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Transmission System Operators
for Electricity

REGIONAL COORDINATION PROCESSES DATA EXCHANGE SPECIFICATION

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36 Version Notes

37 This document is release 2.5.0 of the Regional Coordination Processes Data Exchange
38 Specification (RCP DES). This release is a minor release which addresses complex use cases
39 and feedback received since the release of version 2.4.0.

40 Updates of the linkage between the RCP DES and the open-source, anonymous test
41 configuration (model) [ReliCapGrid](#) were done which allows for direct references to parts of
42 the information model in order to illustrate the use cases. In this way the RCP DES's readability
43 and usability is improved.

44 This document and its subsequent revisions will be also used for Standard Vetting
45 Interoperability (SV-IOP) tests. Therefore, it is considered a public document.

46 The document was additionally updated to incorporate the agreements and use cases
47 exposed in the SV-IOP test held in May 2026 (refer to the [report](#)).

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

51 For additional details on the previous versions of the document, please refer to section [Annex](#)
52 [B: Document Revision History](#).

53 For details of the introduced changes and use cases, please consult the accompanying Release
54 Notes and *Differences* dataset available on the [ENTSO-E CGMES Library](#).

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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 report¹. 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 multiple² or frequently changing namespace information for different data objects.

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

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 Q) together with 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.

2.1 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.

576

Table 1 – Document versions

Document	Version
ENTSO-E Assessed Element profile specification	2.4.1
ENTSO-E Availability Schedule profile specification	2.4.0
ENTSO-E Contingency profile specification	2.3.3
ENTSO-E Equipment Reliability specification	2.5.0
ENTSO-E Impact Assessment Matrix profile specification	2.4.1
ENTSO-E Monitoring Area profile specification	2.3.2
ENTSO-E Object Registry profile specification	3.0.0
ENTSO-E Power Schedule profile specification	2.5.0
ENTSO-E Power System Project profile specification	2.3.1
ENTSO-E Remedial Action profile specification	2.5.0
ENTSO-E Remedial Action Schedule profile specification	2.4.1
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	2.5.0
ENTSO-E Steady State Hypothesis Schedule profile specification	1.1.1
ENTSO-E Steady State Instructions profile specification	2.5.0
ENTSO-E Metadata for Dataset and Distribution specification	2.4.0
ENTSO-E Boundary and Common Data Exchange application specification	1.0.0
ENTSO-E Network Codes Canonical Extensions Specification	2.5.0

577

578 **3.4 Other References**

- 579 • [The Harmonised Electricity Market Role Model.](#)

- 580 • Report on Inter-RCC and Inter-CCR Coordination for Coordinated Regional Security
- 581 Analyses V1.2 (internal ENTSO-E).
- 582 • CSA Coordination Function – Business Requirements Specification v1.0 (internal
- 583 ENTSO-E).
- 584 • CSA Input Data Consistency Function – Business Requirements Specification v1.0
- 585 (internal ENTSO-E).
- 586 • CSA Data Classification v1.0 (internal ENTSO-E).
- 587 • CGM-RCC Users Group - Business Requirements Specification v1.0 (internal ENTSO-E).
- 588 • [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.

693 [SOURCE: CSA project group]

694 **4.24 Individual Grid Model (IGM)**

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

699 [SOURCE: CACM art.2.1]

700 **4.25 Individual action**

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

703 [SOURCE: CSAm art.14.2]

704 **4.26 Internal contingency**

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

706 [SOURCE: SOGL art.3.2.23]

707 **4.27 Load Shift Key**

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

711 [SOURCE: Coordinated Capacity Calculation IG v1.0]

712 **4.28 N-situation**

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

715 [SOURCE: SOGL art.3.2.3]

716 **4.29 N-1 situation**

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

719 [SOURCE: SOGL art.3.2.15]

720 **4.30 Normal state**

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

724 [SOURCE: SOGL art.3.2.5]

725 **4.31 Ordinary contingency**

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

727 [SOURCE: SOGL art.3.2.54]

728 **4.32 Operational security analysis**

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

732 [SOURCE: SOGL art.3.2.50]

733 **4.33 Out of range contingency**

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

737 [SOURCE: SOGL art.3.2.55]

738 **4.34 Overlapping zone**

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

741 [SOURCE: CSA data exchange project group]

742 **4.35 Power Transfer Corridor (PTC)**

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

746 [SOURCE: CSA data exchange project group]

747 **4.36 Preventive remedial action**

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

751 [SOURCE: CSAm art.2.1.18]

752 **4.37 Proposed remedial action**

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

756 [SOURCE: CSA project group]

757 **4.38 Remedial action**

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

760 [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 scheme³ 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

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

797 [SOURCE: [North American Electric Reliability Corporation glossary](#)]

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

799 **4.46 System Operator**

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

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

807

808 5 Abbreviated Terms

809	CCR	Capacity Calculation Region
810	CGMES	Common Grid Model Exchange Standard
811	CIM	Common Information Model (electricity)
812	CROSA	Coordinated Regional Operational Security Assessment
813	CCROSA	Cross Coordinated Regional Operational Security Assessment
814	CSA	Coordinated Security Analysis
815	CSAm	Coordinated Security Analysis Methodology
816	EIC	Energy Identification Codes
817	ENTSO-E	European Network of Transmission System Operators for Electricity
818	HVDC	High Voltage Direct Current
819	IEC	The International Electrotechnical Commission
820	IVA	Individual Adjustment Value
821	MAS	Model Authority Set
822	mRID	CIM Master Resource Identifier
823	MTU	Market Time Unit
824	OPC	Outage Planning Coordination
825	PATL	Permanent Admissible Thermal Limit
826	PGM	Power-Generating Module
827	RAO	Remedial Action Optimization
828	RCC	Regional Coordination Centre
829	RDF	Resource Description Framework
830	RDFS	RDF Schema
831	RefHour	Reference Hour
832	ROSC	Regional Operational Security Coordination
833	RSA	Regional Operational Security Analysis
834	SHACL	Shapes Constraint Language
835	SO	System Operator
836	SOC	ENTSO-E System Operations Committee
837	SOGL	System Operations Guideline
838	SIPS	System Integrity Protection Scheme
839	SPS	Special Protection Scheme (often terms SIPS and SPS are used interchangeably)
840	STA	Short Term Adequacy

841	TSO	Transmission System Operator
842	TATL	Temporary Admissible Thermal Limit
843	UCTE DEF	Union for the Coordination of the Transmission of Electricity Data Exchange
844		Format
845	URI	Uniform Resource Identifier
846	UUID	Universally Unique Identifier
847	XML	Extensible Markup Language
848	XNE	Cross-border relevant Network Element
849	XNEC	Cross-border relevant Network Element with contingency
850	XRA	Cross-border relevant Remedial Action
851	XSD	XML Schema Definition
852		

6 CSA Business Process Overview

This section is 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.

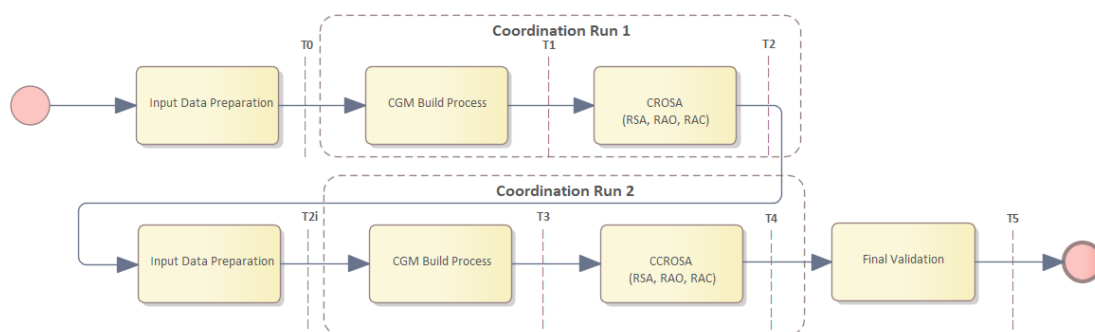


Figure 1 – Day-ahead process, steps and timings (for information only)

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.

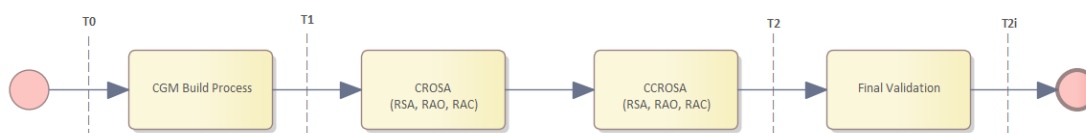


Figure 2 - Intraday process, steps and timings (for information only)

- **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](#).

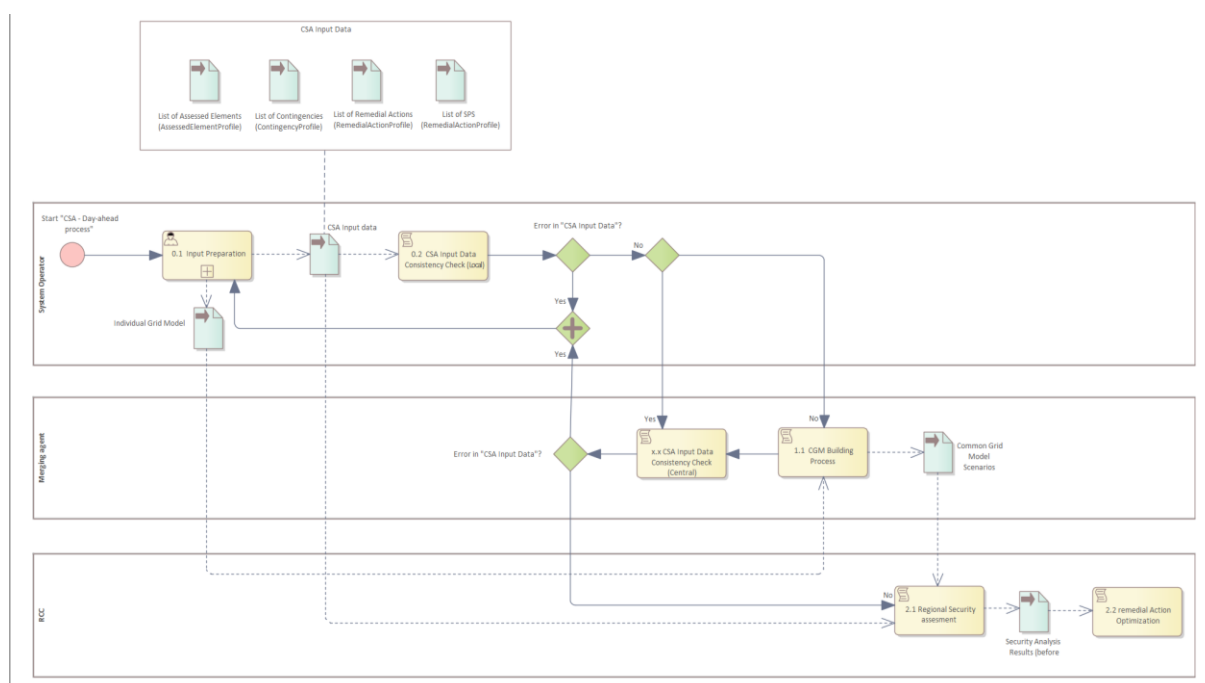


Figure 3: Detailed BPMN for day-ahead process (for information only)

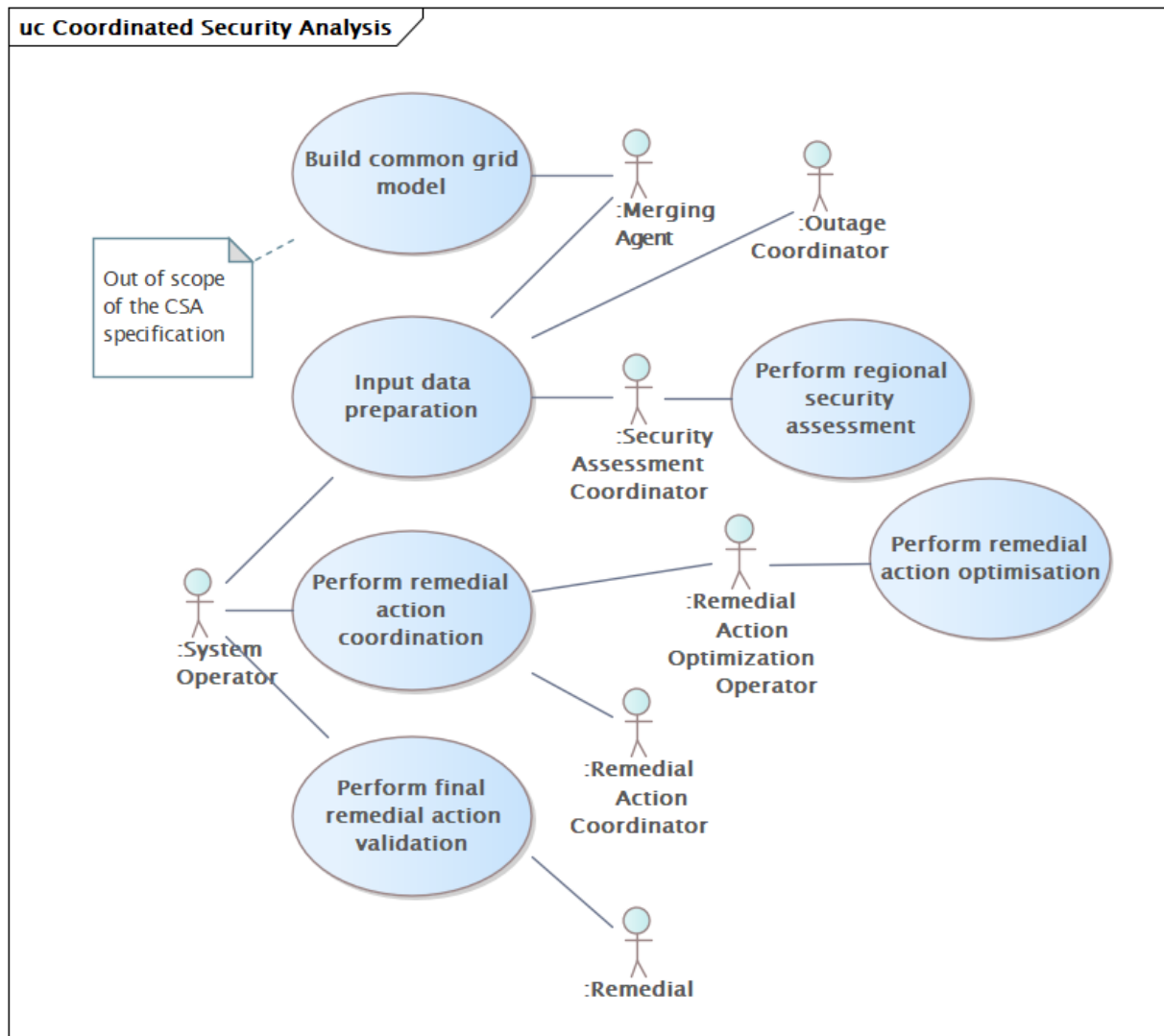
933 **6.2 Use Cases**934 **Figure 4 - Use Cases**
935

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.

950
951

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.
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952

953

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.

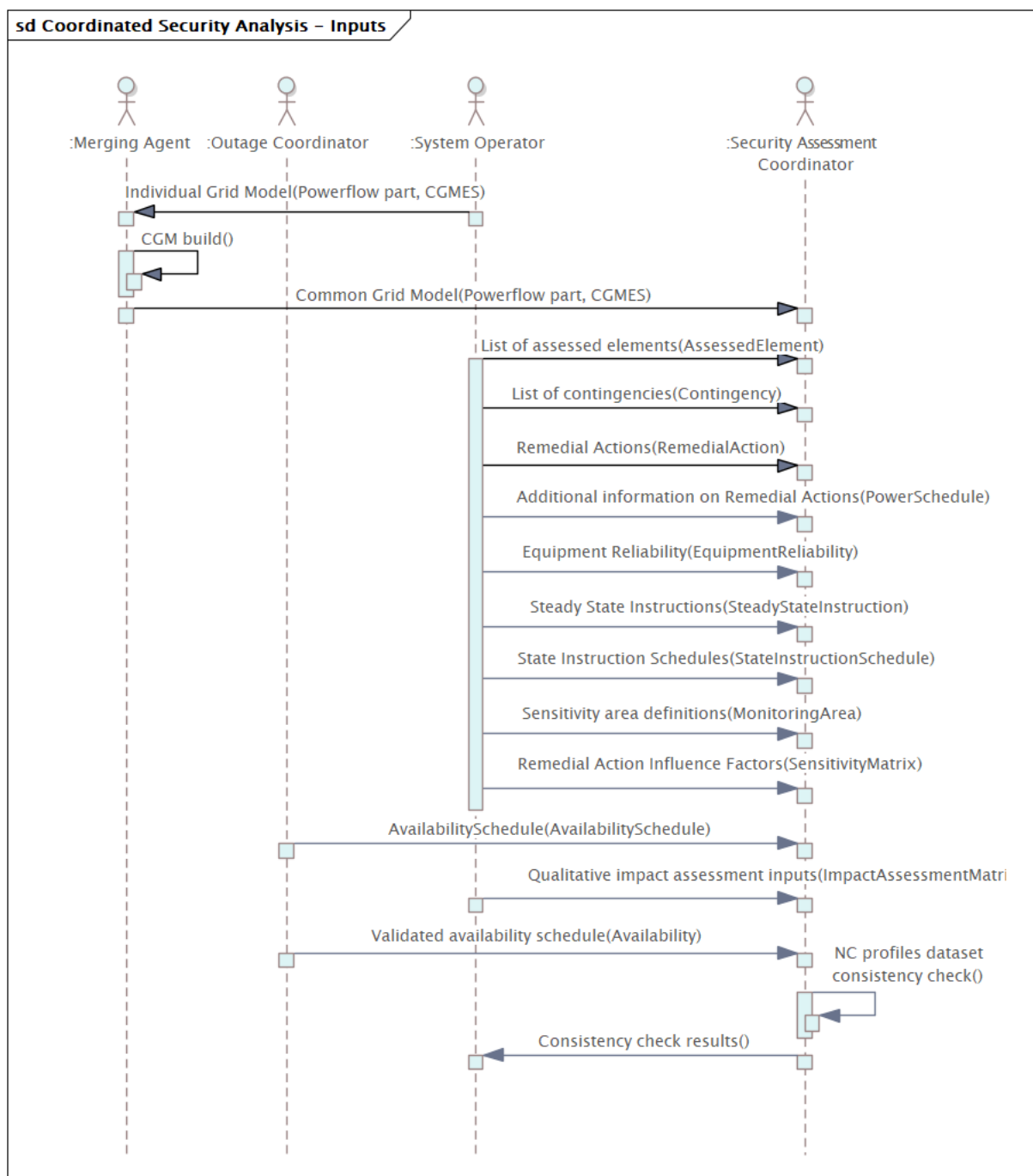


Figure 5 – CSA inputs Sequence diagram

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

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

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

978

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.

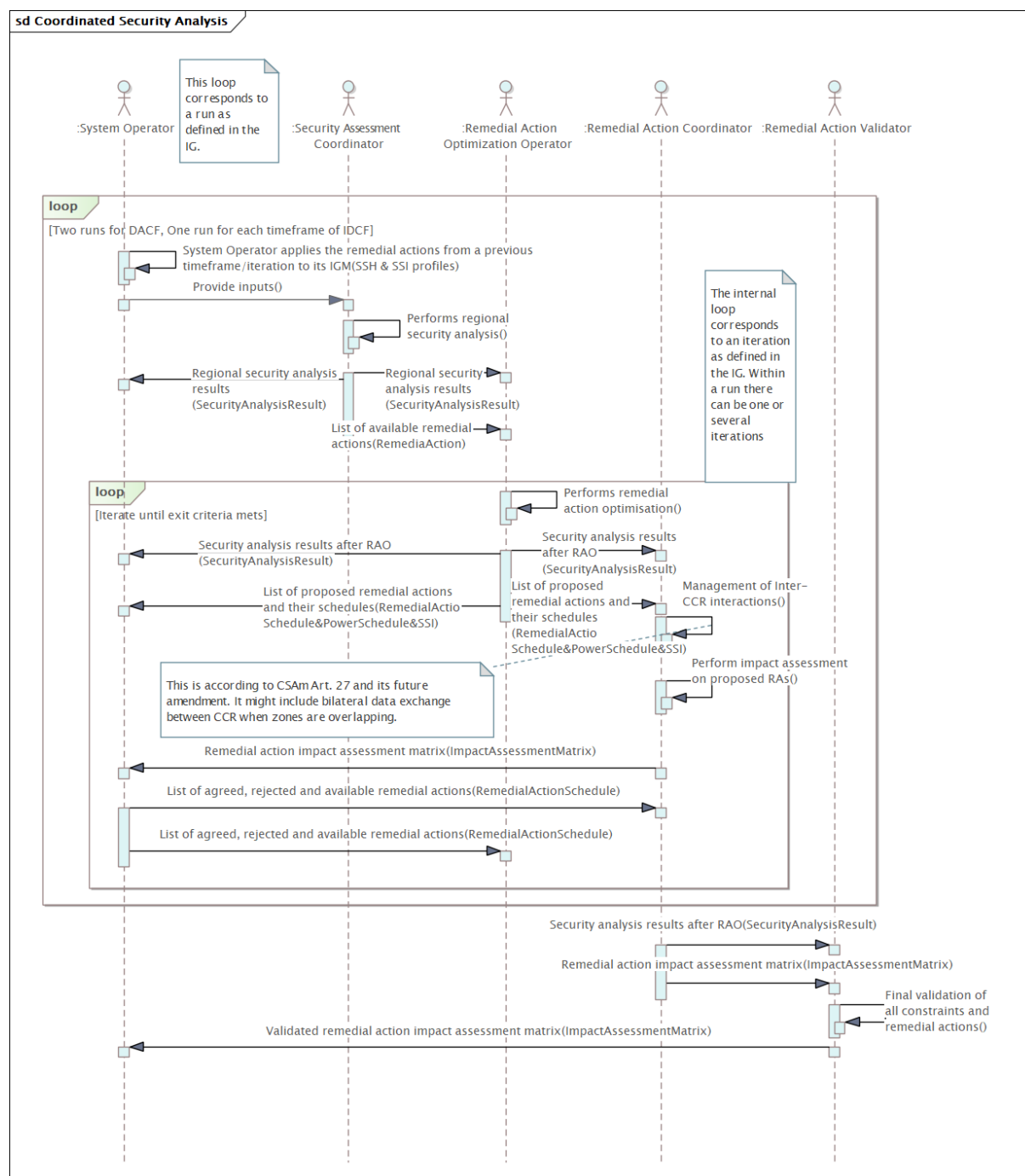


Figure 6 - CSA general sequence diagram

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

989 situation) and considering contingencies (N-1, N-x situation). Apart from the violations,
990 Security Assessment Coordinator also provides the remedial actions to the Remedial Action
991 Optimization Operator. These remedial actions are part of the structural data and designed to
992 solve identified constraints.

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

997 After that, Remedial Action Coordinator addresses the cross-CCR interactions which consists
998 in addressing the cross-impacts between CCRs on the overlapping zones. Just after the CCR
999 interactions, remedial action coordinator performs the impact assessment on the proposed
1000 remedial actions. Readers might refer to section [7.4.4](#) for a specific use case.

1001 The outcome of this process is the impact assessment matrix⁵. The main purpose of the matrix
1002 is to identify the affected SOs for each remedial action. The impact assessment matrix is
1003 delivered to the SOs. It can also serve as input provided by an SO in case of qualitative
1004 assessment process. Each SO shall agree or reject each remedial action by which it is impacted.

1005 If a SO rejects a remedial action, it shall provide the reasoning and (optionally) suggest
1006 alternative new available remedial actions or modified available remedial actions. Both
1007 optimization and coordination are repeated during several iterations until exit criteria is met.
1008 The exit criteria can be, for instance, when all the identified constraints have been solved with
1009 the agreed remedial actions, or time limit is reached.

1010 The big loop is also defined as run. In Day-Ahead there will be two coordination runs and in
1011 Intraday only one. Basically, for the day ahead, the process is repeated twice.

1012 After coordination, a final remedial action validation session is performed by the remedial
1013 action validator which receives from remedial action optimization operator the security
1014 analysis results and the impact assessment matrix.

1015 The main activity during the Final Validation Session is to review unresolved relevant identified
1016 constraints (on assessed elements) and discuss or find possible follow-up activities by SOs and
1017 Remedial Action Validator. Finally, the validated impact assessment matrix is delivered to the
1018 System Operator and the process finishes.

⁵ As part of the quantitative assessment. The qualitative 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).

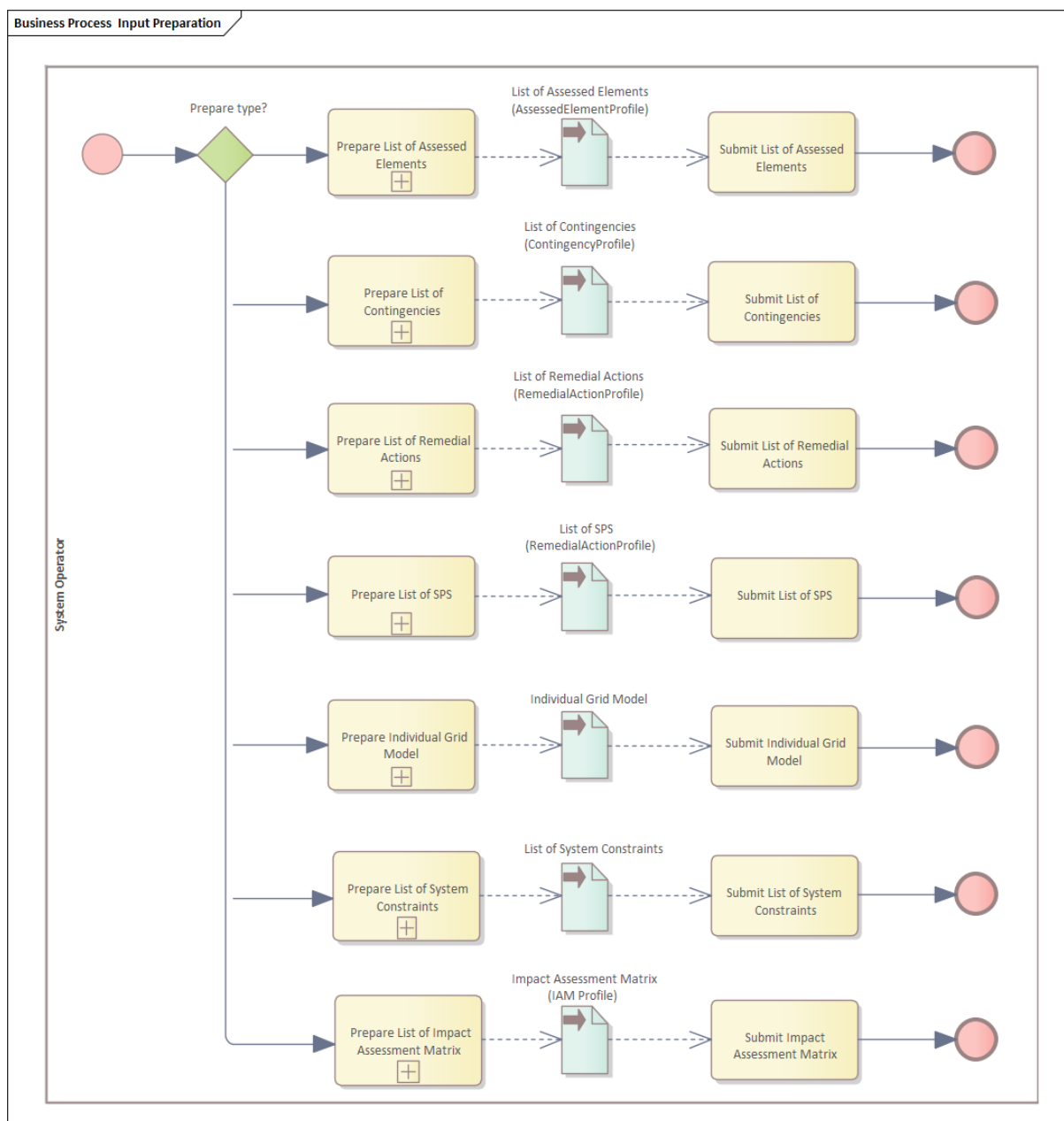


Figure 7 – Input Data Preparation

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).

1105 There could be multiple datasets of the same type for the purpose to separate the usage. For
1106 instance, some regions can use metadata to enable the use case of providing a set of
1107 AssessedElement objects for one part of the power system and another set of
1108 AssessedElement objects for another part of the power system. This will require that the
1109 receiving party understands the metadata provided in the manifest and/or in the dataset
1110 header if the party is interested in studying only one part of the power system or performing
1111 separate studies.

1112 **7.1.3.2 Date and Time notations in NC profiles**

1113 CGMES uses UTC date/time references and normally NC profiles shall be consistent with this.
1114 However, in general, the date/time in NC profiles' datasets can be defined with or without
1115 time zone and this depends on the use cases. The recommendation is that there is a time zone
1116 and how strict this should be is left to the business processes utilizing NC profiles. Therefore,
1117 the business process should decide if there is a need to define a SHACL business constraint to
1118 restrict this.

1119 **7.1.3.3 Datatypes – Active Power versus Current**

1120 Business processes may use different units for flow quantities e.g. as power (MW) or as
1121 current (A). CIM and CGMES mostly uses power instead of current and this is followed by NC
1122 profiles. Therefore, when implementing the profiles vendors need to take into account
1123 potential units' conversion in case there is a requirement to represent the quantities for
1124 reporting or other purposes. CGMES and NC profiles provide necessary information to
1125 convert.

1126

7.1.3.4 SchedulingArea, BiddingZone and ControlArea Relationship

The CommonData dataset by ENTSO-E, provided on the CGMES Library, shall offer a populated list of identifiers that ER datasets' instances should refer to.

A special note is made for the design of the relationships between the SchedulingArea, BiddingZone, and ControlArea classes.

Such classes relationships are part of the ER profile as shown in [Figure 8](#).

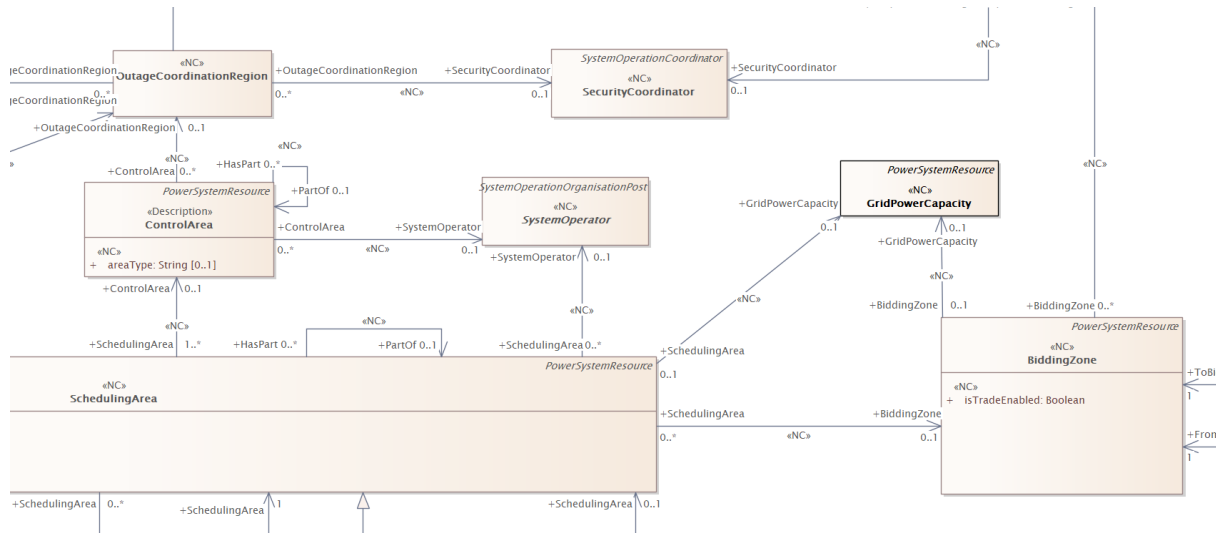


Figure 8: Partial extract of the EnergyArea model in the ER profile showing the SchedulingArea, BiddingZone, and ControlArea classes

Note that the cardinality of the SchedulingArea-BiddingZone classes' association was changed from "1" to "0..1" in the BiddingZone class side of the association. This is done to accommodate cases in some regions (i.e., Italy North).

One could imagine a region having for instance three BiddingZones but only one SchedulingArea. A way of modelling this by creating a virtual (aggregating) scheduling area that refers to three sub scheduling areas and finally to have a distribution factor for every sub scheduling area.

As a consequence, the three sub scheduling areas would also have a direct association with their respective BiddingZone(s) classes. However, the aggregating scheduling area would not have any link with the BiddingZones.

This justifies the need for having a "0..1" cardinality instead of "1" in the BiddingZone side of the SchedulingArea-BiddingZone classes' association.

1149 **7.1.4 Conformity Requirements**

1150 To be able to support input data preparation the Application shall conform to the following
1151 Application functions:

- 1152 • Import of single dataset.
- 1153 • Export of single dataset.
- 1154 • Structural data setup.
- 1155 • Scheduled data setup.

1156

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.

1173 **7.1.5.1 Modelling of Conventional and Renewable Generation from** 1174 **Underlying Network**

1175 Within the energy transition framework and for redispatch processes used for congestion
1176 management, TSOs increasingly need to rely not only on conventional power plants connected
1177 to the transmission grid but also on smaller capacity power generating modules (PGMs)
1178 connected to a lower voltage network.

1179 The objective of this use case is to provide guidance for accurate modelling, when simplifying
1180 due to e.g. aggregation of generation resources or network reduction, of both conventional
1181 and renewable, that are connected to the distribution grid, typically at 110 kV or below.

1182 A key modelling enhancement that TSOs seek is the ability to model these redispatch
1183 resources after network reduction as generation equivalents, suitable for use in CSA processes
1184 (i.e., ROSC).

1185

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 9](#) 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.).

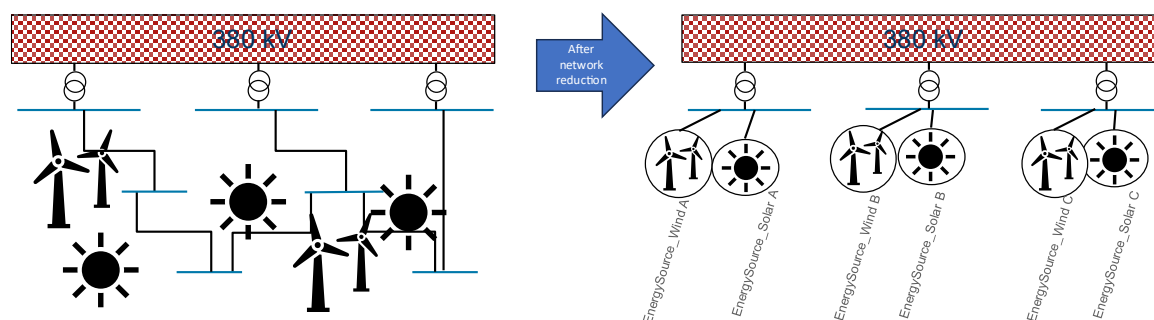


Figure 9: Example of renewable generation connected to TSO or DSO grid

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 PGM⁷).
 - 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 10](#) 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.).

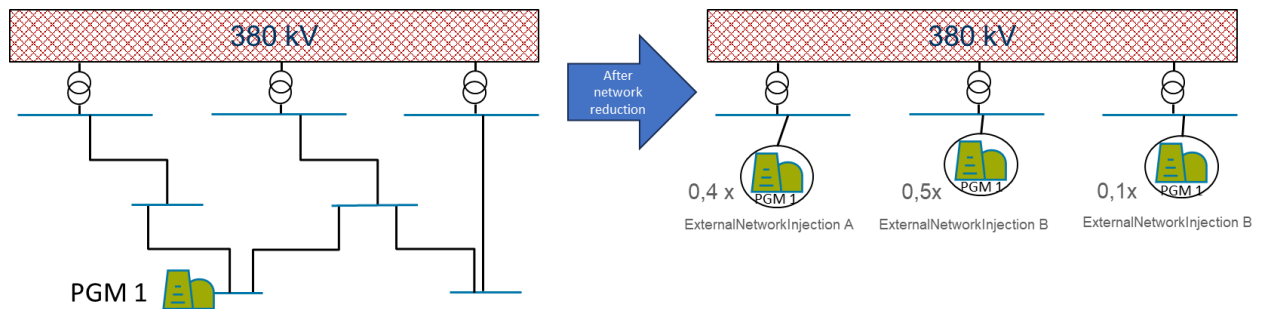


Figure 10 Example of conventional PGM after network reduction with impact distribution

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 underlying grid, generation and load is
 - Either grouped together into a few, injections or loads, depending on the underlying topology.
 - Or split up to multiple injections or loads, depending on the underlying 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 12](#)).
- 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 11](#).
- 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 11](#) as well as in the ER profile extract in [Figure 12](#).
 - 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 13](#) 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 enumeration⁸.

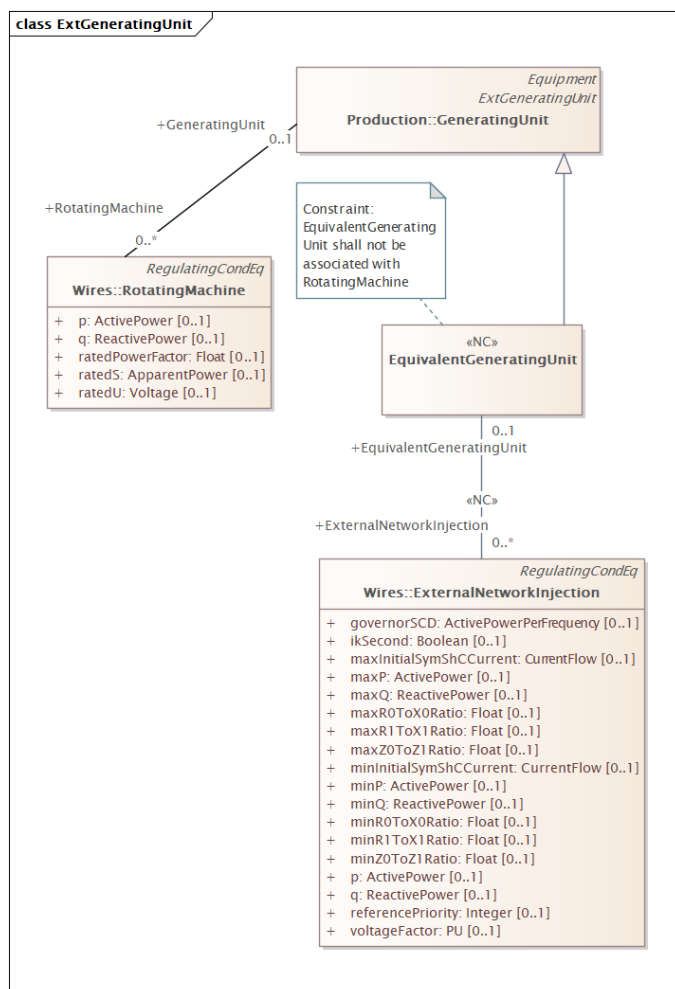


Figure 11: Extract from EuropeanCIMExtensions/ExtNetworkCodes/ExtGeneratingUnit package showing the design of EquivalentGeneratingUnit

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

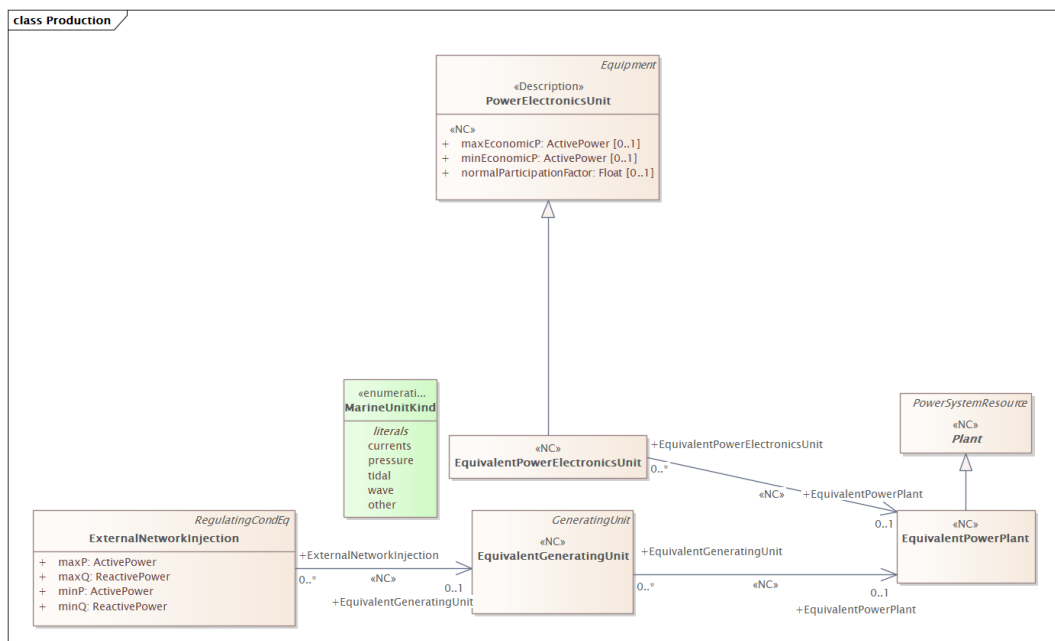


Figure 12: Extract from the ER profile (*Production* diagram) showing the associations of EquivalentGeneratingUnit and EquivalentPowerElectronicsUnit

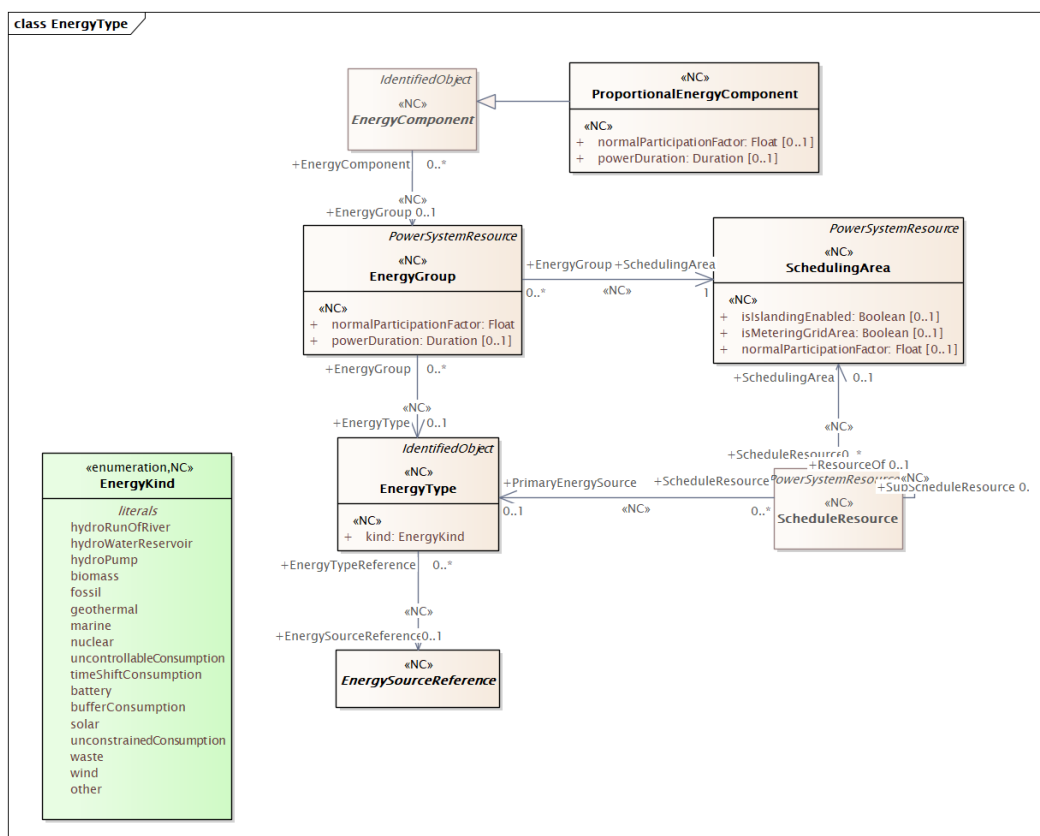
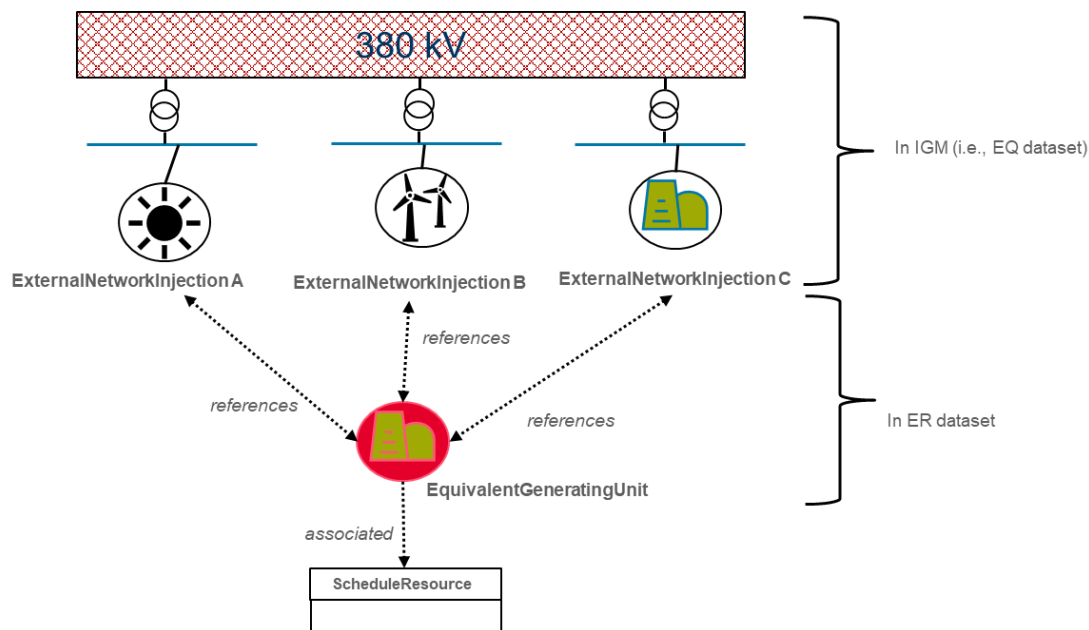


Figure 13: Extract from the ER profile (*EnergyType* diagram) showing the associations of the ScheduleResource, SchedulingArea, EnergyGroup and EnergyType classes

1369 The Figure 14 shows the recommended way to model the network reduction while keeping
1370 all the necessary information to optimise the redispatches.

1371



1372

1373

1374

Figure 14: Recommended approach using EquivalentGeneratingUnit

1375 Readers might note that *Power Park Modules* which have non-synchronous behaviour will
1376 need to be modelled by the *PowerElectronicsUnit* class in future expansions of the Network
1377 Code or future CIM versions (v18 and beyond).

1378

1379 7.1.5.1.6 Type B and C Power-Generating Modules

1380 They are larger than type A but below type D threshold and they can be modelled both
1381 explicitly (in detail), as aggregated, or as aggregated and equivalents units. The
1382 recommendations for each case are as follows:

- 1383 • For an explicit (in detail) model:
 - 1384 ○ Using `GeneratingUnit/PowerElectronicsUnit` with `Equipment.aggregate` set to
 - 1385 `FALSE`.
- 1386 • For an aggregation of explicit (in detail) models
 - 1387 ○ Using `GeneratingUnit/PowerElectronicsUnit` with `Equipment.aggregate` set to
 - 1388 `TRUE`.
- 1389 • For an aggregated (“*simplified*”) model:
 - 1390 ○ Using `EquivalentGeneratingUnit/EquivalentPowerElectronicsUnit` with
 - 1391 `Equipment.aggregate` set to `TRUE` (e.g., in the same way as type A PGMs).
- 1392 • For a non-aggregated (“*simplified*”) model of a single PGM
 - 1393 ○ Using `EquivalentGeneratingUnit/EquivalentPowerElectronicsUnit` with
 - 1394 `Equipment.aggregate` set to `FALSE`

1395 Indeed, in case these generators are modelled explicitly (in detail), the recommendation is
1396 using the *GeneratingUnit* class as well as considering relevant its subclasses (*specialisations*)
1397 depending on the requirements for splitting per type of generation (e.g., hydro, thermal, solar,
1398 etc.).

1399 As for Type A generators, the information about the generation technology can be derived
1400 through the use of classes derived from *EnergyComponent* as illustrated in [Figure 13](#).
1401 Additionally, one can make use of *fuelType* enumeration as shown in [Figure 15](#).

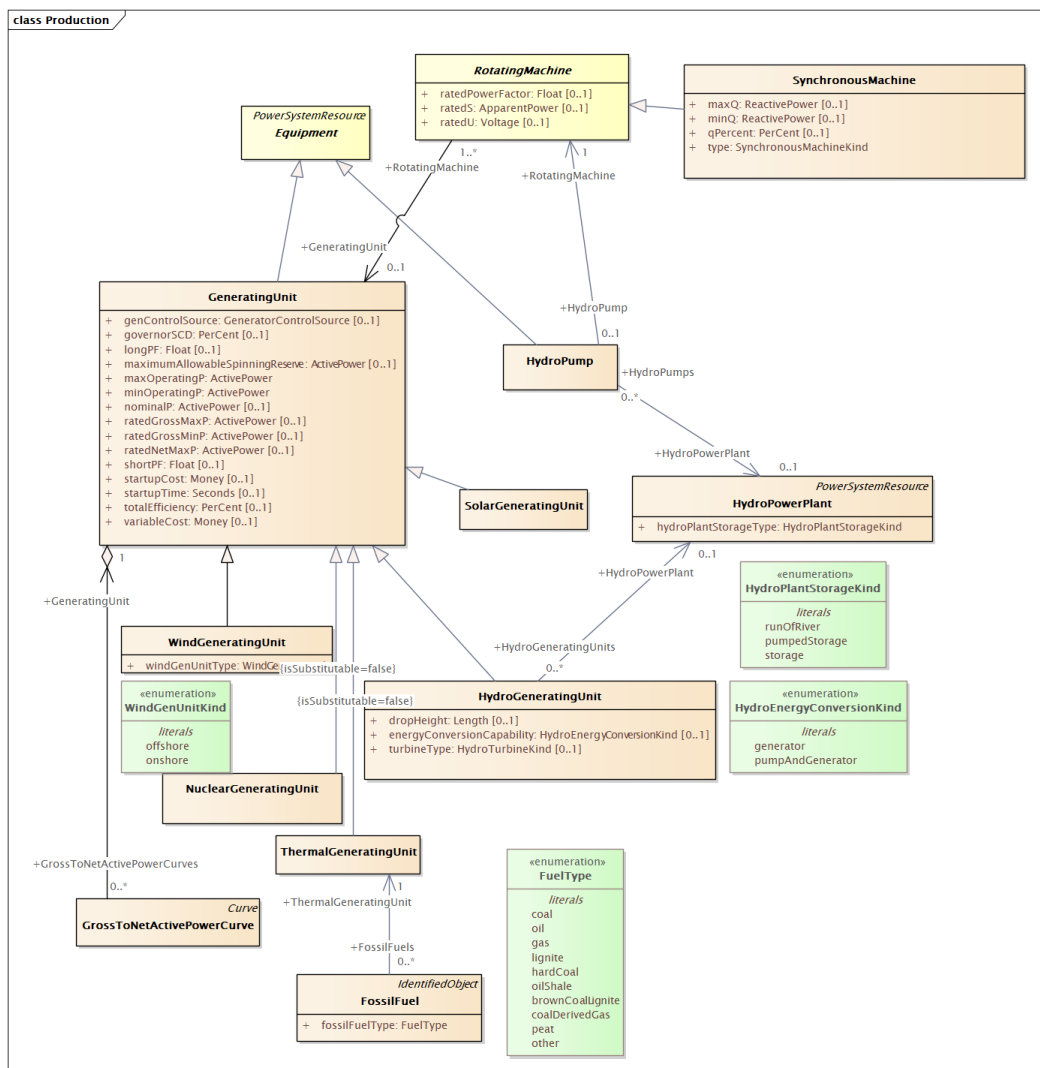


Figure 15: Extract of CoreEquipmentProfile ("EQ") dataset of IEC 61970-452 (CGMES)

1405 **7.1.5.1.7 Type D Power-Generating Modules**

1406 Type D are large units, providing detailed electrical characteristics, real-time data and
1407 scheduled information which need a detailed representation (real-time visibility). As
1408 mentioned in the section above, this is also known as “explicit” (in detail) generation
1409 modelling.

