Report on the Quality of Electricity Supply

- Data for Fiscal Year 2016 -

October 2018

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 2016 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.

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.

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

CONTENTS

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.

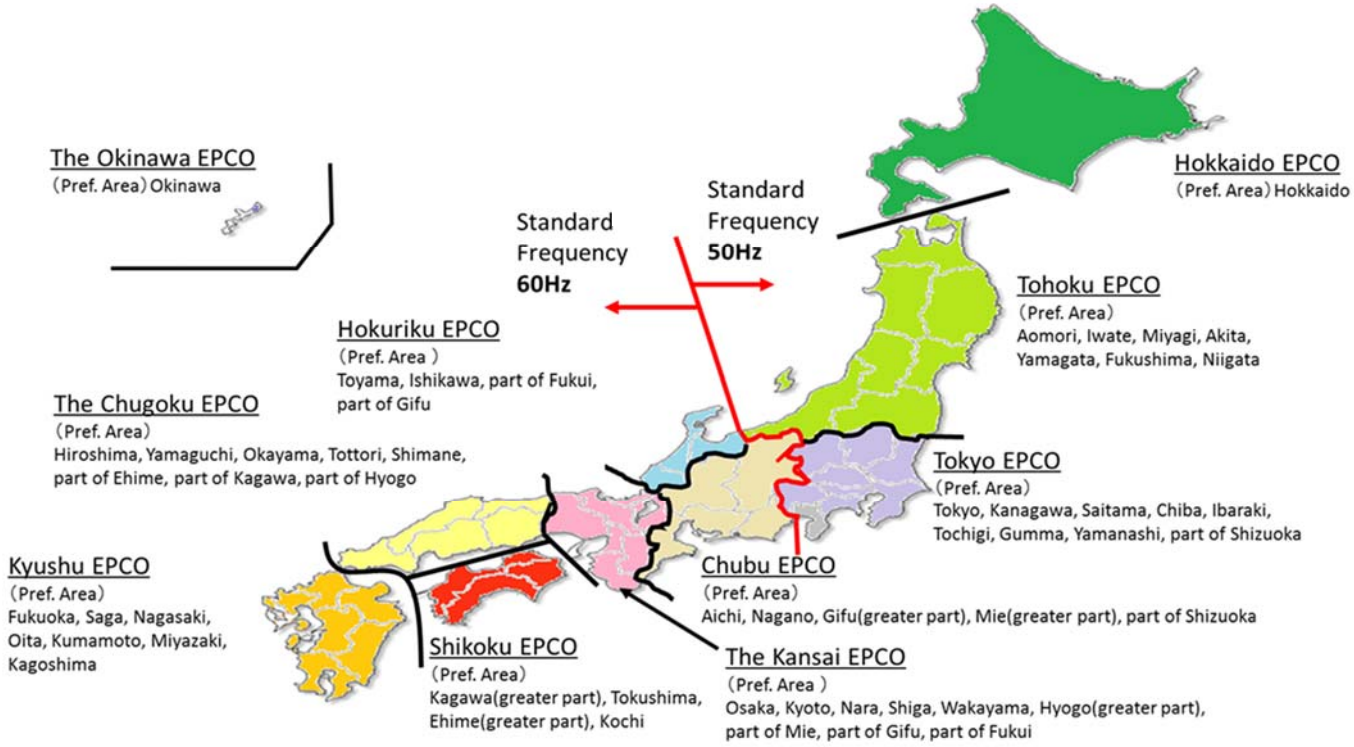

Figure 1　Regional Service Areas of the 10 General Transmission and Distribution Companies and their Standard Frequency

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 Regional Service Areas (FY 2012-2016)

Tables 2 to 11 show the time kept ratio by regional service areas from FY 2012 to 2016 and Figures 2 to 11 show the trend of maintaining the frequency within 0.1 Hz variance.

The time kept ratio for FY 2016 was adequately maintained within the target variance in all regional service areas. In addition, the target time kept ratio within 0.1 Hz variance for the period FY 2012-2016 did not show significant deterioration in the ratio.

【Criteria】

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

Table 2 Frequency Time Kept Ratio (Hokkaido, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.65	99.84	99.91	99.83	99.96
Within 0.2Hz	99.99	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

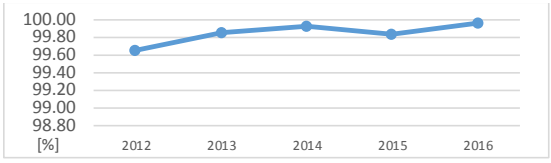

Figure 2 Time Kept Ratio within 0.1Hz (Hokkaido, FY 2012-2016)

Table 3 Frequency Time Kept Ratio (Tohoku, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.94	99.88	99.88	99.89	99.83
Within 0.2Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

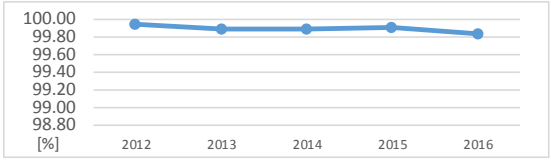

Figure 3 Time Kept Ratio within 0.1Hz (Tohoku, FY 2012-2016)

Table 4 Frequency Time Kept Ratio (Tokyo, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.91	99.83	99.84	99.85	99.78
Within 0.2Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

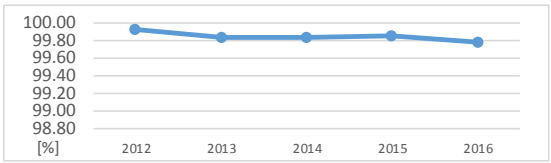

Figure 4 Time Kept Ratio within 0.1Hz (Tokyo, FY 2012-2016)

Table 5 Frequency Time Kept Ratio (Chubu, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.22	99.19	99.15	99.22	99.08
Within 0.2Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

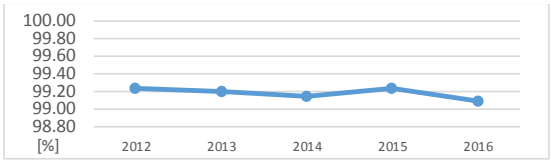

Figure 5 Time Kept Ratio within 0.1Hz (Chubu, FY 2012-2016)

Table 6 Frequency Time Kept Ratio (Hokuriku, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.18	99.17	99.13	99.18	99.03
Within 0.2Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

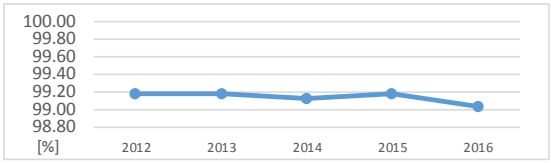

Figure 6 Time Kept Ratio within 0.1Hz (Hokuriku, FY 2012-2016)

Table 7 Frequency Time Kept Ratio (Kansai, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.22	99.21	99.17	99.22	99.08
Within 0.2Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

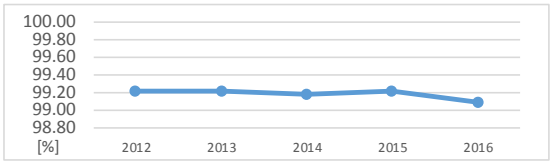

Figure 7 Time Kept Ratio within 0.1Hz (Kansai, FY 2012-2016)

Table 8 Frequency Time Kept Ratio (Chugoku, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.21	99.22	99.17	99.23	99.09
Within 0.2Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

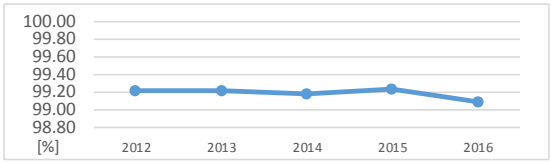

Figure 8 Time Kept Ratio within 0.1Hz (Chugoku, FY 2012-2016)

Table 9 Frequency Time Kept Ratio (Shikoku, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.22	99.22	99.17	99.22	99.08
Within 0.2Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

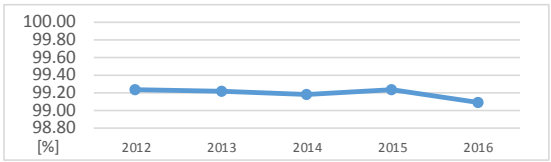

Figure 9 Time Kept Ratio within 0.1Hz (Shikoku, FY 2012-2016)

