2016 ICS Annual Report

Incident Classification Scale Subgroup

22 January 2018
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INTRODUCTION

The 2016 annual report of the incident classification scale is prepared according to the incident classification scale [1] developed by ENTSO-E pursuant to the Article 8(3)(a) of the Regulation (EC) 714/2009.

The incident classification scale that has been approved by the System Operations Committee on 10 April 2014 and the Assembly on 8 May 2014 was submitted to ACER on 25 June 2014 for opinion pursuant to Article 9(2) of the Regulation (EC) 714/2009.

Recording of the incidents according to the common classification enables:

➢ monitoring of the number of incidents and system performance during the year, comparisons with previous years;
➢ identifying occurrences of high risk to a breach of system security;
➢ identification of incident investigations to be organized; and
➢ analysis of the incidents and the potential to improve system operation.

The annual report aggregates the data from the reports prepared by each transmission system operator at the synchronous area level. The report provides a detailed information on the incidents on scale 1 to 3 at a synchronous area level and a high level summary of scale 0 incidents.

The 2016 annual report of the incident classification scale covers the incident reports from 100% of ENTSO-E full members. The information regarding the incidents leading to frequency degradation in Continental Europe used in the report was provided by System Frequency subgroup under System Operations Committee.

An update of the ICS methodology started in mid-2016 and will be implemented from the beginning of 2018. A supporting document including frequently asked questions regarding the methodology will be available for the TSOs as an annex to the methodology with the purpose to further facilitate the harmonised interpretation of the classification criteria. In addition, an annual workshop will be established to improve the quality of the reporting further.

Compared to previous years, the details on scale 0 and scale 1 incidents are given on a regional level in dedicated chapters for each synchronous area.
INCIDENT CLASSIFICATION SCALE

The methodology

The criteria for incident classification have been defined by using definitions from the Commission Regulation (EU) establishing a guideline on electricity transmission system operation and IEC standards. Each criterion describes factually an incident or a situation which is observable.

Only significant incidents are recorded and classified according to a scale based on severity. Therefore, this report is not a compilation of all the incidents which occurred in 2016 but only the incidents which meet the criteria of the incident classification scale are included.

The incident classification scale has 4 levels increasing in severity from anomalies up to major or widespread incidents. It is compliant with the system states definitions in the Commission Regulation (EU) (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation [2]:

- scale 0 for anomaly, local incidents;
- scale 1 for noteworthy incidents;
- scale 2 for extensive incidents; and
- scale 3 for widespread incidents or major incidents in the control area of one transmission system operator.

Table 1. Incident classification scale

<table>
<thead>
<tr>
<th>Scale 0 Anomaly</th>
<th>Scale 1 Noteworthy incidents</th>
<th>Scale 2 Extensive incidents</th>
<th>Scale 3 Major incidents or widespread incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority / Short definition</td>
<td>Priority - Short definition</td>
<td>Priority - Short definition</td>
<td>Short definition</td>
</tr>
<tr>
<td>#17 Incidents leading to frequency degradation (F0)</td>
<td>#9 Incidents on load (L1)</td>
<td>#2 Incidents on load (L2)</td>
<td>#1 Blackout (OB3)</td>
</tr>
<tr>
<td>#18 Incidents on transmission network elements (T0)</td>
<td>#10 Incidents leading to frequency degradation (F1)</td>
<td>#3 Incidents leading to frequency degradation (F2)</td>
<td></td>
</tr>
<tr>
<td>#19 Incidents on power generating facilities (G0)</td>
<td>#11 Incidents on transmission network elements (T1)</td>
<td>#4 Incidents on transmission network elements (T2)</td>
<td></td>
</tr>
<tr>
<td>#20 Violation of standards on voltage (OV0)</td>
<td>#12 Incidents on power generating facilities (G1)</td>
<td>#5 Incidents on power generating facilities (G2)</td>
<td></td>
</tr>
<tr>
<td>#21 Lack of reserve (OR0)</td>
<td>#13 N-1 violation (ON1)</td>
<td>#6 N violation (ON2)</td>
<td></td>
</tr>
<tr>
<td>#14 Violation of standards on voltage (OV1)</td>
<td>#15 Lack of reserve (OR1)</td>
<td>#7 Separation from the grid (RS2)</td>
<td></td>
</tr>
<tr>
<td>#16 Loss of tools and facilities (LT1)</td>
<td>#17 Incidents leading to frequency degradation (F0)</td>
<td>#8 Loss of tools and facilities (LT2)</td>
<td></td>
</tr>
</tbody>
</table>
GLOBAL OVERVIEW

Significant changes in the grid

During 2016 the trend of declining dispatchable generation capacity in Europe continued. In contrast, renewable installed capacities, mainly wind and photovoltaic, continued to grow strongly.

Compared to last year, the global net generating capacity in Europe has even slightly decreased which seems to indicate that traditional generation units are being decommissioned at a faster rate than renewable energy sources are being installed [3].

The following chapters give the statistical overview of incidents which occurred at pan-European level in 2016.