1410 The recommended modelling approach is to use *GeneratingUnit* set with the attribute
1411 *Equipment.aggregate* set to *FALSE* and to provide proper linkage to real network location and
1412 voltage level.

1413 It is not recommended to do a network reduction where Type D PGMs are connected although
1414 this might be the case sometimes. For this purpose, the use of
1415 *EquivalentGeneratingUnit/EquivalentPowerElectronicsUnit* with *Equipment.aggregate* set to
1416 *FALSE* would be applicable.

1417 As for Type A generators, the information about the generation technology can be derived
1418 through the use of classes derived from *EnergyComponent* as illustrated in [Figure 13](#).
1419 Additionally, one can make use of *fuelType* enumeration as shown in [Figure 15](#)

1420 This approach facilitates the integration of real-time scheduling information of both grid and
1421 market models.

1422

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 underlying network

Sub-use case	Recommended class	Note
Simplified model with aggregation	EquivalentGeneratingUnit / EquivalentPowerElectronicsUnit Equipment.aggregate set to TRUE	n <i>ExternalNetworkInjection</i> class can be associated. A <i>RotatingMachine</i> class cannot be associated ⁹ .
Simplified model without aggregation	EquivalentGeneratingUnit/EquivalentPowerElectronicsUnit with Equipment.aggregate set to FALSE	A <i>RotatingMachine</i> class not be associated
Explicit (in detail) model without aggregation	GeneratingUnit/PowerElectronicsUnit (and subclasses) with Equipment.aggregate attribute set to FALSE	A <i>RotatingMachine</i> 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 <i>RotatingMachine</i> 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 and it is expected to be deprecated in future

⁹ *RotatingMachine* cannot be associated with *EquivalentGeneratingUnit* as per the UML design. 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, <i>Equipment</i> class as per in the canonical CIM with <i>aggregate</i> attribute set to <i>TRUE</i>. From TSO perspective, they may use the associations <i>AggregatedEquipment</i> and <i>DetailedEquipment</i> in <i>Equipment</i> 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.

1429

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.

1466 To ensure consistency between generation and market models, the class *ScheduleResource*
1467 should be used as the key interface. This enables:

- 1468 • Coherent modelling of connection points and
- 1469 • Classification of generator types (e.g., SPGM, SPU) in line with aforementioned EU
1470 Regulations.

1471

1472

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.

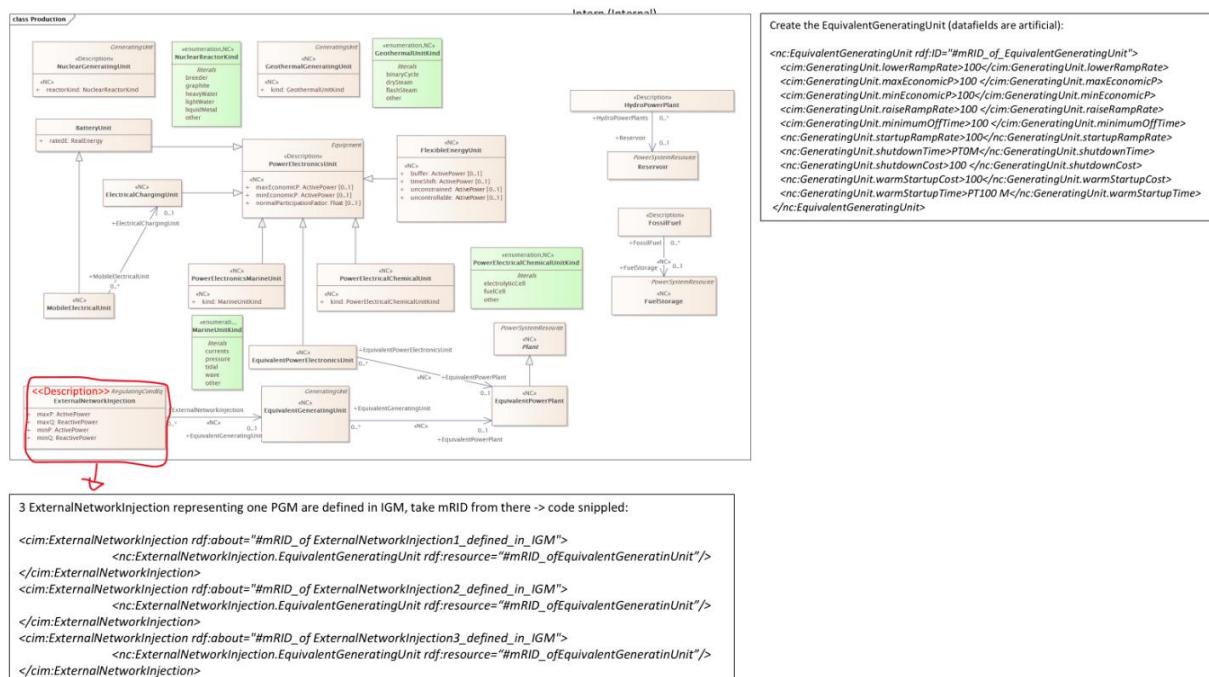


Figure 16: Example showing the creation of an ExternalNetworkInjection in the ER dataset

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 PowerShiftKeyDistribution3 instances where each ExternalNetworkInjection class is linked and associated with its participation factor (PF).

7.1.5.2 Representation of HVDC Interconnections

The representation of HVDC interconnections involves several modelling, boundary and data-exchange aspects. The RCP DES does not define these aspects in detail. Instead, the Network Code Profiles provide additional classes that enable a more detailed representation of HVDC interconnections, including their representation as part of a DC IGM. The applicable exchange rules and implementation guidance are specified in other documents, in particular the [ENTSO-E Boundary and Common Data Exchange Specification](#) and the [CGM Building Process Implementation Guide \(AC and DC Parts\)](#). The latter also provides implementation guidance for cases in which previous versions of CGMES are used.

The Boundary and Common Data Exchange Specification supports different modelling styles for HVDC systems, including the DC Injection Model, the DC Circuit Equivalent Model and the DC Converter Element Model. The selected modelling style determines whether the DC system is represented as an equivalent injection, as a simplified DC circuit or through detailed converter, pole, and DC network equipment. It also determines whether the relevant boundaries are located on the AC side, at a DC line, or within a DC substation. Both AC and DC boundary points are supported.

An important principle of the new boundary model is the distinction between the BoundaryPoint and the PointOfCommonCoupling. A BoundaryPoint identifies the agreed location at which modelling responsibility changes between two or more parties and where their model representations are connected. The PointOfCommonCoupling identifies the electrical connection of the HVDC facility to the surrounding AC network. Although these locations may coincide in a simple point-to-point interconnection, they represent different concepts and shall not be assumed to be identical in all cases. The new model supports boundary points located inside substations and requires the relevant boundary objects, connectivity nodes, point-of-common-coupling terminals, and equivalent injections to be aligned between the participating Parties.

This distinction is particularly important for complex hybrid interconnections such as Kriegers Flak, connecting Germany, Denmark, and Sweden. In such a configuration, the scheduled exchange boundary, the physical AC connection points of the offshore generation, and the connection of the HVDC system to the AC network may be located at different points. The model shall therefore identify the following separately:

- the boundary point(s) at which modelling responsibility changes;
- the relevant point-of-common-coupling terminals at which the converters or equivalent HVDC representation connect to the AC network;
- the AC line sections and offshore generation connected between those points; and
- the HVDC system or equivalent injection representing the scheduled transfer.

The CGM Building Process Implementation Guide explains as an example that the Kriegers Flak arrangement includes offshore wind production and two AC transmission lines whose combined flow is scheduled. The scheduled HVDC transfer is derived from the boundary schedule together with the forecast wind production and the AC transmission losses. It also

1536 notes that the two AC branches are represented within one Line container because the
1537 schedule applies to their combined flow rather than to each branch individually.

1538 Under the new boundary approach, the appropriate use of BoundaryPoint, PccTerminal¹⁰,
1539 ConnectivityNode or DCNode, and the associated AC or DC equipment shall be determined
1540 according to the selected modelling style and the agreed division of modelling responsibility.
1541 For the DC Injection Model, the boundary points are generally located at the AC interfaces
1542 represented by the equivalent injections. For the DC Circuit Equivalent Model and the DC
1543 Converter Element Model, the DC system is represented explicitly, and boundary points may
1544 be associated with the relevant DCPole structures at the applicable AC or DC interfaces.

1545 The boundary and common-data rules also permit controlled duplication of agreed boundary
1546 information in the relevant IGMs. This allows each IGM to be validated independently and
1547 avoids unresolved cross-model references, provided that the duplicated instances use the
1548 same identifiers and attribute values as the authoritative boundary dataset. The detailed
1549 selection of the boundary location, the point of common coupling and the HVDC modelling
1550 style shall therefore be agreed by the participating modelling authorities and implemented
1551 consistently in the boundary dataset and all related IGMs.

1552

1553

¹⁰ The association to PccTerminal (the point of common coupling terminal) is exchanged in the CGMES EQ dataset.

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.

1574 **7.1.5.4 CGMES/CIM Properties not Part of NC Profiles**

1575 There are some properties that are part of CIM, canonical extensions such as NC or CGMES
1576 profiles, but not part of the NC profiles. NC profiles now contain SHACL based constraints ¹¹to
1577 indicate if the dataset contains additional, not defined in the profile, properties. Such
1578 properties are not expected to be processed without an explicit agreement within the data
1579 exchange that applies NC profiles.

1580 In order to enable business processes to supply necessary information the ER profile includes
1581 “normal” values for these attributes. These attributes are going to be repositioned in the right
1582 profiles with the merge of ER and EQ profiles in future releases of the CIM international
1583 standard.

1584 Until that moment, the information and data can be supplied with ER datasets.

1585

¹¹ Refer to the Application Profiles Library on the ENTSO-E CGMES Library for SHACL constraints serialised in Turtle and to the human-readable 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 17](#).

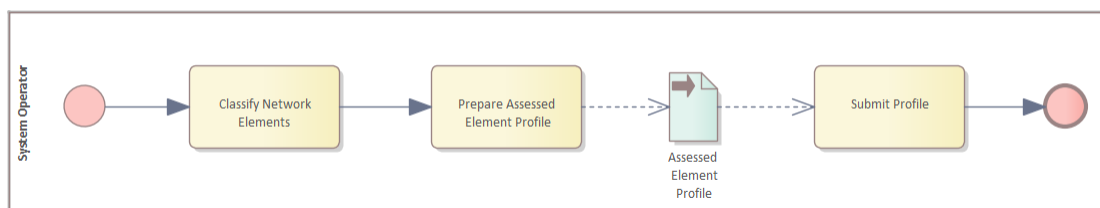


Figure 17 –List of Assessed Elements provision

The first step is to classify the Network Elements in the grid, the network element category diagram is represented in [Figure 18](#).

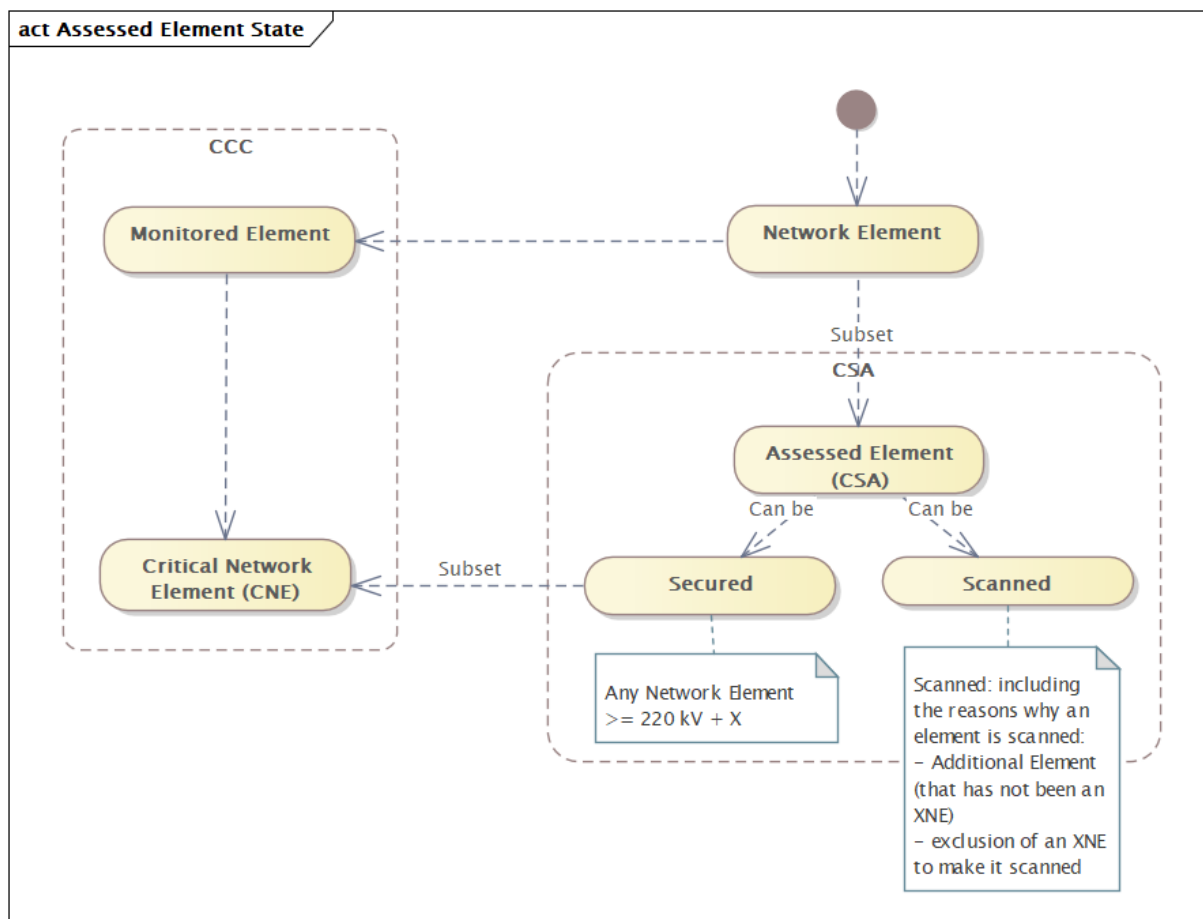


Figure 18 – Network element category diagram

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

1602 relief violations of an operational security limit identified during the regional or cross-regional
1603 security analysis. For instance, a secured element would be a cross-border relevant network
1604 element (XNE), which includes all grid elements with a voltage level higher than or equal to
1605 220 kV that are not intentionally excluded.

1606 A scanned element is an Assessed Element on which the electrical state (at least flows) shall
1607 be computed and shall be subject to an observation rule during the regional security analysis
1608 process. Such observation rule can be for example avoiding the increase of a constraint or
1609 avoiding the creation of a constraint on this element, as a result of the design of remedial
1610 actions needed to relieve violations on the secured elements. A scanned element could be any
1611 grid element if the grid element is not a Critical Network Element (CNE).

1612 A Critical Network Element (CNE) is a network element monitored during the coordinated
1613 capacity calculation process. Critical network elements are a subset of the secured elements.

1614 The second step is to provide the list of Assessed Elements using the Assessed Element profile.
1615 If an Assessed Element defined in the Assessed Element profile refers to an equipment or its
1616 controls that cannot be exchanged using CGMES Equipment profile dataset used in the CGM
1617 Build process, there is a need to define it in the Equipment Reliability profile in case that profile
1618 supports the definition of the new equipment and/or its controls. For instance, Equipment
1619 Reliability profile defines additional equipment and controls on HVDC, limits, reactive
1620 capability curves. Figure illustrates the profiles dependencies. The System Operator shall
1621 ensure that the Assessed Elements are consistent with the power system model (IGM) valid
1622 for the validity period of the Assessed Element data.

1623 The following general aspects apply when modelling assessed elements:

- 1624 • The grid equipment that is assessed is in the Equipment profile dataset and is
1625 referenced by its mRID;
- 1626 • The Region and SystemOperator in which/by which the AssessedElement is assessed
1627 are referenced by their mRIDs defined in the common data dataset (see Section 0)
1628 which conforms to the Equipment Reliability profile.
- 1629 • When the reference to ConductingEquipment (e.g. a line, a transformer) is defined and
1630 there is no reference to *OperationalLimit*, the assessment is performed for all limits
1631 defined at all ends of the equipment. In case an AssessedElement object refers to a
1632 ConductingEquipment that has no limits defined in the underlying model the
1633 assessment will not be performed. Therefore, this needs to be detected in the
1634 consistency checks constraints. The advantage of using reference to *OperationalLimit*
1635 is that the target point of the assessment is defined in an exact way because the
1636 *OperationalLimit* relates to a type (e.g., PATL, TATL, etc.) and location (e.g., terminal at
1637 side 1 of the equipment).

1638

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.

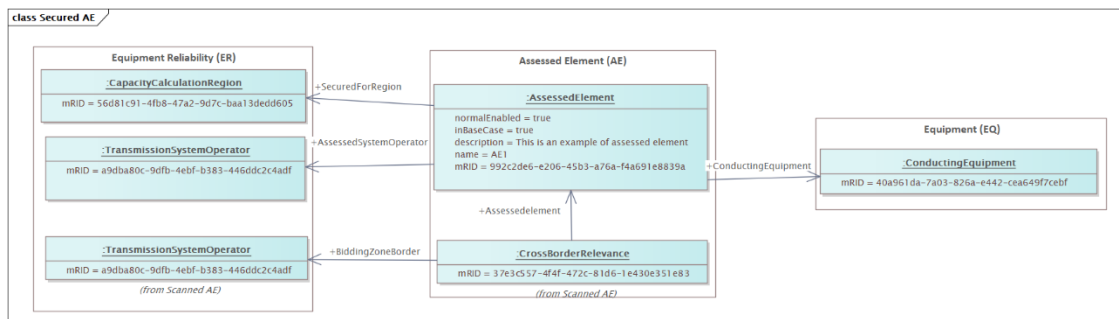


Figure 19 – Secured Assessed Element example.

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.

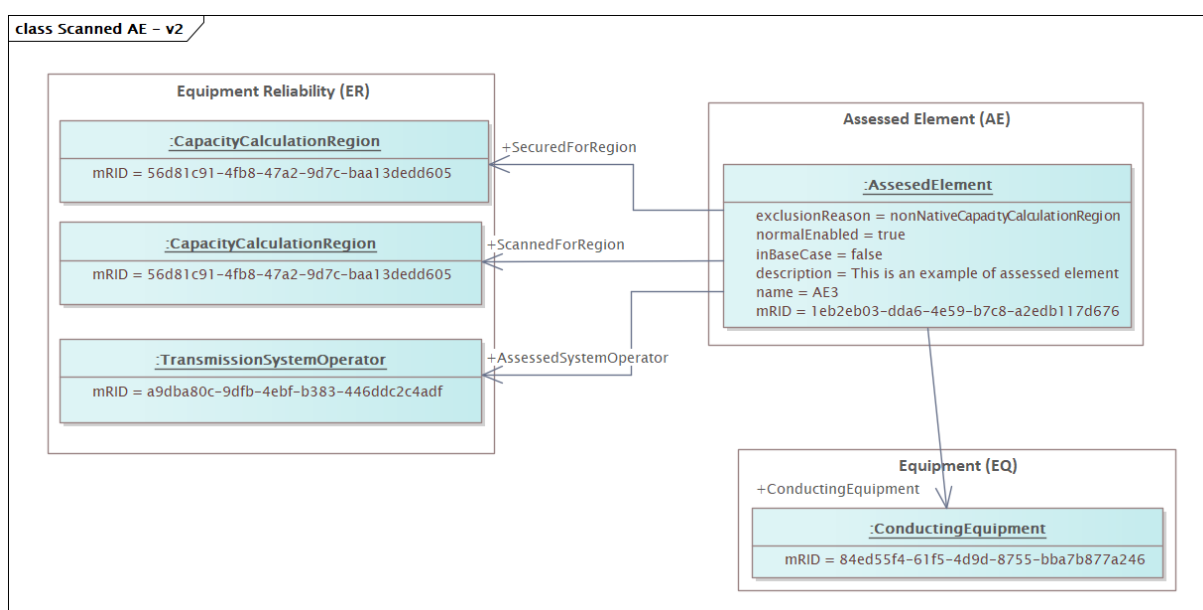


Figure 20 – Scanned Assessed Element example

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 [Q](#). In addition, normally in case it is necessary to exclude a secured AssessedElement object, a reason for this exclusion needs to be provided.

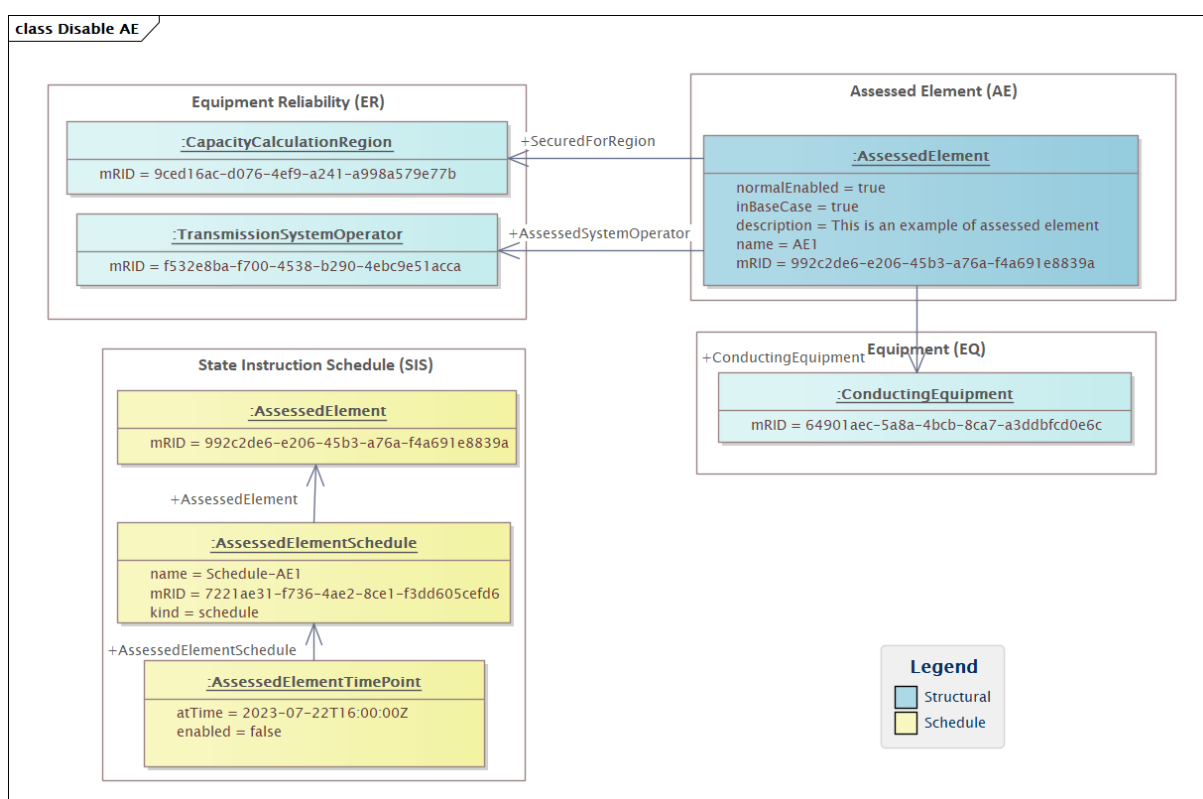


Figure 21 – Example Disable Assessed Element via SIS dataset

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.

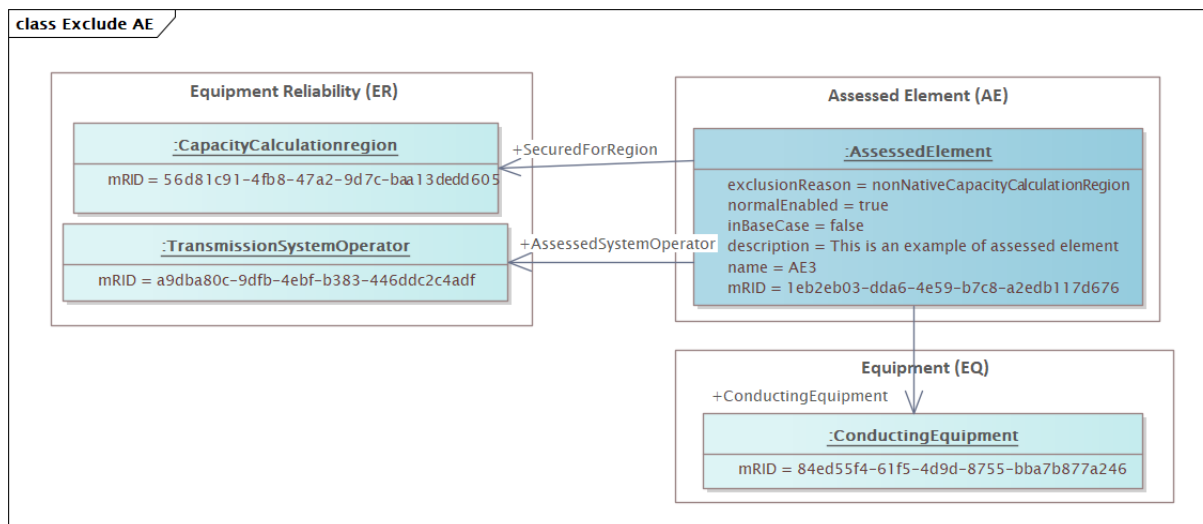


Figure 22 – Exclude Assessed Element example.

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 AssessedElement 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

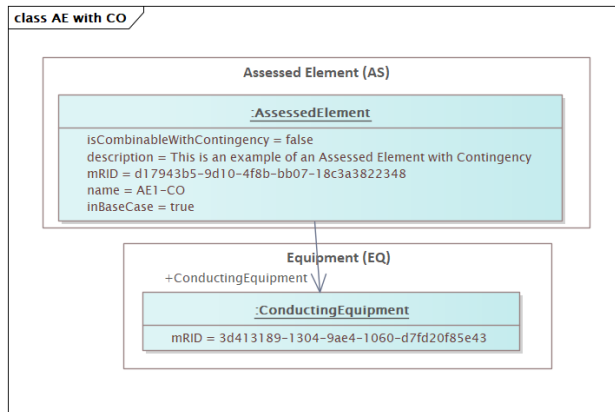


Figure 23 – Assessed Element with Contingency – Scenario 1.

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.

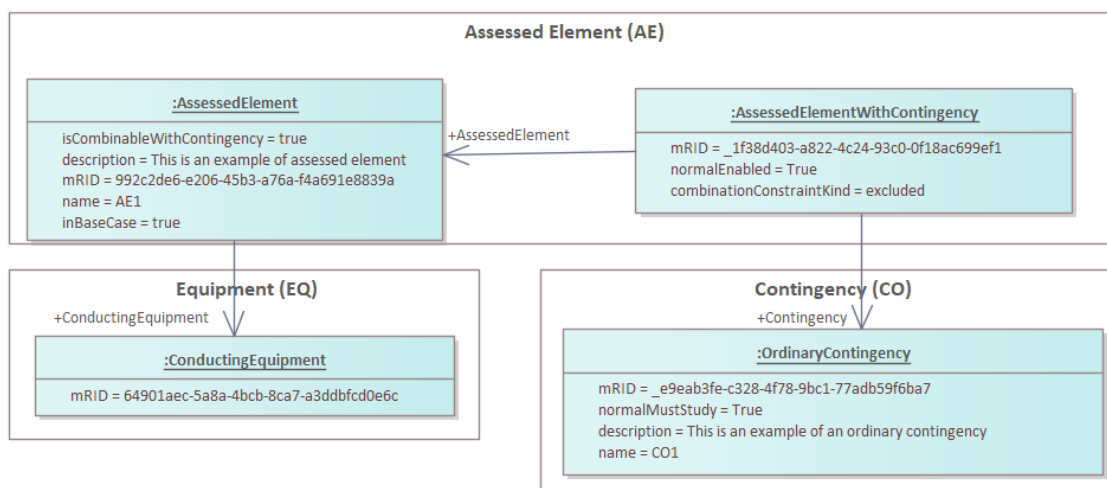


Figure 24 – Assessed Element with Contingency – scenario 2.

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.

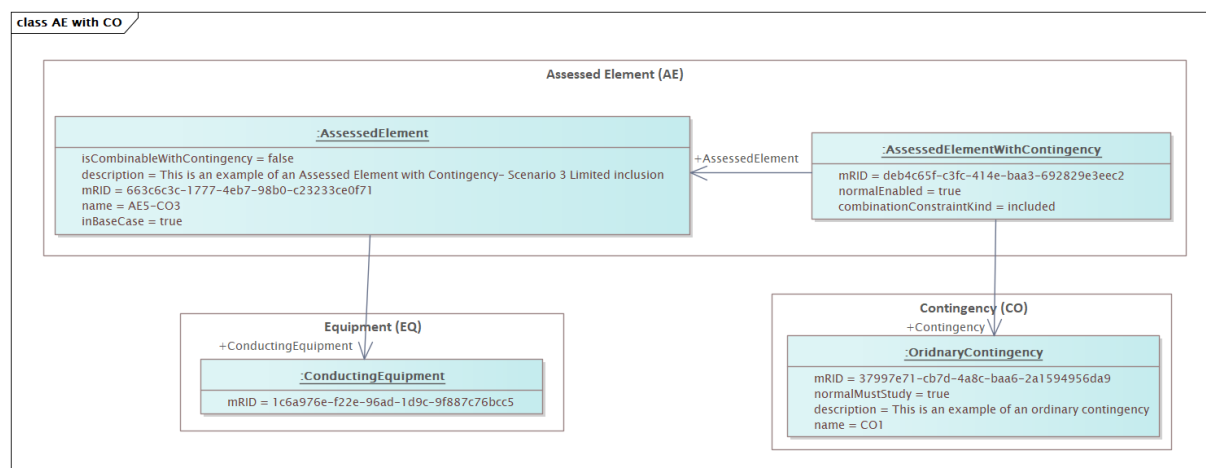


Figure 25 – Assessed Element with Contingency – scenario 3.

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 “isCriticalForCapacityCalculation” will allow to identify in CSA the subset of Secured AEs which were 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.

1868 The guidance above expects to clarify how critical elements may be modelled in both CSA and
1869 CC process. Other important remarks are:

- 1870 • Not every XNE in CSA was CNE in CC, but every CNE from CC has to be XNE in CSA.
- 1871 • In CSA the term “monitoring” is not used. CSA uses “Scanned” elements (which are
1872 monitored in RAO). Those are indicated via the ScannedForRegion relationship. CSA does
1873 not require information of which AssessedElements were monitored in CC process
1874 (therefore no need for flag “isMonitoredForCapacityCalculation”).
- 1875 • On the other hand, although the indication of “monitoring” in the CSA process is the use
1876 of ScannedForRegion, the CC process might use the attribute Monitored to indicate this
1877 concept.

1878 As indicated above and although deprecated, the attribute AssessedElement.criticalElement
1879 and the enumeration *CriticalElementKind* are included in the AE profile, and they are used to
1880 cover the following legacy implementations on the AssessedElement:

- 1881 • validation – if the AssessedElement is not Critical Network Element and Contingency
1882 (CNEC) and it is not Monitored Network Element and Contingency (MNEC)
- 1883 • monitored - if the AssessedElement is not CNEC and it is MNEC
- 1884 • critical - if the AssessedElement is CNEC and it is not MNEC
- 1885 • criticalAndMonitored - if the AssessedElement is CNEC and it is MNEC

1886 This together with the Individual Adjustment Value (IVA) and Common Adjustment Value
1887 (CVA) may be used for the intraday capacity calculation and it is provided to the flow-based
1888 calculation method.

1889 In the flow-based methodology IVA share is modified by TSOs during their security analysis.
1890 This part of the business process is where those parameters should be defined in the AE profile
1891 but might need SIS for updates. The current version of NCP integration, IVA updates are not
1892 included in the scope. This is why for now, only structured data for adjustment values is
1893 needed.

1894 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 with 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 `AssessedElement` 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 remedial 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 `AssessedElement` with a “Tap Position” Remedial Action.

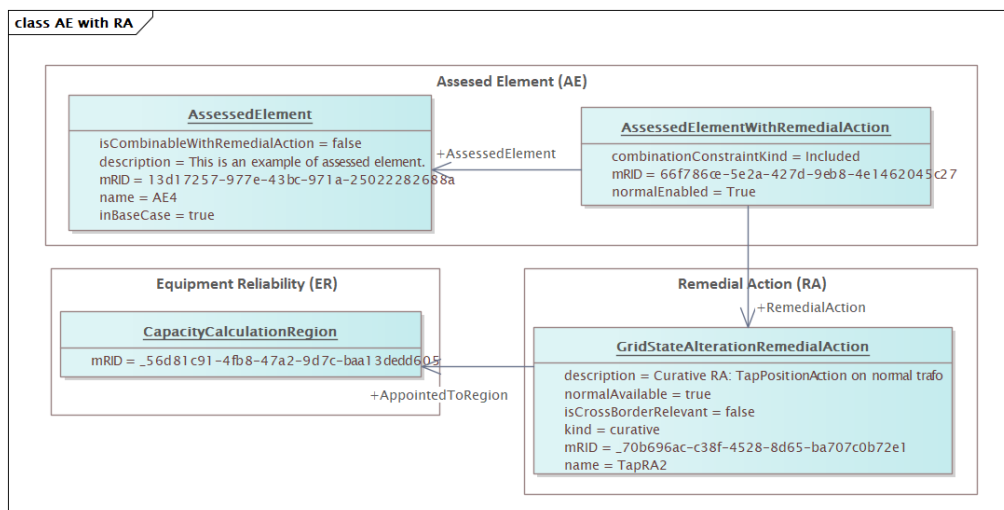


Figure 26 – Assessed Element with Remedial Action.

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.

- GridStateAlterationRemedialAction rdf: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 [Q](#)), 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.

2019 7.1.6.9 Assessed Element with Different Limits Between Base Case and 2020 Contingency Analysis

2021 In some power systems, regulatory requirements specify that certain equipment, for example
2022 overhead lines, must operate under two distinct thermal limits: one applicable in the base
2023 case (BC) and another, typically higher, applicable under contingency conditions (CO-case). In
2024 such situations, it is necessary to model an operational current limit that is explicitly valid only
2025 for the base case, enabling the coordination process to distinguish between the lower base
2026 case threshold and the higher contingency threshold.

2027 To model this situation, the NCP features a *BaseCaseCurrentLimit* class in the AssessedElement
2028 profile, Steady State Instruction and State Instruction Schedule profiles. The
2029 *BaseCaseCurrentLimit* class is a specialisation of the existing *OperationalLimit* class, ensuring
2030 compatibility with the CGMES model and avoiding duplication of limit definitions.

2031 The base case current limit is associated with the corresponding equipment in the EQ profile
2032 through the *OperationalLimitSet* object, and it is valid exclusively when the attribute
2033 *inBaseCase* in the *AssessedElement* class is set to *true*. A SHACL constraint enforces this rule,
2034 ensuring that the limit is applied only in base case conditions and that its lower value is
2035 respected in comparison to the contingency case limit.

2036 Because the *BaseCaseCurrentLimit* class is a child of *OperationalLimit*, it inherits compatibility
2037 with the *AvailabilitySchedule* profile without requiring additional modifications there.

2038 When the transition of IGM to CGMES 3.0 is completed, the *OperationalLimitType* class
2039 together with *LimitKind.stability* enumeration value in the EQ profile shall be used to
2040 differentiate between base case and contingency current limits.

2041

2042 **7.1.6.10 Expected Use Cases**

2043 The following expected use cases are not explained in full detail. The next versions of the
2044 document could include more details. This list is also not exhaustive.

2045 **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	

2046

2047

2048

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 27](#).

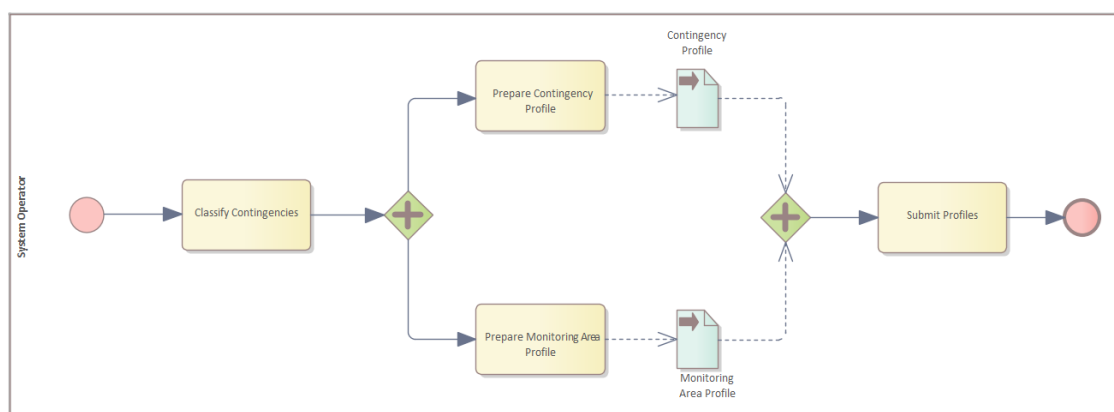


Figure 27 – Contingency list provision

The first step is to classify the contingencies as one of the three types illustrated in the category diagram shown in [Figure 28](#).

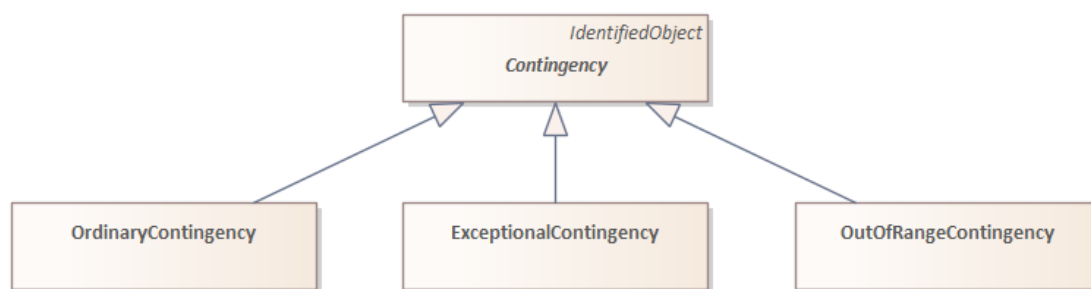


Figure 28 – Contingency category diagram

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

2075 Equipment (EQ) profile through their unique mRID (Master Resource Identifier). It is possible
2076 to define if a contingency should be considered in the security analysis by properly setting the
2077 Contingency parameter normalMustStudy. The permanent and temporary occurrence
2078 increasing factor types (CSAm art.8.3) for each exceptional contingency can be defined in the
2079 ContingencyConditionKind enumeration.

2080 As per the SOGL Article 33:

- 2081 • Each TSO shall inform the TSOs in its observability area about the external
2082 contingencies included in its contingency list.

2083 As per the SOGL Article 3:

- 2084 • ‘internal contingency’ means a contingency within the TSO's control area, including
2085 interconnectors.
- 2086 • ‘external contingency’ means a contingency outside the TSO's control area and
2087 excluding interconnectors, with an influence factor higher than the contingency
2088 influence threshold;

2089 The “internal” CO dataset could be validated together with TSO A IGM. Let us suppose that
2090 TSO A has two borders, one with TSO B and TSO C. TSO A needs to have as may “external” CO
2091 datasets relevant of the other TSOs it shares borders with. In this example, TSO A would create
2092 two external CO datasets which represents the external contingencies used to study the
2093 neighbouring TSO B and TSO C grid. These two external CO datasets are separated as they
2094 need to be validated with different EQ and ER dataset.

2095 The interpretation is that TSOs are responsible to determine their external contingencies with
2096 [CSAm Article 6](#) are to be studied from their neighbouring grids that are part of their
2097 observability area.

2098 That is, TSO A should inform TSO B and TSO C on what elements of TSO B and TSO C's
2099 observability area TSO A is studying. TSO A does this by sharing with TSO B and TSO C one
2100 external CO dataset respectively.

2101 TSOs can distinguish which TSO the information comes from by using the header of the CO
2102 datasets.

2103 In addition, the specification of the external exceptional contingencies from the list can be
2104 done using the Monitoring Area profile. The external contingencies that are included in the
2105 contingency list of a System Operator are the contingencies which are in the Contingency Area
2106 also defined using the Monitoring Area profile. An example of monitoring area definition is
2107 provided in section 0.

2108

2109

2110 7.1.7.1 Ordinary Contingency

2111 According to the “CSAm” or *Methodology for Coordinating Operational Security Analysis* ([link](#)
2112 [to 2nd Amendment - ACER Decision 07/2024](#)) Article 7 definition of ordinary contingencies,
2113 the following list offers a recommendation on which CIM classes to use for representing them:

- 2114 • Loss of a single line/ cable

2115 The technical recommendation is to use ACLineSegment and SeriesCompensator classes.

- 2116 • Loss of a single transformer

2117 The technical recommendation is to use PowerTransformer class.

- 2118 • Loss of a single phase-shifting transformer

2119 The technical recommendation is to use PowerTransformer class.

- 2120 • Loss of a single voltage compensation device

2121 The interpretation is that this contingency category refers generally to FACTS equipment
2122 (Static VAR Compensator - SVC) devices and shunt compensators.

2123 The technical recommendation is to use the ShuntCompensator, SeriesCompensator and
2124 ShuntCompensator classes.

- 2125 • Loss of a single component of a HVDC system such as a line or a cable or a single HVDC
2126 converter unit

2127 The technical recommendation is to use the ACDCconverter and DCConductingEquipment
2128 classes.

- 2129 • Loss of a single power generation unit

2130 The technical recommendation is to support only RotatingMachine and do not use
2131 GeneratingUnit.

2132 As an alternative, to represent generation units based on power electronics, the technical
2133 recommendation is to use the class PowerElectronicConnection.

2134 If there are multiple units in the plant where a TSO would like to put out of service as a
2135 contingency, an exceptional contingency shall be used.

- 2136 • Loss of a single demand facility

2137 The interpretation is that this includes the load behaviour. It is important to note that the CIM
2138 model does not represent an explicit load model but the aggregate model of loads.

2139 The technical recommendation is to use NonConformLoad, RotatingMachine and
2140 PowerElectronicsConnection classes.

- 2141 • Loss of a single busbar coupler, in case it is protected by an overcurrent protection
2142 device.

2143 The technical interpretation is to represent the situations of opening a Breaker class when it
2144 is closed as well closing a Breaker class when it open.

2145 TSOs can define contingencies depending on their knowledge on whether busbars are
2146 protected against overcurrent or under/over voltage.

- 2147 • Loss of a single busbar coupler, in case it is protected by an over/under voltage
2148 protection device.

2149 The technical interpretation is to represent the situations of opening a Breaker class when it
2150 is closed as well closing a Breaker class when it open.

2151 TSOs can define contingencies depending on their knowledge on whether busbars are
2152 protected against overcurrent or under/over voltage.

2153 Note: it is expected that tools support Switch class or any of its specialisation and
2154 contingencies can be applied to any of these classes, but Breaker and
2155 DisconnectingCircuitBreaker shall be supported. It is up to the business process' owner to use
2156 any of the specialisations of this class. If software vendors do not support all the functionalities
2157 of Switch, they need to inform what they do not support.

2158 In cases where a single branch, or other element is modelled / represented in the IGM with
2159 multiple objects due to data exchange representations, an OrdinaryContingency can have
2160 references to multiple ContingencyElement objects in order to refer to all objects part of this
2161 ordinary contingency.

2162

7.1.7.1.1 Definition of Ordinary Contingency

Figure 29 illustrates how to specify an Ordinary Contingency.

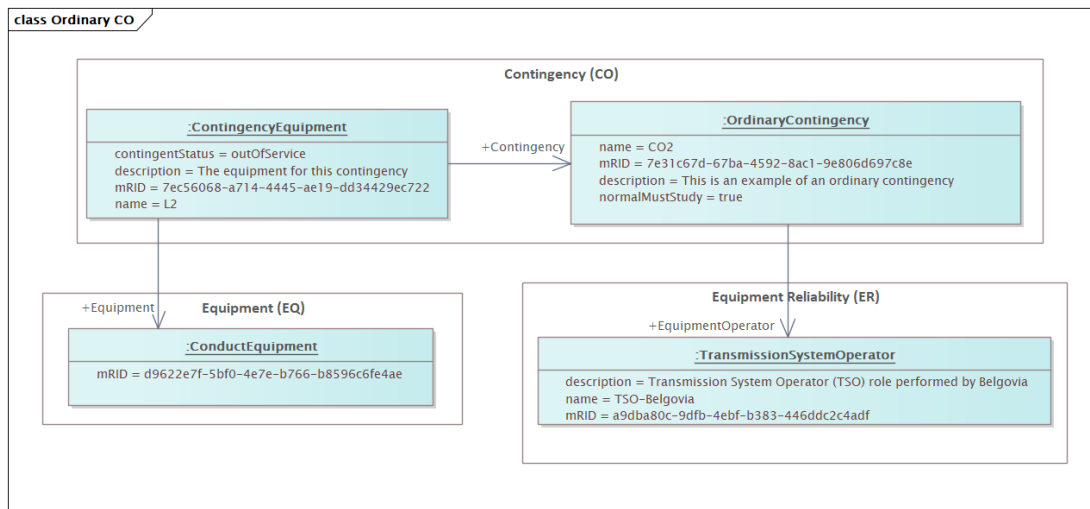


Figure 29 – Ordinary Contingency

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 Q 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. Other attributes such as `.normalMustStudy` have NC namespace as they are part of the NC extensions.

2185 **7.1.7.1.2 Summary table with recommended equipment CIM classes necessary to fulfil CSAm requirements on**
2186 **contingencies**

Indicated Equipment in CSAm	cim:Equipment	Sub classes	Comment	Example test data in ReliCapGrid model open-source
Generation Unit	cim:RotatingMachine	AsynchronousMachine, SynchronousMachine	Some vendors have already used RotatingMachine .	- Contingency describing the loss of a synchronous mahcine (mRID = 37997e71-cb7d-4a8c-baa6-2a1594956da9) - Missing example using AsynchronousMachine
	cim:PowerElectronicsConnection	N/A	Others use AsynchronousMachine and SynchronousMachine	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

	cim:ShuntCompensator	nc:StaticVarCompensator		compensator Roanoke SC in Espheim (mRID = 62eac668-82a1-4739-8cfc-de929b78ef7e).
		LinearShuntCompensator and		Example using NonlinearShuntCompensator:
		NonlinearShuntCompensator		Contingency describing the loss of a the compensator FT62_X3 in Svedala (mRID = ab92defa-ef8e-4d13-a242-5b1a9fe956f6).
		nc:ModularStaticSynchronousSeriesCompensator		Missing example using ThyristorControlledSeriesCompensator
Demand Facility	cim:EnergyConsumer	cim:NonConformLoad	Software tools should support the class EnergyConsumer so TSOs have the flexibility to use ConformLoad and NonConformLoad	Missing example using StaticVarCompensator
				Missing example using ModularStaticSynchronousSeriesCompensator
	cim:EnergyConsumer	cim:NonConformLoad		Example with NonConformLoad
				Contingency describing the loss of a Demand Facility in Belgovia (mRID = 65582e87-5035-4465-8dd9-cb655224b29f).

			(any of the specialisation) Some vendors use "equivalent injection"	Missing example using EnergyConsumer
	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 <i>Breaker</i> and <i>DisconnectingCircuitBreaker</i>. 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
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2187

2189 7.1.7.2 Exceptional Contingency

2190 According to the “CSAm” or *Methodology for Coordinating Operational Security Analysis* ([link](#)
2191 [to 2nd Amendment - ACER Decision 07/2024](#)) Article 7, exceptional contingencies are:

- 2192 • loss of network elements having common fault mode, meaning that a single fault (such
2193 as a fault on a busbar, HVDC grounding system, circuit breaker, measurement
2194 transformer etc.) will lead to the loss of more than one network element.
- 2195 • loss of overhead lines built on same tower.
- 2196 • loss of underground cables built in same trench.
- 2197 • loss of grid users having common process mode, meaning that the total or partial
2198 sudden loss of one grid user will lead to the total or partial loss of the others (for
2199 example: Combined cycle units etc.).
- 2200 • loss of network elements/users simultaneously disconnected as a result of the
2201 operation of a Special Protection Scheme.
- 2202 • loss of multiple generation units (including solar and wind farms) disconnected
2203 because of a voltage drop on the network or system frequency deviation.

2204 In contrast with section [7.1.7.1](#), the CIM does not necessarily include a one-to-one
2205 representation for the concepts listed above (i.e., one cannot represent an overhead line build
2206 on the same tower in CIM). This is why, the RCP DES does not offer concrete CIM modelling
2207 recommendations for such concepts.

2208 However, the following example illustrates how to specify an Exceptional Contingency.

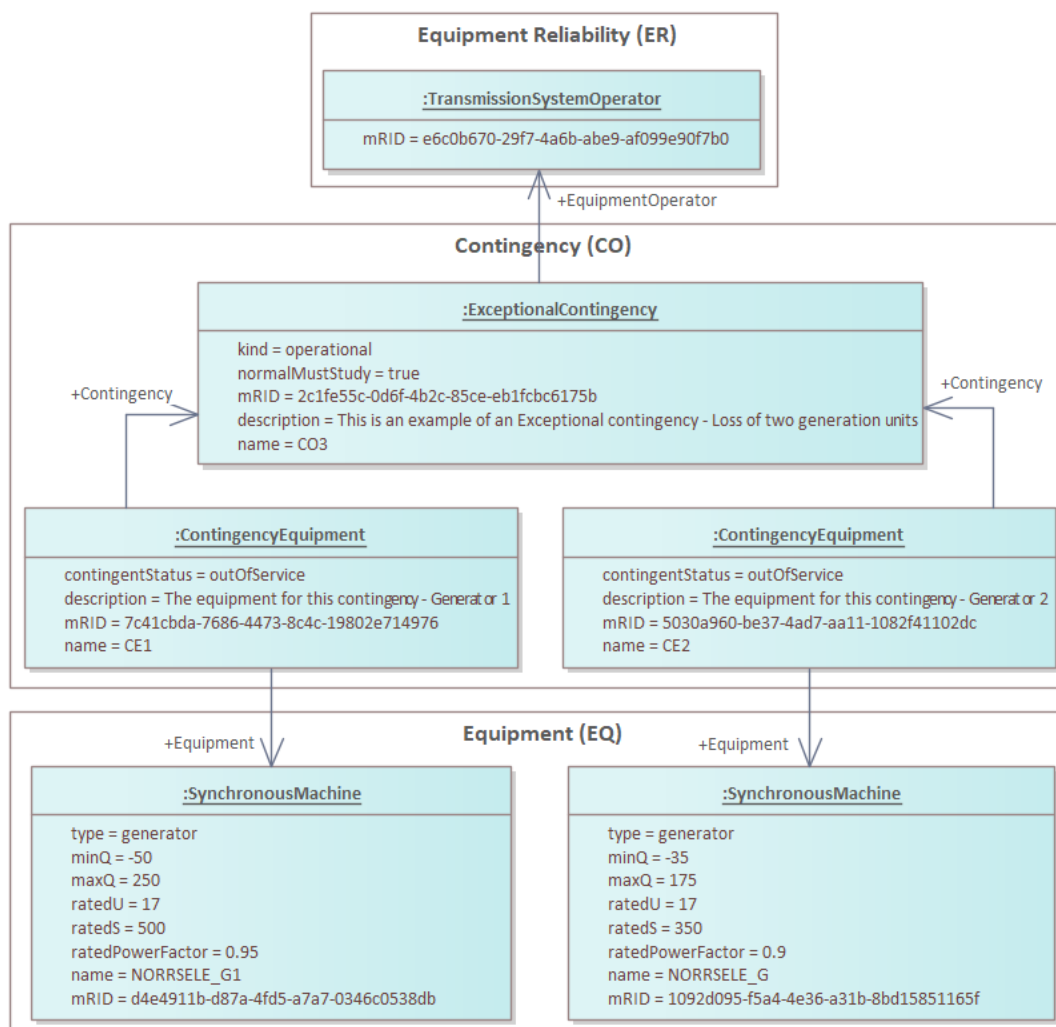


Figure 30 - Exceptional Contingency

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 SynchronousMachine 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:

- permanent occurrence increasing factors
- temporary occurrence increasing factors

2224 From ROSC perspective, the exceptional contingencies are therefore split into permanent and
2225 temporary exceptional contingencies. Permanent exceptional contingencies are always
2226 included in the Daily ROSC process while temporary exceptional contingencies are included
2227 only in case a TSO requests the inclusion during daily process.

