European Network of
Transmission System Operators
for Electricity

REGIONAL COORDINATION PROCESSES DATA EXCHANGE SPECIFICATION

2025-09-11

ICTC APPROVED
VERSION 2.4.0

2026-06-10

CIM WG AGREED
VERSION 2.4.2
CONFIDENTIALITY CATEGORY: PUBLIC

Copyright notice

This document is maintained by the ENTSO-E CIM Working Group in coordination relevant System Operation Committee task teams and Regional Implementation Projects responsible for different business processes. Comments or remarks are to be provided at **cim@entsoe.eu**

NOTE CONCERNING WORDING USED IN THIS DOCUMENT

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

- SHALL: This word, or the terms “REQUIRED” or “MUST”, means that the definition is an absolute requirement of the specification.
- SHALL NOT: This phrase, or the phrase “MUST NOT”, means that the definition is an absolute prohibition of the specification.
- SHOULD: This word, or the adjective “RECOMMENDED”, means that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
- SHOULD NOT: This phrase, or the phrase “NOT RECOMMENDED”, means that there may exist valid reasons in particular circumstances when the particular behaviour is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behaviour described with this label.
- MAY: This word, or the adjective “OPTIONAL”, means that an item is truly optional.

Version Notes

This document is release 2.4.2 of the Regional Coordination Processes Data Exchange Specification (RCP DES). This release is a patch release of main 2.4.1 which focuses on enhancements related to more complex use cases and their representation in example datasets.

Indeed, an important update is the linkage between the RCP DES and the open-source, anonymous test configuration (model) ReliCapGrid which allows for direct references to parts of the information model in order to illustrate the use cases. In this way the RCP DES's readability and usability is improved.

This version of the document was reviewed in August 2025 by CSA CC Task Team, CIM WG, Regional Implementation projects and experts contributing to the document development. The approval process included the endorsement of the Steering ICT Strategy and ICTC publication approval on 11 September 2025 (refer to public ICTC minutes).

This document and its subsequent revisions will be also used for standard vetting interoperability tests (SV-IOP). Therefore, it is considered a public document.

The document was additionally updated to incorporate the agreements and use cases exposed in the SV-IOP held in May 2025 (refer to the report).

Updates are limited to the scope of a minor release and they motivated changes in the CIM-based Network Code Profiles (NCP) to the version reflected in Table 1. The rest of identified issues are scheduled for the next release.

For additional details on the previous versions of the document, please refer to section Annex B: Document Revision History.

For details of the introduced changes and use cases, please consult the accompanying Release Notes and *Differences* dataset available on the ENTSO-E CGMES Library.

Table of Content

List of figures

List of tables

1 Introduction

The Regional Coordination Processes Data Exchange Specification (RCP DES) describes the framework for data exchange in business processes utilizing Network Codes data exchange profiles. The specified business processes—the so called Regional Coordinated Processes (RCP)—encompass Coordinated Security Analysis (CSA), Outage Planning Coordination (OPC), Coordinated Capacity Calculation (CCC), and Short-Term Adequacy (STA). The current iteration of the document predominantly focusses on CSA, serving as the first business process to use Network Codes data exchange profiles.

Regular updates to the document will be undertaken to align with the evolving of data exchange needs and advancements in various business processes. The core objective of the RCP DES is to establish a standardised data exchange based on the Network Codes profiles, thereby mitigating IT implementation costs and fostering interoperability among Transmission System Operators (TSOs) and Regional Coordination Centres (RCCs).

The goal is to empower software vendors to create IT applications for TSOs and RCCs that facilitate seamless information exchange across all relevant business processes. In this regards, ENTSO-E supports constant conversation with these actors organising standard-vetting interoperability tests (SV-IOP), and also welcomes feedback (communicate to cim@entsoe.eu).

Furthermore, the RCP DES offers guidance on modelling diverse use cases and defines requirements for conformity assessment. These elements are crucial for business stakeholders, providing them with the necessary framework to steer the implementation of data exchange within a business process.

In essence, the RCP DES seeks to streamline and enhance the efficiency of data exchange between TSOs, RCCs and any third parties that are required to participate in business processes covered by RCP DES or exchange data using some of the NC profiles.

This document defines a structured way of exchanging the following data:

- Remedial action
- Assessed element
- Contingency
- System Integrity Protection Scheme (SIPS) configuration
- Security limits and system constraints
- Generation and load shift keys (GLSK)
- Power transfer corridor (PTC)
- Steady state instructions
- Remedial action schedule (to exchange proposed, accepted/rejected, activated remedial action)
- Security analysis result

- Impact assessment matrix
- Remedial action sensitivity matrix
- The redispatch and countertrading cost sharing (in accordance with CACM Article 74(7)).

1.1 Further Information and Material

The ENTSO-E CGMES Library is the central webpage the ENTSO-E CIM WG uploads material to and that the current document will refer throughout its chapters. Readers may want to specially consider the following tabs:

- Network Code (NC) profiles
- Regional coordination Processes (RCP)
- ENTSO-E CGMES Extension and Profile
  - The latest UML diagram is available here as well as relevant documentation for profiling and getting started.
- Application Profiles Library
  - All the machine artifacts (vocabulary in RDFS and constraints in SHACL) are gathered under a single library.
  - The ReadMe file offers insightful information on SHACL constraint design.
- Metadata for Dataset and Distribution Specification
- Boundary and Reference Data

Other subsites such as the CIM Conformity and Interoperability host information on the Standard-Vetting Interoperability Tests (SV-IOP) reports or the registry of software tools having conformed to the ENTSO-E CGMES Conformity Assessment Scheme.

Lastly, readers may also navigate the ENTSO-E GitHub account as useful pieces of information like the ReliCapGrid open-source test model are hosted in there.

1.2 Future Releases

Future releases of the specification will focus on the following items:

- Coverage of other business processes, i.e., OPC, CCC, Regional STA, FAP, etc.
- CSA methodology amendment, if any impacting changes.
- Development of use cases currently classified as “Expected Use Cases”.

1.3 Out of Scope

The following is out of scope of the current version of the specification:

- The reporting and the monitoring of the CSA (pursuant to SOGL article 17)
- The Probabilistic Risk Assessment (pursuant to Article 44(4) of CSAm)

1.4 Special Considerations

The following should be taken into account when reading the document:

- The current version of the document covers use case submitted by all stakeholders (e.g., TSOs, RCCs, Regional Implementation Projects and Software Vendors) implementing pan-European and regional business processes. Some additional use cases are listed as "Expected Use Cases" that can be specified in next versions of the specification in addition to any other proposed use cases. Stakeholders are encouraged to provide necessary information to enable consideration of additional use cases.
- Code snippets are progressively replaced by references to the ReliCapGrid open-source, anonymous test model (refer to section 2.1). The aim is providing with machine-readable examples ("*code examples*").
- Examples are only provided to illustrate and help the implementation. The code provided is not completely functional as it is only small part that focuses on the presented use case. It could also be the case that not all required attributes are provided.
- Examples refer to identifiers that are only used to explain the relationship, i.e. in most cases identifiers are random UUID or strings that shall not be referred as a reference in any implementations of Network Codes profiles. The correct identifiers are to be provided from common and reference data datasets (refer to section 0).
- Business Process Model Notation (BPMN) diagrams are taken from the Inter-RSC report[1]. The BPMN diagrams are accompanied with a table describing the "Inputs" and "Outputs" of the process. The business terms used in the Inter-RSC report cannot be linked directly to the terms used in the NC profile specifications and RCP DES. The BPMN diagrams are subject to changes depending on business requests.

[1] Report on Inter-RCC and Inter-CCR Coordination for Coordinated Regional Security Analyses V1.2 (internal ENTSO-E document).

2 Network Codes Profiles General Implementation Guidance

During the developmental and implementation phases of NC Profiles and RCP DES, numerous activities involve amending methodologies and introducing Regional Operational Security Coordination (ROSC) processes. The progression of these activities necessitates alignment with data exchange profiles, specifications, and guidance. To facilitate the implementation of these complex business processes and related data exchanges, the following general implementation guidance is provided:

- **Individual Release and Versioning**: Network Codes profiles will not be bundled as a package; instead, they will be released individually. Each profile and its accompanying documentation will adhere to Semantic Versioning 2.0.0. For instance, an exchange may utilise RCP DES v2.3.0, Equipment Reliability profile v2.2.0, and Remedial Action Profile v2.3.0. Development will carefully manage dependencies between profiles and ensure that all profiles designed to be compatible use the same namespaces and are derived from the same version of the canonical model. RCP DES version will be updated every time one of the profiles is changed.
- **Frequent RCP DES Updates**: RCP DES will undergo frequent updates to incorporate additional clarifications, use cases, and coverage of new business processes.
- **Transition**: Business processes should ensure that there is a transition plan to support the transition between versions of different NC profiles and specifications.
- **IGM modifications**: Equipment Reliability (ER) profile enables TSOs to include additional equipment in the models which cannot be represented using CGMES structures. However, this can change the power flow situation and therefore the IGM already included in a CGM prior CSA or other process using the CGM. The objective is to include ER datasets in the CGM building process, but the transition process for doing this needs to be organised. Business processes need to be cautious noting that if a given functionality is covered by the ER profile, the effect of it can only be seen once the profile is considered as part of CGM build process either separately (ER + EQ) or as being integrated in Equipment profile in a future versions of CGMES EQ profile.
- **Understanding Power System Model Dependencies**: Implementing parties (TSOs, RCCs, CCRs, Vendors, etc.) must be aware of dependencies and capabilities related to modelling the power system model (IGM/CGM) using the IEC CGMES set of profiles. The evolving nature of NC profiles and business requirements requires corresponding advancements in the CGMES set of profiles.
- **Feedback and Standard Vetting Interoperability Tests**: Both NC profiles and RCP DES will rely on feedback collected in Standard Vetting Interoperability Tests (SV-IOP) organised by ENTSO-E. This practice aims to enhance the maturity of data exchange specifications and support ongoing implementation efforts. Readers can express their interest in participating contacting ENTSO-E through cim@entso.eu.
- **Machine-Readable Artifacts and Namespace/Versioning Information**: Implementers should rely on machine-readable artifacts provided with NC profiles and be prepared

for multiple[2] or frequently changing namespace information for different data objects. Changes will be controllable to minimise impacts, with an understanding that these profiles will be proposed as international CIM standards in the coming years. Changes can also happen due to the implementation of common data and reference data (refer to section 0) together will the implementation of better approaches to handle metadata between or within different business processes.

- **Persistent Identifiers**: Increased complexity in data exchanges, such as
  - detailed power system modelling,
  - substantial additional information exchange mandated by EU Network Codes,
  - shared data sets across multiple business processes,
  - the dependency on the timeframes,
  - requirements on reporting within business processes and towards external parties such as ACER, etc.,

requires the implementation of persistent identifiers. This approach optimises data transfer by exchanging only the most relevant information. Therefore, IT and business implementations should align with this vision.

- **Data Validation:** Development of Data Quality Management Provisions (DQMP) is required by Coordinated Security Analysis Methodology (CSAm) Art 42(1) and it will be prepared as part of the Regional Coordination Processes Data Quality Management Provisions (RCP DQMP) document. The RCP DQMP will define the data validation framework and business specific constraints (consistency rules) that apply for all regions or are regions specific. Standard or specification related constraints will be part of the NC profiles. Therefore, when data validation is performed, it will rely on constraints defined in NC Profiles specifications and in the NC DQMP document. NC DQMP constraints will not contradict the standard NC profile constraints or extend the profiles or canonical model. The constraints will only be more restrictive with the aim of improving data quality and satisfy the business requirements on data consistency as defined in the methodologies.

The overarching goal is to facilitate a seamless and efficient implementation of NC Profiles and RCP DES, ensuring adaptability to evolving requirements and interoperability across diverse stakeholders.

[2] Multiple namespaces are used in the datasets and in profiles. CIM namespace, ENTSO-E namespace, NC namespace, W3C DCAT namespace, etc.

2.1 Test Use Cases and Test Configuration (Test Data)

Since the SV-IOP 2025 (refer to the report), ENTSO-E fosters the use of a synthetic, anonymised test configuration, a power system model which is prepared for the purpose to illustrate and guide the implementation of the use cases reflected in the current document. The test configuration is maintained by ENTSO-E and it is available as a repository ReliCapGrid on ENTSO-E GitHub's account.

Each use case provided for integration in RCP DES is illustrated in ReliCapGrid as well as there is test procedure, i.e. a test use case to follow a test logic. The latter is related to the implementation of a Conformity Assessment Scheme in RCP DES (RCP DES CAS) profiles and use cases. While the preparation of the RCP DES CAS is ongoing the RCP DES document makes references to draft test use cases in the ReliCapGrid repository.

It should be noted that the content of the ReliCapGrid repository is subject to change based on suggested improvements and should not be taken as definitive reference but as an implementation example or a guidance.

The community implementing RCP DES and NC profiles in general is encouraged to contribute in the ReliCapGrid repository in order to identify and resolve any issues found and enhance the use cases covered by the repository.

3 References

3.1 Legal References

- Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (SOGL);
- Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (CACM);
- Annex I - ACER Decision 07-2024 - Second CSAM Amendment;
- Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (Clean Energy Package)

3.2 Normative References

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- IEC 61970-301:2021 Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base;
- IEC 61970-600-1:2021 Energy management system application program interface (EMS-API) - Part 600-1: Common Grid Model Exchange Standard (CGMES) - Structure and rules;
- IEC 61970-600-2:2021 Energy management system application program interface (EMS-API) - Part 600-2: Common Grid Model Exchange Standard (CGMES) - Exchange profiles specification;
- IEC 61968-11:2013 Application integration at electric utilities - System interfaces for distribution management - Part 11: Common information model (CIM) extensions for distribution

3.3 Specification Documents References

The following specification documents, in whole or in part, are referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Not all profiles are related to a single business process. The usage of the profiles depends on the needs of the business process and covered use cases.

Table 1 specifies the versions of the referenced documents that are considered in the current version of the RCP DES. The version of the RCP DES will be updated any time the versions of the referenced documents change.

571

Table 1 – Document versions

Document	Version
ENTSO-E Assessed Element profile specification	2.4.0
ENTSO-E Availability Schedule profile specification	2.3.1
ENTSO-E Contingency profile specification	2.3.1
ENTSO-E Equipment Reliability specification	2.4.2
ENTSO-E Impact Assessment Matrix profile specification	2.4.0
ENTSO-E Monitoring Area profile specification	2.3.1
ENTSO-E Object Registry profile specification	2.2.2
ENTSO-E Power Schedule profile specification	2.4.0
ENTSO-E Power System Project profile specification	2.3.1
ENTSO-E Remedial Action profile specification	2.4.0
ENTSO-E Remedial Action Schedule profile specification	2.4.0
ENTSO-E Security Analysis Result profile specification	2.5.0
ENTSO-E Sensitivity Matrix profile specification	2.3.1
ENTSO-E State Instruction Schedule profile specification	2.4.0
ENTSO-E Steady State Hypothesis Schedule profile specification	1.1.0
ENTSO-E Steady State Instructions profile specification	2.4.0
ENTSO-E Metadata for Dataset and Distribution specification	2.4.0
ENTSO-E Boundary and Reference Data Exchange application specification	1.0.0
ENTSO-E Network Codes Canonical Extensions Specification	2.4.1

572

573 ## 3.4 Other References

574 • The Harmonised Electricity Market Role Model.

- Report on Inter-RCC and Inter-CCR Coordination for Coordinated Regional Security Analyses V1.2 (internal ENTSO-E).
- CSA Coordination Function – Business Requirements Specification v1.0 (internal ENTSO-E).
- CSA Input Data Consistency Function – Business Requirements Specification v1.0 (internal ENTSO-E).
- CSA Data Classification v1.0 (internal ENTSO-E).
- CGM-RCC Users Group - Business Requirements Specification v1.0 (internal ENTSO-E).
- CGMES profiling user guide v1.0.

4 Terms and Definitions

4.1 Agreed remedial action

Agreed remedial action means a cross-border relevant remedial action for which TSOs in a region agreed to implement, or any other remedial action for which TSOs have agreed that it does not need to be coordinated.

[SOURCE: CSAm art. 2.1.19]

4.2 Assessed element

Assessed element is a network element for which the electrical state is evaluated in the regional or cross-regional process and which value is expected to fulfil regional rules function of the operational security limits.

Where necessary, for defining the regional or cross-regional rules for ensuring the system security, assessed elements can be subdivided into two sub-classes – secured elements and scanned elements.

[SOURCE: 2019 Inter-RSC report, BRS CAS consistency function, 4.1]

4.3 Availability schedule

A given availability schedule with a given status and cause that include multiple equipment that need to follow the same scheduling periods

[SOURCE: CSA project group]

4.4 Available remedial action

Available remedial action is a remedial action which is available to solve identified constraints. It includes the needed technical and cost information.

[SOURCE: 2019 Inter-RSC report]

4.5 Capacity Calculation Region

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

[SOURCE: CACM art.2.3]

4.6 Common Grid Model (CGM)

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

[SOURCE: CACM art.2.2]

4.7 Constraint

Constraint means a situation in which there is a need to prepare and activate a remedial action in order to respect operational security limits.

[SOURCE: SOGL art.3.2.2]

4.8 Contingency

Contingency means the identified and possible or already occurred fault of an element, including not only the transmission system elements, but also significant grid users and distribution network elements if relevant for the transmission system operational security.

[SOURCE: CACM art.2.10]

4.9 Contingency analysis

Contingency analysis means a computer-based simulation of contingencies from the contingency list.

[SOURCE: SOGL art.3.2.27]

4.10 Contingency list

Contingency list means the list of contingencies to be simulated in order to test the compliance with the operational security limits.

[SOURCE: SOGL art.3.2.4]

4.11 Countertrading

Countertrading means a cross zonal exchange initiated by system operators between two bidding zones to relieve physical congestion.

[SOURCE: Reg 2019/943 art.2.27]

4.12 Critical Network Element (CNE)

Critical network element means 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.

[SOURCE: Reg 2019/943 art.2.69]

4.13 Critical Network Element Contingency (CNEC)

CNEC means a CNE associated with a contingency used in capacity calculation. For the purpose of this methodology, the term CNEC also cover the case where a CNE is used in capacity calculation without a specified contingency.

[SOURCE: Day-ahead capacity calculation methodology of the Core capacity calculation region art 2.10]

4.14 Coordinated Regional Operational Security Assessment (CROSA)

Coordinated regional operational security assessment (CROSA) means an operational security analysis performed by RCCs on a common grid model on a regional level.

[SOURCE: SOGL art.78]

4.15 Cross Coordinated Regional Operational Security Assessment (CCROSA)

Cross Coordinated Regional Operational Security Assessment (CCROSA) means an operational security analysis performed by RCCs on a common grid model on a cross-regional level.

[SOURCE: ACER Decision on CSAM art. 33.e]

4.16 Cross-border relevant Network Element' (XNE)

Cross-border relevant Network Element' (XNE) means a network element identified as cross border relevant and on which operational security violations need to be managed in a coordinated way.

[SOURCE: ACER Decision on CSAM: Annex I art 2.1.8]

4.17 Cross-border relevant Remedial Action (XRA)

Cross-border relevant Remedial Action (XRA) means a remedial action identified as cross border relevant and needs to be applied in a coordinated way.

[SOURCE: CSAm art.2.1.12]

4.18 Curative remedial action

Curative remedial action means a remedial action that is the result of an operational planning process and is activated straight subsequent to the occurrence of the respective contingency for compliance with the (N-1) criterion, taking into account transitory admissible overloads and their accepted duration.

[SOURCE: CSAm art.2.1.24]

4.19 Exceptional contingency

Exceptional contingency means the simultaneous occurrence of multiple contingencies with a common cause.

[SOURCE: SOGL art.3.2.39]

4.20 External contingency

External contingency means a contingency outside the TSO's control area and excluding interconnectors, with an influence factor higher than the contingency influence threshold.

[SOURCE: SOGL art.3.2.24]

4.21 Generation Shift Key

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.

[SOURCE: CACM art.2.12]

4.22 Identified constraint

Identified constraint is a group of elements composed by one or more assessed elements and the contingency leading to a violation of an operational security limit or a function of this operational security limit.

[SOURCE: CSA project group]

4.23 Impact assessment

Impact assessment determines the impact of changes of a grid model on each TSO's grid and assesses whether this impact qualifies as so significant that the respective TSO is deemed "impacted" by the change.

[SOURCE: CSA project group]

4.24 Individual Grid Model (IGM)

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

[SOURCE: CACM art.2.1]

4.25 Individual action

Individual action is an action that is one of the single remedial actions as defined in Article 22 of the SO Regulation.

[SOURCE: CSAm art.14.2]

4.26 Internal contingency

Internal contingency means a contingency within the TSO's control area, including interconnectors.

[SOURCE: SOGL art.3.2.23]

4.27 Load Shift Key

It constitutes a list specifying those load that shall contribute to the shift in order to take into account the contribution of generators connected to lower voltage levels (implicitly contained in the load figures of the nodes connected to the EHV grid).

[SOURCE: Coordinated Capacity Calculation IG v1.0]

4.28 N-situation

N-situation means the situation where no transmission system element is unavailable due to occurrence of a contingency.

[SOURCE: SOGL art.3.2.3]

4.29 N-1 situation

N-1 situation means the situation in the transmission system in which one contingency from the contingency list occurred.

[SOURCE: SOGL art.3.2.15]

4.30 Normal state

Normal state means a situation in which the system is within operational security limits in the N-situation and after the occurrence of any contingency from the contingency list, taking into account the effect of the available remedial actions.

[SOURCE: SOGL art.3.2.5]

4.31 Ordinary contingency

Ordinary contingency means the occurrence of a contingency of a single branch or injection.

[SOURCE: SOGL art.3.2.54]

4.32 Operational security analysis

Operational security analysis means the entire scope of the computer based, manual and automatic activities performed in order to assess the operational security of the transmission system and to evaluate the remedial actions needed to maintain operational security.

[SOURCE: SOGL art.3.2.50]

4.33 Out of range contingency

Out of range contingency means the simultaneous occurrence of multiple contingencies without a common cause, or a loss of power generating modules with a total loss of generation capacity exceeding the reference incident.

[SOURCE: SOGL art.3.2.55]

4.34 Overlapping zone

A collection of all the overlapping cross border assessed elements which have the same sets of impacted and impacting regions.

[SOURCE: CSA data exchange project group]

4.35 Power Transfer Corridor (PTC)

A Power Transfer Corridor is defined as a set of circuits (transmission lines or transformers) separating two portions of the power system, or a subset of circuits exposed to a substantial portion of the transmission exchange between two parts of the system.

[SOURCE: CSA data exchange project group]

4.36 Preventive remedial action

Preventive remedial action means a remedial action that is the result of an operational planning process and needs to be activated prior to the investigated timeframe for compliance with the (N-1) criterion.

[SOURCE: CSAm art.2.1.18]

4.37 Proposed remedial action

Proposed remedial action is a remedial action proposed by RCC after remedial action optimization or proposed by TSOs as an alternative for the Rejected RAs. RCC coordinates proposed remedial actions with affected TSOs for intra-CCR and with affected TSOs and RCC for cross-CCR.

[SOURCE: CSA project group]

4.38 Remedial action

Remedial action means any measure applied by a TSO or several TSOs, manually or automatically, in order to maintain operational security.

[SOURCE: CACM art.2.13]

4.39 Remedial action influence factor

Remedial action influence factor means a flow deviation on a XNEC resulting from the application of a remedial action, normalised by the permanent admissible loading on the associated XNE.

[SOURCE: CSAm art.2.1.11]

4.40 Regional Coordination Centre (RCC)

It means regional coordination centre established pursuant to Article 35 of Regulation 2019/943. Most RSCs evolve into RCCs on 1st July 2022.

[SOURCE: Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity]

4.41 Regional Security Coordinator (RSC)

Regional Security Coordinator (RSC) means the entity or entities, owned or controlled by TSOs, in one or more capacity calculation regions performing tasks related to TSO regional coordination.

[SOURCE: SOGL art.3.2.89]

4.42 Restoring remedial action

Restoring remedial action means a remedial action that is activated subsequent to the occurrence of an alert state for returning the transmission system into normal state again.

[SOURCE: CSAm art.2.1.13]

4.43 Scanned element

Scanned element is an assessed element on which the electrical state (at least flows) shall be computed and shall be subject to an observation rule during the regional security analysis process. Such observation rule can be for example avoiding the increase of a constraint or avoiding the creation of a constraint on this element, as a result of the design of remedial actions needed to relieve violations on the secured elements. A scanned element within a CCR can be any element of any CCR (irrespective of any potential qualification as XNE by one or more CCRs).

[SOURCE: CSA project group]

4.44 Secured element

Secured element is an assessed element on which remedial actions are identified to relief violations, when violations of an operational security limit are identified during the regional or cross-regional security analysis. On the CCR context, a secured element is an XNE.

[SOURCE: CSA project group]

4.45 System (Integrity) Protection Scheme (SIPS)

System integrity protection scheme[3] is an automatic protection system designed to detect abnormal or predetermined system conditions and take corrective actions other than and/or in addition to the isolation of faulted components to maintain system reliability. Such actions may include changes in demand, generation or system configuration to maintain system stability, acceptable voltage or power flows.[4]

[SOURCE: North American Electric Reliability Corporation glossary]

Note: SOGL art.37 defines tasks to TSOs which use Special Protection Schemes (SPS)

3 The system protection scheme (SPS) can be called system integrity protection schemes (SIPS) in some CCRs (e.g. Nordic CCR) or in CIGRE

4 North American Electric Reliability Corporation glossary

4.46 System Operator

A party responsible for operating, ensuring the maintenance of and, if necessary, developing the system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution or transmission of electricity.

[SOURCE: Harmonized Role Model based on the Directive 2009/72/EC of the European parliament and of the council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC, Article 2 (Definitions).

5 Abbreviated Terms

CCR	Capacity Calculation Region
CGMES	Common Grid Model Exchange Standard
CIM	Common Information Model (electricity)
CROSA	Coordinated Regional Operational Security Assessment
CCROSA	Cross Coordinated Regional Operational Security Assessment
CSA	Coordinated Security Analysis
CSAm	Coordinated Security Analysis Methodology
EIC	Energy Identification Codes
ENTSO-E	European Network of Transmission System Operators for Electricity
HVDC	High Voltage Direct Current
IEC	The International Electrotechnical Commission
IVA	Individual Adjustment Value
MAS	Model Authority Set
mRID	CIM Master Resource Identifier
MTU	Market Time Unit
OPC	Outage Planning Coordination
PATL	Permanent Admissible Thermal Limit
PGM	Power-Generating Module
RAO	Remedial Action Optimization
RCC	Regional Coordination Centre
RDF	Resource Description Framework
RDFS	RDF Schema
RefHour	Reference Hour
ROSC	Regional Operational Security Coordination
RSA	Regional Operational Security Analysis
SHACL	Shapes Constraint Language
SO	System Operator
SOC	ENTSO-E System Operations Committee
SOGL	System Operations Guideline
SIPS	System Integrity Protection Scheme
SPS	Special Protection Scheme (often terms SIPS and SPS are used interchangeably)
STA	Short Term Adequacy

TSO	Transmission System Operator
TATL	Temporary Admissible Thermal Limit
UCTE DEF	Union for the Coordination of the Transmission of Electricity Data Exchange Format
URI	Uniform Resource Identifier
UUID	Universally Unique Identifier
XML	Extensible Markup Language
XNE	Cross-border relevant Network Element
XNEC	Cross-border relevant Network Element with contingency
XRA	Cross-border relevant Remedial Action
XSD	XML Schema Definition

6 CSA Business Process Overview

This section in only informative and does not specify business requirements. Business requirements are specified in respective network codes, methodologies, or business process documents (as specified in section 3).

6.1 Introduction

The CSA is a business process defined in the CSA methodology (CSAm)—refer to the 2024 Amendment (ACER Decision on 07/2024)—, as required in SOGL Article 75. Its primary objective is to uphold the security of the supply within the European electricity grid.

The CSA process also includes the regional operational security coordination per CCR (as per SOGL Article 76) as well as the cross-RCC and cross-CCR Coordination (required by the SOGL article 75 and 76). Each CCR has its own regional operational security coordination (ROSC) methodology that has regional scope.

Therefore, the CSA process is relying on input data from TSOs that are shared to the RCCs to perform security analysis and solving constraints by optimizing a set of remedial actions for a CCR and in cooperation with the other CCRs.

The RCP DES is a prerequisite for correct functions' handling and storing any of the key input data for the CSA in a harmonised, secure and adequate manner.

The cross-RCC Coordination is required by SOGL for RCCs when performing their tasks defined in SOGL (Art 77 to 81) at CCR level. The CSAm provides a set of requirements for TSOs and RCCs, and defines the content and objectives of this cross-RCC coordination.

The regional and cross-regional day-ahead process major steps and timings are defined in the CSAm Article 33. When harmonising different versions of Common Grid Model Methodology (CGMM) and including additional requirements ENTSO-E agreed to define Pan-European Operational Processes Timings Framework document to define the timings of the steps for all business processes that use common datasets. This includes the mapping between timings defined in the CSAm Art 33 and the new set of harmonised timings.

This document uses this only to provide background information and not to specify the process. The design and sequence of subprocesses including timings are governed in separate documents that are kept aligned with modifications in CGMM, CSAm and implementation timelines of ROSC process in each CCR. For example, until inter-CCR process is implemented, ROSC process shall include only single CGM build process in Day-ahead timeframe.

For day ahead process, steps and timings are described below.

The CSA process is divided in four phases as detailed in the Report on Inter-RSC and Inter-CCR coordination for CSA. The T0 to T5 notation is used in the CSAm and the present CGMM versions. However, updates of CGMM and alignment on the timings between different business processes can change these notations. The information provided here is only for information to facilitate the reading of the document.

- **Preparation phase (before T0):** This corresponds to the preparation and provision of the System Operators' IGMs and of all other data needed to perform a coordinated security analysis (e.g. updates of available remedial actions, contingencies, etc.).
- **Coordination Run 1 phase (from T0 to T2):** This includes steps of the CGM Build Process which provides the CGM for 24 hours of next day and the run of the CROSA process related to regional and cross regional security analyses (contingency analysis, remedial action optimization, coordination) and its possible loops.
- **Coordination Run 2 phase (from T2 to T4):** The second coordination run is performed to evaluate the combined effects of all remedial actions preliminary agreed in the first run by using the updated CGM with all the latest information available, which is built based on the updated IGMs sent by the SOs. These updated IGMs include all agreed preventive remedial actions, agreed curative remedial actions, new forecasts, any other changes to the inputs updated and shared from T2 to T3. When CGM is available (max at T3) to T4: all the phases of regional and cross-regional security analyses (contingency analysis, remedial action optimization, coordination) and its possible steps are performed.
- **Final Validation phase (from T4 to T5):** According to Art. 31(1)(f) of CSAm, during the final validation session, TSOs and RCCs shall consolidate the final outcomes of the whole process in a common teleconference involving also the TSOs from impacting CCRs. TSOs shall evaluate the Agreed RAs, in application of Article 78(4) of the SO Regulation. Each TSO shall participate in this session or shall appoint its RCC to represent it at the session while the TSO keeps the legal responsibility to agree on RAs.

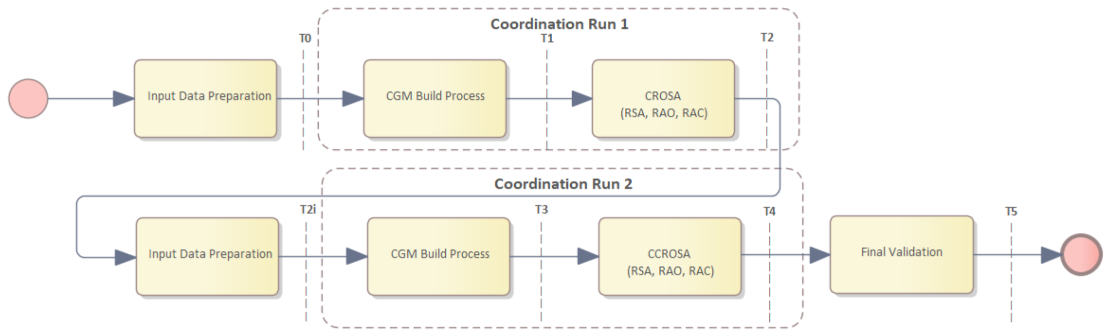


Figure 1 – Day-ahead process, steps and timings (for information only)

Each coordination run includes the building of a CGM model, a regional security analysis and remedial action optimization with a cross-RCC and cross-CCR coordination. Figure 1 depicts the target CSA process that is expected to be implemented across all CCRs in the end.

For intraday process, steps and timings are described below.

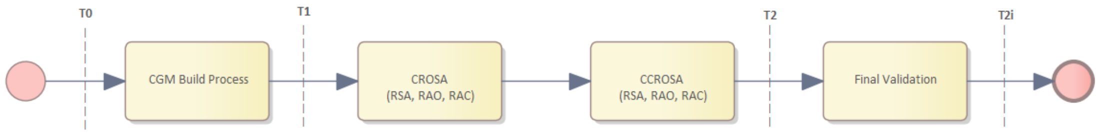


Figure 2 - Intraday process, steps and timings (for information only)

- **Preparation phase:** The IGMs are made available for the remaining hours until the end of the day. The CGM Build process provides the CGM for the remaining hours.
- **From T1 to T2:** The regional and cross-regional process are executed.
- **From T2 to T3:** The intraday final validation is executed.

Detailed business process (BPMN) for the day-ahead CSA process in Figure 3.

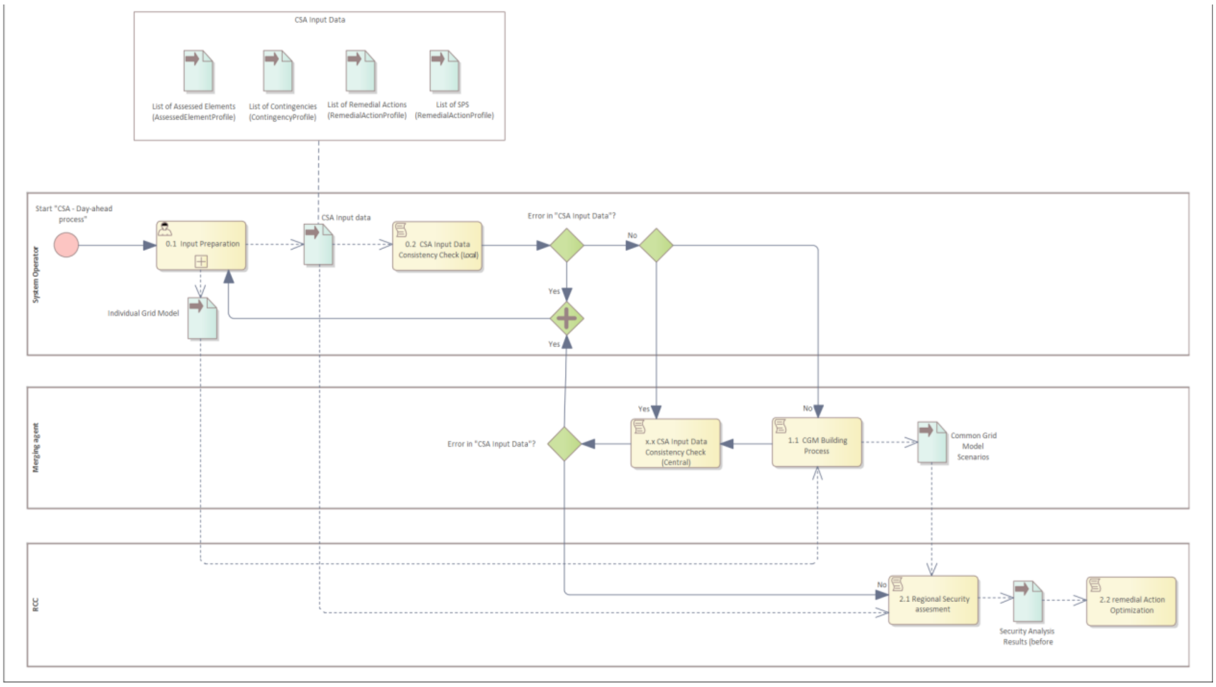
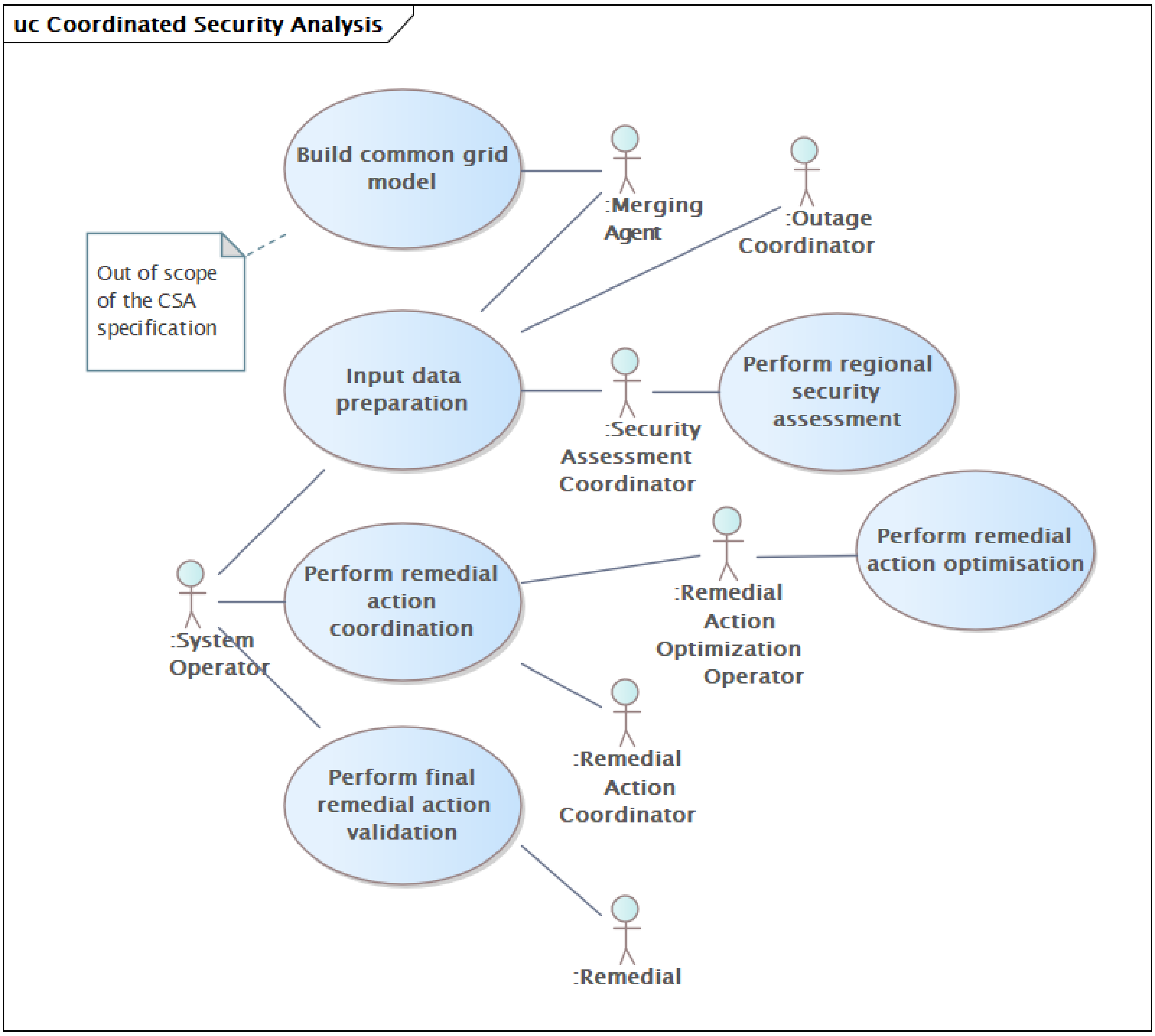


Figure 3: Detailed BPMN for day-ahead process (for information only)

930 ## 6.2 Use Cases



931

932 **Figure 4 - Use Cases**

Table 2 and Figure 4 give a list of roles involved in the business processes. Some of these roles such as Outage Planning Agent are not strictly part of CSA process.

Table 2 - Role labels and descriptions

Role Label	Role Description	Performed by
Merging Agent	The Merging Agent is responsible to gather the IGMs from SOs and build the CGM. The Merging Agent provides the CGM to the security assessment coordinator, who uses it as an input to perform the security analysis.	RCC
Outage Coordinator	Outage Coordinator provides the availability plan to the security assessment coordinator who uses this in case a remedial action would be the cancellation or shortening of an outage plan.	RCC
System Operator	SO provides most of the needed inputs to perform the security analysis. This role also participates in the remedial action coordination agreeing or rejecting the remedial actions.	TSO
Security Assessment Coordinator	The Security Assessment Coordinator performs the security assessment against contingencies in order to identify potential congestions in the grid and propose to the SO a set of remedial actions to solve the found issues.	RCC
Remedial Action Optimization Operator	Remedial Action Optimization Operator performs the remedial action optimization based on security assessment result before RAO and remedial actions defined as part of the structural data.	RCC
Remedial Action Coordinator	The Remedial Action Coordinator main task is to get the agreement on all proposed remedial actions identified by the remedial action optimization step and potentially any additional remedial actions specifically requested by a SO.	RCC
Remedial Action Validator	The main activity of the Remedial Action Validator during the final validation session is to review unresolved relevant identified constraints (on assessed elements), discuss/find possible follow-up activities by TSOs and RCCs and deliver the conclusions.	RCC

Table 3 gives a list of use cases for the CSA business process.

Note that in this specification, roles refer to the specific functions defined within the CSA process—such as Merging Agent or RAO Operator. These roles describe what needs to be done and by whom in a functional manner.

Actors, on the other hand, are the entities (organisations) that perform these roles in practice. For example, RCCs typically execute the RAO Operator role, while TSOs act as System Operators.

This distinction helps clarifying responsibilities without tying them to specific organizations or individuals.

947
948 **Table 3 - CSA use cases**

Use case label	Roles involved	Action descriptions and assertions
Input data preparation	SO, Merging Agent, Outage Planning Agent, Security Assessment Coordinator	In order to allow the representation of the grid as well as the proper assessment of its security and the identification of potential effective and efficient remedial actions for the mitigation of identified constraints, the SO shall provide the list of assessed elements, contingencies, remedial action (including SIPS) and equipment reliability (e.g. Power transfer Corridor, reliability limits, etc), scheduled data and per market time unit data. Optionally Generation and Load Shift keys can be provided. SO shall provide as well its IGM to the Merging Agent, who builds the CGM as input to the business processes. Outage Planning Agent provides the availability plan. Finally, the security assessment coordinator performs a business check on all the received data.
Build common grid model	Merging Agent	Merging agent builds the CGM as the comprehensive aggregation and calculation on the basis of the IGMs and some relevant additional input data (e.g. boundary information, common data, reference data); this is out of the scope of this document and part of the CGM Build Process.
Perform regional security assessment	Security Assessment Coordinator	The Security Assessment Coordinator performs the security assessment against contingencies to identify potential congestions in the grid. This security assessment is run according to rules defined in the CCR Article 76 methodology (at least flows and potentially other aspects of security).
Perform remedial action optimization	Remedial Action Optimization Operator	The Remedial Action Optimization Operator performs the remedial action optimization to select the most suitable remedial actions to operate the network efficiently while ensuring security of supply.
Perform remedial action coordination	SO, Remedial Action Optimization Operator, Remedial Action Coordinator.	The Remedial Action Coordination is divided in two steps. The first step consists of managing the interactions within the CCR. The purpose is to apply rules (According to CSAm Art. 27) to address the cross-impacts between CCRs on the overlapping zones. In the second step, the impact assessment of all proposed and adjusted remedial actions is performed. This impact assessment consists of identifying the affected SOs for each remedial action, based on the rules defined in the CCR Article 76 methodology (qualitative and/or quantitative rules) and rules for cross-CCR impact (to be defined according to the amendment of CSAm Article 27).
Perform final remedial action validation	Remedial Action Validator, SO	The main activity during the final validation session is to review unresolved relevant identified constraints (on assessed elements), discuss/find

		possible follow-up activities by SO and Remedial Action Validator and record the conclusions. Remedial Action Validator shall provide the results and decisions to the SO.

6.3 Sequence Diagram

Figure 5 shows a sequence diagram with the inputs of the CSA data exchange process. Not all inputs are mandatory for every data exchange.

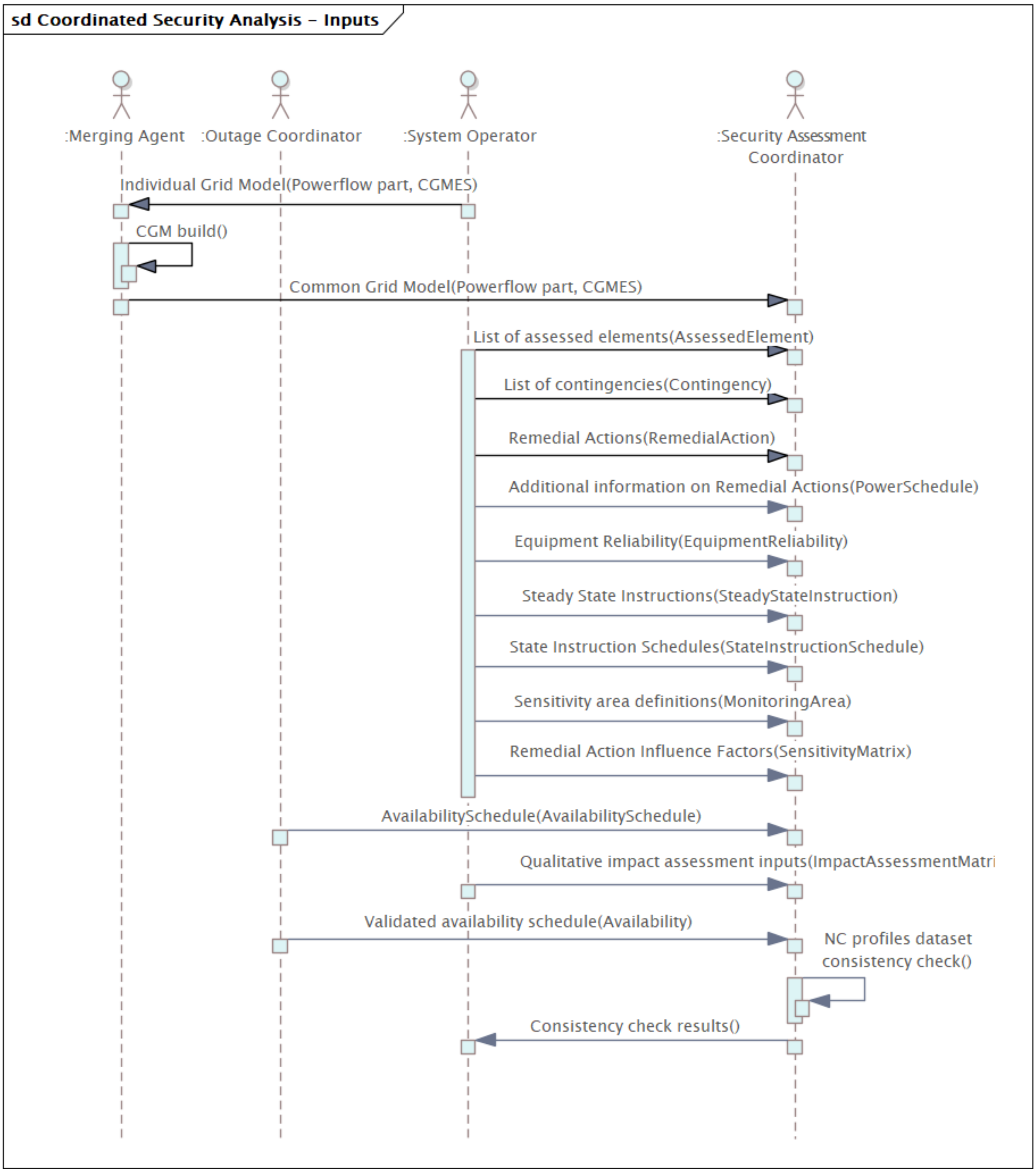


Figure 5 – CSA inputs Sequence diagram

The process starts with the submission of the IGM from each SO to the Merging Agent. Each solved IGM is composed by at least four datasets conforming to profiles providing data for power flow calculation and its result (i.e. Equipment, Topology, Steady State Hypothesis and State Variables). The frequency of submission of these profiles is different. In the case of equipment and topology and their boundaries have to be submitted when there are equipment or topology changes. For steady state hypothesis and state variables, they will have to be submitted per market time unit (e.g. 1 hour or 15 min resolution). Merging Agent merges all the IGMs and provides the CGM to the Security Assessment Coordinator.

In addition, the SO provides all relevant data needed for the business process, e.g. the list of assessed elements, contingencies, remedial actions, power schedule, equipment reliability, steady state instructions, schedules, sensitivity area definitions, remedial action influence factors and availability schedules. Outage planning agent provides the validated availability schedules which is an output of the OPC process.

Validation of consistency between "All relevant data" and CGM is performed as part of the business process, and it is not in scope for the CGM Build business process. For details, refer to section 8.1.

Figure 6 shows a sequence diagram of the CSA data exchange process. Note that not all data exchanges shown are mandatory for each variation of the business process.

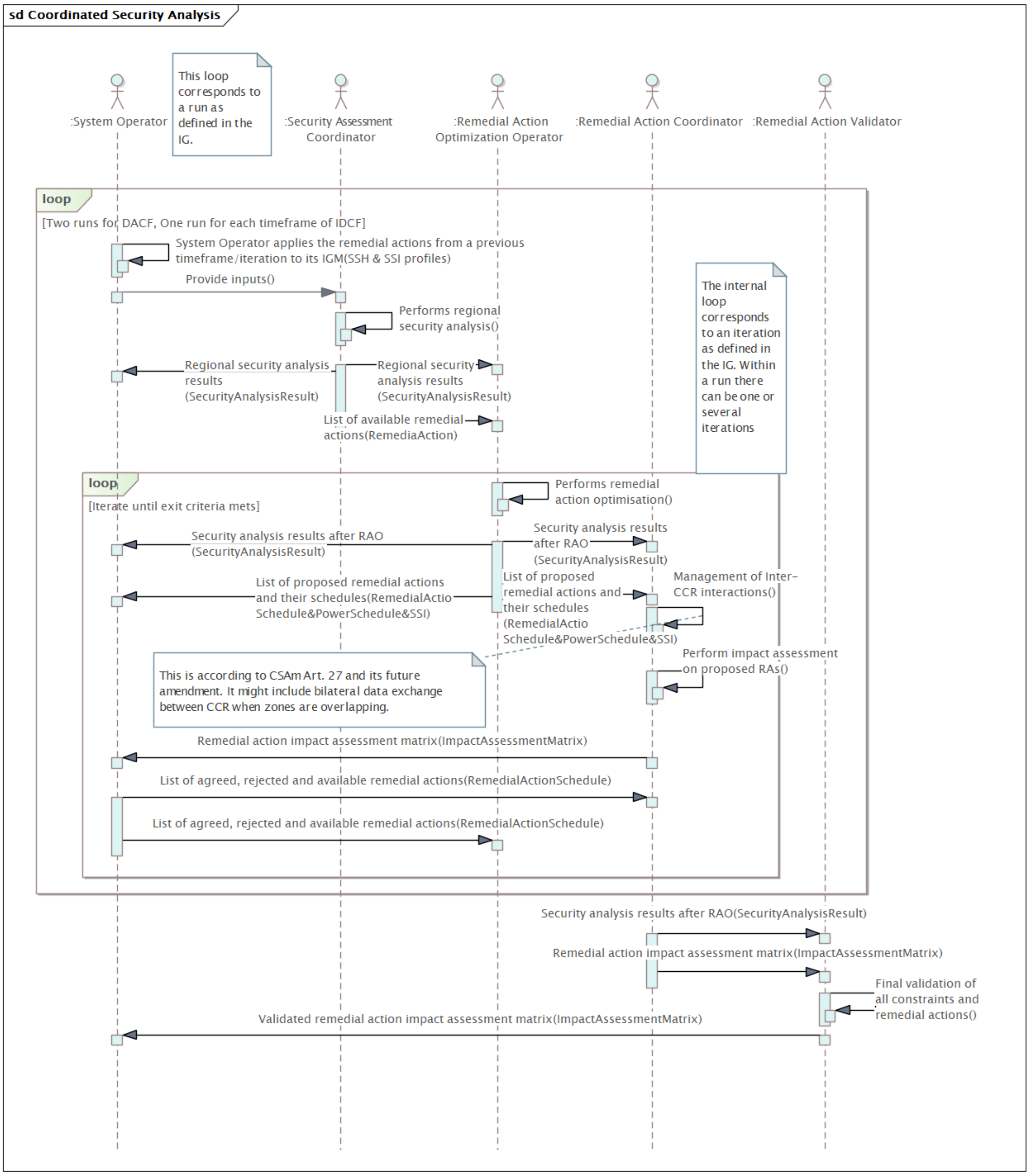


Figure 6 - CSA general sequence diagram

With all the inputs, Security Assessment Coordinator runs the regional security analysis. Basically, the security assessment allows to identify potential congestions in the grid. The result of this contingency analysis contains the identified limit violations in both base case (N situation) and considering contingencies (N-1, N-x situation). Apart from the violations, Security Assessment Coordinator also provides the remedial actions to the Remedial Action Optimization Operator. These remedial actions are part of the structural data and designed to solve identified constraints.

The remedial action optimization is performed for each Capacity Calculation Region. As a result of the optimisation, the security analysis after RAO and a list of proposed remedial actions together with their schedules are delivered to both System Operator and Remedial Action Coordinator.

After that, Remedial Action Coordinator addresses the cross-CCR interactions which consists in addressing the cross-impacts between CCRs on the overlapping zones. Just after the CCR interactions, remedial action coordinator performs the impact assessment on the proposed remedial actions. Readers might refer to section 7.4.4 for a specific use case.

The outcome of this process is the impact assessment matrix[5]. The main purpose of the matrix is to identify the affected SOs for each remedial action. The impact assessment matrix is delivered to the SOs. It can also serve as input provided by an SO in case of qualitative assessment process. Each SO shall agree or reject each remedial action by which it is impacted.

If a SO rejects a remedial action, it shall provide the reasoning and (optionally) suggest alternative new available remedial actions or modified available remedial actions. Both optimization and coordination are repeated during several iterations until exit criteria is met. The exit criteria can be, for instance, when all the identified constraints have been solved with the agreed remedial actions, or time limit is reached.

The big loop is also defined as run. In Day-Ahead there will be two coordination runs and in Intraday only one. Basically, for the day ahead, the process is repeated twice.

After coordination, a final remedial action validation session is performed by the remedial action validator which receives from remedial action optimization operator the security analysis results and the impact assessment matrix.

The main activity during the Final Validation Session is to review unresolved relevant identified constraints (on assessed elements) and discuss or find possible follow-up activities by SOs and Remedial Action Validator. Finally, the validated impact assessment matrix is delivered to the System Operator and the process finishes.

5 As part of the quantitative assessment. The qualitive assessment already took place before.

7 CSA Subprocesses

The CSA subprocesses are detailed in the following sections.

7.1 Input Data Preparation

7.1.1 Overview

Figure 7 illustrates the subprocess in which the System Operator prepares and provides the input data to be used in the business process (e.g. CSA).

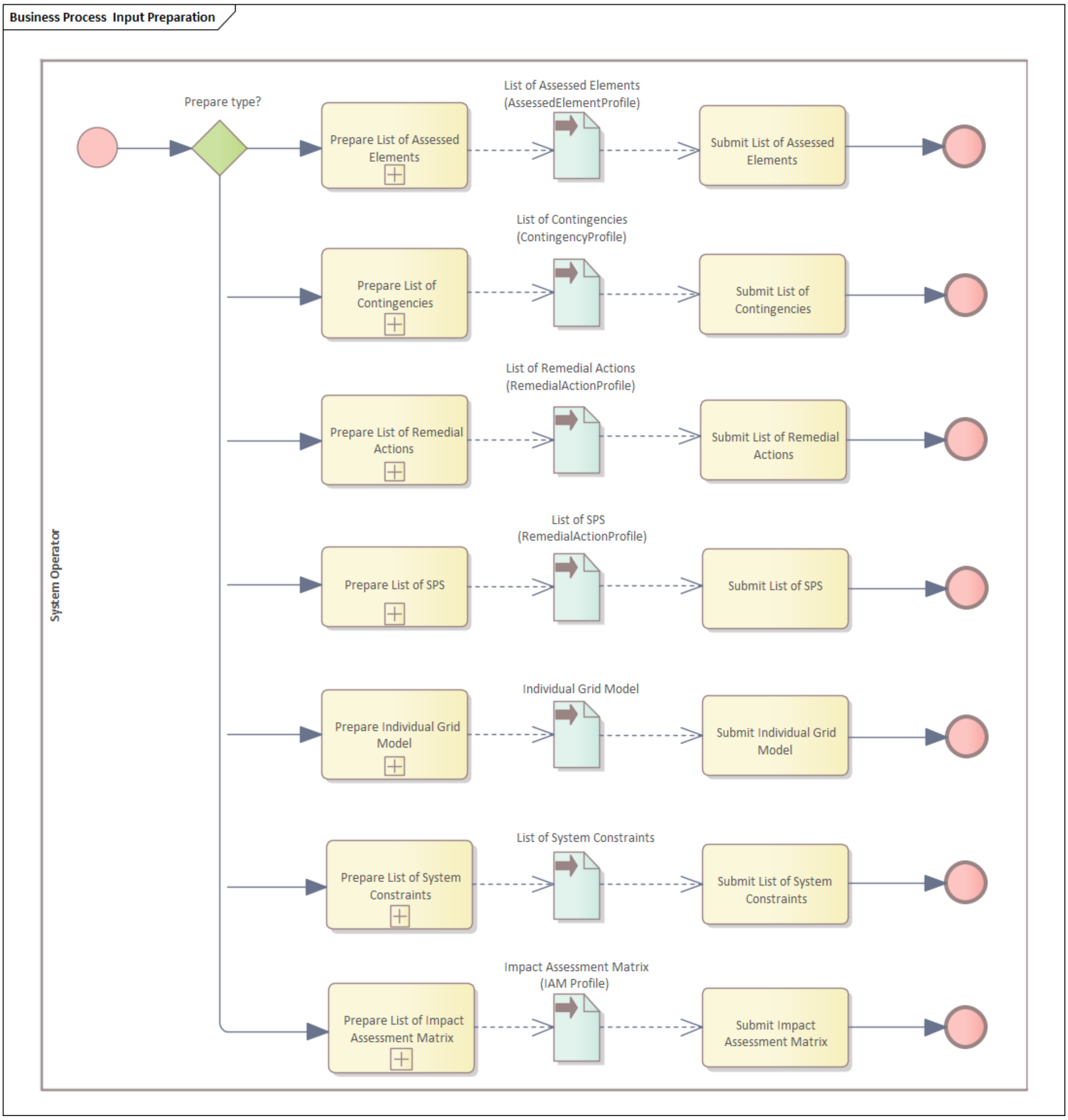


Figure 7 – Input Data Preparation

7.1.2 Inputs and Outputs

The list of Inputs and Outputs that are part of the "Input Data Preparation" subprocess is defined in Table 4.

Table 4 – Inputs and Outputs for Input Data Preparation

Inputs	Outputs
N/A	Individual Grid Model (for the studied timeframe)
N/A	List of Assessed Elements
N/A	List of Contingencies
N/A	List of Remedial Actions
N/A	List of SPS (optional)
N/A	List of System Constraints
N/A	Impact assessment matrix

As the Input Data Preparation is considered the start of the business process, the datasets prepared by the TSOs are considered as outputs of this step.

The inputs listed in Table 4 can be provided using different data exchange profiles, according to the process and/or timeframe. The profile dependency and profile hierarchy are explained in § 8.2.

Please, refer to section 7.1.3 to better understand how to exchange the presented information as structural (*offline*) or scheduled (*online*) data.

7.1.3 Input Data Design

The NC profiles are designed to support various use cases and profile flexibility on how the data is defined. There are three main categories of data:

- Structural data: data that is exchanged to define the configuration, the structure, of a given set of information. This data is exchanged only if the configuration is changed.
- Scheduled data: data that includes information for multiple time stamps in the form of a schedule.
- Data per time unit (MTU): data that is updated and exchanged for each market time unit, which can be hourly or less.

Readers may refer to section 8.2 for more information on dataset dependency.

Each instance of data (*dataset)* is uniquely identified by its identifier. The identifier shall be kept persistent to enable optimal data exchange that relies on the principle of exchanging only the necessary data and it shall not be duplicated. Besides the objective to achieve optimal volume of data exchange, it is required to track and report on different outcomes of the business processes, and this can only be achieved if the identifiers are persistent. For instance, to report on the agreement process on a remedial action schedule the identifiers of the RemedialAction, RemedialActionSchedule and the RemedialActionScheduleResponse have to be persistent.

By design, the NC profiles implement a clear hierarchy between the profiles that govern structural data, scheduled data and data per time unit. For the scope of application of scheduled data and data per time unit, some data (normally has normal values) provided as part of structural data could be updated.

The possibility of exchanging these values as a schedule is provided by State Instruction Schedule profile (SIS) as well as the Steady State Hypothesis Schedule (SHS).

The possibility to update the values on a per time unit basis is provided by Steady State Instruction profile (SSI). In some cases, there are a couple of options that can be applied when designing the setup of the input data. These options are as follows:

- **Option 1: Rely on information in structural data.**

This option is applied when the System Operator assesses that some type of data will not be changed so often and there is no need to provide schedule or per time unit exchange. In this case there is no need to use SIS and SSI profiles for this type of data.

- **Option 2: Provide default (normal) values in the structural data and supply scheduled information.**

This option is used when the System Operator assesses that there is a need to update or complement the data by using a schedule, i.e. profile the status information for the next 24 hours. The provision of normal values in structural data is optional. Any data for which a schedule exists will override normal values in structural data for this schedule calculation.

- **Option 3: Provide default (normal) values in the structural data and supply data on a per time unit basis**

This option is used when the System Operator assesses that there is a need to update the information per each market time unit. Any data for which per time unit data is provided exists will override both normal values provided by structural data and scheduled data, if defined – for this very MTU. The provision of normal values in structural data is not required for all properties.

- **Option 4: Combine different approaches**

This approach combines different options in order to achieve an optimal data exchange by providing only the information essential for the business process.

- **Option 5: Scheduled data provided after per time unit data**

This option is used when the System Operator provides scheduled data after submission of per time unit data. This option requires you to also consider the sequence of data submission and give priority to SIS data over the SSI data, which overrules the main principle that SSI data is expected to be more exact. Therefore, this option is not recommended and if business processes would like to use it will need to define additional rules.

The receiving systems shall be designed to handle different of the options above taking into account the priority of the profiles. It should be noted that the options may not be applied in a consistent way for the complete dataset and it is allowed to be mixed depending on the nature of the input data.

7.1.3.1 Enabling an Assessed Element

Table 5 illustrates the approach for the enabling of an assessed element using the AssessedElement (AE) dataset.

