2011 Tohoku Chiho-Taiheiyo-Oki Earthquake
- Damage of electric power facilities in Tohoku Electric Power Co., Inc. -

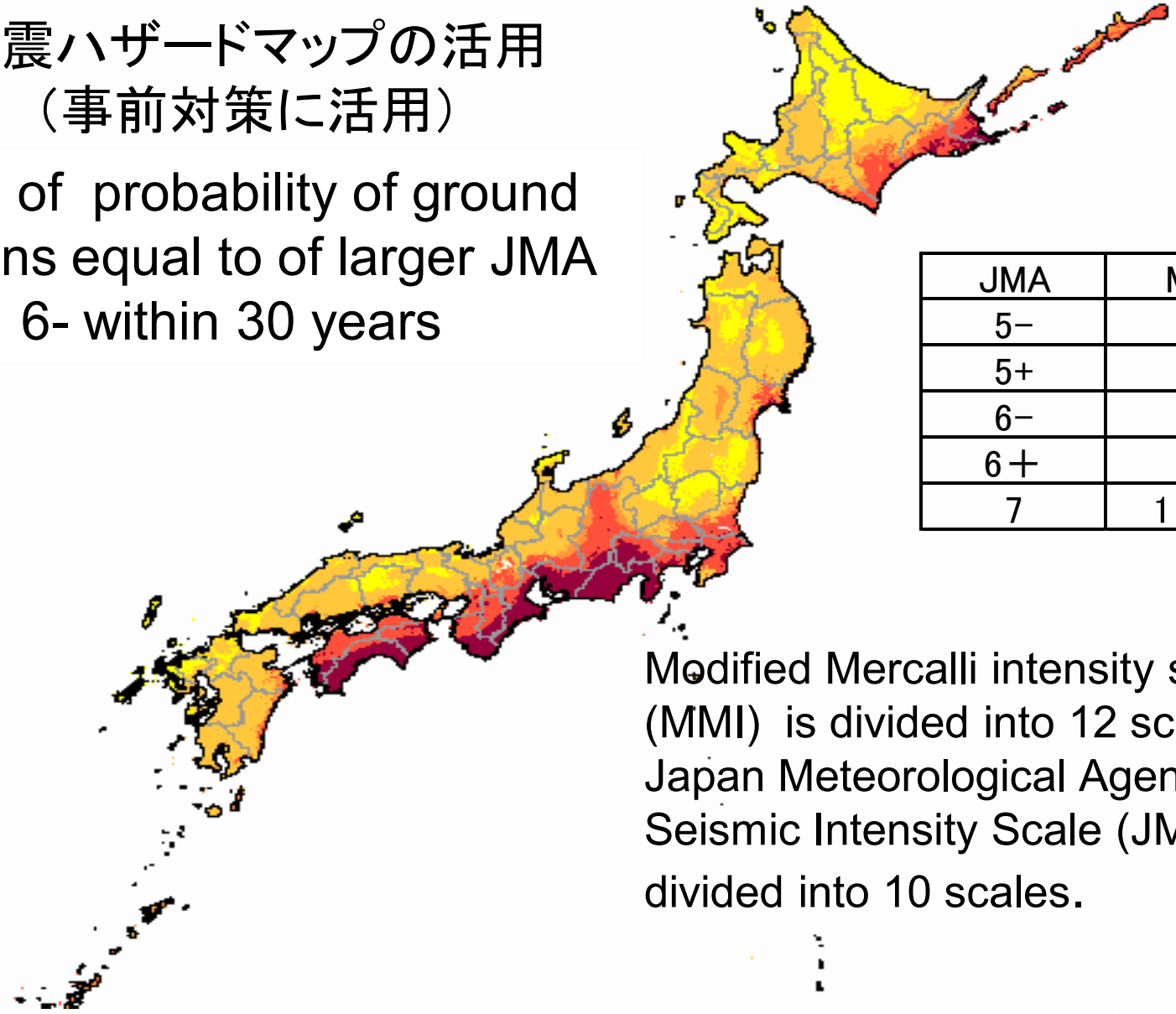
Yoshiharu Shumuta
Central Research Institute of Electric Power Industry
Civil Engineering Lab.

Topics

- Seismic hazard and its countermeasures of electric power system in Japan
- Earthquakes and their damage in Tohoku Electric Power Co., inc.
- Power outage and damaged power network
- Emergency response in Earthquakes

