Report on the Quality of Electricity Supply

- Data for Fiscal Year 2021 -

January 2023

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

Introduction

One of the objectives of the Organization for Cross-regional Coordination of Transmission Operators, Japan (OCCTO) is to evaluate supply reliability conditions in securing a stable electricity supply. Thus, 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 the evaluation of the data. These data are collected from each regional service area for the 2021 fiscal year (FY 2021). OCCTO uses these data to evaluate and analyze whether frequencies or voltages have been maintained within certain parameters, or whether there are frequent supply interruptions. In addition, although the data conditions regarding supply interruption, are not uniform, a comparison with major states in the United States (US) was conducted as a reference.
Here, the goal of the OCCTO 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

In this report, the quality of nationwide electricity supply in FY 2021 was reviewed in this report based on the provisions of Article 181 of OCCTO's Operational Rules.
Three aspects, namely, frequency, standard voltage, and interruption, of the quality of electricity supply were evaluated in this report, namely, frequency, standard voltage, and interruption. Although different indices are available for evaluating each of these items, this report used the same indices as those published in previous years to allow for historical comparison.

Frequency

The frequency time-kept ratio, which is the ratio of time that the metered frequency is maintained within a given target control range, was used to analyze frequency. Four areas, i.e., were grouped into synchronized frequency regions: Hokkaido, Eastern Japan, Central and Western Japan, and Okinawa, were grouped into synchronized frequency regions. The transmission operators in the Eastern and Western areas of Japan use 50 Hz and 60 Hz, respectively.
For this report, the frequency time-kept ratios in these four synchronized regions were reviewed, and no deviation beyond the target control range was found.

Standard Voltage

The standard voltage was evaluated considering 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). The Act sets the targets for transmission operators to ensure a standard voltage supply within a certain range of values.
At the request by OCCTO, the transmission operators submitted their data. Nationwide, there was no violation of standard voltage among 6,589 points for 100 V and 6,523 points for 200 V.

Interruption

Interruptions were monitored from three perspectives: 1) the number of supply disturbances by the place of occurrence, 2) the number of supply disturbances by cause, i.e., beyond the given standards in time duration and lost capacity, and 3) system average interruption frequency index (SAIFI) and system average interruption duration index (SAIDI) values for low-voltage (LV) customers.
In the first analysis, the total number of supply disturbances was found to be 11,563, which is below the level of disturbances recorded in the previous year. This decreasing trend was observed for the third consecutive year. In addition, the number of supply disturbances decreased or stayed at the same level compared to the previous year in every regional service area.
The second analysis categorizes the causes of supply disturbances into two factors, i.e., maintenance problems or natural disasters, the latter being irrelevant to maintenance problems.
These analyses indicate 27 cases of supply disturbances, i.e., the number of supply disturbances is increased by 8 cases compared to that of the previous year. With respect to the causes of disturbances, there were 17 cases of disturbances triggered by natural disasters, i.e., this number

increased by 12 cases compared to that of the previous year. The main cause triggered by natural disasters was earthquake. In particular, 8 cases of 9 disturbances by natural disaster were caused by the Fukushima Earthquake in March 2022 in Tohoku area. However, the number of disturbances triggered by the fault of facility or maintenance was decreased compared to that of the previous year. In the final analysis, SAIFI and SAIDI values were historically monitored. The data for FY 2021 were 0.13 interruptions and 10 minutes, per one customer, respectively. These values were lower compared with the corresponding data from the previous year and were the least values for the past 5 years. The number of supply disturbances either decreased or stayed at the same level compared with the previous year data for all study areas, except for Hokkaido area, which was affected by wind and rain.
For reference, the report also compares SAIFI and SAIDI values with those of the US states, although the comparison is not straightforward given that index definitions are not identical across the US states.

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

CONTENTS

<Errata>

2024/2/2	P3	Table 7	Data from FY 2017 to 2021 are altered.

I. Frequency data

1. Standard frequency in Japan

General transmission and distribution (GT&D) companies are required to maintain the frequency value of the electricity supply at the levels specified by the Ordinance of the Ministry of Economy, Trade and Industry, i.e., according to the provisions of Article 26 of the Electricity Business Act (hereafter, the Act). Figure 1 shows the regional service areas of the 10 GT&D companies considered in this report and their standard frequencies.

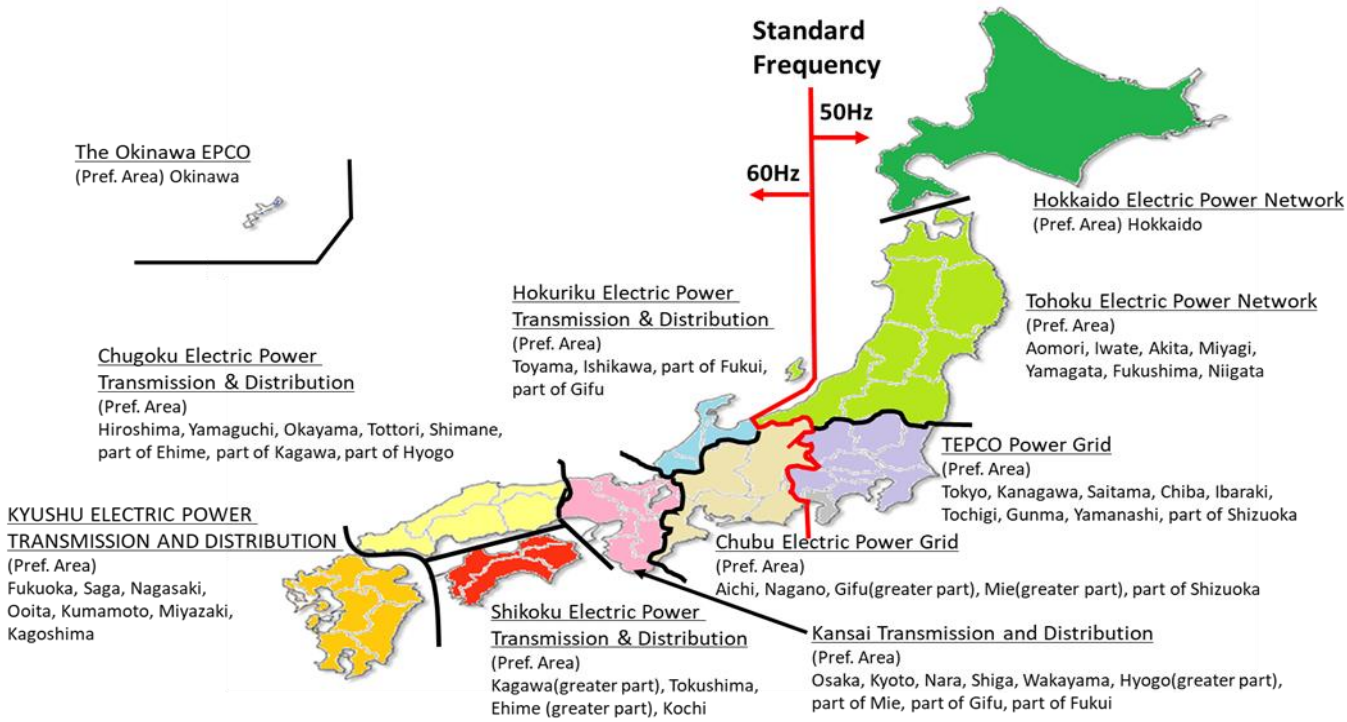

Figure 1 Regional service areas of the 10 GT&D companies and their standard frequencies

2. Frequency time-kept ratio

The maintained frequency was examined using 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 is calculated by the following formula:

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

3. Frequency control rule[1]

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

Table 1 Frequency control rule under normal condition for each regional service areas

Areas	Hokkaido	Tohoku, Tokyo	Chubu, Hokuriku, Kansai, Chugoku, Shikoku, Kyushu	Okinawa
Frequency standard	50 Hz	50 Hz	60 Hz	60 Hz
Control target (for the standard)	±0.3 Hz	±0.2 Hz	±0.2 Hz	±0.3 Hz
Target time-kept ratio within ± 0.1 Hz	—	—	95% over	—

[1] According to item 2 of Article 38 of the Ministerial Ordinance of the Act, frequency value defined by Ministerial Order is deemed to be the same frequency that general transmission and distribution companies supplies; general transmission and distribution companies set their frequency control target by its code, standard or manual.

