Report on the Quality of Electricity Supply

- Data for Fiscal Year 2015 -

December 2016

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

- Introduction -

Japan has experienced Great East Japan Earthquake in March, 2011. The earthquake and tsunami have brought significant damage to electric facilities, leading to large scale supply interruption with 8.7million customers in regional service areas of Tohoku and Tokyo EPCO. Further, the damage of the earthquake and tsunami forced rotating blackout to the service area of Tokyo EPCO. In April 2016, 480thousand customers have lost electricity supply by Kumamoto Earthquake. From the above frequent natural disasters leading to significant supply interruptions, more concerns to stable electricity supply are growing.

According to progress of Electricity System Reform, the numbers of new players show steady increases in both generation and retail business as well as greater integration of Renewable Energy has rapidly proceeded. As part of the Reform, full liberalization of retail market, business license system and balancing scheme are introduced and further in F.Y.2020, unbundling of generation sector from transmission/distribution sector shall be introduced. Electric system is one of crucial social infrastructures impacting human life as well as economic activity. Stable electricity supply must be secured even in the midst of drastic structural change. As part of its role, Organization for Cross-regional Coordination of Transmission Operators, JAPAN, (hereinafter, the Organization) shall grasp condition of supply reliability to secure stable electricity supply. For this purpose, the Organization shall continuously comprehend quality of electricity supply and carefully watch supply reliability.

This report aggregates actual data of Frequency, Voltage and Interruptions as “Quality of Electricity Supply” and implements its evaluation, according to the provision of Article 181 of Operational Rules of the Organization. The data up to F.Y.2015 are collected by regional service areas. With these data, the Organization evaluates and analyses whether frequency or voltage have been maintained within certain scope, or whether occurrence of supply interruption have not become worse. In addition, regarding to supply interruption, though data conditions are not uniform, comparison with EU countries or major states of U.S. are approached as reference.

The Organization would appreciate if aggregated actual data, evaluation and analyses could be of any help to electricity business as reference.

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Revision History

Date		Revision
Oct. 2018	Cover	Subtitle of the report corrected
	P1	Clerical error corrected
	P2	Clerical error corrected
	P17 and P18	Numbering of Tables corrected
	P22	Numbering of Table corrected
		Clerical error corrected

I. Actual Data of Frequency in Nationwide

1. Standard Frequency in Japan

General Transmission and Distribution (T/D) Companies must endeavor to maintain 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(hereinafter, the Act). Figure 1 shows regional service areas of 10 General T/D Companies and their standard frequency.

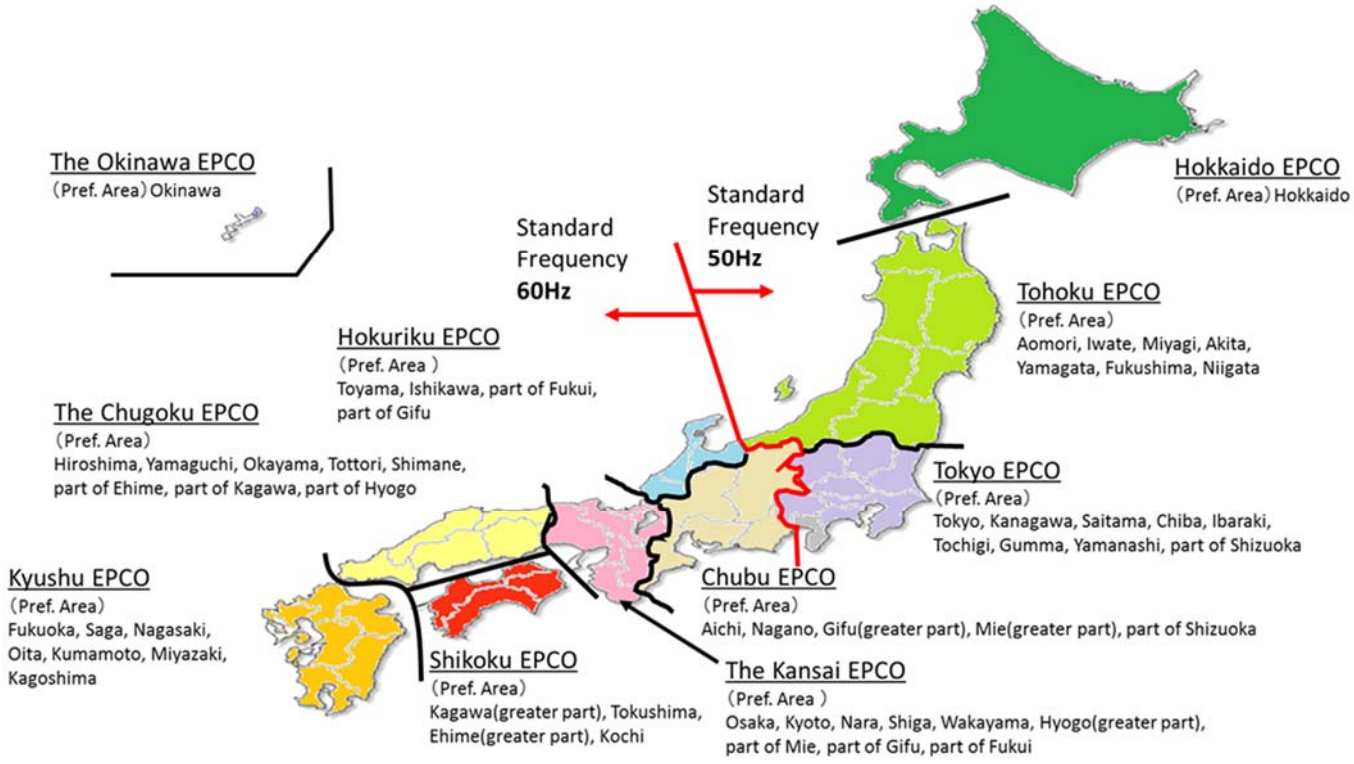

Figure 1　Regional Service Areas of 10 General T/D Companies and their Standard Frequency

As criteria of maintained frequency, Time Kept Ratio, which means ratio of time that actual metered frequency maintained within given variance of the standard has applied in the calculation formula below;

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

According to the indices of the formula above, Table 1 shows Control Rule of Frequency in normal condition in the regional service areas.

Table 1　Control Rule of Frequency in 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% and above	—

2. Time Kept Ratio of Frequency in Nationwide (by regional service areas, F.Y.2012～2015)

Table 2 to Table 11 show Time Kept Ratio by regional service areas from F.Y.2012 to F.Y.2015 and Figure 2 to Figure 11 show its trend, respectively. These actual data are submitted from General T/D Companies and aggregated by the Organization according to Article 268 of Network Codes[1].

Time Kept Ratio by regional service areas in F.Y.2015 is analyzed as below.

- Time Kept Ratio within Control Target achieved 100% in all regional service areas.
- Average Time Kept Ratio within 0.1Hz variance for 60Hz area is above the control target of 95%.

Thus, Frequency in Nationwide is evaluated to be maintained adequately in light of Frequency Standard and Control Target.

Table 2 Time Kept Ratio of Frequency (Hokkaido, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.65	99.84	99.91	99.83
Within 0.2Hz	99.99	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

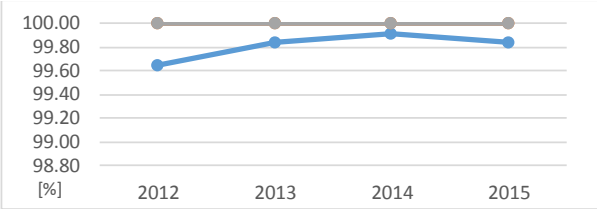

Figure 2 Transition of Time Kept Ratio (Hokkaido, F.Y.2012～2015)

Table 3 Time Kept Ratio of Frequency (Tohoku, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.94	99.88	99.88	99.89
Within 0.2Hz	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

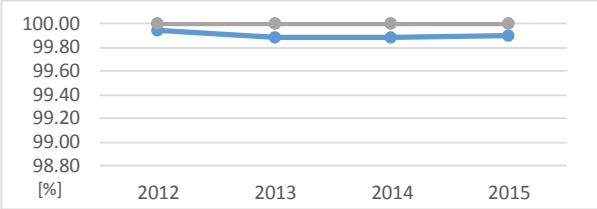

Figure 3 Transition of Time Kept Ratio (Tohoku, F.Y.2012～2015)

Table 4 Time Kept Ratio of Frequency (Tokyo, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.91	99.83	99.84	99.85
Within 0.2Hz	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

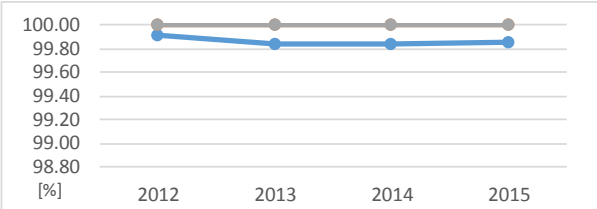

Figure 4 Transition of Time Kept Ratio (Tokyo, F.Y.2012～2015)

[1] 50Hz area except Hokkaido (Tohoku and Tokyo) or 60Hz area except Okinawa (Chubu, Hokuriku, Kansai, Chugoku, Shikoku and Kyushu) are respectively interconnected each other area in AC system, so Frequency in their regional service areas must be the same at all times. However, various frequencies in the same Hz area are reported, estimating that sampling method implemented for the record by General T/D Companies is not coordinated.
Besides, actual data of Time Kept Ratio does not include those of isolated islands in the regional service area.