Number of classified incidents

Figure 1. Classified incidents in 2016 by scale

943 incidents were reported by transmission system operators in 2016.
65.2% of the reported incidents were in scale 0 and 34.4% in scale 1. Two scale 2 incidents were reported during 2016.
In the Nordic synchronous area the number of reported scale 1 incidents was much larger than the number of scale 0 incidents. There were many scale 1 incidents on HVDC interconnectors leading to the reduction of the cross-border exchange capacity. In the isolated systems and Baltic region we have an equal distribution between scale 0 and 1 incidents. In Great Britain and Ireland there have been very few scale 1 incidents relative to the total; 9% and 3% respectively.
<table>
<thead>
<tr>
<th>Criteria scale 0</th>
<th>Number of incidents</th>
<th>Criteria scale 1</th>
<th>Number of incidents</th>
<th>Criteria scale 2</th>
<th>Number of incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of classified scale 0 incidents</td>
<td>614</td>
<td>Total number of classified scale 1 incidents</td>
<td>327</td>
<td>Total number of classified scale 2 incidents</td>
<td>2</td>
</tr>
<tr>
<td>Incidents leading to frequency degradation</td>
<td>15</td>
<td>Incidents leading to frequency degradation</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidents on transmission network elements</td>
<td>467</td>
<td>Incidents on transmission network elements</td>
<td>201</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidents on power generating facilities</td>
<td>110</td>
<td>Incidents on power generating facilities</td>
<td>3</td>
<td>Incidents on power generating facilities</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N-1 violation</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Violation of standards on voltage</td>
<td>20</td>
<td>Violation of standards on voltage</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of reserve</td>
<td>2</td>
<td>Lack of reserve</td>
<td>1</td>
<td>Loss of tools and facilities</td>
<td>23</td>
</tr>
</tbody>
</table>
Table 3. Summary of Scale 1 incidents in 2016 by synchronous area

<table>
<thead>
<tr>
<th>Incident Type</th>
<th>Baltic</th>
<th>Continental Europe</th>
<th>Great Britain</th>
<th>Ireland</th>
<th>Isolated systems</th>
<th>Nordic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidents leading to frequency degradation (F1)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidents on load (L1)</td>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Incidents on power generating facilities (G1)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Incidents on transmission network elements (T1)</td>
<td>13</td>
<td>122</td>
<td>9</td>
<td>1</td>
<td>5</td>
<td>51</td>
</tr>
<tr>
<td>Lack of reserve (OR1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loss of tools and facilities (LT1)</td>
<td>4</td>
<td>15</td>
<td>1</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>N-1 violation (ON1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Violation of standards on voltage (OV1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>

Incidents per length of circuit and energy consumption

The figures below show the ratio between the number of incidents and the annual consumption and the ratio between number of incidents and total length of circuits.

Information about the length of circuits on 31 December 2016 and the energy consumption in 2016 is based on ENTSO-E statistical data [4].
Figure 6. Number of incidents per 1 TWh of energy consumption

Figure 7. Number of incidents per 100 km of circuit

Figure 8. Number of incidents resulting in final tripping of transmission network equipment per 100 km of circuit:
Evolution from 2013 to 2016

The methodology for compiling the ICS annual report changed in 2015 hence if data collected before 2015 is to be compared with data collected after 2015; adjustments have to take to account for the change in methodology.

The total number of reported incidents decreased from 1084 in 2015 to 943 incidents in 2016, i.e. 13%. The proportion of the number of incidents in Scale 1 changed from 2015 to 2016. In 2015 there were 2.6 times more Scale 0 than Scale 1 incidents whereas in 2016 this figure reduced to 1.9 times.

The number of reported scale 0 incidents, reduced significantly from 783 to 614 between 2015 and 2016. Whereas the number of scale 1 incidents increased slightly from 297 to 327 between 2015 and 2016.

Figure 9. Incidents by scale from 2013 to 2016

Figure 10. Number of scale 0 incidents per 100km of circuit
Figure 11. Number of scale 0 incidents with transmission network equipment per 100km of circuit

Figure 12. Number of scale 0 incidents per 1 TWh of energy consumption
Figure 13. Number of scale 1 incidents per 100km of circuit

Figure 14. Number of scale 1 incidents with transmission network equipment per 100km of circuit
It is not the intention of the ICS Methodology to compare incidents in different synchronous areas. The reason for this is that making comparisons is not straightforward because of inherent differences in the way networks have been designed and are operated.
OPERATIONAL SECURITY INDICATORS

The operational security indicators relevant for operational security are the following:

- **OS-A**: number of tripped transmission system elements per year; it is calculated adding up all transmission network elements tripped in any incident in scale 1, 2 or 3.
- **OS-B**: number of tripped power generation facilities per year; it is calculated adding up all power generation facilities tripped in any incident in scale 1, 2 or 3 with dominating or subsidiary criterion G1 or G2.
- **OS-C**: energy not supplied per year due to unscheduled disconnection of demand facilities; it is calculated adding up all energy not supplied in any incident in scale 1, 2 or 3 with dominating or subsidiary criterion L1 or L2.
- **OS-D**: time duration of being in operational states other than normal state; it is calculated adding up all the time that a transmission system operator has declared to have been in alert, emergency, blackout or restoration state. If two or more transmission system operators have been in an operational state other than normal state at the same time, the time is considered separately for each transmission system operator.
- **OS-E**: time duration within which there was a lack of reserves identified; it is calculated adding up all the time with lack of reserves identified in any incident in scale 1, 2 or 3 with dominating or subsidiary criterion OR1.
- **OS-F**: the number of voltage deviations exceeding the voltage thresholds for normal state; it is calculated by adding up the number of incidents in scale 1, 2 or 3 with dominating or subsidiary criteria OV1.
- **OS-G1**: number of events within which there was a frequency deviation per Synchronous Area; it is calculated by adding up all the incidents in scale 1, 2 or 3 with dominating or subsidiary criteria F1 or F2. The incidents are calculated once per synchronous area. In case two transmission system operators have reported frequency deviation at the same time it is counted once.
- **OS-G2**: time duration within which there was a frequency deviation per synchronous area; it is calculated by adding up all the time with frequency deviation in any incident in scale 1, 2 or 3 with dominating or subsidiary criteria F1 or F2. The incidents are calculated once per synchronous area. In case two transmission system operators have reported frequency deviation at the same time it is counted once.
- **OS-H**: number of system-split, separations or local blackouts; it is calculated by adding up all the incidents in scale 2 or 3 with dominating or subsidiary criteria RS2.
- **OS-I**: number of blackouts involving two or more transmission system operators; it is calculated by adding up all the incidents with criteria OB3.

According to this calculation methodology for the operational security performance indicators, the values for each synchronous area for the year 2016 are shown in table 3.
Table 3. Operational security indicators relevant for operational security for each synchronous area

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Continental Europe</th>
<th>Nordic</th>
<th>Great Britain</th>
<th>Baltic</th>
<th>Ireland</th>
<th>Isolated systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>OS-A [Tripped elements]</td>
<td>175</td>
<td>55</td>
<td>10</td>
<td>15</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>OS-B [Tripped PGF]</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>OS-C [Energy not supplied MWh]</td>
<td>440</td>
<td>599</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>433</td>
</tr>
<tr>
<td>OS-D [minutes]</td>
<td>22043</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>OS-E [minutes]</td>
<td>191</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>OS-F [Incidents]</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>OS-G1 [Incidents]</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>OS-G2 [minutes]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>OS-H [Incidents]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>OS-I [blackouts]</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The operational security indicators relevant for operational planning and scheduling are the following:

- **OPS-1A**: the number of events in which an incident contained in the contingency list led to a degradation of system operation conditions; it is calculated adding up all incidents in scale 1, 2 or 3, with a dominating or subsidiary criteria with loss of one transmission system element.
- **OPS-1B**: the number of events in which a degradation of system operation conditions occurred as a result of unexpected discrepancies of demand or generation forecast; it is calculated adding up all incidents in scale 1, 2 or 3 with dominating or subsidiary criteria with loss of one transmission system element.
- **OPS-2A**: the number of events in which there was a degradation in system operation conditions due to an out-of-range contingency; it is calculated adding up all incidents in scale 1, 2 or 3, with any dominating or subsidiary criteria with loss of more than one transmission system element.
- **OPS-2B**: the number of events counted by indicator OPS-2A in which a degradation of system operation conditions occurred as a result of unexpected discrepancies of demand or generation forecast; it is calculated adding up all incidents in scale 1, 2 or 3 with dominating or subsidiary criteria OR1 and loss of more than one transmission system element.
- **OPS-3**: the number of events leading to a degradation in system operation conditions due to lack of active power reserves; it is calculated adding up all incidents with lack of reserves identified in any incident in scale 1, 2 or 3 with dominating or subsidiary criteria OR1.
According to this calculation methodology for the operational security performance indicators, the values for each synchronous area for the year 2016 are shown in table 4.

Table 4. Operational security indicators relevant for operational planning and scheduling for each synchronous area

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Continental Europe</th>
<th>Nordic</th>
<th>Great Britain</th>
<th>Baltic</th>
<th>Ireland</th>
<th>Isolated systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 OPS-1A</td>
<td>111</td>
<td>52</td>
<td>8</td>
<td>13</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2 OPS-1B</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3 OPS-2A</td>
<td>15</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>4 OPS-2B</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5 OPS-3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Evolution from 2013 to 2016

The figures 16-21 show, as far as possible, the non-zero comparison between the values calculated for 2013, 2014, 2015 and 2016. The values for 2013 can be considered as the starting point to analyse trends in following years.
Figure 16: Operational security indicator OS-A

Figure 18: Operational security indicator OS-D

Figure 17: Operational security indicator OS-C

Figure 19: Operational security indicator OPS-1A

Figure 20: Operational security indicator OPS-2A

Figure 21: Operational security indicator OPS-3
Incidents in continental europe

Seasonal adequacy review for the region

In 2016 the installed capacities of conventional power plants (lignite, hard coal, nuclear and other thermal capacities) decrease, whereas the installed capacity of renewables increase. The gas capacity also increases, but to a lesser extent. The MW installed capacity of renewable cannot replace the equivalent MW capacity of dispatchable generation one to one: wind or solar produce at a certain period only, not always correlated to the consumption needs or with network topology at different periods (e.g. N - 1 violation situations).