2228 The distinction between permanent and temporary exceptional contingency is implemented
2229 by defining the ContingencyConditionKind for each ExceptionalContingency as given in the
2230 Figure 31:

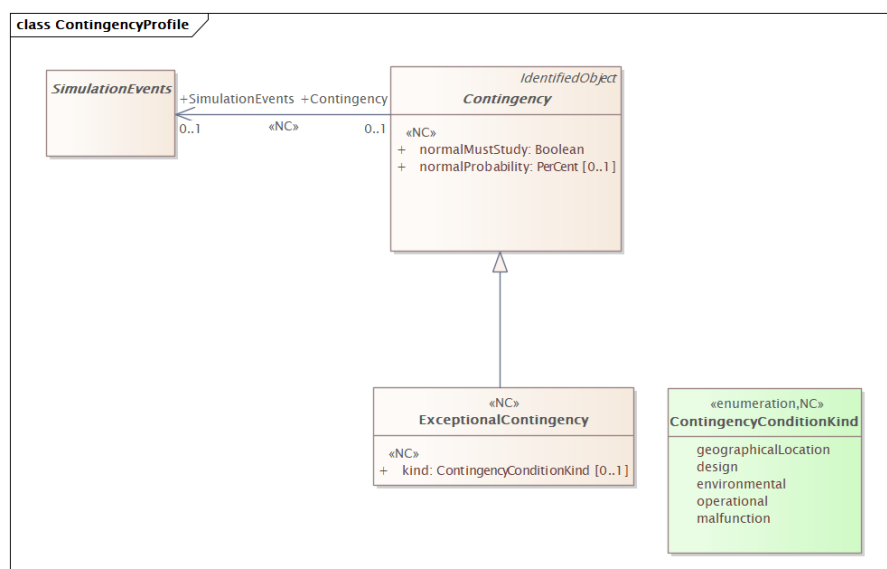


Figure 31: Extract of the ContingencyProfile diagram

- 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 be elaborated in future releases.

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

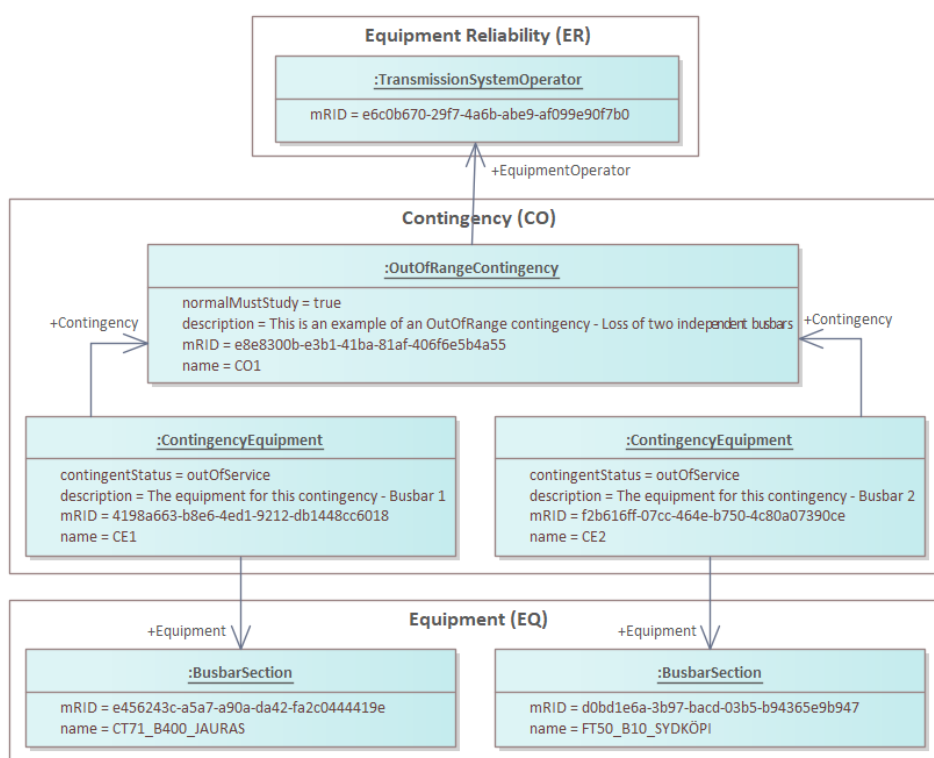


Figure 32 - Out of Range Contingency

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

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

2260 The Equipment dataset example can be located in Svedala IGM file,
2261 20220615T2230Z__Svedala_EQ_1.xml:

- 2262 • BusbarSection rdf:ID="_e456243c-a5a7-a90a-da42-fa2c0444419e"
- 2263 • BusbarSection rdf:ID="_d0bd1e6a-3b97-bacd-03b5-b94365e9b947"

2264 For simplicity, some parts of the Equipment dataset snippet are not represented in the
2265 diagram (e.g., association of the SynchronousMachine objects with EquipmentContainer and
2266 RegulatingControl objects).

2267

7.1.8 List of Remedial Actions

The List of Remedial Actions provision process is illustrated in Figure 33.

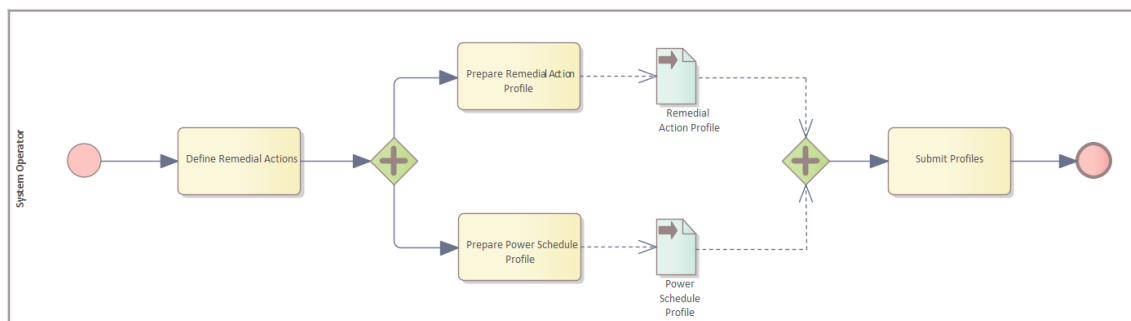


Figure 33 – List of Remedial Actions provision

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 34](#)). 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.

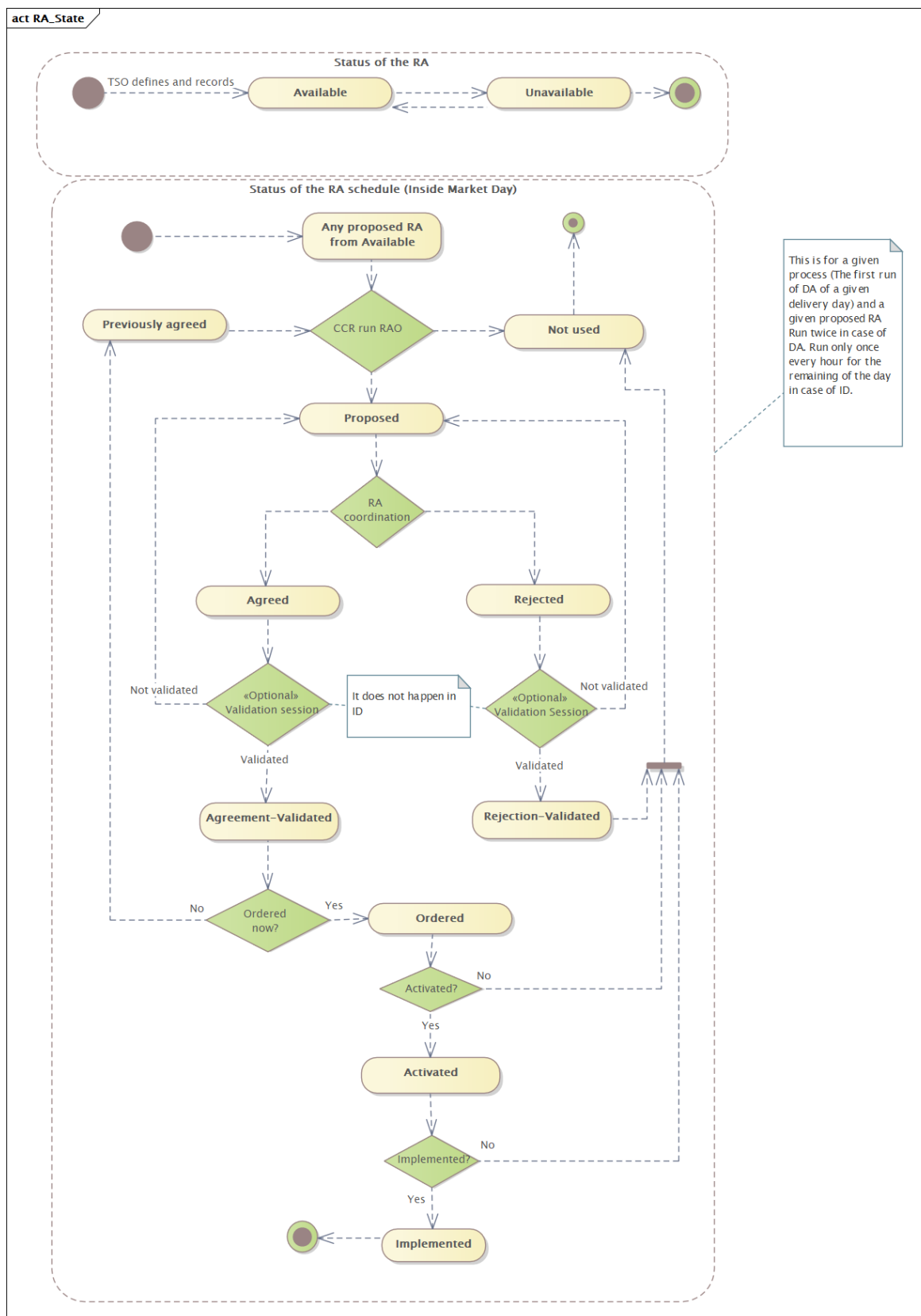


Figure 34 – Remedial action state diagram

2284 All available remedial actions can be used for the remedial action optimization process which
2285 will choose the most appropriate remedial actions to solve the different issues in the scenario.
2286 These remedial actions are denominated as proposed remedial actions.

2287 Just after the remedial action optimisation process is finished, remedial action coordination
2288 starts. If it passes the coordination, the remedial action can be agreed or rejected. These two
2289 states must be validated during the validation session. If they are not finally validated, they
2290 become proposed again.

2291 In case that a rejected remedial action is validated, then it becomes Rejection-Validated. On
2292 the other hand, if the agreed remedial action is validated, then it becomes Agreement-
2293 Validated. Agreement-Validated remedial actions can be ordered now or in a later stage. In
2294 case that a remedial action is not ordered now, then it becomes a previously agreed remedial
2295 action. If it is ordered now, then the remedial action changes its status to Ordered.

2296 Ordered means that the SO sends the order to the corresponding party to proceed with the
2297 RA, and in most cases ordered means it is a binding order (could be that still, in an exceptional
2298 case, the RA could be cancelled after being ordered) In case that an ordered RA is not finally
2299 activated, then it becomes Not used.

2300 After ordered, the RA can become activated and in that case the forecast case information is
2301 updated with regards to the acceptance criteria. In case that an activated RA is not finally
2302 implemented, then it becomes Not used. However, if the activated RA is implemented, then
2303 it becomes Implemented and the process finishes.

2304 The following types of remedial actions can be defined:

2305 • **Grid state alteration remedial action** – describes one or many grid state alterations
2306 applied to a grid model state or a particular scenario in order to resolve one or more
2307 identified constraints.

2308 • **Scheme remedial action** – involves a scheme that can include conditional logic and
2309 stages of grid alteration. The primary remedial action is the arming of these schemes,
2310 which will then perform curative remedial action when the condition is met. System
2311 Integrity Protection Scheme (SIPS) and Special Protection Scheme (SPS) are example of
2312 this. Scheme remedial actions can be coordinated or non-coordinated.

2313 • **Redispatch remedial action** - Redispatch means a measure, including curtailment, that
2314 is activated by one or more transmission system operators or distribution system
2315 operators by altering the generation, load pattern, or both, in order to change physical
2316 flows in the electricity system and relieve a physical congestion or otherwise ensure
2317 system security (Regulation (EU) 2019/943). In its essence from CSA perspective,
2318 redispatch remedial action is always defined by potential increase or decrease of power
2319 infeed in a known location, i.e. exact node of the grid model.

2320 • **Countertrade remedial action** - Countertrade means a trade between bidding zone to
2321 solve a congestion. Therefore, a countertrade remedial action means a measure
2322 performed by one or several TSOs in one or several bidding zones in order to relieve
2323 physical congestions where the location of activated resources within the bidding zone
2324 is not known. A countertrade offer by a TSO is in general based on some existing third

2325 party bids since a TSO shall not offer countertrade randomly and risk whether it can
2326 really provide it. Therefore, countertrade can be associated to:

- 2327 ○ bid from the market
- 2328 ○ bid from tertiary energy providers (which is a control area bid, not associated to a
2329 specific unit by its definition).

- 2330 • A countertrade offer, which a TSO offers to RAO, consists of a merit order of MW-price
2331 blocks which are actually individual discrete bids and shall contain additional
2332 parameters which are currently defined in PowerBidSchedule (i.e., lead time, step
2333 increment, max activation).

2334 In order to allow correct modelling of countertrade offer within the grid model, the
2335 countertrade remedial action is linked to a GLSK (provided in ER dataset) which defines
2336 how a change in the balance / net position (single value) of a zone is transformed into
2337 a set of values of delta injections in specified nodes (multiple values) of a certain grid
2338 model. By default, a countertrade is associated to the so-called "country GSK" meaning
2339 an increase of infeed proportional to the remaining available capacity on all generating
2340 units within a bidding zone, excluding nuclear and renewable types.

- 2342 • **Availability remedial action** - cancels or reschedules an availability schedule.

2343 A remedial action can include multiple grid state alteration and this is necessary in order to
2344 model multiple actions within one remedial action. The design depends on the business need
2345 and the complexity of the remedial action that needs to be modelled. For instance, a topology
2346 action would in most of the cases act on multiple switches to achieve a change in a substation
2347 topology. In addition, remedial actions can be grouped into groups, and the dependency
2348 between them specified (refer to section [7.4.5](#)).

2350 The following sections illustrate several remedial actions that are often used by system
2351 operator.

2352
2353

7.1.8.1 Grid State Alteration Remedial Action – Tap position

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

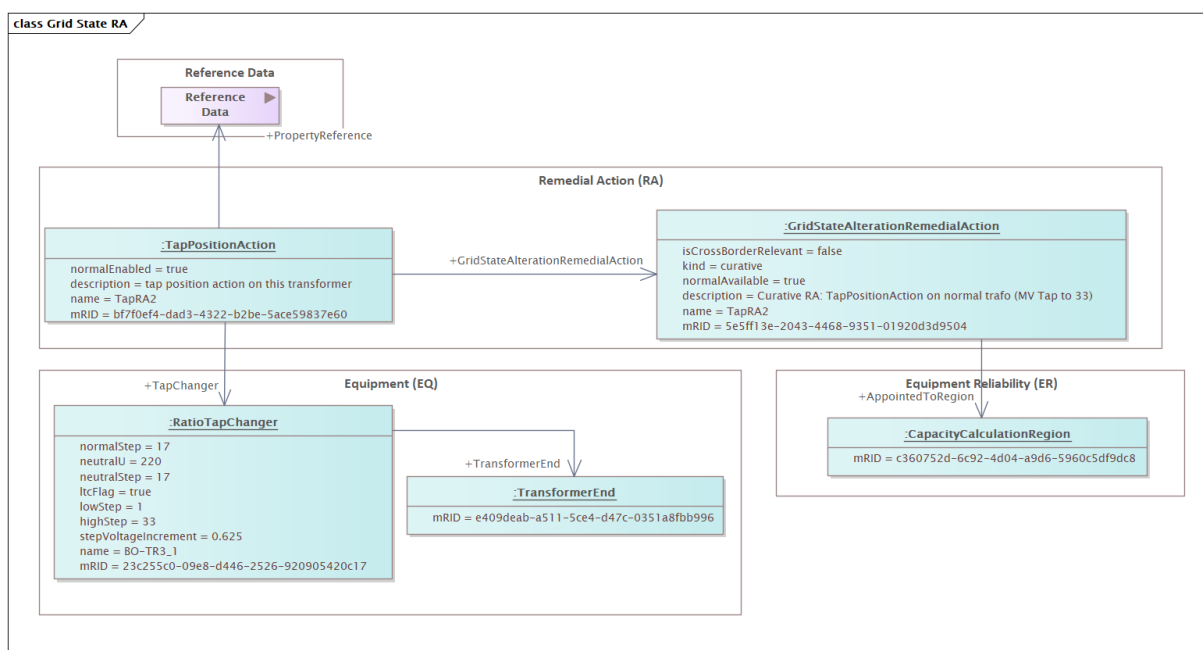


Figure 35 - Grid State Alteration (Tap Position) Example

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.

2374 7.1.8.2 Grid State Alteration Remedial Action – Topology

2375 The NC Profiles support Topology Grid State Alteration Remedial Actions which are modelled
2376 and linked with the RAS dataset objects at both stages: when a remedial action schedule is an
2377 output of the RAO and when it is a TSO proposal prior RAO using SSI, SIS and RA profiles.

2378 Therefore, NC Profiles enable a data exchange allowing to:

- 2379 • Communicate activation of Topology RA on a per market time unit basis;
- 2380 • Model a Remedial Action that consists of multiple topology changes.

2381 It should be noted that the negotiation or optimisation of remedial actions in a given market
2382 time unit (MTU) might affect other remedial actions scheduled for later market time units.

2383 In general, a Topological RA can be designed with one or many GridStateAlterations
2384 (TopologyActions). In addition, there are different stages where it is possible to modify or add
2385 information to a remedial action.

2386 The following list contains the most common situations:

- 2387 • Topology remedial action with one TopologyAction;
- 2388 • Topology remedial action with multiple TopologyActions, and such *TopologyActions*
2389 can be modified via scheduled (SIS) or per MTU (SSI) profiles, which would change the
2390 configuration of the Topology RA. This can be done prior to RAO.
- 2391 • Topology remedial action activation as an output of RAO where the whole content of
2392 the Topology RA is activated or deactivated as a collection (set of TopologyActions).

2393 The following applies when designing topology remedial actions:

- 2394 • It is required that topological remedial actions are modelled to act on the switches in
2395 the elements and not by indicating which element is switched.
2396 Therefore, this requires that the underlying power system model contains switching
2397 devices for at least the elements that are going to be used in topology remedial actions
2398 or any other remedial actions that require change of switching device status.
2399

2400 This does not mean that the underlying model shall be full SCADA/EMS node-breaker
2401 model. The level of detail is driven by the need for remedial actions and the
2402 requirements in the SOGL for reporting statuses of the switching devices.

- 2403 • The TSO can design the remedial action to either provide RAO with full flexibility or
2404 constrain the action that can be performed on the switching device.
2405 For instance, a remedial action can allow for a change of the status of a switch
2406 regardless of the initial status of the switch or it can instruct to only open or only close
2407 a switch. If the remedial action is designed to only open a switch and if in the grid model
2408 the switch is already open in the SSH, RAO will not be selecting this remedial action as
2409 its implementation will be pointless.

2410
2411 These constraints on switching devices in case of Topology grid state alteration are
2412 defined by using StaticPropertyRange. For switching devices the attribute

2413 RangeConstraint.direction can only have values RelativeDirectionKind.upAndDown
2414 (which will allow RAO to either open or close the switch) or RelativeDirectionKind.none
2415 (which instructs RAO that only the RangeConstraint.normalValue shall be applied, i.e.
2416 is normalValue is 1, which mean Switch.open should be set to true, RAO can only open
2417 the switch if the switch is closed in the base case). Following the different aspects each
2418 of the use case described above, the NC profiles can be used as follows:

- 2419 ○ Scheduling and per-MTU ability to modify GridStateAlteration prior RAO;
- 2420 ○ Activating Topology remedial action with one GridStateAlteration as part of RAS
- 2421 (post RAO);
- 2422 ○ Modifying / proposing changes to RAS on a topology remedial action in case of one
- 2423 GridStateAlteration (post RAO);
- 2424 ○ Defining a Remedial Action, composed of one or several TopologyActions via RA
- 2425 profile (prior to CROSA)
- 2426 ● Activating Topology remedial action with multiple GridStateAlterations as part of RAS
- 2427 (post RAO);
- 2428 ● Modifying / proposing changes to RAS on a topology remedial action in case of multiple
- 2429 GridStateAlteration (post RAO).

2430 Normally *TopologyActions* and related *RemedialActions* classes are applied to specific MTUs.
2431 However, in case of post RAO or when suggesting modifications, NC profiles only support
2432 activation at *RemedialAction* class level instead of at the *TopologyAction* class level.

2433 From a business perspective, the current requirements for RAO targets optimisation at the RA
2434 level, i.e., enabling/disabling the topology remedial actions as a whole, and the RAO is not
2435 intended to optimise individual switching equipment to find the best topology configuration.

2436 The design of the RemedialAction (RA) and RemedialActionSchedule (RAS) profiles allows for
2437 setting the switching device status to be modified on a per-MTU basis. As shown in [Figure 36](#),
2438 this can be done by using *GridStateIntensitySchedule* with references to
2439 *GenericValueTimePoint* and *GridStateAlteration* (which refers to *Switch.open*
2440 *PropertyReference* in the *RemedialAction* profile).

2441 However, such setup is not applicable for topology remedial actions. This is because, normally
2442 modification of status of one switching device requires modification of other switching
2443 devices.

2444 The recommended approach is not to use *GridStateIntensitySchedule* for expressing the RAO
2445 result of a topology remedial action, but rather to rely on the mechanism to activate or
2446 deactivate the whole remedial action (refer to section [7.1.9.1.1](#)).

2447
2448
2449

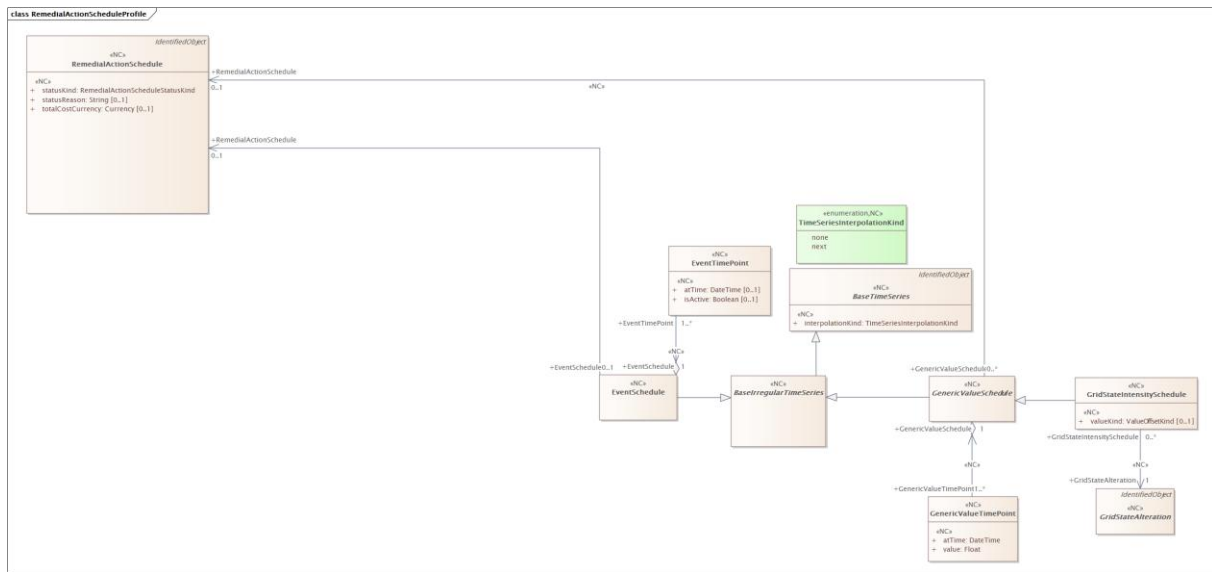


Figure 36: Extract of the RemedialActionSchedule diagram showing GridStateAlteration and GridStateIntensitySchedule related classes

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.

2467 **7.1.8.2.1 Topology Remedial Action with One Topology Action and without**
2468 **Dependencies**

2469 For illustration purposes, readers can refer to the EQ and RAS synthetic dataset of the fictitious
2470 TSO *Svedala* part of the ReliCapGrid GitHub repository and follow the indicated mRID below.

- 2471 • The *GridStateAlterationRemedialAction* is the basic case where we have one Topology
2472 remedial action with one topology action.
- 2473 • 6d2c8901-d068-4d22-8ce9-7379644b4f17
- 2474 • The topology remedial action is designed to open a switch in the *Svedala* fictitious IGM
2475 EQ dataset.
- 2476 • 176d262c-701c-4ced-99b2-a155c136e787

2477

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

2495 7.1.8.2.3 Modification Prior RAO of Topology Remedial Action

2496 A certain TSO modifies (enables/disables) Topology Actions part of a topology RA class using
2497 the SIS and SSI profiles prior to RAO. For illustration purposes, please refer to the SSI and SIS
2498 synthetic datasets of the fictitious TSO *Espheim* part of the ReliCapGrid GitHub repository and
2499 follow the indicated mRID below.

- 2500 • Using SIS the modification can be done by:
- 2501 • *GridStateAlterationSchedule* (f5205bd4-637a-4eb7-b0d8-e03638bc570b) per Topology
2502 Action (4d3757fd-b40a-4d7b-be47-6553935234ff) part of the Topology RA (d856a2a2-
2503 3de4-4a7b-aea4-d363c13d9014)
- 2504 • Multiple *GridStateAlterationTimePoint* to enable/disable the Topology action per time
2505 point.
- 2506 • Using SSI the modification can be done by:
- 2507 • *GridStateAlteration* per TopologyAction (4d3757fd-b40a-4d7b-be47-6553935234ff)
- 2508

2509 **7.1.8.2.4 Proposing modifications of a Topology Remedial action after RAO**

2510 Modification of any remedial action schedule involves the approach outlined in the section
2511 7.4.5. This is preceded by a coordination process where the TSO refuses the
2512 *RemedialActionSchedule* and proposes a new one as described in section 0.

- 2513 • To refuse a *RemedialActionSchedule* a TSO needs to send
2514 *RemedialActionScheduleResponse*. In the example this is illustrated by the class
2515 (96f93b71-420f-456f-932e-9ac3f724b683).
2516
- 2517 • To propose a new schedule a TSO needs to send *RemedialActionScheduleDependency*
2518 and a new *RemedialActionSchedule*. In a simple situation there is no need to create
2519 *RemedialActionScheduleGroup* (that is, *RemedialActionScheduleDependencyKind* is
2520 set to none).

2521 In the example this is illustrated by the following classes *RemedialActionScheduleDependency*
2522 (f7231aa5-d497-41f3-a5d5-9d4af74444f0) and a new *RemedialActionSchedule* (51361821-
2523 0a40-4e5a-a49d-29c266ea2ecc).

2524 In general, when making a new proposal TSOs need to send *EventSchedule*. In the example,
2525 another identifier is created for the *EventSchedule* coming out of the counter proposal (in this
2526 case, refusal).

2527 That is, when the TSO creates the remedial action schedule class, the TSO would also create
2528 the complete schedule and the time points. The schedule needs to be complete as there is no
2529 rejection on a particular timepoint. The refusal is on the whole schedule, and a proposal has
2530 to be complete too.

2531 Section 7.4.4.2 complements well.

2532

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, there are two remedial actions 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 participating in 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

- 2591 ○ In EquipmentReliability profile dataset
- 2592 ▪ PowerShiftKeyStrategy is defined with all the setup using SchedulingArea
- 2593 ○ In StateInstructionSchedule profile dataset
- 2594 ▪ PowerShiftKeyDistribution object refers to PowerShiftKeySchedule object.
- 2595 ▪ PowerShiftKeyDistribution object also refers to the PowerShiftKeyStrategy
- 2596 object in the ER dataset. It is possible to have different
- 2597 PowerShiftKeyStrategy per PowerShiftkeyDistribution

2598 In this option there is no need that PowerShiftKeySchedule object refers to GeneratingUnit as
 2599 this is done via the PowerShiftKeyStrategy. There is no need to use
 2600 ParticipationFactorTimePoint.

- 2601 • Option 5: Using bid schedule and power shift key strategy

2602 The following classes are used:

- 2603 ○ In RemedialAction profile dataset
- 2604 ▪ PowerRemedialAction refers to BiddingZone and/or BiddingZoneBorder
- 2605 ▪ PowerShiftKeyStrategy object refers to the PowerRemedialAction
- 2606 ○ In EquipmentReliability profile dataset
- 2607 ▪ PowerShiftKeyStrategy class using enumeration
- 2608 PowerShiftKeyKindeSchedulingArea with corresponding references to
- 2609 generating unit(s) in case of RedispatchRemedialAction (for
- 2610 CountertradeRemedialAction not mandatory)
- 2611 ○ In StateInstructionSchedule profile dataset
- 2612 ▪ PowerBidSchedule object that refers to PowerRemedialAction
- 2613 ▪ PowerBidSchedule has PowerBidScheduleTimePoint that provides the
- 2614 active power and price for points in time
- 2615 ▪ PowerShiftKeyDistribution with reference to PowerShiftKeySchedule
- 2616 ▪ In case of ExplicitInstruction PowerShiftKeySchedule is required with
- 2617 ParticipationFactorTimePoints and potential reference to GeneratingUnit
- 2618 (exactly the same as stated in ER)

2619 With this approach clear distinction between structured data (offline data) and schedule data
 2620 (e.g. daily process) is achieved since only SIS is used in daily process with reference to ER and
 2621 RA profiles.

2622

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 37](#) below.

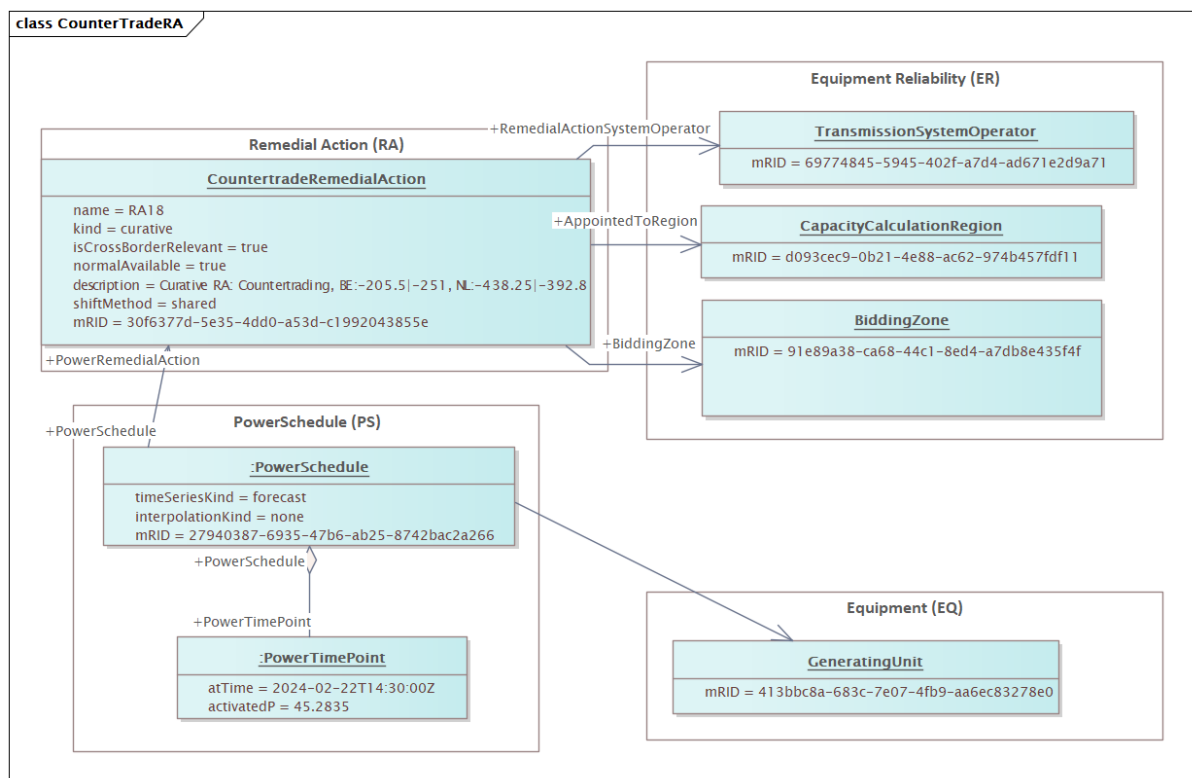


Figure 37 - Countertrade Remedial Action Example with PowerSchedule

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 38](#) below.

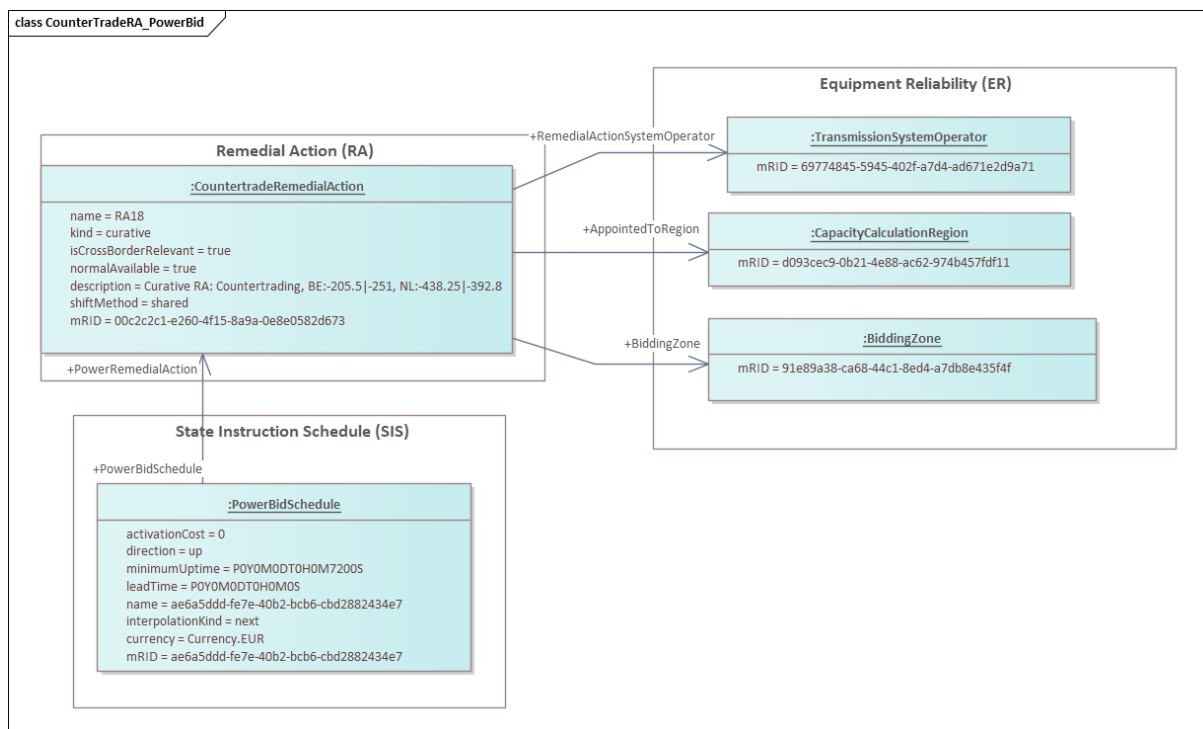


Figure 38 - Countertrade Remedial Action Example with PowerBidSchedule

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".

2649 7.1.8.3.3 Shared Remedial Action in a Boundary Data Set

2650 A remedial action should be defined in a boundary dataset where its complete and
2651 unambiguous description depends on information governed by more than one party. This is
2652 typically the case for remedial actions associated with cross-border equipment,
2653 interconnectors, HVDC systems, shared protection schemes or coordinated actions whose
2654 triggering conditions and resulting actions involve network elements located in different
2655 control areas.

2656 Placing such a remedial action in a boundary dataset establishes a single shared definition that
2657 can be referenced by all participating parties. This avoids each party creating a separate and
2658 potentially inconsistent representation of the same remedial action. The shared definition
2659 should include the common identity of the remedial action or remedial action scheme, its
2660 stages, triggering logic and the actions that need to be interpreted consistently by all affected
2661 parties. Persistent identifiers shall be agreed and reused so that schedules, availability
2662 information, coordination results and other datasets can refer to the same shared objects.

2663 A boundary definition is particularly necessary where one party cannot describe the remedial
2664 action independently. For example, the trigger may depend on measurements or equipment
2665 states from both sides of a border, while the resulting action may affect equipment belonging
2666 to one or more system operators. The parties shall therefore agree which objects are defined
2667 in the boundary dataset and which locally owned equipment objects are referenced from their
2668 respective datasets. Changes to the shared remedial action should be coordinated, since a
2669 unilateral modification could result in different interpretations of its activation logic or
2670 expected effect.

2671 The ReliCapGrid example DC-Espheim-Svedala_RA.xml illustrates a shared remedial action
2672 scheme associated with the Espheim-Svedala HVDC connection. The dataset defines one
2673 normally armed SIPS-type RemedialActionScheme with two ordered stages. Each stage is
2674 associated with a separate GridStateAlterationCollection representing an HVDC runback
2675 action.

2676 The first stage represents the west–south runback and has priority 1, while the second
2677 represents the east–north runback and has priority 2. Each stage has its own trigger and
2678 associated gate logic. The triggers use active-power measurements at explicitly referenced
2679 terminals and equipment-tripping indications. Depending on the detected power-flow
2680 direction and the tripping condition, the relevant stage is activated.

2681 The resulting grid-state alterations modify the ACDCCConverter.targetPpcc property of the
2682 relevant converters. Static property ranges define incremental changes of positive or negative
2683 250 MW, thereby representing the required HVDC runback according to the detected
2684 operating direction and event. The example consequently combines measurements, tripping
2685 conditions and converter actions that relate to the shared HVDC connection and cannot be
2686 fully interpreted as an isolated action of only one party.

This shared representation ensures that both parties and the RCC use the same remedial action identity, triggering logic, stage order and expected control effect when performing security analysis, remedial action assessment and coordination.

7.1.8.3.4 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 39) 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".

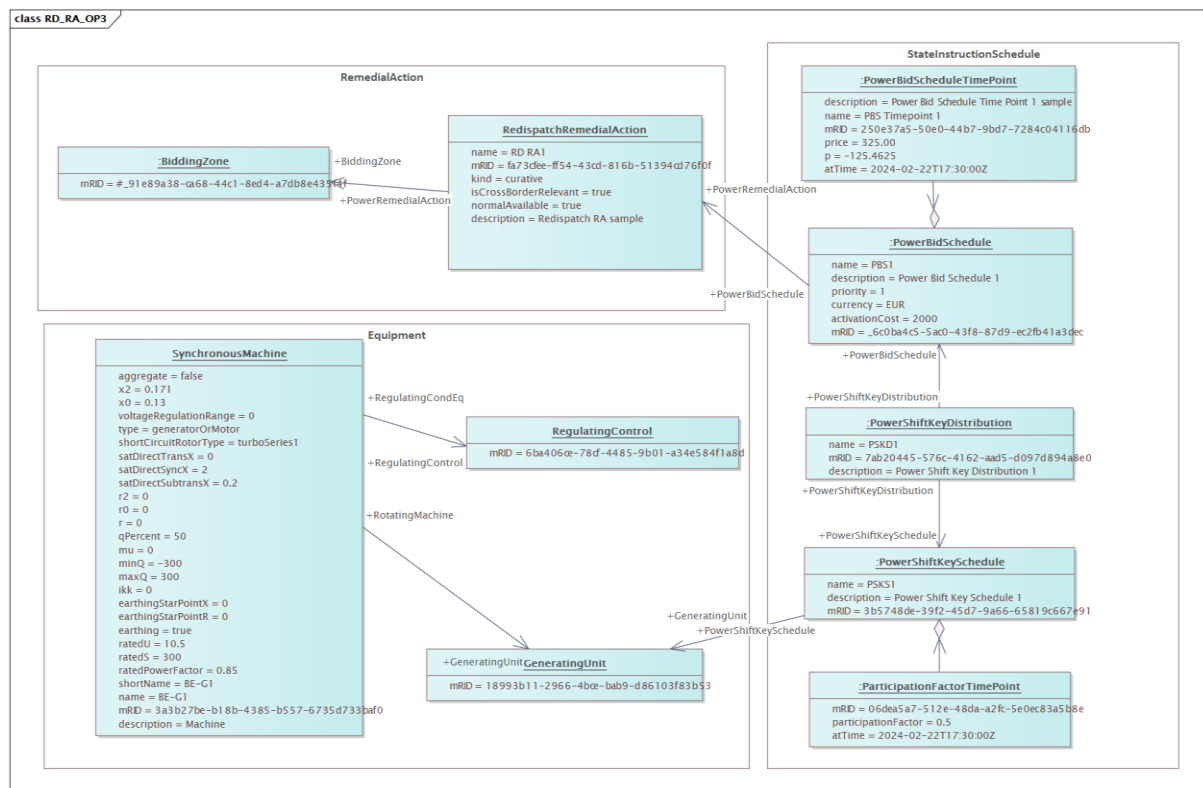


Figure 39 - Redispatch Remedial Action Example Option 3

2706 The second way to define a RedispatchRemedialAction is illustrated in the [Figure 40](#) below
2707 and utilizes power shift key strategy, as explained above in Option 4. The RemedialAction
2708 profile is defined in Belgovia_RA.xml:

- 2709 • RedispatchRemedialAction rdf:ID="_9d72d12a-f135-437a-83fa-ef3e5b23f41f".

2710 The corresponding State Instruction Schedule dataset example can be located in ReliCapGrid
2711 in Belgovia_SIS.xml:

- 2712 • PowerShiftKeyDistribution rdf:ID="_7ab20445-576c-4162-aad5-d097d894a8e0"

- 2713 • PowerShiftKeySchedule rdf:ID="_3b5748de-39f2-45d7-9a66-65819c667e91".

2714 The corresponding Equipment reliability dataset example can be located in ReliCapGrid in
2715 Belgovia_ER.xml:

- 2716 • PowerShiftKeyDistribution rdf:ID="_7ab20445-576c-4162-aad5-d097d894a8e0"

- 2717 • PowerShiftKeySchedule rdf:ID="_3b5748de-39f2-45d7-9a66-65819c667e91".

2718

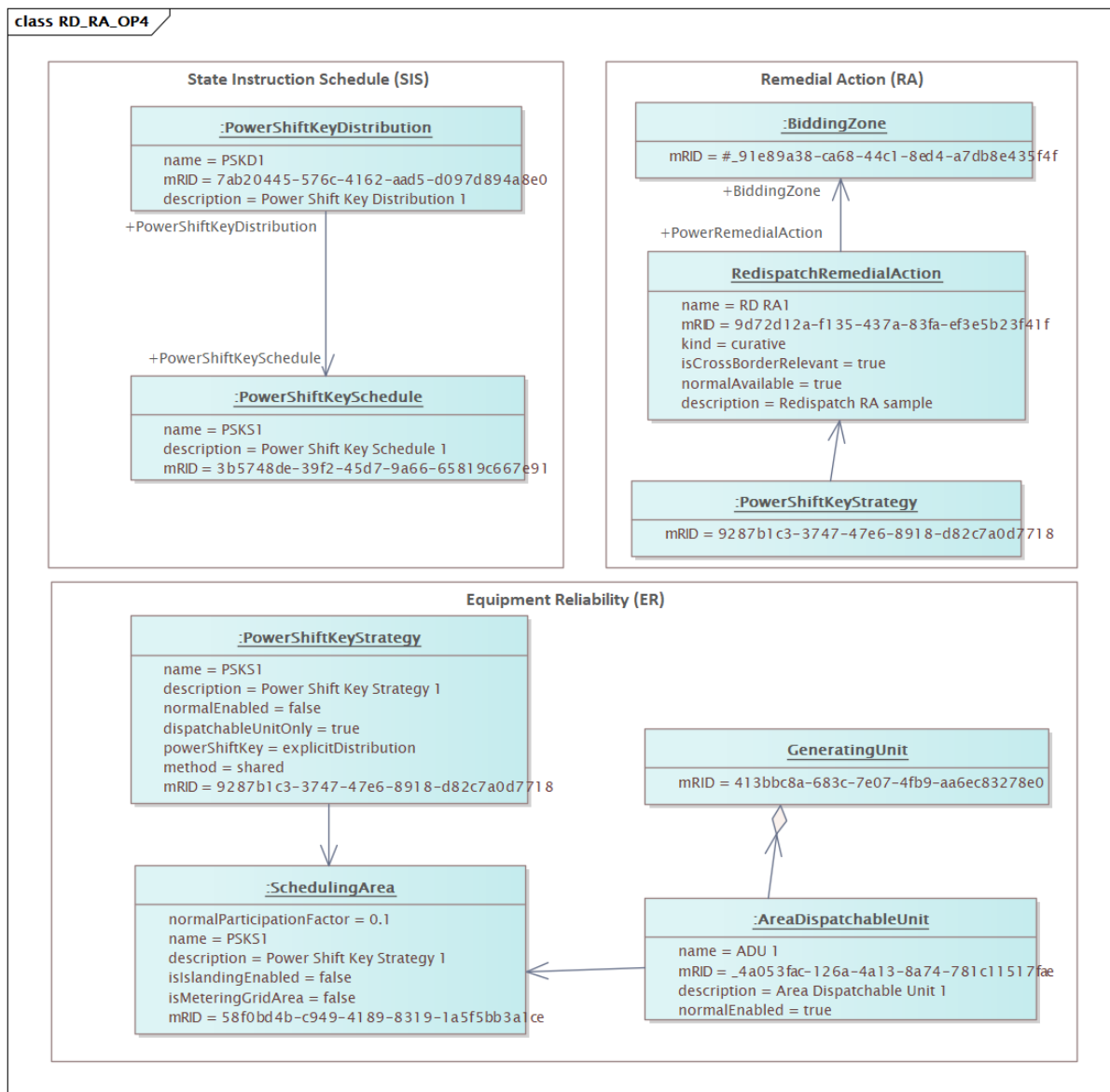


Figure 40 - Redispatch Remedial Action Example Option 4

2721 7.1.8.3.4.1 Power Bid Schedule dependency (*Parent-Child* dependency)

2722 This section explains a use case where TSOs manage power plants—such as gas and steam
2723 turbines—that involve parent-child dependencies with operational constraints like delays and
2724 mandatory run requirements.

2725 TSOs typically have a diverse generation portfolio, ranging from traditional gas or coal-fired
2726 power plants to hydro and renewable energy sources. Some costly remedial actions include
2727 bid offers from different generation types, where parent-child relationships are used to model
2728 dependencies between two or more bids. For example, the parent might be a gas generator,
2729 and the child a steam turbine.

2730 Each generation type comes with its own operational constraints that must be respected
2731 when submitting a bid offer. These parent-child relationships can be defined either within a
2732 single remedial action or across different RAs and may also be used to represent constraints
2733 at the generator level.

2734 To model a parent-child dependency:

- 2735 1. Power bids must first be created.
- 2736 2. Parent-child dependencies can then be established between them.

2737 It is important distinguishing between the dependencies in the activation of the parent and
2738 child bid from the conditions such bids shall respect when (and if) running.

2739 The recommendation is to use the *PowerBidSchedule* class in the SIS profile to model bid
2740 offers, as well as the *PowerBidDependency* class including the attributes required to define
2741 the dependencies, as outlined below.

2742 Readers can use the [Figure 41](#) to visualize the key attributes of *PowerBidDependency* class.

2743 The first dependency is the activation condition using the attribute *kind* as below.

- 2744 • *kind*: Type of dependency between bids. It indicates the activation dependency
2745 between dependee (parent) and dependent (child) bids. It does not indicate any
2746 running condition between dependee and dependent bids.

2747
2748 If *PowerBidDependencyKind* equals to restrictive, a combination of the following
2749 attributes *PowerBidDependency.startToStartLag*,
2750 *PowerBidDependency.finishToStartLag*, *PowerBidDependency.finishToFinishLag* , or
2751 *PowerBidDependency.overlap* shall be used.

- 2752 ○ The *kind* attribute can take the following *PowerBidDependencyKind* values:

- 2753 ■ *exclusive*: Bids are exclusive depending on each other. Bids are exclusive
2754 depending on each other. Only dependee (parent) bids can be activated if
2755 dependent (child) is activated or vice versa. For instance, dependent (child)
2756 must not be activated if the dependee (parent) is activated.
- 2757 ■ *inclusive*: Bids are inclusive depending on each other. Both dependee
2758 (parent) and dependent (child) bids must be activated, i.e., dependent
2759 (child) must be activated if the dependee (parent) is activated.

2760 ▪ restrictive: Bids are restrictive depending on each other. The activation of
2761 dependent (child) bids is optional if the dependee (parent) is activated.

2762 • Secondly, TSOs can set the running dependencies or conditions between the parent
2763 and the child bids with the following of attributes.

2764 • *startToStartLag*: Time between the activation of dependee (parent) bids and the
2765 activation of dependent (child) bids. It cannot be used when the
2766 PowerBidDependency.kind is set to exclusive.
2767

2768 Depending on the startToStartLagKind the value has the following meaning:

- 2769 ○ exact: the indicated lag should be exactly respected.
- 2770 ○ minimum: the indicated lag should be the minimum respected one and a higher or
2771 equal lag for the activation of the dependent (child) after the activation of the
2772 dependee (parent) is allowed.
- 2773 ○ maximum: the indicated lag is the maximum that can occur, and a smaller or equal
2774 lag for the activation of the dependent (child) after the activation of the dependee
2775 (parent) is allowed.

