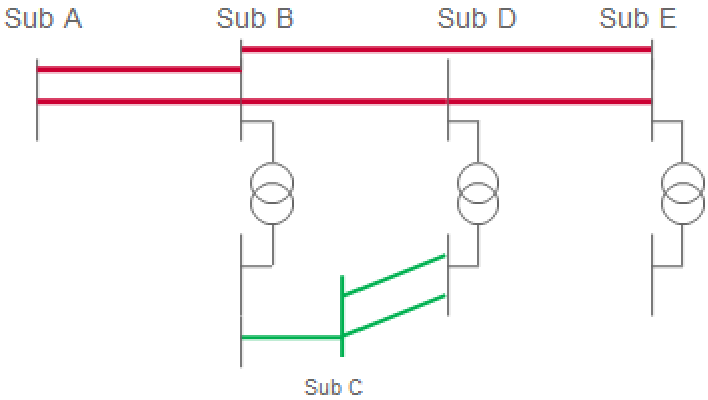
It is now clear that the line will go by substation Sub B. This will trigger that the line between Sub B and Sub C will be removed after Sub A and Sub B are connected. The full removed can only be done when Sub D is "moved" and connected the line already constructed from Sub B and Sub E.
The sequences of the subproject are described in the diagram below.

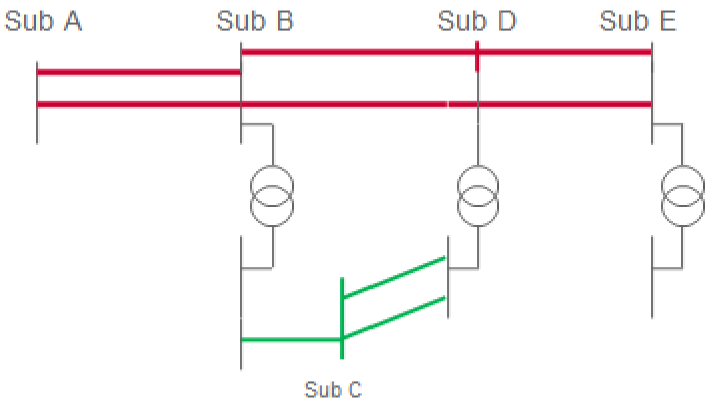


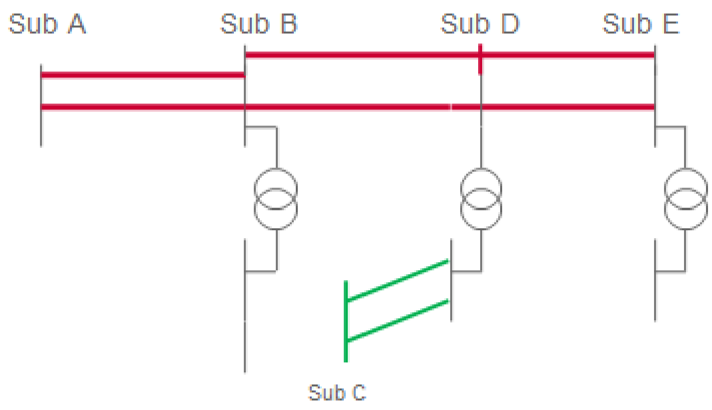





Sub A
Sub B
Sub D
Sub E
Sub C


Sub A
Sub B
Sub D
Sub E
Sub C


Sub A
Sub B
Sub D
Sub E
Sub C



The following analysis/operation should be able to be done:

- Power Flow solution including the new line segment
- Short-circuit level (balanced 3 phase)
- Protection planning and fault analysis (all fault types)
- Display diagram including the new line segment
- Accurate geographical location information
- Positive and zero sequence system model necessary (including dynamic model)

Stage.4. Build/Construction Stage

The project is updated by subproject are update with detail separately. Vendor catalogue values are replaced with actual "measured" values. Part of the project is committed to the base model as-build model. Breaker information, measurement and control information are added to support an EMS model. Only additional breaker information will be part of this test case.
The subproject (or full project) that includes the "as-build" information will be imported to a State Estimate based system (EMS).
Planned outage, switch plan and EMS based analysis are not included in this test case.

Stage.5. Operational Stage

The changes are added to the base model. Operations of the added equipment are controlled by planned outage. Changes to the model are handled as new change set rather than update to existing change set.
Planned outage, switch plan and EMS based analysis in addition to fault analysis including protection are not included in this test case.

8.4.5 TU PSP04: Power System Resource Variance Study

A System Development Planning study normally start with a given future base model. This model will include the collection of most probabilistic changes up to the data of Power System Resource variance Study.

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9 Appendix D: Variation handling – use cases and requirements – for information (2014)

9.1 Context

9.1.1 Introduction

The goal of this document is to facilitate the production of the Common Grid Model as defined in Article 33 of the Capacity Allocation and Congestion Management Network Code, Article 13 of Operational Security Network Code, Article 9 of the operational Planning and Scheduling Network Code when handling asset variations.

Each TSO or Regional Merging function is responsible for supplying an accurate Individual Grid model (IGM) of their network(s). As time passes it is likely that networks will change due to the following types of variations or outages:

- **Power System Resource Variations**: investments and modifications in the infrastructure: this could vary in number depending on the size or complexity of the network per year. Variations could be defined by the: Asset Management Department, System Development Planning several times per year by means of "Variations" and "Expansion Stages" in the equipment model. These Variations are time bound and are activated automatically, depending on the calculation target time. There could also be power system variations due to modelling changes eg: redefining a Shunt compensator from Linear to Non-linear.
- **Planned outages**: Up to tens of variations per week. Planned variations are prepared weekly by operational planners. For this purpose, "Planned Outages" are prepared into 7*24-hours expansion stages and operational scenarios. These stages and scenarios are activated automatically, depending on the calculation target time.
- **Forced outages**: Several hundreds of possible incidents at any moment. Forced variations are defined as contingencies and are processed one by one during the (n-1) contingency analysis process. Any Forced Outage that can not be returned within operational window should become a Planned Outage for return.
- **Operational variations**: Modification of the operational conditions during the business day: up to tens of variations per day. Operational variations are entered by the operational planners for all relevant hours. These modifications are entered and stored into the 7*24-hours expansion stages and operational scenarios and are activated automatically, depending on the calculation target time. Any topological reconfiguration, tap positions, ratings, production, consumption, remedial actions and SIPS.

For change due to an: Power System Resource Variation or Planned Outage, these changes would be captured ahead of real-time occurrence and should appear in a TSO’s IGM submissions. Either as a Change project in the case of an asset variation. Or as part of the relevant time stamp Scenario for a Planned Outage.

Operational Variations depending on the nature of this change and if any co-ordination is needed with other parties, such as DSO or DNO, this change to the network would also appear contained in the Scenario file as part of a TSO’s IGM submission. However if this type of variation is take purely with respect to System conditions as observed by a TSO’s control engineer, this type of change will be more problematic to specify and capture ahead of real-time.

In both these instances the duration of these variations is likely to be controlled by actual system conditions and hence the duration may not be predictable.

For Forced Outages these are not likely to be known about ahead of real-time switch out of the system plant. So this change would start in an Intra-day timescale. Then depending on the length of the outage it should then form part of the TSO’s Scenarios until such time as the fault has been resolved and a known time for return to service has been defined. In effect the Forced outage will become a planned return to service.

Looking at each of these types of changes to a TSO network in more detail:

9.2 Building Scenario

9.2.1 When defining a Scenario the following decisions need to be taken

All elements are selected for the relevant timing

Assemble the power grid model based on the Framework for Model Exchange given the geographical scope and relevant / desired[1] projects.

Select relevant/desired Planned Outages

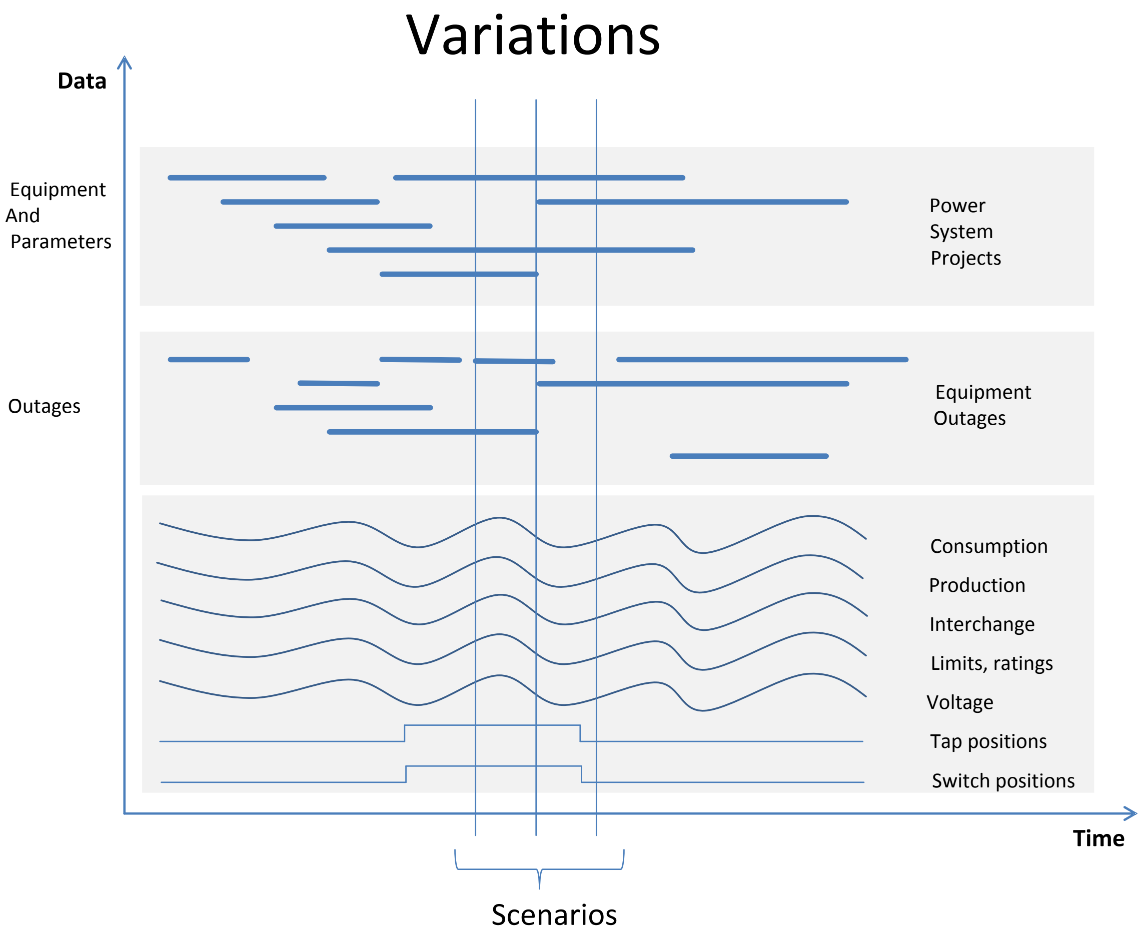

Figure 1. Shows the various system data sets needed to construct a Scenario

From figure 1:

- Variations – evolution of data over time
- Power System Project – Sets of changes in to power system equipment and its parameters

[1] In case of competing projects

- Outages – Schedules for unavailability of equipment
- Operational data
  - Forecasts – Weather dependent data
    - Consumption and DER Production
    - Limits, e.g. transmission line current limits
  - Schedules – Plans for
    - Production and Interchange, typically from market
    - Positions and Voltage, typically from operations planning
  - Patterns – Daily and/or seasonal curves recorded from real time data
    - Consumption and DER Production
      - Conforming that vary over a day
      - Non-conforming typically constant over the day
    - Production
    - Interchange
    - Positions
    - Voltage

Select the relevant Study Inputs from the Operational Variations:
Switch Positions
Tap Positions
Consumption
Production
Ratings
SIPS
Remedial Actions
Scheduled Inter Change

Each TSO shall collect all Year-Ahead individual grid condition data for each scenario.
This data shall be based on realized situations corresponding to the defined scenario or any other means that is appropriate for the TSO. The scenarios for these timestamps are the ones at which peak and valley demand occurs in Spring, Summer, Autumn and Winter.

9.3 Power System Resource Variations

9.3.1 Addition, Removal Modification of Network Items

Network changes occur on TSO networks via project stages. These Projects depending on their size and scope can have either a single date and time of start and completion or several stages with each stage having start and end dates and times, so in principle to accurately mimic the changes to a TSO's network in their IGM(s) to an acceptably detailed time granularity the TSO will decided the detail required in the delta files for their IGM.

These increments make reversible changes to the network being modelled as the changes each makes do not form part of the base model data until such time that the Delta File changes are consolidated and a new base data IGM is submitted.

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The submitting TSO(s) will have other data items that are time varying: such as: Thermal Ratings, Substation Running Arrangements, Activation Time assessed. TSOs tend to implement these in addition to the network ahead of the commissioning of the plant item. These data item are then held in the CGM until they become activated once the activation time has been reached or passed.

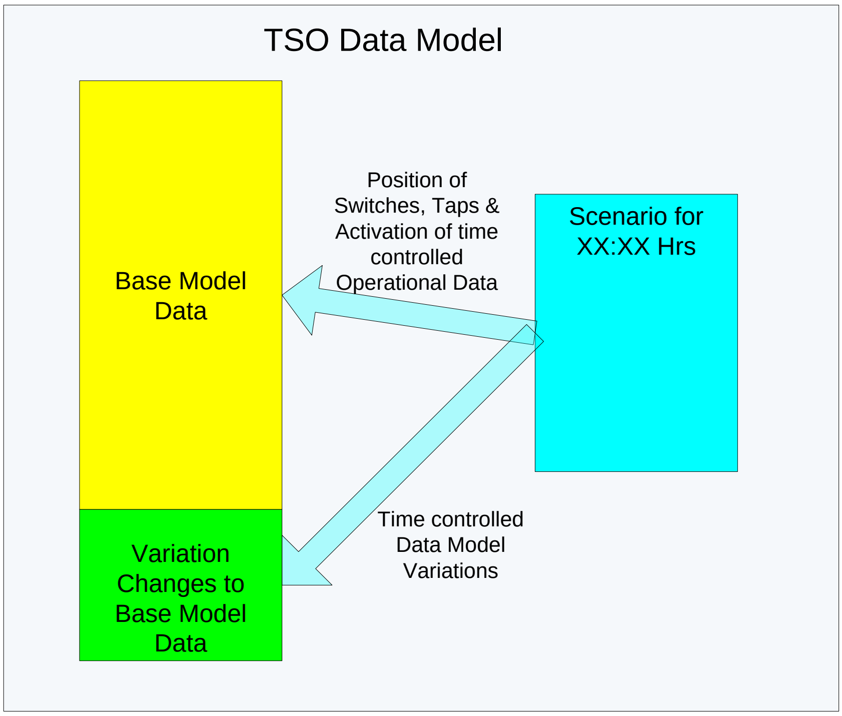


Figure 2. Model & Update Basic Structure

9.3.2 Scenario Variations

The list of data in any IGM used to define a Scenario, contains time varying data which affects the results of the loadflow calculation. These items are:

Date, Time and Duration[2] of calculation being studied
Switch Positions
Tap Positions
Thermal Ratings being applied
Generation levels and Availability
Load Size

.

9.4 Planned Outages

9.4.1 Commissioning/De-commissioning

[2] The supervised time frame for dynamic studies could be an example of Duration

9.4.2 Maintenance

9.5 Forced Outages

This type of outage will initially need to be implemented by a TSO in an Intra-day update to their relevant IGM(s), to better reflect their actual system topology and that being modelled. Depending on the length of this outage due to the actual nature of the fault, this outage will become a planned outage for the purposes of returning the faulted item back into service as part of a TSO's IGM(s).

9.6 Operational Variations

9.6.1 Introduction

Some TSOs can use topology changes for the purposes of system voltage management at times of low generation and low demand. These type of network topology changes usually take the form of switching out of service for a period of time wholly cable branches to remove the MVar gain these branches provide. These outages are not likely to be planned as they will be dependent on the system conditions at any given time.
Some planning when there is a cable branch with a supply transformer, which would require some co-ordination with the relevant DSO/DNO to make this network change acceptable to both TSO and DSO.
The duration of such outages will also be controlled by the system requirements on that particular day.

9.7 Equipment / Topology for Operating IGM/CGMES Studies Process

9.7.1 Introduction

When Node-Breaker modeling is used, the model must contain information that will force the bus-branch model that will result from topology processing to have the same bus names and identifiers that would have resulted from a bus-branch model.

9.7.2 Equipment Profile

An equipment file in all cases represents the fixed physical model. It is meant to be invariant as an engineer studies different operating possibilities. The practical value of this is that when a base case is created and then studied under many operating conditions, the equipment instance file does not change and only needs to be produced and processed once.

