



European Network of
Transmission System Operators
for Electricity

INCIDENTS CLASSIFICATION SCALE METHODOLOGY

23 March 2012

AD HOC TEAM INCIDENTS CLASSIFICATION SCALE
UNDER SYSTEM OPERATION COMMITTEE

Table of contents

- 1. Introduction.....3
- 2. Definitions.....3
- 3. Classified events typology5
- 4. Ranking methodology6
- 5. Classification Scale7
- 6. Reporting Methodology 10
 - 6.1 Step 1: identification of the different criteria related to a single disturbance..... 10
 - 6.2 Step 2: identification of dominating criterion 10
 - 6.3 Step 3: Reporting on the classification scale by filling templates 11
 - 6.4 Step 4: Yearly report on all incidents according the Incidents classification scale ... 12
- 7. Investigation procedure 12
 - 7.1 Disturbances ranked on level 0 12
 - 7.2 Disturbances ranked on level 1: national events 12
 - 7.3 Disturbances ranked on level 2 and 3: regional events OR massive loss of load on one TSO 12
- 8. Change request.....14
- 9. Related documents.....14

1. Introduction

Power system is subjected to various contingencies (grid disturbances, system disturbances) that may potentially, regardless of where they occur, lead to widespread incident over a large part of interconnected systems. The knowledge of main causes and most important sources of disturbance and the learning from recent incidents are necessary for Transmission System Operators to avoid their recurrence.

Regulation n°714/2009 of July 13th 2009 asks TSOs to develop a common incidents (i.e.: grid disturbances and system disturbances) classification scale.

The implementation of this classification should:

- Describe the principles of classification with full explanations about the methodology used to establish correspondence between events and level of importance with regard to security system;
- Define the process each TSO will have to apply in order to analyze on classified events;
- Define reporting and analyses procedures at ENTSO-E level;
- Permit to follow the number of events;
- Permit to follow the status of security level by analysing the violations of preset thresholds;
- Put into evidence needs to perform feedback analyses and, possibly, facilitate the identification of ways of progress to improve grid codes in order to avoid the reproduction of known situations.

2. Definitions

Area

An area is a part of the power system within a subsystem; an area can potentially comprise an entire subsystem. An area is bordered by transmission cross-sections in the national subsystems or by cross-border links.

Black out

Blackout shall mean interruption of electricity generation, transmission, distribution and consumption processes, when operation of the power system or a part thereof is terminated.

Disconnection

The physical separation of Users (or Customers) from the National Electricity Transmission System or a User System as the case may be:

- Tripping of equipments or loss of generation.
- Activation of Load Shedding OR manual disconnection.

Disturbance

It is a disturbance to the power system. This can be the loss of a line, a bus bar, a transformer, a production unit or consumption.

Isolated network operation

Independent operation of a part of the Network that is isolated after its disconnection from the interconnected system, having at least one Generating Unit in operation with ability to speed/frequency control.

Load

Load means an end-use device or customer that receives power from the electric system. Load should not be confused with demand, which is the measure of power that a load receives or requires. Load is often wrongly used as a synonym for demand.

Load shedding

Automatic or manual disconnection of consumption.

Loss of generation

Interruption of generation process due to the disconnection from the grid of power plants (thermal conventional, hydro, nuclear, renewable...). The power plants supply solely their auxiliaries.

N-1 criteria

Are a way of expressing a level of *system security* entailing that a power system can withstand the loss of an individual principal component (production unit, line, transformer, bus bar, consumption etc.). Correspondingly, n-2 entails two individual principal components being lost.

N-1 criterion

The N-1 criterion is a rule according to which elements remaining in operation after failure of a single network element (such as transmission line / transformer or generating unit, or in certain instances a busbar) must be capable of accommodating the change of flows in the network caused by that single failure.

National area

An area covered by a single set of national electricity arrangements established at government level. This is not necessarily the same as the geographical boundaries of a nation. Additional information: This is a type of Market Area.

Peak load

The maximum hourly demand during a period of time: day, month or year.

The national definition of the peak load will be used temporarily to enable each TSO to begin the use of classification scale. Later it is possible to use the definition of the peak load from transparency platform.