Table 10 Frequency Time Kept Ratio (Kyushu, FY 201-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.23	99.22	99.17	99.22	99.08
Within 0.2Hz	100.00	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00	100.00

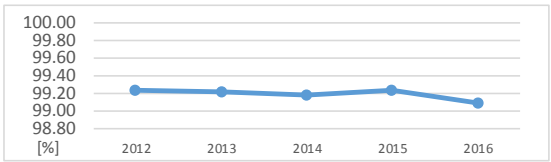

Figure 10 Time Kept Ratio within 0.1Hz (Kyushu, FY 2012-2016)

Table 11 Frequency Time Kept Ratio (Okinawa, FY 2012-2016) [%]

Variance	2012	2013	2014	2015	2016
Within 0.1Hz	99.65	99.65	99.87	99.89	99.94
Within 0.2Hz	99.98	99.99	100.00	100.00	100.00
Within 0.3Hz	99.99	100.00	100.00	100.00	100.00

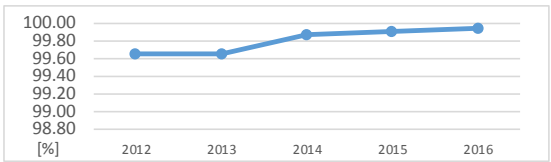

Figure 11 Time Kept Ratio within 0.1Hz (Okinawa, FY 2012-2016)

II. Voltage Data

1. Voltage Standard in Japan

General transmission and distribution companies should endeavor to maintain the voltage value of the electricity supply at the levels specified by the Act. Table 12 shows the voltage standard and target voltage control nationwide.

Table 12 Voltage Standard and Target Voltage Control

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

The criteria for maintained voltage include the number of deviated measured points where metered voltage deviates from the above-stated standard ("deviated measured points") and ratio of deviated points to the total number of measured points ("deviation ratio").

The deviation ratio is calculated by the following formula.

$$\text{Deviation Ratio (\%)} = \frac{\text{Numbers of Deviated Measued Points}}{\text{Total Number of Measured Points}} \times 100$$

2. Deviation Ratio of Voltage by Regional Service Areas (FY 2012-2016)

Tables 13 to 22 show the total measured points, deviated measured points, and deviation ratio by regional service areas from FY 2012 to 2016.

From the FY 2016 data, we see that no deviation from the voltage standard was observed in any regional service areas and the nationwide voltage was maintained adequately with respect to voltage standard.

Table 13 Voltage Deviation Ratio (Hokkaido, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	386	386	386	387	387
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	386	386	386	387	387
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 14 Voltage Deviation Ratio (Tohoku, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	686	690	689	691	692
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	682	686	687	687	689
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 15 Voltage Deviation Ratio (Tokyo, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	1,493	1,493	1,488	1,483	1,493
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	1,489	1,489	1,485	1,479	1,485
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 16 Voltage Deviation Ratio (Chubu, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	959	956	957	954	954
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	954	953	951	949	949
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 17 Voltage Deviation Ratio (Hokuriku, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	216	217	219	220	224
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	204	204	206	208	211
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 18 Voltage Deviation Ratio (Kansai, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	1,373	1,372	1,379	1,370	1,387
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	1,363	1,333	1,333	1,358	1,367
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 19 Voltage Deviation Ratio (Chugoku, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	472	473	474	475	474
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	470	472	473	474	473
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 20 Voltage Deviation Ratio (Shikoku, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	224	224	224	224	224
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	224	224	224	224	224
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 21 Voltage Deviation Ratio (Kyushu, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	638	640	640	643	646
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	630	631	633	635	638
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

Table 22 Voltage Deviation Ratio (Okinawa, FY 2012-2016) [points,%]

Voltage		2012	2013	2014	2015	2016
100V	Total Measured Points	102	102	105	107	109
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00
200V	Total Measured Points	102	102	105	107	109
	Deviated Points	0	0	0	0	0
	Deviation Ratio	0.00	0.00	0.00	0.00	0.00

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 misoperation of electric facilities[1]. The case in which electricity supply is resumed by automatic re-closing[2] of the transmission line is not applicable to supply disturbance.

(2) Data of the Number of Supply Disturbances Nationwide and by Regional Service Areas (FY 2012 -2016)

Table 23 and Figure 12 show the number of supply disturbances where interruption originated for the period FY 2012-2016 nationwide. Tables 24 to 33 and Figures 13 to 22 show the data by regional service areas.[3]

Analysis of the data for FY 2016 indicates the following points.

- The total number of supply disturbances remained at almost the same level during the 5-years period in all regional service areas. The lowest numbers of supply disturbances over this period were for the regional service areas of Chugoku, Shikoku, Okinawa, and nationwide.
- Breakdown of the tables shows that most of the supply disturbances occurred in high voltage lines.

Table 23 Number of Supply Disturbances Where Interruption Originated (nationwide, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		66	56	42	45	70	55.8
Transmission Lines & Extra High Voltage Lines	Overhead	329	314	186	204	230	252.6
	Under-ground	16	11	9	13	9	11.6
	Total	345	325	195	217	239	264.2
High Voltage Lines	Overhead	13,577	11,928	11,532	10,370	10,235	11,528.4
	Under-ground	246	198	189	198	215	209.2
	Total	13,823	12,126	11,721	10,568	10,450	11,737.6
Demand Facilities		1					0.2
Involvng Accidents*		504	476	460	333	269	408.4
Total Disturbances		14,739	12,983	12,418	11,163	11,028	12,466.2

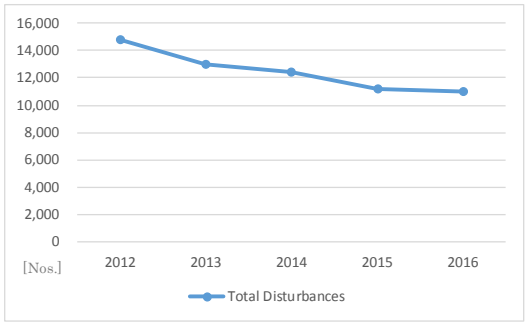

Figure 12 Transition of Supply Disturbances (nationwide, FY 2012-2016)

[1] 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 Act.

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

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

Table 24 Number of Supply Disturbances Where Interruption Originated (Hokkaido, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		4	4	2	1	1	2.4
Transmission Lines & Extra High Voltage Lines	Overhead	24	20	15	20	24	20.6
	Under-ground			2			0.4
	Total	24	20	17	20	24	21.0
High Voltage Lines	Overhead	1,012	1,053	1,119	1,145	1,289	1,123.6
	Under-ground	14	10	13	10	13	12.0
	Total	1,026	1,063	1,132	1,155	1,302	1,135.6
Demand Facilities							
Involvng Accidents*		22	24	34	24	28	26.4
Total Disturbances		1,076	1,111	1,185	1,200	1,355	1,185.4

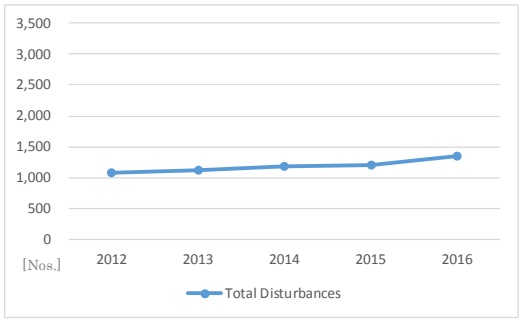

Figure 13 Transition of Supply Disturbances (Hokkaido, FY 2012-2016)

Table 25 Number of Supply Disturbances Where Interruption Originated (Tohoku, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		8	5	5	5	8	6.2
Transmission Lines & Extra High Voltage Lines	Overhead	27	19	19	7	11	16.6
	Under-ground						
	Total	27	19	19	7	11	16.6
High Voltage Lines	Overhead	2,769	2,141	1,912	1,327	1,403	1,910.4
	Under-ground	10	9	6	5	12	8.4
	Total	2,779	2,150	1,918	1,332	1,415	1,918.8
Demand Facilities							
Involvng Accidents*		38	28	43	22	22	30.6
Total Disturbances		2,852	2,202	1,985	1,366	1,456	1,972.2

