Report on the Quality of Electricity Supply

\- Data for Fiscal Year 2018 -

February 2020

OCCTO
電力広域的運営推進機関
Organization for Cross-regional Coordination of Transmission Operators, JAPAN

Introduction

Part of the role of the Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO), is to evaluate supply reliability conditions in securing a stable electricity supply. For this purpose, OCCTO continuously gathers and publishes actual data on the quality of electricity supply according to the provisions of Article 181 of OCCTO's Operational Rules.

This report aggregates actual data for frequency, voltage, and interruptions under the title "Quality of Electricity Supply" and presents their evaluation of the data, which are collected from each regional service area for the fiscal year in 2018 (FY 2018). With these data, OCCTO evaluates and analyses whether frequencies or voltages have been maintained within certain parameters, or whether the occurrence of supply interruption has become more frequent. In addition, regarding supply interruption, although the data conditions are not uniform, a comparison with European Union (EU) countries and major states from the United States of America (US) was conducted as a reference.
OCCTO's objective is to facilitate the use of the aggregated data, evaluations, and analyses as a reference for the electricity business.

The data presented in the report were submitted by general transmission and distribution companies and aggregated by OCCTO according to the provisions of Article 268 of OCCTO's Network Codes.

SUMMARY

The quality of nationwide electricity supply in FY 2018 was reviewed in this report based on Article 181 in OCCTO's Operational Rule.

Three aspects of the quality of electricity-supply, were evaluated in this report: i.e., frequency, standard voltage, and interruption.

Although indices are available for evaluating each item above, this report used the same indices as those in the previous reports to allow for historical comparison.

Frequency

Frequency was analyzed using the frequency time-kept ratio which is the ratio of time that the metered frequency is maintained within a given target control range. Four areas were grouped into synchronized frequency regions: Hokkaido, Eastern Japan, Central and Western Japan, and Okinawa. The transmission operators in the Eastern and Western areas of Japan use 50 Hz and 60 Hz, respectively.
This report checked the ratios in these four synchronized regions, and observed that a deviation beyond the target control range was recognized only in the Hokkaido region, which was probably due to the blackout caused by the Hokkaido Eastern Iburi Earthquake.

Standard Voltage

The standard voltage was evaluated using the number of points where the standard voltage did not satisfy the target values, as defined by the enforcement regulations of the Electricity Business Act, (hereafter, the Act), which sets the targets for transmission operators to maintain a standard voltage supply within a certain range of values.
Transmission operators handed in their data at OCCTO's request. No violation of standard voltage was observed nationwide among 6,575 points for 100 V and 6,505 points for 200 V, respectively.

Interruption

Finally, interruptions were monitored from three perspectives; i.e., the number of supply disturbances by the place of occurrence, the number of supply disturbances by cause, i.e., beyond the given standards in time duration and lost capacity, and System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI) values for low-voltage (LV) customers.
The first analysis indicated that the number of supply disturbances was 25,274 in total, which was almost double that in the previous year.

The second analysis divided the causes into two factors: i.e., maintenance problems or a natural disaster, irrelevant to the maintenance problem.
These analyses indicate that the number of supply disturbances that were reported was 31 in total, which was almost double that of the previous year. The number of supply disturbances caused by natural disasters was 20, which was also double the average of the last 5 years.
The final analysis was the historical monitoring of SAIFI and SAIDI values, which were both at their highest levels compared with the data from the past 5 years. In particular, a markedly significant increase was observed in SAIDI values, which was attributable to the blackout in the Hokkaido region and heavy rainfalls from typhoons and seasonal fronts in the Central and Western, and the Okinawa regions.

For reference, the report also compared SAIFI and SAIDI values with those of other countries and states, although the index definitions were not the same among these other countries and states.

We hope that this report will help you to understand the quality of electricity supply in Japan.

CONTENTS

<Errata>

2021/11/17	P7, P9	Table 8 & Figure 9 (Nationwide), Table 14 & Figure 15 (Kansai) Number of Supply Disturbances Where Interruptions Were Originated	Data for FY 2018 are partly altered.
	P16 P18	Table 34(Hokkaido), Table 42(Kyushu) Indices of System Average Interruption	Descripiton of data are partly corrected.
2024/2/2	P5	Table 7	Data for FY 2017 and 2018 are altered.

I. Frequency Data

1. Standard Frequency in Japan

In Japan, general transmission and distribution companies must endeavor to maintain the frequency value of the electricity supply at the levels specified by Ordinance of the Ministry of Economy, Trade and Industry in principle according to Article 26 of the Act. Figure 1 shows the regional service areas of the 10 general transmission and distribution companies and their standard frequencies.

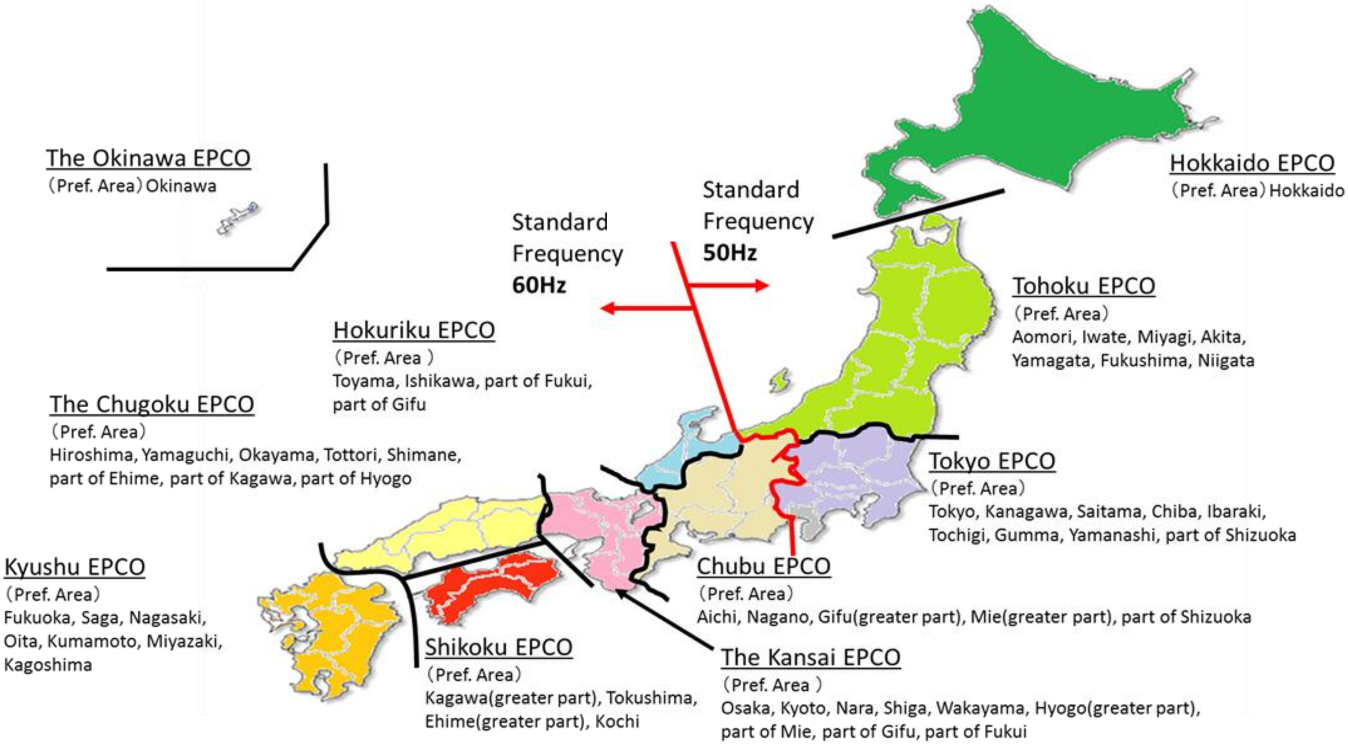

Figure 1 Regional Service Areas of the 10 General Transmission and Distribution Companies and their Standard Frequencies

2. Frequency Time-kept Ratio

The frequency time-kept ratio is the criterion of maintained frequency; i.e., the ratio of time that the metered frequency is maintained within a given variance of the standard, which is calculated by the following formula:

$$\text{Frequency Time kept ratio}(\%) = \frac{\Sigma \text{ Time that metered frequency is maintained within a given variance of the standard}}{\text{Total time in given period}} \times 100$$

3. Frequency Control Rule

According to the indices of the frequency time-kept ratio formula, Table 1 shows the frequency control rule under normal conditions for the regional service areas.

Table 1 Frequency Control Rule under Normal Condition for the Regional Service Areas

Areas	Hokkaido	Tohoku, Tokyo	Chubu, Hokuriku, Kansai, Chugoku, Shikoku, Kyushu	Okinawa
Frequency Standard	50Hz	50Hz	60Hz	60Hz
Control Target(for Standard)	±0.3Hz	±0.2Hz	±0.2Hz	±0.3Hz
Target Time Kept Ratio within ±0.1Hz	—	—	95% over	—

4. Frequency Time-kept Ratio by Frequency-synchronized Region (FY 2014–2018)

Tables 2 to 5 show the frequency time-kept ratio by frequency-synchronized regions from FY 2014 to 2018 and Figures 2 to 5 show the trend of maintaining the frequency within 0.1 Hz variance.

The target frequency time-kept ratios within 0.1 Hz variance for FY 2018 were lower in three regions, including Hokkaido, Central and Western, and Okinawa regions compared with the previous year's data. They were at their second lowest values for the past 5 years.

For the Hokkaido region, the control target for the standard frequency became lower than the frequency time-kept ratio for the previous year, and under 100% for the past 5 years.