4. Frequency time-kept ratio by frequency-synchronized region (FY 2017–2021)

Tables 2–5 show the frequency time-kept ratios by frequency-synchronized regions from FY 2017 to 2021, while Figures 2–5 show the trend of maintaining the frequency within 0.1 Hz variance.

The frequency time-kept ratio set by GT&D companies was recorded as 100% in all regions for FY 2021. In the Central and Western region, the target frequency time-kept ratio within 0.1 Hz variance for FY 2021 was 98.12%, which was slightly lower than that of the previous year (98.50%), but above the target time-kept ratio of 95.00%.

【Criteria】

Control target ··· 100.00%

Target time-kept ratio within ±0.1 Hz ··· 95.00% Over

Table 2 Frequency time-kept ratio (Hokkaido, FY 2017–2021) [%]

Variance	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Within 0.1 Hz	99.97	99.86	99.98	99.93	99.87
Within 0.2 Hz	100.00	99.95	100.00	100.00	99.99
Within 0.3 Hz	100.00	99.98	100.00	100.00	100.00
Beyond 0.3 Hz	0.00	0.02	0.00	0.00	0.00

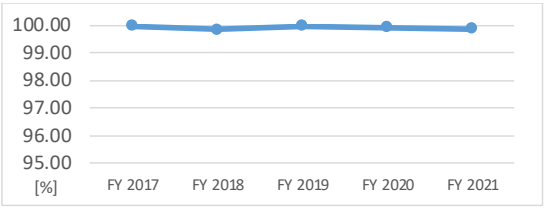

Figure 2 Frequency time-kept ratio within 0.1 Hz (Hokkaido, FY 2017-2021)

Table 3 Frequency time-kept ratio (Eastern region,[2] FY 2017–2021) [%]

Variance	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Within 0.1 Hz	99.80	99.84	99.83	99.71	99.50
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

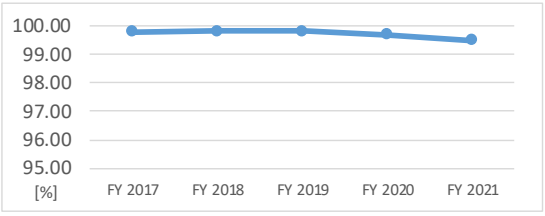

Figure 3 Frequency time-kept ratio within 0.1 Hz (Eastern region,[2] FY 2017-2021)

Table 4 Frequency time-kept ratio (Central & Western region,[3] FY 2017–2021) [%]

Variance	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Within 0.1 Hz	99.17	99.13	99.02	98.50	98.12
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

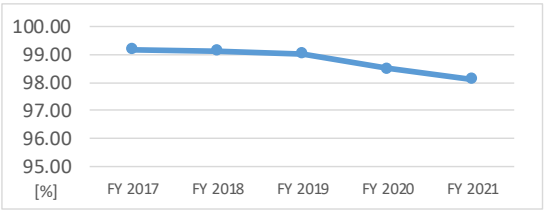

Figure 4 Frequency time-kept ratio (Central & Western region,[3] FY 2017–2021)

Table 5 Frequency time-kept ratio (Okinawa, FY 2017–2021) [%]

Variance	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
Within 0.1 Hz	99.92	99.89	99.89	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

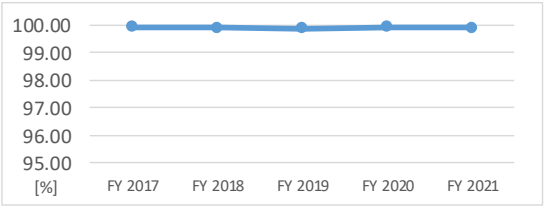

Figure 5 Frequency time-kept ratio (Okinawa, FY 2017–2021)

[2] Eastern region includes the regional service areas of the Tohoku Electric Power Network and TEPCO Power Grid. Actual data were collected from the area of TEPCO Power Grid.

[3] Central and Western regions of Japan include the regional service areas of Chubu Electric Power Grid, Hokuriku Electric Transmission & Distribution, Kansai Transmission & Distribution, Chugoku Electric Power Transmission & Distribution, Shikoku Electric Power Transmission & Distribution, and Kyushu Electric Power Transmission & Distribution. Actual data were collected from the area of Kansai Transmission & Distribution.

II. Voltage Data

1. Japanese voltage standard

GT&D companies should endeavor to maintain the voltage value of the electricity supply at the levels specified by the provisions of Article 26 of the Act. Table 6 shows the voltage standard and nationwide 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 the provisions of Article 39 of the Ordinance of the Act, GT&D companies should measure voltage during the period designated by the Director General of the Regional Bureau of Economy, Trade, and Industry. The Director General administers regional service areas or supply points (for Hokuriku EPCO, this is the Director General of Chubu Bureau of Economy, Trade, and Industry, Electricity and Gas Department Hokuriku) once over 24 consecutive hours at selected measuring points, unless otherwise stated. GT&D companies calculate the average of 30 minutes, including the maximum and the minimum values, and review whether these values deviated from the average or not.

3. Nationwide voltage deviation ratio (FY 2017–2021)

Table 7 shows the total measured points, deviated measured points, and nationwide deviation ratio from FY 2017 to 2021.

For the FY 2021 data, the GT&D companies reported that the voltage standard was maintained adequately, with no deviation in voltage standard.

Table 7 Voltage deviation measurement (Nationwide, FY 2017–2021) [points]

Voltage		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021
100V	Total measured points	6,565	6,575	6,567	6,562	6,589
	Deviated points	0	0	0	0	0
200V	Total measured points	6,506	6,505	6,502	6,498	6,523
	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 interruption of 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]

[4] Electric facilities include machinery, apparatus, dams, conduits, reservoirs, electric lines, and other facilities installed for the generation, storage transformation, transmission, distribution, or consumption of electricity as defined by the provisions of the item 18, paragraph 1 of the Article 2 of the Act.

[5] 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 on 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 vii, Paragraph 2 of Article 1 of Reporting Rules of the Electricity Business, 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; hereafter, the same shall apply in this article) due to malfunction, misuse, or disoperation of the electric facility. However, the case in which electricity supply is resumed by automatic reclosing of the transmission line is not applicable to supply disturbance.

(2) Data on number of supply disturbances nationwide and by regional service area (FY 2017–2021)

Table 8 and Figure 6 show the number of supply disturbances nationwide, where the interruptions originated in the period FY 2017–2021. Tables 9–18 and Figures 7–16 show the number of supply disturbances from regional service areas. In addition, the category "Involving Accidents" in the tables indicates the number of supply disturbances that were induced from accidents of electric facilities other than from the corresponding GT&D companies. The table columns are blank for zero values or if the data are not available. An analysis of the FY 2021 data indicates the following.

With respect to FY 2021 data, the total number of supply disturbances was 11,563, which was below the level of disturbances recorded in the previous year. This decrease in value was for the third consecutive year. The number of supply disturbances decreased or stayed at the same level from the previous year in every regional service area.