2776 • *finishToStartLag*: Time between the deactivation of the dependee (parent) bids and the
2777 activation of dependent (child) bids. It cannot be used when the
2778 PowerBidDependency.kind is set to exclusive.
2779

2780 Depending on the finishToStartLagKind the value has the following meaning

- 2781 ○ exact: the indicated lag should be exactly respected.
- 2782 ○ minimum: the indicated lag should be the minimum respected one, and a greater
2783 or equal lag for the activation of the dependent (child) after the deactivation of the
2784 dependee (parent) is allowed.
- 2785 ○ maximum: the indicated lag is the maximum that can occur, and a less or equal lag
2786 for the activation of the dependent (child) after the deactivation of the dependee
2787 (parent) is allowed.

2788 • *finishToFinishLag*: Time between the deactivation of the dependee (parent) bids and
2789 the deactivation of dependent (child) bids. It cannot be used when the
2790 PowerBidDependency.kind is set to exclusive.
2791

2792 Depending on the finishToFinishLagKind the value has the following meaning:

- 2793 ○ exact: the indicated lag should be exactly respected.
- 2794 ○ minimum: the indicated lag should be the minimum respected one, and a greater
2795 or equal lag for the deactivation of the dependent (child) after the deactivation of
2796 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.

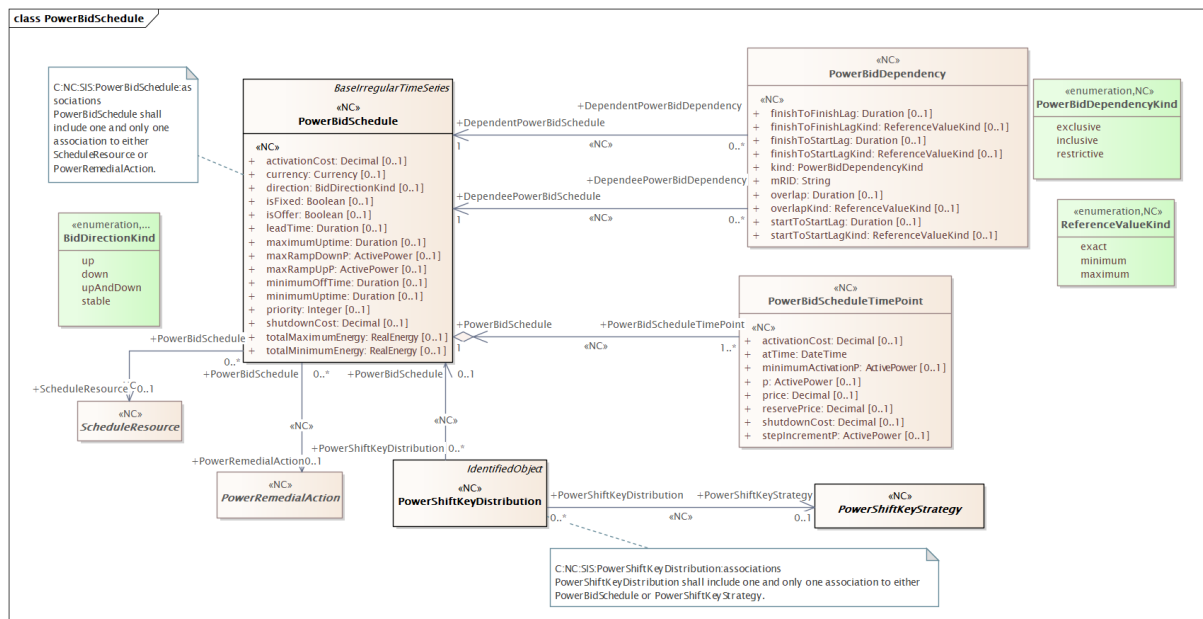


Figure 41: Extract of the SIS profile visualising the *PowerBidSchedule* and *PowerBidDependency* classes

7.1.8.3.4.1.1 Summary illustrations of different combinations of PowerBidDependency parameters

The Figure 42 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:

- 2823 • “Parent must run”: It describes a running condition in which the child bid can only run
2824 / be active when the parent is running / active.
- 2825 • “Child delay kind”: a situation in which the child bid activation is delayed with respect
2826 the parent activation.
- 2827 • “Continuous activation”: a situation in which the child bid is activated immediately
2828 after the parent bid deactivation.
- 2829 • “Parent child duration activation”: a situation in which the parent is activated for a
2830 given duration.
- 2831 On the other hand, Figure 43 Figure 44 Figure 45 depict other relevant combinations of the
2832 PowerBidDependency attributes.

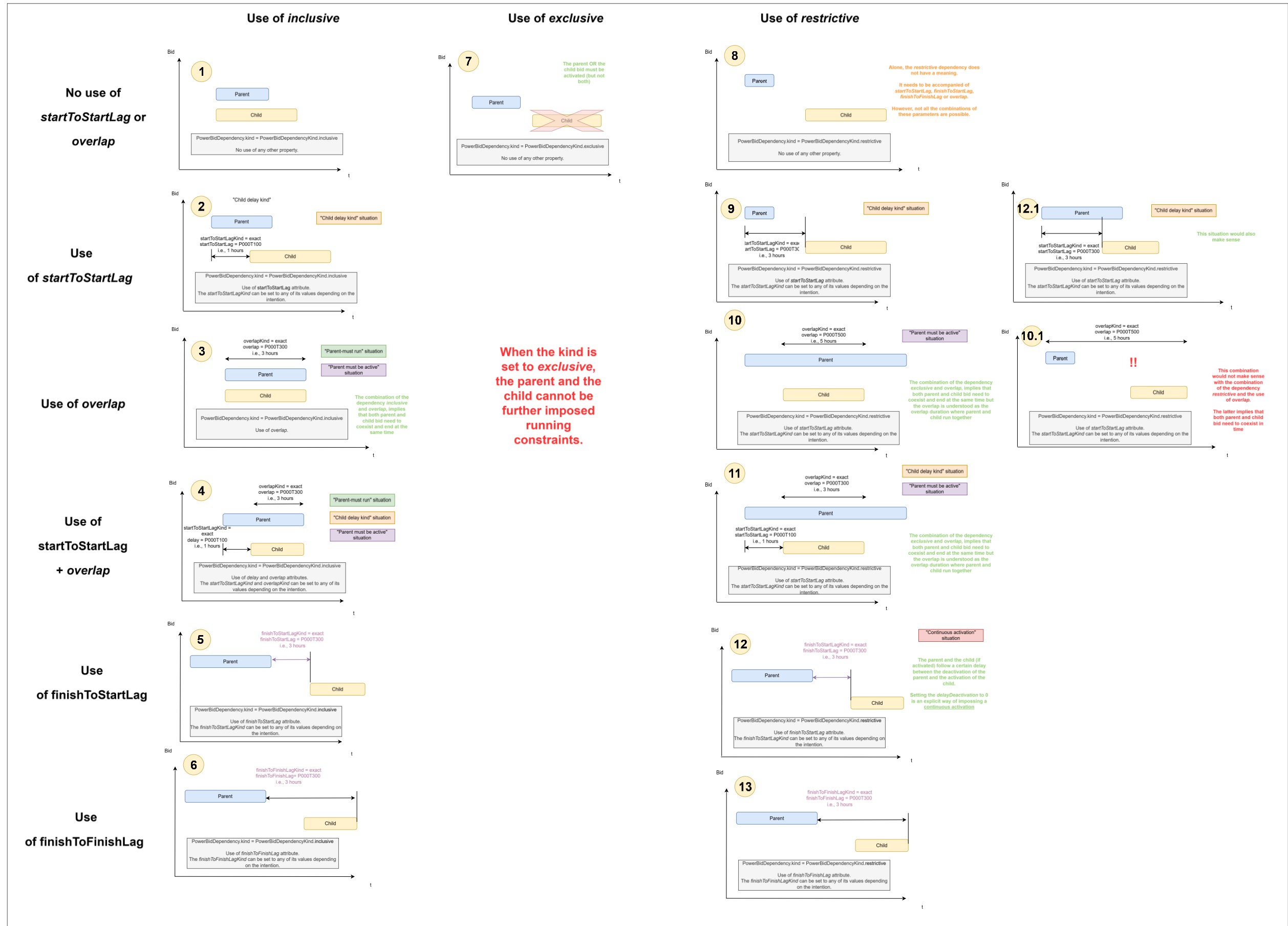


Figure 42: Summary illustration of different combinations of PowerBidDependency parameters

finishToStartLag

Effects of changing finishToStartLagKind

With *kind* set to *inclusive* or *restrictive*

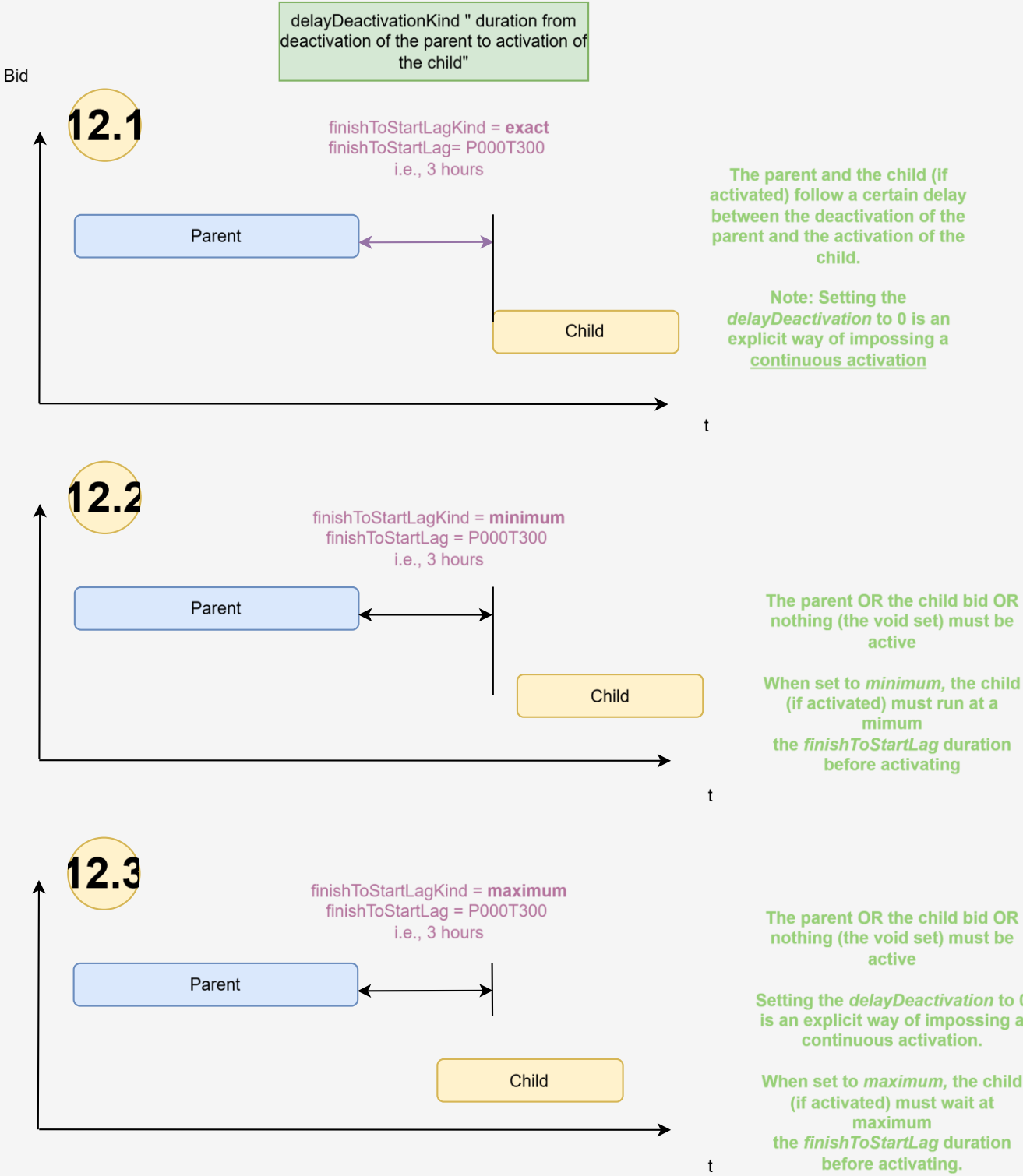


Figure 43: Effects of changing *finishToStartLagKind* values

finishToFinishLag

Effects of changing finishToFinishLag

With *kind* set
to *inclusive* or *restrictive*

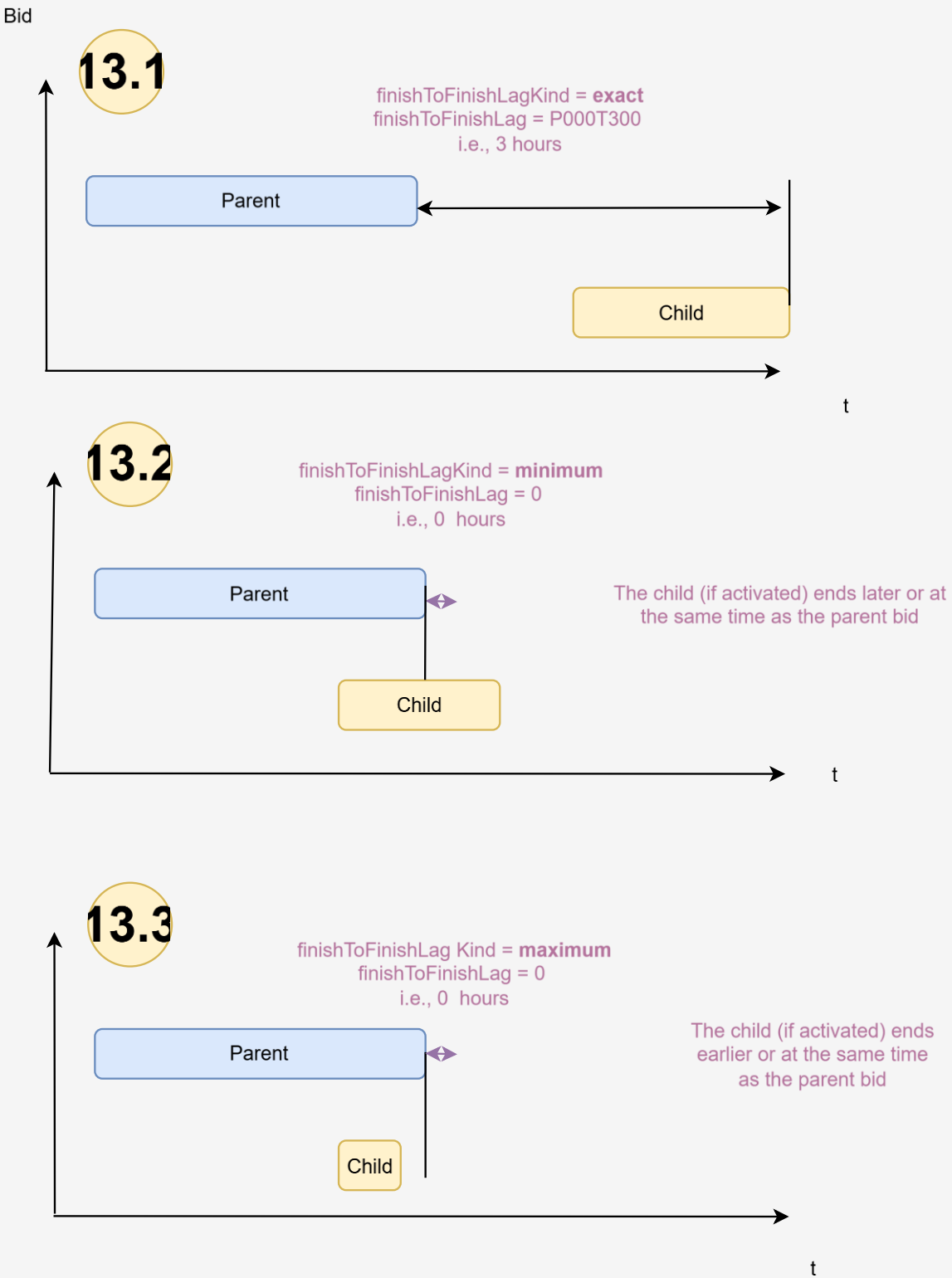
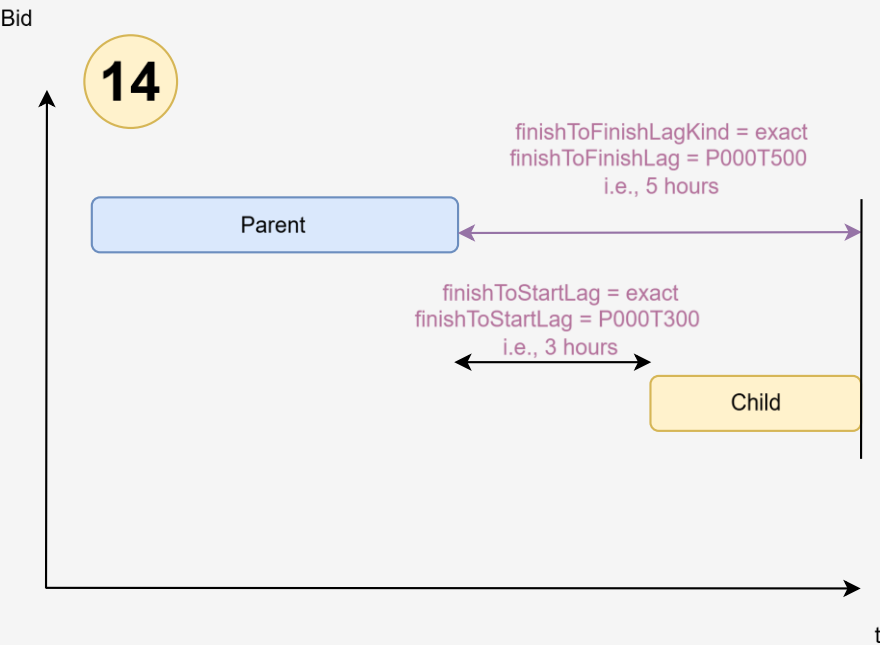


Figure 44: Effects of changing finishToFinishLagKind values

2838
2839

Other relevant combinations

finishToFinishLag + finishToStartLag



One could have all these combinations also with but with kind = *inclusive*

finishToFinishLag + overlap

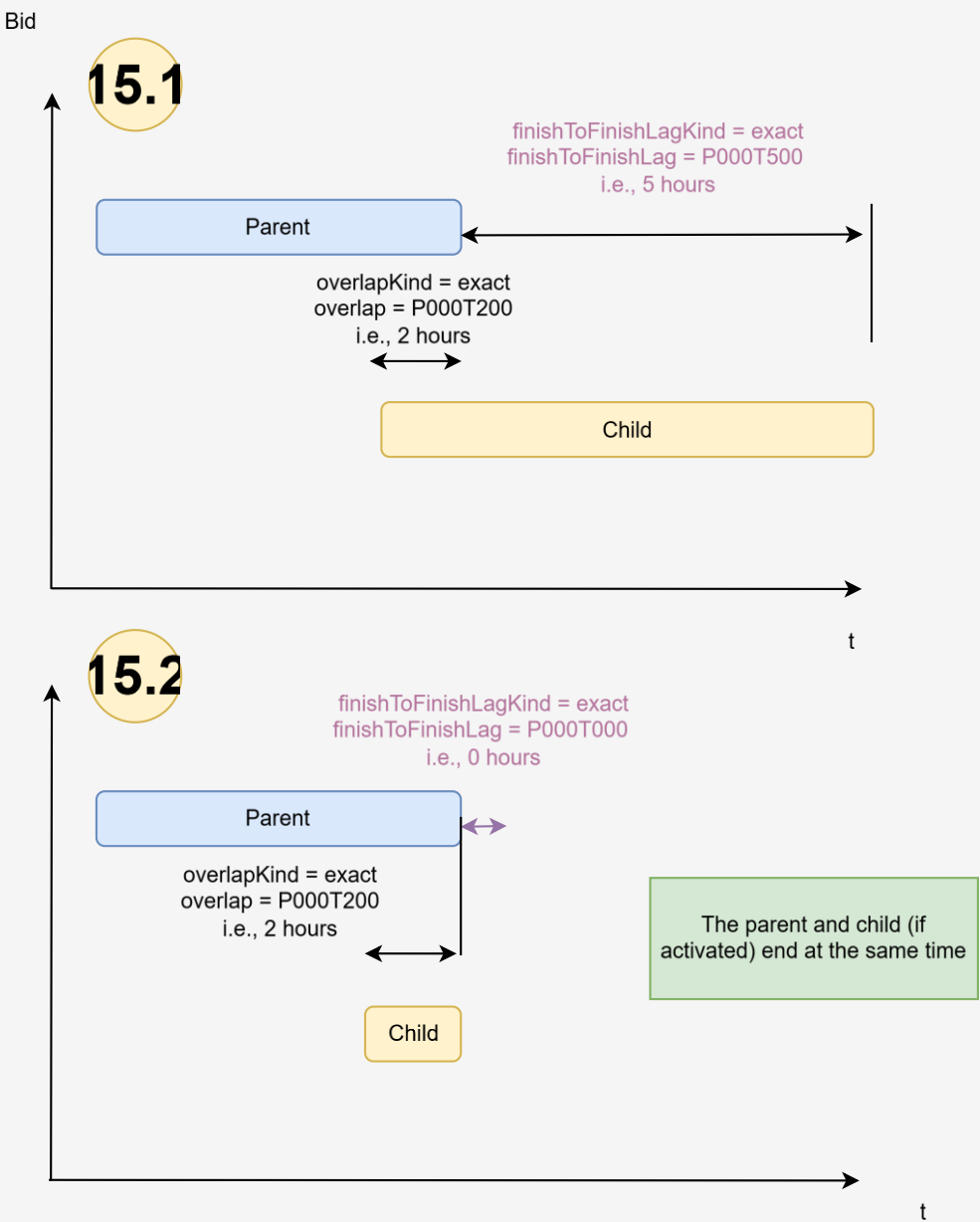


Figure 45: Other relevant combinations of PowerBidDependency attributes

2841
2842
2843

2845

2846 **7.1.8.3.4.1.2 Reference Implementation Examples of Power Bid Schedule** 2847 **Dependency**

2848 The power bid schedule dependency is illustrated using the following two examples:

- 2849 • Two power plans connected following the parent-child dependency
- 2850 • Generators are not allowed to start simultaneously

2851 **7.1.8.3.4.1.2.1 Two power plans connected following the parent-child** 2852 **dependency**

2853 In the following example two power plans are connected following the parent-child
2854 dependency. One power plant only starts exactly one hour after the other power plant is
2855 selected. The parent needs to stay active as long as the child is active as per the customer
2856 specification.

2857 The corresponding PowerBidSchedule dataset examples can be located in ReliCapGrid in
2858 Belgovia_SIS.xml:

- 2859 • Parent PowerBidSchedule rdf:ID="_ae6a5ddd-fe7e-40b2-bcb6-cbd2882434e7".
- 2860 • Child PowerBidSchedule rdf:ID="_5e08ba42-c0b5-45ed-bc8b-dbb854ed0897".
- 2861 • PowerBidDependency rdf:ID="_0ba48b90-9ce6-4a38-8b11-ab66cc23f04e".

2862

2863 **7.1.8.3.4.1.2.2 Generators are not allowed to start simultaneously**

2864 Readers are recommended to consult the maintained SIS profile XML example available on
2865 the ENTSO-E GitHub repository. The corresponding PowerBidSchedule dataset examples can
2866 be located in ReliCapGrid in Belgovia_SIS.xml:

- 2867 • Parent PowerBidSchedule rdf:ID="_ae6a5ddd-fe7e-40b2-bcb6-cbd2882434e7".
- 2868 • Child PowerBidSchedule rdf:ID="_42f85661-6877-4d5c-a87b-a97938642835".
- 2869 • PowerBidDependency rdf:ID="_9439f6fe-3da6-428b-95aa-9fac541e6a7b".

2870

7.1.8.3.5 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 46](#), a nuclear plant serves as a reference use case. The violet curve shows that at 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: it 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 48](#) 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).

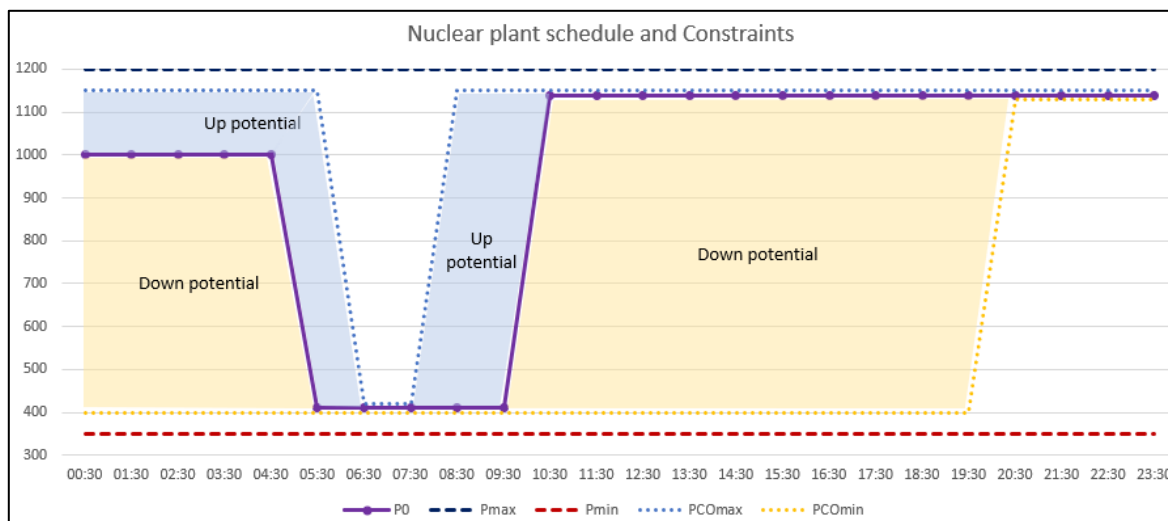


Figure 46: Nuclear plant schedule and constraints

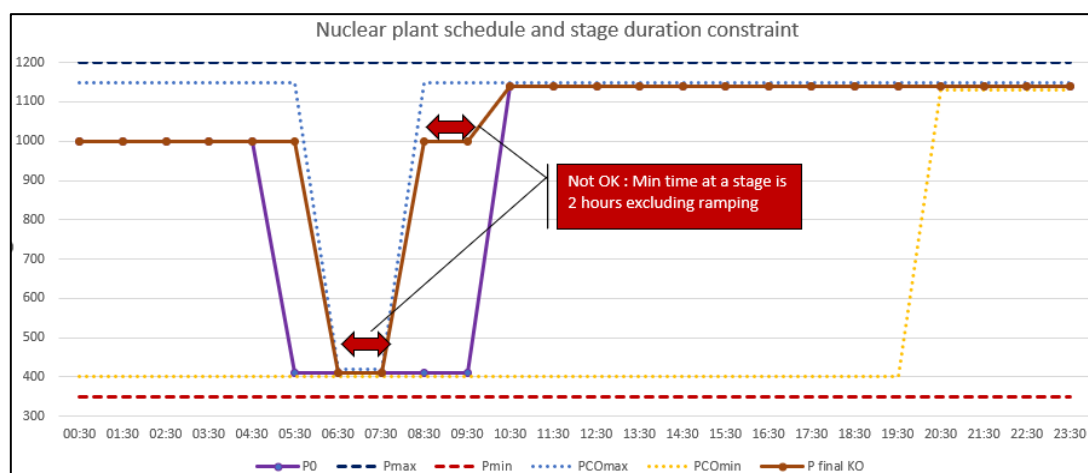


Figure 47: Non-acceptable nuclear power plant schedule

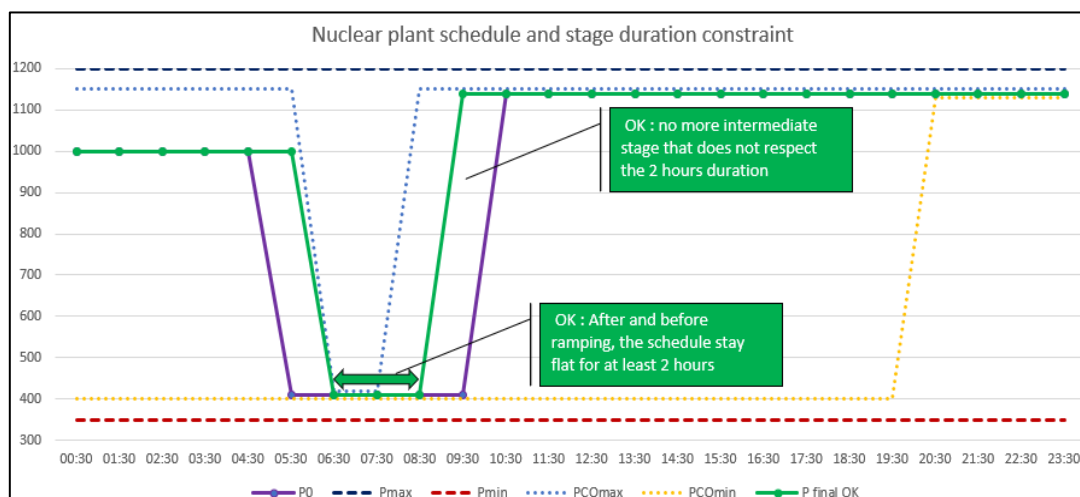


Figure 48: Acceptable nuclear power plant schedule

2915 Assuming there is no explicit attribute indicating whether a unit is ramping, the determination
2916 of ramping status must be inferred by the Remedial Action Optimiser (RAO) based on existing
2917 attributes within the *GeneratingUnit* class.

2918 To address the outlined challenge, the solution involves implementing a holding time that
2919 must elapse before a generating unit is permitted to adjust its production level again.

2920 *EquipmentReliability* extends the *GeneratingUnit* class with the attribute *rampLockTime* which
2921 indicates the time between end or start of ramping. If a unit has just stopped the ramping, it
2922 will need to wait this time until a new ramping can start. An example can be located in
2923 ReliCapGrid in Galia_ER.xml:

- 2924 • The GeneratingUnit rdf:ID="_2a2d438f-41b3-a9ea-f897-20ae9f28fbec".

2925

7.1.8.3.6 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 49](#) 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 50](#) 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 51](#)): 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 52](#)): 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.

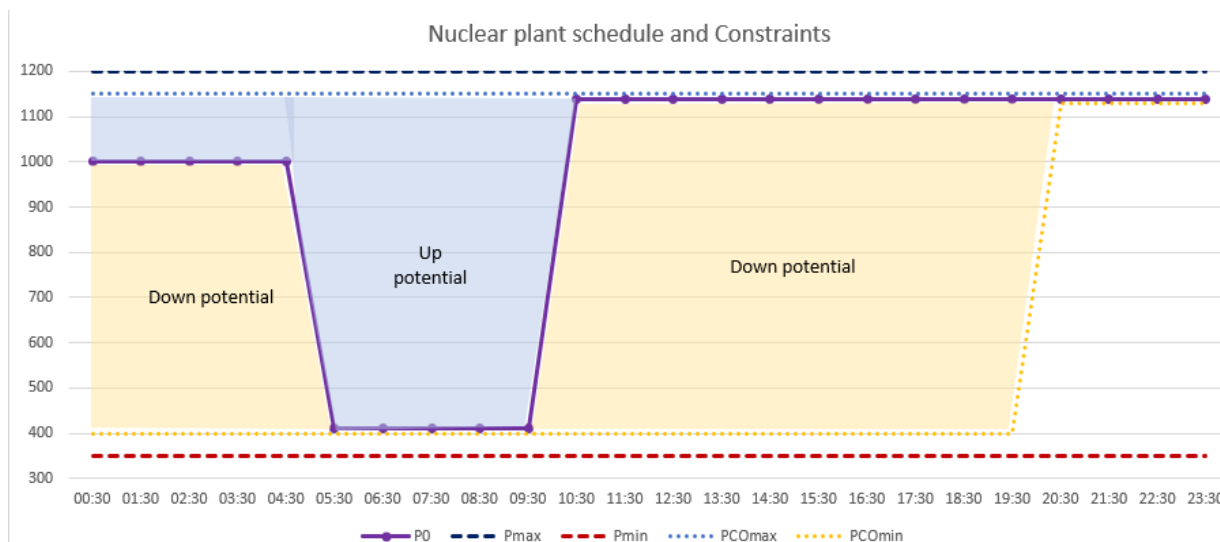


Figure 49: Another nuclear power plant schedule and constraints

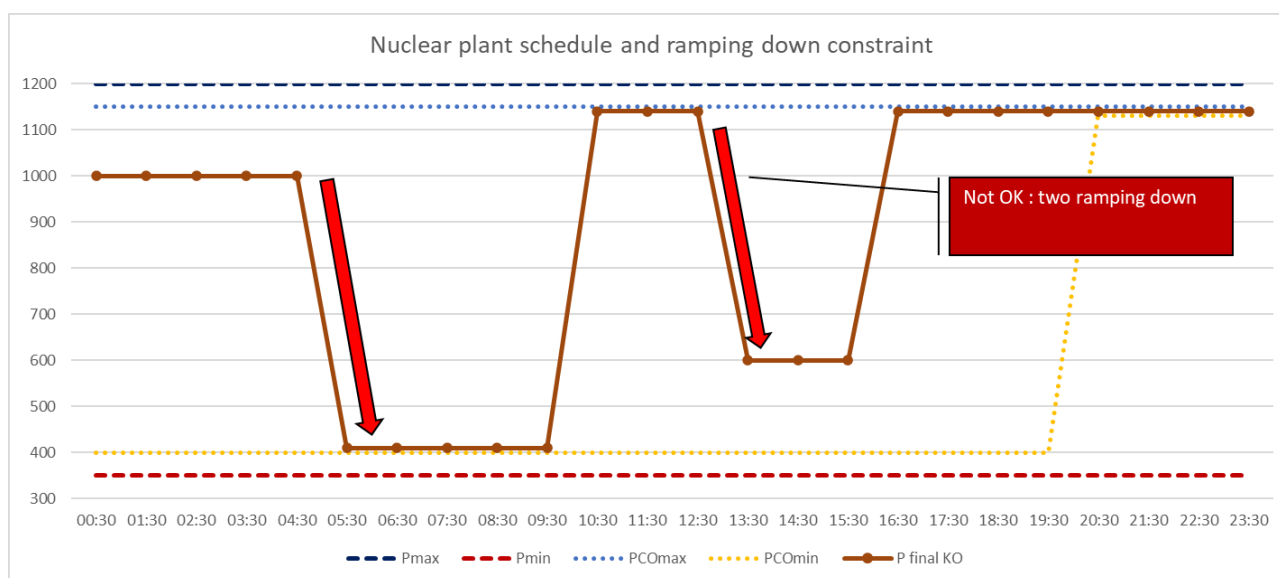


Figure 50: Non-acceptable nuclear power plant schedules due to ramping down

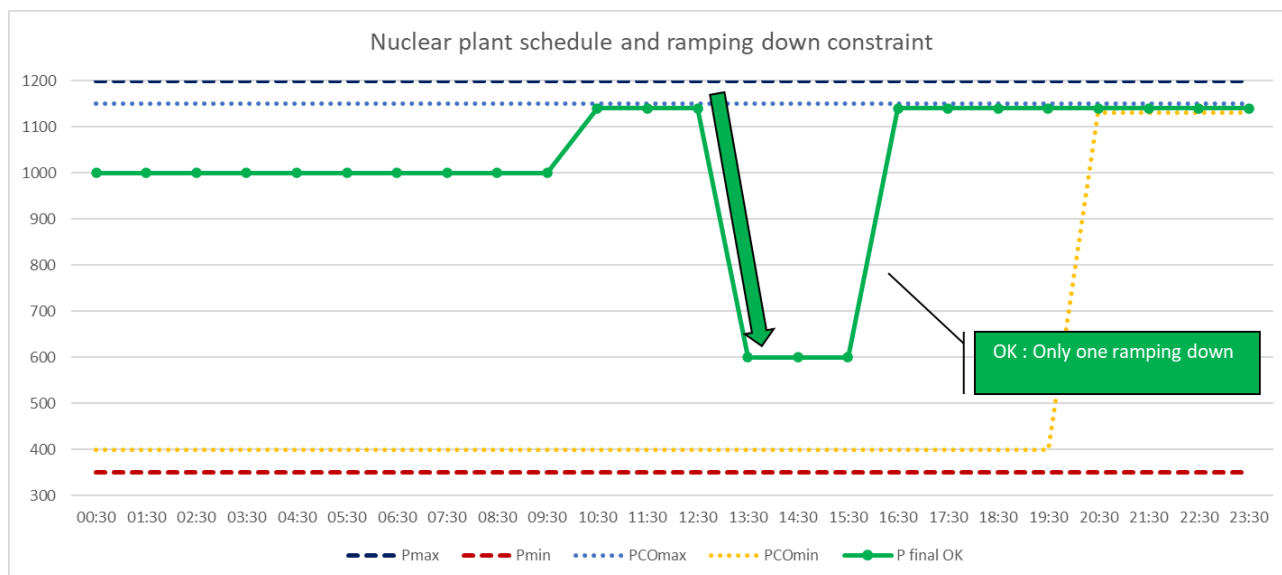


Figure 51: Acceptable nuclear power plant schedule integrating ramp down constraint

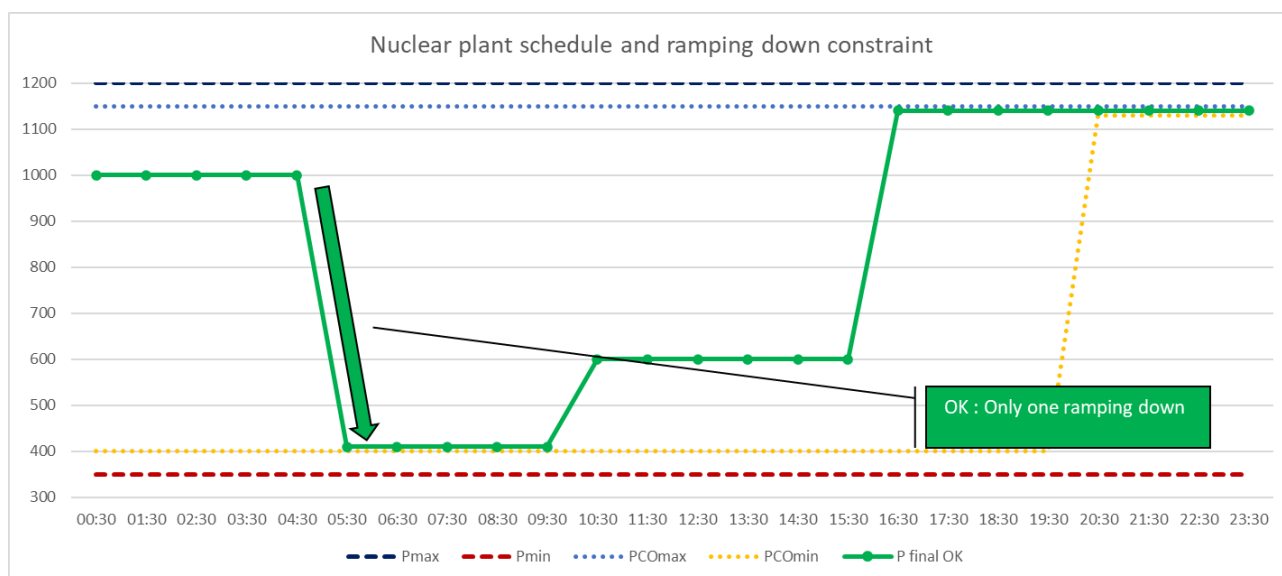


Figure 52: Another acceptable nuclear power plant schedule integrating ramp down constraint

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.

7.1.8.3.7 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 [7.1.8.3.4.1](#) for a better comprehension of how such attributes work.

7.1.8.3.8 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 53](#) 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).

Pump Storage Power Plant (generator & pump mode) (2/2)

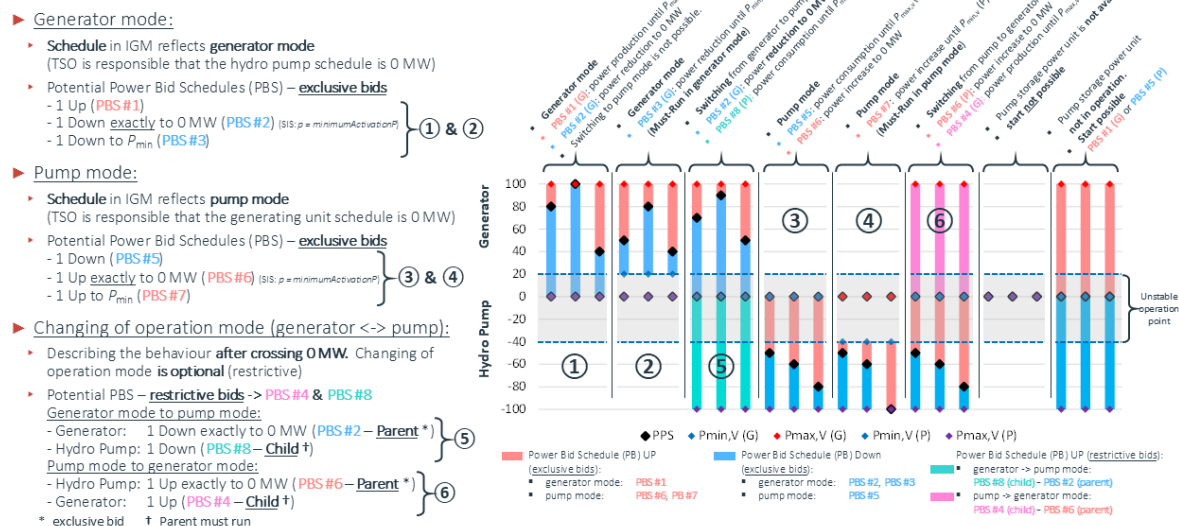


Figure 53: Modelling of Multiple Pump Storage Power Plants (I)

For plants with multiple generating and pumping units, the same mechanism applies using PowerShiftKey classes. [Figure 54](#) 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.

Multiple Pump Storage (generator & pump modes) (2/2)

Generator mode:

- Schedule in IGM reflects **generator mode** (TSO is responsible that the hydro pump schedule is 0 MW)
- Potential Power Bid Schedules (PBS) – **exclusive bids**
 - 1 Up (PBS #1)
 - 1 Down **exactly** to 0 MW (PBS #2) (SS: $p \neq \text{minimum activation}$)
 - 1 Down to $P_{\min}$ (PBS #3)

Pump mode:

- Schedule in IGM reflects **pump mode** (TSO is responsible that the generating unit schedule is 0 MW)
- Potential Power Bid Schedules (PBS) – **exclusive bids**
 - 1 Down (PBS #5)
 - 1 Up **exactly** to 0 MW (PBS #6) (SS: $p \neq \text{minimum activation}$)
 - 1 Up to $P_{\min}$ (PBS #7)

Changing of operation mode (generator <-> pump):

- Describing the behaviour **after crossing 0 MW**. Changing of operation mode is **optional** (restrictive)
- Potential PBS – **restrictive bids** -> PBS #4 & PBS #8
 - Generator mode to pump mode:
 - Generator: 1 Down exactly to 0 MW (PBS #2 – Parent *)
 - Hydro Pump: 1 Down (PBS #8 – Child †)
 - Pump mode to generator mode:
 - Hydro Pump: 1 Up exactly to 0 MW (PBS #6 – Parent *)
 - Generator: 1 Up (PBS #4 – Child †)

* exclusive bid † Parent must run

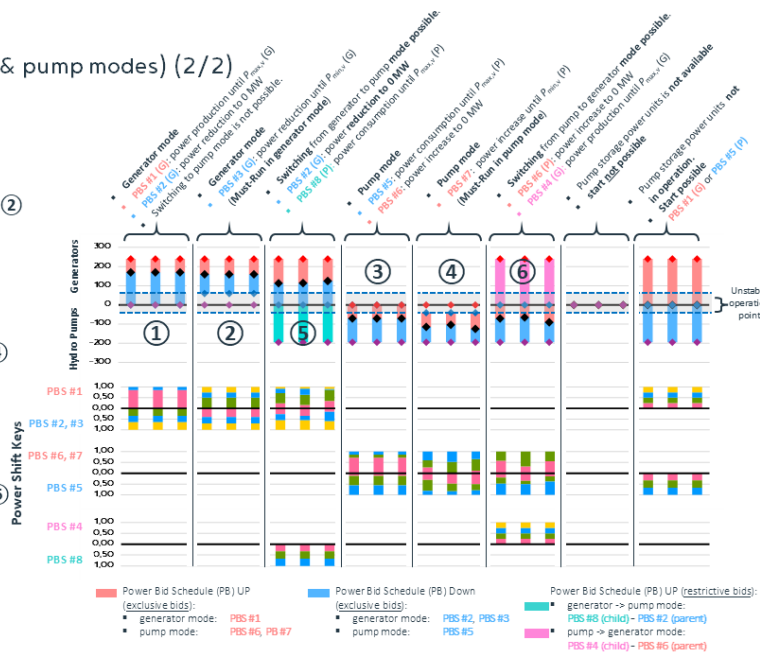


Figure 54: Modelling of Multiple Pump Storage Power Plants (II)

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.

7.1.8.3.9 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.

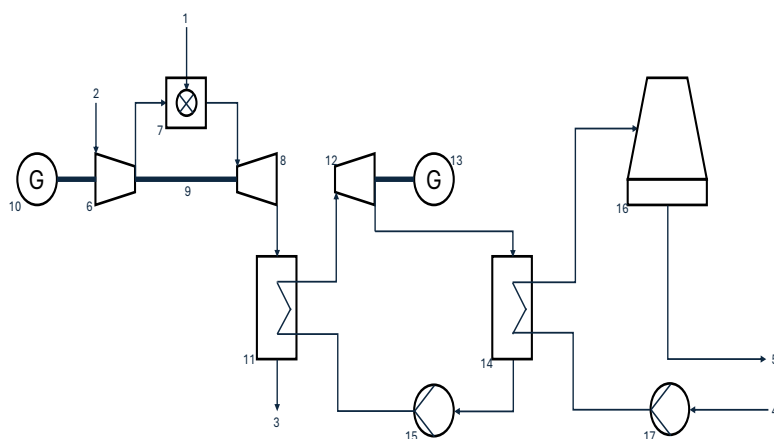
While it can detect and reflect deviations when supported by reliable measurements, it does not dynamically recalculate P and Q limits during ramping. Instead, it expects those limits to be predefined in the model or provided by operational data sources.

7.1.8.3.10 Power Plant: Generating Unit Dependency (Combined Cycle Power Plant)

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. In contrast to section 7.1.8.3.3.1 this section makes deliberate use of dependencies between GeneratingUnits instead of dependencies between PowerBidSchedules.

Consider a simplified Combined Cycle Power Plant (CCPP) as visualised in Figure 55. This power plant consists of an open cycle gas turbine (6 ,7 ,8) and a closed cycle steam turbine (11, 12, 14, 15). Input air (2) is compressed (6) and forwarded to the combustion chamber (7). In addition to the compressed air, gas (1) is also injected into the combustion chamber where it is ignited. The high-pressure/-temperature product from the combustion chamber is passed through a gas-turbine (8) resulting in mechanical rotation that is used for generating electrical power (10) and torque for compressing air (6). The relatively high-pressure/-temperature product from the gas turbine (8) is then further utilised to evaporate high-pressure water (15) inside a heat exchanger (11) before it leaves the system (3). The resulting high –pressure/-temperature water steam is then channelled through the steam turbine (12), resulting in mechanical rotation for creating electrical power in generator (13). Finally, the product from the steam-turbine is condensed (14) before it is pressurised again (15). Condensation is realised by pumping cool water (17) into the condenser (14). The resulted hot water is then cooled in is a cooling tower (16) before it is pumped out of the system (5).

Intern (Internal)



Position	Equipment
1	Fuel
2	Air
3	Exhaust Gas
4	Cooling Water
5	Cooling Water
6	Compressor
7	Combustion Chamber
8	Gas Turbine
9	Drive Shaft
10	Synchronous Machine
11	Evaporator
12	Steam Turbine
13	Synchronous Machine
14	Condenser
15	Condensate Pump
16	Cooling Tower
17	Cooling Water Pump

Figure 55: Schematics of a simplified CCPP

Intuitively, the following possible operating modes can be inferred from the schematics:

	Gas turbine	Steam turbine
Mode 1	Inactive	Inactive
Mode 2	Active	Inactive
Mode 3	Active	Active

Additionally, in the case of the provided example, the gas turbine must start a fixed amount of time before the steam turbine can be activated. Modelling these constraints through PowerBidDependencies would lead to schedules, which in turn are dependent on the current operating point of the generators. They would be subject to change over time, complex and not intuitively understood by a human. Therefore, in this case, it seems more practical to model the constraints not as dependencies between PowerBidSchedules (Section 7.1.8.3.3.1) but instead as dependencies between the GeneratingUnits themselves.

Examples on how the lag parameters should be used:

3126

3127 startToStartLag:

- 3128 • exact: the dependent must change its state to active exactly when the dependee is in
- 3129 a continuously active state for the specified duration.

- 3130 ○ Example:

- 3131 ▪ Consider a startToStartLag duration of 180 minutes with the
- 3132 startToStartLagKind set to exact:

3133 The DependentGeneratingUnit must start exactly when the DependeeGeneratingUnit has

3134 been continuously running for 180 minutes.

- 3135 • minimum: the dependent may change its state to active only after the dependee is in
- 3136 a continuously active state for the specified duration.

- 3137 ○ Example:

- 3138 ▪ Consider a startToStartLag duration of 180 minutes with the
- 3139 startToStartLagKind set to minimum:

3140 The DependentGeneratingUnit can only start if the DependeeGeneratingUnit has been

3141 continuously running for at least 180 minutes.

- 3142 • maximum: the dependent must change its state to active before the dependee is in a
- 3143 continuously active state for the specified duration.

- 3144 ○ Example:

- 3145 ▪ Consider a startToStartLag duration of 180 minutes with the
- 3146 startToStartLagKind set to maximum:

3147 The DependentGeneratingUnit must start before the DependeeGeneratingUnit has been

3148 continuously running for 180 minutes.

3149

3150 finishToStartLag:

- 3151 • exact: the dependent must change its state to active exactly when the dependee is in
- 3152 a continuously inactive state for the specified duration.

- 3153 ○ Example:

- 3154 ▪ Consider a finishToStartLag duration of 180 minutes with the
- 3155 finishToStartLagKind set to exact:

3156 The DependentGeneratingUnit must start exactly when the DependeeGeneratingUnit has

3157 been continuously not running for 180 minutes.

- 3158 • minimum: the dependent may change its state to active only after the dependee is in
- 3159 a continuously inactive state for the specified duration.

- 3160 ○ Example:

- 3161 ▪ Consider a finishToStartLag duration of 180 minutes with the
- 3162 finishToStartLagKind set to minimum:

3163 The DependentGeneratingUnit can only start if the DependeeGeneratingUnit has been
3164 continuously not running for at least 180 minutes.

- 3165 • maximum: the dependent must change its state to active before the dependee is in a
3166 continuously inactive state for the specified duration.

- 3167 ○ Example:

- 3168 ▪ Consider a finishToStartLag duration of 180 minutes with the
3169 finishToStartLagKind set to maximum:

3170 The DependentGeneratingUnit must start before the DependeeGeneratingUnit has been
3171 continuously not running for 180 minutes.

3172

3173 finishToFinishLag:

- 3174 • exact: the dependent must change its state to inactive exactly when the dependee is
3175 in a continuously inactive state for the specified duration.

- 3176 ○ Example:

- 3177 ▪ Consider a finishToFinishLag duration of 180 minutes with the
3178 finishToFinishLagKind set to exact:

3179 The DependentGeneratingUnit must shut down exactly when the DependeeGeneratingUnit
3180 has been continuously not running for 180 minutes.