【Criteria】

	Control Target	···	100.00%
	Target Time Kept Ratio within ±0.1Hz	···	95.00% Over

Table 2 Frequency Time Kept Ratio (Hokkaido, FY 2014–2018) [%]

Variance	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Within 0.1 Hz	99.91	99.83	99.96	99.97	99.86
Within 0.2 Hz	100.00	100.00	100.00	100.00	99.95
Within 0.3 Hz	100.00	100.00	100.00	100.00	99.98
Beyond 0.3 Hz	0.00	0.00	0.00	0.00	0.02

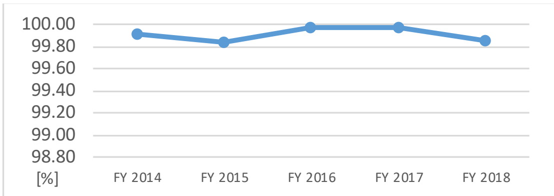

Figure 2 Time Kept Ratio within 0.1 Hz (Hokkaido, FY 2014-2018)

Table 3 Frequency Time Kept Ratio (Eastern region,[1] FY 2014–2018) [%]

Variance	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Within 0.1 Hz	99.84	99.85	99.78	99.80	99.84
Within 0.2 Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3 Hz	100.00	100.00	100.00	100.00	100.00
Beyond 0.3 Hz	0.00	0.00	0.00	0.00	0.00

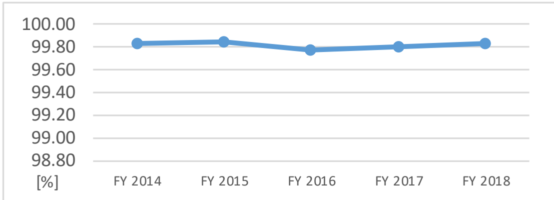

Figure 3 Time Kept Ratio within 0.1 Hz (Eastern region,[1] FY 2014-2018)

Table 4 Frequency Time Kept Ratio (Central & Western region,[2] FY 2014–2018) [%]

Variance	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Within 0.1 Hz	99.17	99.22	99.08	99.17	99.13
Within 0.2 Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3 Hz	100.00	100.00	100.00	100.00	100.00
Beyond 0.3 Hz	0.00	0.00	0.00	0.00	0.00

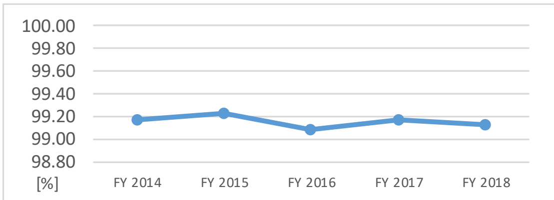

Figure 4 Time Kept Ratio within 0.1 Hz (Central & Western region,[2] FY 2014-2018)

Table 5 Frequency Time Kept Ratio (Okinawa, FY 2014–2018) [%]

Variance	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
Within 0.1 Hz	99.87	99.89	99.94	99.92	99.89
Within 0.2 Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3 Hz	100.00	100.00	100.00	100.00	100.00
Beyond 0.3 Hz	0.00	0.00	0.00	0.00	0.00

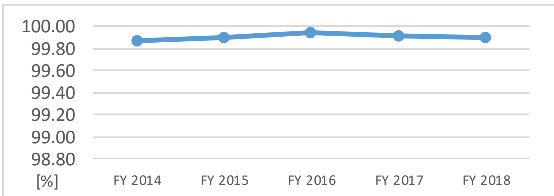

Figure 5 Time Kept Ratio within 0.1 Hz (Okinawa, FY 2014-2018)

1 The Eastern region includes the regional service areas of the Tohoku electric power company (EPCO) and TEPCO PG. Actual data were collected from the area of TEPCO PG.

2 The Central and Western regions of Japan include the regional service areas of Chubu, and Hokuriku, and the Kansai, and the Chugoku, and Shikoku, and Kyushu EPCOs. Actual data were collected from the area of the Kansai EPCO.

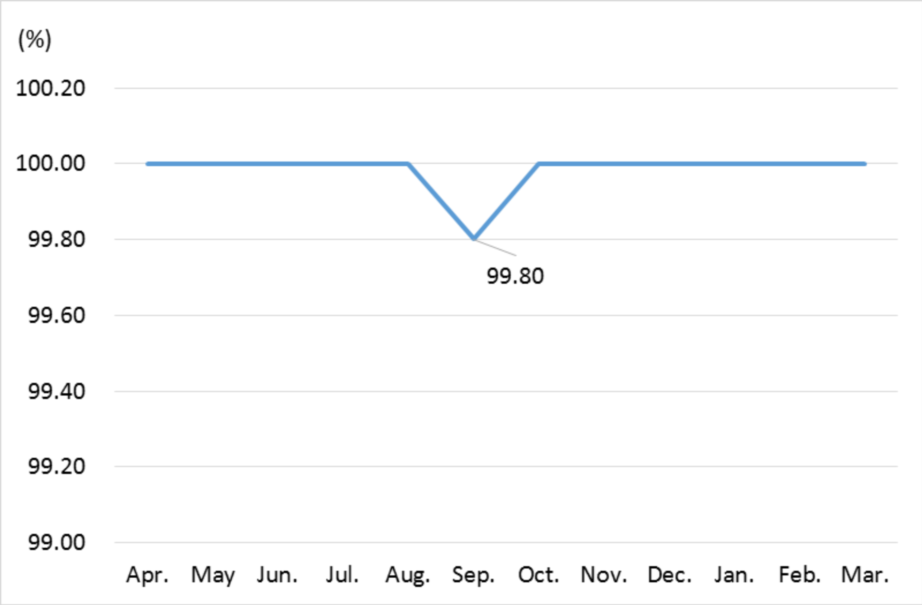

Figure 6 Monthly Frequency Time-kept Ratio against Control Target for the Standard Frequency

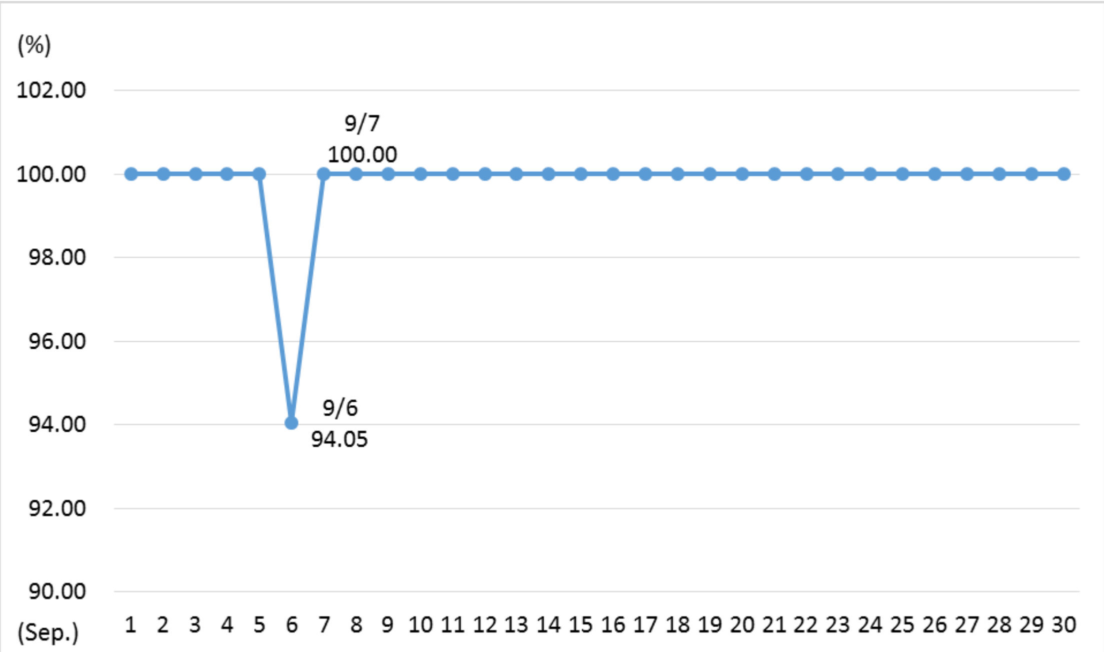

Figure 7 Daily Frequency Time-kept Ratio against Control Target for the Standard Frequency

Figures 6 and 7 show the monthly and daily frequency time-kept ratio in the Hokkaido region, respectively. The monthly frequency time-kept ratio fell under 100% only in September (Figure 6) and the only day which the daily frequency time-kept ratio fell was on September 6 (Figure 7). The Hokkaido Eastern Iburi Earthquake occurred on September 6; thus, the frequency fluctuation was possibly caused by the major supply interruption (i.e., a 'blackout') that spread over the whole region after the earthquake.

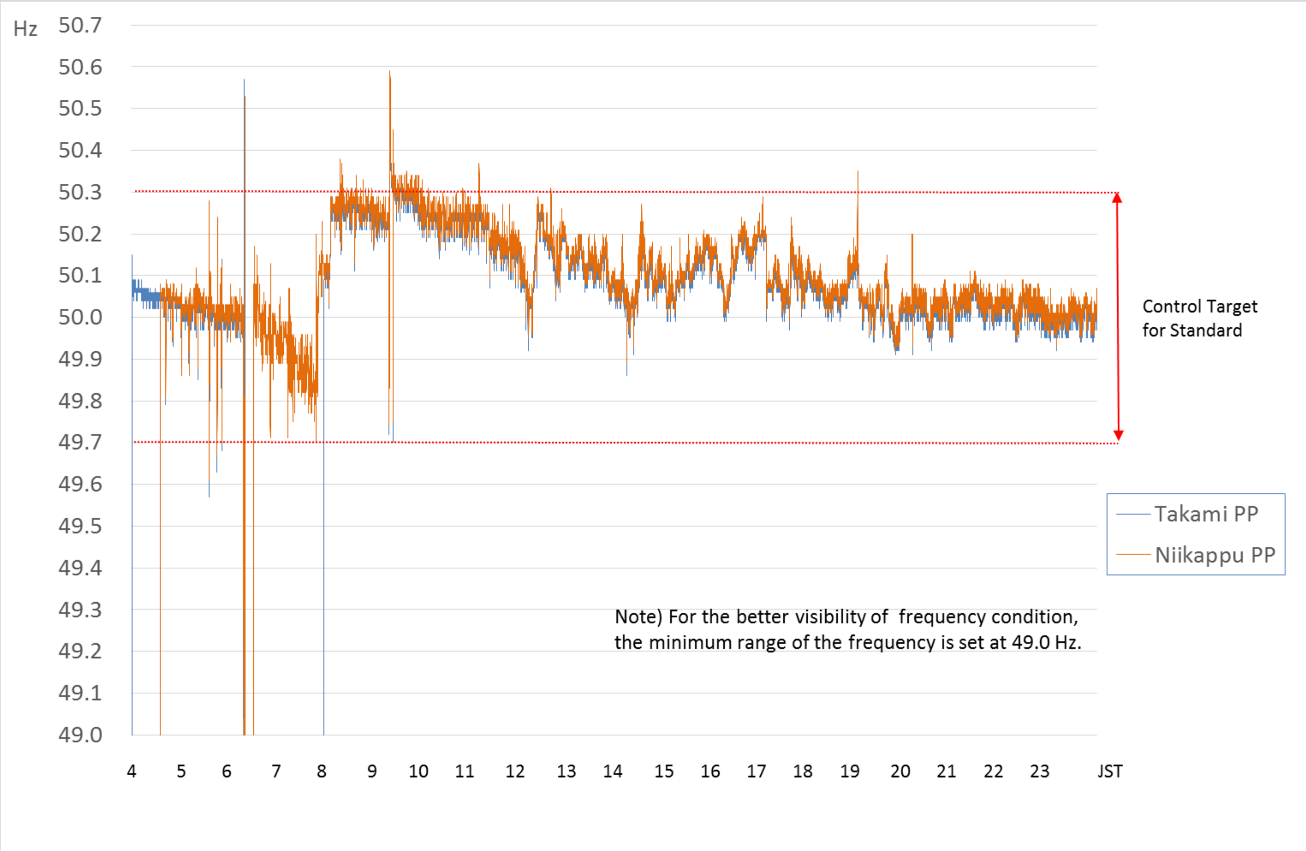

Figure 8 Bus Frequency at Takami Power Plant and Niikappu Power Plant of Hokkaido EPCO on Sep. 6, 2018 (Hz; sampling in every 3 seconds from 4:00 to 24:00 JST. Prepared anew from materials of Investigation Committee on the Major Blackout by the 2018 Hokkaido Eastern Iburi Earthquake by OCCTO)

Figure 8 shows the hourly frequency fluctuations on September 6. After the blackout, the central dispatching center of Hokkaido Electric Power Company Inc. (EPCO) directed black-start processes to restore system operation. The first and the second directions for the black start were given to Unit #1 of Takami Power Plant and to Units #1 and #2 of Niikappu Power Plant, respectively. As shown in Figure 8, the bus frequencies of both power plants temporarily fluctuated beyond the control target range after the second black-start attempt at 6:30 am: however, they gradually stabilized around 50 Hz according to the increased supply capability.

