Biennial Progress Report on

Operational Probabilistic Coordinated Security Assessment and Risk Management

December 2023

entsoe

ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the **association for the cooperation of the European transmission system operators (TSOs)**. The 39 member TSOs, representing 35 countries, are responsible for the **secure and coordinated operation** of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E **brings together the unique expertise of TSOs for the benefit of European citizens** by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the **security of the interconnected power system in all time frames at pan-European level** and the **optimal functioning and development of the European interconnected electricity markets**, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first **climate-neutral continent by 2050** by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires **sector integration** and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources.

ENTSO-E acts to ensure that this energy system **keeps consumers at its centre** and is operated and developed with **climate objectives** and **social welfare** in mind.

ENTSO-E is committed to using its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

ENTSO-E acts in **solidarity** as a community of TSOs united by a shared **responsibility.**

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by **optimising social welfare** in its dimensions of safety, economy, environment and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and **innovative responses to prepare for the future** and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with **transparency** and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its legally mandated tasks, ENTSO-E's key responsibilities include the following:

- Development and implementation of standards, Network Codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;
- Assessment of the adequacy of the system in different timeframes;
- Coordination of the planning and development of infrastructures at the European level (Ten-Year Network Development Plans, TYNDPs);
- Coordination of research, development and innovation activities of TSOs;
- Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the **implementation and monitoring** of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

Contents

Executive Summary

The 2023 Biennial operational probabilistic coordinated security assessment and risk management Progress Report (hereafter the 2023 PRA Report) provides a view on all TSOs' progress towards an operational probabilistic coordinated security assessment and risk management (hereafter PRA) pursuant to the methodology for coordinating operational security analysis (hereafter CSAM), specifically Article 44 (1) and 44 (2).

Following ACER's decision which established the CSAM in June 2019, TSOs have set-up sequential governance structures, within ENTSO-E's steering group operational framework and under the guidance of the System Operations Committee, to prepare and plan for the move towards PRA.

The 2023 PRA Report is the second public report detailing the progress, the expected challenges and the next steps towards the development of a PRA methodology by the end of 2027. To develop a robust probabilistic approach, a large set of reliable and high-quality data is needed. One of the focus areas of Working Group Probabilistic Risk Assessment (WG PRA) during its initial years was to determine the required data set and to establish consistency in the definitions of grid disturbances.

Since then, ENTSO-E project team WG PRA has focused on improving the data collection process and moving forward with setting the basis of the PRA methodology.

Progress

Since the issue of the first Biennial report, the WG PRA and the TSOs have made the following progress, supported by ENTSO-E:

1. The first version of the Grid Disturbance Profile has been developed. It enables the harmonised reporting of grid disturbances and is compatible with the Common Information Model (CIM).
2. WG PRA developed a new IT infrastructure, as an extension to the ENTREC platform, that allows TSOs to securely upload and validate their PRA data based on the Grid disturbance profile. Workshops have been held to support TSOs in the transition to that platform and the 2022 PRA data collection is currently ongoing.
3. WG PRA has set the basis for the development of the PRA methodology. A first version of the impact assessment has been drafted. WG PRA is also investigating the means to achieve probability calculations.

Challenges

Changes in TSOs' operational processes, particularly at a pan-European level, are accompanied by challenges and hurdles. The surveys submitted to the TSOs for each Biennial report allowed the key challenges the TSOs foresee in the development and implementation of a PRA methodology to be identified:

- changes to current TSOs' internal, regional and pan-European processes which require a move from a well-proven and comprehensible deterministic approach to a more complex probabilistic one;
- the need for additional investment (labour and IT) that is required to address a move towards PRA;
- managing an increased volume of data while simultaneously ensuring the data is secure, of high quality and reliable to build the PRA methodology; and
- ensuring the development of a methodology, consistent with the legal mandate; one that strikes a balance between complexity, practicality, network security and socioeconomic benefits.

Those challenges will be considered in the development of the PRA methodology and further discussed with the TSOs.

Next Steps

WG PRA will continuously engage with TSOs to ensure the PRA methodology tackles the identified challenges and to prepare TSOs in the future implementation of it in their processes.

WG PRA will continue with the development of the impact assessment and probability calculations that form the basis of PRA. Workshops will be organised to discuss with TSOs and present the improvements made in the development of the methodology.

WG PRA will continue to support TSOs in the data collection process via the newly developed PRA data collection platform and ensure quality management via the validation of those data on the platform. The PRA dataset will be continuously reviewed to ensure it meets the requirements for the PRA methodology development.

WG PRA would like to extend an invitation to relevant parties (i. e. research institutes or other bodies) to get in touch if they wish to discuss their PRA-related research. To reach the WG PRA, please email us at PRA@entsoe.eu.