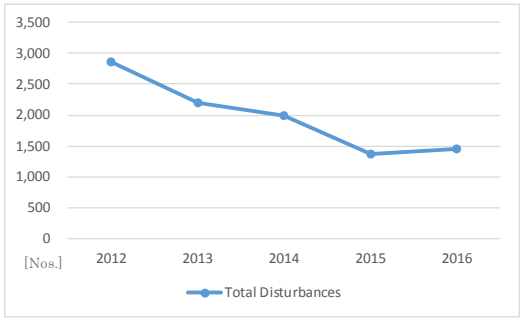

Figure 14 Transition of Supply Disturbances (Tohoku, FY 2012-2016)

Table 26 Number of Supply Disturbances Where Interruption Originated (Tokyo, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		10	6	10	10	14	10.0
Transmission Lines & Extra High Voltage Lines	Overhead	25	95	26	30	16	38.4
	Under-ground	8	3	2	5	2	4.0
	Total	33	98	28	35	18	42.4
High Voltage Lines	Overhead	2,185	3,075	1,854	1,755	2,204	2,214.6
	Under-ground	71	72	67	74	75	71.8
	Total	2,256	3,147	1,921	1,829	2,279	2,286.4
Demand Facilities							
Involvng Accidents*		141	196	118	125	93	134.6
Total Disturbances		2,440	3,447	2,077	1,999	2,404	2,473.4

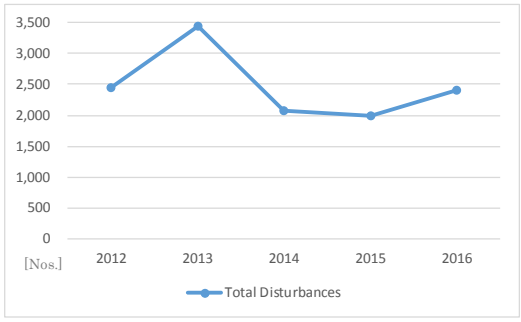

Figure 15 Transition of Supply Disturbances (Tokyo, FY 2012-2016)

Table 27 Number of Supply Disturbances Where Interruption Originated (Chubu, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		3	6	2	5	6	4.4
Transmission Lines & Extra High Voltage Lines	Overhead	20	33	12	8	16	17.8
	Under-ground	1					0.2
	Total	21	33	12	8	16	18.0
High Voltage Lines	Overhead	1,911	1,621	1,592	1,066	1,069	1,451.8
	Under-ground	14	8	8	7	5	8.4
	Total	1,925	1,629	1,600	1,073	1,074	1,460.2
Demand Facilities							
Involvng Accidents*		93	65	86	38	40	64.4
Total Disturbances		2,042	1,733	1,700	1,124	1,136	1,547.0

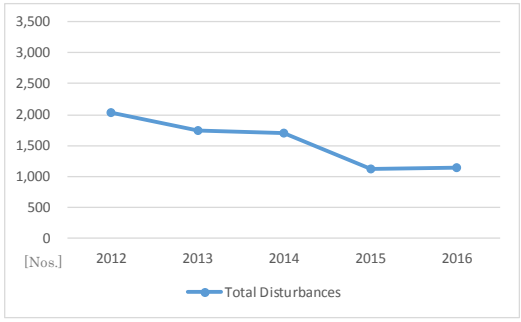

Figure 16 Transition of Supply Disturbances (Chubu, FY 2012-2016)

Table 28 Number of Supply Disturbances Where Interruption Originated (Hokuriku, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		3	1	4		3	2.2
Transmission Lines & Extra High Voltage Lines	Overhead	2	3	6	5	7	4.6
	Under-ground				1		0.2
	Total	2	3	6	6	7	4.8
High Voltage Lines	Overhead	558	271	364	258	303	350.8
	Under-ground	11	6	4	7	10	7.6
	Total	569	277	368	265	313	358.4
Demand Facilities							
Involvng Accidents*		25	17	18	10	17	17.4
Total Disturbances		599	298	396	281	340	382.8

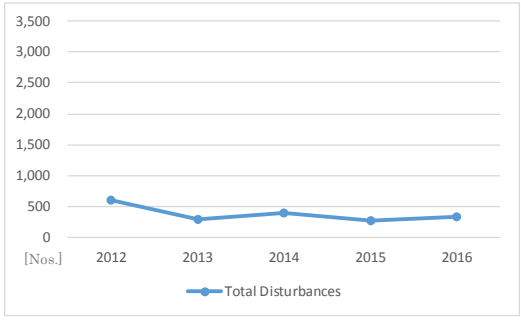

Figure 17 Transition of Supply Disturbances (Hokuriku, FY 2012-2016)

Table 29 Number of Supply Disturbances Where Interruption Originated (Kansai, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		8	6	2	7	13	7.2
Transmission Lines & Extra High Voltage Lines	Overhead	68	59	44	42	80	58.6
	Underground	4	4	4	6	3	4.2
	Total	72	63	48	48	83	62.8
High Voltage Lines	Overhead	1,378	1,040	1,127	943	1,171	1,131.8
	Underground	89	61	45	51	63	61.8
	Total	1,467	1,101	1,172	994	1,234	1,193.6
Demand Facilities		1					0.2
Involvng Accidents*		63	57	59	43		44.4
Total Disturbances		1,611	1,227	1,281	1,092	1,330	1,308.2

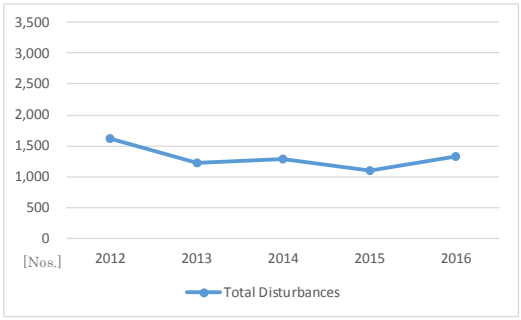

Figure 18 Transition of Supply Disturbances (Kansai, FY 2012-2016)

Table 30 Number of Supply Disturbances Where Interruption Originated (Chugoku, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		15	18	11	10	7	12.2
Transmission Lines & Extra High Voltage Lines	Overhead	17	11	13	14	16	14.2
	Underground	1	2	1			0.8
	Total	18	13	14	14	16	15.0
High Voltage Lines	Overhead	1,149	1,172	1,122	1,211	960	1,122.8
	Underground	22	11	23	23	13	18.4
	Total	1,171	1,183	1,145	1,234	973	1,141.2
Demand Facilities							
Involvng Accidents*		40	46	36	37	25	36.8
Total Disturbances		1,244	1,260	1,206	1,295	1,021	1,205.2

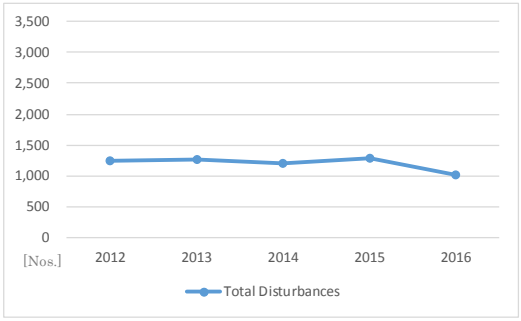

Figure 19 Transition of Supply Disturbances (Chugoku, FY 2012-2016)

Table 31 Number of Supply Disturbances Where Interruption Originated (Shikoku, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations			3	1	3		1.4
Transmission Lines & Extra High Voltage Lines	Overhead	1	2	4	3	5	3.0
	Underground	1	1				0.4
	Total	2	3	4	3	5	3.4
High Voltage Lines	Overhead	491	356	673	425	357	460.4
	Underground	5	4	3	5	4	4.2
	Total	496	360	676	430	361	464.6
Demand Facilities							
Involvng Accidents*		16	8	14	8	6	10.4
Total Disturbances		514	374	695	444	372	479.8

