Wind Power in Japan
- Present situation and the Future -

System Engineering Research Laboratory
Central Research Institute of Electric Power Industry
Toshiya NANAHARA

Wind Integration Workshop in Tokyo
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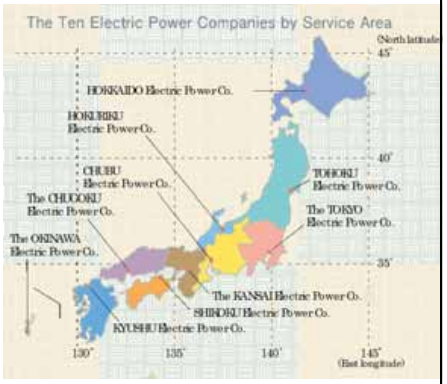
[Photo] Otonrui Wind Farm

Outline of Japan's Power System

- Number of major control areas: 10
- Annual Demand (for utilities): 931TWh (2010)
- Annual Peak Demand (10 utilities): 179GW (in 2007)
- Annual Load Factor (10 utilities): 62.5% (2010)
- Total Installed Capacity (for utilities): 228GW (March, 2011)



[Source] FEPC, "Electricity Review Japan -- 2011"

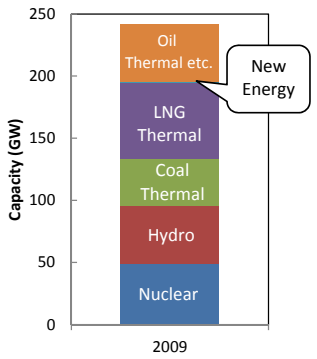
[Data Source] 電気事業便覧（平成23年版）

Outline of Presentation

1. Outline of Japan's power system
2. Projected increase of renewables
3. Impacts of large scale integration of intermittent renewables
4. Related topics
5. Closing remark

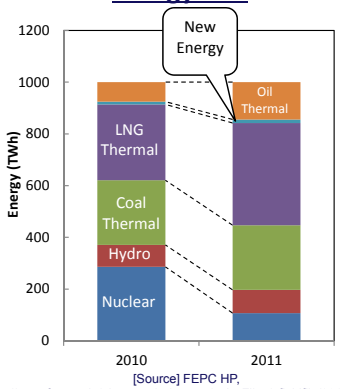
Generation Mix

Capacity Mix



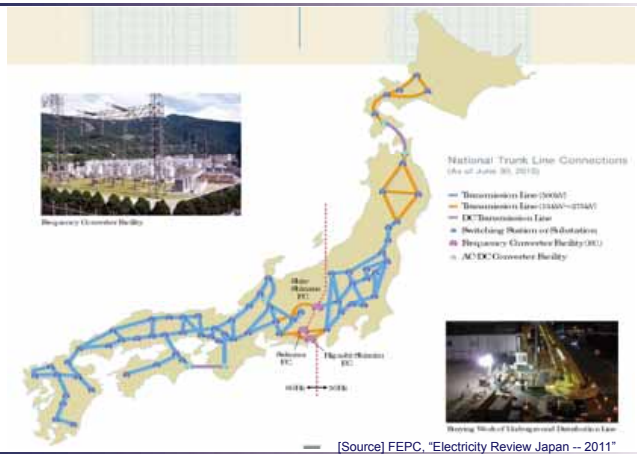
[Source] CEPC, "Outline of Electricity Supply Plan, 2010"

Energy Mix



[Source] FEPC HP,
http://www.fepc.or.jp/about_us/pr/sonota/__icsFiles/afieldfile/2012/06/13/kouseihi_2011.pdf

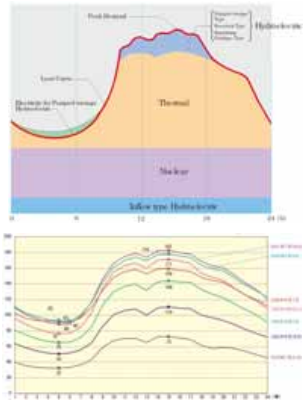
Trunk Transmission System



[Source] FEPC, "Electricity Review Japan -- 2011"

Features of Japan's System (1)

- ◆Low load factor: large daily and annual gap in a load curve
- ◆The generation mix has been relatively inflexible (e.g. nuclears, hydros, must-run thermals, etc.)
  --> Less regulating power during night
- ◆Relatively large share of pumped storage



[Source] FEPC, "Graphical Flip-chart of Nuclear & Energy Related Topics"

Features of Japan's System (2)

- ◆Transmission/ distribution voltage

Transmission	Distribution
500kV,275kV, ・・・・, 66kV , ・・	6kV partly 33,22kV
	100/200V

- ◆Basic system configuration:
  - ➢Trunk system; the system has loops, but is not a mesh configuration
  - ➢Subtransmission system: radial
  - →These features facilitate management of load flow.