1 Introduction

Historically and currently in Europe, power system operational security management has relied on the "N-1" criterion[1] as the criteria governing security assessment. This means that the power system is always able to withstand an unexpected failure or outage of a system component while accommodating the new operational situation without violating existing security limits.

PRA is a complementary operational security management approach, which allows TSOs to consider the probability and subsequent impact of failure of the power system in establishing its security limits. This is an expansion to existing methods ("N-1" criterion), which assume that all disturbances and failures are of equal probability. The establishment of the PRA approach entails quantifying the expected performance of the system, while considering the uncertainties in its operational conditions (for example, weather conditions and generation) over a specified period.

The legal obligation for TSOs to develop a PRA methodology is defined in CSAM Article 44:

CSAM Article 44 – "Towards probabilistic risk assessment"

Art.44.1 – By 31 December 2027, all TSOs shall jointly develop the methodology on common probabilistic risk assessment taking full account of the requirements of **Article 75(1)(b)** and **Article 75(5)** of the SO Regulation, and shall propose it as an amendment of this methodology in accordance with Article 7(4) of the SO Regulation. After its approval in accordance with Article 7 of the SO Regulation, the methodology on common probabilistic risk assessment shall form an annex to this methodology.

Where the SO Regulation Article 75(1)(b) requires that the CSAM shall at least cover the principles for common risk assessment for the contingencies referred to in Article 33 and SO Regulation Article 75(5) specifies that those principles shall include, among others, the evaluation of the probability and impact of exceptional contingencies. SO Regulation Article 33 determines how TSOs shall establish their contingency list based on a classification of each contingency as ordinary, exceptional or out-of-range.

To that purpose, ENTSO-E, with the support of TSOs, has created WG PRA, whose main goal is to develop the PRA methodology by 2027. This work has been initiated in 2019, and the first Biennial report was issued in December 2021 and presented the achievements made since the start of the project, which are summarised below.

The purpose of this report is to present the accomplishments made by WG PRA, with the support of TSOs, in 2022 and 2023, towards the development of the PRA methodology.

1 Throughout this report, the "N-1" criterion will be considered pursuant to System Operation Guideline definitions, that is, "N-1" refers to the N-state minus 1 contingency. Each contingency can consist of one element (ordinary contingency) or of several elements (exceptional contingency).

1.1 PRA Progress report 2021

The first Biennial report was issued in December 2021. It presented:

- ENTSO-E governance structures and the project teams established to achieve the legal obligations and the current roadmap of the instated workgroup responsible for managing the efforts towards the development of PRA methodology by 2027;
- The progress made by TSOs' towards PRA based on a survey aimed at identifying benefits and challenges/hurdles in implementing PRA at a pan-European level (with a particular focus on data collection practices) in addition to questions about the PRA's advancement so far and future prospects;
- The first version of the PRA methodology, focusing on the required data to develop the methodology;
- The definitions for grid disturbances in the transmission grids, to ensure a common understanding of the terms used when collecting the required data for the PRA;
- The set of exogeneous data identified as having an impact on the PRA; and
- The requirements for an efficient data collection and quality management.

The report also presented the next steps for the development of the methodology, focused on:

- The development of an ENTSO-E IT infrastructure to monitor the addressed data collection inconsistencies across TSOs and complete the dataset if need be; and
- The setup of the groundwork for the PRA methodology development: investigating options and strategies and defining the way-forward for computing risk.

The reader can refer to the 2021 PRA Biennial Progress report for additional information on those topics.

1.2 2023 Biennial PRA Report outline

The 2023 Biennial PRA Report is divided into four chapters:

Chapter 1 introduces the report and briefly explains what PRA is and its expected benefits. It also describes the outcome of the last Biennial report 2021.

Chapter 2 presents the organisation of the WG PRA established at ENTSO-E and responsible for the development of PRA methodology by 2027. The focus area and achievements of these 2 years triggered some adaptations to the organisation and the timeline compared to those presented in the first report.

Chapter 3 describes the achievements made in these years. First, the improvements made by TSOs based on the 2023 survey similar to the one conducted in 2021 are summarised. Then, the progress made by WG PRA in the development of the PRA methodology – impact assessment and probability computations – and regarding data collection.

Chapter 4 presents the roadmap for moving towards PRA methodology by 2027 and clarifies the target steps for the next Biennial Report 2025.

2 Working Group Probabilistic Risk Assessment (WG PRA)

To fulfil the long-term mandate of the PRA development and to ensure continuity and knowledge retention for such a complex topic, ENTSO-E established a (semi) permanent structure till 2027 named WG PRA.

The Terms of Reference for WG PRA were approved in April 2021 with the main objective of supporting TSOs to fulfil their PRA-related mandates. The size of the working group has increased since 2021 and today encompasses 16 TSOs[2] and two Regional Coordination Centres (RCCs).

