EFFECT OF USING PAPERS REGARDING TO HIGH VOLTAGE SURGE ARRESTERS ON ENGINEERING EDUCATION

—Earthquake・Tsunami Dated 2011.3.11, Nuclear Power Plants and HVDC Converter Stations—

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Abstract: Nowadays, Drawing of Electric Equipment has been transferred to CAD (Computer Aided Design) from design drafters in business section. But, drawing on a personal computer CAD has a theme that is difficult to recognize the feeling sense with the actual dimension of equipment in case of using on display screens. It is necessary to investigate what methods are required to educate young students under learning Drawing of Electrical Equipment from the viewpoint of the technology transfer and the development of the new technology. It is required to cultivate the actual dimension sense for electrical equipment. This paper describes reaction comments using author's published papers regarding to High Voltage surge arresters, and Japan's strongest record Earthquake・Tsunami dated 2011.3.11, nuclear power plants and HVDC converter stations.

1 INTRODUCTION

Nowadays, the information through the Internet can be obtained on liquid screens by keyboarding or touching panel. On the actual business, drawing methods have been transferred to the CAD (Computer Aided Design) or personal computers from a conventional manual drawing. But, there are some problems to recognize the dimension sense for an actual designed equipment drawing on a display screen. It is easy to draw, and to paint in bright colors by using personal computers.

Peoples are often to misunderstand as if drawn figures are actual without realizing. It is desired that those feeling can be compensated on Engineering Education. On the other hand, there are precise and troublesome problems on the manual drawing. What way can promote the dimension sense designing the power equipment?

In 2011.3.11, Japan's strongest on record, connected tremendous Earthquake M (magnitude) 9 and subsequent huge Tsunami occurred in the Tohoku-Kanto offshore area of East Japan. That huge Tsunami clipped 4 Fukushima Dai-Ichi nuclear power plants among 6 plants in front of 40 years commercial operation.

Natural force strikes and hints to the human technology. Those phenomena teach us that it is important to think operating conditions with the transition of the age, although it is difficult to modify good operation equipment. But, those matters may be permanent investigated items considering of Engineering Education.

This paper describes an example of a manual drawing that designate the dimension in order to promote the dimension sense on Engineering Education of power equipment using papers regarding to author's and other's high voltage surge arresters.

2 TRANSITION OF SUBMISSION TO ISH

Authors and others have submitted to IEEE, ISH, IEEJ, IWHV regarding to high voltage surge arresters. Fig.1 shows author's submitted paper to 8—17th **ISH** [(1)–(7)].

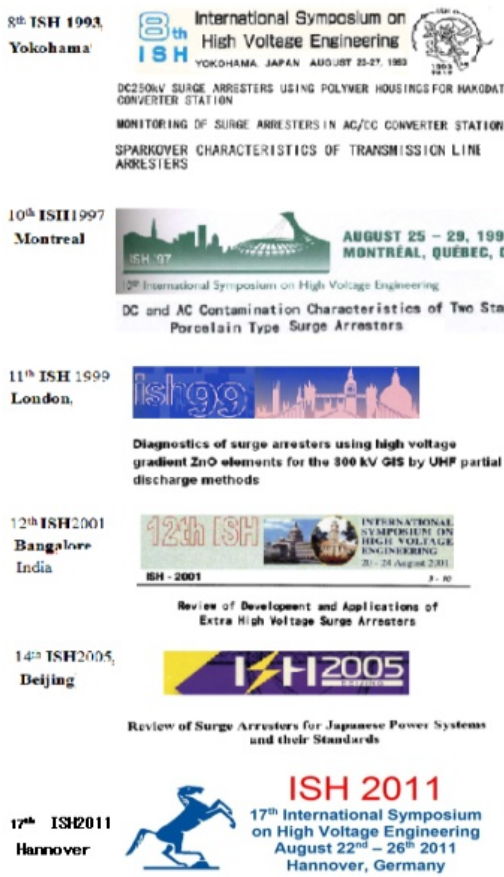

Fig.1 Submitted Papers of 8—17th **ISH** [(1)–(7)] Regarding to High Voltage Surge Arresters

3 USED PAPER'S MAIN THEMES

Table 1 shows used paper's themes regarding to High Voltage surge arresters on Drawing of Electrical Equipment. Manual described student's answers can be obtained naturally from themes asking questionnaires for papers of No.1– No.6 in the fourth year at university [18] [19].