Features of Japan's System (3)

- ◆Basically one-point interconnections between control areas and longitudinal system configuration;

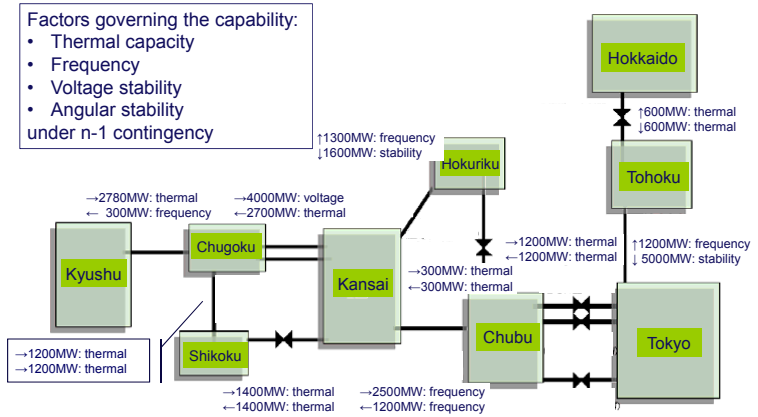
- ◆Transfer capability of interconnection lines are decided by angle stability, voltage stability , frequency in addition to thermal capacity in determining transfer capability.
- ◆ Matching supply and demand in each control area strictly
  --> Stringent control of tie-line load flow
  Control to prevent cascaded outages

- ◆No international Interconnections.

Transfer Capability: Sample

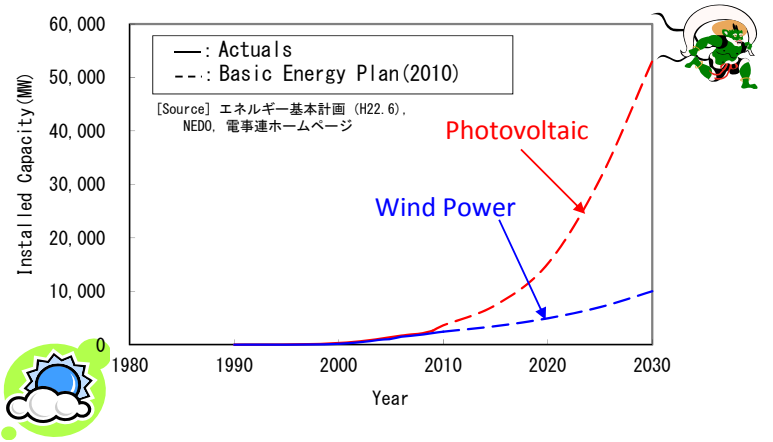
Factors governing the capability:
- Thermal capacity
- Frequency
- Voltage stability
- Angular stability

under n-1 contingency



[Source] ESCJ, "Report on reinforcement of interconnection lines," Feb., 2007 (in Japanese)

Capacity of Wind Power and PV in Japan



Outline of Presentation

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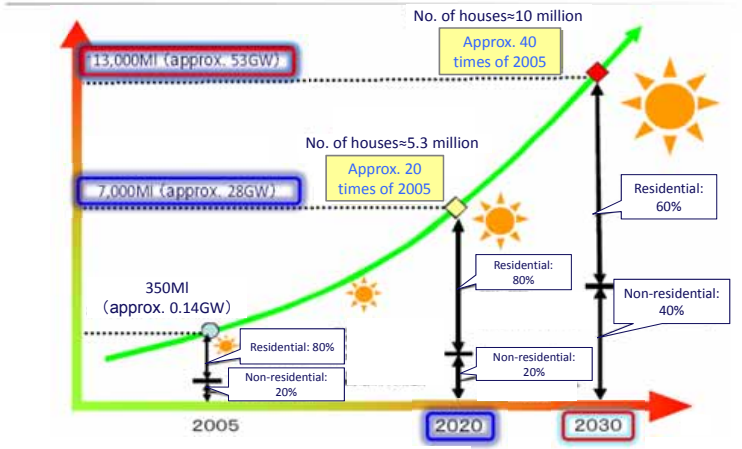
Future Scenario for PV Installation