Table 8 Number of supply disturbances where interruption originated (Nationwide, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		45	65	56	48	65	55.8
Transmission lines & Extra High Voltage lines	Overhead	278	409	246	274	260	293.4
	Under-ground	14	10	13	9	17	12.6
	Total	292	419	259	283	277	306.0
High Voltage lines	Overhead	12,679	20,729	13,958	13,539	10,775	14,336.0
	Under-ground	216	265	227	201	201	222.0
	Total	12,895	20,994	14,185	13,740	10,976	14,558.0
Demand facilities		1					0.2
Involvng accidents		343	359	372	277	245	319.2
Total disturbances		13,576	21,837	14,872	14,348	11,563	15,239.2

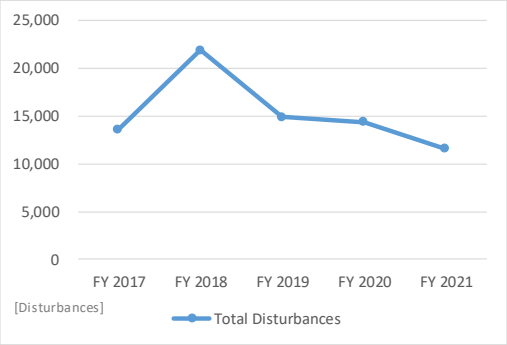

Figure 6 Transition of supply disturbances (Nationwide, FY 2017–2021)

Table 9 Number of supply disturbances where interruption originated (Hokkaido, FY 2016–2020)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations			5	2	2	3	2.4
Transmission lines & Extra High Voltage lines	Overhead	30	25	12	21	20	21.6
	Under-ground			1	1		0.4
	Total	30	25	13	22	20	22.0
High Voltage lines	Overhead	1,144	1,139	600	801	848	906.4
	Under-ground	19	13	15	15	12	14.8
	Total	1,163	1,152	615	816	860	921.2
Demand facilities							
Involvng accidents		17	12	11	10	14	12.8
Total disturbances		1,210	1,194	641	850	897	958.4

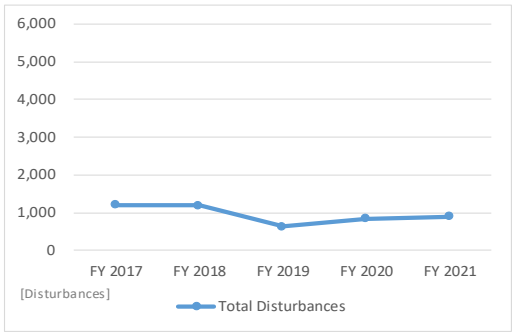

Figure 7 Transition of supply disturbances (Hokkaido, FY 2016–2020)

Table 10 Number of supply disturbances where interruption originated (Tohoku, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		4	9	8	9	9	7.8
Transmission lines & Extra High Voltage lines	Overhead	16	11	16	31	31	21.0
	Under-ground	1					0.2
	Total	17	11	16	31	31	21.2
High Voltage lines	Overhead	1,957	1,478	1,646	2,528	1,686	1,859.0
	Under-ground	5	11	7	13	7	8.6
	Total	1,962	1,489	1,653	2,541	1,693	1,867.6
Demand facilities							
Involvng accidents		26	20	29	17	18	22.0
Total disturbances		2,009	1,529	1,706	2,598	1,751	1,918.6

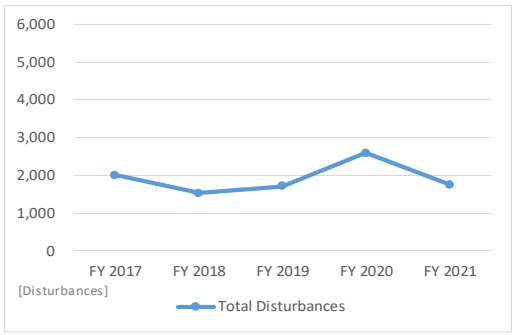

Figure 8 Transition of supply disturbances (Tohoku, FY 2017–2021)

Table 11 Number of supply disturbances where interruption originated (Tokyo, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		17	16	17	5	10	13.0
Transmission lines & Extra High Voltage lines	Overhead	24	38	21	10	10	20.6
	Under-ground	4		4	3	5	3.2
	Total	28	38	25	13	15	23.8
High Voltage lines	Overhead	2,311	3,841	5,186	2,472	2,316	3,225.2
	Under-ground	65	100	97	75	87	84.8
	Total	2,376	3,941	5,283	2,547	2,403	3,310.0
Demand facilities							
Involvng accidents		96	107	134	74		82.2
Total disturbances		2,517	4,102	5,459	2,639	2,428	3,429.0

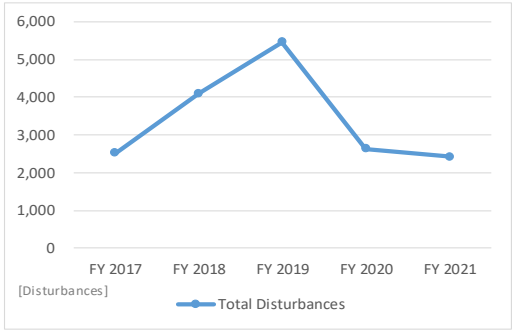

Figure 9 Transition of supply disturbances (Tokyo, FY 2017–2021)

Table 12 Number of supply disturbances where interruption originated (Chubu, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		3	6	10	4	7	6.0
Transmission lines & Extra High Voltage lines	Overhead	9	26	19	15	9	15.6
	Under-ground				1		0.2
	Total	9	26	19	16	9	15.8
High Voltage lines	Overhead	1,607	4,053	1,570	1,359	1,338	1,985.4
	Under-ground	11	39	6	4	10	14.0
	Total	1,618	4,092	1,576	1,363	1,348	1,999.4
Demand facilities							
Involvng accidents		49	66	60	71	64	62.0
Total disturbances		1,679	4,190	1,665	1,454	1,428	2,083.2

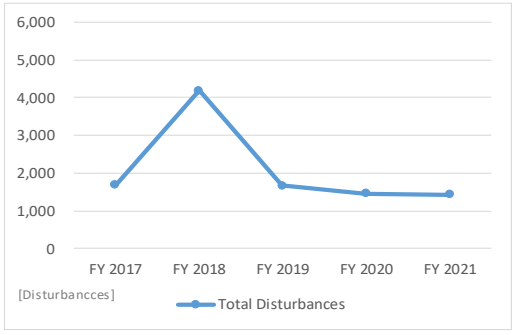

Figure 10 Transition of supply disturbances (Chubu, FY 2017–2021)

Table 13 Number of supply disturbances where interruption originated (Hokuriku, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		1		2	3	4	2.0
Transmission lines & Extra High Voltage lines	Overhead	4	7	2	3		3.2
	Under-ground		2	2			0.8
	Total	4	9	4	3	0	4.0
High Voltage lines	Overhead	542	385	199	444	215	357.0
	Under-ground	5	3	1	4	1	2.8
	Total	547	388	200	448	216	359.8
Demand facilities							
Involvng accidents		15	21	10	10	14	14.0
Total disturbances		567	418	216	464	234	379.8

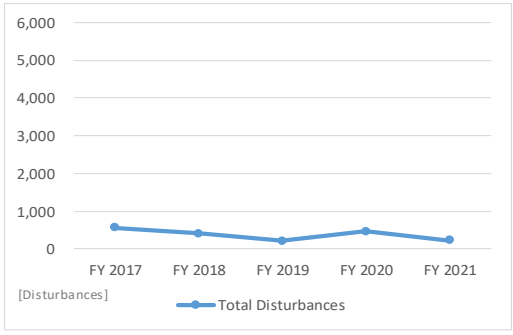

Figure 11 Transition of supply disturbances (Hokuriku, FY 2017–2021)

Table 14 Number of supply disturbances where interruption originated (Kansai, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		9	8	3	6	10	7.2
Transmission lines & Extra High Voltage lines	Overhead	102	190	82	84	86	108.8
	Underground	7	6	3	4	8	5.6
	Total	109	196	85	88	94	114.4
High Voltage lines	Overhead	1,695	5,270	1,300	1,254	1,384	2,180.6
	Underground	48	56	50	50	33	47.4
	Total	1,743	5,326	1,350	1,304	1,417	2,228.0
Demand facilities							
Involvng accidents		65	70	64	44	56	59.8
Total disturbances		1,926	5,600	1,502	1,442	1,577	2,409.4