地震ハザードマップの活用
（事前対策に活用）

Map of probability of ground motions equal to of larger JMA 6- within 30 years



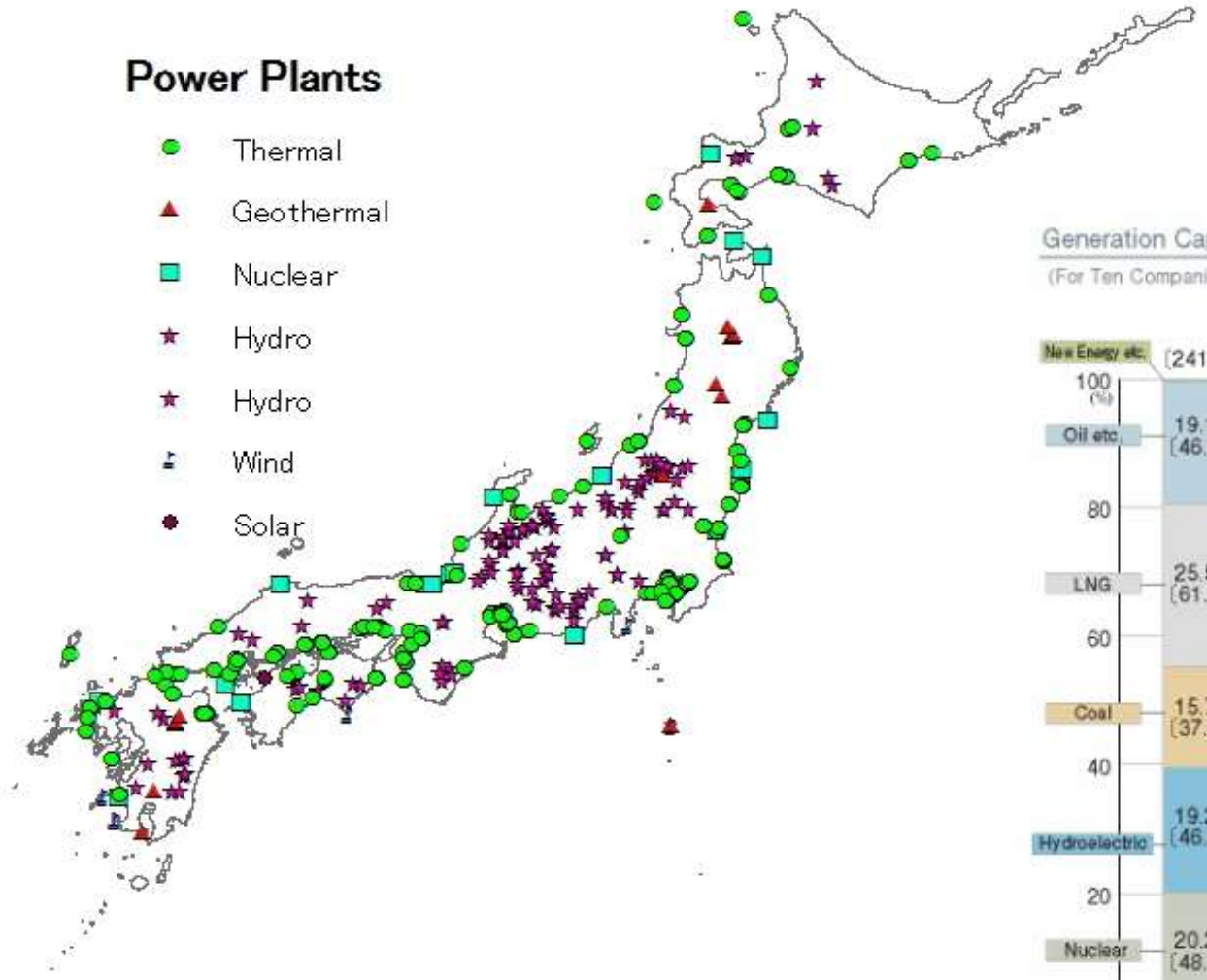
JMA	MMI
5−	7
5+	8
6−	9
6＋	10
7	11,12

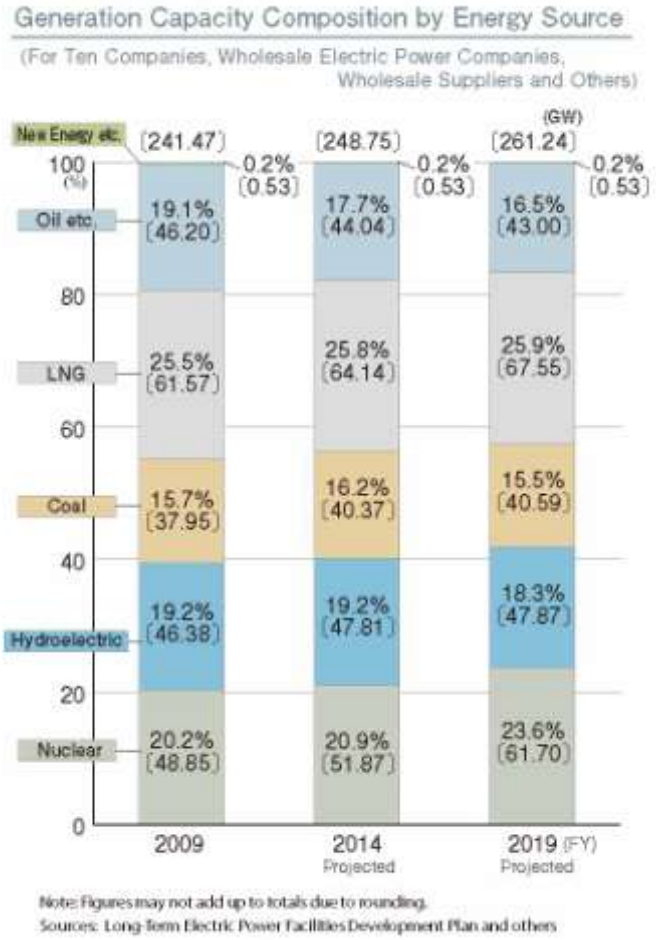
Modified Mercalli intensity scale (MMI) is divided into 12 scales. Japan Meteorological Agency Seismic Intensity Scale (JMA)is divided into 10 scales.

Refer from http://www.j-shis.bosai.go.jp/j-shis/

NIED

Electric Power Plants in Japan





Basic concept of the seismic classification and performance of electric power facilities

Classification I 区分 I Dam, LNG tank, Oil tank ダム、LNGタンク、油タンク

Dam
ダム

LNG tank
LNGタンク

Oil tank
油タンク

A. In ordinary seismic ground motion
No major functional failure in individual electric power facilities

B. Even in the case of severe seismic ground motion
No major impact on human life

A. 一般的な地震動に際して
個々の設備ごとに機能に重大な支障が生じないこと

B. 高レベルの地震動に際しても
人命に重大な影響を与えないこと

Basic concept of the seismic classification and performance of electric power facilities

Classification II 区分II

Power plant buildings, turbines, boilers, substation facilities, power transmission facilities, power distribution facilities, load dispatching center, communication equipment for power security, etc.

発電所建屋、タービン、ボイラー、変電設備、送電設備、配電設備、給電所、電力保安通信設備 等

Power plant buildings
発電所建屋

Power transmission facilities
送電設備

Substation facilities
変電設備

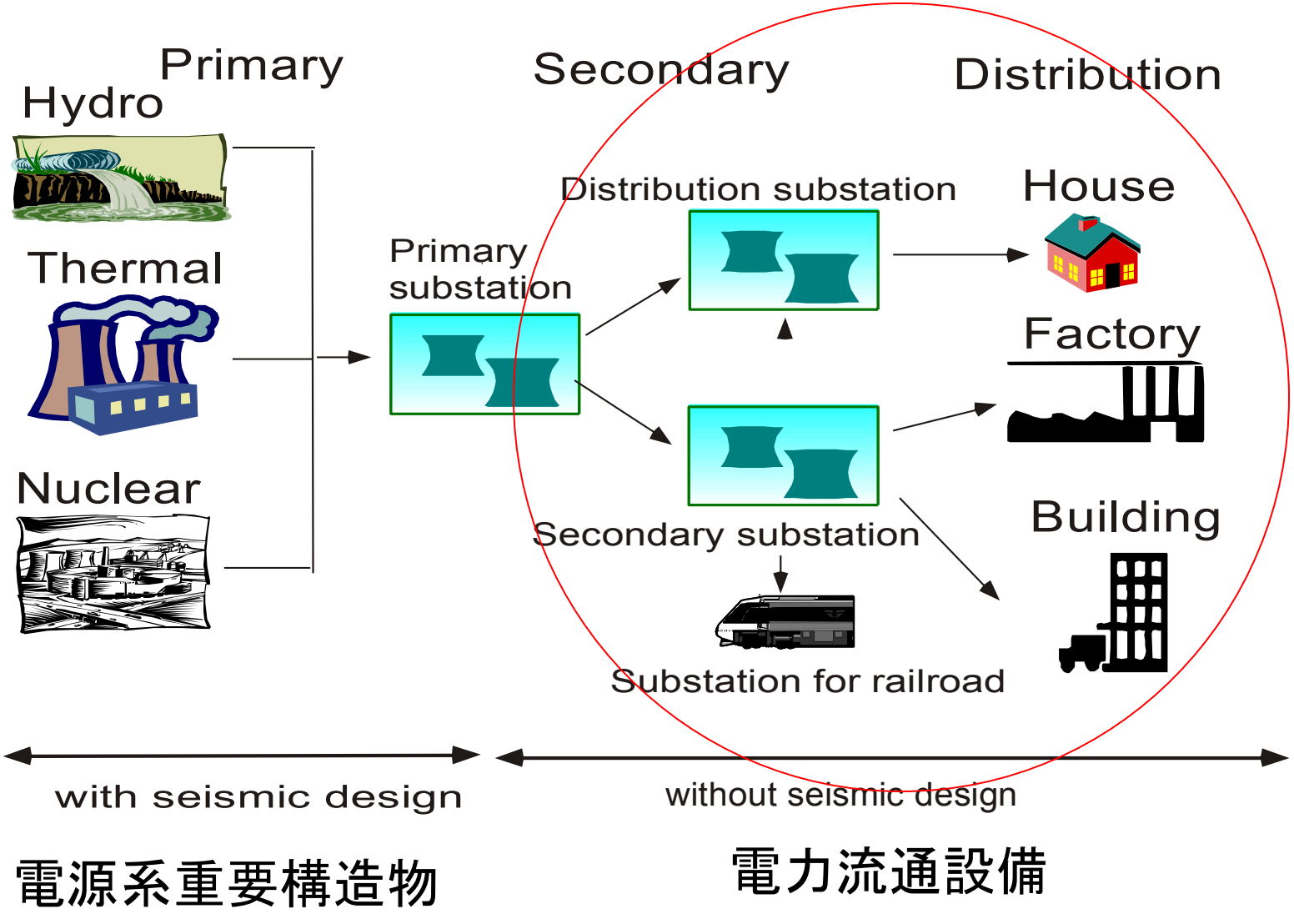
A. In ordinary seismic ground motion
No major functional failure in individual electric power facilities

B. Even in the case of severe seismic ground motion
Ensuring comprehensive system functions by securing alternatives and through multiplex ties to prevent significant (long time and wide area) supply failure

A. 一般的な地震動に際して
個々の設備ごとに機能に重大な支障が生じないこと

B. 高レベルの地震動に際しても
著しい（長期的かつ広範囲）供給支障が生じないよう、代替性の確保、多重化等により総合的にシステムの機能が確保されること

Electric Power System



電源系重要構造物

電力流通設備

Main Differences of JEAG,IEEE 693 and IEC

			JEAG 5003	IEEE 693	IEC
Frequency range			0.5～10Hz	0.3～33Hz	0.5～35Hz
Vertical/Horizontal			0.5	0.8	0.5
Analysis	Dynamic analysis	method	Time-history	Response spectrum	Response spectrum
		Design seismic force	0.3G resonant three cycles sine wave	RRS (1)High:0.5G (2)Middle:0.25G	RRS (1)High:0.5G (2)Middle:0.3G (3)small:0.2G
	Static & Static Coeff. analysis		Corresponding equipment is specified	Static:N. F ＞34Hz Static Coeff. analysis	Static:N.F ＞36Hz Static Coeff. analysis
Test	Input waveform		Resonant three cycles sine wave	Artificial earthquake wave, 10 cycles/beat	Artificial earthquake wave,5 cycles/beat
	Input acceleration		0.3G	(High) 0.5G (Middle)0.25G	(High)0.5G (Middle)0.3G (Small)0.2G
	Exciting direction		Not specified	2or3 directions, simultaneously	2or3 directions, simultaneously

