Report on the Quality of Electricity Supply

- Data for Fiscal Year 2017 -

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

Introduction

The Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO), evaluates the condition of supply reliability to secure stable electricity supply as part of its role. For this purpose, OCCTO continuously gathers actual data on the quality of electricity supply and publishes them according to the provisions of Article 181 of OCCTO's Operational Rules.

This report aggregates actual data of frequency, voltage, and interruptions under the title "Quality of Electricity Supply" and presents their evaluation. The data for FY 2017 are collected in each regional service area. With these data, OCCTO evaluates and analyses whether frequency or voltage has 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 EU countries and major US states is conducted as a reference.

OCCTO's objective is to facilitate the use of the aggregated data, evaluation, and analyses as a reference for the electricity business.

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

SUMMARY

This report reviews the quality of electricity supply nationwide in the 2017 fiscal year (FY2017), based on Article 181 in Operational Rules of the Organization for Cross-regional Coordination of Transmission Operators, JAPAN (OCCTO).

Three aspects of the quality of electricity, 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 kept ratio. The frequency kept ratio is the ratio of time that the metered frequency is maintained within a given target control range. In Japan, transmission operators use 50 Hz and 60 Hz in the Eastern and Western areas, respectively. The synchronized frequency areas were grouped into four areas, i.e., Hokkaido, Eastern Japan, Central and Western Japan, and Okinawa.

The report checked the ratios in these four synchronized areas, and observed no deviation beyond the target control range.

Consequently, the report concluded that there were no problems in terms of frequency management.

Standard Voltage

The standard voltage was evaluated using the number of points where the standard voltage did not satisfy the target values, defined in the enforcement regulations of the Electricity Business Act, which sets the targets for transmission operators to maintain a standard voltage supply within a certain range of values.

The OCCTO requested transmission operators to hand in their data, but they did not find any violation of standard voltage nationwide among 6,565 points for 100 V and 6,506 points for 200 V, respectively.

Interruption

Finally, interruptions were monitored by three perspectives; i.e., the number of supply disturbance by the place of occurrence, the number of supply disturbance by cause, i.e., beyond 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 shows that number of supply disturbances was 13,576 in total, and it stayed at almost the same level as the 5- year average.

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 15 in total, which did not increase compared with the previous year. The number of supply disturbances caused by natural disaster factor was 7, which stayed at the same level as the average of the last 5 years. The final analysis was the historical monitoring of SAIFI and SAIDI values, which stayed at similar levels to those from past 5 years.

Conclusion: The Quality of Electricity Supply in FY 2017

Considering the information provided by each analysis conducted above on frequency, standard voltage, and interruption, the report concludes that the quality of electricity supply was maintained adequately in FY 2017.

Finally, the report also compared SAIFI and SADI values with those of other countries and states for reference, 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 in FY 2017.

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<Errata>

2024/2/2	P3	Table 7	Data for FY 2017 are altered.

I. Frequency Data

1. Standard Frequency 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 Electricity Business Act (hereafter, the Act). Figure 1 shows the regional service areas of the 10 general transmission and distribution companies and their standard frequency.

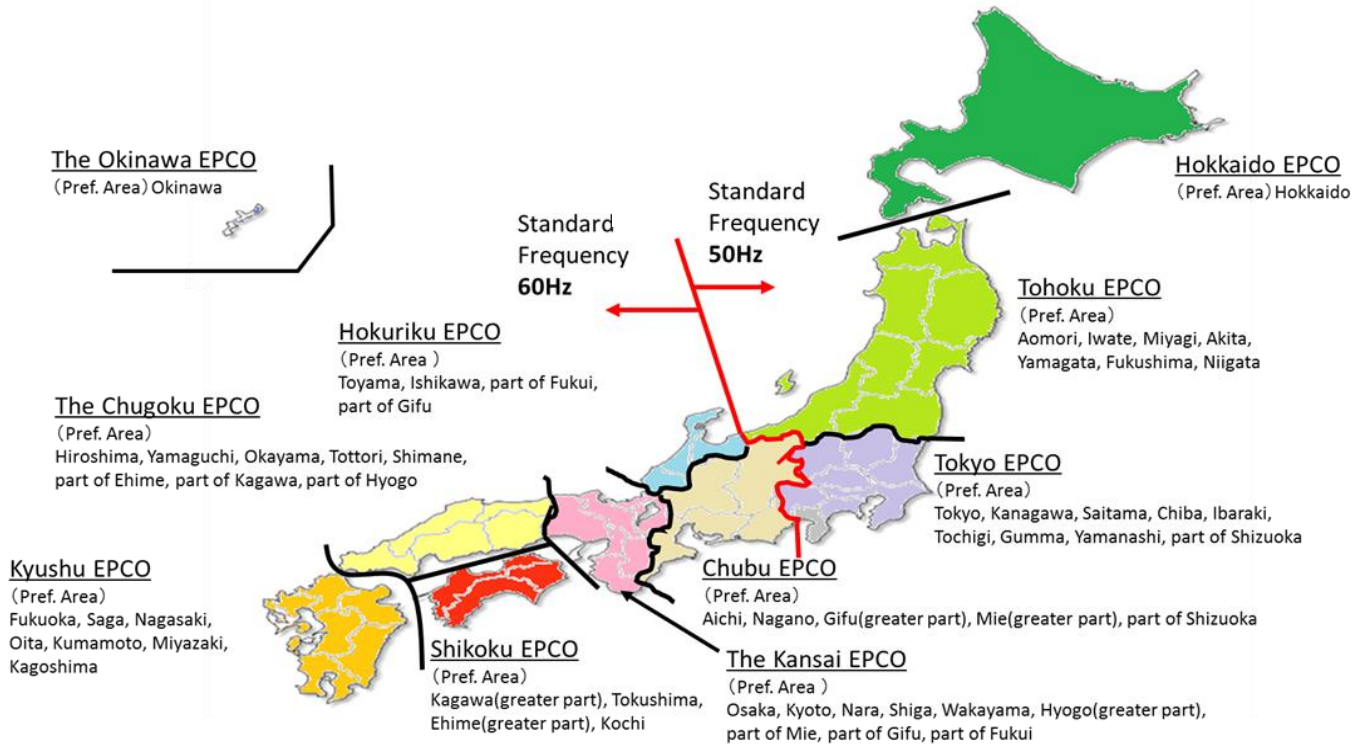

Figure 1　Regional Service Areas of the 10 General Transmission and Distribution Companies and their Standard Frequency

2. Frequency Time Kept Ratio

The time kept ratio is the criterion of maintained frequency.　The time kept ratio means the ratio of time that the metered frequency is maintained within a given variance of the standard, and is calculated by the following formula.

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

3. Frequency Control Rule

According to the indices of the time kept ratio formula, Table 1 shows the frequency control rule under normal condition 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 2013–2017)

Tables 2 to 5 show the time kept ratio by frequency synchronized regions from FY 2013 to 2017 and Figures 2 to 5 show the trend of maintaining the frequency within 0.1 Hz variance.

The time kept ratio for FY 2017 was adequately maintained within the target variance in all frequency synchronized regions. In addition, the target time kept ratio within 0.1 Hz variance for the period FY 2013–2017 was at roughly the same level as the past average.