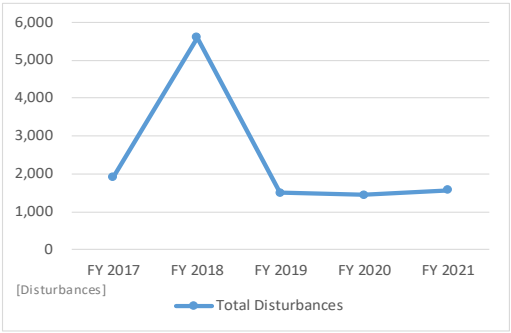

Figure 12 Transition of supply disturbances (Kansai, FY 2017–2021)

Table 15 Number of supply disturbances where interruption originated (Chugoku, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		2	8	6	3	6	5.0
Transmission lines & Extra High Voltage lines	Overhead	16	14	17	11	25	16.6
	Underground	1	1	1		1	0.8
	Total	17	15	18	11	26	17.4
High Voltage lines	Overhead	1,066	1,172	1,015	1,163	1,193	1,121.8
	Underground	24	20	16	12	15	17.4
	Total	1,090	1,192	1,031	1,175	1,208	1,139.2
Demand facilities		1					0.2
Involvng accidents		33	31	35	32	37	33.6
Total disturbances		1,143	1,246	1,090	1,221	1,277	1,195.4

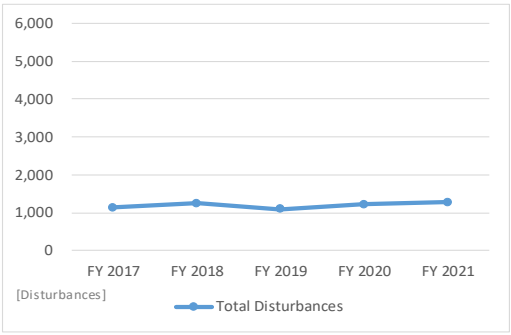

Figure 13 Transition of supply disturbances (Chugoku, FY 2017–2021)

Table 16 Number of supply disturbances where interruption originated (Shikoku, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		6	4	2	5	3	4.0
Transmission lines & Extra High Voltage lines	Overhead	3	4	4	1	10	4.4
	Underground						
	Total	3	4	4	1	10	4.4
High Voltage lines	Overhead	630	616	439	447	393	505.0
	Underground	9	8	6	6	10	7.8
	Total	639	624	445	453	403	512.8
Demand facilities							
Involvng accidents		5	5	7	6	10	6.6
Total disturbances		653	637	458	465	426	527.8

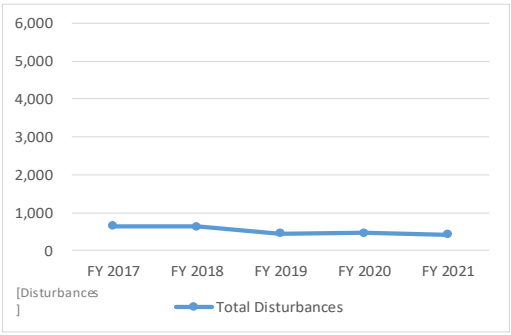

Figure 14 Transition of supply disturbances (Shikoku, FY 2017–2021)

Table 17 Number of supply disturbances where interruption originated (Kyushu, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations		3	1	4	7	11	5.2
Transmission lines & Extra High Voltage lines	Overhead	32	42	38	42	24	35.6
	Underground		1			1	0.4
	Total	32	43	38	42	25	36.0
High Voltage lines	Overhead	1,349	1,888	1,547	2,614	1,088	1,697.2
	Underground	30	15	22	17	22	21.2
	Total	1,379	1,903	1,569	2,631	1,110	1,718.4
Demand facilities							
Involvng accidents		23	16	19	13	18	17.8
Total disturbances		1,437	1,963	1,630	2,693	1,164	1,777.4

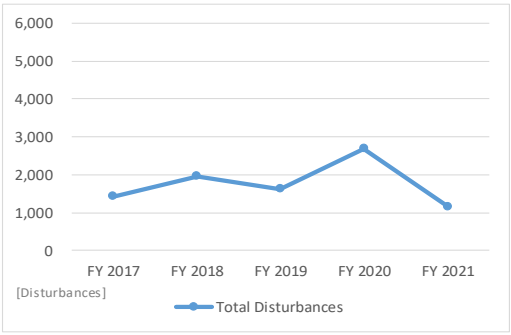

Figure 15 Transition of supply disturbances (Kyushu, FY 2017–2021)

Table 18 Number of supply disturbances where interruption originated (Okinawa, FY 2017–2021)

Occurrence at		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years average
Disturbance of general transmission & distribution companies' facilities							
Substations			8	2	4	2	3.2
Transmission lines & Extra High Voltage lines	Overhead	42	52	35	56	45	46.0
	Underground	1		2		2	1.0
	Total	43	52	37	56	47	47.0
High Voltage lines	Overhead	378	887	456	457	314	498.4
	Underground			7	5	4	3.2
	Total	378	887	463	462	318	501.6
Demand facilities							
Involvng accidents		14	11	3		14	8.4
Total disturbances		435	958	505	522	381	560.2

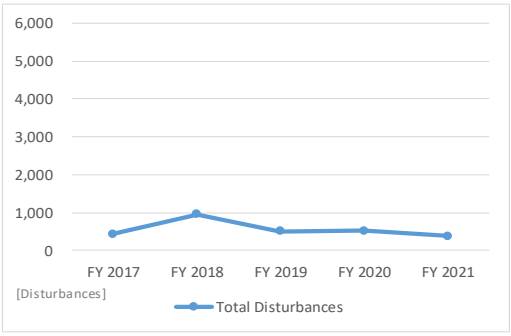

Figure 16 Transition of supply disturbances (Okinawa, FY 2017–2021)

2. Number of supply disturbances where interruptions originated with their causes

(1) Data on supply disturbances over a certain scale

Disturbances over a certain scale were reported along with their causes for the data on supply disturbances where the interruption originated as described in the previous section. This section analyzes these causes. Figure 17 illustrates the number of supply disturbances indicating where interruptions originated versus the scale of interruption. Table 19 shows the nationwide data for FY 2020[7]. The columns in the table were left blank if value was zero or data are unavailable. It should be noted here that supply disturbances that was caused by blackout are not included in the statistics.

- 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

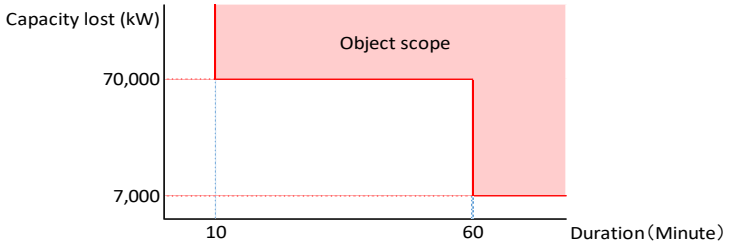

Figure 17 Image of supply disturbances over a certain scale

Table 19 Number of supply disturbances where interruption originated by scale of interruption (Nationwide, FY 2021) [Disturbances]

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 Disturbances
		70,000kW to 100,000kW under	100,000kW over[8]	70,000kW to 100,000kW under	100,000kW over[8]	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over[8]	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over[8]	
Accidents of facilities of General transmission & distribution companies												
Substations						5			3		1	9
Transmission lines & Extra High Voltage lines	Overhead		1			5		1	11			18
	Under-ground											
	Total		1			5		1	11			18
High Voltage distribution lines	Overhead											
	Under-ground											
	Total											
Demand facilities												
Involved accidents												
Total disturbances			1			10		1	14		1	27

[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 of lost capacity of 70,000–100,000 kW, the loss is reported to the Director of Regional Industrial Safety and the Inspection Department that directs the area where 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 improper production (improper design, fabrication, or material of electric facilities) or improper installation (improper operation of construction or maintenance work).
Maintenance fault		Due to improper 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 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 public’s 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) Number and causes of supply disturbances over a certain scale (FY 2017–2021)

Table 21 and Figure 18 show the nationwide data for the number of supply disturbances where interruption originated over a certain scale. Tables 22–31 show the same data from each regional service area for the period FY 2017–2021.[8,9]

The number and the causes of supply disturbances over a certain scale for the FY 2021 data were analyzed. Nationwide, there were 27 cases of supply disturbance over a certain scale; this value was increased by 8 cases compared to that of the previous year. For the causes of disturbances, there were 17 cases of disturbance triggered by natural disaster; this value was an increased of 12 cases compared to the previous year. The major cause of disturbance was earthquake, particularly the 8 cases of 9 disturbances by natural disaster were caused by the Fukushima Earthquake in March 2022 in Tohoku area. In comparison, there was a decrease in the number of disturbances triggered by fault of facility or maintenance.