- 3181 • minimum: : the dependent may change its state to inactive only after the dependee is
3182 in a continuously inactive state for the specified duration.

- 3183 ○ Example:

- 3184 ▪ Consider a finishToStartFinish duration of 180 minutes with the
3185 finishToFinishLagKind set to minimum:

3186 The DependentGeneratingUnit can only shut down if the DependeeGeneratingUnit has been
3187 continuously not running for at least 180 minutes.

- 3188 • maximum: : the dependent must change its state to inactive exactly when the
3189 dependee is in a continuously inactive state for the specified duration.

- 3190 ○ Example:

- 3191 ▪ Consider a finishToFinishLag duration of 180 minutes with the
3192 finishToFinishLagKind set to maximum:

3193 The DependentGeneratingUnit must shut down before the DependeeGeneratingUnit has
3194 been continuously not running for 180 minutes.

3195

3196 **7.1.8.3.11Expected Use Cases**

3197
3198 Table 8: Expected Use Cases Related for Power Remedial Actions (Redispatch and
3199 Countertrade)

Name	Description	Comment
Redispatch in another country		

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 *AvailabilityExceptionalLimit*. 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.

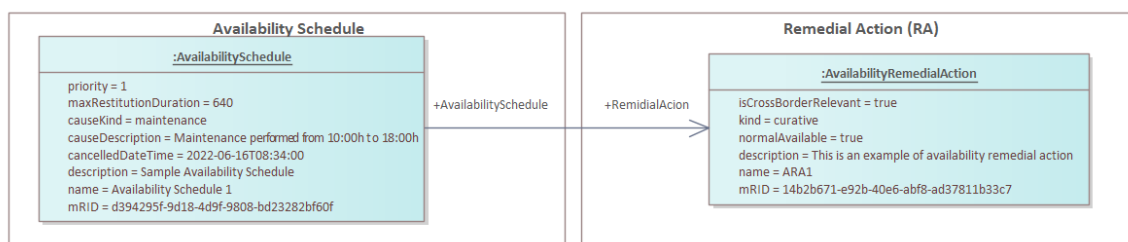


Figure 56 - Availability Schedule Remedial Action Example

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.

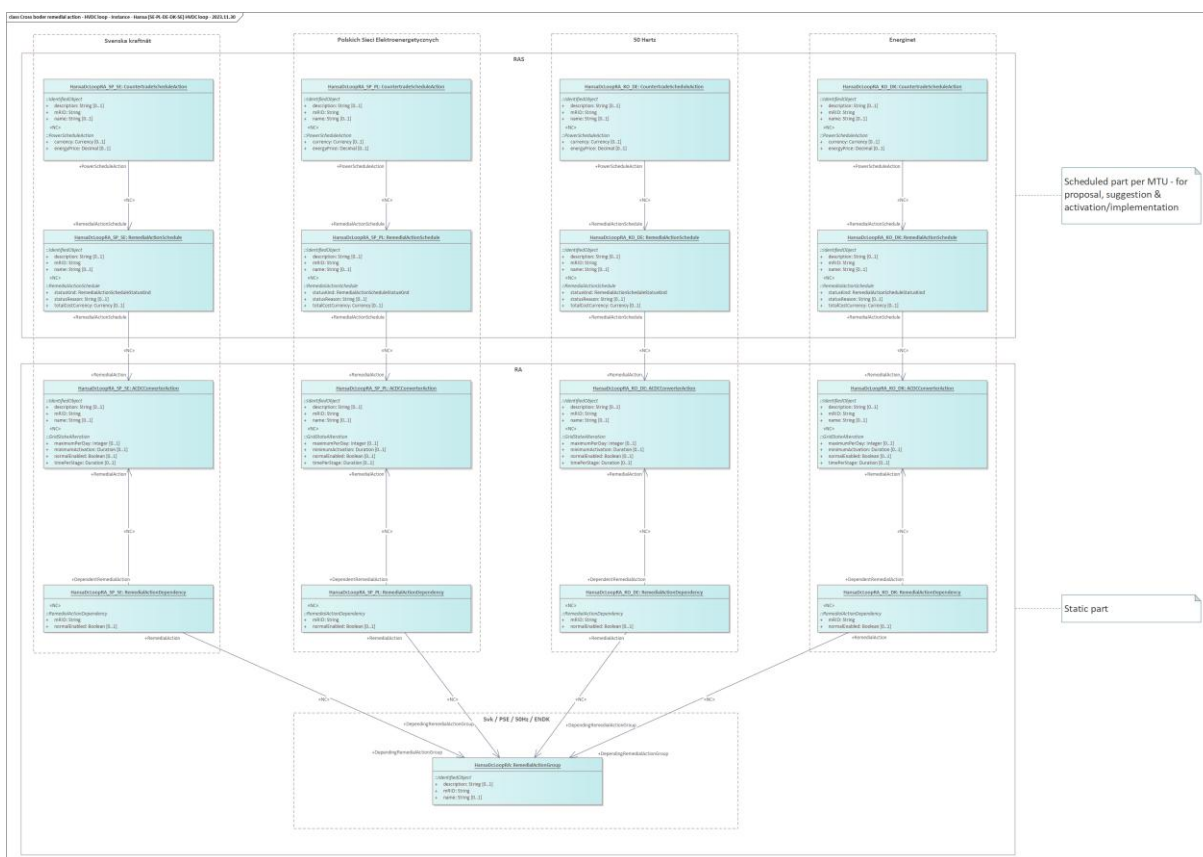
Business processes require information to categorise different groups. For instance, for a group of grid state alterations related to PST the following options are expected:

- 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

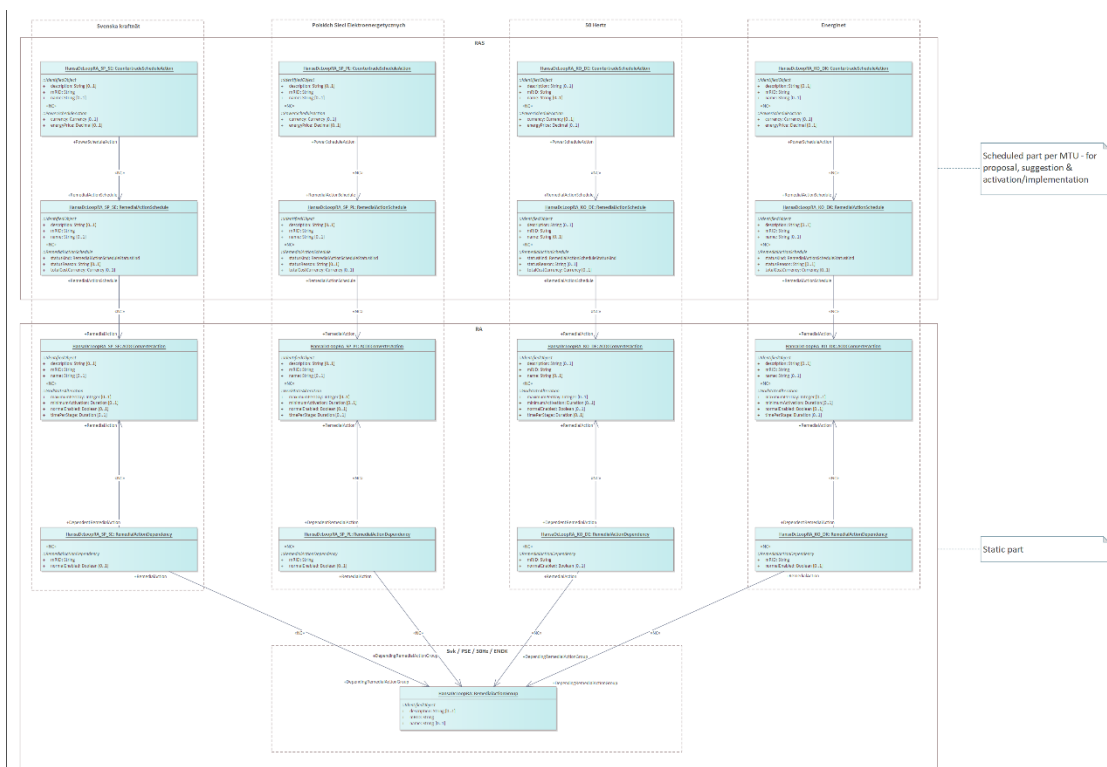
To fulfil this requirement RCP DES profiles, use the attribute *GridStateAlterationRemedialAction.isActivationRestricted*. If the attribute is true, all *GridStateAlterations* associated with the *GridStateAlterationRemedialAction* need to be available in order to activate the RA. If false, it means 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 of 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.



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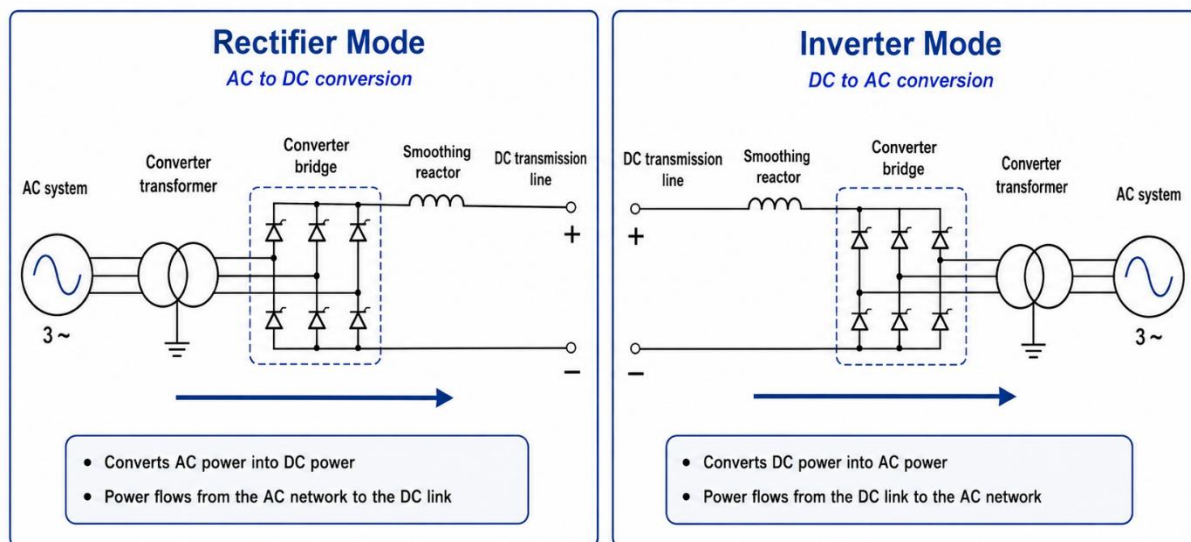
3250

Figure 57 – Remedial Action with Dependencies – HVDC case

7.1.8.6 Restricting HVDC Flow Polarity in Time

This section defines how to restrict the HVDC polarity to be changing unlimited by RAO. Frequent power-flow reversals in cable-based LCC-HVDC links should not be regarded as an unrestricted operating condition. Since power reversal requires DC voltage polarity reversal, the cable insulation is subjected to transient electric-field redistribution associated with residual space charge. Therefore, the allowable number of reversals, the minimum interval between consecutive reversals, the voltage reversal rate, and the zero-voltage relaxation period should be defined according to the qualified operating duty of the cable system and the manufacturer's requirements.

HVDC Converter Operating Modes



Conceptual diagram based on standard HVDC converter operation principles.

Figure 58 – HVDC Converter Operating Modes

The HVDC will be associated with a CsConverter where the attribute operatingMode can be used to set how the HVDC will work, as rectifier or inverter (see figure above). To model this restriction on the reversal polarities (changing on operational mode) on the GridAlteration the attribute maximumPerDay (description: Maximum number of alterations per day) can be used. Therefore, polarity change can be controlled by this attribute as input to the optimizer that will then add a restriction to prevent the polarity change.

7.1.8.7 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.

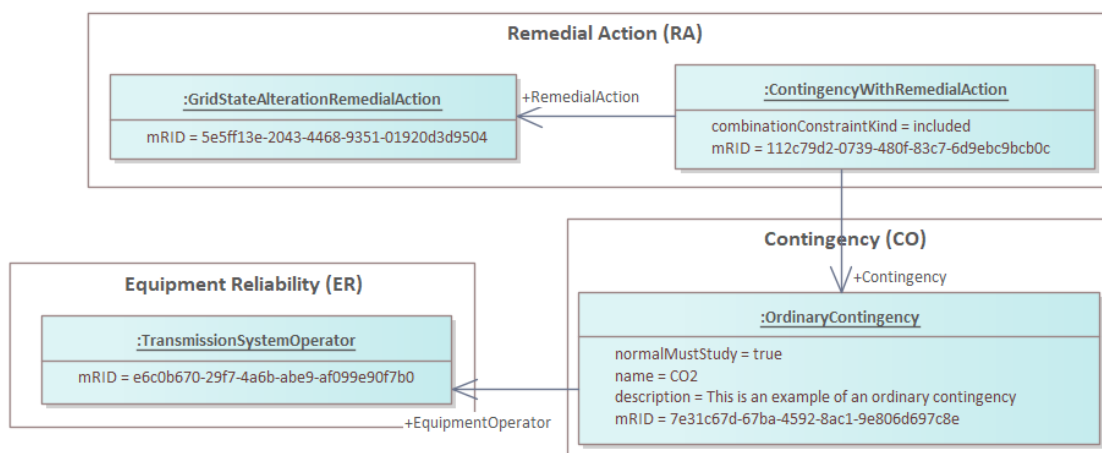


Figure 59 – Remedial Action with Contingency

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"

7.1.8.8 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 detail 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		

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7.1.9 List of SPS/SIPS

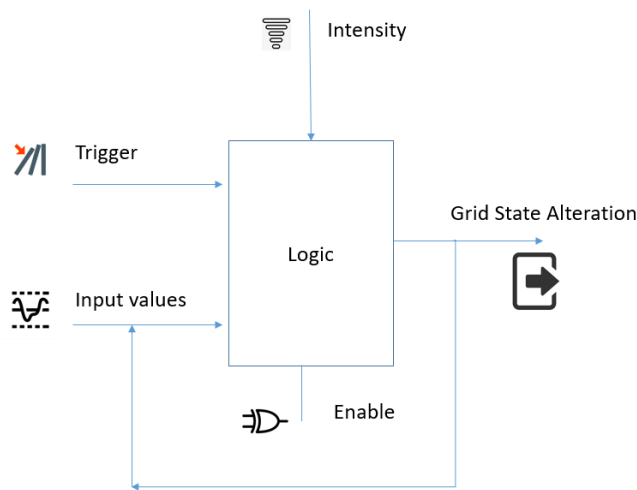


Figure 60 – SIPS overview

System Integrity Protection Schemes (SIPS), Special Protection Schemes (SPS), and Remedial Action Schemes (RAS) are often applied by TSOs to better utilise the transmission grid capacity, while still maintaining reliability operations and the security of supply. SIPS and SPS are used interchangeably, but in general, SPS is considered part of SIPS.

Note that other schemes are also in use for systems protection such as emergency power on HVDC links, load shedding, and network splitting. These protection schemes, including SIPS, contribute to maximising the grid transfer capacity while preventing cascading blackouts and minimising collateral damage in case of contingencies since islanding is controlled. Therefore, modelling SIPS or RAS results in more realistic congestion/overload.

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

- 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).As shown in [Figure 60](#), a SIPS is based on a logic which has inputs signals and associated 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.

3360 In the NC Profiles, the structural data for SIPS remedial action is defined in the
3361 RemedialActionProfile package. The class '*Gate*' is for defining the input logic and the class
3362 '*Stage*' for defining the output that is linked to a *GridStateAlterationCollection*, allowing
3363 multiple grid state alterations to be part of a Stage (i.e. the change(s) will be applied after the
3364 gate trigger conditions are met). NC Profiles also allow to create more complex logics by using
3365 several interconnected gates or stages, which can be armed or disarmed depending on the
3366 input conditions. In addition, it is possible to provide *normalEnabled* for *GateInputPin* in ER
3367 profile and to provide different value using *GenericEnablingSchedule* in SIS profile and
3368 *GateInputPin* in SSI profile. Any values described in SSH, SIS, and SSI datasets can be input
3369 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 61](#) 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 61](#)).
 - *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).

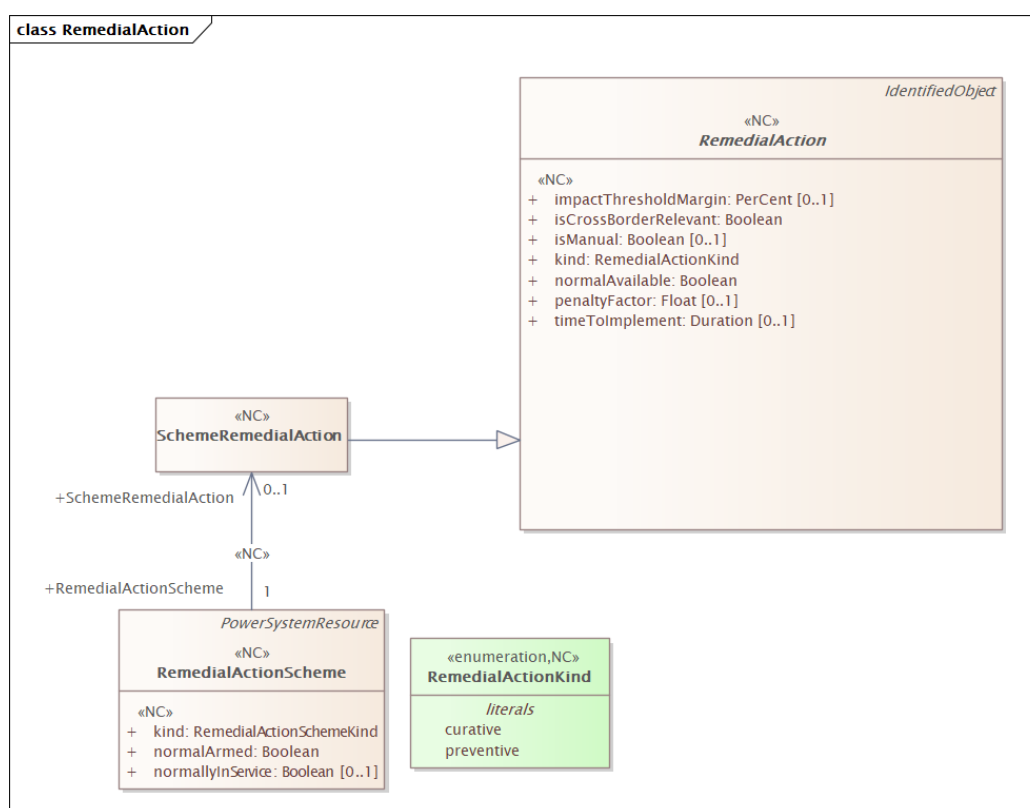


Figure 61: Extract of Remedial Action profile showing classes to distinguish (non)coordinated SPS

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 62](#) with the *RemedialActionSchemeTimePoint.armed*.

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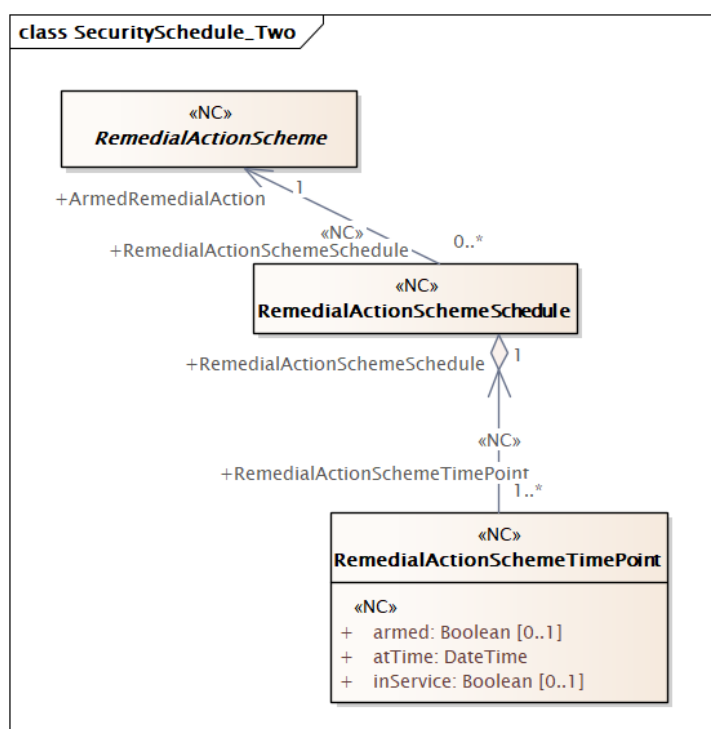


Figure 62: Extract of the SIS profile

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.

3521 **7.1.9.1.3 The use of RemedialAction.kind for SIPS/SPS**

3522 It is relevant to address how to use *RemedialAction.kind* for a SPS, particularly in the context
3523 of a *SchemeRemedialAction* that operates independently from a direct contingency link.

3524 The *RemedialAction.kind* attribute indicates if the remedial action is curative or preventive.

3525 However, SPS logics are often triggered by conditions other than a defined contingency, for
3526 instance, system state changes (modelled via *PinContingency* or other input *pins*).

3527 It is recommended to classify *SchemeRemedialAction* as “*curative*”, even if it is not directly
3528 connected to a *Contingency* object¹². This is because a SPS is designed in advance, and
3529 activated in real time based on system state, hence behaving like a curative remedial action.

3530

¹² Based on [CSAm Art. 2.1.24](#).

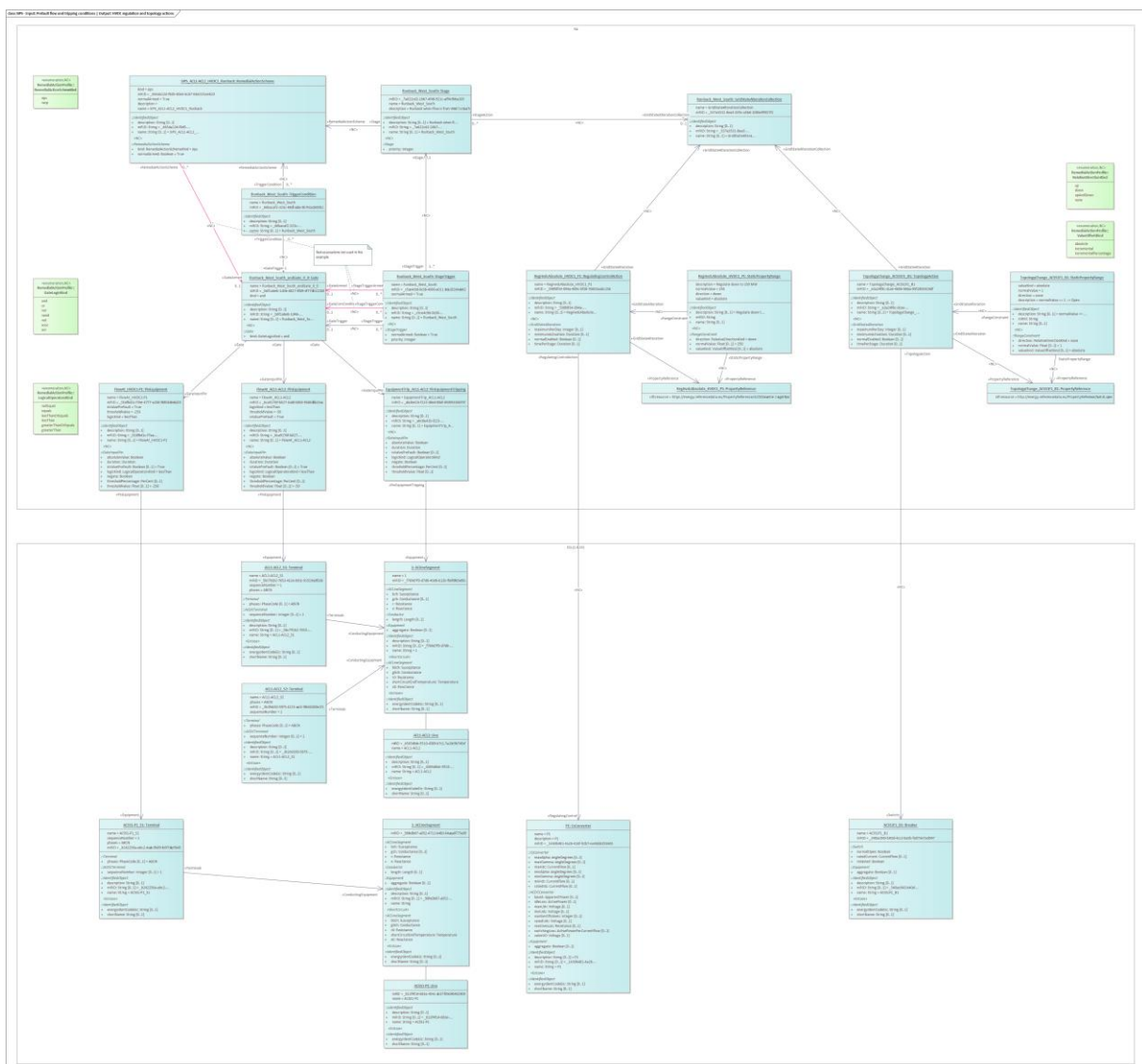
7.1.9.2 Monitoring of a Line and Actions on Topology and HVDC

In the SIPS example shown in [Figure 63](#), 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.



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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 64](#) below to visualise these concepts.

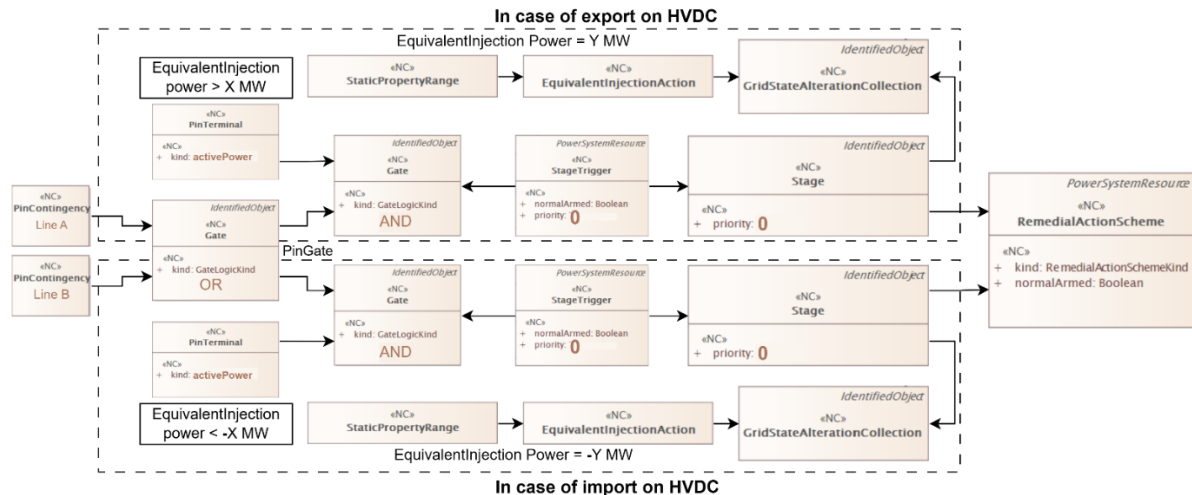


Figure 64: Modelling of complex triggering schemes

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 65](#) 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.

3634 The action is to disconnect the line A. It can

3635 be done similarly to the topological remedial action, by changing the status of switches on
3636 both ends of the line (*Switch.open* = TRUE).

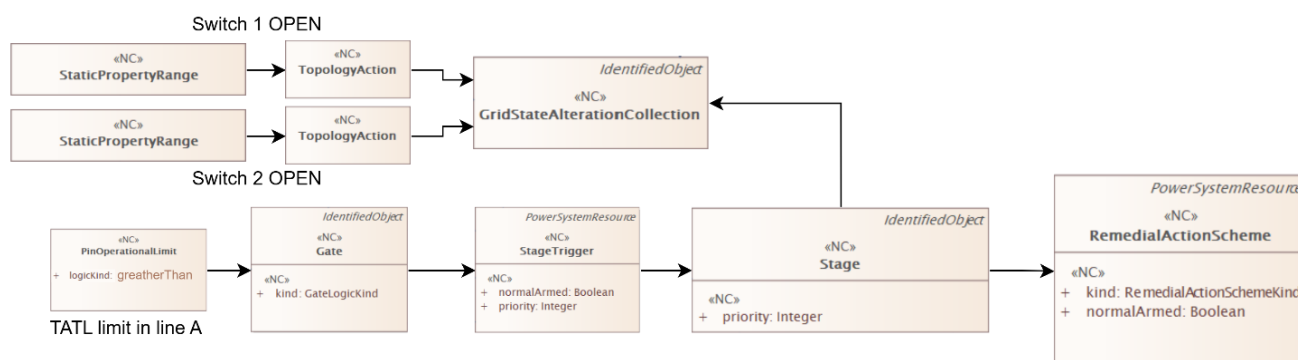


Figure 65: Example of a use case referencing to PATL or TATL values is SIPS which disconnects an element if another element is overloaded

3641 Readers will find a test use case—subject to be further developed—to demonstrate the use
3642 case above in the TestUseCase folder of the ReliCapGrid GitHub repository. More concretely,
3643 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 66](#) 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 (*Breaker*).

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.

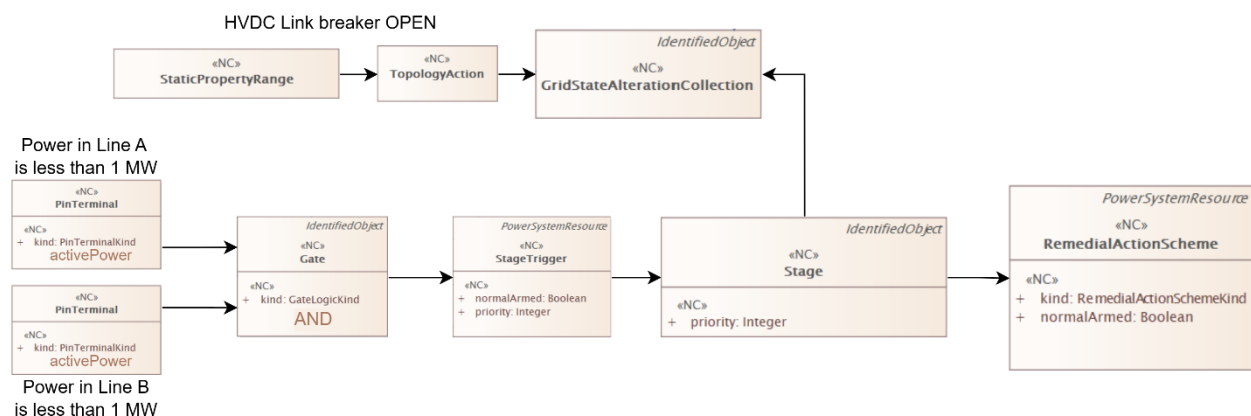


Figure 66: Last Line Disconnection example

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 *greaterThan* respectively.

The [Figure 67](#) 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.

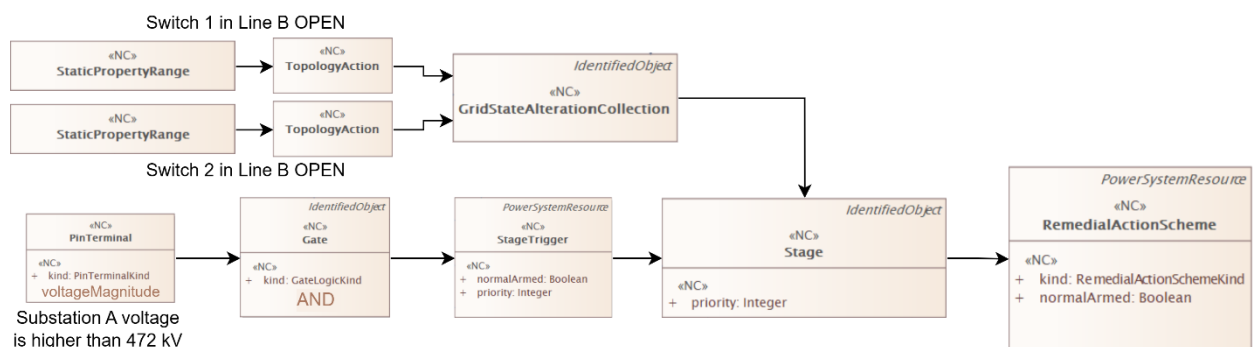


Figure 67: Overvoltage Protection which protects equipment installed in substation against long and short-term over voltages

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 68 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.

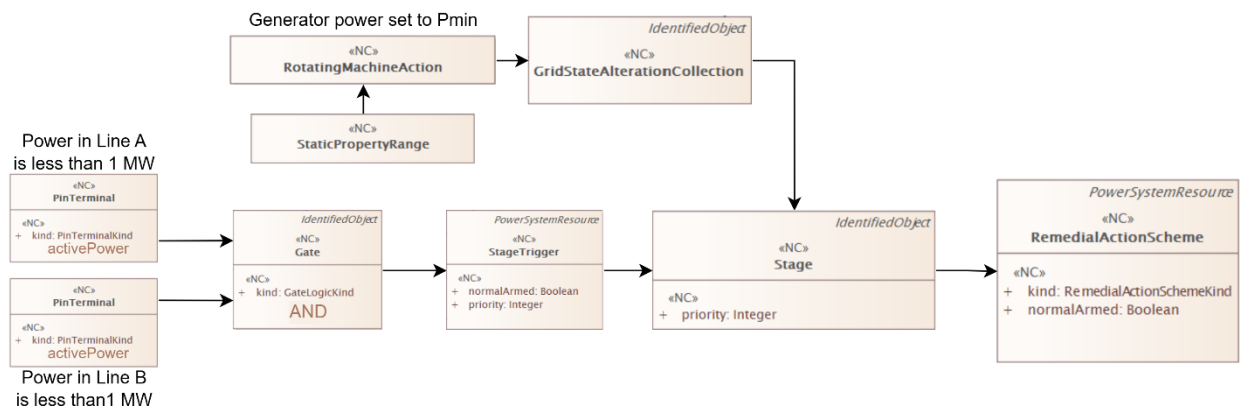


Figure 68: Anti-swing protection example

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 69](#) 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.

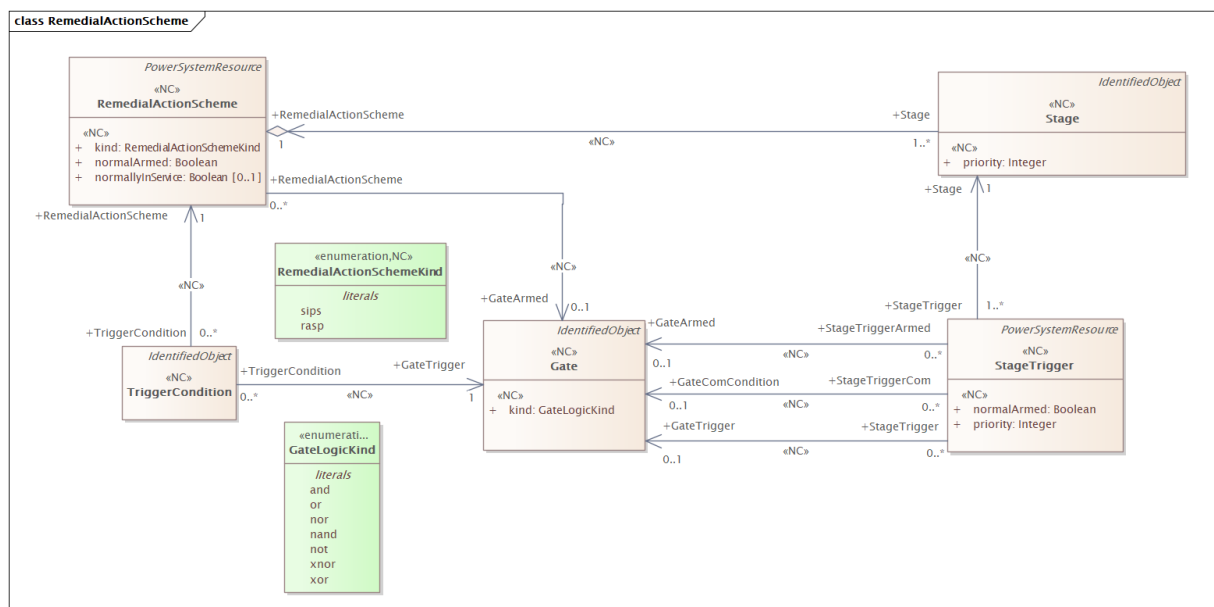


Figure 69: Extract of the RemedialActionScheme diagram in Remedial Action profile

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.

3751 The complex logic follows a decision tree that evolves depending on the severity and
3752 persistence of the overload, and it takes different actions based on whether the line current
3753 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 70](#).

- Moderate Overload Case:
 - If $\text{Intensity_PATL} < \text{Intensity_LOAD} < \text{Intensity_TATL}$:
 - Then Reduce generator output (generator 1)
 - Wait 20 minutes
 - If still $\text{PATL} < \text{Intensity_LOAD}$ (the element is still overloaded):
 - Then disconnect generator 1.
 - If still $\text{Intensity_PATL} < \text{Intensity_LOAD}$ (the element is still overloaded):
 - Then disconnect generator 3.
 - Severe Overload Case:
 - If $\text{Intensity_LOAD} > \text{Intensity_TATL}$:
 - Then disconnect generator 1 connected to the same busbars.
 - If still $\text{Intensity_LOAD} > \text{Intensity_TATL}$ (the element is still overloaded):
 - Then disconnect generator 3 connected to the same busbars.
 - If $\text{Intensity_PATL} < \text{Intensity_LOAD} < \text{Intensity_TATL}$ (the element is still overloaded):
 - Then reduce power on generator 3.
 - If $\text{Intensity_PATL} < \text{Intensity_LOAD}$ (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 *GridStateAlterations* with attribute *normalEnable* set to true/false, depending on the chosen generator).

The SIPS logic can be reflected as decision tree shown in [Figure 70](#).

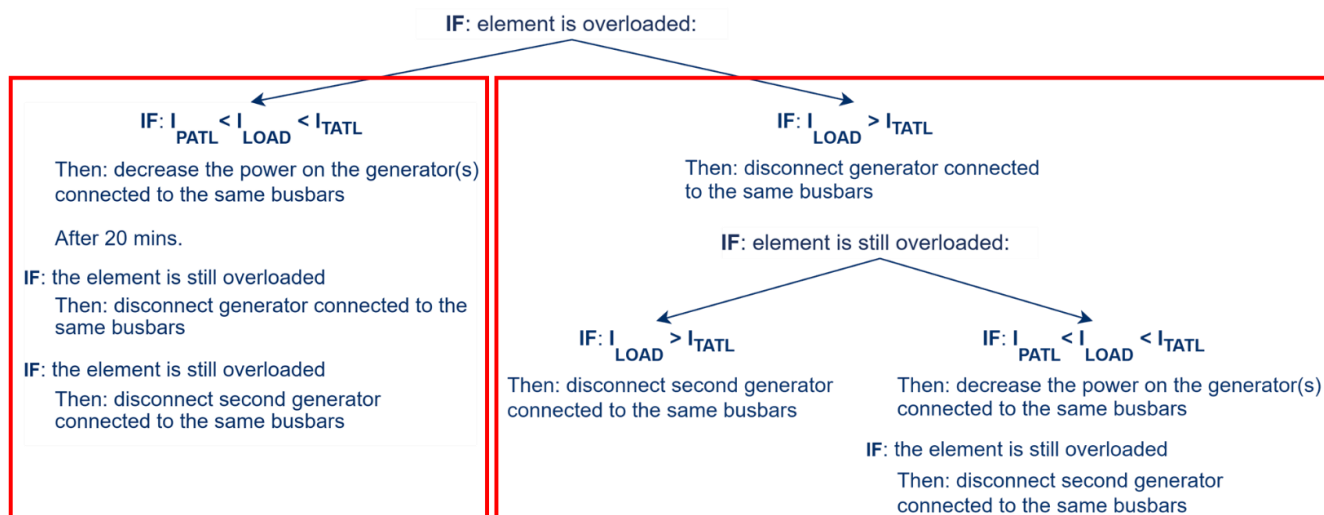


Figure 70: Complex triggering logic

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 71**.

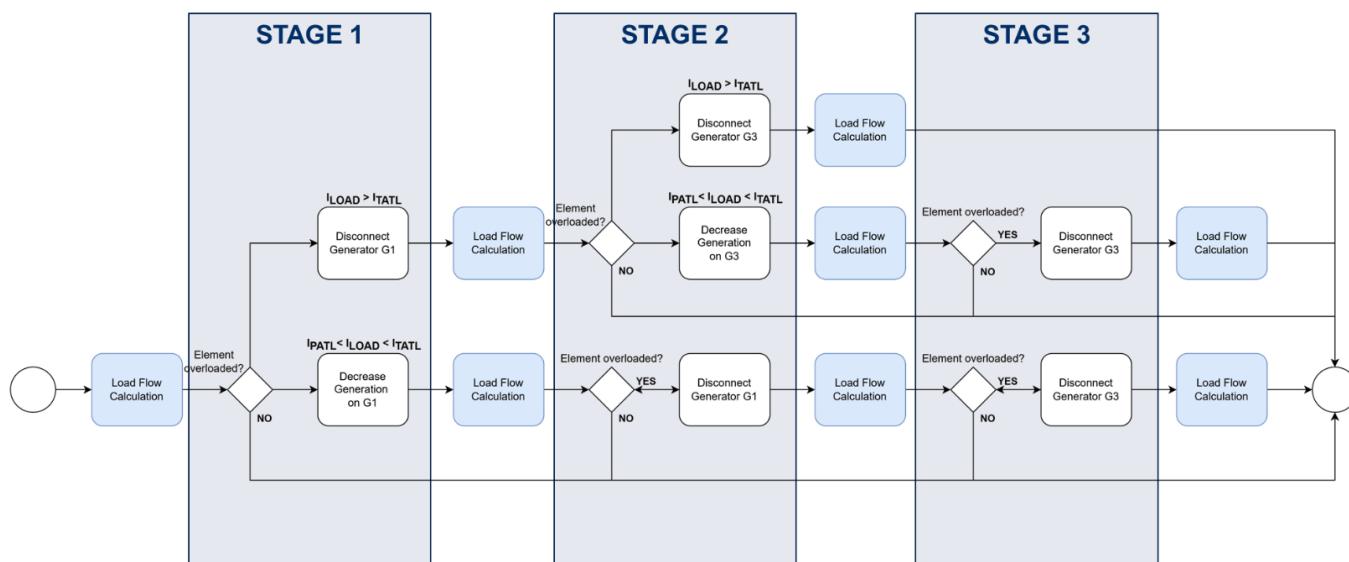


Figure 71: Operational Stages Action Chain

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 72).

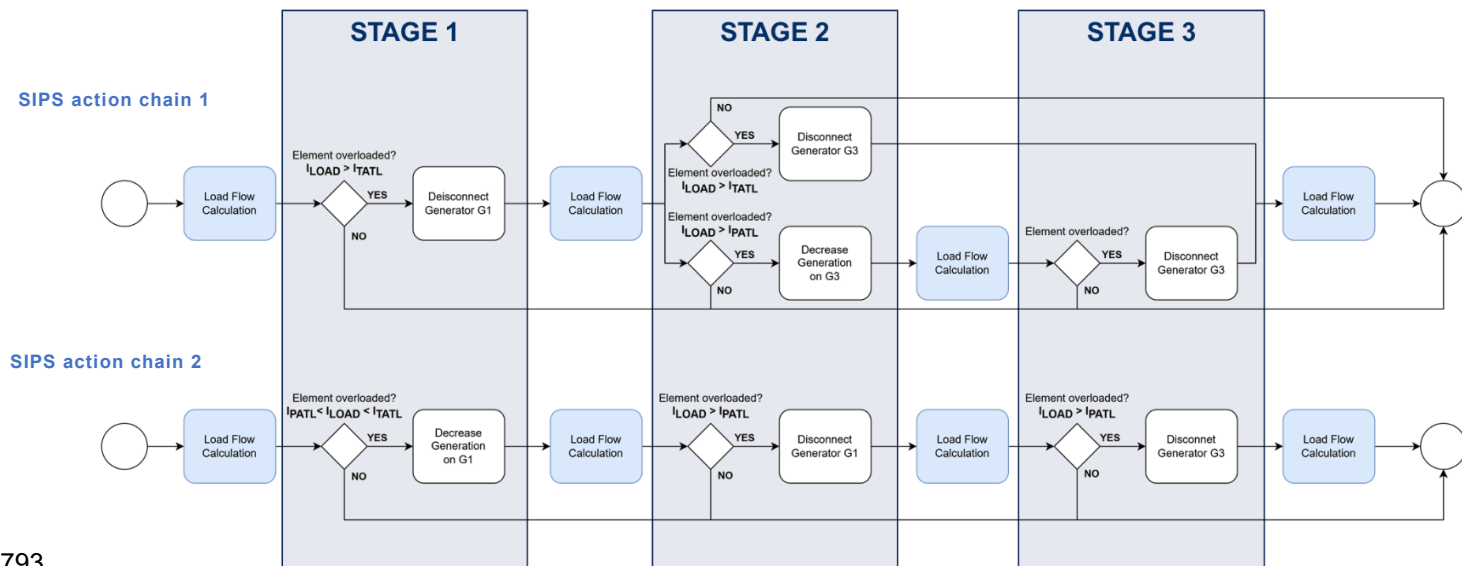


Figure 72: Operational Stages Action Chain (simplification 1)

Currently, the CIM based Network Code Profiles cannot cover such a complex action chain dependency level as described in [Figure 72](#). 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 73](#).

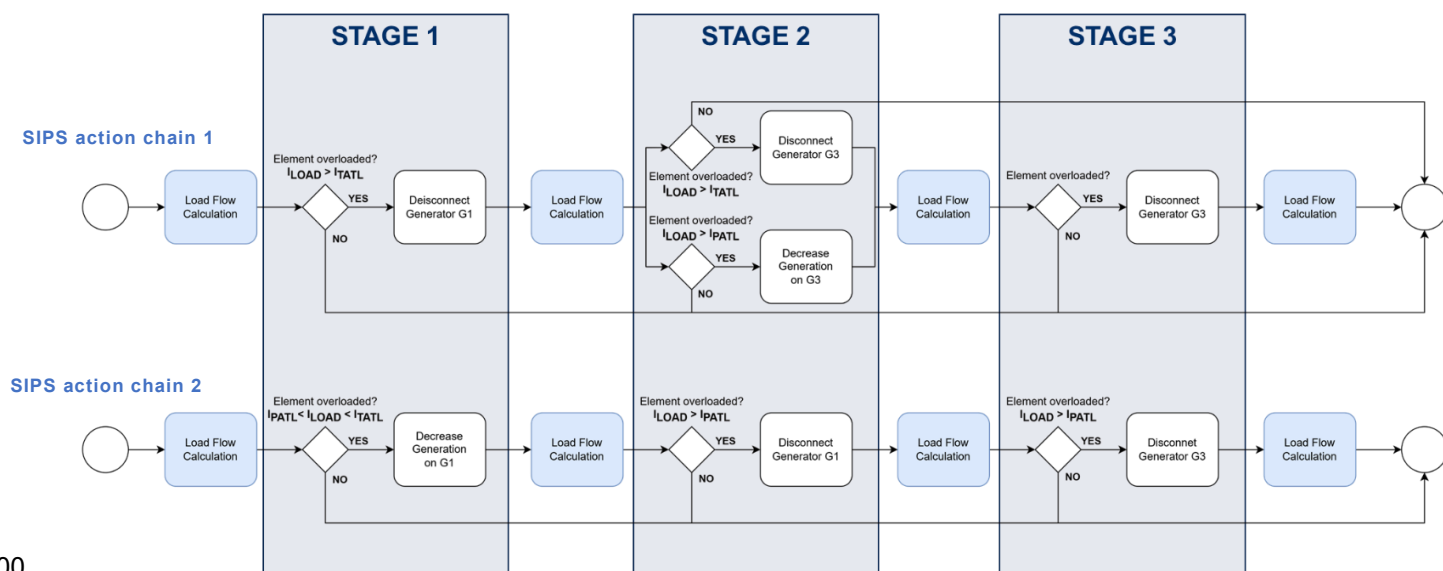
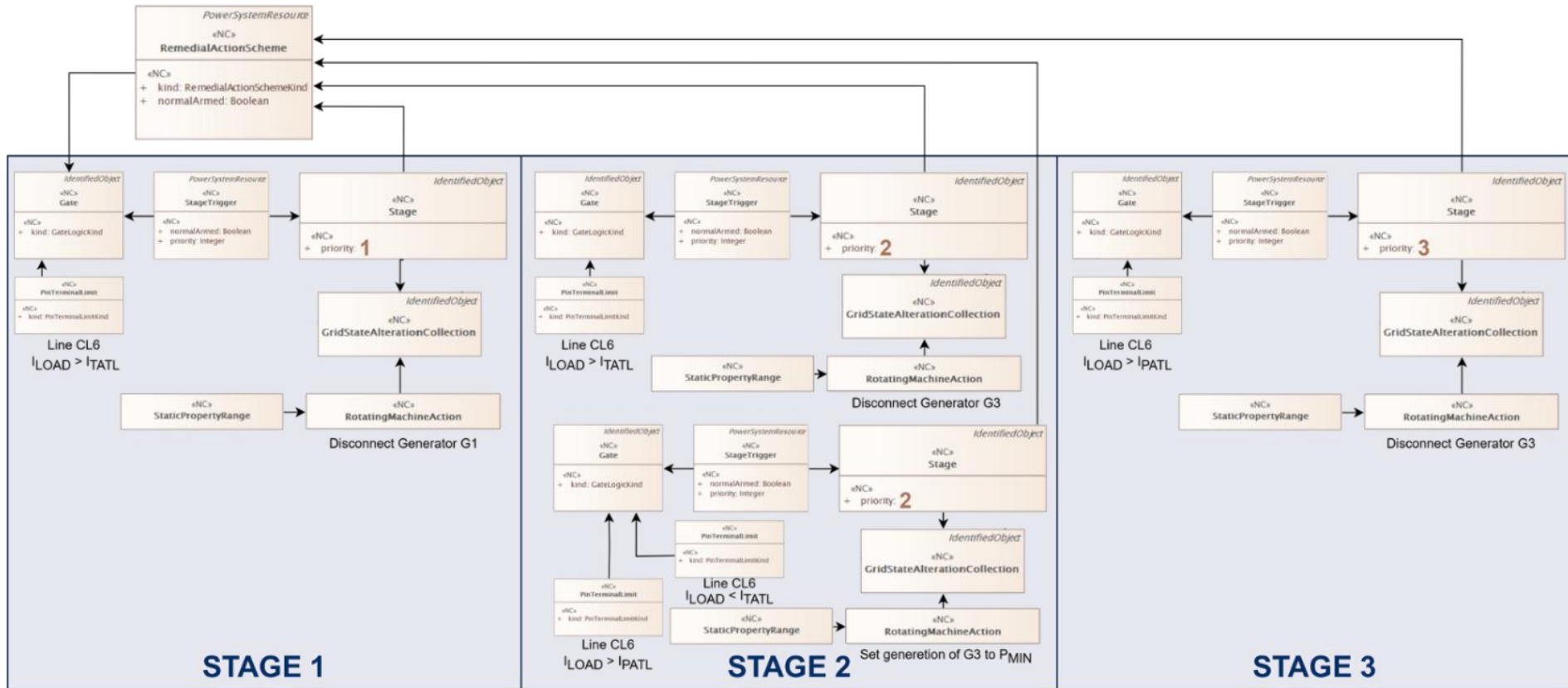


Figure 73: Operational Stages Action Chain (simplification 2)

3803 **7.1.9.8.3 Example Use of Network Code Profiles**

3804 The use of the Network Code Profiles is exemplified for SIPS action chain 1 in **Error! Reference source not found.**

3805 The use of the Network Code Profiles is exemplified for SIPS action chain 2 in **Figure 72.**



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Figure 74 : Example for SIPS action chain 1 (part 1)

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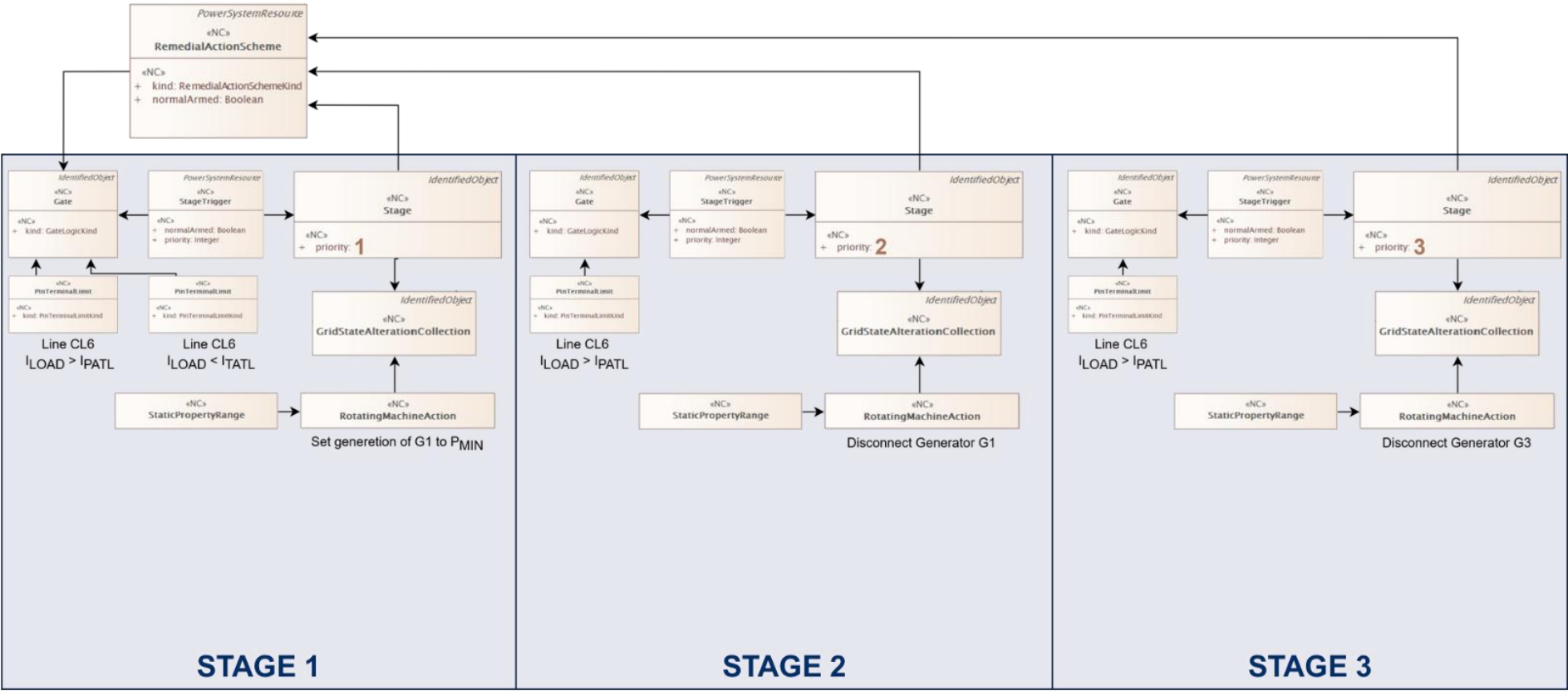


Figure 75 Example for SIPS action chain 2

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

This use case describes the modelling of a S(l)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 76](#), 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.