9.7.3 Planned Outages

A planned outage normally goes through a process that begins with a request to outage during some time period. The request is followed by studies to approve the outage. As the time nears to launch an approved outage, a multi-stage switching plan is created that forecasts roughly when switching changes will be executed.
Our problem in network analysis is to factor the forecasted state of outages into operating studies like. For this purpose, what we need to know is the expected state of devices at a particular time.
The key fact of an outage, aside from timing, is that there are two ways that the impact of an outage is stated:

- Initially, there is a request to outage equipment. The idea here is that this equipment must isolated (dead) so that it can be worked on.
- At some time after approval is given for an outage, the switch statuses are changed. This defines the isolate and restore status of the desired equipment.
    - The switching plan implements the desired outage, but could isolate more than the actual request.
- Note that a request to outage a breaker is not the same as a switching move that opens a breaker. To isolate a breaker for maintenance you have to open other devices.

We assume here that the list of outaged equipment is always available for an outage, and the status are available to redefine the network configuration.
ENTSO-E will maintain a set of outages that will support the network configuration changes held in the central critical outage database.

9.7.4 Commissioning

New construction goes through the same sort of scenario as with outages, although there may be a much longer period between conception and execution. The first thing we know is the net impact of the planned configuration change. Nearer to construction completion any desired changes of standard substation running arrangements will be developed.
Any new construction must be added to the initial case for the day, but if it will not be put in service immediately, rather it must be either marked out of service or switched out of service in that case, so that the same Equipment model remains in effect until the time of commissioning or removal from the TSO system and model. There are two ways that this may be accomplished.

- The TSO may have a practice of adding imminent construction to its ‘as-built’ Equipment model days or even weeks in advance, but with appropriate switch status to keep it out of service.

9.7.5 Contingencies

Contingencies can be expressed in terms of:

- The outaged equipment
- The fault location
- The breaker actions that isolate the fault (if the breakers exist in the model)

Only the first method can be used for bus-branch models.
It is also becoming increasingly important to model SIPS installations in contingency analysis. Accurate SIPS modeling often requires node-breaker modeling, but this is ultimately up to the TSO to determine.

9.7.6 Proposal for Bus-Branch representation in CIM

With this approach, X-nodes are defined by ConnectivityNodes in a boundary EQ instance. There is no need for any other boundary file.
In a bus-branch model where one end of a line is open and the branch end voltage is to be reported:

- Open state is indicated by the connected attribute on the line terminal.
- The Terminal to ConnectivityNode association remains with the original ConnectivityNode, so that Equipment is unchanged by a line opening.
- The Terminal to TopologyNode association in TP points to a new temporary bus so that the branch end voltage may be represented.
- The ConnectivityNode to TopologyNode association in TP remains pointed at the real bus, to indicate the bus to which the line end will connect when closed.

9.7.7 Function Notation

We are working on a function notation for describing formally how to assemble CIM models and how to document an audit trail of how models were assembled. An introduction to the function notation.
We use the mathematical idea of a function to describe an operation on argument variables, yielding another variable.

$$w = \mathbf{f}\,(x, y, z)$$

Since function results are data, functions can be embedded as arguments, producing a nested structure of arbitrary complexity. This will be convenient to capture in exchanges because it will be very natural to model in XML.
Two kinds of variables (two data types) can be used:

- CIM datasets are basically profile instances, such as EQ, SSH, TP, SV. They are expressed as:

  - VariableName^{EQ} , where the profile type is given as a superscript.
- CIM projects are annotated incremental models. They are expressed as:
  - ΔVariableName^{EQ} , where the profile type is given as a superscript.

In both of the above cases, we would expect that the value of a variable may be expressed either by explicitly including CIM/XML instances, or by referencing the name and version of an instance that has previously been made public.

Functions are written **bold**, and in this note, we use the following functions:

- The function **U** composes any number of CIM datasets into a resulting CIM dataset.
- The function **Inc** applies the first argument, which must be a CIM project, to a second argument, which must be a CIM dataset. The result is a CIM dataset.
- The function **Topology** takes an EQ dataset and an SSH dataset as input, and produces a TP dataset.
- The function **PowerFlow** takes an EQ dataset, an SSH dataset and a TP dataset as input and produces a TP dataset.
- The function **Diff** takes to CIM datasets and generates a project representing the difference.

One final notational element, braces { } around a variable indicate a set of similar arguments. For example, { Boundary^{EQ} } could be used to denote all of the bilateral boundary files for a TSO.

9.8 TSO Submits Their Base Case

The first case in any study sequence is the 'base case'. The base case is the case for the first hour of the day or if no network changes have been implemented to a TSO network, then the previously supplied base case will be used. In the first stage, each TSO must develop a base case representing its footprint. This will include full EQ, SSH, TP and SV parts.

The exchange form has been designed so that if the internal cases are prepared using the same model authority set framework, and the model authority sets representing TSOs and boundaries are preserved in the case development, then extracting the payload is described as follows.

The following sections describe the base case payload.

9.8.1 EQ Parts

The EQ parts of the base case are:

- From ENTSO-E, the TSO should already have boundary instances of EQ. These are the defined X Nodes which each neighbour.
- From the CGM, the TSO will be able to define 'edge' EQ models of their neighbours, containing equivalent generators whose terminals associate to the X-ConnectivityNodes.

  Note: 'Edge' models are used to complete a boundary when the TSO on the other side is not represented in detail. When using bilateral boundaries (i.e. connecting a pair of TSOs), two standard Edge models can be prepared in advance. These simply contain a generator and Load element at the X-node whose output can be set to balance tie flow.
- The TSO develops and supplies an EQ instance representing their territory and connecting to the boundary. This model should include any new construction expected to be in service.

If the TSO EQ model needs to be updated for new construction, then this model should be derived from plans represented as CIM projects. Such plans would be available in the *Central Outage Database* and would have names by which they can be referenced. In order to develop an EQ model for time T, all projects prior to T must be incorporated in sequence, since the incremental operator is sequence dependent:

$$\mathrm{TSO}^{EQ}_{T} = \mathbf{Inc}\ (\ \Delta\mathrm{TSO}^{EQ}_{n}\ ,\ \ldots\ \ (\ \mathbf{Inc}\ (\Delta\mathrm{TSO}^{EQ}_{2}\ ,\ \mathbf{Inc}\ (\ \Delta\mathrm{TSO}^{EQ}_{1}\ ,\ \mathrm{TSO}^{EQ}_{now}\ )\ )\ )$$

In all cases, whether the TSO uses bus-branch or node-breaker modeling approach, the EQ model incorporates any new construction changes, but is not impacted in any way by outages or switching plans.

9.8.2 SSH Parts

SSH contains several major subsets of data. Here we are only talking about how to set up the data that represents device status.

- No SSH boundary instance is required.
- One SSH instance is required for each edge model containing the equivalent generator output, but there is no data in an edge model that affects status of equipment.
- The main SSH instance corresponds 1:1 with the TSO EQ model. It needs to reflect all device status properly for the time T.
    - Status consists principally of switch status, branch end status and device remove status.
    - Base values of status would be taken from current state or from normal scenarios.
    - Planned outages are then added if applicable:
        - Set equipment remove flags based on the equipment to be on outage.
        - If the model includes breaker detail, then any active switching state(s) Must be added.
    - Restoration must be a similar processe either for conclusion of a planned outage or to put a new construction change into effect.
    - The branch end state of the tie at the X-node may not be opened.

Outage plans will result in the *CGMES Outage database*, expressed as CIM SSH projects. These projects will have names and versions by which they can be referenced, in a directory outages.

The end result for the TSO SSH may then be expressed as:

$$TSO^{SSH}_T = \mathbf{Inc}\ (\ \Delta TSO^{SSH}_n\ ,\ \ldots\ \ (\ \mathbf{Inc}\ (\Delta TSO^{SSH}_2\ ,\ \mathbf{Inc}\ (\ \Delta TSO^{SSH}_1\ ,\ TSO^{SSH}_{now}\ )\ )\ )$$

Note that SSH also contains energy injections and voltage regulation that the TSO must set up, but we are not covering that part of the process here.

9.8.3 TP and SV Parts

Once the EQ and SSH parts are defined, the TSO can run a power flow and validate that they have the correct complete state. The analysis will first generate a TP and then compute an SV solved state.

- The topology processing at the TSO/ *Regional Merging Functions* must produce one TP instance for the entire submitted case.
    - It will include all TopologyNodes, including the X-nodes.
    - It will define the associations from all terminals of TSO equipment to TopologyNodes and from all ConnectivityNodes to TopologyNodes.
- Similarly, the solution at the TSO/ *Regional Merging Functions* must produce an SV instance corresponding to the entire submitted case.

9.8.4 Base Case Exchange

Assuming bilateral boundary and edge files, the payload (in function notation) then consists of a zip file including:

- For each neighbor, k, a boundary file $Boundary^{EQ}_k$ (or a reference to a stored boundary)
- For each neighbor, k, an edge file $Edge^{EQ}_k$ (or a reference to a stored boundary)
- $TSO^{EQ}_T = \mathbf{Inc}\ (\ \Delta TSO^{EQ}_n\ ,\ \ldots\ \ (\ \mathbf{Inc}\ (\Delta TSO^{EQ}_2\ ,\ \mathbf{Inc}\ (\ \Delta TSO^{EQ}_1\ ,\ TSO^{EQ}_{now}\ )\ )\ )$, where ΔTSO^{EQ}_i represents planned construction i
- For each neighbor, k, an edge file $Edge^{SSH}_k$
- $TSO^{SSH}_T = \mathbf{Inc}\ (\ \Delta TSO^{SSH}_n\ ,\ \ldots\ \ (\ \mathbf{Inc}\ (\Delta TSO^{SSH}_2\ ,\ \mathbf{Inc}\ (\ \Delta TSO^{SSH}_1\ ,\ TSO^{SSH}_{now}\ )\ )\ )$, where $\Delta TSO^{SSH}_{\mathbf{i}}$ represents planned outage or restoration step i
- $TSO^{TP}_T = \mathbf{Topology}\ (\ \mathbf{U}\ (\ \{\ Boundary^{EQ}_k\ \},\ TSO^{EQ}_T\ )\ ,\ \mathbf{U}\ (TSO^{SSH}_T\ ,\ \{\ Edge^{SSH}\ \}\ )\ )$
- $TSO^{SV}_T = \mathbf{PowerFlow}\ (\ \mathbf{U}\ (\ \{\ Boundary^{EQ}_k\ \},\ \{\ Edge^{EQ}_k\ \},\ TSO^{EQ}_T\ ),\ \mathbf{U}\ (TSO^{SSH}_T\ ,\ \{\ Edge^{SSH}\ \}\ )\ ,\ TSO^{TP}_T\ )$

The profile instances being exchanged would also be accompanied by an audit trail expressed in the above functional notation – this is the main purpose for developing it. For example, the $TSO^{SSH}{}_T$ instance shown above would not simply be one SSH instance with no clue as to how it was prepared. Instead, there would be a reference to the starting SSH, plus the references to each planned outage that was added. Combined with versioning on these datasets, this gives the user a very compact method of checking the content of a given exchange.

9.9 Incremental Hourly / Seasonal Time Period Submissions

A sequence of times cases: hourly or seasonal, for the different time stamps and delivery periods. The base case is a full description. The hourly cases may be sent in incremental form.

9.9.1 EQ Parts

Nothing required. EQ will not change in DACF.
In other procedures, this might differ and incremental EQ updates may be desired.

9.9.2 SSH Parts

New full SSH should be sent for each hour, since energy injections everywhere will change. New outage or restoration steps may be included by the same procedure outlined for the base case.

9.9.3 TP and SV Parts

New full TP and SV should be generated for each hour.

9.9.4 TSO Hourly Exchange

Same as base except that EQ is not repeated.

9.10 Case Assembly for Hourly / Seasonal Time Periods

The submitted TSO cases must be assembled to produce a complete cases. The procedure is the same for each time period, the first case is where most of the problems will be detected, if they exist. This section assumes that case assembly is producing the entire CGMES. *Section 9*.11 describes modifications necessary for security coordinators that are covering only part of the total footprint.
The following sections assume that every TSO / *Regional Merging Function* has completed their exchanges as described above.

9.10.1 EQ Parts

$Edge^{EQ}$ parts may are ignored in assembly of the CGMES case. All other EQ parts compose without any change.

$$CASE^{EQ}{}_T = \mathbf{U}\ (\ \{\ TSO^{EQ}{}_T\ \}\ ,\ \{\ Boundary^{EQ}{}_T\ \}\ )$$

Where

$\{\ TSO^{EQ}{}_T\ \}$ is the set of submitted TSO^{EQ} instances

$\{\ Boundary^{EQ}{}_T\ \}$ is the set of bilateral boundary instances. Each has been included with two submissions, but only one is needed.

This result is the same for all relevant time periods.

9.10.2 SSH Parts

Each pair of edge SSH parts must be checked for compatibility of assumptions prior to going ahead with case assembly. The two SSH for each edge should have exactly the same set of generators referenced and the values of the generation should agree closely on the tie flow. If this is not true, then the process has to go back to the TSO(s) / *Regional Merging Function*.
Provided that the edge models agree, they can then be completely ignored in the assembly of the case because the essentially just cancel each other out. The submitted TSO SSH parts then compose without any change.

$\text{CASE}^{\text{SSH}}{}_{\text{T}} = \mathbf{U}\ (\ \{\ \ \text{TSO}^{\text{SSH}}{}_{\text{T}}\ \}\ )$

9.10.3 TP

The TP could be assembled by composition of the $\text{TSO}^{\text{TP}}{}_{\text{T}}$, but note that such composition must recognize that there would be duplicate X-topologynodes and be smart enough to ignore duplicates.

In practice, one would probably just produce a new complete TP by running topology processing, and the point of composing the $\text{TSO}^{\text{TP}}{}_{\text{T}}$ would be to diff against the computed TP as a check.

$\text{CASE}^{\text{TP}}{}_{\text{T}} = \mathbf{Topology}\ (\ \text{CASE}^{\text{EQ}}{}_{\text{T}}\ ,\ \text{CASE}^{\text{SSH}}{}_{\text{T}}\ )$

Or

$\text{CASE}^{\text{TP}}{}_{\text{T}}{'} = \mathbf{U}\ (\ \{\ \ \text{TSO}^{\text{TP}}{}_{\text{T}}\ \}\ )$, where the composition operator must recognize the duplicate X-TopologyNodes and combine to one

The result of differencing should be an empty project:

$\Delta\text{Null} = \mathbf{Diff}\ (\ \text{CASE}^{\text{TP}}{}_{\text{T}}{'}\ ,\ \text{CASE}^{\text{TP}}{}_{\text{T}}\ )$

Note that in order for **Diff** to be valuable here, it is a requirement of the **Topology** operator that it will generate the same MRID for each planning bus. i.e. When the planning bus name is generated, that generation process must always assign the same MRID.

9.10.4 SV

A power flow for the case can be generated from a flat start, ignoring the solutions of the submissions.

$\text{CASE}^{\text{SV}}{}_{\text{T}} = \mathbf{PowerFlow}\ (\ \text{CASE}^{\text{EQ}}{}_{\text{T}}\ ,\ \text{CASE}^{\text{SSH}}{}_{\text{T}}\ ,\ \text{CASE}^{\text{TP}}{}_{\text{T}}\ )$

This case solution can then be compared to the submitted cases, but with a little special processing to adjust for the angle reference of each submitted cases.

- Find each TSO reference bus angle in the new solution.
- Calculate the difference at the reference between the CGMES case and each TSO cases.
- Adjust each TSO case SV by the difference for that TSO case.
- Then compare the SV directly.

An alternative procedure that could be useful is to use the submitted case solutions as the basis for selecting starting values for the power flow, but some special logic would be required to rationalize the differing angle references.