Figure 2.1: WG PRA is divided into three workstreams with their own focus areas.

2 As of October 2023, the WG PRA includes members from the following TSOs and RCCs: APG, ELES, REE, Energinet, Elia, SEPS, TSCNET, RTE, Statnett, HOPS, Nordic RCC, REN, Landsnet, TenneT, ČEPS, MAVIR, Terna and PSE.

The objectives of the working group are to:

- Develop PRA Methodology and proactively provide expertise and support the TSOs on the implementation and interpretation of the methodology;
- Develop and set up together with RCCs the infrastructure required to collect and process the data for probabilistic risk assessment;
- Manage the changes and necessary amendments on CSAM entailed by PRA methodology and assess whether there is a need to amend the operational network codes and guidelines (i. e. SO Regulation);
- Address all the other network code regulatory issues of relevance related to probabilistic risk assessment, including the implications and impact on system operation from / to the connection codes and market codes;
- Proactively follow the development of new regulations and monitor developments in the field of probabilistic risk assessment;
- Develop and publish (on ENTSO-E's website) reports on the progress achieved in Europe on the operational probabilistic coordinated security assessment and risk management; and
- Manage and facilitate a constructive dialog between ENTSO-E, stakeholders and regulatory authorities.

WG PRA is divided into three workstreams which have been revised to address the targeted objectives in the timeline. The focus areas of each workstream for 2022 and 2023 are presented in the Figure 2.1. It is expected that WG PRA review the workstreams objectives on an annual basis to accommodate the continuous evolution of the work.

Workstream 1

Workstream 1 is responsible for the Biennial reports, stakeholder engagement and proactive engagement with industry evolutions. During 2022, the focus has been on stakeholder engagement and industry evolution. Workstream 1 has conducted several meetings with research labs to discuss the PRA topic and will continue to engage with them. The confidentiality of the data provided by the TSOs has to be considered when exchanging with a third-party on the work of WG PRA.

Workstream 2

Workstream 2 is responsible for continuous ENTSO-E infrastructure development, improvement and monitoring regarding PRA data. In 2023, ENTREC was extended to collect PRA disturbance data in CIM/XML format. Moreover, workstream 2 has supported TSOs in the annual collection of the PRA disturbance data by addressing their questions and issues.

Workstream 3

Workstream 3 has been further divided into two sub-streams. Workstream 3A has been focusing on identifying the exogenous data needed for PRA and started investigating the way-forward in collecting those data and in performing probability calculation on the data collected via workstream 2. Workstream 3B determined the operational data needed for PRA and added them to the collection process under the responsibility of workstream 2. Furthermore, workstream 3B has been investigating the impact assessment and the general flowchart of PRA methodology. The results of both workstreams will subsequently be combined into PRA methodology.

3 Progress on Operational Probabilistic Coordinated Security Assessment and Risk Management

This chapter provides a more detailed view of the achieved progress on operational probabilistic coordinated security assessment and risk management (also referred to above as PRA) by highlighting the developments, reviewing future potential hurdles and obstacles, and assessing the necessary steps and precautions for developing the methodology on common probabilistic risk assessment by 2027.

3.1 Progress achieved compared to 2021 levels

As previously mentioned, to assess all TSOs' preparedness towards PRA, WG PRA conducted a survey which covered the expected benefits and challenges/hurdles in implementing PRA at a pan-European level (with a particular focus on data collection practices) in addition to questions about the PRA's advancement so far and future prospects (2023 survey). The survey's questions were extended from similar surveys made in 2021 and 2019.

A comparison between 2023 and the previous surveys identified that several TSOs have progressed in different areas related to probabilistic risk assessment, which can be summarised as follows:[3]

- Two TSOs progressed in recording the location of a contingency;
- Four TSOs progressed in classifying their contingencies as being ordinary, exceptional or out of range; and
- Three TSOs have improved their process for data collection and are now fully ready to collect information about grid disturbances, faults and outages according to the ENTSO-E Grid disturbance definitions for the power system above 100 kV.

New questions were also introduced in the 2023 survey and the responses received indicate that:

- Almost 43 % of TSOs that responded already collect weather conditions at the time of a contingency; and
- 38 % of the TSOs compute the Energy Not Supplied (ENS) when evaluating operational security and of those TSOs, most of them (62.5 %) do it according to the ENTSO-E Grid disturbance definitions for the power system above 100 kV.

In addition, in the 2021 survey, TSOs identified challenges and hurdles regarding the development and the implementation of PRA methodology. The 2023 survey confirmed that those were still pertinent for the TSOs. In the upcoming year, WG PRA will organise a workshop with TSOs to discuss those challenges and hurdles to consider them in the future development of the methodology.