For details of the blackout, please see the report from the Investigation Committee on the Major Blackout by the 2018 Hokkaido Eastern Iburi Earthquake.[3]

[3] http://www.occto.or.jp/iinkai/hokkaido_kensho/files/Final_report_hokkaido_blackout.pdf
http://www.occto.or.jp/iinkai/hokkaido_kensho/files/Final_report_hokkaido_blackout_summarized.pdf

II. Voltage Data

1. Japanese Voltage Standard

General transmission and distribution companies should endeavor to maintain the voltage value of the electricity supply at the levels specified by Article 26 of the Act. Table 6 shows the nationwide voltage standard and target voltage control.

Table 6 Voltage Standard and Target Voltage Control

Voltage Standard	Target Voltage Control
100 V	within ±6 V of 101 V
200 V	within ±20 V of 202 V

2. Voltage Measurements

According to Article 39 of the Ministerial Ordinance of the Act, general transmission and distribution companies should measure their voltage during the period designated by the Director General of the Regional Bureau of Economy, Trade, and Industry, who administrates regional service areas or supply points (for Hokuriku EPCO, Director General of Chubu Bureau of Economy, Trade, and Industry, Electricity and Gas Department Hokuriku) for once over 24 consecutive hours at selected measuring points, unless otherwise stated. General transmission and distribution companies must calculate the averages every 30 minutes, including the maximum and the minimum values, and review whether these values deviate from the average or not.

3. Nationwide Voltage Deviation Ratio (FY 2014–2018)

Table 7 shows the total measured points, deviated measured points, and nationwide deviation ratio from FY 2014 to 2018.

From the FY 2018 data, we see that no deviation from the voltage standard was observed and the nationwide voltage was maintained adequately with respect to the voltage standard.

Table 7 Voltage deviation measurement (Nationwide, FY 2014–2018) [points]

Voltage		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018
100V	Total measured points	6,561	6,554	6,590	6,565	6,575
	Deviated points	0	0	0	0	0
200V	Total measured points	6,483	6,508	6,532	6,506	6,505
	Deviated points	0	0	0	0	0

III. Interruption Data

1. Data of Number of Supply Disturbances Where Interruption Originated

(1) Indices and Definition of Supply Disturbances

The criteria for supply interruption include the number of supply disturbances where interruption originated, indicating where and how many supply disturbances occurred, according to the electric facilities in the system.

A supply disturbance means the interruption of the electricity supply or emergency restriction of electricity use due to malfunction or misuse of electric facilities.[4] The case in which electricity supply is resumed by automatic reclosing[5] of the transmission line is not applicable to supply disturbance.[6]

(2) Data for the Number of Supply Disturbances Nationwide and by Regional Service Area (FY 2014–2018)

Table 8 and Figure 9 show the number of supply disturbances nationwide where interruptions originated in the period FY 2014–2018. Tables 9 to 18 and Figures 10 to 19 show the data from regional service areas. Further, the “Involving Accidents” category in the tables indicate the number of supply disturbances that were induced from the accidents of electric facilities other than the corresponding general transmission and distribution companies. The table columns were left blank if zero value or the data are not available.

An analysis of the FY 2018 data indicates the following points.

- The total number of supply disturbances increased by almost 10,000 compared to the 5-year average. Eight regional areas other than Hokkaido and Tohoku EPCOs, exceeded the 5-year average.
- A breakdown of the tables shows that most of the supply disturbances occurred in high-voltage (HV) overhead lines.
- The significant increase in supply disturbances at HV overhead lines were attributable to several natural disasters that occurred in FY 2018. They are;
  - ✓ A series of weather conditions from May to July that were designated as extreme disasters, such as heavy rainfalls and rainstorms, including heavy rainfall in July, typhoons no.5 (Maliksi), no.6 (Gaemi), no.7 (Prapiroon), and no.8 (Maria).

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[4] Electric facilities include machinery, apparatus, dams, conduits, reservoirs, electric lines, and other facilities installed for the generation, transformation, transmission, distribution, or consumption of electricity as defined by the Article 38 of the Act.

[5] The automatic reclosing of a transmission line means the reconnection of a transmission line by re-switching of the circuit breaker after a given period, when an accident such as a lightning strike occurs to the transmission or distribution line and isolated fault section by opening of the circuit breaker due to the action of a protective relay.

[6] According to the provision of Item viii, Paragraph 2 of Article 1 of Reporting Rules of the Act, a supply disturbance means the interruption of electricity supply or emergency restriction of electricity use for electricity consumers (excluding a person who manages the corresponding electric facility, hereinafter, the same shall apply in this article) due to malfunction, misuse or disoperation of electric facility. However, the case in which electricity supply is resumed by automatic reclosing of the transmission line is not applicable to supply disturbance.

✓ Typhoon no.21 (Jebi) in September 2018 which powerfully hit the southern part of Tokushima Prefecture and crossed into the Kansai region for the first time in 25 years since 1993, was later designated as an extreme disaster.

✓ Typhoon no.24 (Trami) in September 2018 which also powerfully hit Wakayama Prefecture and crossed into mainland Japan with rapidly accelerating speed, was also later designated as an extreme disaster.

・In addition to the above disasters, a major blackout occurred in the Hokkaido region due to the 2018 Hokkaido Eastern Iburi Earthquake on September 6. This blackout might be included in the supply disturbance; however, the origin of the interruption could not be identified because of complex factors. Therefore, the number of supply disturbances does not include the case evoked by the blackout.

Table 8 Number of Supply Disturbances Where Interruption Originated (Nationwide, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		42	45	70	45	65	53.4
Transmission Lines & Extra High Voltage Lines	Overhead	186	204	230	278	409	261.4
	Under-ground	9	13	9	14	10	11.0
	Total	195	217	239	292	419	272.4
High Voltage Lines	Overhead	11,532	10,370	10,235	12,679	20,729	13,109.0
	Under-ground	189	198	215	216	265	216.6
	Total	11,721	10,568	10,450	12,895	20,994	13,325.6
Demand Facilities					1		0.2
Involvng Accidents		460	333	269	343	359	352.8
Total Disturbances		12,418	11,163	11,028	13,576	21,837	14,004.4

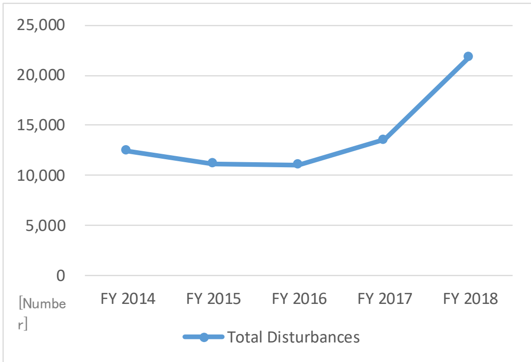

Figure 9 Transition of Supply Disturbances (Nationwide, FY 2014–2018)

Table 9 Number of Supply Disturbances Where Interruption Originated (Hokkaido, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		2	1	1		5	1.8
Transmission Lines & Extra High Voltage Lines	Overhead	15	20	24	30	25	22.8
	Under-ground	2					0.4
	Total	17	20	24	30	25	23.2
High Voltage Lines	Overhead	1,119	1,145	1,289	1,144	1,139	1,167.2
	Under-ground	13	10	13	19	13	13.6
	Total	1,132	1,155	1,302	1,163	1,152	1,180.8
Demand Facilities							
Involvng Accidents		34	24	28	17	12	23.0
Total Disturbances		1,185	1,200	1,355	1,210	1,194	1,228.8

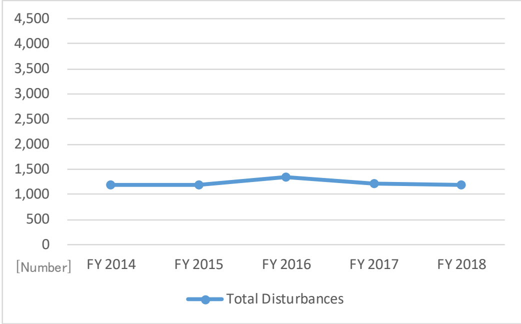

Figure 10 Transition of Supply Disturbances (Hokkaido, FY 2014–2018)

Table 10 Number of Supply Disturbances Where Interruption Originated (Tohoku, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		5	5	8	4	9	6.2
Transmission Lines & Extra High Voltage Lines	Overhead	19	7	11	16	11	12.8
	Under-ground				1		0.2
	Total	19	7	11	17	11	13.0
High Voltage Lines	Overhead	1,912	1,327	1,403	1,957	1,478	1,615.4
	Under-ground	6	5	12	5	11	7.8
	Total	1,918	1,332	1,415	1,962	1,489	1,623.2
Demand Facilities							
Involvng Accidents		43	22	22	26	20	26.6
Total Disturbances		1,985	1,366	1,456	2,009	1,529	1,669.0