Table 5 – Illustration of input data combinations for enabling of an AssessedElement

Structural data	Scheduled data (SIS)	Per MTU data (SSI)	Result
Provided	Not provided	Not provided	AssessedElement.normalEnabled from structural data applies
Provided	Provided	Not provided	AssessedElementTimePoint.enabled from SIS applies
Provided	Provided	Provided	AssessedElement.enabled from SSI applies
Provided for AE 1, Provided for AE 2 Not provided for AE 3[6]	Provided for AE 1, Not provided for AE 2 Not provided for AE 3	Not provided for AE 1 Not provided for AE 2 Provided for AE 3	AssessedElementTimePoint.enabled from SIS applies for AE 1 AssessedElement.normalEnabled from structural data applies for AE 2 AssessedElement.enabled from SSI applies for AE 3 The rule is: For a given property (value), use SSI if available, otherwise SIS if available, otherwise normal value in structural data.
Provided	Provided but after SSI	Provided	AssessedElementTimePoint.enabled from SIS applies because the data is submitted after the SSI data. This option requires tracing of the submission time.

[6] Structural data can optionally exchange normalEnabled (by profile definition), but the value in the normalEnabled is not provided (because optional).

There could be multiple datasets of the same type for the purpose to separate the usage. For instance, some regions can use metadata to enable the use case of providing a set of AssessedElement objects for one part of the power system and another set of AssessedElement objects for another part of the power system. This will require that the receiving party understands the metadata provided in the manifest and/or in the dataset header if the party is interested in studying only one part of the power system or performing separate studies.

7.1.3.2 Date and Time notations in NC profiles

CGMES uses UTC date/time references and normally NC profiles shall be consistent with this. However, in general, the date/time in NC profiles' datasets can be defined with or without time zone and this depends on the use cases. The recommendation is that there is a time zone and how strict this should be is left to the business processes utilizing NC profiles. Therefore, the business process should decide if there is a need to define a SHACL business constraint to restrict this.

7.1.3.3 Datatypes – Active Power versus Current

Business processes may use different units for flow quantities e.g. as power (MW) or as current (A). CIM and CGMES mostly uses power instead of current and this is followed by NC profiles. Therefore, when implementing the profiles vendors need to take into account potential units' conversion in case there is a requirement to represent the quantities for reporting or other purposes. CGMES and NC profiles provide necessary information to convert.

7.1.4 Conformity Requirements

To be able to support input data preparation the Application shall conform to the following Application functions:

- Import of single dataset.
- Export of single dataset.
- Structural data setup.
- Scheduled data setup.

7.1.5 Equipment Modelling Representation

The RCP DES and NC profiles are built with the latest data exchange standards (IEC 61970-600-1:2021, IEC 61970-600-2:2021 and beyond) in mind.

There are significant difficulties in fulfilling requirements in a future proof way by using older versions of data exchange standards and different styles of modelling representations used in the power system models.

Some of the topics are much beyond data exchange itself and touch on how the power system is studied, used, and planned in an optimal and efficient way.

Equipment Reliability profile is designed to cover at least some of the most urgent gaps. This profile is helping to realise the transition between versions of CGMES, and it will be incorporated in next versions of CGMES with the expectation that business processes will also transition to next versions of CGMES.

This section gives guidance on equipment modelling that is realised using Equipment Reliability profile in combination with other profiles to make it includable in CSA-processes via NC-Profiles.

7.1.5.1 Modelling of Conventional and Renewable Generation from Underlaying Network

Within the energy transition framework and for redispatch processes used for congestion management, TSOs increasingly need to rely not only on conventional power plants connected to the transmission grid but also on smaller capacity power generating modules (PGMs) connected to a lower voltage network.

The objective of this use case is to provide guidance for accurate modelling, when simplifying due to e.g. aggregation of generation resources or network reduction, of both conventional and renewable, that are connected to the distribution grid, typically at 110 kV or below.

A key modelling enhancement that TSOs seek is the ability to model these redispatch resources after network reduction as generation equivalents, suitable for use in CSA processes (i.e., ROSC).

7.1.5.1.1 Current modelling approach

One of the current modelling approaches that is part of this UC follows two types of strategies, depending on the nature of the resource and its network context:

1. Renewable generation aggregation (many-to-one)

- *EnergySource* objects (class), located on the low-voltage side of high-voltage transformers, are employed to model aggregated renewable production after the network reduction of the DSO grid.
    - This represents a many-to-one aggregation, where multiple small-scale renewable generators are collectively modelled and reduced into a single representative source.

For the sake of representation, Figure 8 shows a TSO and DSO grid before and after network reduction. Inside the DSO grid, renewable generation is connected decentralized at different busbars. These infeeds might already resemble aggregates of many smaller PGMs. After network reduction, the renewable generation is aggregated once more and modelled at the low voltage side of a high voltage transformer as EnergySource (class).This approach implies the loss of relevant information due to missing attributes and relations of the EnergySource class (i.e., ramp up costs, shutdown costs, etc.).

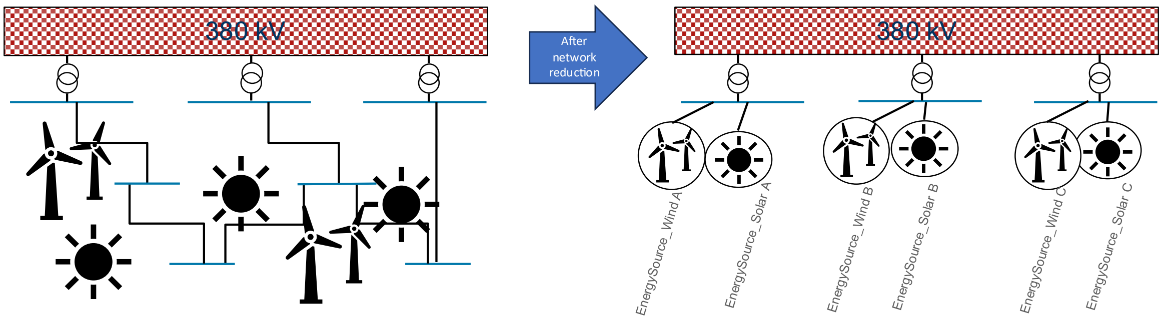


Figure 8: Example of renewable generation connected to TSO or DSO grid

2. Conventional generation representation (one-to-many)

- *ExternalNetworkInjection* objects (class) are used after the DSO grid reduction to represent the infeed from conventional power plants connected within the DSO grid but impacting different high-voltage transformers (sum of infeeds equals original infeed of the PGM[7]).
    - This approach is necessary because the system already contains a specific model for conventional generation, and TSOs now need to share these capabilities as redispatch volumes for regional CSA coordination (i.e., in a regional platform).

For the sake of representation, Figure 9 shows a conventional PGM connected to a busbar inside the DSO grid. After network reduction this PGM is modelled as multiple scaled infeeds using the ExternalNetworkInjection class.

[7] To be in line with SOGL and CSAm lexis, this term refers to SGU of type PGM.

This approach implies the loss of relevant information due to missing attributes and relations of the ExternalNetworkInjection class (i.e., ramp up costs, shutdown costs, etc.).

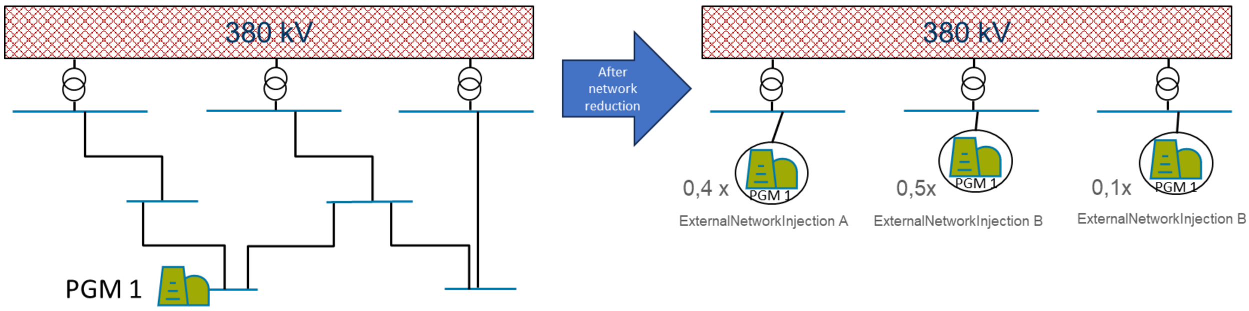


Figure 9 Example of conventional PGM after network reduction with impact distribution

One could think that a first viable alternative to the presented modelling approach would be modelling generating units explicitly, even at lower voltage levels, by using the RotatingMachine (SynchronousMachine) class. This approach would offer higher fidelity and realism in the model, and it supports more accurate representation of generator behaviour.

However, it was already discussed, and considered a non-viable approach for every kind of generation model as it requires additional modelling effort and is not universally adopted among TSOs due to its increased complexity and maintenance overhead.

However, the current implementation does not allow TSOs to design a *RedispatchRemedialActions* out of the use of *ExternalNetworkInjections* and *EnergySource* classes with all applicable constraints for *GeneratingUnits*.

Therefore the following sections propose a recommended use of the NC profiles to allow TSOs to provide redispatch capabilities for the CSA process, even when the generators are embedded in the reduced (i.e., DSO) network model.

7.1.5.1.2 Business drivers and use cases

Multiple business requirements and use cases drive the transition towards a recommended modelling approach. At the same time, the recommended approach aims to close some gaps in the current way of modelling PGMs both in the IGM (for CGM BP purposes) and in the NCP (for CSA purposes)

Some of the business requirements taken into account during the design of the present version of RCP DES and next versions of CGMES are provided here as background information:

- SO GL Art. 41:
    - It requires distinction between different fuel types in the grid model.
- CGM Methodology v4 Art. 9:
    - It supports identification of generation type in grid models.
- Article 5 of EU RfG 2016/631:
    - Defines categories of Significant Power Generating Modules (SPGM): Types A, B, C, and D, based on connection voltage and installed capacity.
    - These determine modelling obligations and requirements for control and communication.
- Impact of generating units on Short-Circuit and Stability Studies:
    - The modelling of DERs (power electronic based) as generating units (or *SynchronousMachine* objects) affects short-circuit and stability calculations, which is not always desired from a model fit-for-purpose perspective.
- Information traceability:
    - Aggregating and disaggregating models across planning stages (market, operational, system development) represents challenges for keeping relevant information and ensure models' compatibility.
- Grid reduction implications (as described above):
    - As a result of a network reduction of the underlaying grid, generation and load is
        - Either grouped together into a few, injections or loads, depending on the underlaying topology.
    - Or split up to multiple injections or loads, depending on the underlaying topology.
    - The use of GLSK strategy is used to minimise the effect of information *loss* and produce an approximately correct power flow for a given situation.

7.1.5.1.3 A note on generation modelling vocabulary

It is useful to set readers on the same page when using modelling vocabulary. This will help them navigate the chapters below.

- Explicit (detailed) model
  - A close to reality representation of a power system or its assets.
- Equivalent model
  - An Equivalent Model is a simplified representation of a power system that preserves the essential electrical and dynamic characteristics of the original system representation while reducing the number of elements or characteristics.

    It replaces a detailed network or component representation with mathematically derived equivalents, ensuring that key system properties such as impedance, power flows, and dynamic responses are maintained depending on the purpose of the study where the equivalent model is used.
- Aggregation model
  - An Aggregation Model is a generalised model that groups multiple system elements into a single representation

    Unlike an equivalent model, which aims to preserve the exact electrical response, an aggregation model focuses on statistical, geographical, fuel or operational similarity. Additionally, an aggregated model can be disaggregated because in theory one can trace the elements being aggregated.

7.1.5.1.4 Recommended modelling approach per generation type in case of reduced grid models

The proposed modelling solution addresses the complexities arising when grid model reduction is applied—often necessary for optimisation performance—but it demands traceable aggregation logic to allow for accurate disaggregation of resources when needed.

Furthermore, the proposed approach takes into account some anticipated requirements outlined in the upcoming Network Code on Demand Response, ensuring that the solution is future-compatible.

Before defining different exemplary use cases, some general modelling recommendations should be considered:

- It is not recommended using the *EquivalentInjection* class for either load or generation components.
- Generation and Load should always be split up. This approach avoids ambiguity as pure load models obscure the presence of generation.

When describing the recommended approach, it is convenient to split it following the Article 5 of the EU RfG 2016/631 classification for different generation types to distinguish different exemplary use cases

7.1.5.1.5 Type A Power-Generating Modules

These are typically small, renewable, not dispatchable generation sources that are forecasted and non-scheduled. Furthermore, these PGMs are already aggregated inside the section of the DSO grid (ControlArea) that the TSO typically sees.

The recommended modelling approach is as follows:

- Recommended approach:
    - Using *EquivalentGeneratingUnit* or EquivalentPowerElectronicsUnit which is available in the *EquipmentReliability* profile in combination with Equipment.aggregate set to TRUE (for details, refer to the *Production* diagram, which for ease is offered in Figure 11).
- Deprecated approach:
    - Using *EnergySource and/or EquivalentInjection* (used only for legacy transition purposes for the EQ profile between CGMES versions).
        - Refer to the section below for recommendations on how to transition from using *EnergySource* to *EquivalentGeneratingUnit.*
- Other considerations:
    - As the electricity grid is getting a higher mix of energy resources and storage capacity, grouping them together might be beneficial when forecasting these resources. Therefore, the ER profile offers the *EnergyComponent* class which provides a mechanism for grouping of consumption and production with the same characteristics(as shown below).

When modelling the current example using the ER profile, the class *EquivalentGeneratingUnit/ EquivalentPowerElectronicsUnit* indicates the virtual representation of a distributed set of resources, aggregated for forecasting/scheduling. This represents several advantages from the modelling point of view:

- As the class inherits from *GeneratingUnit/ PowerElectronicsUnit*, it can be associated with *ScheduleResource* (in the ER profile). This can be observed in Figure 10.
- The *EquivalentGeneratingUnit* class is also associated with *ExternalNetworkInjection* (defined in the EQ profile of CGMES both v2.4 and v3.0). This is also depicted in Figure 10 as well as in the ER profile extract in Figure 11.
    - The *ExternalNetworkInjection* part of the EQ dataset can be referenced to the *EquivalentGeneratingUnit* in the ER dataset.
- Although not visible in the Production diagram, the GeneratingUnit class is associated with the class ScheduleResource too. This allows the EquivalentGeneratingUnit class to participate in the market processes and to use the concept of SchedulingArea as the Figure 12 shows.

To distinguish by generation type, one could make use of the classes derived from

EnergyComponent: EnergyGroup and EnergyType.

A SchedulingArea may have different energy groups, each of such groups, being linked to an energy type. Thanks to the attribute kind of the EnergyType class, one can choose from a list defined in the EnergyKind enumeration[8].

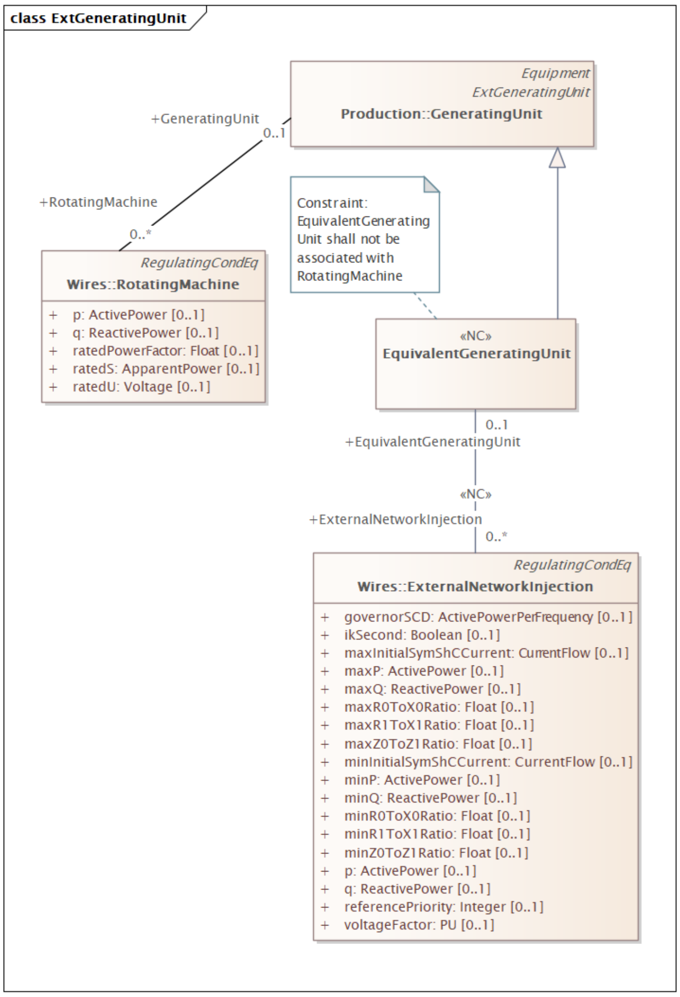


Figure 10: Extract from EuropeanCIMExtensions/ExtNetworkCodes/ExtGeneratingUnit package showing the design of EquivalentGeneratingUnit

[8] This list in the EnergyKind enumeration is in line with the *Association of Issuing Bodies* Fact Sheet 05 standard.

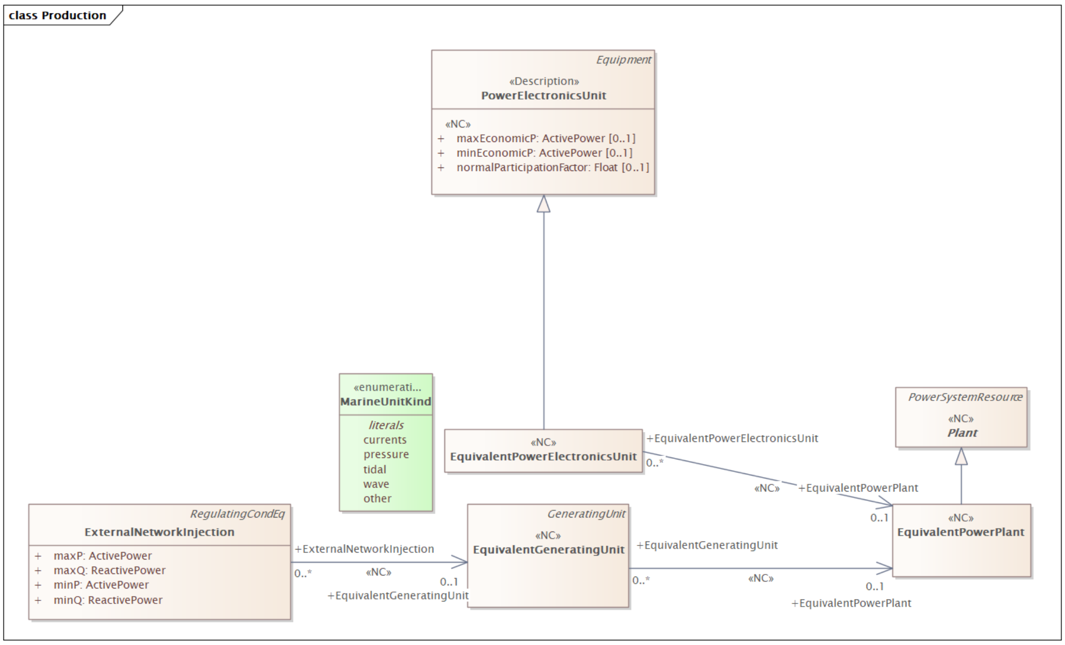


Figure 11: Extract from the ER profile (*Production* diagram) showing the associations of EquivalentGeneratingUnit and EquivalentPowerElectronicsUnit

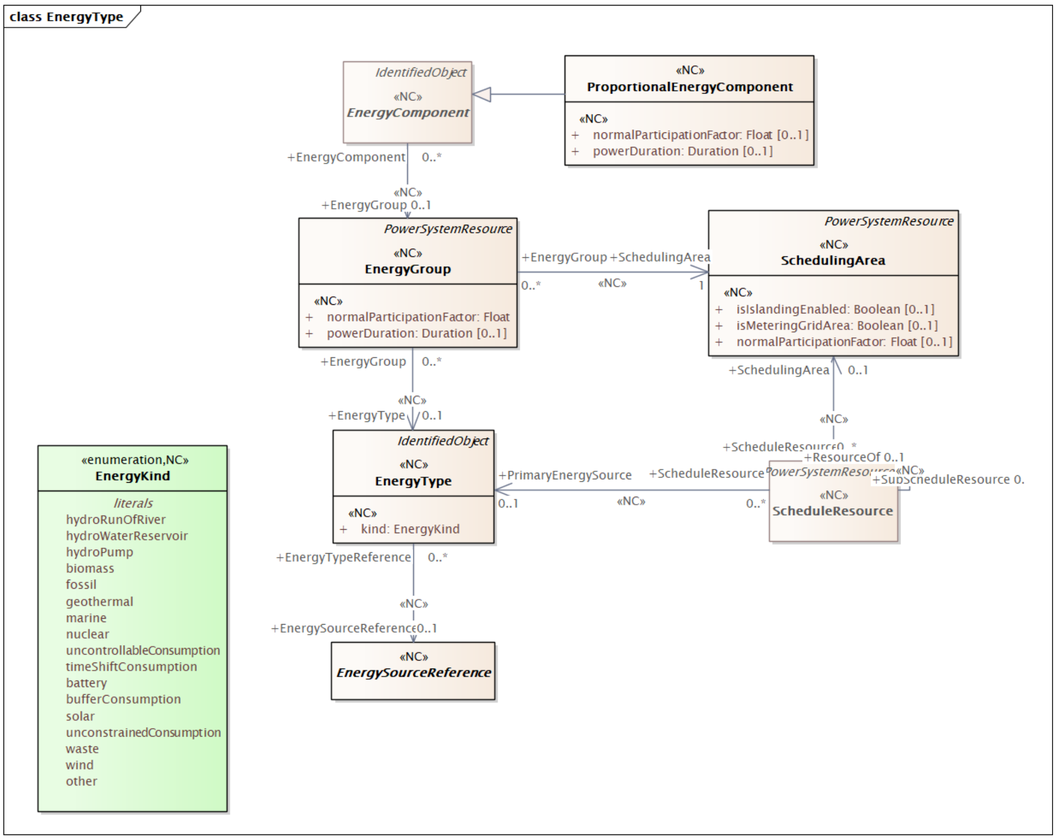


Figure 12: Extract from the ER profile (EnergyType diagram) showing the associations of the ScheduleResouce, SchedulingArea, EnergyGroup and EnergyType classes

The Figure 13 shows the recommended way to model the network reduction while keeping all the necessary information to optimise the redispatches.

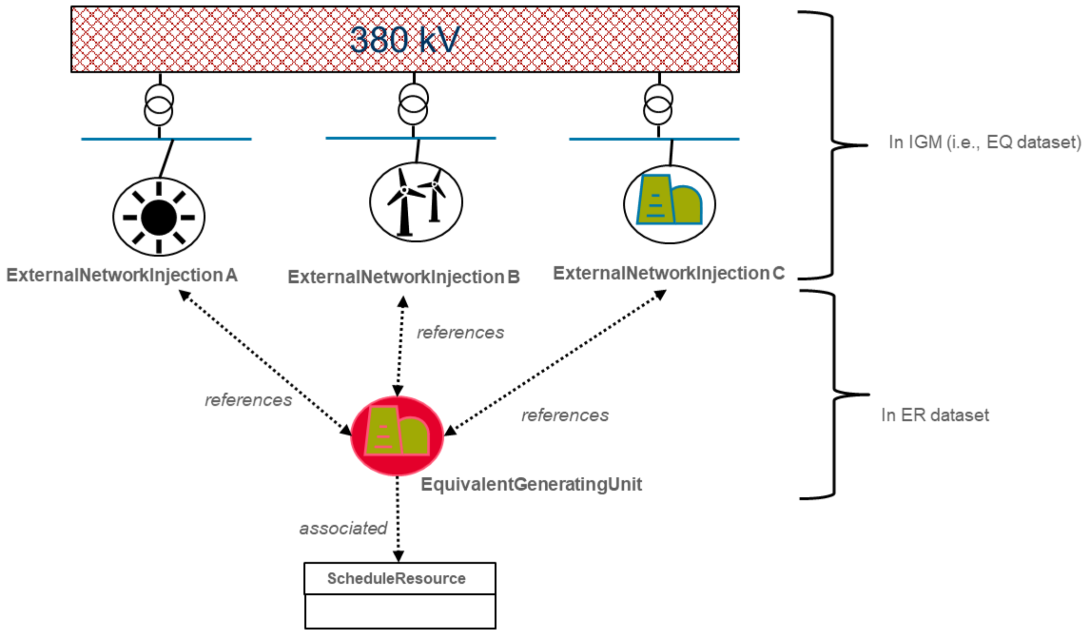


Figure 13: Recommended approach using EquivalentGeneratingUnit

Readesr might note that *Power Park Modules* which have non-synchronous behaviour will need to be modelled by the *PowerElectronicsUnit* class in future expansions of the Network Code or future CIM versions (v18 and beyond).

7.1.5.1.6 Type B and C Power-Generating Modules

They are larger than type A but below type D threshold and they can be modelled both explicitly (in detail), as aggregated, or as aggregated and equivalents units. The recommendations for each case are as follows:

- For an explicit (in detail) model:
  - Using GeneratingUnit/PowerElectronicsUnit with Equipment.aggregate set to FALSE.
- For an aggregation of explicit (in detail) models
  - Using GeneratingUnit/PowerElectronicsUnit with Equipment.aggregate set to TRUE.
- For an aggregated ("*simplified"*) model:
  - Using EquivalentGeneratingUnit/EquivalentPowerElectronicsUnit with Equipment.aggregate set to TRUE (e.g., in the same way as type A PGMs).
- For a non-aggregated ("simplified") model of a single PGM
  - Using EquivalentGeneratingUnit/EquivalentPowerElectronicsUnit with Equipment.aggregate set to FALSE

Indeed, in case these generators are modelled explicitly (in detail), the recommendation is using the *GeneratingUnit* class as well as considering relevant its subclasses (*specialisations*) depending on the requirements for splitting per type of generation (e.g., hydro, thermal, solar, etc.).

As for Type A generators, the information about the generation technology can be derived through the use of classes derived from EnergyComponent as illustrated in Figure 12. Additionally, one can make use of *fuelType* enumeration as shown in Figure 14.

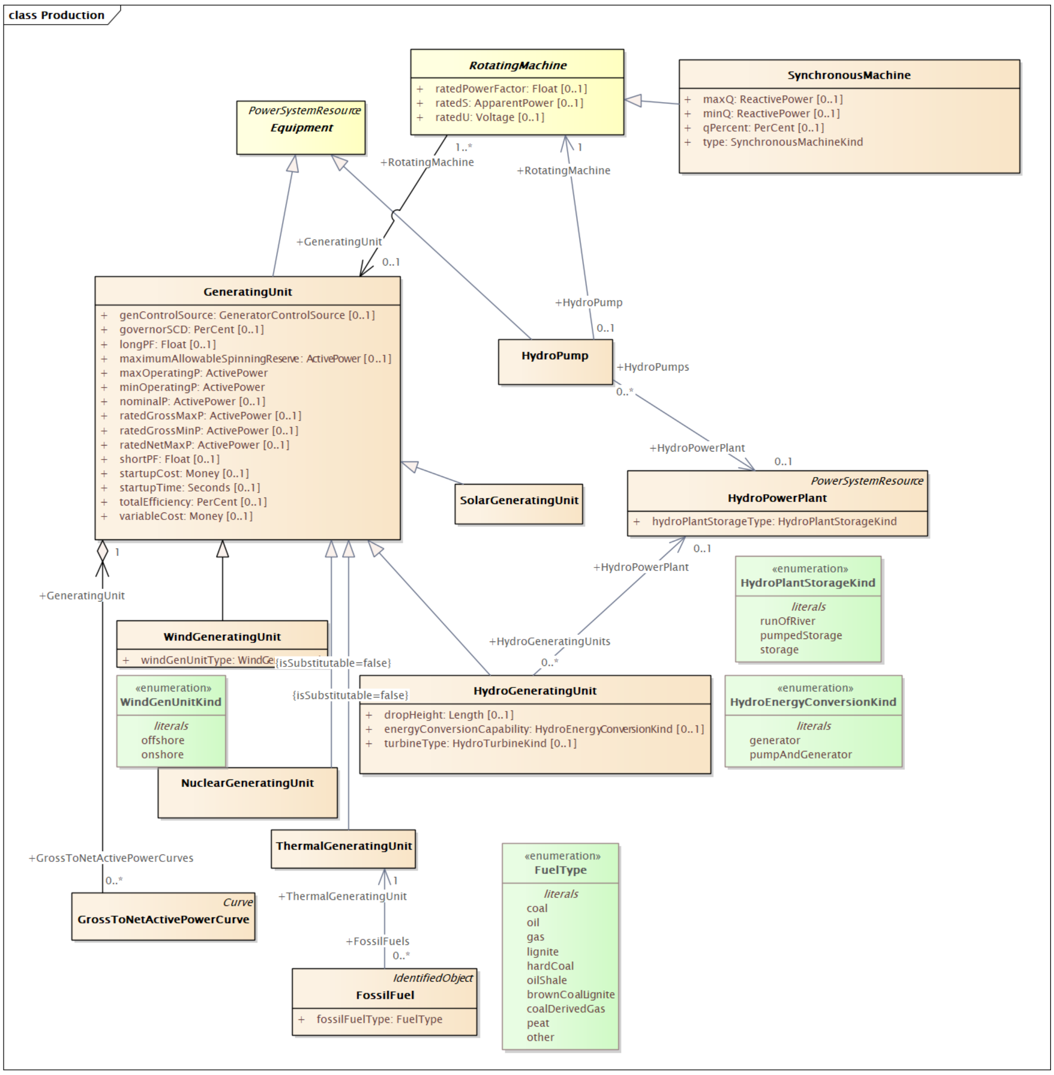


Figure 14: Extract of CoreEquipmentProfile ("EQ") dataset of IEC 61970-452 (CGMES)

7.1.5.1.7 Type D Power-Generating Modules

Type D are large units, providing detailed electrical characteristics, real-time data and scheduled information which need a detailed representation (real-time visibility). As mentioned in the section above, this is also known as “explicit” (in detail) generation modelling.

The recommended modelling approach is to use *GeneratingUnit* set with the attribute *Equipment.aggregate* set to *FALSE* and to provide proper linkage to real network location and voltage level.

It is not recommended to do a network reduction where Type D PGMs are connected although this might be the case sometimes. For this purpose, the use of EquivalentGeneratingUnit/EquivalentPowerElectronicsUnit with *Equipment.aggregate* set to FALSE would be applicable.

As for Type A generators, the information about the generation technology can be derived through the use of classes derived from EnergyComponent as illustrated in Figure 12. Additionally, one can make use of *fuelType* enumeration as shown in Figure 14

This approach facilitates the integration of real-time scheduling information of both grid and market models.

7.1.5.1.8 Summary of Recommendations

The Table 6 summarises the guidance outlined in the chapters above. These recommendations can be applied depending on the intention or sub-use case for the modelling of underlying generation.

Table 6: Summary recommendations on the modelling of conventional and renewable generation from underlaying network

Sub-use case	Recommended class	Note
Simplified model with aggregation	*EquivalentGeneratingUnit / EquivalentPowerElectronicsUnit* with *Equipment.aggregate* set to *TRUE*	n *ExternalNetworkInjection* class can be associated. A *RotatingMachine* class cannot be associated[9].
Simplified model without aggregation	*EquivalentGeneratingUnit/EquivalentPowerElectronicsUnit with Equipment.aggregate* set to FALSE	A *RotatingMachine* class not be associated
Explicit (in detail) **model without aggregation**	*GeneratingUnit/PowerElectronicsUnit* (and subclasses) with *Equipment.aggregate* attribute set to *FALSE*	A *RotatingMachine* class can be associated.
Explicit (in detail) model with aggregation	*GeneratingUnit/* or *PowerElectronicsUnit* (and subclasses) with *Equipment.aggregate* attribute set to *TRUE.*	Fr B. A *RotatingMachine* class can be associated. i.e. when aggregating multiple machines of the exact same type
Historical/legacy or temporary implementation and adoption	*EnergySource* class	The use of this class is deprecated. This class is not future-proof ant it is expected to be deprecated in future

[9] *RotatingMachine* cannot be associated with *EquivalentGeneratingUnit* as per the UML desgin. However, *RotatingMachine* can be associated with *GeneratingUnit*.

period modelling		CIM standard releases. See section below with recommendations for transition.
Other relevant, more general aggregation cases (i.e., DSO, SGU, etc.)	From DSO, SGU perspective*, Equipment* class as per in the canonical CIM with *aggregate* attribute set to *TRUE.* From TSO perspective, they may use the associations *AggregatedEquipment* and *DetailedEquipment* in Equipment class in the ER profile when receiving information from DSOs, SGUs, etc.	This approach allows to obtain the reverse references and traceability from the original unit.
Load representation from distribution level	*EnergyConsumer* class	This approach uses the same aggregation logic as for generation.

1408

7.1.5.1.9 Modelling Recommendations for transition period from using *EnergySource* to using *EquivalentGenerationUnit/ EquivalentPowerElectronics* classes

It is important to note that the use of *EnergySource* class for modelling aggregated renewable generation is not recommended. This class is used in CIM for modelling injections from the transmission to the distribution grid.

The preferred long-term solution is to migrate to the use of *EquivalentGenerationUnit/ EquivalentPowerElectronicsUnits* (based on *GeneratingUnit/PowerElectronicsUnit)* in combination with *EnergyType* for a more accurate and standards-compliant representation.

As long as EquivalentGenerationUnit/ EquivalentPowerElectronicsUnits cannot be included in the CGM process we would need to have two separate functional representation of the same item. ObjectRegistry is used to link them together by providing a link from EquivalentGenerationUnit/ EquivalentPowerElectronicsUnits to the Name object that include Name.mRID (new UUID), Name.name = mRID to the EnergySource and Name.UniqueIdentifiedObject is the association that shall be used.

This transitional solution has the following advantages:

- It allows easy adaptation for software tools, and they just need to interpret that there are two separate instantiations of classes, and the OR profile tells the tool they are the same.
    - For instance: Instantiating equivalent objects such as *EquivalentGeneratingUnit*, *ExternalNetworkInjection* or *EnergySource* within the NC profiles, thus ensuring that existing use cases remain supported.
- It supports further transition for matching concepts between the TSO and DSO world.
- It supports the use of the Object Registry profile which is also used in the OPC process.

Nevertheless, software tools need to pay special attention to not counting the power of the generating units behind the *EquivalentGeneratingUnit* and *EnergySource* twice.

Other recommendations for keeping information traceability, especially critical when dealing with grid-reduced models and disaggregation back to original units, are:

- Using *Equipment.aggregate*: to indicate whether an element is part of an aggregation,
- Using the association between *ScheduleResource* and *EnergyType*: to preserve information about the generation source,
- Using *Equipment.networkAnalysisEnable*: to control inclusion of equipment in network analysis
- Using *Equipment.AggregatedEquipment*: to inform on the details of the aggregation.

These features provide the semantic linkages needed for transparent and auditable aggregation logic.

To ensure consistency between generation and market models, the class *ScheduleResource* should be used as the key interface. This enables:

- Coherent modelling of connection points and
- Classification of generator types (e.g., SPGM, SPU) in line with aforementioned EU Regulations.

7.1.5.1.10 Reference Implementation Example of the use of EquivalentGeneratingUnit along with ExternalNetworkInjection to be included in a RedispatchRemedialAction

The intention of this chapter is to guide TSOs on what they need to add in their ER profile instances so the information of EquivalentGeneratingUnit is available for the CSA process.

Based on the relevant parameters of the PGM, TSOs would need to create a new EquivalentGeneratingUnit in the ER Profile which contains all attributes of a GeneratingUnit. The existing ExternalNetworkInjections introduced in the IGM need to be addressed and linked to this new EquivalentGeneratingUnit.

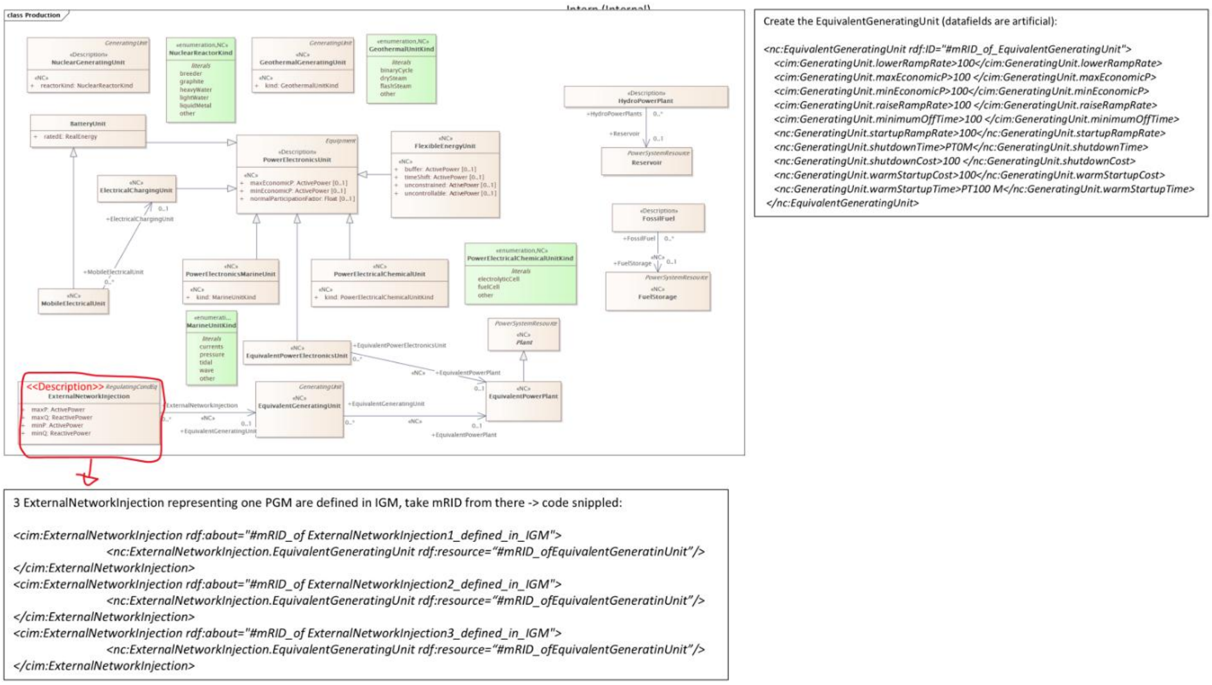


Figure 15: Example showing the creation of a ExternalNetworkInjection in the ER dataset

The EquivalentGeneratingUnit would now deliver the parameters for the PGM but it does not have any physical representation in the IGM. This is also seen due to the fact that one does not associate a RotatingMachine with EquivalentGeneratingUnit.

Afterwards, the modelling of the RedispatchRemedialAction is done as followed (similarly to a regular RedispatchRemedialAction):

1. RemedialAction (RA) dataset: Definition of one RedispatchRemedialAction
2. StateInstructionSchedule (SIS) dataset:
   - Creating PowerBidSchedule instances connected to multiple PowerShiftKeyDistribution instances where each ExternalNetworkInjection class is linked and associated with its participation factor (PF).

7.1.5.2 Representation of HVDC Interconnections

The topic on representation of HVDC has different aspects. The RCP DES does not deal with it in detail. The NC profiles provide additional classed to enable more detail representation of the HVDC interconnections as part of DC IGM, but the details on how to exchange them are topics of other documents such as ENTSO-E Boundary and reference data exchange application specification and CGM Implementation guide (AC and DC parts) for cases when previous versions of CGMES are implemented.

7.1.5.3 Grid Modelling Representation Styles

Different versions of CGMES provide guidance on the how to model bus-branch and node-breaker modelling representations. RCP DES recommends usage of at least IEC 61970-600-1/-2:2021 as this version provides better interoperability conditions. From NC Profiles point of view and for full compliance with SO GL topology related definitions it is required to use node-breaker modelling style. Necessary switching equipment needs to be present in the model (IGM/CGM) in order to enable operations on this equipment via instructions given by the NC profiles.

In the process of clarifying modelling styles, the topic on retainment of switches was addressed. Future versions of CGMES will clearly specify this, however in the meantime RCP DES requires that:

- Switch.retained property (part of CGMES EQ profile) is only used in case a switch has to be operated as part of a control during the power flow calculation algorithm (note that contingencies and remedial actions are considered as not being part of a power flow calculation algorithm). Therefore, if such requirement does not exist an IGM shall not have retained switches.
- Systems that need to execute remedial actions that act on switches shall perform a topology processing in order to calculate the target topology and shall not rely on the initially submitted IGM or CGM.

7.1.5.4 CGMES/CIM Properties not Part of NC Profiles

There are some properties that are part of CIM, canonical extensions such as NC or CGMES profiles, but not part of the NC profiles. NC profiles now contain SHACL based constraints [10]to indicate if the dataset contains additional, not defined in the profile, properties. Such properties are not expected to be processed without an explicit agreement within the data exchange that applies NC profiles.

In order to enable business processes to supply necessary information the ER profile includes "normal" values for these attributes. These attributes are going to be repositioned in the right profiles with the merge of ER and EQ profiles in future releases of the CIM international standard.

Until that moment, the information and data can be supplied with ER datasets.

[10] Refer to the Application Profiles Library on the ENTSO-E CGMES Library for SHACL constraints serialised in TURTLe and to the human-readible specifications per Network Code Profile for further information. The ReadMe of the Application Profiles Library also offers insightful information on SHACL constraint design.

7.1.6 List of Assessed Elements

The List of Assessed Elements provision is illustrated in Figure 16.

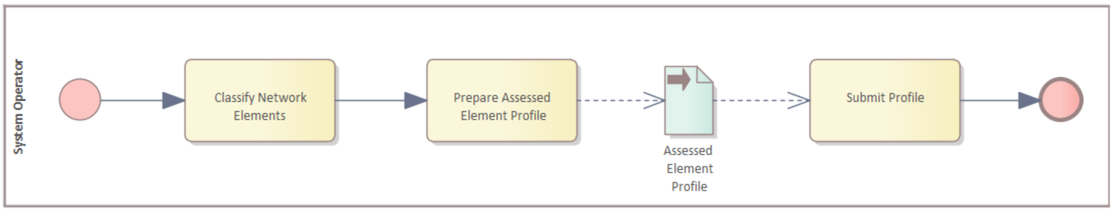


Figure 16 –List of Assessed Elements provision

The first step is to classify the Network Elements in the grid, the network element category diagram is represented in Figure 17.

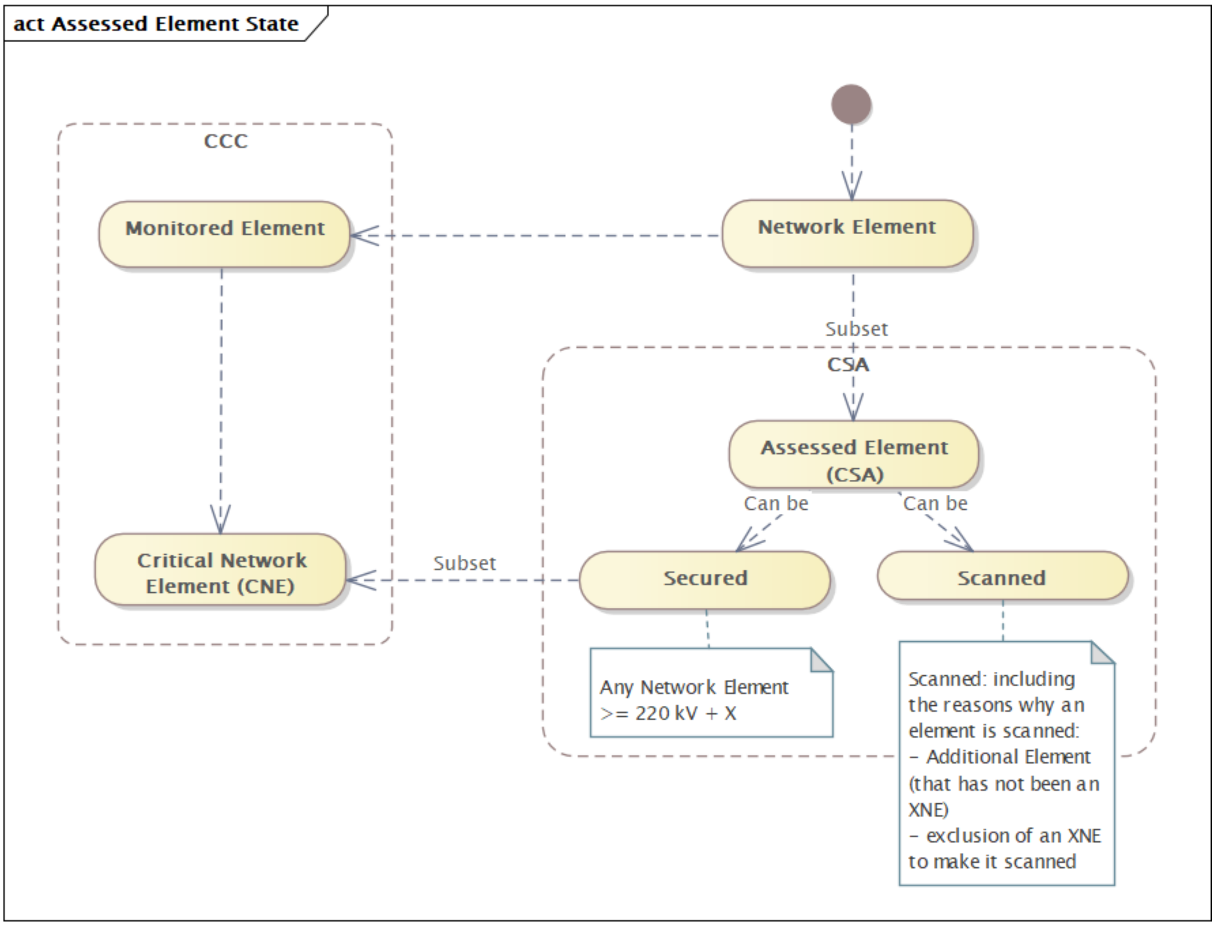


Figure 17 – Network element category diagram

Any network element can be an assessed element in a business process. The decision of which network elements are referred as assessed elements lies with the entity preparing the structural data, e.g. a TSO preparing assessed elements according to the requirements of business processes that perform the assessment. The assessed elements can be secured or scanned. A Secured element is an Assessed Element on which remedial actions are needed to relief violations of an operational security limit identified during the regional or cross-regional security analysis. For instance, a secured element would be a cross-border relevant network element (XNE), which includes all grid elements with a voltage level higher than or equal to 220 kV that are not intentionally excluded.

A scanned element is an Assessed Element on which the electrical state (at least flows) shall be computed and shall be subject to an observation rule during the regional security analysis process. Such observation rule can be for example avoiding the increase of a constraint or avoiding the creation of a constraint on this element, as a result of the design of remedial actions needed to relieve violations on the secured elements. A scanned element could be any grid element if the grid element is not a Critical Network Element (CNE).

A Critical Network Element (CNE) is a network element monitored during the coordinated capacity calculation process. Critical network elements are a subset of the secured elements.

The second step is to provide the list of Assessed Elements using the Assessed Element profile. If an Assessed Element defined in the Assessed Element profile refers to an equipment or its controls that cannot be exchanged using CGMES Equipment profile dataset used in the CGM Build process, there is a need to define it in the Equipment Reliability profile in case that profile supports the definition of the new equipment and/or its controls. For instance, Equipment Reliability profile defines additional equipment and controls on HVDC, limits, reactive capability curves. Figure illustrates the profiles dependencies. The System Operator shall ensure that the Assessed Elements are consistent with the power system model (IGM) valid for the validity period of the Assessed Element data.

The following general aspects apply when modelling assessed elements:

- The grid equipment that is assessed is in the Equipment profile dataset and is referenced by its mRID;
- The Region and SystemOperator in which/by which the AssessedElement is assessed are referenced by their mRIDs defined in the common data dataset (see Section 0) which conforms to the Equipment Reliability profile.
- When the reference to ConductingEquipment (e.g. a line, a transformer) is defined and there is no reference to *OperationalLimit*, the assessment is performed for all limits defined at all ends of the equipment. In case an AssessedElement object refers to a ConductingEquipment that has no limits defined in the underlying model the assessment will not be performed. Therefore, this needs to be detected in the consistency checks constraints. The advantage of using reference to *OperationalLimit* is that the target point of the assessment is defined in an exact way because the *OperationalLimit* relates to a type (e.g., PATL, TATL, etc.) and location (e.g., terminal at side 1 of the equipment).

7.1.6.1 Secured Assessed Element

This example illustrates how to specify a Secured Assessed Element. Note that the example does not reflect universal way of modelling a secured assessed element and may miss regional specificities.

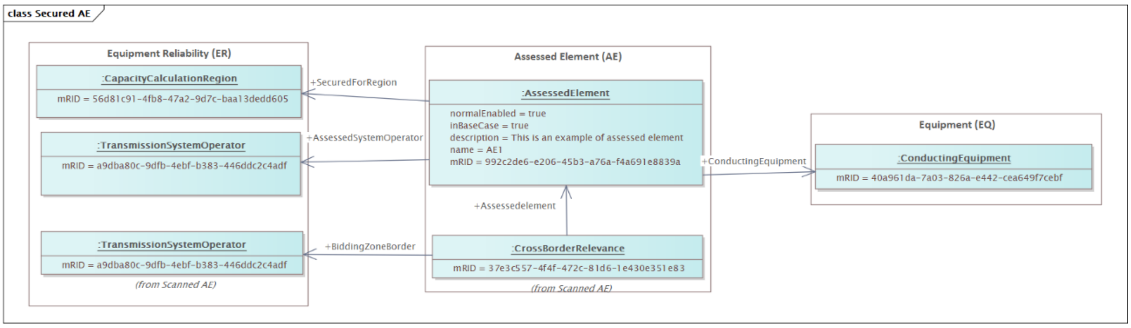


Figure 18 – Secured Assessed Element example.

The corresponding Assessed Element dataset example can be located in the ReliCapGrid Belgovia_AE.xml:

- AssessedElement rdf:ID="_992c2de6-e206-45b3-a76a-f4a691e8839a".

Readers might want to pay attention to the following remark:

- In order to indicate that the assessed element should be assessed in the base case the attribute *AssessedElement.inBaseCase* is set to TRUE. This is applicable not only for this example, but to all assessed elements which are included in the base case.

7.1.6.2 Scanned Assessed Element

This example illustrates how to specify a Scanned Assessed Element which is secured in another Region. Note that the example does not reflect universal way of modelling a scanned assessed element and may miss regional specificities. Additionally, the example only covers how to model the scanned element in one region, however a model of secured element would exist in parallel and would be referencing another region without scanned status set.

In other words, in case of modelling an assessed element which is considered scanned in one region (“excluded XNE with status scanned”) and at the same moment secured in another region (“XNE”), one has to model two objects with different attributes set (ScannedForRegion, SecuredForRegion and ExclusionReason) but referencing same equipment ID in the grid model.

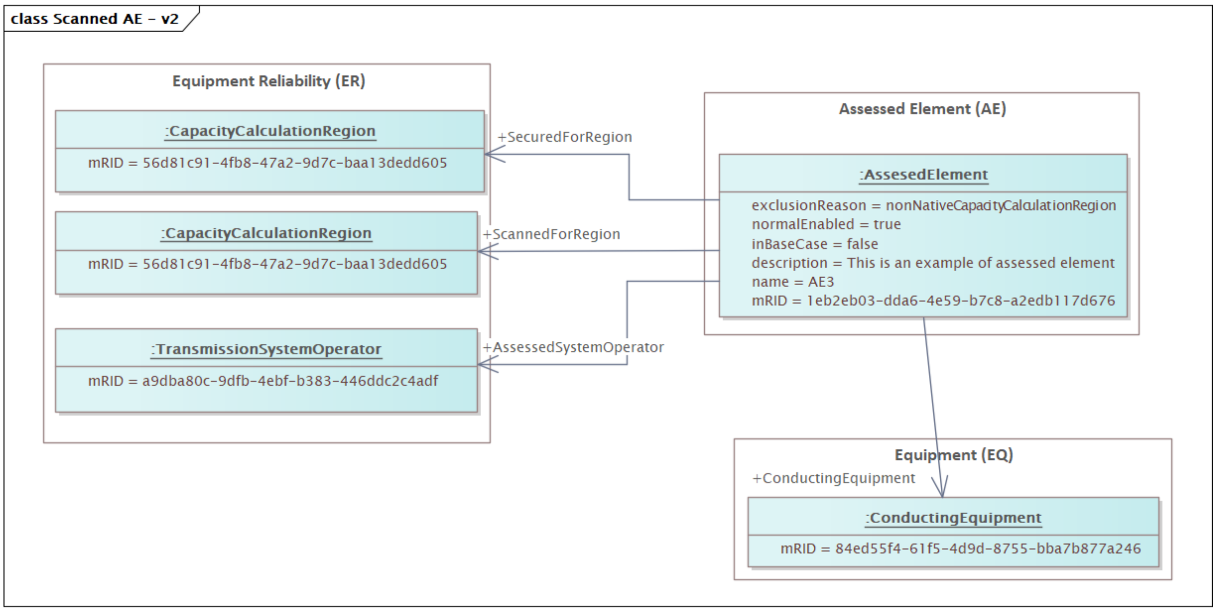


Figure 19 – Scanned Assessed Element example

The corresponding Scanned Assessed Element dataset example can be located in ReliCapGrid in Belgovia_AE.xml:

- AssessedElement rdf:ID="_1eb2eb03-dda6-4e59-b7c8-a2edb117d676".

The following remarks apply to this example:

- In this case the AssessedElement is not assessed in the base case, the attribute AssessedElement.inBaseCase should be set to false.
- Depending on the meaning, if it is meant to be applicable for a secured region (and not for scanned region), the exclusionReason needs to be added.

7.1.6.3 Disable an Assessed Element

An AssessedElement object can be disabled in the structural data and in the scheduled or data per time unit. In case the disabling of the object is done on either scheduled data or per time unit data, this disabling is referred as “Temporary” disabled object.

This example is derived from 7.1.6.1 to show how to disable for a specific time in the process an Assessed Element defined in the structural data. This is done by submission of a State Instruction Schedule (SIS) dataset or by submission of a Steady State Instruction (SSI) dataset (details regarding the profiles hierarchy can be found in § 8.2).

Guidance on the input data design is provided in section 0. In addition, normally in case it is necessary to exclude a secured AssessedElement object, a reason for this exclusion needs to be provided.

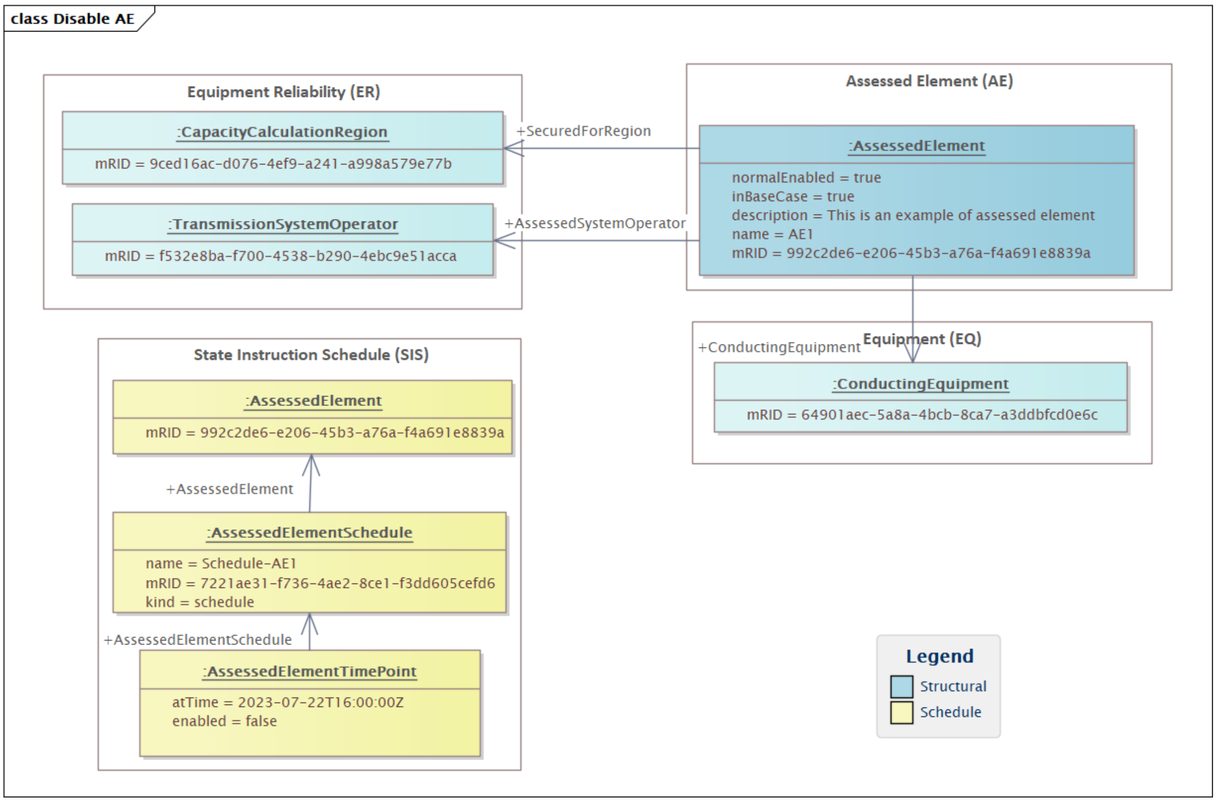


Figure 20 – Example Disable Assessed Element via SIS dataset

The Assessed Element example dataset Belgovia_AE.xml is the same as for Secured Assessed Element example described in section 7.1.6.1. The SIS dataset which disables the assessed element can be located in ReliCapGrid in Belgovia_SIS.xml:

- AssessedElementSchedule rdf:ID="_7221ae31-f736-4ae2-8ce1-f3dd605cefd6"
- AssessedElementTimePoint rdf:ID="_a26e3ae0-0a7d-4f42-ad64-e9105ec3cd41"

7.1.6.4 Exclude an Assessed Element

This example shows how to exclude in the process an Assessed Element defined in the structural data. Exclusion allows regional security analysis calculation, but it is not considered in RAO as an element which would be optimized (secured). Excluded elements can be treated as scanned elements (by setting the scanned status via ScannedForRegion reference) or simply be ignored by RAO.

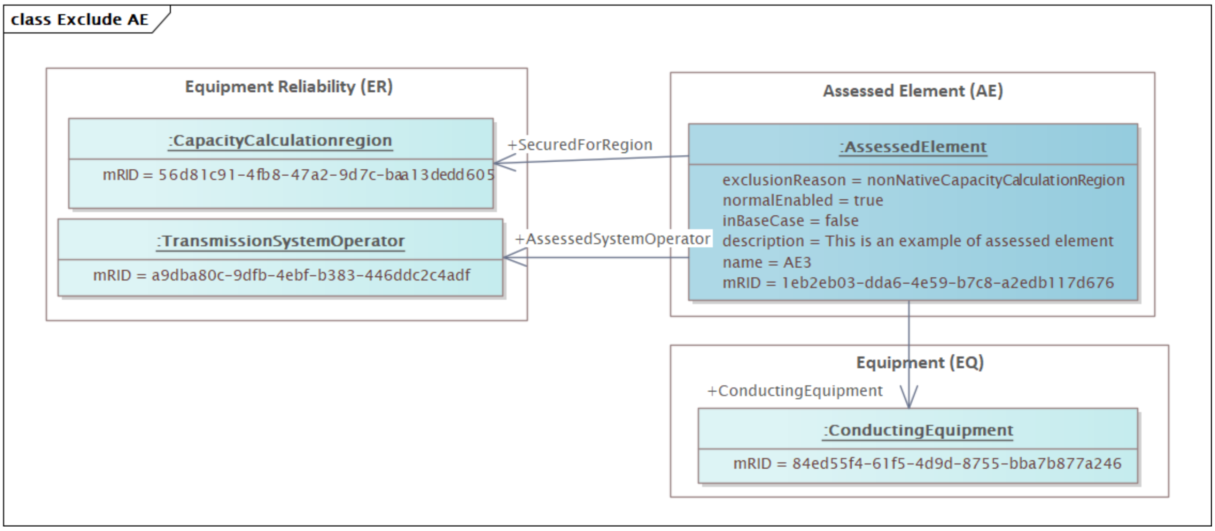


Figure 21 – Exclude Assessed Element example.

The excluded Assessed Element dataset example can be located in ReliCapGrid in [Belgovia_AE.xml] as:

- AssessedElement rdf:ID="_1eb2eb03-dda6-4e59-b7c8-a2edb117d676.

7.1.6.5 Assessed Element with Contingency

This section presents examples to illustrate how to cover different use cases that require specification of an Assessed Element (AE) with a Contingency (CO). The following uses cases are covered:

1) **Full scope**: An AE is considered for all contingencies.
2) **Limited exclusion**: An AE is considered for all contingencies as in this case the isCombinableWithContingency equals true, but pairs with some contingencies are to be excluded. For instance, an “AE1” is excluded, i.e., not considered, when “CO1” or “CO2” are performed.
3) **Limited inclusion**: An AE is considered only for limited number of contingencies as in this case the isCombinableWithContingency equals false and only pairs that should be assessed are defined. For instance, an “AE1” for the equipment "Line1" (considering the operational limit "CurrentLimit1") is checked only after the “CO1” and after the “CO2”. In addition, any remedial action can be used to solve the constraint except the ones that are associated to a particular assessed element (see section 0).

The following general remarks apply to the design of the included or excluded assessed elements:

- By providing a mechanism of inclusion and exclusion, the data exchange specification aims at enabling sending party to reflect on specific situations, to minimize the data exchanged for the business process, to give guidance to the RAO which as a side effect helps the performance of the business process.
- The AE has an attribute isCombinableWithContingency. If this is set to True, RSA and RAO would consider this AE available for combinations with all defined contingencies. If this is the desired behaviour there is no need to define all pairs by using AssessedElementWithContingency. If this is set to False, RSA and RAO would expect to find instructions on concrete pairs (combinations) that are valid to be studied for this AE. If not provided, the default meaning is true, i.e. the assessed element is combinable.
- The AssessedElementWithContingency provides information on the combination between an AssessedElement and a Contingency. This combination can have the meaning of “inclusion” or “exclusion”. If a combination is included RSA and RAO will include it when performing the analysis. It does not make sense to define an included combination for an AsessedElement that has the attribute isCombinableWithContingency set to True as this will result in duplicated combinations. The usage of “inclusion” has a meaning only when used for assessed elements that are constrained, i.e., isCombinableWithContingency attribute is set to False. On the other hand, the usage of “exclusion” of a combination only makes sense when isCombinableWithContingency attribute is set to True, as RSA and RAO would implicitly define all combinations between assessed elements and

contingencies and will exclude the combinations that are provided in the data exchange.

- When defining an AssessedElement the System Operator can create multiple AssessedElements objects that refer to same limit or equipment. This approach helps in cases where it is required to combine the "inclusion" and the "exclusion" approach which targets assessment of the same equipment. This is also required to address the case in which TSO belongs to more than one CCR.

- The data model used for the exchange provides means to enable or disable a combination defined by AssessedElementWithContingency at structural data level. This can be done at structural data level, the schedules or in the data exchange that is per time unit. Therefore, RSA and RAO shall take into account all inputs when setting up the combinations that would apply for a study of a timestamp.

