Reliable Sustainable Connected

2015 ICS Annual Report

Incident Classification Scale Subgroup

10 November 2016

CONTENTS

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

INTRODUCTION

The 2015 annual report of the incident classification scale is prepared according to the incident classification scale [1] developed by ENTSO-E pursuant to Article 8(3)(a) of Regulation (EC) 714/2009.

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

The Commission Regulation (EU) establishing a guideline on electricity transmission system operation [2] has not yet been adopted; therefore, the incident classification scale will be updated to be compliant with the final approved version of the guideline.

Recording the incidents according to the common classification enables:

- monitoring the number of incidents and system performance during the year and comparisons with previous years;
- identifying occurrences of high risk for a breach of system security;
- identification of incident investigations to be organised; 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 (TSO) at the synchronous area level. The report provides detailed information on the incidents on a scale of 1 to 3 at a synchronous area level and a high-level summary of scale 0 incidents.

The 2015 annual report of the incident classification scale covers the incident reports from 100% of ENTSO-E full members. The commitment of transmission system operators to classify and report the incidents has increased compared to the previous year, when 95% of the ENTSO-E members reported their incidents. The information on the incidents leading to frequency degradation in Continental Europe that was used in the report was provided by the System Frequency subgroup under the System Operations Committee.

The difficulties to collect and interpret the data for the report shows the need for further harmonisation in the way the methodology and definitions are used by the transmission system operators in classifying incidents and the need to have a dedicated tool. The methodology is still in the development phase, and the update process has started in 2016 to address this issue.

In the comparison with the previous years, the changes in the methodology need to be taken into account, in particular for the incidents on load – the incidents that were classified as scale 0 incidents on load according to the previous methodology are now classified as scale 1 incidents.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

INCIDENT CLASSIFICATION SCALE

Methodology

The criteria for incident classification have been defined using definitions from the draft Commission Regulation (EU) establishing a guideline on electricity transmission system operation and IEC standards. Each criterion factually describes an incident or situation that 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 that occurred in 2015; only the incidents that meet the criteria of the incident classification scale are included.

The incident classification scale has four levels increasing in severity from anomalies up to major or widespread incidents. The following scale is compliant with the system state definitions in the draft Commission Regulation (EU) establishing a guideline on electricity transmission system operation:

- 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

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

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Changes in the methodology compared to the previous methodology

When providing data for the annual report 2015, the transmission system operators used the Incident Classification Scale Methodology that was approved by the System Operations Committee on 8 April 2014 and by the Assembly on 8 May 2014. The previous report for year 2014 was compiled according to the methodology that was approved by the System Operations Committee on 28 November 2013.

The most notable changes between these two methodologies are the following:

- Criterion L0 – the criterion for events on load on scale 0 disappeared, and the incidents previously classified as events on load on scale 0 according to the new methodology are now included under criterion L1 – incidents on load on scale 1;
- A new criterion OR0 – lack of reserve on scale 0 was added.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

GLOBAL OVERVIEW

System operation review

The winter review 2014/2015 [3] showed a mild winter with average monthly temperatures near or slightly below the average values. As a result, the demand was around the seasonal average in most countries.

In the summer review 2015 [4], most countries reported a very dry and warm summer season compared to previous years, while Denmark and Great Britain experienced a cooler, windier, and wetter summer. Most of the countries had no balancing problems or unexpected difficulties during the summer of 2015. Redispatching had to be applied in order to maintain the security of the supply due to unexpected grid and load-flow situations in some countries.

The high temperatures during the summer led to an increase in the electricity demand and a higher peak load than expected in several countries.

In 2015, more electricity was produced from wind, for example in Denmark and Estonia, whereas, in Spain and Portugal, wind production was lower than average.

The following chapters give the statistical overview of incidents that occurred at the pan-European level in 2015.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Number of classified incidents

Transmission system operators recorded, in total, 1084 classified incidents in 2015. Moreover, 72% of the reported incidents were scale 0 and 27% were scale 1, as shown in Figure 2. Four scale 2 incidents were reported during 2015.

Figure 1. Classified incidents in 2015 by scale.

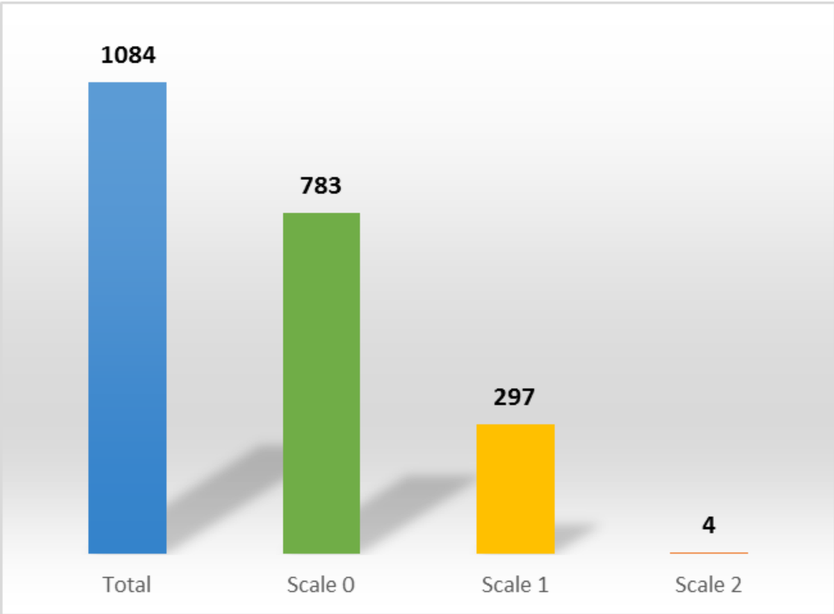
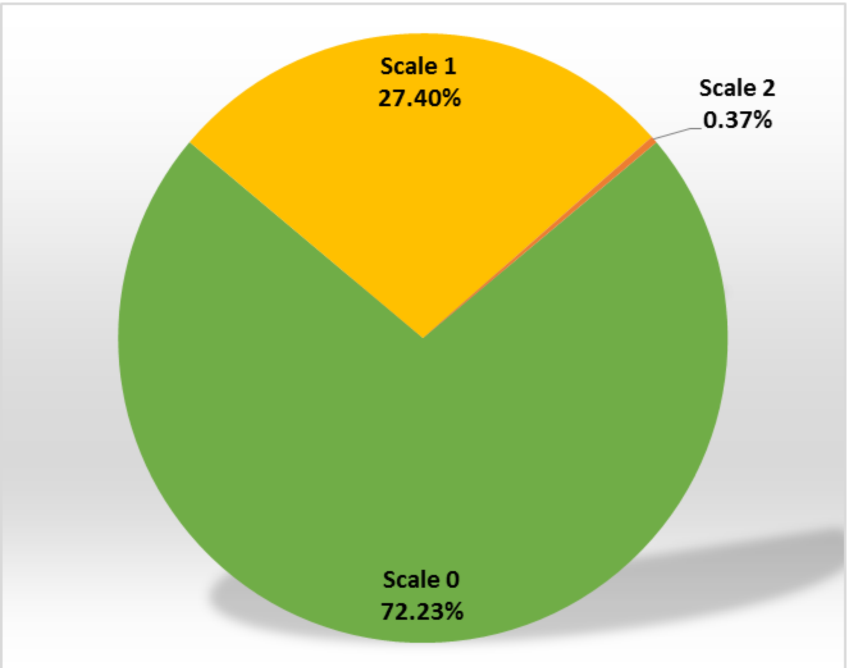


Figure 2. Percentage of classified incidents by scale.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Similar to previous years, incidents reported in synchronous area of Continental Europe represent the largest part – 76% of all the classified incidents.

Figure 3. Number of incidents per synchronous area.

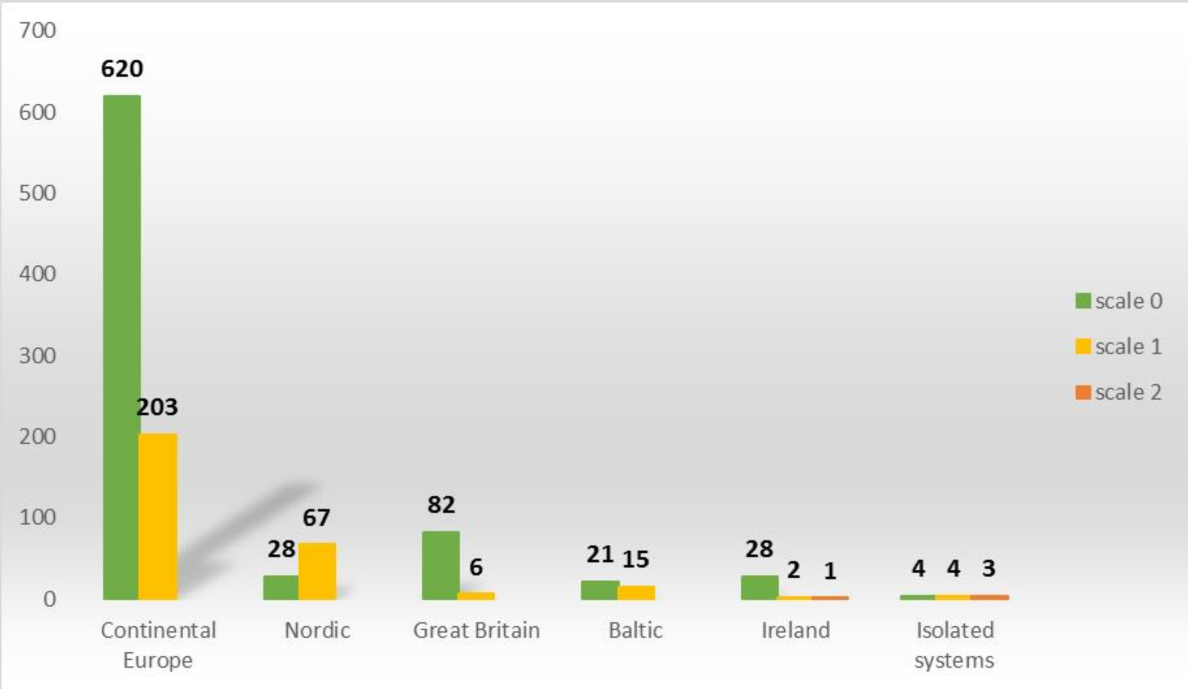


Figure 4. Distribution of incidents by synchronous area.

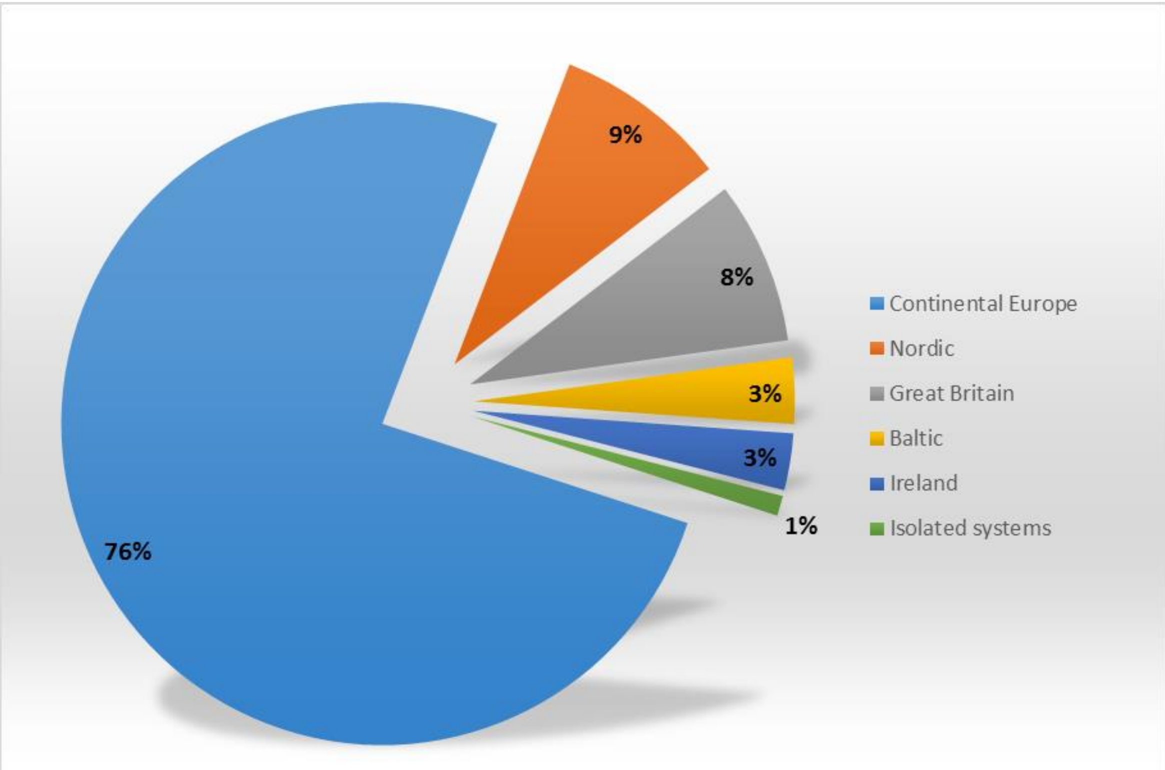
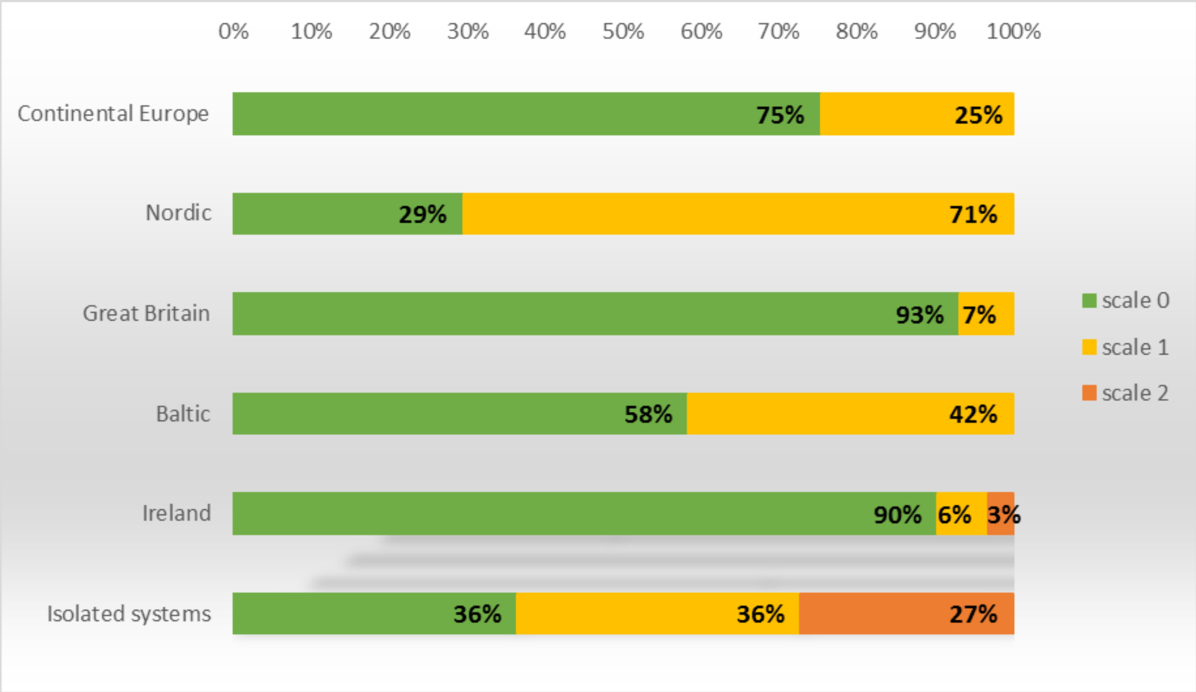


Figure 5. Proportions between scale 0, 1, and 2 incidents per synchronous area.



In the Nordic synchronous area, the number of reported scale 1 incidents was bigger than the number of scale 0 incidents. There was a significant number of scale 1 incidents on HVDC interconnectors leading to the reduction of the cross-border exchange capacity. In the isolated systems, there was almost an equal distribution between scale 0, 1, and 2 incidents. In the Baltic area, the number of scale 0 incidents was only slightly higher than the number of scale 1 incidents. In Great Britain and Ireland, the proportion between scale 0 and scale 1 incidents was similar: around 90% of the incidents were scale 0 incidents and approximately 10% were scale 1 (or scale 2) incidents. In Continental Europe, 75% of the incidents were reported on scale 0, while a quarter of incidents were on scale 1.

The table below contains a global overview of the number and type of incidents that occurred in 2015 on the pan-European level.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Table 2. Incidents by criterion.

Criterion Scale 0	Number of Incidents	Criteria Scale 1	Number of Incidents	Criteria scale 2	Number of incidents
Total number of classified scale 0 incidents	**783**	**Total number of classified scale 1 incidents**	297	**Total number of classified scale 2 incidents**	4
		Incidents on load: disconnection of 1-10% of actual load of TSO before the incident (5-15% for isolated systems)	11	Incidents on load: disconnection of 10-50% of actual load of TSO before the incident (15-70% for isolated systems)	4
Incidents leading to frequency degradation according to scale 0 thresholds	26	Incidents leading to frequency degradation according to scale 1 thresholds	0	Incidents leading to frequency degradation according to scale 2 thresholds	0
Incidents on transmission network elements: final tripping of equipment with no violations of operational security limits and no effect on available cross-border transmission capacity	583	Incidents on transmission network elements: final tripping of equipment causing violations of operational security limits or/and with effect on available cross-border transmission capacity	147	Incidents on transmission system elements	0
Incidents on power generating facilities: loss of generation according to scale 0 thresholds	161	Incidents on power generating facilities: loss of generation according to scale 1 thresholds	0	Incidents on power generating facilities	0
		N-1 violation	103	N violation	0
				Separation from the grid	0
Violation of standards on voltage from 5 to 15 minutes	13	Violation of standards on voltage for more than 15 minutes	21		
Lack of reserve: lack of more than 20% of frequency restoration reserve for more than 15 minutes and less than 30 minutes	0	Lack of reserve: lack of more than 20% of frequency restoration reserve for at least 30 minutes	3		
		Loss of tools and facilities: loss of one or more tools or facilities for more than 30 minutes	12	Loss of tools and facilities	0

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

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 the number of incidents and length of circuits in different synchronous areas.