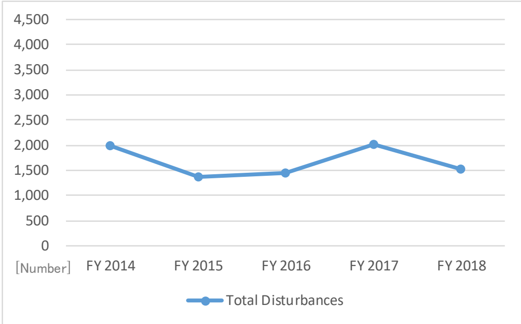

Figure 11 Transition of Supply Disturbances (Tohoku, FY 2014–2018)

Table 11 Number of Supply Disturbances Where Interruption Originated (Tokyo, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		10	10	14	17	16	13.4
Transmission Lines & Extra High Voltage Lines	Overhead	26	30	16	24	38	26.8
	Under-ground	2	5	2	4		2.6
	Total	28	35	18	28	38	29.4
High Voltage Lines	Overhead	1,854	1,755	2,204	2,311	3,841	2,393.0
	Under-ground	67	74	75	65	100	76.2
	Total	1,921	1,829	2,279	2,376	3,941	2,469.2
Demand Facilities							
Involvng Accidents		118	125	93	96	107	107.8
Total Disturbances		2,077	1,999	2,404	2,517	4,102	2,619.8

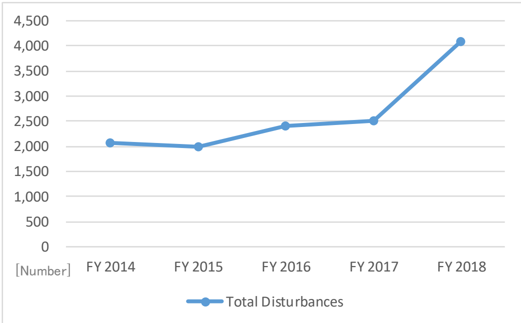

Figure 12 Transition of Supply Disturbances (Tokyo, FY 2014–2018)

Table 12 Number of Supply Disturbances Where Interruption Originated (Chubu, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		2	5	6	3	6	4.4
Transmission Lines & Extra High Voltage Lines	Overhead	12	8	16	9	26	14.2
	Under-ground						
	Total	12	8	16	9	26	14.2
High Voltage Lines	Overhead	1,592	1,066	1,069	1,607	4,053	1,877.4
	Under-ground	8	7	5	11	39	14.0
	Total	1,600	1,073	1,074	1,618	4,092	1,891.4
Demand Facilities							
Involvng Accidents		86	38	40	49	66	55.8
Total Disturbances		1,700	1,124	1,136	1,679	4,190	1,965.8

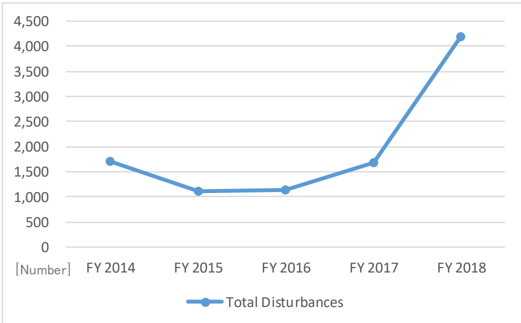

Figure 13 Transition of Supply Disturbances (Chubu, FY 2014–2018)

Table 13 Number of Supply Disturbances Where Interruption Originated (Hokuriku, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		4		3	1		1.6
Transmission Lines & Extra High Voltage Lines	Overhead	6	5	7	4	7	5.8
	Under-ground		1			2	0.6
	Total	6	6	7	4	9	6.4
High Voltage Lines	Overhead	364	258	303	542	385	370.4
	Under-ground	4	7	10	5	3	5.8
	Total	368	265	313	547	388	376.2
Demand Facilities							
Involvng Accidents		18	10	17	15	21	16.2
Total Disturbances		396	281	340	567	418	400.4

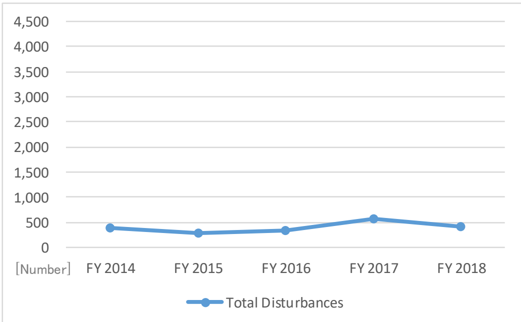

Figure 14 Transition of Supply Disturbances (Hokuriku, FY 2014–2018)

Table 14 Number of Supply Disturbances Where Interruption Originated (Kansai, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		2	7	13	9	8	7.8
Transmission Lines & Extra High Voltage Lines	Overhead	44	42	80	102	190	91.6
	Under-ground	4	6	3	7	6	5.2
	Total	48	48	83	109	196	96.8
High Voltage Lines	Overhead	1,127	943	1,171	1,695	5,270	2,041.2
	Under-ground	45	51	63	48	56	52.6
	Total	1,172	994	1,234	1,743	5,326	2,093.8
Demand Facilities							
Involvng Accidents		59	43		65	70	47.4
Total Disturbances		1,281	1,092	1,330	1,926	5,600	2,245.8

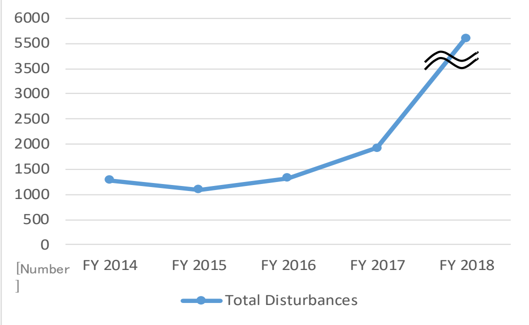

Figure 15 Transition of Supply Disturbances (Kansai, FY 2014–2018)

Table 15 Number of Supply Disturbances Where Interruption Originated (Chugoku, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		11	10	7	2	8	7.6
Transmission Lines & Extra High Voltage Lines	Overhead	13	14	16	16	14	14.6
	Under-ground	1			1	1	0.6
	Total	14	14	16	17	15	15.2
High Voltage Lines	Overhead	1,122	1,211	960	1,066	1,172	1,106.2
	Under-ground	23	23	13	24	20	20.6
	Total	1,145	1,234	973	1,090	1,192	1,126.8
Demand Facilities					1		0.2
Involvng Accidents		36	37	25	33	31	32.4
Total Disturbances		1,206	1,295	1,021	1,143	1,246	1,182.2

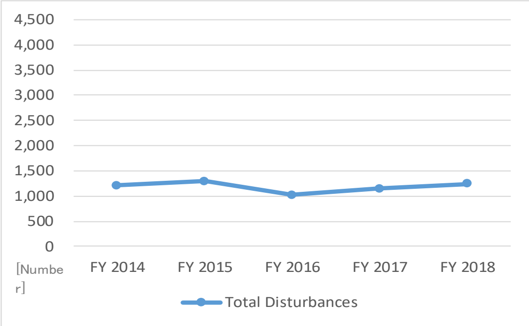

Figure 16 Transition of Supply Disturbances (Chugoku, FY 2014–2018)

Table 16 Number of Supply Disturbances Where Interruption Originated (Shikoku, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		1	3		6	4	2.8
Transmission Lines & Extra High Voltage Lines	Overhead	4	3	5	3	4	3.8
	Under-ground						
	Total	4	3	5	3	4	3.8
High Voltage Lines	Overhead	673	425	357	630	616	540.2
	Under-ground	3	5	4	9	8	5.8
	Total	676	430	361	639	624	546.0
Demand Facilities							
Involvng Accidents		14	8	6	5	5	7.6
Total Disturbances		695	444	372	653	637	560.2

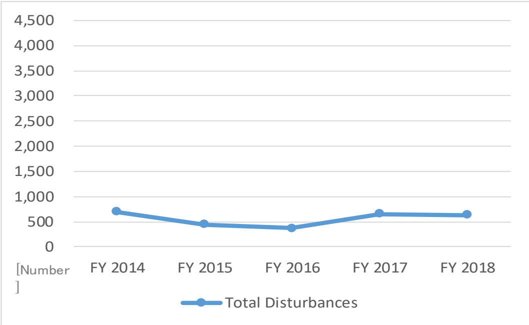

Figure 17 Transition of Supply Disturbances (Shikoku, FY 2014–2018)

Table 17 Number of Supply Disturbances Where Interruption Originated (Kyushu, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		4	3	15	3	1	5.2
Transmission Lines & Extra High Voltage Lines	Overhead	12	24	21	32	42	26.2
	Under-ground		1	4		1	1.2
	Total	12	25	25	32	43	27.4
High Voltage Lines	Overhead	1,088	1,751	1,237	1,349	1,888	1,462.6
	Under-ground	18	15	18	30	15	19.2
	Total	1,106	1,766	1,255	1,379	1,903	1,481.8
Demand Facilities							
Involvng Accidents		31	18	20	23	16	21.6
Total Disturbances		1,153	1,812	1,315	1,437	1,963	1,536.0

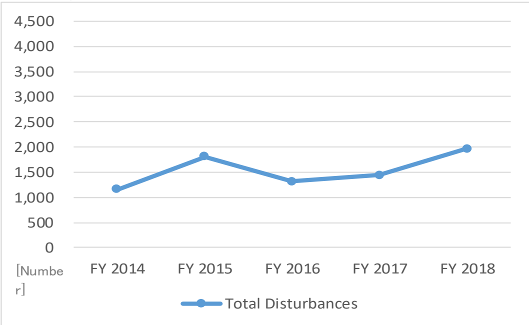

Figure 18 Transition of Supply Disturbances (Kyushu, FY 2014–2018)

Table 18 Number of Supply Disturbances Where Interruption Originated (Okinawa, FY 2014–2018)

Occurrence in		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		1	1	3		8	2.6
Transmission Lines & Extra High Voltage Lines	Overhead	35	51	34	42	52	42.8
	Under-ground				1		0.2
	Total	35	51	34	43	52	43.0
High Voltage Lines	Overhead	681	489	242	378	887	535.4
	Under-ground	2	1	2			1.0
	Total	683	490	244	378	887	536.4
Demand Facilities							
Involvng Accidents		21	8	18	14	11	14.4
Total Disturbances		740	550	299	435	958	596.4

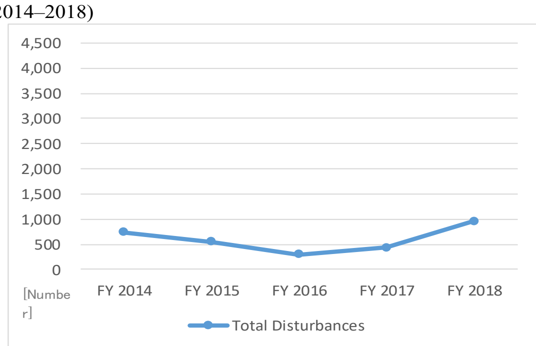

Figure 19 Transition of Supply Disturbances (Okinawa, FY 2014–2018)

2. Number of Supply Disturbances Where Interruptions Originated with Their Causes

(1) Data for Supply Disturbances over a Certain Scale

To obtain the data for supply disturbances where interruptions originated as described in the preceding section, the disturbances over a certain scale were reported with their causes. This section analyses their causes.