Under severe conditions the demand of several countries increased, whilst generation availability might be lower due to, for instance, unfavourable meteorological conditions (high temperature during the summer and also in the beginning of autumn).

Even under severe conditions, demand can be met and reserves can be maintained across nearly all of Europe, thanks to energy surpluses in most regions and available interconnector capacity to supply the regions depending on imports.

In early January, a rare phenomenon called 'line galloping' occurred in the North of the Netherlands. This phenomenon appears only in case of a specific combination of temperature, humidity and wind conditions, resulting in ice accretion on the power lines. Icing makes the power lines more sensitive to wind, which causes significant movement and even hitting between individual lines. This phenomenon caused some voltage dips and incidents within the transmission grid (trips), but did not result in any outages.

Reported incidents 2013 — 2016

Figure 22. Reported incidents 2013 — 2016
Incidents by dominant criteria

In 2016, 664 incidents were reported in Continental Europe. Type of reported incidents covered entire Incident Classification Scale for Scale 0 and Scale 1 (with one exception – Incidents leading to frequency degradation - F1), and no incident of Scale 2 and Scale 3.

Table 5. Number of incidents reported for 2016 in Continental Europe

<table>
<thead>
<tr>
<th>Dominant criteria</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of Reserve (OR0)</td>
<td>2</td>
</tr>
<tr>
<td>Violation of standards on voltage (OV0)</td>
<td>19</td>
</tr>
<tr>
<td>Incidents on power generating facilities (G0)</td>
<td>85</td>
</tr>
<tr>
<td>Incidents on transmission network elements (T0)</td>
<td>319</td>
</tr>
<tr>
<td>Incidents leading to frequency degradation (F0)</td>
<td>15</td>
</tr>
<tr>
<td>Loss of tools and facilities (LT1)</td>
<td>15</td>
</tr>
<tr>
<td>Lack of reserve (OR1)</td>
<td>1</td>
</tr>
<tr>
<td>Violation of standards on voltage (OV1)</td>
<td>15</td>
</tr>
<tr>
<td>N-1 violation (ON1)</td>
<td>68</td>
</tr>
<tr>
<td>Incidents on power generating facilities (G1)</td>
<td>1</td>
</tr>
<tr>
<td>Incidents on transmission network elements (T1)</td>
<td>122</td>
</tr>
<tr>
<td>Incidents on load (L1)</td>
<td>2</td>
</tr>
<tr>
<td>Incidents leading to frequency degradation (F1)</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>664</strong></td>
</tr>
</tbody>
</table>

Disturbances on transmission network elements (T0 and T1) were the most common type of incident. The next largest groups of incidents were the disturbances on power generating facilities (G0) and N - 1 violation (ON1).

The number of incidents recorded in 2016 have a uniform distribution across the year, with one exception – Incidents on transmission network elements (T0). These showed a significant increase during summer (maintenance period) and also in January due to weather conditions. In both cases severe weather conditions were the cause.
Figure 23. Monthly distribution of incidents by dominant criteria – 2016

Legend of criteria

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR0</td>
<td>Lack of reserve</td>
</tr>
<tr>
<td>OV0</td>
<td>Violation of standards of voltage</td>
</tr>
<tr>
<td>G0</td>
<td>Incidents on power generating facilities</td>
</tr>
<tr>
<td>T0</td>
<td>Incidents on transmission network elements</td>
</tr>
<tr>
<td>F0</td>
<td>Incidents leading to frequency degradation</td>
</tr>
<tr>
<td>LT1</td>
<td>Loss of tools and facilities</td>
</tr>
<tr>
<td>OR1</td>
<td>Lack of reserve</td>
</tr>
<tr>
<td>OV1</td>
<td>Violation of standards on voltage</td>
</tr>
<tr>
<td>ON1</td>
<td>N-1 violation</td>
</tr>
<tr>
<td>G1</td>
<td>Incidents on power generating facilities</td>
</tr>
<tr>
<td>T1</td>
<td>Incidents on transmission network elements</td>
</tr>
<tr>
<td>L1</td>
<td>Incidents on load</td>
</tr>
</tbody>
</table>
The distribution of incidents on the basis of time duration is comparable for all intervals at between 11% and 16%. Whereas there were proportionally a larger numbers of incidents with durations of <1h and >24h.

Across Continental Europe 80% incidents regardless of criterion are resolved in less than 24 hours.
Incidents by scale

Figure 26. Incidents by scale 2013 - 2016

Scale 0 incidents reported in 2016 decreased in comparison with previous years.

Scale 1 incidents reported in 2016 marginally increased in comparison with previous years.