【Criteria】

Control Target ··· 100.00%

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

Table 2 Frequency Time Kept Ratio (Hokkaido, FY 2013–2017) [%]

Variance	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Within 0.1 Hz	99.84	99.91	99.83	99.96	99.97
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

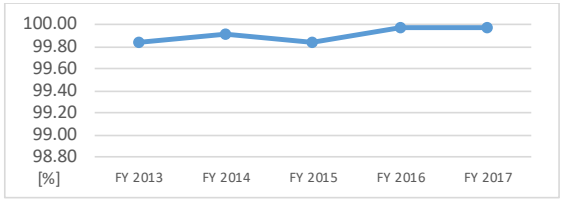

Figure 2 Time Kept Ratio within 0.1 Hz (Hokkaido, FY 2013-2017)

Table 3 Frequency Time Kept Ratio (Eastern region,[1] FY 2013–2017) [%]

Variance	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Within 0.1 Hz	99.83	99.84	99.85	99.78	99.80
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

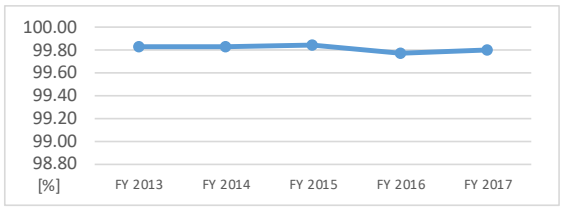

Figure 3 Time Kept Ratio within 0.1 Hz (Eastern region,[1] FY 2013-2017)

Table 4 Frequency Time Kept Ratio (Central & Western region,[2] FY 2013–2017) [%]

Variance	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Within 0.1 Hz	99.21	99.17	99.22	99.08	99.17
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

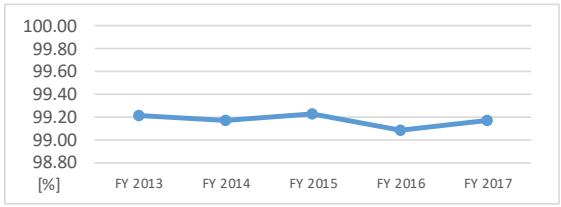

Figure 4 Time Kept Ratio within 0.1 Hz (Central & Western region,[2] FY 2013-2017)

Table 5 Frequency Time Kept Ratio (Okinawa, FY 2013–2017) [%]

Variance	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
Within 0.1 Hz	99.65	99.87	99.89	99.94	99.92
Within 0.2 Hz	99.99	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

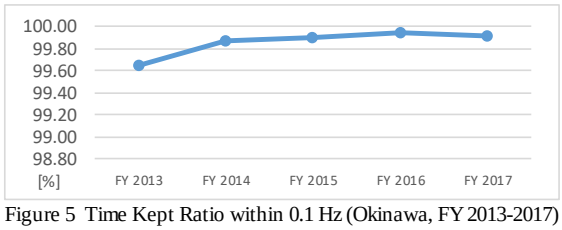

Figure 5 Time Kept Ratio within 0.1 Hz (Okinawa, FY 2013-2017)

[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.

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 voltage standard and target voltage control nationwide.

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. Measurement of Voltage

According to Article 39 of the Ministerial Ordinance of the Act, general transmission and distribution companies should measure 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) over 24 hours. General transmission and distribution 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 2013–2017)

Table 7 shows the total measured points, deviated measured points, and deviation ratio nationwide from FY 2013 to 2017.

From the FY 2017 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 2013–2017) [points]

Voltage		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017
100V	Total measured points	6,553	6,561	6,554	6,590	6,565
	Deviated points	0	0	0	0	0
200V	Total measured points	6,480	6,483	6,508	6,532	6,506
	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.

Supply disturbance means the interruption of the electricity supply or emergency restriction of electricity use due to malfunction or misuse of electric facilities.[3] The case in which electricity supply is resumed by automatic reclosing[4] of the transmission line is not applicable to supply disturbance.

(2) Data of the Number of Supply Disturbances Nationwide and by Regional Service Area (FY 2013–2017)

Table 8 and Figure 6 show the number of supply disturbances where interruption originated for the period FY 2013–2017 nationwide. Tables 9 to 18 and Figures 7 to 16 show the data by regional service areas.[5] Further, "Involving Accidents" 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.

Analysis of the data for FY 2017 indicates the following points.

- The total number of supply disturbances remained at almost the same level during the 5-year period nationwide.
- Breakdown of the tables shows that most of the supply disturbances occurred in high voltage lines.

Table 8 Number of Supply Disturbances Where Interruption Originated (Nationwide, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		56	42	45	70	45	51.6
Transmission Lines & Extra High Voltage Lines	Overhead	314	186	204	230	278	242.4
	Underground	11	9	13	9	14	11.2
	Total	325	195	217	239	292	253.6
High Voltage Lines	Overhead	11,928	11,532	10,370	10,235	12,679	11,348.8
	Underground	198	189	198	215	216	203.2
	Total	12,126	11,721	10,568	10,450	12,895	11,552.0
Demand Facilities						1	0.2
Involvng Accidents		476	460	333	269	343	376.2
Total Disturbances		12,983	12,418	11,163	11,028	13,576	12,233.6

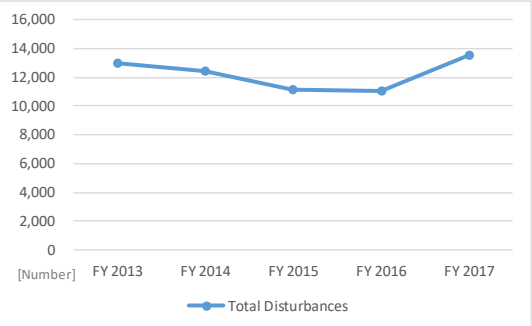

Figure 6 Transition of Supply Disturbances (Nationwide, FY 2013–2017)

[3] 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.

[4] The automatic reclosing of a transmission line means the reconnection of a transmission line by reswitching 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.

[5] Left blank if zero or the data are not available.

Table 9 Number of Supply Disturbances Where Interruption Originated (Hokkaido, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		4	2	1	1		1.6
Transmission Lines & Extra High Voltage Lines	Overhead	20	15	20	24	30	21.8
	Under-ground		2				0.4
	Total	20	17	20	24	30	22.2
High Voltage Lines	Overhead	1,053	1,119	1,145	1,289	1,144	1,150.0
	Under-ground	10	13	10	13	19	13.0
	Total	1,063	1,132	1,155	1,302	1,163	1,163.0
Demand Facilities							
Involvng Accidents		24	34	24	28	17	25.4
Total Disturbances		1,111	1,185	1,200	1,355	1,210	1,212.2

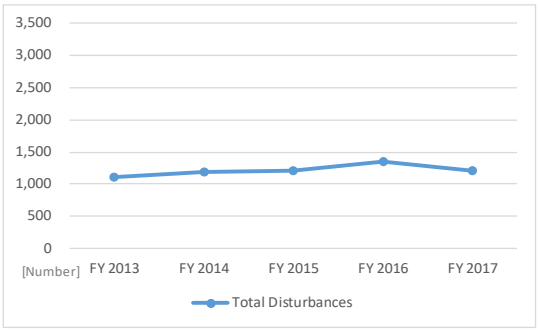

Figure 7 Transition of Supply Disturbances (Hokkaido, FY 2013–2017)

Table 10 Number of Supply Disturbances Where Interruption Originated (Tohoku, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		5	5	5	8	4	5.4
Transmission Lines & Extra High Voltage Lines	Overhead	19	19	7	11	16	14.4
	Under-ground					1	0.2
	Total	19	19	7	11	17	14.6
High Voltage Lines	Overhead	2,141	1,912	1,327	1,403	1,957	1,748.0
	Under-ground	9	6	5	12	5	7.4
	Total	2,150	1,918	1,332	1,415	1,962	1,755.4
Demand Facilities							
Involvng Accidents		28	43	22	22	26	28.2
Total Disturbances		2,202	1,985	1,366	1,456	2,009	1,803.6