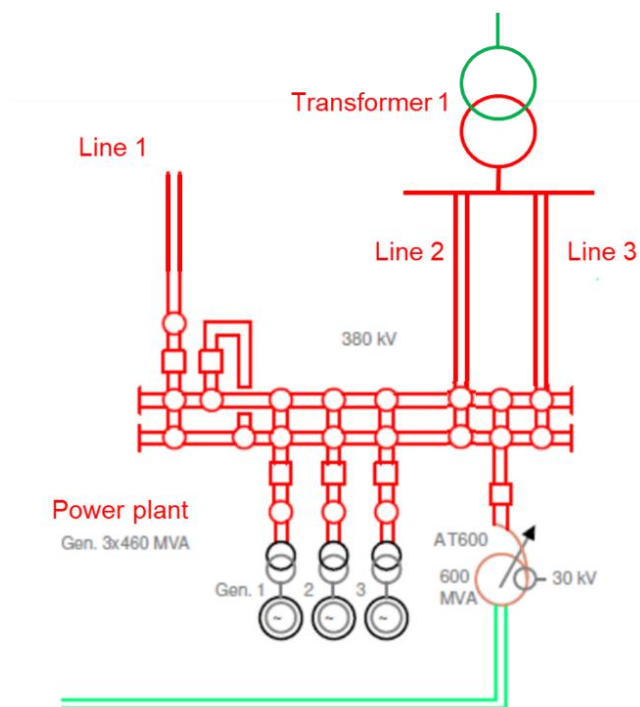


Figure 76: General diagram for use case "Correction of generation production due to a power flow limit violation"

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 $P_{AT} > 600$ 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	<i>PinTerminal</i>
Transformer 1	IN	>1	<i>PinTerminal</i>
Generators 1, 2, 3	IN	>300	<i>PinTerminal</i>
Transformer AT600	IN	>600	<i>PinTerminal</i>

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 $P_{AT} > 600$ MW).
- All conditions are checked for **duration > 10s** not to activate accidentally [mandatory field – filled for this purpose primarily]

3869 If triggered, the stage 2 would lower the generation lower the production of the generators
 3870 until the Transformer AT600 is no longer overloaded, that is, until $P_{AT} \sim 550 \text{ MW}$. This is done
 3871 under the assumption that each generator would equally share the 550 MW, and they would
 3872 produce $\sim 183 \text{ MW}$ each.

3873

Element	In operation	Threshold (MW)	Class to monitor the element
Line 1, 2, 3	IN	>1	<i>PinTerminal</i>
Transformer 1	OUT	=0	<i>PinTerminal</i>
Generators 1, 2, 3	IN	>200	<i>PinTerminal</i>
Transformer AT600	IN	>600	<i>PinTerminal</i>

3874 Again, all actions to be activated if Stage 2 is triggered are gathered using with
 3875 *GridStateAlterationCollection* object. Additionally, there are three *RotatingMachineAction*
 3876 and a corresponding *StaticPropertyRange* set point classes instantiations, one for each
 3877 generator.

3878 For the sake of simplification, to establish the outage of Transformer 1, in this example its
 3879 active power was simply monitored to be 0 MW. However, readers might explore using the
 3880 transformer's breaker *PropertyReference* for pointing to the switch and set its attribute to
 3881 "open".

3882 7.1.9.9.2 Example Use of Network Code Profiles

3883 The describes the instantiation of classes in the Network Code Profiles to cover the
 3884 description of one stage. Both stages 1 and 2 have an AND gate but each of them has their
 3885 own Gates' instantiations.

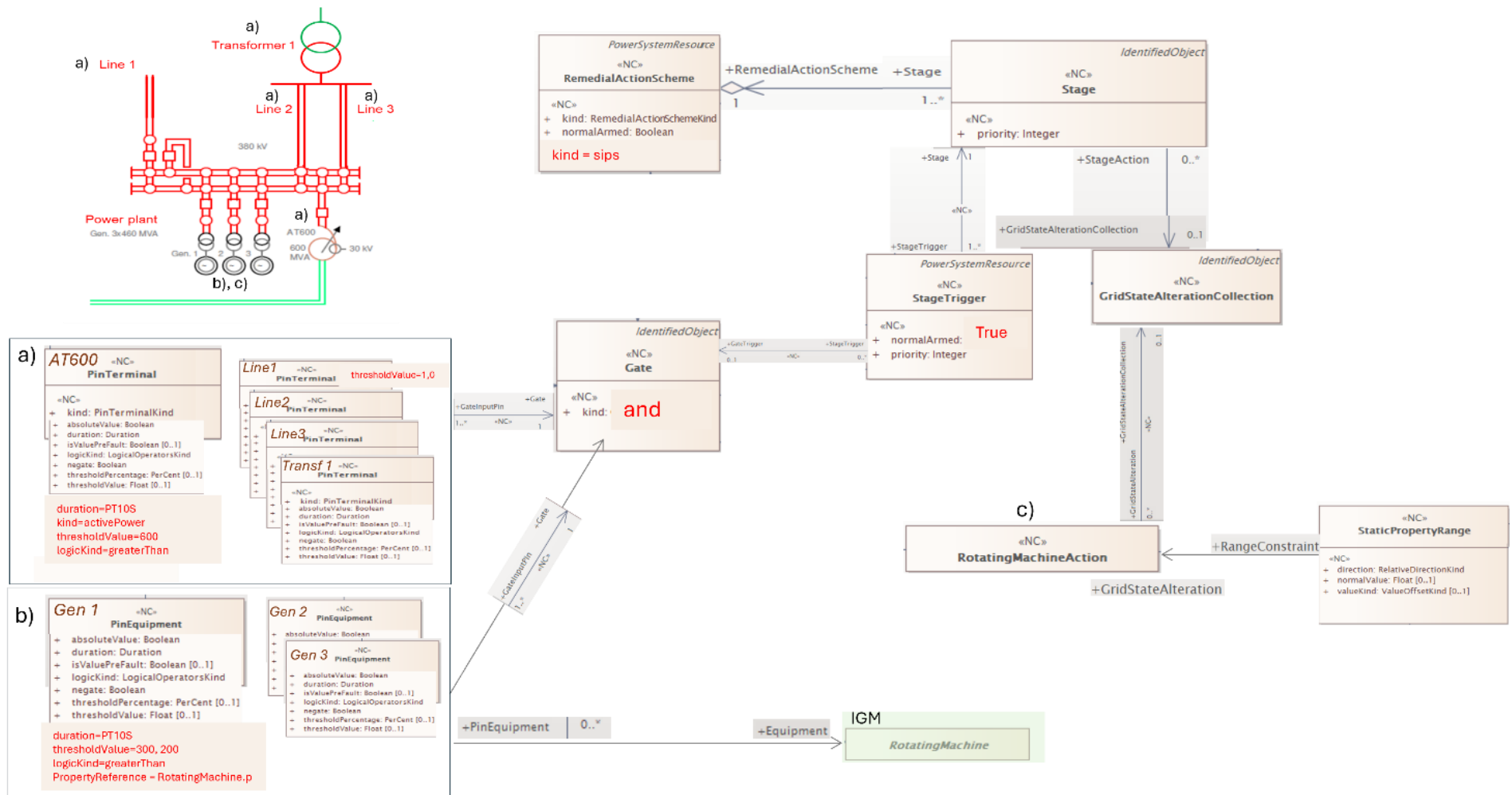
3886 Readers might especially pay attention to the following:

- 3887 • Since this is considered a non-coordinated SPS, the main umbrella class used to model
 3888 it is the *RemedialActionScheme*, with the attribute *RemedialActionScheme.kind* set to
 3889 *sips*.
- 3890 • A specific stage is defined through the objects of *Stage*, *StageTrigger* and the triggering
 3891 conditions. The triggering conditions on the lines and transformers are based on the
 3892 power flow through grid nodes in terminals referenced using the *PinTerminal* class.
- 3893 • The generators are monitored and referenced through the *PinTerminal* class.
- 3894 • The actions triggered by the SPS in this scenario consist of changes in the production
 3895 of such generators. The production changes are described using the
 3896 *GridStateAlterationCollection*, *RotatingMachineAction* and the corresponding
 3897 *StaticPropertyRange* classes. Each generator has its own set of these objects.
- 3898 • The use of *PinTerminal* instead of *PinEquipment* to check whether a generator is in
 3899 operation (i.e., assigning it to value 1 MW) and whether a generator is producing over
 3900 a certain threshold as it embraces future better solutions for modelling this
 3901 information in upcoming versions of the CIM standard by IEC.

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Figure 75: Example use of Network Code Profiles SIPS "Correction of generation production due to a power flow limit violation"

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

A large transfer of active power between two buses generally results in an increased voltage-angle difference between them. Aligned voltage angle across the power system is one factor for maintaining synchronism. Therefore, the angle difference is operationally relevant because circuit breakers may not be able to close safely when the voltage-angle difference across the open breaker exceeds the applicable equipment or operational limit. Following the loss of a highly loaded line, an excessive voltage angle difference may therefore prevent successful circuit breakers reclosing. This can prolong the disconnection and, in severe situations, contribute to subsequent overloads or cascading trips. For this reason, the voltage angle difference shall be monitored at network locations where secure switching or reclosing depends on the angle remaining below a defined limit.

The use case applies both to internal network elements and to tie-lines:

- National lines: both terminals used for the angle comparison are contained in the same TSO's Individual Grid Model (IGM). The TSO can therefore define the applicable voltage-angle limit and reference both terminals using its own Equipment (EQ) and Equipment Reliability (ER) datasets.
- Tie-lines: the two terminals are located in different IGMs and are maintained by different TSOs. A voltage-angle limit defined only in one TSO's IGM (say, IGM X of TSO X) cannot be validated independently without the second limit in the other TSO's IGM (say, IGM Y of TSO Y). The complete angle calculation therefore requires the relevant datasets of both ends to be combined, for example as part of the CGM merging or another validation scope.

The monitored condition is considered secure when the absolute voltage-angle difference between the terminals associated with the *OperationalLimitSet* and the declared angle-reference terminal remains below the applicable *VoltageAngleLimit.normalValue*.

Modelling using the Network Code profiles

The voltage-angle restriction is represented by *VoltageAngleLimit* in the Equipment Reliability profile. The class is a specialisation of *OperationalLimit* and defines the maximum permitted voltage-angle difference through *VoltageAngleLimit.normalValue*.

The limit is associated with:

3946 • an OperationalLimitSet, which identifies one of the terminals forming the angle
3947 comparison; and

3948 • VoltageAngleLimit.AngleReferenceTerminal, which identifies the second terminal used
3949 as the angle reference.

3950 The OperationalLimitSet and both referenced ACDCTerminal instances are defined in the
3951 CGMES EQ dataset. The ER dataset therefore adds the voltage-angle-specific limit while
3952 referencing the relevant structural objects from the EQ dataset. The OperationalLimitSet shall
3953 not be redefined as an ER object.

3954 For an internal line, both referenced terminals are available in the same IGM. For a tie-line,
3955 one terminal may be defined in each of the two neighbouring TSOs and thus their IGMs. The
3956 voltage-angle constraint can therefore be evaluated only when the validation or calculation
3957 scope contains both terminals. This may require combining the ER dataset with the relevant
3958 EQ datasets from both TSOs.

3959 Where the monitored network element is also represented as an AssessedElement, the
3960 Assessed Element profile may reference the element for use in regional security assessment.
3961 The AssessedElement identifies what is assessed, while VoltageAngleLimit defines the angle
3962 criterion that shall be respected.

3963 The cross-referencing issue between neighbouring IGMs is addressed by the new boundary
3964 setup based on the duplication principle. Under this approach, the terminal required for the
3965 voltage-angle comparison may be represented in the boundary dataset and duplicated in both
3966 IGM 1 and IGM 2. Each TSO can therefore reference the same boundary terminal from its own
3967 IGM, while the shared boundary definition provides the common identity needed to relate the
3968 duplicated instances. This allows the VoltageAngleLimit to reference terminals on both sides
3969 of an interconnection without creating unresolved references between independently
3970 exchanged IGMs.

3971 ReliCapGrid example

3972 The corresponding example is provided in the ReliCapGrid Belgovia_ER.xml dataset.

3973 The voltage-angle limit is represented by:

3974 • VoltageAngleLimit: rdf:ID="_bf17bcf4-fee4-4108-a22f-2ead83edb55c"

3975 • IdentifiedObject.name: VoltageAngleLimit1

3976 • VoltageAngleLimit.normalValue: 10.0

3977 • VoltageAngleLimit.AngleReferenceTerminal:
3978 rdf:resource="#_5c206db8-ef8c-4e53-b2b9-38b52b194c5a"

3979 • OperationalLimit.OperationalLimitSet:
3980 rdf:resource="#_6fe5c43b-621c-88ac-1d90-22f075cdb50e"

3981 • OperationalLimit.OperationalLimitType:
3982 rdf:resource="#_0be2bf15-903e-37c9-9d8b-2fd3b0220ea3"

3983 The OperationalLimitSet referenced by _6fe5c43b-621c-88ac-1d90-22f075cdb50e identifies
3984 the other terminal of the angle comparison through its OperationalLimitSet.Terminal

association in the Equipment dataset. The reference terminal _5c206db8-ef8c-4e53-b2b9-38b52b194c5a is also defined as a Terminal in the Equipment dataset. Together, these two terminals define the points between which the voltage-angle difference is calculated.

7.1.10.3 Power Transfer Corridor

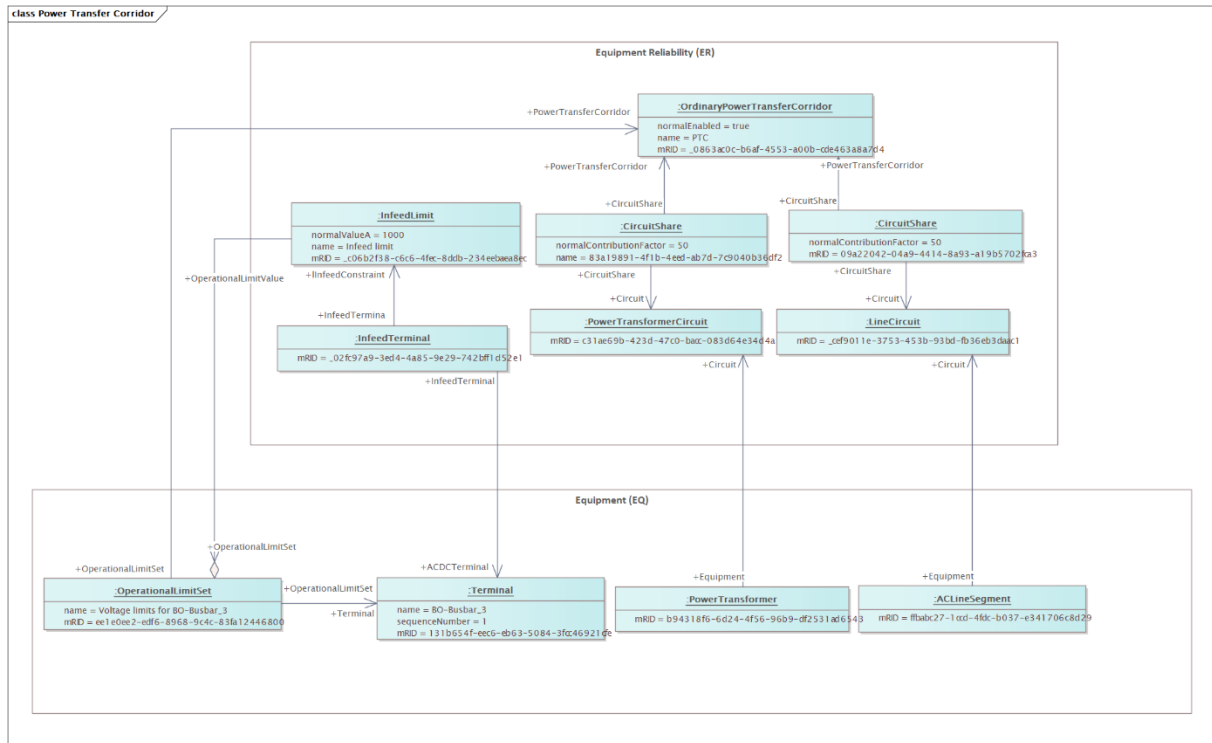


Figure 77 – Power Transfer Corridor

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"

- 4007 • ALineSegment rdf:ID=_ffbabc27-1ccd-4fdc-b037-e341706c8d29"
- 4008 • Terminal rdf:ID="_131b654f-eec6-eb63-5084-3fcc46921cfe"
- 4009 • OperationalLimitSet rdf:ID="_ee1e0ee2-edf6-8968-9c4c-83fa12446800".

4010 In order to cover wider range of use cases the power transfer corridor can be composed by
 4011 using the association Circuit.IdentifyingTerminal. Therefore, a Circuit shall have an association
 4012 with either a Terminal or an Equipment. Figure 78 illustrates this approach.

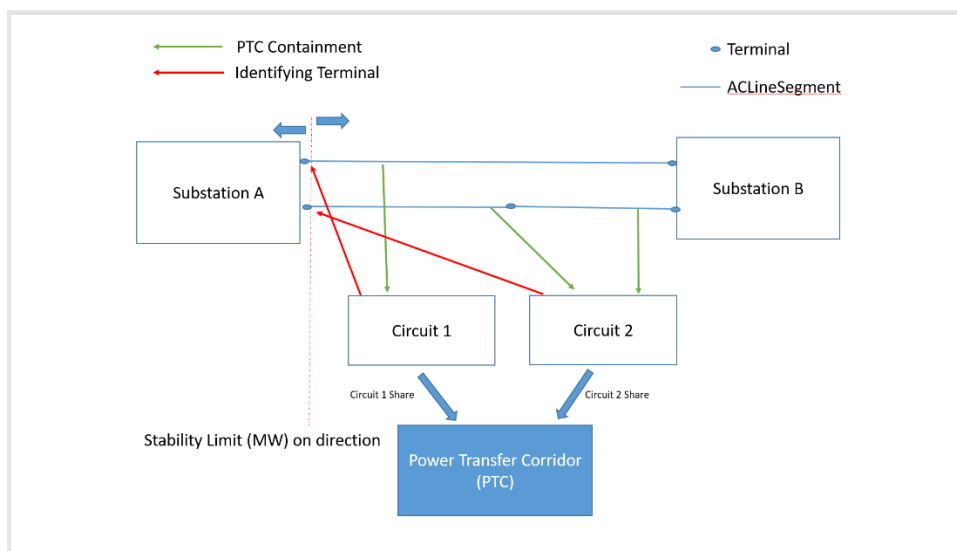


Figure 78 – Power Transfer Corridor – using Terminals

4016 There are at least two use cases where active and reactive power flows are monitored. The
 4017 constraints can be fixed limits or variable limits – per MTU. The following sections illustrate
 4018 the two cases.

4019
 4020

7.1.10.3.1 Monitoring 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.

4057 An example that illustrates this can be located in ReliCapGrid in Belgovia_ER.xml:

4058 • InfeedLimit rdf:ID="_c06b2f38-c6c6-4fec-8ddb-234eebaea8ec".

4059 Readers would find in the ENTSO-E ReliCapGrid GitHub repository (fictitious TSO Svedala
4060 exchanging a AS dataset) an example of the *AvailabilitySchedule* class with mRID set to
4061 31c77d68-cf6a-462a-8194-956d697dc3a2

4062

7.1.10.3.2 Monitoring 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 *OperationalLimits* 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.

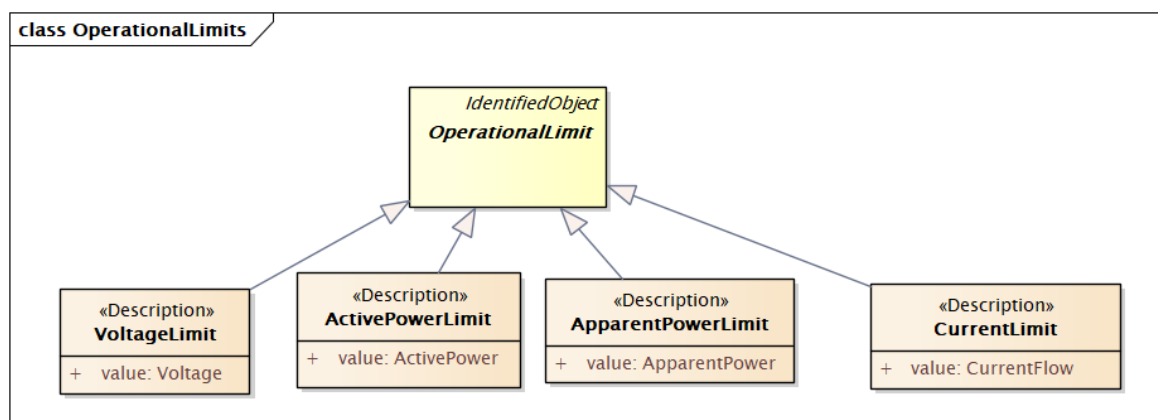


Figure 79: From SSH dataset that should be included in the SSI dataset

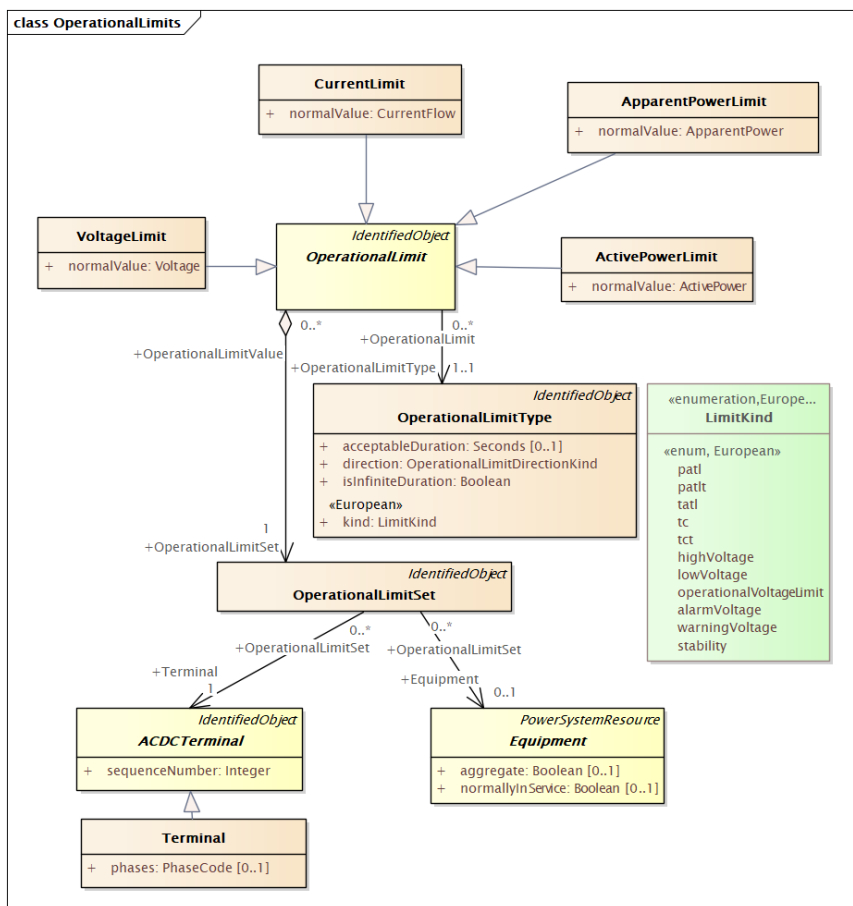


Figure 80: Information from EQ profile, which is instance data in the ER profile

For the scheduled data (not per MTU), one should use the Steady State Hypothesis Schedule (SHS) profile.

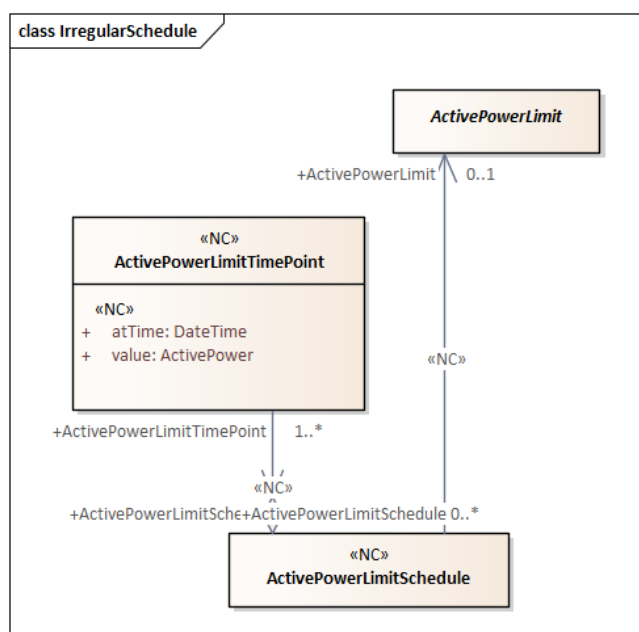


Figure 81: Showing how to exchange active power limits that should be exchanged in the SHS

4093 An example on exchanging current limits through Steady State Hypothesis Schedule profile
4094 can be found in ReliCapGrid in Belgovia_SHS.xml:

4095 • CurrentLimitSchedule rdf:ID="_a246aa9a-1e25-4693-a681-f4f771949d2f".

4096 The corresponding current limit dataset can be located in ReliCapGrid in Belgovia_EQ_1.xml:

4097 • CurrentLimit rdf:ID="_1ee85ce6-8298-c191-b8a0-9ccac2282a66".

4098 Readers would find in the ENTSO-E ReliCapGrid GitHub repository (fictitious TSO Svedala
4099 exchanging a AS dataset) an example of the *AvailabilitySchedule* class with mRID set to
4100 31c77d68-cf6a-462a-8194-956d697dc3a2.

4101

4102 **7.1.10.4 Expected Use Cases**

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4104 **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

4105

4106 7.1.11 Availability Schedule

4107 7.1.11.1 Outage Planning Information

4108 The Availability Schedule profile is used to facilitate the exchange of planned outage
4109 information. This profile is designed with sufficient flexibility to allow relatively
4110 straightforward implementation by other actors as well, such as DSOs.

4111 For illustrative purposes, only a subset of the Availability Schedule profile which is relevant for
4112 the exchange of planned outage data is considered here. This section introduces only the core
4113 elements and selected functionalities of the profile that pertain to planned outage
4114 communication. Depending on the nuances of the use case other available attributes and
4115 classes can be used too.

4116 The data exchange process for Outage Planning Coordination involving TSOs, DSOs, and
4117 significant grid users is expected to evolve over time. Future versions of this document will
4118 progressively elaborate and extend the specification to encompass additional capabilities and
4119 requirements.

- 4120 • Use of AvailabilitySchedule class

4121 The main object of a scheduled outage dataset is the object *AvailabilitySchedule* object. The
4122 object shall have a unique mRID. The mRID shall be persistent to enable updates on the
4123 outage. The *AvailabilitySchedule* shall have a reference to a *PlannedSchedule* object (which is
4124 an instance of *EventSchedule*) to be able to specify the start time and end time of the
4125 interruption.

4126 The following attributes of the *AvailabilitySchedule* class are relevant for this use case:

- 4127 • causeKind: the profile allows for different causes, but for the example 'maintenance'
4128 is selected as the most frequently used.
- 4129 • Priority: it is set to 1 in most of the cases.
- 4130 • causeDescription: Description of the cause of the interruption. It can be the same as
4131 the description in *AvailabilityEquipment*.
- 4132 • description: It is used to indicate the operation order number in case it exists.
- 4133 • maxRestitutionDuration: it is used to indicate how long it is expected before return to
4134 operation. If recovery time is not available, the field is left blank.
- 4135 • cancelledDateTime: It is used to cancel the planned outage (stores the cancellation
4136 time).

4137 Readers would find in the ENTSO-E ReliCapGrid GitHub repository (fictitious TSO Svedala
4138 exchanging a AS dataset) an example of the *AvailabilitySchedule* class with mRID set to
4139 31c77d68-cf6a-462a-8194-956d697dc3a2.

- 4141 • Use of AvailabilityEquipment class

4142 In the data model, a piece of equipment, such as a network element or a production module,
4143 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 groupobject 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'.

4180 The approach for AvailabilityContainer follows the pattern used by AvailabilityEquipment and
4181 it is integrated into ReliCap grid in Svedala_AS.xml. In this context, the following instances
4182 describe the case of reporting availability for a container:

- 4183 • AvailabilityContainer rdf:ID="_0d4d4078-f3ad-409d-8882-73dafef11b80",
- 4184 • AvailabilitySchedule rdf:ID="_9fa5e26d-d64e-4bfb-afb8-fb6dbe884b48".
- 4185 • Use of EventSchedule class

4186 The EventSchedule object describes when the outage will occur and is referenced via the
4187 PlannedSchedule association from the *AvailabilitySchedule* object. Note that the actual start
4188 and end times are defined in the EventTimePoint object.

4189 Used attributes of the EventSchedule:

- 4190 • TimeSeriesInterpolationKind: In most of the cases set to 'previous'.
- 4191 • BaseTimeSeriesKind: In the profile description there is a list of options, but in most
4192 cases, it will be 'schedule'.

4193 The corresponding dataset example is integrated in Svedala_AS.xml:

- 4194 • EventSchedule rdf:ID="_7acbe49b-be64-4dd8-a02e-87778468d55a"
- 4195 • Use of EventTimePoint class

4196 Two instances of the EventTimePoint object are required to specify the start and end time of
4197 the interruption. The isActive attribute defines whether EventTimePoint represents the start
4198 time ('true') or the end time ('false').

4199 In this example, EventTimePoint ab81932c-9fc9-4d1b-a770-36e5e6bfbb9e is the start time
4200 and EventTimePoint 389a8f82-cb8e-4b8c-8aa7-3b26a4957eba is the end time, and the entire
4201 outage takes one day.

4202 The corresponding dataset examples are integrated in Svedala_AS.xml:

- 4203 • EventTimePoint rdf:ID="_389a8f82-cb8e-4b8c-8aa7-3b26a4957eba"
- 4204 • EventTimePoint rdf:ID="_4a69b9d3-39ac-44e7-a68d-1d76657202b4"
- 4205 • EventTimePoint rdf:ID="_ab81932c-9fc9-4d1b-a770-36e5e6bfbb9e"

4206

4207 **7.1.11.2 Update of Security Limits Before or During CROSA Process**

4208 During the execution of the CROSA process, exceptional operational conditions may require a
4209 Core TSO to update the security limits for specific network elements (XNE) or scanned
4210 elements.

4211 These updates can occur both before CROSA execution and after the delivery of the Individual
4212 Grid Model, while CROSA is running.

4213 The paragraphs below describe the modelling enabling the modification of Permanent
4214 Admissible Transmission Limits (PATL) and Temporary Admissible Transmission Limits (TATL)
4215 in response to unforeseen situations such as unexpected outages, severe weather events, or
4216 other operational disturbances.

4217 However, this functionality is not intended for use in dynamic line rating applications.

4218 The recommended approach is based on the *AvailabilitySchedule* profile—an extract is shown
4219 in [Figure 82](#). The updated PATL or TATL values are modelled using the
4220 *AvailabilityExceptionalLimit* class, with the *isActive* attribute in the *EventTimePoint* class set to
4221 *true* to indicate that the exceptional limit is in effect.

4222 The reason for the update is expressed in the *causeKind* attribute of the *AvailabilitySchedule*
4223 class, which can take any value defined in the enumeration.

4224 The status of the element concerned is provided through the *kind* attribute of the
4225 *AvailabilityPowerSystemFunction* class, set to the values *inService* or *underTesting* of the
4226 *availabilityFunctionKind* as appropriate.

4227 If a TSO wishes to link this information with an *Equipment*, they may consider using the
4228 *AvailabilityEquipment* class that inherits directly from the aforementioned
4229 *AvailabilityPowerSystemFunction* class.

4230 This modelling pattern enables the exceptional limit to be directly associated with the relevant
4231 PATL or TATL, ensuring that the updated limits are accurately exchanged and applied within
4232 the CROSA coordination process in compliance with the CGMES and NCP information model.

4233

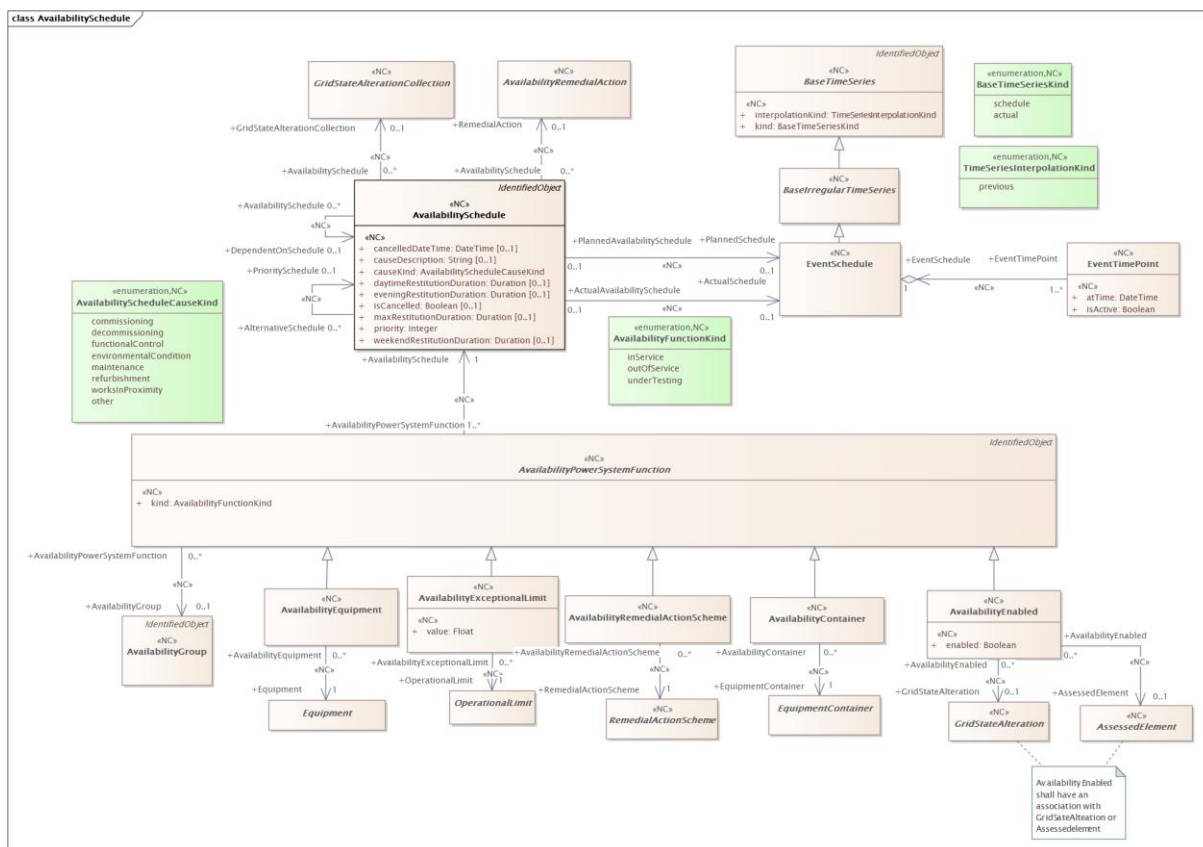


Figure 82: Extract of the AvailabilitySchedule profile.

4234

4235

4236

4237

7.1.11.3 By-passing Configuration

The following roles are involved in this use case: System operator, outage planning agent, RCC.

In the case the outage planning agent needs to take a busbar out of service while keeping the power lines in operation; and depending on the substation design, this can be achieved either as a remedial action or by using temporary equipment.

In the following pictures, the topology before and after the bypass configuration is applied.

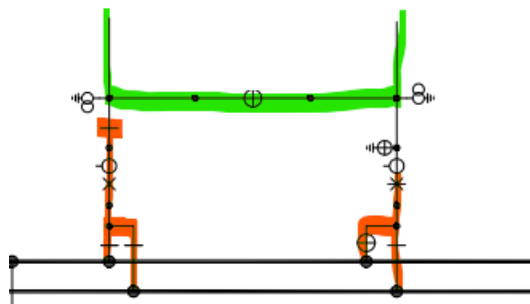
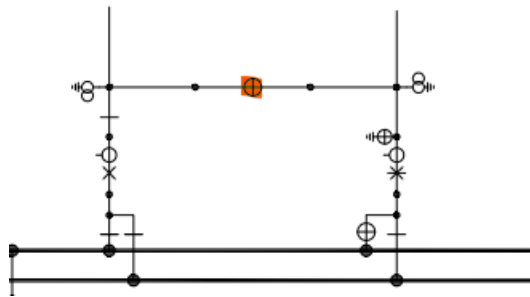


Figure 83: Topology before and after the bypass configuration is applied.

Where an auxiliary busbar is available, power lines can be connected (by closing their disconnectors) to the auxiliary busbar and disconnected (by opening their breakers) from the other busbar that is to be taken out of service.

Alternatively, the two power lines can be directly connected (by closing the disconnector between them, which is normally open) while being disconnected from the busbar(s) (by opening the breakers and disconnectors connecting them). The latter is a remedial action which therefore consists of topology changes used to bypass the substation, resulting in a configuration in which two ordinary power lines are connected and operate as one continuous line. The outage planning agent informs the system operator about the planned remedial action associated with the scheduled outage.

The system operator registers both the scheduled outage and the associated planned remedial action in the individual grid model. The RCC considers the planned remedial action as part of the base case in the common grid model. Since remedial actions of this type are relatively rare, they are typically not considered as candidates in remedial action optimisation.

4263 The topology change may also affect the contingency list, because the tripping of the two
4264 connected power lines should be treated as a single contingency.

4265 **Implementation using the Availability Schedule profile:**

4266 The scheduled outage is represented by an AvailabilitySchedule. The busbar or other
4267 equipment to be taken out of service is identified through an AvailabilityEquipment instance
4268 associated with the schedule. The kind attribute of the availability function is set to
4269 outOfService, while AvailabilitySchedule.causeKind specifies the reason for the outage, such
4270 as maintenance or refurbishment.

4271 The topology changes required to establish the bypass configuration are represented by a
4272 GridStateAlterationCollection associated with the same AvailabilitySchedule. The collection
4273 contains the individual grid-state alterations required to open the connections to the ordinary
4274 busbar and close the connections that establish the bypass. This association ensures that the
4275 receiving application can interpret the equipment outage and the corresponding temporary
4276 topology as one coordinated planned configuration.

4277 Where the bypass is managed as a remedial action, the AvailabilitySchedule may also be
4278 associated with the corresponding AvailabilityRemedialAction. The schedule therefore
4279 identifies the period during which the busbar is unavailable, while the associated grid-state
4280 alterations describe the switching configuration that keeps the selected power lines in service.

4281

4282 **7.1.11.4 Active/Reactive Power Restriction SGU**

4283 The following roles are involved in this use case: System operator, outage planning agent, RCC.

4284 While analysing the power flow of the power system under the condition of planned outages,
4285 it might be the case that the outage planning agent identifies technical or external conditions
4286 that restrict the capability of a Significant Grid User (SGU) to produce active power or regulate
4287 reactive power below its installed capability. In this case the outage planning agent would
4288 need to incorporate these restrictions in the network model and communicate them with the
4289 system operator. The information should include:

- 4290 • the start and end times of the restriction, noting that restrictions may remain
4291 applicable for several weeks or months;
- 4292 • the affected equipment;
- 4293 • the available active-power capacity or reactive-power control capability;
- 4294 • the cause of the restriction; and
- 4295 • any other information relevant to the restoration of the full capability.

4296 The system operator applies the restriction to the individual grid model to ensure an accurate
4297 representation of the production capabilities available within the power system. The
4298 restriction may affect the available active-power reserves, voltage regulation capability and
4299 availability of the generating unit for use as a remedial action.

4300 The RCC considers the restriction when performing congestion forecasting, regional security
4301 analysis, and remedial action optimisation.

4302 • Modelling of the use case

4303 A scheduled restriction may be represented using the models defined in the
4304 AvailabilityScheduleProfile package. The AvailabilitySchedule model defines the period during
4305 which the restriction applies and identifies its cause through AvailabilitySchedule.causeKind.
4306 Depending on the origin of the restriction, the cause for example may indicate maintenance,
4307 environmental conditions, functional control, or another applicable reason.

4308 The affected generating unit or associated equipment may be identified through an
4309 AvailabilityEquipment instance associated with the AvailabilitySchedule. The kind attribute
4310 inherited from AvailabilityPowerSystemFunction indicates the relevant availability condition,
4311 such as inService, outOfService, or underTesting.

4312 Where the generating unit remains in service but is subject to a reduced operational
4313 capability, the restriction may be represented using AvailabilityExceptionalLimit. This class
4314 associates the schedule with the relevant OperationalLimit and specifies the exceptional value
4315 applicable during the scheduled period. It can therefore be used to represent, for example:

- 4316 • a temporarily reduced maximum active-power output;
- 4317 • a restriction on reactive-power production;
- 4318 • a restriction on reactive-power absorption; or
- 4319 • another temporary operational limit affecting the capability of the unit.

4320 The scheduled restriction does not necessarily mean that the generating unit is unavailable.
4321 The unit may remain in service while operating within a reduced active-power or reactive-
4322 power capability. The model should therefore distinguish between the availability state of the
4323 equipment and the temporary exceptional limit applicable to its operation.

4324 Another way to implement this use case with Availability Schedule profile is to use
4325 GridStateAlterationCollection associated with the AvailabilitySchedule object. As part of
4326 GridStateAlteration a StaticPropertyRange is modelled that would define the ranges that need
4327 to apply to the generating unit.

4328 An additional implementation option is the usage of the Steady State Hypothesis Schedule
4329 (SHS) and Steady State Hypothesis (SSH) profiles to provide the forecasted information. SHS
4330 can represent the forecasted values over a sequence of time periods, while SSH provides the
4331 corresponding values for an individual time unit, following the general scheduling design
4332 pattern. These profiles may therefore be used to reflect the expected active-power production
4333 and reactive-power operating point resulting from the restriction in the forecasted system
4334 state.

4335 The Availability Schedule profile describes the restriction itself, including its cause, duration,
4336 affected equipment, and applicable exceptional limits. SHS and SSH complement this
4337 information by representing the forecasted operating values that are expected while the
4338 restriction is in effect.

4339 **7.1.11.5 Acknowledgment Mechanism for Outage Planning Coordination**

4340 This part describes the acknowledgement mechanism for both positive and negative
4341 acknowledgement, respectively written in short as ACK and NACK. The corresponding
4342 information model is OutageRequest which can be found in the AvailabilityScheduleProfile
4343 package. The following use cases describe the exchange and coordination of planned outages
4344 between TSOs, DSOs and other affected parties. The roles indicated below reflect the role
4345 performed by the TSO in each use case.

4346 The mechanism distinguishes between:

- 4347 • the communication of the planned outage through an AvailabilitySchedule;
- 4348 • the formal request for coordination through an OutageRequest;
- 4349 • the response of each affected party through an OutageResponse; and
- 4350 • the final outcome of the coordination process.

4351 An AvailabilitySchedule may therefore be exchanged for information only or as the basis for a
4352 formal outage coordination process.

4353 A) Use case 1 (UC 1): TSO communicates a planned outage

4354 The TSO, acting as the OutagePlanningAgent, identifies the outage plans that need to be
4355 communicated to other parties, either for information or for coordination. The planned
4356 outage is described by creating and exchanging an AvailabilitySchedule.

4357 The TSO is expected to exchange only those outage plans that require coordination with the
4358 relevant national DSOs. Where coordination is required, the exchanged AvailabilitySchedule
4359 is followed by an associated OutageRequest, as described in Use case 2.

4360 The information contained in an AvailabilitySchedule may be updated. Not every update
4361 requires the coordination process to be restarted. Minor corrections or additional descriptive
4362 information may be communicated by issuing an updated version of the schedule without
4363 creating a new OutageRequest.

4364 However, updates that materially change the outage proposal, such as a new start time or end
4365 time, require the coordination to be restarted. In such cases, an updated version of the
4366 AvailabilitySchedule is issued together with a new version of the associated OutageRequest.

4367 B) Use case 2 (UC 2): TSO initiates and completes outage coordination

4368 The TSO, acting as the OutageCoordinator, has previously communicated a planned outage to
4369 the affected DSO or DSOs by exchanging an AvailabilitySchedule.

4370 To initiate the formal coordination process, the TSO creates an OutageRequest associated
4371 with the relevant AvailabilitySchedule and sends it to the same affected parties. The request
4372 applies to the specific outage proposal represented by the corresponding version of the
4373 schedule.

4374 Each affected DSO assesses the proposed outage and responds to the request. The TSO shall
4375 receive the required positive responses from all affected DSOs before the coordination can be
4376 considered successful.

4377 Where all affected parties confirm the request, the TSO communicates that the coordination
4378 has been completed successfully and that the outage is planned.

4379 Where one or more affected DSOs reject the request, the TSO may:

- 4380 • reschedule the outage by updating the AvailabilitySchedule and restarting the
4381 coordination process in accordance with UC 1; or
- 4382 • cancel the planned outage.

4383 Where the outage is cancelled, the associated AvailabilitySchedule is also cancelled using the
4384 applicable cancellation information, including cancelledDateTime.

4385 C) Use case 3 (UC 3): TSO receives an AvailabilitySchedule from a DSO

4386 The TSO receives an AvailabilitySchedule from a DSO. Depending on the affected equipment
4387 or equipment container identified by the associated AvailabilityEquipment or
4388 AvailabilityContainer, and on the applicable business rules, the schedule is interpreted either:

- 4389 • as information only; or
- 4390 • as an outage proposal pending coordination.

4391 Where the schedule is interpreted as pending coordination, the TSO expects to receive an
4392 associated OutageRequest before considering the outage to be planned.

4393 The DSO may subsequently update the AvailabilitySchedule by issuing a revised version. The
4394 DSO may also cancel the planned outage using cancelledDateTime and the other applicable
4395 cancellation information.

4396 D) Use case 4 (UC 4): TSO responds to an OutageRequest received from a DSO

4397 The TSO receives an OutageRequest associated with a previously received
4398 AvailabilitySchedule.

4399 The TSO assesses the impact of the outage on system operation and responds to the request
4400 for the applicable version of the outage proposal. The response may confirm or reject the
4401 request. Where the TSO, or another affected party, rejects the outage proposal, the
4402 coordination can continue only if the initiating DSO:

- 4403 • updates the AvailabilitySchedule and restarts the coordination process; or
- 4404 • cancels the OutageRequest and the associated AvailabilitySchedule.

4405 Where the TSO confirms the request, it accepts that the final outcome communicated by the
4406 initiating DSO may be either planned or cancelled. A positive response from the TSO confirms
4407 only the TSO's acceptance of the proposed outage. The TSO may not be aware of, or
4408 responsible for, the coordination with every other party affected by the outage.

4409 E) Modelling using the Availability Schedule profile

4410 The AvailabilitySchedule represents the outage or restriction being communicated. It
4411 identifies the affected availability function, the applicable period and the relevant outage
4412 characteristics.

4413 The affected resource is represented through an appropriate specialisation of
4414 AvailabilityPowerSystemFunction, such as:

- 4415 • AvailabilityEquipment, for a specific item of equipment;
- 4416 • AvailabilityContainer, for an equipment container;
- 4417 • AvailabilityExceptionalLimit, for a temporary operational limit;
- 4418 • AvailabilityRemedialActionScheme, for the availability of a remedial action scheme; or
- 4419 • AvailabilityEnabled, for the enabled state of a GridStateAlteration or AssessedElement.

4420 The planned and actual timing of the availability condition may be represented by the planned
4421 and actual EventSchedule associations. Each EventSchedule contains one or more
4422 EventTimePoint instances defining when the relevant availability condition becomes active or
4423 inactive.

4424 F) Updating an AvailabilitySchedule

4425 Where the schedule information changes, the AvailabilitySchedule dataset is updated. The
4426 validity information in the dataset header is updated accordingly so that the revised dataset
4427 clearly identifies the period for which the exchanged information applies.