Table 1 Used Themes on Drawing of Electrical Equipment

No	Used Themes
1	" Transition and Submission of IEEE , ISH , CIGRE Colloquium, IWHV and IEEJ Papers Regarding to High Voltage (AC and HVDC) Surge Arresters " **IWHV2010** SP-1-045(2010) [8]
2	" Lightning, Surge Arresters, and Insulation Co-ordination for High Voltage Power Systems " , **IEEJ Technical Report** No.1173, 2009 [9]
3	" 1100kV GIS-arresters " " Development of 1100kV AC and GIS-arrester and the Verification Tests " , **IEC/CIGRE** 2-5-2(2007) [9] [12]
4	" 765kV GIS-Arrester " ,1999 United State Patents No.5,959,823, 1996.Aug.20 [13]
5	" 1000kV Transmission Lines -Aiming at Gentleness for Environment and Reduction- " , T. IEE Japan, Vol.116, No.11 (1996) [16]
6	"Zinc Oxide Surge Arresters and HVDC125 kV－Upgrade 500kV Converter Stations", **IEEJ Trans.PE,**Vol.129, No.10(2009) [17]

4 Used Themes Asking Questions and Reaction Comments of Students

4.1 Used Themes 1 : " Transition and Submission of IEEE, ISH, CIGRE Colloquium, IWHV and IEEJ Papers Regarding to High Voltage (AC and HVDC) Surge Arresters " IWHV2010 (2010.11.13) [8]

4.1.1[Questionnaires1]

Reading the above title's paper,

- write the organized year of the Institute regarding to Power and Energy Society. Append a note for the Institute adopting refereed papers in this article.
- write the site of a meeting according to held year for **IEEE /** PES (Power Engineering Society) in this article.
- write symbol marks according to held year for **ISH (**International Symposium on High Voltage Engineering), and **IWHV** (International Workshop on High Voltage Engineering) in this article.
- compare paper investigation sites in the world.

[Student's Reflection for Questionnaires **1**] [18]

- IEEE/USA has founded in 1884, and also, IEEJ/Japan has founded in 1888. It was surprised that those institutes have been founded at about same periods.
- IEEE / PES meetings have been held in many places.
- IWHV has been held in Japan since 1999, first place, in Okinawa.
- Each country shows a unique symbol and an Internet site, for example, IEEEXplora/USA, IET/UK , J-Stage/Japan etc.. It is very convenient to read papers through Internet sites in the world.

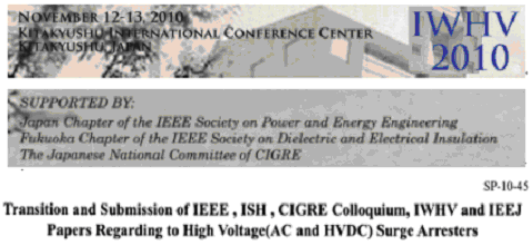

Fig.2 Cover of IWHV2010 / Kitakyushu

Fig.3 Answered Drawing for IWHV2010 Paper

4.2 Used Themes 2 : " Lightning, Surge Arresters, and Insulation Co-ordination for High Voltage Power Systems " [9]

Metal (Zinc) Oxide Surge arresters without gaps departed from Japan in about 1975 are applied to electrical power systems in the world instead of conventional arresters with series gaps [9] [10]. In large lightning, without installing surge arresters, surge overvoltages will breakdown disconnecting switch, circuit breakers or power transformers in substations.

Suppressing lightning surge overvoltages on transmission lines, surge arresters have contributed to supply of electric power, and reduced LIWV (Lightning Impulse Withstand Voltage) and building cost depending on LIWV for high voltage 550, 765, 1100kV electric power systems. In 550kV GIS (Gas Insulated Switchgear), LIWV has been reduced to 1425kV, 1550kV from initial 1800kV at 550kV power systems. LIWV 2250kV has been adopted at the 1100kV verification test system on GIS-arresters in 1996.

It is necessary to take into account to withstand capability of surge arresters against surges.