Figure 19 illustrates the number of supply disturbances where interruptions originated over a certain scale, while Table 19 shows the nationwide data for FY 2018.[7] The table columns were left blank if zero value or the data are not available.

- Capacity lost by disturbance was 7,000–70,000 kW with a duration longer than 1 hour
- Capacity lost by disturbance was over 70,000 kW with a duration longer than 10 minutes

It should be noted that the number of supply disturbances evoked by the September 6 blackout was not included in the statistics.

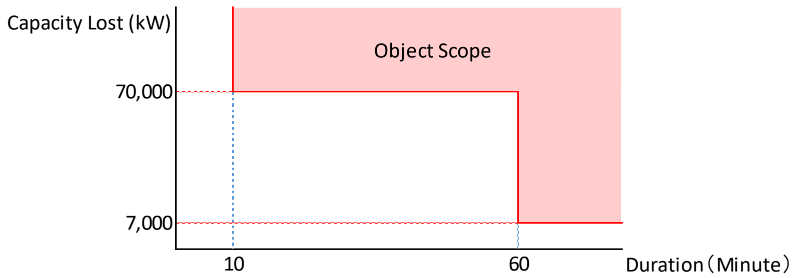

Figure 20 Image of Supply Disturbances over a Certain Scale

Table 19 Number of Supply Disturbances Where Interruption Originated by Scale of Interruption (Nationwide, FY 2018) [Number]

Occurrence at \ Scale of Disturbance [Duration & Capacity lost]		10 min. till 30 min.		30 min. till 1 hour		1hour till 3 hours			Longer than 3 hours			Total Disturbance
		70,000kW to 100,000kW under	100,000kW over[7]	70,000kW to 100,000kW under	100,000kW over[7]	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over[7]	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over[7]	
Accidents of Facilities of General Transmission /Distribution Companies												
Substations			1			3			2			6
Transmission Lines & Extra High Voltage Lines	Overhead					6	1		11			18
	Under-ground	1							1			2
	Total	1				6	1		12			26
High Voltage Lines	Overhead								3			3
	Under-ground					1			1			2
	Total					1			4			5
Demand Facilities												
Involved Accidents												
Total Disturbance		1	1			10	1		18			31

[7] Supply disturbance over a certain scale of 10 minutes and longer was reported for different destinations according to lost capacity under the provisions of Article 3 of the Reporting Rules of the Electricity Business. In the case the lost capacity is 70,000–100,000 kW, the loss is reported to the Director of Regional Industrial Safety and the Inspection Department that directs the area the disturbed electric facility is sited. In the case the lost capacity is over 100,000 kW, the loss is reported to the Ministry of Economy, Trade, and Industry. Thus, the reporting destination differs according to the lost capacity, Table 19 presents the number of disturbances by lost capacity.

(2) Classification and Description of Causes of Supply Disturbances over a Certain Scale

Table 20 classifies and describes the causes of supply disturbances.

Table 20 Classification and Description of the Causes of Supply Disturbances

Classification of Causes		Description
Facility fault		Due to imperfect production (improper design, fabrication, or material of electric facilities) or imperfect installation (improper operation of construction or maintenance work).
Maintenance fault		Due to imperfect maintenance (improper operation of patrols, inspections or cleaning), natural deterioration (deterioration of material or mechanism of electric facilities not due to production, installations or maintenance), or overloading (current over the rated capacity).
Accident/malice		Due to accident by worker, intentional act, or accident by public (stone throwing, wire theft, etc.). In case of accompanying electric shock, instances are classified under “Electric shock (worker)” or “Electric shock (public).”
Physical contact		Due to physical contact by tree, wildlife, or others (kite, model airplane).
Corrosion		Due to corrosion by leakage of current from DC electric railroad or by chemical action.
Vibration		Due to vibration from traffic of heavy vehicle traffic or construction work.
Involving an accident		Due to accident involving the electric facilities of another company.
Improper fuel		Due to accident with improper fuel of notably different ingredients from that designated.
Electric fire		Due to accident with electric fire caused by facility fault, maintenance fault, natural disaster, accident, or work without permission.
Electric shock (worker)		Due to workers’ accident from electric shock caused by misuse of equipment, malfunction of electric facilities, accident by injured or third person, etc.
Electric shock (public)		Due to accident with electric shock of public by misuse of equipment, malfunction of electric facilities, accident by injured or third person, etc.
Natural disaster	Thunderbolt	Due to direct or indirect lightning strike.
	Rainstorm	Due to rain, wind, or rainstorm (including contact with fallen branches, etc.)
	Snowstorm	Due to snow, frazil, hail, sleet, or snowstorm.
	Earthquake	Due to earthquake.
	Flood	Due to flood, storm surge, or tsunami
	Landslide	Due to rock fall, avalanche, landslide, or ground subsidence.
	Dust/gas	Due to briny air, volcanic dust and ash, fog, offensive gas, or smoke and soot.
Unknown		Due to causes that remain unknown despite investigation.
Miscellaneous		Due to causes not categorized above.

(3) The Number and Causes of Supply Disturbances over a Certain Scale (FY 2014–2018)

For the number of supply disturbances where interruption originated over a certain scale, Table 21 and Figure 21 show the nationwide data, while Tables 22 to 31 show the data from each regional service area for the period FY 2014–2018.[8,9]

For the FY 2018 data, the number and the causes of supply disturbances over a certain scale were analyzed. There were 31 cases of supply disturbances over a certain scale nationwide, which was the highest during the 5-year period. The supply disturbances evoked by 2018 July heavy rainfall, typhoon no.8 (Maria) in August, no.21 (Jebi) and no.24 (Trami)[10] in September compromised more than half of the cases in FY 2018, and were the highest number of supply disturbances during the past 5-years. It should be noted that the number of supply disturbances which was evoked by the blackout, and could not be identified where the interruption originated was not included in the statistics.

Table 21 Causes of Disturbances over a Certain Scale (Nationwide, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault	1	1	1	1	4	1.6
Maintenance fault	2	1	3	4	1	2.2
Accident/Malice			1	1	2	0.8
Physical contact			3	2	2	1.4
Involved accident		1	1		1	0.6
Electric shock(worker)	1	1				0.4
Subtotal	4	4	9	8	10	7.0
Natural Disaster						
Thunderbolt	2		3	2	1	1.6
Rainstorm	1		3	3	17	4.8
Snowstorm	2		2	2		1.2
Earthquake			6			1.2
Dust/Gas			2		2	0.8
Subtotal	5		16	7	20	9.6
Unknown	1	1				0.4
Miscellaneous			1		1	0.4
Total Disturbances	10	5	26	15	31	17.4

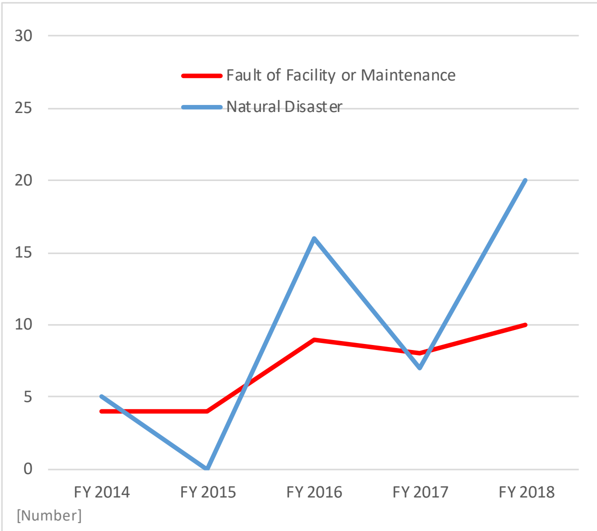

Figure 21 Transition of Disturbances by Causes (Nationwide, FY 2014–2018)

Table 22 Causes of Disturbances over a Certain Scale (Hokkaido, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault					1	0.2
Maintenance fault			1		1	0.4
Accident/Malice						
Physical contact					1	0.2
Involved accident						
Electric shock(worker)						
Subtotal			1		3	0.8
Natural Disaster						
Thunderbolt						
Rainstorm			2			0.4
Snowstorm				1		0.2
Earthquake						
Dust/Gas						
Subtotal			2	1		0.6
Unknown						
Miscellaneous					1	0.2
Total Disturbances			3	1	4	1.6

Table 23 Causes of Disturbances over a Certain Scale (Tohoku, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault						
Accident/Malice			1			0.2
Physical contact			2			0.4
Involved accident						
Electric shock(worker)		1				0.2
Subtotal		1	3			0.8
Natural Disaster						
Thunderbolt						
Rainstorm						
Snowstorm				1		0.2
Earthquake						
Dust/Gas						
Subtotal				1		0.2
Unknown	1					0.2
Miscellaneous						
Total Disturbances	1	1	3	1		1.2

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8 Causes of the disturbances that did not occur in the period FY 2014–2018 are omitted from the tables.
9 Column of the tables left blank if zero or the data are not available.
10 Natural disasters occurred in FY 2018 and their response
Industrial and Product Safety Policy Group, Mar. 19, 2019 (in Japanese only)
https://www.meti.go.jp/shingikai/sankoshin/hoan_shohi/pdf/002_02_00.pdf

Table 24 Causes of Disturbances over a Certain Scale (Tokyo, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault	1	1	1	1	1	1.0
Maintenance fault		1				0.2
Accident/Malice					1	0.2
Physical contact			1	1	1	0.6
Involved accident		1				0.2
Electric shock(worker)						
Subtotal	1	3	2	2	3	2.2
Natural Disaster						
Thunderbolt			1	1	1	0.6
Rainstorm						
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal			1	1	1	0.6
Unknown		1				0.2
Miscellaneous						
Total Disturbances	1	4	3	3	4	3.0

Table 25 Causes of Disturbances over a Certain Scale (Chubu, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault	1					0.2
Accident/Malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Subtotal	1					0.2
Natural Disaster						
Thunderbolt			1			0.2
Rainstorm					1	0.2
Snowstorm	2		2			0.8
Earthquake						
Dust/Gas					2	0.4
Subtotal	2		3		3	1.6
Unknown						
Miscellaneous						
Total Disturbances	3		3		3	1.8