Information about the length of circuits on 31 December 2015 and the energy consumption in 2015 is taken from the ENTSO-E data portal [5].

Figure 6. Number of incidents per 1 TWh of energy consumption.

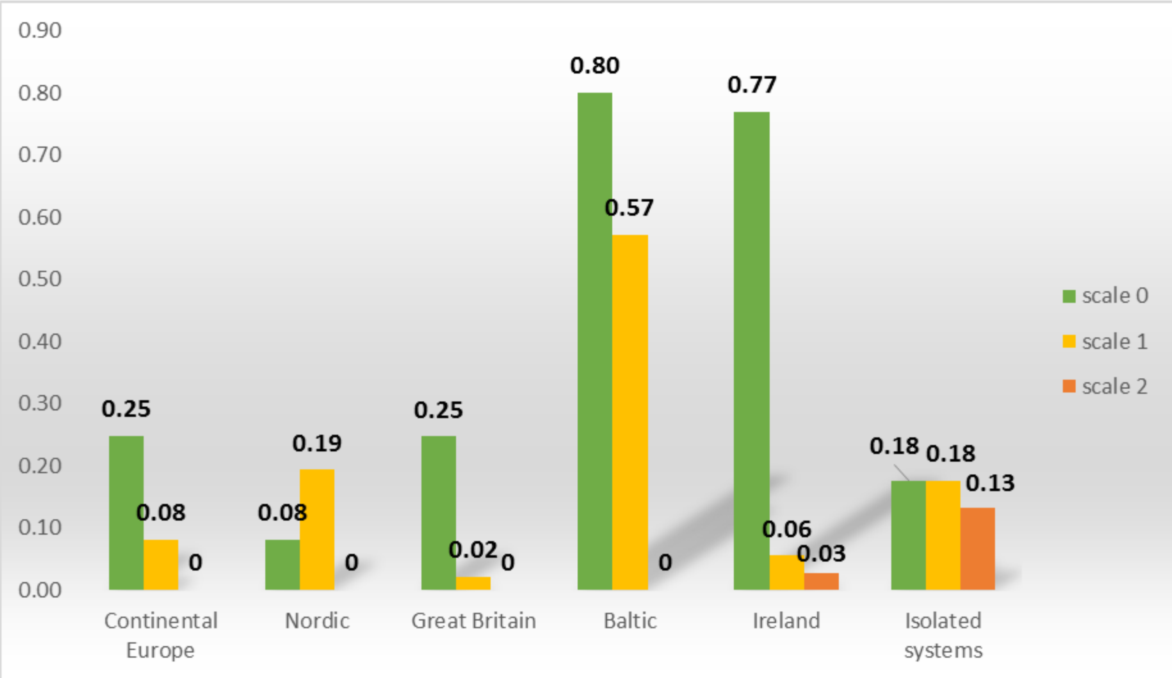
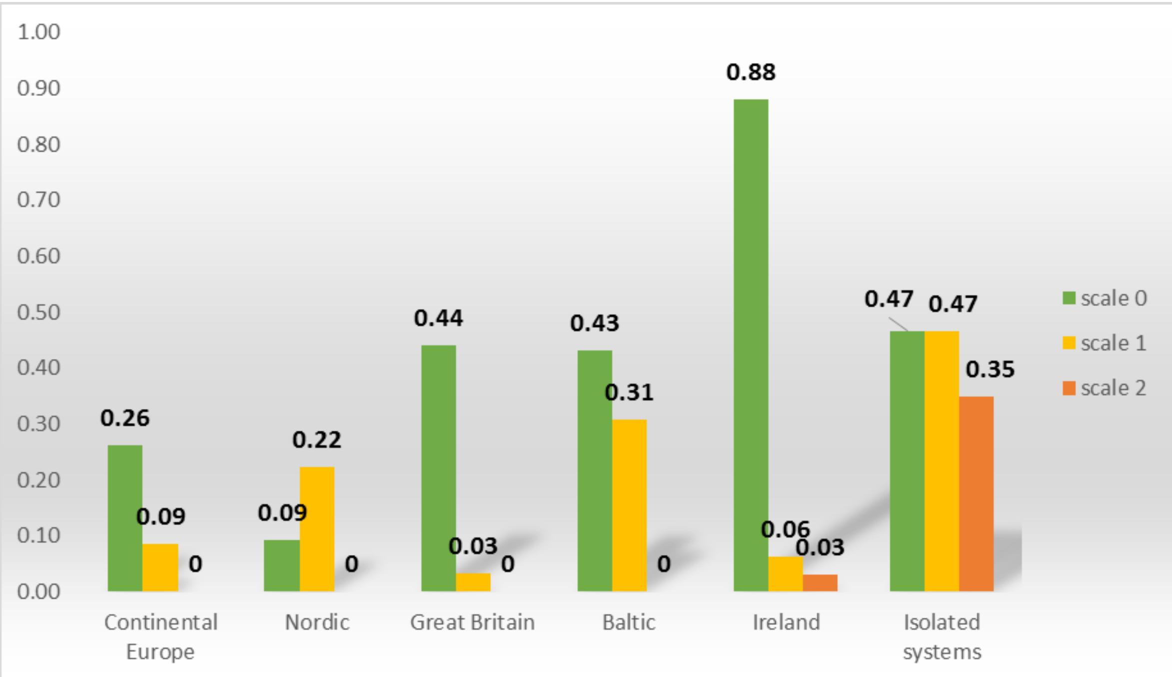
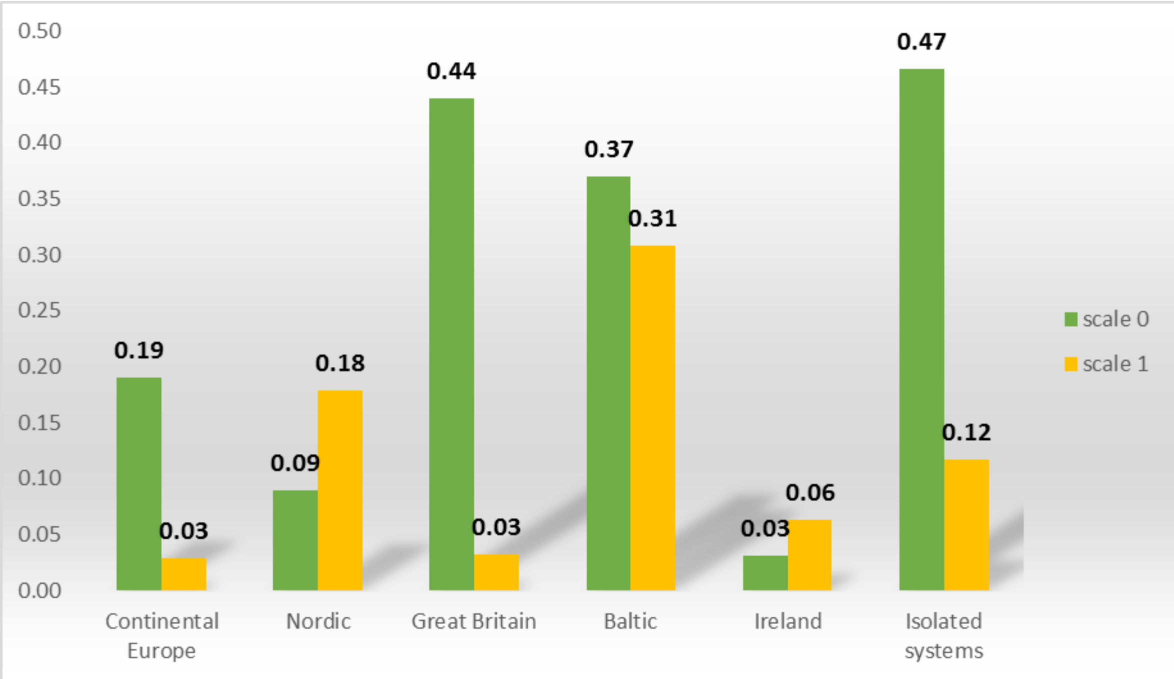


Figure 7. Number of incidents per 100 km of circuit.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 8. Number of incidents resulting in final tripping of transmission network equipment per 100 km of circuit.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

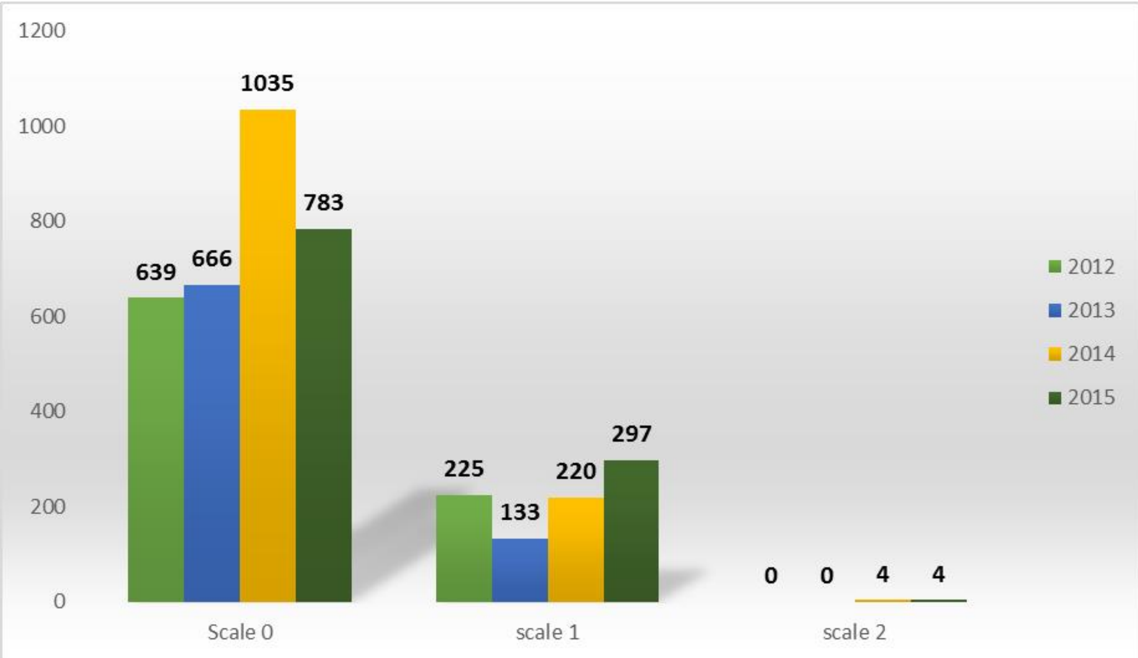
Evolution from 2012 to 2015

The number of scale 0 incidents increased significantly between 2012 and 2014 – from 639 in 2012 to 1035 in 2014, while the number of incidents decreased from 2014 to 2015 by 24.3%. The number of scale 1 incidents increased steadily from 2013 to 2015 – from 133 in 2013 to 297 in 2015.

The total number of reported incidents decreased from 1259 in 2014 by 13.9% to 1084 incidents in 2015. This change is originated from the mild winter and dry summer but also from the revised interpretation for incidents on transmission network elements on scale 0. The remaining differences in interpretation will be addressed during the update of the ICS methodology.

The proportion of the number of incidents in scale 1 to the number of incidents in scale 0 changed from 2014 to 2015. While in 2014 the proportion scale 0/scale 1 was 4.7, in 2015 the proportion was reduced to 2.6.

Figure 9. Incidents by scale from 2012 to 2015.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

For Continental Europe, the indicators per 100 km of circuit and per 1 TWh of energy consumption are similar for all four years.

For other areas, one or more indicators have changed significantly from 2012 to 2014.

Figure 10. Number of scale 0 incidents per 100 km of circuit.

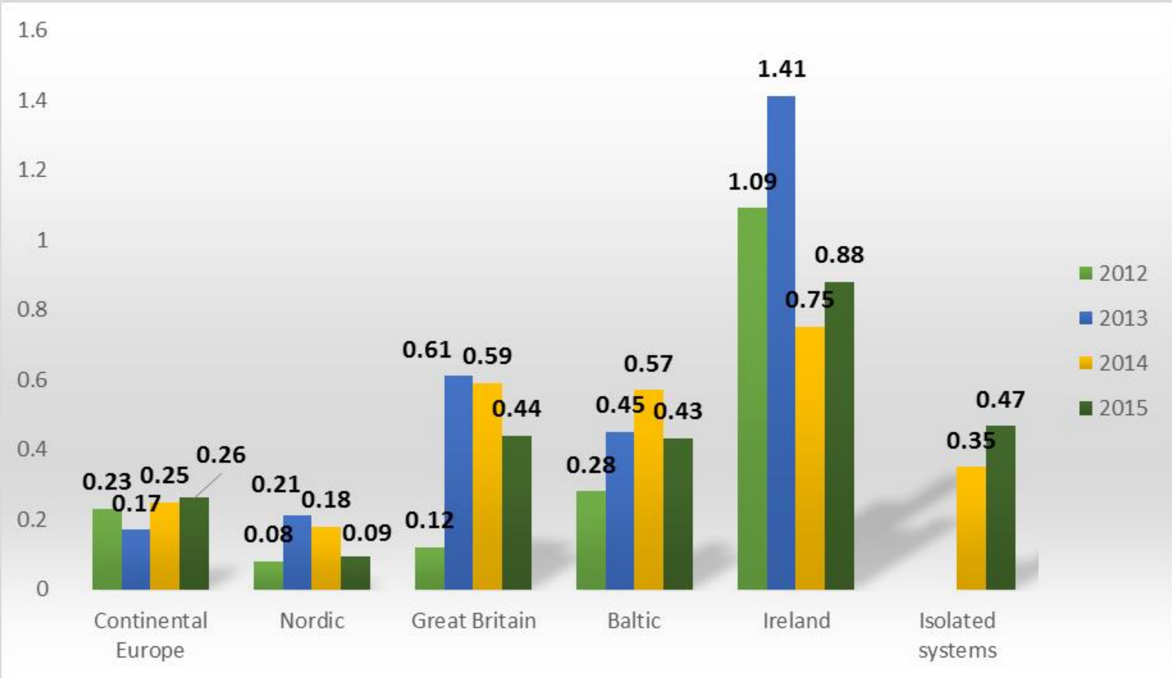
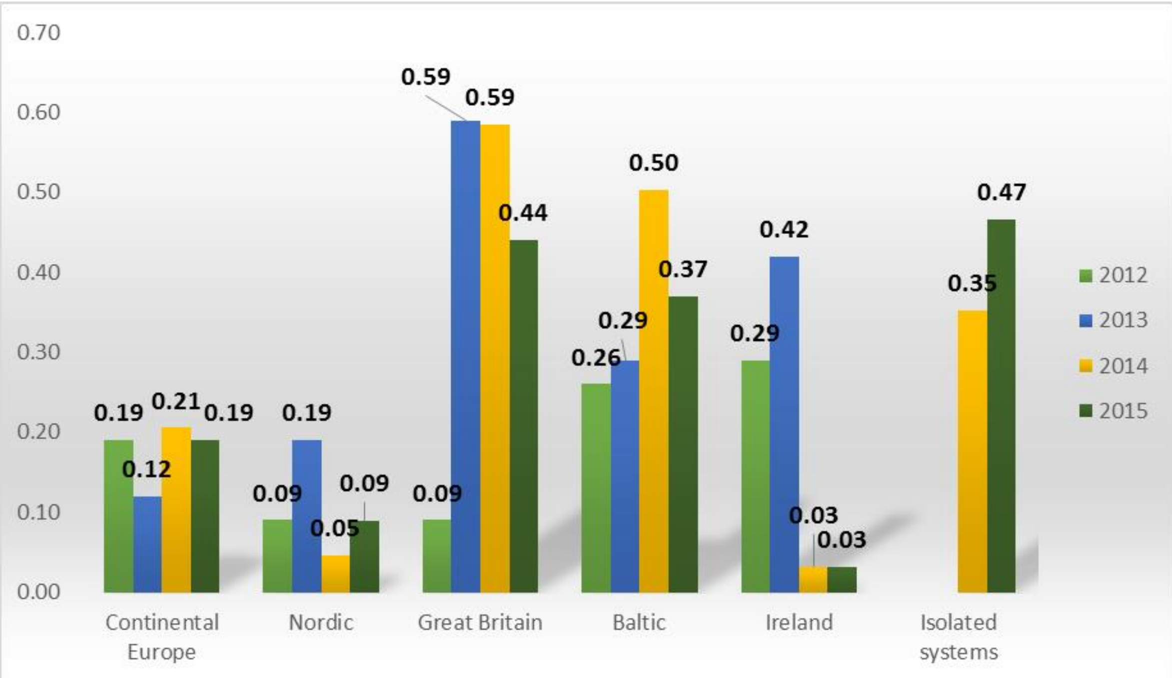


Figure 11. Number of scale 0 incidents with transmission network equipment per 100 km of circuit.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 12. Number of scale 0 incidents per 1 TWh of energy consumption.