4.2.1 Metal (Zinc) Oxide Surge Arresters Without Gaps

[Questionnaires **2]**

Referring IEEJ Technical Report No.1132, draw a comparison figure of surge arresters using conventional SiC (Silicon Carbide) elements with series gaps and using ZnO (Zinc Oxide) elements without series gaps on a scale of 1;10 with handwriting.

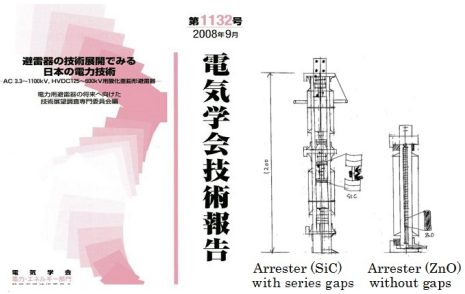

Fig.4 Answered Drawing of Metal (Zinc) Oxide Surge Arresters

[Student's Reflection for Questionnaires **2**]

- Handwriting works dimensioning are troublesome, but are very useful to learn. It can be thought this method trains the brain.
- Experience of hardship with manual drawing will grow basic engineers mind on designed and drawn products.

4.2.2 Applied Effects of Surge Arresters

[Questionnaires **3]**

In case of lightning to a transmission tower, lightning surge invade into a substation like Tsunami. Visualize this situation that surge arresters suppress lightning reflective overvoltage at an open end on a substation entrance. Draw suppression effects of Metal Oxide surge arresters with or without applying on substations. (10) (11)

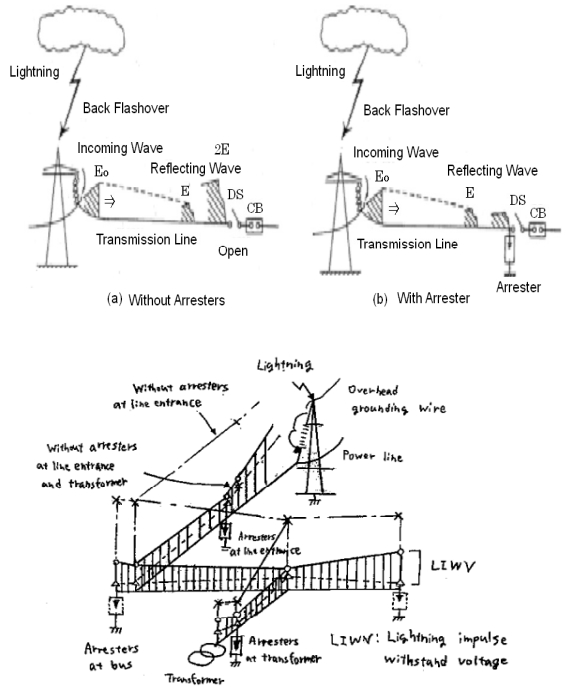

Fig.5 Title of Selected Paper and Drawing Answer of Relation of Lightning Surge Overvoltage Suppression by Metal Oxide Surge Arrester in Substation and Insulation Level LIWV (Lightning Impulse Withstand Voltage)

[Student's Reflection for Questionnaires **3**]

・Metal (Zinc) Oxide surge arresters born in Japan have Creativity, Originality, and Usefulness. These arresters are effective to Insulation Co-ordination on power systems.

- Japan is able to contribute to the world under globalization by developing the new technology like Metal (Zinc) Oxide surge arresters that make a compact , high performance, and reduce cost down and contribute another technology.
- It is difficult to do them continuously, but important.

4.3 Used Themes 3:1100kV GIS-Arresters(9)—(12)

4.3.1[Questionnaires **4]**

Building 1100kV power systems, an adequate insulation design of transmission towers and substations against lightning surges have been required. In order to respond to these needs, the 1100kV high–performance GIS-arresters have developed in Japan. Those 1100kV most advanced GIS-arresters have been verified at Shin-haruna substation in Japan since 1996 , first in the world(12). Reading the above paper, write three kind of internal constructions of 1100kV GIS-arresters on a scale of 1;50 with manual drawing.

[Student's Reflection for Questionnaires **4]**

- Achieving by handwriting, it was understood that there was some difference of internal constructions of 1100kV GIS-arresters on each design.
- It becomes easy to imagine designed targets by drawing a sectional view.