9.11 Security Coordinator or Partial Cases

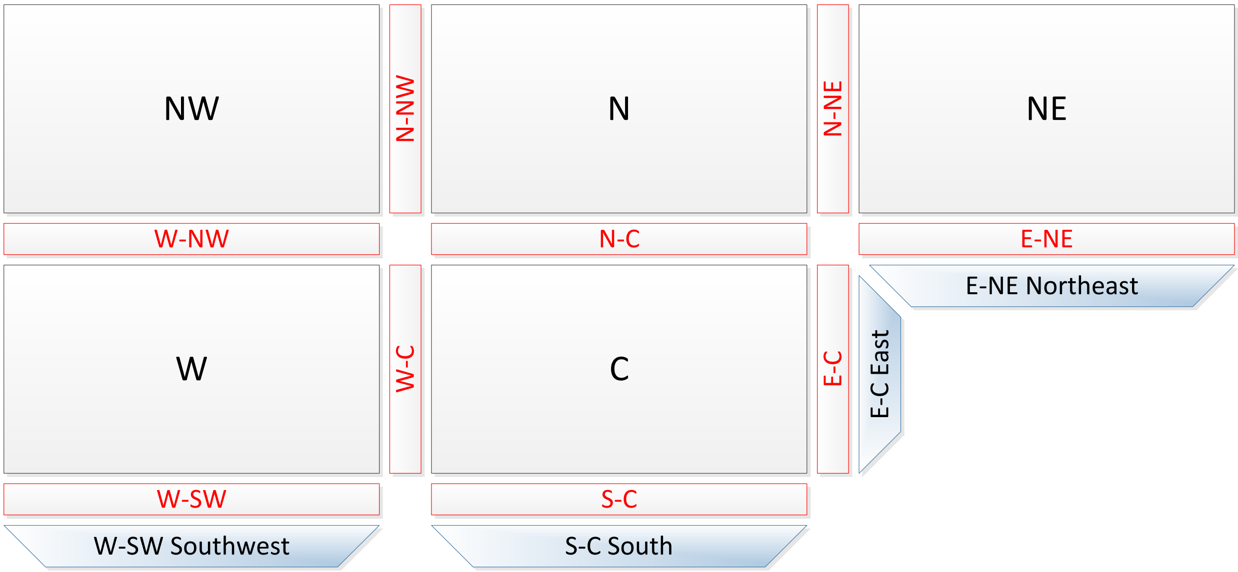
In practice, the CGMES cases will exist for all planning contexts, and for intra-day, the submissions from TSOs may be assembled into intermediate, overlapping security models. The only real difference in requirements is the net territory encompassed by the final assembly.

9.11.1 EQ Parts – Partial Framework Basics

A partial model assembly needs a ‘framework’ defining the assembly. This is established at the EQ level. The framework is established as follows:

1. The TSOs to be included in detail are identified as a set: $\{\ \text{DetailTSO}^{\text{EQ}}{}_{\text{T}}\ \}$
2. All bilateral boundaries touching a member of this set are identified and classified as either: $\{\ \text{InternalBoundary}^{\text{EQ}}{}_{\text{T}}\ \}$ and $\{\ \text{EdgeBoundary}^{\text{EQ}}{}_{\text{T}}\ \}$. (Edge boundaries are those that have only one of its participant TSOs in the security region.)
3. For each Edge Boundary, an Edge^{EQ} is required.

The easiest method by far for creating edges is to use the same edge models that are used by the TSOs in submitting their footprints. The only disadvantage of this approach is that it may force the inclusion of more detail TSOs in order to get enough accuracy.



9.11.2 SSH, SP, SV

All the other parts follow the same procedure as given in *Section* 9.10, except that $Edge^{SSH}$ need to be retained for each $Edge^{EQ}$ in order to supply the equivalent generation at the ties.

9.11.3 More Sophisticated Reduction

The recourse if more sophisticated simplification is required at the edges is to create $ReducedTSO^{EQ}$ models that fit into the same boundaries. Usually, this requires digging into the makeup of the TSO model and extracting the major bulk power elements. If the TSO in question separates the modeling of their bulk power, the process can be quite a bit simpler. Usually, a $ReducedTSO^{EQ}$ will complete more than one edge, but the important thing overall is to wind up with a set of parts that compose to the desired total footprint. Also, whereas Edge models from TSO submittals can very easily be grabbed and used as is, a $ReducedTSO^{EQ}$ may need to be re-generated for each case from submitted TSO detail.

9.12 Use cases

9.12.1 Timing of the outage planning process according to NC OPS

The timings defined in NC OPS are based on current best practices as well as information requirements for different processes and assessments. First, a point in time has to be defined when a first Availability Plan, coordinated between all parties, and assessed by all on its feasibility is established. An important trade-off has to be made here: the later this time point is set, the more and better information is available to all parties. However, as a view on these Availability Plans and their feasibility is necessary for executing several tasks (generation Adequacy assessments, cross-border exchange capacity calculations), for contracting third parties, and to serve as a basis for planning all other, non-Relevant Assets.
As in most systems, some kind of Year-Ahead coordination process is already established (e.g. in continental Europe an extensive Year-Ahead Outage Coordination Process already exists today), the Network Code also refers to this horizon for establishing a feasible starting point. After this Year-Ahead phase, a continuous process of updating and assessing the feasibility of the coordinated Availability Plans is introduced, to allow for a maximal flexibility of planning the Availability Status of Relevant Assets.
In this Year-Ahead coordination process, deadlines are set to ensure that relevant information on the Availability Status of Relevant Assets is available when it is needed for linked processes (for example Security Analysis, System Adequacy assessment and Capacity Calculation).

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The sequence of tasks that are to be performed in the Year-Ahead coordination process, and that determine the time flow and deadlines of this process are depicted in the scheme below. Important to note is that the coordination process between all parties is very much condensed in this diagram to avoid unnecessary clutter and to focus on the time flow of the process.
The main driver for the deadlines set for the different tasks are the preliminary outage plans which need to be available at the beginning of September to be used as an input for the pan-European generation Adequacy assessment and for long-term Capacity Calculations.
Some deadlines reported in figure below are not reflected as requirements in the code and serve simply as an indication for the time flow of the process.

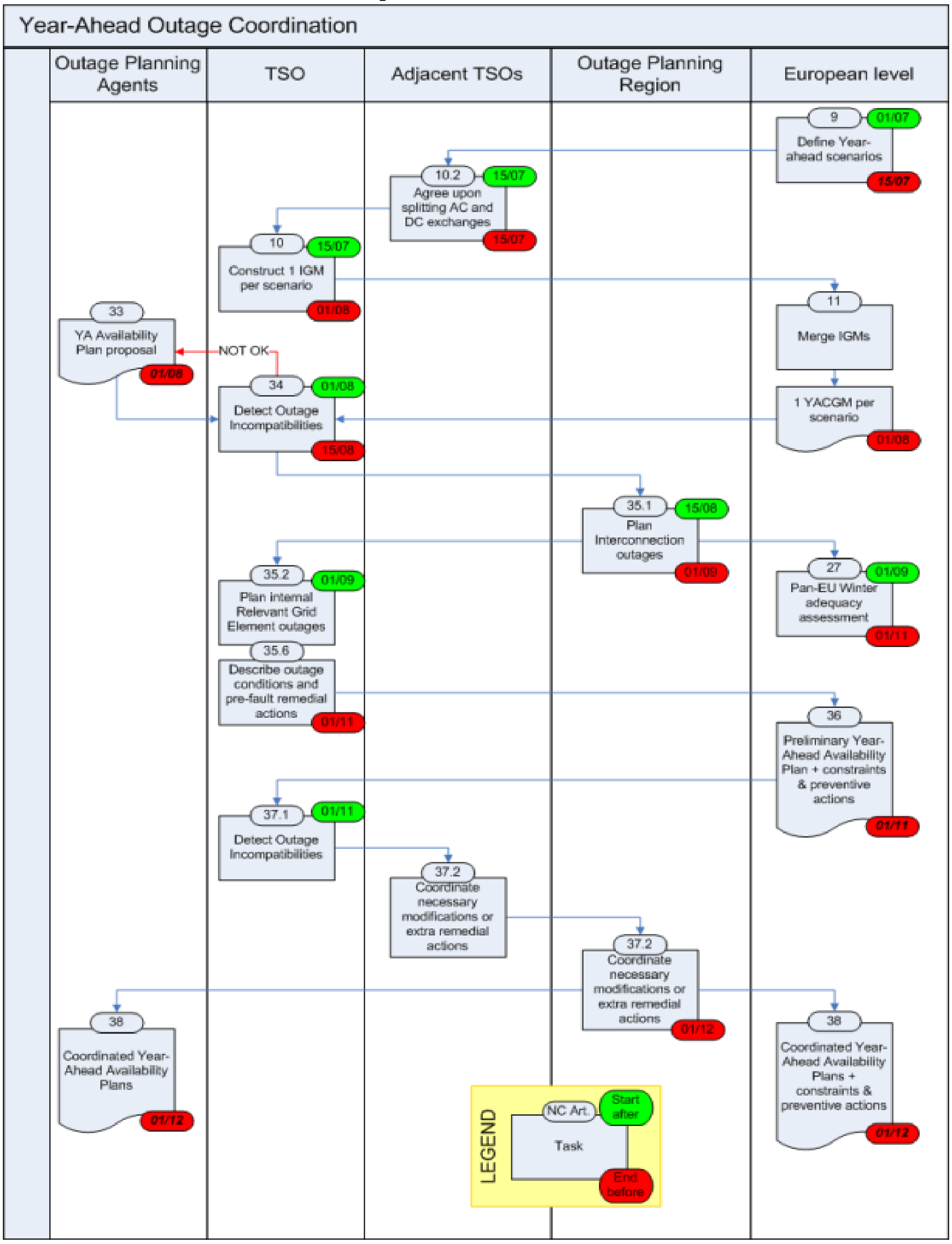

Figure 3. Condensed view on the year ahead coordination process, focussed on time flow and data links

9.12.2 The year ahead outage coordination phase

To illustrate the Year-Ahead outage coordination described in Articles 35 to 39 of the NC OPS, below a flowchart giving an overview of the coordination process is included.

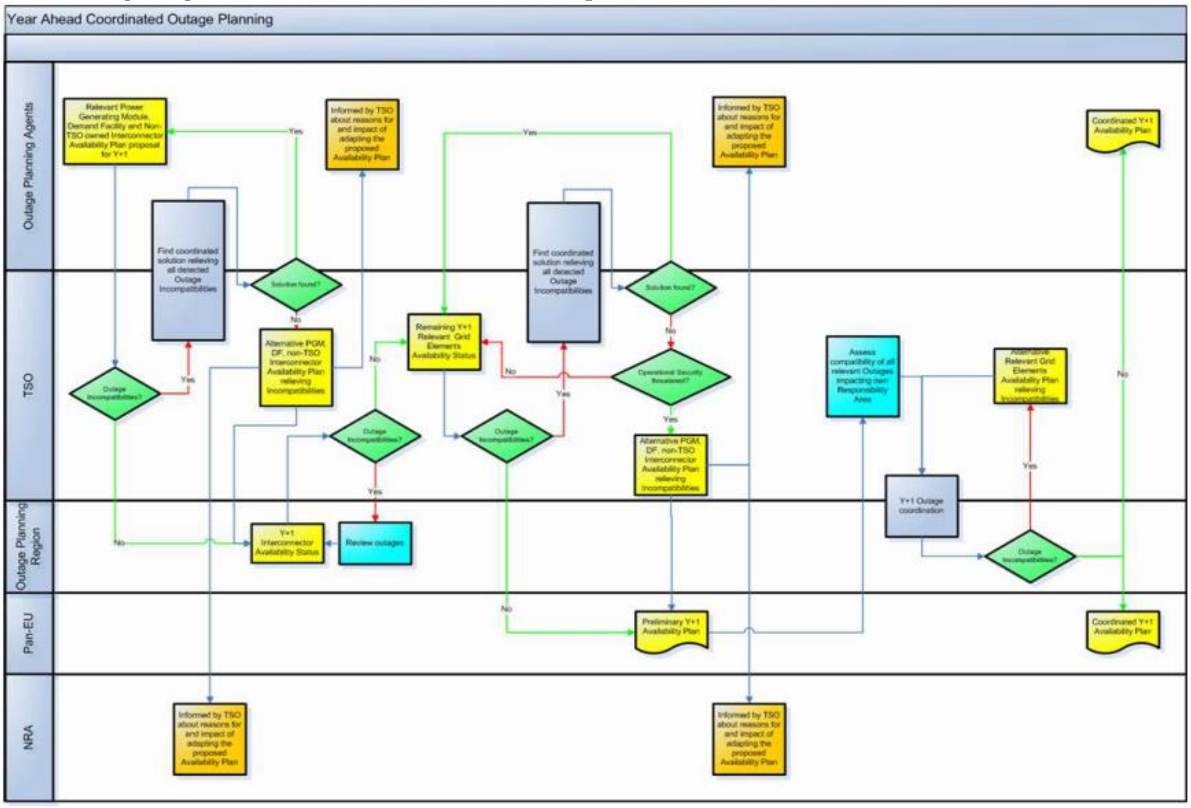

Figure 4. Overview on the year ahead outage coordination phase, focussed on interaction between parties

9.12.3 Updates to the year ahead availability plan

Article 41 of the Network Code describes how all parties can initiate a change to the coordinated Availability Plan. To clarify the described procedure Figure 3 and Figure 4 below present the procedure to be followed as a flowchart, for respectively changes initiated by an Outage Planning Agent, and changes initiated by a TSO. Important to stress here is the meaning of the coordination process to be initiated when Outage Incompatibilities are detected. The exact implementation of this process is not described in this Network Code. This is done on purpose to allow the current best practices installed in the different systems to be honoured. To this end, Article 40 makes a specific reference to the applicable legal framework for elaborating this coordination process.

As an illustration, in the coordination process, it could happen that in order to allow accepting the initial change request, the Availability Plan of other parties must be modified. According to national legislation, bilateral contracts or any other agreed upon mechanism, this could lead to financial compensation from the change initiating party to the changing parties. This Network Code therefore does not oblige nor forbid the instalment of this kind of mechanism, and leaves it open to be regionally or nationally decided.
What is however enforced by this Network Code is that after this coordination process, a feasible coordinated Availability Plan must be achieved.

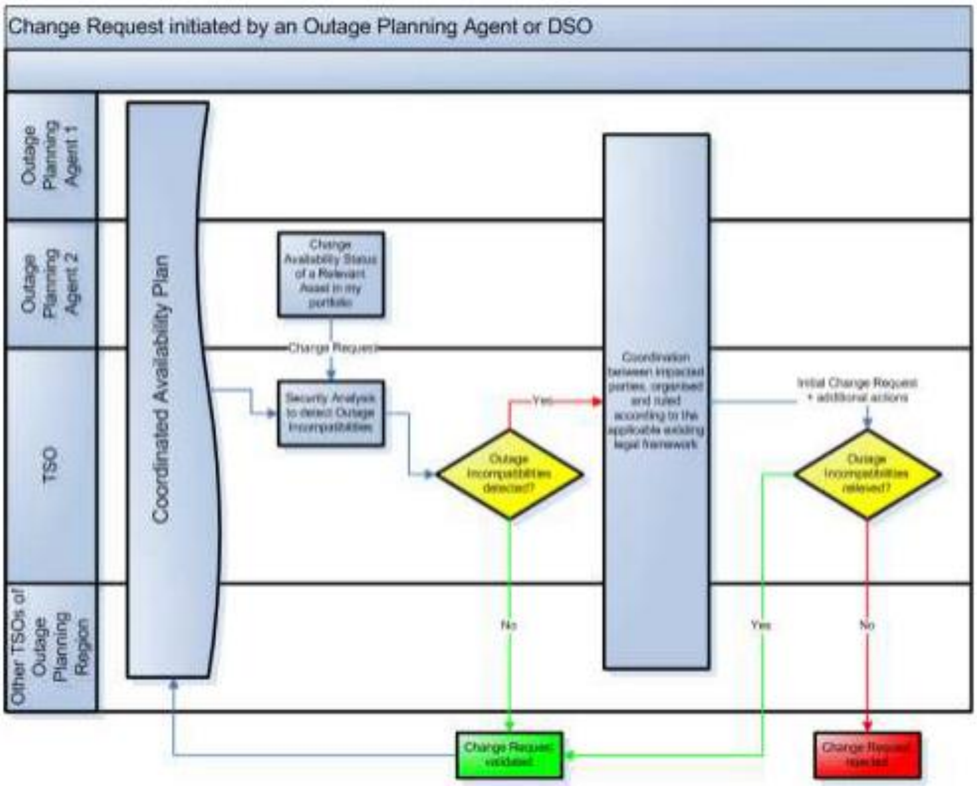

Figure 5. Update procedure for a change initiated by an Outage Planning Agent or DSO