  For example, an "AE1" is defined in the structural data as combinable (isCombinableWithContingency set to True). There are 2 AssessedElementWithContingency defined – "AE1-CO1" and "AE1-CO2" that are both enabled in the structural data as "exclusion". The SIS dataset disables "AE1-CO1" and "AE1-CO2" for hour 1 and hour 2, but SSI dataset enables "AE1-CO1" for hour 1. Therefore, when RAO prepares the study of hour 1, the "AE1" will be assessed for all enabled contingencies for hour 1 except "CO1" as the "exclusion" "AE1-CO1" is enabled in SSI dataset and the "exclusion" "AE1-CO2" remains disabled by SIS dataset.

7.1.6.5.1 Reference Implementation Examples of Assessed Element with Contingency

7.1.6.5.1.1 Scenario 1 – Full scope: Modelling of AssessedElement implicitly combined with all Contingencies

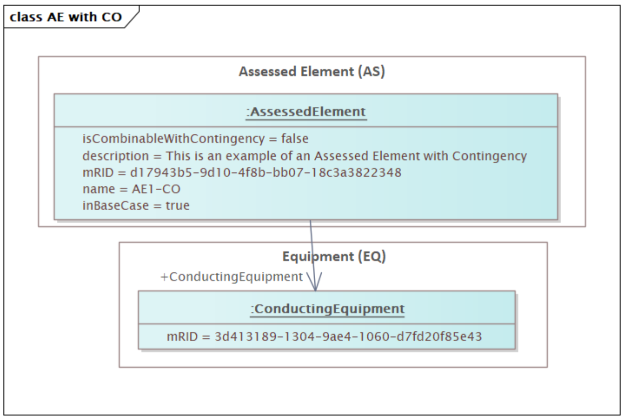


Figure 22 – Assessed Element with Contingency – Scenario 1.

The corresponding dataset example can be located in ReliCapGrid in Belgovia_AE.xml:

AssessedElement rdf:ID="_ d17943b5-9d10-4f8b-bb07-18c3a3822348".

The following remarks apply to this example:

- In this case the AssessedElement is assessed in the base case as the attribute AssessedElement.inBaseCase is set to true.
- The scenario covers the case where an AE is considered for all contingencies (Full scope). The attribute AssessedElement.isCombinableWithContingency is set to true, which means that RSA and RAO will assess this AssessedElement for all contingencies defined in the structural data and enabled for the timestamp that is studied.

7.1.6.5.1.2 Scenario 2 – Limited exclusion: Modelling of AssessedElement with Contingency

Scenario 2 occurs in cases where an assessed element is set as combinable with all Contingency objects defined and enabled for the timestamp that is studied, but a combination with particular Contingency is excluded from the study. The example focuses on OrdinaryContingency but can be applied for any other type of contingencies supported by the Contingency profile.

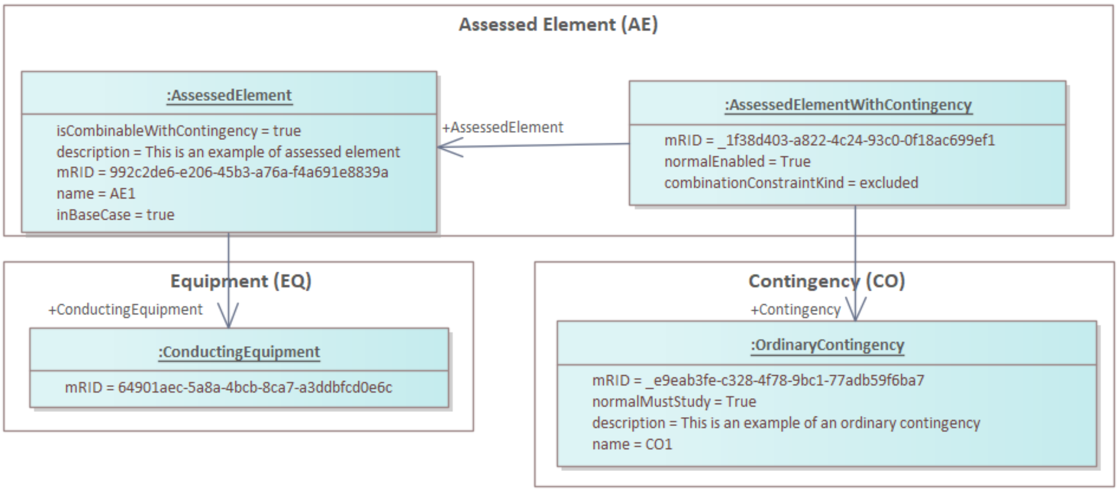


Figure 23 – Assessed Element with Contingency – scenario 2.

The corresponding dataset example for scenario 2 can be located in ReliCapGrid in Belgovia_AE.xml:

- AssessedElement rdf:ID="_992c2de6-e206-45b3-a76a-f4a691e8839a"
- AssessedElementWithContingency rdf:ID="_1f38d403-a822-4c24-93c0-0f18ac699ef1"

The following remarks apply to this example:

- AssessedElementWithContingency object is defined to identify the pair (combination) that is excluded from the study, i.e. contingency analysis.

The Contingency dataset example can be located in ReliCapGrid in Belgovia_CO.xml:

- OrdinaryContingency rdf:ID="_e9eab3fe-c328-4f78-9bc1-77adb59f6ba7".

7.1.6.5.1.3 Scenario 3 – Limited inclusion: Modelling of AssessedElement with Contingency

Scenario 3 occurs in cases where an assessed element is defined as not combinable with all Contingency objects, defined and enabled for the timestamp that is studied, but a combination with particular Contingency is included in the study. The example is focused on OrdinaryContingency but can be applied for any other type of contingencies supported by the Contingency profile.

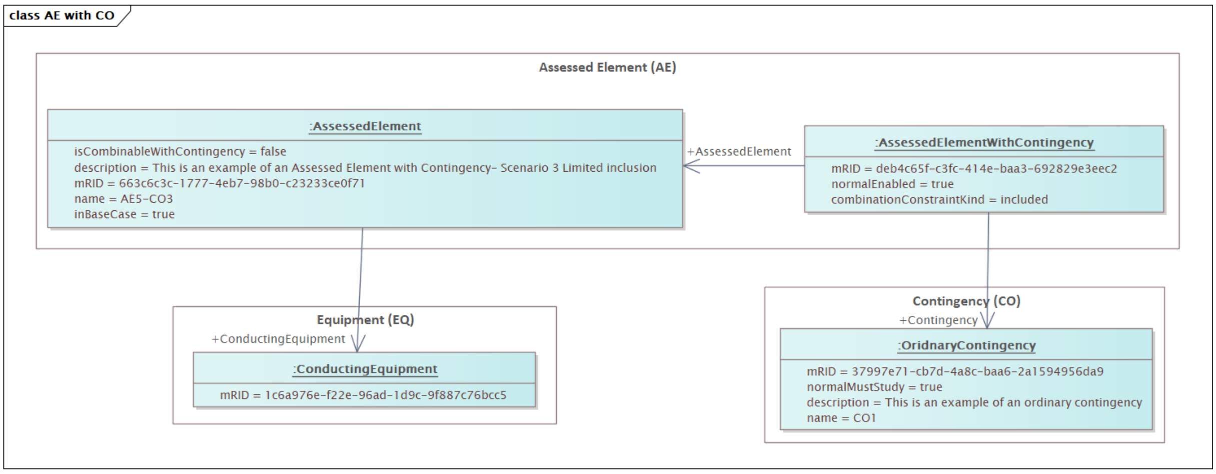


Figure 24 – Assessed Element with Contingency – scenario 3.

The corresponding Assessed Element example for scenario 3 can be located in ReliCapGrid in Belgovia_AE.xml:

- AssessedElement rdf:ID="_663c6c3c-1777-4eb7-98b0-c23233ce0f71"
- AssessedElementWithContingency rdf:ID="_ deb4c65f-c3fc-414e-baa3-692829e3eec2"

The Contingency dataset example can be located in ReliCapGrid in Belgovia_CO.xml:

- OrdinaryContingency rdf:ID="_e9eab3fe-c328-4f78-9bc1-77adb59f6ba7".

The following remarks apply to this example:

- The AssessedElement and the Contingency that are linked are referenced in the AssessedElementWithContingency object by their mRIDs;
- The contingency type can also be ExceptionalContingency and OutOfRangeContingency;
- AssessedElement class has other mandatory attributes already presented in section 7.1.6.1 and 0.

7.1.6.6 Modelling of Critical Network Elements

The CC and CSA business processes may have different uses on the AssessedElement class and further alignments between processes are needed. The following paragraphs aim at exposing the current understanding on how to model Critical Network Elements (CNE) cross business process.

A relevant business requirement from CSA is that an AE does not need to be compulsory associated with a contingency. This motivated the following renaming:

- AssessedElement class
  - Attribute criticalElementContingency to criticalElement.
  - Attribute normalCriticalElementContingencyJustification to normalCriticalElementJustification.
- Enumeration CriticalElementContingencyKind to CriticalElementKind.

Additionally, the use of these attributes is deprecated. That is, the attributes can still be used in version 2.4 of the NCP, but the recommendation is not to use them because they may be deleted in the next release.

Instead, the following points cover the current recommendations and understanding from CSA and CC perspectives on how to model a CNE.

- In the CSA process:
  - isCriticalForCapacityCalculation indicates that the element is critical (CNE).
    - CSA contains many Secured Assessed Elements which were not CNEs in the CC process (CC focuses on critical elements only while CSA on almost all), therefore the relationship to SecuredForRegion is not sufficient.
    - The flag “isCriticalForCapacitzCalculation” will allow to identify in CSA the subset of Secured AEs which where CNEs in CC process.
    - The use of this flag would avoid the CSA process from using the deprecated properties mentioned above.
  - ScannedForRegion may indicate that the element is scanned (monitored in RA Optimization).
- In the CC process:
  - SecuredForRegion may indicate that the element is critical (CNE).
  - ScannedForRegion may indicate that the element is monitored.
  - The use of both SecuredForRegion and ScannedForRegion may indicate that the element is critical (CNE) and monitored (MNE). Alternatively, there could be two instances of the AE, one defined as CNE, one as MNE.
  - The use of isCriticalForCapacityCalculation (boolean) may indicate whether the CC process used the element in its assessment. The information is however relevant mainly for CSA and it is duplicate in the context of CC.

The guidance above expects to clarify how critical elements may be modelled in both CSA and CC process. Other important remarks are:

- Not every XNE in CSA was CNE in CC, but every CNE from CC has to be XNE in CSA.
- In CSA the term “monitoring” is not used. CSA uses “Scanned” elements (which are monitored in RAO). Those are indicated via the ScannedForRegion relationship. CSA does not require information of which AssessedElements were monitored in CC process (therefore no need for flag “isMonitoredForCapacityCalculation”).
- On the other hand, although the indication of “monitoring” in the CSA process is the use of ScannedForRegion, the CC process might use the attribute Monitored to indicate this concept.

As indicated above and although deprecated, the attribute AssessedElement.criticalElement and the enumeration *CriticalElementKind* are included in the AE profile, and they are used to cover the following legacy implementations on the AssessedElement:

- validation – if the AssessedElement is not Critical Network Element and Contingency (CNEC) and it is not Monitored Network Element and Contingency (MNEC)
- monitored - if the AssessedElement is not CNEC and it is MNEC
- critical - if the AssessedElement is CNEC and it is not MNEC
- criticalAndMonitored - if the AssessedElement is CNEC and it is MNEC

This together with the Individual Adjustment Value (IVA) and Common Adjustment Value (CVA) may be used for the intraday capacity calculation and it is provided to the flow-based calculation method.

In the flow-based methodology IVA share is modified by TSOs during their security analysis. This part of the business process is where those parameters should be defined in the AE profile but might need SIS for updates. The current version of NCP integration, IVA updates are not included in the scope. This is why for now, only structured data for adjustment values is needed.

Updates on this topic are expected in future versions of the RCP DES.

7.1.6.7 Assessed Element with Remedial Action

This section presents examples to illustrate how to cover different use cases that require specification of an Assessed Element (AE) with a Remedial Action (RA). The following uses cases are covered:

1) **Full scope**: All defined and enabled remedial actions are considered when resolving a violation of an assessed element.
2) **Limited inclusion**: One or limited number of remedial actions are considered (the only RA that are applicable) when resolving a violation of an assessed element.
3) **Limited exclusion**: One or limited number of remedial actions are not considered when resolving a violation of an assessed element. For instance, “RA1” is excluded, i.e., not considered/not used as possible RA, when “AE1” or “AE2” are having violations.
4) **Consideration**: One or limited number of remedial actions can be considered when resolving a violation of an assessed element. The difference between limited inclusion and consideration is that in consideration multiple remedial action can be considered, while in the limited inclusion only defined remedial action are applicable.

The following general remarks apply to the design of the included, excluded, or considered remedial actions:

- By providing a mechanism of inclusion and exclusion, the data exchange specification aims at enabling sending party to reflect on specific situations, to minimize the data exchanged for the business process, to give guidance to the RAO which as a side effect helps the performance of the business process. In general, all remedial actions can be considered for all assessed elements, but this would take significant amount of time.
- Constraining RAO by limiting the possibilities on which remedial actions can be used for resolving violations on assessed elements can be considered a breach of the requirements defined in Network Codes and methodologies. Therefore, it should only be used in cases where this helps the performance of the process but does not limit the effect of optimising remedial actions and finding the best possible solution.
- The AE has an attribute isCombinableWithRemedialAction. If this is set to True, RAO would consider this AE available for combinations will all defined remedial actions. if this is the desired behaviour there is no need to define all pairs by using AssessedElementWithRemedialAction. If this is set to False, RAO would expect to find instructions on which concrete pairs (combinations) are valid to be studied for this AE. If not provided, the default meaning is true, i.e. the assessed element is combinable.
- The AssessedElementWithRemedialAction provides information on the combination between an AssessedElement and a RemedialAction. This combination can have the meaning of “inclusion”, “exclusion” or “consideration”. If a combination is included RAO will include it when performing the analysis. It does not make sense to define an

included combination for an AsessedElement that has the attribute isCombinableWithRemedialAction set to True as this will result in duplicated combinations. The usage of “inclusion” has a meaning only when used for assessed elements that are constrained, i.e., isCombinableWithRemedialAction attribute is set to False. On the other hand, the usage of “exclusion” of a combination only makes sense when isCombinableWithRemedialAction attribute is set to True, as RAO would implicitly define all combinations between assessed elements and remedial actions and will exclude the combinations that are provided in the data exchange.

- When defining an AssessedElement the System Operator can create multiple AssessedElements objects that refer to same limit or equipment. This approach helps in cases where it is required to combine “inclusion”, “exclusion”, and “consideration” approaches which targets assessment of same equipment.
- The data model used for the exchange provides means to enable or disable a combination defined by AssessedElementWithRemedialAction. This can be done at structural data level, the schedules or in the data exchange that is per time unit. Therefore, RAO shall take into account all inputs when setting up the combinations that would apply for a study of a timestamp. For example, an “AE1” is defined in the structural data as combinable (isCombinableWithRemedialAction set to True). There are 2 AssessedElementWithRemedialAction defined – “AE1-RA1” and “AE1-RA2” that are both enabled in the structural data as “exclusion”. The SIS dataset disables “AE1-RA1” and “AE1-RA2” for hour 1 and hour 2, but SSI dataset enables “AE1-RA1” for hour 1. Therefore, when RAO prepares the study of hour 1, a violation of “AE1” will be resolved by one of all enabled remedial actions for hour 1 except “RA1" as the “exclusion” “AE1-RA1” is enabled in SSI dataset and the “exclusion” “AE1-RA2” remains disabled by SIS dataset.
- Depending on the design of the remedial actions and assessed elements some combinations between assessed element and remedial action can be defined as “included” and some as “considered”. This will provide information to RAO that first the remedial actions that are “included” need to be optimised and if they are not able to resolve the violation some of the “considered” remedial actions can be studied/optimised. This approach can potentially be used with the design to include multiple remedial actions in a group and describe the dependency between the remedials actions in this group. The level of complexity increases and the guidance is to use this only when it is necessary and represents the real behaviour of these remedial actions.

7.1.6.7.1 Example of Assessed Element with a Tap Position Remedial Action

This example shows how to specify an Assessed Element with a “Tap Position” Remedial Action.

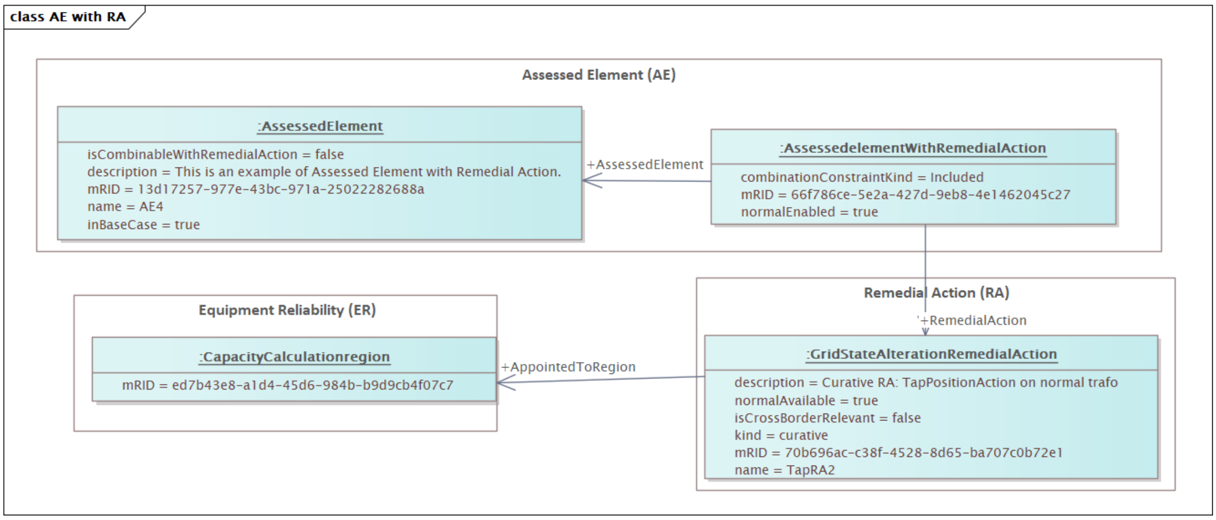


Figure 25 – Assessed Element with Remedial Action.

The corresponding Assessed Element example can be located in ReliCapGrid in Belgovia_AE.xml:

- AssessedElement rdf:ID="_13d17257-977e-43bc-971a-25022282688a"
- AssessedElementWithRemedialAction rdf:ID="_66f786ce-5e2a-427d-9eb8-4e1462045c27"

The snippet in RemedialAction dataset for a tap position remedial action can be found in ReliCapGrid in Belgovia_RA.xml. Note that other remedial action types are possible.

*GridStateAlteration*RemedialActionrdf:ID="_70b696ac-c38f-4528-8d65-ba707c0b72e1.

7.1.6.8 Ad-hoc exclusion of Assessed Elements

In some stages of the business processes there is a need to model ad-hoc exclusion of assessed elements. These exclusions would be valid for certain short period of time, currently foreseen only for the running or upcoming CROSA timeframe. RCP DES provides a degree of flexibility to deal with this requirement and there are three ways how to realise this. The choice of the option is left to the business process implementation.

- **Option 1: Complete exchange of the pair combinations**

This option requires all pair combinations between AssessedElement and Contingency to be exchanged as structured data which will allow some pairs to be enabled or disabled via either SSI or SIS datasets.

The disadvantage of this option is that AssessedElement dataset and would have to be often changed as the CSA Process requires combination of the AE with all Contingencies of all other TSOs (i.e. each change in Contingency list of any TSO would trigger re-submission of AssessedElement profiles of all TSOs with updated pairs of AE-CO).

- **Option 2: Exchange AssessedElement dataset to amend information**

This option requires to exchange AssessedElement dataset as full / complete dataset in terms of serialisation method, but containing only information that is amended. For example, if only one object of AssessedElementWithContingency is to be defined as excluded for a couple of hours, the dataset will only contain this object.

Metadata information in the dataset's header shall be used (i.e., *dcat:startDate, dcat:isVersionOf,* etc.) to refer to the activity of ad-hoc exclusion. This will ensure that receiving system will not disregard previous structural data, as well as considering datasets for the right period of time.

- **Option 3: Exchange AssessedElement difference dataset**

A difference dataset is used in this option to only exchange the AssessedElementWithContingency object that needs to be amended for exclusion. As the dataset is adding information to the structured dataset, the header-metadata information will refer to the activity and the relevant structured datasets (i.e., AE). The content of the dataset will only contain forward statements as information is being added.

Note: In the dataset's header, the use of *generatedBy* is reserved for the *activity* that created the dataset. Though the activity reference data is still not fully standardised in the CommonData dataset (refer to section 0), TSOs could use this item to better distinguish between AE datasets. As an example, still under discussion at the time of writing:

- "CGM-AE" or "EX-RAS" (EX for exclusion)

More details on the practical implementation of these options are expected in the next releases of either ReliCapGrid repository, CommonData dataset or/and RCP DES.

7.1.6.9 Assessed Element with Different Limits Between Base Case and Contingency Analysis

In some power systems, regulatory requirements specify that certain equipment, for example overhead lines, must operate under two distinct thermal limits: one applicable in the base case (BC) and another, typically higher, applicable under contingency conditions (CO-case). In such situations, it is necessary to model an operational current limit that is explicitly valid only for the base case, enabling the coordination process to distinguish between the lower base case threshold and the higher contingency threshold.

To model this situation, the NCP features a *BaseCaseCurrentLimit* class in the AssessedElement profile, Steady State Instruction and State Instruction Schedule profiles. The *BaseCaseCurrentLimit* class is a specialisation of the existing *OperationalLimit* class, ensuring compatibility with the CGMES model and avoiding duplication of limit definitions.

The base case current limit is associated with the corresponding equipment in the EQ profile through the *OperationalLimitSet* object, and it is valid exclusively when the attribute *inBaseCase* in the *AssessedElement* class is set to *true*. A SHACL constraint enforces this rule, ensuring that the limit is applied only in base case conditions and that its lower value is respected in comparison to the contingency case limit.

Because the *BaseCaseCurrentLimit* class is a child of *OperationalLimit*, it inherits compatibility with the *AvailabilitySchedule* profile without requiring additional modifications there.

When the transition of IGM to CGMES 3.0 is completed, the *OperationalLimitType* class together with *LimitKind.stability* enumeration value in the EQ profile shall be used to differentiate between base case and contingency current limits.

7.1.6.10 Expected Use Cases

The following expected use cases are not explained in full detail. The next versions of the document could include more details. This list is also not exhaustive.

Table 7 – Expected Use Cases Related to Assessed Element

Name	Description	Comment
Non-overlapping XNE in a CCR	A line is XNE / secured for a CCR. CNE status can be TRUE or FALSE	consider also how element should be modelled/represented in the other CCR
Overlapping XNE in a CCR	A line is XNE / secured for a CCR. CNE status can be TRUE or FALSE and the XNE is considered overlapping for another CCR.	consider also how element should be modelled/represented in the other CCR
Excluded XNE 1	A line is EXCLUDED for a CCR because it is a e.g. powerplant line (=Internal reason). Scanned status in that CCR = TRUE or FALSE.	consider also how element should be modelled/represented in the other CCR
Excluded XNE 2	A line is EXCLUDED for a CCR (e.g. Core) because Core TSO-s agreed so (=EXCLUDED CORE reason). Scanned status in Core = TRUE or FALSE	consider also how element should be modelled/represented in the other CCR
Excluded XNE 3	A line is EXCLUDED for a CCR (e.g. Core) because it is XNE/secured for other CCR (=OTHER CCR reason). Element is overlapping. Scanned status in Core = TRUE or FALSE (Is overlapping a MUST in this case?)	consider also how element should be modelled/represented in the other CCR
Additional Scanned Element	A line (line < 220 kV) is AdditionalElement in a CCR (e.g. Core) and is Scanned for Core	consider also how element should be modelled/represented in the other CCR
Future XNE	A line is scheduled to be put into operation in Q4 of the next year as XNE/Secured in a CCR (e.g. Core)	consider also how element should be modelled/represented in the other CCR

Update of XNE region	A line is to be XNE/secured for first 6 months in a CCR (e.g. Core) and EXCLUDED-SCANNED in Other CCR. For other 6 months line is to be EXCLUDED-SCANNED in Core and XNE/secured for Other CCR. Exclusion reason is always Other CCR	
Update of XNE Limits - PATL	Update of Security Limits of Assessed Elements (PATL), valid only for specific hours	
Update of XNE Limits - TATL	Update of Security Limits of Assessed Elements (TATL), valid only for specific hours	
Re-inclusion of XNE (excluded to XNE)	A line is EXCLUDED in a CCR (e.g. Core), but for specific CROSA needs to be reincluded as XNE for Core.	
Exclusion of specific XNECs in Offline process	A combination of XNE / Contingency in a CCR (e.g. Core) that do not need to be addressed in ROSC	
Ad hoc Exclusion of specific XNEC	A combination of XNE / Contingency in a CCR (e.g. Core) that do not need to be addressed in CROSA (complete or certain hours) exceptionally because more efficiently addressed outside CROSA	

7.1.7 Contingency List

TSOs should be able to exchange the following list of contingencies in accordance with Article 7 of the amended Methodology for coordinating operational security analysis.

The following classes shall be supported to fulfil the requirements by the CSAm: RotatingMachine, PowerElectronicConnection, PowerTransformer, ACLineSegment, FACTSEquipment, ShuntCompensator, SeriesCompensator, ACDCconverter, DCConductingEquipment, DCLineSegment, cim:DCBusbar (optional), DCChopper (optional), NonConformLoad, ConformLoad, Breaker.

A warning is triggered if any other classes are used.

The Contingency List provision is illustrated in Figure 26.

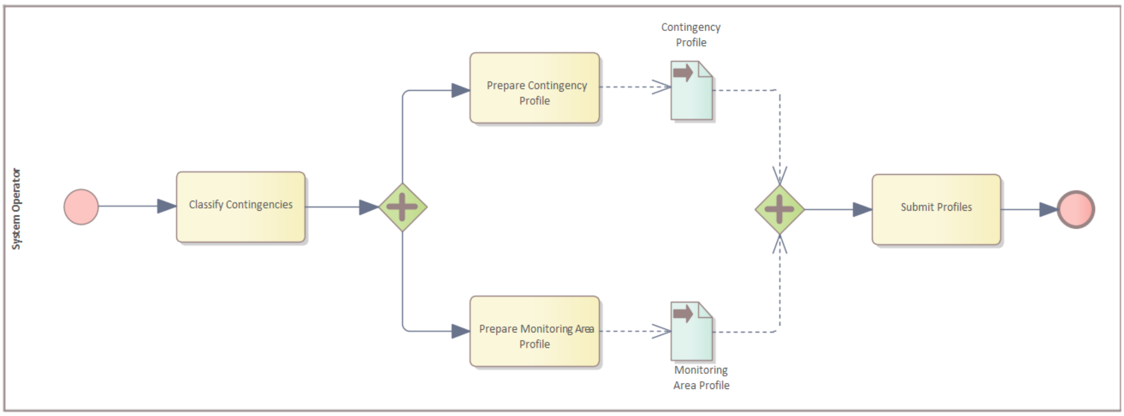


Figure 26 – Contingency list provision

The first step is to classify the contingencies as one of the three types illustrated in the category diagram shown in Figure 27.

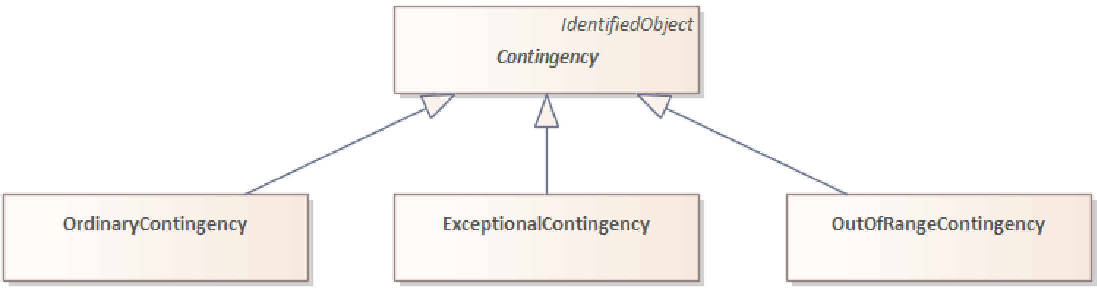


Figure 27 – Contingency category diagram

Contingencies classified as ordinary and as exceptional (fulfilling the criteria specified in CSAm art.10.1) shall be included in the Contingency List dataset. TSOs can also include external exceptional contingencies when they potentially endanger the operational security of its transmission system (CSAm art.10.3).

The Contingency profile is the main profile used for the delivery of the contingency list dataset. The Contingency class is instantiated to represent each contingency record in the list. Each instance can be linked to one or more equipment (e.g., a transmission line terminal) in the Equipment (EQ) profile through their unique mRID (Master Resource Identifier). It is possible to define if a contingency should be considered in the security analysis by properly setting the Contingency parameter normalMustStudy. The permanent and temporary occurrence increasing factor types (CSAm art.8.3) for each exceptional contingency can be defined in the ContingencyConditionKind enumeration.

As per the SOGL Article 33:

- Each TSO shall inform the TSOs in its observability area about the external contingencies included in its contingency list.

As per the SOGL Article 3:

- 'internal contingency' means a contingency within the TSO's control area, including interconnectors.
- 'external contingency' means a contingency outside the TSO's control area and excluding interconnectors, with an influence factor higher than the contingency influence threshold;

The "internal" CO dataset could be validated together with TSO A IGM. Let us suppose that TSO A has two borders, one with TSO B and TSO C. TSO A needs to have as may "external" CO datasets relevant of the other TSOs it shares borders with. In this example, TSO A would create two external CO datasets which represents the external contingencies used to study the neighbouring TSO B and TSO C grid. These two external CO datasets are separated as they need to be validated with different EQ and ER dataset.

The interpretation is that TSOs are responsible to determine their external contingencies with CSAm Article 6 are to be studied from their neighbouring grids that are part of their observability area.

That is, TSO A should inform TSO B and TSO C on what elements of TSO B and TSO C's observability area TSO A is studying. TSO A does this by sharing with TSO B and TSO C one external CO dataset respectively.

TSOs can distinguish which TSO the information comes from by using the header of the CO datasets.

In addition, the specification of the external exceptional contingencies from the list can be done using the Monitoring Area profile. The external contingencies that are included in the contingency list of a System Operator are the contingencies which are in the Contingency Area also defined using the Monitoring Area profile. An example of monitoring area definition is provided in section 0.

7.1.7.1 Ordinary Contingency

According to the “CSAm” or *Methodology for Coordinating Operational Security Analysis* (link to 2nd Amendment - ACER Decision 07/2024) Article 7 definition of ordinary contingencies, the following list offers a recommendation on which CIM classes to use for representing them:

- **Loss of a single line/ cable**

The technical recommendation is to use ACLineSegment and SeriesCompensator classes.

- **Loss of a single transformer**

The technical recommendation is to use PowerTransformer class.

- **Loss of a single phase-shifting transformer**

The technical recommendation is to use PowerTransformer class.

- **Loss of a single voltage compensation device**

The interpretation is that this contingency category refers generally to FACTS equipment (Static VAR Compensator - SVC) devices and shunt compensators.

The technical recommendation is to use the ShuntCompensator, SeriesCompensator and ShuntCompensator classes.

- **Loss of a single component of a HVDC system such as a line or a cable or a single HVDC converter unit**

The technical recommendation is to use the ACDCconverter and DCConductingEquipment classes.

- **Loss of a single power generation unit**

The technical recommendation is to support only RotatingMachine and do not use GeneratingUnit.

As an alternative, to represent generation units based on power electronics, the technical recommendation is to use the class PowerElectronicConnection.

If there are multiple units in the plant where a TSO would like to put out of service as a contingency, an exceptional contingency shall be used.

- **Loss of a single demand facility**

The interpretation is that this includes the load behaviour. It is important to note that the CIM model does not represent an explicit load model but the aggregate model of loads.

The technical recommendation is to use NonConformLoad, RotatingMachine and PowerElectronicsConnection classes.

- **Loss of a single busbar coupler, in case it is protected by an overcurrent protection device.**

The technical interpretation is to represent the situations of opening a Breaker class when it is closed as well closing a Breaker class when it open.

TSOs can define contingencies depending on their knowledge on whether busbars are protected against overcurrent or under/over voltage.

- **Loss of a single busbar coupler, in case it is protected by an over/under voltage protection device.**

The technical interpretation is to represent the situations of opening a Breaker class when it is closed as well closing a Breaker class when it open.

TSOs can define contingencies depending on their knowledge on whether busbars are protected against overcurrent or under/over voltage.

Note: it is expected that tools support Switch class or any of its specialisation and contingencies can be applied to any of these classes, but Breaker and DisconnectingCircuitBreaker shall be supported. It is up to the business process' owner to use any of the specialisations of this class. If software vendors do not support all the functionalities of Switch, they need to inform what they do not support.

In cases where a single branch, or other element is modelled / represented in the IGM with multiple objects due to data exchange representations, an OrdinaryContingency can have references to multiple ContingencyElement objects in order to refer to all objects part of this ordinary contingency.

7.1.7.1.1 Definition of Ordinary Contingency

Figure 28 illustrates how to specify an Ordinary Contingency.

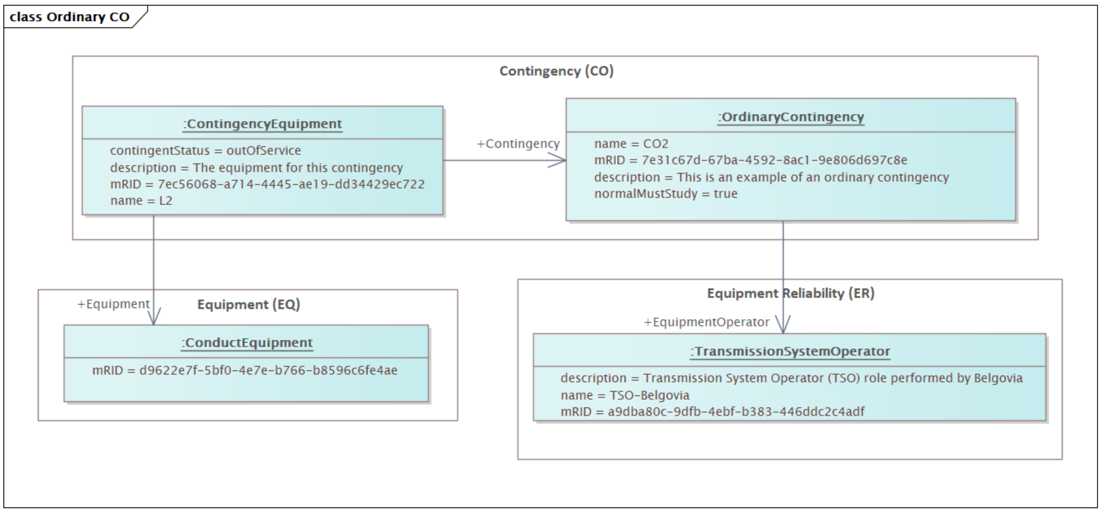


Figure 28 – Ordinary Contingency

The corresponding Contingency dataset example can be found in ReliCapGrid in Belgovia_CO.xml:

- OrdinaryContingency rdf:ID=”_7e31c67d-67ba-4592-8ac1-9e806d697c8e”
- ContingencyEquipment rdf:ID=”_7ec56068-a714-4445-ae19-dd34429ec722”

The referred System Operator is defined in the Common Data dataset, in NineRealms_CGM-CD.xml. Here it is Belgovia:

- TransmissionSystemOperator rdf:ID="_a9dba80c-9dfb-4ebf-b383-446ddc2c4adf".

The following remarks apply to this example:

- Like AssessedElement, the Contingency has a logic which allows a given Contingency to be active in the study (to be performed in a contingency analysis). The attribute normalMustStudy in the structural data is used for this purpose. Additionally, ContingencyTimePoint.mustStudy is exchanged in the SIS dataset and Contingency.mustStudy is exchanged in the SSI dataset. The logic presented in section 0 is followed. This is not specific for ordinary contingency and applies to all other types of contingencies.
- Note that the namespace of the Contingency.mustStudy and CIM as the attribute is part of the canonical model prior NC extensions. Othe attributes such as .normalMustStudy have NC namespace as they are part of the NC extensions.

7.1.7.1.2 Summary table with recommended equipment CIM classes necessary to fulfil CSAm requirements on contingencies

Indicated Equipment in CSAm	cim:Equipment	Sub classes	Comment	Example test data in ReliCapGrid open-source model
Generation Unit	cim:RotatingMachine	AsynchronousMachine, SynchronousMachine	Some vendors have already used RotatingMachine. Others use AsynchronousMachine and SynchronousMachine	• Contingency describing the loss of a synchronous mahcine (mRID = 37997e71-cb7d-4a8c-baa6-2a1594956da9) • Missing example using AsynchronousMachine
	cim:PowerElectronicsConnection	N/A		Missing example using PowerElectronicsConnection
(AC) Line/Cable	cim:ACLineSegment	N/A		Using cim:ACLineSegment: • Contingency describing the loss of the TieLine between Belgovia and Galia (mRID = 7e31c67d-67ba-4592-8ac1-9e806d697c8e) • Contingency describing the loss of the TieLine between Belgovia and Svedala (mRID = e9eab3fe-c328-4f78-9bc1-77adb59f6ba7) • Contingency describing the loss of the TieLine between Espheim

				and Svedala (mRID = 8cdec4c6-10c3-40c1-9eeb-7f6ae8d9b3fe)
	cim:SeriesCompensator	N/A		Missing example using cim:SeriesCompensator
HVDC Line/Cable/Converter	cim:ACDCconverter	CsConverter and VsConverter	Some vendors use EquivalentInjection.	Example using CsConverter: • Contingency describing the loss of a HVDC converter (mRID = 038ce404-30dc-4289-b9db-7076cb870b8e). Concretely, the loss of *DC-3P-Convert-1* in between Espheim and Svedala (CsConverter) (mRID = 038ce404-30dc-4289-b9db-7076cb870b8e) Example with VsConverter • Contingency describing the loss of a HVDC converter in Galia (mRID = a4f7a22a-736f-4d36-a476-3559828e4c7a). Concretely, the loss of a converter in between Nordheim and Galia (VsConverter) (mRID = 43e7ef11-9353-4ea0-9511-7c9baec7c99e)
	cim:DCConductingEquipment	DCChopper, DCGround, DCBusbar, DCShunt, DCSeriesDevice, and DCLineSegment.		Example with DCLineSegment: • Contingency describing the loss of a HVDC line (mRID = 504b48fb-de1f-4f7e-928f-

				8585daaf7b72). Concretely, the loss of a DCLineSegment between Espheim and Svedala (mRID = be09fc02-de3f-49e4-aa84-94803bcc5d76) Missing example using DCSeriesDevice Missing example using DCChopper Missing example using DCSwitch Missing example using DCBusbar Missing example using DCShunt
(Phase-Shifting) Transformer	cim:PowerTransformer	N/A		• Contingency describing the loss of a power transformer in Svedala (mRID = e05bbe20-9d4a-40da-9777-8424d216785d).
Voltage Compensation	nc:FACTSEquipment	nc:ThyristorControlledSeriesCompensator		Example using LinearShuntCompensator • Contingency describing the loss of a the compensator *Roanoke SC* in Espheim (mRID = 62eac668-82a1-4739-8cfc-de929b78ef7e).
		nc:StaticVarCompensator		

	cim:ShuntCompensator	LinearShuntCompensator and NonlinearShuntCompensator nc:ModularStaticSynchronousSeriesCompensator		Example using NonlinearShuntCompensator: • Contingency describing the loss of a the compensator *FT62_X3* in Svedala (mRID = ab92defa-ef8e-4d13-a242-5b1a9fe956f6). Missing example using ThyristorControlledSeriesCompensator Missing example using StaticVarCompensator Missing example using ModularStaticSynchronousSeriesCompensator
Demand Facility	cim:EnergyConsumer	cim:NonConformLoad	Software tools should support the class EnergyConsumer so TSOs have the flexibility to use ConformLoad and NonConformLoad (any of the specialisation)	Example with NonConformLoad • Contingency describing the loss of a Demand Facility in Belgovia (mRID = 65582e87-5035-4465-8dd9-cb655224b29f). Missing example using EnergyConsumer

			Some vendors use "equivalent injection"	
	cim:RotatingMachine	AsynchronousMachine, SynchronousMachine, and RegulatingCondEq		Missing example using RotatingMachine
	cim:PowerElectronicsConnection	N/A		Missing example using PowerElectronicsConnection
Single component of HVDC system	cim:EquivalentInjection	N/A	This is an equivalent model. In the case there is HVDC in a simplified model, it makes sense to use it.	Missing example using EquivalentInjection
	cim:ExternalNetworkInjection			Missing example using ExternalNetworkInjection

Busbar coupler	Wires:Switch (cim:Breaker)* (cim:DisconnectingCircuitBreaker)* *Software vendors MUST support the classes *Breaker* and *DisconnectingCircuitBreaker*. If software vendors do not support all the functionalities of Switch, they need to notify what they do not support to their clients TSOs.	N/A	Users can model the loss of a busbar coupler as well as the loss of a busbar by using Wires:Switch. Software tools shall support Wires:Switch class or any of its specialisation. Moreover, it is up to the business owners to use any of the specialisations of this class.	Missing example using Switch

2123

2124

European Network of
Transmission System Operators
for Electricity

7.1.7.2 Exceptional Contingency

According to the "CSAm" or *Methodology for Coordinating Operational Security Analysis* (link to 2nd Amendment - ACER Decision 07/2024) Article 7, exceptional contingencies are:

- loss of network elements having common fault mode, meaning that a single fault (such as a fault on a busbar, HVDC grounding system, circuit breaker, measurement transformer etc.) will lead to the loss of more than one network element.
- loss of overhead lines built on same tower.
- loss of underground cables built in same trench.
- loss of grid users having common process mode, meaning that the total or partial sudden loss of one grid user will lead to the total or partial loss of the others (for example: Combined cycle units etc.).
- loss of network elements/users simultaneously disconnected as a result of the operation of a Special Protection Scheme.
- loss of multiple generation units (including solar and wind farms) disconnected because of a voltage drop on the network or system frequency deviation.

In contrast with section 7.1.7.1, the CIM does not necessarily include a one-to-one representation for the concepts listed above (i.e., one cannot represent an overhead line build on the same tower in CIM). This is why, the RCP DES does not offer concrete CIM modelling recommendations for such concepts.

However, the following example illustrates how to specify an Exceptional Contingency.

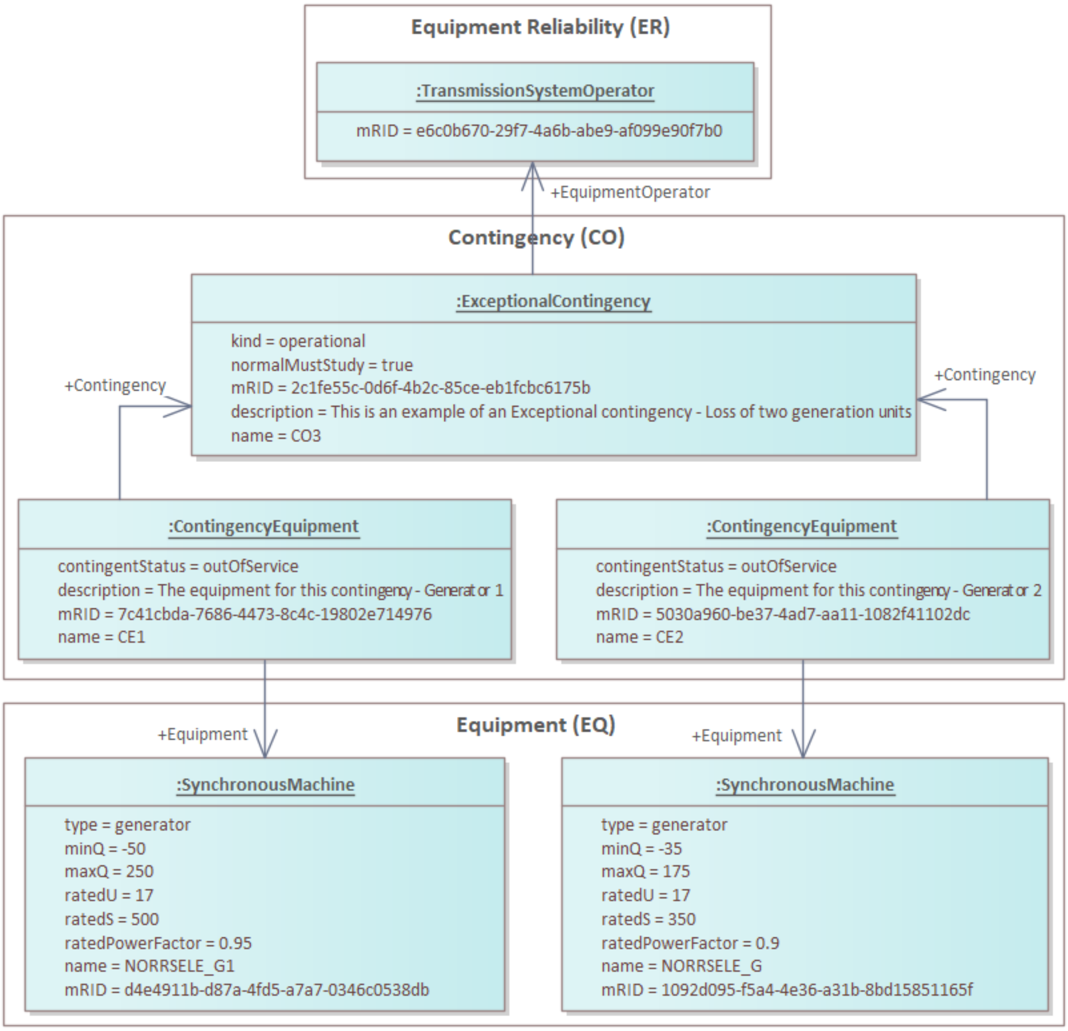


Figure 29 - Exceptional Contingency

The Contingency dataset can be located in ReliCapGrid in Svedala_CO.xml file:

- ExceptionalContingency rdf:ID="_2c1fe55c-0d6f-4b2c-85ce-eb1fcbc6175b".

The Equipment dataset example can be located in Svedala IGM file, 20220615T2230Z__Svedala_EQ_1.xml:

- SynchronousMachine rdf:ID="_d4e4911b-d87a-4fd5-a7a7-0346c0538db3"
- SynchronousMachine rdf:ID="_1092d095-f5a4-4e36-a31b-8bd15851165f"

For simplicity, some parts of the Equipment dataset snippet are not represented in the diagram (e.g., association of the SynchrounousMachine objects with EquipmentContainer and RegulatingControl objects).

In line with CSAm Article 8, each TSO shall determine for each exceptional contingency the relevance and criteria of application of the following occurrence increasing factors:

(a) permanent occurrence increasing factors

(b) temporary occurrence increasing factors

From ROSC perspective, the exceptional contingencies are therefore split into permanent and temporary exceptional contingencies. Permanent exceptional contingencies are always included in the Daily ROSC process while temporary exceptional contingencies are included only in case a TSO requests the inclusion during daily process.

The distinction between permanent and temporary exceptional contingency is implemented by defining the ContingencyConditionKind for each ExceptionalContingency as given in the Figure 30:

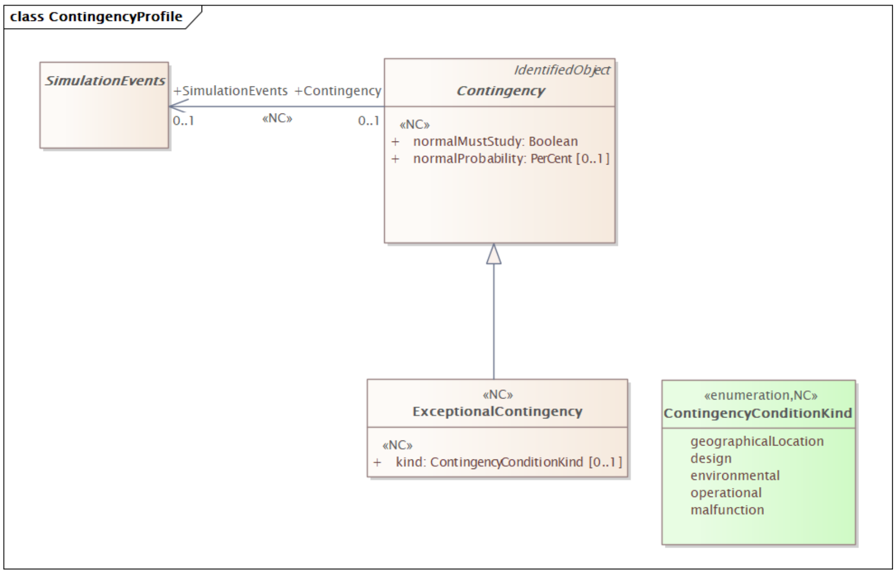


Figure 30: Extract of the ContingencyProfile diagram

- Permanent exceptional contingency is defined by ContingencyConditionKind: geographicalLocation or design
- Temporary exceptional contingency is defined by ContingencyConditionKind: environmental, operational or malfunction

By default, for all temporary exceptional contingencies mustStudy shall be set to false in the structural data. Afterwards, in case it is required by TSO to include it during the daily process via SSI / SIS profile the value of mustStudy is changed to true for specific time period.

7.1.7.3 Out-of-range Contingency

According to the “CSAm” or *Methodology for Coordinating Operational Security Analysis* (link to 2nd Amendment - ACER Decision 07/2024) Article 7, out-of-range contingencies are:

- loss of two or more independent lines
- loss of two or more independent cables
- loss of two or more independent transformers or phase shifter transformers
- loss of two or more independent grid users (power generating unit or demand facility)
- loss of two or more independent voltage compensation devices
- loss of two or more independent busbars
- loss of two or more independent components of a HVDC system such as lines, cables or HVDC converter units

In contrast with section 7.1.7.1, the RCP DES does not offer concrete CIM modelling recommendations for the concepts listed above. Further recommendations may elaborated in future releases.

However, the following example illustrates how to specify an out-of-range Contingency.

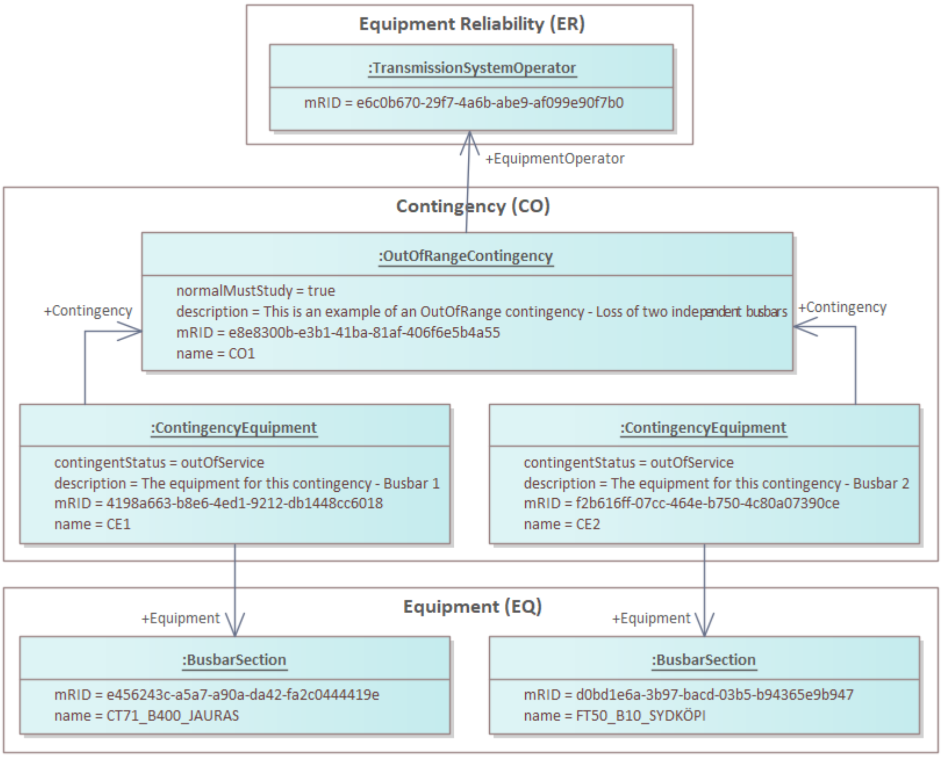


Figure 31 - Out of Range Contingency

The Contingency dataset can be located in ReliCapGrid in Svedala_CO.xml file:

- OutOfRangeContingency rdf:ID="_e8e8300b-e3b1-41ba-81af-406f6e5b4a55"

The Equipment dataset example can be located in Svedala IGM file, 20220615T2230Z__Svedala_EQ_1.xml:

- BusbarSection rdf:ID="_e456243c-a5a7-a90a-da42-fa2c0444419e"
- BusbarSection rdf:ID="_d0bd1e6a-3b97-bacd-03b5-b94365e9b947"

For simplicity, some parts of the Equipment dataset snippet are not represented in the diagram (e.g., association of the SynchrounousMachine objects with EquipmentContainer and RegulatingControl objects).

7.1.8 List of Remedial Actions

The List of Remedial Actions provision process is illustrated in Figure 32.

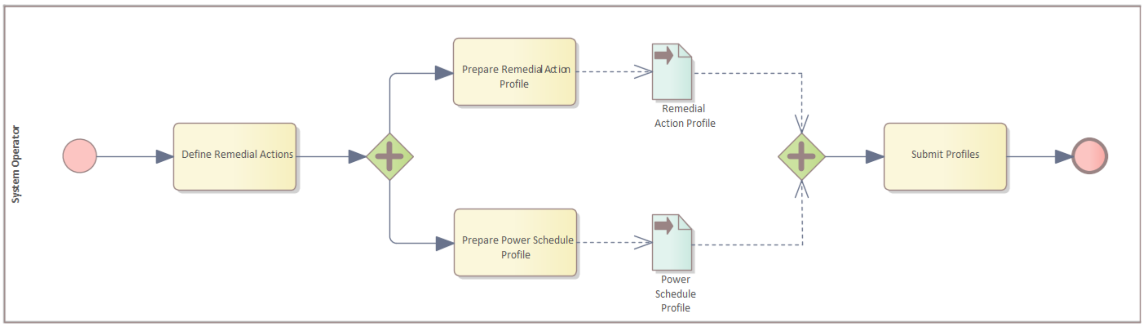
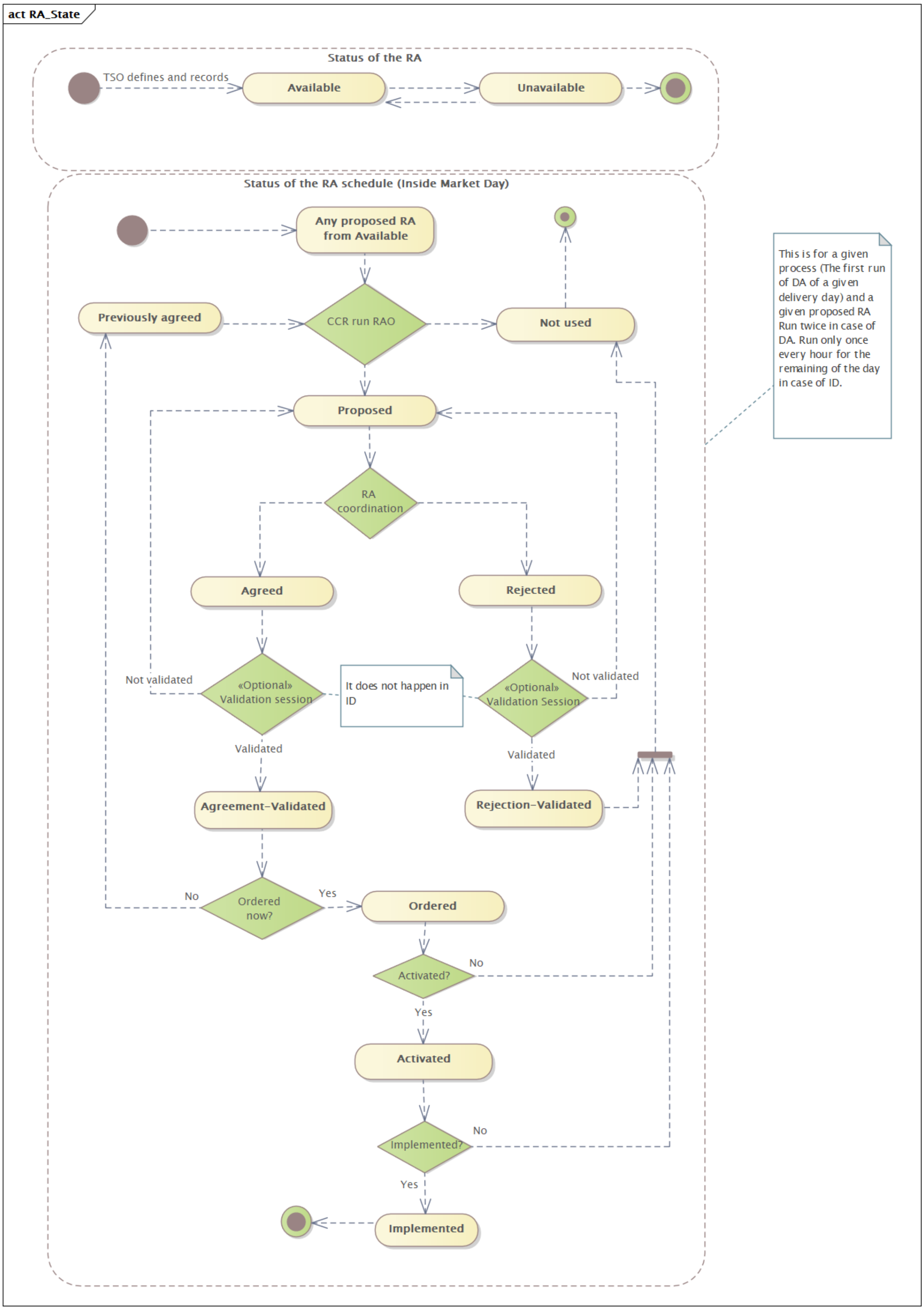


Figure 32 – List of Remedial Actions provision

System operator can define a set of remedial actions as part of the structural data. Once defined, a remedial action can be considered as available (depending on the value of normalAvailable and data provided in SIS or SSI datasets), in this case the remedial action can be considered when running the business process or unavailable in case that a remedial action cannot be used (upper part of Figure 33). In case that a remedial action is not needed anymore, once it is disabled, it can be archived for tracking and historic purposes.

The Remedial Action profile is used for the provision of the list of Remedial Actions. Additionally, the Power Schedule profile can be used depending on the use case.

2218 

2219 **Figure 33 – Remedial action state diagram**

2220

All available remedial actions can be used for the remedial action optimization process which will choose the most appropriate remedial actions to solve the different issues in the scenario. These remedial actions are denominated as proposed remedial actions.

Just after the remedial action optimisation process is finished, remedial action coordination starts. If it passes the coordination, the remedial action can be agreed or rejected. These two states must be validated during the validation session. If they are not finally validated, they become proposed again.

In case that a rejected remedial action is validated, then it becomes Rejection-Validated. On the other hand, if the agreed remedial action is validated, then it becomes Agreement-Validated. Agreement-Validated remedial actions can be ordered now or in a later stage. In case that a remedial action is not ordered now, then it becomes a previously agreed remedial action. If it is ordered now, then the remedial action changes its status to Ordered.

Ordered means that the SO sends the order to the corresponding party to proceed with the RA, and in most cases ordered means it is a binding order (could be that still, in an exceptional case, the RA could be cancelled after being ordered) In case that an ordered RA is not finally activated, then it becomes Not used.

After ordered, the RA can become activated and in that case the forecast case information is updated with regards to the acceptance criteria. In case that an activated RA is not finally implemented, then it becomes Not used. However, if the activated RA is implemented, then it becomes Implemented and the process finishes.

The following types of remedial actions can be defined:

- **Grid state alteration remedial action** – describes one or many grid state alterations applied to a grid model state or a particular scenario in order to resolve one or more identified constraints.
- **Scheme remedial action** – involves a scheme that can include conditional logic and stages of grid alteration. The primary remedial action is the arming of these schemes, which will then perform curative remedial action when the condition is met. System Integrity Protection Scheme (SIPS) and Special Protection Scheme (SPS) are example of this. Scheme remedial actions can be coordinated or non-coordinated.
- **Redispatch remedial action** - Redispatch means a measure, including curtailment, that is activated by one or more transmission system operators or distribution system operators by altering the generation, load pattern, or both, in order to change physical flows in the electricity system and relieve a physical congestion or otherwise ensure system security (Regulation (EU) 2019/943). In its essence from CSA perspective, redispatch remedial action is always defined by potential increase or decrease of power infeed in a known location, i.e. exact node of the grid model.
- **Countertrade remedial action** - Countertrade means a trade between bidding zone to solve a congestion. Therefore, a countertrade remedial action means a measure performed by one or several TSOs in one or several bidding zones in order to relieve physical congestions where the location of activated resources within the bidding zone is not known. A countertrade offer by a TSO is in general based on some existing

third party bids since a TSO shall not offer countertrade randomly and risk whether it can really provide it. Therefore, countertrade can be associated to:

- bid from the market
- bid from tertiary energy providers (which is a control area bid, not associated to a specific unit by its definition).

A countertrade offer, which a TSO offers to RAO, consists of a merit order of MW-price blocks which are actually individual discrete bids and shall contain additional parameters which are currently defined in PowerBidSchedule (i.e., lead time, step increment, max activation).

In order to allow correct modelling of countertrade offer within the grid model, the countertrade remedial action is linked to a GLSK (provided in ER dataset) which defines how a change in the balance / net position (single value) of a zone is transformed into a set of values of delta injections in specified nodes (multiple values) of a certain grid model. By default, a countertrade is associated to the so-called "country GSK" meaning an increase of infeed proportional to the remaining available capacity on all generating units within a bidding zone, excluding nuclear and renewable types.

- **Availability remedial action** - cancels or reschedules an availability schedule.

A remedial action can include multiple grid state alteration and this is necessary in order to model multiple actions within one remedial action. The design depends on the business need and the complexity of the remedial action that needs to be modelled. For instance, a topology action would in most of the cases act on multiple switches to achieve a change in a substation topology. In addition, remedial actions can be grouped into groups, and the dependency between them specified (refer to section 7.4.5).

The following sections illustrate several remedial actions that are often used by system operator.

7.1.8.1 Grid State Alteration Remedial Action – Tap position

This example illustrates how to specify a Grid State Alteration Remedial Action.