Table 5 Time Kept Ratio of Frequency (Chubu, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.22	99.19	99.15	99.22
Within 0.2Hz	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

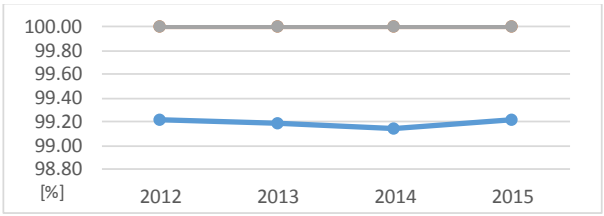

Figure 5 Transition of Time Kept Ratio (Chubu, F.Y.2012～2015)

Table 6 Time Kept Ratio of Frequency (Hokuriku, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.18	99.17	99.13	99.18
Within 0.2Hz	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

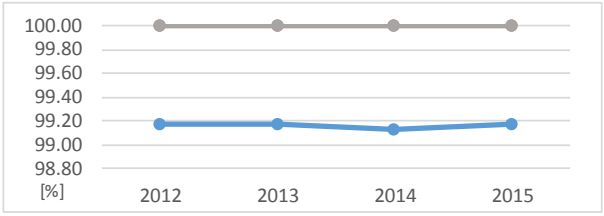

Figure 6 Transition of Time Kept Ratio (Hokuriku, F.Y.2012～2015)

Table 7 Time Kept Ratio of Frequency (Kansai, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.22	99.21	99.17	99.22
Within 0.2Hz	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

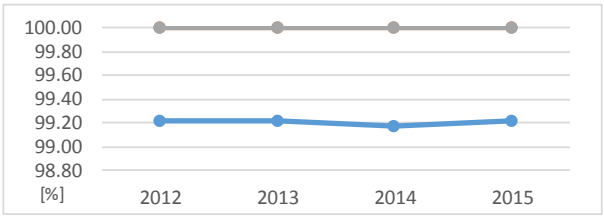

Figure 7 Transition of Time Kept Ratio (Kansai, F.Y.2012～2015)

Table 8 Time Kept Ratio of Frequency (Chugoku, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.21	99.22	99.17	99.23
Within 0.2Hz	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

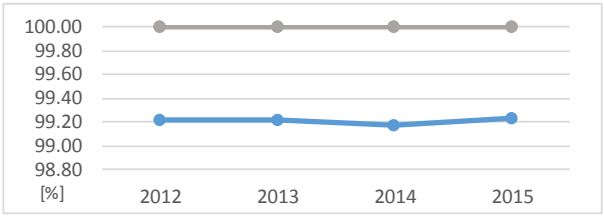

Figure 8 Transition of Time Kept Ratio (Chugoku, F.Y.2012～2015)

Table 9 Time Kept Ratio of Frequency (Shikoku, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.22	99.22	99.17	99.22
Within 0.2Hz	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

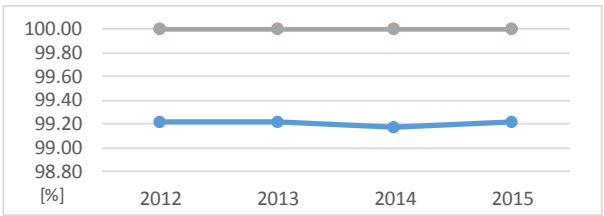

Figure 9 Transition of Time Kept Ratio (Shikoku, F.Y.2012～2015)

Table 10 Time Kept Ratio of Frequency (Kyushu, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.23	99.22	99.17	99.22
Within 0.2Hz	100.00	100.00	100.00	100.00
Within 0.3Hz	100.00	100.00	100.00	100.00
0.3Hz Over	0.00	0.00	0.00	0.00

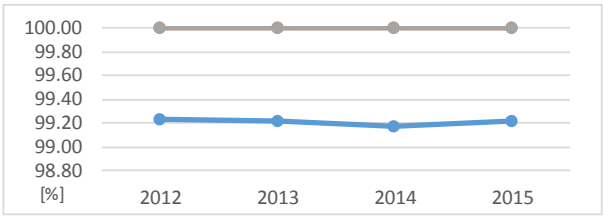

Figure 10 Transition of Time Kept Ratio (Kyushu, F.Y.2012～2015)

Table 11 Time Kept Ratio of Frequency (Okinawa, F.Y.2012～2015) [%]

Variance	2012	2013	2014	2015
Within 0.1Hz	99.65	99.65	99.87	99.89
Within 0.2Hz	99.98	99.99	100.00	100.00
Within 0.3Hz	99.99	100.00	100.00	100.00
0.3Hz Over	0.01	0.00	0.00	0.00

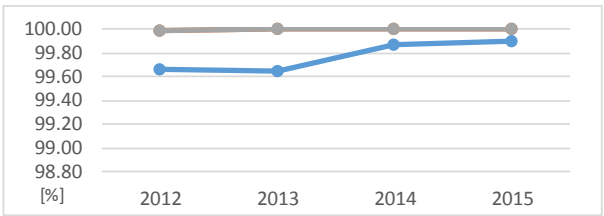

Figure 11 Transition of Time Kept Ratio (Okinawa, F.Y.2012～2015)

II. Actual Data of Voltage in Nationwide

1. Standard Voltage in Japan

General T/D Companies are deemed to endeavor maintaining the voltage value of the electricity supply at the levels specified[2]. Table 12 shows voltage standard and target voltage control in 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

As criteria of maintained voltage, the number of Deviated measuring points and ratio of deviated points against total measuring points have applied.

Deviation Ratio is calculated as the formula below;

$$\text{Deviation Ratio}\ (\%) = \frac{\text{Nos. of Deviated Points in Measurement}}{\text{Total Measured Points}} \times 100$$

[2] General T/D Companies are deemed to endeavor maintaining the voltage value and frequency value of the electricity supply at the levels specified by Ordinance of the Ministry of Economics, Trade and Industry according to Article 26 of the Act.

2. Deviation Ratio of Voltage in Nationwide (by regional service areas, F.Y.2012～2015)

Table 13 through Table 22 show Total Measured Points, Deviated Points in Measurement, and Deviation Ratio by regional service areas from F.Y.2012 to F.Y.2015[3].

Reviewing actual data of F.Y.2015, no deviation from the voltage standard is observed through the Nationwide. Thus, it is evaluated that voltage is maintained adequately in light of Voltage Standard in each regional service area.

Table 13 Voltage Deviation Ratio (Hokkaido, F.Y.2012～2015) [points,%]

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

Table 14 Voltage Deviation Ratio (Tohoku, F.Y.2012～2015) [points,%]

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

Table 15 Voltage Deviation Ratio (Tokyo, F.Y.2012～2015) [points,%]

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

Table 16 Voltage Deviation Ratio (Chubu, F.Y.2012～2015) [points,%]

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

Table 17 Voltage Deviation Ratio (Hokuriku, F.Y.2012～2015) [points,%]

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

Table 18 Voltage Deviation Ratio (Kansai, F.Y.2012～2015) [points,%]

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

Table 19 Voltage Deviation Ratio (Chugoku, F.Y.2012～2015) [points,%]

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

Table 20 Voltage Deviation Ratio (Shikoku, F.Y.2012～2015) [points,%]

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

Table 21 Voltage Deviation Ratio (Kyushu, F.Y.2012～2015) [points,%]

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

Table 22 Voltage Deviation Ratio (Okinawa, F.Y.2012～2015) [points,%]

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

[3] This report aggregates the data General T/D Companies submitted to the Organization according to the provision of Article 268 of Network Codes.

III. Actual Data of Interruption in Nationwide

1. Actual Data of the Numbers of Supply Disturbances where interruption originated

(1) Indices and Definition of Supply Disturbances

As criteria of supply interruption, Numbers of Supply Disturbances where interruption originated has been applied, indicating where and how many supply disturbances occurred, according to Electric Facilities in the system.

Further, Supply Disturbance means interruption of electric supply or emergent restriction of electricity use due to malfunction or misoperation of Electric Facilities[4]. Besides, the case in which electricity supply is resumed by automatic re-closing[5] of transmission line is not applicable to Supply Disturbance.

Table 23 indicates explanations for Electric Facilities applied to the actual data of the Supply Disturbances where interruption originated.

Table 23 Explanations for Electric Facilities
[applied to the actual data of the Supply Disturbance where interruption originated]

Electric Facilities	Explanations
Transmission Lines	Lines which interconnect Generation Plant and Substation, Generation Plants or Substations
Distribution Lines	Lines which interconnect Substation and demanding end
Extra High Voltage Lines	Distribution Lines for supply at the Extra High Voltage (7,000V above) to high-rise buildings or major factories
High Voltage Lines	Distribution Lines for supply at the High Voltage (600V to 7,000V) to medium-rise buildings, supermarkets or hotels
Low Voltage Lines	Distribution Lines for supply at the Low Voltage (600V under) to stores, offices or residencies
Demand Facilities	Electric Facilities installed at the demanding end such as factories or buildings

[4] Electric Facilities include machinery, apparatus, dam, conduit, reservoir, electric lines and other facilities those installed for generation, transformation, transmission, distribution or consumption of electricity defined by the Act.

[5] Automatic re-closing of transmission line means reconnection of transmission line by re-switching of circuit breaker after a given period when accident such as lightning strike occurred to transmission or distribution line and isolated fault section by opening circuit breaker due to action of protective relay.

(2) Actual Data of Numbers of Supply Disturbances (in Nationwide and by regional service areas, F.Y.2010～2015)

Table 24 and Figure 12 show Numbers of Supply Disturbances where interruption originated for the period of F.Y.2010 through F.Y.2015 in Nationwide, and Table 25 to 34 with Figure 13 to 22 show those data by regional service areas, respectively[6].