The challenges envisioned by the TSOs are summarised below, in addition to the WG PRA feedback on them:

- **Changes to current processes** – the PRA methodology is likely to result in changes to existing TSOs' processes, including the system operators' way of working. There is an operational challenge to ensure that operators can understand the PRA methodology and interpret the results properly to make sound decisions. The "N-1" criterion is well-established, easy to understand and thus easier to trust.

3 21 TSOs provided answers to the 2023 survey.

The PRA methodology should not be seen as a replacement for the "N-1" criterion, but rather as an additional support for operators to ensure the security of the operations and planning of the grid. The operators will benefit from additional information that will complement the "N-1"results to help them assess a grid situation in its full complexity. Once the PRA methodology is sufficiently mature to be implemented into the TSOs practices, operators will have to be trained on it beforehand to ensure the full understanding of the process.

- **Data volume and quality** – to appropriately establish a robust methodology, it must be based on accurate and high-quality data, consistent across all TSOs. The quality and quantity of input data will be a challenge. For example, TSOs must have reliable and effective probabilistic data for their grid-elements' faults/outages such that a reliable security assessment may be performed.

  As the data collection has been a challenge, it has been one of the main focus areas of WG PRA since the beginning of the project. The PRA dataset has evolved and grown to allow TSOs time to implement the collection process. Workshops have been organised to support this work and WG PRA will continue to assist the TSOs in their data management. The quality assessment performed on those data is meant to help TSOs improve the quality of their dataset over time. It is intended that the data will become increasingly reliable and so will the PRA methodology.

- **Development of a reliable methodology** – the high complexity and the large amount of required PRA data may lead to calculation errors without adequate controls. In addition, the methodology would need to strike a balance between the tendency to neglect contingencies due to their low probability (which could increase the risk level compared to today) and the need to consider forecast uncertainties (which contributes to lowering the risk level). The acceptable risk level will also have to be determined.

  The PRA methodology development should be a collaborative effort from all TSOs as it is an opportunity to gain more insights into the network. As mentioned previously, PRA will be used in parallel to the "N-1" criterion and will become increasingly reliable as the data quality improves. Given the high complexity of the issue, WG PRA will engage with the TSOs during the development phase and follow-up during the implementation. It is also intended that the first implementation of the methodology would help TSOs assess the risk level at which they are operating their grid now. This would help the TSOs align on an acceptable risk level.

- **Additional investment for all TSOs** – the methodology is expected to require significant investment, both in the level of resources and IT systems, to facilitate changes to processes and internal procedures to ensure appropriate readiness. This may be a difficult exercise for TSOs with competing priorities and limited budgets.

  The development of the methodology will be conducted in collaboration with all TSOs to mitigate this. A balance will have to be found between the efficiency of the PRA methodology and a reasonable investment for all TSOs.

3.2 Progress of WG PRA on the PRA methodology

The centre of the work on the PRA methodology is on the term of risk which can be calculated for each contingency or summed up on a regional level for any system state. Risk is the product of probability of occurrence of an event and its impact. Following this definition, the main challenge is the calculation of probability and impact, which is described in more detail in the following:

The calculated information can be used to improve the current CSA processes by:

- Using probability and risk as information when deciding on the activation of remedial actions;
- Using risk as information to decide on the efficiency of measures and acceptable risks; and
- Using probability to consider the costs of curative remedial actions more accurately.

3.2.1 Probability calculations

A robust PRA methodology should account for the effect of the exogenous parameter on the probability calculations. Those therefore need to be based on historical weather data (reanalysis) and historical failure data in addition to weather forecasts. Some of the environmental data and parameters that WG PRA deemed as a necessary minimum for the calculations are summarised in Table 3.1.

Weather parameter	UNIT
Eastward wind component	speed [m/s]
Northward wind component	speed [m/s]
Vertical wind speed	speed [m/s]
Precipitation type (e. g. rain, sleet, snow, etc.)	dimensionless
K index (lightning)	dimensionless
TT index (lightning)	dimensionless
Total volume of precipitation	height [mm]

Table 3.1: Weather data and parameters required for probability calculations

One of the possible repositories of weather data is the European Union's COPERNICUS ERA5 hourly data on single levels from 1959 to present database. This can be used for weather data reanalysis in the absence of more accurate data. Similarly, GIS position of transmission line towers and substations (submitted by TSOs as part of the data collection) have to be used to evaluate the weather exposure of these elements. This means that an individual historical failure rate can be calculated for all elements in addition to an individual probability of (future) failure (if proper forecast data is available).

Since the publication of the last Biennial report in 2021, the WG PRA members have investigated with TSOs the use of probabilistic calculations. Some TSOs (most notably Landsnet and Statnett) already have probability calculations developed that WG PRA will further investigate as potential options for the PRA methodology. One of the calculation options that WG PRA will be testing is the VAFFEL methodology.