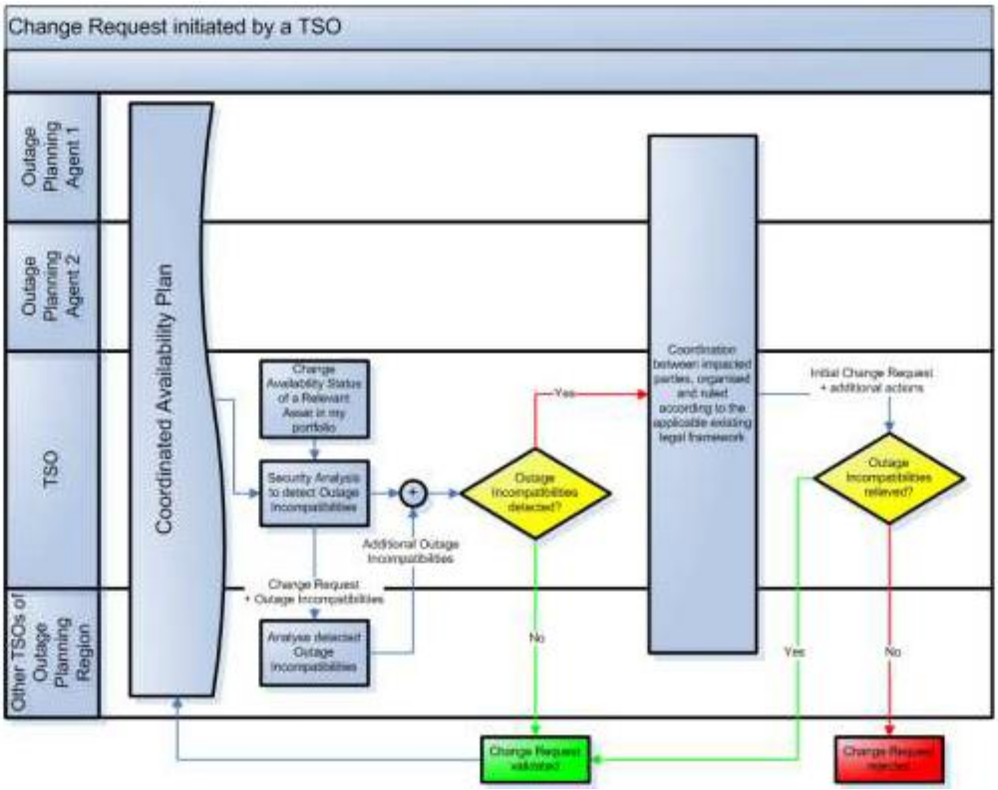

Figure 6. Update procedure for a change initiated by a TSO

9.12.4 Availability of information

Relevant information is shared between TSOs not only on a regional level, but on the EU-wide scale through the means of an ENTSO-E Operational Planning Data Environment (OPDE). Every TSO is obliged to load and update its data (regarding Availability Plans and other information necessary for Security Analysis and coordination) under a common format on this environment, where it is accessible by all EU TSOs (and RSCIs operating within this area). This principle allows a TSO to filter the data that is deemed relevant for its purpose, with the access to the full EU-wide dataset if desired. The data used to develop TSO Availability Plans is limited to those network assets which are named as Relevant assets by the operating TSO. The data to be used from the OPDE used for network security analysis co-ordination is a large data subset.
Currently no such single centralized data environment exists for sharing relevant information concerning Availability Plans between TSOs. Having such a data environment should greatly ease and stimulate collaboration and coordination between TSOs, provides an environment where needed information can be found on request, and enforces TSOs in using common data formats, common timelines and – to a certain level – common methodologies.
The data that a TSO will be required to provide to allow another affected TSO(s) to determine the effects a specific grid element outage(s) will have on its system will vary depending on the time scale that the TSO(s) are looking at. The flags are specified in OPS Article 32 (4) are:

1. Available

2. Unavailable

3. Testing this is applied to items during their commissioning phase or post maintenance work only.

Looking at Year Ahead to Week Ahead Time scales
All grid elements of a transmission or relevant distribution system that should be provided but not limited to the following:

Transmission system element name, dates from and too when Unavailable, with times if known.
Generating unit name and dates when either available or Unavailable. Capability of the unit is available or if restricted what the revised capability is planned to be.
For any large demand connection its name and dates when it is Available or Unavailable or if there is a change in the capability this should be listed.
For any new Grid Element, Generating or Demand unit a TSO must manage this data in their submitted IGM(s) so that it will be flagged as 'Testing'. The dates for commencement and completion of this phase should be provided, along with the capability or restriction to be imposed and the times. If a TSO wanted to have new elements in their IGM(s) significantly before they are due to undergo commissioning then they should be flagged as Unavailable.
Similarly for Grid Elements, Generators or Demand units that are to be removed from a TSO transmission system, the point at which they are no-longer available for configuration or production they should be flagged as Unavailable. At some point in the future after the de-commissioning date the relevant TSO would have to reflect the changes to their Base Network data file of their IGM, to remove the items that are being de-commissioned. Although this type of element outage has no end date, since there will be no return to service, a date which extends past the date of deletion from a TSO system will be needed. The ENTSO-E Operational Planning Data Environment and the TSO IGM(s) will then have to be updated and aligned by the relevant TSO to reflect the removal of equipment from their transmission system.

For all the above if a time for the commencement and removal of the Unavailability or restriction can be given in a granularity of hourly time blocks this is required. Similarly if there is a known Emergency or Non-work completed time to return to Service any item to be Available this should also be provided and any date restrictions to the return to service timings. If for any outage there will need to be a change to the TSO transmission system configuration, this information should also be available.
D-2 and D-1 Time Scales

For these time scales depending on the market type and its time scales for Generation or Demand, that is operated in a particular Bidding Zone or area covered by a particular RSCI, the greater data clarity if available as to the planned/scheduled Generation or demand unit profile(S). If available this increased clarity should be reflected in the available in both the ENTSO-E Operational Planning Data Environment and the various IGM(s) provided for these time scales.
In these time scales a greater clarity as to the necessary system configuration should be known by a TSO. Hence any specific system reconfigurations that will be required to facilitate a particular grid element outage can reasonably be predicted. This data should also be available.
Intraday Time Scales
In this time scale the most significant changes to the transmission system will be Forced Outages. These outages will not have been planned and may pose the greatest risk to the security and/or stability of a particular TSO(s) transmission system. Neighbouring and/or regionally grouped TSO(s) should have agreed critical assets that will be monitored for such an outage. The impact on the capability or availability of the identified critical system network assets should be updated on the ENTSO-E Operational Planning Data Environment and similarly reflected in updated IGM(s) from affected TSO(s).
Once the full implications of any Forced Outage has been determined by the TSO, the details of the outage, the duration for rectification of the transmission system of this outage should be made available via the ENTSO-E Operational Planning Data Environment and updates to the D-1 and D-2 IGM(s) as necessary.
The linking of data made available in the ENTSO-E Operational Planning Data Environment and a data item in a particular TSO submitted IGM has not yet been specified, but this functionality would facilitate data alignment between these two data blocks, especially for those TSO(s) wishing to use availability data about another TSO network which is or likely to impact the operation of their transmission network.

9.12.5 Data exchanges and parties involved in Outage Co-ordination

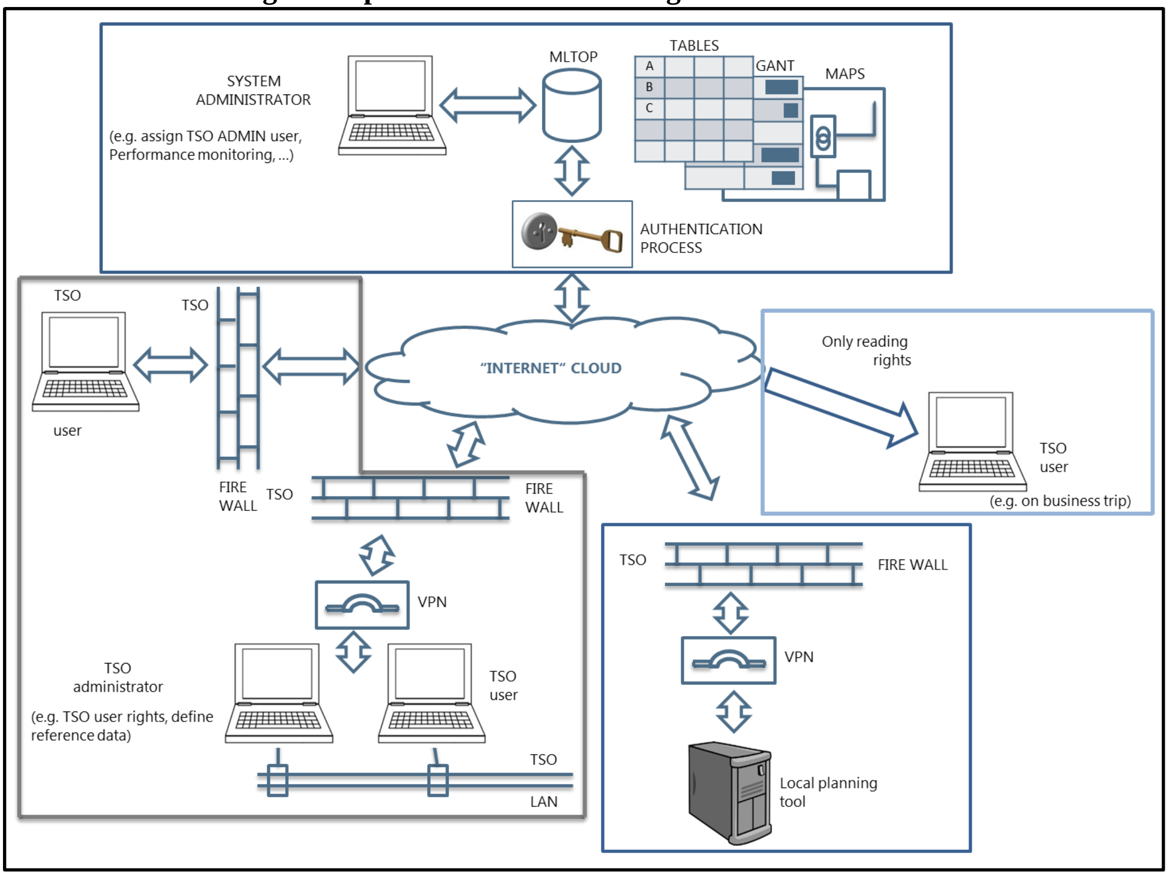

Figure 7. Overview of related systems. Human users with full rights are in the grey box, Automated users are in the dark blue box and should have the rights following the "need to know" principle. New users of human users with restricted access rights are in the light blue box

This is an example of the exchanges between neighbouring TSO(s) carrying out Outage co-ordination. The tool is designed as an application accessible through the Internet. It is secured by individual login-password access extendable via a user token. Different ways how TSO users can access the tool via the Internet are shown in Figure 6. The standard connection is from TSOs' offices through a firewall. Alternatively, this could be extended via a VPN tunnel (or alternatively secured connection) and a firewall. If users cannot connect via a secured gateway e.g. due to a low-bitrate connection users are allowed to access the tool with reading rights only without additional security standards beyond the standard login-password access. However, this is up to individual TSOs' decisions as they are responsible for data changes in the tool. Following Figure6, three different major types of roles are required, a standard user, a system administrator and a local TSO administrator. TSOs decide on the rights which are related to each of their defined user roles. Therefore, operational planning staff can have different rights depending on their individual TSOs.

9.12.6 Business needs

The following business needs can be distinguished:

- a need for outage planners to upload their planned outages to the tool from their administrative (ERP) tools and be able to see data from their neighbours in the tool, so they can simulate the impact in their local LF tools by manually entering these outages. A flag showing the status of the outage: Accepted, Requested (Roughly planned) or Rejected. This is a minimum requirement. This should be possible but even more (see next point):
- a need for outage planners to download data about their neighbours from the tool and load this into their local LF tool, so they can analyse the impact in their local LF tool. It should be possible to download the agreed critical network of neighbouring TSO(s), e.g. all relevant outages and use this data with their local tool. Implementation of this outage data is the responsibility of individual TSO(s). In a later stage a "download" directly to LF Tools should be possible. To be more precise, a download directly to a LF tool is a very simple description, but imagine a download directly to a tool that creates the IGMs together with additional information.
- a need for outage planners to upload their planned outages to the tool from their administrative (ERP) tools, make changes (e.g. shift dates) in and be able to download their own modified data from the tool into their local ERP tools, so they don't have to manually synchronize the two systems. At first it will be a manual up-and download, later it should be more or less an "online" (always up to date)-tool e.g. automatic update based on changes on both sides, either on a local tool or directly in the . There maybe a need for the Outage Co-ordinating TSO to be able to modify another TSOs outages following agreement by all relevant/affected TSO(s).
- a need for outage planners to upload their planned outages to the tool from their administrative (ERP) tools and be able to analyse the impact in the CTDS environment, make changes if necessary and synchronize their local ERP tools. As mentioned above: Between outage information download and impact analysis (with LF and CA calculation) there happens a lot more (IGM creation, validation, merging, etc.). So this possibility is not covered so far but as an idea already existing,
- What is already described as a similar use case is the grid security assessment that is planned as a two step approach. The minimal solution here is to have a grid map where planned outages can be displayed so it is visible on a glance that in a certain region for a certain period of time there a a lot of outages and

this situation has to be further investigated e.g. by doing some additional coordination and/or LF+CA calculation (this is already the second approach).

- A user interface for the outage planners based on equipment (also interface with the ERP tools) and an interface based on switches for the LF tool (so topological changes can be made).

9.13 Attributes that need to be exchanged

For the interface between the local ERP tools and the environment the following attributes are relevant:

Case data:

case ID	• case ID is an identifier individual for each case • starts with TSO code and is a TSO-unique code with letters or numbers • the number of digits is not limited
project ID / name	• if multiple cases belong together, one common project ID for these cases has to be determined by the requesting TSO • additional to case ID
date of last change	• versioning of the case • date and time of last change of the case information of the requesting TSO
Status Information	• Status

Grid Element Data:

Element ID	• Enter the code which is used for the unique identification of this grid element.	• EMFIP required
Coding Scheme	• Enter the name of the coding scheme used.	•
Long Name	• The long name for the grid element(s) has to be provided. • • The following naming convention should be used for new grid elements: • Substation: Voltage level (optional), name • Line: Voltage level (optional), Subst. 1, Subst.2, Subst. X (in alphabetical order), name (optional) • Transformer: Voltage levels (optional), Subst., name • For a transition period the long name field could also be used for UCTE coding for elements	• EMFIP required
Element Type	• LINE (internal overheadline or cable) • TIE (tieline) • DCL (DC-line) • TRA (transformer) • BUB (busbar)	• EMFIP required only for identified Critical Network elements

	• CAP (capacitor) • IND (inductor) • GEN (generating unit) • LOAD (consumption unit) • SUB (substation) • PPL (powerplant-Line)	
Voltage Level [kV]	• Voltage level of the grid element	• EMFIP required
Status	• To be marked whether element is "active" or "inactive" • After an element reaches its end of time it is not simply deleted from the REF data base but its status is changed from active to inactive.	• EMFIP required
Notification	• Add the TSO(s) that should be notified that a case or a change to a case for an element was uploaded/inserted to OPDE (i.e. for creation of the observability area). • Only the "responsible" TSO can fill in other TSOs to be notified. If a TSO wishes to be added to "Notification" he has to contact the responsible TSO by email or phone.	• EMFIP required
Responsible	• TSO that is responsible for reference data maintenance and can send cases (outage planning/availability data for this element). • Exceptions: • If the element type is TIE more than one TSOs can be listed here. The following rules are applicable: • The TSO, that is listed first is responsible for reference data management • All TSOs listed under "responsible" can send cases (outage planning/availability data for this element). • All TSOs listed under "responsible " must be listed under "coordination" as well. (Important for filtering purposes and for coordination process via MLTOP)	• EMFIP required
Planning Region	• Is the element part of a planning or market region eg: DACH, CCE, CWE etc.	• EMFIP required
Co-ordination	• Insert the ISO country code for all TSO(s) who have to coordinate for this element (e.g. tielines) • - TSOs that are listed in this column must not be put to the "notification area" as they will be	• EMFIP required

	notified by the "Coordination process" about cases and changes to a existing case • - The responsible TSO(s) must be put also to this column (for filtering purposes "show all grid elements where I am in coordination")	
Cap Calc Relevance	• Either yes 'Y' or no 'N'	• EMFIP required
Part of Multipod [ID of Multipod]	• Enter the element ID which is used for the unique identification of the multipod.	•
Special relation to another element [ID]	• Add here the element ID of the element that has a special relationship to this element(s). • This information is needed for interdependency checks.	•
Remarks	• If needed any additional information can be provided here.	• EMFIP required

Unavailability Information:

Case type	The case type indicates the status of the involved grid element(s): • OUT: outage (element is out of operation) • 1BBO: single bus bar operation (only valid for Element type Substation "SUB") • xBBO: multi-bus bars operation (only valid for for Element type Substation "SUB"); In field "Operational hint for Substation" it can be indicated which element is connected to which busbar • AUX: auxiliary bus bar operation (element is IN service but connected via Auxiliary busbar) • SSS: special switching state (for element types Substation "SUB", "LINE" and Transformer "TRA"); Elements are in service but in a special switching state • AR: protection function „Automatic reclosing" is switched off • BBprot: protection function „Busbar protection" is switched off • ON: line in operation if off is the default state of the element • NEW: new element which is not yet in operation • EOL: End of lifetime, element is available but cannot be used anymore • ITS: interim solution: element is available only for a limited period of time	• EMFIP required