N.F: Natural frequencies of equipment

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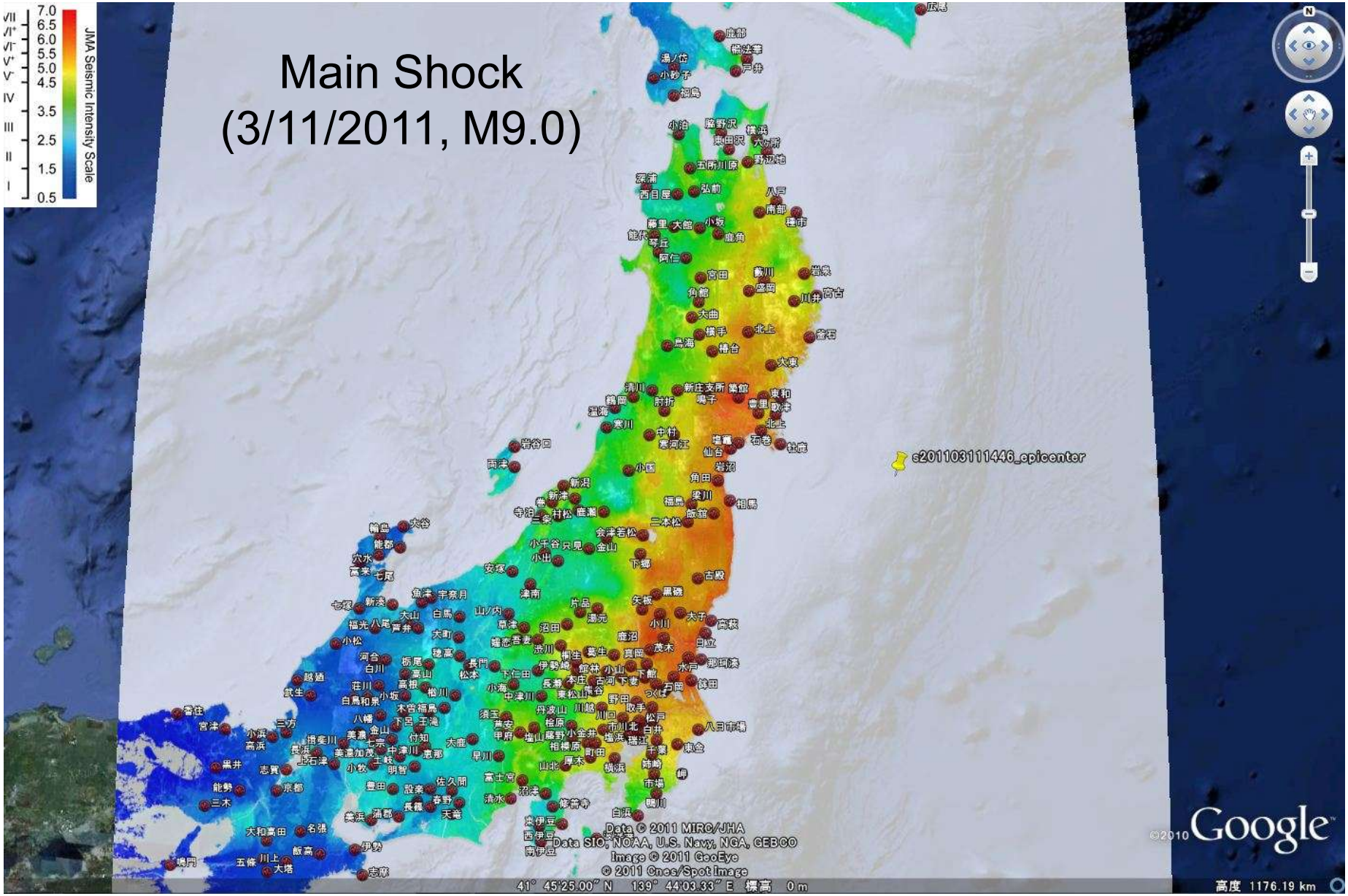

Tsunami

Tsunami Damage

Thermal (Coal)

Substation

Transmission tower

Distribution

Damage Statistics

Earthquakes

Earthquake	Day	Time	M	Hypocenter			JMA
				Area	Lati.	Long.	
Main (0311)	March 11th	14:46	9.0	Sanriku offing	38.0N	142.9E	7
After(0312)	March 12th	3:59	6.6	Norther part of Nagano	37.0N	138.6E	6-
After(0407)	April 7th	23:32	7.1	Miyagi Offing	38.2N	142.0E	6+
After(0411)	April 11th	17:16	7.1	Fukushima Hmadai	36.9N	140.7E	6-
After[(0412)	April 12th	14:07	6.3	Fukushima Hamadai	37.0N	140.7E	6-

JMA	MMI
5-	7
5+	8
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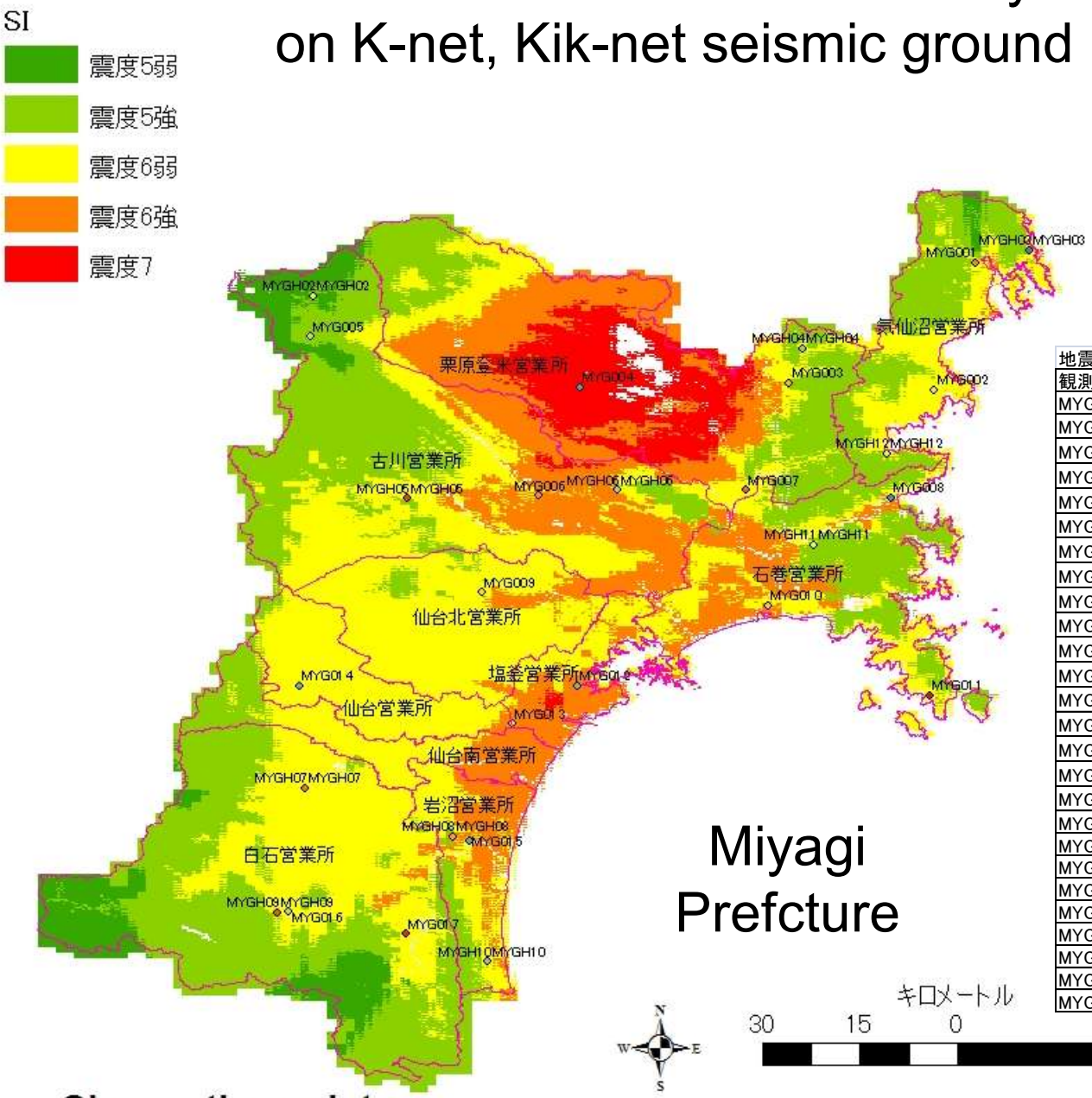
7	11,12