Analysis of data of F.Y.2015 indicates;

- Numbers of Supply Disturbances record the lowest for past 6 years in regional service areas of Tohoku, Tokyo, Hokuriku, Kansai and in Nationwide.
- On the other hand, those become the highest for past 6 years in regional service areas of Hokkaido, Chugoku and Kyushu. It is likely to be attributable to damage caused by Typhoon No.23 (CHOI-WAN) in October for Hokkaido, Typhoon No.15 (GONI) in August for Kyushu, and Typhoon No.15 as well as blizzard in January for Chugoku.

Table 24 Numbers of Supply Disturbances where interruption originated (Nationwide, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		63	62	66	56	42	45	55.7
Transmission Lines & Extra High Voltage Lines	Overhead	288	236	329	314	186	204	259.5
	Underground	17	11	16	11	9	13	12.8
	Total	305	247	345	325	195	217	272.3
High Voltage Lines	Overhead	11,002	11,494	13,577	11,928	11,532	10,370	11,650.5
	Underground	239	208	246	198	189	198	213.0
	Total	11,241	11,702	13,823	12,126	11,721	10,568	11,863.5
Low Voltage Lines				1				0.2
Demand Facilities				1				0.2
Involved Accidents*		443	441	504	476	460	333	442.8
Total Disturbance		12,052	12,452	14,740	12,983	12,418	11,163	12,634.7

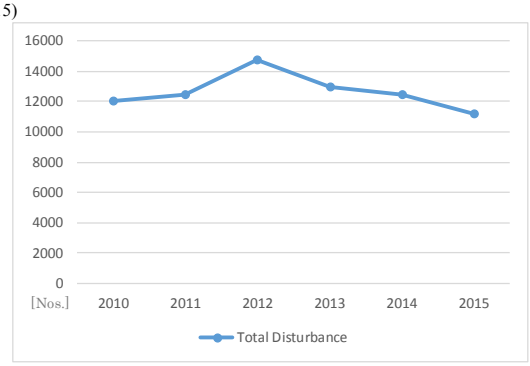

Figure 12 Transition of Supply Disturbances (Nationwide, F.Y.2010～2015)

Table 25 Numbers of Supply Disturbances where interruption originated (Hokkaido, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		4	2	4	4	2	1	2.8
Transmission Lines & Extra High Voltage Lines	Overhead	15	13	24	20	15	20	17.8
	Underground					2		0.3
	Total	15	13	24	20	17	20	18.2
High Voltage Lines	Overhead	806	835	1,012	1,053	1,119	1,145	995.0
	Underground	15	10	14	10	13	10	12.0
	Total	821	845	1,026	1,063	1,132	1,155	1,007.0
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		10	16	22	24	34	24	21.7
Total Disturbance		850	876	1,076	1,111	1,185	1,200	1,049.7

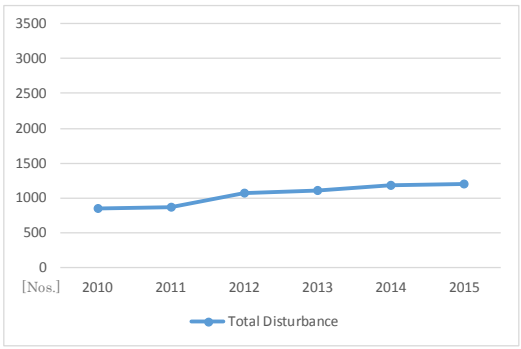

Figure 13 Transition of Supply Disturbances (Hokkaido, F.Y.2010～2015)

Table 26 Numbers of Supply Disturbances where interruption originated (Tohoku, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		14	11	8	5	5	5	8.0
Transmission Lines & Extra High Voltage Lines	Overhead	25	20	27	19	19	7	19.5
	Underground							
	Total	25	20	27	19	19	7	19.5
High Voltage Lines	Overhead	2,554	1,874	2,769	2,141	1,912	1,327	2,096.2
	Underground	17	18	10	9	6	5	10.8
	Total	2,571	1,892	2,779	2,150	1,918	1,332	2,107.0
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		59	60	38	28	43	22	41.7
Total Disturbance		2,669	1,983	2,852	2,202	1,985	1,366	2,176.2

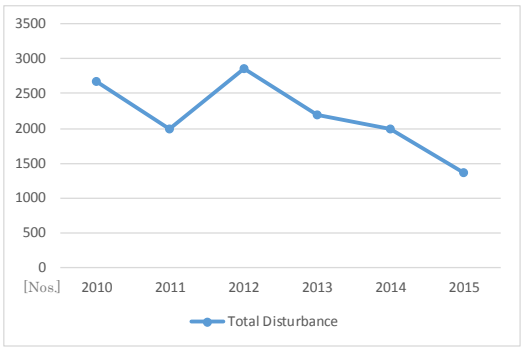

Figure 14 Transition of Supply Disturbances (Tohoku, F.Y.2010～2015)

[6] This report aggregates the data those General T/D Companies submitted to the Organization, according to the provision of Article 268 of Network Codes.

Table 27 Numbers of Supply Disturbances where interruption originated (Tokyo, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		9	8	10	6	10	10	8.8
Transmission Lines & Extra High Voltage Lines	Overhead	53	25	25	95	26	30	42.3
	Underground	5	1	8	3	2	5	4.0
	Total	58	26	33	98	28	35	46.3
High Voltage Lines	Overhead	3,111	2,404	2,185	3,075	1,854	1,755	2,397.3
	Underground	61	57	71	72	67	74	67.0
	Total	3,172	2,461	2,256	3,147	1,921	1,829	2,464.3
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		173	123	141	196	118	125	146.0
Total Disturbance		3,412	2,618	2,440	3,447	2,077	1,999	2,665.5

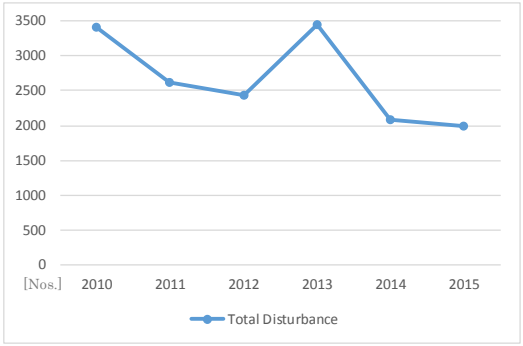

Figure 15 Transition of Supply Disturbances (Tokyo, F.Y.2010～2015)

Table 28 Numbers of Supply Disturbances where interruption originated (Chubu, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		13	10	3	6	2	5	6.5
Transmission Lines & Extra High Voltage Lines	Overhead	20	16	20	33	12	8	18.2
	Underground	1	1	1				0.5
	Total	21	17	21	33	12	8	18.7
High Voltage Lines	Overhead	683	1,770	1,911	1,621	1,592	1,066	1,440.5
	Underground	12	6	14	8	8	7	9.2
	Total	695	1,776	1,925	1,629	1,600	1,073	1,449.7
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		40	66	93	65	86	38	64.7
Total Disturbance		769	1,869	2,042	1,733	1,700	1,124	1,539.5

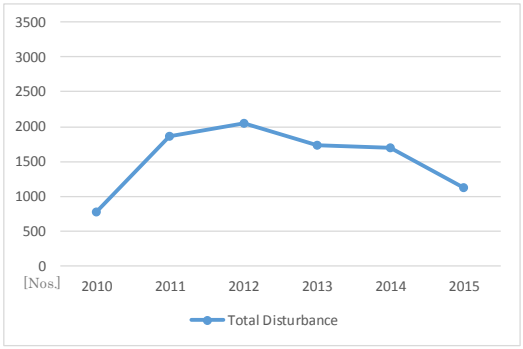

Figure 16 Transition of Supply Disturbances (Chubu, F.Y.2010～2015)

Table 29 Numbers of Supply Disturbances where interruption originated (Hokuriku, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		5	3	3	1	4		2.7
Transmission Lines & Extra High Voltage Lines	Overhead	4	4	2	3	6	5	4.0
	Underground						1	0.2
	Total	4	4	2	3	6	6	4.2
High Voltage Lines	Overhead	349	268	558	271	364	258	344.7
	Underground	7	6	11	6	4	7	6.8
	Total	356	274	569	277	368	265	351.5
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		23	8	25	17	18	10	16.8
Total Disturbance		388	289	599	298	396	281	375.2

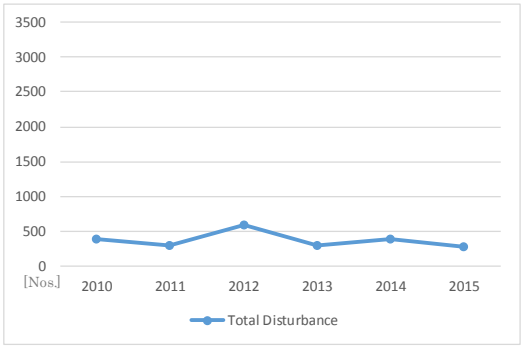

Figure 17 Transition of Supply Disturbances (Hokuriku, F.Y.2010～2015)

Table 30 Numbers of Supply Disturbances where interruption originated (Kansai, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		6	6	8	6	2	7	5.8
Transmission Lines & Extra High Voltage Lines	Overhead	81	83	68	59	44	42	62.8
	Underground	9	8	4	4	4	6	5.8
	Total	90	91	72	63	48	48	68.7
High Voltage Lines	Overhead	1,101	1,339	1,378	1,040	1,127	943	1,154.7
	Underground	87	67	89	61	45	51	66.7
	Total	1,188	1,406	1,467	1,101	1,172	994	1,221.3
Low Voltage Lines				1				0.2
Demand Facilities				1				0.2
Involved Accidents*		47	67	63	57	59	43	56.0
Total Disturbance		1,331	1,570	1,612	1,227	1,281	1,092	1,352.2