Alternating	• If two elements are used alternatingly, both elements belong to the same case ID and an "X" is required in this column.	• EMFIP required

Status Information:

Status	Always filled even if no coordination necessary for this element. The following status of the unavailable grid element(s) are possible: • ROP=roughly planned • PID= planned in details • CAN=Cancelled	• EMFIP required

Outage Time:

Start date	• start date of the unavailability • date format DD.MM.YYYY	• EMFIP required
Start time	• start time of the unavailability • time format hh:mm [CET/CEST]	• EMFIP required
End date	• end date of the unavailability • date format DD.MM.YYYY	• EMFIP required
End time	• start time of the unavailability • time format hh:mm [CET/CEST]	• EMFIP required
offset [+/- days]	• additional time period in calendar days in which the unavailability can be started earlier or finalized later	• EMFIP required

Time profile:

Daily / Continuously	• to be marked with "X" if the outage or special switching state is repeated every day referring to the specified times	• EMFIP required
Mo-Fri	• to be marked with "X" if unavailability is on all week days	• EMFIP required
Saturday	• to be marked with "X" is unavailability is on Saturdays	• EMFIP required
Sunday	• to be marked with "X" is unavailability is on Sundays	• EMFIP required
excluded days [date; date]	• dates when the unavailability does not exist • date format DD.MM.YYYY	• EMFIP required

Restitution Information:

max	• maximum restitution time in hours • If no restitution time possible = "N"; if "0"=element can be switched back on "asap"
daytime	• restitution time during daytime in hours
nighttime	• restitution time during nighttime in hours

weekend	• restitution time on weekends in hours

Outage Information:

Cause of request	• Indicates the reason for the outage
remarks	• more specific information about the outage can be provided here such as information about substations and their operation or location specific information such as "between Pylons 123 and 127" (free text)
location	• specification of the location of the unavailable grid element (free text)

Attributes for local approval process information:

Co-ordination status	This field is used for coordination by both, the requester TSO and the requested TSO the confirmation status must be entered here. The following status are possible: • REQ=requested • REJ=rejected • CON=confirmed	• EMFIP required
case-reference (change request)	• if two cases affect each other and the status of one turns to "approved", the status of the other must be changed to "cancelled" and the case ID of the replacing case must be entered here for tracking reasons	•
rejection remark	• If the request is rejected the reason for the rejection can be entered here	•

Generating Unit / Consumers/Compensation Elements:

unavailable capacity	• Enter the unavailable capacity in MW for generation units/consumers and in Mvar for compensation elements (IND, CAP)	• EMFIP required
installed capacity	• Capacity in [MW] for generation and consumption units • Capacity in [Mvar] for compensation elements such as CAP and IND • Negative sign ("-") must be used for consumption units and and IND; generation units and CAP are given as positive value	• EMFIP required
fuel type of generation unit	• For generation units add the fuel type of the unit	• EMFIP required

9.13.1 Introduction

Network models which will be used to construct the various CGM(s) will be based on blocks of data. These will be: Network Topology data, Changes to Network Topology data and Scenario data. The method by which the TSOs will provide data to the Central Merging Function so that the CGM(s) constructed from the various IGM(s) will as true as possible representations of the networks on the ground at the various times both now and in the future.

9.13.2 Base Network Topology Data

The Base Network topology file will for the base data set defining the network of any TSO. To minimise the necessity to continue to resend this data file every time there is a change to the TSO Network. A change file that can be applied to the Base Network file which will implement the change to the base data set so that it reflects the network as on the ground.
At regular intervals a new Base Network Topology file should be re-submitted to consolidate all the change files and remove any doubt as to the actual network topology.

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9.14 Glossary of terms

For the purpose of this specification the following relevant definitions shall apply:

Term	Definition	Source
(N-1)-Criterion	the rule according to which elements remaining in operation within TSO's Responsibility Area after a Contingency from the Contingency List must be capable of accommodating the new operational situation without violating Operational Security Limits	NC OS, Article 2
(N-1)-Situation	the situation in the Transmission System in which a Contingency from the Contingency List has happened	NC OS, Article 2
Aggregated Netted External Schedule	a Schedule representing the netted aggregation of all External TSO Schedules and External Commercial Trade Schedules between two Scheduling Areas or between a Scheduling Area and a group of other Scheduling Areas	NC OPS, Article 2
Allocation Constraints	the constraints to be respected during Capacity Allocation that are needed to maintain the transmission system within Operational Security Limits and were not translated into Cross Zonal Capacity or are needed to increase the efficiency of Capacity Allocation. Allocation Constraints may include constraints related to generation or generation reserves within a Bidding Zone or, constraints related to change of power flows on interconnection between consecutive Market Time Units (ramping constraints) and constraints related to transmission losses on interconnections between Bidding Zones;	NC CACM, Article 2
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, Article 2
Capacity Allocation	the attribution of cross zonal capacity	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Common Grid Mode	a European-wide or multiple-TSO-wide data set describing power system characteristics (generation, loads and grid topology) and rules to change these characteristics during capacity calculation, created through the merging of relevant data;	NC CACM, Article 2
Congestion	a situation in which an interconnection linking national transmission networks cannot accommodate all physical flows resulting from international trade requested by market participants, because of a lack of capacity of the interconnectors and/or the national transmission systems concerned	Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009, Article 2
Congestion Income	the revenues received as a result of Capacity Allocation;	NC CACM, Article 2

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Term	Definition	Source
Constraint	a situation in which there is a need to implement Remedial Action in order to respect Operational Security Limits	NC OPS, Article 2
Contingency	the identified and possible or already occurred Fault of an element within or outside a TSO's Responsibility Area, including not only the Transmission System elements, but also Significant Grid Users and Distribution Network elements if relevant for the Transmission System Operational Security. Internal Contingency is a Contingency within the TSO's Responsibility Area. External Contingency is a Contingency outside the TSO's Responsibility Area, with an Influence Factor higher than the Contingency Influence Threshold	NC OS, Article 2
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, Article 2
Coordinated Capacity Calculator	the role of calculating Cross Zonal Capacity, at least at a regional level and managing the validation process;	NC CACM, Article 2
Countertrading	a cross zonal exchange initiated by system operators between two bidding zones to relieve physical congestion	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Critical Network Element	a network element either within a bidding zone or between bidding zones taken into account in the capacity calculation process, limiting the amount of power that can be exchanged	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Critical Network Element Flow Margin	the maximum additional flows allowed on Critical Network Elements as a consequence of the changes in Net Positions resulting from Capacity Allocation in Capacity Calculation Region;	NC CACM, Article 2
Cross Zonal	across a border between two bidding zones;	NC CACM, Article 2
Cross Zonal Capacity	the capability of the interconnected system to accommodate energy transfer between bidding zones	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Cross Zonal Capacity	the capability of the Interconnected System to accommodate energy transfer between Bidding Zones. It can be expressed either as a Coordinated Net Transmission Capacity value or Flow Based Parameters,	NC CACM, Article 2
Cross-Border Flow	a physical flow of electricity on a transmission network of a Member State that results from the impact of the activity of producers and/or consumers outside that Member State on its transmission network	Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009, Article 2

Term	Definition	Source
Day Ahead Market	the market timeframe until the Day Ahead Market Gate Closure Time where commercial electricity transactions are executed the day prior to the day of delivery of traded products for each market time Unit,	NC CACM, Article 2
Dynamic Stability	a common term including the Rotor Angle Stability, Frequency Stability and Voltage Stability	NC OS, Article 2
Dynamic Stability Assessment (DSA)	the Operational Security Assessment in terms of Dynamic Stability	NC OS, Article 2
Exceptional Contingency	the loss of a busbar or more than one element such as, but not limited to: a common mode Fault with the loss of more than one Power Generating Module, a common mode Fault with the loss of more than one AC or DC line, a common mode Fault with the loss of more than one transformer	NC OS, Article 2
Explicit Allocations	the allocation of cross zonal capacity only, without the energy transfer	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
External Commercial Trade Schedule	a Schedule representing the commercial exchange of electricity between Market Participants in different Scheduling Areas	NC OPS, Article 2
External TSO Schedule	a Schedule representing the exchange of electricity of TSOs between different Scheduling Areas	NC OPS, Article 2
Flow Based Approach	a method for capacity calculation in which the exchanges between Bidding Zones are limited by the maximum flows on the Critical Network Elements and Power Transfer Distribution Factors;	NC CACM, Article 2
flow Based Parameters	the available margins on critical network elements with associated power transfer distribution factors	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Forward	the timeframe in which transmission rights are allocated ahead of the Day Ahead timeframe	NC FCA, Article 2
Forward Capacity Allocation	the attribution of Long Term Cross Zonal Capacity through an auction	NC FCA, Article 2
Generation Shift Keys	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;	NC CACM, Article 2
Implicit Allocation	a congestion management method in which energy is obtained at the same time as cross zonal capacity	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2

Term	Definition	Source
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;	NC CACM, Article 2
Interconnector	a transmission line which crosses or spans a border between Member States and which connects the national transmission systems of the Member States	Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009, Article 2
Internal Commercial Trade Schedule	a Schedule representing the commercial exchange of electricity within a Scheduling Area between different Market Participants or between Nominated Electricity Market Operators and Market Coupling Operators	NC OPS, Article 2
Intraday Market	the electricity market which operates for the period of time between Intraday Cross Zonal Gate Opening Time and Intraday Cross Zonal Gate Closure Time, where commercial electricity transactions are executed prior to the delivery of traded products after Day Ahead Market Gate Closure Time for Standard and Non-Standard Intraday Products; ;	NC CACM, Article 2
Long Term	a time period longer than 24 hours;	NC FCA, Article 2
Market Congestion	a situation in which the Economic Surplus for the single day-ahead or intraday coupling has been limited by the Cross Zonal Capacity or other active Allocation Constraints;	NC CACM, Article 2
Market Participant	market participant within the meaning of the Regulation (EU) No 1227/2011 of the European Parliament and of the Council of 25 October 2011 on wholesale energy market integrity and transparency;	NC CACM, Article 2
Net Position	the netted sum of electricity exports and imports for each Market Time Unit for a Bidding Zone.	NC CACM, Article 2
Netted Area AC Position	the netted aggregation of all AC-external Schedules of an area	NC OPS, Article 2
Network	plant and apparatus connected together in order to transmit or distribute electrical power	NC RfG, Article 2
Network Operator	an entity that operates a Network. These can be either a TSO, a DSO or CDSO	NC RfG, Article 2
Nomination	the notification of the use of Long Term Cross Zonal Capacity by a Physical Transmission Rights holder and their counterparty to the respective Transmission System Operator(s)	NC FCA, Article 2

Term	Definition	Source
N-Situation	the situation where no element of the Transmission System is unavailable due to a Fault	NC OS, Article 2
Offered Capacity	the cross zonal capacity offered by the transmission capacity allocator to the market	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Operational Security	keeping the Transmission System within agreed Operational Security Limits;	NC CACM, Article 2
Ordinary Contingency	the loss of a Transmission System element such as, but not limited to: a single line, a single transformer, a single phase-shifting transformer, a voltage compensation installation connected directly to the Transmission System; it also means the loss of a single Power Generating Module connected directly to the Transmission System, the loss of a single Demand Facility connected directly to the Transmission System, or the loss of a single DC line	NC OS, Article 2
Out-of-Range Contingency	the simultaneous loss, without a common mode Fault, of several Transmission System elements such as, but not limited to: two independent lines, a substation with more than one busbar, a tower with more than two circuits, one or more Power Generating Facilities with a total lost capacity exceeding the Reference Incident	NC OS, Article 2
Planned	an event known ex ante by the primary owner of the data	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Power Transfer Distribution Factor	a representation of the physical flow on a critical network element induced by the variation of the net position of a bidding zone	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Profile	a geographical boundary between one bidding zone and several neighbouring bidding zones	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Redispatching	a measure activated by one or several system operators by altering the generation and/or load pattern in order to change physical flows in the transmission system and relieve a physical congestion	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Reliability Margin	the necessary margin reserved on the permissible loading of a Critical Network Element or Cross Zonal Capacity to cover uncertainties of power flows in the period between the capacity calculation and real time, taking into account the availability of Remedial Actions;	NC CACM, Article 2
Remedial Action	a measure activated by one or several TSOs, manually or automatically, that relieves or contributes to relieving Physical Congestions, for example redispatching or countertrading.. They can be applied pre-fault or post-fault and may involve costs;	NC CACM, Article 2

Term	Definition	Source
Remedial Action with costs	a Remedial Action with direct payments made to procure the service which may include but shall not be limited to Countertrading and Redispatching;	NC CACM, Article 2
Remedial Action without costs	a Remedial Action without direct payments by a TSO;	NC CACM, Article 2
Rotor Angle Stability	the ability of synchronous machines to remain in synchronism under N-Situation and after being subjected to a disturbance	NC OS, Article 2
Scheduled Exchange	the transfer scheduled between geographic areas, for each Market Time Unit and for a given direction;	NC CACM, Article 2
Stability Limits	the permitted operating boundaries of the Transmission System in terms of respecting the constraints of Voltage Stability, Rotor Angle Stability and Frequency Stability	NC OS, Article 2
Structural Congestion	congestion in the Transmission System that can be unambiguously defined, is predictable,, is geographically stable over time and is frequently reoccurring under common circumstances;	NC CACM, Article 2
System Security	the ability of the power system to withstand unexpected disturbances or contingencies;	NC CACM, Article 2
Transitory Admissible Overloads	the temporary overloads of Transmission System elements which are allowed for a limited period and which do not cause physical damage to the Transmission System elements and equipment as long as the defined duration and thresholds are respected	NC OS, Article 2
Transmission Capacity Allocator	the entity empowered by TSOs to manage the allocation of cross zonal capacities	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Voltage Stability	the ability of a Transmission System to maintain acceptable voltages at all buses in the Transmission System under N-Situation and after being subjected to a Disturbance	NC OS, Article 2
Year-Ahead Forcast Margin	the difference between the yearly forecast of available generation capacity and the yearly forecast of maximum total load taking into account the forecast of total generation capacity, the forecast of availability of generation and the forecast of reserves contracted for system services	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2

9.15 EMFIP Data to be exchanged

Data Items to be supplied by TSO, DSO or Generators:

- Out-turn total Load per Market time unit
- Forecast total load 9D-1, W-1, M-1 and Y-1
- planned and unplanned unavailability of consumption units (.100 MW)
- Y-1 forecast Margin
- Future changes to transmission infrastructure [including interconnectors]
- Planned and unplanned availability of transmission infrastructure
- Estimation and offer of cross zonal capacities
- Use of cross zonal capacities
- Congestion management measures [re-dispatching and countertrading]
- Total installed capacity [Production units =>1 MW]
- Details of existing & planned production units [=> 100 MW]
- D-1 estimate of scheduled generation
- D-1 forecast of RES production
- Planned and unplanned availability of generation [=> 100 MW]
- Actual aggregated generation by production type
- Actual or estimated RES output

10 Appendix E: Profiles for capacity calculation – use cases and requirements - for information (2014)

10.1 Context

10.1.1 Introduction

Article 16 of Regulation (EC) No 714/2009 states that the maximum capacity of the interconnections and the transmission systems affecting cross-border flows shall be made available to market participants, complying with safety standards of secure network operation and that network congestion problems shall be addressed with non-discriminatory market-based solutions which give efficient economic signals to the market participants and TSOs involved.

This Regulation defines common rules for capacity calculation and allocation in the day ahead and intraday timeframes and is meant to introduce an ultimately EU-wide system of day-ahead and intraday market coupling.

To implement market coupling, the available cross-border capacities need to be calculated jointly by the TSOs. For this purpose, they establish a common grid model including estimates on generation, load and network status for each hour. The available capacities will normally be calculated according to the so-called flow-based calculation method, a method that takes account that electricity can flow via different paths and optimises the representation of available capacities in meshed grids.

The available cross-border capacities are one key input for the further calculation process, in which all EU bids and offers, collected by power exchanges, are matched, taking into account the available cross-border capacities in an economically optimal manner. Market Coupling ensures that power usually flows from low price to high price areas. The Market Coupling Operator, hereinafter MCO, uses a specific algorithm to match bids and offers in an optimal manner. As a monopoly function, the MCO function will be regulated. The results of the calculation are made available to all power exchanges on a non-discriminatory basis. Based on the results of the calculation by the MCO, the power exchanges inform their clients on the successful bids and offers. Subsequently, the energy is transferred across the network according to the results of the MCO calculation. A similar process applies for the single intraday market coupling, with the exception that it uses a continuous process of auctions throughout the day and not one single calculation as in day-ahead.