Damages

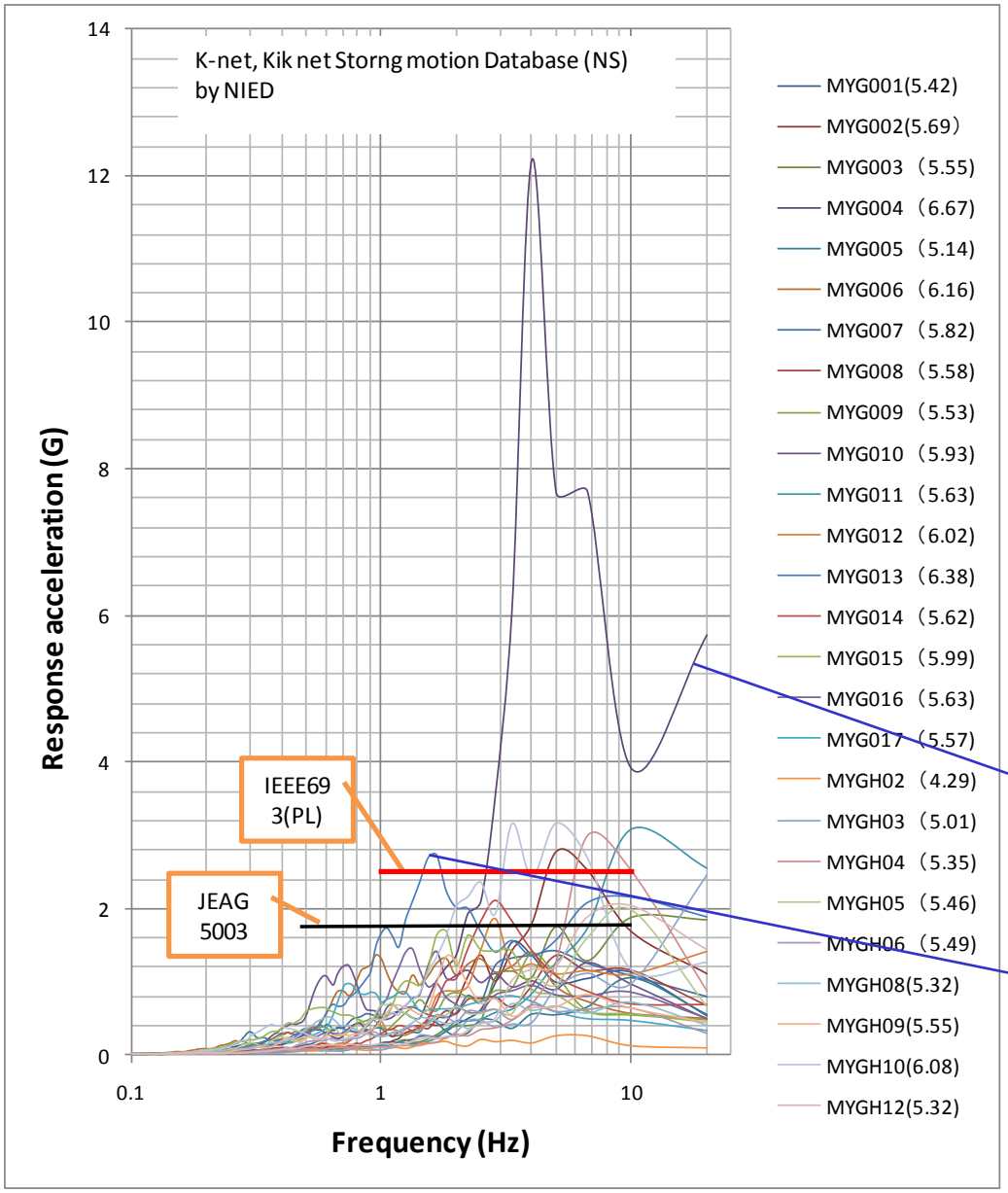
Facility		Number of Damages			
		Main(0311)	After(0407)	After(0411,0412)	1995 Kobe
Thermal	plants	4			10
Hydro	plants	10	2	7	0
Substation	Transformer	70	15	1	52
	Circuit Breaker	197	15	1	10
	Disconnector	179		2	41
Transmission	Steel Truss Tower	42			20
	line /insulator	22	5	5	3/39
	underground cable	14			405
Distribution	Pole	23744	7831	572	11289
	Line	23550	13711	1085	7760
	Transformer, Switch	7112	2288	121	5346

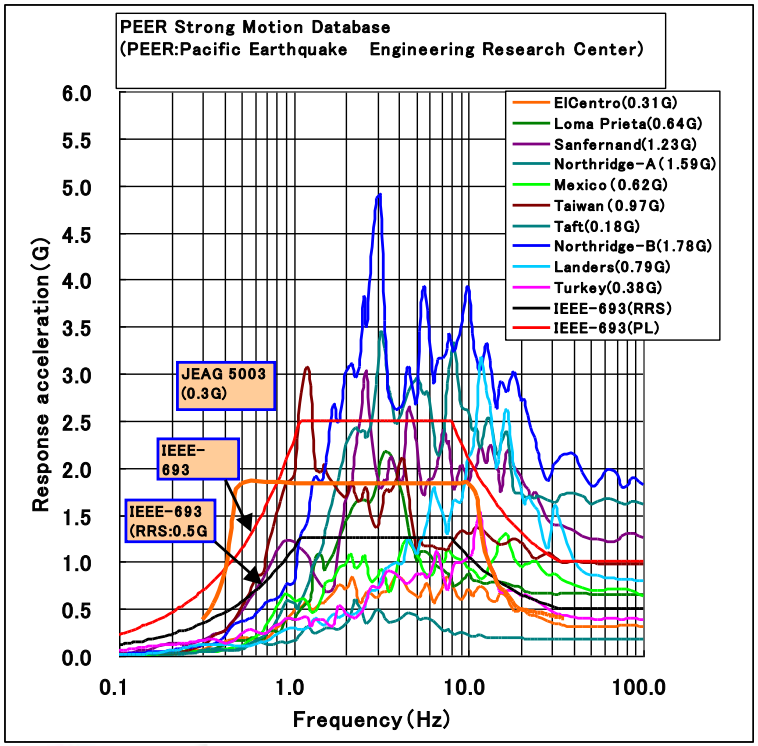
Estimated JMA seismic intensity distribution based on K-net, Kik-net seismic ground motion records

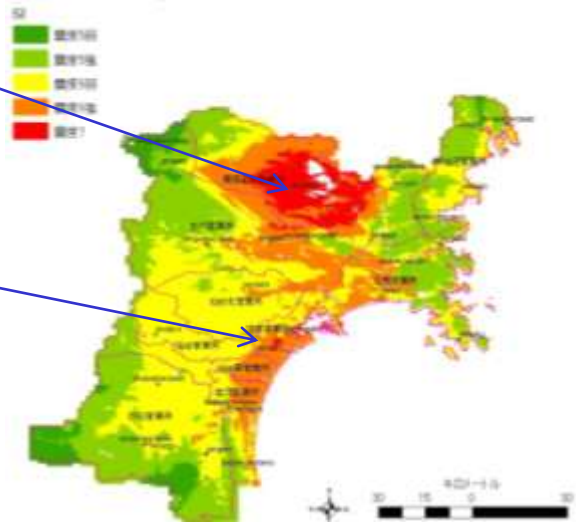


地震　03/11/2011　本震					
観測点	観測点名	緯度	経度	計測震度	最大加速度
MYG001	気仙沼	38.9	141.57	5.42	426
MYG002	歌津	38.726	141.511	5.69	658
MYG003	東和	38.735	141.311	5.55	781
MYG004	築館	38.729	141.022	6.67	2700
MYG005	鳴子	38.799	140.651	5.14	254
MYG006	古川	38.58	140.965	6.16	571
MYG007	豊里	38.588	141.251	5.82	651
MYG008	北上	38.577	141.451	5.58	372
MYG009	大和	38.447	140.887	5.53	548
MYG010	石巻	38.428	141.281	5.93	458
MYG011	牡鹿	38.305	141.504	5.63	921
MYG012	塩釜	38.318	141.019	6.02	1969
MYG013	仙台	38.266	140.929	6.38	1517
MYG014	作並	38.318	140.636	5.62	496
MYG015	岩沼	38.1	140.87	5.99	411
MYG016	白石	38.008	140.621	5.63	406
MYG017	角田	37.976	140.782	5.57	160
MYGH02	鳴子	38.8558	140.6547	4.29	85
MYGH03	唐桑	38.9178	141.6412	5.01	454
MYGH04	東和	38.7831	141.3289	5.35	553
MYGH05	小野田	38.5764	140.7839	5.46	488
MYGH06	田尻	38.5878	141.0744	5.49	263
MYGH08	岩沼	38.1103	140.8475	5.32	283
MYGH09	白石	38.0061	140.6061	5.55	323
MYGH10	山元	37.9381	140.8958	6.08	871
MYGH12	志津川	38.6386	141.4463	5.32	526