Scale 2 and Scale 3 incidents reported in 2016 – none
Scale 0 incidents

Figure 27. Scale 0 incidents by dominating criteria 2013 - 2016

Violations of standards of voltage (OV0) have increased in comparison with 2015, while incidents on power generating facilities (G0), incidents on transmission network elements (T0) and incidents leading to frequency degradation (F0) have decreased in comparison with 2015.

Figure 28. Duration of scale 0 incidents

The number of scale 0 incidents with time duration of less than 1 h and more than 24 are almost equal and together make up almost 50% of the total number. There is a fairly uniform distribution of scale 0 incidents within the time durations 1-2 h, 2-5 h, 5-10 h, 10-24 h.
Scale 1 incidents

Figure 29. Scale 1 incidents by dominating criteria 2013 – 2016

Number of violations of standards on voltage (OV1), N-1 violations (ON1), instances of lack of reserve (OR1) and incidents on load (L1) have decreased in comparison with 2015, while number of incidents on transmission network elements (T1), incidents on power generating facilities (G1) and instances of loss of tools and facilities (LT1) have increased in comparison with 2015.

Figure 30. Duration of scale 1 incidents

The majority of scale 1 incidents had a time duration less than 1 h
N - 1 violations

68 N-1 violations were reported by 10 TSOs in 2016, less compared to 2015 when 103 incidents were reported. Similarly to 2015 the unexpected/unscheduled flows were the main cause of N - 1 violations (90 %), the remaining N - 1 violations were caused by transmission equipment failure. Unexpected flows occur as a result of a combination of increased shares of variable renewable energy sources, interdependencies between the different transmission systems, planning/unplanning outages of equipments and shorter market time intervals. As a consequence it is more important to increase cooperation between transmission system operators to coordinate the remedial actions necessary to avoid or solve N - 1 violations.

Reducing the occurrence of unexpected flows requires coordination between transmission system operators in all operational planning phases, in intraday, redispatching power sources and measures to change network configuration.

Table 7. N-1 Violation overview

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of N - 1 violation incidents reported</td>
<td>68</td>
</tr>
<tr>
<td>No. of TSO's with N - 1 violation reported incidents</td>
<td>10</td>
</tr>
<tr>
<td>No. of N - 1 violation incidents with impact on other TSO's</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>38</td>
</tr>
<tr>
<td>No</td>
<td>26</td>
</tr>
<tr>
<td>Unknown</td>
<td>4</td>
</tr>
<tr>
<td>No. of incident outside the normal state</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>32</td>
</tr>
<tr>
<td>No</td>
<td>36</td>
</tr>
</tbody>
</table>
Figure 31. N - 1 violation reported in 2016 across Continental Europe

Figure 32. Duration of N - 1 violation
Figure 33. Causes of N-1 violations

- Transmission equipment failure: 90%
- Unexpected/unscheduled flows: 10%

Figure 34. N-1 violations 2013 - 2016

- 2013: 73 incidents
- 2014: 45 incidents
- 2015: 103 incidents
- 2016: 68 incidents
Figure 35. Monthly occurrence of reported N-1 violation – from 2013-2016

Figure 36. Time to be in outside normal state

The majority of excursions outside the normal state are resolved within 1 hour which is commensurate with the time taken for TSOs to implement efficient remedial actions. This demonstrates how diligent operation is giving the network in Continental European a high level of resilience.
Analysis of significant changes in trends

In 2016 a total of 664 incidents have been reported in Continental Europe, which is a decrease in comparison with 2015 when 823 incidents were reported. Dominant incidents were: Incidents on transmission network elements (T0 and T1), incidents on power generating facilities (G0) and N - 1 violation (ON1). The number of Scale 0 incidents decreased and the number of Scale 1 incidents increased during 2016. The number of N - 1 violation incidents decreased significantly. For the other type of incidents there is no significant changes in comparison with previous years.
INCIDENTS IN NORDIC

Reported incidents 2013 – 2016

Figure 37. Reported incidents 2013 – 2016

The high number of incidents in 2014 was due to 43 Scale 0 violation of standards on voltage in Denmark and happened during HVDC ramping. They were a consequence of low load and low overnight reactive power demand in Denmark.

Incidents by dominating criteria

Nordic Area reported 76 incidents in 2016. There were 10 Scale 0 incidents and 66 Scale 1 incidents. No incidents of Scale 2 or Scale 3.

Table 8. Number of incidents reported in Nordic Area during 2016

<table>
<thead>
<tr>
<th>Dominant criteria</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidents on transmission network elements (T0)</td>
<td>10</td>
</tr>
<tr>
<td>Loss of tools and facilities (LT1)</td>
<td>3</td>
</tr>
<tr>
<td>N-1 violation (ON1)</td>
<td>9</td>
</tr>
<tr>
<td>Incidents on power generating facilities (G1)</td>
<td>1</td>
</tr>
<tr>
<td>Incidents on transmission network elements (T1)</td>
<td>51</td>
</tr>
<tr>
<td>Incidents on load (L1)</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>76</strong></td>
</tr>
</tbody>
</table>
Disturbances on transmission network elements (T0 and T1) made up the largest part of reported incidents. The next largest group of incidents was N-1 violation (ON1).