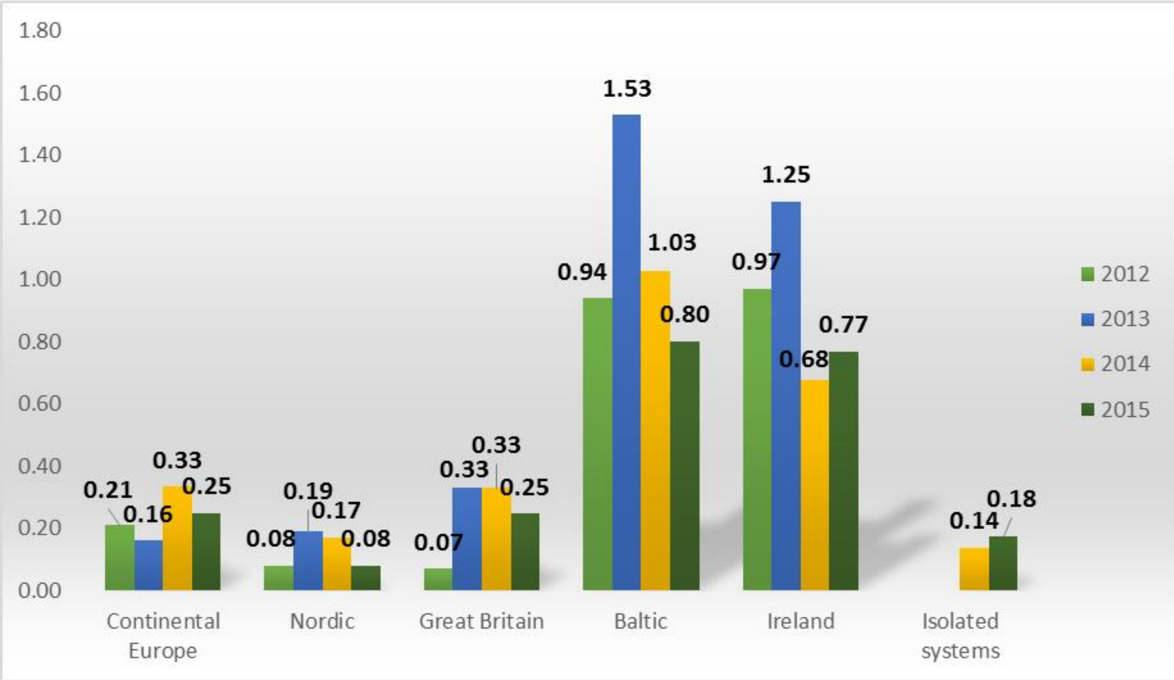


Figure 13. Number of scale 1 incidents per 100 km of circuit.

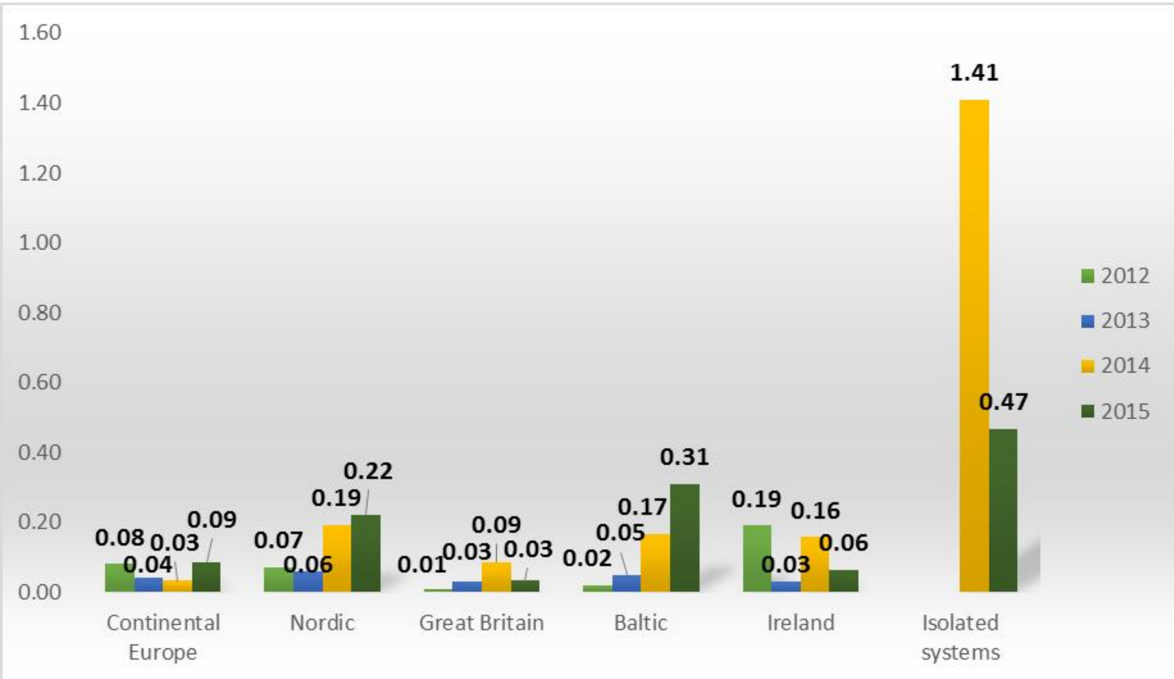


Figure 14. Number of scale 1 incidents on transmission network per 100 km of circuit.

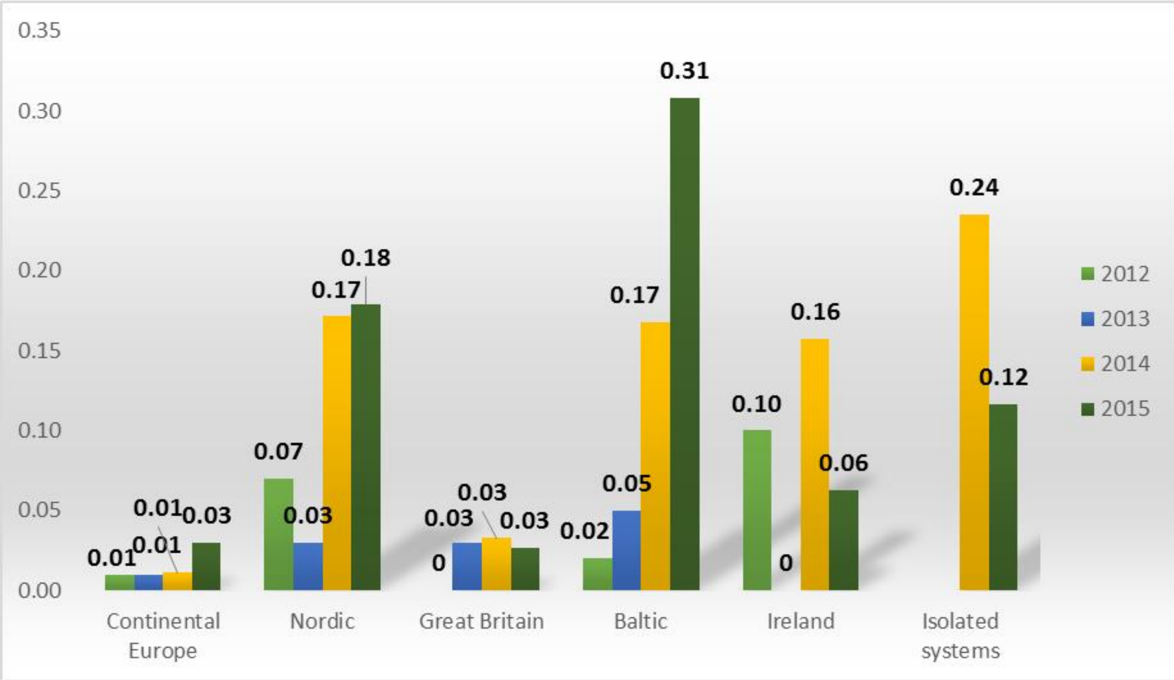
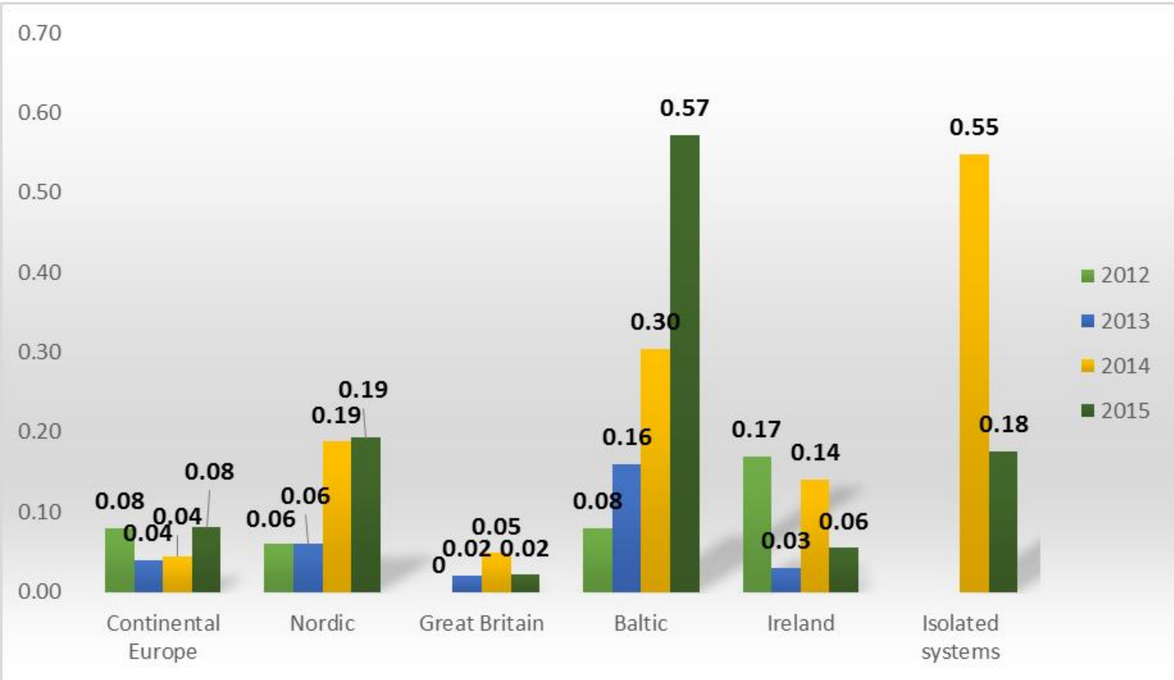


Figure 15. Number of scale 1 incidents per 1 TWh of energy consumption.



The data for synchronous areas is not directly comparable because the network design is adapted to the specificity of the countries, the energy mix. Additionally, the operational conditions (for example weather) are very different from one synchronous area to another.

OPERATIONAL SECURITY INDICATORS

List of 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 by 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 by 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 by 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: duration of being in operational states other than the normal state; it is calculated by 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: duration within which there was a lack of reserves identified; it is calculated by adding up all the time with the 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 criterion 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 criterion F1 or F2. The incidents are calculated once per synchronous area. In the case in which two transmission system operators have reported frequency deviation at the same time, it is counted once.
- OS-G2: duration of time 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 criterion F1 or F2. The incidents are calculated once per synchronous area. In the case in which 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 criterion RS2.
- OS-I: number of blackouts involving two or more transmission system operators; it is calculated by adding up all the incidents with criterion OB3.

According to this calculation methodology for the operational security performance indicators, the values for each synchronous area for the year 2015 are shown in table 3.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Table 3. Operational security indicators relevant for operational security for each synchronous area

	Indicator	Continental Europe	Nordic	Great Britain	Baltic	Ireland	Isolated systems
1	**OS-A [Tripped elements]**	128	71	6	15	3	32
2	**OS-B [Tripped PGF]**	0	0	0	0	0	0
3	**OS-C [Energy not supplied MWh]**	4502	933	0	0	101	1585
4	**OS-D [Minutes]**	10334	453	0	0	0	0
5	**OS-E [Minutes]**	283	0	0	0	0	0
6	**OS-F [Incidents]**	21	0	0	0	0	0
7	**OS-G1 [Incidents]**	0	0	0	0	0	0
8	**OS-G2 [Minutes]**	0	0	0	0	0	0
9	**OS-H [Incidents]**	0	0	0	0	0	0
10	**OS-I [Blackouts]**	0	0	0	0	0	0

Note: Load shedding and reduction is not taken into account on OS-C.

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 by adding up all incidents in scale 1, 2, or 3, with dominating or subsidiary criterion with the loss of one transmission system element.
- OPS-1B: the number of events counted by indicator OPS-1A in which a degradation of system operation conditions occurred as a result of unexpected discrepancies of demand or generation forecast; it is calculated by adding up all incidents in scale 1, 2, or 3 with dominating or subsidiary criterion OR1 and the 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 by adding up all incidents in scale 1, 2, or 3, with any dominating or subsidiary criterion 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 by adding up all incidents in scale 1, 2, or 3 with dominating or subsidiary criterion OR1 and the 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 by adding up all incidents with the lack of reserves identified in any incident in scale 1, 2, or 3 with dominating or subsidiary criterion OR1.

According to this calculation methodology for the operational security performance indicators, the values for each synchronous area for the year 2015 are shown in table 4.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

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

	Indicator	Continental Europe	Nordic	Great Britain	Baltic	Ireland	Isolated Systems
1	**OPS-1A [Incidents]**	84	54	5	15	3	7
2	**OPS-1B [Incidents]**	0	0	0	0	0	0
3	**OPS-2A [Incidents]**	6	13	1	0	0	6
4	**OPS-2B [Incidents]**	0	0	0	0	0	0
5	**OPS-3 [Incidents]**	4	0	0	0	0	0

Evolution from 2013 to 2015

Figures 16 to 21 show, as far as possible, the non-zero comparison between the values calculated for 2013, 2014, and 2015. The values for 2013 can be considered the starting point to analyse trends in the following years.

Several load shedding and reduction events were not taken into account to calculate OS-C. Energy not supplied due to load shedding and reduction was 48500 MWh.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 16: Operational security indicator OS-A.

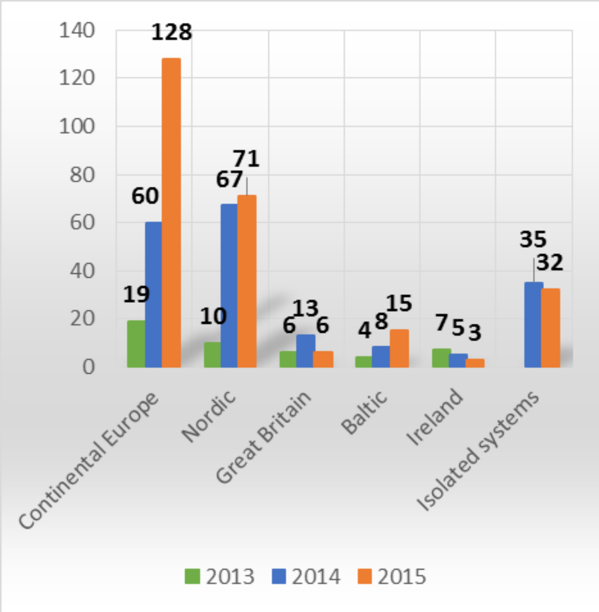


Figure 17: Operational security indicator OS-C.

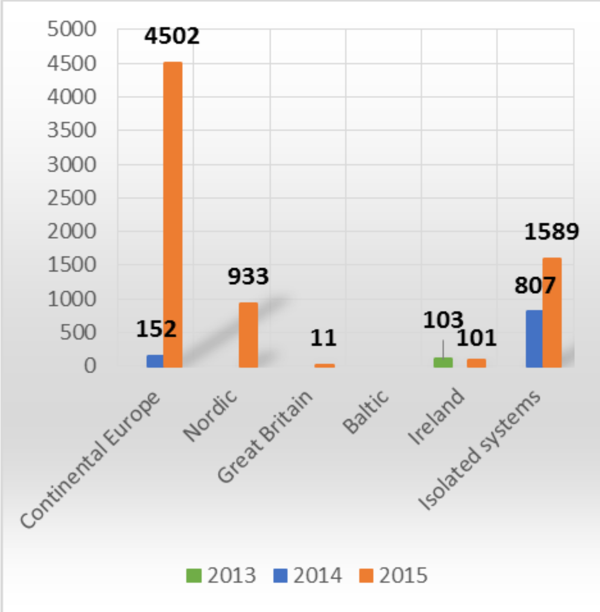


Figure 18: Operational security indicator OS-D.