The VAFFEL methodology [1], developed by Statnett, will help WG PRA explore the probability calculation process.

While the failure rates can be calculated using the reanalysis of COPERNICUS data, the probability calculation needs more than just the knowledge of individual failure rates. The main idea behind the VAFFEL methodology is based on the following steps:

1. **Calculate the global annual failure rate** (mean failure rate for all overhead lines) for each voltage level;
2. **Calculate the individual annual failure rates for each overhead line** by adjusting the global failure rate with observed historical failures for each line (Bayesian adjustment);
3. **Create fragility curves for each line (segment)** that gives the connection between weather intensity and the probability of failure for the line (segment). Historical weather data (reanalysis data) for each tower position on the line is needed in this step, and a fragility curve is calculated for each line segment; and
4. **Calculate the hourly probability of failure on each line using weather forecasts** – from the weather forecast, extract max hourly weather data for each tower position, use these values to find the probability of failure for each line segment, then calculate the probability that one or more line segment fails during that given hour.

There are several simplifications made in the VAFFEL methodology, the most important being that the wind direction and position of the historical failures are not considered. The model only includes overhead lines for the time being, but it is possible to expand the model to include failures on cables, end-components and transformers. Adjustments are foreseen in the future.

The first calculations of probability are expected to start in early 2024, and will be focused on the testing of the VAFFEL engine. In parallel, WG PRA will continue to investigate other options currently being developed by other TSOs.

3.2.2 Impact assessment

In short, the current "N-1" criterion currently applied pursuant to the CSAm considers the system secure as long as no contingency leads to a loss of load. If any contingency lead to a loss of load and therefore an ENS, that would be assessed by a nationally or internally defined method; and compared to a nationally or internally defined threshold. In contrast, PRA might consider the system secure when a contingency leads to a loss of load or an ENS is deemed acceptable because the probability of occurrence of this contingency is deemed sufficiently low. The calculated risk can be compared with the costs for reducing the risk and therefore allow more efficient grid operation. Consequently, the security analyses currently being performed or developed by European TSOs and RCCs should be updated to include an additional assessment of the loss of load and the ENS resulting from the occurrence of the contingency.

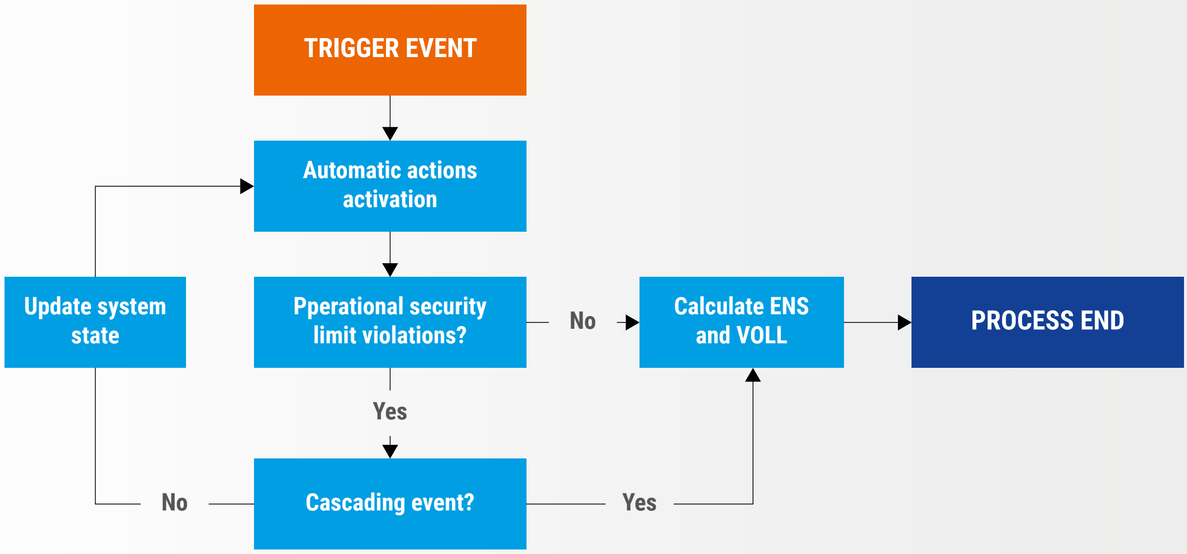

Figure 3.1: Flowchart for impact assessment calculations

WG PRA proposes to divide this additional assessment in two steps.

The first step aims at determining the final system state resulting from a trigger event. Once the event is simulated, automatic actions are activated (such as SPS, overload protection, etc.). If operational security limit violations are remaining, those elements will trip, defining a new system state. Then, the loop starts again with automatic actions, etc.

The first step ends when the loop ends, either because there are no operational security violations or because the trigger event has initiated a cascade. The threshold at which the assessment considers that there is a cascading event should be further determined.