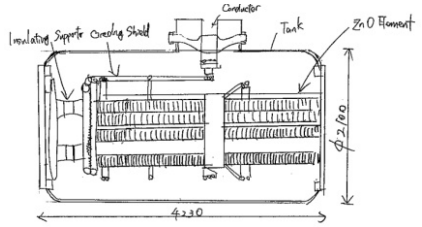

Fig.6 Example of Answered Drawing of UHV AC 1100kV GIS-Arrester (LIWV 2250kV/1620kV at 20kA)

4.4 Used Themes 4：United State Patents "Tank Type Surge Arrester" —765kV GIS-arrester—-

4.4.1[Questionnaires **5]**

There is United State Patent (Number 5,959,823) of " Tank Type Surge Arrester " (13). Using figures in this patent, draw an internal construction and voltage distribution of 765kV GIS-arresters on a A4 size sheet adequately.

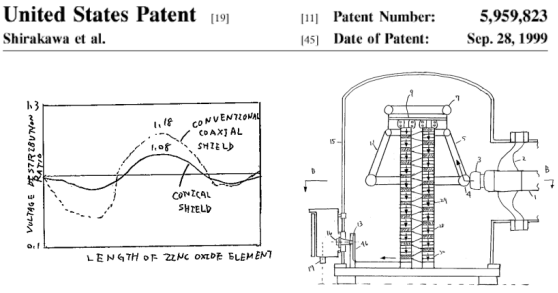

Fig.7 Answered Drawing of 765kV GIS-arresters

[Student's Reflection for Questionnaires **5]**

- This USA Patent shows number of 8 figures regarding to inventions in 8 pages among 12 pages. It is convenient that drawn figures are useful for an explanation.
- It is understood that drawn works are useful, and also activated for submission of patents.

※ Note

In 1985, 735kV porcelain-housed arresters [9] have been developed in Hydro Quebec, Canada in order to suppress TOV (temporary overvoltage). In 1999, 765kV metal-enclosed GIS-arresters [14] using high voltage gradient ZnO elements have developed. Those 765kV GIS-arresters [9][10] considering the salt pollution and anti-seismic characteristics have applied to Korea [15] as shown in Fig. 8. Fig.9 shows the relation of LIWV and high voltage 550kV-1100kV power systems in East Asia.

Fig.8 Outside View of 765kV GIS-arresters [10]

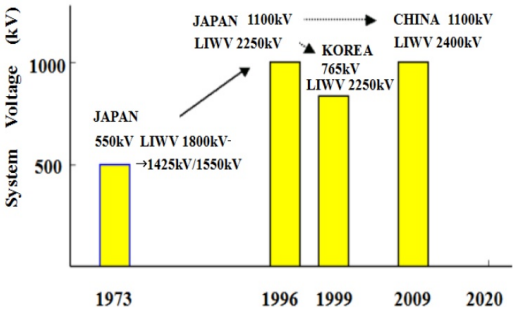

Fig.9 Transition of 550kV-1100kV LIWV Insulation Co-ordination according to Metal (Zinc) Oxide Surge Arresters born in Japan

4.5 Used Themes 5：“Transition of System Voltage of High Voltage Transmission Line”

4.5.1Transition of System Voltage

[Questionnaires 6**]**

After reading the IEEJ paper of “ 1000kV Transmission Lines - Aiming at Gentleness for Environment and Reduction-” [16], make a graph regarding to transmission voltage of power systems extending vertical axis from 2000 to 2040 in the world . Express features of 1000kV Transmission Lines and towers.

[Student's Reflection for Questionnaires **6]**

・If a conventional 500kV transmission tower's design is simply extrapolated in Japan, a dimension of 1000kV transmission towers becomes huge. Suppressing overvoltages on lightning and switching by developing high-performance GIS-arresters (Tank Type), a design of 1000kV transmission towers has been rational and compact. It is imagined that those points are most superior points.