出典:新エネルギー部会資料

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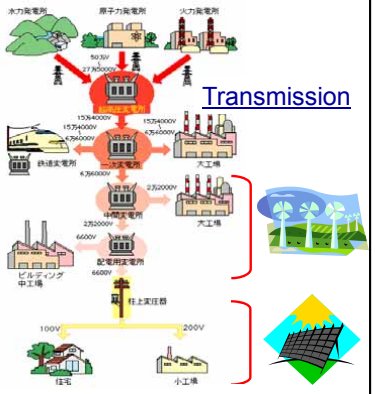
Challenges in Connecting Renewables

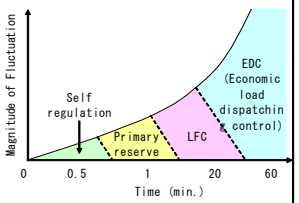
- Distributed generators interconnected to a weak grid
- Intermittency of output power with difficulties in accurate output forecasting.
- Different generator characteristics from conventional generators.



[Source] FEPC HP

Challenges: Intermittency

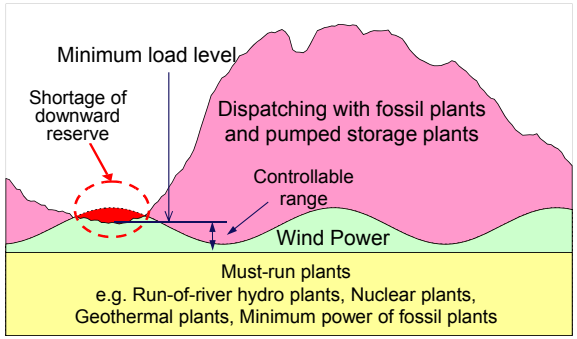
Output of PV and wind power is inter-mittent with little correlation with demand. Forecasting error is inevitable.



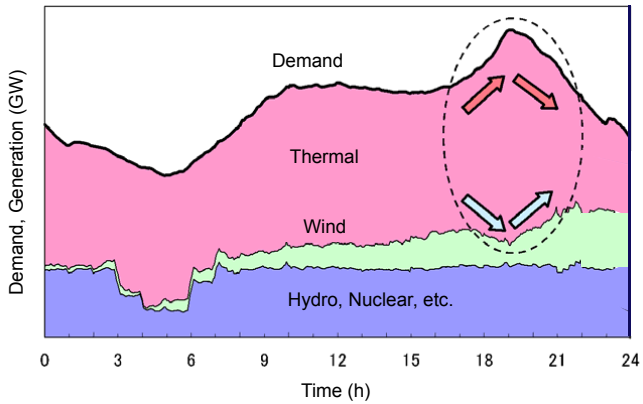
- Short term fluctuation
  - Impacts on LFC (Load Frequency Control)
- Long term fluctuation
  - Steep ramp problem: in particular, during the period with rapid demand change
  - Deficiency of controllable generation during light load period: minimum load problem

Deficiency of Controllable Generation

Controllable generation can be short under light load periods because of high penetration of base-load plants and low load factor.



Steep Ramp of Wind Power



[Source] ESCJ 風力発電連系可能量確認ワーキンググループ資料(in Japanese)

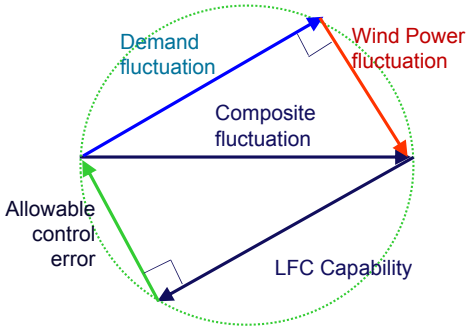
Present Ceiling for Wind Power

	Upper limit [MW]*			Note
	General	Others	Total	
Hokkaido	310	25		ment: 50MW, nection**: 200MW
Tohoku	85			MW, on: 400MW
Tokyo				
Chubu				
Hokuriku				n: 300MW
Kansai				
Chugoku				
Shikoku	200			ment: 50MW, rconnection: 200MW
Kyushu	1000			
Okinawa	25	–	25	

The methodology and related data, etc. have been scrutinized in a WG of the Electric Power System Council of Japan.