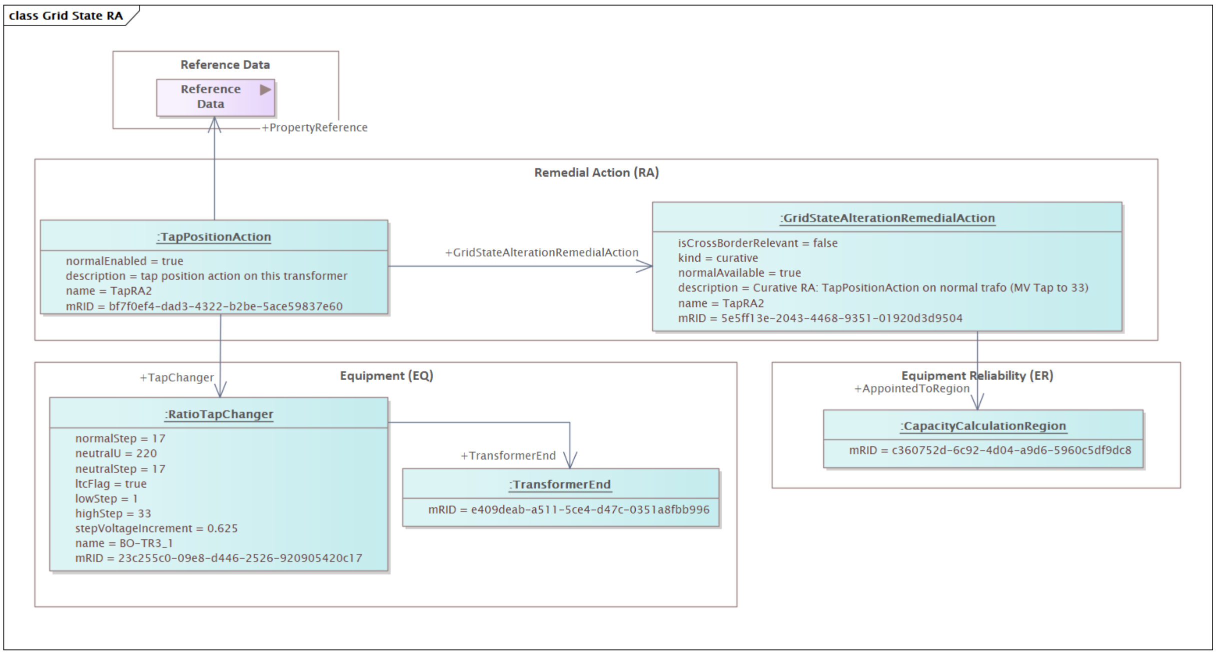


Figure 34 - Grid State Alteration (Tap Position) Example

The corresponding Remedial Action dataset example can be found in ReliCapGrid in Belgovia_RA.xml:

- GridStateAlterationRemedialAction rdf:ID="_5e5ff13e-2043-4468-9351-01920d3d9504"
- TapPositionAction rdf:ID="_bf7f0ef4-dad3-4322-b2be-5ace59837e60"

The corresponding Equipment dataset snippet is as follows:

- RatioTapChanger rdf:ID="_23c255c0-09e8-d446-2526-920905420c17"

The following remarks apply to this example:

- The diagram does not include explicit reference to the PropertyReference, but the dataset snippet indicates this.
- Depending on the setup a tap position action can be constrained to only allow tap change within a predefined range that is different than the tap changer regulation capabilities provided in the power flow part of the IGM. Constraints of this character are implemented by using StaticPropertyRange and IntertemporalPropertyRange.

7.1.8.2 Grid State Alteration Remedial Action – Topology

The NC Profiles support Topology Grid State Alteration Remedial Actions which are modelled and linked with the RAS dataset objects at both stages: when a remedial action schedule is an output of the RAO and when it is a TSO proposal prior RAO using SSI, SIS and RA profiles.

Therefore, NC Profiles enable a data exchange allowing to**:**

- Communicate activation of Topology RA on a per market time unit basis;
- Model a Remedial Action that consists of multiple topology changes.

It should be noted that the negotiation or optimisation of remedial actions in a given market time unit (MTU) might affect other remedial actions scheduled for later market time units.

In general, a Topological RA can be designed with one or many GridStateAlterations (TopologyActions). In addition, there are different stages where it is possible to modify or add information to a remedial action.

The following list contains the most common situations:

- Topology remedial action with one TopologyAction;
- Topology remedial action with multiple TopologyActions, and such *TopologyActions* can be modified via scheduled (SIS) or per MTU (SSI) profiles, which would change the configuration of the Topology RA. This can be done prior to RAO.
- Topology remedial action activation as an output of RAO where the whole content of the Topology RA is activated or deactivated as a collection (set of TopologyActions).

The following applies when designing topology remedial actions:

- It is required that topological remedial actions are modelled to act on the switches in the elements and not by indicating which element is switched.
  Therefore, this requires that the underlying power system model contains switching devices for at least the elements that are going to be used in topology remedial actions or any other remedial actions that require change of switching device status.

  This does not mean that the underlying model shall be full SCADA/EMS node-breaker model. The level of detail is driven by the need for remedial actions and the requirements in the SOGL for reporting statuses of the switching devices.
- The TSO can design the remedial action to either provide RAO with full flexibility or constrain the action that can be performed on the switching device.
  For instance, a remedial action can allow for a change of the status of a switch regardless of the initial status of the switch or it can instruct to only open or only close a switch. If the remedial action is designed to only open a switch and if in the grid model the switch is already open in the SSH, RAO will not be selecting this remedial action as its implementation will be pointless.

  These constraints on switching devices in case of Topology grid state alteration are defined by using StaticPropertyRange. For switching devices the attribute

RangeConstraint.direction can only have values RelativeDirectionKind.upAndDown (which will allow RAO to either open or close the switch) or RelativeDirectionKind.none (which instructs RAO that only the RangeConstraint.normalValue shall be applied, i.e. is normalValue is 1, which mean Switch.open should be set to true, RAO can only open the switch if the witch is closed in the base case). Following the different aspects each of the use case described above, the NC profiles can be used as follows:

  - Scheduling and per-MTU ability to modify GridStateAlteration prior RAO;
  - Activating Topology remedial action with one GridStateAlteration as part of RAS (post RAO);
  - Modifying / proposing changes to RAS on a topology remedial action in case of one GridStateAlteration (post RAO);
  - Defining a Remedial Action, composed of one or several TopologyActions via RA profile (prior to CROSA)
- Activating Topology remedial action with multiple GridStateAlterations as part of RAS (post RAO);
- Modifying / proposing changes to RAS on a topology remedial action in case of multiple GridStateAlteration (post RAO).

Normally *TopologyActions* and related *RemedialActions* classes are applied to specific MTUs. However, in case of post RAO or when suggesting modifications, NC profiles only support activation at *RemedialAction* class level instead of at the *TopologyAction* class level.

From a business perspective, the current requirements for RAO targets optimisation at the RA level, i.e., enabling/disabling the topology remedial actions as a whole, and the RAO is not intended to optimise individual switching equipment to find the best topology configuration.

The design of the RemedialAction (RA) and RemedialActionSchedule (RAS) profiles allows for setting the switching device status to be modified on a per-MTU basis. As shown in Figure 35, this can be done by using *GridStateIntensitySchedule* with references to *GenericValueTimePoint* and *GridStateAlteration* (which refers to *Switch.open PropertyReference* in the *RemedialAction* profile).

However, such setup is not applicable for topology remedial actions. This is because, normally modification of status of one switching device requires modification of other switching devices.

The recommended approach is not to use *GridStateIntensitySchedule* for expressing the RAO result of a topology remedial action, but rather to rely on the mechanism to activate or deactivate the whole remedial action (refer to section 7.1.9.1.1).

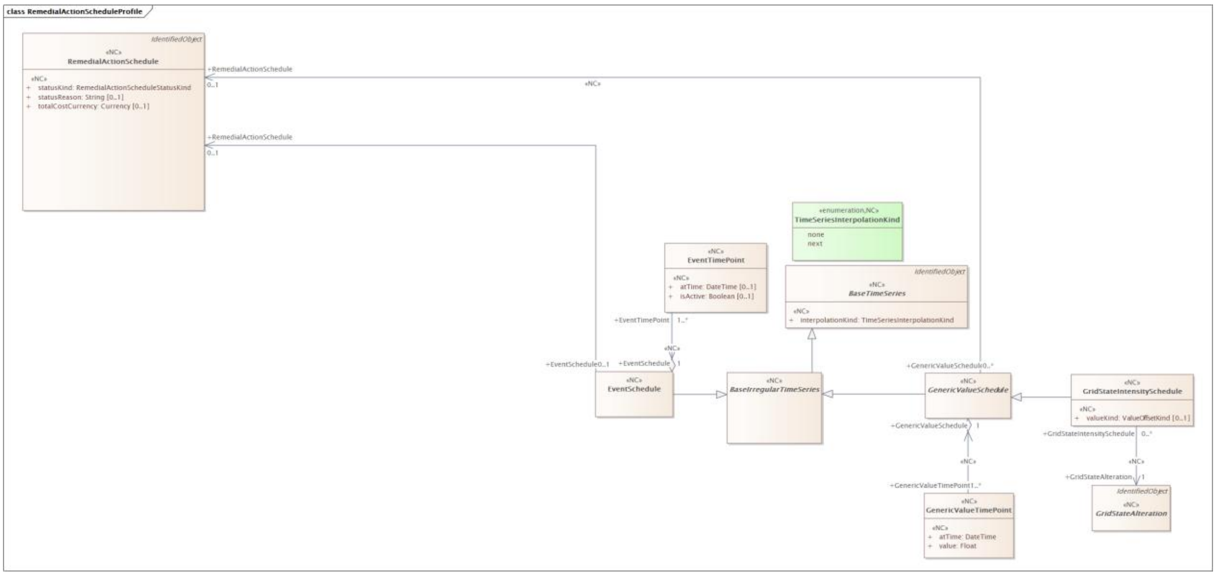


Figure 35: Extract of the RemedialActionSchedule diagram showing GridStateAlteration and GridStateIntensitySchedule related classes

Regions can limit the possibility to modify the structural *RemedialAction* dataset content by using SIS and/or SSI profiles. To do so, they shall agree on a regional constraint which shall be machine readable expressed in SHACL.

In order to inform on whether the RAS dataset is input to RAO or an output from RAO, the dataset header refers to an *Action*.

In general, the RAO is operating per MTU—which should be included in the header using the items *startDate* and *endDate* information.

The RAS dataset itself can include timeseries capabilities. This is to handle restrictions that occur due to time—very relevant for generators, not so relevant to topology. However, the topology might also have some time restrictions too.

There are five cases which are illustrated using ReliCapGrid model and described in the next subchapters.

7.1.8.2.1 Topology Remedial Action with One Topology Action and without Dependencies

For illustration purposes, readers can refer to the EQ and RAS synthetic dataset of the fictitious TSO *Svedala* part of the ReliCapGrid GitHub repository and follow the indicated mRID below.

- The *GridStateAlteration*RemedialAction is the basic case where we have one Topology remedial action with one topology action.
- 6d2c8901-d068-4d22-8ce9-7379644b4f17
- The topology remedial action is designed to open a switch in the *Svedala* fictitious IGM EQ dataset.
- 176d262c-701c-4ced-99b2-a155c136e787

7.1.8.2.2 Dependent Topology Remedial Action with Multiple Topology Actions

This section explains how to model Topological Remedial Actions using the RA and RAS profiles. For illustration purposes, please refer to the RA and RAS synthetic datasets of the fictitious TSO *Svedala* part of the ReliCapGrid GitHub repository and follow the indicated mRID below.

The grouping of remedial actions is needed in case a TSO detects dependency between remedial actions (section 7.4.5 complements well). The following illustrates a situation where this can occur and references objects in ReliCapGrid:

- There are two topology remedial actions in Substation A that include actions on four switches that cannot be applied at the same time because they are both a target topology configuration of the substation. They are composed of topology actions on same switches but setting different status on these switches.
- Two exclusive dependencies between the two remedial actions are defined:
  - 598ab84e-a575-40ad-bf66-c1ab41c65093
  - 13c29cc3-3d99-4c5b-abac-085f0d319eab

7.1.8.2.3 Modification Prior RAO of Topology Remedial Action

A certain TSO modifies (enables/disables) Topology Actions part of a topology RA class using the SIS and SSI profiles prior to RAO. For illustration purposes, please refer to the SSI and SIS synthetic datasets of the fictitious TSO *Espheim* part of the ReliCapGrid GitHub repository and follow the indicated mRID below.

- Using SIS the modification can be done by:
- *GridStateAlterationSchedule* (f5205bd4-637a-4eb7-b0d8-e03638bc570b) per Topology Action (4d3757fd-b40a-4d7b-be47-6553935234ff) part of the Topology RA (d856a2a2-3de4-4a7b-aea4-d363c13d9014)
- Multiple *GridStateAlterationTimePoint* to enable/disable the Topology action per time point.
- Using SSI the modification can be done by:
- *GridStateAlteration* per TopologyAction (4d3757fd-b40a-4d7b-be47-6553935234ff)

7.1.8.2.4 Proposing modifications of a Topology Remedial action after RAO

Modification of any remedial action schedule involves the approach outlined in the section 7.4.5. This is preceded by a coordination process where the TSO refuses the *RemedialActionSchedule* and proposes a new one as described in section 0.

- To refuse a RemedialActionSchedule a TSO needs to send RemedialActionScheduleResponse. In the example this is illustrated by the class (96f93b71-420f-456f-932e-9ac3f724b683).

- To propose a new schedule a TSO needs to send RemedialActionScheduleDependency and a new RemedialActionSchedule. In a simple situation there is no need to create RemedialActionScheduleGroup (that is, RemedialActionScheduleDependencyKind is set to none).

In the example this is illustrated by the following classes RemedialActionScheduleDependency (f7231aa5-d497-41f3-a5d5-9d4af74444f0) and a new RemedialActionSchedule (51361821-0a40-4e5a-a49d-29c266ea2ecc).

In general, when making a new proposal TSOs need to send EventSchedule. In the example, another identifier is created for the EventSchedule coming out of the counter proposal (in this case, refusal).

That is, when the TSO creates the remedial action schedule class, the TSO would also create the complete schedule and the time points. The schedule needs to be complete as there is no rejection on a particular timepoint. The refusal is on the whole schedule, and a proposal has to be complete too.

Section 7.4.4.2 complements well.

7.1.8.2.5 Activation After RAO of Topology Remedial Action

In this case, the RCC (as an output from RAO) indicates the activation time for a topology RA.

For illustration purposes, readers can refer to the RA and RAS synthetic datasets of the fictitious TSO *Svedala* part of the ReliCapGrid GitHub repository and follow the indicated mRID below.

- In the RA dataset, there are two topology remedial actions with multiple *GridStateAlteration*.
  - 7e422768-207d-455f-976e-0b1cb2338509
  - fa3e3533-345a-4ef1-a46d-3ab6d251924a
- In the RA dataset, the are two remedial actions are in a group and they have exclusive dependencies.
  - 6a9b5221-bb3f-421b-89c1-886b100aa68a
- To communicate the activation, the RCC needs to export RAS dataset which includes the following classes per remedial action
  - *EventSchedule* objects (class)
    - 1c1e39cf-15a1-4874-9739-d9e6dc90ee11
    - 023512a8-150d-4300-8159-807275eafd48
  - RemedialActionSchedule objects (class)
    - 279bfb00-1b2a-4592-af3a-dba9403d1abd
    - 87e90c47-43d8-4e5c-b2ad-5c67d3a74842
- EventTimePoint objects for each of the timestamps to communicate if activated or not

The recommendation is to use the *EventSchedule* class which value is the information of the activation of the remedial action.

7.1.8.3 Power Remedial Actions: Countertrade and Redispatch

7.1.8.3.1 Design options

There are four option that use different mechanisms to realise the countertrade and redispatch remedial actions.

- **Option 1: Using grid state alteration**

This option relies on grid state alterations remedial actions which require that a *GridStateAlteration* is defined for each of the generating units part of the redispatch or countertrade.

- **Option 2: Using power schedule. The following classes are used:**
    - In RemedialAction profile dataset
    - PowerRemedialAction refers to BiddingZone and/or BiddingZoneBorder
    - In PowerSchedule profile dataset
    - PowerSchedule objects point to PowerRemedialAction
    - One PowerSchedule object refers to one GeneratingUnit. The PowerTimePoint is used to provide information on time and power (the allocated power for the given point in time).
- **Option 3: Using bid schedule**

This is the only option where process can be assigned. The following classes are used:

- In RemedialAction profile dataset
- PowerRemedialAction refers to BiddingZone and/or BiddingZoneBorder
- In StateInstructionSchedule profile dataset
- PowerBidSchedule object that refers to PowerRemedialAction
- PowerShiftKeyDistribution object refers to PowerBidScheduleePowerBidSchedule has PowerBidScheduleTimePoint that provides the active power for points in time
- PowerShiftKeyDistribution object refers to PowerShiftKeySchedule which refers to the GeneratingUnit
- ParticipationFactorTimePoint which refers to the PowerShiftKeySchedule is used to exchange the participation factors for different points in time.

- **Option 4: Using power shift key strategy**

The following classes are used:

- In RemedialAction profile dataset
- PowerRemedialAction refers to BiddingZone and/or BiddingZoneBorder
- PowerShiftKeyStrategy object refers to the PowerRemedialAction
- In EquipmentReliability profile dataset

- PowerShiftKeyStrategy is defined with all the setup using SchedullingArea
- In StateInstructionSchedule profile dataset
- PowerShiftKeyDistribution object refers to PowerShiftKeySchedule object.
- PowerShiftKeyDistribution object also refers to the PowerShiftKeyStrategy object in the ER dataset. It is possible to have different PowerShiftKeyStrategy per PowerShiftkeyDistribution

In this option there is no need that PowerShiftKeySchedule object refers to GeneratingUnit as this is done via the PowerShiftKeyStrategy. There is no need to use ParticipationFactorTimePoint.

- **Option 5: Using bid schedule and power shift key strategy**

The following classes are used:

- In RemedialAction profile dataset
- PowerRemedialAction refers to BiddingZone and/or BiddingZoneBorder
- PowerShiftKeyStrategy object refers to the PowerRemedialAction
- In EquipmentReliability profile dataset
- PowerShiftKeyStrategy class using enumeration PowerShiftKeyKindeSchedulingArea with corresponding references to generating unit(s) in case of RedispatchRemedialAction (for CountertradeRemedialAction not mandatory)
- In StateInstructionSchedule profile dataset
- PowerBidSchedule object that refers to PowerRemedialAction
- PowerBidSchedule has PowerBidScheduleTimePoint that provides the active power and price for points in time
- PowerShiftKeyDistribution with reference to PowerShiftKeySchedule
- In case of ExplicitInstruction PowerShiftKeySchedule is required with ParticipationFactorTimePoints and potential reference to GeneratingUnit (exactly the same as stated in ER)

With this approach clear distinction between structured data (offline data) and schedule data (e.g. daily process) is achieved since only SIS is used in daily process with reference to ER and RA profiles.

7.1.8.3.2 Countertrade Remedial Action

This example illustrates how to define a Countertrade Remedial Action in two different ways.

The first way uses the PowerSchedule profile, as shown in the Figure 36 below.

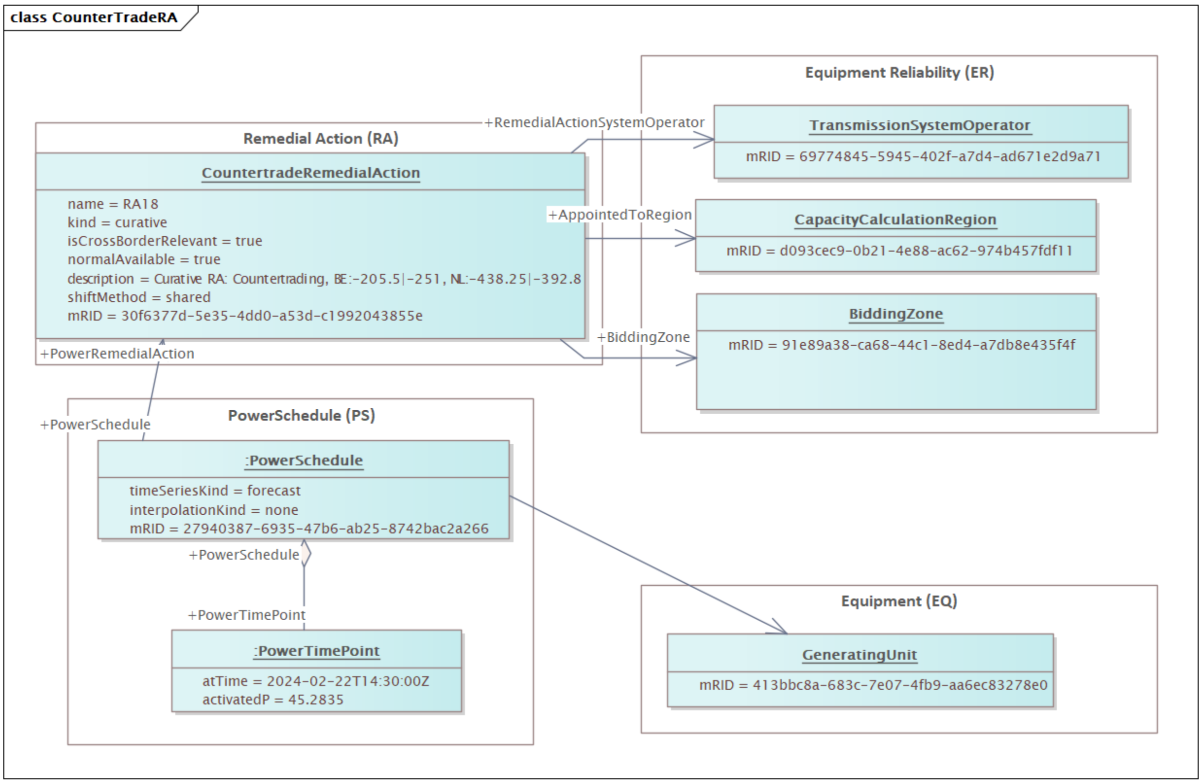


Figure 36 - Countertrade Remedial Action Example with PowerSchedule

The corresponding PowerSchedule dataset example can be located in ReliCapGrid in Belgovia_PS.xml:

- PowerSchedule rdf:ID="_27940387-6935-47b6-ab25-8742bac2a266".

The corresponding CountertradeRemedialAction can be found in ReliCapGrid in Belgovia_RA.xml:

- CountertradeRemedialAction rdf:ID="_30f6377d-5e35-4dd0-a53d-c1992043855e".

The corresponding GeneratingUnit can be located in ReliCapGrid in Belgovia_EQ_1.xml :

- GeneratingUnit rdf:ID="_413bbc8a-683c-7e07-4fb9-aa6ec83278e0"

The second way to specify a Countertrade remedial action is by using PowerBidSchedule concept in the SIS profile, as illustrated in the Figure 37 below.

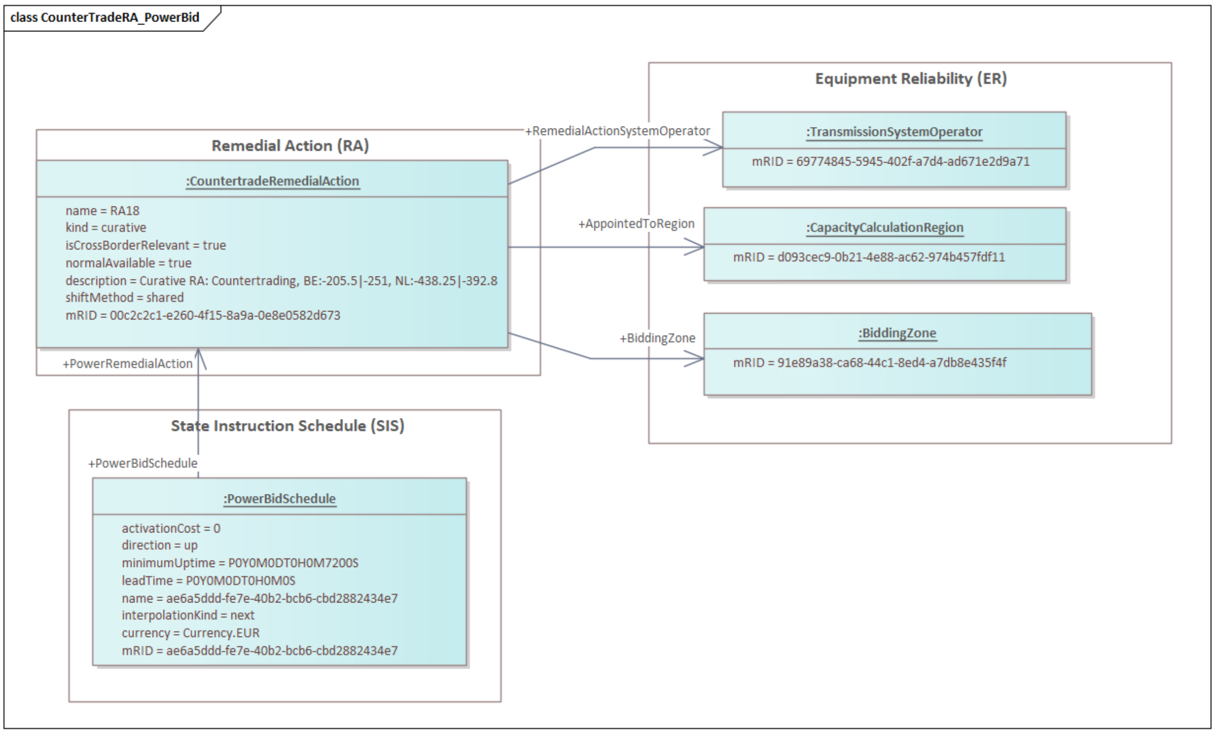


Figure 37 - Countertrade Remedial Action Example with PowerBidSchedule

The corresponding CountertradeRemedialAction dataset example can be located in ReliCapGrid in Belgovia_RA.xml:

- CountertradeRemedialAction rdf:ID="_30f6377d-5e35-4dd0-a53d-c1992043855e".

The corresponding PowerBidSchedule dataset example can be located in ReliCapGrid in Belgovia_SIS.xml:

- PowerBidSchedule rdf:ID="_ae6a5ddd-fe7e-40b2-bcb6-cbd2882434e7".

7.1.8.3.3 Redispatch Remedial Action

The following example illustrates two ways how to specify a Redispatch Remedial Action. Both examples refer to the following Equipment profile in ReliCapGrid: Belgovia_EQ_1.xml :

- SynchronousMachine rdf:ID="_3a3b27be-b18b-4385-b557-6735d733baf0".

The first way illustrates (along with Figure 38) the usage of the abovementioned Option 3, i.e., using bid schedules. The RemedialAction profile is defined in Belgovia_RA.xml:

- RedispatchRemedialAction rdf:ID="_fa73cfee-ff54-43cd-816b-51394cd76f0f".

The corresponding State Instruction Schedule dataset example can be located in ReliCapGrid in Belgovia_SIS.xml:

- PowerBidSchedule rdf:ID="_6c0ba4c5-5ac0-43f8-87d9-ec2fb41a3dec".
- PowerBidScheduleTimePoint rdf:ID="_250e37a5-50e0-44b7-9bd7-7284c04116db".
- PowerShiftKeySchedule rdf:ID="_3b5748de-39f2-45d7-9a66-65819c667e91".

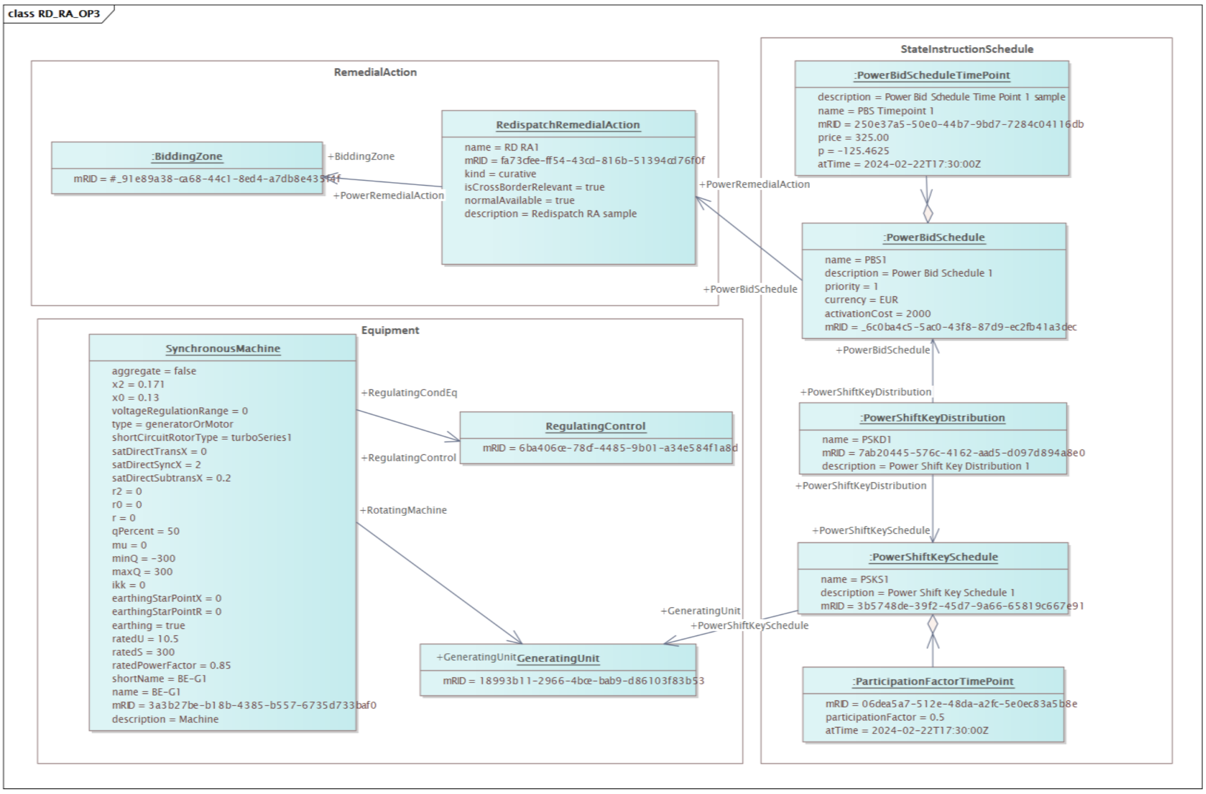


Figure 38 - Redispatch Remedial Action Example Option 3

The second way to define a RedispatchRemedialAction is illustrated in the Figure 39 below and utilizes power shift key strategy, as explained above in Option 4. The RemedialAction profile is defined in Belgovia_RA.xml:

- RedispatchRemedialAction rdf:ID="_9d72d12a-f135-437a-83fa-ef3e5b23f41f".

The corresponding State Instruction Schedule dataset example can be located in ReliCapGrid in Belgovia_SIS.xml:

- PowerShiftKeyDistribution rdf:ID="_7ab20445-576c-4162-aad5-d097d894a8e0"
- PowerShiftKeySchedule rdf:ID="_3b5748de-39f2-45d7-9a66-65819c667e91".

The corresponding Equipment reliability dataset example can be located in ReliCapGrid in Belgovia_ER.xml:

- PowerShiftKeyDistribution rdf:ID="_7ab20445-576c-4162-aad5-d097d894a8e0"
- PowerShiftKeySchedule rdf:ID="_3b5748de-39f2-45d7-9a66-65819c667e91".

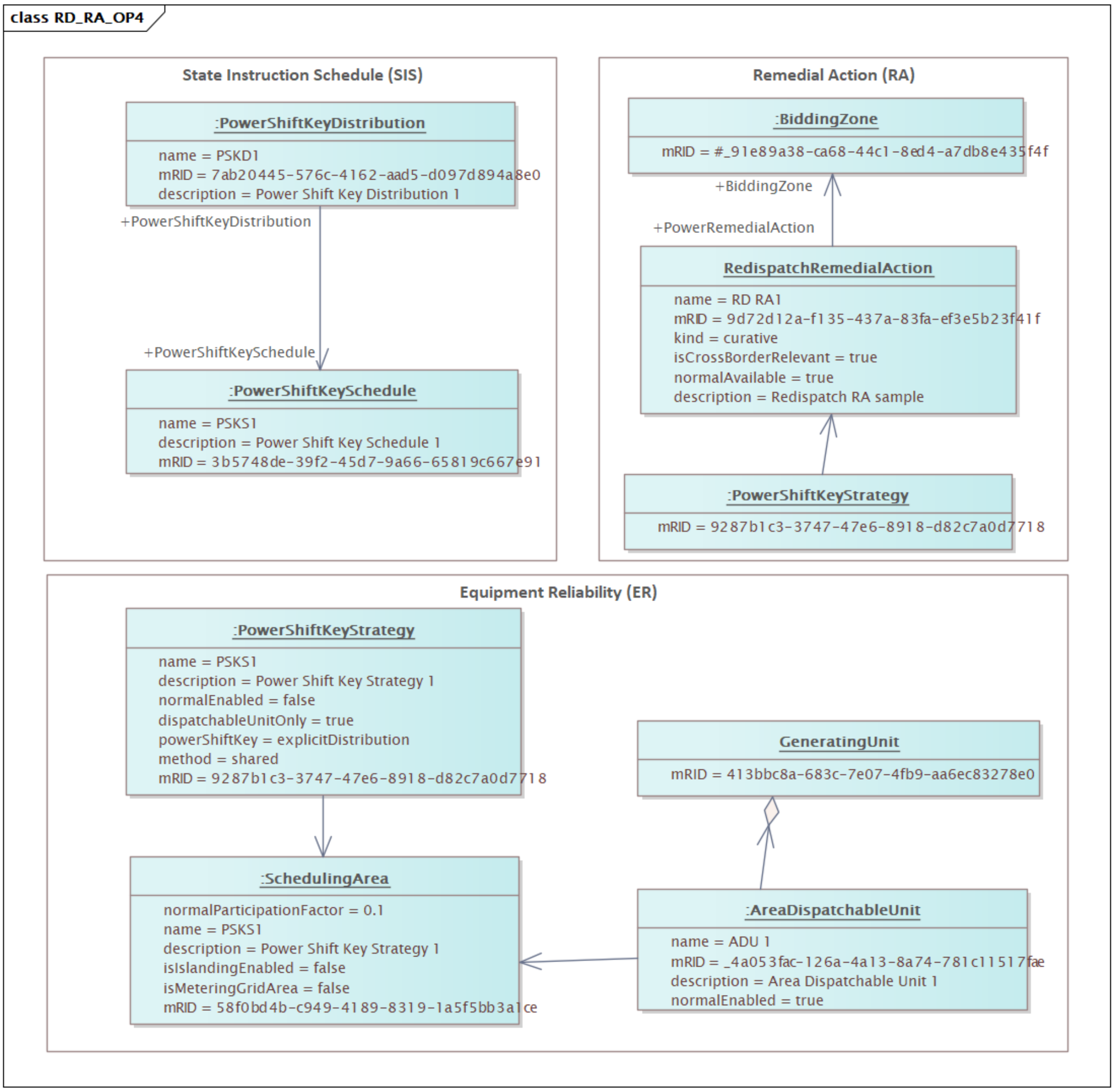


Figure 39 - Redispatch Remedial Action Example Option 4

7.1.8.3.3.1 Power Bid Schedule dependency (*Parent-Child* dependency)

This section explains a use case where TSOs manage power plants—such as gas and steam turbines—that involve parent-child dependencies with operational constraints like delays and mandatory run requirements.

TSOs typically have a diverse generation portfolio, ranging from traditional gas or coal-fired power plants to hydro and renewable energy sources. Some costly remedial actions include bid offers from different generation types, where parent-child relationships are used to model dependencies between two or more bids. For example, the parent might be a gas generator, and the child a steam turbine.

Each generation type comes with its own operational constraints that must be respected when submitting a bid offer. These parent-child relationships can be defined either within a single remedial action or across different RAs and may also be used to represent constraints at the generator level.

To model a parent-child dependency:

1. Power bids must first be created.
2. Parent-child dependencies can then be established between them.

It is important distinguishing between the dependencies in the activation of the parent and child bid from the conditions such bids shall respect when (and if) running.

The recommendation is to use the *PowerBidSchedule* class in the SIS profile to model bid offers, as well as the *PowerBidDependency* class including the attributes required to define the dependencies, as outlined below.

Readers can use the Figure 40 to visualize the key attributes of *PowerBidDependency* class.

The first dependency is the activation condition using the attribute *kind* as below.

- *kind*: Type of dependency between bids. It indicates the activation dependency between dependee (parent) and dependent (child) bids. It does not indicate any running condition between dependee and dependent bids.

  If PowerBidDependencyKind equals to restrictive, a combination of the following attributes PowerBidDependency.startToStartLag, PowerBidDependency.finishToStartLag, PowerBidDependency.finishToFinishLag , or PowerBidDependency.overlap shall be used.

  - The kind attribute can take the following PowerBidDependencyKind values:
    - exclusive: Bids are exclusive depending on each other. Bids are exclusive depending on each other. Only dependee (parent) bids can be activated if dependent (child) is activated or vice versa. For instance, dependent (child) must not be activated if the dependee (parent) is activated.
    - inclusive: Bids are inclusive depending on each other. Both dependee (parent) and dependent (child) bids must be activated, i.e., dependent (child) must be activated if the dependee (parent) is activated.

        - restrictive: Bids are restrictive depending on each other. The activation of dependent (child) bids is optional if the dependee (parent) is activated.

Secondly, TSOs can set the running dependencies or conditions between the parent and the child bids with the following of attributes.

- *startToStartLag*: Time between the activation of dependee (parent) bids and the activation of dependent (child) bids. It cannot be used when the PowerBidDependency.kind is set to exclusive.

  Depending on the startToStartLagKind the value has the following meaning:

    - exact: the indicated lag should be exactly respected.
    - minimum: the indicated lag should be the minimum respected one and a higher or equal lag for the activation of the dependent (child) after the activation of the dependee (parent) is allowed.
    - maximum: the indicated lag is the maximum that can occur, and a smaller or equal lag for the activation of the dependent (child) after the activation of the dependee (parent) is allowed.

- *finishToStartLag*: Time between the deactivation of the dependee (parent) bids and the activation of dependent (child) bids. It cannot be used when the PowerBidDependency.kind is set to exclusive.

  Depending on the finishToStartLagKind the value has the following meaning

    - exact: the indicated lag should be exactly respected.
    - minimum: the indicated lag should be the minimum respected one, and a greater or equal lag for the activation of the dependent (child) after the deactivation of the dependee (parent) is allowed.
    - maximum: the indicated lag is the maximum that can occur, and a less or equal lag for the activation of the dependent (child) after the deactivation of the dependee (parent) is allowed.

- *finishToFinishLag*: Time between the deactivation of the dependee (parent) bids and the deactivation of dependent (child) bids. It cannot be used when the PowerBidDependency.kind is set to exclusive.

  Depending on the finishToFinishLagKind the value has the following meaning:

    - exact: the indicated lag should be exactly respected.
    - minimum: the indicated lag should be the minimum respected one, and a greater or equal lag for the deactivation of the dependent (child) after the deactivation of the dependee (parent) is allowed.

- maximum: the indicated lag is the maximum that can occur, and a less or equal lag for the deactivation of the dependent (child) after the deactivation of the dependee (parent) is allowed.

- *overlap*: It indicates the duration the dependee (parent) and dependent (child) bids are active (run) at the same time. It cannot be used when the PowerBidDependency.kind is set to exclusive.

  Depending on the overlapKind the value has the following meaning:

  - exact: the dependee (parent) and the dependent (child) should be active (running) for the exact (equal) specified duration.
  - minimum: the dependee (parent) and the dependent (child) should be active (running) at least (greater than or equal) for the specified duration.
  - maximum: the dependee (parent) and the dependent (child) should be active (running) at the most (less than or equal) for the specified duration.

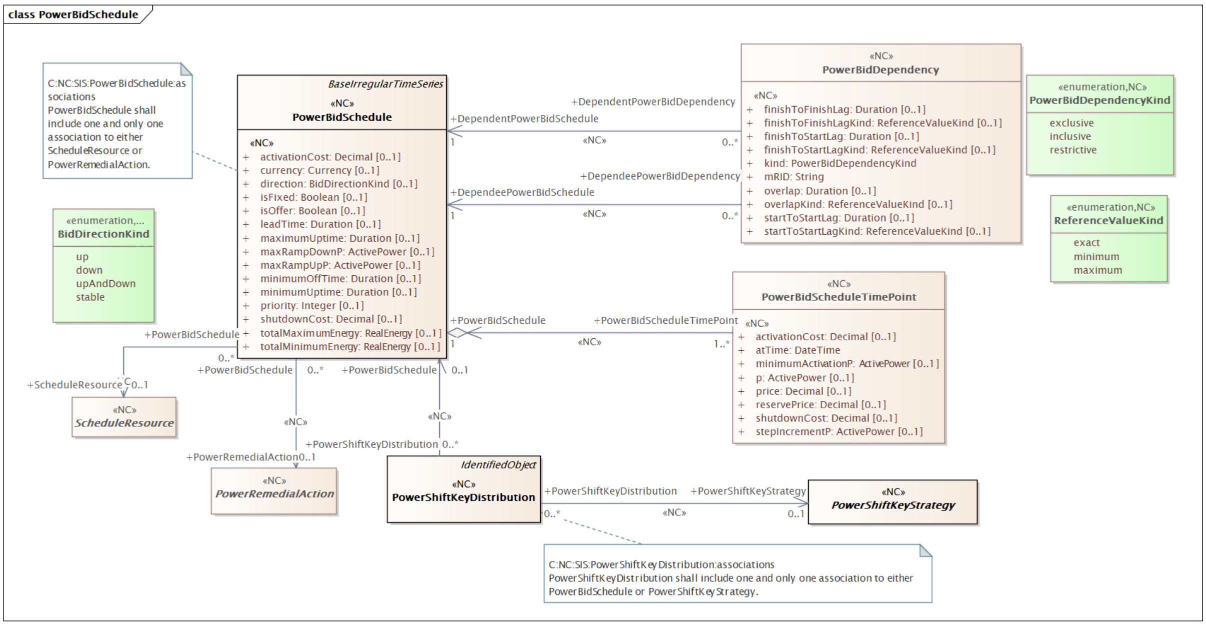


Figure **40**: Extract of the SIS profile visualising the *PowerBidSchedule* and *PowerBidDependency* classes

7.1.8.3.3.1.1 Summary illustrations of different combinations of PowerBidDependency parameters

The Figure 41 shows a summary illustration of the some of the main combinations of the PowerBidDependency parameters' combination.

Some of these combinations represent the following commonly named terms in regional implementation:

- "Parent must run": It describes a running condition in which the child bid can only run / be active when the parent is running / active.
- "Child delay kind": a situation in which the child bid activation is delayed with respect the parent activation.
- "Continuous activation": a situation in which the child bid is activated immediately after the parent bid deactivation.
- "Parent child duration activation": a situation in which the parent is activated for a given duration.

On the other hand, Figure 42 Figure 43 Figure 44 depict other relevant combinations of the PowerBidDependency attributes.

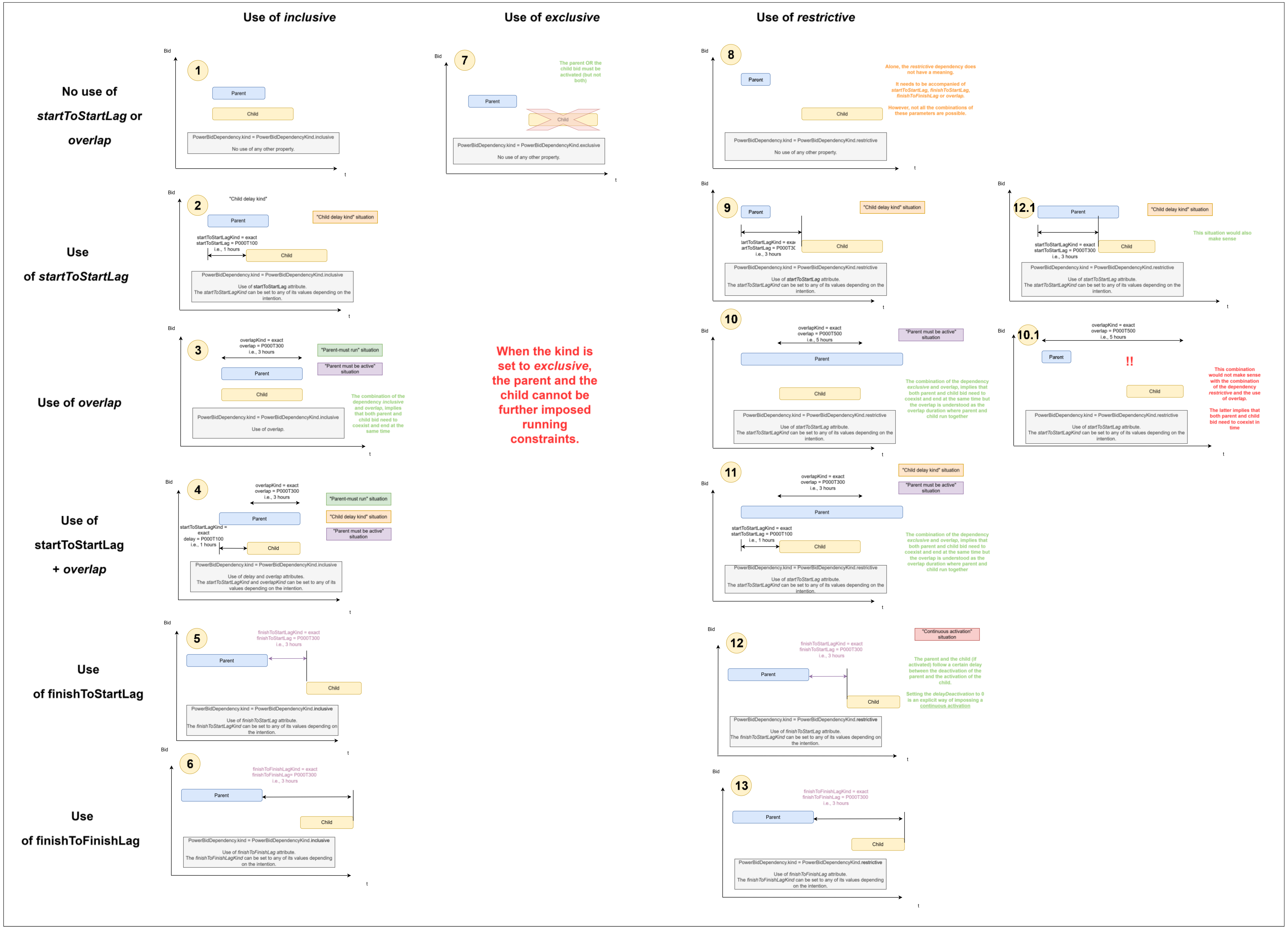
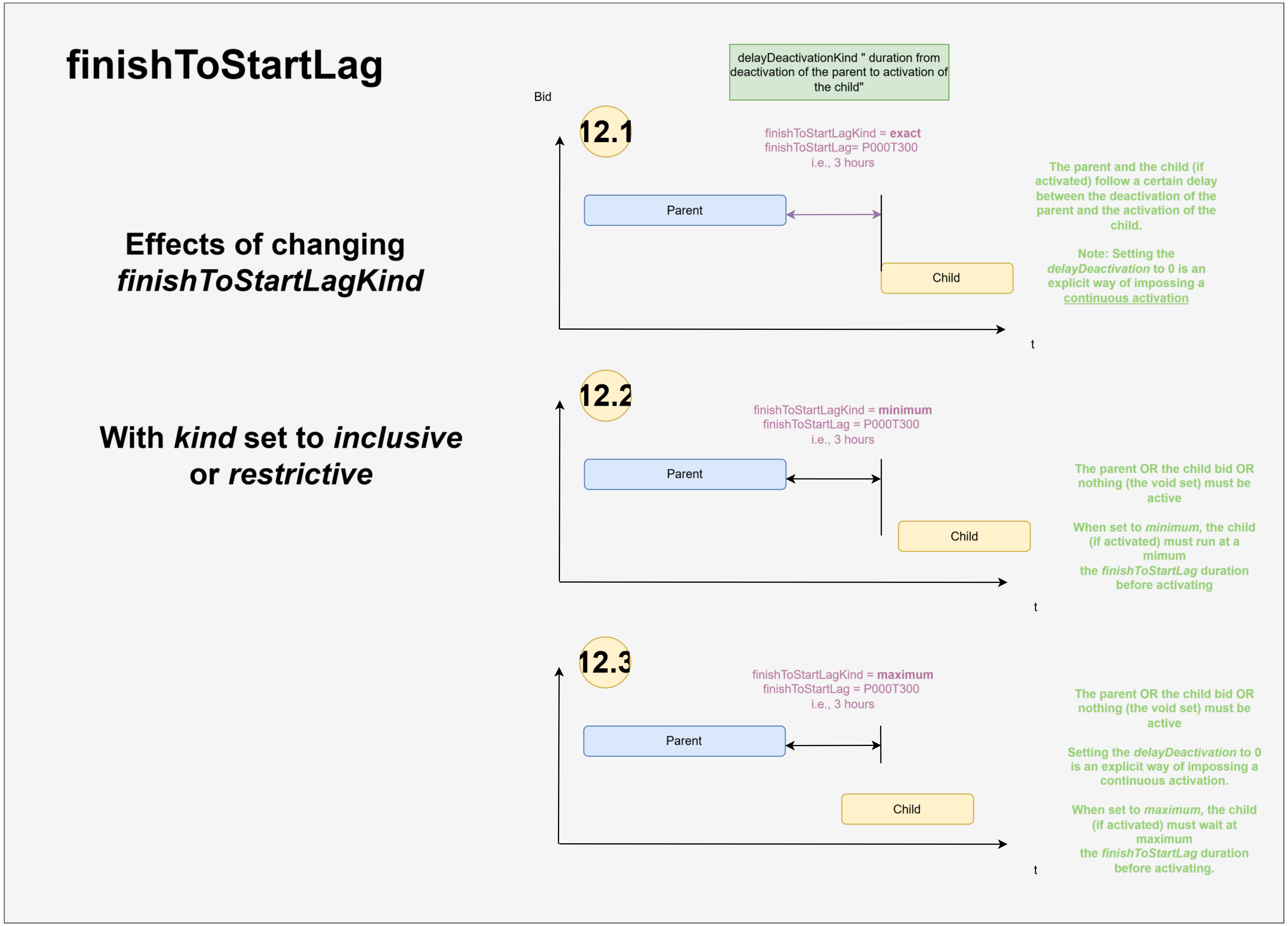


Figure 41: Summary illustration of different combinations of PowerBidDependency parameters

2734



2735
2736 Figure 42: Effects of changing *finishToStartLagKind* values

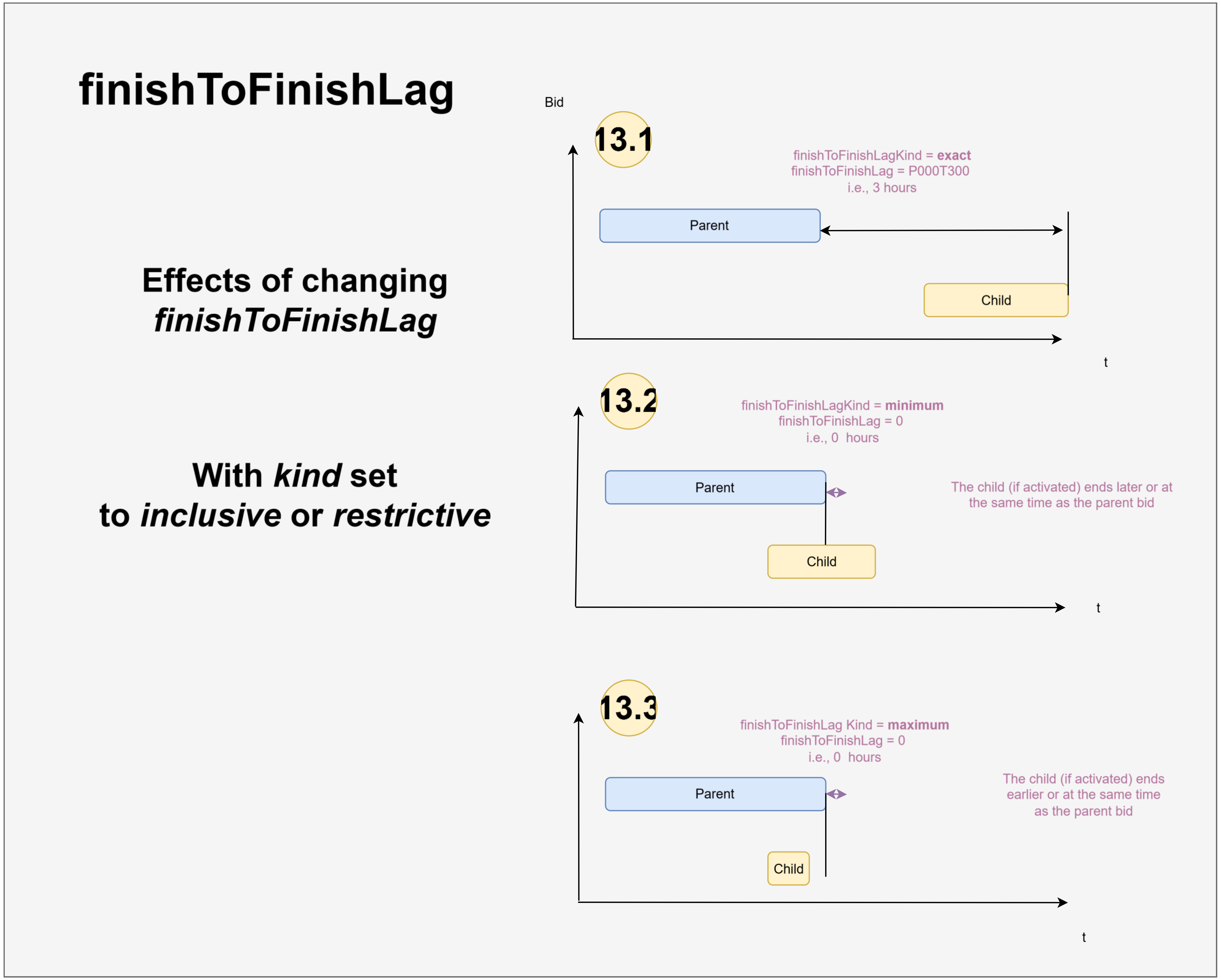
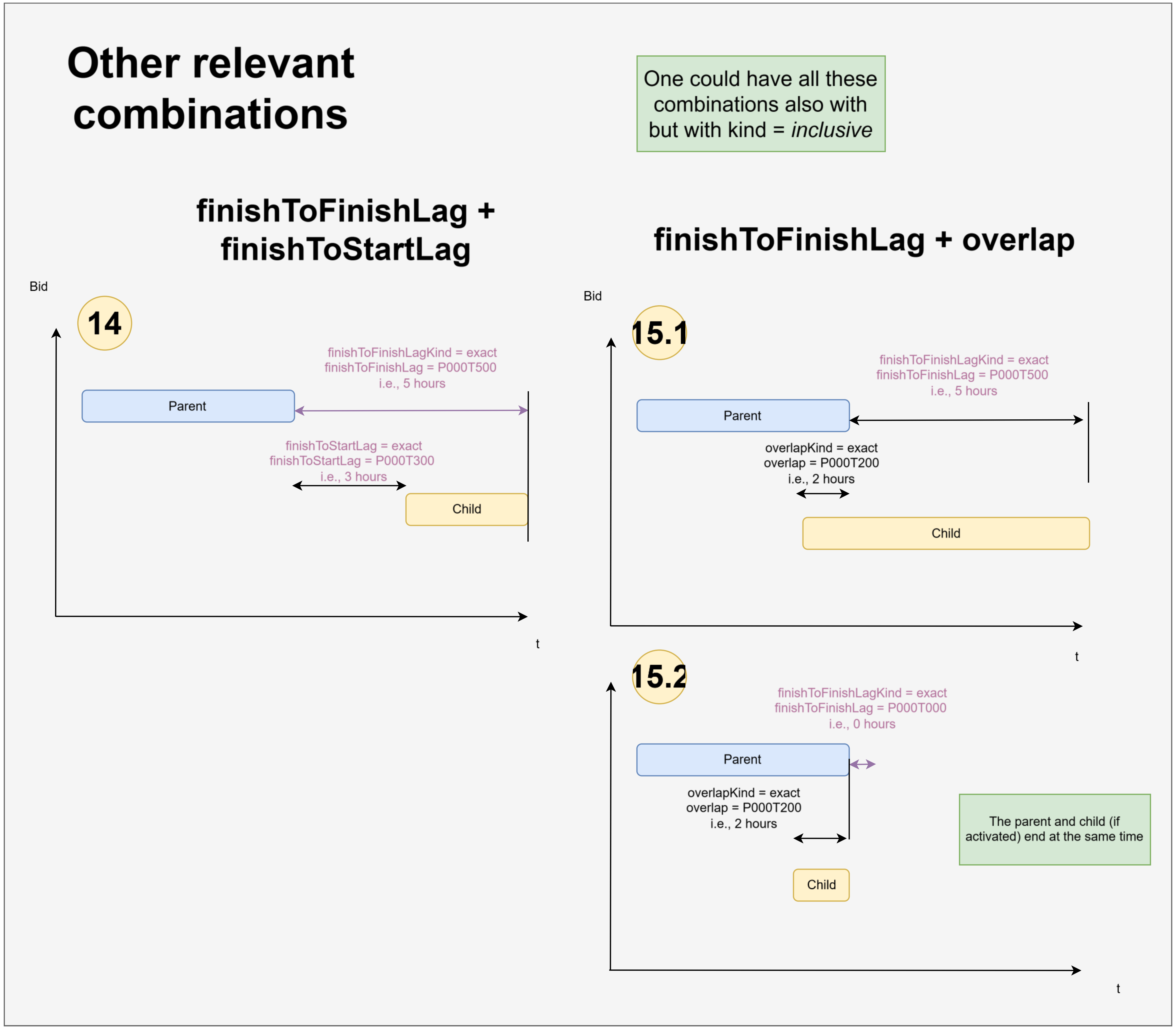


Figure 43: Effects of changing finishToFinishLagKind values

2739



2740
2741 Figure 44: Other relevant combinations of PowerBidDependency attributes
2742

2743

European Network of
Transmission System Operators
for Electricity

7.1.8.3.3.1.2 Reference Implementation Examples of Power Bid Schedule Dependency

The power bid schedule dependency is illustrated using the following two examples:

- Two power plans connected following the parent-child dependency
- Generators are not allowed to start simultaneously

7.1.8.3.3.1.2.1 Two power plans connected following the parent-child dependency

In the following example two power plans are connected following the parent-child dependency. One power plant only starts exactly one hour after the other power plant is selected. The parent needs to stay active as long as the child is active as per the customer specification.

The corresponding PowerBidSchedule dataset examples can be located in ReliCapGrid in Belgovia_SIS.xml:

- Parent PowerBidSchedule rdf:ID="_ae6a5ddd-fe7e-40b2-bcb6-cbd2882434e7".
- Child PowerBidSchedule rdf:ID="_5e08ba42-c0b5-45ed-bc8b-dbb854ed0897".
- PowerBidDependency rdf:ID="_0ba48b90-9ce6-4a38-8b11-ab66cc23f04e".

7.1.8.3.3.1.2.2 Generators are not allowed to start simultaneously

Readers are recommended to consult the maintained SIS profile XML example available on the ENTSO-E GitHub repository. The corresponding PowerBidSchedule dataset examples can be located in ReliCapGrid in Belgovia_SIS.xml:

- Parent PowerBidSchedule rdf:ID="_ae6a5ddd-fe7e-40b2-bcb6-cbd2882434e7".
- Child PowerBidSchedule rdf:ID="_42f85661-6877-4d5c-a87b-a97938642835".
- PowerBidDependency rdf:ID="_9439f6fe-3da6-428b-95aa-9fac541e6a7b".

7.1.8.3.4 Power Plant Schedule Level: Holding Time After Remedial Action

Some power plants require a minimum holding time before their production levels can be adjusted again. Rapid switching between increasing and decreasing production from one time step to the next introduces several issues:

- Technical limitations: Certain generating units must maintain a stable output for a specified duration before they are allowed to ramp up or down again.
- Increased equipment fatigue: Repeated fluctuations accelerate wear and tear, reducing the lifespan of critical components.
- Operational challenges: Constant adjustments complicate the efficient management of redispatch and RAO outcomes.

The overarching goal is to prevent redispatches from triggering remedial actions that, in turn, result in non-acceptable power plant schedules. Enforcing smoother, time-constrained schedules help create solutions that are more realistic and operationally viable.

However, these operational constraints cannot be communicated solely through bids. TSOs must explicitly define and share criteria for what constitutes an acceptable schedule.

As illustrated in Figure 45, a nuclear plant serves as a reference use case. The violet curve shows that a certain point in time, the production schedule is decreased, but the power plant then needs to wait some time until it can ramp up to a higher production level.

There could be various reasons for this behaviour might be several (i.e., appliance of a remedial action, occurrence of an outage, etc.) but this use case intends to focus on the modelling of the power plant in CIM.

depicts a redispatch leading to a non-acceptable schedule, characterized by unrealistic transitions.

In contrast, Figure 47 presents a compliant schedule that respects holding time constraints.

The critical difference lies in the timing between a ramp-down followed immediately by a ramp-up. Empirical evidence shows that such minimum time restrictions can vary daily and between different Generating Units.

Unlike controls of PSTs—where the initial value is known, and adjustments occur within a defined delta range—power plant schedules are not known a priori. As a result, TSOs must explicitly provide constraints to define acceptable operational windows.

As a consequence, the business requirements could be summarised as:

- These parameters apply for the entire business day.
- No modifications at the MTU level are needed at this stage.
- The constraints are independent of the generating unit’s state (e.g., operating mode or similar conditions).