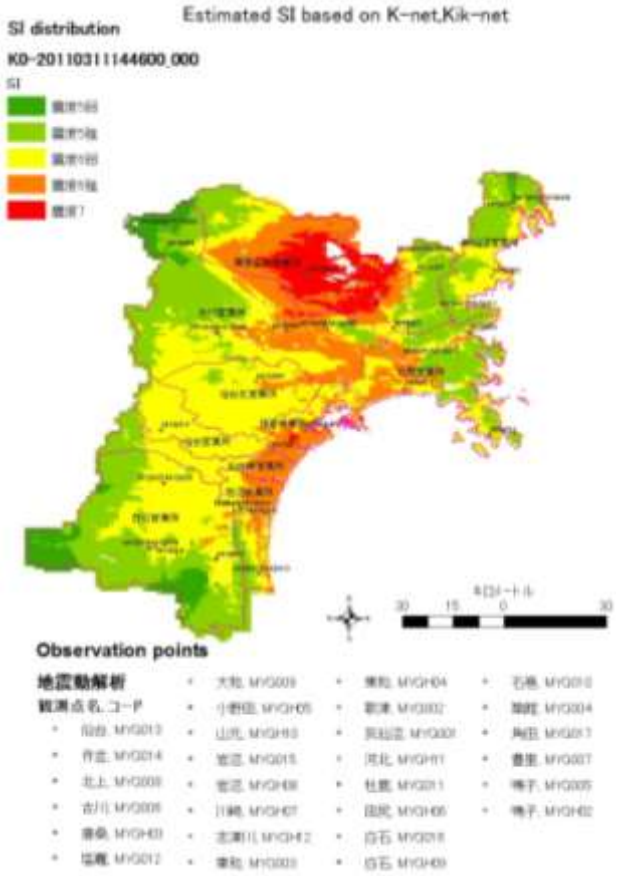
Response Spectrum (Acc) h=0.05

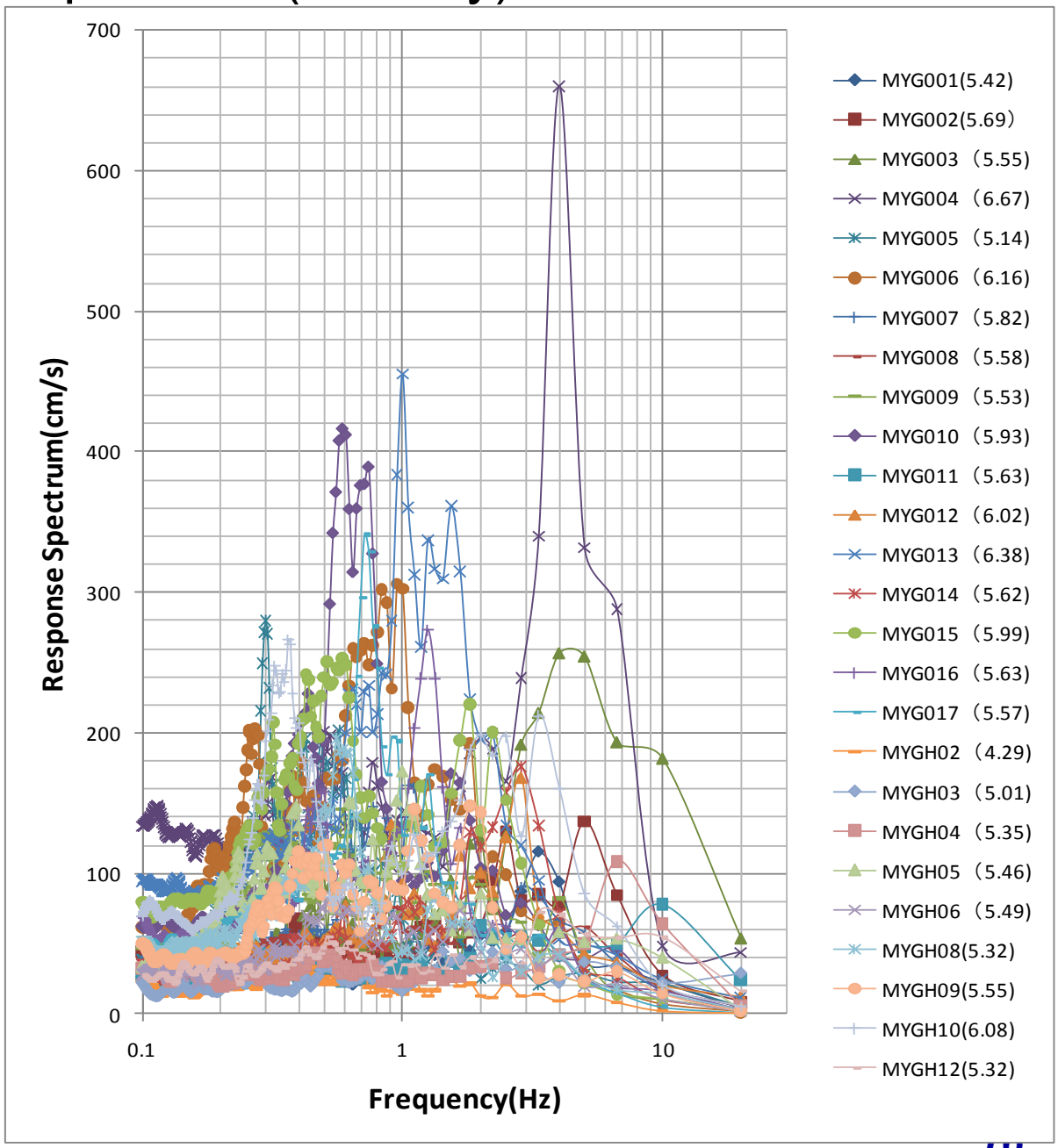




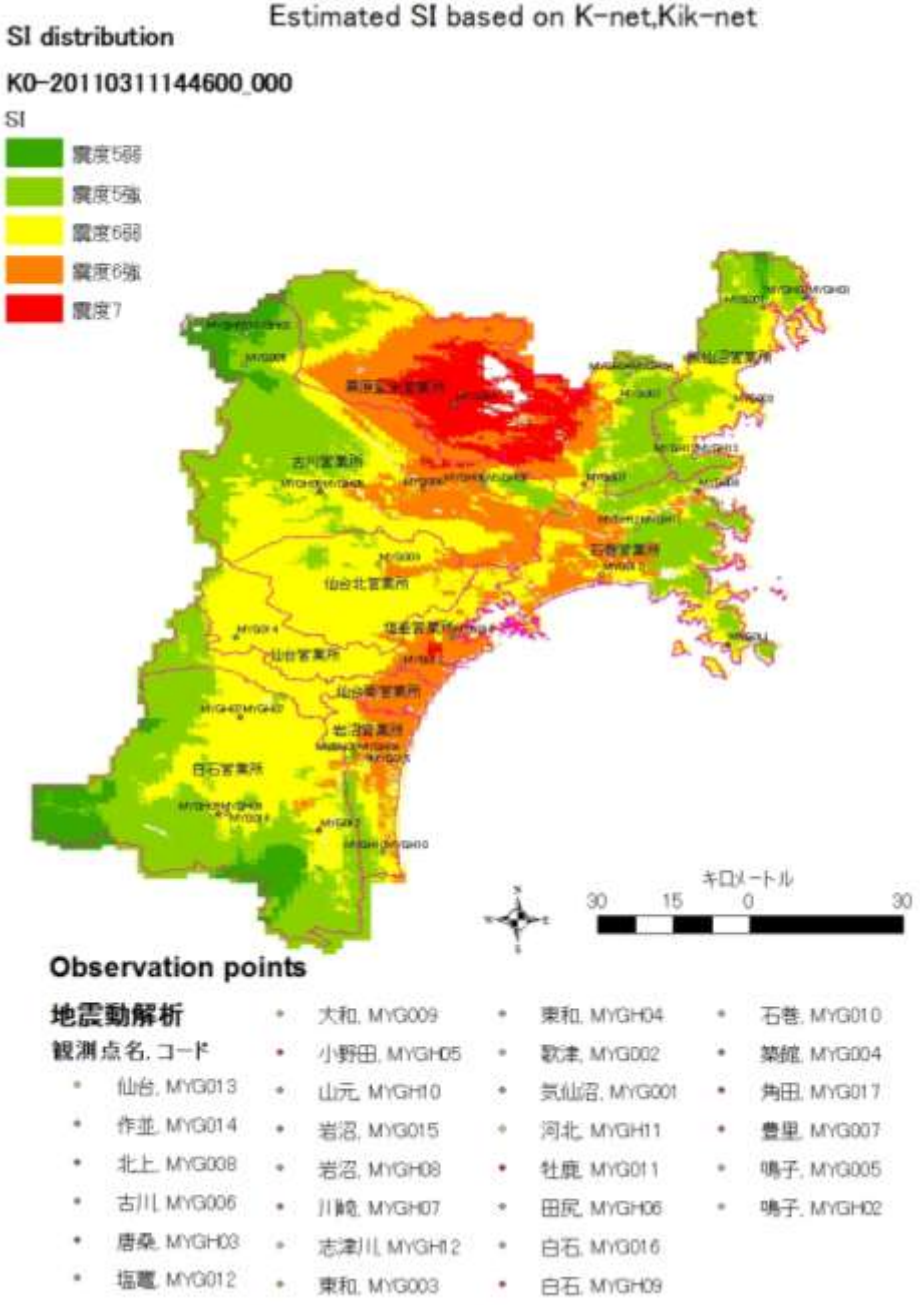


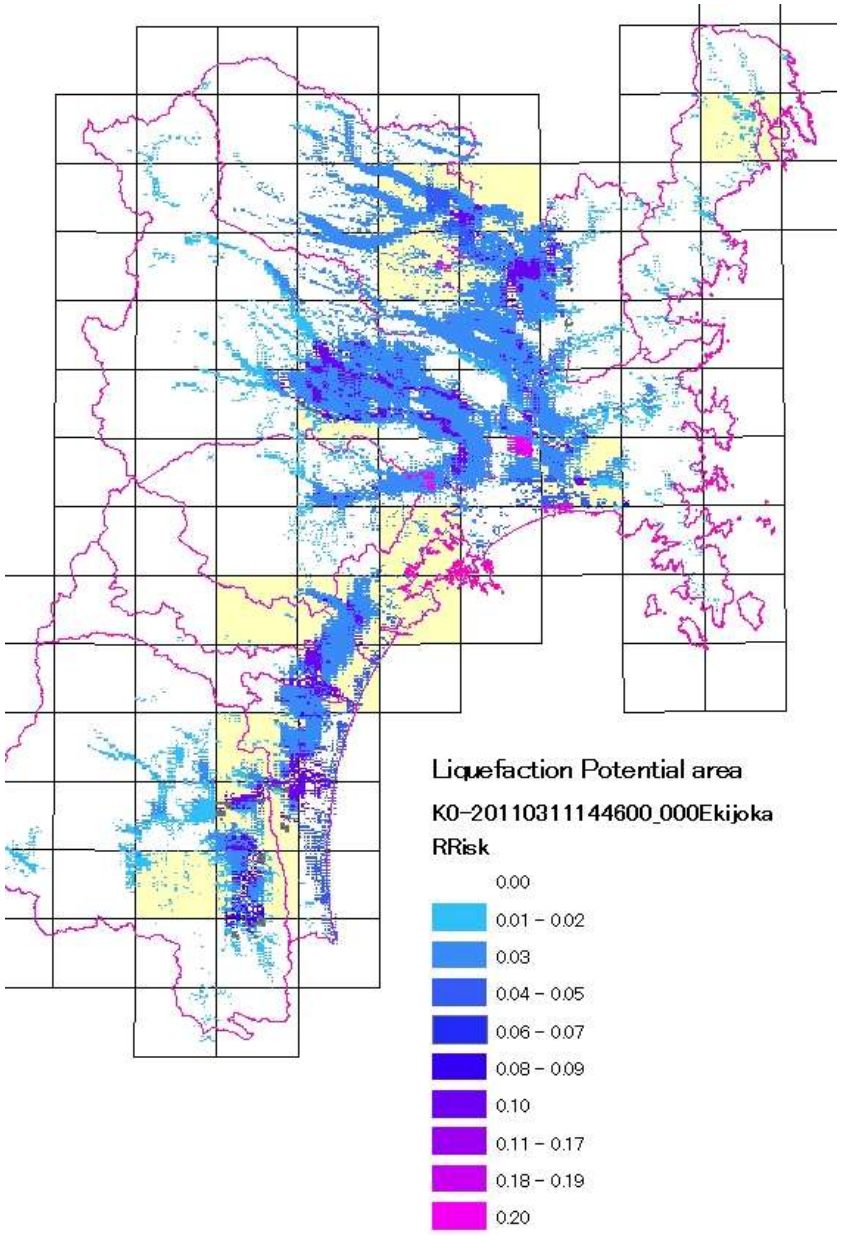