Table 26 Causes of Disturbances over a Certain Scale (Hokuriku, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault						
Accident/Malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Subtotal						
Natural Disaster						
Thunderbolt						
Rainstorm						
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal						
Unknown						
Miscellaneous						
Total Disturbances						

Table 27 Causes of Disturbances over a Certain Scale (Kansai, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault					2	0.4
Maintenance fault				3		0.6
Accident/Malice				1	1	0.4
Physical contact				1		0.2
Involved accident			1		1	0.4
Electric shock(worker)						
Subtotal			1	5	4	2.0
Natural Disaster						
Thunderbolt	1					0.2
Rainstorm			1	3	10	2.8
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal	1		1	3	10	3.0
Unknown						
Miscellaneous						
Total Disturbances	1		2	8	14	5.0

Table 28 Causes of Disturbances over a Certain Scale (Chugoku, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault	1					0.2
Accident/Malice						
Physical contact						
Involved accident						
Electric shock(worker)	1					0.2
Subtotal	2					0.4
Natural Disaster						
Thunderbolt				1		0.2
Rainstorm					2	0.4
Snowstorm						
Earthquake			1			0.2
Dust/Gas						
Subtotal			1	1	2	0.8
Unknown						
Miscellaneous			1			0.2
Total Disturbances	2		2	1	2	1.4

Table 29 Causes of Disturbances over a Certain Scale (Shikoku, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault				1		0.2
Accident/Malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Subtotal				1		0.2
Natural Disaster						
Thunderbolt						
Rainstorm	1					0.2
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal	1					0.2
Unknown						
Miscellaneous						
Total Disturbances	1			1		0.4

Table 30 Causes of Disturbances over a Certain Scale (Kyushu, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault			1			0.2
Maintenance fault						
Accident/Malice						
Physical contact			1			0.2
Involved accident						
Electric shock(worker)						
Subtotal			2			0.4
Natural Disaster						
Thunderbolt	1					0.2
Rainstorm					2	0.4
Snowstorm						
Earthquake			5			1.0
Dust/Gas			2			0.4
Subtotal	1		7		2	2.0
Unknown						
Miscellaneous						
Total Disturbances	1		9		2	2.4

Table 31 Causes of Disturbances over a Certain Scale (Okinawa, FY 2014–2018)

	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault						
Accident/Malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Subtotal						
Natural Disaster						
Thunderbolt			1			0.2
Rainstorm					2	0.4
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal			1		2	0.6
Unknown						
Miscellaneous						
Total Disturbances			1		2	0.6

3. Data of Interruptions for LV Customers

(1) Indices of System Average Interruption for LV Customers

The criteria for customer interruption include two indices that indicate frequency and duration of forced or planned outages that occurred for one customer and one year.

System Average Interruption Frequency Index (SAIFI/number)

$$= \frac{\text{Low voltage customers affected by interruption}}{\text{Low voltage customers served at the beginning of the fiscal year}}$$

System Average Interruption Duration Index (SAIDI/minute)

$$= \frac{\text{Interruption duration (min)} \times \text{Low voltage customers affected by interruption}}{\text{Low voltage customers served at the beginning of the fiscal year}}$$

Table 32 shows the definitions of outage-related terms.

Table 32 Definition of Outage-related Terms

Term	Definition
Forced outage	Supply interruption occurred to end-use customers by accident, such as the malfunction of the electric facility, excluding resumption of electricity supply by automatic reclosing.[11][12]
Planned outage	Electric power company interrupts its electricity supply in planned manner to construct, improve, and maintain its electric facility.

[11] See footnote 5 for definitions.
[12] See footnote 6 for definitions.

(2) Data of System Average Interruption Nationwide and by Regional Service Area (FY 2014–2018)

Table 33 and Figure 22 show the nationwide data for system average interruptions for FY 2014–2018. Tables 34 to 43 and Figures 23 to 32 show the data for each regional service area. [13] Table 44 shows the nationwide data for system average interruptions for FY 2018, for which both the SAIFI and SAIDI values of forced outages became the highest during the 5-year average.

For the SAIFI value of forced outages, the four regional service areas of Hokkaido, Chubu, Kansai, and Okinawa EPCOs have marked their highest number of outages during the 5-year average period. For the SAIDI value of forced outages, the seven regional service areas of Hokkaido, Tokyo, Chubu, Kansai, Chugoku, Shikoku, and Okinawa EPCOs registered their longest outages during this period.

In particular, the area supplied by Hokkaido EPCO experienced a markedly significant increase for SAIDI from 10 minutes in FY 2017 to 2,154 minutes (almost 36 hours) in FY 2018. This figure includes the interrupted time of supply disturbances evoked by the blackout, which shows that the blackout was certain both in scale and time. In the Central and Western, and the Okinawa regions, the increased SAIDI values are mainly attributable to the very strong power of several typhoons, which were later designated as extreme disasters, and seasonal fronts causing heavy rainfalls.

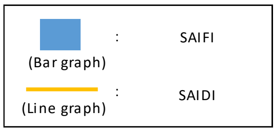

Table 33 Indices of System Average Interruption (Nationwide, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.13	0.10	0.14	0.11	0.28	0.15
	Planned	0.04	0.03	0.03	0.03	0.03	0.03
	Total	0.16	0.13	0.18	0.14	0.31	0.18
SAIDI [Minute]	Forced	16	18	21	12	221	58
	Planned	4	4	4	3	4	4
	Total	20	21	25	16	225	61

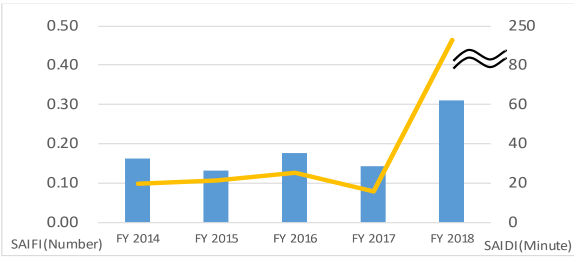

Figure 22 System Average Interruption Indices of LV Customers (Nationwide, FY 2014–2018)

Table 34 Indices of System Average Interruption (Hokkaido, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.13	0.15	0.17	0.13	1.19	0.35
	Planned	α	α	α	0.01	α	0.01
	Total	0.13	0.15	0.17	0.14	1.19	0.36
SAIDI [Minute]	Forced	8	10	35	10	2,154	443
	Planned	α	α	1	α	α	1
	Total	9	10	36	10	2,154	444

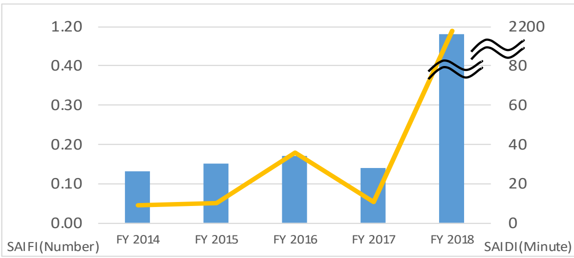

Figure 23 System Average Interruption Indices of LV Customers (Hokkaido, FY 2014–2018)

Table 35 Indices of System Average Interruption (Tohoku, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.12	0.08	0.11	0.13	0.09	0.10
	Planned	0.04	0.04	0.03	0.02	0.02	0.03
	Total	0.16	0.12	0.14	0.15	0.11	0.14
SAIDI [Minute]	Forced	9	11	24	10	7	12
	Planned	5	4	4	3	2	4
	Total	14	15	28	13	10	16

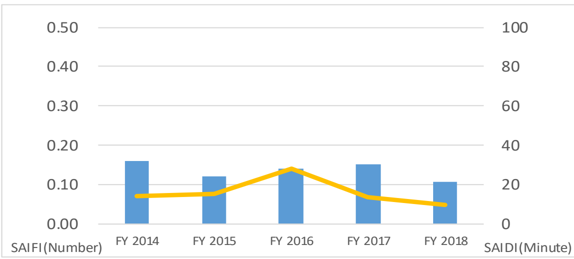

Figure 24 System Average Interruption Indices of LV Customers (Tohoku, FY 2014–2018)

[13] Alpha (α) is shown if the data are a fraction less than a unit. For SAIFI, α falls to 0 <α< 0.005, for SAIDI, α falls to 0 <α< 0.5.

Table 36 Indices of System Average Interruption (Tokyo, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.07	0.06	0.13	0.09	0.13	0.10
	Planned	0.01	0.01	0.02	0.01	0.01	0.01
	Total	0.08	0.07	0.15	0.10	0.14	0.11
SAIDI [Minute]	Forced	4	6	7	6	19	8
	Planned	α	1	1	1	3	1
	Total	4	6	8	7	22	9

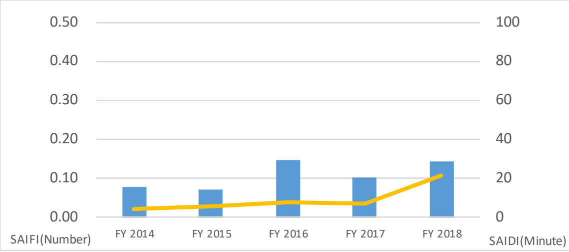

Figure 25 System Average Interruption Indices of LV Customers (Tokyo, FY 2014–2018)

Table 37 Indices of System Average Interruption (Chubu, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.16	0.07	0.17	0.08	0.39	0.17
	Planned	0.07	0.06	0.06	0.06	0.06	0.06
	Total	0.23	0.13	0.23	0.14	0.45	0.24
SAIDI [Minute]	Forced	18	4	5	10	348	77
	Planned	9	7	7	7	8	8
	Total	27	11	12	17	356	85

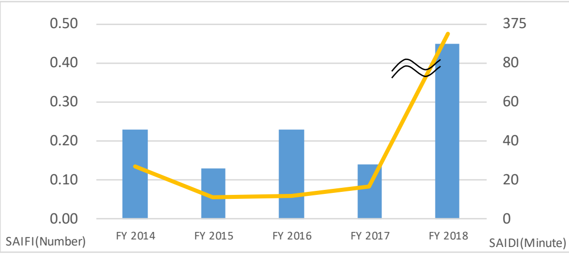

Figure 26 System Average Interruption Indices of LV Customers (Chubu, FY 2014–2018)

Table 38 Indices of System Average Interruption (Hokuriku, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.09	0.04	0.06	0.09	0.06	0.07
	Planned	0.10	0.10	0.10	0.09	0.09	0.10
	Total	0.20	0.14	0.16	0.17	0.15	0.17
SAIDI [Minute]	Forced	5	4	4	11	9	7
	Planned	17	16	17	15	15	16
	Total	22	20	21	26	24	23