(*) Based on published data (ie, home pages of utility companies).
(**) See the next slide.

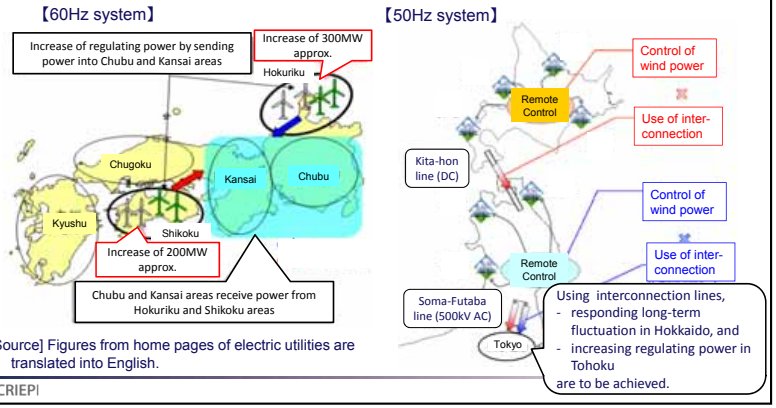
Statistical Diagram Describing LFC



Each vector stands for the magnitude (e.g., standard deviation) of the component.

Utilization of Interconnection Lines

Utilization of regulating power of the other control areas is exploited to increase wind power integration using interconnection lines.



[Source] Figures from home pages of electric utilities are translated into English.

Other Challenges in Power System

- ◆Thermal capacity of transmission lines; many wind farms are located in not densely populated area.
- ◆Voltage: e.g., fluctuations due to passage of front lines
- ◆Coordination of protective relays
- ◆FRT capability: the requirement will go to effects soon.

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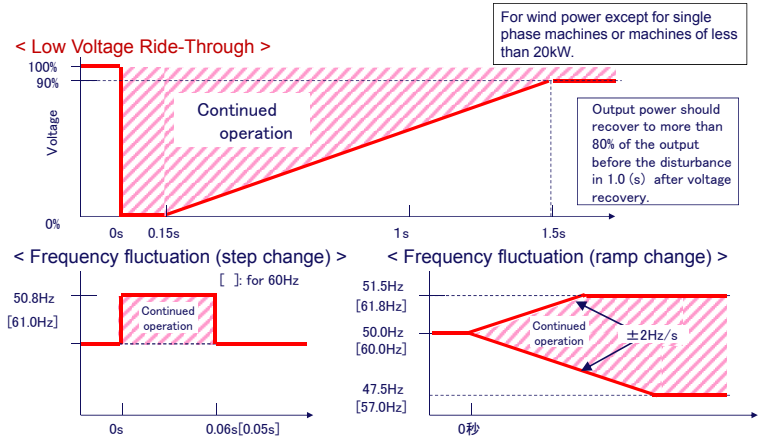
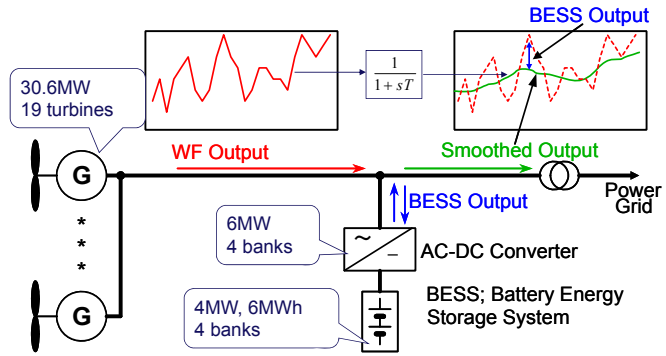
4. Related topics
   - Battery
   - Output forecasting
   - Dynamics of a power system
5. Closing remark