Primary failure or fault

An event occurring on an electric system such as a short circuit, a broken wire, or an intermittent connection. Those events occur in the power system and lead to a reduced capacity or loss of a line, bus bar, transformer, production units or consumption. A fault causes an operational disturbance in the power system.

Power plant

Power Plant consists of one or more Power Units, which usually have a common infrastructure and which are either able to operate independently or their operation is mutually influenced or limited by specific operating regimes and technology. Remark: Exact definition and delimitation of power units and power plants is up to each power producer, who provides data to a responsible TSO.

Reliability

Reliability describes the degree of performance of the elements of the bulk electric system that results in electricity being delivered to customers within accepted standards and in the amount desired. Reliability on the transmission level may be measured by the frequency, duration, and magnitude (or the probability) of adverse effects on the electric supply / transport / generation. Electric system reliability can be addressed by considering two basic and functional aspects of the electric system:

- Adequacy:
The ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.
- Security:
The ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements.

Security

A measure of a power systems ability to withstand sudden disturbances, such as electric short circuits or unanticipated losses of system components or load conditions together with operating constraints. Another aspect of security is system integrity, which is the ability to maintain interconnected operations. Integrity relates to the preservation of interconnected system operation, or the avoidance of uncontrolled separation, in the presence of specified severe disturbances.

Sustained Frequency deviation

Frequency deviation means a departure of the actual system frequency from the set value frequency.

Synchronous area or interconnected system

An interconnected system is a system consisting of two or more individual electric systems that normally operate in synchronism and are physically connected via tie lines.

System adequacy

System adequacy of a power system is a measure of the ability of a power system to supply the load in all the steady states in which the power system may exist considering standards conditions. System adequacy is analyzed through Generation Adequacy and Transmission Adequacy (main focus on generation capacity and load and on simultaneous interconnection transmission capacity).

Violation of standards/rules

Security limits define the acceptable operating boundaries (thermal, voltage and stability limits). The TSO must have defined security limits for its own network. The TSO shall ensure adherence to these Security limits. Violation of security limits for prolonged time could cause damage and/or an outage of another element that can cause further deterioration of system operating conditions.

3. Classified events typology

The classification scale has been designed to be **reliable and simple**. Following the review of practices, the classification scale should take into account events on pan-European level originated in the transmission network or in the production system of ENTSO-E area which:

- Have **influence on the cross-border transfer capacity** and trade (e.g. significant generation outage, outage of transmission equipment, split of the system);
- Have **social consequences** (e.g. disconnection of load, partial to total black-out);
- Lead to a **degradation of the system reliability** (e.g. violation of the system parameters);
- Lead to a **degradation of system adequacy** (e.g. shortage of reserves).

4. Ranking methodology

The classification scale levels have been designed to rank grid disturbances and system disturbances by placing them on a **four degrees scale**. Those levels (0 to 3) correspond to incidents of growing seriousness up to a general Europe wide incident.

Operating reliability events are those that significantly affect the integrity of interconnected system operations. They **are divided into 5 general fields** of system reliability alteration to take into account their different system impact:

- **Events on Transmission Network equipments** – final tripping of transmission grid equipments over 220 kV;
- **Events on generation** – final tripping of generation leading to degradation of system reliability or system adequacy;
- **Events on load** – system disturbance or grid disturbances leading to noticeable events on load for one TSO;
- **Degradation in System Operation conditions leading to non-fulfilment of the security criteria or violation of standards;**
- **System disturbance leading to Reliability degradation.**

For each category, criteria have been defined by using definitions (from ENTSO-E draft Glossary and IEC standards) of faults, incidents, events, disturbances, reasons, etc. for developing of common understanding. Each criterion describes “factually” an event or a situation which is observable. Only **significant events are recorded and classified** at their right level of gravity.

Furthermore, different **thresholds have been introduced** into the classification principles to take into account the **differences existing between each synchronous area** and specificities of *isolated systems*¹. Therefore, specific thresholds are defined for:

- Definition of loss of generation;
- Definition of loss of load;
- Frequency deviation;
- Percentage of peak load affected by black out.