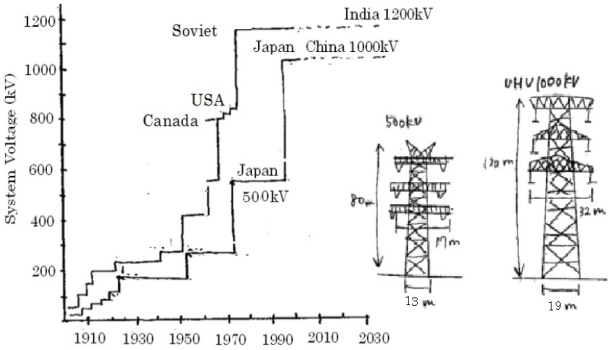

Fig.10 Answered Drawing of Trend of Power System Voltage and 500kV/1000kV Transmission Tower

- Configurations of transmission line's wires have been modified well. It is surprised that this is a preventive method against the wind noise, and also the transmission line technology has been always improved.

4.6 Used Themes 6：“Zinc Oxide Surge Arresters and HVDC125 kV－Upgrade 500kV Converter Stations”

In old times, HVDC surge arresters using SiC elements with series gaps have very complicated constructions. But, HVDC surge arresters are innovated by metal (zinc) oxide surge arresters without series gaps. HVDC surge arresters are very effective to determine setting number of a thyristor of HVDC thyristor valves in consideration of residual voltage of surge arresters. [17]

4.6.1 HVDC using Submarine Cables

Power systems between Hokkaido and Tohoku at north area of Japan have been isolated individually. In 1979, those power systems have interconnected by HVDC 250kV power systems using submarine cables [9]. Therefore, write the HVDC 250kV transmission tower on a scale of 1；500 and circuit diagram including HVDC insulation co-ordination with manual drawing referring IEEJ Technical Report No.1173.

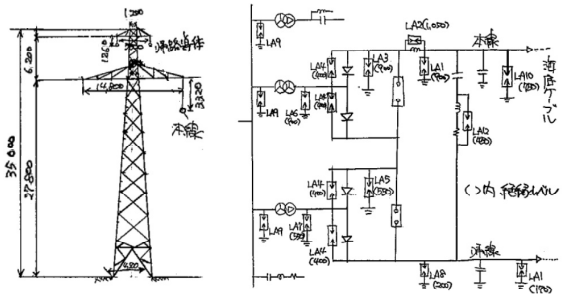

Fig.11 Answered Drawing of HVDC 250kV Transmission Tower, Surge Arrester Arrangement and Insulation Level in Hokkaido-Honshu HVDC Link

[Student's Reflection for Questionnaires **7]**

- It is felt that the design of HVDC insulation co-ordination contributes to consider building costs of HVDC systems, and it is essential to suppress overvoltages by surge arresters.
- At present, electric power flow from Hokkaido to Tohoku (Honshu) is commonly used. But, this project has performed by HVDC converter stations and submarine cables before 30 years ago.

4.6.2 Surge Arresters and HVDC Frequency Converter Stations

[Questionnaires 8**]**

After reading IEEJ 2009.10 " Zinc Oxide Surge Arresters and HVDC 125kV ― upgrade 500kV Converter Stations ― Power Technology of Japan through the Experience of Developments and Applications of Gapless Metal Oxide Surge Arresters ― " [17] , draw electric power map of Japan (2003) and schemes of a.c., d.c. Arresters of HVDC 125kV Frequency Converters Substation.

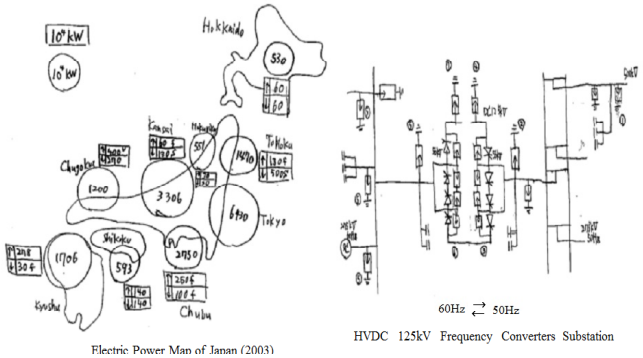

Fig.12 Drawing of Answered Example of HVDC Frequency Converter Station and Surge Arresters

[Student's Reflection for Questionnaires **8]**

- Zinc Oxide surge arresters contribute to the insulation co-ordination on HVDC frequency converter stations.
- This IEEJ paper has published in English version. It is useful to submit IEEJ papers in English, not only in Japanese under globalization.