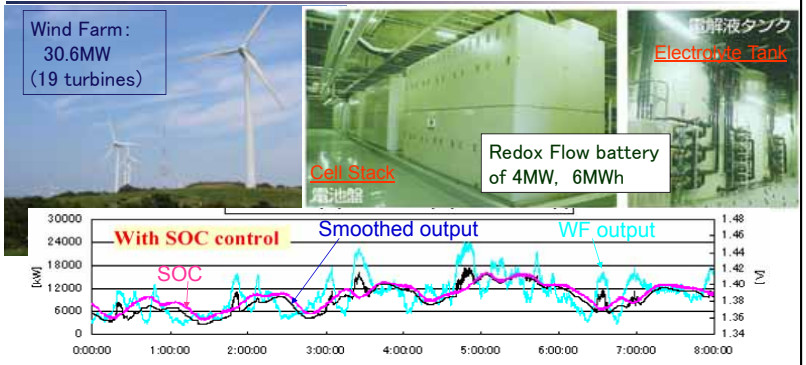
Requirement for FRT Capability in Japan



Outline of the Hybrid System



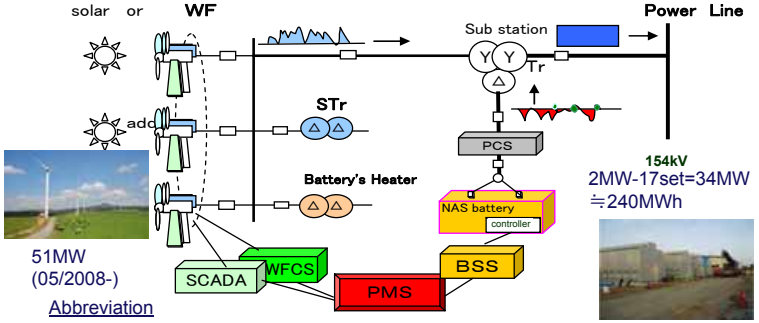
Wind Farm with Storage (2003-07)



Control method for battery energy storage system is examined. Smoothing up to some ten minutes is pursued.

[Source] NEDO: Wind Power Stabilization Technology Development Project

Battery with Renewables (Futamata WF)



Abbreviation

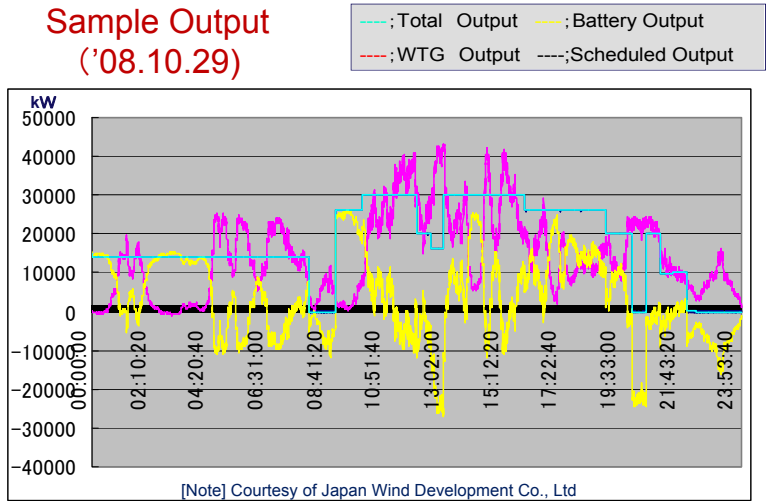
SCADA; Supervisory Control And Data Acquisition

WFCS; Wind Farm Control System PCS; Power Conversion System

BSS; Battery Supporting System PMS; Power Management System

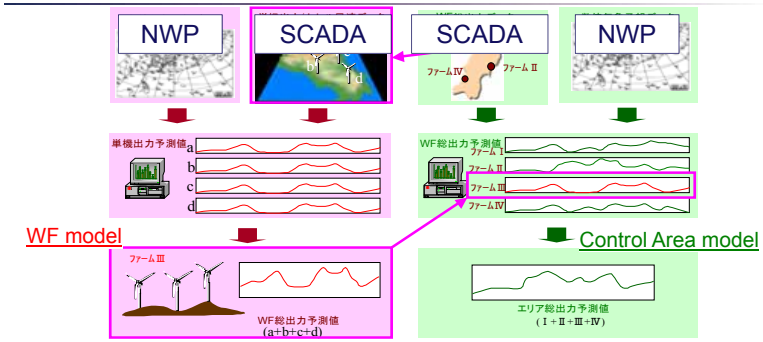
[Note] Courtesy of Japan Wind Development Co., Ltd

Sample Output ('08.10.29)