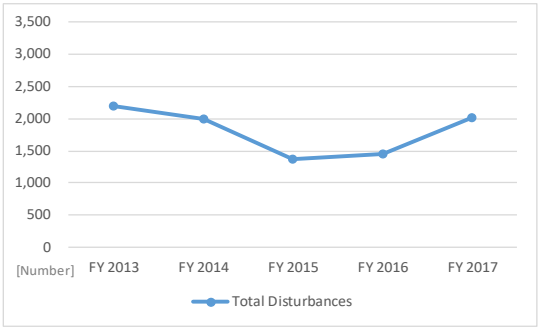

Figure 8 Transition of Supply Disturbances (Tohoku, FY 2013–2017)

Table 11 Number of Supply Disturbances Where Interruption Originated (Tokyo, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		6	10	10	14	17	11.4
Transmission Lines & Extra High Voltage Lines	Overhead	95	26	30	16	24	38.2
	Under-ground	3	2	5	2	4	3.2
	Total	98	28	35	18	28	41.4
High Voltage Lines	Overhead	3,075	1,854	1,755	2,204	2,311	2,239.8
	Under-ground	72	67	74	75	65	70.6
	Total	3,147	1,921	1,829	2,279	2,376	2,310.4
Demand Facilities							
Involvng Accidents		196	118	125	93	96	125.6
Total Disturbances		3,447	2,077	1,999	2,404	2,517	2,488.8

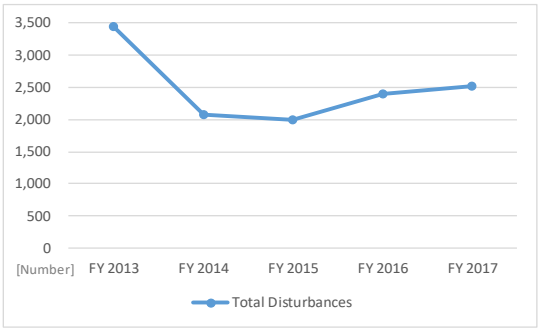

Figure 9 Transition of Supply Disturbances (Tokyo, FY 2013–2017)

Table 12 Number of Supply Disturbances Where Interruption Originated (Chubu, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		6	2	5	6	3	4.4
Transmission Lines & Extra High Voltage Lines	Overhead	33	12	8	16	9	15.6
	Under-ground						
	Total	33	12	8	16	9	15.6
High Voltage Lines	Overhead	1,621	1,592	1,066	1,069	1,607	1,391.0
	Under-ground	8	8	7	5	11	7.8
	Total	1,629	1,600	1,073	1,074	1,618	1,398.8
Demand Facilities							
Involvng Accidents		65	86	38	40	49	55.6
Total Disturbances		1,733	1,700	1,124	1,136	1,679	1,474.4

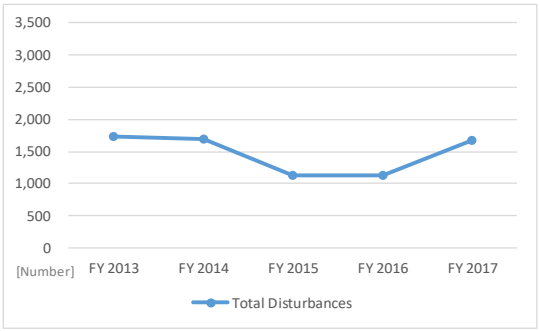

Figure 10 Transition of Supply Disturbances (Chubu, FY 2013–2017)

Table 13 Number of Supply Disturbances Where Interruption Originated (Hokuriku, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		1	4		3	1	1.8
Transmission Lines & Extra High Voltage Lines	Overhead	3	6	5	7	4	5.0
	Under-ground			1			0.2
	Total	3	6	6	7	4	5.2
High Voltage Lines	Overhead	271	364	258	303	542	347.6
	Under-ground	6	4	7	10	5	6.4
	Total	277	368	265	313	547	354.0
Demand Facilities							
Involvng Accidents		17	18	10	17	15	15.4
Total Disturbances		298	396	281	340	567	376.4

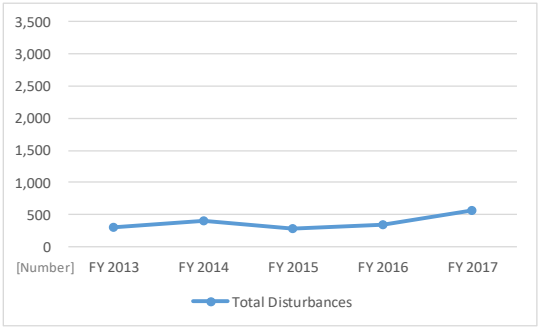

Figure 11 Transition of Supply Disturbances (Hokuriku, FY 2013–2017)

Table 14 Number of Supply Disturbances Where Interruption Originated (Kansai, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		6	2	7	13	9	7.4
Transmission Lines & Extra High Voltage Lines	Overhead	59	44	42	80	102	65.4
	Under-ground	4	4	6	3	7	4.8
	Total	63	48	48	83	109	70.2
High Voltage Lines	Overhead	1,040	1,127	943	1,171	1,695	1,195.2
	Under-ground	61	45	51	63	48	53.6
	Total	1,101	1,172	994	1,234	1,743	1,248.8
Demand Facilities							
Involvng Accidents		57	59	43		65	44.8
Total Disturbances		1,227	1,281	1,092	1,330	1,926	1,371.2

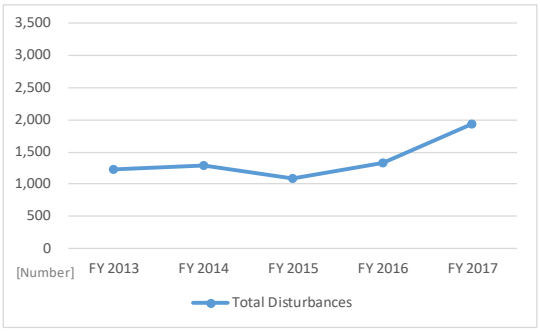

Figure 12 Transition of Supply Disturbances (Kansai, FY 2013–2017)

Table 15 Number of Supply Disturbances Where Interruption Originated (Chugoku, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		18	11	10	7	2	9.6
Transmission Lines & Extra High Voltage Lines	Overhead	11	13	14	16	16	14.0
	Under-ground	2	1			1	0.8
	Total	13	14	14	16	17	14.8
High Voltage Lines	Overhead	1,172	1,122	1,211	960	1,066	1,106.2
	Under-ground	11	23	23	13	24	18.8
	Total	1,183	1,145	1,234	973	1,090	1,125.0
Demand Facilities						1	0.2
Involvng Accidents		46	36	37	25	33	35.4
Total Disturbances		1,260	1,206	1,295	1,021	1,143	1,185.0

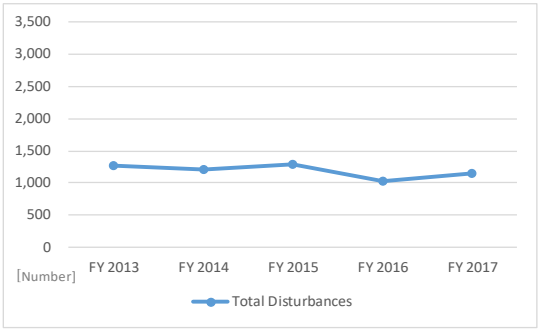

Figure 13 Transition of Supply Disturbances (Chugoku, FY 2013–2017)

Table 16 Number of Supply Disturbances Where Interruption Originated (Shikoku, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		3	1	3		6	2.6
Transmission Lines & Extra High Voltage Lines	Overhead	2	4	3	5	3	3.4
	Under-ground	1					0.2
	Total	3	4	3	5	3	3.6
High Voltage Lines	Overhead	356	673	425	357	630	488.2
	Under-ground	4	3	5	4	9	5.0
	Total	360	676	430	361	639	493.2
Demand Facilities							
Involvng Accidents		8	14	8	6	5	8.2
Total Disturbances		374	695	444	372	653	507.6