5 CONCLUSION

Applying author's and others papers for high voltage surge arresters , this paper describes effect of using questionnaires and reflections of students[18] [19]. It is desired to contribute to design and draw new designated or modified products for young students and engineers in future.

Note : ISH2011 initial abstract deadline, 28 Feb. 2011, was prolonged to 10 April. 2011. Unfortunately, the author could describe very rare natural phenomena 2011.3.11 stroked East Coast about 500km Area of Japan, and used HVDC technology of Fig.11 and Fig.12 as shown in a following appendix.

6 APPENDIX

JAPAN'S STRONGEST RECORD CONNECTED EARTHQUAKE M9・SUBSEQUENT HUGE TSUNAMI DATED 2011.3.11, NUCLEAR POWER PLANTS AND HVDC CONVERTER STATIONS

In 2011.3.11 14:46, the authors have encountered unusual connected earthquake M9 occurred in the Tohoku-Kanto offshore area of East Japan. In an instant, I wondered how long would continue. Those earthquakes had broken our house dishes. After earthquake, electric power, gas, and water supply have stopped. After two days, electric power has recovered on March 13. Immediately, switching on TV, earthquake and Tsunami disasters have been broadcasted.

①Japan's Tremendous Connected Earthquake,
2011.3.11 14:46 M9.0 (Miyagi offshore)
2011.3.11 15:08 M7.4 (Iwate offshore)
2011.3.11 15:15 M7.7 (Ibaraki offshore)
: ―Damage of Building, Equipment ―

②Japan's Large Disasters by Huge Tsunami in East Japan pacific regions (Iwate, Miyagi, Fukushima, Ibaraki etc., about 500km area)
: ―Outflow of Materials―

③ Clipped Fukushima Dai-Ichi Nuclear Plants (No.1, No.2, No.3, No.4) by Earthquake M9・subsequent Huge Tsunami (Max. Height 15m) in front of 40-33 years operation

- Diminishing backup External Power Source
  : ―Oil tank spill (for Diesel Generator) by Tsunami ―
  : ― Breakdown of Transmission Line, Towers―
- Recovery of Fukushima Dai-Ichi nuclear power (No.5, No.6) by Newly Installed Instant External Power Sources through power cables
- Normal Operation (Emergency Reactor Stop and Cooling) of Fukushima Dai-Ni nuclear power (No.1, No.2, No.3, No.4) plants by cooling systems of nuclear reactors
- After Quake : 2011.4.7 23:32 M7.1 (Miyagi Offshore) , 2011.4.11 17:16 M7.0 (Ibaraki Offshore), 2011.4.12 14:07 M6.3(Fukushima)→, 50 min. Diminishing of Backup External Power Source of Fukushima Dai-Ichi nuclear power (No.1, No.2, No.3, No.4): ―Recovery by Newly Emergency Mobile Power Car―
- Outflow of Radiation from Clipped Fukushima Dai-Ichi nuclear power plants (No.1, No.2, No.3, No.4) with week cooling ability of reactors

④ Electric Power Connection 1000MW by HVDC125kV Frequency Converter 60Hz→50Hz /4 routes[2] [17] , 600MW / HVDC250kV Hokkaido →Tohoku (Honshu) [1] [17] as shown in Fig.13.

On the other hand, the author has about 40 years experience fighting with natural lightning through High Voltage surge arresters. (a) Puncture of 500kV Surge Arresters [9] or Power Circuit Breakers against strong lightning to a transmission line, (b) Breakdown of Tap-Changer of 500kV

Power Transformer [9], (c) Breakdown of Surge Arresters by strong Earthquakes [9] [10]. We have learned and experienced that natural force strikes an opening of human knowledge over expectation on the earth, and the engineers have to overcome.

In 2011.3.11, Japan has learned the cooling problems of nuclear reactors by connected earthquakes M9 and subsequent Tsunami (Max. Height 15m) through the finishing backup External Power Source without experiences on nuclear plant accidents of Chernobyl in 1986 and Three Mile Island in 1979. Japan will overcome those matters and phenomena. West and Middle (Chubu) Area of Japan did not stroked.

And, at present, the authors coordinate nuclear power plants, live at a distance of about 9km from the Tokai-DaiNi Nuclear Power Plant, and about 100km from the Fukushima Dai-Ichi Nuclear Power Plant.