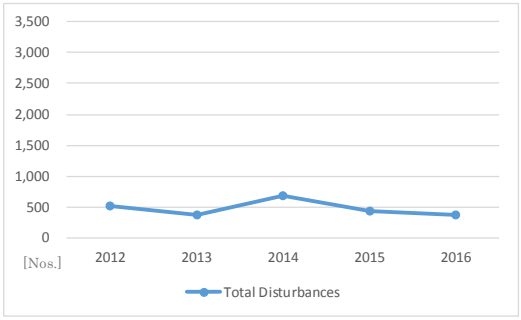

Figure 20 Transition of Supply Disturbances (Shikoku, FY 2012-2016)

Table 32 Number of Supply Disturbances Where Interruption Originated (Kyushu, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		5	6	4	3	15	6.6
Transmission Lines & Extra High Voltage Lines	Overhead	27	22	12	24	21	21.2
	Underground	1			1	4	1.2
	Total	28	22	12	25	25	22.4
High Voltage Lines	Overhead	1,057	889	1,088	1,751	1,237	1,204.4
	Underground	10	16	18	15	18	15.4
	Total	1,067	905	1,106	1,766	1,255	1,219.8
Demand Facilities							
Involvng Accidents*		39	30	31	18	20	27.6
Total Disturbances		1,139	963	1,153	1,812	1,315	1,276.4

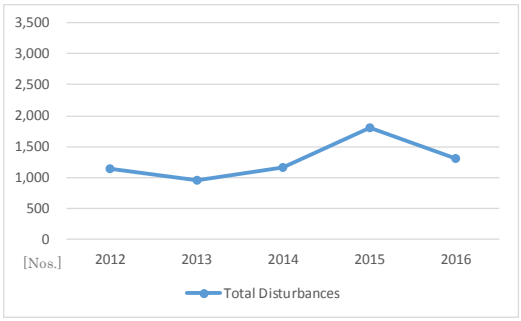

Figure 21 Transition of Supply Disturbances (Kyushu, FY 2012-2016)

Table 33 Number of Supply Disturbances Where Interruption Originated (Okinawa, FY 2012-2016)

Occurrence in		2012	2013	2014	2015	2016	5-years average
Disturbance of General Transmission & Distribution Companies' Facilities							
Substations		10	1	1	1	3	3.2
Transmission Lines & Extra High Voltage Lines	Overhead	118	50	35	51	34	57.6
	Underground		1				0.2
	Total	118	51	35	51	34	57.8
High Voltage Lines	Overhead	1,067	310	681	489	242	557.8
	Underground		1	2	1	2	1.2
	Total	1,067	311	683	490	244	559.0
Demand Facilities							
Involvng Accidents*		27	5	21	8	18	15.8
Total Disturbances		1,222	368	740	550	299	635.8

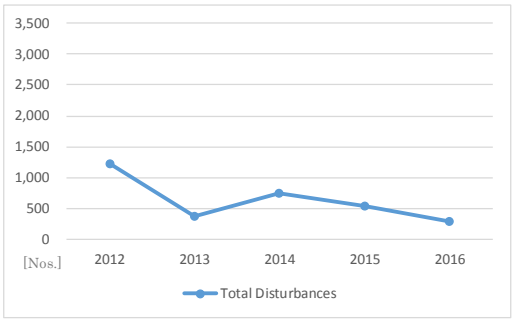

Figure 22 Transition of Supply Disturbances (Okinawa, FY 2012-2016)

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. Analysis of their causes is provided in this section.

Supply disturbance over a certain scale applies to the following.

- Capacity lost by disturbance is 7,000-70,000 kW and its duration is longer than 1 hour
- Capacity lost by disturbance is over 70,000 kW and its duration is longer than 10 minutes

Figure 23 illustrates the number of supply disturbances where interruptions originated by scale of interruption. Table 34 shows the nationwide data for FY 2016.

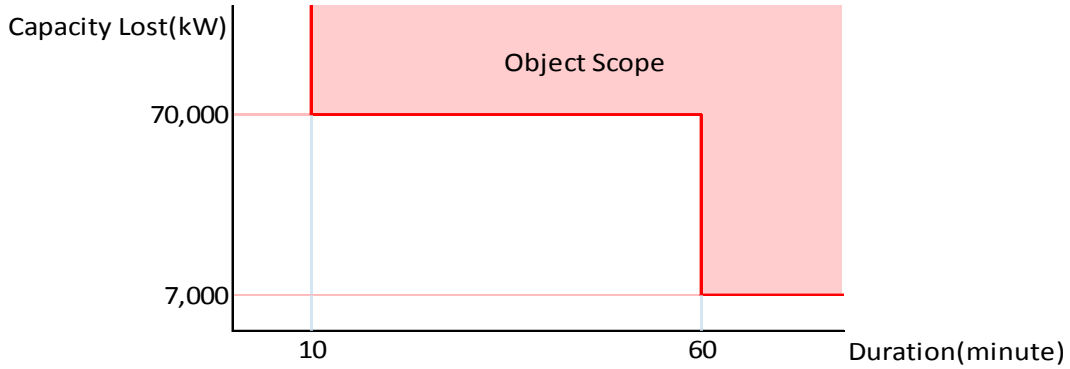

Figure 23 Number of Supply Disturbances over a Certain Scale

Table 34 Number of Supply Disturbances Where Interruption Originated by Scale of Interruption (nationwide, FY 2016) [Number]

Scale of Disturbance / [Duration & Capacity lost] / Occurrence in		from 10 to 30 minutes		from 30 minutes to 1 hour		from 1 to 3 hours			Longer than 3 hours			Total
		70,000kW to 100,000kW under	100,000kW over[4]	70,000kW to 100,000kW under	100,000kW over[4]	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over[4]	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over[4]	Disturbances
Accidents of Facilities of General Transmission & Distribution Companies												
Substations						3	1	2	5		2	13
Transmission Lines & Extra High Voltage Lines	Overhead		1		2	3			6			12
	Under-ground		1									1
	Total		2		2	3			6			13
High Voltage Lines	Overhead											
	Under-ground											
	Total											
Demand Facilities												
Involving Accidents												
Total Disturbances			2		2	6	1	2	11		2	26

[4] Supply disturbance over a certain scale of 10 minutes and longer is reported to different destination according to lost capacity under the provisions of Article 3 of the Reporting Rules of the Electricity Business. In case the lost capacity is 7,000-100,000 kW, it is reported to the Director of Regional Industrial Safety and the Inspection Department that directs the area the disturbed electric facility is located. In case the lost capacity is over 100,000 kW, it is reported to the Ministry of Economy, Trade, and Industry. Thus, the reporting destination differs according to the lost capacity, Table 34 presents the number of disturbances by lost capacity.

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

Table 35 classifies and describes the causes of supply disturbances.

Table 35 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 patrol, inspection or cleaning), natural deterioration (deterioration of material or mechanism of electric facilities not due to production, installation or maintenance), or overloading (overcurrent more than 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 is accompanied, 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 accident with electric shock of worker caused by misoperation 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 misoperation 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 in spite of investigation
Miscellaneous		Due to causes not categorized above

(3) The Number and the Causes of Supply Disturbances over a Certain Scale

For the number of supply disturbances over a certain scale where interruption originated, Table 36 and Figure 24 show the nationwide data, and Tables 37 to 46 show the data by regional service areas for the period FY 2012-2016.

For the data for FY 2016, the number and the causes of supply disturbances over a certain scale are summarized as follows.

- There were 9 cases nationwide of supply disturbances over a certain scale due to faults of the facility or maintenance, which roughly reflects the 5-year average.
- There were 16 cases nationwide of supply disturbances over a certain scale due to natural disaster, which is greater than the 5-year average. Many of these cases are much attributable to the 2016 Kumamoto earthquakes and the eruption of Mount Aso in the regional service area of Kyushu EPCO.