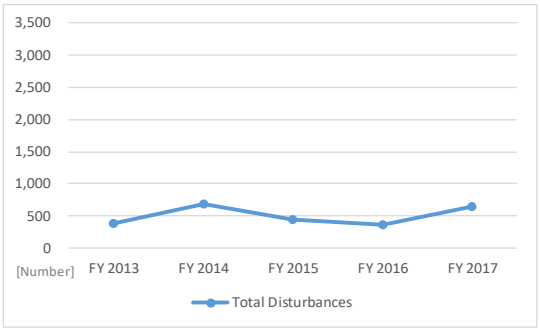

Figure 14 Transition of Supply Disturbances (Shikoku, FY 2013–2017)

Table 17 Number of Supply Disturbances Where Interruption Originated (Kyushu, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		6	4	3	15	3	6.2
Transmission Lines & Extra High Voltage Lines	Overhead	22	12	24	21	32	22.2
	Under-ground			1	4		1.0
	Total	22	12	25	25	32	23.2
High Voltage Lines	Overhead	889	1,088	1,751	1,237	1,349	1,262.8
	Under-ground	16	18	15	18	30	19.4
	Total	905	1,106	1,766	1,255	1,379	1,282.2
Demand Facilities							
Involvng Accidents		30	31	18	20	23	24.4
Total Disturbances		963	1,153	1,812	1,315	1,437	1,336.0

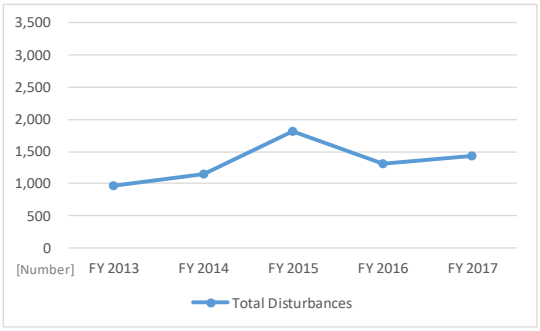

Figure 15 Transition of Supply Disturbances (Kyushu, FY 2013–2017)

Table 18 Number of Supply Disturbances Where Interruption Originated (Okinawa, FY 2013–2017)

Occurrence in		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		1	1	1	3		1.2
Transmission Lines & Extra High Voltage Lines	Overhead	50	35	51	34	42	42.4
	Under-ground	1				1	0.4
	Total	51	35	51	34	43	42.8
High Voltage Lines	Overhead	310	681	489	242	378	420.0
	Under-ground	1	2	1	2		1.2
	Total	311	683	490	244	378	421.2
Demand Facilities							
Involvng Accidents		5	21	8	18	14	13.2
Total Disturbances		368	740	550	299	435	478.4

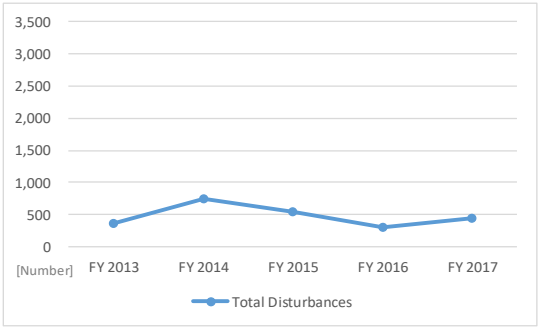

Figure 16 Transition of Supply Disturbances (Okinawa, FY 2013–2017)

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

(1) Data of Supply Disturbances over a Certain Scale

For the data of supply disturbances where interruption originated described in the preceding section, disturbances over a certain scale were reported with their causes. This section analyses their causes. Supply disturbance over a certain scale applies to the following. Figure 17 illustrates the number of supply disturbances where interruptions originated by scale of interruption. Table 19 shows the nationwide data for FY 2017.[6]

- 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

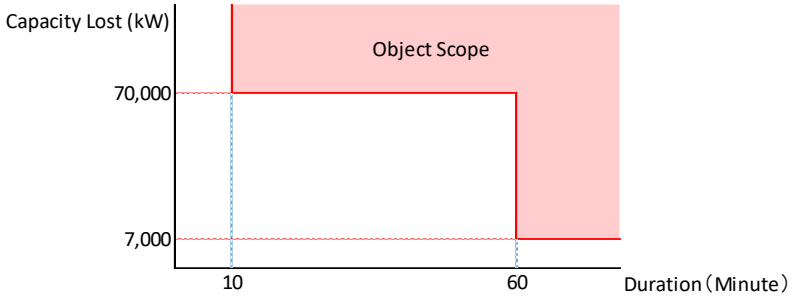

Figure 17 Image of Supply Disturbances over a Certain Scale

Table 19 Number of Supply Disturbances Where Interruption Originated by Scale of Interruption (Nationwide, FY 2017) [Number]

Scale of Disturbance / [Duration & Capacity lost] / Occurrence at		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		2		1				4
Transmission Lines & Extra High Voltage Lines	Overhead					2			6			8
	Under-ground								1			1
	Total					2			7			13
High Voltage Lines	Overhead					1						1
	Under-ground											
	Total					1						1
Demand Facilities										1		1
Involved Accidents												
Total Disturbance				1		5		1	7	1		15

[6] See footnote 5.

[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 the Causes of Supply Disturbances over a Certain Scale (FY 2013–2017)

For the number of supply disturbances over a certain scale where interruption originated, Table 21 and Figure 18 show the nationwide data, and Tables 22 to 31 show the data by regional service area for the period FY 2013–2017.[8,9]

For the data for FY 2017, the number and the causes of supply disturbances over a certain scale were analyzed. There were 15 cases nationwide of supply disturbances over a certain scale, which remained at almost the same level during the 5-year period.

Table 21 Causes of Disturbances over a Certain Scale (Nationwide, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
Fault of Facility or Maintenance						
Facility Fault	2	1	1	1	1	1.2
Maintenance fault	4	2	1	3	4	2.8
Accident/Malice				1	1	0.4
Physical contact	3			3	2	1.6
Involved accident	1		1	1		0.6
Electric shock(worker)		1	1			0.4
Subtotal	10	4	4	9	8	7.0
Natural Disaster						
Thunderbolt	7	2		3	2	2.8
Rainstorm	2	1		3	3	1.8
Snowstorm	10	2		2	2	3.2
Earthquake				6		1.2
Dust/Gas				2		0.4
Subtotal	19	5		16	7	9.4
Unknown		1	1			0.4
Miscellaneous				1		0.2
Total Disturbances	29	10	5	26	15	17.0

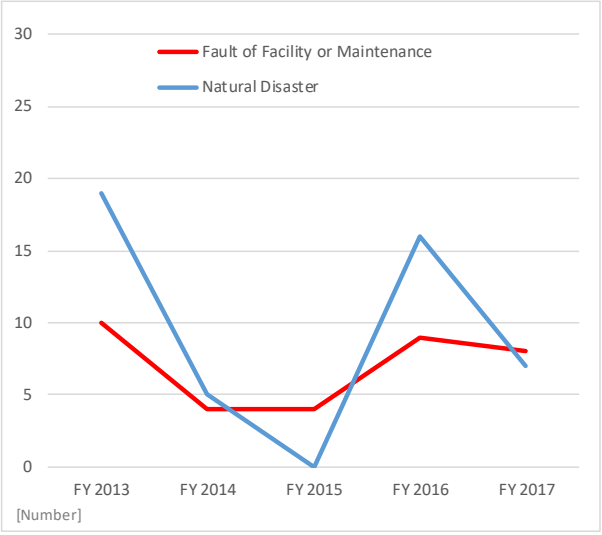

Figure 18 Transition of Disturbances by Causes (Nationwide, FY 2013–2017)