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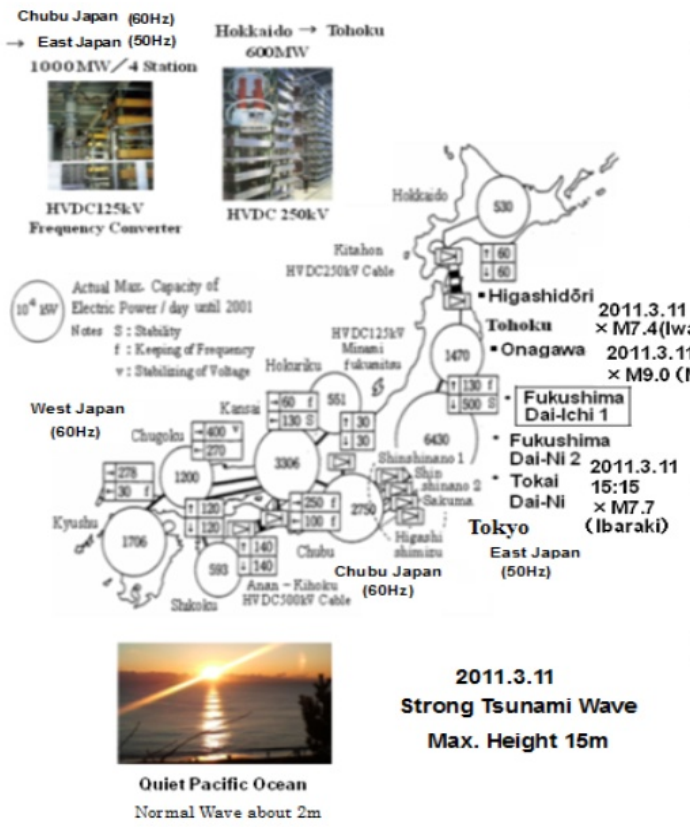

Quiet Pacific Ocean
Normal Wave about 2m

2011.3.11
Strong Tsunami Wave
Max. Height 15m

Nuclear Power Plant	Earthquake M9.0 Tsunami (Max. Height :15m) 2011.3.11 14:46	After Quake 2011.4.7, 2011.4.11, 2011.4.12
▪Higashidōri	No.1 /2005, 110(10⁴kW) *1 *2	*3 *1 After Quake M7.1
▪Onagawa	No.1/1984, 52.4(10⁴kW) *1 *2	2011.4.7 23:32 After Quake M7.1 Diminishing External Power Source *3 *1
	No.2/1984, 82.5(10⁴kW) *1 *2	
	No.3 /1984,82.5(10⁴kW) *1 *2	
▪Fukushima Dai-Ichi 1	X No.1 /1971, 46(10⁴kW) *3 *4	2011.4.12 14:07 After Quake M6.3 Newly Instant Installed External Power Source 50 min. Shutdown. *3 *5 *6 After Quake M6.3 *3 *5 *6
	X No.2 /1974, 78.4(10⁴kW) *3 *4	
	X No.3 /1976, 78.4(10⁴kW) *3 *4	
	X No.4 /1978, 78.4(10⁴kW) *3 *4	
	No.5 /1978,78.4 (10⁴kW) *3 *5	
	No.6 /1979,110 (10⁴kW) *3 *5	
▪Fukushima Dai-Ni 2	No.1 /1982,110 (10⁴kW) *1 *2	
	No.2 /1984,110 (10⁴kW) *1 *2	
	No.3/1985,110 (10⁴kW) *1 *2	
	No.4 /1987,110 (10⁴kW) *1 *2	
▪TokaiDai-Ni	No.1 /1982,110 (10⁴kW) *1 *2	

From Hearing Broadcasted News
*1 Sound (Recovered by Emergency Diesel Generators)
*2 Sound (Recovered by External Power Source)
*3 Diminishing External Power Source
(Damage of Diesel Generators by Salt Water on Tsunami, Breakdown of Transmission Lines, Towers)
*4 Clipped by diminishing External Power Source
*5 Recovered by newly Instant Installed External Power Source
*6 Recovered by newly Used Emergency Mobile Power Car

Fig.13 Earthquake・Tsunami dated 2011.3.11, Nuclear Power Plants and Power Systems [1/] of Japan