All the required information for this assessment is already provided by TSOs to RCCs and the latter should be readily able to perform it.

This comes with the advantage of having one shared simulation of the scenario triggered by the contingency for the whole region instead of potentially conflicting scenarios which is the case if each TSO performs their own simulation.

Then, in the second step, the ENS and the value of loss load (VOLL) on the final system state is assessed. As it depends on the duration of the outage and the reenergising strategy that can be implemented by grid operators, performing this assessment by RCCs would require additional information to be provided by TSOs to RCCs. In particular, reenergising strategies vary greatly among TSOs as this task involves safety concerns (once a network element is in an outage state, the TSO has to make sure that reenergising it does not endanger anything or anyone). Therefore, TSOs should be, at least at first, better fitted to perform the ENS assessment, taking the loss of load assessed by RCCs as input. Each TSO performs this assessment for their respective area, and the total ENS for a contingency can then be aggregated on a regional level.

Should the regional assessment conclude that there is a cascading event expected in the case of the contingency, then the ENS and VOLL will not be calculated, but a very high or infinitive value will be set, indicating an unacceptable high risk. The flowchart for the impact assessment is presented in Figure 3.1.

The main open questions currently being discussed are:

- How accurate can such a simulation by the RCCs be?
- At what point is a simulation considered cascading?
- Do TSOs have sufficient data to predict the ENS and VOLL?
- How accurate can the calculation of the ENS and VOLL be?
- What is the computational time for this assessment? Is a preselection e.g. based on probability and information calculated earlier necessary to manage the computational time? This will determine at which timeframe the PRA methodology can be performed.

3.3 Progress of WG PRA on the data collection

3.3.1 The PRA data collection platform on ENTREC

Since the first Biennial PRA Report, WG PRA has worked on improving the data collection process and infrastructure and ensuring the data exchange can function securely and efficiently. WG PRA collaborated with ENTSO-E's Common Information Model Working Group (CIM WG) to produce the first version of the Grid Disturbance Profile. The Grid Disturbance Profile is compatible with the CIM and allows detailed and harmonised reporting of grid disturbances. Compatibility with the CIM ensures that PRA can be incorporated into existing operational processes in the future.

WG PRA has emphasised the importance of secure data exchange while improving the data collection process of grid disturbances in line with the 2021 survey results that highlighted data security as one of the biggest concerns. To secure the data collection process, the PRA data collection platform has been developed as an extension of the existing ENTREC platform. It allows TSOs to upload and validate their data in compliance with ENTSO-E processes.

The 2023 survey identified that some TSOs require continued support to provide information about grid disturbances. In 2023, over 80 % of the respondents indicated partial or full readiness to report detailed grid disturbances with the CIM compatible Grid Disturbance Profile format.

3.3.2 Data collection and quality assurance

In 2022, TSOs were trained to report grid disturbance data on an aggregated level with detailed fault causes according to the ENTSO-E Grid disturbance definitions for the power system above 100 kV. In 2023, data were submitted through the newly developed ENTREC tool extension in CIM/XML format, including mandatory data such as the location of the faults, type of auto-reclosing and detailed fault causes. Using the CIM/XML format also enabled the automatic validation of the data in ENTREC. Overall, 29 TSOs provided grid disturbance data in 2022 (for 2021 disturbances) and, so far, 22 TSOs submitted their data this year for the 2022 disturbances Some TSOs have not been able to deliver grid disturbance data because of resource constraints and lacking data collection on their side.

The received 2022 data was assessed by WG PRA for its quality and consistency. The summary of the collected data was analysed with the approaches used in the 2022 Nordic and Baltic Grid Disturbance Statistics due to the same data collection principles used for both. The results of the analysis concluded that there are too high levels of unknown fault causes registered by TSOs. Furthermore, there is a sparse coverage of faults in the 100–150 kV power grid because many TSOs have no ownership or supervision over the assets in that voltage range. WG PRA plans to direct support towards the better identification of fault causes in addition to reducing manual processing times, to guarantee the best results regarding data consistency and quality of the collected grid disturbance data that, at a subsequent stage, will have a positive impact on probability and impact assessment.

WG PRA will continue to provide support to TSOs to aid the transition to the CIM/XML format. Furthermore, targeted support will be provided to TSOs that are behind in the progress. In 2023, two workshops were organised for all TSOs, and additional workshops are planned for the upcoming year.

4 Future Roadmap

Since the start of the project, WG PRA has set the groundwork for the development of the PRA methodology. The future roadmap consists in building upon this work by developing more precisely each step of the risk assessment.