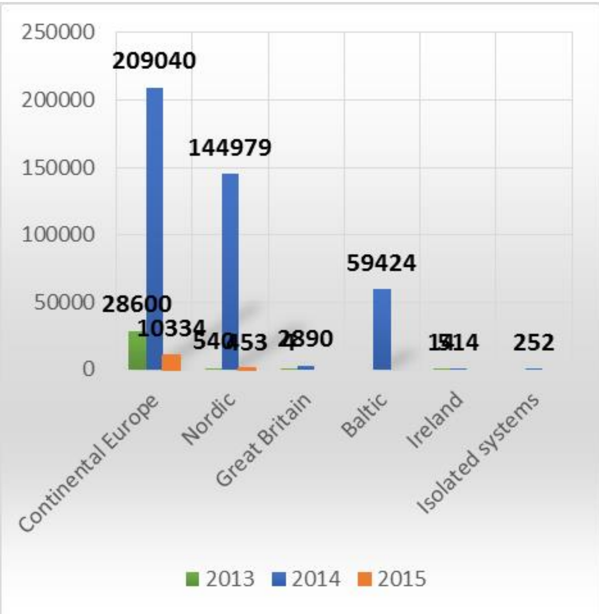
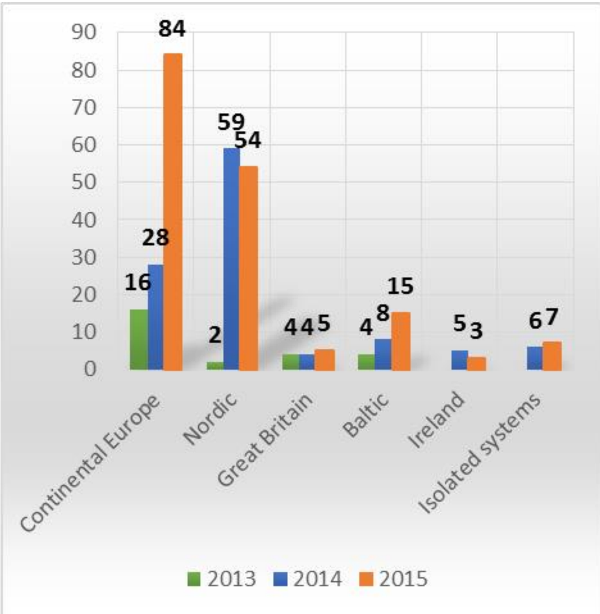


Figure 19: Operational security indicator OPS-1A.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 20: Operational security indicator OPS-2A.

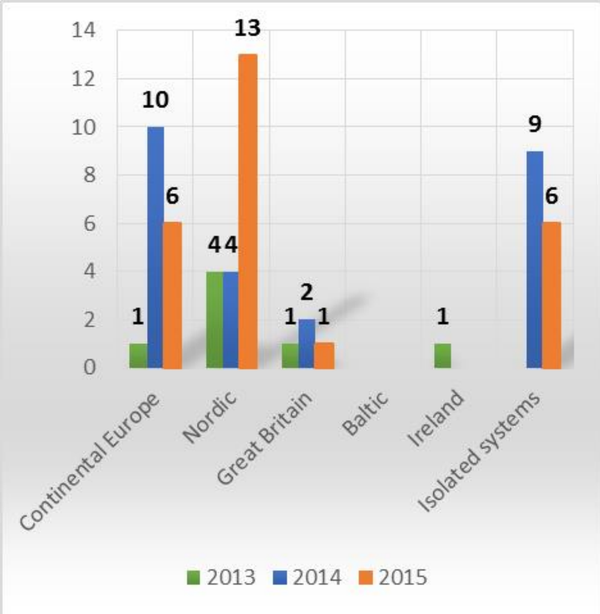
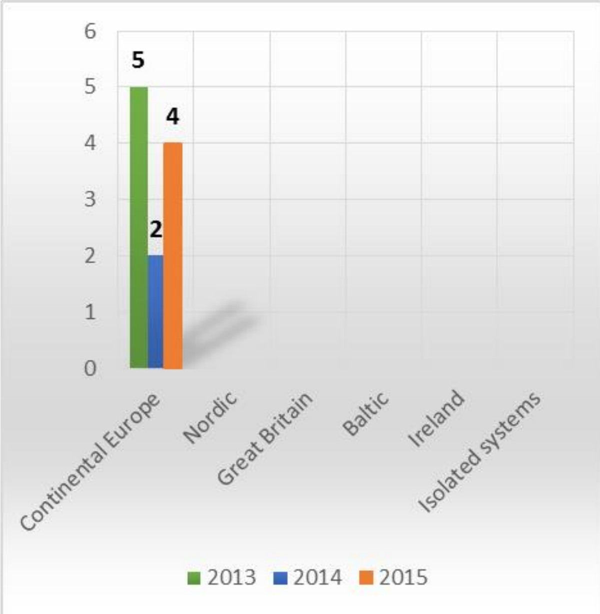


Figure 21: Operational security indicator OPS-3.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

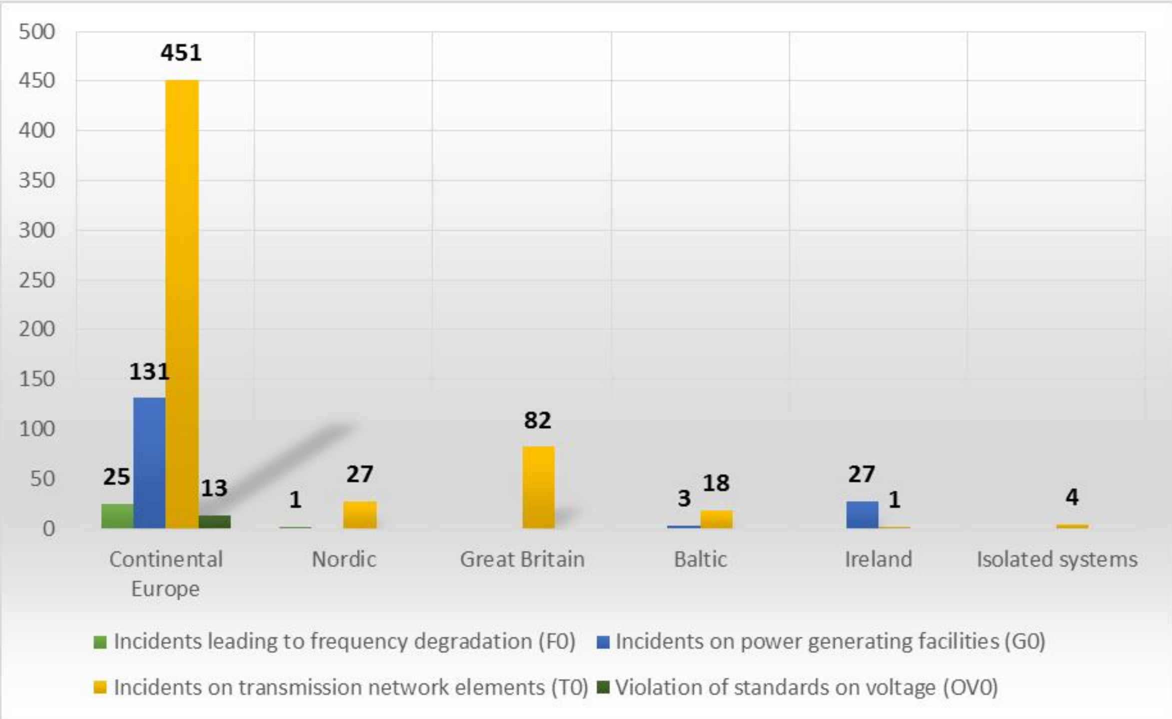
SCALE 0 INCIDENTS

Overview

In 2015, disturbances on transmission network equipment made up the largest part, 74% of the incidents classified as scale 0 incidents – similar to year 2014 when the percentage was 79% and 2013 when the percentage was also 74%.

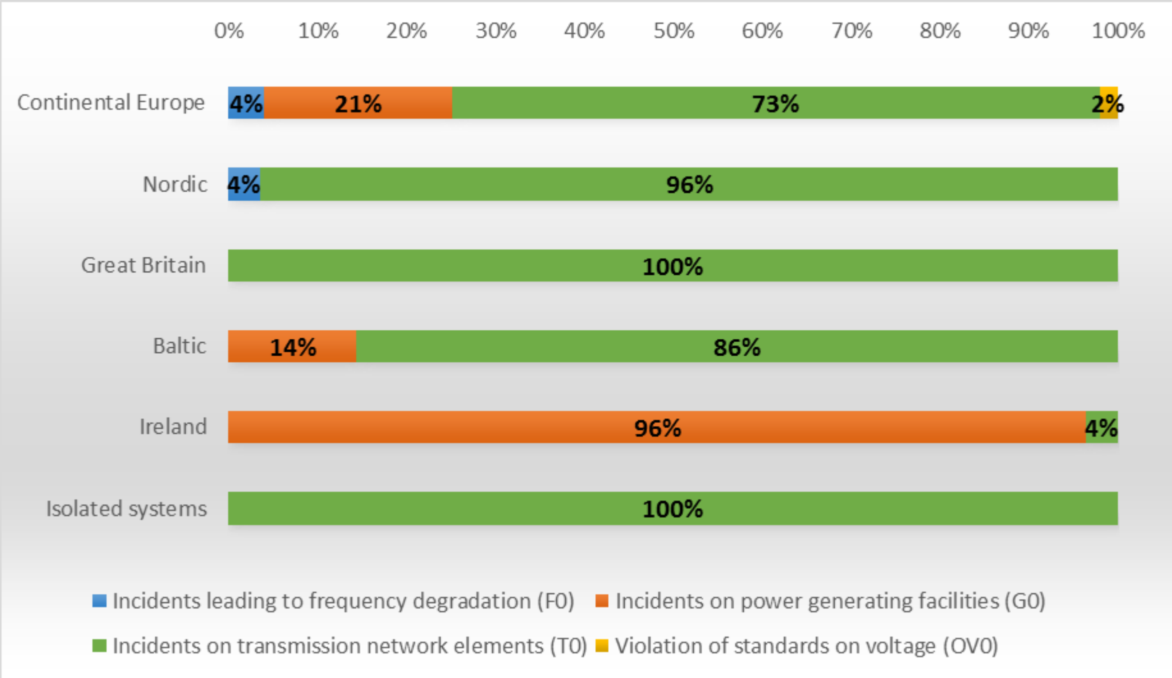
The next largest group of incidents were the disturbances on power generating facilities that made up 21% of the scale 0 incidents; in 2014, the percentage was 12%, and in 2013, the percentage was 19%.

Figure 22. Scale 0 incidents by criteria for each synchronous area.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 23. Percentage of scale 0 incidents by criterion for each synchronous area.



Of the scale 0 incidents, 95% were final tripping of equipment or loss of generation.

Synchronous areas other than Continental Europe are not directly comparable with the synchronous area of Continental Europe, as the thresholds for classifying an incident on power generating facility as scale 0 incident are larger compared to the overall system demand. Therefore, most generator trips in these systems are qualified as scale 0 events, whereas this would not be the case in larger power systems with more interconnections. For this reason, the number of scale 0 events per 100 km of circuit and 1 TWh of consumption for these systems are also not directly comparable with those of other systems.

The big increase in the number of incidents under criterion F0 in Continental Europe from 2014 to 2015 was recorded due to the improvement of the cooperation between the Incident Classification Scale subgroup and System Frequency subgroup that gathers the information regarding the incidents leading to frequency degradation.

In the previous year (2014), Nordic transmission system operators reported 44 violations of standards on voltage (OV0). As a result of the increased focus on the voltage regulation in the control centres, the commissioning of the new HVDC interconnector between Denmark and Norway (Skagerrak 4), and the commissioning of reactors and synchronous machines in Denmark, the number of OV0 incidents was reduced to zero in 2015.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Evolution from 2013 to 2015

Figure 24. Disturbances on transmission network equipment (T0).

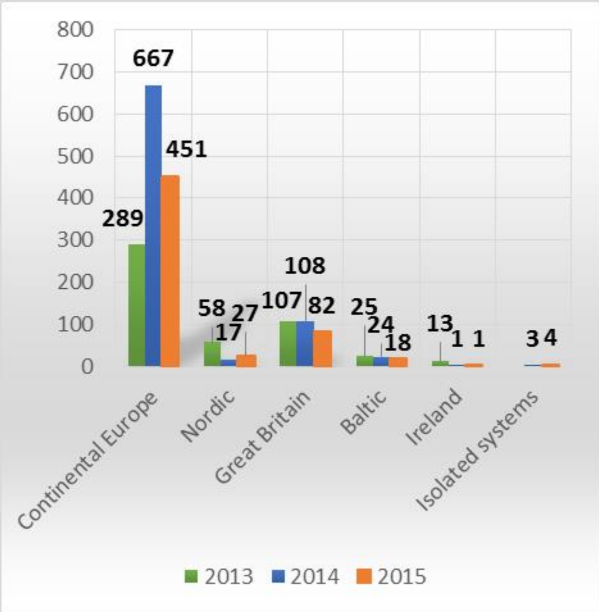


Figure 25. Disturbances on power generating facilities (G0).

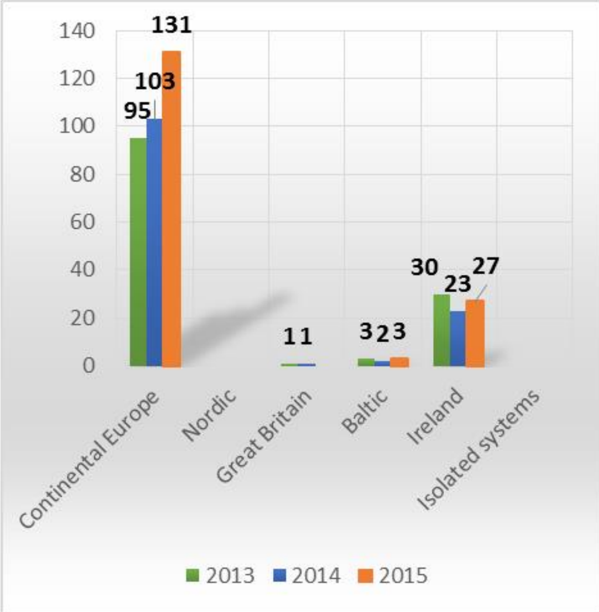


Figure 26. Disturbances leading to frequency degradation (F0).

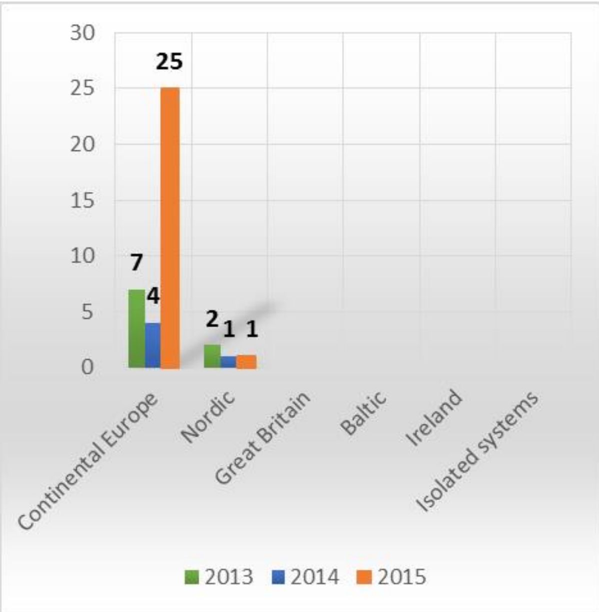
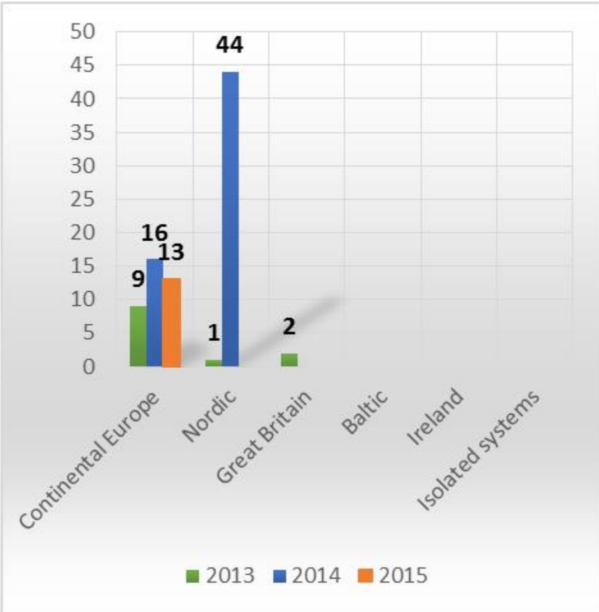


Figure 27. Violation of standards on voltage (OV0).



SCALE 1 INCIDENTS

Overview

In 2015, 297 scale 1 incidents were reported by 22 transmission system operators. In comparison, 220 incidents were reported in 2014 (increase of 35%). Scale 1 incidents were caused predominantly by events on transmission network elements and N-1 violations.

No scale 1 disturbances leading to frequency degradation or on power generating facilities occurred in 2015.

Figure 28. Scale 1 incidents by criterion.