Response spectrum (Velocity) h=0.02 NS





Liquefaction potential





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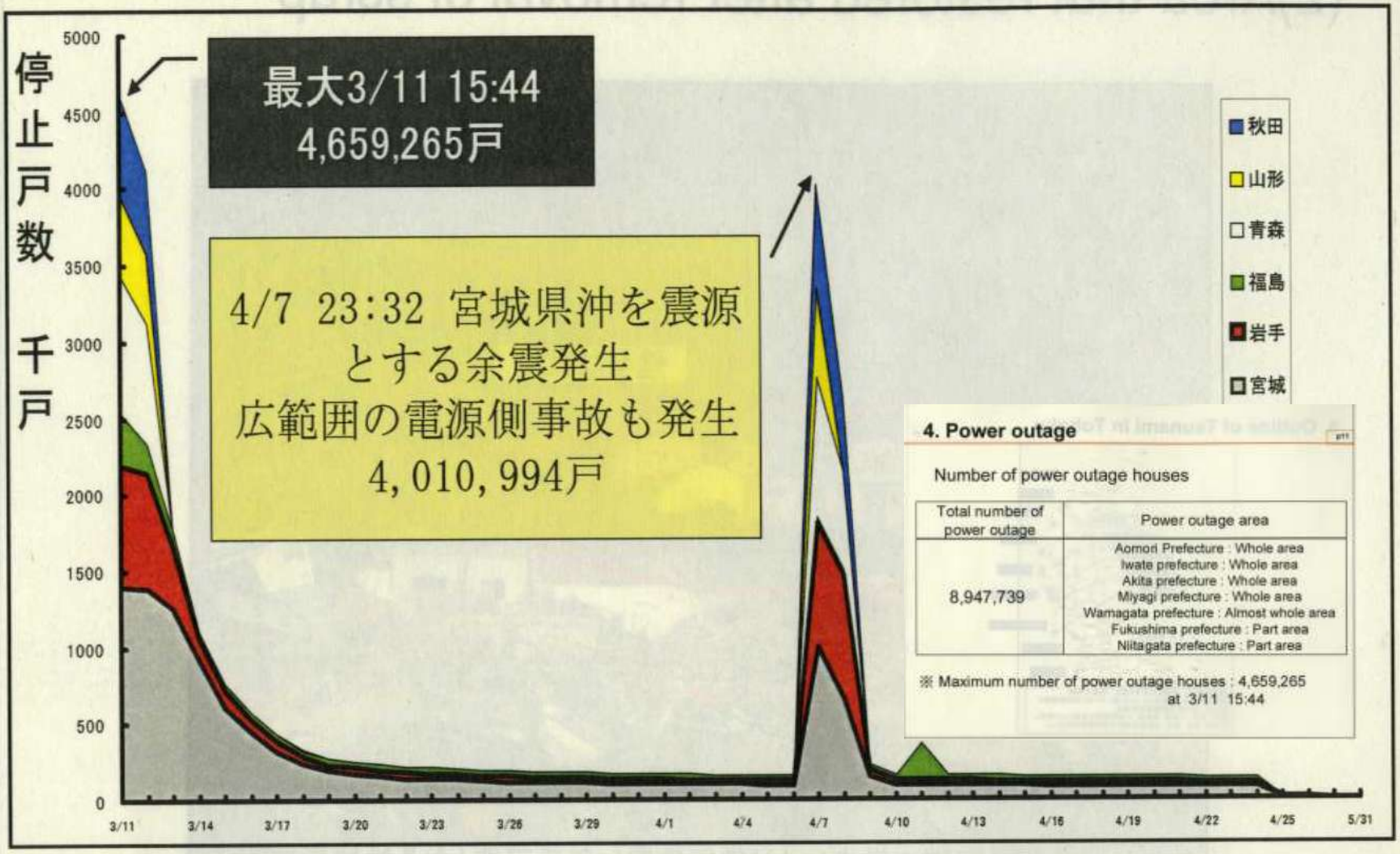
5. Number of power outage houses