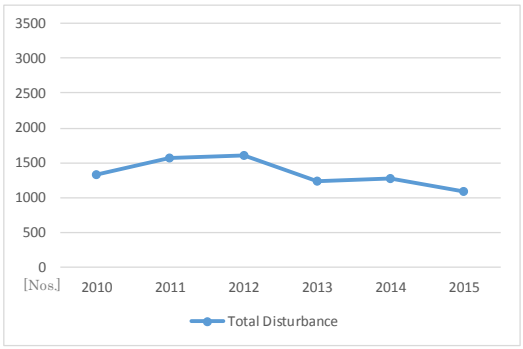

Figure 18 Transition of Supply Disturbances (Kansai, F.Y.2010～2015)

Table 31 Numbers of Supply Disturbances where interruption originated (Chugoku, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		7	5	15	18	11	10	11.0
Transmission Lines & Extra High Voltage Lines	Overhead	19	19	17	11	13	14	15.5
	Underground	1		1	2	1		0.8
	Total	20	19	18	13	14	14	16.3
High Voltage Lines	Overhead	1,153	1,026	1,149	1,172	1,122	1,211	1,138.8
	Underground	10	21	22	11	23	23	18.3
	Total	1,163	1,047	1,171	1,183	1,145	1,234	1,157.2
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		31	39	40	46	36	37	38.2
Total Disturbance		1,221	1,110	1,244	1,260	1,206	1,295	1,222.7

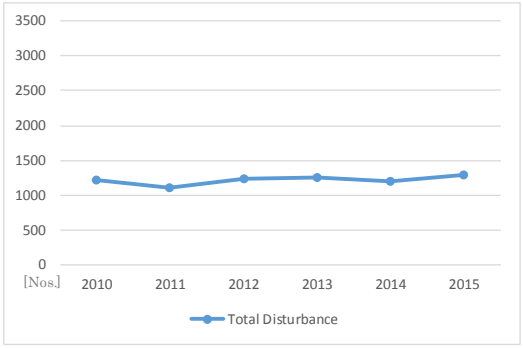

Figure 19 Transition of Supply Disturbances (Chugoku, F.Y.2010～2015)

Table 32 Numbers of Supply Disturbances where interruption originated (Shikoku, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		1			3	1	3	1.3
Transmission Lines & Extra High Voltage Lines	Overhead	3	2	1	2	4	3	2.5
	Underground	1		1	1			0.5
	Total	4	2	2	3	4	3	3.0
High Voltage Lines	Overhead	312	405	491	356	673	425	443.7
	Underground	7	5	5	4	3	5	4.8
	Total	319	410	496	360	676	430	448.5
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		8	13	16	8	14	8	11.2
Total Disturbance		332	425	514	374	695	444	464.0

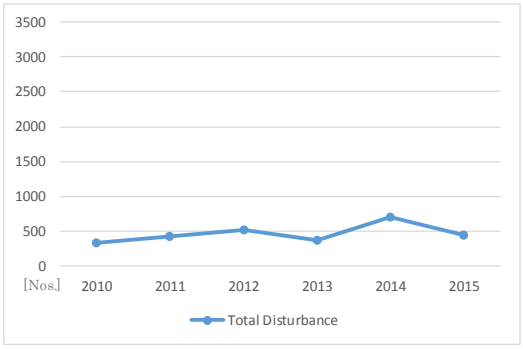

Figure 20 Transition of Supply Disturbances (Shikoku, F.Y.2010～2015)

Table 33 Numbers of Supply Disturbances where interruption originated (Kyushu, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		3	5	5	6	4	3	4.3
Transmission Lines & Extra High Voltage Lines	Overhead	20	13	27	22	12	24	19.7
	Underground		1	1			1	0.5
	Total	20	14	28	22	12	25	20.2
High Voltage Lines	Overhead	627	702	1,057	889	1,088	1,751	1,019.0
	Underground	20	16	10	16	18	15	15.8
	Total	647	718	1,067	905	1,106	1,766	1,034.8
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		33	36	39	30	31	18	31.2
Total Disturbance		703	773	1,139	963	1,153	1,812	1,090.5

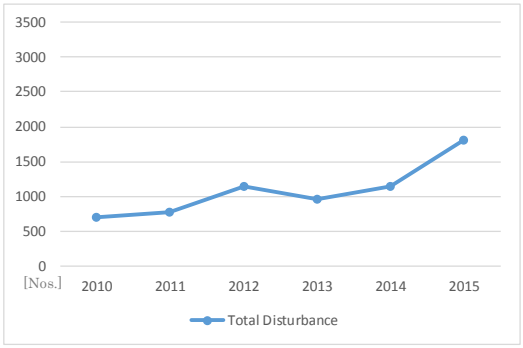

Figure 21 Transition of Supply Disturbances (Kyushu, F.Y.2010～2015)

Table 34 Numbers of Supply Disturbances where interruption originated (Okinawa, F.Y.2010～2015)

Occurrence at		2010	2011	2012	2013	2014	2015	6 years Average
Disturbance of General T/D Companies' Facilities								
Substations		1	12	10	1	1	1	4.3
Transmission Lines & Extra High Voltage Lines	Overhead	48	41	118	50	35	51	57.2
	Underground				1			0.2
	Total	48	41	118	51	35	51	57.3
High Voltage Lines	Overhead	306	871	1,067	310	681	489	620.7
	Underground	3	2		1	2	1	1.5
	Total	309	873	1,067	311	683	490	622.2
Low Voltage Lines								
Demand Facilities								
Involved Accidents*		19	13	27	5	21	8	15.5
Total Disturbance		377	939	1,222	368	740	550	699.3

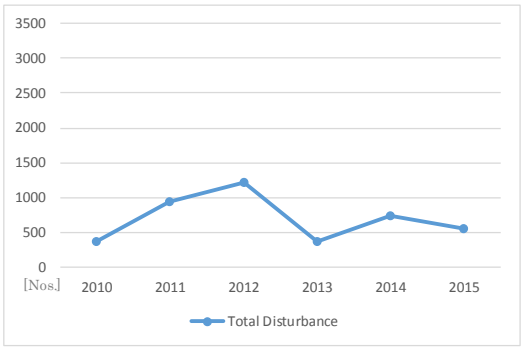

Figure 22 Transition of Supply Disturbances (Okinawa, F.Y.2010～2015)

Table 35 shows the actual data of the Numbers of Supply Disturbances where interruptions originated by scale of interruption in Nationwide for F.Y.2015.

Table 35 Numbers of Supply Disturbances where interruptions originated by scale of interruption [7](in Nationwide, F.Y.2015)

[Nos.]

Scale of Disturbance / [Duration & Capacity lost] / Occurrence at		Shorter than 10 min.				10 min. till 30 min.				30 min. till 1 hour				1hour till 3 hours				Longer than 3 hours				Total
		7,000kW under	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over	7,000kW under	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over	7,000kW under	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over	7,000kW under	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over	7,000kW under	7,000kW to 70,000kW under	70,000kW to 100,000kW under	100,000kW over	Disturbance
Accidents of facilities of General T/D Companies																						
Substations		19	12	1	1	2	4				3				2			1				45
Transmission Lines & Extra High Voltage Lines	Overhead	73	17			26	14			16	3			25	1			29				204
	Under-ground	4	2			1	1							1				4				13
	Total	77	19			27	15			16	3			26	1			33				217
High Voltage Lines	Overhead	508				463				880				4,498				4,021				10,370
	Under-ground	27				7				47				65	1			51				198
	Total	535				470				927				4,563	1			4,072				10,568
Low Voltage Lines																						
Demand Facilities																						
Involved Accidents[8]		11			1	20				86				188	1			26				333
Total Disturbance		642	31	1	2	519	19			1,029	6			4,777	5			4,132				11,163

[7] Left blank if the data is zero or not available.
[8] Accidents originated other than facilities of General T/D Companies.

2. Actual Data of Supply Disturbances over a certain scale and analysis of causes

For the actual data of Supply Disturbances where interruption originated described in preceding section, disturbances over a certain scale were reported with their causes. Analysis is given to their causes in this section.

Supply Disturbances over a certain scale apply to:

- Capacity lost by the disturbance is 7,000kW to 70,000kW under and its duration is longer than 1 hour.
- Capacity lost by the disturbance is 70,000kW to 100,000kW under and its duration is longer than 10 minutes.
- Capacity lost by the disturbance is 100,000kW over and its duration is longer than 10 minutes.

Table 36 classifies the causes of disturbances.

Table 36 Classification of the Causes of Disturbances

Classification of the Causes		Description
Natural Disaster	Thunderbolt	Due to direct lightning stroke or indirect lightning stroke
	Rainstorm	Due to rain, wind or rainstorm (including contact with blown boughs, etc.)
	Snowstorm	Due to snow, frazil, hail, sleet or snowstorm
	Earthquake	Due to earthquake
Miscellaneous	Physical contact	Due to physical contact by tree, wildlife, or others(kite, model airplane)
	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 by production, installation or maintenance), or overloading (overcurrent more than rated capacity).
	Accident/ Malice	Due to accident by worker, intention or accident by public (stone throwing, wire stealing, etc.) In case of electric shock is accompanied, it is classified in “Electric shock (worker)” or “Electric shock (public)”.
	Involved accident	Due to involved accident by other Electric Facilities of the Company or Electric Facilities of other Company.
	Electric shock(worker)	Due to accident with electric shock of worker by misoperation of work, 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 work, malfunction of Electric Facilities, accident by injured or third person, etc.
	Unknown	Due to the causes remain unknown in spite of exploring

For the numbers of Supply Disturbances over a certain scale where interruption originated[9] for the period of F.Y.2010～2015, Table 37 and Figure 23 show the data of Nationwide, and Table 38 to 47 show the data of regional service areas[10], respectively.