¹ Every isolated system can have different thresholds suitable for the system. In the case of Spanish isolated systems (SEIE) incidents do not have impact on other TSOs, and usually are not even relevant at national scale. Because of that, reporting of incidents and scale degree for these systems will be discretionary, depending on lessons learned and relevance, evaluated by the TSO for each incident.

5. Classification Scale

LEVEL 0

Is assigned to local events (e.g.: consequences limited to one TSO) events with low effect on reliability, which means that the primary failure may have low security influence and/or low market influence consequences.

- **Events on transmission network equipment:** final tripping of equipments (normal, exceptional or out of range contingences without impact in other TSO – the events can have consequences but only on national area). Final tripping of HVDC link between synchronous areas.
- **Events on generation (power plants connected to transmission network):** loss of generation in time period of 30 minutes without noticeable consequences (below N-1 i.e. from a minimal threshold defined specifically for each synchronous area to the tripping of the most important power station in the TSO area):
 - Continental Europe, from 600 MW to 1500 MW;
 - Ireland and Northern Ireland, from 200 MW to 500 MW;
 - Nordic region, from 1200 MW to 1500 MW;
 - Great Britain, from 1320 MW to 1800 MW;
 - Baltic region, from 200 MW to 450 MW;
 - Isolated systems: the biggest unit in the system.
- **Events on load:**
 - All regions except isolated systems: disconnection of load < 5% peak load before incident if reasons are in the transmission grid.
 - Isolated systems: if frequency remains 49,5 Hz – 49,0 Hz for at least 5 minutes and/or load shedding is < 5%.

LEVEL 1

(Noteworthy disturbance) is assigned to national events. The consequences of the events classified level 1 are **manageable by only one TSO**.

Various criteria have been created to help each TSO to distinct each typology of disturbance.

- **Events on Transmission Network equipments:** final tripping of equipments with **noticeable** consequences on national area or/and consequences on capability of exchange. Final tripping of two (2) or more HVDC links between synchronous areas.
- **Events on generation:** loss of generation more important than biggest power station output in time period of 30 minutes with consequences on capability of exchange or leading to reliability degradation:
 - Continental Europe: from 1500 MW to 3000 MW;
 - Ireland and Northern Ireland: from 500 MW to 850 MW;
 - Nordic region: from 1500 MW to 3000 MW;
 - Great Britain: from 1800 MW to 3000 MW;
 - Baltic region: from 450 MW to 900 MW;
 - Isolated systems: two units in the system (one of them is the biggest unit in the system).

- **Events on load:**
 - All regions except isolated systems: disconnection of load on 1 TSO area from 5% to 10% of load at the time of the incident related to tripping of equipments, loss of generation or manual / automatic activation of load shedding;
 - Isolated systems: load shedding from 5% to 15% of load at the time of the incident.
- **Degradation in System Operation conditions:** ALERT state (endangered state precision) - real time alert transmitted by "ENTSO-E wide awareness system" (EAS or traffic light system). Does not apply to isolated systems.
- **Degradation in System Operation conditions:** Lack of more than 20% of reserve (secondary and tertiary reserve are considered combined) on a control area for at least 60 minutes for all areas.
- **Degradation in System Operation conditions (does not apply to isolated systems):**
 - Violation of standards/rules on highest transmission voltage (higher or equal to 300 kV of nominal voltage level) network node operated at voltage exceeding voltage $\pm 10\%$ of the pre-fault level (downward or upward) affecting at least 2 TSO's.
 - N-1 violation situation with consequences on, at least, 2 TSO's with cross border overloads.
- **System disturbances leading to reliability degradation.** Sustained Frequency deviation to both directions:
 - Continental Europe: 100 mHz – 800 mHz for at least 5 minutes
 - Ireland and Northern Ireland: 1,15 Hz – 1,5 Hz for at least 5 minutes
 - Nordic region: 500 mHz – 1,3 Hz for at least 30 seconds
 - Great Britain: 800 mHz – 1,2 Hz for at least 5 minutes (with first block of automatic LF demand disconnection set at 48.8Hz)
 - Baltic region: 400 mHz – 800 mHz
 - Isolated systems: 1 Hz – 2 Hz for at least 5 minutes