4. Power outage

Number of power outage houses

Total number of power outage	Power outage area
8,947,739	Aomori Prefecture : Whole area Iwate prefecture : Whole area Akita prefecture : Whole area Miyagi prefecture : Whole area Wamagata prefecture : Almost whole area Fukushima prefecture : Part area Niitagata prefecture : Part area

※ Maximum number of power outage houses : 4,659,265
at 3/11 15:44

1. Outline of Tohoku : Damaged major PS

Higashidori Nuclear PS

Onagawa Nuclear PS

Sendai Thermal PS

Shin-Sendai Thermal PS

Soma kyodo thermal power company Sinchi PS

Haramachi Thermal PS

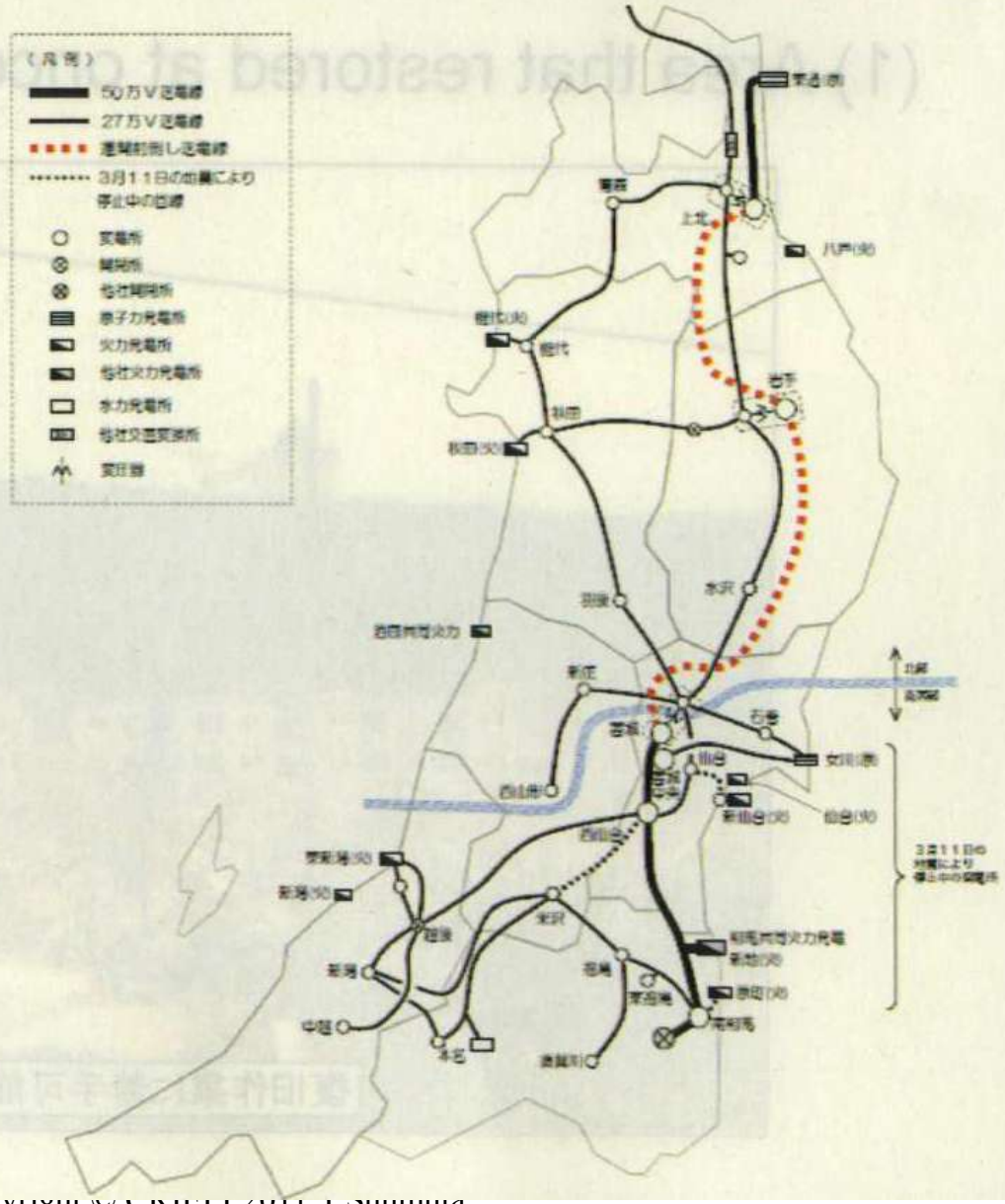
Joban joint thermal power company Nakoso PS

4. Power outage

Power outage area

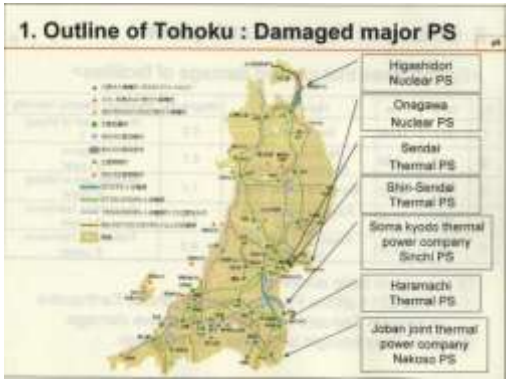
All of northern power system and

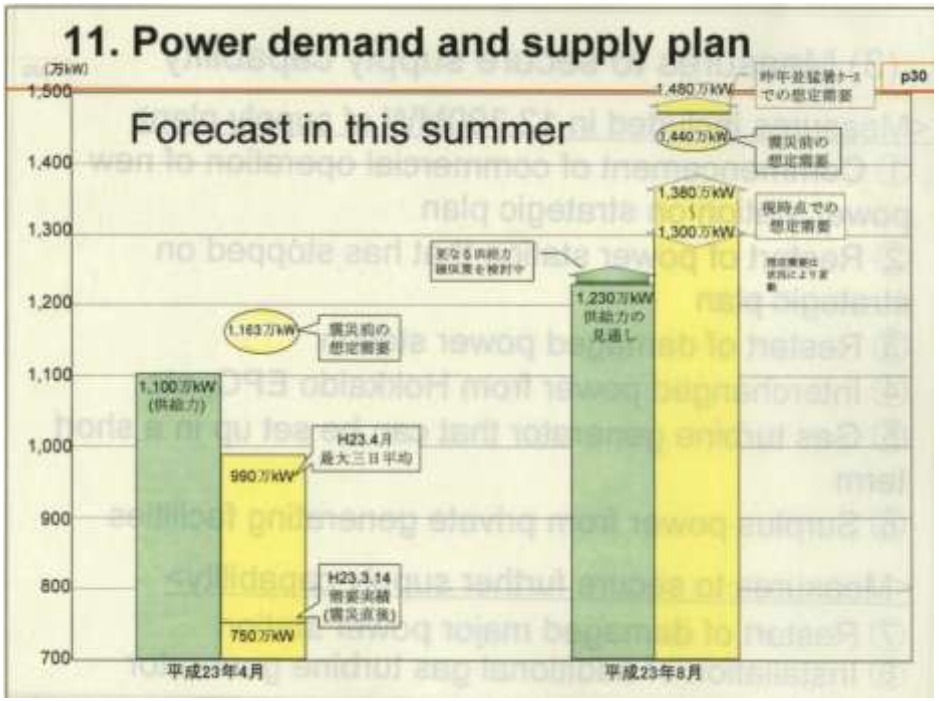
Coast part of Miyagi, Fukushima prefecture