The monthly distribution is quite even. Only difference is June when eight incidents on transmission network elements (T1) happened.

**Figure 38. Monthly distribution of incidents by dominating criteria – 2016**

![Monthly distribution of incidents](image)

**Figure 39. Duration of incidents**

![Duration of incidents](image)

71% of incidents have a short duration i.e. <5h.
Figure 40. Duration of incidents by dominating criteria 2016

Most types of incident have a relatively short duration the exception being Scale 1 incidents on transmission network elements (T1). There were 18 HVDC link trips with duration 2-5 h. The longest duration was almost 4 months due to a permanent fault in 420 kV sea cable.

Figure 41. Incidents by scale 2013 - 2016

Scale 0 incidents reported in 2016 decreased in comparison with previous years.

Scale 1 incidents reported in 2016 were at the same level as the previous years.

Scale 2 incidents reported in 2013 - 2016 – none.

Scale 3 incidents reported in 2013 - 2016 – none.
There was a bit different methodology for 2013 reports, which affected a lot for Nordic T0 and T1 incidents. Final tripping of one HVDC link was T0 incident in 2013. For 2014 – 2016 reports, it is T1.

**Scale 0 incidents**

Figure 42. Scale 0 incidents by dominating criteria 2013 – 2016

There was a different methodology for 2013 reports. In 2013, final tripping of one HVDC link was T0 incident. Today it is T1.

Figure 43. Duration of scale 0 incidents in 2016
80% of incidents have a short duration i.e. <5h.

**Scale 1 incidents**

Figure 44. Scale 1 incidents by dominating criteria 2013 – 2016

The dominating criteria has been incidents on transmission network elements (T1). There was a different methodology for 2013 reports. In 2013, final tripping of one HVDC link was scale 0 disturbance. In 2014 - 2016 it is scale 1.

**N-1 violation (ON1)** – at the same level in comparison with 2015.

**Incidents on transmission network elements (T1)** - decrease in comparison with 2015.

**Violation of standards on voltage (OV1)** - none in 2016.

**Loss of tools and facilities (LT1)** – increase in comparison with 2015.

**Incidents on load (L1)** - decrease in comparison with 2015.
Figure 45. Duration of scale 1 incidents in 2016

71% of scale 1 incidents have a short duration i.e. <5h.

N-1 violations

Table 9. N-1 Violation overview

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of N - 1 violation incidents reported</td>
<td>9</td>
</tr>
<tr>
<td>No. of TSO’s with N - 1 violation reported incidents</td>
<td>2</td>
</tr>
<tr>
<td>No. of N - 1 violation incidents with impact on other TSO’s</td>
<td>No 0 Ye 9</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
</tr>
<tr>
<td>No. of incident outside the normal state</td>
<td>No 0 Ye 9</td>
</tr>
</tbody>
</table>
Figure 46. N-1 Violation across Nordics

Figure 47. Duration of N - 1 violations

- <1h: 11%
- 1-2h: 89%
Figure 48. Causes of N-1 violation

- Unexpected / unscheduled flows: 11%
- Transmission equipment failure: 89%

Figure 49. N-1 violations 2013 – 2016

- 2013: 0 incidents
- 2014: 2 incidents
- 2015: 8 incidents
- 2016: 6 incidents

Figure 50. Time to be in outside normal state – 2016

- <1h: 11%
- 1-2h: 89%
Analysis of significant changes in trends 2016

In 2016 a total of 76 incidents have been reported in Nordic Area, which is a decrease in comparison with 2015 when 95 incidents was reported. Dominant incidents were incidents on transmission network elements (T0 and T1) and N - 1 violation (ON1). The number of scale 0 and scale 1 incidents decreased in 2016. The number of incidents on transmission network elements (T0) decreased significantly. For the other type of incidents, there were no significant changes in trends compared with previous years.
INCIDENTS IN GREAT BRITAIN

Reported Incidents 2013-2016

The Great Britain (GB) synchronous area recorded 112 incidents in 2016 which compares with 88 incidents in 2015, 125 incidents in 2014 and 115 incidents in 2013.

Figure 51 Reported Incidents 2013-2016

The high number of incidents in 2014 was due to 109 scale 0 and 16 scale 1 incidents. There were 108 scale 0 incidents resulted from disturbances on transmission network equipment (T0) which formed the majority.

Incidents by dominating criteria

Great Britain synchronous area has reported 112 incidents in total in 2016. This includes 102 Scale 0 incidents and 10 Scale 1 incidents.

Table 10 Number of incidents reported in GB Area during 2016

<table>
<thead>
<tr>
<th>Dominant Criteria</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidents on Transmission Network elements (T0)</td>
<td>101</td>
</tr>
<tr>
<td>Incidents on power generating facilities (G0)</td>
<td>1</td>
</tr>
<tr>
<td>Disturbance on Transmission network elements (T1)</td>
<td>9</td>
</tr>
<tr>
<td>Loss of tools &amp; facilities (LT1)</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>112</td>
</tr>
</tbody>
</table>
Disturbances on transmission network elements (T0 and T1) made up the largest part of reported incidents. In addition, there was one incident each reported for the loss of power generating facilities (G0) and for the loss of tools & facilities (LT1).