Table 36 Causes of Disturbances over a Certain Scale (nationwide, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault	1	2	1	1	1	1.2
Maintenance fault	3	4	2	1	3	2.6
Accident/malice	2				1	0.6
Physical contact	2	3			3	1.6
Involving accident		1		1	1	0.6
Electric shock(worker)			1	1		0.4
Subtotal	8	10	4	4	9	7.0
Natural Disaster						
Thunderbolt	4	7	2		3	3.2
Rainstorm	4	2	1		3	2.0
Snowstorm	9	10	2		2	4.6
Earthquake					6	1.2
Briny air, volcanic ash or gas					2	0.4
Subtotal	17	19	5		16	11.4
Unknown			1	1		0.4
Miscellaneous					1	0.2
Total	25	29	10	5	26	19.0

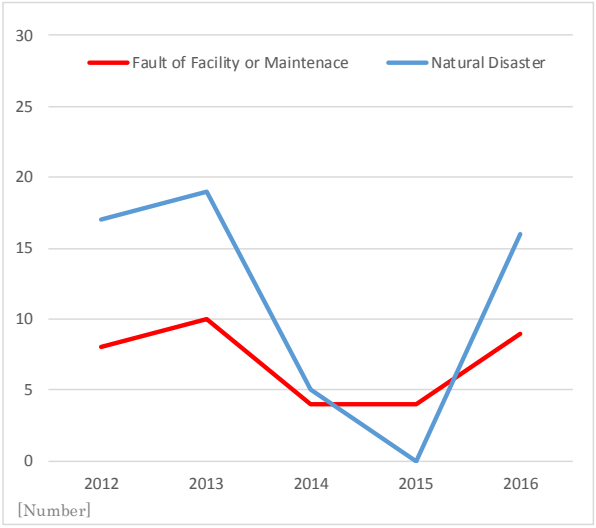

Figure 24 Transition of Disturbances by Causes (nationwide, FY 2012-2016)

Table 37 Causes of Disturbances over a Certain Scale (Hokkaido, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault						
Maintenance fault					1	0.2
Accident/malice						
Physical contact						
Involving accident						
Electric shock(worker)						
Subtotal					1	0.2
Natural Disaster						
Thunderbolt		1				0.2
Rainstorm					2	0.4
Snowstorm	6					1.2
Earthquake						
Briny air, volcanic ash or gas						
Subtotal	6	1			2	1.8
Unknown						
Miscellaneous						
Total	6	1			3	2.0

Table 38 Causes of Disturbances over a Certain Scale (Tohoku, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault						
Maintenance fault						
Accident/malice					1	0.2
Physical contact		1			2	0.6
Involving accident						
Electric shock(worker)				1		0.2
Subtotal		1		1	3	1.0
Natural Disaster						
Thunderbolt		2				0.4
Rainstorm	1					0.2
Snowstorm	1					0.2
Earthquake						
Briny air, volcanic ash or gas						
Subtotal	2	2				0.8
Unknown			1			0.2
Miscellaneous						
Total	2	3	1	1	3	2.0

Table 39 Causes of Disturbances over a Certain Scale (Tokyo, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault			1	1		0.4
Maintenance fault	2	2		1	2	1.4
Accident/malice	2					0.4
Physical contact	1	1				0.4
Involving accident				1		0.2
Electric shock(worker)						
Subtotal	5	3	1	3	2	2.8
Natural Disaster						
Thunderbolt	1	1			1	0.6
Rainstorm	2	1				0.6
Snowstorm	1	9				2.0
Earthquake						
Briny air, volcanic ash or gas						
Subtotal	4	11			1	3.2
Unknown				1		0.2
Miscellaneous						
Total	9	14	1	4	3	6.2

Table 40 Causes of Disturbances over a Certain Scale (Chubu, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault						
Maintenance fault			1			0.2
Accident/malice						
Physical contact	1	1				0.4
Involving accident						
Electric shock(worker)						
Subtotal	1	1	1			0.6
Natural Disaster						
Thunderbolt					1	0.2
Rainstorm						
Snowstorm		1	2		2	1.0
Earthquake						
Briny air, volcanic ash or gas						
Subtotal		1	2		3	1.2
Unknown						
Miscellaneous						
Total	1	2	3		3	1.8

5

[5] Causes of the disturbances that did not occur in the period FY 2012-2016 are omitted from the tables.

Table 41 Causes of Disturbances over a Certain Scale (Hokuriku, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault						
Maintenance fault						
Accident/malice						
Physical contact						
Involving accident						
Electric shock(worker)						
Subtotal						
Natural Disaster						
Thunderbolt		1				0.2
Rainstorm						
Snowstorm						
Earthquake						
Briny air, volcanic ash or gas						
Subtotal		1				0.2
Unknown						
Miscellaneous						
Total		1				0.2

Table 42 Causes of Disturbances over a Certain Scale (Kansai, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault		1				0.2
Maintenance fault	1					0.2
Accident/malice						
Physical contact						
Involving accident					1	0.2
Electric shock(worker)						
Subtotal	1	1			1	0.6
Natural Disaster						
Thunderbolt			1			0.2
Rainstorm					1	0.2
Snowstorm						
Earthquake						
Briny air, volcanic ash or gas						
Subtotal			1		1	0.4
Unknown						
Miscellaneous						
Total	1	1	1		2	1.0

Table 43 Causes of Disturbances over a Certain Scale (Chugoku, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault		1				0.2
Maintenance fault		1	1			0.4
Accident/malice						
Physical contact						
Involving accident						
Electric shock(worker)			1			0.2
Subtotal		2	2			0.8
Natural Disaster						
Thunderbolt	2	2				0.8
Rainstorm						
Snowstorm	1					0.2
Earthquake					1	0.2
Briny air, volcanic ash or gas						
Subtotal	3	2			1	1.2
Unknown						
Miscellaneous					1	0.2
Total	3	4	2		2	2.2

Table 44 Causes of Disturbances over a Certain Scale (Shikoku, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault						
Maintenance fault		1				0.2
Accident/malice						
Physical contact						
Involving accident						
Electric shock(worker)						
Subtotal		1				0.2
Natural Disaster						
Thunderbolt						
Rainstorm			1			0.2
Snowstorm						
Earthquake						
Briny air, volcanic ash or gas						
Subtotal			1			0.2
Unknown						
Miscellaneous						
Total		1	1			0.4

Table 45 Causes of Disturbances over a Certain Scale (Kyushu, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault	1				1	0.4
Maintenance fault						
Accident/malice						
Physical contact					1	0.2
Involving accident		1				0.2
Electric shock(worker)						
Subtotal	1	1			2	0.8
Natural Disaster						
Thunderbolt			1			0.2
Rainstorm		1				0.2
Snowstorm						
Earthquake					5	1.0
Briny air, volcanic ash or gas					2	0.4
Subtotal		1	1		7	1.8
Unknown						
Miscellaneous						
Total	1	2	1		9	2.6

Table 46 Causes of Disturbances over a Certain Scale (Okinawa, FY 2012-2016) [number]

	2012	2013	2014	2015	2016	5-years average
Fault of Facility or Maintenance						
Facility fault						
Maintenance fault						
Accident/malice						
Physical contact						
Involving accident						
Electric shock(worker)						
Subtotal						
Natural Disaster						
Thunderbolt	1				1	0.4
Rainstorm	1					0.2
Snowstorm						
Earthquake						
Briny air, volcanic ash or gas						
Subtotal	2				1	0.6
Unknown						
Miscellaneous						
Total	2				1	0.6

3. Data of Interruptions for Low Voltage (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 47 shows the definition of terms relating to outage.

Table 47 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 re-closing[6].
Planned outage	Electric power company interrupts its electricity supply in planned manner to construct, improve, and maintain its electric facility.

[6] See footnote 2 for definitions.