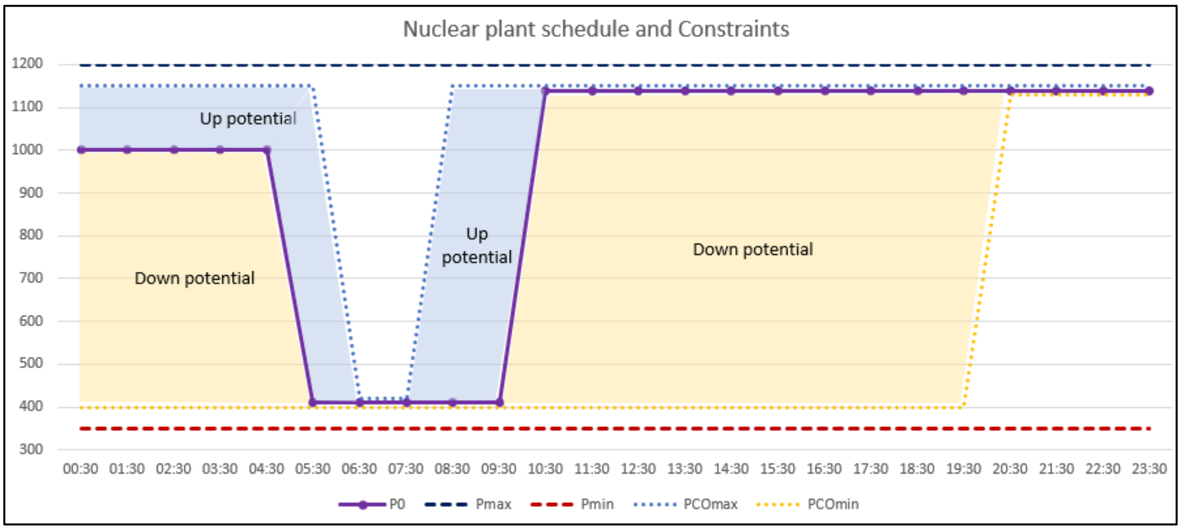


Figure 45: Nuclear plant schedule and constraints

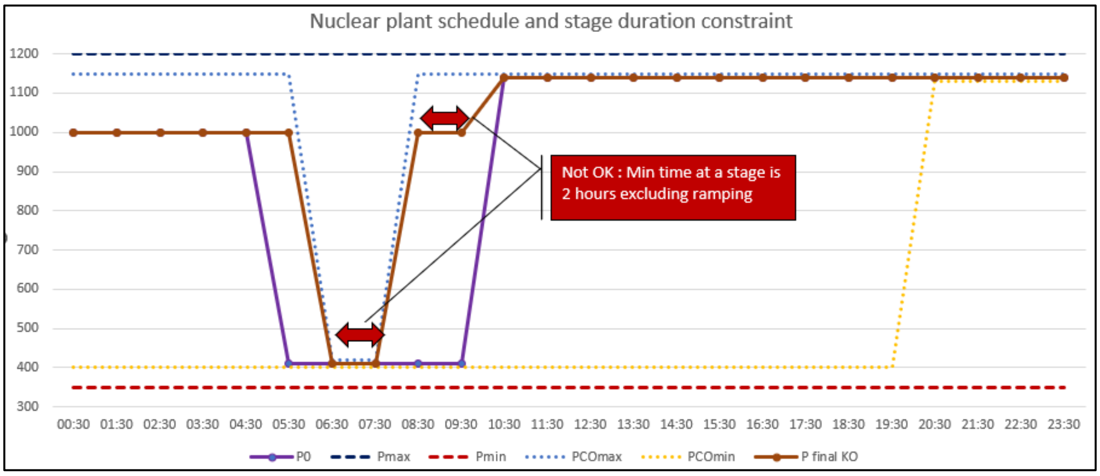


Figure 46: Non-acceptable nuclear power plant schedule

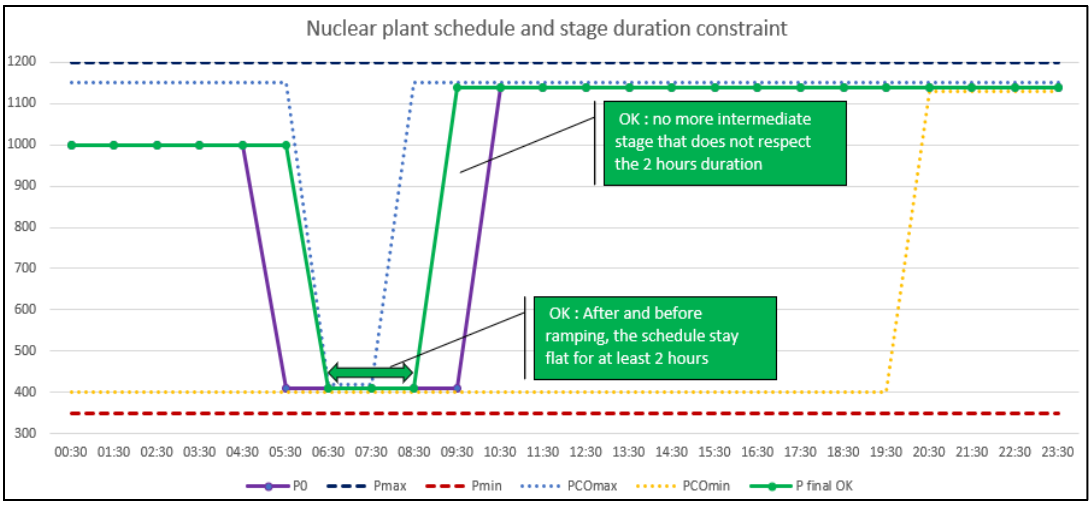


Figure 47: Acceptable nuclear power plant schedule

Assuming there is no explicit attribute indicating whether a unit is ramping, the determination of ramping status must be inferred by the Remedial Action Optimiser (RAO) based on existing attributes within the *GeneratingUnit* class.

To address the outlined challenge, the solution involves implementing a holding time that must elapse before a generating unit is permitted to adjust its production level again.

EquipmentReliability extends the *GeneratingUnit* class with the attribute *rampLockTime* which indicates the time between end or start of ramping. If a unit has just stopped the ramping, it will need to wait this time until a new ramping can start. An example can be located in ReliCapGrid in Galia_ER.xml:

- The GeneratingUnit rdf:ID="_2a2d438f-41b3-a9ea-f897-20ae9f28fbec".

7.1.8.3.5 Power Plant Schedule Level: Limiting Ramping Down Within a Period

In certain cases, a generating unit is permitted to reduce its power output only once per business day. This operational constraint introduces two main categories of scheduling rules:

- **Case 1: No prior ramp-down**
  - If the pre-CROSA schedule remained constant at maximum power output throughout the day, the RAO may reduce the output only once during that business day.
  - The default constraint is often set to one ramp-down per day, but this value is configurable and may vary depending on specific plant characteristics.
- **Case 2: Existing ramp-down present**
  - If the pre-CROSA schedule already includes a downward adjustment, the only permitted modifications are:
  - Advancing the time of the scheduled reduction
  - Modifying or cancelling the scheduled downward change

These constraints are critical for maintaining operational feasibility and aligning with the technical limitations of certain power plants. However, such rules cannot be enforced solely via scheduling logic and must instead be externally modelled or constrained.

The limitation on the number of allowable ramp-downs per time window is typically provided by the power plant owner and is based on empirical operational considerations.

For example, in the case of a nuclear power plant, a limiting factor might be the availability of storage for the fluid used to control the fission reaction.

Based on this limitation, the plant owner may specify—for the sake of this use case—a maximum of one ramp-down of the nuclear power output within a 24-hour period.

Retaking the example from last chapter, Figure 48 shows another nuclear power plant schedule used to demonstrate this scenario. It indicates that the power plant is producing at its maximum expect in the early morning hours.

On the other hand, Figure 49 illustrates a redispatch leading to a non-acceptable schedule, given that the power plant is ramping down two times.

Down below two acceptable example alternatives are described. Both schedule alternatives—among many other—adheres to the imposed ramp-down limit of one-fold:

- **Alternative 1** (Figure 50): the RAO could choose to do a redispatch cancelling the ramp down in the morning and allowing the nuclear power plant just to ramp down in the afternoon.
- **Alternative 2** (Figure 51): the RAO could choose to anticipate the afternoon ramp down and propose another redispatch allowing the nuclear power plant to stay at

lower production levels during the morning and ramp up its production throughout the day.

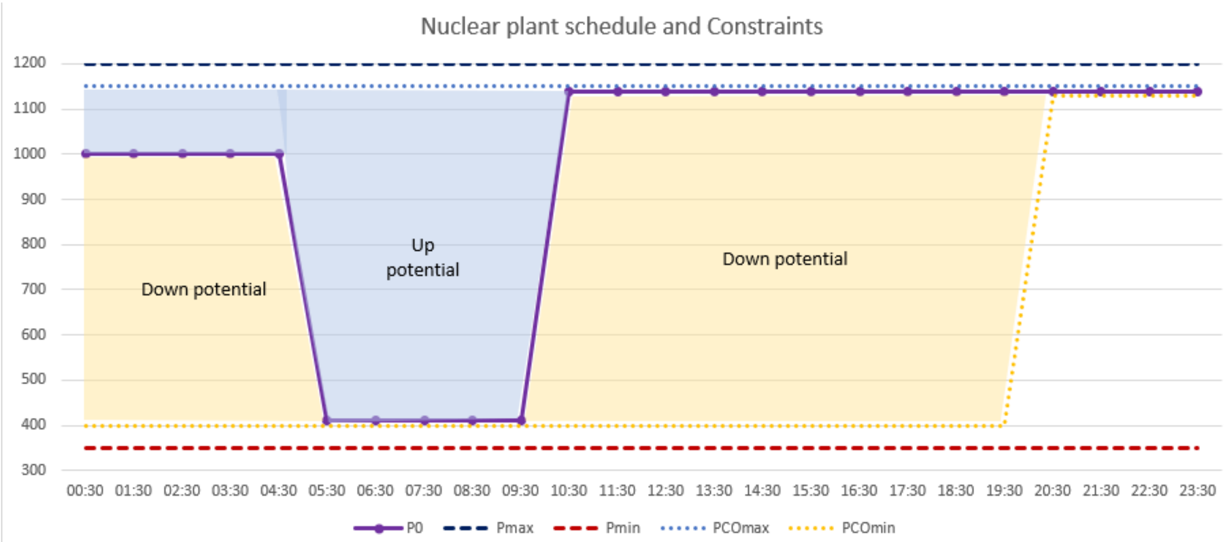


Figure 48: Another nuclear power plant schedule and constraints

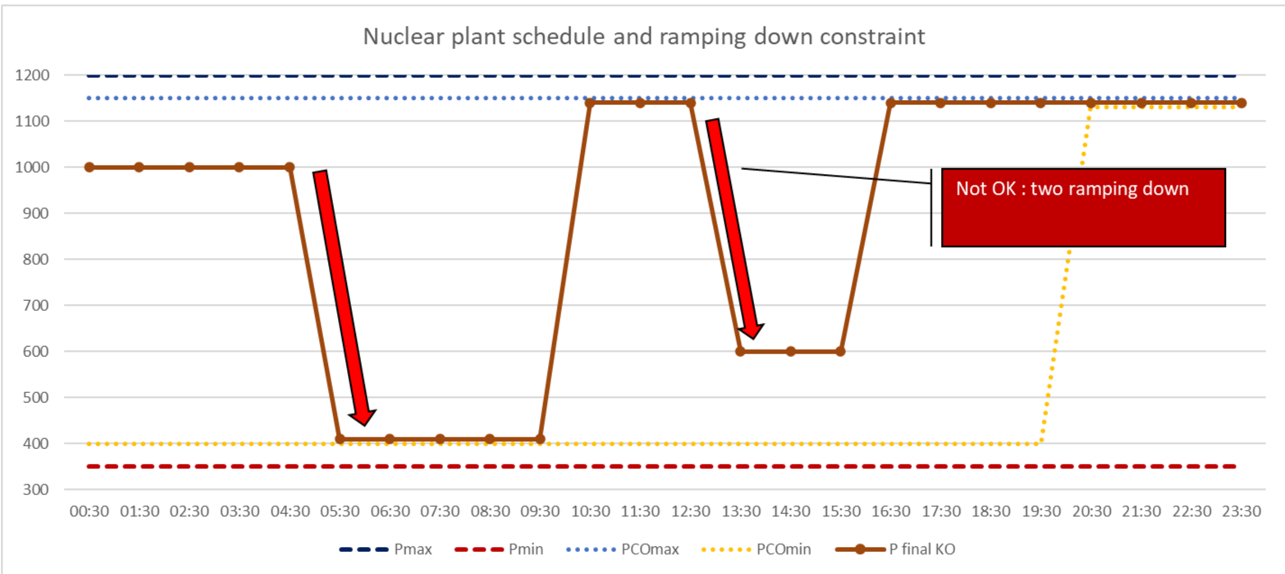


Figure 49: Non-acceptable nuclear power plant schedules due to ramping down

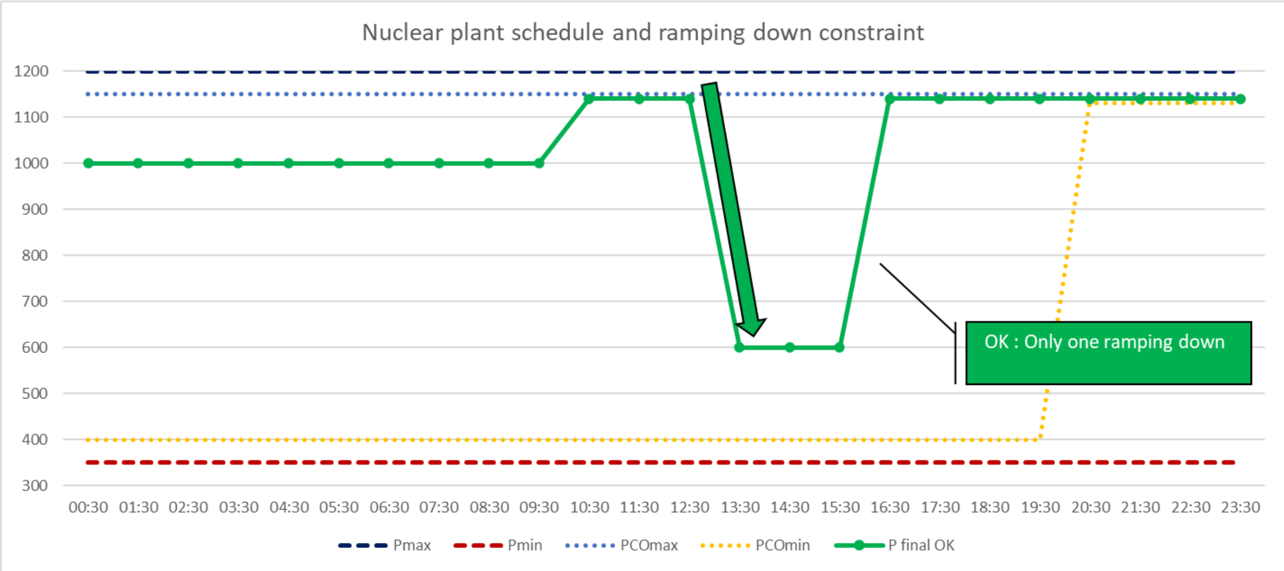


Figure 50: Acceptable nuclear power plant schedule integrating ramp down constraint

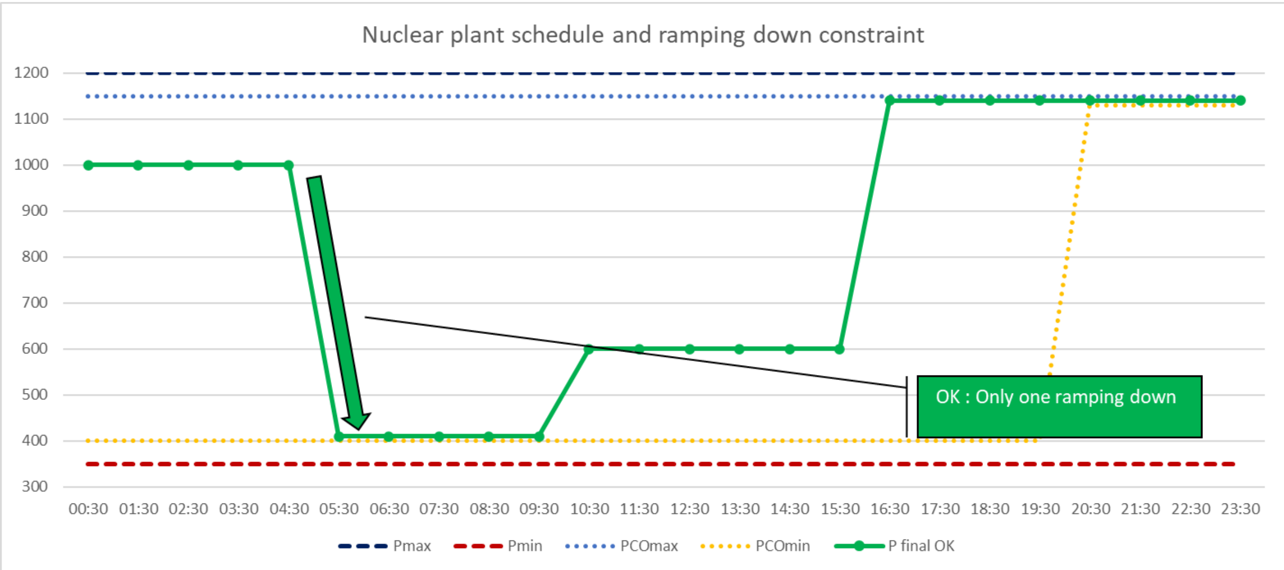


Figure 51: Another acceptable nuclear power plant schedule integrating ramp down constraint

The recommendation is to use the *GeneratingUnit* class makes use of the attribute *maxRampDownCountPerDay* within the *EquipmentReliability* profile. Such attribute specifies the number of times the unit can do ramp down within a calendar day. An example can be located in ReliCapGrid in Galia_ER.xml:

- The GeneratingUnit rdf:ID="_2a2d438f-41b3-a9ea-f897-20ae9f28fbec".

Note that one ramp down consists of a decrease of a power plant production level from a stable schedule to another regardless of how much time the power plant stays in such stable operating stage.

7.1.8.3.6 Continuous Activation of Generation Modes and Holding Time

The objective of this use case is to prevent gaps between bid activations by informing the RAO of the required continuity between related bids. This ensures the seamless transition between operating modes of a power plant, particularly for complex thermal generation units.

Thermal generation plants often support multiple operating modes. In this example, we consider a Gas Turbine Combined Cycle (GTCC) plant composed of two gas turbines and one steam turbine.

Even when such plants are not operating in a market-driven mode, it remains challenging to model their operational capabilities and transitions precisely. This is particularly true when market operating points vary throughout the day, even for simpler plants.

While using the *PowerBidSchedule* class can sufficiently model many aspects of such behaviour, it lacks the semantics required to enforce continuous transitions.

There is a clear need for an information model that ensures uninterrupted progression from one *PowerBidSchedule* to another. Each operating mode is defined by its own *Pmin* and *Pmax* parameters, and it is represented by a unique *PowerBidSchedule* schedule.

For instance:

- Let PowerBidSchedule A represent mode GT1.
- Let PowerBidSchedule B represent mode GT2.

If the RAO initially activates PowerBidSchedule A, and subsequently determines more power is needed, it must be able to immediately switch to PowerBidSchedule B, enabling a continuous ramp-up in output. This means:

- PowerBidSchedule A is deactivated (set to zero),
- While PowerBidSchedule B is simultaneously activated,
- Without any temporal gap between the two.

It shall not be possible for the RAO to:

- Activate PowerBidSchedule A for 4 hours,
- Then pause operations for 2 hours,
- And only afterward activate PowerBidSchedule B.

Such a break in continuity would violate the technical and operational constraints of GTCC plants and could lead to inefficient or infeasible redispatch outcomes.

The modelling recommendation for expressing a continuity condition between two dependent bids is setting the attribute finishToStartLag from the PowerBidDependency class to a value of 0 and the finishToStartLagKind set to ReferenceValueKind.exact.

Reader can refer to the previous section 7.1.8.3.3.1 for a better comprehension of how such attributes work.

7.1.8.3.7 Power Bids for Pump Storage Power Plant: Multiple Pump Storage

In some hydro power plants systems, pump storage units can switch between generating and pumping modes within a few minutes. Modern facilities can perform this mode change several times per day, driven by market and operational needs.

The power bid modelling of this process shall correctly represent such plants operational reality, including:

- Setting the generation or pumping power target exactly to zero, using a minimum activation power parameter to define a range between zero and the minimum permissible output.
- Changing operation mode directly from generating to pumping or vice versa, controlled via restrictive bits that govern allowable transitions and target power ranges.

To model this behaviour using the NCP, restrictive bids are used in conjunction with power bid schedules.

For example, Figure 52 illustrates the use of restrictive dependency between power bids to model the switching from generator to pump mode (*group 5* in the picture). When in generation mode, the power bid that goes exactly to 0, must be activated, (in this case, it is the parent bid #2) and afterwards the system is allowed to activate the restrictive bid (in this case, child bid #8) and go to pump mode any anywhere between—Pmin (-40 MW) and Pmax (-100 MW).

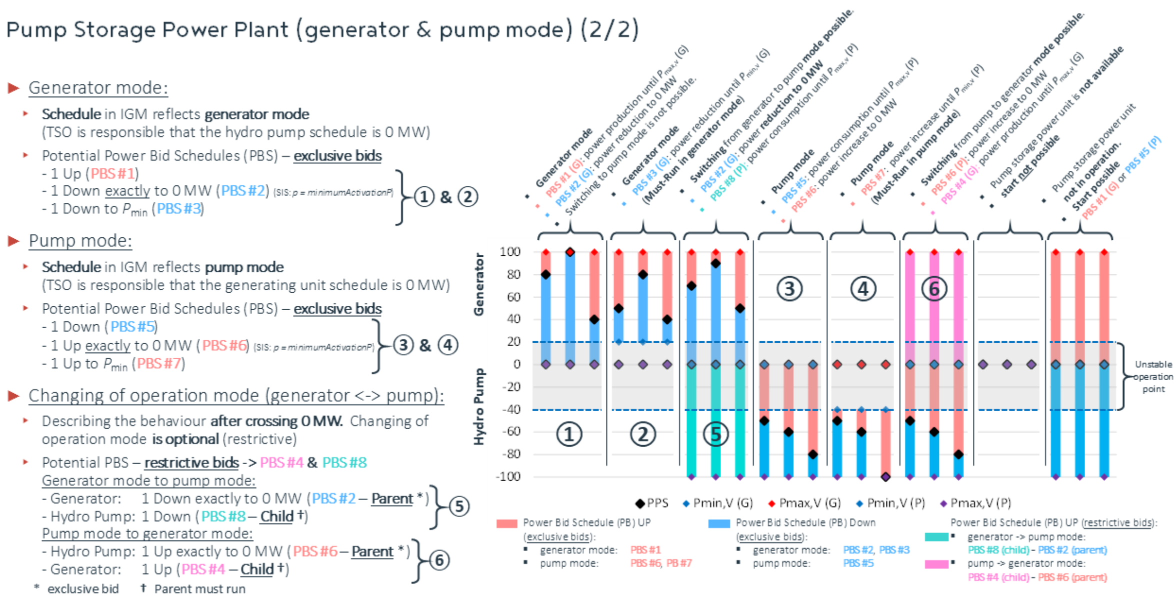


Figure 52: Modelling of Multiple Pump Storage Power Plants (I)

For plants with multiple generating and pumping units, the same mechanism applies using PowerShiftKey classes. Figure 53 reflects that.

The advantage of this multiple pump storage model is that it allows to combine different generation pumps into one remedial action, helping to reduce the total number of remedial actions and power bid schedules (in comparison if every generator/pump was modelled individually).

Grouping reflects how TSOs and market operators request redispatch: the operator specifies the total desired change (e.g. +100 MW generation) at the plant level, while the plant operator decides how to allocate the change among its units.

This approach enables TSOs to represent the operational flexibility of pump storage plants without creating excessive remedial action definitions.

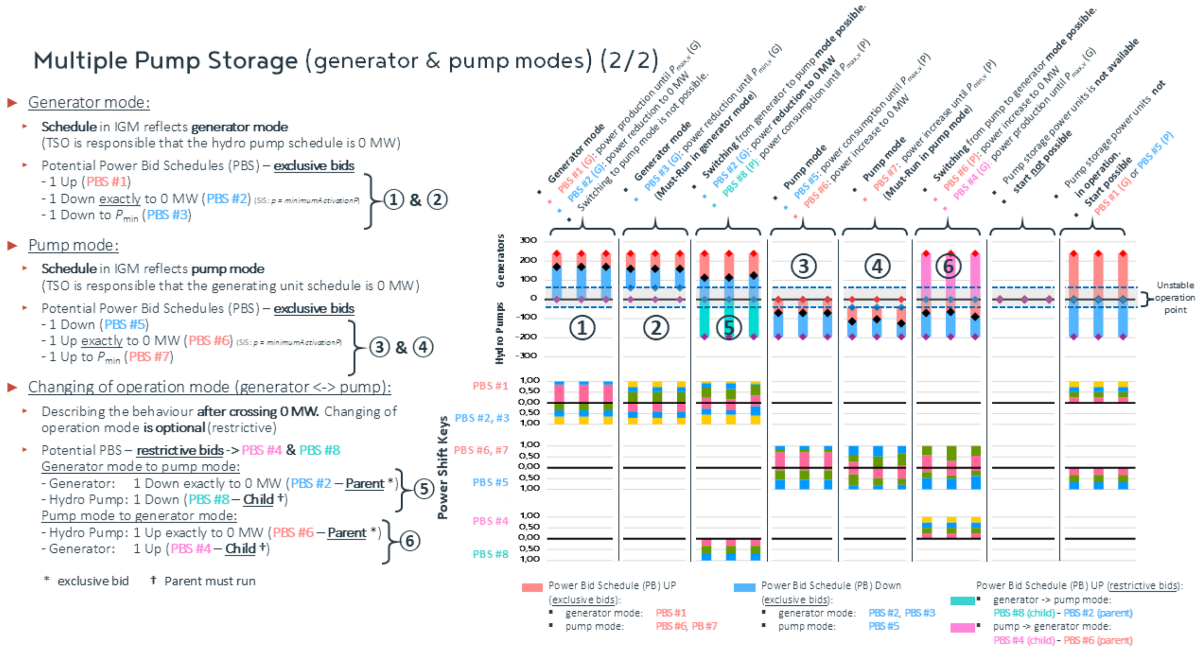


Figure 53: Modelling of Multiple Pump Storage Power Plants (II)

Where alignment with market processes is required, the ScheduledResource class (linked to the PowerBidSchedule class) can be used to group units in a way that is consistent with market-facing scheduling units. This facilitates consistency between operational coordination and market schedules, while preserving the flexibility needed for real-time dispatch.

Summarising, the NCPs allow CIM efficient modelling respecting the real-life grid operation logics:

- The market operator receives the aggregated plant bid and updates the schedule accordingly.
- The TSO incorporates the updated schedule into operational security calculations.

- The grouping of multiple pump storage units into a single remedial action avoids unnecessary modelling complexity and reduces the number of individual schedules exchanged.

7.1.8.3.8 Note on State Estimation and the Treatment of P/Q Limits During Ramping and Redispatch

In the context of power system operation, questions often arise regarding how active (P) and reactive (Q) power limits are treated in state estimation, particularly during ramping periods and when remedial actions such as redispatch are executed.

In the CIM framework, the State Estimator may compare real-time measurements from SCADA with the state variables derived from the EQ and TP profiles. Under normal conditions, generating units are assumed to operate within their ReactiveCapabilityCurve and defined P/Q limits.

These limits are not dynamically recalculated by the State Estimator unless updated values are provided through the model (e.g. as time-series or operating-mode-dependent parameters).

Measurement values are validated against the declared operational limits to prevent incorrect data from influencing the estimated state. If validated measurements indicate operation beyond these limits, the State Estimator may reflect the deviation. Overload conditions are handled by SCADA/EMS functions through alarms or automatic control actions.

For remedial action optimisation (e.g. via PowerRemedialAction or RotatingMachineAction), the optimiser would respect the P/Q limits provided in the model.

While it can detect and reflect deviations when supported by reliable measurements, it does not dynamically recalculate P and Q limits during ramping. Instead, it expects those limits to be predefined in the model or provided by operational data sources.

2997 #### 7.1.8.3.9 Expected Use Cases

2998
2999 Table 8: Expected Use Cases Related for Power Remedial Actions (Redispatch and
3000 Countertrade)

Name	Description	Comment
Redispatch in another country		

3001

7.1.8.4 Availability Remedial Action

Availability remedial action is a remedial action that cancels or reschedules an availability schedule. It is used when it is desired to cancel or shorten an outage.

The following example illustrates how to define an Availability Remedial Action. To define an availability remedial action, it is required to define *AvailabilitySchedule* which is defined in the *AvailabilitySchedule* dataset.

Availability remedial action can also use availability schedule for defining changes in the operational limits by using the class AvailabilityExceprionalLimit. This can be used, for instance, for enabling or disabling the current limit on ACLineSegment terminal in combination with other availability functions with the same availability schedule or de-rating due to fault. It is not recommended to use this approach to just provide new set of limits that can be provided by using Steady State Hypothesis profile.

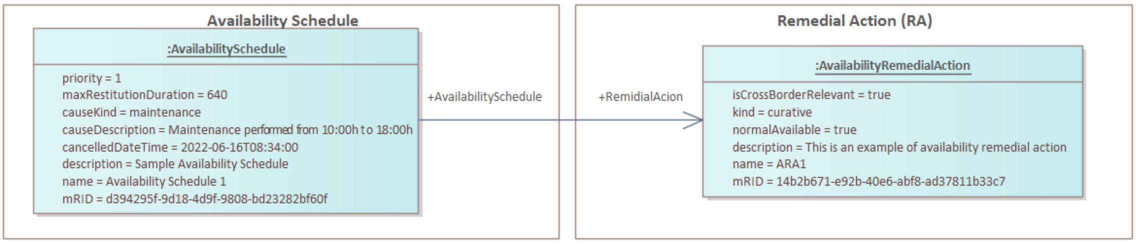


Figure 54 - Availability Schedule Remedial Action Example

The corresponding Availability Schedule dataset example can be located in ReliCapGrid in Svedala_AS.xml:

- AvailabilitySchedule rdf:ID="_d394295f-9d18-4d9f-9808-bd23282bf60f".

The corresponding Remedial Action example can be located in ReliCapGrid in Svedala_RA.xml:

- AvailabilityRemedialAction rdf:ID="_14b2b671-e92b-40e6-abf8-ad37811b33c7"

7.1.8.5 Remedial Action with Dependencies

Remedial action profile enables definition of a remedial action dependency. This is realised by using the RemedialActionDependency. The dependency can be of different kind and applies to all remedial actions that have dependencies and are included in a RemedialActionGroup.

One use case of using this dependency mechanism is when remedial actions from multiple TSOs are to be treated as one Remedial Action, e.g., the so-called DC-loop in the HANSA region, where two HVDC must be regulated at the same time when the remedial action is activated.

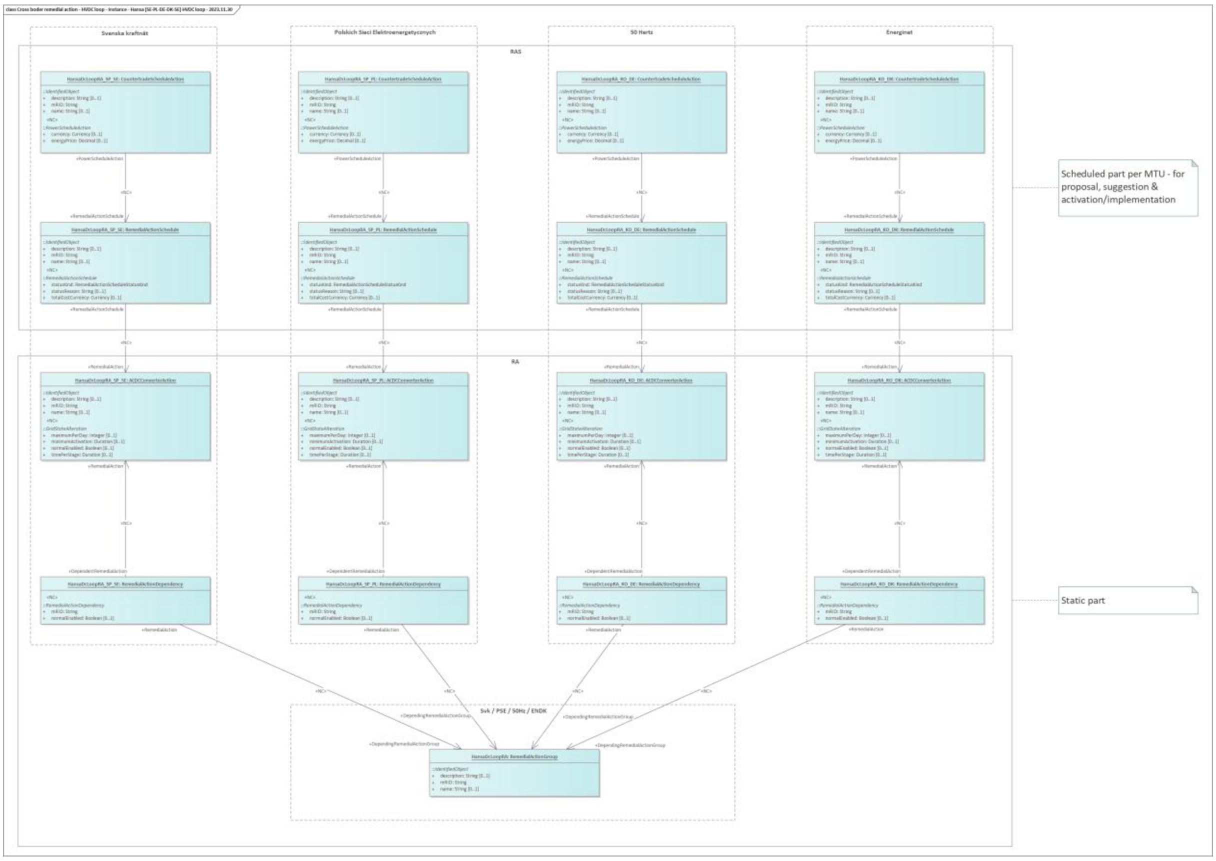
Business processes require information to categorise different groups. For instance, for a group of grid state alterations related to PST the following options are expected:

- Reduced group: All remaining PSTs have to be operated in a group mode
- Relaxed: All remaining PSTs are operated individually
- Blocker: No PST of the group will be available, i.e. the whole RA will be unavailable

To fulfil this requirement RCP DES profiles, use the attribute *GridStateAlterationRemedialAction*.*isActivationRestricted*. If the attribute is true, all *GridStateAlterations* associated with the *GridStateAlterationRemedialAction* need to be available in order to activate the RA. If false, it means that even if one or more *GridStateAlterations* is/are not available then the rest of the *GridStateAlterationRemedialAction* can be activated. Being available means it is not in a contingency or out or service. A switch that has an action of opening is still available if it is open. GridStateAlteration.*normalEnabled* or *GridStateAlteration*.*enabled* equal to false does not make the *GridStateAlterationRemedialAction* not available even if *GridStateAlteration* as part of the remedial action cannot be used in a *GridStateAlterationRemedialAction*.

For the particular example, to cover “reduced group case” the *isActivationRestricted* attribute will be false and for the “blocker” case – *true*.

This example will be elaborated more in detail in the next version of the document.



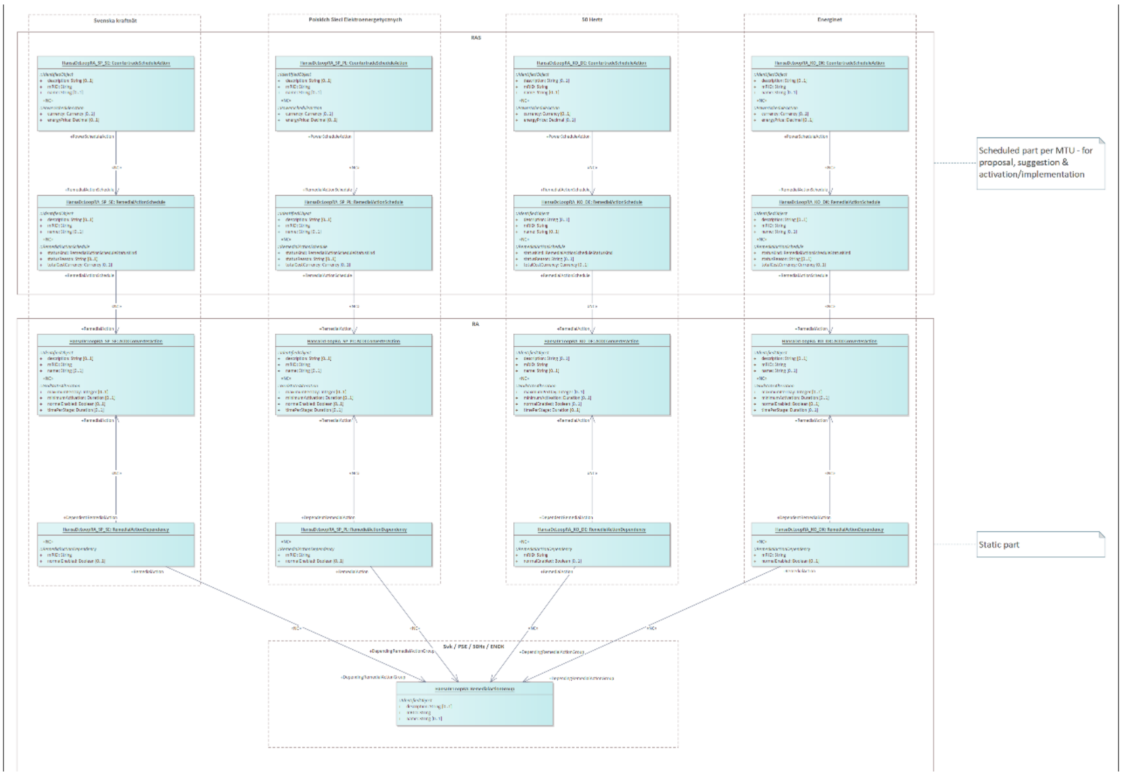


Figure 55 – Remedial Action with Dependencies – HVDC case

7.1.8.6 Contingency with Remedial Action

This section defines how to cover different use cases that require specification of a Contingency (CO) with a Remedial Action (RA). The following uses cases are covered:

1) **Full scope**: All defined and enabled remedial actions are considered when resolving a violation of an assessed element after a contingency.
2) **Limited inclusion**: One or limited number of remedial actions are considered (the only RA that are applicable) when resolving a violation of an assessed element after a contingency.
3) **Limited exclusion**: One or limited number of remedial actions are not considered when resolving a violation of an assessed element after a contingency. For instance, “RA1” is excluded, i.e., not considered/not used as possible RA, when “AE1” or “AE2” are having violations for “CO1”.
4) **Consideration**: One or limited number of remedial actions can be considered when resolving a violation of an assessed element after a contingency.

The following general remarks apply to the design of the included, excluded, or considered remedial actions with contingency:

- The objective is to minimize the data exchanged for the business process, but at the same time give guidance to the RAO in order to help the performance of the business process. In general, all remedial actions can be considered for all assessed elements, but this would take significant amount of time. Therefore, the data model provides a mechanism to help limiting cases to be studied.
- It should be noted that constraining RAO by limiting the possibilities on which remedial actions can be used for resolving violations on assessed elements can be considered a breach of the requirements defined in Network Codes and methodologies. Therefore, it should only be used in cases where this helps the performance of the process but does not limit the effect of optimising remedial actions and finding the best possible solution.
- Contingencies can be referenced by remedial actions and/or assessed elements which helps to minimize computational efforts when performing contingency analysis during remedial action optimization and the business processes in general. For additional details, refer to section 7.1.6.7 on combinations between assessed element and remedial action.

The link between contingency and remedial action is provided in the exchange of remedial actions and the link with assessed element is defined in the exchange of assessed elements. This means that in case some specific combinations need to be defined, contingency objects should be defined prior to the definition of the combinations with assessed elements and remedial actions.

In case a TSO applies the design in which contingencies are relevant for all assessed elements and remedial actions (i.e., no explicit combinations), there is no explicit dependency between the process of contingencies creation and the processes of defining assessed elements and remedial actions.

The example below illustrates how to specify a Remedial Action that is to be applied when a specific Contingency occurs.

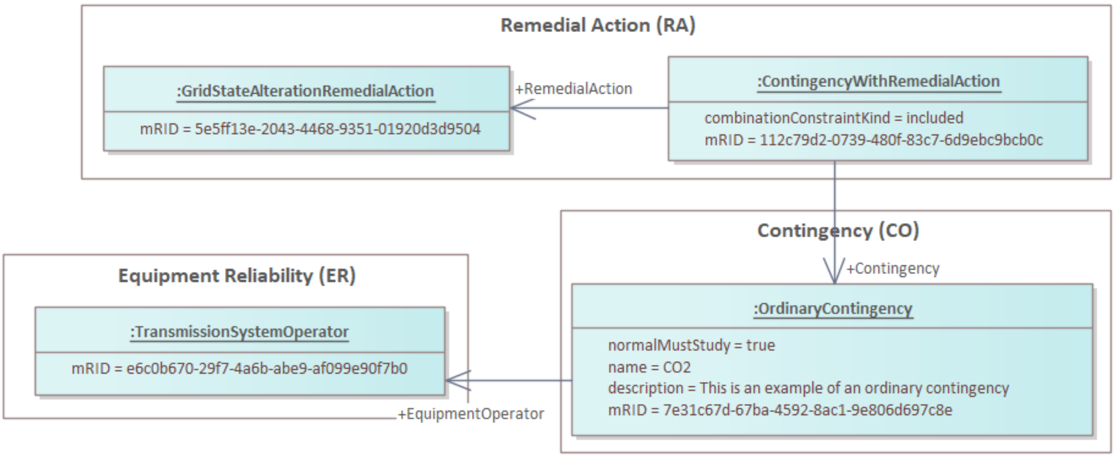


Figure 56 – Remedial Action with Contingency

The corresponding Remedial Action dataset example can be found in ReliCapGrid in Belgovia_RA.xml:

- GridStateAlterationRemedialAction rdf:ID="_5e5ff13e-2043-4468-9351-01920d3d9504"
- ContingencyWithRemedialAction rdf:ID="_112c79d2-0739-480f-83c7-6d9ebc9bcb0c"

The corresponding Contingency dataset example can be found in ReliCapGrid in Belgovia_CO.xml:

- OrdinaryContingency rdf:ID="_7e31c67d-67ba-4592-8ac1-9e806d697c8e"

7.1.8.7 Expected Use Cases

The following expected use cases are not explained in full detail. The next versions of the document could include more details. The list of use cases is not exhaustive.

Table 9 – Expected Use Cases Related to Remedial Action.

Name	Description	Comment
Preventive and curative topological RAs	Defining a RA as both preventive and curative with the same resulting switching state.	Due to the structure of the NC profiles, two different RAs (preventive and curative) with the same resulting switching state need to be defined.
Open busbar coupler and move a line from one Busbar to another	Defining a RA with opening the Busbar coupler (in order to create 2 different nodes) and performing reconfiguration of a line.	
Opening busbar coupler	Opening a busbar coupler (preventive), no dependency to another switch needed	
Open/close of a single grid element - preventive	Switching on/off a single line / transformer as a topological RA. (Preventive)	
Open/close of a single grid element - curative	Switching on/off a single line / transformer as a topological RA. (Curative)	
Combination of topological actions - exclusive relationship	Two different RAs in the same substation but cannot be applied at the same time due to some technical or operational constraint	
Tap change on a power transformer as RA	Changing the tap position on a power transformer as RA	
SSSC (static synchronous series compensator)	Using SSSC's capability of changing the current on a specific line as an RA to reduce the flows on a congested grid element	The way of modelling the RA use case is highly depending on how the SSSC is modelled in the power flow part of the IGM. The SSSC is covered in detain in the ER profile part of the NC profiles.
Switching on a grid element with restitution time	Switching on a grid element in maintenance with restitution time. (preventive)	
Bypassing a PST in base case	Open one or several switches to bypass a PST	
Bypassing a PST after contingency	Open one or several switches to bypass a PST after a specific contingency occurs	
Modelling of Topological RAs with bus-branch IGMs	Modelling all the abovementioned use cases in a bus-branch case	This requires either modification of the grid model creation process or a post processing where the switches are added model and kept persistent.

PST taps preventive RA	Changing PST taps in a predefined range in a preventive way in base case	
PST taps curative RA	Changing PST taps in a predefined range in a curative way after contingency	
Target flow	Aiming for a maximal target flow in base case/after contingency, automatic change of taps to keep the flow under a predefined threshold	
Parallel PST operation	Two or more PSTs are operated in parallel; the PSTs are grouped so the tap change on each unit is the same	
PST with simultaneous preventive RA and curative RA	Two RAs, one preventive and the other curative, pointing to the same PST.	
PST action for PST groups	Asymmetrical tap changes of 4 parallel PSTs during voltage control	PSTs should be grouped into different groups and subgroups with appropriate availability flags
Single generating plant providing preventive redispatch volumes	Preventive RA on a generating plant connected to a single node capable of providing positive and negative active power	
Parent Child (one generating unit, two modes)	Different operation modes of combined-cycle power plants	
Parent Child (two generating units)	Generators not allowed to start simultaneously	
Group combined minimum/maximum infeed	Restriction of the sum power for a group of generators connected to a same node (e.g. in case of power plant line outage).	
Preventive RA pump storage	Preventive RA on a Pump Storage Power Plant with 2 modes for PGM - generating and pump mode, where Pmin and Pmax and other offline parameters are defined separately for each mode.	
Already realized redispatch (before DA CROSA)	Already ordered RA, as offline data to be linked with the RA schedule afterwards, but the volumes / prices are adapted according to what was already ordered.	
Curative redispatch with predefined pairs of single generating plants	Predefined pair of curative RD is triggered for a single contingency case	
Curative redispatch compensated by countertrade in the same bidding zone	Curative redispatch compensated by countertrade located in the bidding zone where the RA is activated for a single contingency case (simulating aFRR)	The constraints related to balancing the system still apply to these curative RAs. This balance is achieved via compensation by a slack distribution located in the

		bidding zone where the curative RA is activated.
Countertrade with multiple steps and a single GLSK	Single countertrade offer by a TSO covering 24 hours, expressed in price-MWh/h steps/pairs, associating a GLSK defined as proportional to the remaining available capacity (pro-rata distribution based on headroom) at all generator nodes in the TSO grid model	
Single nodal offer with multiple steps for different hours	Single-node offer which consists of MWh max, min step size defined for each power bid schedule, Pmin, Pmax defined for the Generator itself (structural data and underlying model) and a number of MWh-EUR steps covering different hours during the day	
Hydro pump with parent-child generation with time shift	Single step hydro pump with the parent-child bid defined in opposite directions for a specific time shift	
Simple countertrade preventive	Potential of countertrade upwards/downwards with a single price of activation in base case	
Simple countertrade curative	Potential of countertrade upwards/downwards with a single price of activation after contingency	
Redispatch without TSO balancing	Potential from Reduction of renewable infeed which does not need balancing from TSO side	
Preventive redispatch with predefined group of loads	Preventive redispatch action where the redispatch potential is in the predefined set of loads which is a part of distribution grid and may also cross TSO borders	
Cross border HVDC with preventive and curative volumes using bandwidth attribute	Sharing the upwards and downwards potential for an HVDC between two control areas within a CCR, assuming that both TSOs may deliver their own view on the available volumes and the RAO should take the most constraining input as final.	
Preventive RA: HVDC setpoint change	Change the setpoint in base case, only one connecting TSO, for HVDC cables connecting a TSO that belongs to one CCR with a TSO which belongs to another CCR	For some HVDCs between two different synchronous zone this must be done via redispatch because this type of HVDC has associated prices while this

		attribute is not foreseen for HVDC category so far.
Curative RA: HVDC setpoint change	Change the setpoint after contingency, only one connecting TSO	
Preventive RA: HVDC mode switch	Switch from one mode to another one in base case: DC setpoint/AC mode/hybrid mode.	Relevant for HVDC on AC border only.
Curative RA: HVDC mode switch	Switch from one mode to another one after contingency	Relevant for HVDC on AC border only
Preventive RA: HVDC Hybrid mode	Changing the hybrid mode in base case (parameter k)	Relevant for HVDC on AC border only
Curative RA: HVDC Hybrid mode	Changing the hybrid mode after contingency (parameter k)	Relevant for HVDC on AC border only
Manually proposed Remedial Actions (via RA Schedule)		
Cancelled earlier agreed Remedial Actions		
Suggestion of Alternative RAs for RAC (might be in RAC part)		
RAO proposing GeneratingUnit shut down		

3114

3115

7.1.9 List of SPS/SIPS

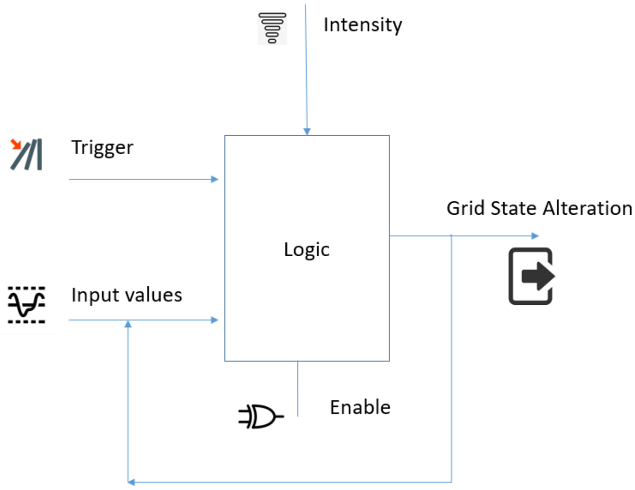


Figure 57 – SIPS overview

System Integrity Protection Schemes (SIPS), Special Protection Schemes (SPS) and Remedial Action Schemes (RAS) are often applied by TSOs to utilize the transmission capacity beyond conventional N-1 considerations. In many cases SIPS and SPS are used interchangeably, but in general SPS are considered part of SIPS.

This is done while still maintaining reliability of supply, for example by relieving overloaded lines through immediate disconnection of generator units when lines are disconnected by their protective relay equipment. Other schemes are also in use, such as emergency power on HVDC links, load shedding and network splitting. Without modelling SIPS or RAS unrealistic congestion/overload will be reported by the power flow simulation tools.

As shown in Figure 57, a SIPS is based on a logic which has inputs signals and related triggers to start the logic. Depending on the logic conditions and the intensity of the event, if the logic is enabled, the output of the SIPS will result in a grid state alteration.

In the NC profiles the structural data for SPS remedial action is defined using Remedial Action profile dataset. The Gate is defining the input logic and then Stage the output that is linked to a *GridStateAlterationCollection* allowing multiple grid state alterations to be part of a Stage, i.e. change to that will be applied after the gate trigger conditions are met. NC profiles also allow to create more complex logics by using several interconnected gates or stages, which can be armed or disarmed depending on the input conditions.

The following are some examples of the objectives of system-wide protection/control schemes:

- Overload mitigation
- System separation for transient stability
- Load and generation shedding/rejection

- Under and over voltage load shedding
- Under and over frequency generation/load shedding
- Detection/shutdown of islanded network
- Over frequency tripping of unloaded generators
- Improvement of power transmission to increase total transfer capability
- Improvement of system stability under the large deployment of renewable energy resources
- Maximize the capability of apparatus (the thermal limit of apparatus**).**

Any values described in SSH, SIS and SSI datasets can be input values for Grid State Alteration value.

7.1.9.1 Relevant remarks on the use of Network Code Profiles

7.1.9.1.1 Role of Service, Availability and Arming

The clarification is as follows:

- Service: the following attributes indicate whether the *RemedialActionScheme* is currently available:
    - The *RemedialActionScheme.normallyInService* (for RA profile) attribute.
    - The *RemedialActionScheme.inService* (for SSI profile) attribute.
    - The *RemedialActionSchemeTimePoint.inService (*for SIS profile) attribute.

    These attributes indicate whether the asset is available in the power system to be operated.

    These attributes specify whether the remedial action scheme and the assets it points to are active and can participate in the system operation. In other words, the whether the assets are energised, and they are candidates for being *armed*.

    Note: The case where *RemedialActionScheme.normallyInService = FALSE* and *RemedialActionScheme.normalArmed = TRUE* does not have a meaning.

- Availability: the following attributes indicate whether the *SchemeRemedialAction* is currently available for activation
    - The *RemedialAction.normalAvailable* (RA profile)
    - The *RemedialAction.available* (for SSI profile) attribute.
    - The *AvailabilityTimePoint.available* (for SIS profile) attribute.

    These attributes identify whether the remedial action can be used in further processes. For instance, remedial action optimisation and coordination. True means available, False means unavailable.

- Arming: Preparing the *RemedialActionScheme* for activation.
    - The *RemedialActionScheme.normalArmed* (for RA profile) attribute.
    - The *RemedialActionScheme.armed* (for SSI profile) attribute.
    - The *RemedialActionSchemeTimePoint.armed (*for SIS profile) attribute.

    Readers might note that *arming* is the process of placing an SPS device and its accordingly defined actions under active surveillance conditions, making it ready for execution once a specified contingency or operational threshold is met.

Arming an SPS means configuring and enabling it so that it is ready to be activated if a specific triggering (condition) event or threshold is reached (is true) in the power system.

- Study phase: a special mention is to be made when users might want to simulate the SPS under a certain condition, one can:
  - Use the *normalArmed* flag.
  - Link the remedial action to a *Contingency*, if needed.
  - Use *PinContingency* or *PinTerminal* inputs for dynamic triggering logic (see the use cases in this further section).

Readers might note:

- That the attributes starting with “*normally*” or “*normal*” indicate the status under normal operating conditions (by default) reflected in structural datasets such as the RemedialAction profile.
- That the Service and Arming refer to *RemedialActionScheme*(s) having physical grid assets associated to them, whilst the *Availability* refers to *RemedialAction*(s) which are to be used in a business process. Therefore, in general the attributes *InService* and *Armed* refer to both: coordinable and non-coordinable SPS, while *Availability* is more applicable only for coordinable SPS.

It is crucial to understand that if a *normalArmed* SPS affects a neighbouring TSO and is later disarmed, such neighbouring TSOs shall be informed. The way of doing this might vary among CCRs but this disarming shall be reflected in the OPC and/or ROSC processes.

In certain contexts and in certain regions—and here only applicable for coordinated-SPS as described in section 7.1.9.1.2—the availability of a remedial action indicates whether the RAO can optimise such remedial action.

Arming is an action that *enables* (i.e. so that it is ready to be activated) or *disables* the remedial action, and it is different from making the remedial action available. In this sense, *normalArmed* can be used for power flow calculations and ensures that pre-armed actions are considered for simulations.

As a summary and practical guidance:

1. If the intention is to arm the *SPS*, then, set (*normal)Armed* to *true*. Readers can do so in a schedule dataset (SSI or SIS) and in structural dataset (RA).
2. If the intention is to simulate or study the *SPS*, then, link it to the necessary *Contingency* (optional) and/or use *PinContingency*/*PinTerminal*
3. If the impacted TSOs agreed that the SPS should be available for real time operation, then, use the *inService*-like attributes set to *true* (read above).

7.1.9.1.2 SIPS Distinction Coordinated vs Non-Coordinated SPS

This chapter clarifies how to distinguish, and model (allowed/can be) coordinated and non-coordinated SPS using the RA profile, particularly in the context of remedial action coordination and optimisation.

TSOs pragmatically categorize SPS into two types based on their role in the RAO process. Reader would keep in mind Figure 58 as a reference while going throughout this chapter.

- **Coordinated SPS**: The optimiser (RAO) propose whether they should be armed or not.
    - They are defined as *SchemeRemedialAction* class, which inherits from *RemedialAction* class—that is *SchemeRemedialAction* is a child class of *RemedialAction*.
        - The fact that a TSO defined this information as a *RemedialAction*, is entitling it to be coordinated.
        - Additionally, the TSOs could *enable* or *disable* the coordination of the SPS using the *RemedialAction.available* (in SSI dataset) and use *RemedialAction.normalAvailable* to indicate that this is normally coordinated or not in the RA dataset. When this attribute is set to FALSE, the SPS is not enabled for RAO to propose it.
    - They have a *RemedialActionScheme* class associated (see cardinality with *SchemeRemedialAction* in Figure 58).
        - *RemedialActionScheme.normalArmed* attribute can be set either to TRUE or FALSE.
        - Their *RemedialActionScheme.kind* attribute could be set to either *RemedialActionSchemeKind.sips (for field automation SPS)* or *RemedialActionSchemeKind.rasp (for manual or semi-manual controlled SPS)*.
        - As explained above, *RemedialActionScheme.normalArmed* should not be used to indicate whether the SPS can be coordinated or not, but rather the fact that *RemedialActionScheme* are connected to *SchemeRemedialAction* (child class of *RemedialAction*).
    - The RAO might propose to *arm* a *not-armed* SPS or to *not-arm* an already *armed* SPS.
    - They shall have an impact assessment done, published using the Impact Assessment Matrix (IAM) dataset to indicate the normally impacted TSOs.
- **Non-coordinated SPS**: they are not subject to RAO optimisation.
    - They are exchanged so that in the security analysis can use them as part of the contingency to solve relevant contingencies.

- They are defined as *RemedialActionScheme* objects that are not associated to *SchemeRemedialAction*. In other words, they are only instantiated as a *RemedialActionScheme* class which is not associated with any *RemedialAction*, thus, not considered for optimisation.
    - Note that with the above definition, if TSOs choose to have a *non-coordinated* SPS, it would not be possible to indicate which other TSOs might be impacted by the relevant SPS.
    - Therefore, in some special cases, TSOs wishing to have visibility on the impact of a non-coordinated SPS may still choose to connect it to a *SchemeRemedialAction* class. In this case, the *RemedialAction.normalAvailable* must compulsorily set to FALSE.
        - Readers might note that this special case is not used in the Core region. However, it may be used in other regional implementation projects.
- A non-coordinated SPS that does not have a *SchemeRemedialAction* cannot have an Impact Assessment Matrix (IAM) dataset associated.
    - This might represent a challenge for TSOs that are impacted to know that they have to monitor the schedule of the SPS. For example, a *RemedialActionSchedule* that a TSO relies on is not armed for a concrete period.
    - Their *RemedialActionScheme.kind* attribute can only be set to *RemedialActionSchemeKind.sips* in the frame of the pan-European business processes (i.e. as a business requirement).

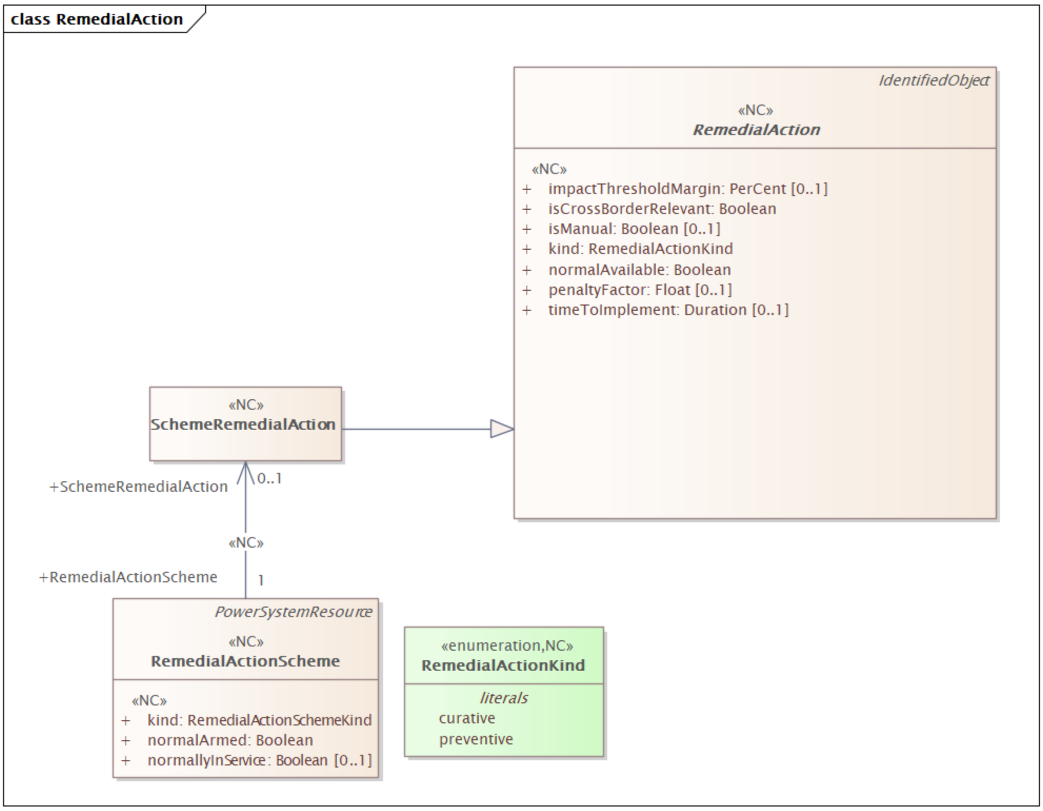


Figure 58: Extract of Remedial Action profile showing classes to distinguish (non)coordinated SPS

Readers might want to remember that they can define the value of the arming status in the RA profile as structural data. Additionally, they can also do so as a schedule in SSI or SIS dataset defining whether a certain *RemedialActionScheme* is armed or not. For the example of SSI profile, this is shown in Figure 59 with the *RemedialActionSchemeTimePoint.armed.*

Further explanation is given in chapter **Error! Reference source not found.**.

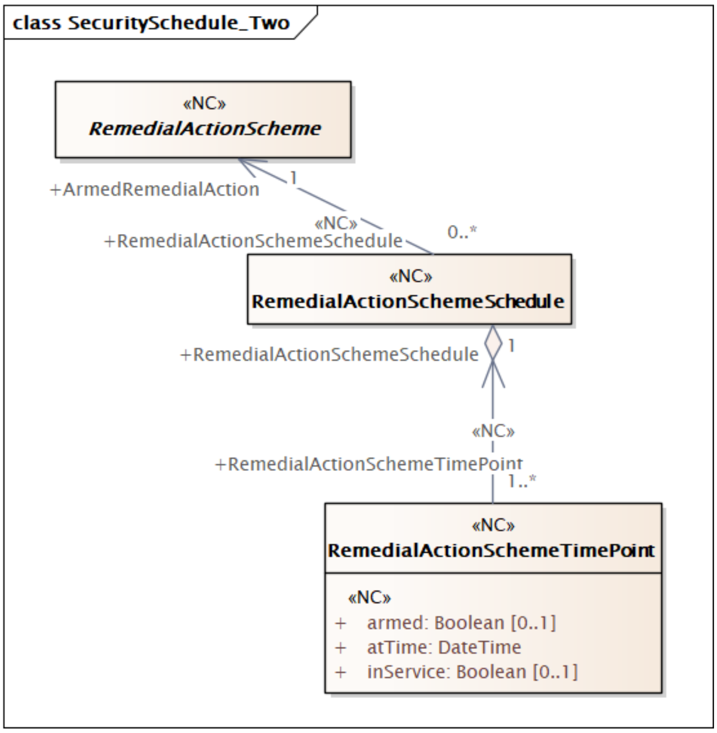


Figure 59: Extract of the SIS profile

The Impact Assessment Matrix (IAM) profile should be considered in the modelling of the use case as it helps determining which TSOs need to be coordinated. The concept of *coordination* should be determined at the remedial action level, and only those remedial actions connected to Impact Assessment Matrix profile should be included in coordination among TSOs.

On the other hand, curative remedial actions may require coordination even if the preventive action has already been activated.

7.1.9.1.3 The use of RemedialAction.kind for SIPS/SPS

It is relevant to address how to use *RemedialAction.kind* for a SPS, particularly in the context of a *SchemeRemedialAction* that operates independently from a direct contingency link.

The *RemedialAction.kind* attribute indicates if the remedial action is curative or preventive.

However, SPS logics are often triggered by conditions other than a defined contingency, for instance, system state changes (modelled via *PinContingency* or other input *pins*).

It is recommended to classify *SchemeRemedialAction* as "*curative*", even if it is not directly connected to a *Contingency* object[11]. This is because a SPS is designed in advance, and activated in real time based on system state, hence behaving like a curative remedial action.

[11] Based on CSAm Art. 2.1.24.