Table 21 Causes of disturbances over a certain scale (Nationwide, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault	1	3	1	1	2	1.6
Maintenance fault	4	1	1	1	1	1.6
Accident/malice	1	2	4	4	1	2.4
Physical contact	2	2	5	6	4	3.8
Involved accident		1	1			0.4
Electric shock(worker)						
Electric shock(public)					1	
Subtotal	8	9	12	12	9	10.0
Natural disaster						
Thunderbolt	2	1	2	2	4	2.2
Rainstorm	3	17			2	4.4
Snowstorm	2				2	0.8
Earthquake			3	3	9	3.0
Dust/Gas		2				0.4
Subtotal	7	20	5	5	17	10.8
Unknown			1	1	1	0.6
Miscellaneous		2	1	1		0.8
Total disturbances	15	31	18	19	27	22.0

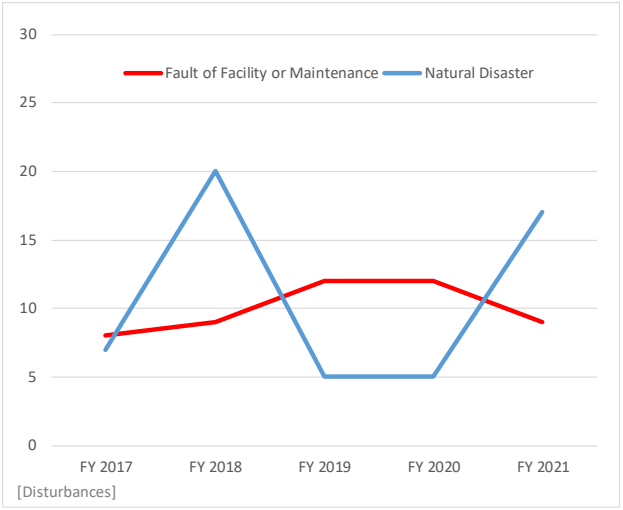

Figure 18 Transition of disturbances by causes (Nationwide, FY 2017–2021)

Table 22 Causes of disturbances over a certain scale (Hokkaido, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault						
Maintenance fault		1				0.2
Accident/malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Electric shock(public)						
Subtotal		1				0.2
Natural disaster						
Thunderbolt						
Rainstorm					1	0.2
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal	1		1		1	0.6
Unknown					1	0.2
Miscellaneous						
Total disturbances	1	1	1		2	1.0

Table 23 Causes of disturbances over a certain scale (Tohoku, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault						
Maintenance fault						
Accident/malice					1	0.2
Physical contact					1	0.2
Involved accident						
Electric shock(worker)						
Electric shock(public)						
Subtotal					2	0.4
Natural disaster						
Thunderbolt			1			0.2
Rainstorm						
Snowstorm	1					0.2
Earthquake				3	8	2.2
Dust/Gas						
Subtotal	1		1	3	8	2.6
Unknown						
Miscellaneous						
Total disturbances	1		1	3	10	3.0

[8] Causes of the disturbances that did not occur in the period FY 2017–2021 are omitted from the tables.
[9] Column of the tables are left blank if zero or the data are not available.

Table 24 Causes of disturbances over a certain scale (Tokyo, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault	1					0.2
Maintenance fault					1	0.2
Accident/malice		1	1	2		0.8
Physical contact	1	1	1	1	1	1.0
Involved accident						
Electric shock(worker)						
Electric shock(public)					1	
Subtotal	2	2	2	3	3	2.4
Natural disaster						
Thunderbolt	1	1	2		2	1.2
Rainstorm			3			0.6
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal	1	1	5		2	1.8
Unknown				1		0.2
Miscellaneous		1		1		0.4
Total disturbances	3	4	7	5	5	4.8

Table 25 Causes of disturbances over a certain scale (Chubu, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault						
Maintenance fault						
Accident/malice				1		0.2
Physical contact			2		2	0.8
Involved accident						
Electric shock(worker)						
Electric shock(public)						
Subtotal			2	1	2	1.0
Natural disaster						
Thunderbolt				1		0.2
Rainstorm		1				0.2
Snowstorm						
Earthquake						
Dust/Gas		2				0.4
Subtotal		3		1		0.8
Unknown						
Miscellaneous			1			0.2
Total disturbances		3	3	2	2	2.0

Table 26 Causes of disturbances over a certain scale (Hokuriku, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault						
Maintenance fault						
Accident/malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Electric shock(public)						
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 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault		3			2	1.0
Maintenance fault	3			1		0.8
Accident/malice	1			1		0.4
Physical contact	1		2	4		1.4
Involved accident		1				0.2
Electric shock(worker)						
Electric shock(public)						
Subtotal	5	4	2	6	2	3.8
Natural disaster						
Thunderbolt			1	1	1	0.6
Rainstorm	3	10	1		1	3.0
Snowstorm					1	0.2
Earthquake						
Dust/Gas						
Subtotal	3	10	2	1	3	3.8
Unknown						
Miscellaneous						
Total disturbances	8	14	4	7	5	7.6

Table 28 Causes of disturbances over a certain scale (Chugoku, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault						
Maintenance fault						
Accident/malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Electric shock(public)						
Subtotal						
Natural disaster						
Thunderbolt	1				1	0.4
Rainstorm		2				0.4
Snowstorm					1	0.2
Earthquake						
Dust/Gas			1			0.2
Subtotal	1	2	1		2	1.2
Unknown						
Miscellaneous						
Total disturbances	1	2	1		2	1.2

Table 29 Causes of disturbances over a certain scale (Shikoku, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault						
Maintenance fault	1					0.2
Accident/malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Electric shock(public)						
Subtotal	1					0.2
Natural disaster						
Thunderbolt						
Rainstorm						
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal						
Unknown						
Miscellaneous						
Total disturbances	1					0.2

Table 30 Causes of disturbances over a certain scale (Kyushu, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault						
Maintenance fault						
Accident/malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Electric shock(public)						
Subtotal						
Natural disaster						
Thunderbolt						
Rainstorm		2				0.4
Snowstorm						
Earthquake					1	0.2
Dust/Gas						
Subtotal		2			1	0.6
Unknown						
Miscellaneous						
Total disturbances		2			1	0.6

Table 31 Causes of disturbances over a certain scale (Okinawa, FY 2017–2021) [Disturbances]

	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
Fault of facility or maintenance						
Facility fault						
Maintenance fault						
Accident/malice						
Physical contact				1		0.2
Involved accident						
Electric shock(worker)						
Electric shock(public)						
Subtotal				1		0.2
Natural disaster						
Thunderbolt						
Rainstorm		2	1			0.6
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal		2	1			0.6
Unknown						
Miscellaneous						
Total disturbances		2	1	1		0.8

3. Data of interruptions for low-voltage 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 over one year.

$$\text{System average interruption frequency index (SAIFI/interruptions)} = \frac{\text{Low voltage customers affected by interruption}}{\text{Low voltage customers served at the beginning of the fiscal year}}$$

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

Table 32 shows the definitions of terms related to outage.