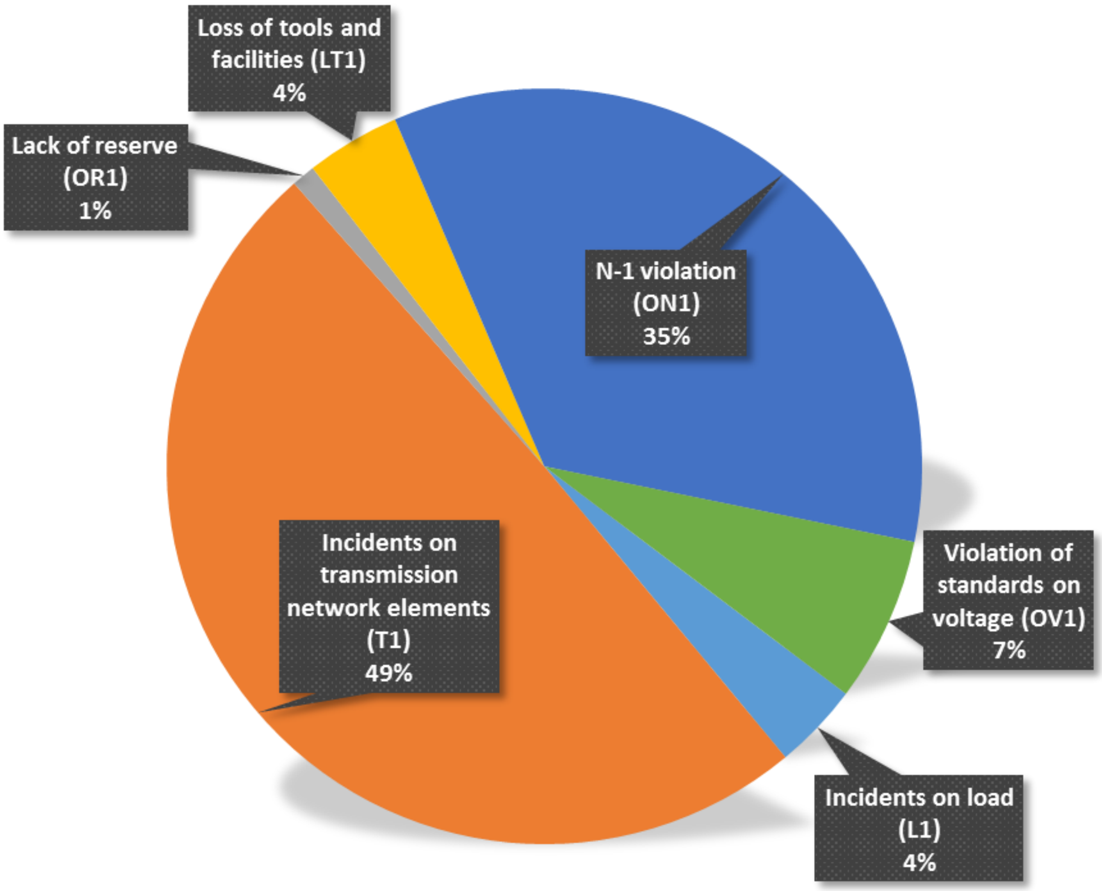
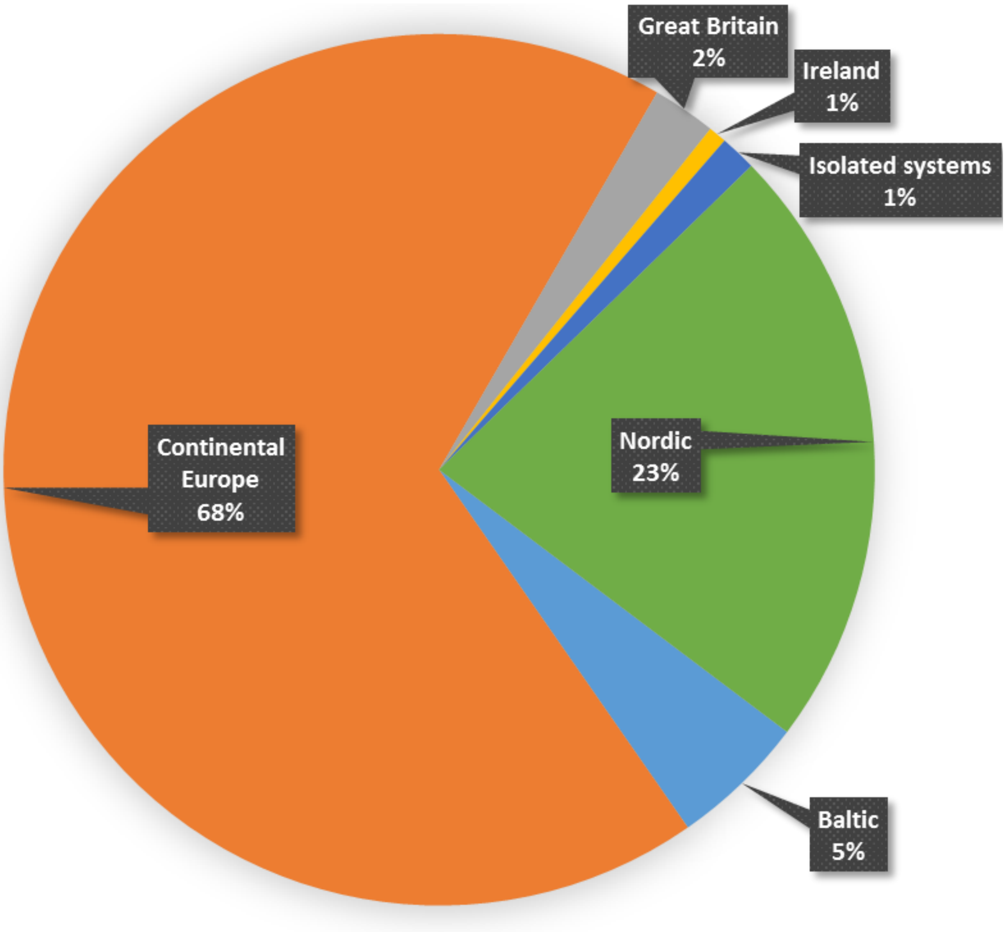


Table 5. Scale 1 incidents by criterion in each synchronous area.

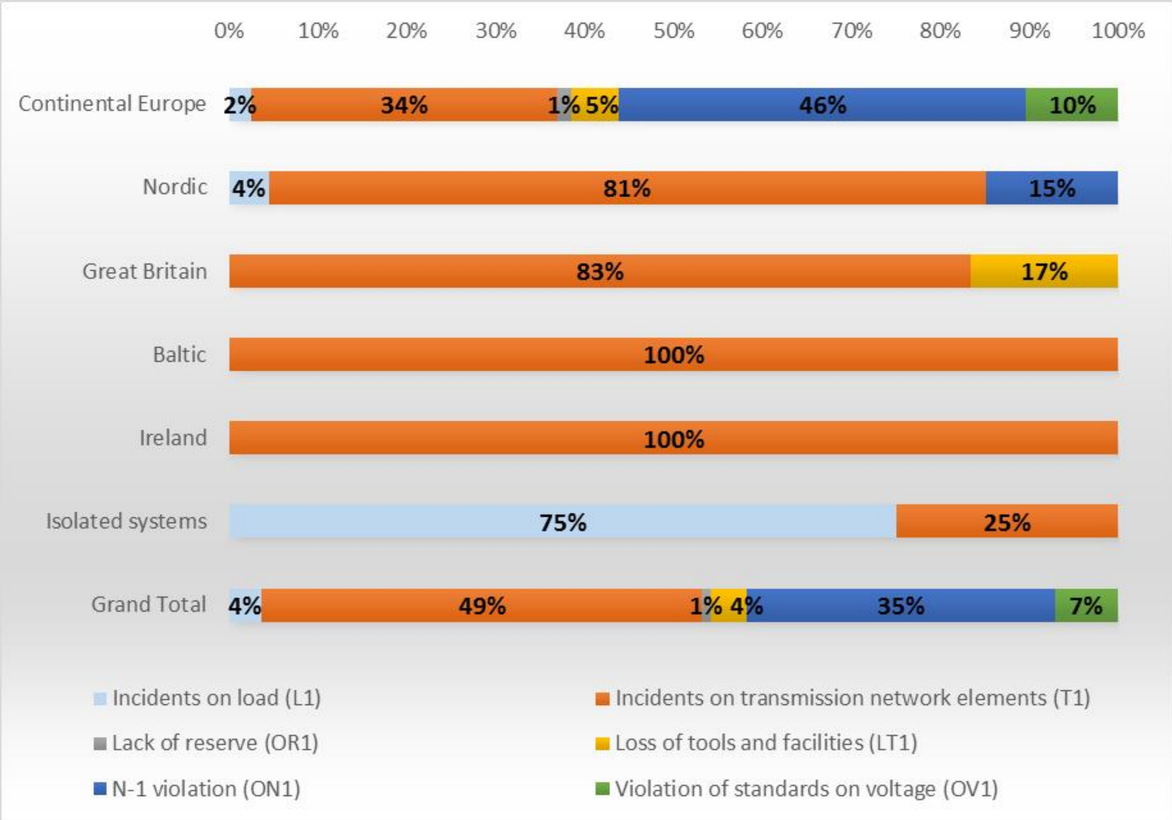
	Continental Europe	Nordic	Great Britain	Baltic	Ireland	Isolated Systems	Grand Total
Incidents on load (L1)	5	3				3	**11**
Incidents on transmission network elements (T1)	70	54	5	15	2	1	**147**
N-1 violation (ON1)	93	10					**103**
Violation of standards on Voltage (OV1)	21						**21**
Lack of reserve (OR1)	3						**3**
Loss of tools and facilities (LT1)	11		1				**12**
Grand Total	**203**	**67**	**6**	**15**	**2**	**4**	**297**

Figure 29. Distribution of scale 1 incidents by synchronous areas.



The majority of the reported scale 1 incidents (270 of 297) occurred in the Continental Europe and Nordic synchronous areas.

Figure 30. Percentage of the recorded scale 1 incidents by synchronous area.

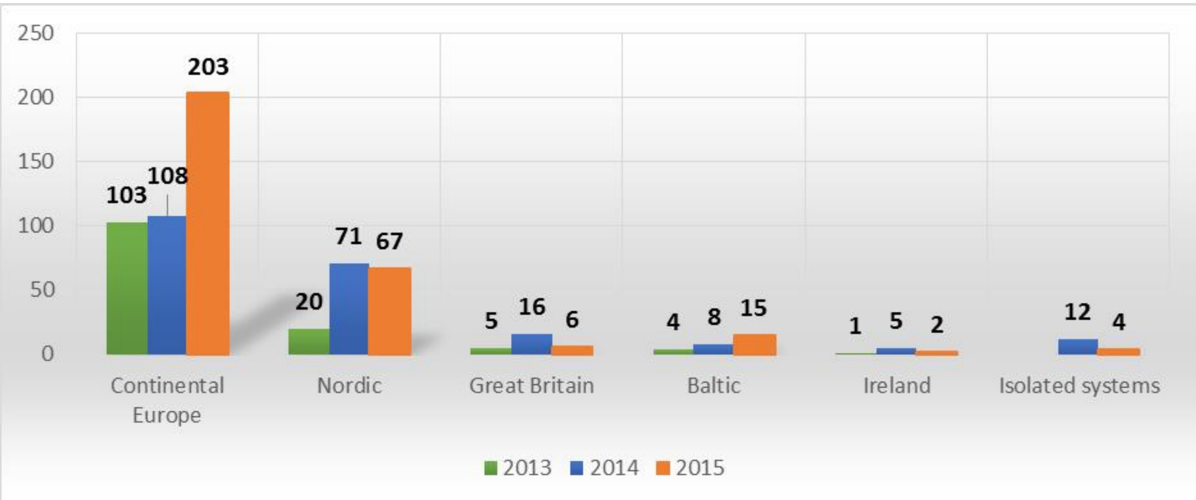


In the Baltic and Irish synchronous areas, all scale 1 incidents were incidents on transmission network elements (T1).

Evolution from 2013 to 2015

The reporting of scale 1 incidents in Continental Europe and the Baltic region doubled in 2015 compared to the previous two years.

Figure 31. Number of scale 1 incidents by synchronous area from 2013 to 2015.



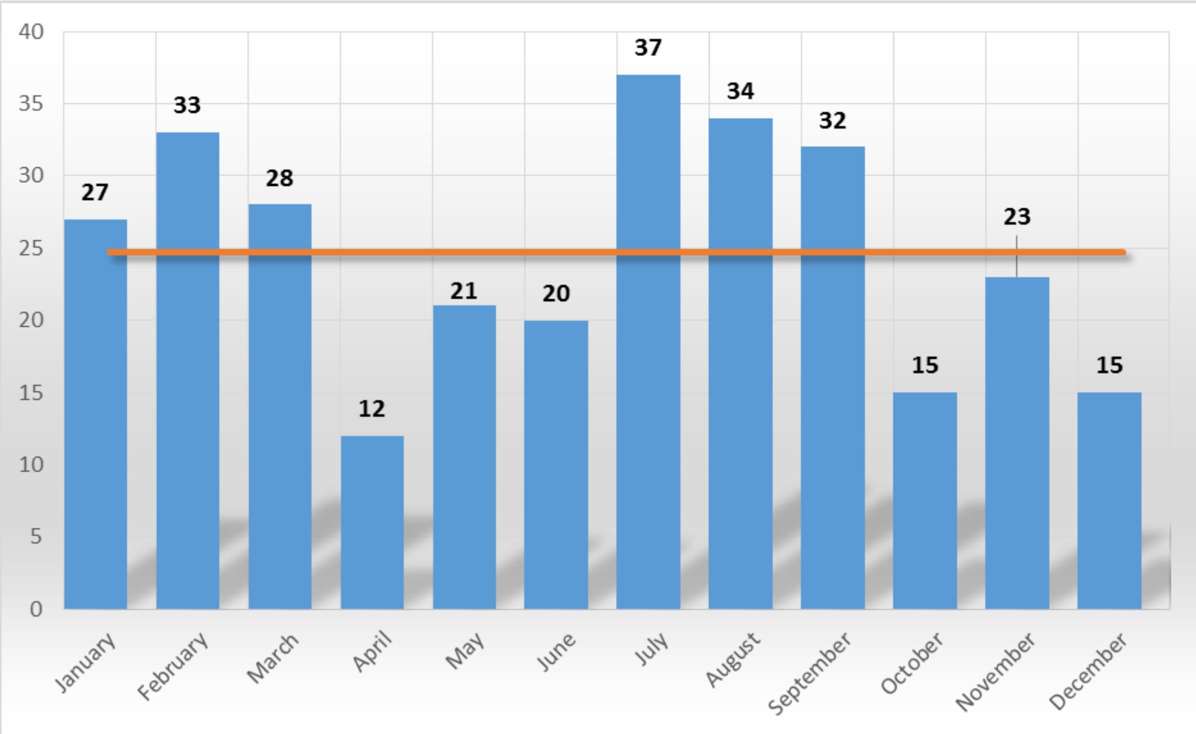
ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Monthly distribution of scale 1 incidents

Figure 32 shows the number of scale 1 incidents recorded in each month of 2015.

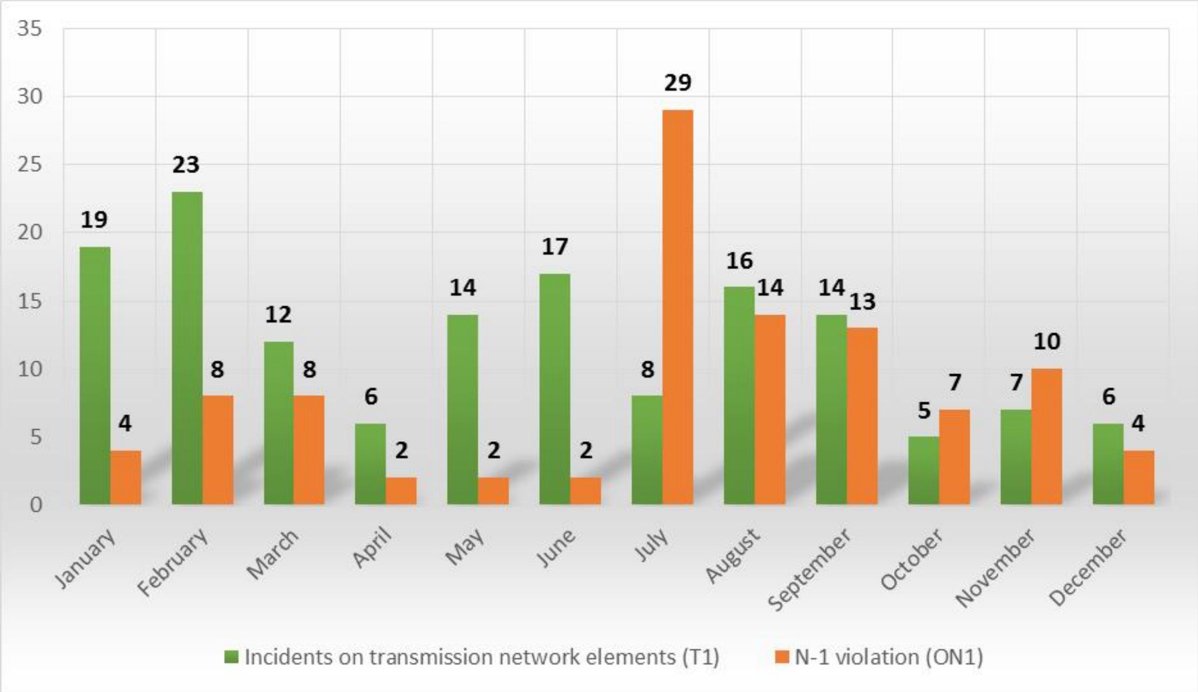
The largest number of incidents occurred in February and from July to September. The month with the highest number of incidents was July when 78% of the recorded incidents were N-1 violations and the remaining disturbances were on transmission network elements. On average, there were 25 scale 1 incidents per month recorded in 2015. Moreover, 28% of all the N-1 violations occurred in July, while the incidents on transmission network elements were most common in February, as shown in figure 33.

Figure 32. Monthly distribution of scale 1 incidents.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

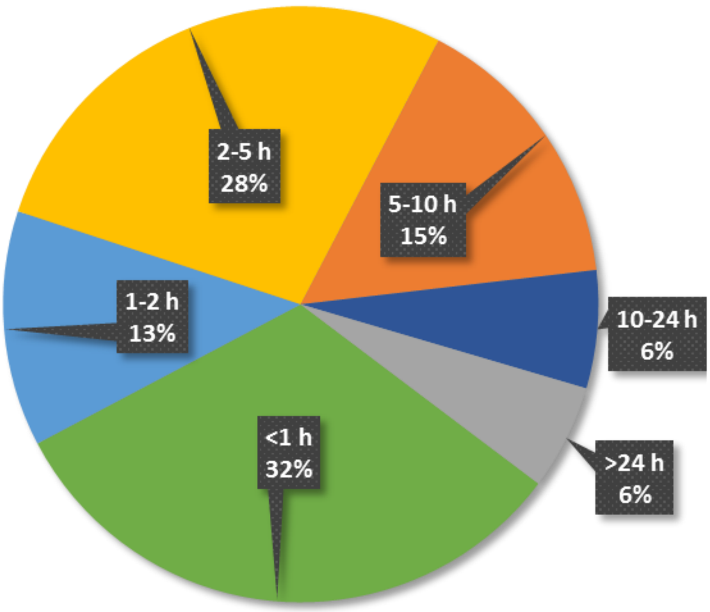
Figure 33. Monthly distribution of scale 1 incidents on transmission network elements and N-1 violations.