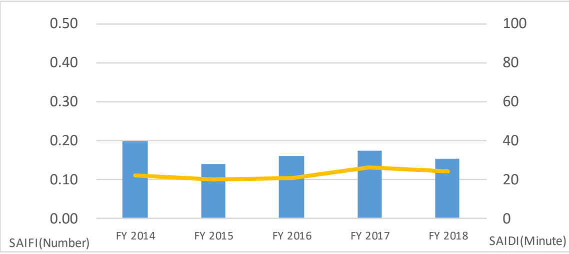

Figure 27 System Average Interruption Indices of LV Customers (Hokuriku, FY 2014–2018)

Table 39 Indices of System Average Interruption (Kansai, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.06	0.07	0.07	0.12	0.40	0.14
	Planned	0.02	0.01	0.01	0.01	0.01	0.01
	Total	0.08	0.08	0.09	0.13	0.41	0.16
SAIDI [Minute]	Forced	4	3	4	14	396	84
	Planned	1	1	1	1	1	1
	Total	5	4	5	15	397	85

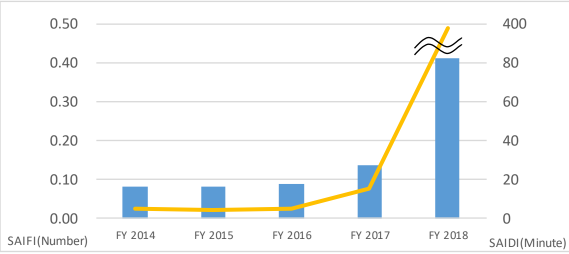

Figure 28 System Average Interruption Indices of LV Customers (Kansai, FY 2014–2018)

Table 40 Indices of System Average Interruption (Chugoku, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.19	0.18	0.15	0.12	0.14	0.16
	Planned	0.11	0.11	0.11	0.11	0.09	0.11
	Total	0.31	0.29	0.26	0.23	0.23	0.26
SAIDI [Minute]	Forced	10	17	6	7	24	13
	Planned	11	12	12	12	10	11
	Total	21	29	18	19	33	24

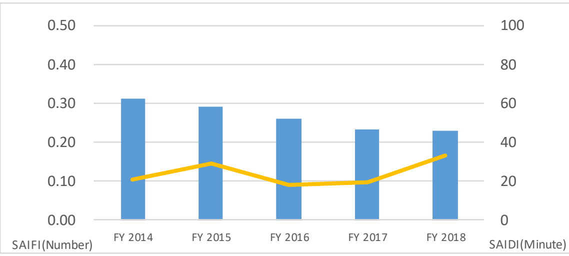

Figure 29 System Average Interruption Indices of LV Customers (Chugoku, FY 2014–2018)

Table 41 Indices of System Average Interruption (Shikoku, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.21	0.12	0.09	0.19	0.20	0.16
	Planned	0.20	0.19	0.18	0.16	0.14	0.18
	Total	0.40	0.31	0.27	0.36	0.34	0.34
SAIDI [Minute]	Forced	27	13	6	21	32	20
	Planned	20	21	20	17	15	19
	Total	47	34	26	38	47	38

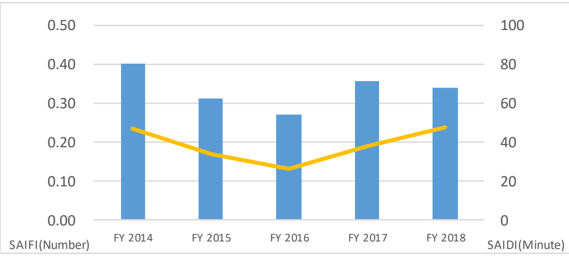

Figure 30 System Average Interruption Indices of LV Customers (Shikoku, FY 2014–2018)

Table 42 Indices of System Average Interruption (Kyushu, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	0.09	0.16	0.24	0.08	0.14	0.14
	Planned	0	0	0	0	0	0
	Total	0.09	0.16	0.24	0.08	0.14	0.14
SAIDI [Minute]	Forced	45	101	128	25	103	80
	Planned	0	0	0	0	0	0
	Total	45	101	128	25	103	80

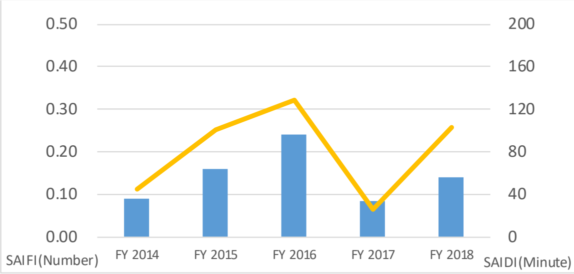

Figure 31 System Average Interruption Indices of LV Customers (Kyushu, FY 2014–2018)

Table 43 Indices of System Average Interruption (Okinawa, FY 2014–2018)

		FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	5-years Average
SAIFI [Number]	Forced	2.58	1.04	0.57	0.98	3.62	1.76
	Planned	0.08	0.08	0.08	0.07	0.07	0.08
	Total	2.67	1.12	0.65	1.05	3.69	1.84
SAIDI [Minute]	Forced	437	150	35	117	1,269	402
	Planned	8	8	8	7	6	8
	Total	445	158	43	124	1,275	409

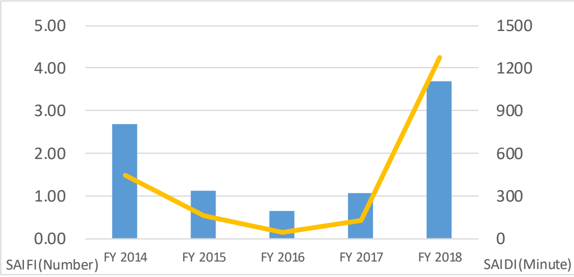

Figure 32 System Average Interruption Indices of LV Customers (Okinawa, FY 2014–2018)

Table 44 System Average Disturbances Where Interruption Originated by Outages (Nationwide, FY 2018)[14]

			Hokkaido	Tohoku	Tokyo	Chubu	Hokuriku	Kansai	Chugoku	Shikoku	Kyushu	Okinawa	Nationwide
SAIFI [Number]	Forced Outage												
		Generators	1.09	α	0.05	0.04	α	0.05	0.02	0.01	0.02	0.22	
		HV Lines	0.10	0.08	0.08	0.35	0.06	0.34	0.12	0.18	0.11	3.39	
		LV Lines	α	α	α	0.01	α	0.01	0.00	α	α	0.01	
		Subtotal	1.19	0.08	0.13	0.39	0.06	0.40	0.14	0.20	0.14	3.62	0.28
	Planned Outage												
		Generators	α	α	0.00	α	α	α	0.00	0.00	0.00	α	
		HV Lines	α	0.02	0.01	0.04	0.07	0.01	0.07	0.08	0.00	0.02	
		LV Lines	α	α	α	0.02	0.02	0.01	0.02	0.06	0.00	0.05	
		Subtotal	α	0.02	0.01	0.06	0.09	0.01	0.09	0.14	0.00	0.07	0.03
	Total Outage												
		Generators	1.09	α	0.05	0.04	α	0.05	0.02	0.01	0.02	0.22	
		HV Lines	0.10	0.09	0.09	0.39	0.13	0.35	0.19	0.26	0.11	3.41	
		LV Lines	α	α	0.01	0.03	0.02	0.01	0.02	0.06	α	0.06	
		Total	1.19	0.09	0.14	0.45	0.15	0.41	0.23	0.34	0.14	3.69	0.31
SAIDI [Minute]	Forced Outage												
		Generators	2,127	α	1	3	α	5	5	8	8	11	
		HV Lines	27	6	17	344	8	378	18	23	95	1,236	
		LV Lines	α	1	1	1	1	13	0	1	1	22	
		Subtotal	2,154	7	19	348	9	396	24	32	104	1,269	221
	Planned Outage												
		Generators	α	α	0	0	α	α	0	0	0	α	
		HV Lines	α	2	3	5	13	1	8	11	0	2	
		LV Lines	α	α	α	2	2	1	2	4	0	4	
		Subtotal	α	2	3	8	15	1	10	15	0	6	4
	Total Outage												
		Generators	2,127	α	1	3	α	5	5	8	8	11	
		HV Lines	27	8	20	349	21	379	25	34	95	1,238	
		LV Lines	α	1	1	4	3	13	2	5	1	26	
		Total	2,154	9	22	356	24	397	33	47	103	1,275	225

* The nationwide figures are calculated by weighing the figures from all regional service areas.

[14] Electric facilities such as generating plants, substations, transmission lines, or extra high voltage lines.

IV. Conclusion

Frequency

The criterion for maintained frequency is the frequency time-kept ratio, which is the ratio of time that the metered frequency is maintained within a given variance of the standard. The frequency time-kept ratio within the target variance of the standard for frequency-synchronized regions for FY 2018 was achieved 100% except in the Hokkaido region. The fall of the ratio in Hokkaido EPCO area was temporary due to the Hokkaido Eastern Iburi Earthquake. The frequency fluctuation stabilized according to the increased supply capability in the area after the earthquake.

Voltage

The criteria of maintained voltage include the number of measured points where the metered voltage deviates from the above-stated standard and the deviation ratio, which is the ratio of deviated points against the total number of measured points. No deviation from the voltage standard was observed nationwide in FY 2018.

Supply Disturbances and Interruption for LV Customers

The criteria of supply interruptions include the number of supply disturbances and the system average interruption indices, SAIFI and SAIDI. In FY 2018, the number of supply disturbances nationwide increased by about 10,000 cases compared with the average of the past 5-years. Eight of 10 areas, except the Hokkaido and Tohoku regions, indicated a higher number of supply disturbances than the 5-year average. For the breakdown by where interruptions originated, supply disturbances at HV overhead lines dominated the increase in the number of cases, which were likely to be caused by natural disasters, such as typhoons and heavy rainfall.

The 31 supply disturbances over a certain scale for FY 2018 was an increase by 16 from 15 supply disturbances recorded in FY 2017, which was the biggest in the past 5 years. Among these supply disturbances, the number due to rainstorms was 17, which was an increase of 14 from three for FY 2017. Considering the data from interruption for LV customers, the SAIFI data from four areas and SAIDI data from seven areas for FY 2018 registered the highest values during the past 5-year period, respectively. For the Hokkaido EPCO area, the increased SAIDI was mainly attributable to the blackout. For the Central and Western, and the Okinawa regions, those increases were mainly due to several very strong typhoons and heavy rainfall.