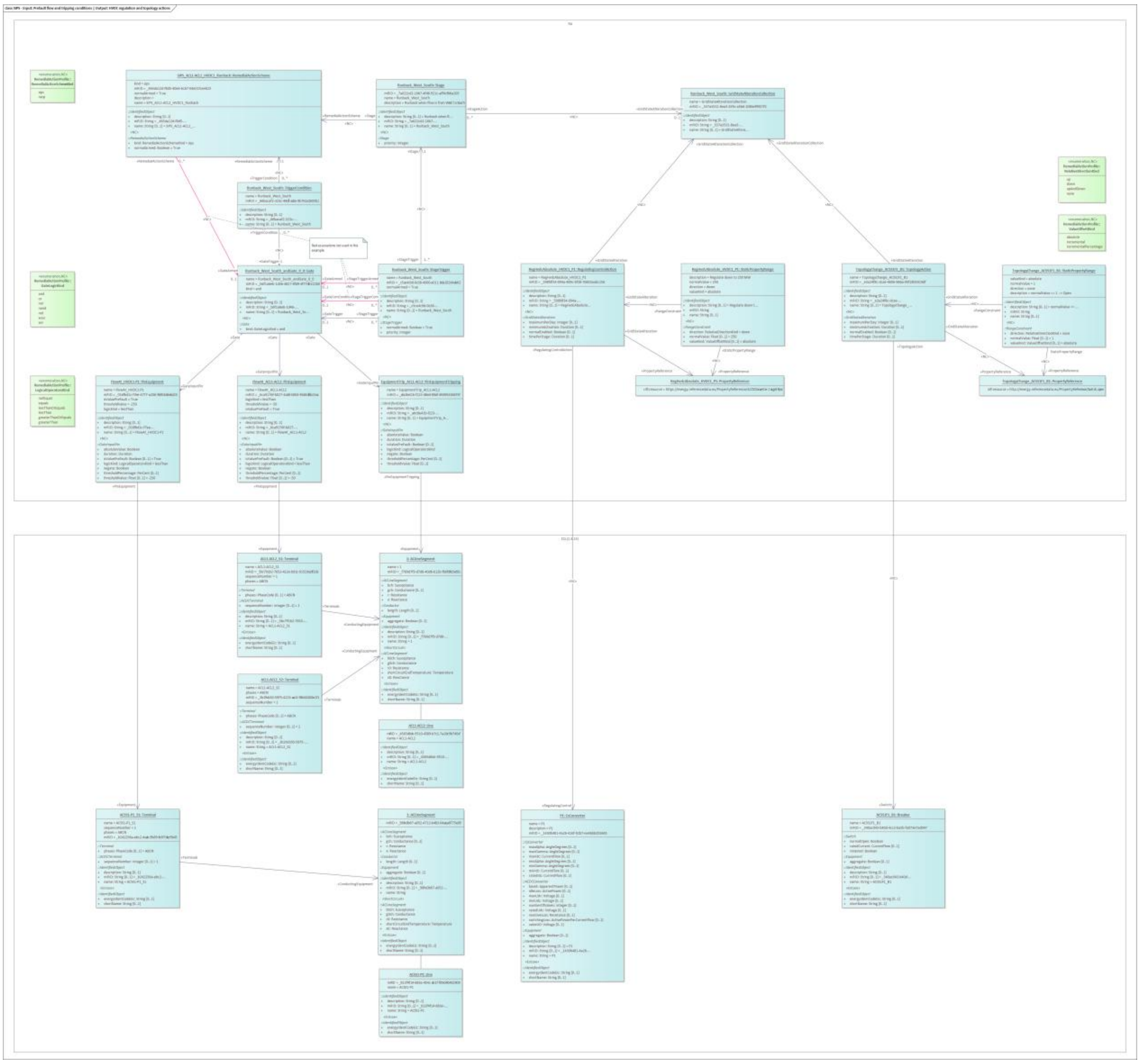
7.1.9.2 Monitoring of a Line and Actions on Topology and HVDC

In the SIPS example shown in Figure 60 , a pre-fault flow values on a line and a trip of the same line are used as input trigger conditions. On the grid state alteration output side, flow changes on a HVDC as well as topology changes on filters are shown.

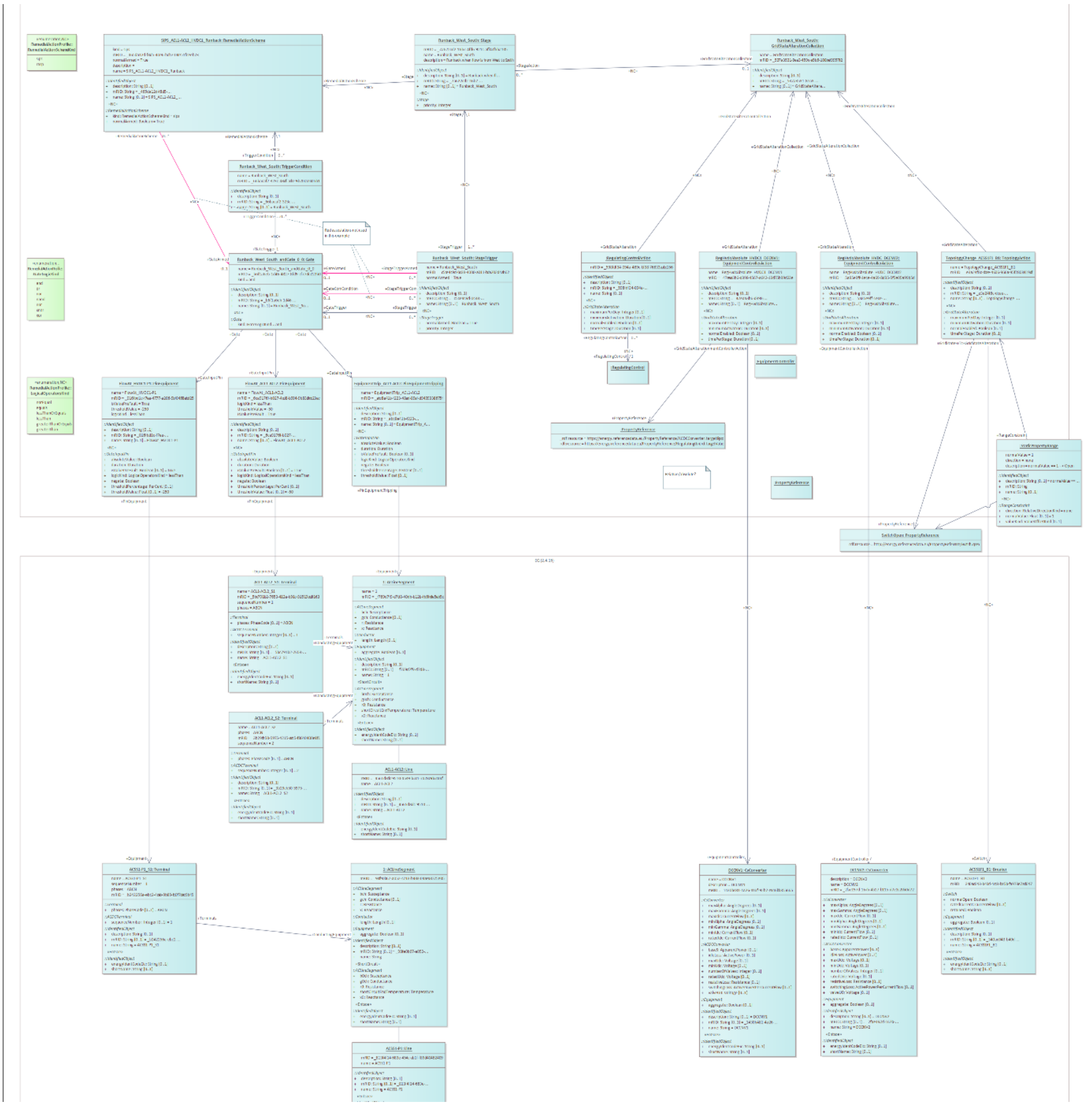
In cases where a *GridStateAlteration* is used to modify a setpoint and this value is not subject to optimisation. The following approach is used (note that this is considered as a short-term approach; more elaborated solution will be proposed in the next versions of this document):

- StaticPropertyRange is defined for the given *GridStateAlteration*
- RangeConstraint.direction is defined as RelativeDirectionKind.none
- RangeConstraint.normalValue is considered as the target value / setpoint which is fixed
- The StaticPropertyRange shall not get RangeConstraint.value as part of other profiles (e.g. SSI dataset) that would supersede normalValue defined in the RA dataset.

The next versions of the document will elaborate more on this example.



3337

3338 

3339 **Figure 60 – SIPS Monitoring of a Line and Actions on Topology and HVDC**

3340

7.1.9.3 Implementing SIPS Gate Logic with Cardinality Constraints (Run-back Function on HVDC Link)

The use case describes how to model triggering logic for SIPS using gate logic, particularly under the constraint that one gate's output must be reused as input for multiple other gates.

The main task of this use case is to alter the power flow of the HVDC link when certain elements trip.

In some TSOs' SIPS implementations, the triggering logic must differentiate between import and export conditions on an HVDC connection.

More specifically, a SIPS could be triggered when one of several lines are disconnected and there is an HVDC power flow condition. Such conditions could be, for instance, that the import or the export on the HVDC link is greater than 150 MW.

To model the situation, TSOs might opt to split the SIPS logic into two parts: one for import and one for export, while reusing a common triggering condition (line disconnected). The intuitive solution is to chain gates, where the output from one gate (e.g., line disconnected) serves as input to two other gates (handling import and export respectively).

The NC Profiles support one output being referenced by multiple input pins. This is allowed and does not violate cardinality rules.

To model this, PinGate instances must be created:

- Each PinGate should refer to the same Gate (output).
- Each PinGate should be associated with a different Gate (input).

Please note that the *TriggerCondition* class is deprecated in the latest model versions (RCP DES and NCP v2.4) and it should not be used.

The logic on the HVDC link is as follows:

- If: line A or line B trips **AND** the power flow on HVDC is higher than X MW
    - Then: decrease power flow on HVDC to Y MW.

In this case the HVDC connection is modelled in simplified way using *EquivalentInjection* class.

Because it is necessary to distinguish between import and export, the case has to be split into two parts:

- For import:
    - **IF** line A or line B trips **AND IF** the power on EqInj is lower than **-**X MW **THEN** set it to **-**Y MW.
- For export:
    - **IF** line A or line B trips **AND IF** the power on EqInj is higher than X MW **THEN** set it to Y MW.

To use intermediate gates to split the logic (represented in a Contingency dataset):

- Gate A: Detects line disconnection by pointing to the certain contingencies from the Contingency List (Contingency profile).
- Gate B and Gate C: Evaluate import and export conditions respectively.
- Gate A's output is reused as input for both Gate B and Gate C via two PinGate instances.

This structure allows for a clean and logical modelling of complex triggering schemes using existing CIM elements. Readers might refer to Figure 61 below to visualise these concepts.

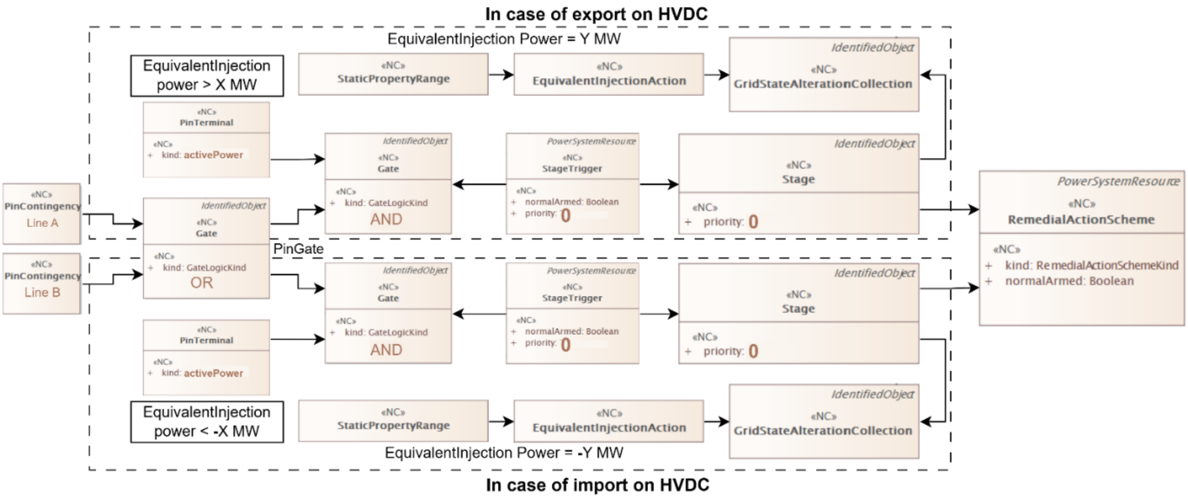


Figure 61: Modelling of complex triggering schemes

Readers will find a test use case—subject to be further developed—to demonstrate the use case above in the TestUseCase folder of the ReliCapGrid GitHub repository. More concretely, readers should look at the file Belgovia_RA.xml:

- RemedialActionScheme rdf:ID="_3ecde63d-c87f-4947-a1f2-3622dc2092ba.

7.1.9.4 Modelling Current Flow Conditions Against PATL or TATL

This use case addresses the modelling need to trigger remedial action scheme when the current flow in an element (e.g. line or transformer) exceeds a defined limit, namely *PATL* or *TATL* (refer to chapter 5)

The NC Profiles support the modelling of current-based triggering. To be able to refer to PATL or TATL values the *PinOperationalLimit* class should be used with reference to the relevant OperationalLimit (via mRID).

As the limit is connected to a specific terminal, there is no need to separately indicate the terminal in which violation of the limit has to be checked. More in detail:

- Use of *PinOperationalLimit*
  - When the triggering logic refers to a specific operational limit defined by PATL or TATL:
    - OperationalLimit should be used as a reference.
    - dynamic ratings are supported, and referencing the OperationalLimit ensures accurate and up-to-date limit values.
  - GateInputPin.logicKind attribute defines the logical comparison (e.g., greater than, less than).
- It must point to the limit connected to the Terminal of the equipment (e.g., line or transformer) where the violation is monitored.
  - In the GatePin, you:
    - Indicate whether the comparison is against an absolute value.
    - Do not define the threshold or reference value (as it is taken from *OperationalLimit*).

Please, note that it is recommended to reference the *OperationalLimit* object rather than hardcoding values, as this enables the model to support DLR and automatically reflect real-time conditions.

Note that different *OperationalLimits* may be defined for both ends (Terminals) of an element. It is important to refer to the right limit (usually more restrictive). If limits on both ends of the elements should be monitored than two *PinOperationalLimits* should be used, referencing to the same Gate with logicKind set to “or”.

The example in Figure 62 illustrates an example of a use case referencing to PATL or TATL values is SIPS which disconnects an element if another element is overloaded.

The logic is as follows:

- **If**: line A is overloaded above TATL
  - **Then**: disconnect the line.

The triggering condition is modelled using *PinOperationalLimit* with reference to the TATL limit pinned to the Terminal to which the line A is connected. The Violation is monitored only on one end of the line.

The action is to disconnect the line A. It can be done similarly to the topological remedial action, by changing the status of switches on both ends of the line (*Switch.open* = TRUE).

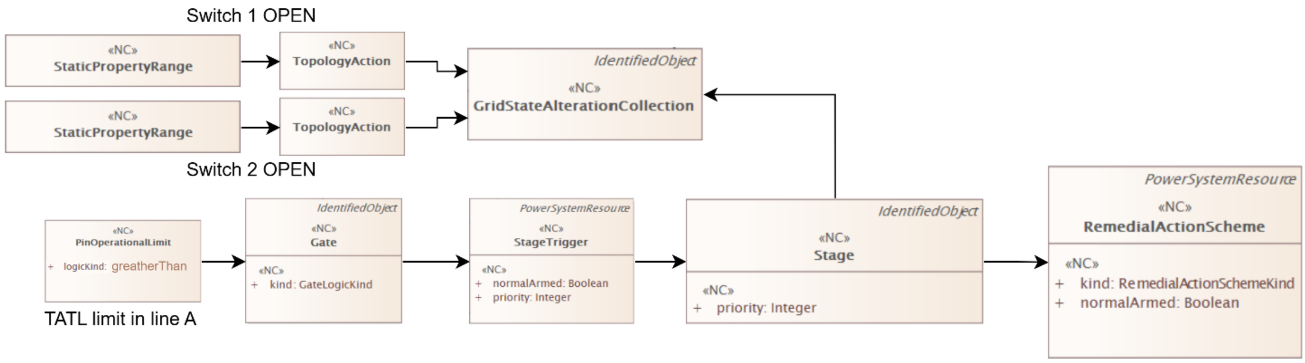


Figure 62: Example of a use case referencing to PATL or TATL values is SIPS which disconnects an element if another element is overloaded

Readers will find a test use case—subject to be further developed—to demonstrate the use case above in the [TestUseCase](#) folder of the ReliCapGrid GitHub repository. More concretely, readers should look at the file [20220615T2230Z__Belgovia_EQ_1.xml](#)

7.1.9.5 Modelling Element Disconnection by Monitoring the Power Flow (Last Line Disconnection)

This use case describes how to model triggering logic for SIPS using power flow results.

Some SIPS monitor whether certain elements are disconnected due to planned outage or in case of a fault trip.

The disconnection of an element in CIM/CGMES model can be done in different ways, including:

1) Changing the status of the element (*inService* = FALSE).
2) Opening switches on the end of an element.
3) Applying the contingency on an element.
4) Switching off connectivity nodes to which the element is connected.
    a. Note to readers: This is a deprecated alternative, and it shall not be used;

To include all possible options, it would be necessary to use several triggering gates which would much complicate the use case. In order to simplify this, it is sufficient to monitor the flow of current or power on selected elements.

When the flow is below the predefined level (e.g. 1 MW), then SIPS can assume that the element has been switched off.

To model that use case, the flow through certain terminal is monitored (using class *PinTerminal*) and when it is lower than 1 MW SIPS is activated.

The Figure 63 illustrates the SIPS use case described above and named Last Line Disconnection. The logic is as follows:

- **If**: lines A and B trips or disconnected
    - **Then**: disconnect HVDC Link.

The triggering condition is modelled using *PinTerminal* with *PinTerminalKind* set to “activePower” which is connected to the single *Gate* with *GateLogicKind* “lessThan” (1MW).

The action is to disconnect the HVDC by which is realized by opening a switch (B*reaker*).

In this case the HVDC connection is modelled in simplified way using *EquivalentInjection* class.

If there is not any switch, it is sufficient to set the power on that *EquivalentInjection* to 0 (MW). This is done by using the *EquivalentInjectionAction* class together with the *StaticPropertyRange*, which allows to set the power on the HVDC connection to 0 MW.

In this example the HVDC link is disconnected by opening the breaker.

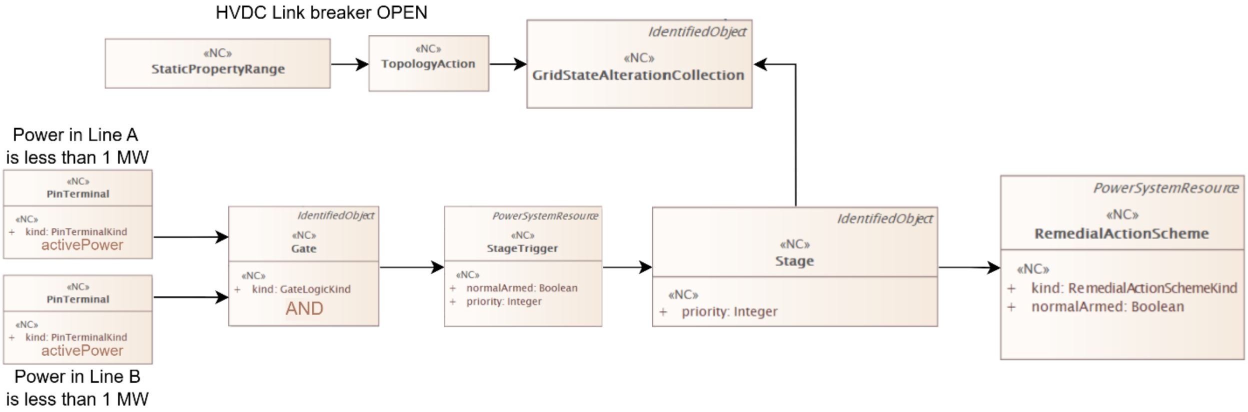


Figure 63: Last Line Disconnection example

Readers will find a test use case—subject to be further developed—to demonstrate the use case above in the [TestUseCase]() folder of the ReliCapGrid GitHub repository.

7.1.9.6 Modelling Voltage Dependent Tripping Conditions (Overvoltage Protection)

This use case aims at representing a SIPS protecting equipment installed in a substation against long and short-term over-voltages.

The triggering conditions are based on voltage values derived from power flow analysis. For that, the *PinTerminal* class is used with reference to the *Terminal* (node in the grid) which has to be monitored.

In the *PinTerminalKind* class, the attribute *voltageMagnitude* shall be used. Depending on whether the SIPS is to be activated on undervoltage or overvoltage, the *LogicalOperatorskind* parameter should be set to *lessThan* or *greatherThan* respectively.

The Figure 64 illustrates an example of the use case mentioned above. The logic is as follows:

- **If** the voltage on 400 kV busbars in station A exceeds 1.18 Un (472 kV)
    - **Then**: Disconnect line B after 5 seconds

OR

- **If**: voltage on 400 kV busbars in station A exceeds 1.23Un (492 kV)
    - **Then**: Disconnect line B after 0.5 seconds

Because the power flow and contingency analysis are static (time independent) only first condition is taken into account.

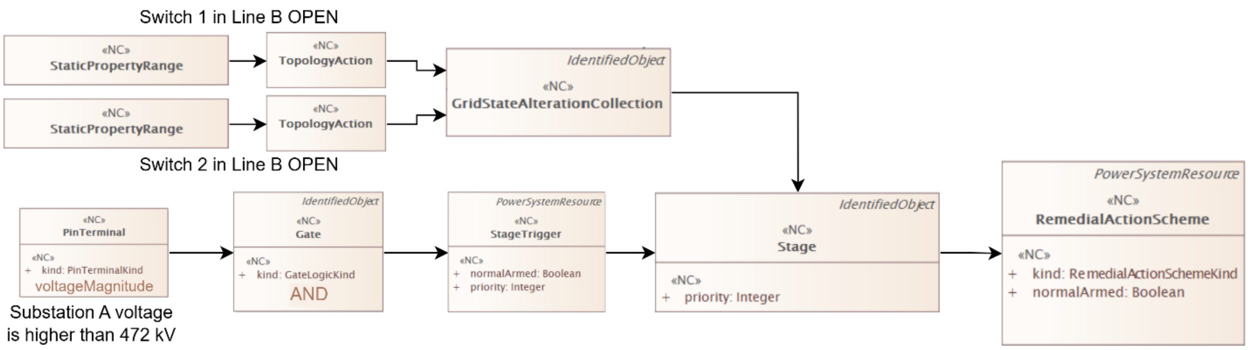


Figure 64: Overvoltage Protection which protects equipment installed in substation against long and short-term over voltages

Readers will find a test use case—subject to be further developed—to demonstrate the use case above in the TestUseCase folder of the ReliCapGrid GitHub repository.

7.1.9.7 Modelling SIPS Actions Based on Generation (Anti-swing Protection)

The use case aims at representing SIPS interacting with generators. The action is to set the generator active power to minimum in case of a line tripping.

To model it, readers shall use the *RotatingMachineAction* class together with *StaticPropertyRange* where *RotatingMachine.p* attribute can be set to a certain *Pmin*.

Figure 65 describes an example of the use case described above called *Antiswing Protection.* The logic is as follows:

- **If**: lines A and line B trip are disconnected
  - **Then**: set the generator (the one with the highest power) connected to the same busbars output power to *Pmin*.

Readers might note that because there is no logic allowing power system analysis software to automatically choose the generator with highest power, it should be predefined in the SIPS model.

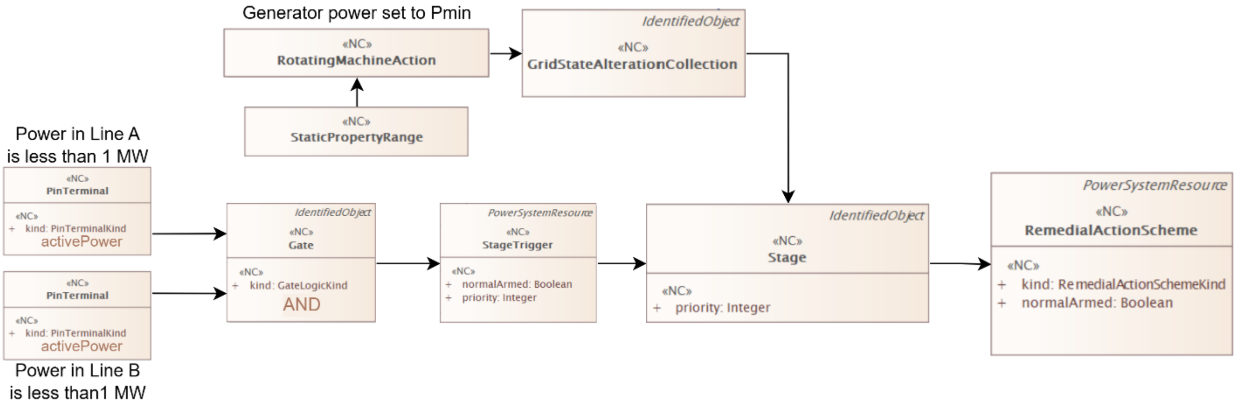


Figure 65: Anti-swing protection example

A preliminary test use case demonstrating the application described above is provided in the TestUseCase directory of the ReliCapGrid GitHub repository. This example is intended as a starting point and is subject to further development.

7.1.9.8 Modelling complex SIPS logic (Automatic Generation Shedding)

The use case describes a SPS/SIPS with a complex logic, in which each action depends on the initial conditions and results after each step of its operation.

In order to make the operation of SIPS dependent on initial conditions, multiple *RemedialActionScheme* classes shall be used in combination with *Gate* classes, in which the conditions for arming individual schemes would be defined. The Figure 66 shows the relevant classes in the context of the Remedial Action profile.

Subsequently, within each *RemedialActionScheme* class, several *Stages* classes can be grouped and assigned different priorities (indicating the order in which they are activated after subsequent rounds of calculations).

Finally, *StageTrigger* class in combination with a *Gate* class shall be used to set the triggering conditions for each stage.

The shows the aforementioned classes in the context of the Remedial Action profile._Please, note that the *TriggerCondition* class is deprecated in the latest model versions (RCP DES and NCP v2.4) and it should not be used.

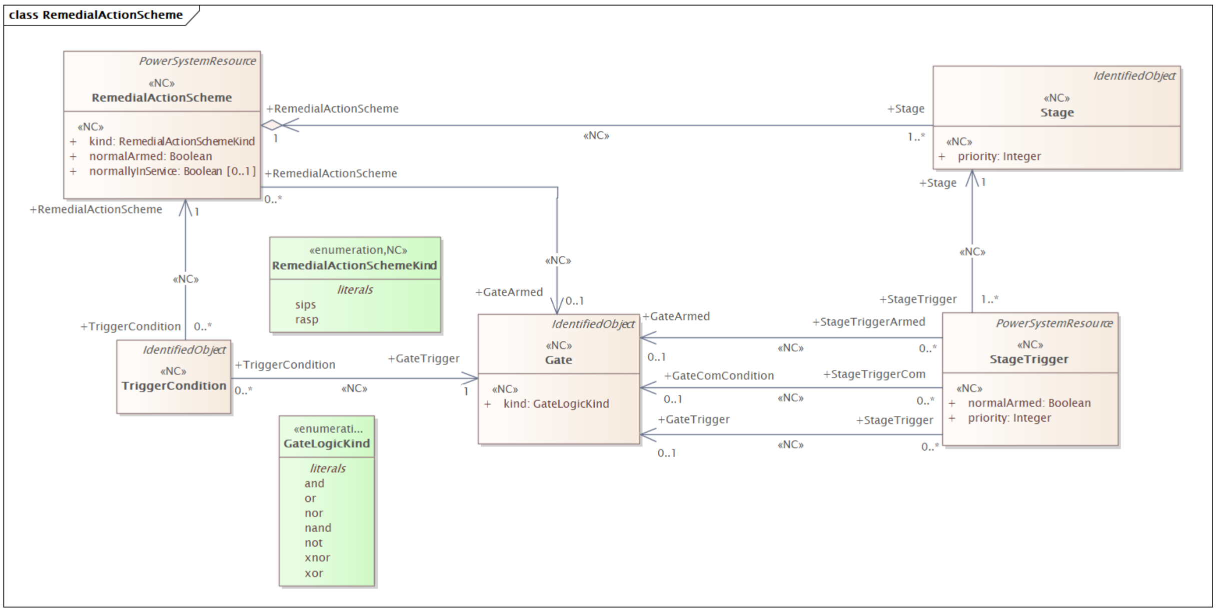


Figure 66: Extract of the RemedialActionScheme diagram in Remedial Action profile

The following lines illustrate this use case with the example called *Automatic Generation Shedding* which protects elements connected to a substation against over loadings. The objectives are to:

- Gradually reduce generation output.
- Disconnect generators if the overload persists.
- Ensure that system protection logic reflects conditional decision-making over time.

The complex logic follows a decision tree that evolves depending on the severity and persistence of the overload, and it takes different actions based on whether the line current exceeds PATL or TATL limits.

7.1.9.8.1 Triggering Logic

The triggering logic is divided in two main stages depending on the loading level of the element as shown in Figure 67.

- Moderate Overload Case:
    - **If** Intensity_PATL < Intensity_LOAD < Intensity_TATL:
        - **Then** Reduce generator output (generator 1)
        - **Wait** 20 minutes
        - **If** still PATL < Intensity_LOAD (the element is still overloaded):
            - **Then** disconnect generator 1.
        - **If** still Intensity_PATL < Itensity_LOAD (the element is still overloaded):
            - **Then** disconnect generator 3.
- Severe Overload Case:
    - **If** Intensity_LOAD > Itensity_TATL:
        - **Then** disconnect generator 1 connected to the same busbars.
        - **If** still Itensity_LOAD > Itensity_TATL (the element is still overloaded):
            - **Then** disconnect generator 3 connected to the same busbars.
        - **If** Itensity_PATL < Itensity_LOAD < Itensity_TATL (the element is still overloaded):
            - **Then** reduce power on generator 3.
        - **If** Itensity_PATL < Itensity_LOAD (the element is still overloaded):
            - **Then** disconnect generator 3

Actual SIPS automatically selects the generator based on its generated power (with highest power), connected to the same busbars as overloaded element. Because there is no logic which will allow power system analysis software to automatically choose the generator based on the conditions above, the set of generators have to be predefined in the SIPS (or use multiple *GridStateAlteration*s with attribute *normalEnable* set to true/false, depending on the chosen generator).

The SIPS logic can be reflected as decision tree shown in Figure 67.

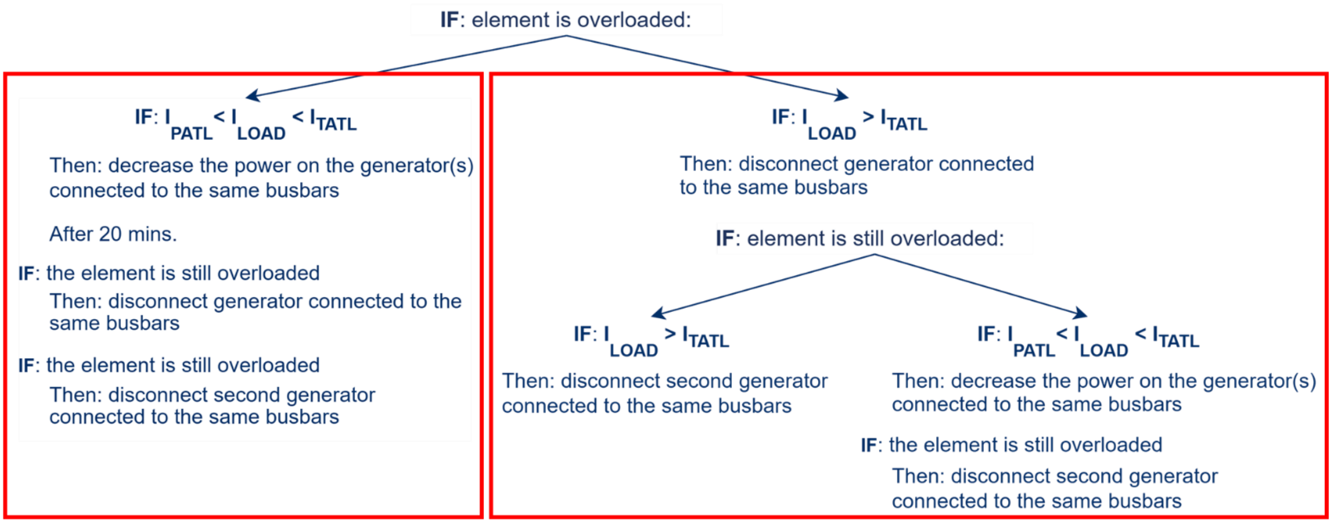


Figure 67: Complex triggering logic

7.1.9.8.2 Operational Stages Action Chains

Based on the triggering logic, the operational stages of this SIPS can be represented as the action chain shown in **Figure 68**.

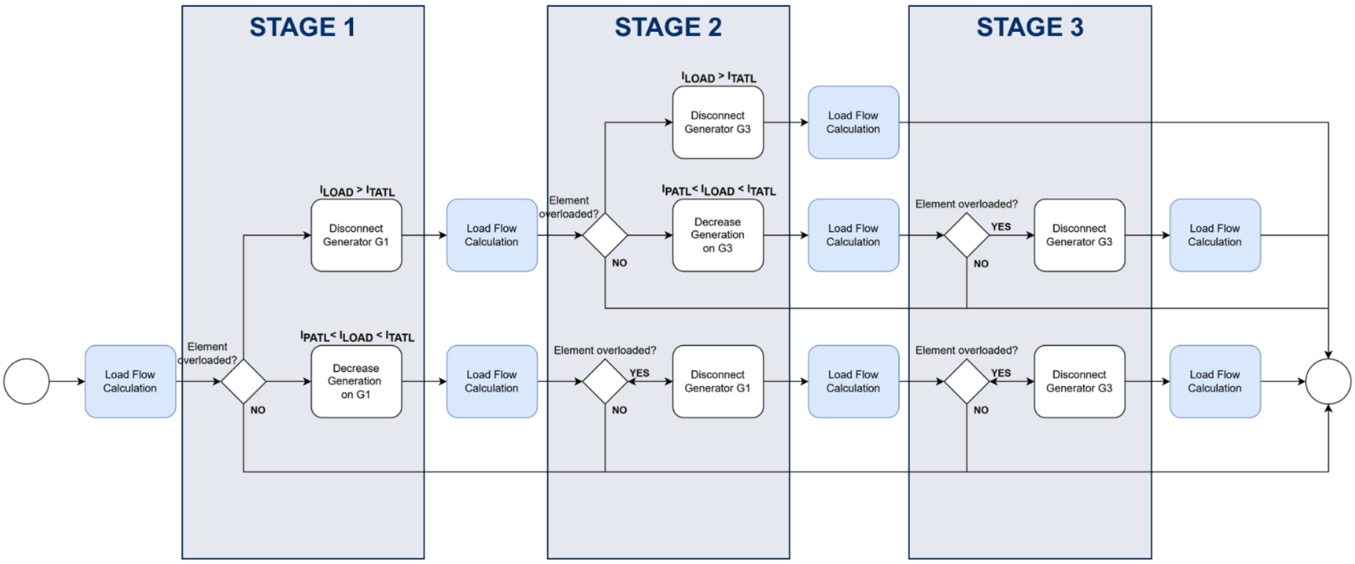


Figure 68: Operational Stages Action Chain

Each stage—with an assigned priority 1, 2 or 3—represents the subsequent power flow after which the SIPS action should be implemented.

To model the first action split, the whole example was divided into two separate SIPS action chains (denoted as 1 and 2 in Figure 69).

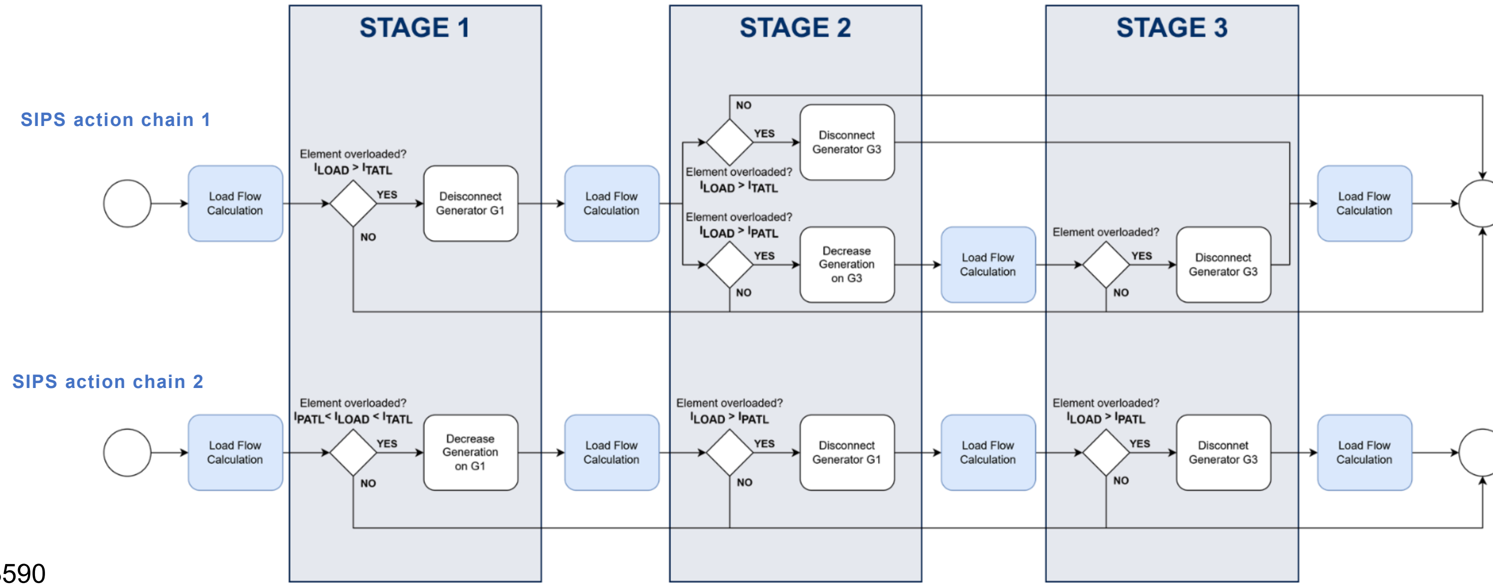


Figure 69: Operational Stages Action Chain (simplification 1)

Currently, the CIM based Network Code Profiles cannot cover such a complex action chain dependency level as described in Figure 69. This is the reason why the output actions in stage 2 for the *SIPS action chain 1* are merged into one action. Such simplification is reflected in Figure 70.

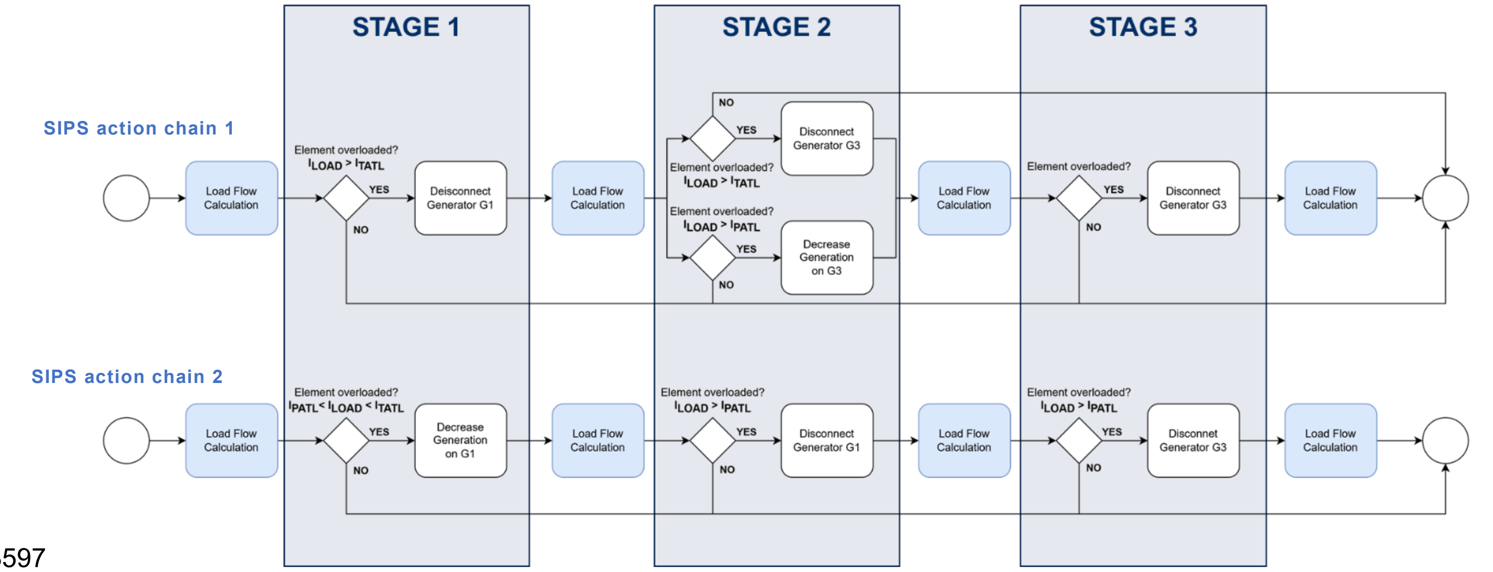


Figure 70: Operational Stages Action Chain (simplification 2)

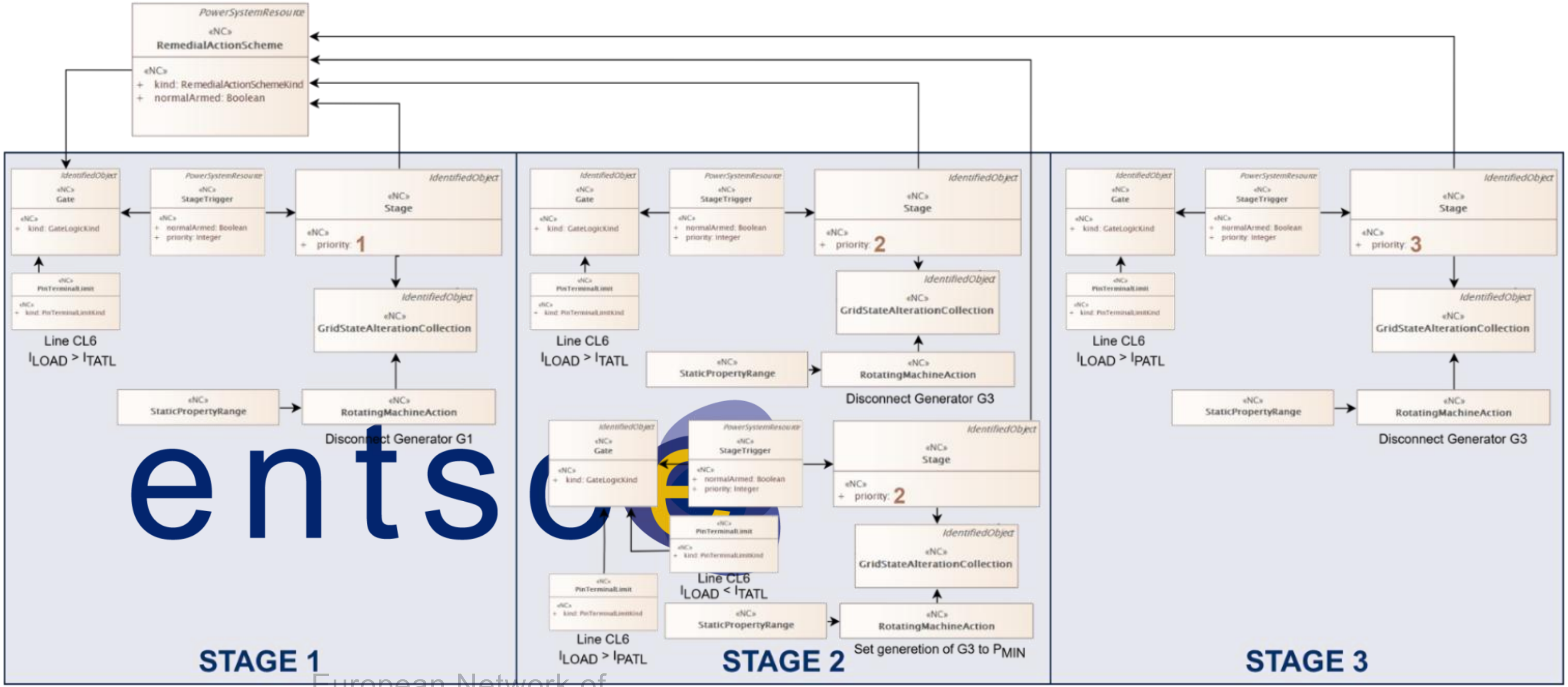
7.1.9.8.3 Example Use of Network Code Profiles

The use of the Network Code Profiles is exemplified for SIPS action chain 1 in Figure 71.

The use of the Network Code Profiles is exemplified for SIPS action chain 2 in Figure 72.

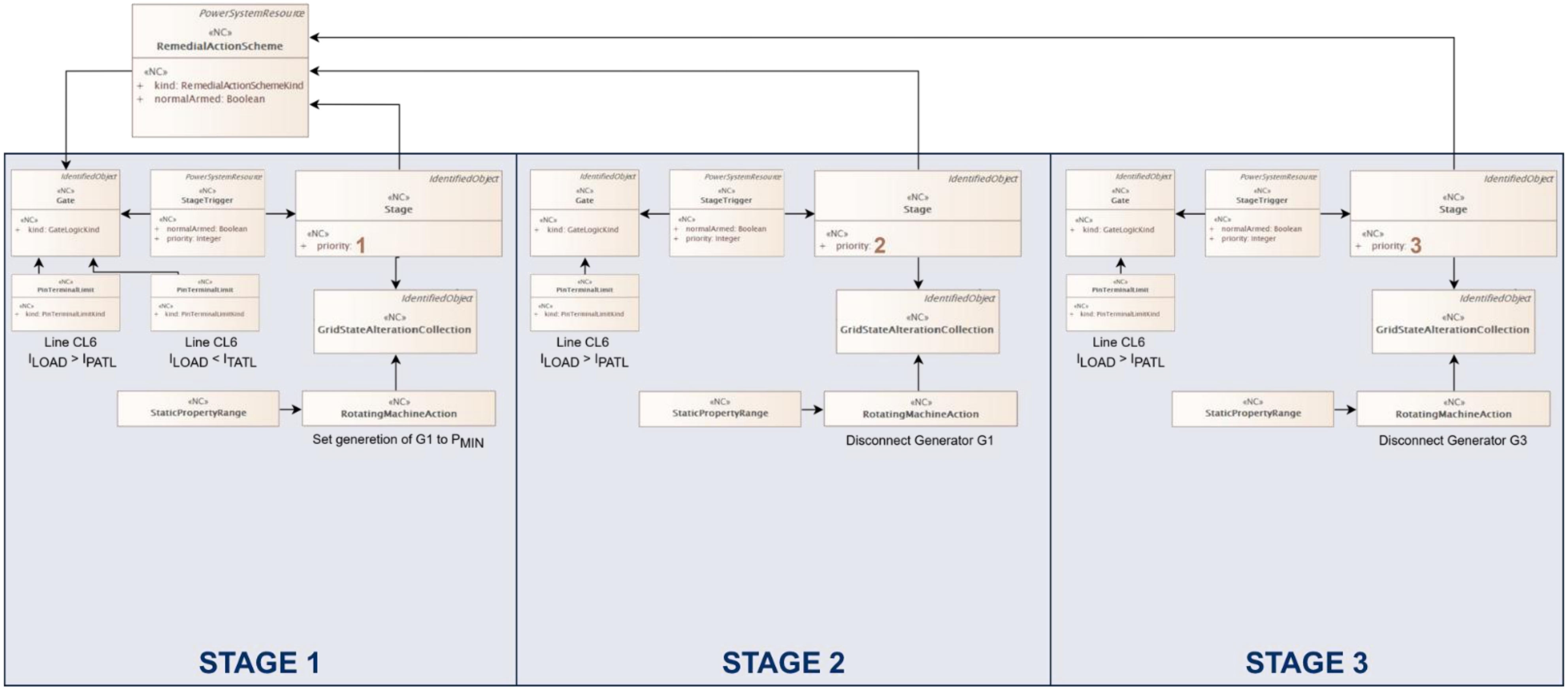
3604

European Network of
Transmission System Operators
for Electricity



3606

3607 Figure 71: Example for SIPS action chain 1 (part 1)

3608 

3609 Figure 72: Example for SIPS action chain 2

3610

European Network of
Transmission System Operators
for Electricity

7.1.9.9 Correction of generation production due to a power flow limit violation

This use case describes the modelling of a S(I)PS logic correcting a generation production level due to a power flow exceeding a set limit.

This SPS is not based on a contingency, but just monitoring the state of the system and based on a potential overload, it will trigger some actions.

Therefore, readers may want to note that no contingency is the trigger for this procedure.

As depicted in Figure 73, the SPS in question is monitoring three lines, two transformers and three generators. Once triggered, it commands three generators to adjust their production to maintain grid integrity and security.

The following lines will also provide examples on how to use Remedial Action profile classes' to fully describe the SPS.

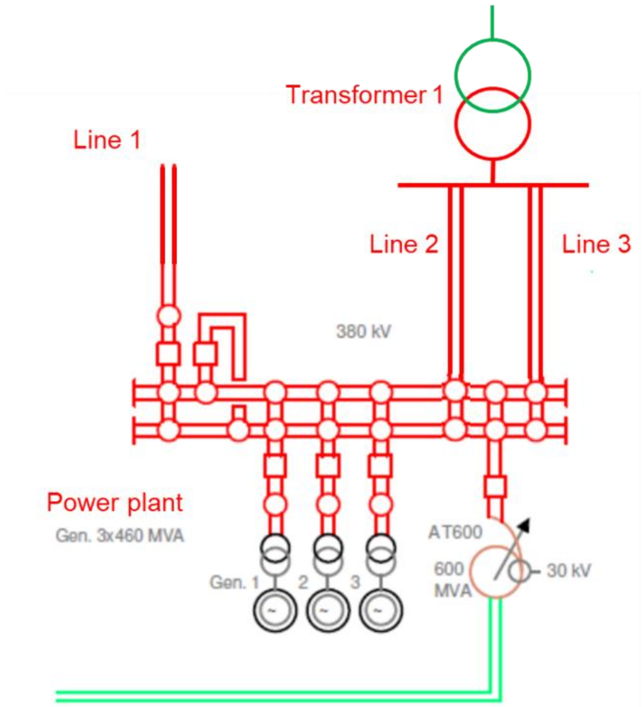


Figure **73**: General diagram for use case "Correction of generation production due to a power flow limit violation"

A preliminary test use case demonstrating the application described above is provided in the TestUseCase directory of the ReliCapGrid GitHub repository. This example is intended as a starting point and is subject to further development.

7.1.9.9.1 Operational Stages

For the grid configuration described in , this SPS for this use case consists of two stages. The main condition/trigger is common across all stages and entails an overload on the AT transformer.

However, readers might notice that the difference between stage 1 and 2 is that the *Transformer 1* is out of operation in stage 2.

Stage 1:

The following conditions are monitored:

- Line 1, Line 2, Line 3, Transformer 1 are in operation (the flow through them is >1MW).
- Generators 1, 2, 3 are in operation and producing more than 300 MW each (their production is >300 MW).
- Transformer AT600 is overloaded (its active power is $\mathbf{P_{AT} > 600}$ **MW**).
- All conditions are checked for **duration > 10s** in order to avoid accidental activation.

If triggered, the stage 1 would lower the generation until each generation is ~300 MW until the Transformer AT600 is no longer overloaded.

Element	In operation	Threshold (MW)	Class to monitor the element
Line 1, 2, 3	IN	>1	*PinTerminal*
Transformer 1	IN	>1	*PinTerminal*
Generators 1, 2, 3	IN	>300	*PinTerminal*
Transformer AT600	IN	>600	*PinTerminal*

All actions to be activated if Stage 1 is triggered are gathered using with *GridStateAlterationCollection* object. Additionally, there are three *RotatingMachineAction* and a corresponding *StaticPropertyRange* set point classes instantiations, one for each generator.

Stage 2:

The following conditions are monitored:

- Line 1, Line 2, Line 3 in operation
- Transformer 1 is out – this is assumed to be a planned outage, and no Contingency object is needed.
- Generators 1, 2, 3 are in operation and producing 300 MW each (their production is >300MW).
- Transformer AT600 is overloaded (its active power is $\mathbf{P_{AT} > 600}$ **MW**).
- All conditions are checked for **duration > 10s** not to activate accidentally [mandatory field – filled for this purpose primarily]

If triggered, the stage 2 would lower the generation lower the production of the generators until the Transformer AT600 is no longer overloaded, that is, until **P_{AT} ~ 550 MW**. This is done under the assumption that each generator would equally share the 550 MW, and they would produce ~ 183 MW each.

Element	In operation	Threshold (MW)	Class to monitor the element
Line 1, 2, 3	IN	>1	*PinTerminal*
Transformer 1	OUT	=0	*PinTerminal*
Generators 1, 2, 3	IN	>200	*PinTerminal*
Transformer AT600	IN	>600	*PinTerminal*

Again, all actions to be activated if Stage 2 is triggered are gathered using with *GridStateAlterationCollection* object. Additionally, there are three *RotatingMachineAction* and a corresponding *StaticPropertyRange* set point classes instantiations, one for each generator.

For the sake of simplification, to establish the outage of Transformer 1, in this example its active power was simply monitored to be 0 MW. However, readers might explore using the transformer's breaker *PropertyReference* for pointing to the switch and set its attribute to "open".

7.1.9.9.2 Example Use of Network Code Profiles

The describes the instantiation of classes in the Network Code Profiles to cover the description of one stage. Both stages 1 and 2 have an AND gate but each of them has their own Gates' instantiations.

Readers might especially pay attention to the following:

- Since this is considered a non-coordinated SPS, the main umbrella class used to model it is the *RemedialActionScheme*, with the attribute *RemedialActionScheme.kind* set to *sips.*
- A specific stage is defined through the objects of *Stage, StageTrigger* and the triggering conditions. The triggering conditions on the lines and transformers are based on the power flow through grid nodes in terminals referenced using the *PinTerminal* class.
- The generators are monitored and referenced through the *PinTerminal* class.
- The actions triggered by the SPS in this scenario consist of changes in the production of such generators. The production changes are described using the *GridStateAlterationCollection*, *RotatingMachineAction* and the corresponding *StaticPropertyRange* classes. Each generator has its own set of these objects.
- The use of *PinTerminal* instead of *PinEquipment* to check whether a generator is in operation (i.e., assigning it to value 1 MW) and whether a generator is producing

over a certain threshold as it embraces future better solutions for modelling this information in upcoming versions of the CIM standard by IEC.

European Network of
Transmission System Operators
for Electricity

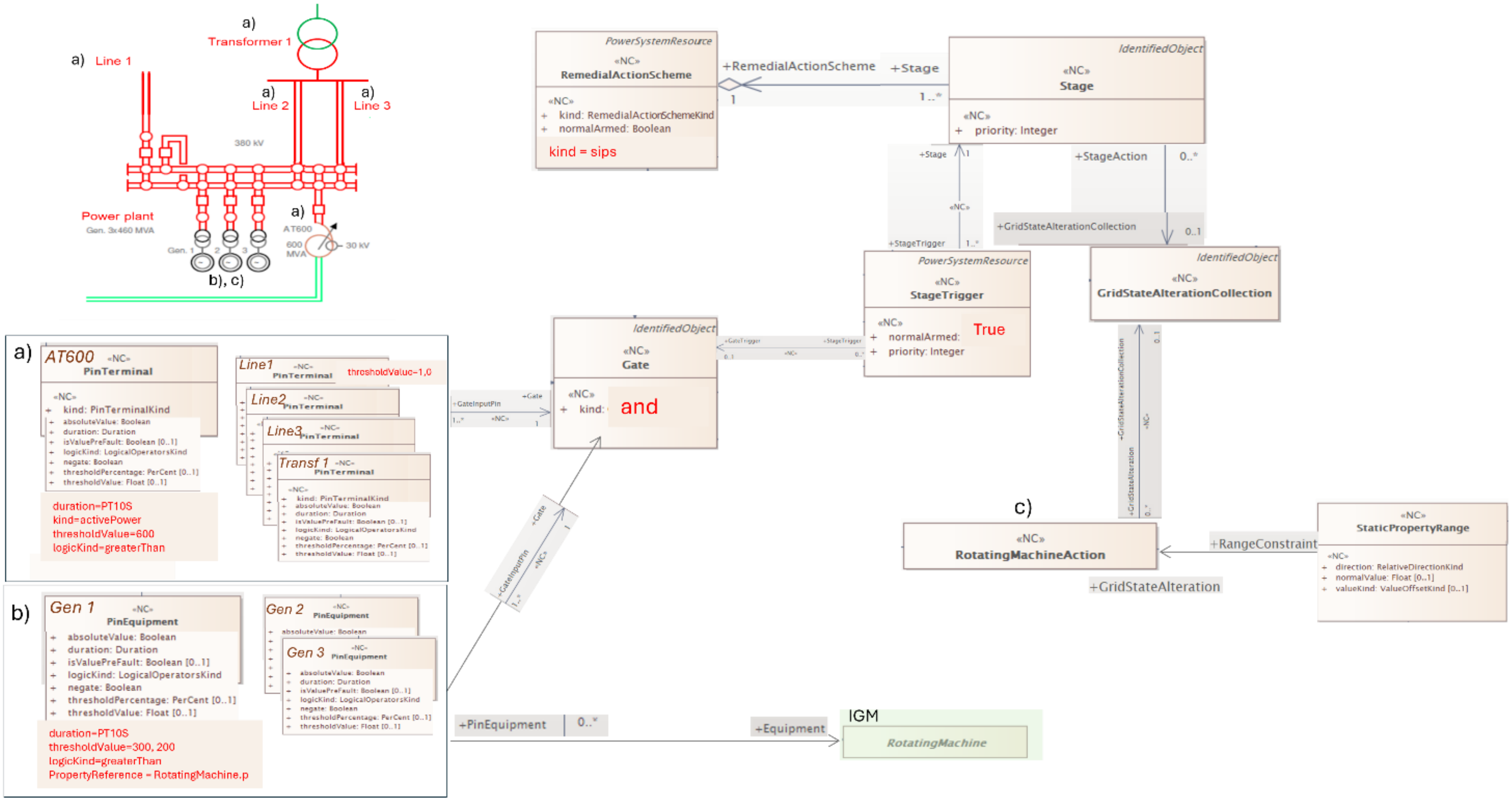


Figure 74: Example use of Network Code Profiles SIPS "Correction of generation production due to a power flow limit violation"

3704

European Network of
Transmission System Operators
for Electricity

7.1.10 List of System Constraints

There are different types of system constraints. Defining stability limits, voltage angle limits as well as infeed limits defined on a power transfer corridor. These limits can be linked with the assessed elements so that they can be scanned or secured.

7.1.10.1 System Constraint Justification

In accordance with business requirements a justification for the application of each system constraint as part of the list of these constraints. The justifications for system constraints, e.g. *InfeedLimit* are exchanged in the description attribute (*IdentifiedObject.description*) of the constraint.

7.1.10.2 Voltage Angle Limit

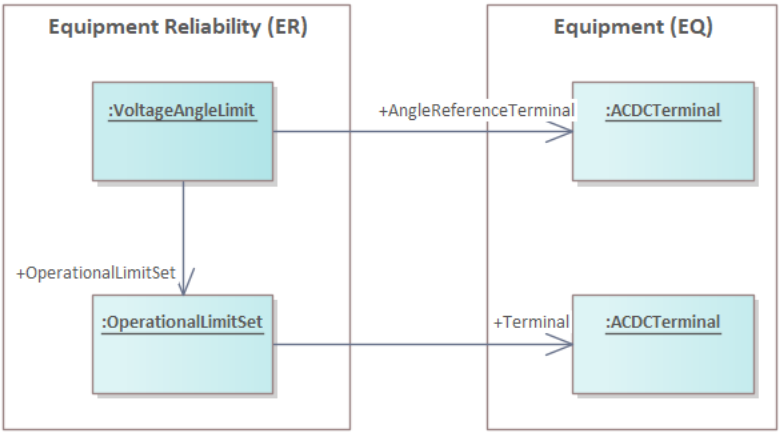


Figure 75 – Voltage Angle Limit

The corresponding Equipment Reliability dataset example can be located in ReliCapGrid in Belgovia_ER.xml:

- VoltageAngleLimit rdf:ID="_c06b2f38-c6c6-4fec-8ddb-234eebaea8ec".

The corresponding Equipment dataset examples can be found in Belgovia_EQ.xml:

- Terminal rdf:ID="_5c206db8-ef8c-4e53-b2b9-38b52b194c5a" (as AngleReferenceTerminal)
- OperationalLimitSet rdf:ID="_6fe5c43b-621c-88ac-1d90-22f075cdb50e"
- Terminal rdf:ID="_1b4c6e73-2657-f88b-277d-2ba248a4dd98".

7.1.10.3 Power Transfer Corridor

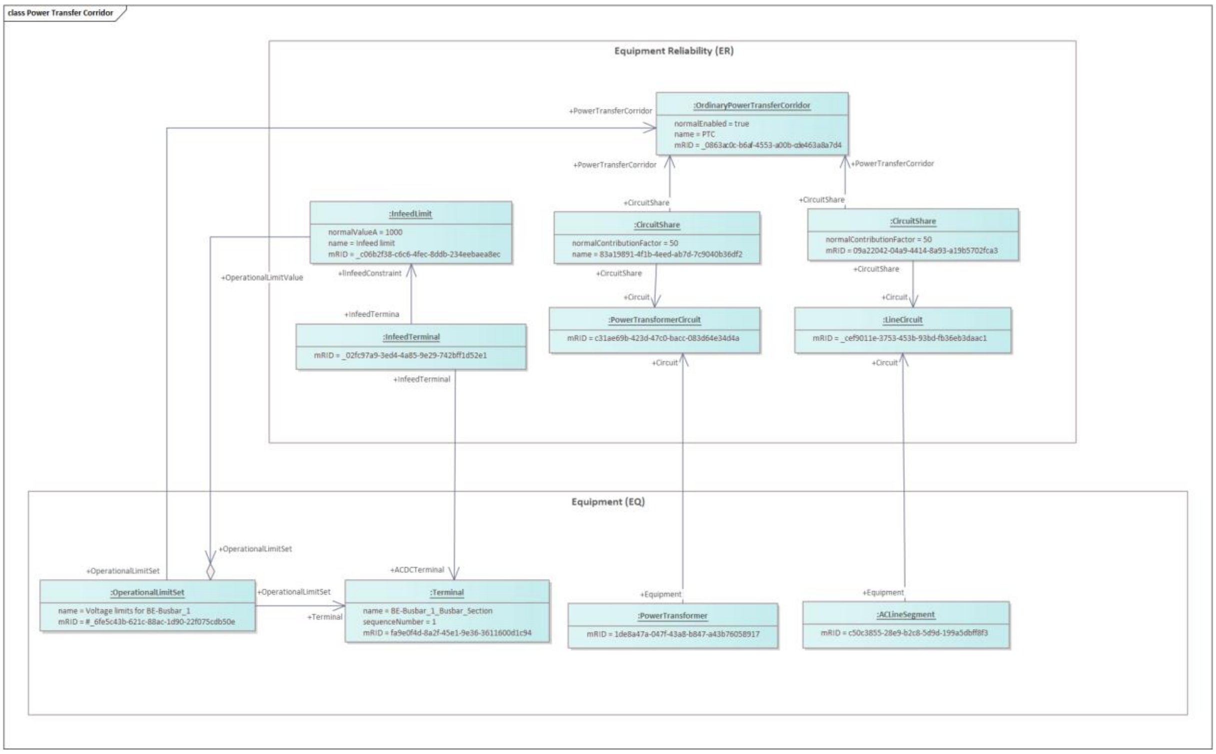


Figure 76 – Power Transfer Corridor

Power transfer corridor is defined by PowerTransferCorridor class in the Equipment Reliability dataset. It can be exceptional or ordinary type. In the example the ordinary power transfer corridor is illustrated.