(2) Data of System Average Interruption Nationwide and Regional Service Areas (FY 2012-2016)

Table 48 and Figure 25 show the nationwide data of system average interruptions for FY 2012-2016. Tables 49 to 58 and Figures 26 to 35 show the data by regional service area. Table 59 shows the nationwide data of system average interruptions for FY 2016, 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.[7]

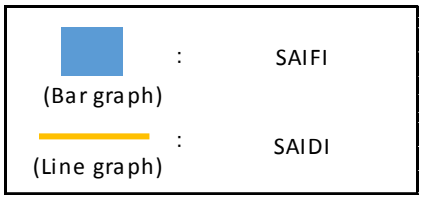

Table 48 System Average Interruption Indices of LV Customers (nationwide, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.14	0.13	0.13	0.10	0.14	0.13
	Planned	0.04	0.03	0.04	0.03	0.03	0.04
	Total ●	0.18	0.16	0.16	0.13	0.18	0.16
SAIDI [minute]	Forced	32	12	16	18	21	20.1
	Planned	5	4	4	4	4	3.9
	Total ●	37	16	20	21	25	23.9

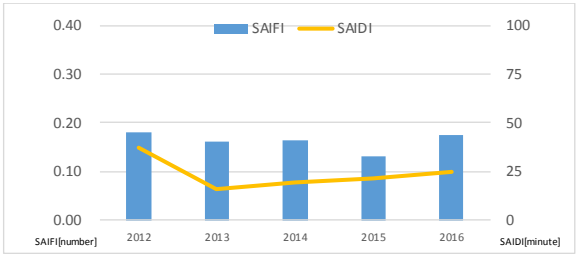

Figure 25 System Average Interruption Indices of LV Customers (nationwide, FY 2012-2016)

Table 49 System Average Interruption Indices of LV Customers (Hokkaido, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.18	0.15	0.13	0.15	0.17	0.16
	Planned	0.01	0.01	α	α	α	0.01
	Total ●	0.19	0.16	0.13	0.15	0.17	0.16
SAIDI [minute]	Forced	47	9	8	10	35	21.8
	Planned	α	1	α	α	1	1.0
	Total ●	48	9	9	10	36	22.4

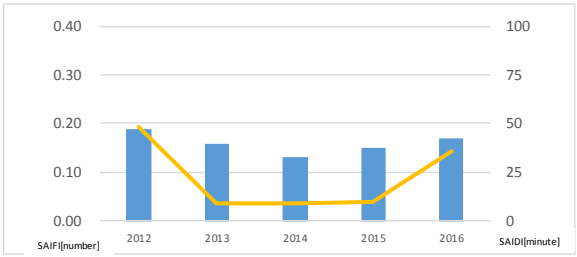

Figure 26 System Average Interruption Indices of LV Customers (Hokkaido, FY 2012-2016)

Table 50 System Average Interruption Indices of LV Customers (Tohoku, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.21	0.14	0.12	0.08	0.11	0.13
	Planned	0.08	0.05	0.04	0.04	0.03	0.05
	Total ●	0.30	0.19	0.16	0.12	0.14	0.18
SAIDI [minute]	Forced	48	19	9	11	24	22.1
	Planned	10	7	5	4	4	5.9
	Total ●	58	25	14	15	28	28.0

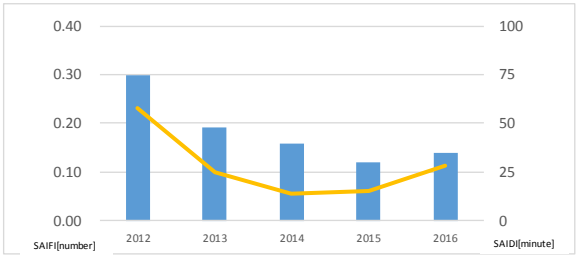

Figure 27 System Average Interruption Indices of LV Customers (Tohoku, FY 2012-2016)

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

Table 51 System Average Interruption Indices of LV Customers (Tokyo, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.07	0.14	0.07	0.06	0.13	0.09
	Planned	0.01	0.01	0.01	0.01	0.02	0.01
	Total 🔵	0.08	0.15	0.08	0.07	0.15	0.11
SAIDI [minute]	Forced	5	15	4	6	7	7.4
	Planned	3	1	α	1	1	1.4
	Total 🟡	8	16	4	6	8	8.3

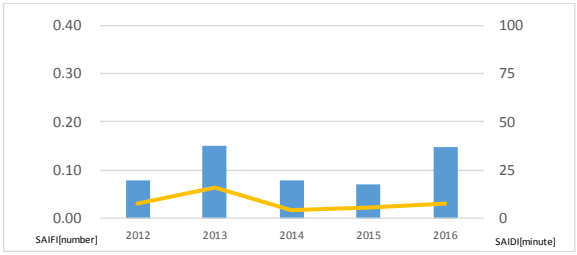

Figure 28 System Average Interruption Indices of LV Customers (Tokyo, FY 2012-2016)

Table 52 System Average Interruption Indices of LV Customers (Chubu, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.17	0.13	0.16	0.07	0.17	0.14
	Planned	0.07	0.06	0.07	0.06	0.06	0.06
	Total 🔵	0.24	0.19	0.23	0.13	0.23	0.20
SAIDI [minute]	Forced	46	13	18	4	5	17.2
	Planned	8	8	9	7	7	7.8
	Total 🟡	54	21	27	11	12	25.0

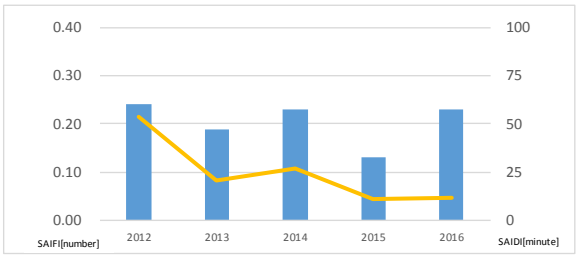

Figure 29 System Average Interruption Indices of LV Customers (Chubu, FY 2012-2016)

Table 53 System Average Interruption Indices of LV Customers (Hokuriku, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.12	0.11	0.09	0.04	0.06	0.08
	Planned	0.10	0.10	0.10	0.10	0.10	0.10
	Total 🔵	0.21	0.21	0.20	0.14	0.16	0.18
SAIDI [minute]	Forced	9	4	5	4	4	5.2
	Planned	16	16	17	16	17	16.4
	Total 🟡	25	20	22	20	21	21.6

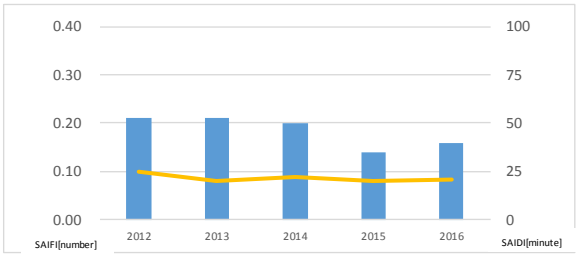

Figure 30 System Average Interruption Indices of LV Customers (Hokuriku, FY 2012-2016)

Table 54 System Average Interruption Indices of LV Customers (Kansai, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.08	0.06	0.06	0.07	0.07	0.07
	Planned	0.02	0.01	0.02	0.01	0.01	0.01
	Total 🔵	0.09	0.07	0.08	0.08	0.09	0.08
SAIDI [minute]	Forced	5	4	4	3	4	4.0
	Planned	1	1	1	1	1	1.0
	Total 🟡	7	5	5	4	5	5.2

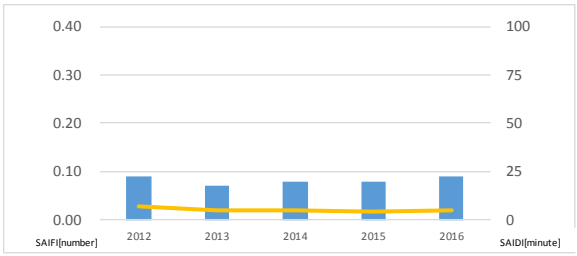

Figure 31 System Average Interruption Indices of LV Customers (Kansai, FY 2012-2016)

Table 55 System Average Interruption Indices of LV Customers (Chugoku, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.20	0.19	0.19	0.18	0.15	0.18
	Planned	0.13	0.13	0.11	0.11	0.11	0.12
	Total 🔵	0.33	0.32	0.31	0.29	0.26	0.30
SAIDI [minute]	Forced	8	9	10	17	6	10.0
	Planned	11	12	11	12	12	11.6
	Total 🟡	19	21	21	29	18	21.6

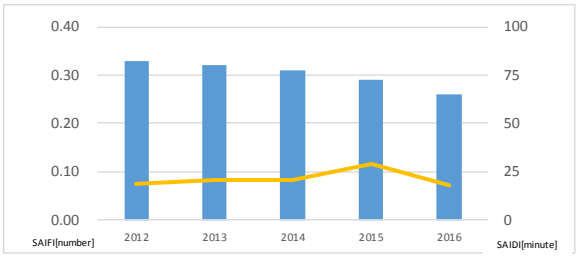

Figure 32 System Average Interruption Indices of LV Customers (Chugoku, FY 2012-2016)