Analyses of the actual data and the causes of Supply Disturbances over a certain scale are;

<For F.Y.2015>

- There are no Supply Disturbances over a certain scale attributable to Natural Disaster through the Nationwide, as well as total Supply Disturbance for the year is the least for the past 6 years.
- Supply Disturbances due to miscellaneous causes are 5 cases. Data in recent years shows that the disturbances due to miscellaneous causes fall on 5 to 10 cases per year. So increasing trend is not observed due to miscellaneous causes, such as facility fault which considered as structural factor.

<For the period of F.Y.2010～2014>

- For F.Y.2010, Supply Disturbances over a certain scale due to earthquake have been recorded significantly, which was attributable to Great East Japan Earthquake.
- For F.Y.2012, Supply Disturbances over a certain scale due to snowstorm have been recorded 9 cases in Nationwide. 6 cases out of 9 were attributable to snowstorm in Hokkaido area.
- For F.Y.2013, Supply Disturbances over a certain scale due to snowstorm have been recorded 10 cases in Nationwide. 7 cases out of 10 were occurred on February 7 to 8, remaining 3 cases were occurred on February 14 to 16, for both were attributable to record-breaking snowfall in Kanto-Koshin area.

[9] This report aggregates the data which General T/D Companies submitted to METI for Report on Accident of Electricity Business according to Reporting Rules of Electricity Business. Preparing Table 37 to 47 and Figure 23 of the report, the Organization has collected and aggregated the data of disturbance due to natural disaster which is not necessarily to be submitted to METI by Reporting Rules.

Table 37 Causes of Disturbances over a certain scale (Nationwide、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt	3	1	4	7	2		2.8
Rainstorm		3	4	2	1		1.7
Snowstorm	1	1	9	10	2		3.8
Earthquake	38	3					6.8
Subtotal	42	8	17	19	5		15.2
Subtotal (except Earthquake)	4	5	17	19	5		8.3
Miscellaneous							
Physical contact	2		2	3			1.2
Facility fault		3	1	2	1	1	1.3
Maintenance fault	2	4	3	4	2	1	2.7
Accident/Malice			2				0.3
Involved accident				1		1	0.3
Electric shock(worker)					1	1	0.3
Electric shock(public)	1						0.2
Unknown	1				1	1	0.5
Subtotal	6	7	8	10	5	5	6.8
Total	48	15	25	29	10	5	22.0
Total(except Earthquake)	10	12	25	29	10	5	15.2

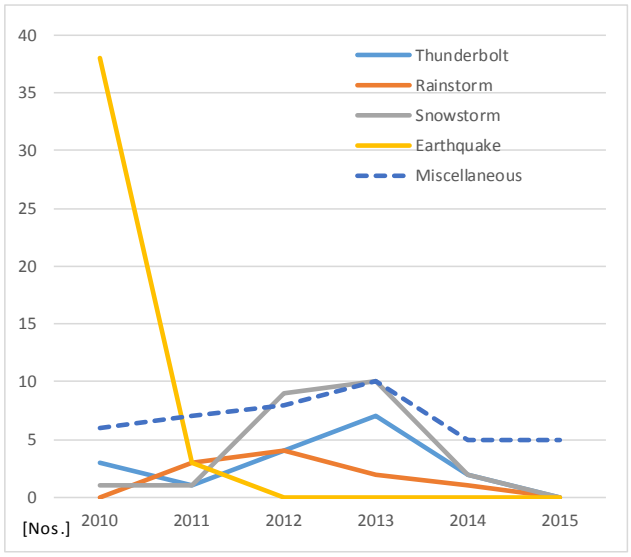

Figure 23 Transition of the numbers of Disturbances by causes (Nationwide, F.Y.2010～2015)

Table 38 Causes of Disturbances over a certain scale (Hokkaido、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt				1			0.2
Rainstorm							
Snowstorm			6				1.0
Earthquake							
Subtotal			6	1			1.2
Miscellaneous							
Physical contact							
Facility fault							
Maintenance fault							
Accident/Malice							
Involved accident							
Electric shock(worker)							
Electric shock(public)							
Unknown							
Subtotal							
Total			6	1			1.2

Table 39 Causes of Disturbances over a certain scale (Tohoku、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt		1		2			0.5
Rainstorm			1				0.2
Snowstorm			1				0.2
Earthquake	* 1	3					0.7
Subtotal	1	4	2	2			1.5
Miscellaneous							
Physical contact	1			1			0.3
Facility fault							
Maintenance fault		1					0.2
Accident/Malice							
Involved accident							
Electric shock(worker)						1	0.2
Electric shock(public)							
Unknown					1		0.2
Subtotal	1	1		1	1	1	0.8
Total	2	5	2	3	1	1	2.3

* Disturbances due to Great East Japan Earthquake are reported as single case.

Table 40 Causes of Disturbances over a certain scale (Tokyo、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt			1	1			0.3
Rainstorm		1	2	1			0.7
Snowstorm			1	9			1.7
Earthquake	37						6.2
Subtotal	37	1	4	11			8.8
Miscellaneous							
Physical contact			1	1			0.3
Facility fault		1			1	1	0.5
Maintenance fault	1	2	2	2		1	1.3
Accident/Malice			2				0.3
Involved accident						1	0.2
Electric shock(worker)							
Electric shock(public)							
Unknown	1					1	0.3
Subtotal	2	3	5	3	1	4	3.0
Total	39	4	9	14	1	4	11.8

Table 41 Causes of Disturbances over a certain scale (Chubu、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt	3						0.5
Rainstorm							
Snowstorm		1		1	2		0.7
Earthquake							
Subtotal	3	1		1	2		1.2
Miscellaneous							
Physical contact	1		1	1			0.5
Facility fault		1					0.2
Maintenance fault					1		0.2
Accident/Malice							
Involved accident							
Electric shock(worker)							
Electric shock(public)							
Unknown							
Subtotal	1	1	1	1	1		0.8
Total	4	2	1	2	3		2.0

[10] Left blank if the data is zero.

Table 42 Causes of Disturbances over a certain scale (Hokuriku、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt				1			0.2
Rainstorm							
Snowstorm							
Earthquake							
Subtotal				1			0.2
Miscellaneous							
Physical contact							
Facility fault							
Maintenance fault							
Accident/Malice							
Involved accident							
Electric shock(worker)							
Electric shock(public)							
Unknown							
Subtotal							
Total				1			0.2

Table 43 Causes of Disturbances over a certain scale (Kansai、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt					1		0.2
Rainstorm							
Snowstorm							
Earthquake							
Subtotal					1		0.2
Miscellaneous							
Physical contact							
Facility fault				1			0.2
Maintenance fault	1	1	1				0.5
Accident/Malice							
Involved accident							
Electric shock(worker)							
Electric shock(public)							
Unknown							
Subtotal	1	1	1	1			0.7
Total	1	1	1	1	1		0.8

Table 44 Causes of Disturbances over a certain scale (Chugoku、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt			2	2			0.7
Rainstorm							
Snowstorm	1		1				0.3
Earthquake							
Subtotal	1		3	2			1.0
Miscellaneous							
Physical contact							
Facility fault				1			0.2
Maintenance fault				1	1		0.3
Accident/Malice							
Involved accident							
Electric shock(worker)					1		0.2
Electric shock(public)	1						0.2
Unknown							
Subtotal	1			2	2		0.8
Total	2		3	4	2		1.8

Table 45 Causes of Disturbances over a certain scale (Shikoku、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt							
Rainstorm					1		0.2
Snowstorm							
Earthquake							
Subtotal					1		0.2
Miscellaneous							
Physical contact							
Facility fault							
Maintenance fault				1			0.2
Accident/Malice							
Involved accident							
Electric shock(worker)							
Electric shock(public)							
Unknown							
Subtotal				1			0.2
Total				1	1		0.3

Table 46 Causes of Disturbances over a certain scale (Kyushu、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt					1		0.2
Rainstorm				1			0.2
Snowstorm							
Earthquake							
Subtotal				1	1		0.3
Miscellaneous							
Physical contact							
Facility fault		1	1				0.3
Maintenance fault							
Accident/Malice							
Involved accident				1			0.2
Electric shock(worker)							
Electric shock(public)							
Unknown							
Subtotal		1	1	1			0.5
Total		1	1	2	1		0.8

Table 47 Causes of Disturbances over a certain scale (Okinawa、F.Y.2010～2015)

	2010	2011	2012	2013	2014	2015	6 years Average
Natural Disaster							
Thunderbolt			1				0.2
Rainstorm		2	1				0.5
Snowstorm							
Earthquake							
Subtotal		2	2				0.7
Miscellaneous							
Physical contact							
Facility fault							
Maintenance fault							
Accident/Malice							
Involved accident							
Electric shock(worker)							
Electric shock(public)							
Unknown							
Subtotal							
Total		2	2				0.7

3. Actual Data of Low Voltage Customers Interruption

(1) Indices of System Average Interruption for Low Voltage Customers

As criteria of customer interruption, two indices have been applied, indicating frequency and duration of Forced Outage or Planned Outage has occurred for one customer and one year.

$$\text{System Average Interruption Frequency Index(SAIFI/nos.)} = \frac{\text{Low Voltage Customers Affected by Interruption}}{\text{Low Voltage Customers Served at the beginning of the Fiscal Year}}$$

$$\text{System Average Interruption Duration Index(SAIDI/min.)} = \frac{\text{Interruption Duration(min.)} \times \text{Low Voltage Customers Affected by Interruption}}{\text{Low Voltage Customers Served at the beginning of the Fiscal Year}}$$

Table 48 shows definition of terms relating to outage.