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.[10][11]
Planned outage	Electric power company interrupts its electricity supply in planned manner to construct, improve, and maintain its electric facility.

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

(2) Data on system average interruption nationwide and by regional service area (FY 2017–2021)

Table 33 and Figure 19 show the nationwide data for system average interruptions for FY 2017–2021. Tables 34–43 and Figures 20–29 show the data for each regional service area. Table 44 shows the nationwide data for system average interruptions for FY 2021.[12]

The actual data on system average interruption for LV customers are summarized below. Regarding the nationwide SAIFI and SAIDI data, the data for FY 2021 were 0.13 interruptions and 10 minutes, per one customer, respectively. These values were lower compared with the corresponding data from the previous year and were the least values in the past 5 years. All regional service areas showed that the number of interruptions decreased or stayed at the same level compared with the previous data, except for Hokkaido area, which was affected by wind and rain.

Table 33 Indices of system average interruption (Nationwide, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.11	0.28	0.19	0.13	0.10	0.16
	Planned	0.03	0.03	0.04	0.04	0.03	0.03
	Total ●	0.14	0.31	0.23	0.17	0.13	0.20
SAIDI [Minutes]	Forced	12	221	82	24	7	69
	Planned	3	4	3	3	3	3
	Total ●	16	225	86	27	10	73

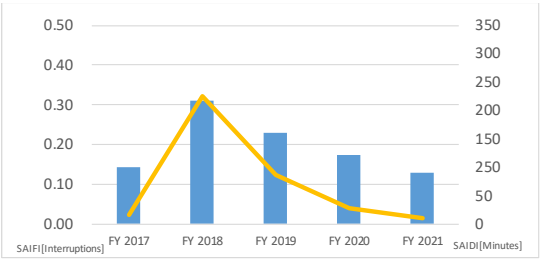

Figure 19 System average interruption indices of LV customers (Nationwide, FY 2017–2021)

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

Table 34 Indices of system average interruption (Hokkaido, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.13	1.19	0.11	0.09	0.14	0.33
	Planned	0.01	α	α	α	α	0.01
	Total 🔵	0.14	1.19	0.11	0.09	0.14	0.33
SAIDI [Minutes]	Forced	10	2,154	4	5	12	437
	Planned	0	α	α	α	α	0
	Total 🟡	10	2,154	4	5	12	437

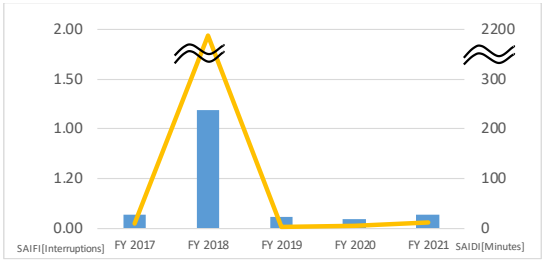

Figure 20 System average interruption indices of LV customers (Hokkaido, FY 2017–2021)

Table 35 Indices of system average interruption (Tohoku, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.13	0.09	0.11	0.16	0.11	0.12
	Planned	0.02	0.02	0.02	0.02	0.02	0.02
	Total 🔵	0.15	0.11	0.12	0.18	0.13	0.14
SAIDI [Minutes]	Forced	10	7	15	25	15	15
	Planned	3	2	2	4	2	3
	Total 🟡	13	10	17	29	18	17

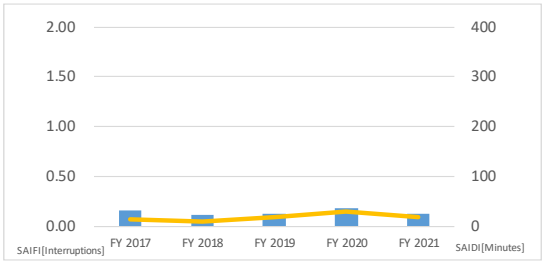

Figure 21 System average interruption indices of LV customers (Tohoku, FY 2017–2021)

Table 36 Indices of system average interruption (Tokyo, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.09	0.13	0.33	0.11	0.10	0.15
	Planned	0.01	0.01	0.03	0.06	0.01	0.02
	Total 🔵	0.10	0.14	0.36	0.17	0.11	0.18
SAIDI [Minutes]	Forced	6	19	200	7	6	48
	Planned	1	3	1	1	1	1
	Total 🟡	7	22	201	8	7	49

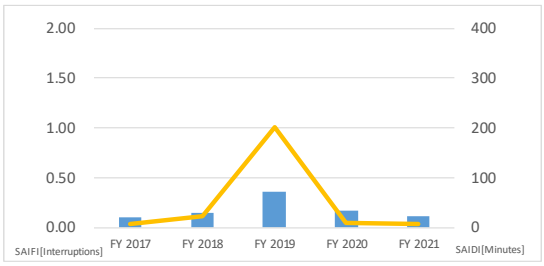

Figure 22 System average interruption indices of LV customers (Tokyo, FY 2017–2021)

Table 37 Indices of system average interruption (Chubu, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.08	0.39	0.11	0.07	0.09	0.15
	Planned	0.06	0.06	0.06	0.05	0.05	0.06
	Total 🔵	0.14	0.45	0.17	0.13	0.14	0.20
SAIDI [Minutes]	Forced	10	348	32	6	5	80
	Planned	7	8	8	7	7	7
	Total 🟡	17	356	40	12	12	87

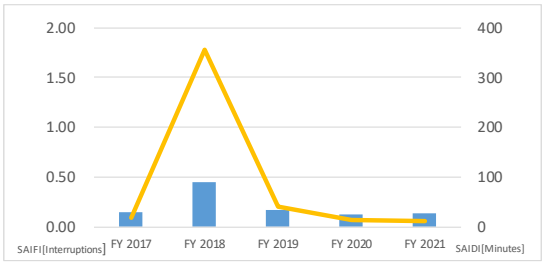

Figure 23 System average interruption indices of LV customers (Chubu, FY 2017–2021)

Table 38 Indices of system average interruption (Hokuriku, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.09	0.06	0.03	0.06	0.04	0.05
	Planned	0.09	0.09	0.09	0.08	0.08	0.09
	Total 🔵	0.17	0.15	0.13	0.14	0.12	0.14
SAIDI [Minutes]	Forced	11	9	3	7	3	7
	Planned	15	15	16	15	14	15
	Total 🟡	26	24	19	22	17	21

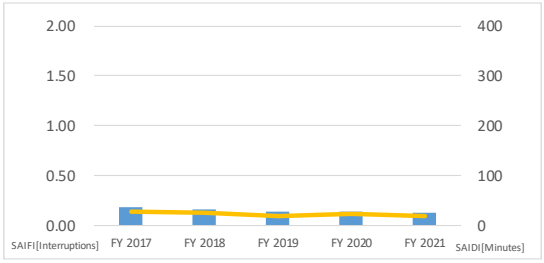

Figure 24 System average interruption indices of LV customers (Hokuriku, FY 2017–2021)

Table 39 Indices of system average interruption (Kansai, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.12	0.40	0.10	0.09	0.08	0.16
	Planned	0.01	0.01	0.01	0.01	0.01	0.01
	Total	0.13	0.41	0.11	0.10	0.10	0.17
SAIDI [Minutes]	Forced	14	396	5	7	6	85
	Planned	1	1	1	1	2	1
	Total	15	397	6	8	7	87

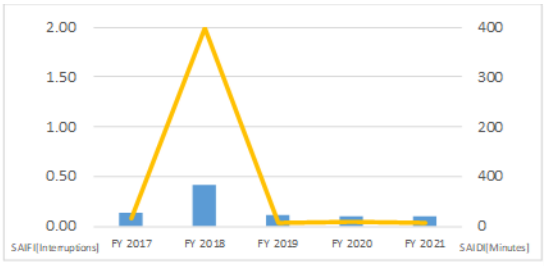

Figure 25 System average interruption indices of LV customers (Kansai, FY 2017–2021)