Duration of incidents

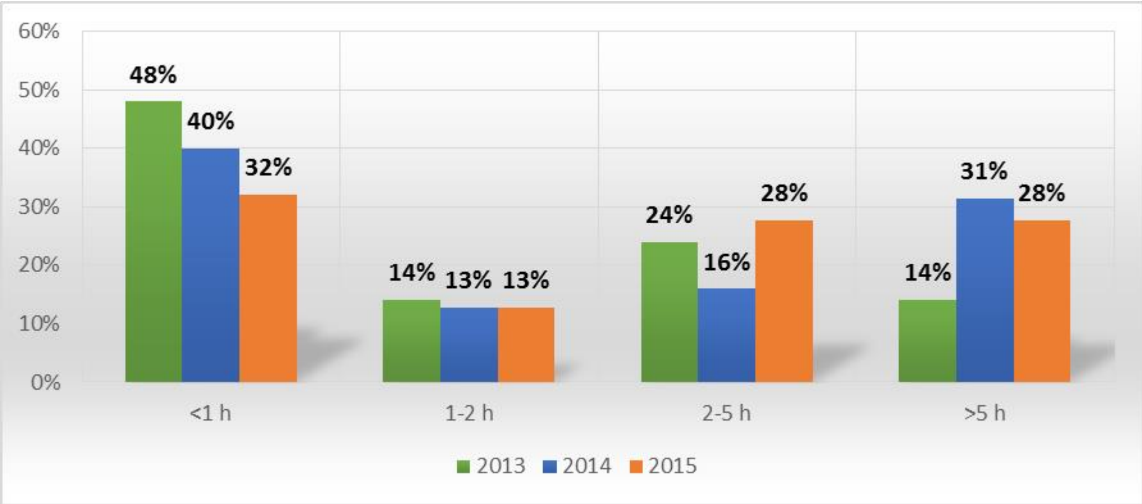
As in the previous years, the duration of scale 1 incidents had a wide range. Furthermore, 32% of scale 1 incidents lasted less than 1 hour, while 27% of incidents had durations longer than 5 hours.

Figure 34. Duration of scale 1 incidents.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

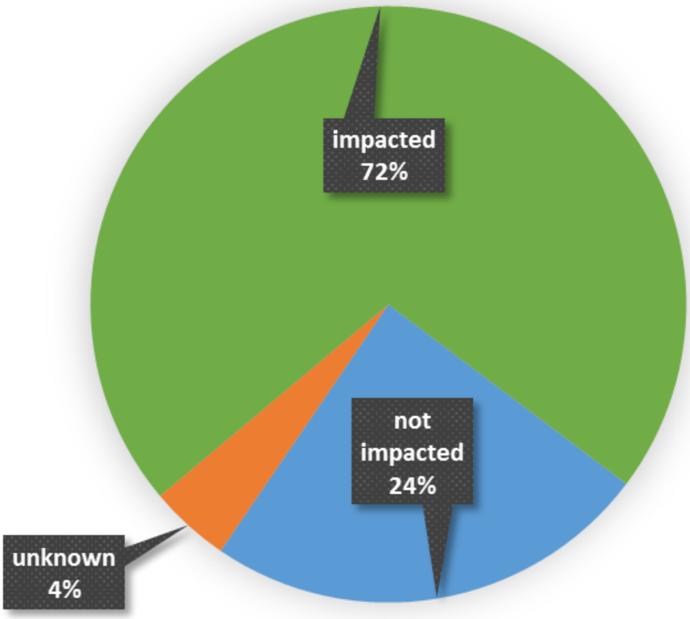
Figure 35. Comparison of scale 1 incident duration from 2013 to 2015.



Impact on other transmission system operators

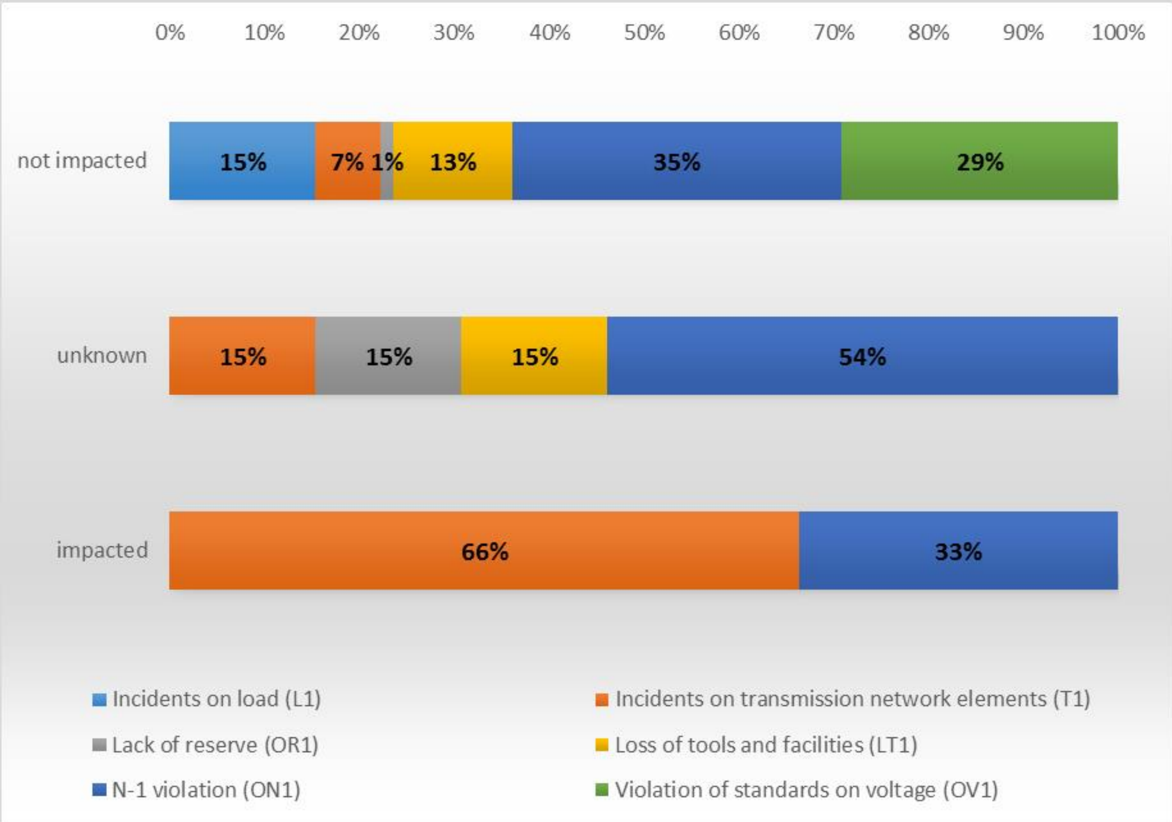
In addition, 72% of the reported scale 1 incidents affected one or more transmission system operators in control areas other than the control area where the incident occurred (according to assessment of the reporting transmission system operator). For 24% of the incidents, there was no impact identified outside the transmission system operator control area. For the rest of the reported scale 1 incidents, the impact on the other transmission system operators was unknown.

Figure 36. Impact on other transmission system operators.



Additionally, 66% of the scale 1 incidents that affected the control areas of other transmission system operators were incidents on transmission network elements (T1), while 33% of the incidents were N-1 violations (ON1), and the rest of the incidents (below 1%) with impact outside own control area were recorded under the criterion for loss of tools and facilities (LT1).

Figure 37. Impact on other transmission system operators by dominating criterion.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

N-1 violations

There were 103 N-1 violations recorded in 2015 by nine transmission system operators – 93 in Continental Europe and 10 in the Nordic synchronous area. The largest number of N-1 violations occurred from July to September 2015.

A notable increase – 129% – of N-1 violations was recorded from 2014 to 2015 after the decrease from 2012 to 2014.

Figure 38. N-1 violations 2012–2015.

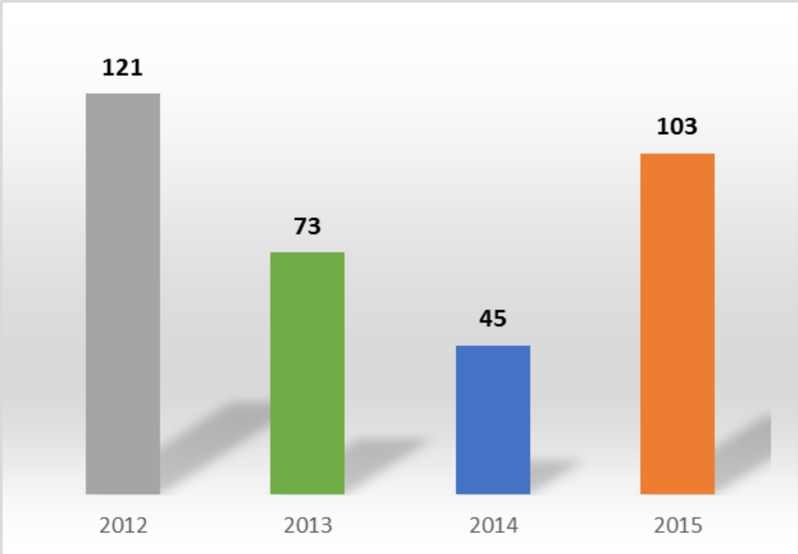
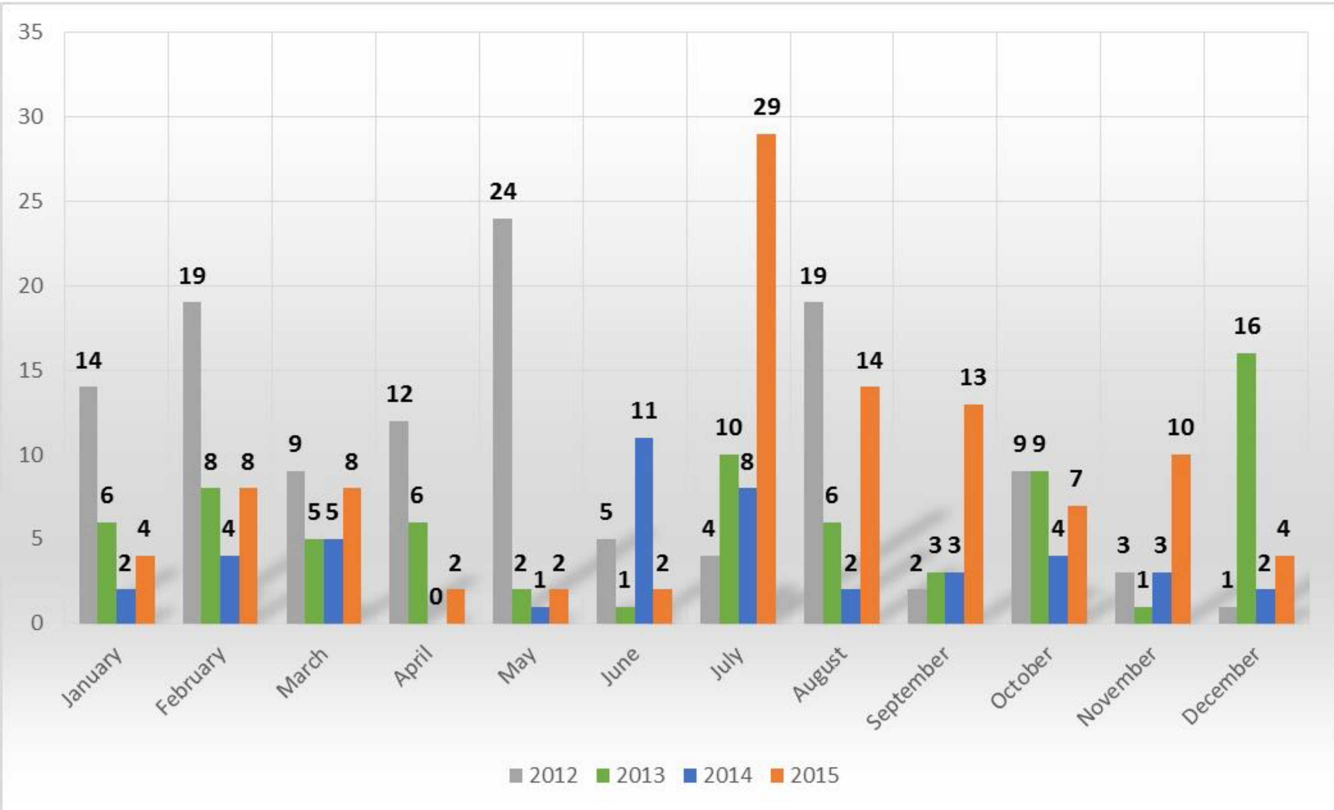


Figure 39. Monthly occurrence of reported N-1 violations from 2012–2015.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

The N-1 violations lasted from 17 minutes to 20 hours. About 79% of the N-1 violations lasted less than 5 hours, while the average duration of all the N-1 violations was 3.7 hours.

The share of N-1 violations that lasted more than 5 hours decreased compared to the previous year (from 33% to 22%). The causes for those N-1 violations were analysed to identify the ways to reduce the duration and occurrence of this kind of violation in the future.

Figure 40. Duration of N-1 violations.

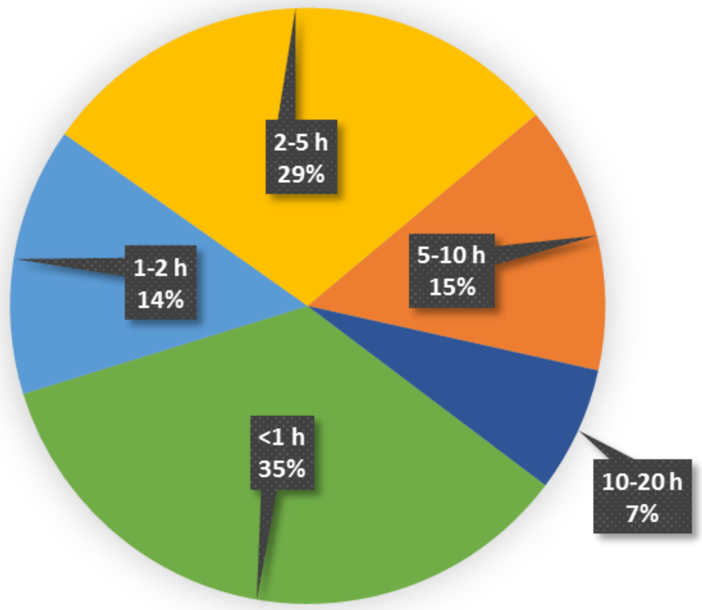
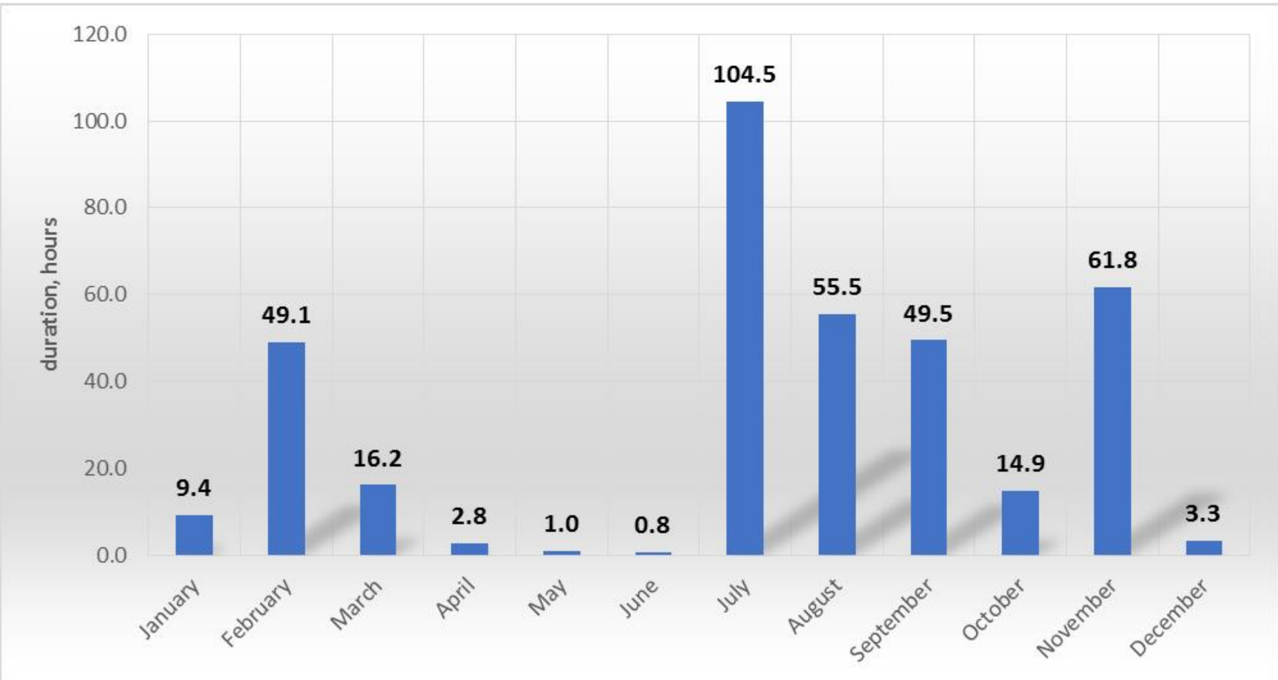


Figure 41. Total duration of N-1 violations by month (in hours).