Table 22 Causes of Disturbances over a Certain Scale (Hokkaido, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	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				2		0.4
Snowstorm					1	0.2
Earthquake						
Dust/Gas						
Subtotal	1			2	1	0.8
Unknown						
Miscellaneous						
Total Disturbances	1			3	1	1.0

Table 23 Causes of Disturbances over a Certain Scale (Tohoku, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault						
Accident/Malice				1		0.2
Physical contact	1			2		0.6
Involved accident						
Electric shock(worker)			1			0.2
Subtotal	1		1	3		1.0
Natural Disaster						
Thunderbolt	2					0.4
Rainstorm						
Snowstorm					1	0.2
Earthquake						
Dust/Gas						
Subtotal	2				1	0.6
Unknown		1				0.2
Miscellaneous						
Total Disturbances	3	1	1	3	1	1.8

[8] Causes of the disturbances that did not occur in the period FY 2013–2017 are omitted from the tables.
[9] See footnote 5.

Table 24 Causes of Disturbances over a Certain Scale (Tokyo, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
Fault of Facility or Maintenance						
Facility Fault		1	1	1	1	0.8
Maintenance fault	2		1			0.6
Accident/Malice						
Physical contact	1			1	1	0.6
Involved accident			1			0.2
Electric shock(worker)						
Subtotal	3	1	3	2	2	2.2
Natural Disaster						
Thunderbolt	1			1	1	0.6
Rainstorm	1					0.2
Snowstorm	9					1.8
Earthquake						
Dust/Gas						
Subtotal	11			1	1	2.6
Unknown			1			0.2
Miscellaneous						
Total Disturbances	14	1	4	3	3	5.0

Table 25 Causes of Disturbances over a Certain Scale (Chubu, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault		1				0.2
Accident/Malice						
Physical contact	1					0.2
Involved accident						
Electric shock(worker)						
Subtotal	1	1				0.4
Natural Disaster						
Thunderbolt				1		0.2
Rainstorm						
Snowstorm	1	2		2		1.0
Earthquake						
Dust/Gas						
Subtotal	1	2		3		1.2
Unknown						
Miscellaneous						
Total Disturbances	2	3		3		1.6

Table 26 Causes of Disturbances over a Certain Scale (Hokuriku, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	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						
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal	1					0.2
Unknown						
Miscellaneous						
Total Disturbances	1					0.2

Table 27 Causes of Disturbances over a Certain Scale (Kansai, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
Fault of Facility or Maintenance						
Facility Fault	1					0.2
Maintenance fault					3	0.6
Accident/Malice					1	0.2
Physical contact					1	0.2
Involved accident				1		0.2
Electric shock(worker)						
Subtotal	1			1	5	1.4
Natural Disaster						
Thunderbolt		1				0.2
Rainstorm				1	3	0.8
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal		1		1	3	1.0
Unknown						
Miscellaneous						
Total Disturbances	1	1		2	8	2.4

Table 28 Causes of Disturbances over a Certain Scale (Chugoku, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
Fault of Facility or Maintenance						
Facility Fault	1					0.2
Maintenance fault	1	1				0.4
Accident/Malice						
Physical contact						
Involved accident						
Electric shock(worker)		1				0.2
Subtotal	2	2				0.8
Natural Disaster						
Thunderbolt	2				1	0.6
Rainstorm						
Snowstorm						
Earthquake				1		0.2
Dust/Gas						
Subtotal	2			1	1	0.8
Unknown						
Miscellaneous				1		0.2
Total Disturbances	4	2		2	1	1.8

Table 29 Causes of Disturbances over a Certain Scale (Shikoku, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
Fault of Facility or Maintenance						
Facility Fault						
Maintenance fault	1				1	0.4
Accident/Malice						
Physical contact						
Involved accident						
Electric shock(worker)						
Subtotal	1				1	0.4
Natural Disaster						
Thunderbolt						
Rainstorm		1				0.2
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal		1				0.2
Unknown						
Miscellaneous						
Total Disturbances	1	1			1	0.6

Table 30 Causes of Disturbances over a Certain Scale (Kyushu, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
Fault of Facility or Maintenance						
Facility Fault				1		0.2
Maintenance fault						
Accident/Malice						
Physical contact				1		0.2
Involved accident	1					0.2
Electric shock(worker)						
Subtotal	1			2		0.6
Natural Disaster						
Thunderbolt		1				0.2
Rainstorm	1					0.2
Snowstorm						
Earthquake				5		1.0
Dust/Gas				2		0.4
Subtotal	1	1		7		1.8
Unknown						
Miscellaneous						
Total Disturbances	2	1		9		2.4

Table 31 Causes of Disturbances over a Certain Scale (Okinawa, FY 2013–2017)

	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	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						
Snowstorm						
Earthquake						
Dust/Gas						
Subtotal				1		0.2
Unknown						
Miscellaneous						
Total Disturbances				1		0.2

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 outage or planned outage that occurred for one customer and one year.

$$\text{System Average Interruption Frequency Index (SAIFI/number)} = \frac{\text{Low voltage customers affected by interruption}}{\text{Low voltage customers served at the beginning of the fiscal year}}$$

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

Table 32 shows the definition of terms relating to outage.

Table 32 Definition of Terms Relating to Outage

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

[10] See footnote 4 for definitions.

(2) Data of System Average Interruption Nationwide and by Regional Service Area (FY 2013–2017)

Table 33 and Figure 19 show the nationwide data of system average interruptions for FY 2013–2017. Tables 34 to 43 and Figures 20 to 29 show the data by regional service area. Table 44 shows the nationwide data of system average interruptions for FY 2017, for which both the System Average Interruption Frequency Index (SAIFI) and the System Average Interruption Duration Index (SAIDI) remained at roughly the same level as the 5-year average.[11]

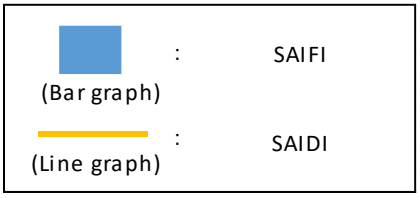

Table 33 Indices of System Average Interruption (Nationwide, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.13	0.13	0.10	0.14	0.11	0.12
	Planned	0.03	0.04	0.03	0.03	0.03	0.03
	Total 🔵	0.16	0.16	0.13	0.18	0.14	0.15
SAIDI [minute]	Forced	12	16	18	21	12	16
	Planned	4	4	4	4	3	4
	Total 🟡	16	20	21	25	16	20

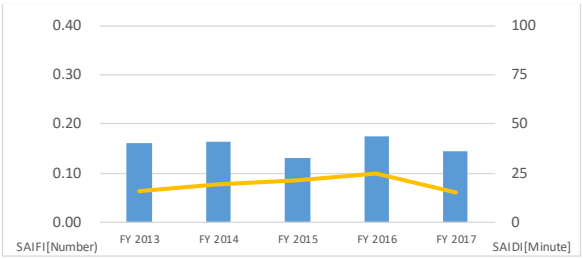

Figure 19 System Average Interruption Indices of LV Customers (Nationwide, FY 2013–2017)

Table 34 Indices of System Average Interruption (Hokkaido, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.15	0.13	0.15	0.17	0.13	0.15
	Planned	0.01	α	α	α	0.01	0.01
	Total 🔵	0.16	0.13	0.15	0.17	0.14	0.15
SAIDI [minute]	Forced	9	8	10	35	10	14
	Planned	1	α	α	1	α	1
	Total 🟡	9	9	10	36	10	15