Table 40 Indices of system average interruption (Chugoku, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.12	0.14	0.13	0.15	0.15	0.14
	Planned	0.11	0.09	0.09	0.10	0.08	0.09
	Total	0.23	0.23	0.21	0.25	0.23	0.23
SAIDI [Minutes]	Forced	7	24	10	20	10	14
	Planned	12	10	9	11	9	10
	Total	19	33	19	31	19	24

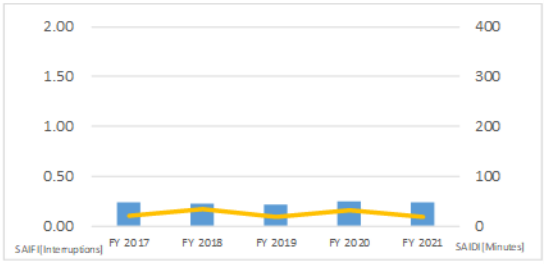

Figure 26 System average interruption indices of LV customers (Chugoku, FY 2017–2021)

Table 41 Indices of system average interruption (Shikoku, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.19	0.20	0.13	0.14	0.12	0.16
	Planned	0.16	0.14	0.14	0.14	0.14	0.15
	Total	0.36	0.34	0.27	0.28	0.26	0.30
SAIDI [Minutes]	Forced	21	32	8	10	7	16
	Planned	17	15	15	15	15	15
	Total	38	47	23	24	23	31

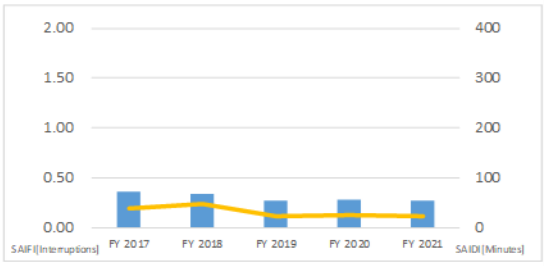

Figure 27 System average interruption indices of LV customers (Shikoku, FY 2017–2021)

Table 42 Indices of system average interruption (Kyushu, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.08	0.14	0.08	0.21	0.07	0.12
	Planned	0	0	0	0	0	0
	Total	0.08	0.14	0.08	0.21	0.07	0.12
SAIDI [Minutes]	Forced	25	103	15	139	3	57
	Planned	0	0	0	0	0	0
	Total	25	103	15	139	3	57

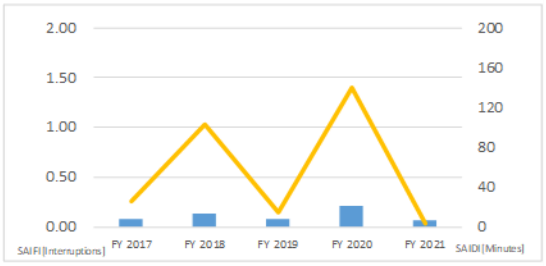

Figure 28 System average interruption indices of LV customers (Kyushu, FY 2017–2021)

Table 43 Indices of system average interruption (Okinawa, FY 2017–2021)

		FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	5-years Average
SAIFI [Interruptions]	Forced	0.98	3.62	1.11	1.12	0.57	1.48
	Planned	0.07	0.07	0.05	0.06	0.05	0.06
	Total	1.05	3.69	1.17	1.18	0.61	1.54
SAIDI [Minutes]	Forced	117	1,269	215	90	40	346
	Planned	7	6	6	11	5	7
	Total	124	1,275	221	101	45	353

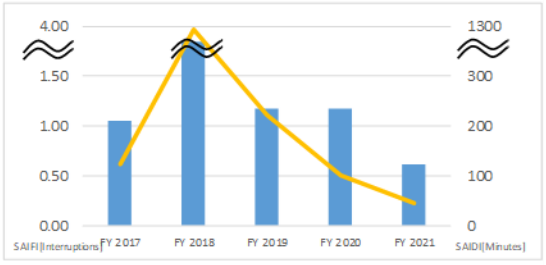

Figure 29 System average interruption indices of LV customers (Okinawa, FY 2017–2021)

Table 44 System average disturbances where interruptions were occurred by outages (Nationwide, FY 2021)[13,]

		Hokkaido	Tohoku	Tokyo	Chubu	Hokuriku	Kansai	Chugoku	Shikoku	Kyushu	Okinawa	Nationwide
SAIFI [Interruptions]	Forced outage											
	Generators	0.07	0.02	0.07	0.03	0.01	0.02	0.03	0.01	0.03	0.15	
	HV lines	0.07	0.08	0.04	0.05	0.03	0.06	0.11	0.10	0.04	0.40	
	LV lines	α	α	α	α	α	α	α	α	α	0.01	
	Subtotal	0.14	0.11	0.10	0.09	0.04	0.08	0.15	0.12	0.07	0.56	0.10
	Planned outage											
	Generators	0.00	α	α	0.00	α	α	α	0.00	0.00	α	
	HV lines	α	0.01	0.01	0.04	0.07	0.01	0.06	0.08	0.00	0.02	
	LV lines	α	α	α	0.01	0.02	0.01	0.02	0.06	0.00	0.03	
	Subtotal	α	0.02	0.01	0.05	0.08	0.01	0.08	0.14	0.00	0.05	0.03
	Total outage											
	Generators	0.07	0.02	0.07	0.03	0.01	0.02	0.03	0.01	0.03	0.15	
	HV lines	0.07	0.10	0.04	0.09	0.10	0.07	0.17	0.19	0.04	0.42	
	LV lines	α	0.01	α	0.02	0.02	0.01	0.02	0.06	α	0.04	
	Total	0.14	0.13	0.11	0.14	0.12	0.10	0.23	0.26	0.07	0.61	0.13
SAIDI [Minutes]	Forced outage											
	Generators	5	6	2	α	α	1	1	α	1	4	
	HV lines	7	8	3	4	2	4	8	6	2	32	
	LV lines	α	2	α	1	1	α	1	1	α	4	
	Subtotal	12	15	6	5	3	6	10	7	3	40	7
	Planned outage											
	Generators	0	α	α	0	α	α	α	0	0	α	
	HV lines	α	2	1	5	12	1	8	11	0	2	
	LV lines	α	1	α	2	2	α	1	4	0	3	
	Subtotal	α	2	1	7	14	2	9	15	0	5	3
	Total outage											
	Generators	5	6	2	α	α	1	1	α	1	4	
	HV lines	7	9	4	9	14	6	16	18	2	34	
	LV lines	α	2	α	3	3	1	2	5	α	7	
	Total	12	18	7	12	17	7	19	23	3	45	10

* Nationwide values are calculated by weighing the values of whole regional service areas.

[13] Electric facilities such as generating plants, substations, transmission lines, or extra high voltage lines. Alpha (α) is shown if the data are a fraction less than a unit.

IV. Conclusion

Frequency

The frequency time-kept ratio, which is the ratio of time where 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 2021 was achieved at 100%.

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 2021.

Supply disturbances and interruption for LV customers

Supply interruption include the following criteria: number of supply disturbances and the system average interruption indices, SAIFI and SAIDI.

In FY 2021, the total number of supply disturbances was 11,563, which was below the level of disturbances recorded in the previous year, and the decrease trend was observed for the third consecutive year. The number of supply disturbances decreased or stayed at the same level from the previous year in every regional service area.

The number of supply disturbances over a certain scale is deemed to report to the government. For FY 2021, the number of supply disturbances was 27, which was more than that of the previous year by 8 cases. The disturbance triggered by the natural disaster was observed in 17 cases, which was an increase of 12 cases from that of the previous year. These disturbances were mainly caused due to earthquakes. In particular, 8 cases of 9 disturbances by natural disaster were caused by the Fukushima Earthquake in March 2022 in Tohoku area. The disturbance triggered by the fault of facility or maintenance was found to decrease compared to that in the previous year.