Table 56 System Average Interruption Indices of LV Customers (Shikoku, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.14	0.11	0.21	0.12	0.09	0.13
	Planned	0.18	0.18	0.20	0.19	0.18	0.19
	Total 🔵	0.32	0.29	0.40	0.31	0.27	0.32
SAIDI [minute]	Forced	9	7	27	13	6	12.4
	Planned	17	19	20	21	20	19.4
	Total 🟡	27	25	47	34	26	31.8

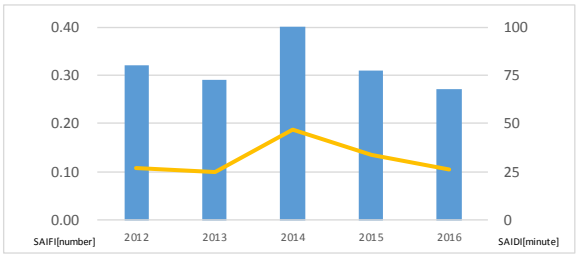

Figure 33 System Average Interruption Indices of LV Customers (Shikoku, FY 2012-2016)

Table 57 System Average Interruption Indices of LV Customers (Kyushu, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	0.08	0.05	0.09	0.16	0.24	0.12
	Planned	0.00	0.00	0.00	0.00	0.00	0.00
	Total 🔵	0.08	0.05	0.09	0.16	0.24	0.12
SAIDI [minute]	Forced	77	12	45	101	128	72.6
	Planned	0	0	0	0	0	0.0
	Total 🟡	77	12	45	101	128	72.6

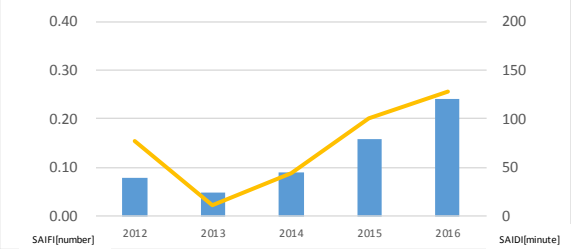

Figure 34 System Average Interruption Indices of LV Customers (Kyushu, FY 2012-2016)

Table 58 System Average Interruption Indices of LV Customers (Okinawa, FY 2012-2016)

		2012	2013	2014	2015	2016	5-years average
SAIFI [number]	Forced	2.76	0.74	2.58	1.04	0.57	1.54
	Planned	0.09	0.09	0.08	0.08	0.08	0.08
	Total 🔵	2.85	0.83	2.67	1.12	0.65	1.62
SAIDI [minute]	Forced	896	67	437	150	35	317.0
	Planned	8	8	8	8	8	8.0
	Total 🟡	904	75	445	158	43	325.0

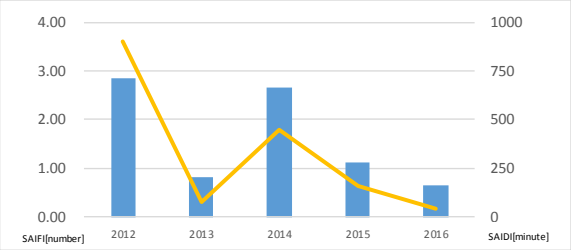

Figure 35 System Average Interruption Indices of LV Customers (Okinawa, FY 2012-2016)

Table 59 System Average Disturbances Where Interruption Originated by Cause (nationwide, FY 2016[8])

		Hokkaido	Tohoku	Tokyo	Chubu	Hokuriku	Kansai	Chugoku	Shikoku	Kyushu	Okinawa	Nationwide
SAIFI [number]	Forced Outage											
	Generators[8]	0.05	0.03	0.09	0.12	0.01	0.02	0.04	α	0.13	0.16	
	HV Lines	0.11	0.08	0.04	0.05	0.04	0.05	0.11	0.08	0.11	0.40	
	LV Lines	α	α	α	α	α	α	α	α	α	0.01	
	Subtotal	0.17	0.11	0.13	0.17	0.06	0.07	0.15	0.09	0.24	0.57	0.14
	Planned Outage											
	Generators[8]	α	α	0.00	α	α	α	α	0.00	0.00	α	
	HV Lines	α	0.02	0.02	0.04	0.09	α	0.09	0.11	0.00	0.03	
	LV Lines	α	0.01	α	0.02	0.01	0.01	0.02	0.07	0.00	0.05	
	Subtotal	α	0.03	0.02	0.06	0.10	0.01	0.11	0.18	0.00	0.08	0.03
	Total Outage											
	Generators[8]	0.05	0.03	0.09	0.12	0.01	0.02	0.04	α	0.13	0.16	
	HV Lines	0.12	0.10	0.06	0.09	0.13	0.06	0.20	0.19	0.11	0.43	
	LV Lines	α	0.01	α	0.02	0.02	0.01	0.02	0.07	α	0.06	
	Grand Total	0.17	0.14	0.15	0.23	0.16	0.09	0.26	0.27	0.24	0.65	0.18
SAIDI [minute]	Forced Outage											
	Generators[8]	12	4	2	2	α	α	1	α	27	9	
	HV Lines	23	19	5	3	3	3	5	5	94	24	
	LV Lines	α	1	α	α	α	α	α	1	7	2	
	Subtotal	35	24	7	5	4	4	6	6	128	35	21
	Planned Outage											
	Generators[8]	α	α	0	0	α	α	α	0	0	α	
	HV Lines	α	3	1	5	16	α	11	15	0	3	
	LV Lines	α	1	α	2	2	1	1	5	0	5	
	Subtotal	1	4	1	7	17	1	12	20	0	8	4
	Total Outage											
	Generators[8]	13	4	2	2	α	α	1	α	27	9	
	HV Lines	23	22	6	8	19	4	16	20	94	27	
	LV Lines	α	2	α	2	2	1	2	5	7	7	
	Grand Total	36	28	8	12	21	5	18	26	128	43	25

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

IV. Conclusion

Based on the analysis and the results, OCCTO concludes that the quality of the electricity supply was adequately maintained 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 2016 was adequately maintained within the target variance in all regional service areas. In addition, the target time kept ratio within 0.1 Hz variance for FY 2012-2016 did not show significant deterioration in the ratio.

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 2016, 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 2016, the number of supply disturbances and interruptions for LV customers remained at roughly the same level as the 5-year average as indicated in Table 48, and the number of supply disturbances was the lowest in FY 2016 within the period FY 2012-2016 as indicated in Table 23.

Further, supply disturbances over a certain scale[9] resulting from facility faults or maintenance faults did not increase in FY 2016 compared with the period FY 2012-2015. Although the number of supply disturbances over a certain scale due to natural disaster was higher than the average in FY 2012-2016, about one third of the nationwide data was attributable to the 2016 Kumamoto earthquakes in the regional service area of Kyushu EPCO.

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[9] The definitions are as follows.

- Capacity lost by disturbance is 7,000-70,000 kW and its duration is longer than 1 hour.
- Capacity lost by disturbance is over 70,000 kW and its duration is longer than 10 minutes.

<Reference> Comparison of System Average Interruption in Japan with Various Countries and US States for 2012-2016

Table 60 and Figure 36 show the SAIDI values, and Table 61 and Figure 37 show the SAIFI values for Japan and various countries and US states for the period 2012-2016. Data for EU countries are cited from the report[10] of the Council of European Energy Regulators (CEER); those for major US states are from the report[11] of the Public Utilities Commission in each state. These data were aggregated and analyzed by OCCTO[12].

For condition of monitoring, such as observed voltage, annual period of monitoring (starting from January or April)[13], or including/excluding natural disaster, vary in each country/state so that interruption data between Japan and various countries/states may not be compared adequately. However, both SAIDI and SAIFI have been in lower level than those of various countries/states. In addition, Japan observes only low voltage customers' data, however, customers except low voltage are very few so that interruptions of customers except low voltage are estimated to have slight influence to the interruption data.