Figure 51 Monthly distribution of incidents by dominating criteria – 2016

The monthly distribution indicates that large amount of incidents occurred during the winter time. The maximum number of 16 incidents appeared in November due to adverse weather conditions.

Figure 52 Duration of incidents

There were 56.25% incidents that had a short duration, i.e. <5h.

In addition, there were 30.36% incidents lasting longer than 24 hours. Thorough site investigations were initiated and mitigating actions were deployed in most incidents to ensure
the network elements were suitable for function before re-energisation; hence the restoration times were longer.

Figure 53 Duration of incidents by dominating criteria 2016

Most of scale 1 incidents (T1 & LT1) have relatively short durations. There were 8 instances when HVDC interconnector tripped and were subsequently returned to service within 10 hours.

Incidents by scales 2013-2016

Figure 45 Incidents by Scale 2013-2016

The number of scale 0 incidents reported in 2016 was higher than that reported in 2015; however, the number of incidents were considerably lower than those reported in 2013 and 2014.
The number of scale 1 incidents reported in 2016 increased as compared to 2015 and 2013, but it was lower than the number of scale 1 incidents reported in the year 2014.

Scale 2 incidents reported in 2014 - 2016 – none.
Scale 3 incidents reported in 2014 - 2016 – none.

**Scale 0 Incidents**

The number of Great Britain scale 0 incident records is 102 in 2016 which compares with 82 records in 2015, 109 records in 2014 and 110 records in 2013.

Figure 55 Scale 0 incidents by dominating criteria 2013 – 2016

Great Britain synchronous area experienced 102 scale 0 incidents in 2016. There were 101 incidents associated with final tripping of transmission network elements (T0) and only one incident associated with unexpected disconnection from the grid of power generating facilities (G0). All of these incidents were secured following the application of curative remedial actions within appropriate timescales. The only G0 incident was caused by a gas supply issue which tripped two Combined-Cycle Gas Turbine (CCGT) units and hence disconnected 1378MW from the grid.
There were 55% scale 0 incidents that had a short duration, i.e. <5h.

More than half of the T0 incidents in 2016 were caused by primary system faults that resulted in the automatic operation of circuit breakers following the detection of primary system fault current. The system remained secure following all the incidents.
Scale 1 incidents

Great Britain has recorded 10 incidents on scale 1. This compares with 6 scale 1 incidents recorded in 2015, 16 records in 2014 and 5 records in 2013.

Figure 58 Scale 1 incidents by dominating criteria 2013 – 2016

Great Britain synchronous area experienced 9 scale 1 incidents associated with the final tripping of Transmission network elements (T1). All of these incidents led to the reduction in the cross-border exchange capacity of the HVDC interconnectors between GB and France (IFA) or GB and Netherlands (BritNed) or GB and Ireland (EWIC).

There was one occasion each when BritNed and EWIC HVDC interconnectors were tripped as a result of a disturbance in GB synchronous area. The remaining seven incidents reported as T1 were associated with the trip of IFA HVDC interconnector; these were a consequence of problems associated with the HVDC convertor station on the GB end of the interconnector.

Only one scale 1 incident was recorded in GB under the Loss of Tools (LT1) category when Balancing Mechanism (BM) system was lost for 145 minutes.
There were 80% scale 1 incidents that had a short duration, i.e. <5h.

Analysis of significant changes in trends 2016

In 2016, a total of 112 incidents have been reported in GB synchronous area, which has increased as compared to 88 reported incidents in 2015. Dominant incidents were incidents on transmission network elements (T0 and T1). The number of scale 0 and scale 1 incidents in 2016, both increased as compared to the numbers in 2015. There was no scale 2 or scale 3 incidents, which remained unchanged in 2016. For the other type of incidents, there were no significant changes in trends compared with previous years.
INCIDENTS IN BALTIC

Reported incidents 2013 – 2016

Figure 61 Reported Incidents 2013-2016

Incidents by dominating criteria 2016

Baltic TSOs reported 41 incidents in 2016. There were 22 Scale 0 incidents and 19 Scale 1 incidents. No incidents of Scale 2 or Scale 3.

Table 11. Number of incidents reported in according dominating criteria 2016

<table>
<thead>
<tr>
<th>Dominating criteria</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidents on power generating facilities (G0)</td>
<td>3</td>
</tr>
<tr>
<td>Incidents on Transmission Network elements (T0)</td>
<td>19</td>
</tr>
<tr>
<td>Incidents leading to frequency degradation (F1)</td>
<td>1</td>
</tr>
<tr>
<td>Loss of tools and facilities (LT1)</td>
<td>4</td>
</tr>
<tr>
<td>Incidents on power generating facilities (G1)</td>
<td>1</td>
</tr>
<tr>
<td>Incidents on Transmission Network elements (T1)</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>
Disturbances on transmission network elements (T0 and T1) made up the largest part of reported incidents.