4428 An update to the schedule does not automatically require a new coordination request. The
4429 need for a new request depends on whether the update materially changes the outage
4430 proposal.

4431 For example:

- 4432 • a correction to descriptive information may require only an updated schedule dataset;
- 4433 • a change to the outage start or end time normally requires a revised OutageRequest;
4434 and
- 4435 • cancellation of the outage is represented by updating the schedule with the applicable
4436 cancellation information.

4437 The dataset may contain multiple availability schedules where those schedules are valid for
4438 the same exchange period. This allows related outage or availability information to be
4439 combined in one dataset, provided that the schedules share the relevant dataset validity.

4440 G) OutageRequest and outage-specific coordination

4441 Formal coordination is represented separately from the AvailabilitySchedule. An
4442 OutageRequest is created when an outage requires an explicit coordination decision. The
4443 request refers to the corresponding outage information through an OutageAvailability
4444 instance associated with the relevant AvailabilitySchedule.

4445 The OutageRequestResource identifies the affected PowerSystemResource and the required
4446 AvailabilityFunctionKind. This provides a direct indication of the resource and availability state
4447 requested as part of the coordination.

4448 The outage request information is exchanged in a dedicated dataset. This separation is
4449 required for Outage Planning Coordination and allows the exchanged requests to be organised
4450 according to the responsible OutageCoordinator.

4451 H) Versioning

4452 The model supports explicit versioning of outage plans and requests. An
4453 AvailabilityPlanVersion is a specialisation of RecordVersion and identifies the applicable
4454 version of an AvailabilityPlan. The record includes information such as:

- 4455 • the record identifier;
- 4456 • the version;
- 4457 • the creation time;
- 4458 • the record status; and
- 4459 • an optional change description.

4460 A revised version may reference the version it replaces through the revision relationship.
4461 Similarly, an OutageRequestVersion identifies a specific version of an OutageRequest. Where
4462 a material change to the associated outage requires the coordination to be restarted, a new
4463 request version is created. This ensures that each acknowledgement applies to a clearly
4464 identified request and outage proposal.

4465 I) Positive ACK and negative NACK

4466 The response to an OutageRequest is represented by OutageResponse. The status attribute
4467 uses RequestResponseKind and supports the following response types:

- 4468 • accepted;
- 4469 • refused;
- 4470 • acceptedWithConditions;
- 4471 • alternativeProposal;
- 4472 • noResponseTimeout; and
- 4473 • acknowledged.

4474 A positive acknowledgement, or ACK, is normally represented by accepted. Where the outage
4475 is acceptable only under specified conditions, acceptedWithConditions may be used.

4476 A negative acknowledgement, or NACK, is represented by refused. Where the receiving party
4477 proposes a different time, configuration or condition, alternativeProposal may be used
4478 instead.

4479 The response may include a comment explaining the decision, applicable conditions or the
4480 proposed alternative.

4481 Each OutageResponse is associated with the relevant OutageRequestVersion. The response
4482 therefore applies only to that specific version of the request. Where the schedule or request
4483 is materially revised, the previous acknowledgement shall not be assumed to apply to the new
4484 version.

4485 J) Overall coordination outcome

4486 An individual positive response indicates that the responding party accepts the proposed
4487 outage from its own perspective. It does not necessarily represent the final result of the
4488 complete coordination process.

4489 The OutageCoordinator collects the responses from all affected parties and determines the
4490 overall outcome. The outage can be considered successfully coordinated only when all
4491 required positive responses have been received.

4492 Where any required party rejects the proposal, the outage shall either be revised and
4493 resubmitted for coordination or cancelled.

4494

4495

4496 **7.1.12 Define Scope of the Analysis**

4497 Monitoring area profile defines possibility to exchange the definition of the following types of
4498 areas: monitoring area, observability area, sensitivity area, contingency area. Some of the use
4499 cases when usage of area definition is necessary are:

- 4500 - In cases where it is required to identify the are based on influence factors
- 4501 - In cases where the receiving system does not select all data submitted but needs to
- 4502 analyse part of the area. For instance, region A analysis needs to include part of region
- 4503 B.

4504 Are definition uses the class AreaBorderTerminal to define the borders of the area. The
4505 following snippet illustrates definition of a monitoring area with two terminals. Eventually it
4506 is expected that there will be many terminals defined as the border needs to circle the area.

```

4507 <nc:MonitoringArea rdf:ID="_adf0cf12-8f61-45af-b073-d73dd30e078d">
4508   <cim:IdentifiedObject.mRID>adf0cf12-8f61-45af-b073-d73dd30e078d</cim:IdentifiedObject.mRID>
4509   <cim:IdentifiedObject.name>My observability area</cim:IdentifiedObject.name>
4510   <nc:MonitoringArea.SystemOperator rdf:resource="#_b1a6650b-bf47-469b-81f5-0319c265354b"/>
4511 <nc:MonitoringArea.SynchronousArea rdf:resource="#_104f34a9-4b02-41a1-b3fb-2e3802e166b8"/>
4512 </nc:MonitoringArea >
4513
4514 <nc:AreaBorderTerminal rdf:ID="_d7777b3f-4acb-452a-acca-5b100b299ba8">
4515   <nc:AreaBorderTerminal.mRID>d7777b3f-4acb-452a-acca-5b100b299ba8</
4516 nc:AreaBorderTerminal.mRID >
4517   <nc:AreaBorderTerminal.MonitoringArea                      rdf:resource="#_adf0cf12-8f61-45af-b073-
4518 d73dd30e078d"/>
4519 <nc:AreaBorderTerminal.Terminal rdf:resource="#_e504d183-64fb-4e44-9598-d19760660919"/>
4520 </nc:ObservabilityArea >
4521
4522 <nc:AreaBorderTerminal rdf:ID="_418469cd-5e95-4320-bb1f-28e5dc0ea15f">
4523   <nc:AreaBorderTerminal.mRID>418469cd-5e95-4320-bb1f-28e5dc0ea15f</
4524 nc:AreaBorderTerminal.mRID >
4525   <nc:AreaBorderTerminal.MonitoringArea                      rdf:resource="#_adf0cf12-8f61-45af-b073-
4526 d73dd30e078d"/>
4527 <nc:AreaBorderTerminal.Terminal rdf:resource="#_c677bd82-40f3-40ac-a11b-01832631ced9"/>
4528 </nc:ObservabilityArea >

```

4529

4530 In future releases of the RCP DES, this example will be integrated in the ReliCapGrid open-
4531 source test model.

4532

4533 7.1.13 Control Model

4534 The Equipment Reliability profile includes a control model for representing steady-state
4535 control functions that are required for power-flow calculation and regional coordination
4536 processes but are not yet fully covered by the current CGMES Equipment profile. The model
4537 is intended to describe what a control function regulates, what information it measures, which
4538 equipment it acts upon, and which equipment property is modified by the control. It does not
4539 represent the internal dynamic behaviour, control-block parameters, or transient response of
4540 the controller.

4541 The control model is applicable to continuous and discrete controls, including, for example:

- 4542 • voltage control by a synchronous machine;
- 4543 • voltage control by a ratio tap changer;
- 4544 • active-power control by a phase-shifting transformer;
- 4545 • active-power, reactive-power, AC-voltage and DC-voltage controls of AC/DC
4546 converters.

4547 The model separates three related concepts:

- 4548 1. The equipment controller, represented by a specialisation of AutomationFunction,
4549 identifies the physical or logical controller associated with the controlled equipment.
- 4550 2. The control function, represented by a specialisation of ControlFunctionBlock,
4551 identifies the regulated quantity and the behaviour expected from a particular control
4552 loop.
- 4553 3. The input and output variables explicitly identify the measured power-system quantity
4554 and the equipment property modified by the control.

4555 This separation is important because one equipment controller may contain more than one
4556 simultaneously active control function. This is particularly relevant for converter-based
4557 equipment, where one controller may regulate active power and AC voltage at the same time,
4558 while another converter may regulate reactive power and DC voltage.

4559 The control model is currently included in the ER profile as an interim extension. It is expected
4560 that the control model will be integrated into the Equipment profile of the next version of
4561 CGMES. Following that integration, the corresponding classes will be removed from the ER
4562 profile, and the control definitions will be exchanged as part of the underlying CGMES
4563 equipment model. Implementations should therefore preserve persistent identifiers and
4564 avoid application-specific assumptions that would prevent the control objects from being
4565 migrated to the future CGMES representation.

7.1.13.1 General Modelling Principles

An equipment controller identifies the controlled equipment. Depending on the equipment type, the controller may be represented by classes such as:

- RotatingMachineController;
- TapChangerController;
- ACDCCConverterController.

The controller is associated with one or more control function blocks. Typical function-block specialisations include:

- VoltageControlFunction;
- ActivePowerControlFunction;
- ReactivePowerControlFunction;
- DCVoltageControlFunction.

The normalEnabled property indicates whether the controller or function is normally available and enabled in its reference configuration. The actual enabled state applicable to a specific operating time may be provided by an SSI dataset or by an enabling schedule in an SIS dataset.

A control function also indicates whether its result is continuous or discrete. A continuous function may, for example, vary the reactive-power output of a synchronous machine or converter. A discrete function changes a property with discrete positions, such as the step of a ratio or phase tap changer. Where applicable, a target deadband may be defined. The deadband represents an interval around the target value within which the discrete controller is not expected to change its output.

A control function shall not be represented only by its name or by an association to the controlled equipment. Its input and output variables are required to be declared explicitly. This requirement enables a receiving application to determine the complete control relationship without relying on vendor-specific interpretation.

The input identifies the measured quantity used by the control. For example:

- PinTerminal for quantities measured at an AC terminal; or
- PinDCTerminal for quantities measured at a DC terminal.

The pin identifies both:

- the terminal at which the value is measured; and
- the kind of measured quantity, such as active power, reactive power, voltage magnitude or DC voltage.

This explicit association also distinguishes local control from remote control. A control is local where the measurement terminal belongs to the controlled equipment or its immediate connection. A control is remote where the regulated quantity is measured at another point in the network, such as a remote bus or point of common coupling.

4602 The output is represented by FunctionOutputVariable. It identifies the property modified by
4603 the function by means of a property reference. Examples include:

- 4604 • RotatingMachine.q;
- 4605 • TapChanger.step;
- 4606 • ACDCCConverter.p;
- 4607 • ACDCCConverter.q;
- 4608 • ACDCCConverter.udc.

4609 The declared output therefore describes the actuator or controlled equipment variable. The
4610 target value of the function shall not be confused with this output. For example, a voltage-
4611 control target may be a bus-voltage magnitude, whereas the control output may be the
4612 reactive-power injection of a machine. Similarly, the input and target of an active-power
4613 controller may be active power measured at a terminal, while its output is a phase-tap
4614 position.

4615 The complete interpretation is consequently, measure the quantity declared by the input pin,
4616 compare it with the target applicable to the function, and modify the property declared by the
4617 output variable using the associated equipment controller.

4618 **7.1.13.2 Scheduling and Operating-state Information**

4619 The ER dataset defines the relatively stable structure of the control: its type, controlled
4620 equipment, measurement location, input quantity and output property. Operational values
4621 that vary with time are exchanged separately.

4622 The State Instruction Schedule profile is designed to provide schedules for:

- 4623 • the target values of control functions; and
- 4624 • the enabled or disabled state of the control functions.

4625 An enabling schedule can therefore state that a control is enabled during one period and
4626 disabled during another. A target-value schedule can provide the target that applies at each
4627 relevant time. This permits the stable control structure to remain in the ER dataset while only
4628 the changing operational instructions are exchanged in the SIS dataset.

4629 The Steady State Instruction profile is capable of providing the same categories of information
4630 for one specific time unit, following the general design pattern used by the Network Code
4631 Profiles. Instead of exchanging a time series, SSI directly states the enabled state and target
4632 value applicable to the represented market time unit or operating situation.

4633 The structural ER object and its SIS or SSI instructions shall use the same persistent identifier.
4634 Receiving applications shall resolve the SIS or SSI reference to the control function defined in
4635 ER and shall apply the instructed value for the relevant time.

4636 **7.1.13.3 ReliCapGrid examples**

4637 The following examples are provided in the cgmes-3.0_ncp-2.5_tc-2.0 branch of the
4638 ReliCapGrid repository.

4639 • Example 1: Synchronous-machine voltage control

4640 Main object: _963a48e2-0d4b-4bf9-af74-30c00ec1a790
4641 Dataset: Instance/Svedala/NetworkCode/cimxml/Svedala_ER.xml

4642 This example represents the automatic voltage regulation of the NORRSELE_G2 synchronous
4643 machine.

4644 A RotatingMachineController is associated with the synchronous machine. The related
4645 VoltageControlFunction is a continuous function. Its input is the voltage magnitude measured
4646 at a specified remote terminal. Its output is the RotatingMachine.q property, meaning that
4647 the machine varies its reactive-power output to maintain the instructed voltage target at the
4648 measurement point.

4649 Conceptually, the control performs the following function. Measure the voltage magnitude at
4650 the declared remote terminal and adjust the synchronous machine's reactive-power output
4651 to maintain the specified voltage target.

4652 The example demonstrates why both the input and output must be declared. The association
4653 with the synchronous machine alone would not indicate whether the machine controls local
4654 voltage, remote voltage, reactive power or another quantity. The PinTerminal identifies the
4655 remote measurement point and the voltage-magnitude input, while the
4656 FunctionOutputVariable states that reactive power is the variable modified by the controller.

4657 • Example 2 — Transformer ratio-tap voltage control

4658 Main object: _9ca43877-e992-4369-8ec2-6ec9cf0d1cbb
4659 Dataset: Instance/Svedala/NetworkCode/cimxml/Svedala_ER.xml

4660 This example represents voltage control by the ratio tap changer of transformer XT201-T1.

4661 The TapChangerController is associated with a RatioTapChanger. The related
4662 VoltageControlFunction measures voltage magnitude at a remote terminal and changes
4663 TapChanger.step. The function is marked as discrete and includes a target deadband of 0.275.

4664 Conceptually, the control performs the following function. Measure the voltage magnitude at
4665 the declared remote terminal and move the ratio tap changer by discrete steps when the
4666 measured voltage is outside the deadband around the instructed target.

4667 The remote measurement terminal may differ from the terminal of the transformer. The
4668 example therefore explicitly identifies the measurement location through PinTerminal. The
4669 output property reference to TapChanger.step establishes that the control acts through tap-
4670 position changes rather than through another equipment variable.

4671 The associated Svedala SIS example also illustrates that this control can be enabled for one
4672 period and disabled for a later period. The Svedala SSI example provides the enabled state and
4673 the target value applicable to a single time unit.

4674 • Example 3 — Phase-shifting-transformer active-power control

4675 Main object: _34d704f9-fc52-4006-9380-e5055e402409
4676 Dataset: Instance/Espheim/NetworkCode/cimxml/Espheim_ER.xml

4677 This example represents active-power-flow control using a linear phase tap changer.

4678 The TapChangerController is associated with a PhaseTapChangerLinear. The related
4679 ActivePowerControlFunction measures active power at a terminal of its own transformer. The
4680 control is therefore local in this example. The output is TapChanger.step, and the function is
4681 discrete with a target deadband of 500.

4682 Conceptually, the control performs the following function. Measure active-power flow at the
4683 declared transformer terminal and change the phase-tap position in discrete steps to maintain
4684 the instructed active-power target within the specified deadband.

4685 The example distinguishes the regulated quantity from the actuator. Active power is the
4686 measured and targeted quantity, but the active-power value is not directly overwritten.
4687 Instead, the phase-tap step is changed, which alters the phase angle across the transformer
4688 and consequently changes the active-power flow.

4689 The corresponding Espheim SSI dataset enables this function and assigns an active-power
4690 target value of 250 for the represented time unit.

4691 • Example 4 — Coordinated VSC converter controls

4692 Main objects:

4693 _36d3de6a-32e0-41e8-9496-369e17851f31

4694 _bff12795-0fae-415f-8222-645b0f6f4937

4695 Dataset: Instance/Britheim/NetworkCode/cimxml/Britheim_ER.xml

4696 This example demonstrates the representation of simultaneous control loops for two voltage-
4697 source converters. Each ACDCCConverterController groups the control functions belonging to
4698 one converter.

4699 The first converter controller, _36d3de6a-32e0-41e8-9496-369e17851f31, includes:

- 4700 • an active-power control function that measures active power at the point of common
4701 coupling and modifies ACDCCConverter.p; and
- 4702 • an AC-voltage control function that measures voltage magnitude at the point of
4703 common coupling and modifies ACDCCConverter.q.

4704 Conceptually, this converter regulates its active-power transfer while using reactive-power
4705 output to maintain AC voltage at the point of common coupling.

4706 The second converter controller, _bff12795-0fae-415f-8222-645b0f6f4937, includes:

- 4707 • a reactive-power control function that measures reactive power at an AC terminal and
4708 modifies ACDCCConverter.q; and
- 4709 • a DC-voltage control function that measures voltage at a DC terminal and modifies
4710 ACDCCConverter.udc.

4711 Conceptually, this converter regulates reactive-power exchange on its AC side while
4712 maintaining the required DC voltage.

4713 The example demonstrates that an ACDCCConverterController may group multiple function
4714 blocks that operate simultaneously. Each function nevertheless has its own input and output
4715 declarations. This is necessary because the controller association alone does not identify the

4716 selected converter operating mode or indicate which terminal quantities are regulated. The
4717 control mode is obtained from the combination of the function classes, input pins and output
4718 property references.

4719 **7.1.14 Cross-Zonal Network Element**

4720 A cross-zonal network element is exchanged as an object in ER profile and represents a
4721 network element that participates in the transfer of electrical power between two bidding
4722 zones. The class provides a common abstraction for different physical asset types that may
4723 form part of a cross-zonal connection, including AC lines, power transformers and DC poles.

4724 Each CrossZonalNetworkElement shall be associated with exactly two BiddingZoneBorder
4725 instances. These two border instances represent the same pair of bidding zones, but in
4726 opposite directions. Consequently, the FromBiddingZone of one border shall correspond to
4727 the ToBiddingZone of the other border, and vice versa. The two bidding zones shall be
4728 different. This bidirectional representation makes it possible to refer unambiguously to the
4729 relevant bidding-zone pair while preserving the directional nature of cross-zonal exchanges.

4730 The abstract CrossZonalNetworkElement class is specialised according to the type of
4731 underlying network equipment:

- 4732 • CrossZonalLine references a Line;
- 4733 • CrossZonalPowerTransformer references a PowerTransformer;
- 4734 • CrossZonalDCPole references a DCPole.

4735 A cross-zonal line represents an AC line participating in power transfer between the two
4736 bidding zones. A cross-zonal power transformer represents a transformer forming part of a
4737 cross-zonal connection, including cases where the bidding-zone boundary is located within or
4738 close to a substation. A cross-zonal DC pole represents one pole of an HVDC connection.
4739 Where several poles belong to the same interconnector, each pole may be represented
4740 separately.

4741 The model separates the identification of the physical equipment from the definition of the
4742 bidding-zone borders. This allows the same bidding-zone pair to be reused consistently across
4743 multiple cross-zonal network elements and supports the representation of complex
4744 interconnections consisting of several lines, transformers or DC poles.

4745 **7.1.15 Interface with External (Market) Schedules**

4746 Market schedules are normally defined for aggregated commercial or scheduling objects, such
4747 as bidding zones, scheduling areas or HVDC corridors. They do not necessarily identify the
4748 individual network equipment or control function to which the scheduled exchange shall be
4749 applied. Consequently, market schedules cannot generally be used directly as inputs to a
4750 power-flow calculation without an additional allocation and transformation step.

4751 The Network Code profiles therefore provide a mechanism for exchanging active-power
4752 schedules and, where required by specific use cases, reactive-power schedules. For HVDC
4753 interconnections, the model also represents the direction of the scheduled transfer. The
4754 complete implementation combines structural information from the Equipment Reliability

4755 profile, schedule and allocation information from the State Instruction Schedule and Power
4756 Schedule profiles, and the per time unit values from the Steady State Instruction profile.

4757 Structural representation in the Equipment Reliability profile

4758 The Equipment Reliability profile provides the relatively stable structural information required
4759 to interpret schedules for HVDC borders and corridors.

4760 A DCTieCorridor represents the commercial or operational corridor over which the scheduled
4761 power transfer is defined. The corridor has a required association with a dedicated
4762 SchedulingArea. This allows the existing scheduling mechanisms for a SchedulingArea to be
4763 reused rather than introducing a separate scheduling pattern specifically for HVDC corridors.
4764 The scheduled active power, and where applicable reactive power, is provided for that
4765 scheduling area. The scheduling area therefore acts as the aggregated object for which the
4766 external schedule is exchanged.

4767 The transfer direction is represented separately. A BiddingZoneBorder is directional and
4768 identifies a source and destination bidding zone. The DCTieCorridor is associated with the
4769 directional border through its source bidding-zone relationship. This makes it possible to
4770 interpret the sign and direction of a scheduled flow consistently. A schedule associated with
4771 one direction of the border represents transfer from the source bidding zone towards the
4772 opposite bidding zone.

4773 The DCTieCorridor may also contain relatively stable operating information, such as minimum
4774 and maximum regulating reserve and the applicable ramping principle. These attributes
4775 describe corridor-level capabilities and constraints rather than the schedule values for a
4776 specific operating period.

4777 Power Schedule profile

4778 The Power Schedule profile is used to exchange the scheduled active- and reactive-power
4779 values.

4780 A PowerSchedule is a time series composed of one or more PowerTimePoint instances. Each
4781 time point may provide:

- 4782 • scheduled active power through p ;
- 4783 • scheduled reactive power through q ;
- 4784 • activated active or reactive power, where applicable;
- 4785 • price information; and
- 4786 • a merit-order position where required by the business process.

4787 The PowerSchedule identifies the nature of the exchanged series through
4788 powerScheduleKind, for example a power, price or merit-order schedule. The direction may
4789 additionally be specified using RelativeDirectionKind.

4790 For HVDC scheduling, a PowerSchedule may be associated with:

- 4791 • the SchedulingArea belonging to the DCTieCorridor;
- 4792 • the directional BiddingZoneBorder;

- 4793 • the DCTieCorridorDirectionTimePoint; or
- 4794 • an individual DCPole, where the schedule is already defined at pole level.

4795 The scheduling-area association represents the aggregated corridor schedule. The directional
4796 bidding-zone border provides the source direction needed to interpret the scheduled transfer.
4797 The DCTieCorridorDirectionTimePoint allows the applicable direction to be stated for
4798 individual time points. All schedules associated with the same corridor and scheduling area
4799 shall use aligned time points so that the direction and scheduled power values can be
4800 interpreted together.

4801 The Power Schedule profile may therefore represent either:

- 4802 1. a schedule for the complete HVDC corridor; or
- 4803 2. a schedule already allocated to a particular DCPole.

4804 Where only the corridor schedule is provided, the receiving application must distribute that
4805 schedule among the participating poles.

4806 Distribution to individual DC poles using the State Instruction Schedule profile

4807 The State Instruction Schedule profile provides the scheduled allocation information needed
4808 to translate an aggregated corridor schedule into instructions applicable to individual
4809 equipment.

4810 A PowerShiftKeySchedule may be associated with a DCPole and contains one or more
4811 ParticipationFactorTimePoint instances. Each time point defines the participation factor
4812 applicable to that pole for the corresponding period.

4813 The participation factors determine how the scheduled active power of the corridor is
4814 distributed among its DC poles. For a corridor schedule P_{corridor} , the initial active-power
4815 allocation for a pole may be calculated as:

$$4817 \quad P_{\text{pole},i} = PF_i \cdot P_{\text{corridor}}$$

4816 where PF_i is the applicable participation factor of the pole. The participating factors should be
4818 consistent across all poles included in the allocation, normally resulting in a complete
4819 distribution of the corridor schedule.
4820

4821 The participation factors may vary over time. This is relevant where:

- 4822 • one pole is unavailable;
- 4823 • the operating mode of a bipole changes;
- 4824 • the poles have unequal ratings;
- 4825 • reserve or security requirements require an asymmetric distribution; or
- 4826 • another operational restriction changes the expected sharing.

4827 The PowerShiftKeySchedule follows the common time-series pattern. Where it forms part of
4828 a bid pattern, individual participation-factor time points may omit their own timestamps and

4829 follow the bid times defined by the associated schedule. Otherwise, the applicable time shall
4830 be explicitly provided.

4831 The State Instruction Schedule profile can therefore contain the scheduled participation
4832 factors used to distribute the corridor schedule across the poles. It does not itself define the
4833 complete HVDC control structure; that structure is defined in the Equipment Reliability profile.

4834 Representation of the applicable state in the Steady State Instruction profile

4835 The Steady State Instruction profile represents values applicable to one individual operating
4836 time unit. It may therefore contain the resulting active-power instruction for the scheduling
4837 area, bidding-zone border or other relevant object for the represented time.

4838 The profile can also provide the values required by the power-flow calculation after the
4839 external schedule and participation factors have been processed. In this sense, SSI represents
4840 the resolved operating instruction for one time unit, while the Power Schedule and SIS profiles
4841 represent time series covering multiple periods.

4842 The same general pattern applies to other scheduled information:

- 4843 • Power Schedule provides the external time series;
- 4844 • SIS provides time-dependent allocation or instruction information;
- 4845 • SSI provides the values applicable to one specific time unit.

4846 Application of schedules to a DCPole

4847 A DCPole may be associated directly with a PowerSchedule. This association is appropriate
4848 where the market or operational schedule is already provided separately for each pole.

4849 More commonly, the schedule is initially provided for the DCTieCorridor or its dedicated
4850 SchedulingArea. In that case, the application shall:

- 4851 1. identify the corridor and the applicable directional bidding-zone border;
- 4852 2. obtain the active- and reactive-power values for the relevant time point;
- 4853 3. identify the DC poles forming part of the corridor;
- 4854 4. obtain the participation factor applicable to each pole;
- 4855 5. allocate the corridor schedule to the individual poles; and
- 4856 6. convert the resulting pole-level allocation into executable HVDC control targets.

4857 The association of a PowerSchedule with a DCPole shall not be interpreted as directly setting
4858 an electrical state variable of the pole. The pole is an aggregation of HVDC equipment, while
4859 the power-flow calculation is performed using converter and control-model variables.

4860 Propagation to HVDC control targets

4861 After the corridor schedule has been distributed to the individual DC poles, the resulting
4862 values must be propagated to the target values of the control functions responsible for
4863 operating the HVDC system.

4864 The Equipment Reliability profile defines the HVDC control structure, including:

- 4865 • the relevant DirectCurrentMasterController, DirectCurrentPoleController or
- 4866 ACDCConverterController;
- 4867 • the active-power, reactive-power, AC-voltage or DC-voltage control functions;
- 4868 • the input terminals and measured quantities; and
- 4869 • the equipment properties modified by the control functions.

4870 For example, an active-power control function may measure active power at the AC point of
4871 common coupling and modify the converter active-power property. Another converter in the
4872 same HVDC system may control DC voltage, while its accompanying function regulates
4873 reactive power or AC voltage.

4874 The application shall identify which converter control function is responsible for implementing
4875 the allocated pole schedule. The pole-level active-power value is then used as the target of
4876 the corresponding active-power control function. Where reactive-power schedules are
4877 provided, the reactive-power value is similarly propagated to the target of the applicable
4878 reactive-power control function.

4879 This propagation is necessary because a scheduled value associated with a SchedulingArea,
4880 DCTieCorridor or DCPole is not by itself sufficient to initialise a power-flow calculation. The
4881 calculation requires the scheduled value to be translated into a target for a specific control
4882 function acting on a specific converter.

4883 The process can therefore be summarised as follows: external schedule for the corridor →
4884 interpretation of direction → allocation to DC poles using participation factors → identification
4885 of the applicable converter control functions → assignment of the resulting values as control
4886 targets.

4887 For instance, the converter that maintains DC voltage shall normally retain its DC-voltage
4888 control responsibility. Consequently, the distribution of an active-power schedule shall
4889 respect the configured HVDC control modes. The scheduled active power should be assigned
4890 to the converter control functions operating in active-power control, while the converter
4891 responsible for DC-voltage control balances the remaining losses and deviations according to
4892 the configured control strategy.

4893 Where there is a need to schedule or control active-power flow on an AC interconnection, the
4894 corresponding schedule should be associated with a SchedulingArea rather than directly with
4895 an ACTieCorridor. Depending on the business use case and the agreed market modelling, this
4896 may be a dedicated SchedulingArea associated with the relevant BiddingZone, or it may be
4897 represented through a separate BiddingZone with its own scheduling area. The selected
4898 approach shall make clear which aggregate is being scheduled and how the scheduled
4899 exchange relates to the physical AC interconnection.

4900 This modelling principle explains why ACTieCorridor does not carry active- or reactive-power
4901 schedules. An AC tie corridor represents the physical connection between areas, whereas
4902 market schedules are defined for commercial or scheduling aggregates. The scheduled power
4903 is therefore exchanged for the applicable SchedulingArea, and the receiving application is
4904 responsible for translating that aggregate schedule into the corresponding network injections
4905 and flows. Reactive-power schedules, where required by a specific use case, should follow the

4906 same principle and be associated with the relevant scheduling aggregate rather than directly
4907 with the ACTieCorridor.

4908 Relationship between the profiles

4909 The profiles fulfil complementary roles:

- 4910 • Equipment Reliability profile: defines the DCTieCorridor, its dedicated SchedulingArea,
4911 the relationship to directional bidding-zone borders, the associated DC poles and the
4912 structural HVDC control model.
- 4913 • Power Schedule profile: exchanges the scheduled active- and reactive-power time
4914 series for the scheduling area, corridor direction, bidding-zone border or individual
4915 pole.
- 4916 • State Instruction Schedule profile: provides time-dependent participation factors and
4917 other scheduled instructions used to distribute the aggregated corridor schedule
4918 among individual poles and equipment.
- 4919 • Steady State Instruction profile: provides the resolved values applicable per time unit,
4920 including the equipment and control instructions needed to construct the
4921 corresponding steady-state model.

4922

4923

4924

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 84](#).

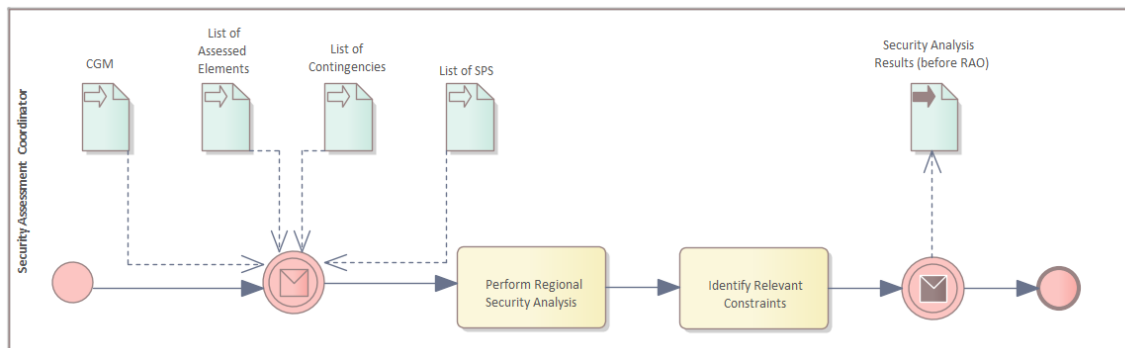


Figure 84 – Regional Security Assessment.

7.2.2 Inputs and Outputs

The list of Inputs and Outputs that are part of the subprocess is defined in Table 11.

Table 11 – 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.

4943 **7.2.4 Security Analysis Result**

4944 The purpose of the Security Analysis Result (SAR) profile is to exchange information about
4945 identified security violations. At present, this information is represented as unstructured text
4946 within a single string attribute, which limits interoperability and automated processing.

4947 The SAR profile is intended to support the exchange of violations identified from power-flow,
4948 Short-Circuit (SC), and Dynamic Stability Analyses (DSA).

4949 In the future releases, developing the model will continue to include Remedial Actions
4950 associated with SC and DSA violations the same way that remedial actions are linked to
4951 power-flow violations.

4952 A single SAR dataset containing all relevant violations associated with a specific contingency
4953 could therefore provide a complete view of the security assessment results. However, the
4954 intention is not to create a "super profile" that also contains all the underlying simulation
4955 results. The SAR profile should remain focused on exchanging the identified violations and
4956 their associated information, while the detailed analysis results continue to be exchanged
4957 through their respective result profiles. These results should be exchangeable independently
4958 of whether they originate from a base case or a contingency case.

4959 In the current SAR profile is not intended to exchange the summary or optimisation
4960 information. Information such as the overall outcome of the security assessment, whether a
4961 feasible solution was found, convergence status, optimisation quality, or reasons why no
4962 acceptable solution could be achieved belongs to a different level of information. Such
4963 information could be exchanged through a separate Security Analysis Summary (or similarly
4964 named) profile, which is to be developed in the future releases. Such a profile would describe
4965 the outcome of the optimisation process rather than the individual violations. This is
4966 particularly relevant for representing non-optimised or infeasible solutions, an area that has
4967 been identified as being of interest to the business processes.

4968 **7.3 Remedial Action Optimization**

4969 **7.3.1 Description**

4970 The Remedial Action Optimization (RAO) is performed by the Remedial Action Optimization
4971 Operator. The RAO subprocess is illustrated in [Figure 85](#).

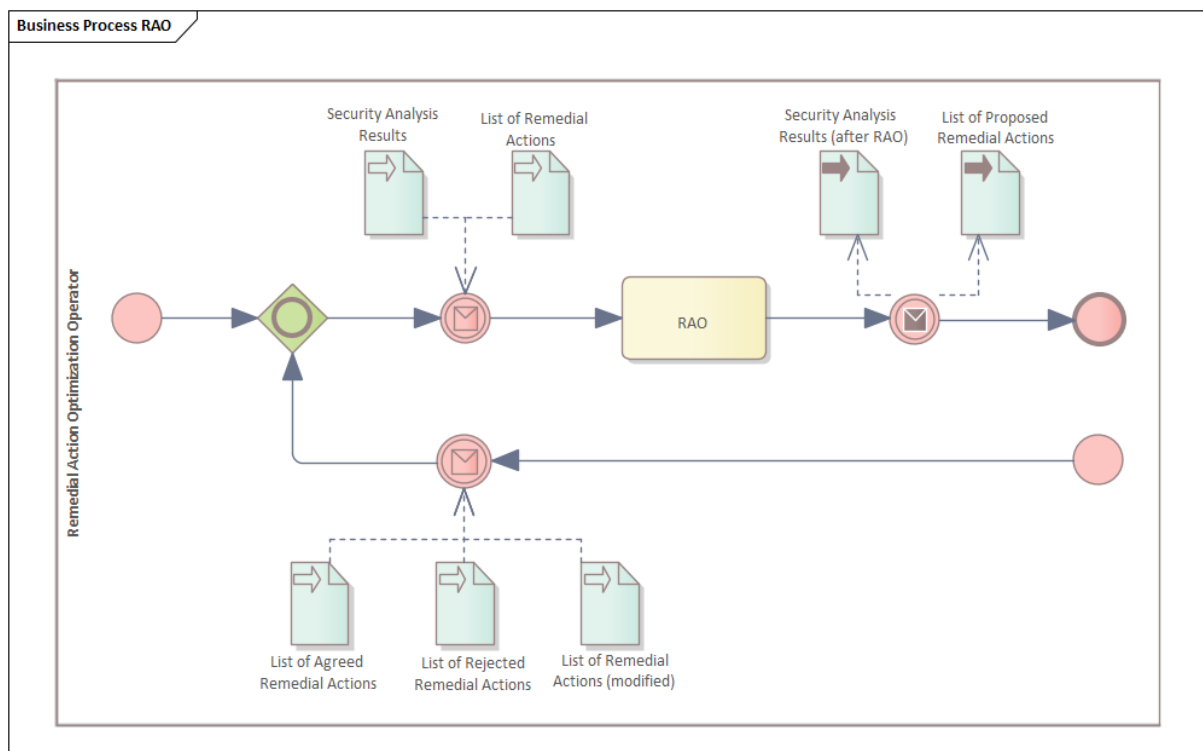


Figure 85 – Remedial Action Optimisation.

7.3.2 Inputs and Outputs

Table 12 – 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.

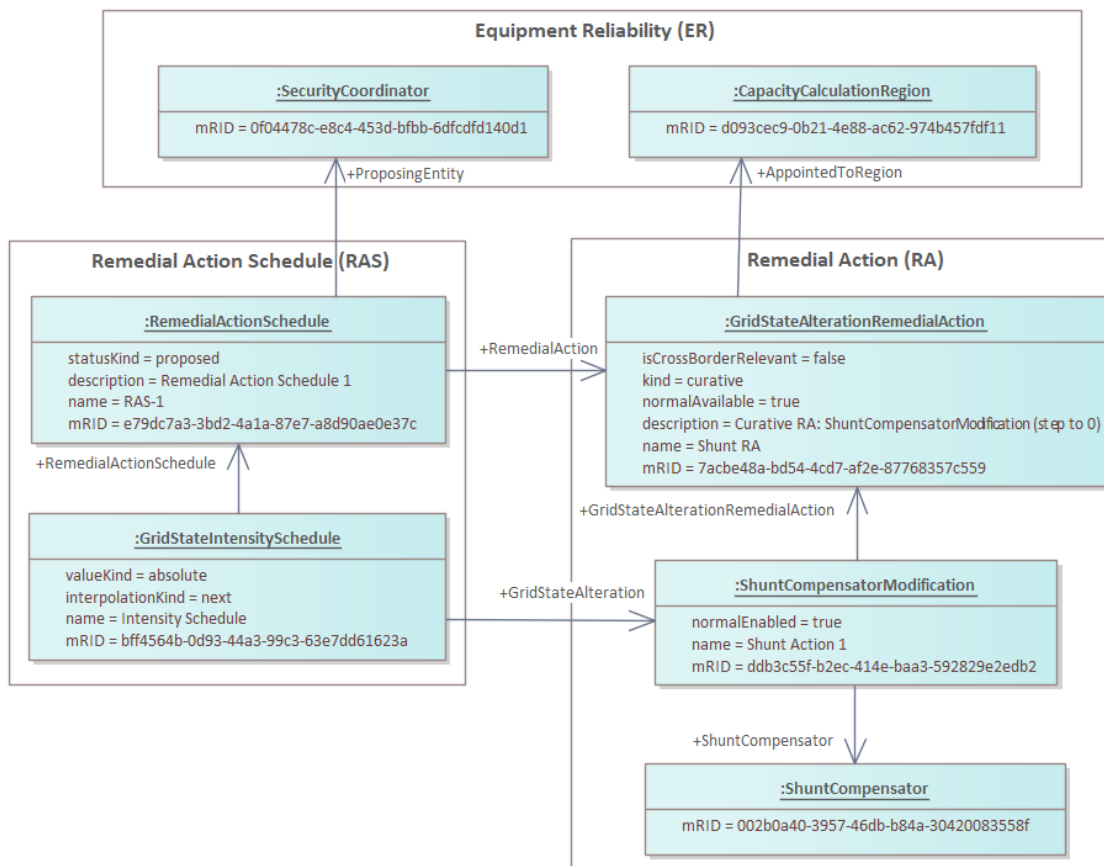


Figure 86 – Proposed Remedial Action Schedule – Grid Intensity

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

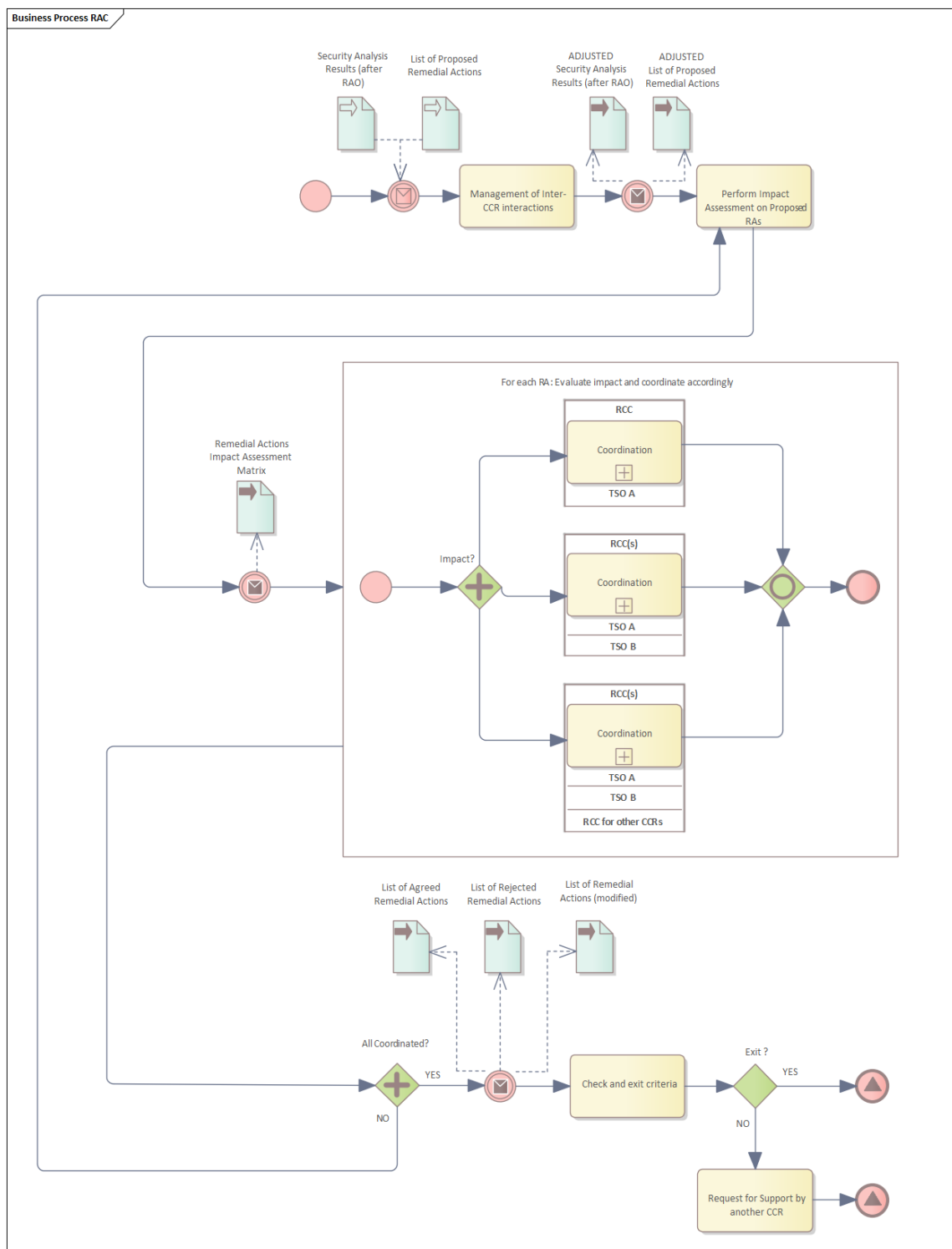
- GridStateIntensitySchedule rdf:ID="_bff4564b-0d93-44a3-99c3-63e7dd61623a"
- GenericValueTimePoint rdf:ID="_7dc3a232-66b2-4258-9f4a-1652bdddea8a"
- RemedialActionSchedule rdf:ID="_e79dc7a3-3bd2-4a1a-87e7-a8d90ae0e37c"

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"

4998 **7.4 Remedial Action Coordination**4999 **7.4.1 Description**

5000 The Remedial Action Coordination (RAC) is performed by the Remedial Action Coordinator.

5001 The RAC subprocess is illustrated in Figure 87.5002 **Figure 87 – Remedial Action Coordination**

5004

5005 **7.4.2 Inputs and Outputs**5006 **Table 13 – 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

5007 **7.4.3 Conformity Requirements**

5008 To be able to support remedial action coordination the Application shall conform to the
5009 following Application functions:

- 5010 • Coordination Confirmation.

5011

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 88](#).

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*¹³ 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.

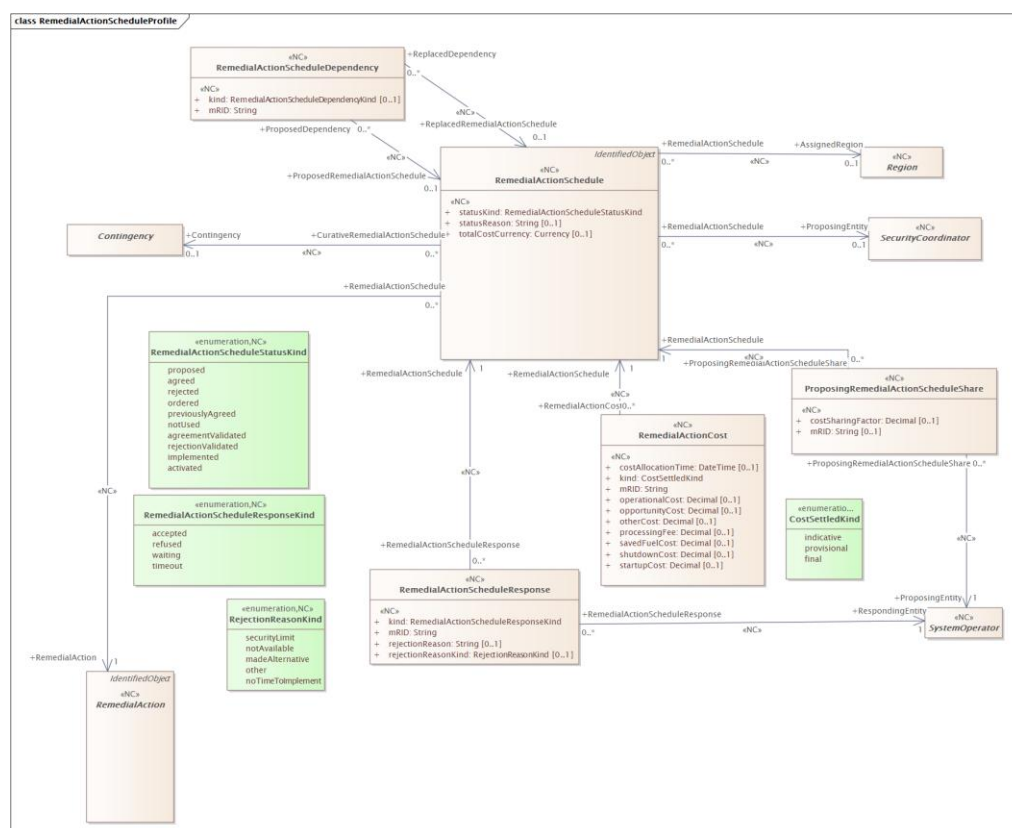


Figure 88: Extract of the RemedialActionScheduleProfile diagram showing RemedialActionScheduleResponse related objects

¹³ In previous versions of the NCP, this class was named *RemedialActionScheduleAcceptance*.

5034 When communicating the response there is no need to exchange *RemedialActionSchedule*
5035 object. A new instance of *RemedialActionSchedule* object is only required in cases where a
5036 TSO would like to make a different proposal for this schedule. In that case, the new instance
5037 of *RemedialActionSchedule* object shall have a new identifier. However, the link to the
5038 *RemedialAction* object is kept persistent as long as the proposal relates to the same
5039 *RemedialAction* object.

5040 An example of remedial action schedule acceptance upon the completion of the coordination
5041 process can be found in ReliCapGrid in 2D_IAM_0530Z_IAM_.xml:

- 5042 • RemedialActionScheduleOutcomeValue rdf:ID="_ac45dd32-c3de-49d3-9664-
5043 689b5a762fd5"

5044 The corresponding dataset example can be found in ReliCapGrid in Belgovia_RAS.xml:

- 5045 • RemedialActionSchedule rdf:ID="_742acf52-139c-4c8f-a90c-a2090de6a619".

5046

5047 Another example of remedial action schedule rejection upon the completion of the
5048 coordination process can be found in ReliCapGrid in 2D_IAM_0930Z_IAM_.xml:

- 5049 • RemedialActionScheduleOutcomeValue rdf:ID="_9f16db8d-3c1f-4fe8-b22f-
5050 51e223c89694"

5051 The corresponding dataset example can be found in ReliCapGrid in Belgovia_RAS.xml:

- 5052 • RemedialActionSchedule rdf:ID="_e79dc7a3-3bd2-4a1a-87e7-a8d90ae0e37c".

5053

5054

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 89 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.

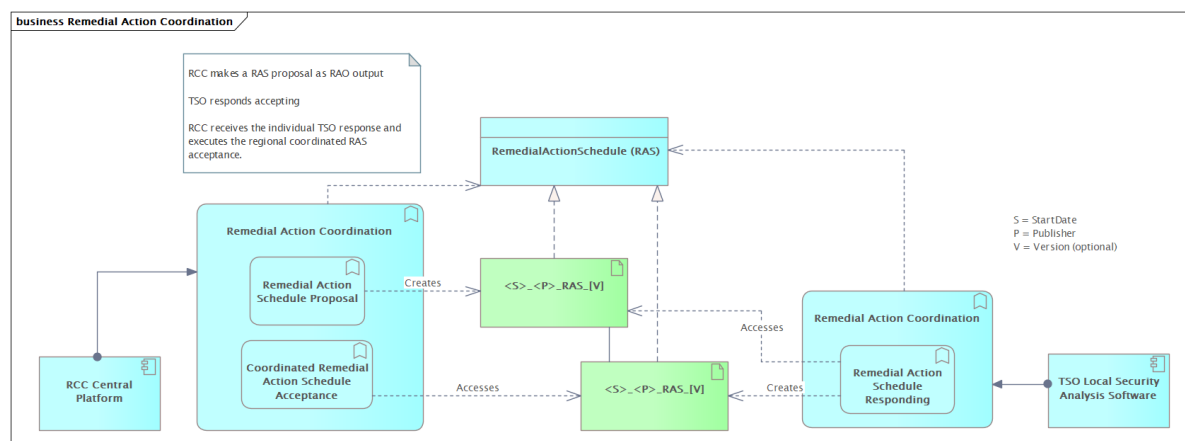


Figure 89: Exchange of information for simple RAC (TSO accepts RCC proposal – without counter proposal)

More in detail, Figure 90 and Figure 91 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*.

- 5083 ○ The RemedialActionSchedule is defined with its identifier 4a9d1cd3-2838-476b-
5084 99a8-11c276c92d52.
- 5085 ○ The *RemedialActionSchedule* association with *RemedialAction* is defined with the
5086 identifier c9c76af9-c11e-49ad-854c-760292b59a6e
- 5087 • Optionally, the RCC indicates that the TSO has not yet validated the proposal making
5088 use of the linked *RemedialActionScheduleResponse* class, setting its *kind* attribute to
5089 *waiting*.
- 5090 The TSO produces a response to the RCC RAS dataset proposal. The RAS dataset the TSO
5091 produces has a new identifier c3540e4a-b397-4ce9-8443-112bbf90d725. Note that the TSO
5092 does not modify the RemedialActionSchedule.statusKind attribute (set to *proposed*) from the
5093 previous RAS dataset the RCC sent. This is because the proposal is yet under coordination at
5094 RCC level.
- 5095 Afterwards, the TSO indicates¹⁴ their response instantiating a
5096 RemedialActionScheduleResponse class:
- 5097 • Figure 90 shows a RemedialActionScheduleResponse class with identifier 2b468ef3-
5098 0ef8-484b-91e1-dc8acefcf7f7.
- 5099 ○ The example shows that the TSO accepts the proposed RAS dataset making use of
5100 the linked *RemedialActionScheduleResponse* class, setting its kind to *accepted*.
- 5101 ▪ More in detail, this is done pointing to the value in the ReferenceData
5102 dataset:
5103 <https://cim4.eu/ns/nc#RemedialActionScheduleResponseKind.accepted>)
- 5104 ○ The remedial action schedule the TSO accepts is the one contained in the RCC
5105 proposed RAS dataset. This is indicated with the association between the
5106 RemedialActionScheduleResponse.RemedialActionSchedule which points to the
5107 RemedialActionSchedule class with identifier 4a9d1cd3-2838-476b-99a8-
5108 11c276c92d52 in the RCC dataset.
- 5109 • Figure 91 shows RemedialActionScheduleResponse class with identifier 1e11da6f-
5110 7313-417f-b263-823472977e34.
- 5111 ○ The example shows that the TSO refuses (without counter proposal) the proposed
5112 RAS dataset making use of the linked *RemedialActionScheduleResponse* class,
5113 setting its kind to *refused*.
- 5114 ▪ More in detail, this is done pointing to the value in the ReferenceData
5115 dataset:
5116 <https://cim4.eu/ns/nc#RemedialActionScheduleResponseKind.refused>)
- 5117 ○ Again, the remedial action schedule the TSO refuses is the one contained in the
5118 RCC proposed RAS. This is indicated with the association between the
5119 RemedialActionScheduleResponse.RemedialActionSchedule which points to the
5120 RedualActionSchedule with identifier 4a9d1cd3-2838-476b-99a8-11c276c92d52 in
5121 the RCC dataset.