First, WG PRA will continue to assist the TSOs in the data collection process via the secure ENTREC PRA platform. The dataset will be monitored and will most likely include additional data. By 2023, more than 80 % of the TSOs (who participated in the survey) indicated partly or fully readiness to report grid disturbance data according to the Grid Disturbance Profile, and we foresee that this percentage will increase further in the years to come. The goal is that all TSOs are fully ready in due time to have a thoroughly tested reporting process in place, with all TSOs participating before 2027. Thus, WG PRA will arrange workshops with TSOs to encourage and improve the reporting harmonisation and share best practice and knowledge. The example scenarios in the Grid Disturbance Definitions should also be further developed and extended.

The quality assurance of the collected data should be further improved, e. g. by introducing more automatic control both locally at each TSO and in the uploading process at ENTSO-E.

Another important task for the data collection workstream is to cooperate closely with the methodology subworkstreams to adjust collected data according to requirements from the proposed PRA methodology. As part of this, additional data may be required, and the data collection workstream must adapt their definitions and collection process accordingly.

Second, the PRA methodology will be further developed. To develop a risk-based approach, the probability and the impact of contingencies must be computed. WG PRA will dedicate the upcoming months to clarifying the open questions on the impact assessment, starting the first probability calculations based on the VAFFEL concept and continuing to investigate other possible options for those calculations.

The topic of incorporating PRA in security assessment is a complex matter. As it largely remains at the R&D stage and there is no common understanding of the topic in the TSO community, TSOs are investigating methods/approaches which are practical and achievable for all TSOs. Some TSOs are reluctant to incorporate probabilistic security assessment in their operations due to the deterministic character of (local) rules and regulation. Therefore, one of the key areas over the next stages is internal and external stakeholder management to ensure a common understanding of the TSOs' starting points and their individual issues, and to plan for the PRA methodology that could be applied on a pan-European level. This will be achieved by organising workshops with TSOs to present and discuss the progress made on the methodology. Once the methodology is clarified, the proof of concept will be demonstrated by testing it on scenarios of the pan-European power system. This will be the opportunity to fine-tune the methodology and present the results to TSOs. Based on these, WG PRA and the TSOs will also assess the benefits of the PRA methodology.

After the development, the following points should be clarified:

- How will PRA be used and how will the operators and planners of the power system make use of the results? It is intended that PRA will be complementing the "N-1" criterion, but the timeframe for the PRA methodology is still to be determined. Once done, how those results will be used in parallel to the "N-1" should be clarified.
- When will PRA be implemented? As mentioned earlier, the reliability of the method depends on the quality of the data, and this should be considered when deciding on an implementation deadline. Moreover, is it possible to define rules and/or processes to determine when PRA has an added value to the "N-1" criterion?
- Where will PRA be used? The benefits of the PRA methodology might be dependent on the characteristics and topology of the system.