The capacity calculation covers the day ahead and intraday market timeframes. Capacities will be updated in a timely manner based on latest information through an efficient capacity calculation process.

Capacity calculation will be coordinated at least at a regional level to ensure reliable capacity calculation and that optimal capacity is made available to the market. Common regional capacity calculation methodologies will be established to define inputs, calculation approach, and validation requirements.

There are two permissible approaches when calculating cross zonal capacity: Flow based or coordinated net transmission capacity based. The flow based approach is preferred over the coordinated net transmission capacity approach for day ahead and intraday capacity calculation where interdependencies of cross zonal capacity between bidding zones is high. Flow based approach should only be introduced after market participants have been consulted and given sufficient preparation time to allow for a smooth transition. The coordinated net transmission capacity approach may be applied in regions where interdependencies between cross zonal capacity are low and there is no added value to apply the flow based approach.

A common grid model representing the European interconnected system, will be established to calculate cross zonal capacity in a coordinated way. The common grid model will include a model of the transmission system and with the location of generation and load units relevant to cross zonal capacity calculation. The provision of accurate and timely information by each TSO is essential to the creation of the common grid model.

The common grid model will require each TSO to prepare an individual grid model of their system and send it to TSOs responsible for merging them into a common grid model. The individual grid models will include information from generation and load units.

TSOs will use a common set of remedial actions to deal with both internal and cross zonal congestions. TSOs will coordinate the use of remedial actions in capacity calculation to facilitate more efficient capacity allocation.

Bidding zones will be defined to ensure efficient congestion management and overall market efficiency. Bidding zones can be subsequently modified by splitting, merging or adjusting the zone borders. Bidding zones will be consistent across different market timeframes.

10.1.2 European electricity markets

With the opening of the electricity markets in Europe by the Directive (EU96/92), enforced on 19 February 1999, it was obvious that the European market integration would not lead to a copper plate. The variety of the generation mixes among the fifteen member states and the available transfer capacity of the interconnectors resulted in the initiative for regional markets interfaced by bottlenecks, rather than one single market with a unique price. European authorities quickly understood this situation and defined a new European Regulation enforced since 1 July 2004, which promotes market based congestion management mechanisms, capable of providing efficient use of the interconnectors as well as supporting appropriate market signals giving the right incentives for investments in transmission capacity of generation capacity.

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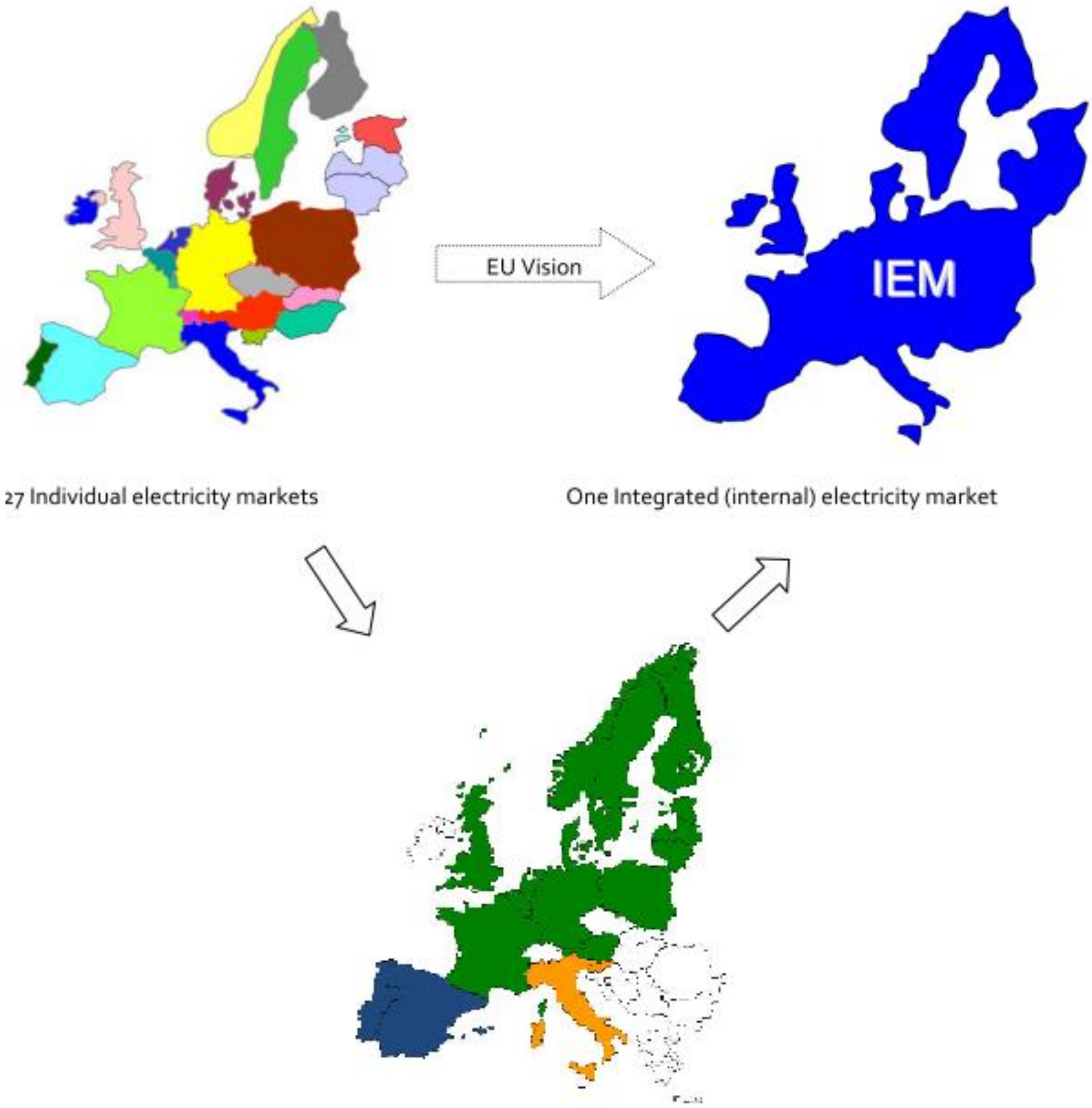

Figure 8. Integration of electricity markets in Europe

10.1.3 Market splitting

Market splitting is an implicit auction process where the capacity is traded simultaneously with the energy. In case of congestion, the market is split into two or more bidding zones (price areas). Each bidding zone is then balanced while fully utilizing the transfer capacities between the bidding zones.

Larger areas with uniform prices are important for the competition and the market splitting approach therefore has many advantages from this point of view. The economic outcome from market splitting would be quite similar to the outcome from market coupling, but the process of getting there is different.

Market splitting is applied in the Nordic market, where the following steps are taken:

- The whole market is divided into smaller bidding zones, mainly defined along the structural bottlenecks (power transfer corridors).
- The TSOs calculate the transfer capacity for each corridor and the capacities for each hour are allocated to the power exchange for trade in the Day-Ahead market. Information on capacities are given to the markets every morning.

- Market participants can then submit their bids in a bidding zone. Transactions must be balanced for each bidding zone.
- Market clearing is performed for each hour by the latest at 2 AM Day Ahead of operation.
- First an uncongested market clearing is performed for the whole market. Flows between bidding zones are checked against the available transfer capacity. In case of violations, the market is split into two bidding zones and clearing is done for each zone.
- This iteration process continues until all corridors are within their limits. All market participants will be compensated and charged according to the market prices in the area they are located.
- The market participants' obligations within each bidding zone are then the basis for a nodal schedule of generation infeed, which are submitted to the TSOs and will be the basis for calculating deviations from the schedules and for billing purposes.

The market splitting method requires a centralized market operator that combines the bids in a market clearing procedure. The market splitting stimulates the competition due to a relative amount of market participants within the same bidding zones. The implicit auction principle guarantees that the capacity is made available to the market participants in a non-discriminatory way since no single market actor can reserve the capacity for its own use. In case of congestion all the market participants can readily see the impact, since the prices will rise in the deficit area. This gives the right incentives to the market participants at both sides of the congested corridor. The price in an area also reflects the value of the electricity for the market participants.
Congestion between the bidding zones will generate a congestion rent to the TSOs, which is equal to the difference between the gross payments by load and the total payments to the generators. According to the EU Directive this congestion rent can only be used for transmission capacity investments, reduced tariffs or counter-trade. In the market splitting method the central load dispatch has been replaced by market forces. This gives as result a system where generation and load are balanced already in the planning phase.
During the operating hour there is a decentralized dispatch where the generators follow their schedules. The System Operators will take care of the imbalances occurring after the planning by using the balancing market.

10.1.4 Flow-based market coupling

New regulatory guidelines of the EU prescribe the implementation of Flow-based Market Coupling.. In the Flow-based Market Coupling the commercial energy bids and available capacity are evaluated simultaneously in an iterative process which should lead to a more efficient use of transmission capacity with respect to commercial value. Optimization is performed based upon commercial bids and the assumed linear relation between accepted bids and physical flows in the flow gates, defined in the Power Transfer Distribution Factor (PTDF) Matrix.
Flow-based Market Coupling is an implicit auction similar to the market splitting, but performed in an opposite order. First each sub-market is cleared, and then the markets are coupled. It is a mixture of a "flow-based modelling" and a "Decentralized Market Coupling". A "flow-based modelling" considers the physical flows that can be exchanged between the different electric systems, taking into account the mutual influence of the exchanges. A "Decentralized Market Coupling" is a method to execute a coordinated market among different markets, using their own market rules in each area.
A simplification must be made, considering that a joint system can be operated as a number of single-price regions, connected with the other regions by interconnectors. The real flow between different nodes is modelled by flow factors and the limits between nodes are calculated taking into account the influence of the bottleneck capacities on the so-called critical network elements (not necessarily the interconnectors).
Bottleneck capacities (F_{max} and F_{ref}) and flow factors (PTDF) need to be estimated and published in advance to inform users and updated before operation of the Day-Ahead market by the TSOs. This information is required by the Day-Ahead markets to describe the state of the simplified transmission model used for the Flow-based Market Coupling.

10.2 Use cases

10.2.1 Introduction

Capacity calculations that take into account the bottlenecks in the grid require a model that is a physical description of the network by means of its critical network elements which might be congested as a result of cross-border market activity.
The ability to transmit power shall be calculated for each state of operation. This applies both to transmissions within each subsystem and to exchanges between subsystems. Most frequently, this is achieved by means of a transmission corridor (connecting line) being defined, and static and dynamic simulations determine how much power can be transmitted in any direction through the corridor before thermal overloads, voltage collapse and/or instability arise following a dimensioning fault. In the corridor, an arbitrary number of lines on different levels of voltage can be included.

10.2.2 Power transfer corridors

From time to time there are certain parts of the grid where transmission demands exceed transmission capacity. When this happens a restriction will occur in the transmission network. Power Transfer Corridors (PTC) are defined in the EMS as a mean to handle and supervise this type of restrictions in the power system. A PTC is a terminology to express the N-1 contingencies from experience and offline studies. A PTC is a way to monitor that operation is secure against a failure in the power network. Monitoring PTCs are of primary importance for the reliable operation of the transmission system at some TSOs.
PTCs can be related to stability -, voltage collapse - and thermal limits. A PTC consists of one or more branches. PTC Limits are determined in two ways, either Operator defined limits, or limits calculated by Network Applications using (N-1) contingency analysis based on thermal, voltage collapse and stability criteria.
Regardless of the nature of a PTC, the power transfer in a PTC is a sum of weighted flows on a set of branches.
The PTC shall be defined as:
PTC_<name>= W1 * Branch_1_Flow + W2 * Branch_2_flow + W3 * Branch_3_Flow + …. + Wn * Branch_n_flow
Wn: A weighting factor –1.0 < =W >= 1.0
Branch_flow: The MW or directional MVA flow of Branch_n

Real-time and study Network Analysis functions shall check and report violations of PTC limits the same way as branch limit violations. PTC limits shall be determined on-line based on thermal, voltage collapse and stability criteria.
A user interface shall be provided to display PTC information. For each PTC, this information shall include the equipment names and limits of the branches. This PTC information shall be used by Network Analysis functions to check and report PTC limit violations. Remedial actions that will remove PTC limit violations shall be suggested by Network Analysis functions.
Short time limits for the branches shall be used for PTC limit calculations. If the warning limit for the branch is violated the alarm limit shall be used.
The information available for the Operator referring to a particular PTC shall include PTC name, calculated power flow, thermal limit, voltage limit, dynamically stability limit, Operator defined limit and percentage loading referred to the limits.
The Operator shall be able get more detailed information about a particular PTC regarding the contingencies leading to the respective limits and details about the calculation leading to the limit. A list of the lines defined for a particular PTC with their weighted flow and respective limits shall be available.
Some examples of user-defined PTCs are explained below.
Example 1: The PTC „Tunnsjødal/Kobbelv-snittet"
The PTC is defined as the weighted sum of the following 4 branches:
M 300 Tunnsjødal – Namsos (L1_flow)
M 300 Tunnsjødal – Verdal (L2_flow)
N 420 Kobbelv – Ofoten (L3_flow)

M 220 Nedre Røssåga – T_Gejmån (L4_flow)
PTC_flow= L1_flow + L2_flow + L3_flow + L4_flow

In this example all weighting factors are 1.

The user defined PTC limit is 1200MW and is based on stability criteria by experience.

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Example 2: A PTC when 420 Dagali-Nore is out of service.
The PTC is defined as:
S 300 Hemsil-Sogn (L1_flow)
S 300 Nes-Sogn (L2_flow)

PTC_flow = 0.4 * L1_flow + L2_flow

In this example all weighting factors are 0.4 and 1.
The PTC limit is depending on the temperature. For instance if the temperature is 20° C the short time limit is 605MW and the alarm limit is 520MW, but if the temperature is 30° C the short time limit is 520MW and the alarm limit is 435MW.

10.2.3 Critical network elements for CWE area

10.2.4 Definition

The essential part of the advanced flow-based approach is to make the contingency analysis an integral part of the allocation process and perform it with the same "philosophy" as the operational security of supply. Thus, the critical network elements include a number of combinations of network elements with additional constraints, such as unplanned production, demand side changes, storage capacity and forced outage of equipment.
Using the whole network and the relevant constraints would result in an enormous amount of constraints: e.g. an entire N-1 analysis of the grid of the region would include about 100 million constraints.
The observation of the grid is reduced to a number of 'critical network elements", which are the line segments or combination of lines (like power transfer corridors) that significantly influence the cross-border allocation and that are at risk to be constrained due to network security reasons, and that can include a number of combinations with additional constraints.
The following scheme illustrates the process: only the black lines will be considered in the simplified model in combination with a number of contingency cases:

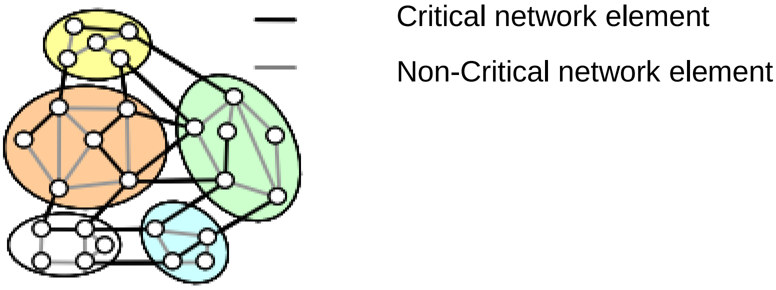

Figure 9. Grid model and critical network elements

Each critical network element is represented in the flow-based allocation mechanism by means of:

- their PTDF (Power Transfer Distribution Factors),
- the flow that is already present prior to the allocation (F_{ref}),
- the maximum allowable flow (F_{max}), expressed in A
- a Flow Reliability Margin (FRM), expressed in MW
- a final adjustment value (FAV), expressed in MW
- the direction of the flow that triggers the violation of the limit

The critical network elements are constituted of the following:

- All tie lines: tie lines are of course very sensitive to cross-border exchanges, so that all of them should be included in the set of critical branches.

- The internal lines that are critical to cross-border exchanges: some internal lines are sensibly exposed to cross-border exchanges and can be the reason for a limitation of cross-border exchanges[3]. In this case, they are included in the set of critical network elements.
- All these elements can be mixed with additional constraints: unplanned production, demand side changes, storage capacity and forced outage of equipment. This represents the fact that the "criticality" of a critical network element under constraint conditions varies with the dispersion of cross-border exchanges and hence the market scenario.