Table 48 Definition of Terms relating to Outage

Term	Definition
Forced Outage	Supply interruption has occurred to end-use customers by accident such as malfunction of electric facility, except resumption of electricity supply by automatic re-closing[11].
Planned Outage	Electric Power Company interrupts its electricity supply in planned manner to construct, improve and maintain its electric facility.
Generation Side	Electric facility such as Generating Plant, Substation, Transmission Lines or Extra High Voltage Lines.

[11] [Aforementioned] Automatic re-closing of transmission line means reconnection of transmission line by re-switching of circuit breaker after a given period when accident such as lightning strike occurred to transmission or distribution line and isolated fault section by opening circuit breaker due to action of protective relay.

(2) Actual Data of System Average Interruption (in Nationwide and regional service areas, F.Y.2010 ～2015)

Table 49 and Figure 24 show actual data of System Average Interruption for the period of F.Y.2010 through F.Y.2015 in Nationwide, and Table 50 to 59 with Figure 25 to 34 show those data by regional service areas, respectively. Also, Table 60 shows the actual data of System Average Interruption where interruptions originated in Nationwide for F.Y.2015[12].

Analysis of data of F.Y.2015 indicates;

- System Average Interruption Frequency Index(SAIFI) records the lowest for past 6 years, and System Average Interruption Duration Index(SAIDI) is in almost the same level of the previous year in Nationwide.
- Both SAIFI and SAIDI are higher than the previous year in regional service area of Kyushu, and Okinawa, where they have significant variance. Both areas have higher SAIDI in trend, for it is likely to be attributable to natural disaster such as Typhoon.

[12] This report aggregates the data those General T/D Companies submitted to the Organization according to the provision of Article 268 of Network Codes.

Table 49 Indices of System Average Interruption(Nationwide, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.25	0.18	0.14	0.13	0.13	0.10	0.15
	Planned	0.69	0.04	0.04	0.03	0.04	0.03	0.15
	Total	0.94	0.22	0.18	0.16	0.16	0.13	0.30
SAIDI [min.]	Forced ●	417	74	32	12	16	18	95.0
	Planned	97	4	5	4	4	4	19.6
	Total	514	79	37	16	20	21	114.6

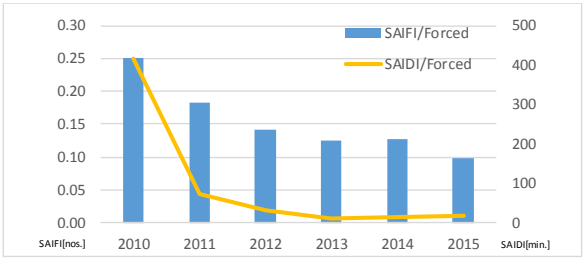

Figure 24 Transition of System Average Interruption(Nationwide, F.Y.2010～2015)

Table 50 Indices of System Average Interruption(Hokkaido, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.13	0.10	0.18	0.15	0.13	0.15	0.14
	Planned	α	0.01	0.01	0.01	α	α	0.01
	Total	0.13	0.11	0.19	0.16	0.13	0.15	0.15
SAIDI [min.]	Forced ●	8	5	47	9	8	10	14.5
	Planned	α	1	α	1	α	α	0.3
	Total	8	6	48	9	9	10	15.0

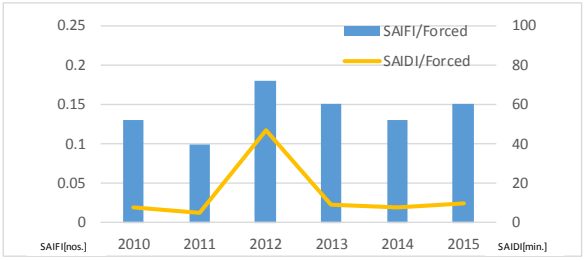

Figure 25 Transition of System Average Interruption(Hokkaido, F.Y.2010～2015)

Table 51 Indices of System Average Interruption(Tohoku, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.94	0.78	0.21	0.14	0.12	0.08	0.38
	Planned	0.07	0.07	0.08	0.05	0.04	0.04	0.06
	Total	1.01	0.85	0.30	0.19	0.16	0.12	0.44
SAIDI [min.]	Forced ●	3,998	582	48	19	9	11	777.7
	Planned	10	8	10	7	5	4	7.3
	Total	4,008	590	58	25	14	15	785.0

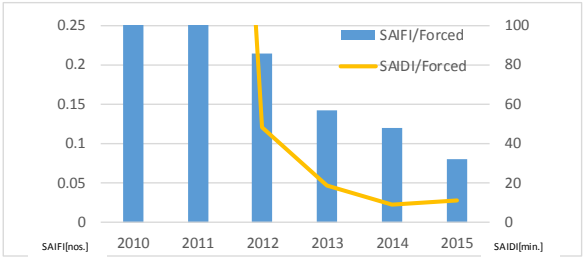

Figure 26 Transition of System Average Interruption(Tohoku, F.Y.2010～2015)

Table 52 Indices of System Average Interruption(Tokyo, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.33	0.10	0.07	0.14	0.07	0.06	0.13
	Planned	1.86	0.01	0.01	0.01	0.01	0.01	0.32
	Total	2.19	0.11	0.08	0.15	0.08	0.07	0.45
SAIDI [min.]	Forced ●	152	9	5	15	4	6	31.9
	Planned	265	1	3	1	α	1	45.2
	Total	417	10	8	16	4	6	76.9

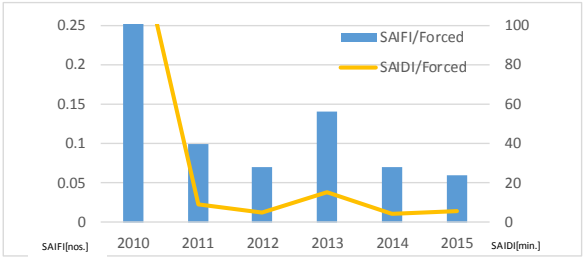

Figure 27 Transition of System Average Interruption(Tokyo, F.Y.2010～2015)

Table 53 Indices of System Average Interruption(Chubu, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.08	0.15	0.17	0.13	0.16	0.07	0.13
	Planned	0.08	0.07	0.07	0.06	0.07	0.06	0.07
	Total	0.16	0.22	0.24	0.19	0.23	0.13	0.20
SAIDI [min.]	Forced ●	3	35	46	13	18	4	19.8
	Planned	9	8	8	8	9	7	8.2
	Total	12	43	54	21	27	11	28.0

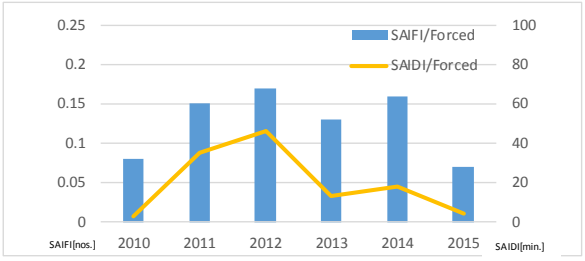

Figure 28 Transition of System Average Interruption(Chubu, F.Y.2010～2015)

Table 54 Indices of System Average Interruption(Hokuriku, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.08	0.05	0.12	0.11	0.09	0.04	0.08
	Planned	0.10	0.10	0.10	0.10	0.10	0.10	0.10
	Total	0.18	0.16	0.21	0.21	0.20	0.14	0.18
SAIDI [min.]	Forced ●	5	4	9	4	5	4	5.2
	Planned	20	19	16	16	17	16	17.3
	Total	25	22	25	20	22	20	22.3

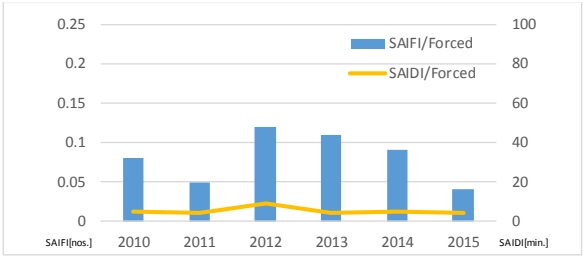

Figure 29 Transition of System Average Interruption(Hokuriku, F.Y.2010～2015)

Table 55 Indices of System Average Interruption(Kansai, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.06	0.09	0.08	0.06	0.06	0.07	0.07
	Planned	0.02	0.02	0.02	0.01	0.02	0.01	0.02
	Total	0.08	0.11	0.09	0.07	0.08	0.08	0.09
SAIDI [min.]	Forced ●	3	43	5	4	4	3	10.3
	Planned	2	2	1	1	1	1	1.3
	Total	5	45	7	5	5	4	11.8

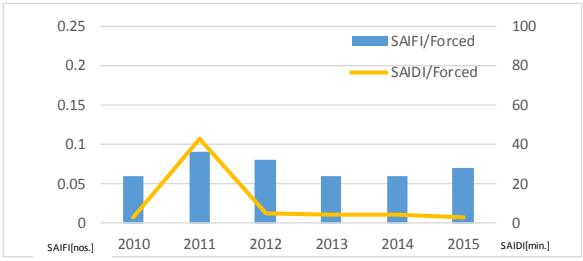

Figure 30 Transition of System Average Interruption(Kansai, F.Y.2010～2015)

Table 56 Indices of System Average Interruption(Chugoku, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.19	0.14	0.20	0.19	0.19	0.18	0.18
	Planned	0.11	0.12	0.13	0.13	0.11	0.11	0.12
	Total	0.30	0.27	0.33	0.32	0.31	0.29	0.30
SAIDI [min.]	Forced ●	19	7	8	9	10	17	11.7
	Planned	9	10	11	12	11	12	10.8
	Total	28	17	19	21	21	29	22.5