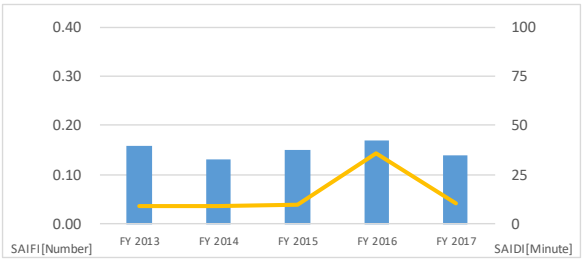

Figure 20 System Average Interruption Indices of LV Customers (Hokkaido, FY 2013–2017)

Table 35 Indices of System Average Interruption (Tohoku, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.14	0.12	0.08	0.11	0.13	0.12
	Planned	0.05	0.04	0.04	0.03	0.02	0.04
	Total 🔵	0.19	0.16	0.12	0.14	0.15	0.15
SAIDI [minute]	Forced	19	9	11	24	10	15
	Planned	7	5	4	4	3	5
	Total 🟡	25	14	15	28	13	19

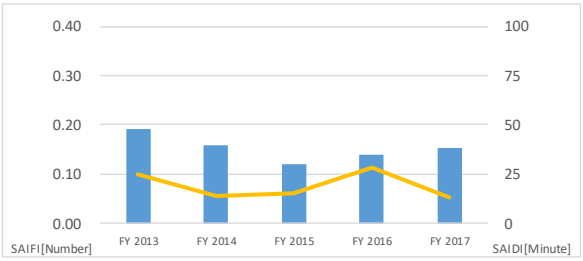

Figure 21 System Average Interruption Indices of LV Customers (Tohoku, FY 2013–2017)

[11] 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 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.14	0.07	0.06	0.13	0.09	0.10
	Planned	0.01	0.01	0.01	0.02	0.01	0.01
	Total🔵	0.15	0.08	0.07	0.15	0.10	0.11
SAIDI [minute]	Forced	15	4	6	7	6	8
	Planned	1	α	1	1	1	1
	Total🟡	16	4	6	8	7	8

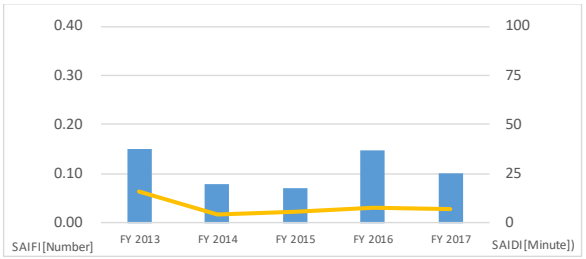

Figure 22 System Average Interruption Indices of LV Customers (Tokyo, FY 2013–2017)

Table 37 Indices of System Average Interruption (Chubu, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.13	0.16	0.07	0.17	0.08	0.12
	Planned	0.06	0.07	0.06	0.06	0.06	0.06
	Total🔵	0.19	0.23	0.13	0.23	0.14	0.18
SAIDI [minute]	Forced	13	18	4	5	10	10
	Planned	8	9	7	7	7	8
	Total🟡	21	27	11	12	17	18

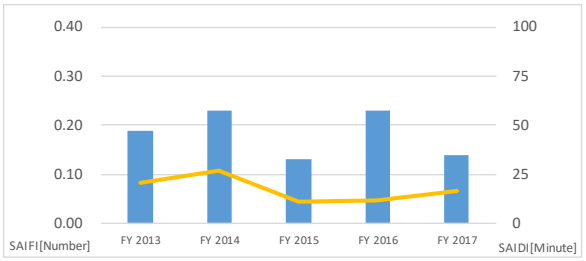

Figure 23 System Average Interruption Indices of LV Customers (Chubu, FY 2013–2017)

Table 38 Indices of System Average Interruption (Hokuriku, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.11	0.09	0.04	0.06	0.09	0.08
	Planned	0.10	0.10	0.10	0.10	0.09	0.10
	Total🔵	0.21	0.20	0.14	0.16	0.17	0.18
SAIDI [minute]	Forced	4	5	4	4	11	6
	Planned	16	17	16	17	15	16
	Total🟡	20	22	20	21	26	22

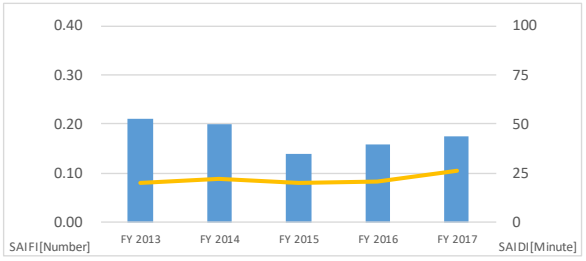

Figure 24 System Average Interruption Indices of LV Customers (Hokuriku, FY 2013–2017)

Table 39 Indices of System Average Interruption (Kansai, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.06	0.06	0.07	0.07	0.12	0.08
	Planned	0.01	0.02	0.01	0.01	0.01	0.01
	Total🔵	0.07	0.08	0.08	0.09	0.13	0.09
SAIDI [minute]	Forced	4	4	3	4	14	6
	Planned	1	1	1	1	1	1
	Total🟡	5	5	4	5	15	7

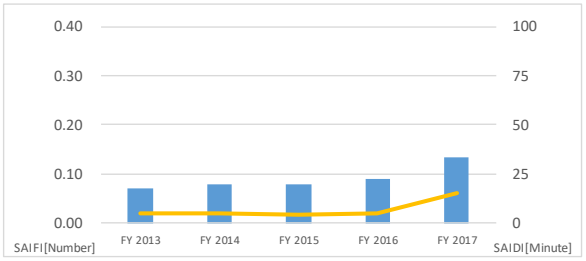

Figure 25 System Average Interruption Indices of LV Customers (Kansai, FY 2013–2017)

Table 40 Indices of System Average Interruption (Chugoku, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.19	0.19	0.18	0.15	0.12	0.17
	Planned	0.13	0.11	0.11	0.11	0.11	0.11
	Total🔵	0.32	0.31	0.29	0.26	0.23	0.28
SAIDI [minute]	Forced	9	10	17	6	7	10
	Planned	12	11	12	12	12	12
	Total🟡	21	21	29	18	19	22

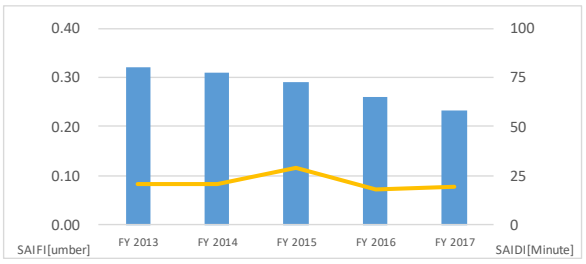

Figure 26 System Average Interruption Indices of LV Customers (Chugoku, FY 2013–2017)

Table 41 Indices of System Average Interruption (Shikoku, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.11	0.21	0.12	0.09	0.19	0.14
	Planned	0.18	0.20	0.19	0.18	0.16	0.18
	Total🔵	0.29	0.40	0.31	0.27	0.36	0.33
SAIDI [minute]	Forced	7	27	13	6	21	15
	Planned	19	20	21	20	17	19
	Total🟡	25	47	34	26	38	34