¹⁴ TSOs also have the possibility of only including the *RemedialActionScheduleResponse* class in their response RAS dataset.

5122 ○ Additionally, the TSO added the reason of rejection making use of the linked
5123 *RemedialActionScheduleResponse* class. In this example, the TSO decided to set the
5124 *rejectionReasonKind* attribute to *RejectionReasonKind.other* and complement with
5125 a free text reason using *RemedialActionScheduleResponse.rejectionReason*.

5126 Once all impacted TSOs finalise their individual assessments of the proposed RAS, the RCC may
5127 change the *statusKind* attribute (i.e., to *agreed*) as a result of the regional coordination.

5128 Readers might like to pay attention to the meaning of the header items in Figure 90 and Figure
5129 91:

5130 • TSOs shall refer to the RCC proposal in their response by using *dcterms:references* and
5131 maintaining the RCC dataset mRID (in this example d49bdfbe-99e8-4f89-bda8-
5132 9600975402da).

5133 • However, because the TSO creates the response RAS dataset, both *dcat:isVersionOf* and
5134 *dcterms:publisher* point to the TSO “Espheim”.

5135 ○ The item *dcterms:publisher* clearly states which actor provided the dataset.

5136 • The use of *generatedBy* (not shown in the example) is reserved for the *activity* that
5137 created the dataset. Though the activity reference data (the “values” the attribute may
5138 take) is still not fully standardised in the CommonData dataset, TSOs can use this item
5139 to better distinguish between proposed and responded RAS datasets. For instance:

5140 ○ CGM-RAS/PRO-RAS (PRO = proposed RAS)

5141 ○ IGM-RAS/RES-RAS (RES = response RAS)

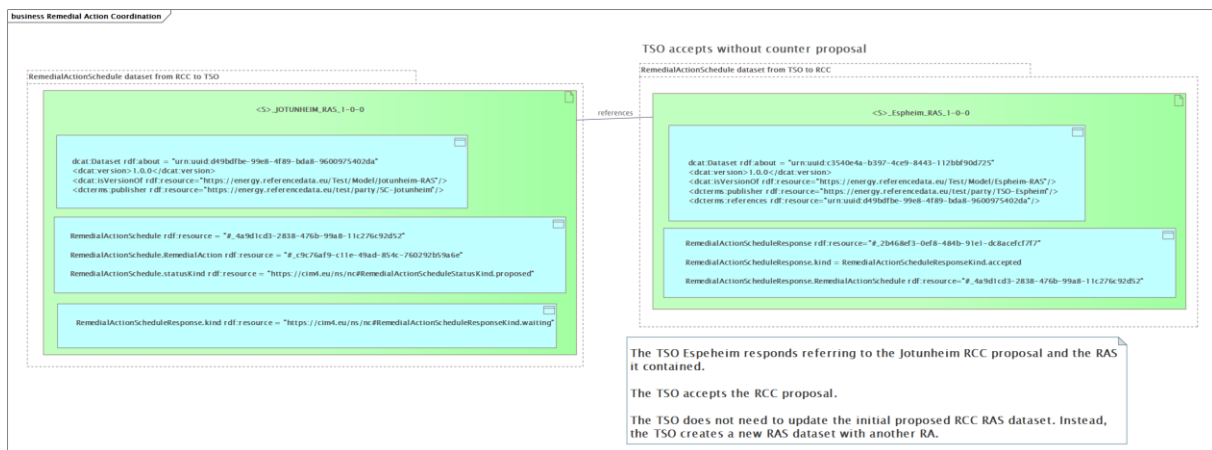


Figure 90: Additional detail on the use for simple RAC (TSO accepts RCC proposal – without counter proposal)

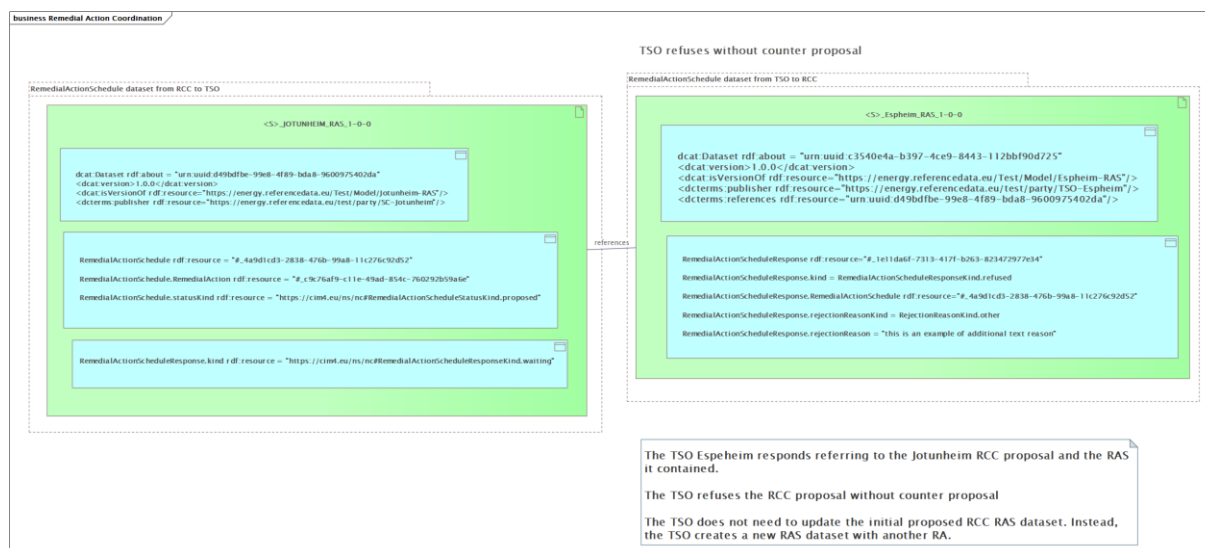


Figure 91: Additional detail on the use for simple RAC (TSO refuses RCC proposal – without counter proposal)

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 92](#) 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.

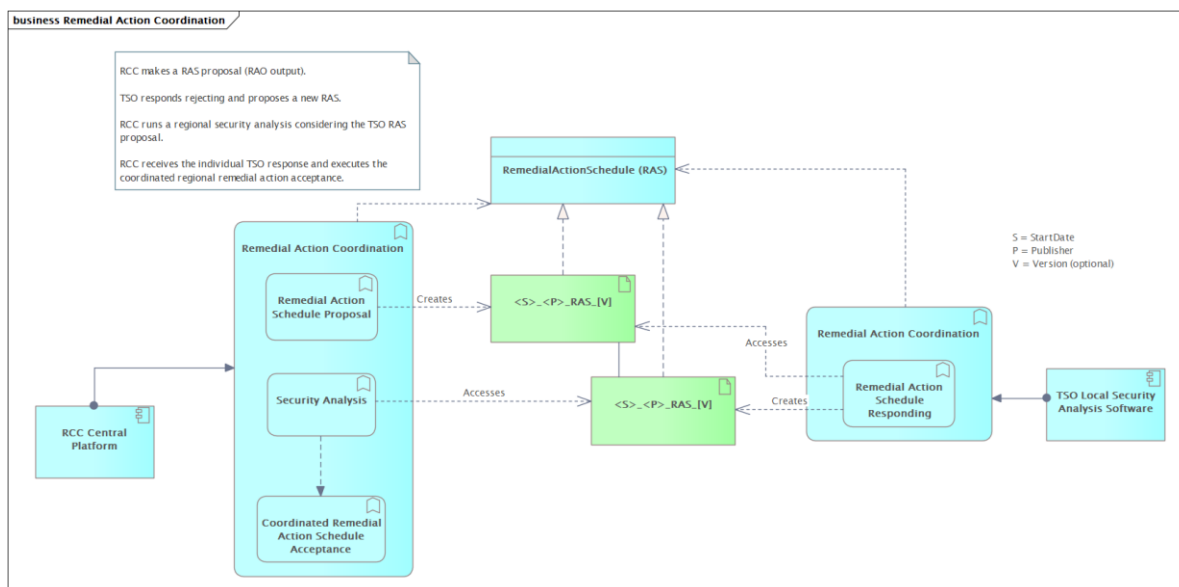


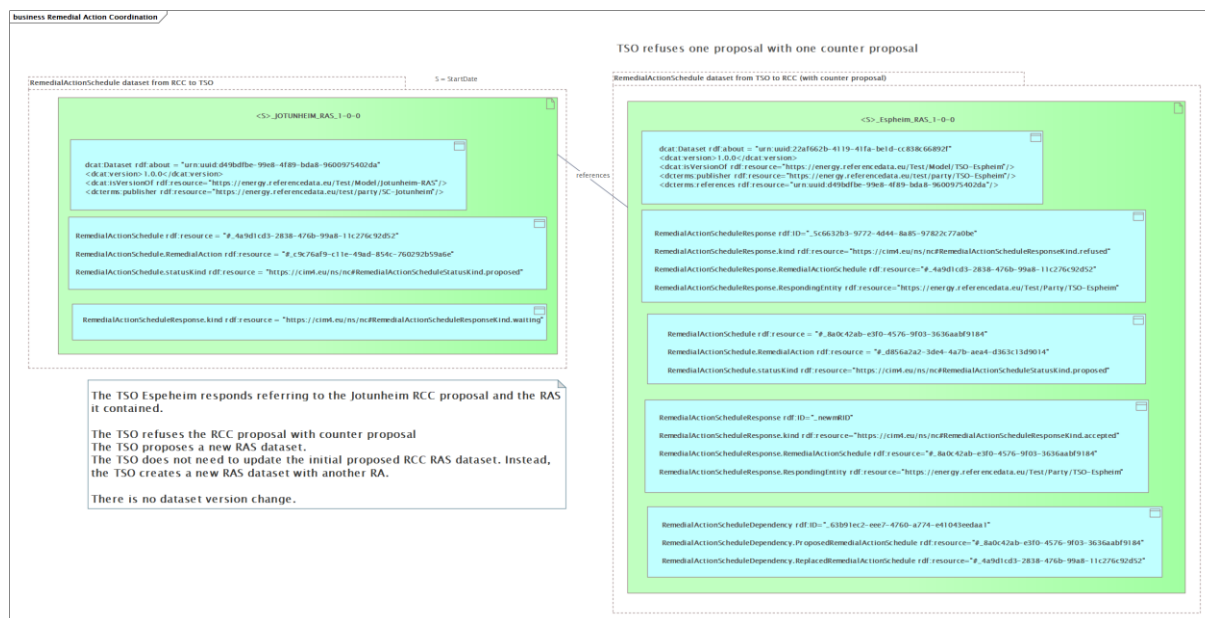
Figure 92: Exchange of information for simple RAC (TSO rejects RCC proposal – with counter proposal)

The [Figure 93](#) 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.

- 5183 ○ The TSO creates a RemedialActionScheduleResponse class (in this example with
5184 identifier 5c6632b3-9772-4d44-8a85-97822c77a0be)
- 5185 ○ The TSO indicates they refuse the proposal using the kind attribute and setting it
5186 to *refused* (pointing to this value in the ReferenceData dataset:
5187 <https://cim4.eu/ns/nc#RemedialActionScheduleResponseKind.refused>)
- 5188 ○ The TSO indicates the original RCC proposal using the association between
5189 RemedialActionScheduleResponse and RemedialActionSchedule, and pointing to
5190 the original RCC proposed RAS (in this example, with identifier 4a9d1cd3-2838-
5191 476b-99a8-11c276c92d52)
- 5192 ○ The TSO indicates that they are the responding entity using the association
5193 between the classes *RemedialActionScheduleResponse* and *SystemOperator* called
5194 *RespondingEntity*.
- 5195 ▪ The values of SystemOperator are defined in the ReferenceData dataset. In
5196 this example, it takes [https://energy.referencedata.eu/Test/Party/TSO-](https://energy.referencedata.eu/Test/Party/TSO-Espheim)
5197 [Espheim](https://energy.referencedata.eu/Test/Party/TSO-Espheim).
- 5198 • The TSO proposes a new remedial action schedule and refers to it using its identifier (in
5199 this example, 8a0c42ab-e3f0-4576-9f03-3636aabf9184)
- 5200 ○ The TSO proposes a new remedial action using the association with between the
5201 classes *RemedialActionSchedule* and *RemedialAction* (in this example, d856a2a2-
5202 3de4-4a7b-aea4-d363c13d9014)
- 5203 ○ The TSO does not modify the RemedialActionSchedule.statusKind attribute (set to
5204 *proposed*) from the previous RAS dataset the RCC sent. This is because yet under
5205 coordination at RCC level.
- 5206 Reader might note that the RCC still needs to coordinate the acceptance of the TSO RAS
5207 counter proposal with other impacted TSOs. Once this is done, the RCC may set
5208 *RemedialActionSchedule.statusKind* to *agreed*.
- 5209
- 5210 This example will be integrated in the open-source ReliCapGrid test model in future releases
5211 of the RCP DES.

5212



5213

5214

5215

Figure 93: 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

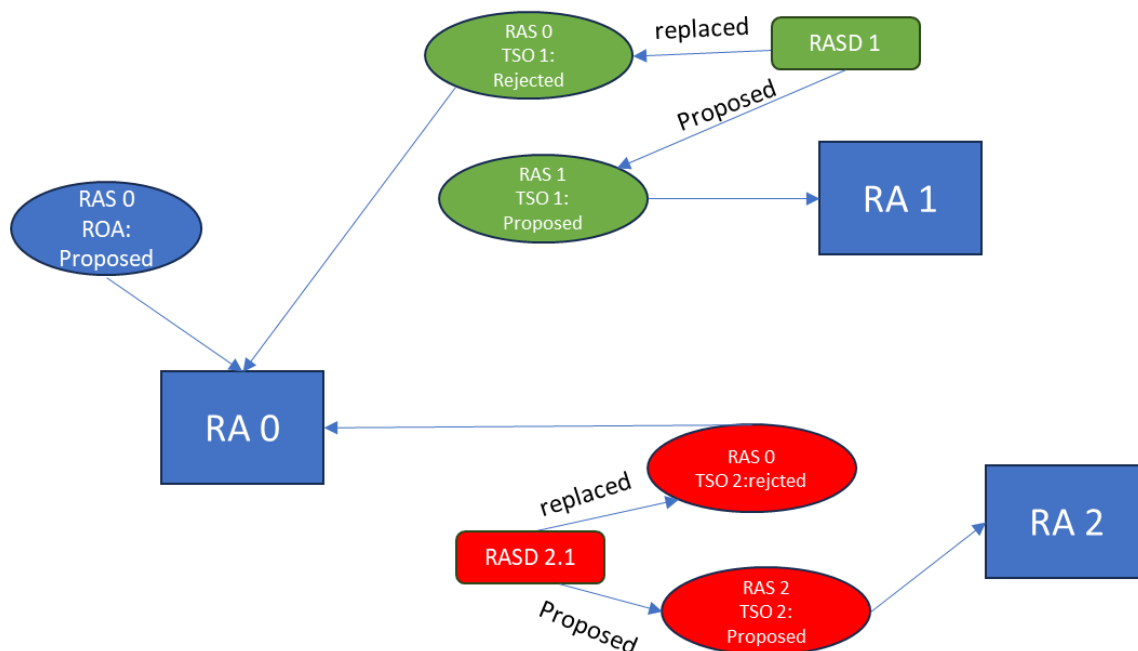


Figure 94 – Remedial Action Schedule Relationship without using the Group

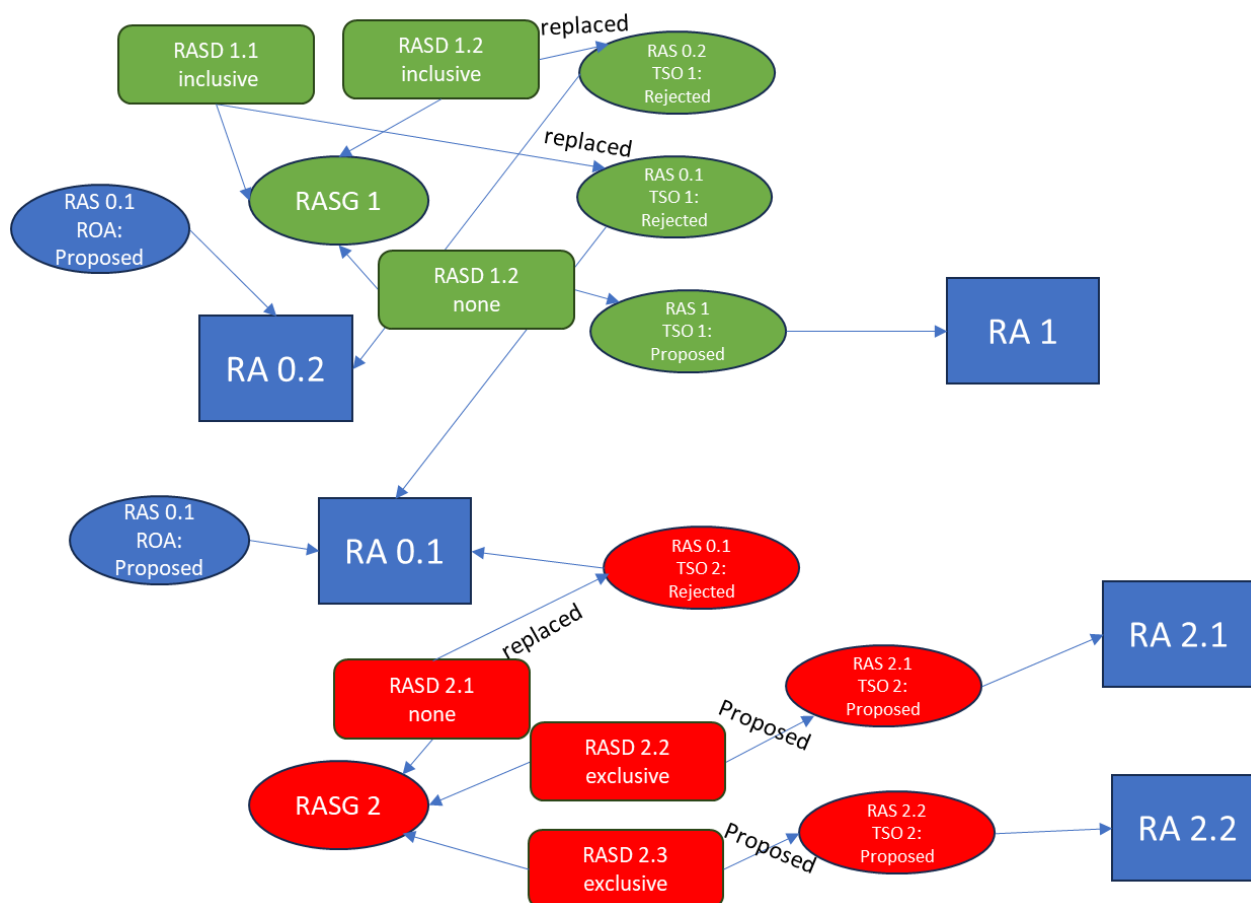


Figure 95 – Remedial Action Schedule Relationship within a Group

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 96](#). 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.

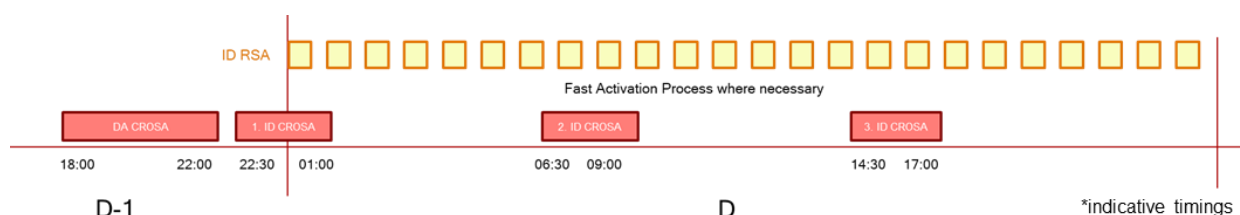


Figure 96: Representation of the Fast Activation Process

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:

- 5268 • The platform may act as a simulation tool, allowing TSOs to explore possible solutions
5269 and coordinate actions with impacted parties.
- 5270 • Bilateral Coordination (Outside the Platform):
- 5271 • If a TSO chooses not to use the common platform, coordination occurs through direct
5272 bilateral calls with other TSOs.
- 5273 **3. Communication & Information Sharing**
- 5274 • When the process is conducted outside the common platform, certain information must
5275 still be shared to ensure all relevant parties remain aware of the ongoing situation.
- 5276 • Communication between the platform and TSOs currently relies on Network Code profiles.
5277 Efforts are ongoing to improve the modelling of communication requirements for better
5278 integration.
- 5279 • Core TSOs need to report the triggering of the FAP. Some TSOs could use the regional
5280 platform and some other may choose to use the Network Code Profiles to provide the
5281 information.
- 5282
- 5283 The CIM WG collaborates with TSOs to offer modelling recommendations for the FAP in future
5284 releases of this data exchange specification.
- 5285
- 5286

5287 **7.4.7 Expected Use Cases**

5288

5289

Table 14: 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.

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5291

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 .

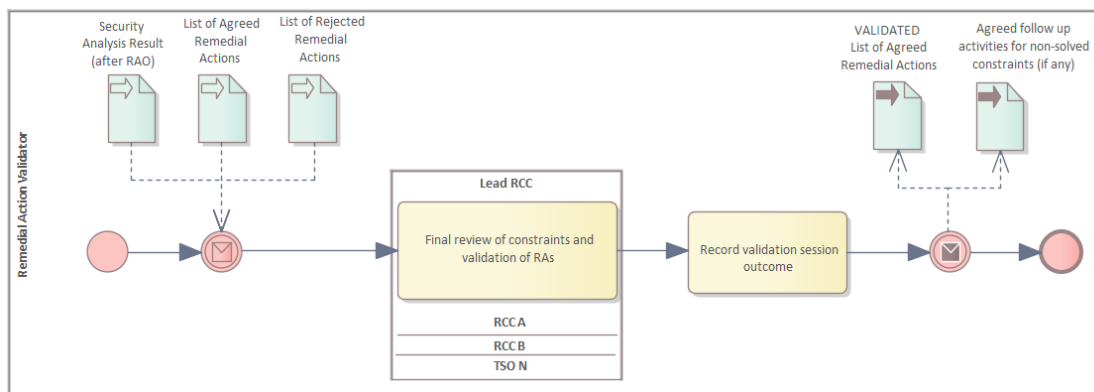


Figure 97 – Final Validation session

7.5.2 Inputs and Outputs

Table 15 – 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".

5315 The corresponding Security Analysis Result dataset example can be found in ReliCapGrid in
5316 2D_SAR_1030Z_Jotunheim.xml:

- 5317 • ContingencyPowerFlowResult rdf:ID="_ea1eebe0-7e5e-46c1-8cf6-af110484adf3"
- 5318 • BaseCasePowerFlowResult rdf:ID="_b1d6ec9a-76d3-4162-b19a-99b09fcd80fa"

5319 The corresponding Contingency dataset example can be found in ReliCapGrid in
5320 Belgovia_CO.xml:

- 5321 • OrdinaryContingency rdf:ID="_7e31c67d-67ba-4592-8ac1-9e806d697c8e"
- 5322 • ContingencyEquipment rdf:ID="_7ec56068-a714-4445-ae19-dd34429ec722".

5323 The corresponding Steady State Hypothesis dataset example can be found in ReliCapGrid in
5324 2D_Belgovia_SSH_1.xml:

- 5325 • CurrentLimit rdf:ID="_b8fa5795-2fb2-3a9f-af51-44051d9face7".

5326

5327 **7.5.3 Conformity Requirements**

5328 To be able to support final validation the Application shall conform to the following
5329 Application functions:

- 5330 • Coordination Confirmation.

5331

8 Application profile specification

8.1 General

Network codes related business process relies 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 CACM¹⁵. 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 information, dynamics data can also be added, if necessary. The IEC CGMES or other

¹⁵ Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.

5373 standards (e.g. IEC 61970-457 for dynamics and simulation settings) can be used to
5374 exchange this information.

5375 • It is expected that all data delivered as IGM, CGM and All relevant data are consistent
5376 and conform to both the specifications defined in the data standards and business
5377 constraints that can be defined at pan-European or regional level. Data providers need
5378 to ensure this as CGM Build process cannot guarantee the consistency due to the fact
5379 that not all data is available in the CGM Build process.

5380 • Consistency validation between "All relevant data" and a CGM is performed as part of
5381 the business process that will use all data and can only result in invalidating "All
5382 relevant data" (i.e., it cannot invalidate a CGM) which may lead to limiting the scope
5383 of the business process. It is not expected that the CGM Build process is restarted to
5384 remedy such inconsistencies. IGM and CGM improvements can be performed during
5385 the CGM Build process.

5386 The CSA needs information on remedial actions, assessed elements, contingencies, etc in
5387 order to complete the data needed to perform the coordinated security analysis. The all
5388 relevant data for CSA is supplied by the following profiles:

- 5389 • Assessed element profile
- 5390 • Availability schedule profile
- 5391 • Contingency profile
- 5392 • Equipment reliability profile which includes SIPS configuration, security limits, Power
5393 Transfer Corridor
- 5394 • Grid disturbance profile
- 5395 • Impact assessment matrix profile
- 5396 • Monitoring area profile
- 5397 • Object registry profile
- 5398 • Power schedule profile
- 5399 • Power system project profile
- 5400 • Remedial action profile
- 5401 • Remedial action schedule profile
- 5402 • Security analysis result profile
- 5403 • Sensitivity matrix profile
- 5404 • State instruction schedule profile
- 5405 • Steady state hypothesis schedule profile
- 5406 • 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.

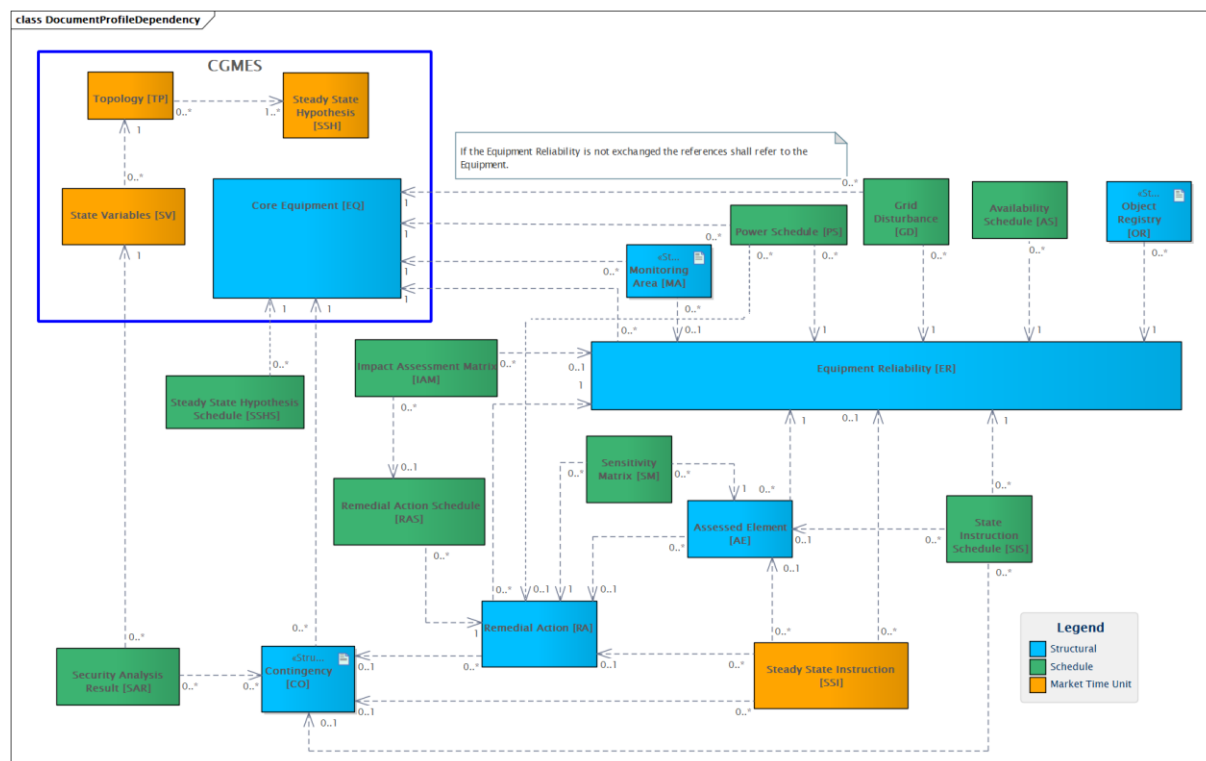


Figure 98 – Dataset dependencies

8.2.1 Dataset Metadata (Header)

Information on dependencies between datasets is provided by the attribute `dterms: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.

8.2.2 Usage of Difference Datasets

Difference datasets enable the exchange of changes relative to a previously exchanged complete dataset. Their purpose is to reduce the volume of data that must be transferred and processed when only a limited part of an existing dataset has changed.

In the current version of the NC profiles, the body of a difference dataset follows the same profile specification as the body of the corresponding CGMES based difference datasets. The distinction between a complete dataset and a difference dataset is therefore primarily expressed through the dataset metadata. The relevant metadata attributes, including the identification of the dataset on which the difference depends and the processing of additions and deletions, are defined in a separate document on metadata specification.

A difference dataset shall be interpreted together with the complete dataset, or with the consolidated dataset state, to which it applies. The receiving application shall therefore be able to identify the correct base dataset and apply subsequent differences in the intended order. Persistent identifiers are essential for this process because they allow the receiving application to determine whether an object is being added, updated or removed.

- Addition and modification of data

A difference dataset may be used to add new objects or modify existing objects. A new object is identified by an identifier that is not present in the applicable base dataset. An existing object is modified by providing information for the same persistent identifier as the object contained in the base dataset. After the difference has been applied, the resulting consolidated dataset shall conform to the relevant profile and business-process requirements.

The body of the difference dataset contains only the objects and properties necessary to communicate the change. Properties that are not included in the difference shall not automatically be interpreted as deleted or reset. Their values remain as defined in the applicable base dataset unless the difference mechanism explicitly indicates otherwise.

- Removal of data

Objects and properties shall not be considered removed merely because they are absent from a difference dataset. A difference dataset represents only the reported changes and is not a replacement for the complete dataset.

The removal of an object or statement shall therefore be explicitly indicated using the deletion mechanism defined by the applicable dataset metadata specification. The persistent identifier of the affected object is used to identify the information to be removed from the consolidated dataset.

After a deletion has been applied, the receiving application shall verify that the resulting dataset remains consistent. This includes checking that no remaining object contains an invalid reference to the removed object and that all applicable cardinality and business consistency requirements are still satisfied.

- Structural data

Difference datasets are primarily recommended for structural data. Structural datasets normally remain stable over relatively long periods and are exchanged again only when their

5469 configuration changes. A difference dataset is therefore suitable for communicating limited
5470 structural changes, such as:

- 5471 ○ adding a new remedial action, assessed element or contingency;
- 5472 ○ modifying the properties or associations of an existing object;
- 5473 ○ adding or removing an association between existing objects; or
- 5474 ○ removing an object that is no longer applicable.

5475 Using difference datasets for structural data can significantly reduce the volume of exchanged
5476 information. However, implementations shall maintain the correct sequence of the complete
5477 dataset and all applicable differences. Where the history of differences is incomplete,
5478 ambiguous or unavailable, a new complete dataset should be exchanged to re-establish a clear
5479 and consistent baseline.

- 5480 • Scheduled data and data per time unit

5481 The use of difference datasets is not prohibited for scheduled data or data exchanged per time
5482 unit, including SIS, SHS, SSI and other schedule-based datasets. A difference dataset may
5483 therefore be used to add, update or remove scheduled values, time points or related objects.

5484 However, these datasets are exchanged more frequently and normally cover a defined validity
5485 period or market time unit. In many cases, exchanging a new complete dataset may be simpler
5486 and less error-prone than maintaining a sequence of differences. The benefit of using a
5487 difference dataset should therefore be assessed against:

- 5488 ○ the size of the dataset;
- 5489 ○ the frequency of updates;
- 5490 ○ the length and complexity of the difference chain;
- 5491 ○ the ability of all receiving applications to reconstruct the consolidated state; and
- 5492 ○ the operational need to obtain a clear and self-contained dataset for a specific time
5493 period.

5494 Where difference datasets are used for scheduled or per-time-unit data, the applicable
5495 schedule, time point or other objects shall be identified by its persistent identifier. A change
5496 to a value is represented as a modification of the identified object, while removal shall be
5497 explicitly communicated through the defined deletion mechanism. The absence of a time
5498 point or schedule object from the difference dataset shall not be interpreted as its removal.

- 5499 • Recommended usage

5500 The recommended approach is to use difference datasets primarily for structural data, where
5501 changes are less frequent and the reduction in exchanged volume is most beneficial. Their use
5502 for scheduled data and data per time unit remains permitted but should be agreed within the
5503 relevant business process and applied only where all participating systems can reliably
5504 manage the base dataset, the order of differences and the resulting consolidated dataset.

5505 Regardless of the type of data, validation should be performed both on the difference dataset
5506 itself and on the consolidated dataset obtained after applying the difference. Validation of the

5507 consolidated dataset is necessary because some errors, such as missing mandatory
5508 information, invalid references or cardinality violations, may become visible only after the
5509 change has been applied.

5510 **8.3 Compatibility with Other Data Exchange Standards**

5511 NC profiles have been designed and developed as extension to the version of CIM used by
5512 CGMES v3.0 (IEC 61970-600-1 and -2:2021). In general, they partially are compatible with
5513 CGMES v2.4 (IEC TS 61970-600-1 and -2:2017) to the extent present in both CGMES v3.0 and
5514 v2.4.

5515 This means, there are model incompatibilities (due to bug fixes in v3.0 and clear
5516 documentation of intent), namespace incompatibilities (due CIM17 vs. CIM16 change), as well
5517 as serious limitations in scope if underlying model remains on CGMES v2.4. Therefore, the
5518 following attention points shall be noted:

- 5519 • If CGMES v2.4 is used to represent the IGM and CGM the remedial action cannot
5520 efficiently model power electronics and battery units as these objects are only
5521 available in CGMES v3.0. This also includes modelling limitation of representing control
5522 functions that have direct impact on the power flow calculation.
- 5523 • The information about the operational limits is exchanged in the equipment instance
5524 data in the case of CGMES v2.4 based data exchange. Therefore, when there is a need
5525 to frequently update the information on the limits, this will require that equipment
5526 data is exchanged more frequently or that difference equipment profile shall be used
5527 to optimize the data exchange. This limitation does not occur if the IGM and CGM are
5528 using CGMES v3.0 as the operational limits is exchanged in the steady state hypothesis
5529 dataset.
- 5530 • In order to achieve an optimal information exchange, it is assumed that persistent
5531 identifiers are used for the IGM and CGM objects. Applying datasets based on NC
5532 profiles as add-on to an exchange which does not rely on persistent identifiers is
5533 neither feasible nor practical for any downstream process relying on CGM.
- 5534 • Handling of topology remedial actions, power transfer corridors and their limits, SPS,
5535 require more detailed underlying model. As CGMES v2.4 has clarity gaps in the
5536 modelling of hybrid node breaker and bus branch models work arounds are not
5537 straight forward. In addition, SOGL and CSAm detail the requirement of using node-
5538 breaker model and defining topology as the data concerning the connectivity of the
5539 different transmission system or distribution system elements in a substation and
5540 includes the electrical configuration and the position of circuit breakers and isolators.

5541 The usage of UCTE DEF as a data exchange format for IGM and CGM for the purpose of CSA,
5542 CCC, OPC, STA processes is not recommended in conjunction with NC set of profiles, for the
5543 following non-exhaustive list of reasons (to name a few):

- 5544 • NC profiles metadata require linkage with the IGM and CGM. UCTE DEF models are
5545 identified by file name. Therefore, an additional metadata layer must be added.

- 5546 • NC profiles require references to identifiers of the elements from IGM in order to link
5547 the remedial actions, assessed elements, etc. UCTE DEF used node codes and circuit
5548 numbers (for interconnecting elements) in order to uniquely identify them. Therefore,
5549 if UCTE DEF is used there will be a need to maintain a list of persistent identifiers and
5550 their relationship with node names or elements names.
- 5551 • CSA requires information on different operational limits that are related to the
5552 different time phases to be studied. UCTE DEF has very limited capabilities to exchange
5553 limits.
- 5554 • Due to the scope of the UCTE DEF the business processes would be limited in terms of
5555 what kind of grid state alterations and remedial actions could be described and
5556 considered in the coordination process. Identification of type and modelling of the
5557 network elements that support voltage control, shunt-connected reactive devices,
5558 voltage regulation on transformers in case of regulator being modelled on the non-
5559 regulated power transformer end, will require special attention as they are not in
5560 scope of UCTE DEF and will be impossible to model without extending UCTE DEF.
- 5561 • Generation capacity used as part of remedial actions should be modelled in detail due
5562 to limits handling in case of aggregated modelling.
- 5563 • UCTE DEF does not separate the information related to the equipment, the
5564 information related to the operating point and it also does not cover the solution
5565 information. Data consistency changes between data exchanged with NC profiles and
5566 UCTE DEF data will be more extensive (full model exchange), have high dependencies
5567 over mapping tables that have to be integrated in the middleware, and will not benefit
5568 from using one equipment model for multiple time stamps.
- 5569 • UCTE DEF does not allow exchange of power flow solution data, therefore this report
5570 will have to be standardized (out of scope of this document) to achieve full information
5571 exchange.
- 5572 • Use of replaced IGM in created CGM is not possible to trace in case of UCTE DEF, that
5573 might complicate the process of data consistency against the grid models and remedial
5574 action applicability.

5575 Therefore, it is highly recommended that business processes plan for a transition to always
5576 rely on latest data exchange standards and specifications in order to benefit from the
5577 consistency at profile level (data exchange definition level) and be able to achieve business
5578 objectives without being constraint by the data exchange.

5579

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.

5616 In general, CGMES based data exchanges will also rely on common data such as information
5617 on base voltages and other common elements that are currently added to boundary datasets.
5618 It should be noted that boundary dataset can be seen as a kind of common data. However,
5619 this dataset has a special function essential for connecting (merging) data from different
5620 publishers (TSOs, modelling authorities – in general).

5621 Common data is serialised according to either CGMES or NC profiles. For example, Equipment
5622 profile is used for the common data related to base voltages and Equipment Reliability profile
5623 is used for capacity calculation regions data and other specified classes in this profile.
5624 Therefore, datasets based on CGMES or NC profiles will refer to common data datasets via the
5625 attribute dcterms:references in the dataset header.

5626 A copy of ENTSO-E's public CommonData dataset can be found on the [CGMES Library](#) under
5627 the tab "Network Code (NC) profiles"

5628 **8.4.1.1 Including Common Dataset References in TSOs' Datasets Instances**

5629 The [Boundary and Common Data Exchange Specification](#) features a chapter discussing this
5630 topic.

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

- 5705 ○ <https://energy.referencedata.eu/NorNed-EQ> – for the equipment of NorNed
- 5706 HVDC
- 5707

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 16 – 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.
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5729

5730 **8.5.4 Exchange and Packaging**

5731 CIM based data exchanges allow for exchanging information based on multiple profiles in a
 5732 single dataset. Example for this is the exchange of equipment, operation and short circuit
 5733 profiles' datasets in a single file. When this happens the dataset header shall include the
 5734 property dcterms:conformsTo to indicate to which profiles and constraints this data conforms
 5735 to.

5736 In an exchange which is structured and follows certain exchange rules, combining different
 5737 profiles cannot happen randomly and needs to be agreed so that receiving systems are
 5738 prepared to receive such information and process it accordingly.

5739 NC profiles can be used for exchange of data related to one CCR or multiple CCR. For example,
 5740 Assessed element profile includes references to regions at object level, which allows for
 5741 combining a list of assessed elements for all CCRs in a single dataset. The setup of the data
 5742 exchange does not require exchange of single dataset, but it is recommended to use all means
 5743 to avoid exchange of duplicate data.

5744 Business processes need to agree on what stages of the process data is handled in separate
 5745 datasets and at which step of the process a combined dataset is necessary. This should take
 5746 into account that manifest dataset can be used to exchange (report) on a combined set of data
 5747 without the need to regroup the data within a single dataset (file). Therefore, it is
 5748 recommended to utilise the manifest way of exchange in order to minimise the post
 5749 processing of the data and bring essential clarity on the source of the data including possibilities
 5750 to exchange the provenance of it.

5751 Datasets serialised in CIMXML tend to have big file size and archive (zip) was traditionally used
 5752 in CGMES based datasets. Similar to CGMES archive-in-archive is not allowed. ENTSO-E
 5753 "Metadata for dataset and distribution specification" recommends using .cimx extension of
 5754 the archived files which are in reality zip archives. It is important that applications support this
 5755 extension and ensure that reading archives is done via stream or other service that does not
 5756 require full unzipping of the data, saving it and then parsing the information.

5757 The recommended approach is to access the archive read the manifest, then assess parts of
 5758 the archive in the necessary sequence and then parsing the information without prior
 5759 unzipping and storage. This specification does not limit the usage of .cimx, i.e. this extension
 5760 can be used when archiving single datasets as well. However if .cimx is used the manifest file
 5761 is required, if .zip is used the content of the .zip shall follow the .zip rules.

5762 8.6 Dataset Validation

5763 Dataset validation is an important part of business process-related data exchanges. In general,
5764 datasets shall conform to the profile specifications on which they are based. In addition, sets
5765 of constraints and consistency rules are defined for the relevant business processes. NC
5766 profiles supply data for multiple business processes, while the applicable methodologies
5767 require consistency rules to be defined for individual processes.

5768 The Network Code Data Quality Management Provisions document will need to be developed
5769 as required by the CSAm. It will define the data validation framework and SHACL-based
5770 constraints, covering both consistency within an individual dataset and consistency across
5771 multiple datasets. These constraints may be applicable to all regions or may be specific to a
5772 particular region. The objective is to minimise the number of constraints that apply to each
5773 particular region.

5774 Validation shall be performed using configurations that correspond to the scope of the
5775 validation. Profiles may define different cardinalities for common properties, such as
5776 IdentifiedObject.name, as well as for other attributes and associations. Consequently,
5777 validating every dataset against all constraints from all profiles may produce false validation
5778 results. SHACL validation configurations shall therefore activate only the constraints that are
5779 relevant to the profiles, datasets and business process being validated. As a good practice,
5780 each individual dataset should first be validated independently against the constraints
5781 applicable to that dataset and its profile. More complex consistency constraints, including
5782 constraints that depend on relationships or information distributed across several datasets,
5783 should then be validated against the combined collection of the relevant datasets.

5784 **9 Dependencies Between Business Processes**

5785 This section will be completed in next versions of RCP DES in which other business processes
5786 such as OPC, CCC, cost-sharing, etc will be covered.

5787

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 17 – Application functions defines necessary Application Functions to be included in the NC CAS.

Table 17 – 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)

5806 In order to target the right testing of the applications, the conformity assessment scheme will
5807 distinguish between the types of applications that are tested.

5808 For instance, an application that is designed to support analytic functions using the profiles as
5809 input will only need to conform to the analytic functions which will also test the ability to
5810 import and export the information.

5811 Therefore, such application will not be required to test separate import/export test use cases.

5812

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)

- 5848 ○ Steady state instruction profile (SSI)
- 5849 • Test configurations shall be developed as conform test configurations. Non-conform
- 5850 test configurations shall be developed as a second phase once it is proven that conform
- 5851 TCs and profiles reach a good level of stability.
- 5852 • Remedial actions shall cover at least the following types:
 - 5853 ○ Simple Remedial Actions of different types – change of setpoint, redispatch
 - 5854 ○ Remedial Action dependent on a specific Contingency
 - 5855 ○ Remedial Action dependent on a specific Assessed Element
 - 5856 ○ Voltage Angle Remedial Actions
 - 5857 ○ Voltage Magnitude Remedial Actions
 - 5858 ○ PST
 - 5859 ○ PST in a group
 - 5860 ○ Topology change
- 5861 • Assessed element shall include lines, transformers, PSTs, busbar coupler, special
- 5862 monitoring for voltage angle and magnitude.
- 5863 • Contingencies shall include at least:
 - 5864 ○ N-1
 - 5865 ○ N-x
 - 5866 ○ Busbar tripping (even if it might be considered N-1)
- 5867 • Equipment reliability shall contain variants on the limits (Current Limits, Voltage Angle
- 5868 Limits, Voltage Magnitude Limits) and SIPS configuration.
- 5869 • GLSK shall cover at least:
 - 5870 ○ Generation ramping up
 - 5871 ○ Generation ramping down
 - 5872 ○ Load "cut-off" example
 - 5873 ○ Example of energy blocks on power plants with several hours of start-up time

10.2.2Types

Table 18 lists some test configurations that are considered important. Additional TCs can be added in the NC Conformity Assessment Scheme (CSA).

Table 18 – 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.

5878 10.3 Test Use Cases

5879 This section defines basic test use cases that are considered important to initiate the
5880 Conformity Assessment Scheme related to NC profiles. Additional test use cases can be added
5881 during the development of NC CAS and it is maintenance.

10.3.1TUC 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.

10.3.2TUC 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

10.3.3TUC 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.

11 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*.

11.1 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.

11.2 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 99](#).

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

Use Case i for Network Code Profile X

- Use case ID
- Use Case name
- Short Description

Fields not yet used:

- Roles
- RCP DES associated chapter for further description
- Pre-condition
- Flow
- Exceptional
- Post-Condition

Dependencies

Document Header	ER profile	AE profile	RA profile	...
USED	NOT USED	USED	USED	...

Figure 99: Summary Information used to Describe a Use Case

11.2.1 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 100](#) 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 101](#). 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 Market Document	Ack Market Document
USED	NEEDED	NOT USED	NOT USED	NOT USED	USED	USED	NOT USED	USED	USED	USED	NOT USED	NOT USED	NOT USED	NOT USED

Figure 100: 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 101: Example of use case dependency (II)

11.2.2 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 DECISIVE*. 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 102](#) condenses the information above for a specific example NCP document.

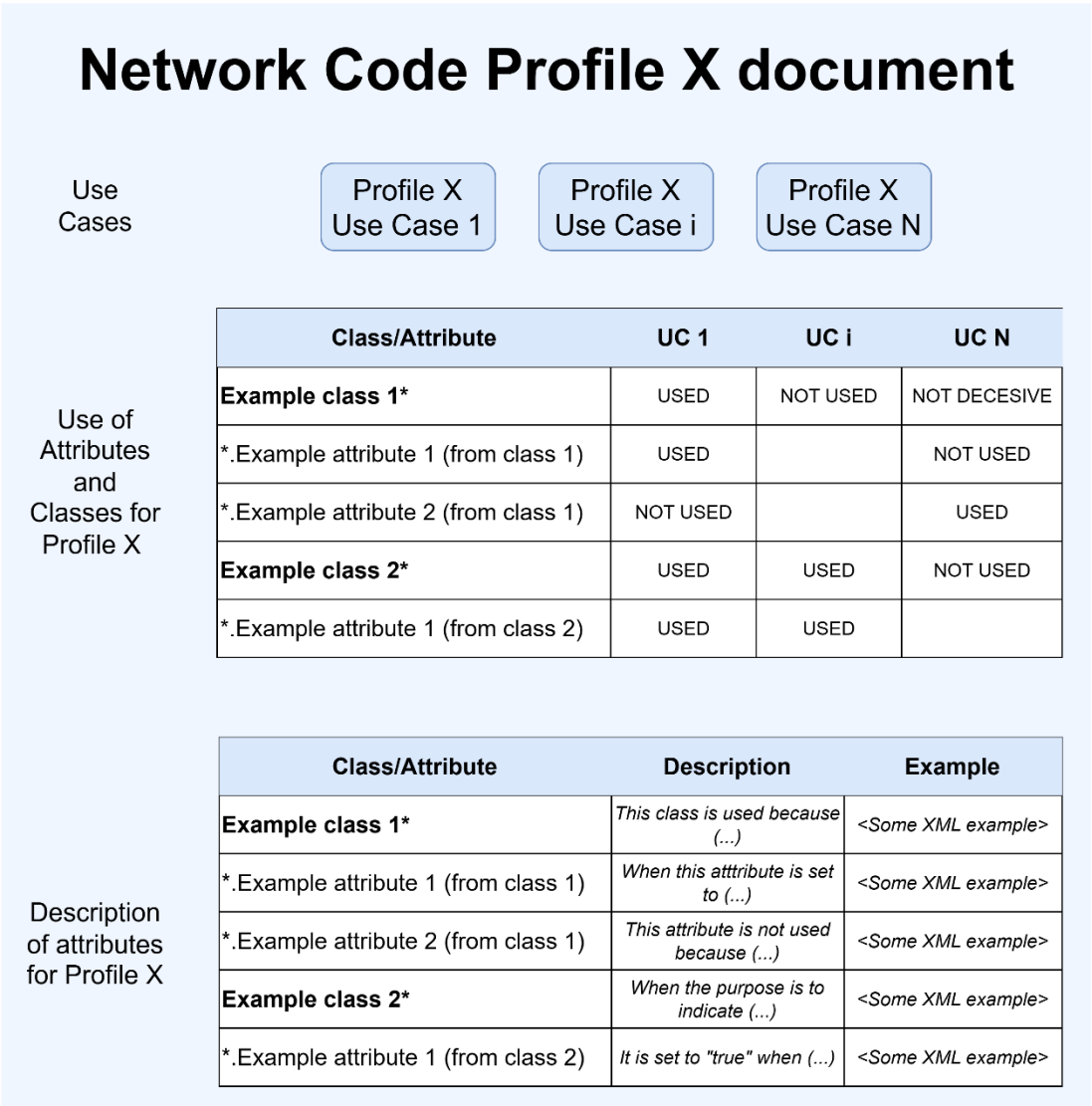


Figure 102: Visualisation of the Reference Legacy Implementation material for one NCP document

5988 **11.3 Intended Use of the Reference Legacy Implementation**

5989 On its side, ENTSO-E publishes this information along with the RCP DES to foster
5990 comprehension on how legacy versions of the NCP are used in real world implementations.
5991 However, ENTSO-E CIM WG's latest modelling recommendations are available in the most
5992 recent version of the RCP DES describing how to use the most recent version of the NCP.

5993 Having this in mind, CoreCCR Reference Legacy Implementation may pave the way to
5994 harmonise use case definition and the implementation of the NCP across other regions in
5995 Europe.

5996 Readers may find more information on this in future release of the RCP DES.

12 Annex B: Document Revision History

Version ¹⁶	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

¹⁶ 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) .
2.4.1	2026-03-09		CIM WG agreed Only modifies the Table 1 to correctly refer to the version numbering of the Network Code profiles patch release 2.4.1
2.4.2	2026-06-10		CIM WG agreed Only modifies the Table 1 to correctly refer to the version numbering of the Network Code profiles patch release 2.4.2

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