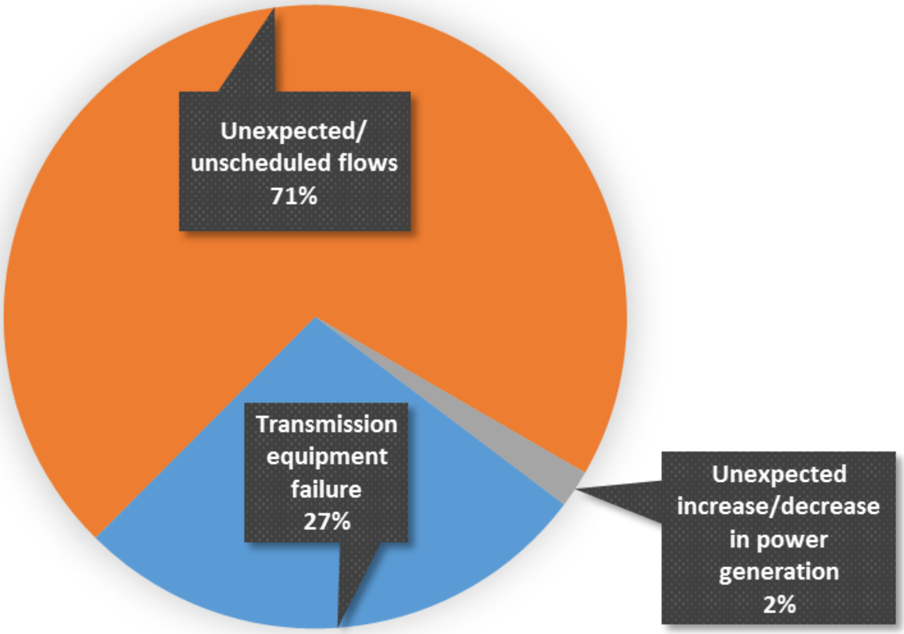
ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Similar to the last year, the unexpected and/or unscheduled flows were the main cause of N-1 violations (71%). The other N-1 violations were caused by transmission equipment failure (27%) and unexpected increase or decrease in power generation (2%).

In nearly the whole summer of 2015 (from June to mid-September) the whole of Europe experienced very high temperatures. This led to larger unavailability of conventional power plants in Central East Europe due to the lack of cooling water, especially in Poland, which caused the reduction of available power for redispatching. This, together with unscheduled load flows from Germany through Poland and the Czech Republic, caused a very tense grid situation in these countries. In addition, the Czech Republic was also affected by unexpected flows.

Due to the described difficulties, the number of N-1 violations increased in 2015 significantly compared to 2013 and 2014.

Figure 42. Causes of N-1 violations.



Fourteen out of the 15 prolonged N-1 violations were caused by unscheduled or unexpected flows, and one N-1 violation that lasted more than 5 hours was caused by transmission equipment failure. In each N-1 violation case, all available remedial actions were used to return the system to the normal state.

Unexpected flows are the result of a combination of different reasons that raise the level of uncertainty in all of the operational planning stages – increasing shares of variable renewable energy sources, complex interdependencies between the different transmission systems, and shorter market time intervals combined with changes on the market closer to real time (intraday market trades). As a consequence, it is more challenging to forecast the physical flows, and transmission system operators have less time to assess and coordinate the remedial actions necessary to avoid or resolve N-1 violations.

Reducing the occurrence of unexpected flows requires a higher level of coordination between transmission system operators in all operational planning phases, but especially

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

in intraday, and access to more accurate forecasts and schedules.

Unexpected flows are the difference between measured and expected physical flows. They originate in the independency of market activities from the underlying physical principles regarding load flow.

A closer link between the physical and scheduled flows could be achieved through a harmonised all-area approach for the coordinated capacity. Improvement in the coordinated processes for capacity calculation between operators or bidding zones, flow-based capacity calculation, further reinforcement of interconnections, and the harmonisation between markets could reduce the number of N-1 violations at tie-lines.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

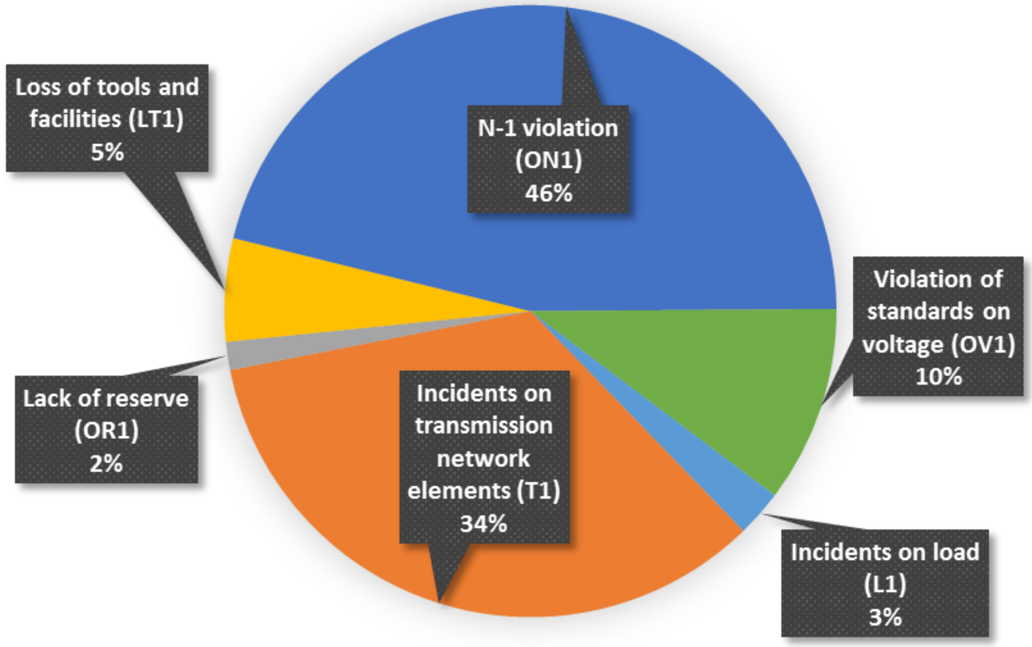
REGIONAL OVERVIEW

Incidents in Continental Europe

In Continental Europe, 203 scale 1 incidents were recorded, representing 68% of all the scale 1 incidents, compared to 49% in 2014.

Moreover, 80% of scale 1 incidents in Continental Europe were N-1 violations or incidents on transmission network elements.

Figure 43. Scale 1 incidents in Continental Europe by criterion.



In 2015, 21 scale 1 incidents on violation of standards on voltage (OV1), which represent 10% of the scale 1 incidents in Continental Europe, were reported. The main reason for these incidents was the unavailability of sufficient reactive compensation during low demand.

The N-1 violations (ON1) had the highest share of scale 1 incidents, mainly caused by unexpected or unscheduled flows. In addition, 46% of the scale 1 incidents (93) were N-1 violations (ON1).

Furthermore, 34% of the scale 1 incidents were incidents on transmission network elements (T1).

Moreover, 3% of scale 1 incidents were on load (L1), which is a significant increase compared to 1% of scale 1 incidents in 2014. The reason for the increase was the change in the methodology – according to the current methodology, the incidents that were previously reported as scale 0 incidents on load are now reported as scale 1 incidents. The criteria for scale 0 incidents

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

on load does not exist in the current methodology.

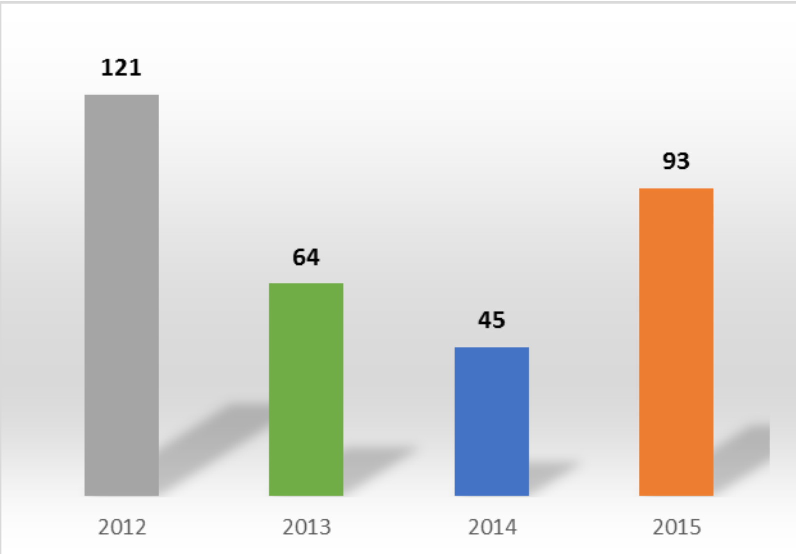
On 27 March 2015, the Netherlands experienced their first large power failure over the last 18 years, interrupting the flow of electricity to approximately one million households for several hours. The outage with a loss of load of almost 1500 MW occurred during maintenance at a 380 kV substation in Diemen. The loss of load was less than 10% of the total amount of load at the time of the incident; therefore, the incident was classified as a scale 1 incident on load.

A significant and important improvement can be noticed regarding the loss of tools and facilities (LT1). There was a decrease from 19% for 2014 compared to 5% for 2015 for loss of tools and facilities incidents. The percentage of the incidents resulting in lack of reserve (OR1) remained the same compared to last year – 2%.

In Greece, two units (about 800 MW capacity) were unavailable for four days. This was caused by a gas shortage that occurred at the west branch of the gas supply system.

No scale 1 disturbances leading to frequency degradation were reported in 2015.

Figure 44. N-1 violations in Continental Europe 2012–2015.



In Poland, there were severe conditions in August 2015. A long heatwave caused a gradual increase of non-usable capacity. As a result of the rapid growth of outages on the evening of 9 August and the morning of 10 August, it was not possible to cover the forecasted load with generation capacities available within Poland and with available imports with a sufficient level of reserves. Therefore, the Polish transmission system operator (PSE), according to the Polish legislation, implemented load reduction in the peak hours of 10 August for industrial consumers. The situation continued until 12 August. During these days, there was no possibility to offer any import capacity to the market on a synchronous profile (with Germany, the Czech Republic, and Slovakia) because of the congested Germany-Poland border due to high unscheduled flows through Poland from the west to the south. Thus, at the same time as the load reductions, a massive multilateral redispatching (up to 4 GW) with sources in

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Austria, Slovenia, Switzerland, and west of Germany and the sink in the east of Germany was activated by PSE on these days to ensure the compliance with N-1 criterion on the border between Germany and Poland.

From June to September, the amount of energy required to limit the flows on the congested Germany-Poland border was seven times higher compared to the same period in 2014 and 78 times higher compared to the summer of 2013. Additionally, the level of used redispatching power increased significantly. On 15 September, it was the highest ever and amounted to 6237 MW. Even with such an unprecedented level of power, it was not enough to limit unscheduled flows to a safe level, and that day for more than 4 hours, the N-1 criterion on the Germany-Poland border was not fulfilled, as there were no other operational measures to keep the system safe.

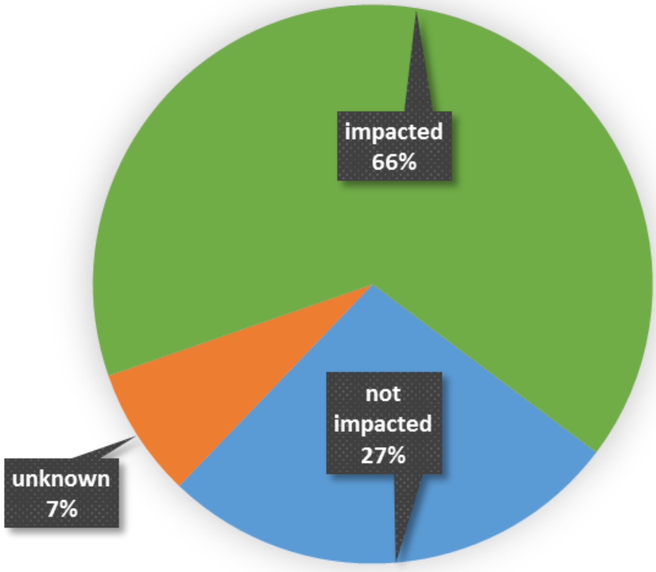
The comparison with 2012 shows a smaller number of N-1 violations for 2015, but compared with 2013 and 2014, the number of N-1 violations increased to 93, compared to 64 in 2013 and 45 in 2014.

In 61 cases out of the 93 N-1 violations, the impact was identified for more than one transmission system operator. This indicates that the majority of N-1 violations occurred at or near the border between transmission system operators. Improvement in the coordinated processes for capacity calculation between operators or bidding zones, flow-based capacity calculation, further reinforcement of interconnections, harmonisation between markets, or introducing one common market could reduce the number of N-1 violations at tie-lines.

The percentage of N-1 violations with unknown influence to other transmission system operators reduced compared to 2014 from 13% to 7%, showing the improvement in the analysis transmission system operator conduct after N-1 violations.

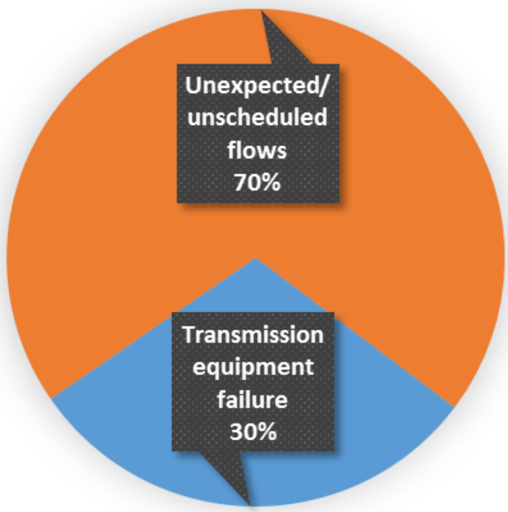
ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 45. Impact of N-1 violations on other transmission system operators in Continental Europe.



Unexpected or unscheduled flows are the main cause of 70% of all the N-1 violations, followed by transmission equipment failure (30%). A minor share of N-1 violations were caused by the change of topology and unexpected increase of power of production facilities which leads to a conclusion that transmission system operators have well determined and sufficient power reserves to cover such incidents.

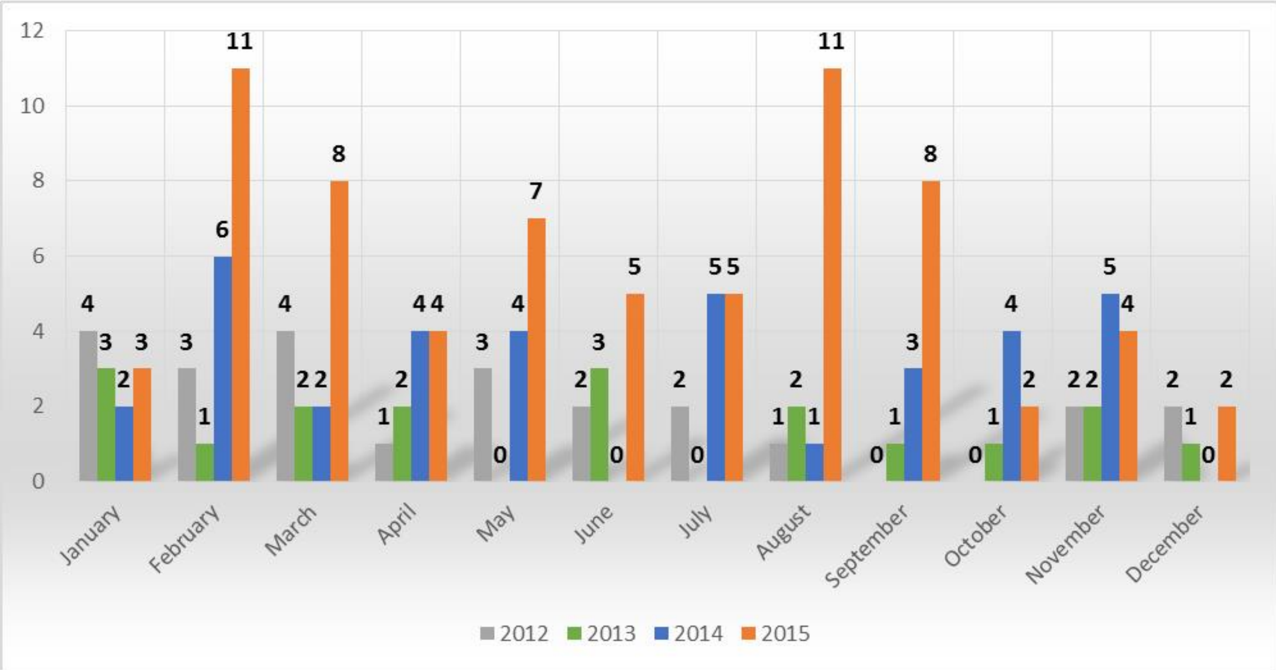
Figure 46. Causes for N-1 violations in Continental Europe.