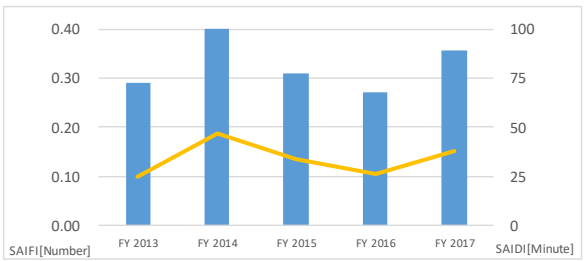

Figure 27 System Average Interruption Indices of LV Customers (Shikoku, FY 2013–2017)

Table 42 Indices of System Average Interruption (Kyushu, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.05	0.09	0.16	0.24	0.08	0.12
	Planned	0.00	0.00	0.00	-	-	0.00
	Total	0.05	0.09	0.16	0.24	0.08	0.12
SAIDI [minute]	Forced	12	45	101	128	25	62
	Planned	0	0	0	-	-	0
	Total	12	45	101	128	25	62

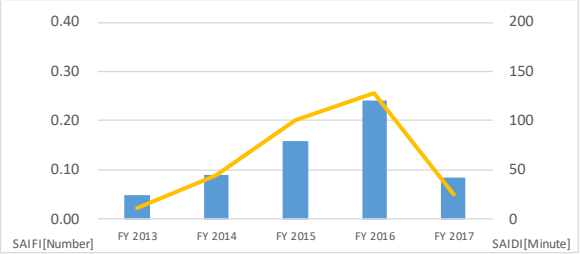

Figure 28 System Average Interruption Indices of LV Customers (Kyushu, FY 2013–2017)

Table 43 Indices of System Average Interruption (Okinawa, FY 2013–2017)

		FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	5-years Average
SAIFI [number]	Forced	0.74	2.58	1.04	0.57	0.98	1.18
	Planned	0.09	0.08	0.08	0.08	0.07	0.08
	Total	0.83	2.67	1.12	0.65	1.05	1.26
SAIDI [minute]	Forced	67	437	150	35	117	161
	Planned	8	8	8	8	7	8
	Total	75	445	158	43	124	169

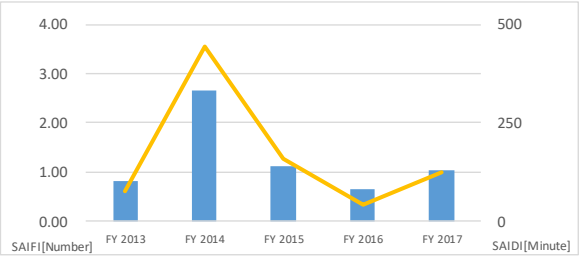

Figure 29 System Average Interruption Indices of LV Customers (Okinawa, FY 2013–2017)

Table 44 System Average Disturbances Where Interruption Originated by Cause (Nationwide, FY 2017)

		Hokkaido	Tohoku	Tokyo	Chubu	Hokuriku	Kansai	Chugoku	Shikoku	Kyushu	Okinawa	Nationwide
SAIFI [Number]	Forced Outage											
	Generators[12]	0.04	0.02	0.05	α	0.01	0.04	0.01	0.02	0.02	0.09	
	HV Lines	0.09	0.11	0.04	0.08	0.08	0.08	0.11	0.17	0.06	0.88	
	LV Lines	α	α	α	α	α	α	α	α	α	0.01	
	Subtotal	0.13	0.13	0.09	0.08	0.09	0.12	0.12	0.19	0.08	0.98	0.11
	Planned Outage											
	Generators[12]	0.01	α	0.00	α	α	0.00	α	α	0.00	α	
	HV Lines	α	0.02	0.01	0.04	0.07	0.00	0.09	0.10	0.00	0.02	
	LV Lines	α	α	α	0.02	0.01	0.00	0.02	0.06	0.00	0.05	
	Subtotal	0.01	0.02	0.01	0.06	0.09	0.00	0.11	0.16	0.00	0.07	0.03
	Total Outage											
	Generators[12]	0.05	0.02	0.05	α	0.01	0.04	0.01	0.02	0.02	0.09	
	HV Lines	0.09	0.13	0.05	0.12	0.15	0.08	0.20	0.27	0.06	0.90	
	LV Lines	α	α	α	0.02	0.02	0.01	0.02	0.07	α	0.06	
	Subtotal	0.14	0.15	0.10	0.14	0.17	0.13	0.23	0.36	0.08	1.05	0.14
SAIDI [Minute]	Forced Outage											
	Generators[12]	3	α	α	α	α	2	α	1	α	1	
	HV Lines	7	9	6	10	9	12	6	19	25	112	
	LV Lines	α	1	α	α	1	1	1	1	α	4	
	Subtotal	10	10	6	10	11	14	7	21	25	117	12
	Planned Outage											
	Generators[12]	α	α	0	0	α	α	α	α	0	α	
	HV Lines	α	3	1	5	13	1	11	13	0	3	
	LV Lines	α	α	α	2	2	1	1	4	0	4	
	Subtotal	α	3	1	7	15	1	12	17	0	7	3
	Total Outage											
	Generators[12]	3	α	α	α	α	2	α	1	α	1	
	HV Lines	7	12	7	15	23	12	17	32	25	115	
	LV Lines	α	1	α	2	3	1	2	5	α	8	
	Subtotal	10	13	7	17	26	15	19	38	25	124	16

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

IV. Conclusion

Based on the results and analysis, OCCTO concludes that the quality of the electricity supply was maintained adequately nationwide.

Frequency

The time kept ratio is the criterion for maintained frequency. The time kept ratio is the ratio of time that the metered frequency is maintained within a given variance of the standard. The time kept ratio for FY 2017 was adequately maintained within the target variance in all frequency synchronized regions. In addition, the target time kept ratio within 0.1 Hz variance in FY 2017 was at roughly the same level as the past average.

Voltage

The criteria of maintained voltage include the number of deviated 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. For FY 2017, no deviation from the voltage standard was observed nationwide.

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. For FY 2017, the number of supply disturbances and interruptions for LV customers remained at roughly the same level as the 5-year average as indicated (Table 33).

Further, supply disturbances over a certain scale[13] resulting from facility faults or maintenance faults did not increase in FY 2017 compared with the previous year. In addition, the number of supply disturbances over a certain scale due to natural disaster was lower than that of the average in FY 2013–2017.

[13] The definitions are as follows: capacity lost by disturbance was 7,000–70,000 kW, with a longer duration than 1 hour; capacity lost by disturbance was over 70,000 kW with a duration longer than 10 minutes.

<Reference> Comparison of System Average Interruption in Japan with Various Countries and US States for 2013–2017

Table 45 and Figure 30 show the SAIDI values, and Table 46 and Figure 31 show the SAIFI values for Japan and various countries and US states for the period 2013–2017. Data for EU countries are cited from the report[14] of the Council of European Energy Regulators (CEER); 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]

As for the monitoring condition, such as the observed voltage, annual period of monitoring (starting from January or April),[17] or including/excluding natural disasters, vary in each country/state; therefore, the interruption data may not be compared adequately between Japan and various countries/states. However, both SAIDI and SAIFI values were at a lower level than those of various countries/states. In addition, Japan observes only LV customers' data; however, customers supplied by other than low voltage network are very few so that interruptions of these customers are estimated to have a slight influence on the interruption data.

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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.