LEVEL 2

(Extensive and major incidents) is assigned to regional events. In the case of Isolated Systems the Level 2 incidents apply to major incidents that lead to extensive load shedding with serious social consequences. Events have Consequences on more than one TSO area (with necessity of action from more than one TSO) with important consequences. It means that the primary failure may lead to degradation of system adequacy or important social consequences or cause noticeable violation of standards for at least 2 TSO:

- **Events on Transmission Network equipments:** Final tripping of equipments with consequences on regional level area (the primary failure may have serious consequences on capability of exchange and social consequences). Does not apply to isolated systems.
- **Events on generation:** Loss of generation in time period of 30 minutes leading to degradation of system adequacy:
 - Continental Europe: > 3000 MW
 - Ireland and Northern Ireland: > 850 MW
 - Nordic region: > 3000 MW
 - Great Britain: > 3000 MW

- Baltic region: > 900 MW
- Isolated systems: loss of the power plant with the biggest units in the system.
- **Events on load:**
 - All regions except isolated systems: disconnection of load on 1 TSO area from 10% to 50% of load at the time of the incident.
 - Isolated systems: load shedding from 15% to 40% of load at the time of the incident
- **Degradation in System Operation conditions: EMERGENCY state (disturbed state) - real time alert transmitted by "ENTSO-E wide awareness system" (EAS or traffic light system). Does not apply to isolated systems.**
- **System disturbances leading to Reliability degradation:**
 - Sustained Frequency deviation to both directions below last step of automatic load shedding:
 - Continental Europe: 800 mHz – 2 Hz;
 - Ireland and Northern Ireland: 1.5 Hz – 2 Hz for at least 5 minutes;
 - Nordic region: 1,3 Hz – 3 Hz for at least 30 seconds;
 - Great Britain: 1,2 Hz – 3 Hz (with last block of automatic LF demand disconnection set at 47.8 Hz);
 - Baltic region: 800 mHz – 3 Hz;
 - Isolated systems: 2 Hz – 2,5 Hz for at least 5 minutes.
 - System disturbance leading to Separation of a significant part from the grid (at least one TSO). Does not apply to isolated systems.
 - System disturbance leading to regional (synchronous area) collapse. Does not apply to isolated systems.

LEVEL 3

(Widespread incident and major incident on one TSO) is assigned to events such as massive loss of load on one TSO, isolated system or regional black out.

- **Events on load:**
 - Disconnection of load on 1 TSO area above 50 % of load at the time of the incident.
 - Isolated systems: 70% of load (load-shedding) at the time of the incident or total shut down.
- **Degradation in System Operation conditions: BLACK STATE - real time alert transmitted by "ENTSO-E wide awareness system" (EAS or traffic light system). Does not apply to isolated systems.**
- **System disturbances leading to Reliability degradation:**
 - Sustained Frequency deviation to both directions below last step of automatic load shedding:
 - Continental Europe: > 2 Hz
 - Ireland and Northern Ireland: > 2 Hz

- Nordic region: > 3 Hz for at least 30 seconds (disconnection of load – all steps completed)
 - Great Britain: > 3 Hz (i.e. below 47 Hz with last block of automatic LF demand disconnection set at 47.8 Hz)
 - Baltic region: > 3 Hz
 - Isolated systems: > 2,5 Hz.
- **Wide black out (more than 90% of load at the time of the incident).**

6. Reporting Methodology

The ranking methodology will be very simple and **consists of 4 main steps**:

- Step 1: Identification of the various items defining the current event;
- Step 2: Classification of the event by choosing the most important one;
- Step 3: Comments and reporting;
- Step 4: Yearly report.

The following planning gives milestones for reporting:

- **t0**: the disturbance occurs;
- **t0 + 1 month**: disturbance reporting.

Remark: As time scales are very different between disturbances reporting and crisis communication, those processes will have to be linked to identify common ways of information sharing between t0 and t0+1 month.

Reporting depends on the importance of the event (need of more or less details, involvement of experts to run the analysis) and could be divided into following steps. Moreover, it is very important to fix the criteria on a risk assessment, by taking into account real and potential consequences (some disturbances have limited effects but are potentially very risky).