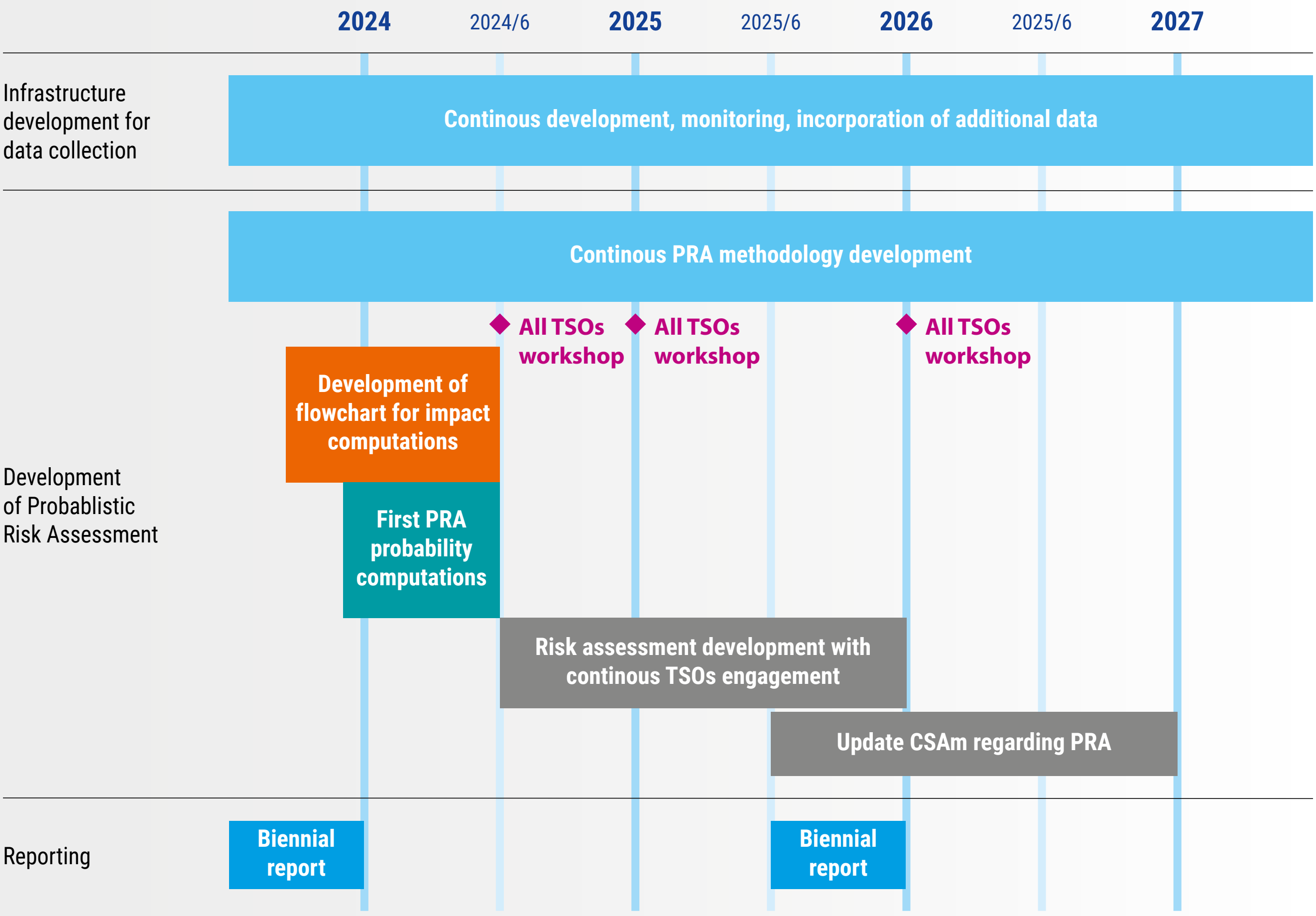

Figure 4.1: High level swimming lane timeline of the development process of the data collection, PRA methodology and administrative tasks. The timeline is subject to change depending on the evolution of the work.

The high-level timeline in Figure 4.1 illustrates WG PRA activities. Due to the complexity associated with the planning and the long timeframe for the PRA methodology development, the timeline is subject to change depending on the evolution of the work. The timeline evolution is expected to be discussed in the upcoming Biennial reports.

The first workshop planned for mid-year 2024 will aim to discuss with TSOs the challenges and hurdles foreseen in the implementation for PRA, presenting the first computations for probabilities and presenting the flowchart for the impact assessment.

The last step of the work will be to amend the CSAm with the PRA methodology, to complete the work of WG PRA as legally mandated.

Conclusion

Consistent with the legal mandate in CSAM Article 44, all TSOs, supported by ENTSO-E, have been investigating and preparing for a move towards a probabilistic approach for risk assessment in the power grid as a potential complement to the currently used "N-1" criterion.

Current advancements include:

- The second draft of the PRA methodology, including the first flowchart for impact assessment;
- The development of the ENTREC tool for the quality checking of submitted data;
- The determination of a set of exogenous data for use in connection with the TSOs' collected data; and
- The investigation of the work done by some TSOs in probability calculations.

In the upcoming months, WG PRA will focus on clarifying the impact assessment and probability computations:

- The first probability computations are intended to be launched in early 2024 and will be based on the VAFFEL concept developed by Statnett. WG PRA will first have to adapt the concept to the PRA dataset and will subsequently have to investigate how to extend it further; and
- The impact assessment flowchart will be further elaborated, and WG PRA will address the open questions presented above.

Those main achievements will be presented and discussed with all TSOs in workshop(s) to ensure a common view and understanding of the PRA methodology and to address the challenges identified by the survey.

Simultaneously, WG PRA will continue to assist the TSOs in their data collection process.

The next milestone for WG PRA will be to couple the probability calculations and impact assessment into a reliable and efficient risk assessment. It is expected that the PRA methodology will be drafted by 2027 as a collaborative work from all TSOs. Considerations about the implementation timeframe will be included in the PRA methodology; note that implementation will occur post-2027.

Glossary

CIM	Common Information Model
CSAM	Methodology for coordinating operational security analysis
ENS	Energy Not Supplied
ENTSO-E	European Network of Transmission System Operators for Electricity
PRA	Probabilistic Risk Assessment
PRAM	Probabilistic Risk Assessment methodology
RCC	Regional Coordination Centre
SPS	System Protection Schemes
TSO	Transmission System Operator
VOLL	Value of Loss Load
VAFFEL	Varsel Før Feil
WG PRA	Working Group Probabilistic Risk Assessment

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This report was prepared by the ENTSO-E Working Group Probabilistic Risk Assessment.

Publisher

ENTSO-E AISBL
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Design

DreiDreizehn GmbH, Berlin | www.313.de

Images

Cover: iStock.com/pinkypills
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Publishing date

December 2023

European Network of
Transmission System Operators
for Electricity