The Japanese government has recognized the importance of resilience in electricity infrastructures, and the necessity to review the ideal networks for highly resilient electricity systems and infrastructures based on the major disturbances due to a series of natural disasters after the summer of 2018. The government has launched the "Working Group on Electricity Resilience" to discuss challenges and countermeasures for the formation of resilient electricity infrastructures and systems. OCCTO continues to collect and publish information about the quality of electricity.

Alpha (α) is shown if the data are a fraction less than a unit.

<Reference> Comparison of System Average Interruptions in Japan with Various Countries and US States for 2014–2018.

Table 45 and Figure 33 show the SAIDI values, while Table 46 and Figure 34 show the SAIFI values for Japan and various countries and US states for the period 2014–2018. The data for EU countries were cited from the report[15] of the Council of European Energy Regulators (CEER), while those for major US states were from the report[16] of the Public Utilities Commission in each state. OCCTO aggregated and analyzed these data.[17]

The monitoring condition, such as the observed voltage, annual period of monitoring (starting from January or April),[18] or including/excluding natural disasters, vary in each country/state; therefore, the interruption data may not be adequately compared between Japan and various countries/states. Nevertheless, both SAIDI and SAIFI values were at lower levels than those of various countries/states. In addition, Japan observes only LV customers' data; however, few customers are supplied by networks other than LV; thus, the interruptions experienced by these customers were estimated to have a slight influence on the interruption data.

[15] Source: "CEER Benchmarking Report 6.1 on the Continuity of Electricity and Gas Supply Data update 2015/2016"
https://www.ceer.eu/documents/104400/-/-/963153e6-2f42-78eb-22a4-06f1552dd34c
This report is published roughly every 3 years using the updated data for the previous 3 years.

[16] Sources:
State of California: California Public Utilities Commission, "Electric System Reliability Annual Reports"
http://www.cpuc.ca.gov/General.aspx?id=4529
State of Texas: Public Utility Commission of Texas,
"Annual Service Quality Report pursuant to PUC Substantive Rule in S.25.81,"
http://www.puc.texas.gov/industry/electrici/reports/sqr/default.aspx
State of New York: Department of Public Service, "Electric Reliability Performance Reports."
http://www3.dps.ny.gov/W/PSCWeb.nsf/All/D82A200687D96D3985257687006F39CA?OpenDocument

[17] Values for states are calculated for California and Texas by weighting the numbers of customers of major electric power companies according to their reliability reports.(For California, SDG&E, PG&E, and SCE are used; for Texas, all electric power companies are used in the calculation.)

[18] The fiscal year (April 1 to March 31) is used for Japan, while the calendar year (January 1 to December 31) is used for other countries/states.

Table 45 SAIDI of Japan and Various Countries/US States for FY 2014–2018 by Forced and Planned Outages

(Minutes/Year: Customer)

Country/State			2014	2015	2016	2017	2018	Condition: Event of	Condition: Observed Voltage	Condition: Natural Disaster
JAPAN			20	21	25	16	225	except auto re-closing	LV	Include
		Forced	16	18	21	12	221			
		Planned	4	4	4	3	4			
U.S.A.	California		122	122	219	308	266	5 minutes and longer	All	Include
		Forced	115	115	124	244	201			
		Planned	7	7	95	64	65			
	Texas		214	277	214	522	175			
		Forced	207	268	205	509	158			
		Planned	7	10	9	13	17			
	New York		162	130	137	270	409			
		Forced	-	-	-	-	-			
		Planned	-	-	-	-	-			
EU	Germany		21	22	24	-	-	3 minutes and longer	All	Include
		Forced	14	15	13	-	-			
		Planned	8	7	10	-	-			
	Italy		153	196	144	-	-		All	Include
		Forced	94	129	65	-	-			
		Planned	60	67	79	-	-			
	France		67	74	71	-	-		All	Include
		Forced	52	58	53	-	-			
		Planned	16	16	18	-	-			
	Spain		63	69	66	-	-		All	Include
		Forced	53	56	54	-	-			
		Planned	11	13	12	-	-			
	UK		104	61	55	-	-		All	Exclude
		Forced	93	51	47	-	-			
		Planned	11	10	8	-	-			
	Sweden		102	135	94	-	-		All	Include
		Forced	84	118	76	-	-			
		Planned	18	17	19	-	-			
	Finland		80	169	81	-	-		except LV	Include
		Forced	67	158	68	-	-			
		Planned	13	12	13	-	-			
	Norway		161	173	129	-	-		All	Include
		Forced	118	129	88	-	-			
		Planned	43	44	41	-	-			

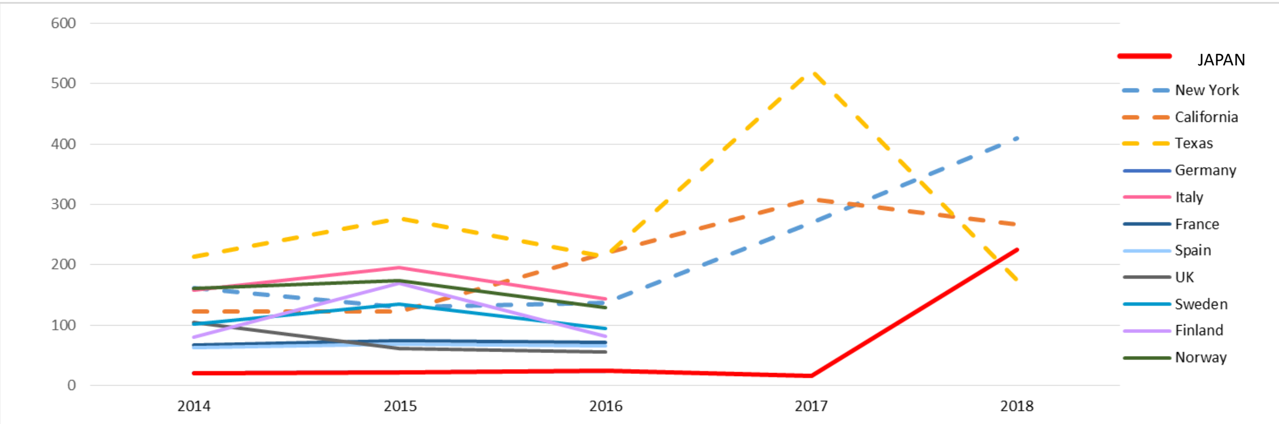

Figure 33 SAIDI of Japan and Various Countries/US States for FY 2014–2018 (Minutes/Year: Customer)

Table 46 SAIFI of Japan and Various Countries/US States for FY 2014–2018 by Forced and Planned Outages

(Number/Year: Customer)

Country/State			Year 2014	2015	2016	2017	2018	Condition: Event of	Observed Voltage	Natural Disaster
JAPAN			0.16	0.13	0.18	0.14	0.31	except auto re-closing	LV	Include
		Forced	0.13	0.10	0.14	0.11	0.28			
		Planned	0.04	0.03	0.03	0.03	0.03			
U.S.A.	California		1.00	0.94	1.31	1.46	1.45	5 minutes and longer	All	Include
		Forced	0.97	0.91	1.05	1.26	0.94			
		Planned	0.03	0.03	0.26	0.20	0.50			
	Texas		1.59	1.91	1.55	1.61	1.54			
		Forced	1.51	1.82	1.48	1.51	1.40			
		Planned	0.08	0.09	0.07	0.15	0.13			
	New York		0.68	0.67	0.79	0.85	1.01			
		Forced	-	-	-	-	-			
		Planned	-	-	-	-	-			
EU	Germany		0.45	0.91	0.59	-	-	3 minutes and longer	All	Include
		Forced	0.37	0.83	0.51	-	-			
		Planned	0.08	0.08	0.08	-	-			
	Italy		2.35	2.81	2.17	-	-		All	Include
		Forced	1.99	2.43	1.76	-	-			
		Planned	0.36	0.37	0.41	-	-			
	France		0.20	0.22	0.22	-	-		All	Include
		Forced	0.07	0.09	0.08	-	-			
		Planned	0.13	0.13	0.14	-	-			
	Spain		1.29	1.31	1.18	-	-		All	Include
		Forced	1.13	1.21	1.09	-	-			
		Planned	0.16	0.10	0.09	-	-			
	UK		0.76	0.60	0.57	-	-		All	Exclude
		Forced	0.72	0.56	0.53	-	-			
		Planned	0.04	0.04	0.04	-	-			
	Sweden		1.46	1.36	1.33	-	-		All	Include
		Forced	1.30	1.22	1.17	-	-			
		Planned	0.16	0.14	0.16	-	-			
	Finland		1.76	2.78	1.58	-	-		except LV	Include
		Forced	1.60	2.64	1.42	-	-			
		Planned	0.15	0.14	0.15	-	-			
	Norway		2.44	2.17	1.89	-	-		All	Include
		Forced	2.15	1.87	1.59	-	-			
		Planned	0.29	0.30	0.30	-	-			

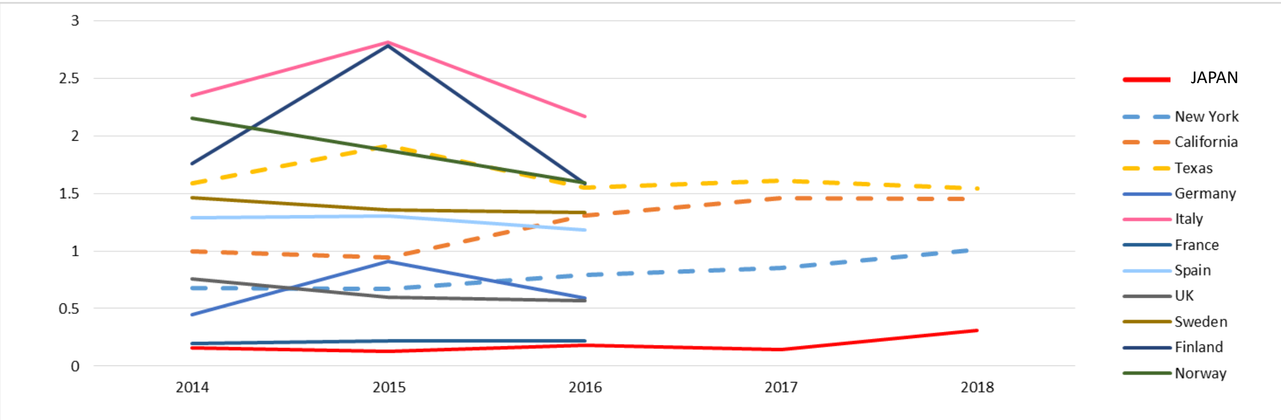

Figure 34 SAIFI of Japan and Various Countries/US States for FY 2014–2018 (Number/Year: Customer)

Organization for Cross-regional Coordination of
Transmission Operators, Japan
http://www.occto.or.jp/en/index.html