Regarding the number of incidents on transmission network elements, a notable number of incidents occurred in February and August, which could be linked to the peak temperatures (both low and high) occurring in these periods.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

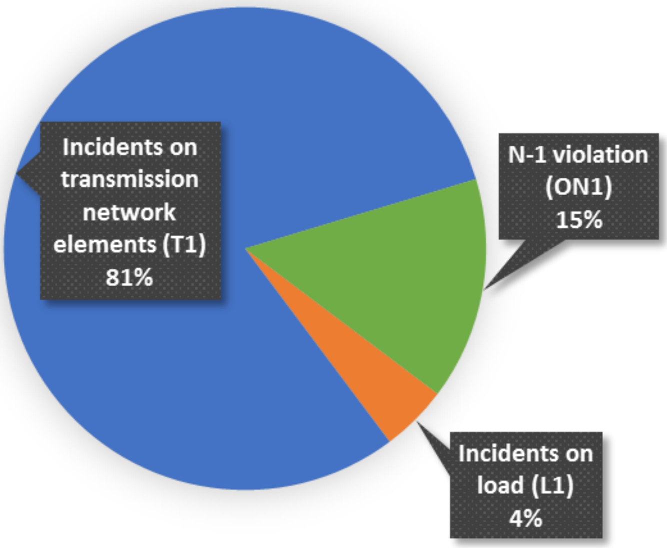
Figure 47. Incidents on transmission network elements – number of incidents per month.



Incidents in the Nordic area

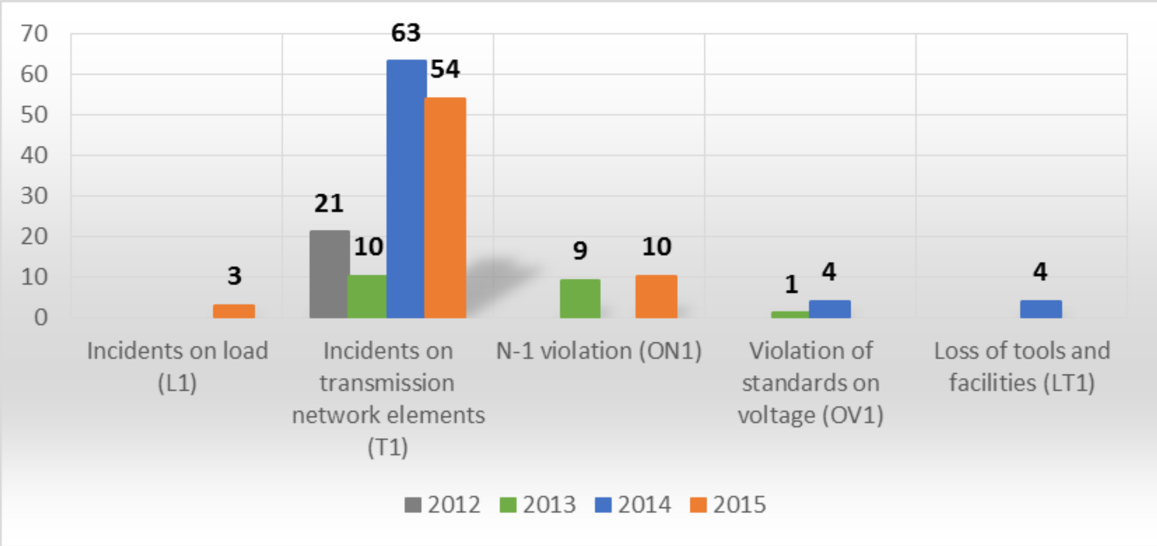
There were 67 scale 1 incidents recorded in the Nordic synchronous area. The majority of the incidents (54 incidents – 81%) were classified as incidents on transmission network elements (T1).

Figure 48. Scale 1 incidents in Nordic synchronous area.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Figure 49. Scale 1 incidents in Nordic synchronous area 2012–2015.



All 54 incidents on transmission network elements led to the reduction of the cross-border exchange capacity. Furthermore, 87% of these incidents were on HVDC links.

The N-1 violations were reported on 10 occasions in the Nordic area. All of these violations were negligible overloads between transmission system operators.

Three scale 1 incidents on load occurred in the Nordic synchronous area, in Norway. These incidents are described below.

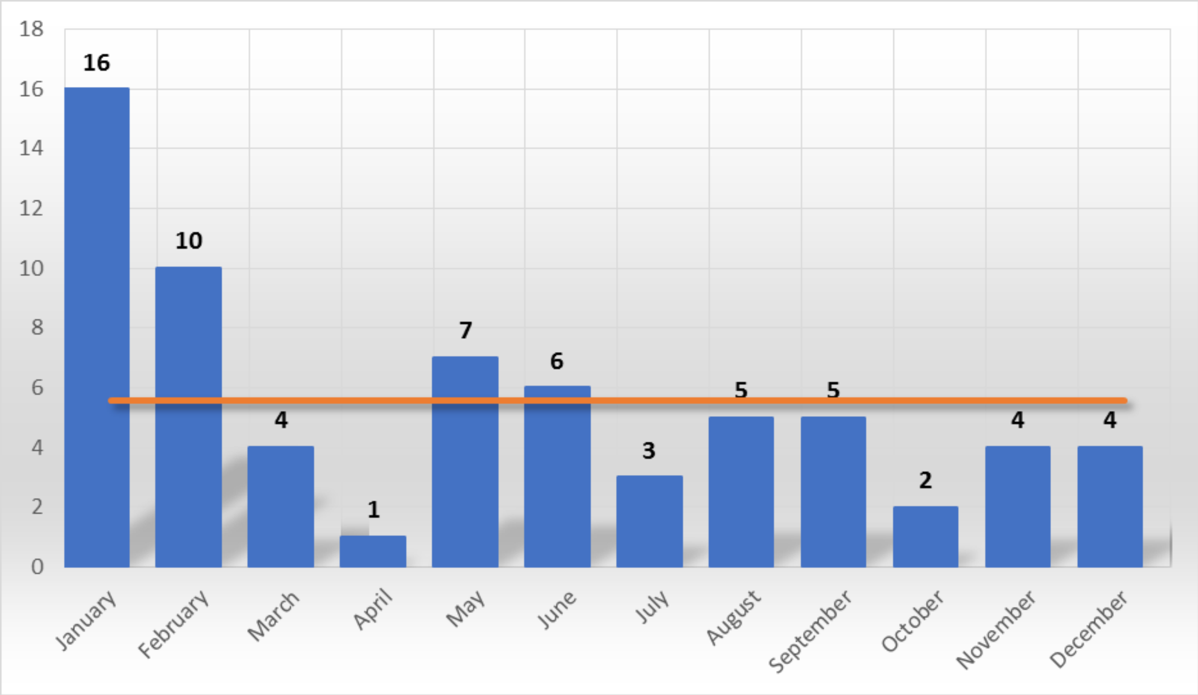
In the end of January 2015 during a storm, the tripping of a 420 kV line in Norway between Ofoten and Kvandal resulted in an N-1 violation, a full transit and overload in the parallel 132 kV network. Shortly after, there was a three-phase fault with unsuccessful disconnection in the 132-kV network, which caused all backup relay functions to also be tripped. The result of these events was islanding, voltage collapse, and a local blackout with disconnected load of 1100 MW.

During maintenance, in mid-November 2015, an outage of all 300 kV feeders on busbar A and B in Smestad occurred due to a SF6-busbar fault (short-circuit). As a result 550 MW of load was disconnected.

In the beginning of December, the transformer protection relay was exposed to extremely high reactive load and caused an outage of 300 kV T2 in Lyse, Norway. It resulted in islanding, voltage collapse, and a local blackout. Due to maintenance, the area had been planned according to N-0 criteria before the incident (compliance with N-1 criteria was not ensured). The amount of disconnected load was 450 MW.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

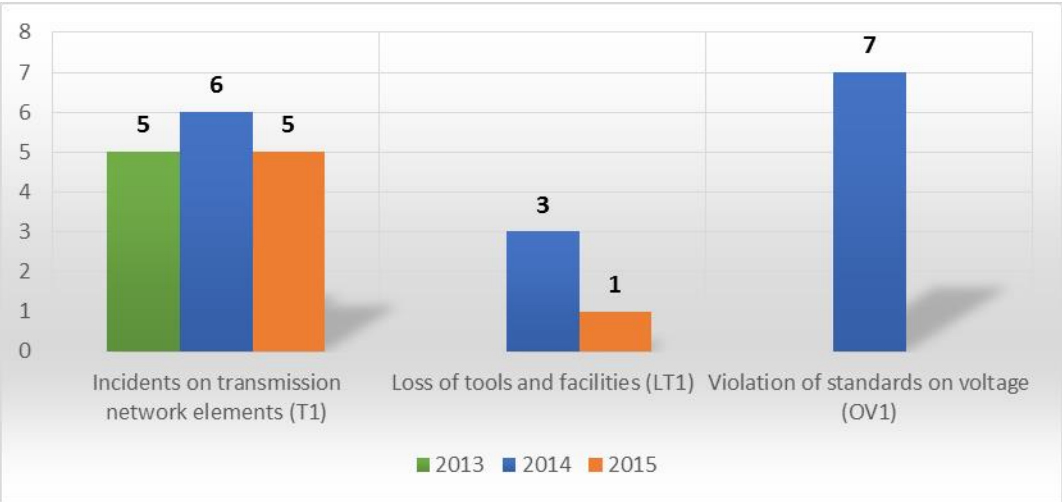
Figure 50. Scale 1 incidents in Nordic synchronous area by month.



Incidents in Great Britain

In Great Britain, six incidents were recorded on scale 1, compared to 16 scale 1 incidents in 2014. Five incidents on transmission network elements (T1) and one occasion of the loss of tools and facilities (LT1) were recorded.

Figure 51. Scale 1 incidents by dominating criterion 2013–2015.



All of the incidents on transmission network elements led to the reduction in the cross-border exchange capacity of the HVDC interconnectors between Great Britain and France (IFA) or Great Britain and Northern Ireland (Moyle).

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

There were two instances when the Moyle HVDC interconnector trip was initiated from the synchronous area of Great Britain: once due to the tripping of equipment on the Scottish Power Transmission network and the other time due to a malfunction in the pole control software of the interconnector. The IFA HVDC interconnector tripped thrice due to a problem associated with the Great Britain end of the interconnector.

As compared to three incidents last year, only one scale 1 incident was recorded under the loss of tools and facilities (LT1) criterion when the balancing mechanism system was lost for 236 minutes.

Incidents in the Baltic area

Fifteen incidents were recorded in the Baltic area on scale 1, compared to eight incidents in 2014 and four incidents in 2013. All scale 1 incidents were classified as incidents on transmission network elements.

Twelve incidents involved the HVDC interconnectors between Estonia and Finland. All of the HVDC cable faults led to a reduction of exchange capability between Estonia and Finland and two HVAC line faults led to the reduction of the transmission capacity between Estonia and Latvia.

Incidents in Ireland

There were two recorded scale 1 incidents in Ireland in 2015. This compares with six such incidents in 2012, one in 2013, and five in 2014.

Both incidents involved the tripping of the East West interconnector (EWIC) between Ireland and Great Britain. These are reported as scale 1 incidents due to the reduction in transmission capacity between Ireland and Great Britain.

There was one scale 2 incident on load in 2015, which was caused by a 110 kV busbar fault on the SONI controlled system. Moreover, 217 MW of load was disconnected for up to 28 minutes. The load disconnected represented more than 10% of the system demand at the time of the incident.

Incidents in the isolated systems

The incidents in the isolated systems are reported starting from 2014.

In total, 11 incidents were recorded in isolated systems compared to 19 in 2014, all incidents were recorded in Iceland.

Four incidents were recorded for both scale 0 and scale 1, and three incidents were recorded in scale 2.

All scale 2 incidents were incidents on load, while all scale 0 incidents were incidents on transmission network elements.

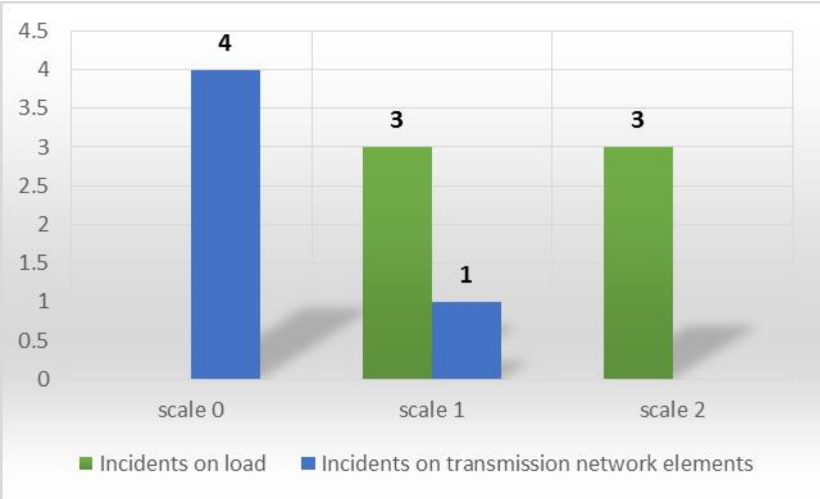
In the end of January, two scale 2 incidents on load were recorded. The first one was caused by an unsuccessful automatic reconnection when, as a result, two generators tripped and caused under-frequency tripping of a power intensive

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

industrial plant. Disconnected load was 356 MW. The second scale 2 incident on load recorded in January was due to a failure in communication; differential relays tripped two transmission lines resulting in an outage of a power station and widespread disconnection of load. Total disconnected load was 341 MW.

In March, during an extreme storm, two transmission lines tripped and resulted in outage of three power intensive industrial plants. Disconnected load was 326 MW.

Figure 52 Incidents in isolated systems.



ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

CONCLUSION

In 2015, a total of **1084 incidents** have been reported, which is a decrease of about 14% compared to 2014. This proves the ongoing high level of safety for the whole European grid.

The number of scale 0 incidents was reduced compared with 2014 by 24%. For all **783 reported scale 0 incidents**, the system remained in the normal state (based on the system design criteria) during and after the incident.

A review of the **297 incidents reported in scale 1** shows a shift in the proportion of scale 0 to scale 1 incidents from 4.7:1 to 2.6:1 as the number of scale 1 incidents increased by 35% compared to the previous year.

Moreover, 49% of the scale 1 incidents were incidents on transmission network elements, which are mostly connections (AC and DC) between transmission system operators. Additionally, 35% of the scale 1 incidents were N-1 violations and express the tense grid situations. The remaining 47 incidents include violations of standards on voltage (7%), loss of tools and facilities (4%), incidents on load (4%), and lack of reserves (1%).

A reason for the especially high number of N-1 violations (compared to last year) was the increased unavailability of units due to the dry and hot summer period in Continental Europe, which reduced the available power, especially for redispatching in Central East Europe.

Three out of the **four incidents reported on scale 2** occurred in the isolated systems and were incidents on load. The fourth incident occurred in the synchronous area of Ireland and was also an incident on load that was caused by a busbar fault.

Due to the effort of ENTSO-E and transmission system operators, no incident was reported in relation with the solar eclipse of 20 March 2015. A special task force was formed to analyse the event beforehand and various measures like the increase of reserve capacities were implemented.

During the analysis of the incident reports provided by transmission system operators, it became obvious that some incident categories were still interpreted differently. To harmonise the interpretation of the criteria, the Incident Classification Scale subgroup has started the review of the methodology in 2016.

The IT-tool EDICT (ENTSO-E Disturbance and Incident Classification Tool) will go live before the end of 2016 and will further improve gathering and analysing the incident reports starting from 2017. The new tool will also provide a better ability to monitor the incident reports and to provide a global overview of incidents continuously throughout the year.

In conclusion, also during 2015, 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.

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

REFERENCES

[1] ENTSO-E – Incident Classification Scale Methodology, 8 May 2014, https://www.entsoe.eu/Documents/SOC%20documents/Incident_Classification_Scale/2014_ICS_Methodology.pdf

[2] ENTSO-E – The draft Commission Regulation (EU) establishing a guideline on electricity transmission system operation, 4 May 2016, https://ec.europa.eu/energy/sites/ener/files/documents/SystemOperationGuideline%20final%28provisional%2904052016.pdf

[3] ENTSO-E – Summer Outlook 2015 and Winter Review 2014/2015, https://www.entsoe.eu/Documents/SDC%20documents/SOAF/150527_SOR15_report.pdf

[4] ENTSO-E – Winter Outlook 2015/2016 and Summer Review 2015, https://www.entsoe.eu/Documents/Publications/SDC/Winter_Outlook_15-16-REPORT_web.pdf

[5] ENTSO-E – ENTSO-E data portal, www.entsoe.eu/data/data-portal/

CONTRIBUTIONS

This publication, based on the data collected and provided by ENTSO-E transmission system operators, has been prepared by the following members of the subgroup Incident Classification Scale under Steering Group Operations of the ENTSO-E System Operations Committee:

David Glaise (convenor)	RTE	France
Eduardo Lorenzo Cabrera	REE	Spain
Jeroen Bakker	TenneT TSO B.V.	The Netherlands
Matthias Broneder	APG	Austria
Jiri Srank	ČEPS	Czech Republic
Mark Dowling	EirGrid	Ireland
Stefan Möller	TenneT TSO GmbH	Germany
Rodica Dumitrescu	Transelectrica	Romania
Jørn Schaug-Pettersen	Statnett	Norway
Zain Habib	National Grid	United Kingdom
Kaur Krusell	Elering	Estonia
Markku Piironen	Fingrid	Finland
Tomasz Barlik	PSE	Poland
Anrijs Maklakovs	AST	Latvia
Kristel Romeo	ENTSO-E	Belgium

ENTSO-E AISBL • Avenue de Cortenbergh 100 • 1000 Brussels • Belgium • Tel + 32 2 741 09 50 • Fax + 32 2 741 09 51 • info@entsoe.eu • www. entsoe.eu

Contact

ENTSO-E AISBL

Avenue de Cortenbergh 100

1000 Brussels – Belgium

Tel +32 2 741 09 50

Fax +32 2 741 09 51

info@entsoe.eu

www.entsoe.eu