**Monthly distribution of incidents by dominating criteria**

Figure 62. Monthly distribution of incidents by dominating criteria – 2016

![Bar chart showing monthly distribution of incidents by dominating criteria for 2016.](chart.png)

**Duration of incidents 2016**

Figure 63. Duration of incidents 2016

![Pie chart showing duration of incidents for 2016.](chart2.png)
Duration of incidents by dominating criteria

Figure 64. Duration of incidents by dominating criteria 2016

![Bar chart showing duration of incidents by dominating criteria 2016]

Incidents by scale 2013 – 2016

Figure 65. Incidents by scale 2013 - 2016

![Bar chart showing incidents by scale 2013 - 2016]

Increase of Scale 1 incidents are due to recently installed HVDC links.
Scale 0 incidents

Figure 66. Scale 0 incidents by dominating criteria 2013 – 2016

Loss of load (L0) incidents in 2013 and 2014 are reported due to differences in previous methodology.

Figure 67. Duration of scale 0 incidents in 2016
Scale 1 incidents

Figure 68. Scale 1 incidents by dominating criteria 2013 – 2016

Figure 69. Duration of scale 1 incidents in 2016
Impact on other transmission system operators

Figure 70. Impact on other transmission system operators in 2016

Analysis of significant changes in trends 2016

In time period 2013 - 2016 Baltic Synchronous Area TSOs every year has reported almost similar amount of incidents. Differences between dominating categories are more connected to changes in methodology and development of Baltic TSOs (HVDC equipment).
INCIDENTS IN IRELAND

Incidents by dominating criterion

In 2016, there were 33 incidents reported for the synchronous area of Ireland; 32 scale 0 and one scale 1. There were no recorded scale 2 or scale 3 incidents in 2016.

Scale 0 incidents were primarily on power generating facilities and transmission network elements. There was one violation of voltage standards.

Table 22: Number of incidents by dominating criteria - Ireland

<table>
<thead>
<tr>
<th>Dominating Criterion</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidents on power generating facilities (G0)</td>
<td>21</td>
</tr>
<tr>
<td>Violation of standards on voltage (OV0)</td>
<td>1</td>
</tr>
<tr>
<td>Incidents on transmission network elements (T0)</td>
<td>10</td>
</tr>
<tr>
<td>Incidents on transmission network elements (T1)</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

The number of incidents per month and dominating criterion shows no discernible pattern. Four of the 11 incidents on transmission network equipment occurred in April however the incidents were unrelated and were due to different causes.

Figure 710: Number of incidents by month and dominating criteria – Ireland
Duration of incidents

Eleven incidents, 33%, lasted longer than 24 hours. Six of those were incidents on power generating facilities and five were on transmission network elements. The violation of standards on voltage lasted only seven minutes.

Figure 711: Duration of all incidents - Ireland

![Pie chart showing duration of incidents]

Table 13: Duration of incidents by dominating criterion - Ireland

<table>
<thead>
<tr>
<th>Dominating Criterion</th>
<th>&lt;1 h</th>
<th>1-2 h</th>
<th>2-5 h</th>
<th>5-10 h</th>
<th>10-24 h</th>
<th>&gt;24 h</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>G0</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>OV0</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>T0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3</strong></td>
<td><strong>3</strong></td>
<td><strong>6</strong></td>
<td><strong>3</strong></td>
<td><strong>7</strong></td>
<td><strong>11</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

Figure 712: Scale 1 incidents by year - Ireland
Analysis of significant changes in trends

There was one recorded scale 1 incident in Ireland in 2016. The incident involved the tripping of the East West interconnector (EWIC) between Ireland and Great Britain. Such incidents are reported as scale 1 due to the reduction in transfer capacity between the synchronous areas. The trend of scale 1 incidents is generally down over this five year period.
CONCLUSION

In the year 2016 a total of **943 incidents** have been reported, which is a decrease of about 13% compared to 2015. This proves the ongoing high level of safety for the whole European grid.

The number of scale 0 incidents reduced compared with 2015 by 22%. For all **614 reported scale 0 incidents** the system remained in the normal state (based on the system design criteria) during and after the incident.

**327 incidents reported in scale 1** shows in increase of 10% compared to last year.

60% of the scale 1 incidents were incidents on transmission network elements, which are mostly connections (AC and DC) between transmission system operators. 77 incidents of the scale 1 incidents were N-1 violations, decrease of 25 % compared to 2015. The remaining 49 incidents include violations of standards on voltage (5%), loss of tools and facilities (7 %), incidents on load (2 %).

2 incidents reported on scale 2 occurred in the isolated systems: one incident on load and one incident on generation (no specific reporting,because they are isolated from the synchronous systems).

In conclusion, also during 2016 transmission system operators showed a high level of coordination and awareness to ensure and maintain the remarkable standard for security of supply all over Europe.
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REPORT_web.pdf
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