The nationwide SAIFI and SAIDI data on interruptions for LV customers for FY 2021 were 0.13 interruptions and 10 minutes, per one customer, respectively. These values were lower compared with the corresponding data from the previous year and were the least in the past 5 years. The number of disturbances in all areas was found to be either decreased or stayed at the same level compared with that of the previous year, except for the Hokkaido area, which was affected by wind and rain.

Based on the analysis and the results indicating that the frequency, voltage and the interruption have remained within the target variance, OCCTO concludes that the quality of the electricity supply was adequately maintained nationwide in FY 2021. OCCTO will continue to collect and publish information on the quality of electricity on the annual basis.

<Reference > Comparison of average system interruptions in Japan with major US States for 2017–2021

Table 47 and Figure 30 show the SAIDI values for Japan and major US states for the period 2017–2021, while Table 48 and Figure 31 show the SAIFI values for the same regions and time periods. The data for EU countries is cited from the report[14] of the Council of European Energy Regulators; however, the data for EU countries could not be collected as there is no publication of reports in recent years. Those for major US states are from the report[15] of the Public Utilities Commission in each state. These data were aggregated and analyzed by OCCTO.[16]

The monitoring conditions, such as observed voltage, annual monitoring period (whether starting from January or April),[17] and data including/excluding natural disasters, vary across the US states. Therefore, the interruption data may not be directly comparable between Japan and the US states. However, both SAIDI and SAIFI values for Japan are lower than those for the major US states. In addition, only the data for LV customers are monitored for Japan. However, interruptions of such customers are estimated to have only a marginal effect on the interruption data because very few customers are supplied by means other than the LV network.

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[14] 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.
<Reference>
SAIDI of EU countries (totaling planned and forced outages; minutes/year, customer) in 2016; Germany 24, Italy 144, France 71, Spain 66, UK 55, Sweden 94, Finland 81, and Norway 129.
SAIFI of EU countries (totaling planned and forced outages; interruptions/year, customer) in 2016; Germany 0.59, Italy 2.17, France 0.22, Spain 1.18, UK 0.57, Sweden 1.33, Finland 1.58, and Norway 1.89

[15] 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

[16] 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.)

[17] 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 47 SAIDI of Japan and Major US States for 2017–2021 by forced and planned outages

(Minutes/year· customer)

Country/State			Year					Condition		
			2017	2018	2019	2020	2021	Event of	Observed voltage	Natural disaster
JAPAN			16	225	86	76	10	except auto re-closing	LV	Include
		Forced	12	221	82	72	7			
		Planned	3	4	3	3	3			
U.S.A.	California		308	266	737	327	355	5 minutes and longer	All	Include
		Forced	244	201	690	310	330			
		Planned	64	65	48	18	25			
	Texas		522	175	335	356	1136			
		Forced	509	158	319	343	1121			
		Planned	13	17	15	13	15			
	New York		270	409	228	538	167			
		Forced	-	-	-	-	-			
		Planned	-	-	-	-	-			

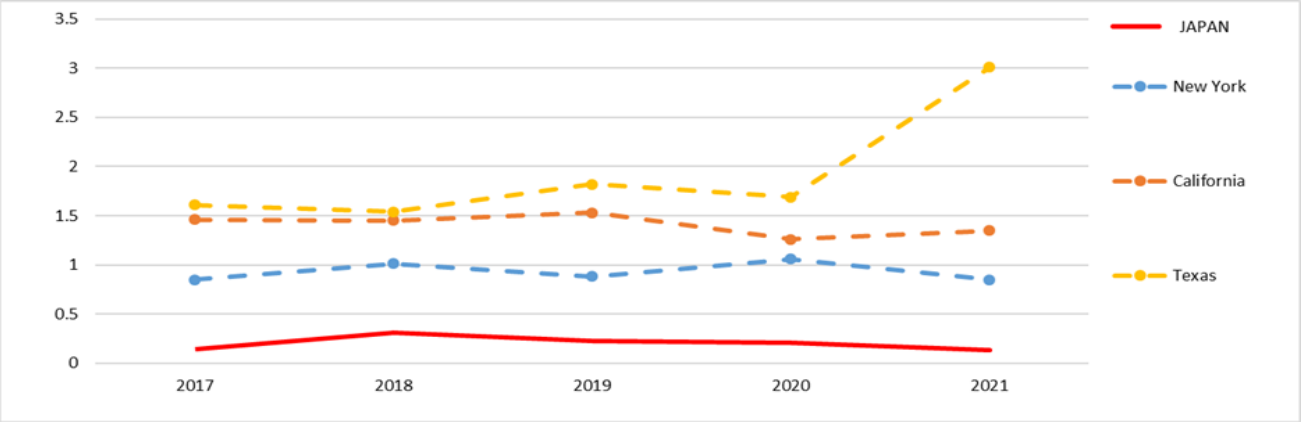

Figure 30 SAIDI of Japan and Major US States for 2017–2021 (Minutes/Year· Customer)

Table 48 SAIFI of Japan and Major US States for 2017–2021 by forced and planned outages

(Interruptions/year· customer)

Country/State			Year					Condition		
			2017	2018	2019	2020	2021	Event of	Observed voltage	Natural disaster
JAPAN			0.14	0.31	0.23	0.21	0.13	except auto re-closing	LV	Include
		Forced	0.11	0.28	0.19	0.17	0.10			
		Planned	0.03	0.03	0.04	0.03	0.03			
U.S.A.	California		1.46	1.45	1.53	1.26	1.35	5 minutes and longer	All	Include
		Forced	1.26	0.94	1.37	1.19	1.20			
		Planned	0.20	0.50	0.16	0.07	0.14			
	Texas		1.61	1.54	1.82	1.69	3.01			
		Forced	1.51	1.40	1.68	1.57	2.88			
		Planned	0.15	0.13	0.14	0.12	0.13			
	New York		0.85	1.01	0.88	1.06	0.85			
		Forced	-	-	-	-	-			
		Planned	-	-	-	-	-			

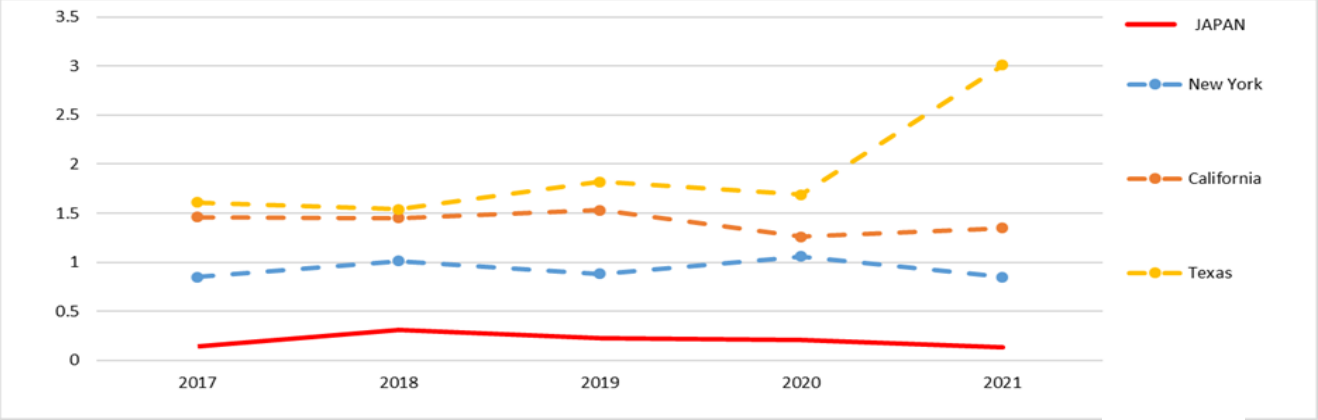

Figure 31 SAIFI of Japan and Major US States for 2017–2021 (Interruptions/year· customer)

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