6.1 Step 1: identification of the different criteria related to a single disturbance

Each TSO will have to perform following actions:

- Identify, for a single disturbance, the different events related to the consequences which have appeared on its own area; one disturbance could cause up to five different events, according with the general fields defined on point 3.2 of this document.
- Identify if the original disturbance is internal or external. Due to the events are measured in terms of consequences, it's possible that the TSO have to report consequences which are originated by external causes, out of its own area. If the original cause is the failure of an interconnected line, this failure may be considered how an internal cause for the 2 TSO involved.
- Characterize the main consequences on its area and choose the gravity level for each event according to the classification; Eventually (for events ranked on level 2 and 3), collect information (see section 5) related to the situation before, during and after the disturbance occurs (measurements, chronological data, snapshots, performance of protections relays, manual actions, other information of people involved, etc). Generally, that information won't have to be shared between TSO's unless investigation committee asks to do it (see section 5).

6.2 Step 2: identification of dominating criterion

Each TSO will have to perform following actions:

- Characterization of dominating criterion in terms of consequence (in case of gravity level equality, the dominating criterion is the most important criterion resulting the comparison of all criteria identified for the reporting of a disturbance); order the different event, characterized on step 4.1, using the classification scale. The final gravity level for the incident for each TSO will be the level of the most important event that occurred in its own area. In case several events have the same level of gravity, the dominating criterion will be chosen take into account the following list, from the most important criterion to the less important:
 - Events on load.
 - Events on generation.
 - System disturbances leading to Reliability Degradation in System Operation conditions.
 - Events on Transmission Network equipments.
- The less important criteria should be memorized by the TSO concerned to give some more information for ex-post analysis.
- In some cases, this final incident classification will only be possible after information collect between TSO's, incidents with affection to more than one TSO. In those cases, the dominating criterion will be chosen comparing the most important criteria for each TSO and ordering these criteria according with the classification gravity scale. In case of equal level of gravity for two or more criteria, the dominating criterion will be chosen take into account the following list, from the most important criterion to the less important:
 - Events on load.
 - Events on generation.
 - System disturbances leading to Reliability Degradation in System Operation conditions.
 - Events on Transmission Network equipments.

There's a need of integration in case of the incidents have affection on regional level, incidents with a gravity level 2 or 3. In these cases, the final integration will be done by the regional groups, take into account that there's an obligation of ex-post analysis.

6.3 Step 3: Reporting on the classification scale by filling templates

Each TSO will have to:

- Report dominating criterion for its own area.
- Report if the incident has been originated in its own area, internal causes, or the origin is out of its area, external causes.
- If the incident has been originated in its own area, internal causes, report the original cause.
- Report all the pre-detected criteria;
- Explanation about how the incident took place in its own area and the different events appeared.
- Comment on causes and conclusions if there's no need of ex-post analysis.

All these data will be used to launch the ex-post analysis into each regional group. In case of ex-post analysis the conclusions will only be possible after this work.

6.4 Step 4: Yearly report on all incidents according the Incidents classification scale

The European-wide incidents classification scale will allow ENTSO-E and Transmission System Operators to draw up a yearly report reflecting the level of operational security all over Europe. It will represent a real opportunity for Transmission System Operators to characterize main issues and to identify ways of progress.

7. Investigation procedure

It is very important to determine the right level to launch ex-post disturbance analysis. The main objective is to ensure that all the incidents which significantly have affected the integrity of interconnected system operations are analyzed.

The investigation procedure aims at defining:

- Agreed criteria to decide specific ex-post analysis.
- The data needed to run ex-post analysis.
- The items to be dealt with.
- The organization to perform ex-post analysis.
- Main milestones about the realization of ex-post analysis.

7.1 Disturbances ranked on level 0

The events related to Level 0 have very low effect on reliability (the primary failure may have very low security influence and/or low market influence consequences) so there is no obligation to run specific analysis on those events. This level was created to allow ENTSO-E to run statistic analysis and TSO's to report events for internal purposes.

7.2 Disturbances ranked on level 1: national events

The events related to level 1 don't affect significantly the integrity of interconnected system operations so there is no obligation to perform ex-post analysis.