Limitations in both directions of a network element are represented by one critical network element in each direction.
Example 3: The possible limiting constrains due to one interconnection line in all network situations could, for example, be represented by 6 critical network elements: 1 normal (N) situation and 2 different constraining N-1 situations, each in both directions.

10.2.5 Computation

The exact determination of critical network elements is decided by each TSO, with respect to the expertise of their internal network, expertise on the criticality of each element in its network and the conditions (load, generation, topology, etc) forecast for day D.
Though, this approach can be completed by reducing mathematically the amount of those constraints which are redundant compared to other more strict ones. This approach can be used for a pre-selection of the critical branches and contingencies which are possibly congested and discard the ones which cannot be binding.
The network elements within the grid that will be seen as "critical" during the allocation might change in time, due to topology changes, maintenance, grid reinforcements etc. So, the review and update of the critical network elements file that is used for the allocation will be a continuous task for operation.
Typically, the number of critical network elements in the CWE region varies between 1000 and 2000, whereas the total number of nodes of the whole 400 and 225 kV is approximately 10,000. Mathematical filtering however allows reducing the amount of constraint to less than 100 in practical cases (and this without altering in any manner the network security).

10.2.6 Maximum allowable flow (Fmax)

The Fmax is a physical quantity of each critical network element. Depending on the equipment of the precise critical network element and on the possible remedial actions available on the network, this value can be set at:

- The maximum value of the protective relay that limits the power flow
- The thermal limit of the equipment
- The value that will induce a voltage collapse
- The value that will induce instability
- In some cases, the physical value can be modified to take into account the congestion relief provided by remedial actions.

[3] It should be noted that the influence of those lines is only linked to the physics of the network, but is completely independent of the methodology that is used to evaluate the maximum cross-border exchanges. In the case of an ATC based methodology, the impact of these lines is also taken into account in the calculation of the ATC. This practice is coherent with the Congestion Management Guidelines, that state that the cross border capacity should not be limited in order to solve internal constraint, except for reasons of operational security of the network.

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If one line is represented by n critical network elements (e.g. 2 directions and 2 situations, 1 N and 1 N-1), then the Fmax will generally be the same for these n critical network elements. Though, in some particular cases when different remedial actions can be used in different situations, they can be different between N and N-k situation, and even between two different N-k situations.

10.2.7 flow reliability margin (FRM)

Some uncertainty is created through this process, and is mainly due to:

- The grid forecast two days ahead
- The linear representation of the grid by means of PTDF

The uncertainty involved in the flow-based process must be quantified and discounted in the allocation process, in order to prevent that on day D the TSOs are confronted with flows that exceed the maximum allowed flows. In order to cover this uncertainty, for each critical network element a Flow Reliability Margin (FRM) is defined, that quantifies how the uncertainty impacts the flow on the critical network element.
The FRM reduces the available space on the critical network elements because a part of this free space must be reserved to cope with these uncertainties.
For each critical network element, the capacity that can be put at the disposal of the day-ahead allocation by the market coupling is defined as: F_{max} – FRM - F_{ref}.
The FRM for each critical network element can neither be obtained from the D-2CF base case nor is it a physical quantity of the line; the FRM is based on operational experience with the D-2CF/flow-based procedure.
The FRM can be split into two margins:

- FRM1: uncertainty linked to the grid forecast two days ahead. This margin can be quantified for instance by comparing the forecasted flow and the realised flow on each critical network element
- FRM2: uncertainty linked to the linear representation of the grid by means of PTDF. This margin can be quantified by comparing the results of an AC loadflow and of a DC loadflow.

The testing of the flow-based methodology conducted by R4CA working group allowed to define a global methodology to primarily set the FRM of each critical network element to 10% of Fmax, which gives FRM values between 150 MW and 300 MW for a 380kV line, and, between 30 MW and 60 MW for a 220 kV line. Though, this first setting of the FRM of each critical network element and will be subjected to a continuous observation and adjustment process by the responsible TSO, during operational testing and after starting of the FBMC.

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10.2.8 PTDF matrix computation

The following picture illustrates the computation of the PTDF matrix which is to be calculated for each base case situation:

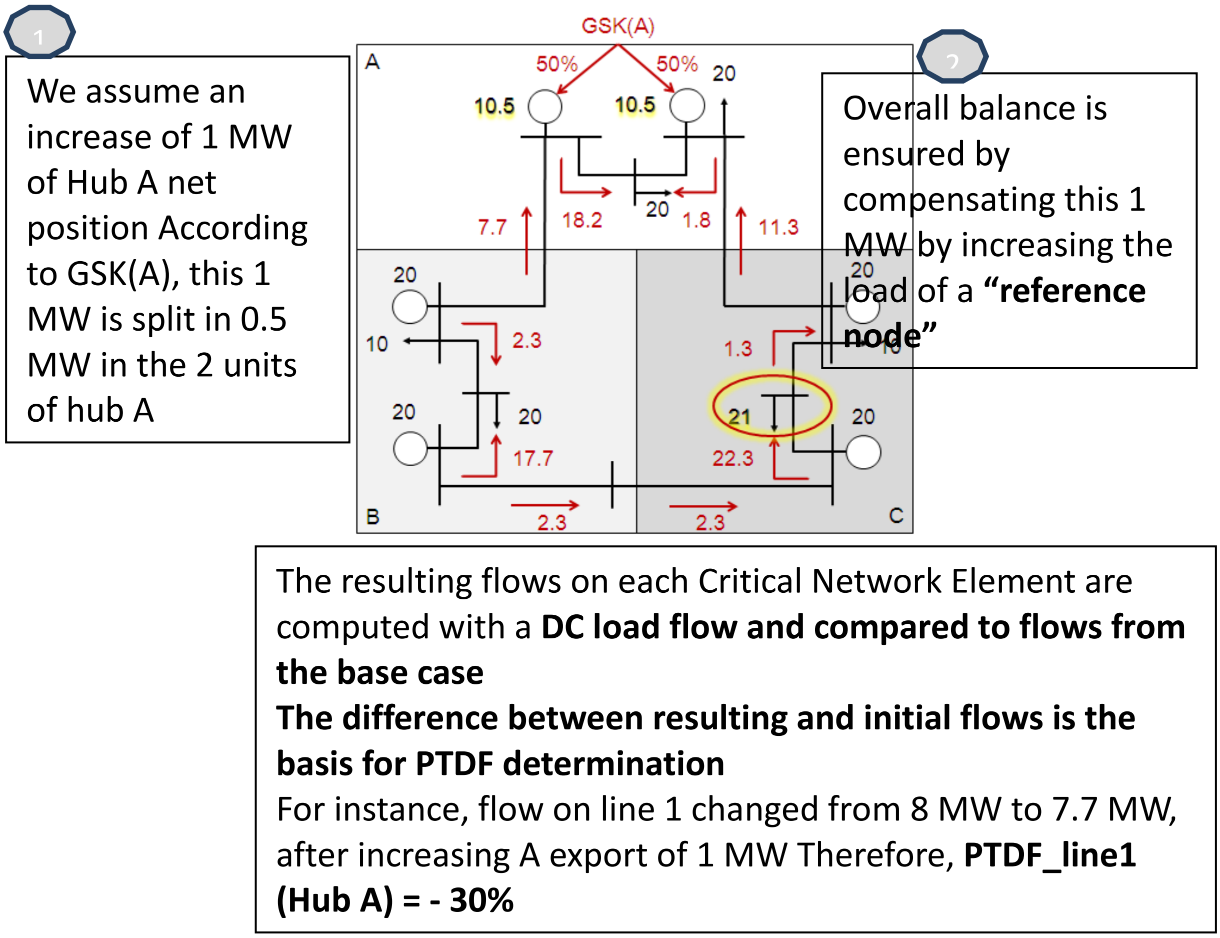

Figure 10.FB parameters computation: PTDF matrix

The process described in figure 3 is repeated for every hub. PTDFs are also computed for every constraint condition when deemed relevant by the TSOs. An exchange of 1 MW from zone A to zone B (for example) is equivalent to:

An exchange of 1 MW **from hub A to the reference node**		An exchange of 1 MW **from hub B to the reference node**

This property holds due to the linearity of the PTDF computation (DC load flow). “Hub-to-hub” PTDFs are therefore easily derived by subtracting the “hub-to-reference” PTDFs computed before.

The following picture shows an example of a PTDF matrix:

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QaVT 9'0	Sorting	All Corners		RefProg
	Max. Remaining Margin	100	Bilateral Exchange NL=>BE	-1401
	Show Critical Network Elements	NL	Bilateral Exchange NL=>DE	-1151
	Hour	20	Bilateral Exchange DE=>FR	227
	Mode	FB Domain Vertices	Bilateral Exchange BE=>FR	-1326
	Only show PTDF |max| >=	-10.000	Corner	0
	Only show PTDF |max| <=	10.000	Net Position BE	75
	Show NP & BEX as	Relative to 0_Margin	Net Position DE	1378
	Show Margin or Flow	Remaining MW Margin	Net Position FR	1099
	Business Date	2013-déc-25	Net Position NL	-2552

Constraint	RA	Critical Element Name	Hr	PTDF BE=>NL	PTDF NL=>DE	PTDF DE=>FR	PTDF FR=>BE	PTDF |max|	Fmax	FRM	FAV	MCO	0-Mrgn	
BASECASE		XVY_MB1 > NMBT381 : MBT-VYK380 W	20	0.220	-0.034	-0.078	-0.108	0.220	1421	355	0	82	686	700
BSL-ZVL380 G outaged		XVY_MB1 > NMBT381 : MBT-VYK380 W	20	0.232	-0.041	-0.081	-0.110	0.232	1421	355	0	72	916	708
MBT-RMK380 W outaged		XSI_MB1 > NMBT381 : MBT-SDF380 Z	20	0.035	-0.247	0.081	0.131	-0.247	1801	163	0	0	1403	877
MBT-VYK380 Z outaged		XVY_MB1 > NMBT381 : MBT-VYK380 W	20	0.253	-0.038	-0.093	-0.122	0.253	1421	355	0	0	930	716
MEE-DIL380 W outaged		NMEE381 > XDI_ME1 : MEE-DIL380 Z	20	-0.122	0.187	-0.041	-0.025	0.187	1053	219	0	0	747	1176
MEE-DIL380 W outaged		XDI_ME1 > NMEE381 : MEE-DIL380 Z	20	0.122	-0.187	0.041	0.025	-0.187	1053	249	0	33	891	462
MEE-DIL380 Z outaged		NMEE381 > XDI_ME1 : MEE-DIL380 W	20	-0.122	0.187	-0.041	-0.025	0.187	1053	219	0	0	747	1176
MEE-DIL380 Z outaged		XDI_ME1 > NMEE381 : MEE-DIL380 W	20	0.122	-0.187	0.041	0.025	-0.187	1053	249	0	33	891	462
ZVL-GT380 W outaged		XVY_MB1 > NMBT381 : MBT-VYK380 W	20	0.240	-0.041	-0.086	-0.114	0.240	1421	355	0	0	873	660
BASECASE		> :	20	1.000	-1.000	0.000	0.000	1.000	4150	0	0	0	4150	1598
BASECASE		> :	20	-1.000	1.000	0.000	0.000	-1.000	4150	0	0	0	4150	6702

Figure 11.Example of a Dutch PTDF matrix

10.2.9 Generation and load shift keys, (Power Shift Key)

The GSK, Generation Shift Key, is the best TSOs' estimate on how the generation in each price area is scaled on each generator. By default the scaling of the generation in the price area has been performed on a pro-rata basis, which means that the ratio of each generator to the total generated power in the country remains unchanged.

Optionally, a different GSK can be defined by each TSO, based on its experience of the producers on its network. The use of GSK is a simplification of the complex problem of generation scaling, and it introduces an error that must be quantified precisely and taken into account while assessing the FRM.

The Generation Shift Key file defines the nodes which will participate in the generation shift applied for various calculations. It can either contain the nodes that participate or the nodes that don't participate. The GSK algorithm for balance adjustments purposes shall consider the operational limits of generators.

Optionally a list of nodes can be defined that participate in the Load Shift. A percentage value has to be defined between GSK and LSK; in case no LSK is defined the percentage for GSK is 100%. 4 types of shift can be defined in GSK and LSK lists:

1) PROP: proportionally to base case generation or load
2) FACT: according to the participation factors
3) RESERVE: proportionally to the remaining available capacity
4) MERITORDER: generating nodes shift according to different merit order lists for shifting up and down

10.2.10 Adjustment of the calculated flows

In the flows observed in the base case (F_{ref}) the impact of the simulated cross-border trade is reflected. The flows are adjusted in accordance to the graph below, by using the PTDF computed before:

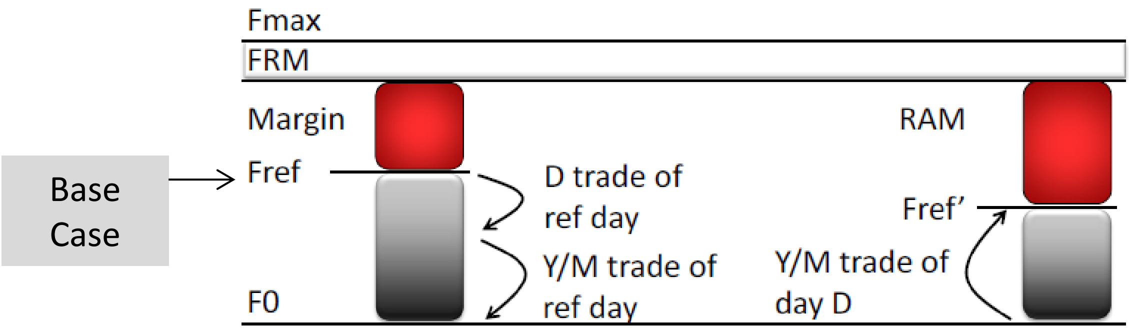


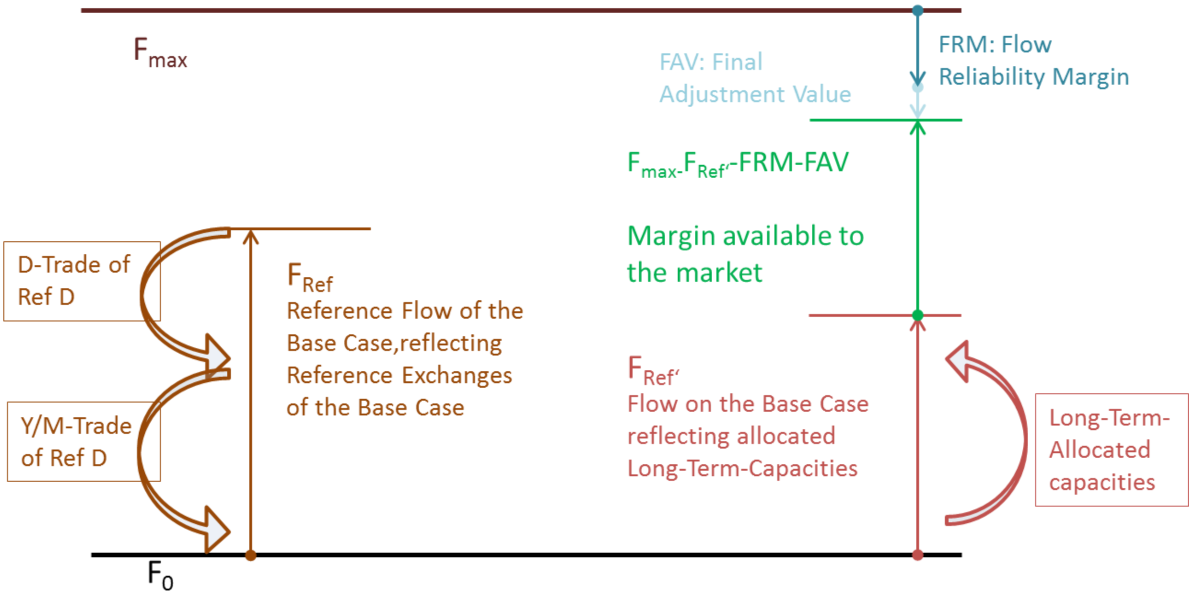
Figure 12.Adjustment of the calculated flows

The Flow-based Market Coupling calculation will then compute the Remaining Available Margin (RAM) for every Critical Network Element:

$$RAM' = Fmax - Fref' - FRM > 0,$$

$$RAM = Fmax - Fref + \sum_{i=hub} PTDFi * (Refprog\ i - LTAi) - FAV - FRM\ (> 0)$$