[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 45 SAIDI of Japan and Various Countries/US States for FY 2013–2017 by Forced and Planned Outages

(Minutes/Year: Customer)

Country/State			Year[17] 2013	2014	2015	2016	2017	Condition: Event of	Observed Voltage	Natural Disaster
JAPAN			16	20	21	25	16	except auto re-closing	LV	Include
		Forced	12	16	18	21	12			
		Planned	4	4	4	4	3			
U.S.A.	California		112	122	122	219	-	5 minutes and longer	All	Include
		Forced	105	115	115	124	-			
		Planned	8	7	7	95	-			
	Texas		199	214	277	214	522			
		Forced	192	207	268	205	509			
		Planned	6	7	10	9	13			
	New York		165	162	130	137	270			
		Forced	-	-	-	-	-			
		Planned	-	-	-	-	-			
EU	Germany		40	21	22	24	-	3 minutes and longer	All	Include
		Forced	33	14	15	13	-			
		Planned	7	8	7	10	-			
	Italy		161	153	196	144	-		All	Include
		Forced	105	94	129	65	-			
		Planned	55	60	67	79	-			
	France		100	67	74	71	-		All	Include
		Forced	84	52	58	53	-			
		Planned	16	16	16	18	-			
	Spain		108	63	69	66	-		All	Include
		Forced	99	53	56	54	-			
		Planned	9	11	13	12	-			
	UK		73	104	61	55	-		All	Exclude
		Forced	61	93	51	47	-			
		Planned	12	11	10	8	-			
	Sweden		171	102	135	94	-		All	Include
		Forced	152	84	118	76	-			
		Planned	19	18	17	19	-			
	Finland		187	80	169	81	-		except LV	Include
		Forced	171	67	158	68	-			
		Planned	15	13	12	13	-			
	Norway		181	161	173	129	-		All	Include
		Forced	144	118	129	88	-			
		Planned	36	43	44	41	-			

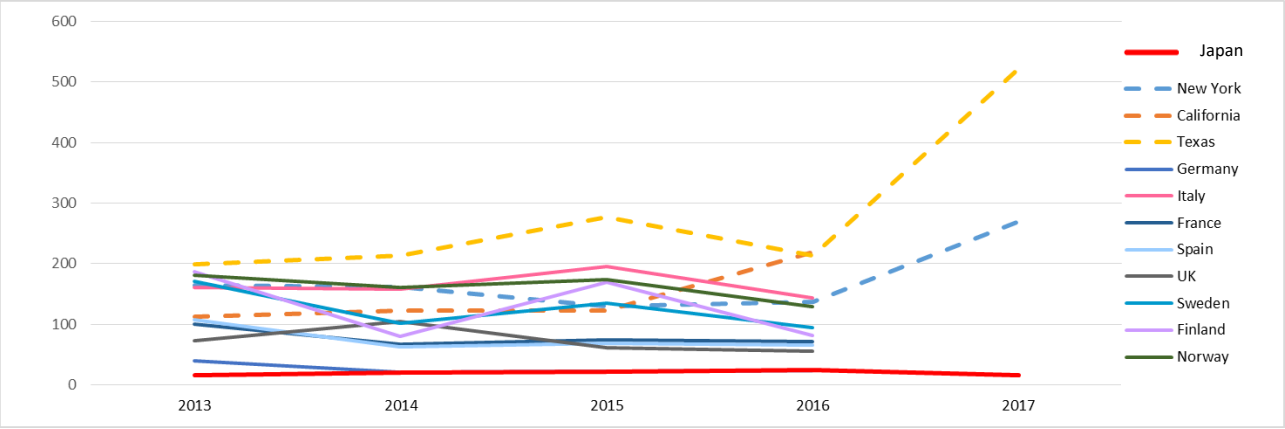

Figure 30 SAIDI of Japan and Various Countries/US States for FY 2013–2017 (Minutes/Year: Customer)

Table 46 SAIFI of Japan and Various Countries/US States for FY 2013–2017 by Forced and Planned Outages

(Number/Year: Customer)

Country/State			Year[17] 2013	2014	2015	2016	2017	Condition: Event of	Observed Voltage	Natural Disaster
JAPAN			0.16	0.16	0.13	0.18	0.14	except auto re-closing	LV	Include
		Forced	0.13	0.13	0.10	0.14	0.11			
		Planned	0.03	0.04	0.03	0.03	0.03			
U.S.A.	California		0.96	1.00	0.94	1.31	-	5 minutes and longer	All	Include
		Forced	0.92	0.97	0.91	1.05	-			
		Planned	0.04	0.03	0.03	0.26	-			
	Texas		1.54	1.59	1.91	1.55	1.61			
		Forced	1.46	1.51	1.82	1.48	1.51			
		Planned	0.08	0.08	0.09	0.07	0.15			
	New York		0.73	0.68	0.67	0.79	0.85			
		Forced	-	-	-	-	-			
		Planned	-	-	-	-	-			
EU	Germany		0.58	0.45	0.91	0.59	-	3 minutes and longer	All	Include
		Forced	0.50	0.37	0.83	0.51	-			
		Planned	0.08	0.08	0.08	0.08	-			
	Italy		2.57	2.35	2.81	2.17	-		All	Include
		Forced	2.20	1.99	2.43	1.76	-			
		Planned	0.37	0.36	0.37	0.41	-			
	France		0.23	0.20	0.22	0.22	-		All	Include
		Forced	0.10	0.07	0.09	0.08	-			
		Planned	0.13	0.13	0.13	0.14	-			
	Spain		1.19	1.29	1.31	1.18	-		All	Include
		Forced	1.04	1.13	1.21	1.09	-			
		Planned	0.15	0.16	0.10	0.09	-			
	UK		0.65	0.76	0.60	0.57	-		All	Exclude
		Forced	0.61	0.72	0.56	0.53	-			
		Planned	0.04	0.04	0.04	0.04	-			
	Sweden		1.48	1.46	1.36	1.33	-		All	Include
		Forced	1.33	1.30	1.22	1.17	-			
		Planned	0.15	0.16	0.14	0.16	-			
	Finland		2.35	1.76	2.78	1.58	-		except LV	Include
		Forced	2.16	1.60	2.64	1.42	-			
		Planned	0.19	0.15	0.14	0.15	-			
	Norway		2.22	2.44	2.17	1.89	-		All	Include
		Forced	1.96	2.15	1.87	1.59	-			
		Planned	0.26	0.29	0.30	0.30	-			

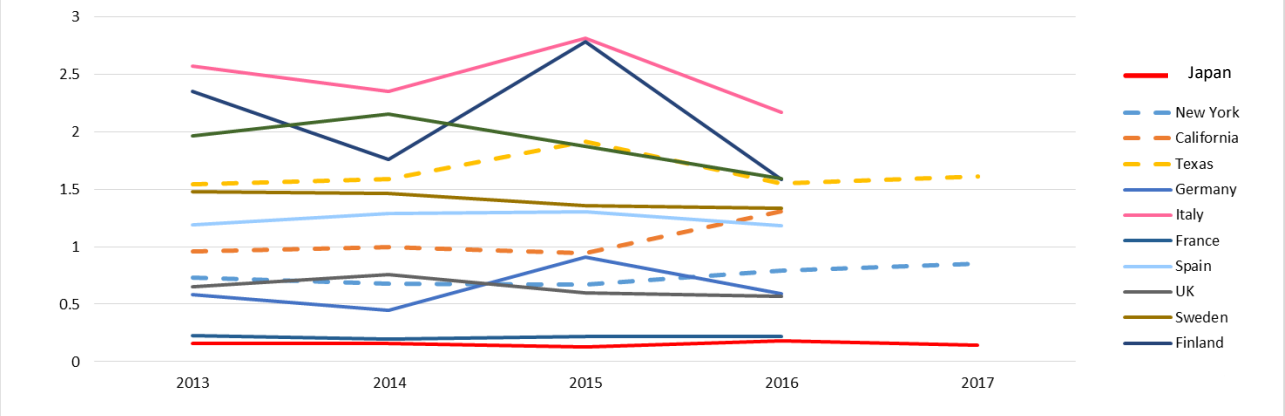

Figure 31 SAIFI of Japan and Various Countries/US States for FY 2013–2017 (Number/Year: Customer)

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