A power transfer corridor can be composed by different circuits that have their share in the corridor. Circuits can be lines, transformers or DC circuits. However, each circuit can have different equipment object included in it.

The example illustrates a power transfer corridor that has a LineCircuit, a PowerTransformerCircuit, InfeedLimit. The corresponding Equipment Reliability dataset example can be located in ReliCapGrid in Belgovia_ER.xml:

- InfeedLimit rdf:ID="_c06b2f38-c6c6-4fec-8ddb-234eebaea8ec"
- LineCircuit rdf:ID="_cef9011e-3753-453b-93bd-fb36eb3daac1"
- PowerTransformerCircuit rdf:ID="_c31ae69b-423d-47c0-bacc-083d64e34d4a"
- OrdinaryPowerTransferCorridor rdf:ID="_0863ac0c-b6af-4553-a00b-cde463a8a7d4.

The corresponding Equipment dataset may be found in ReliCapGrid in Belgovia_EQ.xml :

- PowerTransformer rdf:ID="_b94318f6-6d24-4f56-96b9-df2531ad6543"
- ACLineSegment rdf:ID=_ffbabc27-1ccd-4fdc-b037-e341706c8d29"
- BusbarSection rdf:ID="_0799f76b-346a-1103-4e9b-3ea6bf6b57e8"
- Terminal rdf:ID="_131b654f-eec6-eb63-5084-3fcc46921cfe"

- OperationalLimitSet rdf:ID="_ee1e0ee2-edf6-8968-9c4c-83fa12446800".

In order to cover wider range of use cases the power transfer corridor can be composed by using the association Circuit.IdentifyingTerminal. Therefore, a Circuit shall have an association with either a Terminal or an Equipment. Figure 77 illustrates this approach.

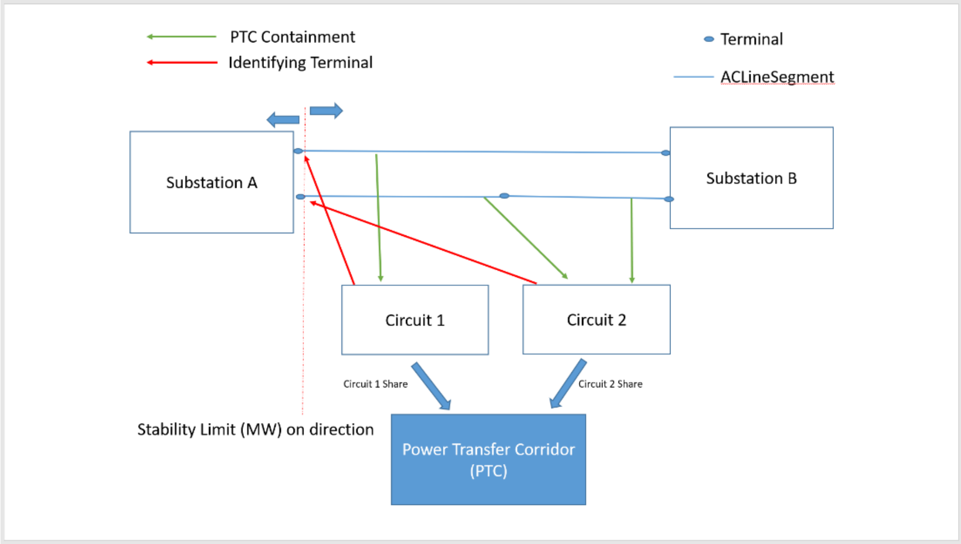


Figure 77 – Power Transfer Corridor – using Terminals

There are at least two use cases where active and reactive power flows are monitored. The constraints can be fixed limits or variable limits – per MTU. The following sections illustrate the two cases.

7.1.10.3.1Monitoring of Active and Reactive Flows Using PowerTransferCorridor and Fixed Limits

It is critical for TSOs to be able to explicitly specify the terminal of a component such as lines, transformer windings, etc. from which they wish to obtain flow measurements. This precision is essential for accurate loss compensation and accounting for reactive power flows.

In that sense, the concept a power transfer corridor (PTC) is advised to fulfil such power flow measurement requirements.

TSOs' main business drivers for using PTCs are:

1. Monitoring active and reactive power flows to study the capacity given to the market between bidding zones,
2. Setting input conditions for SIPS (System Integral Protection Schemes),
3. And apply operational limits that incorporate pre-calculated transient stability constraints in a simplified form.

The Power Transfer Corridor limits (via the use of *OperationalLimit* class) can be exchanged based on three different use cases

1. If the limits are of a more *fixed/stable* nature:
    a. In the core equipment dataset (EQ),
    b. In the equipment reliability dataset (ER) – as for the structural part of the PTC.
2. If the limits need to be updated in a scheduled way:
    a. In the steady state hypothesis schedule dataset (SHS).
3. If the limits need to be updated in an MTU-per-MTU way:
    a. In the steady state hypothesis dataset (SSH) – only valid from CGMES 3.0 onwards.
    b. In the state instruction schedule dataset (SIS)

Because *OperationalLimit* is not formally part of the ER profile, its inclusion will be flagged during ER dataset validation as "*Info*", meaning these are additional instances outside the defined profile (i.e. not errors).

However, the *true* validation of *OperationalLimits* only occurs when the ER and EQ datasets are combined during the validation process. This introduces a clear requirement:
to support correct validation and operational logic: both datasets (ER and EQ) must be considered together.

Since the ER profile uses the persistent CIM namespace, any *OperationalLimit* objects must be:

- Included in the ER dataset, and

- Defined using the persistent CIM namespace to ensure consistency and interoperability.

An example that illustrates this can be located in ReliCapGrid in Belgovia_ER.xml:

- InfeedLimit rdf:ID="_c06b2f38-c6c6-4fec-8ddb-234eebaea8ec".

Readers would find in the ENTSO-E ReliCapGrid GitHub repository (fictitious TSO *Svedala* exchanging a AS dataset) an example of the *AvailabilitySchedule* class with mRID set to 31c77d68-cf6a-462a-8194-956d697dc3a2

7.1.10.3.2Monitoring of Active Power Flows Using PowerTransferCorridor and Variable Limits

TSOs are increasingly interested in modelling PTCs with variable power limits, which can change depending on network conditions, outages, or other operational factors. This use case aims to provide a reference implementation for such modelling by leveraging the combination of both the ER profile and the SHS profile.

Since the operational limits of a PTC can vary over time, it is essential to exchange this data per MTU. This dynamic nature is addressed by including PTC operational limits per MTU in the SSI dataset, where these limits are expressed as “floating” values, i.e. not tied to a fixed reference in the EQ/ER datasets.

Because *OperationalLimit*s are introduced dynamically in the SSI, validation tools should not flag these limits as errors or violations, but rather report them as informational messages. This is due to the fact that the SSI dataset alone does not provide the full context required for validation.

For complete semantic and consistency checks, validation must be performed across the combined datasets SSI and SHS.

This approach ensures that variable limits, especially those reflecting transient or scheduled conditions, are accurately modelled and validated in the context of system reliability and security analysis.

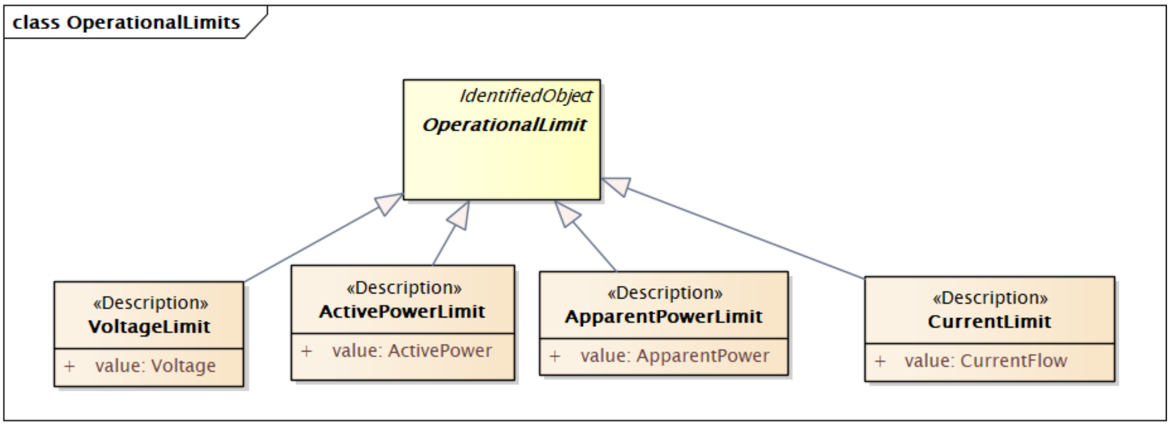


Figure 78: From SSH dataset that should be included in the SSI dataset

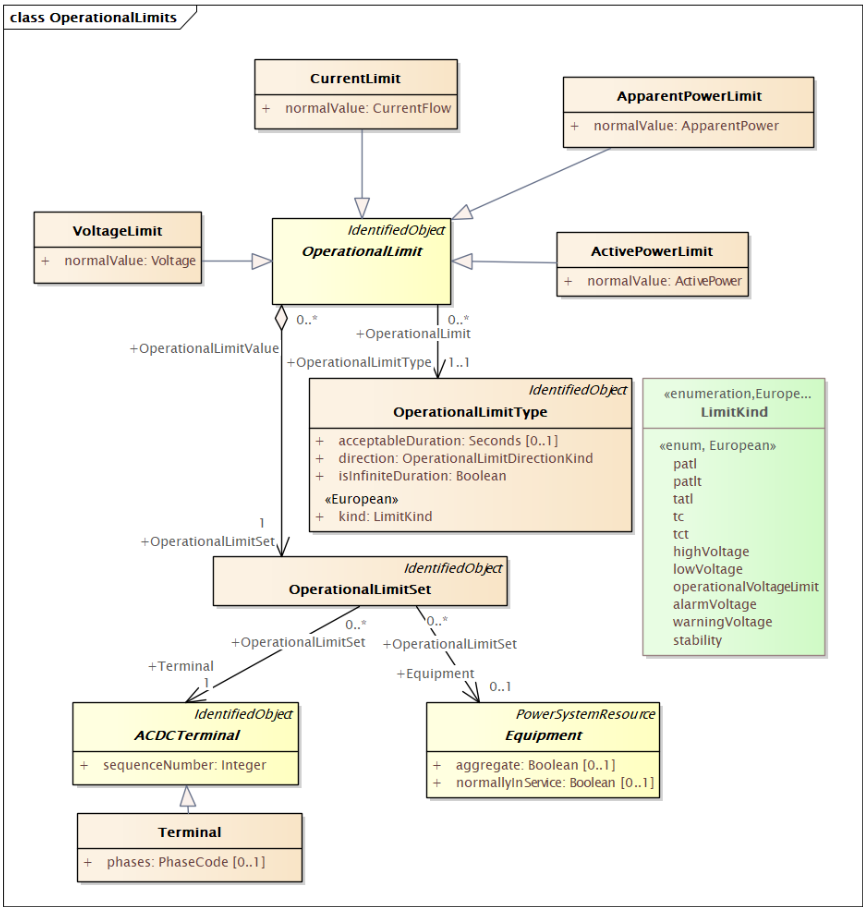


Figure 79: Information from EQ profile, which is instance data in the ER profile

For the scheduled data (not per MTU), one should use the Steady State Hypothesis Schedule (SHS) profile.

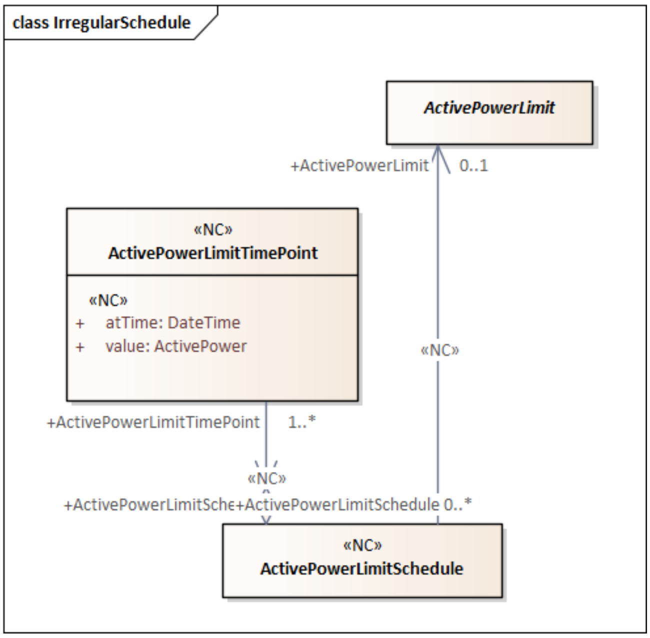


Figure 80: Showing how to exchange active power limits that should be exchanged in the SHS

An example on exchanging current limits through Steady State Hypothesis Schedule profile can be found in ReliCapGrid in Belgovia_SHS.xml:

- CurrentLimitSchedule rdf:ID="_a246aa9a-1e25-4693-a681-f4f771949d2f".

The corresponding current limit dataset can be located in ReliCapGrid in Belgovia_EQ_1.xml:

- CurrentLimit rdf:ID="_1ee85ce6-8298-c191-b8a0-9ccac2282a66".

Readers would find in the ENTSO-E ReliCapGrid GitHub repository (fictitious TSO *Svedala* exchanging a AS dataset) an example of the *AvailabilitySchedule* class with mRID set to 31c77d68-cf6a-462a-8194-956d697dc3a2.

7.1.10.4 Expected Use Cases

Table 10: Expected Use Cases Related to Power Transfer Corridors.

Name	Description	Comment
Modelling Power Transfer Corridors Cross and Intra Bidding Zones	For TSOs, it is crucial to understand the behaviour and constraints of any Power Transfer Corridor (PTC) that crosses a bidding zone boundary. This is relevant in the Nordics, where frequent cross-bidding zone border flows—often within the same TSO control area as is the case in Norway—mean that congestion management, capacity calculation, and operational security depend heavily on accurate corridor modelling.	Pending

7.1.11 Availability Schedule

7.1.11.1 Outage Planning Information

The Availability Schedule profile is used to facilitate the exchange of planned outage information. This profile is designed with sufficient flexibility to allow relatively straightforward implementation by other actors as well, such as DSOs.

For illustrative purposes, only a subset of the Availability Schedule profile which is relevant for the exchange of planned outage data is considered here. This section introduces only the core elements and selected functionalities of the profile that pertain to planned outage communication. Depending on the nuances of the use case other available attributes and classes can be used too.

The data exchange process for Outage Planning Coordination—involving TSOs, DSOs, and significant grid users—is expected to evolve over time. Future versions of this document will progressively elaborate and extend the specification to encompass additional capabilities and requirements.

- Use of AvailabilitySchedule class

The main object of a scheduled outage dataset is the object *AvailabilitySchedule* object. The object shall have a unique mRID. The mRID shall be persistent to enable updates on the outage. The *AvailabilitySchedule* shall have a reference to a PlannedSchedule object (which is an instance of EventSchedule) to be able to specify the start time and end time of the interruption.

The following attributes of the *AvailabilitySchedule* class are relevant for this use case:

- causeKind: the profile allows for different causes, but for the example 'maintenance' is selected as the most frequently used.
- Priority: it is set to *1* in most of the cases.
- causeDescription: Description of the cause of the interruption. It can be the same as the description in AvailabilityEquipment.
- description: It is used to indicate the operation order number in case it exists.
- maxRestitutionDuration: it is used to indicate how long it is expected before return to operation. If recovery time is not availabledu, the field is left blank.
- cancelledDateTime: It is used to cancel the planned outage (stores the cancellation time).

Readers would find in the ENTSO-E ReliCapGrid GitHub repository (fictitious TSO *Svedala* exchanging a AS dataset) an example of the *AvailabilitySchedule* class with mRID set to 31c77d68-cf6a-462a-8194-956d697dc3a2.

- Use of AvailabilityEquipment class

In the data model, a piece of equipment, such as a network element or a production module, is represented as an object, generally referred to as Equipment. When an equipment outage occurs, the affected Equipment shall be linked to an AvailabilityEquipment element, which defines the availability status of that particular object.

It is important to distinguish between individual Equipment and collective entities that group multiple power system objects. These groupings, referred to as EquipmentContainers, are associated with a separate construct, AvailabilityContainer, rather than AvailabilityEquipment when an outage is planned.

Each AvailabilityEquipment shall include:

- A reference to the *AvailabilitySchedule* to which the equipment outage belongs.
- A reference to the affected Equipment object, identified via its persistent mRID within the model.

Used attributes of the AvailabilityEquipment:

- mRID: Unique for each outage. This is not the mRID of the power system objects in the power system model but the identity of this specific instance.
- availabilityFunctionKind: Availability status of the power system object during the current period. To describe outages, this attribute is often set as 'outOfService'.
- description: A free text field used to describe the work to be carried out on the coupled power system object. For example: 'Reinvestment of ZL123', 'Renewal of bay 12', 'Commissioning of new station Stockholm'.

In the same AS profile, the AvailabilityEquipment instance with mRID cbe49fbe-64dd-48e0-8e9b-bbc468265abc represents a decommissioning event for the power system object identified by mRID 536f4b84-db4c-4545-96e9-bb5a87f65d13.

- Use of AvailabilityContainer class

The AvailabilityContainer class describes which collection object is targeted. One type of collection object is Line, which is used to group sections of the same line. Each collection object shall have its own AvailabilityContainer object representing the outage.

In addition, the AvailabilityContainer has references to the main *AvailabilitySchedule* object and the EquipmentContainer object model itself (by reference to its persistent mRID).

Used attributes of the AvailabilityContainer:

- mRID: the identification of the interruption associated with a specific collection object (AvailabilityContainer). This is not the mRID of the groupbject in the power system model but the identity of this specific instance.
- availabilityFunctionKind: The accessibility status of the collection object in the current period. To describe outages this attribute is often set to as 'outOfService'.
- description: A free text field used to describe the work to be carried out on the collection object. For example: 'Reinvestment of ZL123', 'Renewal of bay 12', 'Commissioning of new station Stockholm'.

The approach for AvailabilityContainer follows the pattern used by AvaiabilityEquipment and it is integrated into ReliCap grid in Svedala_AS.xml. In this context, the following instances describe the case of reporting availability for a container:

- AvailabilityContainer rdf:ID="_0d4d4078-f3ad-409d-8882-73dafef11b80",
- AvailabilitySchedule rdf:ID="_9fa5e26d-d64e-4bfb-afb8-fb6dbe884b48".

- Use of EventSchedule class

The EventSchedule object describes when the outage will occur and is referenced via the PlannedSchedule association from the *AvailabilitySchedule* object. Note that the actual start and end times are defined in the EventTimePoint object.

Used attributes of the EventSchedule:

- TimeSeriesInterpolationKind: In most of the cases set to ‘previous’.
- BaseTimeSeriesKind: In the profile description there is a list of options, but in most cases, it will be ‘schedule’.

The corresponding dataset example is integrated in Svedala_AS.xml:

- EventSchedule rdf:ID="_7acbe49b-be64-4dd8-a02e-87778468d55a"

- Use of EventTimePoint class

Two instances of the EventTimePoint object are required to specify the start and end time of the interruption. The isActive attribute defines whether EventTimePoint represents the start time (‘true’) or the end time (‘false’).

In this example, EventTimePoint ab81932c-9fc9-4d1b-a770-36e5e6bfbb9e is the start time and EventTimePoint 389a8f82-cb8e-4b8c-8aa7-3b26a4957eba is the end time, and the entire outage takes one day.

The corresponding dataset examples are integrated in Svedala_AS.xml:

- EventTimePoint rdf:ID="_389a8f82-cb8e-4b8c-8aa7-3b26a4957eba"
- EventTimePoint rdf:ID="_4a69b9d3-39ac-44e7-a68d-1d76657202b4"
- EventTimePoint rdf:ID="_ab81932c-9fc9-4d1b-a770-36e5e6bfbb9e"

7.1.11.2 Update of Security Limits Before or During CROSA Process

During the execution of the CROSA process, exceptional operational conditions may require a Core TSO to update the security limits for specific network elements (XNE) or scanned elements.

These updates can occur both before CROSA execution and after the delivery of the Individual Grid Model, while CROSA is running.

The paragraphs below describe the modelling enabling the modification of Permanent Admissible Transmission Limits (PATL) and Temporary Admissible Transmission Limits (TATL) in response to unforeseen situations such as unexpected outages, severe weather events, or other operational disturbances.

However, this functionality is not intended for use in dynamic line rating applications.

The recommended approach is based on the *AvailabilitySchedule* profile—an extract is shown in Figure 81. The updated PATL or TATL values are modelled using the *AvailabilityExceptionalLimit* class, with the *isActive* attribute in the *EventTimePoint* class set to *true* to indicate that the exceptional limit is in effect.

The reason for the update is expressed in the *causeKind* attribute of the *AvailabilitySchedule* class, which can take any value defined in the enumeration.

The status of the element concerned is provided through the *kind* attribute of the *AvailabilityPowerSystemFunction* class, set to the values *inService* or *underTesting* of the *availabilityFunctionKind* as appropriate.

If a TSO wishes to link this information with an *Equipment,* they may consider using the *AvailabilityEquipment* class that inherits directly from the aforementioned *AvailabilityPowerSystemFunction* class.

This modelling pattern enables the exceptional limit to be directly associated with the relevant PATL or TATL, ensuring that the updated limits are accurately exchanged and applied within the CROSA coordination process in compliance with the CGMES and NCP information model.

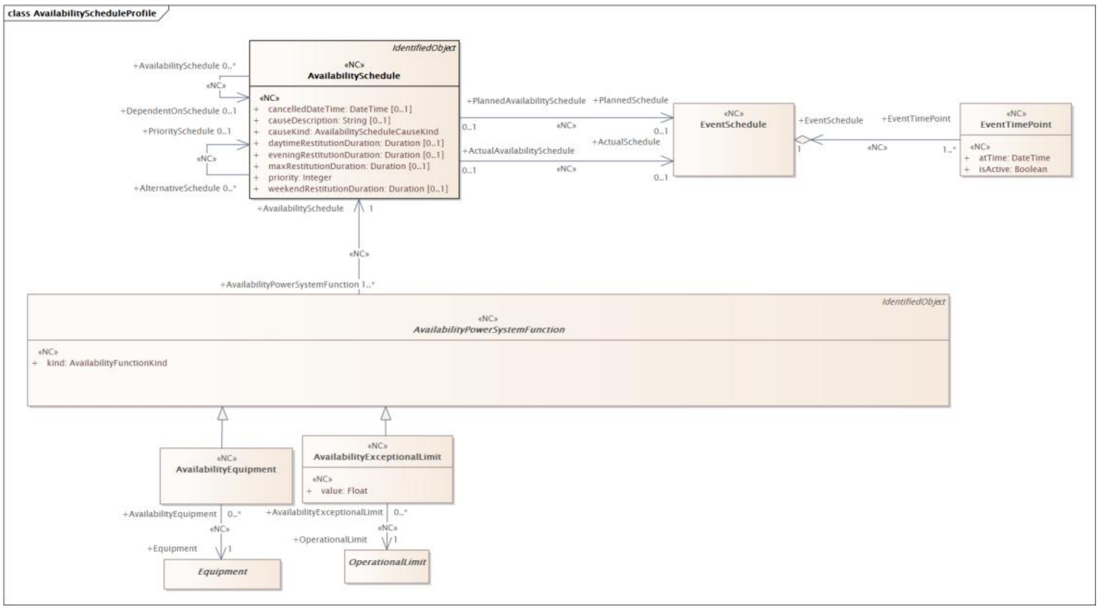


Figure 81: Extract of the AvailabilitySchedule profile.

7.1.11.3 Expected use cases

TSOs plan to further elaborate on the following use cases:

Table 11: Expected Use Cases Related to Availability Schedule.

Name
Bypassing busbar/substation (creating a "long line")
Active power restriction and forecasted restriction in the reactive power control capability for SGU
Disconnection of single underground cable units, that are part of 220-400 kV lines
Acknowledgment mechanism (positive *ACK* and negative *NACK*) for *AvailabilitySchedule*

7.1.12Define scope of the analysis

Monitoring area profile defines possibility to exchange the definition of the following types of areas: monitoring area, observability area, sensitivity area, contingency area. Some of the use cases when usage of area definition is necessary are:

- In cases where it is required to identify the are based on influence factors
- In cases where the receiving system does not select all data submitted but needs to analyse part of the area. For instance, region A analysis needs to include part of region B.

Are definition uses the class AreaBorderTerminal to define the borders of the area. The following snipper illustrates definition of a monitoring area with two terminals. Eventually it is expected that there will be many terminals defined as the border needs to circle the area.

```
 <nc:MonitoringArea rdf:ID="_adf0cf12-8f61-45af-b073-d73dd30e078d">
  <cim:IdentifiedObject.mRID>adf0cf12-8f61-45af-b073-d73dd30e078d</cim:IdentifiedObject.mRID>
  <cim:IdentifiedObject.name>My observability area</cim:IdentifiedObject.name>
  <nc:MonitoringArea.SystemOperator rdf:resource="#_b1a6650b-bf47-469b-81f5-0319c265354b"/>
<nc:MonitoringArea.SynchronousArea rdf:resource="#_104f34a9-4b02-41a1-b3fb-2e3802e166b8"/>
 </nc:MonitoringArea >

 <nc:AreaBorderTerminal rdf:ID="_d7777b3f-4acb-452a-acca-5b100b299ba8">
  <nc:AreaBorderTerminal.mRID>d7777b3f-4acb-452a-acca-5b100b299ba8</
nc:AreaBorderTerminal.mRID >
  <nc:AreaBorderTerminal.MonitoringArea                    rdf:resource="#_adf0cf12-8f61-45af-b073-
d73dd30e078d"/>
<nc:AreaBorderTerminal.Terminal rdf:resource="#_e504d183-64fb-4e44-9598-d19760660919"/>
 </nc:ObservabilityArea >

 <nc:AreaBorderTerminal rdf:ID="_418469cd-5e95-4320-bb1f-28e5dc0ea15f">
  <nc:AreaBorderTerminal.mRID>418469cd-5e95-4320-bb1f-28e5dc0ea15f</
nc:AreaBorderTerminal.mRID >
  <nc:AreaBorderTerminal.MonitoringArea                    rdf:resource="#_adf0cf12-8f61-45af-b073-
d73dd30e078d"/>
<nc:AreaBorderTerminal.Terminal rdf:resource="#_c677bd82-40f3-40ac-a11b-01832631ced9"/>
 </nc:ObservabilityArea >
```

In future releases of the RCP DES, this example will be integrated in the ReliCapGrid open-source test model.

7.2 Regional Security Assessment

7.2.1 Description

The Regional Security Assessment (RSA) is performed by the Security Assessment Coordinator. For information, the RSA is part of CROSA and is performed in intraday. The RSA subprocess is illustrated in Figure 82.

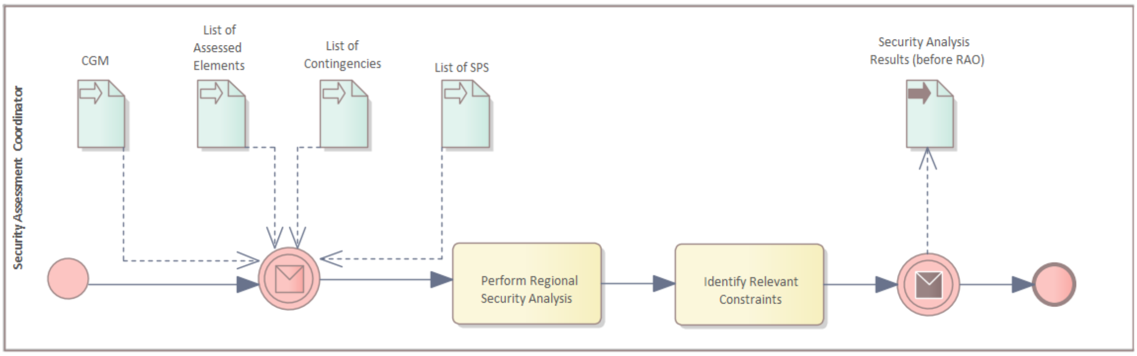


Figure 82 – Regional Security Assessment.

7.2.2 Inputs and Outputs

The list of Inputs and Outputs that are part of the subprocess is defined in Table 12.

Table 12 – Inputs and Outputs for Regional Security Assessment

Inputs	Outputs
Common Grid Model for the studied timeframe	Security Analysis Results (before RAO)
List of Assessed Elements	
List of Contingencies	
List of SPS (optional)	
The intensity (RAS) for agreed curative RA	

7.2.3 Conformity Requirements

To be able to support regional security assessment the Application shall conform to the following Application functions:

- Security analysis.

7.3 Remedial Action Optimization

7.3.1 Description

The Remedial Action Optimization (RAO) is performed by the Remedial Action Optimization Operator. The RAO subprocess is illustrated in Figure 83.

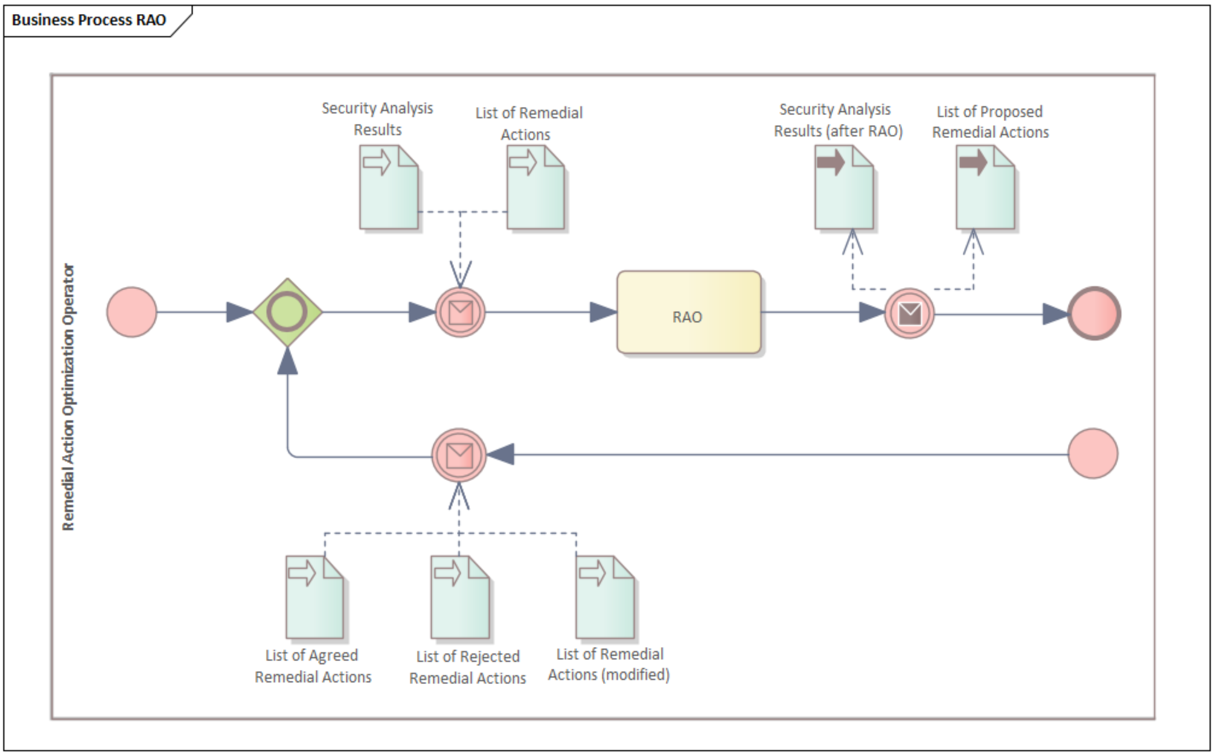


Figure 83 – Remedial Action Optimisation.

7.3.2 Inputs and Outputs

Table 13 – Inputs and Outputs for Remedial Action Optimization

Inputs	Outputs
List of Available Remedial Actions	Security Analysis Results (after RAO, thus including proposed Remedial Actions)
Security Analysis Result (incl. Identified Constraints, before RAO, thus without proposed Remedial Actions)	List of Proposed Remedial Actions including sensitivity of Remedial Actions, at least on violations and cost of proposed Remedial Actions (per RA and in total)
Predefined rules for optimization – the exchange and the process for this is still to be defined	

7.3.3 Conformity Requirements

To be able to support remedial action optimization the Application shall conform to the following Application functions:

- Remedial action optimization.

7.3.4 Proposed Remedial Action Schedule

In general, the RAS profile can be used as an input if it is needed to inform that a remedial action is already used (before optimisation). SSI and SIS datasets include information if the remedial action is available to be used by the optimiser.

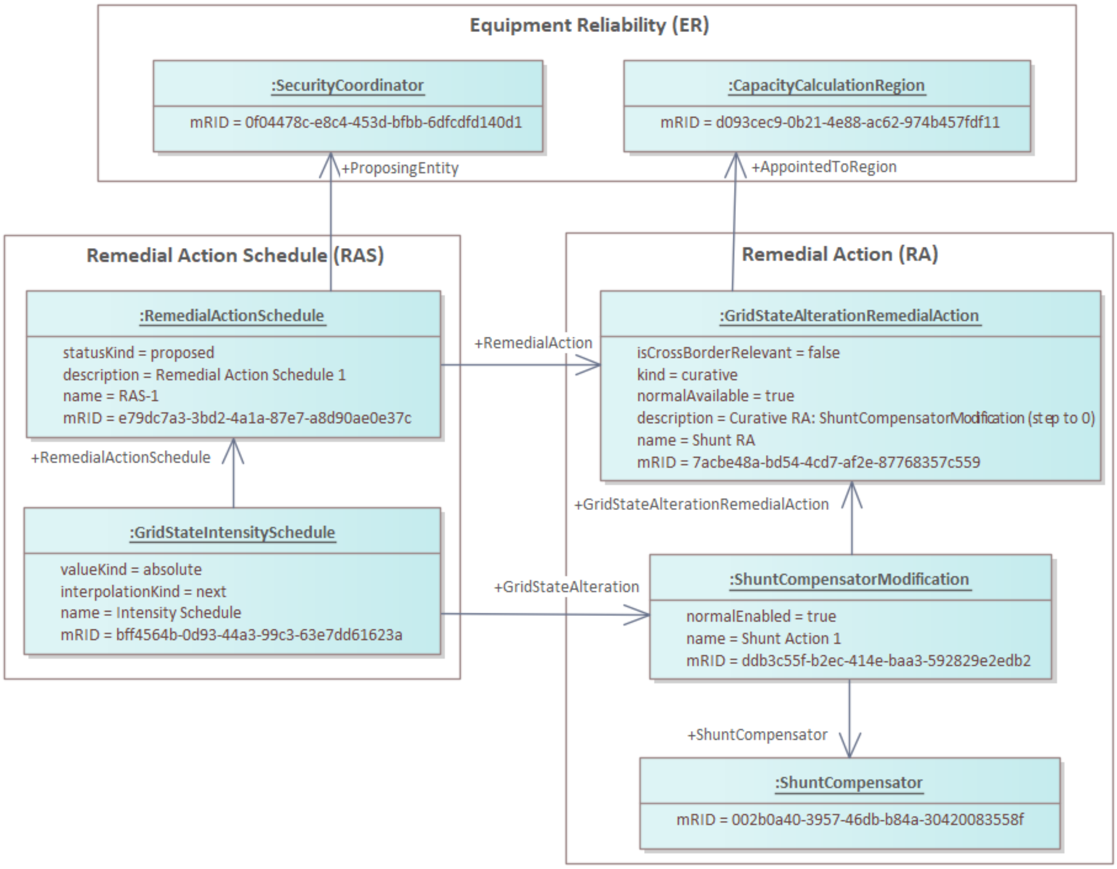


Figure 84 – Proposed Remedial Action Schedule – Grid Intensity

The corresponding Remedial Action Schedule dataset example can be found in ReliCapGrid in Belgovia_RAS.xml:

- GridStateIntensitySchedule rdf:ID="_bff4564b-0d93-44a3-99c3-63e7dd61623a"
- GenericValueTimePoint rdf:ID="_7dc3a232-66b2-4258-9f4a-1652bdddea8a"
- RemedialActionSchedule rdf:ID="_e79dc7a3-3bd2-4a1a-87e7-a8d90ae0e37c"

The Remedial Action dataset can be found in Belgovia_RA.xml:

- ShuntCompensatorModification rdf:ID="_ddb3c55f-b2ec-414e-baa3-592829e2edb2"
- GridStateAlterationRemedialAction rdf:ID="_7acbe48a-bd54-4cd7-af2e-87768357c559"

7.4 Remedial Action Coordination

7.4.1 Description

The Remedial Action Coordination (RAC) is performed by the Remedial Action Coordinator. The RAC subprocess is illustrated in Figure 85.

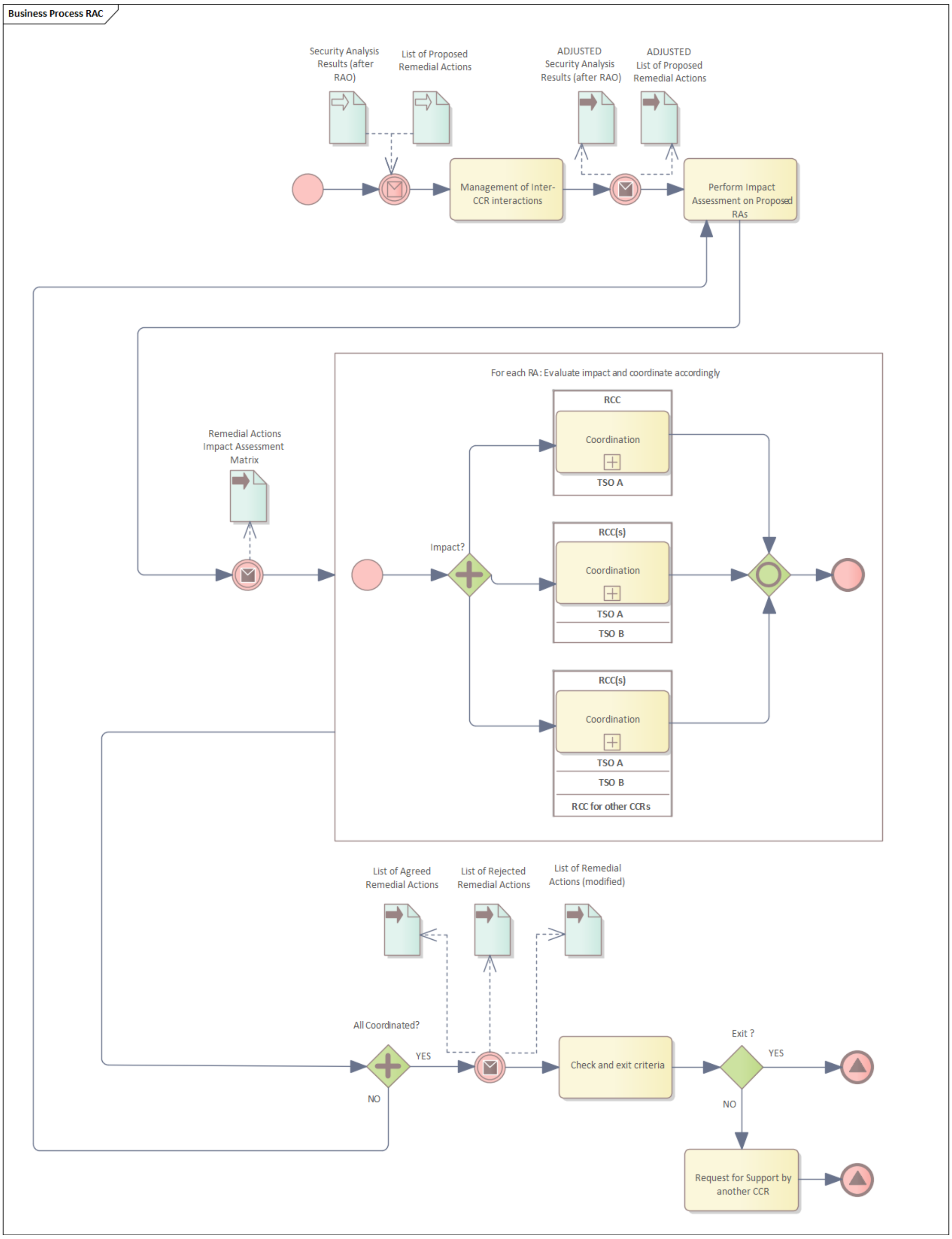


Figure 85 – Remedial Action Coordination

7.4.2 Inputs and Outputs

Table 14 – Inputs and Outputs for Remedial Action Coordination

Inputs	Outputs
List of Proposed Remedial Actions including sensitivity of Remedial Actions on Identified Constraints and costs of proposed Remedial Actions (per Remedial Action and in total)	Remedial Action Impact Assessment Matrix (with indication of impacted TSOs per RA)
Security Analysis Results (after RAO)	List of Agreed Remedial Actions
	List of Rejected Remedial Actions

7.4.3 Conformity Requirements

To be able to support remedial action coordination the Application shall conform to the following Application functions:

- Coordination Confirmation.

7.4.4 Decision about accepted/refused remedial actions for RAC

TSOs will coordinate their remedial action schedule using the *RemedialActionSchedule* dataset. For this matter the *Network Code Profiles* offer the *RemedialActionScheduleResponse* class.

To be able to follow the explanation below, please refer to the classes shown in an extract presented in Figure 86.

From an RCC perspective, it is important to keep in mind that there are two main levels of coordination for remedial actions impacting TSOs:

- Firstly, at individual TSO level, every TSO assesses a certain remedial action.
- Secondly, at RCC level the *coordinated* status considers the assessments from different impacted TSOs per remedial action.

Specifically, when an individual TSO rejects a remedial action (schedule), they can provide the reason for rejection using the optional *rejectionReasonKind* attribute following the *RejectionReasonKind* enumeration within the RemedialActionScheduleResponse[12] class.

Additionally, and only when rejecting, TSOs can provide further details on the rejection reason making use of the free-text attribute *rejectionReason* in the *RemedialActionScheduleResponse* class to complement the *rejectionReasonKind* information.

When TSOs are instantiating *RemedialActionScheduleResponse* object, every time new response is communicated, it shall have unique identifier exchanged via mRID attribute.

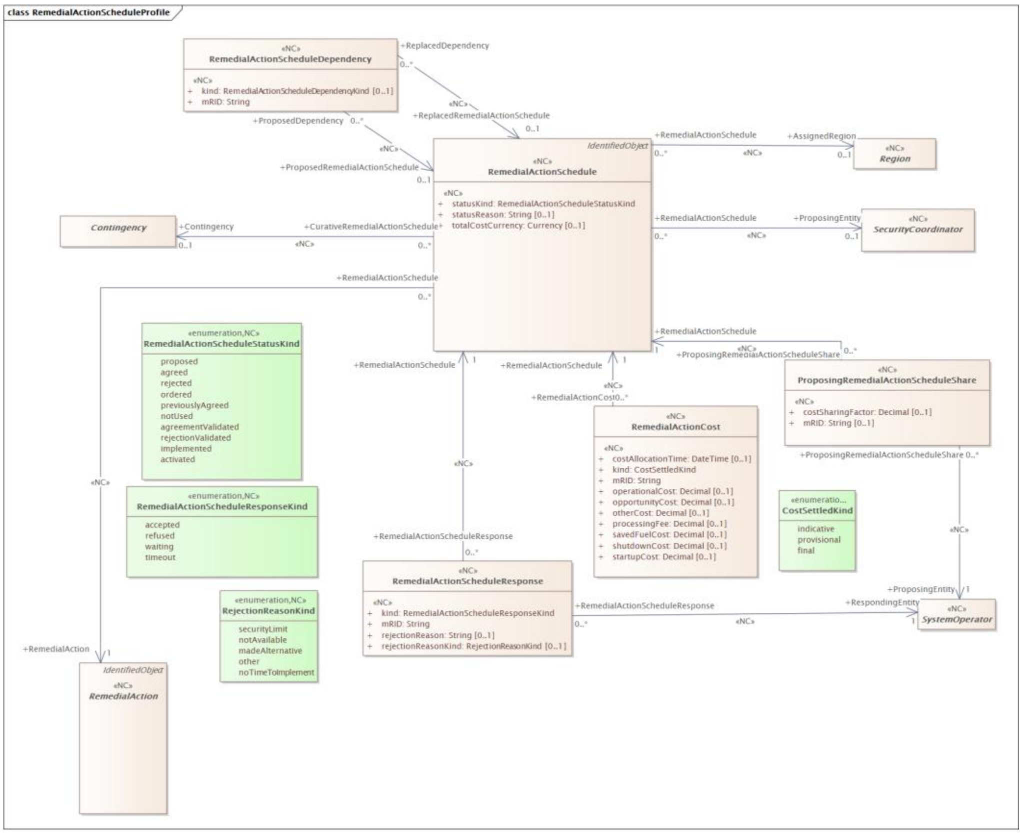


Figure 86: Extract of the RemedialActionScheduleProfile diagram showing RemedialActionScheduleResponse related objects

12 In previous versions of the NCP, this class was named *RemedialActionScheduleAcceptance*.

When communicating the response there is no need to exchange *RemedialActionSchedule* object. A new instance of *RemedialActionSchedule* object is only required in cases where a TSO would like to make a different proposal for this schedule. In that case, the new instance of *RemedialActionSchedule* object shall have a new identifier. However, the link to the *RemedialAction* object is kept persistent as long as the proposal relates to the same *RemedialAction* object.

An example of remedial action schedule acceptance upon the completion of the coordination process can be found in ReliCapGrid in 2D_IAM_0530Z_IAM_.xml:

- RemedialActionScheduleOutcomeValue rdf:ID="_ac45dd32-c3de-49d3-9664-689b5a762fd5"

The corresponding dataset example can be found in ReliCapGrid in Belgovia_RAS.xml:

- RemedialActionSchedule rdf:ID="_742acf52-139c-4c8f-a90c-a2090de6a619".

Another example of remedial action schedule rejection upon the completion of the coordination process can be found in ReliCapGrid in 2D_IAM_0930Z_IAM_.xml:

- RemedialActionScheduleOutcomeValue rdf:ID="_9f16db8d-3c1f-4fe8-b22f-51e223c89694"

The corresponding dataset example can be found in ReliCapGrid in Belgovia_RAS.xml:

- RemedialActionSchedule rdf:ID="_e79dc7a3-3bd2-4a1a-87e7-a8d90ae0e37c".

7.4.4.1 TSO response (accepting or refusing without counter proposal) to an RCC proposal: Use of *StatusKind*

The following paragraphs summarise a simple remedial action coordination (RAC) interaction between an RCC and one TSO. Readers can consult the expected use cases ENTSO-E plans to further expand in the future in section 7.4.7.

Figure 87 depicts the data exchange of a simple case where a TSO responds (accepting without a counter proposal) to an RCC proposal:

1. The RCC sends the TSO a proposed *RemedialActionSchedule* (RAS) dataset (the output from RAO).
2. The TSO responds accepting with another RAS dataset.

When the TSO wishes to respond (i.e., accept, reject,.) a remedial action scheduling using the *RemedialActionResponse* class, one step is to use the *kind* attribute making use of the *RemedialActionScheduleResponseKind* enumeration and link the information with the *RemedialActionSchedule* class.

Complementary, the following paragraphs aim at explaining what the added value of the *statusKind* attribute in the class *RemedialActionSchedule* is.

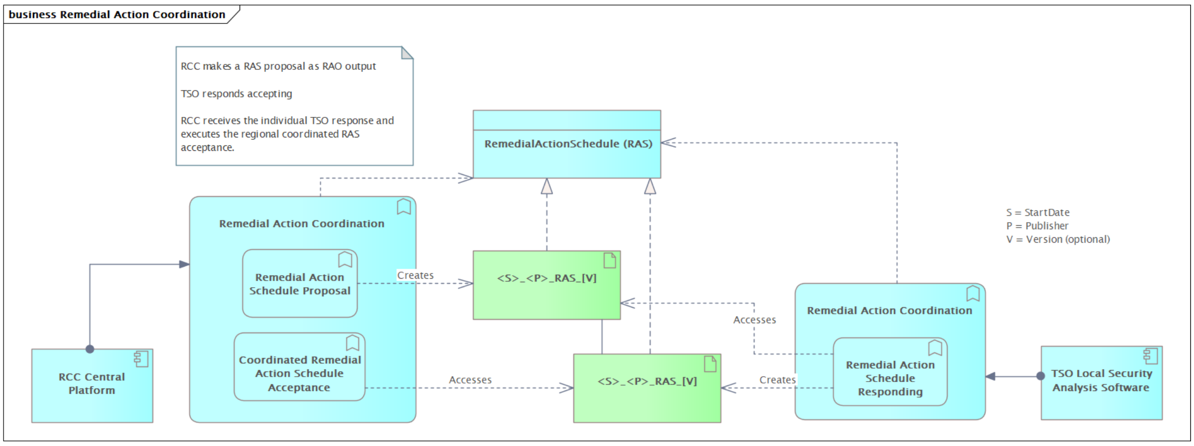


Figure 87: Exchange of information for simple RAC (TSO accepts RCC proposal – without counter proposal)

More in detail, Figure 88 and Figure 89 offer an example of the use of CIM classes and the header dataset where a fictitious RCC "Jotunheim" (playing the role of *Security Coordinator* or *SC*) interacts with a fictitious TSO "Espheim" for accepting or refusing a proposed RAS respectively.

As readers can appreciate, the RCC indicates:

- That the RAS dataset (identifier = d49bdfbe-99e8-4f89-bda8-9600975402da) is a proposal making use of the linked *RemedialActionSchedule* class, setting its *statusKind* attribute to *proposed.*

  - The RemedialActionSchedule is defined with its identifier 4a9d1cd3-2838-476b-99a8-11c276c92d52.
  - The *RemedialActionSchedule* association with *RemedialAction* is defined with the identifier c9c76af9-c11e-49ad-854c-760292b59a6e
- Optionally, the RCC indicates that the TSO has not yet validated the proposal making use of the linked *RemedialActionScheduleResponse* class, setting its *kind* attribute to *waiting*.

The TSO produces a response to the RCC RAS dataset proposal. The RAS dataset the TSO produces has a new identifier c3540e4a-b397-4ce9-8443-112bbf90d725. Note that the TSO does not modify the RemedialActionSchedule.statusKind attribute (set to *proposed*) from the previous RAS dataset the RCC sent. This is because the proposal is yet under coordination at RCC level.

Afterwards, the TSO indicates[13] their response instantiating a RemedialActionScheduleResponse class:

- Figure 88 shows a RemedialActionScheduleResponse class with identifier 2b468ef3-0ef8-484b-91e1-dc8acefcf7f7.
  - The example shows that the TSO accepts the proposed RAS dataset making use of the linked *RemedialActionScheduleResponse* class, setting its kind to *accepted*.
    - More in detail, this is done pointing to the value in the ReferenceData dataset: *https://cim4.eu/ns/nc#RemedialActionScheduleResponseKind.accepted*)
  - The remedial action schedule the TSO accepts is the one contained in the RCC proposed RAS dataset. This is indicated with the association between the RemedialActionScheduleResponse.RemedialActionSchedule which points to the RemedialActionSchedule class with identifier 4a9d1cd3-2838-476b-99a8-11c276c92d52 in the RCC dataset.
- Figure 89 shows RemedialActionScheduleResponse class with identifier 1e11da6f-7313-417f-b263-823472977e34.
  - The example shows that the TSO refuses (without counter proposal) the proposed RAS dataset making use of the linked *RemedialActionScheduleResponse* class, setting its kind to *refused*.
    - More in detail, this is done pointing to the value in the ReferenceData dataset: *https://cim4.eu/ns/nc#RemedialActionScheduleResponseKind.refused*)
  - Again, the remedial action schedule the TSO refuses is the one contained in the RCC proposed RAS. This is indicated with the association between the RemedialActionScheduleResponse.RemedialActionSchedule which points to the RedualActionSchedule with identifier 4a9d1cd3-2838-476b-99a8-11c276c92d52 in the RCC dataset.

[13] TSOs also have the possibility of only including the *RemedialActionScheduleResponse* class in their response RAS dataset.

    - Additionally, the TSO added the reason of rejection making use of the linked *RemedialActionScheduleResponse* class. In this example, the TSO decided to set the *rejectionReasonKind* attribute to *RejectionReasonKind.other* and complement with a free text reason using *RemedialActionScheduleResponse.rejectionReason*.

Once all impacted TSOs finalise their individual assessments of the proposed RAS, the RCC may change the *statusKind* attribute (i.e., to *agreed*) as a result of the regional coordination.

Readers might like to pay attention to the meaning of the header items in Figure 88 and Figure 89:

- TSOs shall refer to the RCC proposal in their response by using *dcterms:references* and maintaining the RCC dataset mRID (in this example d49bdfbe-99e8-4f89-bda8-9600975402da).
- However, because the TSO creates the response RAS dataset, both *dcat:isVersionOf* and *dcterms:publisher* point to the TSO “Espheim”.
    - The item *dcterms:publisher* clearly states which actor provided the dataset.
- The use of *generatedBy* (not shown in the example) is reserved for the *activity* that created the dataset. Though the activity reference data (the “values” the attribute may take) is still not fully standardised in the CommonData dataset, TSOs can use this item to better distinguish between proposed and responded RAS datasets. For instance:
    - CGM-RAS/PRO-RAS (PRO = proposed RAS)
    - IGM-RAS/RES-RAS (RES = response RAS)

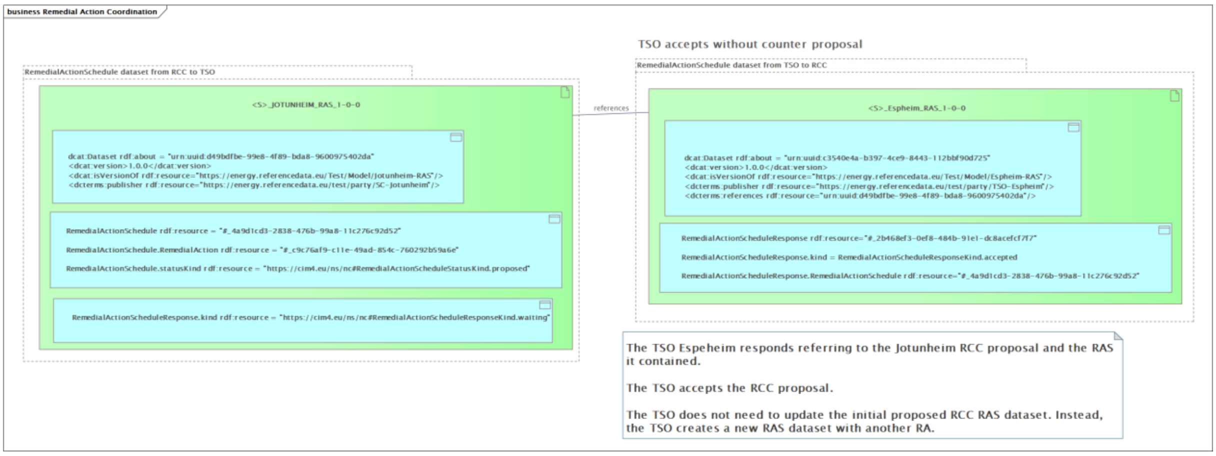


Figure 88: Additional detail on the use for simple RAC (TSO accepts RCC proposal – without counter proposal)

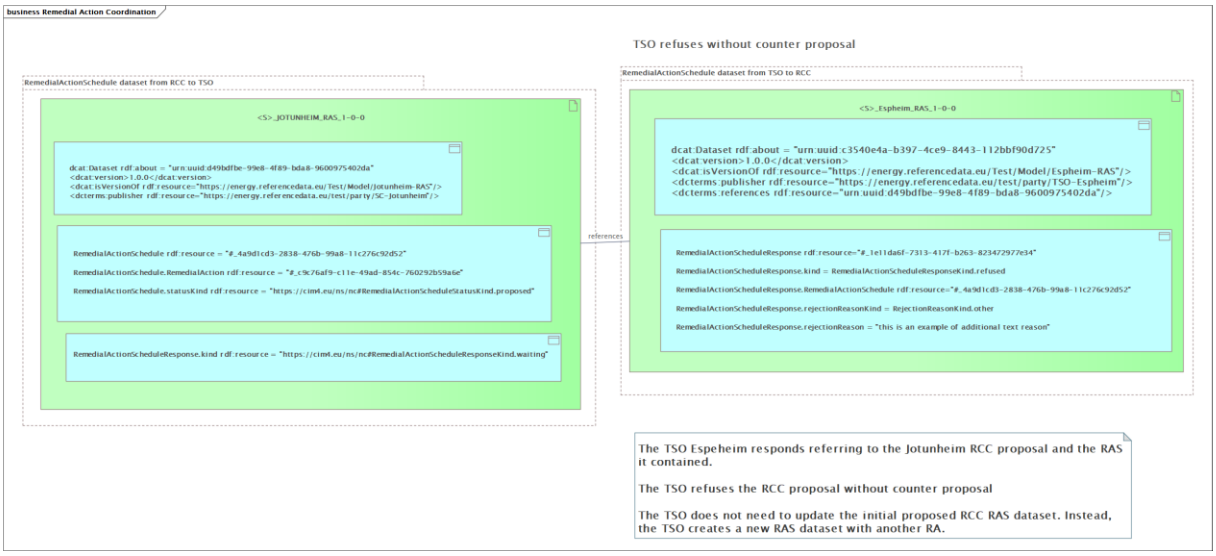


Figure 89: Additional detail on the use for simple RAC (TSO refuses RCC proposal – without counter proposal)

The later paragraphs described the exchange of information directly by updating new datasets in XML. However, other implementations of this process might be realised.

More specifically, in Core CCR, TSOs may provide RAS response information in two ways: through user interface in the RCC regional platform and/or—as described above—by exchanging NCP datasets in XML.

This example will be integrated in the open-source ReliCapGrid test model in future releases of the RCP DES.

7.4.4.2 TSO response (refusing one proposal with one counter proposal) to an RCC proposal

After assessing the RAS dataset, the RCC proposes as an output from RAO, a TSO might also reject. In this case, the TSO shall refuse the complete schedule and not individual timestamps.

The following lines and Figure 90 explain how TSO can create another schedule proposal in the form of a *new/updated* RAS dataset.

It is relevant to distinguish the separation between the RAS dataset that the RCC proposes which becomes *old/outdated* after the TSO rejects it and the *new/updated* RAS dataset that the TSO creates as a counter proposal.

TSOs would not need to share back the *old/outdated* RAS dataset, meaning that the TSO would not need to update the status of such schedule.

With this logic, the proposed schedule alternative would be represented the *new/updated* RAS dataset using the *RemedialActionSchedule* class. TSOs would need to use the value of the attribute *statusKind* and its value to *proposed* when sharing the counter proposal information with the RCC.

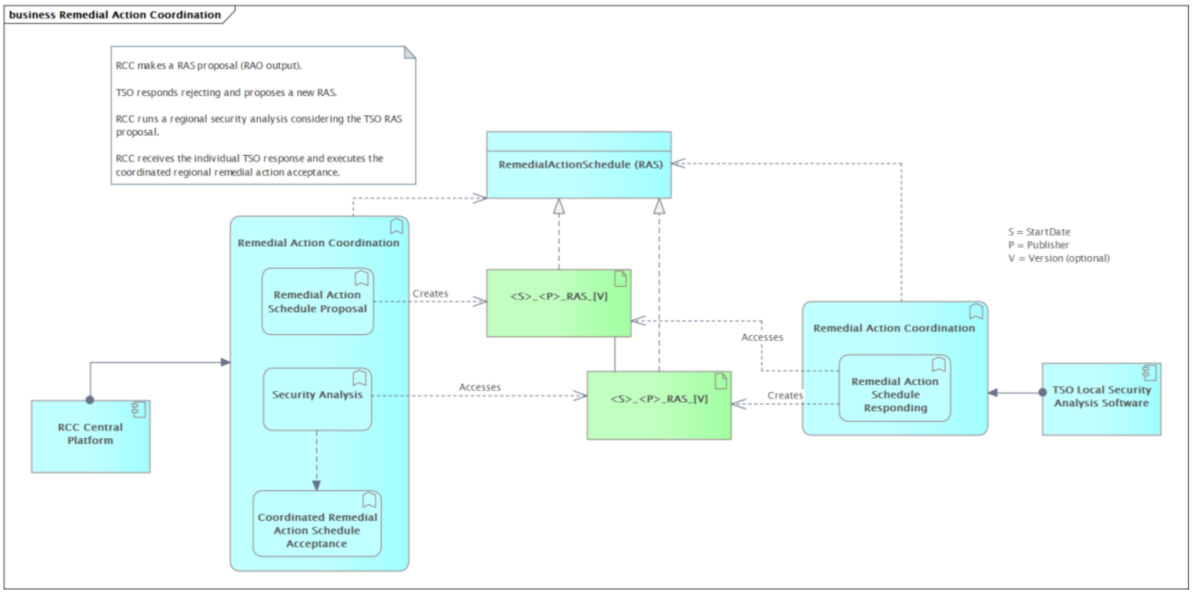


Figure 90: Exchange of information for simple RAC (TSO rejects RCC proposal – with counter proposal)

The Figure 91 offers additional detail on the recommended use of the CIM classes and header attributes. Readers may remark:

- The RCC proposed RAS dataset is the same as in section 7.4.4.1.
- The TSO does may not reference to the RCC proposed RAS dataset (no use of the *dcterms:references* in the header).
- The TSO indicates their response to the RCC proposition using the *RemedialActionScheduleResponse* class.

  - The TSO creates a RemedialActionScheduleResponse class (in this example with identifier 5c6632b3-9772-4d44-8a85-97822c77a0be)
  - The TSO indicates they refuse the proposal using the kind attribute and setting it to *refused* (pointing to this value in the ReferenceData dataset: [*https://cim4.eu/ns/nc#RemedialActionScheduleResponseKind.refused*](https://cim4.eu/ns/nc#RemedialActionScheduleResponseKind.refused))
  - The TSO indicates the original RCC proposal using the association between RemedialActionScheduleResponse and RemedialActionSchedule, and pointing to the original RCC proposed RAS (in this example, with identifier 4a9d1cd3-2838-476b-99a8-11c276c92d52)
  - The TSO indicates that they are the responding entity using the association between the classes *RemedialActionScheduleResponse* and *SystemOperator* called *RespondingEntity*.
    - The values of SystemOperator are defined in the ReferenceData dataset. In this example, it takes [*https://energy.referencedata.eu/Test/Party/TSO-Espheim*](https://energy.referencedata.eu/Test/Party/TSO-Espheim).
- The TSO proposes a new remedial action schedule and refers to it using its identifier (in this example, 8a0c42ab-e3f0-4576-9f03-3636aabf9184)
  - The TSO proposes a new remedial action using the association with between the classes *RemedialActionSchedule* and *RemedialAction* (in this example, d856a2a2-3de4-4a7b-aea4-d363c13d9014)
  - The TSO does not modify the RemedialActionSchedule.statusKind attribute (set to *proposed*) from the previous RAS dataset the RCC sent. This is because yet under coordination at RCC level.