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[10] Source: "CEER 6th Benchmarking Report on the Quality of Electricity and Gas Supply"
http://www.ceer.eu/portal/page/portal/EER_HOME/EER_PUBLICATIONS/CEER_PAPERS/Cross-Sectoral/2016/4-C16-EQS-72-03_CEER-6thBR_Annexes-Lists.pdf
The report is published roughly every 3 years with the updated data for the previous 3 years.

[11] 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

[12] 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.)

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

Table 60 SAIDI of Japan and Various Countries/US States for FY 2012-2016 by Forced and Planned Outages (minute)

Country/State			Year[13] 2012	2013	2014	2015	2016	Condition: Event of	Observed Voltage	Natural Disaster
JAPAN			37	16	20	21	25	except auto re-closing	LV	Include
		Forced	32	12	16	18	21			
		Planned	5	4	4	4	4			
U.S.A.	California		109	112	122	122	219	5 minute and longer	All	Include
		Forced	104	105	115	115	124			
		Planned	5	8	7	7	95			
	Texas		197	199	214	277	214			
		Forced	193	192	207	268	205			
		Planned	4	6	7	10	9			
	New York		1362	165	162	130	137			
		Forced	-	-	-	-	-			
		Planned	-	-	-	-	-			
EU	Germany		29	40	22	-	-	3 minute and longer	All	Include
		Forced	17	33	14	-	-			
		Planned	12	7	8	-	-			
	Italy		199	160	154	-	-		All	Include
		Forced	133	105	94	-	-			
		Planned	66	55	60	-	-			
	France		79	100	68	-	-		All	Include
		Forced	63	84	52	-	-			
		Planned	16	16	16	-	-			
	Spain		81	72	64	-	-		All	Include
		Forced	62	52	53	-	-			
		Planned	19	20	11	-	-			
	UK		82	73	105	-	-		All	Exclude
		Forced	68	61	93	-	-			
		Planned	14	12	12	-	-			
	Sweden		106	171	102	-	-		All	Include
		Forced	89	152	84	-	-			
		Planned	17	19	18	-	-			
	Finland		89	179	80	-	-		except LV	Include
		Forced	68	138	67	-	-			
		Planned	21	41	13	-	-			
	Norway		107	180	161	-	-		All	Include
		Forced	66	144	118	-	-			
		Planned	41	36	43	-	-			

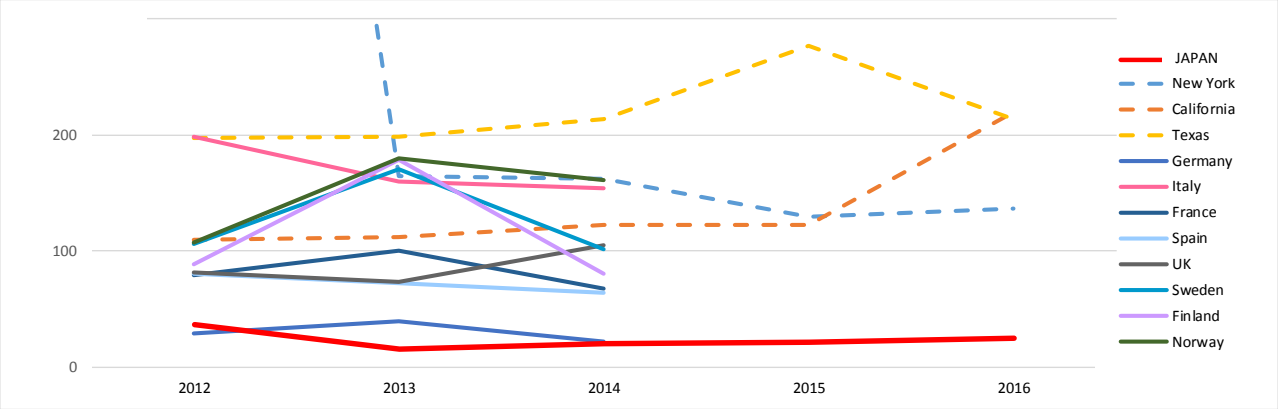

Figure 36 SAIDI of Japan and Various Countries/US States for FY 2012-2016 (minute)

Table 61 SAIFI of Japan and Various Countries/US States for FY 2012-2016 by Forced and Planned Outages (number)

Country/State			Year[13] 2012	2013	2014	2015	2016	Condition: Event of	Observed Voltage	Natural Disaster
JAPAN			0.18	0.16	0.16	0.13	0.18	except auto re-closing	LV	Include
		Forced	0.14	0.13	0.13	0.10	0.14			
		Planned	0.04	0.03	0.04	0.03	0.03			
U.S.A.	California		0.92	0.96	1.00	0.94	1.31	5 minute and longer	All	Include
		Forced	0.90	0.92	0.97	0.91	1.05			
		Planned	0.02	0.04	0.03	0.03	0.26			
	Texas		1.67	1.54	1.59	1.91	1.55			
		Forced	1.61	1.46	1.51	1.82	1.48			
		Planned	0.06	0.08	0.08	0.09	0.07			
	New York		1.03	0.73	0.68	0.67	0.79			
		Forced	-	-	-	-	-			
		Planned	-	-	-	-	-			
EU	Germany		0.41	0.58	0.45	-	-	3 minute and longer	All	Include
		Forced	0.29	0.50	0.37	-	-			
		Planned	0.12	0.08	0.08	-	-			
	Italy		2.74	2.57	2.35	-	-		All	Include
		Forced	2.33	2.20	1.99	-	-			
		Planned	0.41	0.37	0.36	-	-			
	France		1.01	1.03	0.87	-	-		All	Include
		Forced	0.90	0.90	0.74	-	-			
		Planned	0.11	0.13	0.13	-	-			
	Spain		3.52	1.61	1.20	-	-		All	Include
		Forced	3.20	1.31	1.13	-	-			
		Planned	0.32	0.30	0.07	-	-			
	UK		0.71	0.65	0.76	-	-		All	Exclude
		Forced	0.65	0.61	0.72	-	-			
		Planned	0.06	0.04	0.04	-	-			
	Sweden		1.47	1.48	1.46	-	-		All	Include
		Forced	1.33	1.33	1.30	-	-			
		Planned	0.14	0.15	0.16	-	-			
	Finland		2.10	2.90	1.80	-	-		except LV	Include
		Forced	1.80	2.50	1.60	-	-			
		Planned	0.30	0.40	0.20	-	-			
	Norway		1.67	2.30	2.50	-	-		All	Include
		Forced	1.40	2.00	2.20	-	-			
		Planned	0.27	0.30	0.30	-	-			

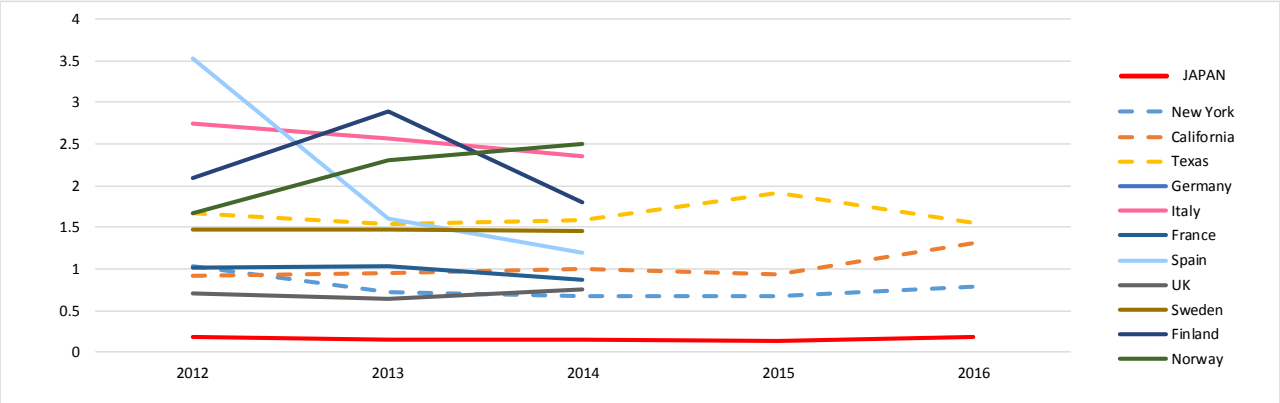

Figure 37 SAIFI of Japan and Various Countries/US States for FY 2012-2016 (number)

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