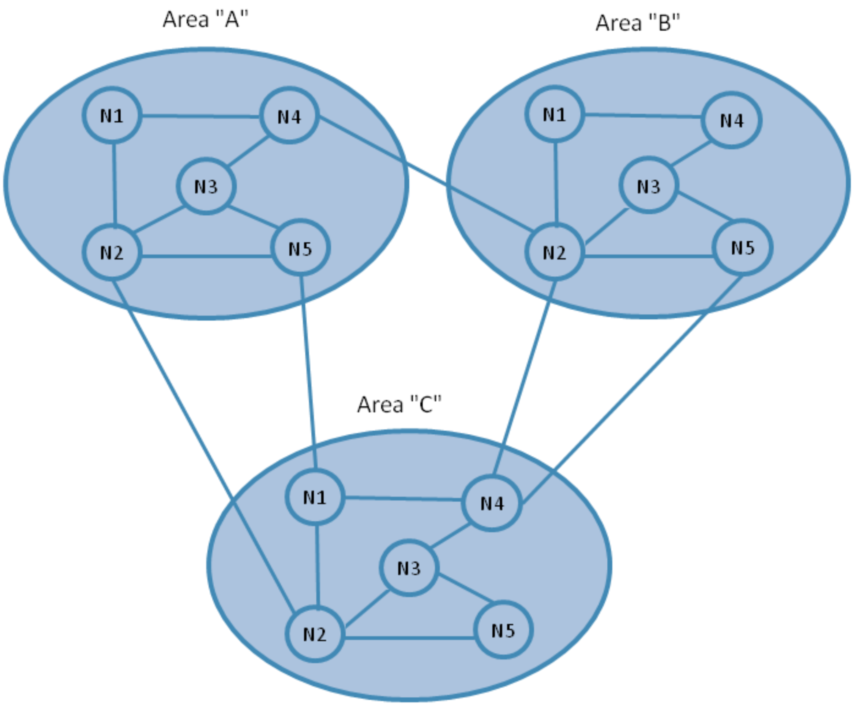
In this equation, LTA is the Long Term Allocated value for the Critical Network Element i, and FAV is Final Adjustment Value


F_{max}
FAV: Final
Adjustment Value
FRM: Flow
Reliability Margin
F_{max}-$F_{Ref'}$-FRM-FAV
Margin available to
the market
D-Trade of
Ref D
F_{Ref}
Reference Flow of the
Base Case,reflecting
Reference Exchanges
of the Base Case
$F_{Ref'}$
Flow on the Base Case
reflecting allocated
Long-Term-Capacities
Long-Term-
Allocated
capacities
Y/M-Trade
of Ref D
F_0

10.2.11 Critical network elements for Nordic area

PTDF

In the Nordic, it is possible to have different pricing areas within one or several countries, this means that one TSO control area can be divided in several pricing areas with a related GSK. Currently in the CWE area there is one GSK per country (Control Block), this will not be the case in the Nordic. It is to note that those areas may change geographically from one day to the other.



$PTDF^{A}_{i,j} = \sum_{\forall \alpha} gsk^{\alpha} PTDF^{\alpha}_{i,j}$, and $\sum_{\forall \alpha} gsk^{\alpha} = 1$

$PTDF^{A}_{i,j}$ = Sensitivity of line i,j to injection in area "A"

$PTDF^{\alpha}_{i,j}$ = Sensitivity of line i,j of injection in node "α"

gsk^{α} = Weight of node α on the PTDF of area "A"

10.3 Attributes that need to be exchanged

10.3.1 Critical Network Elements,Associated Data and Additional Contraints

Case Information:

- Document identification
- Document version
- Sender identification
- Receiver identification
- Creation date & time
- Constraint time interval : Start Date&Time ; End Date&Time

Critical Network Element:

- Domain (to check)
- Equipment tree to monitor : identify by MRID
- Imax of this equipment tree (in A), included in reference of relevant limit set; Direction : Monodirection (equipment monitored when active flow is in one direction), or BiDirection (Equipment monitored whatever active flow direction)
- Flow Reliability Margin (FRM) : Margin chosen by a TSO for a critical network element (in MW)
- FAV : Final Adjustment Value (in MW) will increase or decrease the remaining available margin (RAM) on a Critical Network Element, for simulating implicit remedial actions or as a consequence of the verification phase of the Flow-Based domain

Fault or Constraint (linked to one Critical Network Equipment to monitor)

- Identifier of the Fault/Constraint
- Name of the Fault/Constraint
- Equipment tree 1 name of outage, with MRID
- Equipment tree i name of outage, with MRID (in case of multiple tripping, N-2 for example)
- Impact of this issues on Critical Network Element : Unplanned production, demand side changes, storage capacity

Remedial Actions (linked to a Fault/Constraint)

- Identifier of the Remedial Action
- Name of the Remedial Action
- Detailed Description
- List of Actions :
    - For example Equipment Tree MRID and element name
    - Value (Open, close interconnector, tap position variation,…)
    - Any other remedial action : Change in Production, Load,…

10.3.2 Other Data to exchange

External constraints

- Creation date & time
- Constraint time interval
- Domain
- Max export (MW)
- Max import (MW)

Power Shift Key

- Creation date & time

- Constraint time interval date&time
- Domain
- Production
  - Node name
  - Factor or merit order list

- Load
  - Node name
  - Factor or merit order list

LTA/NTC files (used as a reference)

Netted AC Commercial exchanges on every European Border
- Name of the border CountryA=>CountryB
- Value of the exchange (MW)

10.3.3 Transparency (Data to exchange to Market Parties) *still under discussion with NRA and MP*

Anonymize Presolved Parameters
- PTDF parameters are sent, but without FRM, Fmax, FAV and Fref values. The anonymization procedure takes the generated ID for each CB (combination of Monitored Equipment, Critical Network Element and Remedial Action) and generates random number ranging from 1 to a count of the Variation
- RAM (MW)

10.4 Glossary of terms

For the purpose of this specification the following relevant definitions shall apply:

Term	Definition	Source
(N-1)-Criterion	the rule according to which elements remaining in operation within TSO's Responsibility Area after a Contingency from the Contingency List must be capable of accommodating the new operational situation without violating Operational Security Limits	NC OS, Article 2
(N-1)-Situation	the situation in the Transmission System in which a Contingency from the Contingency List has happened	NC OS, Article 2
Aggregated Netted External Schedule	a Schedule representing the netted aggregation of all External TSO Schedules and External Commercial Trade Schedules between two Scheduling Areas or between a Scheduling Area and a group of other Scheduling Areas	NC OPS, Article 2
Allocation Constraints	the constraints to be respected during Capacity Allocation that are needed to maintain the transmission system within Operational Security Limits and were not translated into Cross Zonal Capacity or are needed to increase the efficiency of Capacity Allocation. Allocation Constraints may include constraints related to generation or generation reserves within a Bidding Zone or, constraints related to change of power flows on interconnection between consecutive Market Time Units (ramping constraints) and constraints related to	NC CACM, Article 2

Term	Definition	Source
	transmission losses on interconnections between Bidding Zones;	
Available Transfer Capacity (ATC)	measure of the transfer capacity remaining in the transmission network for further commercial activity over and above already committed uses. It is thus the part of the NTC(Net Transfer Capacity) that remains available after each phase of the allocation procedure for further commercial activity.	
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, Article 2
Capacity Allocation	the attribution of cross zonal capacity	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Common Grid Mode	a European-wide or multiple-TSO-wide data set describing power system characteristics (generation, loads and grid topology) and rules to change these characteristics during capacity calculation, created through the merging of relevant data;	NC CACM, Article 2
Congestion	a situation in which an interconnection linking national transmission networks cannot accommodate all physical flows resulting from international trade requested by market participants, because of a lack of capacity of the interconnectors and/or the national transmission systems concerned	Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009, Article 2
Congestion Income	the revenues received as a result of Capacity Allocation;	NC CACM, Article 2
Constraint	a situation in which there is a need to implement Remedial Action in order to respect Operational Security Limits	NC OPS, Article 2
Contingency	the identified and possible or already occurred Fault of an element within or outside a TSO’s Responsibility Area, including not only the Transmission System elements, but also Significant Grid Users and Distribution Network elements if relevant for the Transmission System Operational Security. Internal Contingency is a Contingency within the TSO’s Responsibility Area. External Contingency is a Contingency outside the TSO’s Responsibility Area, with an Influence Factor higher than the Contingency Influence Threshold	NC OS, Article 2

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Term	Definition	Source
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, Article 2
Control Block	The composition of one or more control areas, working together to ensure the load frequency control on behalf of RGCE	Entso-e MetaData Repository
Coordinated Capacity Calculator	the role of calculating Cross Zonal Capacity, at least at a regional level and managing the validation process;	NC CACM, Article 2
Countertrading	a cross zonal exchange initiated by system operators between two bidding zones to relieve physical congestion	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Critical Network Element	a network element either within a bidding zone or between bidding zones taken into account in the capacity calculation process, limiting the amount of power that can be exchanged	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Critical Network Element Flow Margin	the maximum additional flows allowed on Critical Network Elements as a consequence of the changes in Net Positions resulting from Capacity Allocation in Capacity Calculation Region;	NC CACM, Article 2
Cross Zonal	across a border between two bidding zones;	NC CACM, Article 2
Cross Zonal Capacity	the capability of the interconnected system to accommodate energy transfer between bidding zones	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Cross Zonal Capacity	the capability of the Interconnected System to accommodate energy transfer between Bidding Zones. It can be expressed either as a Coordinated Net Transmission Capacity value or Flow Based Parameters,	NC CACM, Article 2
Cross-Border Flow	a physical flow of electricity on a transmission network of a Member State that results from the impact of the activity of producers and/or consumers outside that Member State on its transmission network	Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009, Article 2
Day Ahead Market	the market timeframe until the Day Ahead Market Gate Closure Time where commercial electricity transactions are executed the day prior to the day of delivery of traded products for each market time Unit,	NC CACM, Article 2
Dynamic Stability	a common term including the Rotor Angle Stability, Frequency Stability and Voltage Stability	NC OS, Article 2

Term	Definition	Source
Dynamic Stability Assessment (DSA)	the Operational Security Assessment in terms of Dynamic Stability	NC OS, Article 2
Exceptional Contingency	the loss of a busbar or more than one element such as, but not limited to: a common mode Fault with the loss of more than one Power Generating Module, a common mode Fault with the loss of more than one AC or DC line, a common mode Fault with the loss of more than one transformer	NC OS, Article 2
Explicit Allocations	the allocation of cross zonal capacity only, without the energy transfer	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
External Commercial Trade Schedule	a Schedule representing the commercial exchange of electricity between Market Participants in different Scheduling Areas	NC OPS, Article 2
External TSO Schedule	a Schedule representing the exchange of electricity of TSOs between different Scheduling Areas	NC OPS, Article 2
Flow Based Approach	a method for capacity calculation in which the exchanges between Bidding Zones are limited by the maximum flows on the Critical Network Elements and Power Transfer Distribution Factors;	NC CACM, Article 2
flow Based Parameters	the available margins on critical network elements with associated power transfer distribution factors	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Forward	the timeframe in which transmission rights are allocated ahead of the Day Ahead timeframe	NC FCA, Article 2
Forward Capacity Allocation	the attribution of Long Term Cross Zonal Capacity through an auction	NC FCA, Article 2
Generation Shift Keys	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;	NC CACM, Article 2
Implicit Allocation	a congestion management method in which energy is obtained at the same time as cross zonal capacity	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
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;	NC CACM, Article 2

Term	Definition	Source
Interconnector	a transmission line which crosses or spans a border between Member States and which connects the national transmission systems of the Member States	Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009, Article 2
Internal Commercial Trade Schedule	a Schedule representing the commercial exchange of electricity within a Scheduling Area between different Market Participants or between Nominated Electricity Market Operators and Market Coupling Operators	NC OPS, Article 2
Intraday Market	the electricity market which operates for the period of time between Intraday Cross Zonal Gate Opening Time and Intraday Cross Zonal Gate Closure Time, where commercial electricity transactions are executed prior to the delivery of traded products after Day Ahead Market Gate Closure Time for Standard and Non-Standard Intraday Products; ;	NC CACM, Article 2
Long Term	a time period longer than 24 hours;	NC FCA, Article 2
Long Term Allocations (LTA)	Allocated capacity from LT auctions	
Market Congestion	a situation in which the Economic Surplus for the single day-ahead or intraday coupling has been limited by the Cross Zonal Capacity or other active Allocation Constraints;	NC CACM, Article 2
Market Participant	market participant within the meaning of the Regulation (EU) No 1227/2011 of the European Parliament and of the Council of 25 October 2011 on wholesale energy market integrity and transparency;	NC CACM, Article 2
Net Position	the netted sum of electricity exports and imports for each Market Time Unit for a Bidding Zone.	NC CACM, Article 2
Netted Area AC Position	the netted aggregation of all AC-external Schedules of an area	NC OPS, Article 2
Network	plant and apparatus connected together in order to transmit or distribute electrical power	NC RfG, Article 2
Network Operator	an entity that operates a Network. These can be either a TSO, a DSO or CDSO	NC RfG, Article 2
Nomination	the notification of the use of Long Term Cross Zonal Capacity by a Physical Transmission Rights holder and their counterparty to the respective Transmission System Operator(s)	NC FCA, Article 2
N-Situation	the situation where no element of the Transmission System is unavailable due to a Fault	NC OS, Article 2

Term	Definition	Source
Offered Capacity	the cross zonal capacity offered by the transmission capacity allocator to the market	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Operational Security	keeping the Transmission System within agreed Operational Security Limits;	NC CACM, Article 2
Ordinary Contingency	the loss of a Transmission System element such as, but not limited to: a single line, a single transformer, a single phase-shifting transformer, a voltage compensation installation connected directly to the Transmission System; it also means the loss of a single Power Generating Module connected directly to the Transmission System, the loss of a single Demand Facility connected directly to the Transmission System, or the loss of a single DC line	NC OS, Article 2
Out-of-Range Contingency	the simultaneous loss, without a common mode Fault, of several Transmission System elements such as, but not limited to: two independent lines, a substation with more than one busbar, a tower with more than two circuits, one or more Power Generating Facilities with a total lost capacity exceeding the Reference Incident	NC OS, Article 2
Planned	an event known ex ante by the primary owner of the data	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Power Transfer Distribution Factor	a representation of the physical flow on a critical network element induced by the variation of the net position of a bidding zone	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Profile	a geographical boundary between one bidding zone and several neighbouring bidding zones	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Redispatching	a measure activated by one or several system operators by altering the generation and/or load pattern in order to change physical flows in the transmission system and relieve a physical congestion	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Reliability Margin	the necessary margin reserved on the permissible loading of a Critical Network Element or Cross Zonal Capacity to cover uncertainties of power flows in the period between the capacity calculation and real time, taking into account the availability of Remedial Actions;	NC CACM, Article 2
Remedial Action	a measure activated by one or several TSOs, manually or automatically, that relieves or contributes to relieving Physical Congestions, for example redispatching or countertrading.. They can be applied pre-fault or post-fault and may involve costs;	NC CACM, Article 2

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Term	Definition	Source
Remedial Action with costs	a Remedial Action with direct payments made to procure the service which may include but shall not be limited to Countertrading and Redispatching;	NC CACM, Article 2
Remedial Action without costs	a Remedial Action without direct payments by a TSO;	NC CACM, Article 2
Rotor Angle Stability	the ability of synchronous machines to remain in synchronism under N-Situation and after being subjected to a disturbance	NC OS, Article 2
Scheduled Exchange	the transfer scheduled between geographic areas, for each Market Time Unit and for a given direction;	NC CACM, Article 2
Stability Limits	the permitted operating boundaries of the Transmission System in terms of respecting the constraints of Voltage Stability, Rotor Angle Stability and Frequency Stability	NC OS, Article 2
Structural Congestion	congestion in the Transmission System that can be unambiguously defined, is predictable,, is geographically stable over time and is frequently reoccurring under common circumstances;	NC CACM, Article 2
System Security	the ability of the power system to withstand unexpected disturbances or contingencies;	NC CACM, Article 2
Transitory Admissible Overloads	the temporary overloads of Transmission System elements which are allowed for a limited period and which do not cause physical damage to the Transmission System elements and equipment as long as the defined duration and thresholds are respected	NC OS, Article 2
Transmission Capacity Allocator	the entity empowered by TSOs to manage the allocation of cross zonal capacities	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2
Voltage Stability	the ability of a Transmission System to maintain acceptable voltages at all buses in the Transmission System under N-Situation and after being subjected to a Disturbance	NC OS, Article 2
Year-Ahead Forcast Margin	the difference between the yearly forecast of available generation capacity and the yearly forecast of maximum total load taking into account the forecast of total generation capacity, the forecast of availability of generation and the forecast of reserves contracted for system services	Commission regulation (EU) No 543/2013 of 14 June 2013, Article 2

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