Ex-post analysis will only be realized in case of decision of TSO, Coordinated System Operation or any type of working group dedicated on operating issues, Regional Group or SOC. For those types of disturbances, investigation procedures and information sharing have been simplified:

- Relevant information will be shared among TSOs by using the reporting tool.
- In case of decision to launch ex-post analysis is taken by TSO's or Regional Group, a shortened Report (one A4 sheet describing factual, actions, anomalies and learning) will be prepared by impacted TSO's to join the yearly report.

7.3 Disturbances ranked on level 2 and 3: regional events OR massive loss of load on one TSO

All the incidents ranked **on level 2 and 3** (extensive, major, widespread and Europe wide incidents) have to be analyzed following the present method. In case of event related to level 2 and 3, typically detailed Report will be prepared by Regional Group team (formed, reviewed and approved by Regional Group) following specific procedures.

7.3.1 Organization

An expert panel is appointed to perform the ex-post analysis, based on a TSO's (or working group dedicated on operating issues) proposal, and approved by Regional Group. In case

TSO's are asked for quick answers from their regulator or stakeholders, they will report the Regional Group this need to accelerate the process of expert panel definition:

- This expert panel will have to include people from TSO's involved.
- The leadership of the expert panel will have to include to be given to a TSO which is not involved in the disturbance, to ensure a neutral leadership.

7.3.2 Data

To perform relevant analysis, the expert panel will collect data. A questionnaire, prepared by the expert panel will be delivered to concerned TSO's to require all the information needed (e.g.: Ex-ante data (DACF, D2CF...), Real time snapshots, Measurements from SCADA or equipments in substation (behaviour of protections + actions of SPS, automation, PMU WAMS, phone calls, translated in English (depending on legal or confidentiality barriers), legal issues, confidentiality barriers ...).

7.3.3 Reports

The disturbance analysis is performed in two steps:

- After collecting the data, the expert panel realizes **a factual (or preliminary) report**. This factual report aims at providing a very clear understanding of main causes a clear description of disturbance (situation ahead and after), preliminary evaluation of activities of dispatchers and functioning of equipments (thanks to interviews of people involved). All the parties involved must approve this report, before performing analysis and proposing actions plan (analysis report).
- **The analysis (or final) report** will include conclusions and recommendations (actions plan, lesson learned) related both to technical and "human behaviour" aspects. The method used to analyze disturbances should be based on well-known method such as "causes tree" method. This final report is approved by each TSO.

These two reports, which represent the complete disturbance analysis report, are presented to Regional Groups. Any information should not be communicated out of Regional Group prior to agreement. After Regional Group agreement, these two reports are presented to SOC (if asked).

7.3.4 Planning

The following planning gives milestones for disturbance analysis:

- **D0**: the disturbance occurs:
 - For Continental Europe, Nordic and Baltic: as soon as possible a short report is sent by e-mail from affected TSOs to Coordinated System Operation (other TSO's of the synchronous area) or working group dedicated on operating issues.
 - For GB, Ireland/Northern Ireland, Isolated systems: as soon as possible, preparation of a short report.
- **D1 + D5**: decision to launch an ex-post disturbance analysis and appointment of the expert panel (including the leader):
 - Regional Coordinated System Operation (or Telco decided in common by TSO's of the synchronous area).
 - Concerned TSO (for GB and Ireland/Northern Ireland, Isolated systems).
- **D1 + D6**: delivery of questionnaires by the TSOs involved in the incident.
- **D1 + D7**: preliminary description of the incident prepared by the expert panel.

- **D1 + 15 days:** additional data and information, asked by the expert panel, are delivered by requested TSOs.
- **D1+ 1 month:** the factual report (identification/ characterization of original fault) is presented to Regional Committee for System Operation, for approval and further decision.
- **D1 + 2 months:** the analysis report is presented to Regional Coordinated System Operation (or working group dedicated on operating issues) for approval. Then, the Regional Coordinated System Operation convenor reports to the next regional meeting
- Implementations of actions decided: to be monitored in Regional Coordinated System Operation meetings.

8. Change request

Each TSO can submit the proposal to change or supplement the Incidents Classification Scale Methodology to the SOC for further consideration.

9. Related documents

INCIDENT CLASSIFICATION SCALE GUIDELINES – provides more detailed explanation of this Incidents Classification methodology