Power demand and supply

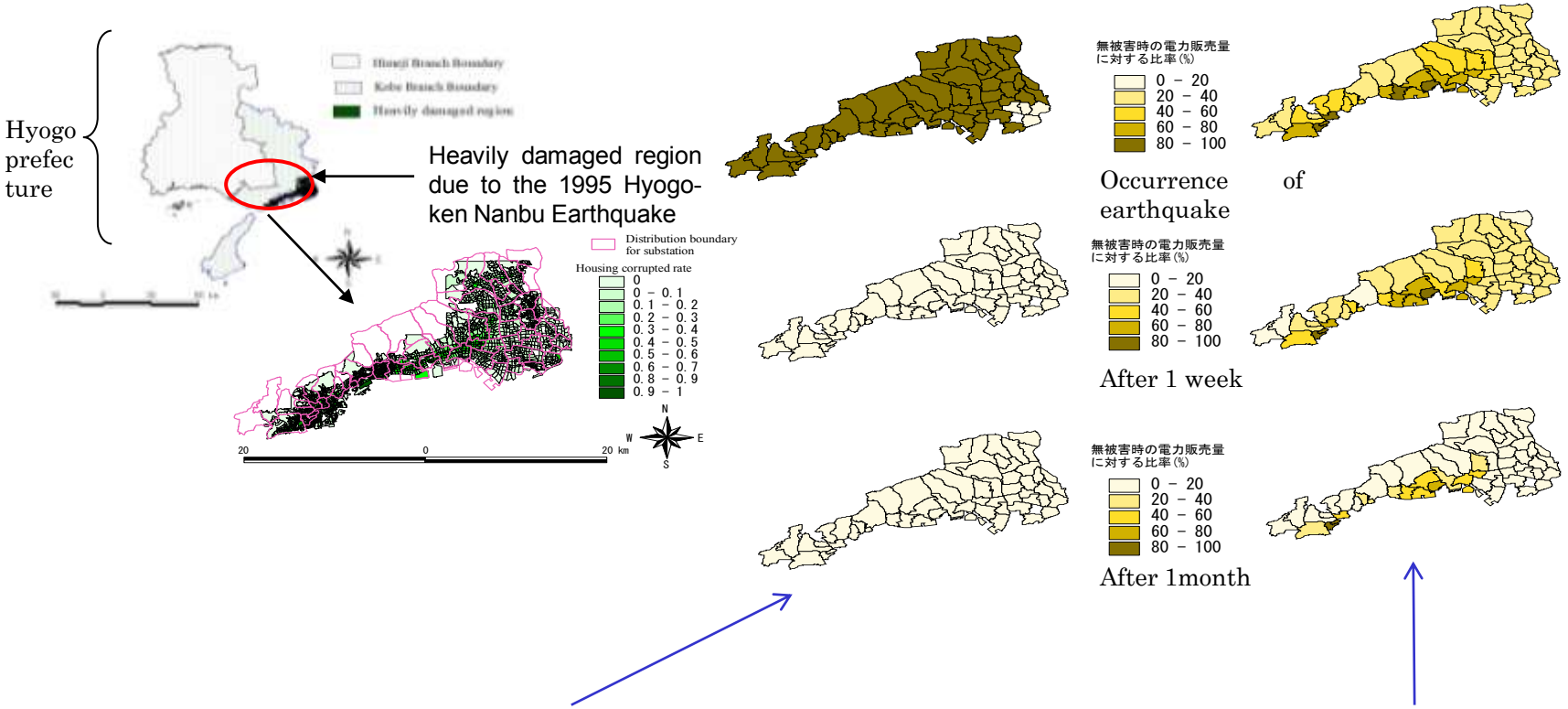
Damage area Large





2011 Tohoku

Power sales reduction against seismic damage of supply and demand sides in the 1995 Hyougoken Nanbu earthquake



Power sales reduction against seismic damage of supply side

Power sales reduction against seismic damage of demand side

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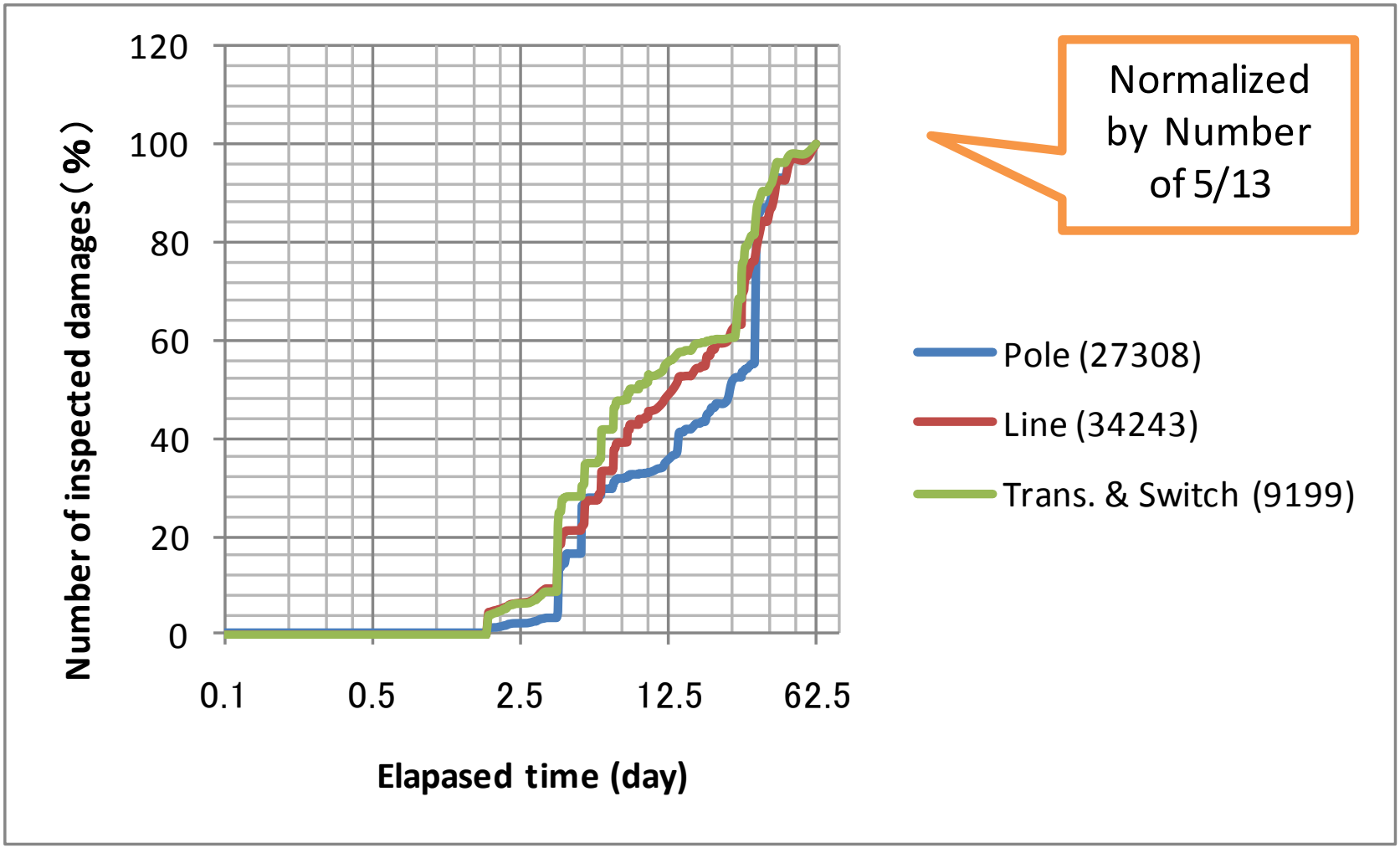
Problem of seismic hazard over large area



Time required for the damage detection of electric power distribution equipment

Risk Assessment and Management System for Power lifeline –Earthqauke realtime- (RAMP-Er)

A system which evaluates some sequential updated seismic intensity distributions including PGA, PGV, and JMA SI

Under test run in Tohoku Electric Power Co., Inc.

Damage information

Input Data

①Seismic intensity evaluation system

②Damage estimation system（RAMP-Er)

Earthquake informatio n from JMA HP

Receiving the earthquake information from JMA

Earthquake occurs

Damage Estimation

Output Data

Damage probability of distribution equipment for the non-inspection area

Situation immediately after occurrence of earthquake

Effect of RAMP-Er

(1)Supporting the initial judgment for dispatching material and human resources

(2) Prioritizing the inspected area

Discussion and survey points

- Inexperienced large area (regional) disaster
- Tsunami damage and its countermeasures
- Seismic damage caused not only by main shock but also by after shock
- Demand and Supply power balance in seismic damaged area
- Emergency response in Earthquakes