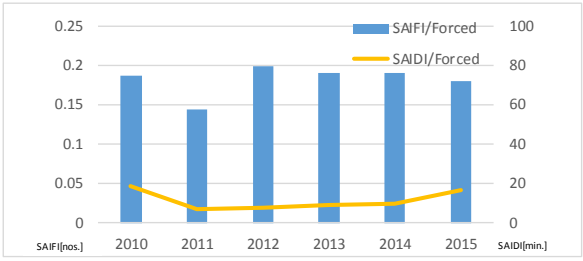

Figure 31 Transition of System Average Interruption(Chugoku, F.Y.2010～2015)

Table 57 Indices of System Average Interruption(Shikoku, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.09	0.13	0.14	0.11	0.21	0.12	0.13
	Planned	0.22	0.19	0.18	0.18	0.20	0.19	0.19
	Total	0.31	0.32	0.32	0.29	0.40	0.31	0.33
SAIDI [min.]	Forced ●	6	10	9	7	27	13	12.0
	Planned	25	21	17	19	20	21	20.5
	Total	31	31	27	25	47	34	32.5

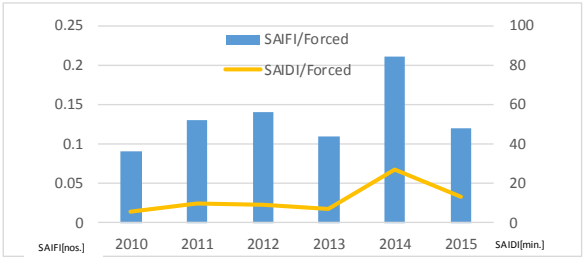

Figure 32 Transition of System Average Interruption(Shikoku, F.Y.2010～2015)

Table 58 Indices of System Average Interruption(Kyushu, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.03	0.08	0.08	0.05	0.09	0.16	0.08
	Planned	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total	0.03	0.08	0.08	0.05	0.09	0.16	0.08
SAIDI [min.]	Forced ●	2	5	77	12	45	101	40.3
	Planned	0	0	0	0	0	0	0.0
	Total	2	5	77	12	45	101	40.3

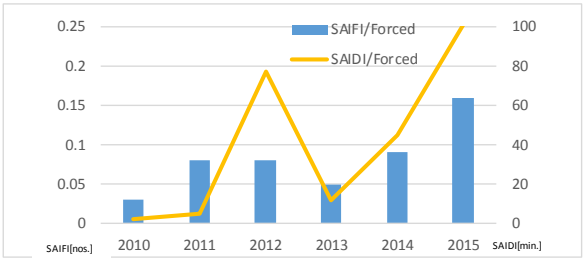

Figure 33 Transition of System Average Interruption(Kyushu, F.Y.2010～2015)

Table 59 Indices of System Average Interruption(Okinawa, F.Y.2010～2015)

		2010	2011	2012	2013	2014	2015	6 years Average
SAIFI	Forced ●	0.59	1.83	2.76	0.74	2.58	1.04	1.59
	Planned	0.09	0.10	0.09	0.09	0.08	0.08	0.09
	Total	0.68	1.93	2.85	0.83	2.67	1.12	1.68
SAIDI [min.]	Forced ●	104	752	896	67	437	150	401.0
	Planned	9	10	8	8	8	8	8.5
	Total	113	762	904	75	445	158	409.5

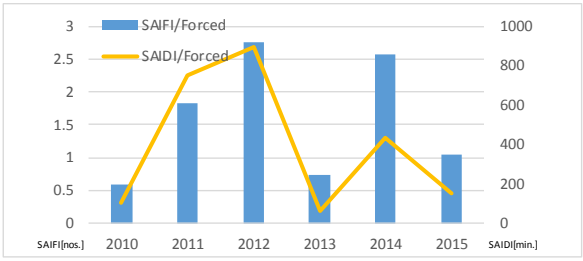

Figure 34 Transition of System Average Interruption(Okinawa, F.Y.2010～2015)

Table 60 System Average Interruption where interruptions originated by cause in Nationwide for F.Y.2015[13]

		Hokkaido	Tohoku	Tokyo	Chubu	Hokuriku	Kansai	Chugoku	Shikoku	Kyushu	Okinawa	Nationwide
SAIFI [nos.]	Forced Outage											
	Generation	0.06	α	0.03	0.01	α	0.02	0.01	0.01	0.03	0.21	
	HV Lines	0.09	0.08	0.03	0.06	0.03	0.04	0.16	0.11	0.12	0.82	
	LV Lines	α	α	α	α	α	α	α	α	α	0.01	
	Total	0.15	0.08	0.06	0.07	0.04	0.07	0.18	0.12	0.16	1.04	0.10
	Planned Outage											
	Generation	α	α	α	α	α	α	α	0.00	0.00	α	
	HV Lines	α	0.03	0.01	0.04	0.08	α	0.09	0.11	0.00	0.02	
	LV Lines	α	0.01	α	0.02	0.02	0.01	0.02	0.08	0.00	0.06	
	Total	α	0.04	0.01	0.06	0.10	0.01	0.11	0.19	0.00	0.08	0.03
	Total Outage											
	Generation	0.06	α	0.03	0.01	α	0.02	0.01	0.01	0.03	0.21	
	HV Lines	0.09	0.11	0.04	0.10	0.12	0.05	0.25	0.23	0.12	0.84	
	LV Lines	α	0.01	α	0.02	0.02	0.01	0.03	0.08	α	0.07	
	Grand Total	0.15	0.12	0.07	0.13	0.14	0.08	0.29	0.31	0.16	1.12	0.13
SAIDI [min.]	Forced Outage											
	Generation	3	α	α	α	α	α	α	α	1	6	
	HV Lines	7	10	5	4	2	3	16	13	100	136	
	LV Lines	α	1	α	α	2	α	1	1	1	8	
	Total	10	11	6	4	4	3	17	13	101	150	18
	Planned Outage											
	Generation	α	α	α	α	α	α	α	0	0	α	
	HV Lines	α	3	1	5	14	α	11	16	0	3	
	LV Lines	α	1	α	2	2	1	1	5	0	5	
	Total	α	4	1	7	16	1	12	21	0	8	4
	Total Outage											
	Generation	3	α	α	α	α	α	α	α	1	6	
	HV Lines	8	13	6	9	17	3	27	28	100	139	
	LV Lines	α	2	α	2	3	1	2	6	1	13	
	Grand Total	10	15	6	11	20	4	29	34	101	158	21

[13] α is shown if data is fraction less than unit.

4. Evaluation of Actual Data of Supply Disturbances and Low Voltage Customers Interruption (F.Y.2015)

Deterioration of actual data of Supply Disturbances and Low Voltage Customers Interruption are observed in particular areas with more natural disasters. Especially, increase of Supply Disturbance is observed in regional service area of Kyushu, due to damage caused by Typhoon No.15 (GONI).

On the other hand, Numbers of Supply Disturbances, Supply Disturbances of a certain scale[14] and SAIFI in Nationwide are the least for past 6 years and SAIDI in Nationwide is almost the same level of the previous year. Also Supply Disturbances of a certain scale excluding natural disaster are lower compared with actual data for the period of F.Y.2010 to 2014.

From the above, although some variance exist in particular areas due to natural disaster, from the viewpoint of Interruption, actual data do not become worse in Nationwide by structural factor such as facility fault. Thus, Supply Reliability in F.Y.2015 is evaluated to be kept adequately in Nationwide.

[14] [Aforementioned] Definitions are:

・Capacity lost by the disturbance is 7,000kW to 70,000kW under and its duration is longer than 1 hour.
・Capacity lost by the disturbance is 70,000kW to 100,000kW under and its duration is longer than 10 minutes.
・Capacity lost by the disturbance is 100,000kW over and its duration is longer than 10 minutes.

<Reference> Comparison of System Average Interruption with various countries for the period of 2010 to 2015

Table 61 and Figure 35 show System Average Interruption Duration Index (SAIDI), Table 62 and Figure 36 show System Average Interruption Frequency Index (SAIFI) of Japan and various countries/states for the period of 2010～2015, respectively. Data of EU countries are cited from the published report[15] of Council of European Energy Regulators (CEER), those of major states of the United States are cited from the published report[16] of Public Utilities Commission in each state. These data are aggregated and analyzed by the Organization[17].

Table 61 SAIDI of Japan and Various Countries from F.Y.2010 to 2015 by type of Outages [min.]