Reader might note that the RCC still needs to coordinate the acceptance of the TSO RAS counter proposal with other impacted TSOs. Once this is done, the RCC may set *RemedialActionSchedule.statusKind* to *agreed.*

This example will be integrated in the open-source ReliCapGrid test model in future releases of the RCP DES.

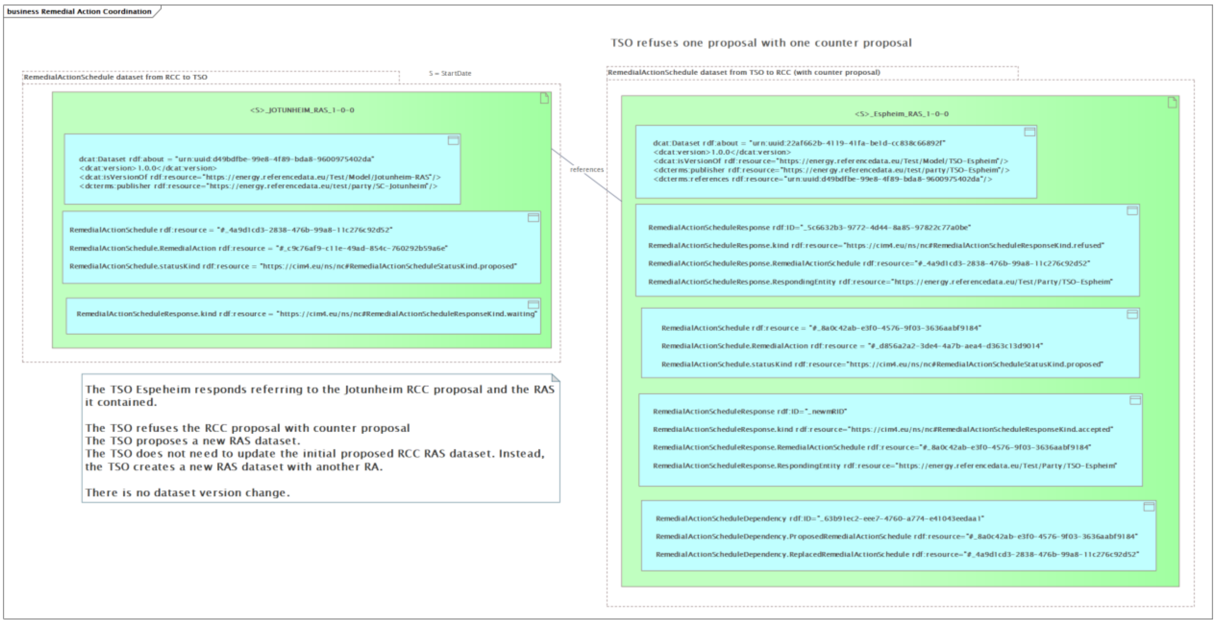


Figure 91: Additional detail on the use for simple RAC (TSO rejects one RCC proposal – with one counter proposal)

7.4.5 Remedial Action Schedule – Grouping

There are multiple use cases where the usage of grouping of remedial action schedules is necessary. The following figures illustrate two possible scenarios of grouping. In the figures RA is the RemedialAction, RAS – RemedialActionSchedule, RASG – RemedialActionScheduleGroup, RASD - RemedialActionScheduleDependency

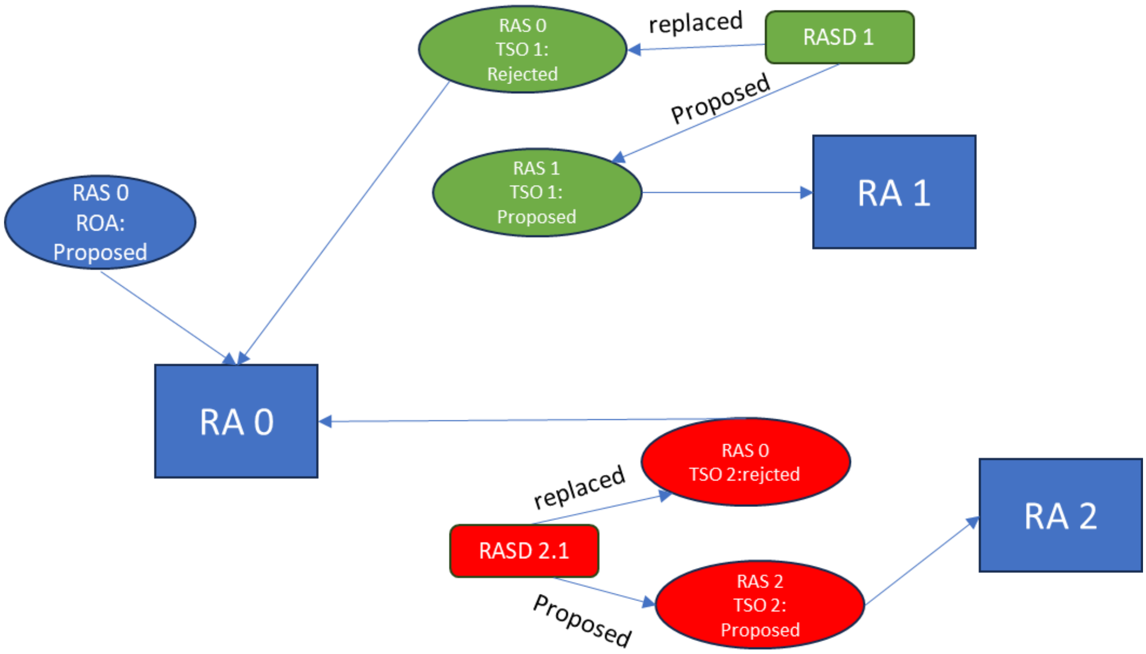


Figure 92 – Remedial Action Schedule Relationship without using the Group

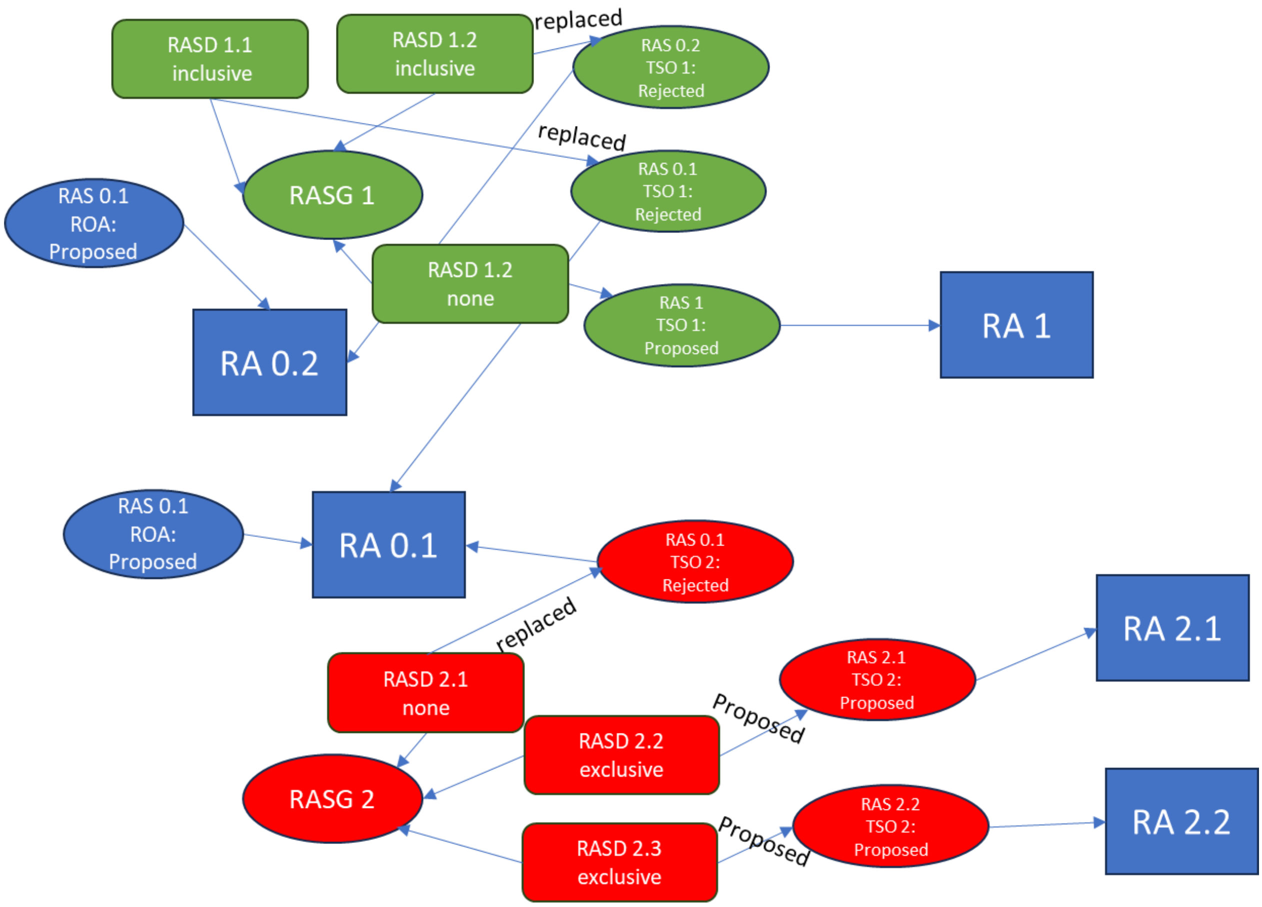


Figure 93 – Remedial Action Schedule Relationship within a Group

These two options of grouping and expressing dependency allow full flexibility and ability to express which remedial action schedules were rejected and that are the proposed alternatives in a complex process where proposals can reject previous proposals and alternative remedial actions can be scheduled.

An example of the concepts exposed above will be integrated in the open-source ReliCapGrid test model in future releases of the RCP DES.

7.4.6 Remedial Actions agreed in Fast Activation Process (FAP)

The ACER Decision 33/2020 (Annex II ROSCm) and the South West Europe (SWE) National Regulatory Agencies (NRAs) decision on 3 December 2020 (refer to the French CRE and the Spanish CNMC) define the *Fast Activation Process* (FAP).

The FAPs is a risk-based and specific process designed to address operational constraints in the power system. It is triggered when TSOs identify an issue that cannot wait until the next CROSA (Cross-Regional Operational Security Assessment) as shown in Figure 94. These issues may include congestion, dynamic stability problems, or other operational constraints that require immediate action.

The FAP is not done for all the region of Core, but only between FAP requester, FAP connected and FAP impacted TSO. The process as of now is not based on automated determination of Remedial Actions but based on local TSO assessment or common tool assessment of Remedial Actions.

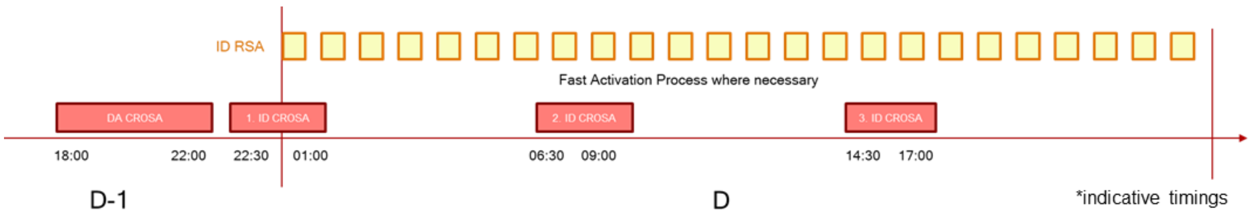


Figure 94: Representation of the Fast Activation Process

7.4.6.1 Process overview

In a nutshell, the FAP process could be summarised in the following steps in the framework of the Core TSOs implementation.

1. **Detection (Triggering Conditions)**

- Within the ROSC framework, TSOs conduct at least three intraday CROSAs and an hourly security assessment.
- If an issue arises in between CROSAs that cannot be resolved within the normal scheduling intervals, the **FAP is activated** to mitigate the risk.
- An example of such the reasons why an issue could arrive are:
  - Incorrect forecast,
  - Unplanned outage,
  - Unavailability of agreed RA

2. **Methods of Activation**

- Using the Common ROSC Platform in Study Mode:

  - The platform may act as a simulation tool, allowing TSOs to explore possible solutions and coordinate actions with impacted parties.
- Bilateral Coordination (Outside the Platform):
  - If a TSO chooses not to use the common platform, coordination occurs through direct bilateral calls with other TSOs.

3. **Communication & Information Sharing**

- When the process is conducted outside the common platform, certain information must still be shared to ensure all relevant parties remain aware of the ongoing situation.
- Communication between the platform and TSOs currently relies on Network Code profiles. Efforts are ongoing to improve the modelling of communication requirements for better integration.
- Core TSOs need to report the triggering of the FAP. Some TSOs could use the regional platform and some other may choose to use the Network Code Profiles to provide the information.

The CIM WG collaborates with TSOs to offer modelling recommendations for the FAP in future releases of this data exchange specification.

7.4.7 Expected Use Cases

Table 15: Expected Use Cases for Remedial Action Coordination

Name	Description	Comment
TSO response (refusing one proposal with multiple counter proposals) to an RCC proposal	The RCC sends the proposed RAS dataset as output of the RAO. One TSO rejects the proposal and sends multiple counter proposals. The RCC runs a security analysis and assess whether to accept the counter proposal.	When a TSO is refusing a certain proposed remedial action schedule, TSOs may suggest an alternative remedial action schedule to implement.
TSO response (refusing multiple proposals with one counter proposals) to an RCC proposal	The RCC sends the proposed RAS dataset as output of the RAO. One TSO rejects multiple proposals and sends one counter proposal. The RCC runs a security analysis and assess whether to accept the counter proposal.	When a TSO is refusing a certain proposed remedial action schedule, TSOs may suggest an alternative remedial action schedule to implement.
TSO response (refusing multiple proposals with multiple counter proposals) to an RCC proposal	The RCC sends the proposed RAS dataset as output of the RAO. One TSO rejects multiple proposals and sends multiple counter proposals. The RCC runs a security analysis and assess whether to accept the counter proposal.	When a TSO is refusing a certain proposed remedial action schedule, TSOs may suggest an alternative remedial action schedule to implement.

7.5 Final Validation

7.5.1 Description

The Final Validation session is performed by the Remedial Action Validator. The subprocess is illustrated in Figure .

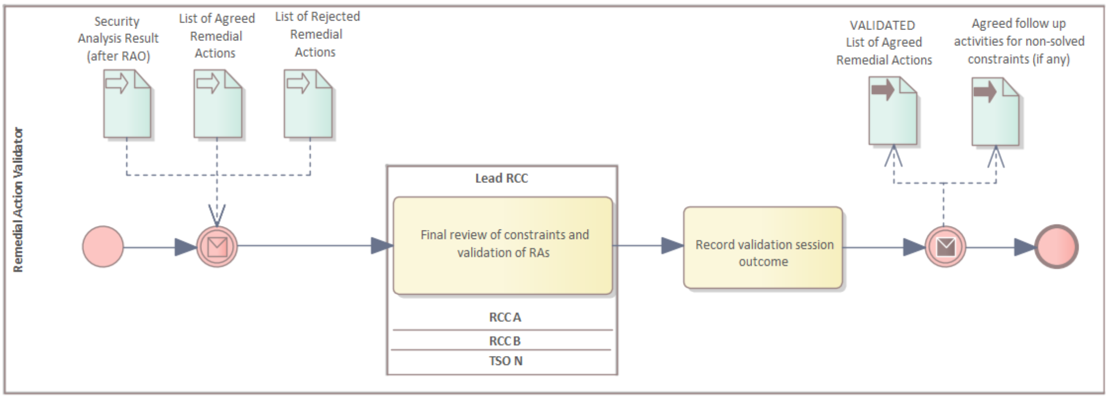


Figure 95 – Final Validation session

7.5.2 Inputs and Outputs

Table 16 – Inputs and Outputs for Final Remedial Action Validation

Inputs	Outputs
Outcome of RA agreement process (agreed remedial actions and their schedule)	Validated and potentially updated Remedial Action Impact Assessment Matrix (with indication of impacted TSOs)
Security Analysis Results (after RAO)	Agreed follow-up activities for non- solved Identified Constraints, if any

An example of the Impact Assessment Matrix can be found in ReliCapGrid in 2D_IAM_1030Z_IAM.xml:

- ImpactAssessmentMatrix rdf:ID="_563b0d83-4a34-4872-9ee6-9d6b5c2a2649"
- RemedialActionOutcomeValue rdf:ID="_8dab8093-2c8e-4c9d-8bb7-7026e5e6bfba"
- RemedialActionScheduleOutcomeValue rdf:ID="_c2283787-a017-47a2-a594-6bda53334fd0 ".
- The corresponding RemedialAction dataset example can be found in ReliCapGrid in Belgovia_RA.xml:GridStateAlterationRemedialAction rdf:ID="_5e5ff13e-2043-4468-9351-01920d3d9504"
- TapPositionAction rdf:ID="_bf7f0ef4-dad3-4322-b2be-5ace59837e60 "
- The corresponding RemedialActionSchedule dataset example can be found in ReliCapGrid in Belgovia_RAS.xml:RemedialActionSchedule rdf:ID="_742acf52-139c-4c8f-a90c-a2090de6a619".

The corresponding Security Analysis Result dataset example can be found in ReliCapGrid in 2D_SAR_1030Z_Jotunheim.xml:

- ContingencyPowerFlowResult rdf:ID="_ea1eebe0-7e5e-46c1-8cf6-af110484adf3"
- BaseCasePowerFlowResult rdf:ID="_b1d6ec9a-76d3-4162-b19a-99b09fcd80fa"

The corresponding Contingency dataset example can be found in ReliCapGrid in Belgovia_CO.xml:

- OrdinaryContingency rdf:ID="_7e31c67d-67ba-4592-8ac1-9e806d697c8e"
- ContingencyEquipment rdf:ID="_7ec56068-a714-4445-ae19-dd34429ec722".

The corresponding Steady State Hypothesis dataset example can be found in ReliCapGrid in 2D_Belgovia_SSH_1.xml:

- CurrentLimit rdf:ID="_b8fa5795-2fb2-3a9f-af51-44051d9face7".

7.5.3 Conformity Requirements

To be able to support final validation the Application shall conform to the following Application functions:

- Coordination Confirmation.

8 Application profile specification

8.1 General

Network codes related business process rely on data exchange standards to exchange the information on power system models as well as the relevant additional information specific for business processes. The set of information used by a business process is complex and has many interdependencies.

In addition, the complexity is amplified by the requirement that this set of information needs to be used by multiple business processes as long as the timeframe (day ahead, two days ahead, etc.) and timestamp (e.g. particular hour in a day ahead timeframe) are the same. The requirements on this are set forth in the Network Codes related EU Regulations and Guidelines.

The following clarifications are important in order to have a common understanding on the types of data that is being exchanged and what data exchange standards or specifications are used to exchange it.

- IGM (Individual Grid Model) is a term defined in CACM[14]. Other network codes and methodologies refer to it. Additional requirements are specified by other network codes and business process methodologies.
- The IGM is the building block to create a common grid model (CGM) which is used to perform business processes for a particular timestamp of a timeframe. It is prepared by the modelling authority responsible for the power system.
- CGM (Common Grid Model) is a term defined in CACM. Other network codes and methodologies refer to it. A CGM includes all IGMs.
- IGMs and a CGM represent the power system, its connectivity and essential characteristics for the purpose of conducting power flow calculations (as a minimum requirement). This comes with all details related to the power system model, e.g. what portions of the grid are present, which data relates to the alternated current (AC) part of the power system or direct current (DC) part of the power system, etc. The IGMs and CGMs data exchange is covered by some of the profiles defined by the IEC CGMES which is a standard that defines various profiles used in the data exchange.
- The creation of IGMs, their collection and merging in CGMs is performed in the CGM Build process.
- The term “All relevant data” is used to describe all information that is exchanged in addition to the CGMs and serves needs of different business processes, i.e., CCC, CSA, OPC and Regional STA. This information includes structural, scheduled and per market time unit data related to modelling of remedial actions, contingencies, assessed network elements, availability plans (outage planning information), etc. The content of this data is a superset of the requirements by all business processes that rely on CGMs of a particular timestamp of a timeframe. This information exchange is covered by ENTSO-E Network Codes profiles. Additional data such as data to support short circuit calculations, geographical location information, diagram layout related

[14] Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.

information, dynamics data can also be added, if necessary. The IEC CGMES or other standards (e.g. IEC 61970-457 for dynamics and simulation settings) can be used to exchange this information.

- It is expected that all data delivered as IGM, CGM and All relevant data are consistent and conform to both the specifications defined in the data standards and business constraints that can be defined at pan-European or regional level. Data providers need to ensure this as CGM Build process cannot guarantee the consistency due to the fact that not all data is available in the CGM Build process.
- Consistency validation between ”All relevant data” and a CGM is performed as part of the business process that will use all data and can only result in invalidating “All relevant data” (i.e., it cannot invalidate a CGM) which may lead to limiting the scope of the business process. It is not expected that the CGM Build process is restarted to remedy such inconsistencies. IGM and CGM improvements can be performed during the CGM Build process.

The CSA needs information on remedial actions, assessed elements, contingencies, etc in order to complete the data needed to perform the coordinated security analysis. The all relevant data for CSA is supplied by the following profiles:

- Assessed element profile
- Availability schedule profile
- Contingency profile
- Equipment reliability profile which includes SIPS configuration, security limits, Power Transfer Corridor
- Grid disturbance profile
- Impact assessment matrix profile
- Monitoring area profile
- Object registry profile
- Power schedule profile
- Power system project profile
- Remedial action profile
- Remedial action schedule profile
- Security analysis result profile
- Sensitivity matrix profile
- State instruction schedule profile
- Steady state hypothesis schedule profile
- Steady state instruction profile

8.2 Dataset Dependency

The dataset dependency is illustrated in Figure . The diagram contains most used datasets conforming to different profiles but not necessarily all profiles. Therefore, for additional dependencies between datasets based on CGMES profiles not shown in the diagram, the dependencies provided in the CGMES are followed.

Note that the RAS profile dataset is exchanged as a schedule and not per time unit.

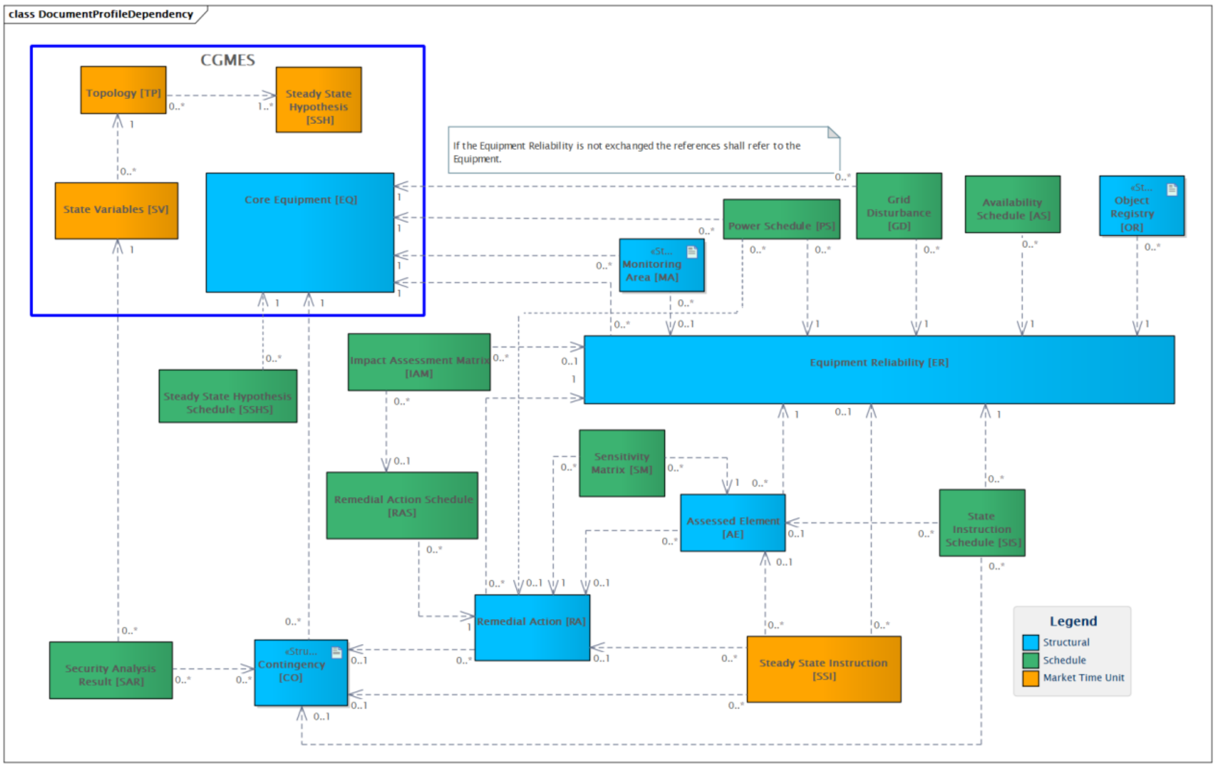


Figure 96 – Dataset dependencies

8.2.1 Dataset Metadata (Header)

Information on dependencies between datasets is provided by the attribute dcterms:references in the dataset metadata. This attribute is part of the ENTSO-E “Metadata for dataset and distribution specification” (refer to the ENTSO-E CGMES Library for the latest version).

The header vocabulary contains all attributes defined in IEC 61970-552 and extended attributes to facilitate transition process for data exchanges that are using IEC 61970-552:2016 header. The updated header definitions rely on W3C recommendations which are used worldwide and are positively recognised by the European Commission.

RCP DES does not use IEC 61970-552:2016 header attributes and relies only on the extended attributes in the ENTSO-E document. SHACL based constraints provided by ENTSO-E as application profiles define required cardinalities for attributes part of the dataset header.

8.3 Compatibility with Other Data Exchange Standards

NC profiles have been designed and developed as extension to the version of CIM used by CGMES v3.0 (IEC 61970-600-1 and -2:2021). In general, they partially are compatible with CGMES v2.4 (IEC TS 61970-600-1 and -2:2017) to the extent present in both CGMES v3.0 and v2.4.

This means, there are model incompatibilities (due to bug fixes in v3.0 and clear documentation of intent), namespace incompatibilities (due CIM17 vs. CIM16 change), as well as serious limitations in scope if underlying model remains on CGMES v2.4. Therefore, the following attention points shall be noted:

- If CGMES v2.4 is used to represent the IGM and CGM the remedial action cannot efficiently model power electronics and battery units as these objects are only available in CGMES v3.0. This also includes modelling limitation of representing control functions that have direct impact on the power flow calculation.
- The information about the operational limits is exchanged in the equipment instance data in the case of CGMES v2.4 based data exchange. Therefore, when there is a need to frequently update the information on the limits, this will require that equipment data is exchanged more frequently or that difference equipment profile shall be used to optimize the data exchange. This limitation does not occur if the IGM and CGM are using CGMES v3.0 as the operational limits is exchanged in the steady state hypothesis dataset.
- In order to achieve an optimal information exchange, it is assumed that persistent identifiers are used for the IGM and CGM objects. Applying datasets based on NC profiles as add-on to an exchange which does not rely on persistent identifiers is neither feasible nor practical for any downstream process relying on CGM.
- Handling of topology remedial actions, power transfer corridors and their limits, SPS, require more detailed underling model. As CGMES v2.4 has clarity gaps in the modelling of hybrid node breaker and bus branch models work arounds are not straight forward. In addition, SOGL and CSAm detail the requirement of using node-breaker model and defining topology as the data concerning the connectivity of the different transmission system or distribution system elements in a substation and includes the electrical configuration and the position of circuit breakers and isolators.

The usage of UCTE DEF as a data exchange format for IGM and CGM for the purpose of CSA, CCC, OPC, STA processes is not recommended in conjunction with NC set of profiles, for the following non-exhaustive list of reasons (to name a few):

- NC profiles metadata require linkage with the IGM and CGM. UCTE DEF models are identified by file name. Therefore, an additional metadata layer must be added.
- NC profiles require references to identifiers of the elements from IGM in order to link the remedial actions, assessed elements, etc. UCTE DEF used node codes and circuit numbers (for interconnecting elements) in order to uniquely identify them. Therefore, if UCTE DEF is used there will be a need to maintain a list of persistent identifiers and their relationship with node names or elements names.

- CSA requires information on different operational limits that are related to the different time phases to be studied. UCTE DEF has very limited capabilities to exchange limits.
- Due to the scope of the UCTE DEF the business processes would be limited in terms of what kind of grid state alterations and remedial actions could be described and considered in the coordination process. Identification of type and modelling of the network elements that support voltage control, shunt-connected reactive devices, voltage regulation on transformers in case of regulator being modelled on the non-regulated power transformer end, will require special attention as they are not in scope of UCTE DEF and will be impossible to model without extending UCTE DEF.
- Generation capacity used as part of remedial actions should be modelled in detail due to limits handling in case of aggregated modelling.
- UCTE DEF does not separate the information related to the equipment, the information related to the operating point and it also does not cover the solution information. Data consistency changes between data exchanged with NC profiles and UCTE DEF data will be more extensive (full model exchange), have high dependencies over mapping tables that have to be integrated in the middleware, and will not benefit from using one equipment model for multiple time stamps.
- UCTE DEF does not allow exchange of power flow solution data, therefore this report will have to be standardized (out of scope of this document) to achieve full information exchange.
- Use of replaced IGM in created CGM is not possible to trace in case of UCTE DEF, that might complicate the process of data consistency against the grid models and remedial action applicability.

Therefore, it is highly recommended that business processes plan for a transition to always rely on latest data exchange standards and specifications in order to benefit from the consistency at profile level (data exchange definition level) and be able to achieve business objectives without being constraint by the data exchange.

8.4 Common and Reference Data

In the context of RCP DES metadata is the following categories of data:

- Common data: a set of data that is common for datasets from different publishers. It is stable data that is kept mainly among TSOs community.
- Reference data: a set of data that is part of taxonomy. It includes necessary minimum and it is stable data that is reachable via URL. It can be defined by ENTSO-E or other bodies and everybody, even outside TSO community can use it.
- Dataset header: metadata that is exchanged as part of the dataset distribution to provide necessary minimum of information.

Both common data and reference data have stable identifiers and are maintained following strict process. The key point with reference data and common data is that they are managed in processes that are outside the process that are in focus, i.e. they are shared across several business processes and among different parties, they are external to any one specific business process, and well-defined coordination is required.

Applications implementing NC related data exchanges shall support the metadata and manage the linkage with datasets conforming to CGMES and NC profiles.

8.4.1 Common Data

Common data is normally maintained outside specific business process as it is valid for multiple business processes. In general, there could be a portion of common data that is common for all publishers within a business process, but this should be rather an exception. For instance, in data exchanges using NC profiles, the following common data is foreseen:

- Synchronous Area
- Organisation and role - Transmission System Operator, Security Coordinator
- Capacity Calculation Region
- Bidding Zone Border
- Bidding Zone
- Overlapping Zone
- Base voltage (currently exchanged as boundary set, but this is being separated in the new setup)
- Any other data agreed to be treated as common data.

Therefore, the IGM creation process (delivering an IGM) and the process to prepare “All relevant data” are dependent on each other so that consistency between different datasets is ensured when datasets are prepared. Publishers (in this case TSOs) will refer to the identifiers defined in the datasets of the common data and IGM. Other parties in the process such as RCC (RAO or other systems) will also use and refer to the common data when prepare the outputs of a business process.

In general, CGMES based data exchanges will also rely on common data such as information on base voltages and other common elements that are currently added to boundary datasets. It should be noted that boundary dataset can be seen as a kind of common data. However, this dataset has a special function essential for connecting (merging) data from different publishers (TSOs, modelling authorities – in general).

Common data is serialised according to either CGMES or NC profiles. For example, Equipment profile is used for the common data related to base voltages and Equipment Reliability profile is used for capacity calculation regions data and other specified classes in this profile. Therefore, datasets based on CGMES or NC profiles will refer to common data datasets via the attribute dcterms:references in the dataset header.

A copy of ENTSO-E's public CommonData dataset can be found on the CGMES Library under the tab "Network Code (NC) profiles"

8.4.2 Reference Data

In order to have a better understanding of the metadata model, please review ENTSO-E "Metadata for dataset and distribution specification" and "ENTSO-E Boundary and reference data exchange application specification" which are available in CGMES library under the ENTSO-E website.

A copy of ENTSO-E ReferenceData dataset can be found on the CGMES Library under the tab "Boundary and Reference Data". Additionally, ENTSO-E maintains such dataset in a prototype solution called "Energy Reference Data" to host machine-readable and resolvable identifiers on ENTSO-E GitHub repository.

In general, reference data can include code list, taxonomies or resources that are maintained in other processes.

- **Code list**: A Code list is a structured and predefined set of codes or identifiers that represent specific values, concepts, or categories within a defined domain. Some Code lists are linked to the information model and are then represented as enumerators. Other code list represent process and domain specific values. An example of a simple Code list is the Confidentiality provided in Energy Reference Data SKOS Concept Schemes.
- **Taxonomy**: Taxonomy is a systematic classification or arrangement of items, concepts, or terms into hierarchical categories based on shared characteristics, attributes, or relationships. It provides a structured framework for organizing information in a way that facilitates understanding, retrieval, and communication. Taxonomies are used in various fields, including biology, information science, knowledge management, and content organization, to create a logical and standardized structure for categorizing and organizing diverse elements. An example of a taxonomy is FaultCauseType provided in Energy Reference Data SKOS Concept Schemes.
- **Linked to resource**: An example of a linked to resource type of reference data is PowerFlowSettings provided in Energy Reference Data SKOS Concept Schemes.

The reference data is built using W3C recommendations, mainly, Provenance ontology (PROV-O), Time Ontology and Data Catalog Vocabulary (DCAT), Simple Knowledge Organization System (SKOS). The reference data can be referenced directly from the datasets. Examples of reference data are:

- Property Reference
- Country ISO codes
- Profiles URIs/identifiers
- Spatial information
- Any other data agreed to be treated as reference data.

As of this writing, reference data is manually created and maintained, and is provided to project participants as-is, to allow for implementations to progress. In the meantime, the process, and the governance for target publication of reference data is under development and will be leveraging linked data technologies and be managed centrally.

It should be noted that there is no intention that applications should implement string decoding of the URI address. The requirement is that applications shall access the URL (either in Internet or locally if a service is provided) and interpret the properties defined in the RDF based dataset that are related to a reference data item. There is some logic applied for the URIs, but this is more for the purpose of human orientation. The following examples illustrate the logic that is going to be applied when preparing the reference data:

- Property Reference
  - https://energy.referencedata.eu/PropertyReference/TapChanger.step
- EIC codes, which is used in the dcterms:publisher in the dataset header
  - https://energy.referencedata.eu/EIC/10T1001C--000170
- Spatial information (Frame, MAS) – in case of multiple modelling authority sets there is a number, if only one MAS the number is not provided.
  - For DK west: https://energy.referencedata.eu/DK-1-Power-Transmission-System
  - For NO: https://energy.referencedata.eu/NO-Power-Transmission-System
  - For HVDC: https://energy.referencedata.eu/NL-NO-Direct-Current-System
  - For HVDC: https://energy.referencedata.eu/FR-UK-1-Direct-Current-System
- Action (multiple business processes can reuse this action, it is used in prov:wasGeneratedBy in the dataset header.)
  - https://energy.referencedata.eu/{PROCESS}-{TIMEFRAME}-{RUN}-{PROFILE_KEYWORD}
  - https://energy.referencedata.eu/CGM-1D-1-RAS

In general, this is a URI that can be used as URL to look up the detail attributes describing the action. However, the URI pattern is descriptive to support human readability. It is not intended to extract the meta information from the URI, {PROCESS}-{TIMEFRAME}-{RUN}, only metadata information should be used for this purpose.

Not all items {PROCESS}-{TIMEFRAME}-{RUN} are relevant for all datasets. Particular structure data like EQ will not necessarily include {TIMEFRAME}-{RUN}. CGM or TYNDP (Ten Years Network Development Planning) might be used for dataset that can be used in multiple processes. If the data is only used by a single process e.g. CSA then CGM is replaced by CSA: https://energy.referencedata.eu/CSA-1D-1.

- Abstract reference to the dataset that can have different versions is provided by dcat:isVersionOf
  - https:/energy.referencedata.eu/Tenet-EQ – for the equipment of TenneT
  - https:/energy.referencedata.eu/NorNed-EQ – for the equipment of NorNed HVDC

8.5 Dataset Distribution

8.5.1 Manifest

ENTSO-E “Metadata for dataset and distribution specification” (refer to the ENTSO-E CGMES Library for the latest version) defines how manifest can be structured and exchanged. The document also includes examples of manifest.

Business processes can optimise the data exchange by using this approach. This approach provides linkage between different datasets and information on the content which is important to know prior importing all the datasets and processing their headers.

8.5.2 File Naming

Specifications of NC profiles do not specify file naming convention as it is required that all relevant metadata is provided via the dataset header and separate manifest dataset which conforms to the ENTSO-E “Metadata for dataset and distribution specification”. In cases naming convention is necessary for human readability the ENTSO-E “Metadata for dataset and distribution specification” recommend one which is in line with manifest specification.

8.5.3 Serialisation Syntax

Different serialisation syntaxes are used when providing the datasets conforming to reference data, common data, constraints, CGMES profiles, and NC profiles. These serialisations will evolve over time following best practices and new specifications by W3C and IEC.

The following list is provided for information.

Table 17 – Serialisation options

Dataset category	Current serialisation	Expected future serialisation
Common data: mainly based on EQ and ER profiles	CIM XML (IEC 61970-552)	JSON-LD
Reference data	RDFXML (W3C), TURTLE (W3C), JSON-LD (W3C)	RDFXML (W3C), TURTLE (W3C), JSON-LD (W3C)
CGMES	CIMXML (IEC 61970-552)	JSON-LD
NC Profiles	CIMXML (IEC 61970-552)	JSON-LD
Manifest	JSON-LD, CIMXML (IEC 61970-552)	JSON-LD
Boundary set	CIMXML (IEC 61970-552)	JSON-LD

SHACL based constraints	TURTLE (W3C) mainly to facilitate human readability. Other RDF serialisations are possible.	TURTLE (W3C) mainly to facilitate human readability. Other RDF serialisations are possible.

8.5.4 Exchange and Packaging

CIM based data exchanges allow for exchanging information based on multiple profiles in a single dataset. Example for this is the exchange of equipment, operation and short circuit profiles' datasets in a single file. When this happens the dataset header shall include the property dcterms:conformsTo to indicate to which profiles and constraints this data conforms to.

In an exchange which is structured and follows certain exchange rules, combining different profiles cannot happen randomly and needs to be agreed so that receiving systems are prepared to receive such information and process it accordingly.

NC profiles can be used for exchange of data related to one CCR or multiple CCR. For example, Assessed element profile includes references to regions at object level, which allows for combining a list of assessed elements for all CCRs in a single dataset. The setup of the data exchange does not require exchange of single dataset, but it is recommended to use all means to avoid exchange od duplicate data.

Business processes need to agree on what stages of the process data is handled in separate datasets and at which step of the process a combined dataset is necessary. This should take into account that manifest dataset can be used to exchange (report) on a combined set of data without the need to regroup the data within a single dataset (file). Therefore, it is recommended to utilise the manifest way of exchange in order to minimise the post processing of the data and bring essential clarify on the source if the data including possibilities to exchange the provenance of it.

Datasets serialised in CIMXML tend to have big file size and archive (zip) was traditionally used in CGMES based datasets. Similar to CGMES archive-in-archive is not allowed. ENTSO-E "Metadata for dataset and distribution specification" recommends using .cimx extension of the archived files which are in reality zip archives. It is important that applications support this extension and ensure that reading archives is done via stream or other service that does not require full unzipping of the data, saving it and then parsing the information.

The recommended approach is to access the archive read the manifest, then assess parts of the archive in the necessary sequence and then parsing the information without prior unzipping and storage. This specification does not limit the usage of .cimx, i.e. this extension can be used when archiving single datasets as well. However if .cimx is used the manifest file is required, if .zip is used the content of the .zip shall follow the .zip rules.

8.6 Dataset Validation

Dataset validation is important part of the business process related data exchanges. In general, datasets shall conform to the profile specifications on which the datasets are based on. In addition, there are sets of constraints / consistency rules that are defined for the business processes. NC profiles are supplying data for multiple business processes and there are requirements by methodologies to define consistency rules for different processes. The document NC Data Quality Management Provisions will need to be developed as required by CSAm. It will define the data validation framework and SHACL based constrains (both for consistencies within a dataset and across datasets) that are business specific and apply to either all regions or to a particular region. The objective is to minimise the number of constraints that apply to a particular region.

9 Dependencies Between Business Processes

This section will be completed in next versions of RCP DES in which other business processes such as OPC, CCC, cost-sharing, etc will be covered.

10 Conformity Assessment Scheme Setup Guidelines

Different applications can be designed to support different parts of the business processes and therefore utilise some or all NC profiles. The conformity assessment categories defined in this section should be used in the Conformity Assessment Scheme designed for the conformity process related to NC profiles (NC CAS). The use cases defined in RCP DES are direct input to the Test Use Cases (TUC) part of NC CAS. Along with TUC it is important to define different datasets (models and related data) that are needed to perform the test use cases. These datasets to be used in the conformity are called Test Configuration (TC).

This section defines the Application Functions that are considered important to cover the use cases outlined in the RCP DES. A set of Test configurations and their high level content is also defined.

The section was reviewed in the SV-IOP in July 2024 and revisions were made. With the establishment of the set of documentation related to conformity assessment scheme on the NC Profiles this section will be moved to that set of documents.

10.1 Application Functions

Table 18 – Application functions defines necessary Application Functions to be included in the NC CAS.

Table 18 – Application functions

Name	Description	Prerequisite	Required profiles
Export of single dataset	The Application supports NC profiles' datasets that are either exported individually or together as a package.	Handling of reference data and common data	Applied for all NC profiles supported by the Application
Import of single dataset	The Application supports NC profiles' datasets that are either imported individually or together as a package.	Handling of reference data and common data	Applied for all NC profiles supported by the Application
Maintenance	The Application supports NC profiles' datasets and can perform maintenance operations (e.g. update, replace) on the data.	Handling of reference data and common data Import and export	Applied for all NC profiles supported by the Application

Structural data setup	The Application supports profiles related to the structural data of a business process.	The Application shall support: - interactions of NC profiles and CGMES profiles defining the underlying power system model. - Export of single profile for the related profiles	Equipment Reliability (ER), Monitoring Area (MA), Contingency (CO), Remedial Action (RA), Assessed Element (AE)
Scheduled data setup	The Application shall support profiles related to the scheduled and per time unit data exchange.	The Application shall support: - interactions of NC profiles and CGMES profiles defining the underlying power system model. - Export of single profile for the related profiles	State Instruction Schedule (SIS), Steady State Instruction (SSI),
Coordination Confirmation	The Application the interactions between parties sending data and parties receiving data.	The Application shall support: - interactions of NC profiles and CGMES profiles defining the underlying power system model. - Export of single profile for the related profiles - Import of single profile for the related profiles	Remedial Action Schedule (RAS), Security Analysis Results (SAR)

Security analysis	The Application supports security analysis using power system model and information on contingencies and assessed elements. The Application can export the result of the security analysis.	The Application shall support: - interactions of NC profiles and CGMES profiles defining the underlying power system model. - Structural data - Scheduled data - Export of single profile for the related profiles	Security Analysis Results (SAR)
Remedial action optimization	The Application supports optimization of the remedial actions and can export the result.	The Application shall support: - interactions of NC profiles and CGMES profiles defining the underlying power system model. - Export of single profile for the related profiles	Remedial Action Schedule (RAS), Impact assessment Matrix (IAM)

In order to target the right testing of the applications, the conformity assessment scheme will distinguish between the types of applications that are tested.

For instance, an application that is designed to support analytic functions using the profiles as input will only need to conform to the analytic functions which will also test the ability to import and export the information.

Therefore, such application will not be required to test separate import/export test use cases.

10.2 Test Configurations

10.2.1 Requirements

Test configurations are necessary to perform test use cases defined for conformity.

- Test configurations (TC) shall not be big models to allow for easy orientation.
- TC shall be designed on CGMES v3.0 IGMs and CGMs.
- There should be at least 4 TSOs represented in the test configuration.
- There should be at least 2 CCR (Capacity Coordinating Regions) in the test configurations.
- Test configurations shall cover all time frames – day ahead, intraday, year ahead, etc.
- All test configurations shall be consistent and have proper header information as well be aligned with reference data in order to allow testing in OPDE at later stage.
- There shall be a set of reference data according to equipment reliability profiles as well as other reference data and boundary information which shall be commonly shared between all test configurations. Using different sets of reference data shall be avoided as this causes issues and increases maintenance effort. However, it shall be possible to demonstrate an update of reference and boundary information.
- Test configurations shall demonstrate the exchange of the following NC related profiles as well as all combinations of dependencies between below mentioned profiles and CGMES profiles:
    - Assessed element profile (AE)
    - Availability schedule profile (AS)
    - Contingency profile (CO)
    - Equipment reliability profile (ER)
    - Grid Disturbance profile (GD)
    - Impact assessment matrix profile (IAM)
    - Monitoring area (MA)
    - Object registry profile (OR)
    - Power schedule (PS)
    - Power system project (PSP)
    - Remedial action profile (RA)
    - Remedial action schedule profile (RAS)
    - Security analysis result profile (SAR)
    - Sensitivity matrix profile (SM)
    - State instruction schedule profile (SIS)
    - Steady state hypothesis schedule profile (SHS)

    - Steady state instruction profile (SSI)
- Test configurations shall be developed as conform test configurations. Non-conform test configurations shall be developed as a second phase once it is proven that conform TCs and profiles reach a good level of stability.
- Remedial actions shall cover at least the following types:
    - Simple Remedial Actions of different types – change of setpoint, redispatch
    - Remedial Action dependent on a specific Contingency
    - Remedial Action dependent on a specific Assessed Element
    - Voltage Angle Remedial Actions
    - Voltage Magnitude Remedial Actions
    - PST
    - PST in a group
    - Topology change
- Assessed element shall include lines, transformers, PSTs, busbar coupler, special monitoring for voltage angle and magnitude.
- Contingencies shall include at least:
    - N-1
    - N-x
    - Busbar tripping (even if it might be considered N-1)
- Equipment reliability shall contain variants on the limits (Current Limits, Voltage Angle Limits, Voltage Magnitude Limits) and SIPS configuration.
- GLSK shall cover at least:
    - Generation ramping up
    - Generation ramping down
    - Load "cut-off" example
    - Example of energy blocks on power plants with several hours of start-up time

10.2.2 Types

Table 19 lists some test configurations that are considered important. Additional TCs can be added in the NC Conformity Assessment Scheme (CSA).

Table 19 – Test configurations

Test configuration	Description
ReliCapGrid	Open-source, synthetic and anonymised test model that gathers many of the features of the other TCs. It is hosted on the ENTSO-E GitHub repository.

FullModelNC	This TC contains at least one instance of all classes and their attributes and associations defined in the NC Profiles.
OptimizedCSA	This TC is developed using available models SmallGrid, Svedala and MicroGrid. This allows for inclusion of four TSOs with different granularity. In case of four TSOs that following setup is realised: •The 4 TSOs (A, B, C and D) have the following 3 borders indicated by the adjacency of the border to the TSOs (A-B, B-C, D-A). •The CCR1 covers the borders AB and BC, while CCR2 covers the border DA. •TSOs A, B and C participate to CCR1, whose impact extends to TSO D. •TSOs A and D participate to CCR2 whose impact extends to TSO B. •TSO A participates in both CCRs, TSO B in CCR1 but not CCR2 (although it is impacted by CCR2), TSO C participates in CCR 1 and it is not impacted by CCR2, and finally TSO D participates to CCR2 but not CCR1 (although it is impacted by CCR1). The resulting overlapping zone thus spans TSOs A, B and D. The test configuration includes minimum 24 and maximum 72 (or 96) hours/time stamps. The following profiles are included in addition to the IGM and CGM instance data: Equipment reliability profile (ER), Remedial action profile (RA), Remedial action schedule profile (RAS), Assessed element profile (AE), Contingency profile (CO), Availability schedule profile (AS), Steady state instruction profile (SSI), State instruction schedule profile (SIS), Impact assessment matrix profile (IAM), Sensitivity matrix profile (SM), Security analysis result profile (SAR), Object registry profile (OR)
PerformanceNC	This TC is used to test performance of applications. The focus is on the volume of data and not on the complexity of the data.

10.3 Test Use Cases

This section defines basic test use cases that are considered important to initiate the Conformity Assessment Scheme related to NC profiles. Additional test use cases can be added during the development of NC CAS and it is maintenance.

10.3.1 TUC 1: Exchange of Initial Information

- TSO A, TSO B, TSO C, TSO D export the following information (in real cases some of these could be optional, but for the purpose of the test full scope is considered):
  - IGM
  - remedial actions
  - assessed elements
  - contingency
  - equipment reliability which includes SIPS configuration, security limits and power transfer corridor definitions
  - steady state instruction
  - GLSK
  - Availability schedule
  - Object registry
- RCC A and RCC B import all information. Consistency checks are performed.
- CGMs are merged and available.

10.3.2 TUC 2: Perform Regional Security Analysis and Export Results

- RCC A and RCC B perform regional security analysis on a CGM
- RCC A and RCC B export security analysis results

10.3.3 TUC 3: Perform RAO and Export Results, perform Coordination and Export results

This includes the workflow of the coordination runs

- RCC A and RCC B perform RAO
- RCC A and RCC B export security analysis results after RAO and proposed remedial actions schedules (using remedial action schedule profile)
- RCC A and RCC B perform impact assessment on proposed remedial actions and exports impact assessment matrix
- TSO A, TSO B, TSO C and TSO D send agreed and rejected remedial actions or eventually propose alternatives (coordination): Alternatives could be available RAs to be considered for the next iteration of RAO, or RA schedules to be further assessed. Please note that currently the RCCs and the CCRs have not yet agreed on a common process and rules for the evaluation and inclusion of alternative RA schedules.
- RCC A and RCC B perform security analysis after Coordination. RCC A and RCC B export security analysis results and updated impact assessment matrix.
- TSO A, TSO B, TSO C and TSO D update IGMs (SSH, TP, SV) if needed.

Annex: A Reference Legacy Implementation of Network Code Profiles v2.2

The regional project *CoreCCR* offers guidance on how a legacy version of the Network Code Profiles (v2.2) are implemented in the Core region for the CSA process. This is considered a *Reference Legacy Implementation*.

Relevant Material

The material composing the Reference Legacy Implementation is divided in two categories when depending of the final system digesting the information:

- Human readable: in PDF or ASCII DOC format when published on the ENTSO-E website (CGMES Library) or GitHub respectively.
- Machine readable: in XML format.

Regardless of the format, the Reference Legacy Implementation delivers the same information. The following lines aim at explaining such information referring to the use case creating process.

Use Cases Definition

Use cases are firstly categorised depending on the main profile they might make use of in the so-called “profile documents”. Readers may refer to Figure 97.

When TSOs describe a use case, they convey the following information:

- Use case ID: field to help identify the use case within CoreCCR.
- Use Case name: a descriptive name for the use case.
- Short Description: explanatory field that TSOs use to define the use case.

The following fields are not yet used for describing use cases, but they may be further expanded:

- Roles: use of the roles described in section 6 of the RCP DES.
- RCP DES Associated chapter for further description
- Pre-condition
- Flow
- Exceptional
- Post-Condition

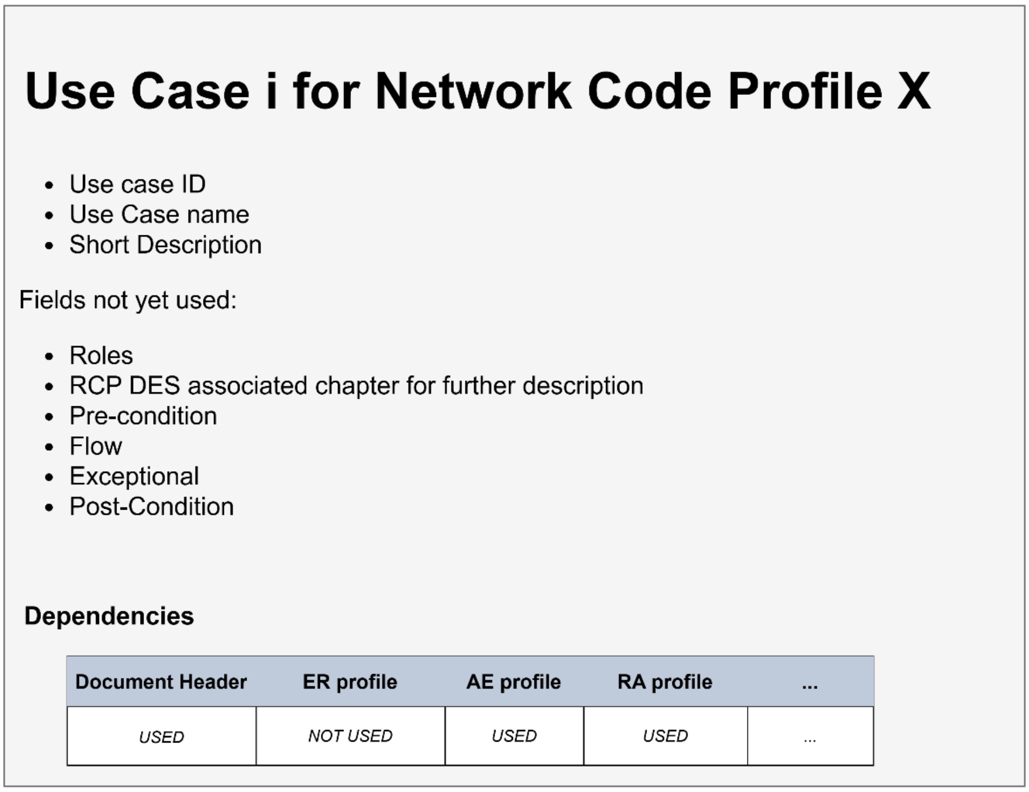


Figure 97: Summary Information used to Describe a Use Case

Profile Dependency

An important remark is that in that a certain use case, might make references to several NCP. In this case, this information is gathered in a dependency table accompanying every use case description.

A practical example in Figure 98 makes use of the *CSA_UC_RA_RDCT_001.* As the ER profile is also set to *Used*, the *CSA_UC_RA_RDCT_001* use case is referenced in the Equipment Reliability document with certain needed attributes as shown in Figure 99. This is the mechanism used to identify what classes and attributes the RA and ER datasets need to include in order to represent the *CSA_UC_RA_RDCT_001* use case. If readers find some gaps when exploring the Reference Legacy Implementation, it might be because a certain use case is still under development.

RemedialAction Use Cases

A.1.1 Single generating plant providing preventive RD Volumes

Use case ID	CSA_UC_RA_RDCT_001
Use case Name	Single generating plant providing preventive RD Volumes
Roles	
Short Description	A specific Generating Plant provides a positive active power and negative active power and is connected to one specific node in grid model (=one generating unit); Preventive RA
Associated chapter for further description	
Pre-condition	
Flow	
Exceptional Flow	
Post-Condition	

Document Header	Equipment Reliability	Assessed Element	Contingency	Monitoring Area	Remedial Action	Power Schedule	Remedial Action Schedule	Equipment Reliability	State Instruction Schedule	Steady State Instruction	Availability Schedule	Impact Assessment Matrix	RA Settlement_MarketDocument	Ack_MarketDocument
USED	NEEDED	NOT USED	NOT USED	NOT USED	USED	USED	NOT USED	USED	USED	USED	NOT USED	NOT USED	NOT USED	NOT USED

Figure 98: Example of use case dependency (I)

A.2 Use of attributes and classes - EquipmentReliability

Used = The Use Case WILL use the attribute, i.e., the XML file will always contain it for the given UC.
Not Used = The Use Case WILL NOT use the attribute, i.e., the XML file will never contain it for the given UC.
Not Decisive = The attribute or whole class CAN be used, but it DOES NOT HAVE TO BE. It has a certain impact, but the UC description i attributes has to be specified (for the case when the class is used).

Table 1/2

Class/Attribute	CSA_UC_ER_001	CSA_UC_SC_001	CSA_UC_SC_002	CSA_UC_SC_003	CSA_UC_RA_RDCT_005	CSA_UC_RA_RDCT_001
md:FullModel*		USED	USED	USED	USED	USED
conformsTo		USED	USED	USED	USED	USED
startDate		USED	USED	USED	USED	USED
endDate		USED	USED	USED	USED	USED
creator		USED	USED	USED	USED	USED
Diagram GLSK						
cim:GeneratingUnit*	NOT USED	NOT USED	NOT USED	NOT USED	USED	NOT DECISIVE
cim:IdentifiedObject.name					USED	USED
cim:IdentifiedObject.description					NOT DECISIVE	NOT DECISIVE

Figure 99: Example of use case dependency (II)

Selection of NCP classes and attributes per use case

When designing a new use case (UC), CoreCCR assesses whether and how they will need to use one of the NCP, and in this case which classes and attributes. Lastly, such classes and attributes are divided into a certain classification: *USED, NOT USED* and *NOT DECESIVE.* The meaning of such classification is as follows:

- Used: The Use Case WILL use the attribute, i.e., the XML file will always contain it for the given UC.
- Not Used: The Use Case WILL NOT use the attribute, i.e., the XML file will never contain it for the given UC.

- Not Decisive: The attribute or whole class CAN be used, but it DOES NOT HAVE TO BE. It has a certain impact, but the UC description is not focused on such an impact. If it is used on the level of class, usage of attributes has to be specified (for the case when the class is used)

With the objective to ease readability, CoreCCR also offers two sections per every profile:

- Use of attributes and classes section: gathering a summary overview of the used classes and attributes of all the use cases using a profile.
- Description of attributes: for every relevant attribute or class, this table is the place where readers will find comments on their use as well as XML/RDF syntax examples.

All the information above about use cases is gathered in "profile documents". The Figure **100** condenses the information above for a specific example NCP document.

Network Code Profile X document

Use Cases

Profile X Use Case 1 | Profile X Use Case i | Profile X Use Case N

Use of Attributes and Classes for Profile X

Class/Attribute	UC 1	UC i	UC N
Example class 1*	USED	NOT USED	NOT DECESIVE
*.Example attribute 1 (from class 1)	USED		NOT USED
*.Example attribute 2 (from class 1)	NOT USED		USED
Example class 2*	USED	USED	NOT USED
*.Example attribute 1 (from class 2)	USED	USED	

Description of attributes for Profile X

Class/Attribute	Description	Example
Example class 1*	*This class is used because (...)*	*<Some XML example>*
*.Example attribute 1 (from class 1)	*When this atttribute is set to (...)*	*<Some XML example>*
*.Example attribute 2 (from class 1)	*This attribute is not used because (...)*	*<Some XML example>*
Example class 2*	*When the purpose is to indicate (...)*	*<Some XML example>*
*.Example attribute 1 (from class 2)	*It is set to "true" when (...)*	*<Some XML example>*

Figure 100: Visualisation of the Reference Legacy Implementation material for one NCP document

Intended Use of the Reference Legacy Implementation

On its side, ENTSO-E publishes this information along with the RCP DES to foster comprehension on how legacy versions of the NCP are used in real world implementations. However, ENTSO-E CIM WG's latest modelling recommendations are available in the most recent version of the RCP DES describing how to use the most recent version of the NCP.

Having this in mind, CoreCCR Reference Legacy Implementation may pave the way to harmonise use case definition and the implementation of the NCP across other regions in Europe.

Readers may find more information on this in future release of the RCP DES.

11 Annex B: Document Revision History

Version[15]	Date	Paragraph	Comments
1.0.0	2021-04-21		SOC approved.
2.0.0	2022-02-16		The specification was enriched with the following extensions and related profiles: • Equipment Reliability (Including energy areas and roles related to network codes, Direct Current related to DC Poles for Corridors). The content of this profile will be integrated as optional extension to the EQ profile of CGMES (similar to e.g. Equipment ShortCircuit). • Steady State Instruction • System Integrity Protection Schemes (SIPS) as part of the Remedial Action profile • Power Transfer Corridors (PTC) as part of Equipment Reliability profile. • Availability plan • Generation and Load Shift Keys (Time phase, contingency induced balance, variation of losses) • Security limits as part of Equipment Reliability SOC approved.
2.1.0	2022-09-21		The specification considers the following changes: • Availability plan was renamed to Availability Schedule • A new profile for sensitivity matrix was included • Small changes to solve bugs and improve consistency of the profiles. • Comments received during v2.0 were considered. SOC approved.
2.2.0	2023-04-20		This new version of the specification is mainly focused on covering gaps identified by CCRs. Most important changes are related to: • Redispatch and countertrade • Schedules • Sensitivity factors • Updates of the control model for power electronics devices and transformers. • Several clarifications were introduced to facilitate the usage of the profiles.
2.2.0	2023-05-10		Reference metadata table updated to be consistent with a bug fix from the maintenance request "Change in Metadata and document header data exchange specification" from May 2023 the 8th. ICTC approved.
2.3.0-alpha	2024-01-29		On request by SOC StG REC the document was renamed to Network Codes Data Exchange Specification to envision that it will cover specifications and implementation guidance for all business processes. The document is significantly updated to include explanations on different used cases.
2.3.0-beta	2024-03-16		On request by SOC the document was renamed to Regional Coordination Processes Data Exchange Specification to envision that it will cover specifications and implementation guidance for

15 Versioning of the document follows Semantic Versioning 2.0.0 where a version number is having four components {major}.{minor}.{patch}-{pre-release}.

			all business processes. The document is updated based on the feedback from review of version v2.3.0-alpha.
2.3.0-gamma	2024-04-09		Version after the CIM WG review and send for the approval process via written voting procedure by ICTC (lead) and SOC (in copy).
2.3.0	2024-05-13		ICTC (lead) + SOC (in copy) approved.
2.3.1	2024-10-16		ICTC approved. Patch changes (bug fixing, corrections and fixing imperfections) after the feedback received in the 2024 SV-IOP.
2.3.2	2025-02-13		ICTC approved. Only modifies the Table 1 to correctly refer to the version numbering of the Network Code profiles patch release 2.3.2.
2.4.0	2025-09-11		ICTC approved The accompanying Release Notes offer an extended overview of the use cases added motivating modifications in this RCP DES and Network Code Profiles (NCP). Inclusion of references to the open-source, synthetic and anonymous ReliCapGrid test model to exemplify/demonstrate use cases. Thus, many “image snippets” and “code snippets” were replaced with references to such test model. Inclusion of the Reference Legacy Implementation NCP v2.2 as an Annex. Enhanced guidance on how to use the ReferenceData and CommonData datasets in section 8.4. This release was aligned and reviewed with Regional Implementation Projects (such as CoreCCR) and software developers in the framework of the 2025 Standard-Vetting Interoperability Test (SV-IOP).