Nation/State			Year[18] 2010	2011	2012	2013	2014	2015	Condition: Event of	Observed Voltage[24]	Natural Disaster[25]
JAPAN			514[19]	79	37	16	20	21	except re-closing[21]	LV	Include
		Forced	417	74	32	12	16	18			
		Planned	97	4	5	4	4	4			
U.S.A.	New York		-	71	61	64	66	73	5 min. and longer[22]	All	Exclude
	California		-	105	101	92	90	92			
	Pennsylvania		-	170	163	145	130	136			
EU	Germany		30	27	29	40	22	-	3 min. and longer[23]	All	Include
		Forced	20	17	17	33	14	-			
		Planned	10	10	12	7	8	-			
	Italy		145	170	199	160	154	-		All	Include
		Forced	89	108	133	105	94	-			
		Planned	56	62	66	55	60	-			
	France		119	73	79	100	68	-		All	Include
		Forced	95	54	63	84	52	-			
		Planned	24	19	16	16	16	-			
	Spain		150	67	81	72	64	-		All	Include
		Forced	141	58	62	52	53	-			
		Planned	9	9	19	20	11	-			
	UK		88	77	75	67	99	-		All	Exclude
		Forced	81	70	68	61	93	-			
		Planned[20]	7	7	7	6	6	-			
	Sweden		112	203	106	171	102	-		All	Include
		Forced	92	186	89	152	84	-			
		Planned	20	17	17	19	18	-			
	Finland		187	244	89	179	80	-		except LV	Include
		Forced	170	225	68	138	67	-			
		Planned	17	19	21	41	13	-			
	Norway		102	258	107	180	161	-		All	Exclude
		Forced	66	216	66	144	118	-			
		Planned	36	42	41	36	43	-			

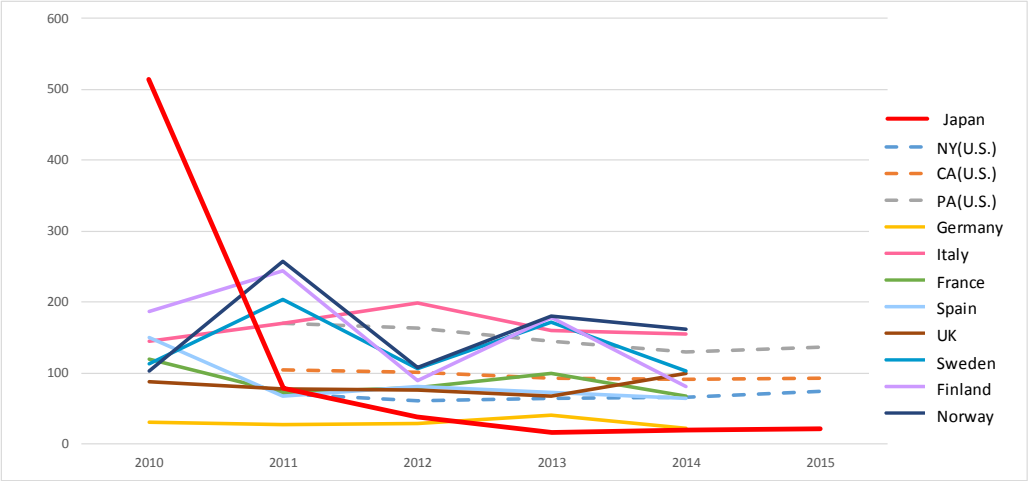

Figure 35 SAIDI of Japan and Various Countries from F.Y.2010 to 2015 [min.]

Table 62 SAIFI of Japan and Various Countries from F.Y.2010 to 2015 by type of Outages [nos.]

Nation/State		Year[18] 2010	2011	2012	2013	2014	2015	Condition: Event of	Observed Voltage[24]	Natural Disaster[25]
JAPAN		0.94[19]	0.22	0.18	0.16	0.16	0.13	except re-closing[21]	LV	Include
	Forced	0.25	0.18	0.14	0.13	0.13	0.10			
	Planned	0.69	0.04	0.04	0.03	0.04	0.03			
U.S.A.	New York	-	0.62	0.53	0.57	0.57	0.62	5 min. and longer[22]	All	Exclude
	California	-	0.89	0.88	0.87	0.85	0.82			
	Pennsylvania	-	1.22	1.09	1.08	1.05	1.08			
EU	Germany	0.41	0.44	0.41	0.58	0.45	-	3 min. and longer[23]	All	Include
	Forced	0.32	0.34	0.29	0.50	0.37	-			
	Planned	0.09	0.10	0.12	0.08	0.08	-			
	Italy	2.61	2.45	2.74	2.57	2.35	-		All	Include
	Forced	2.23	2.08	2.33	2.20	1.99	-			
	Planned	0.38	0.37	0.41	0.37	0.36	-			
	France	1.19	0.95	1.01	1.03	0.87	-		All	Include
	Forced	0.98	0.82	0.90	0.90	0.74	-			
	Planned	0.21	0.13	0.11	0.13	0.13	-			
	Spain	2.02	1.48	3.52	1.61	1.20	-		All	Include
	Forced	1.96	1.42	3.20	1.31	1.13	-			
	Planned	0.06	0.06	0.32	0.30	0.07	-			
	UK	0.75	0.72	0.68	0.63	0.74	-		All	Exclude
	Forced	0.72	0.69	0.65	0.61	0.72	-			
	Planned[20]	0.03	0.03	0.03	0.02	0.02	-			
	Sweden	2.20	1.77	1.47	1.48	1.46	-		All	Include
	Forced	2.02	1.63	1.33	1.33	1.30	-			
	Planned	0.18	0.14	0.14	0.15	0.16	-			
	Finland	2.10	2.70	2.10	2.90	1.80	-		except LV	Include
	Forced	1.80	2.40	1.80	2.50	1.60	-			
	Planned	0.30	0.30	0.30	0.40	0.20	-			
	Norway	1.80	2.70	1.67	2.30	2.50	-		All	Exclude
	Forced	1.50	2.40	1.40	2.00	2.20	-			
	Planned	0.30	0.30	0.27	0.30	0.30	-			

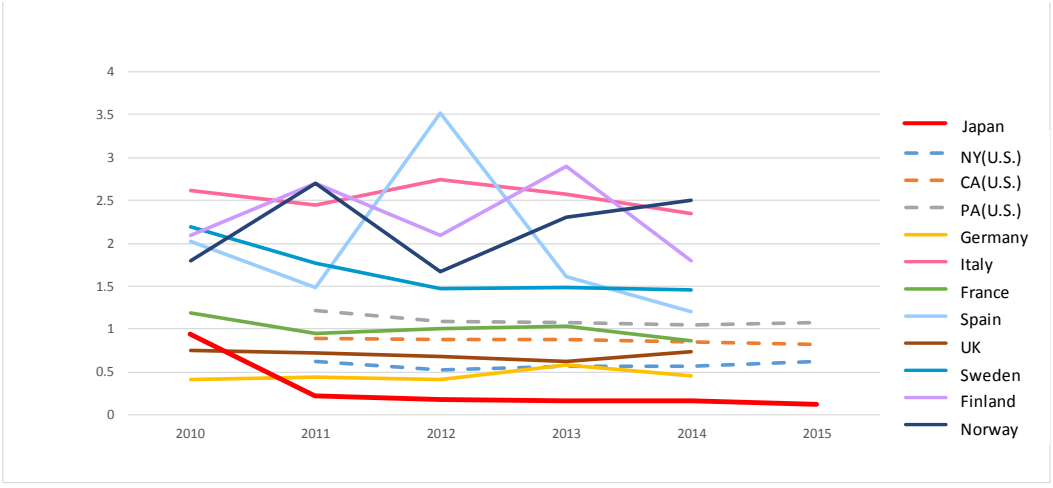

Figure 36 SAIFI of Japan and Various Countries from F.Y.2010 to 2015 [nos.]

For condition of monitoring, such as observed voltage, annual period of monitoring (starting from January or April), or including/excluding natural disaster, vary in each country/state, interruption data between Japan and various countries/states may not be compared adequately, both SAIDI and SAIFI due to Forced Outage or Planned Outage are in lower level than various countries/states except 2010, the year when Great East Japan Earthquake has occurred.

[15] 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

[16] Sources:
State of New York : Department of Public Service, "Electric Service Reliability Reports"
http://www3.dps.ny.gov/W/PSCWeb.nsf/All/D82A200687D96D3985257687006F39CA?OpenDocument
State of California : California Public Utilities Commission, "Electric System Reliability Annual Reports"
http://www.cpuc.ca.gov/General.aspx?id=4529
State of Pennsylvania : Pennsylvania Public Utility Commission, "Electric Service Reliability in Pennsylvania"
http://www.puc.pa.gov/General/publications_reports/pdf/Electric_Service_Reliability2015.pdf

[17] States value is calculated for California and Pennsylvania by weighting numbers of customers of major electric power companies according to their reliability reports.(For California, SDG&E, PG&E and SCE are applied; for Pennsylvania, Duquesne, PECO, PPL, Met Ed, Penelec, Penn Power and WestPenn are applied for calculation.)

[18] Fiscal year for Japan (April 1 to following March 31), calendar year for other countries (January 1 to December 31).

[19] Including interruption caused by Great East Japan Earthquake.

[20] Weightings applied as "Under British incentive, a 50% weighting is applied to CI (equivalent to SAIFI) and CML (equivalent to SAIDI) values for planned interruptions to recognize that these are less inconvenient than an unplanned interruption." (citing from "CEER 6th Benchmarking Report on the Quality of Electricity and Gas Supply")

[21] Data exclude instantaneous interruption reconnected by automatic re-closing due to protective relay though include interruptions not successfully reconnected. There is no definition for length of interruption.

[22] Interruption for 5 minutes and longer is monitored.

[23] All EU countries monitor interruption for 3 min. and longer. Some country monitors those less than 3 min. though not identified in the report.

[24] For observed voltage to monitor, Japan excludes interruption of High Voltage lines. According to the published data on the website of Federation of Electric Power Companies (FEPC), High Voltage Customers are less than 1/40 of Low Voltage Customers and its impact to interruption data is estimated to be slight.

[25] Interruption due to natural disaster with significant impact such as storm, cold wave or earthquake are excluded from reliability evaluation. Criteria of natural disaster is not defined uniformly.
"Natural Disaster" is defined in the below stated manners, cited from above mentioned report.
New York: excluding "service interruptions of at least 10% of customers in an operating area, or if the interruptions last for 24 hours or more."
California: excluding "all outages occurring on any day where its SAIDI is greater than "TMED"
where: TMED ≡ $e^{\text{average over 5 yrs. of Ln (daily SAIDI) + 2.5 * STD DEV of 5 yrs. of Ln (daily SAIDI)}}$"
Pennsylvania: excluding "at least 10% of the customers in the Electric Distribution Companies' service territory during the course of the event for a duration of 5 minutes or greater or unscheduled interruption of electric service resulting from an action taken by an EDC to maintain the adequacy and security of the electrical system."

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