[Note] Courtesy of Japan Wind Development Co., Ltd

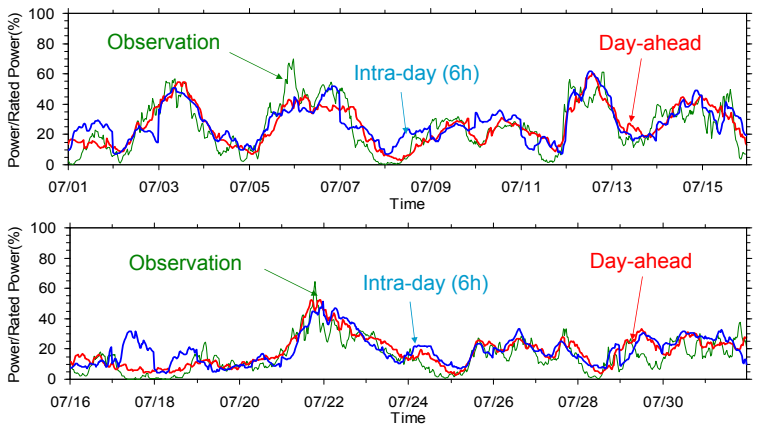
Wind Power Forecasting (2005-07)



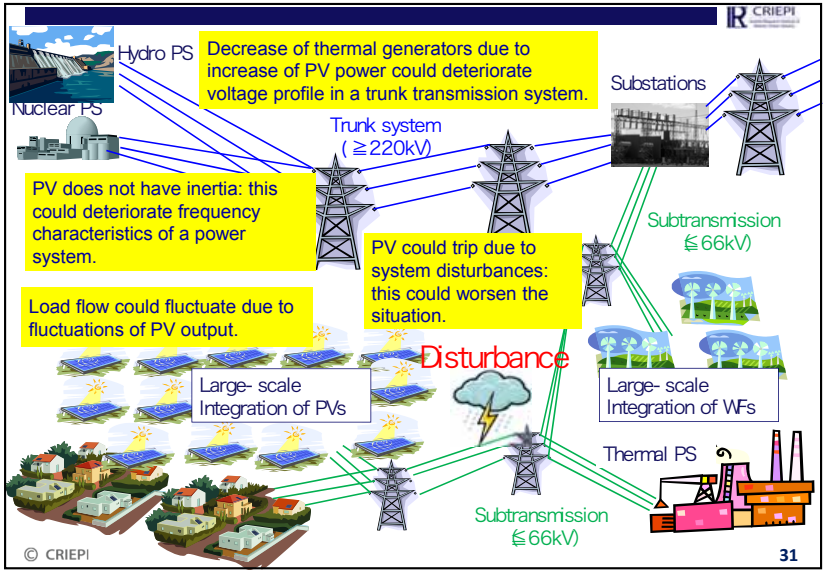
The accuracy is examined in Japan where complex terrain prevails and meteorological conditions are different from Europe. Improving the accuracy is also pursued.

[Source] NEDO: Wind Power Stabilization Technology Development Project

Sample Prediction for Tohoku Area (July)



[Source] NEDO: Wind Power Stabilization Technology Development Project

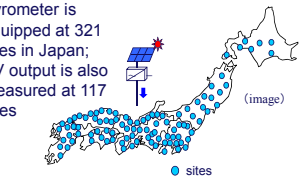


Project on PV Output Fluctuation

The following project was conducted to find out fluctuation characteristics of PV output in case of large penetration.

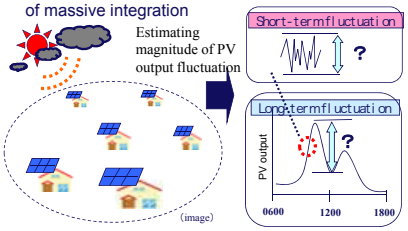
1. Collecting solar insolation data

Pyrometer is equipped at 321 sites in Japan; PV output is also measured at 117 sites



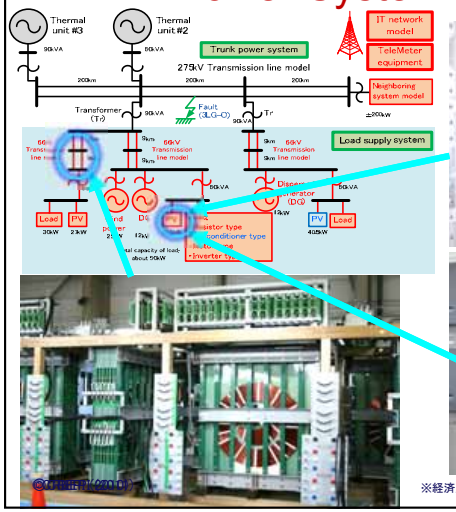
2. Data analyses

・Analyses on smoothing effects of PV outputs
・Estimate of fluctuation of PV outputs in case of massive integration



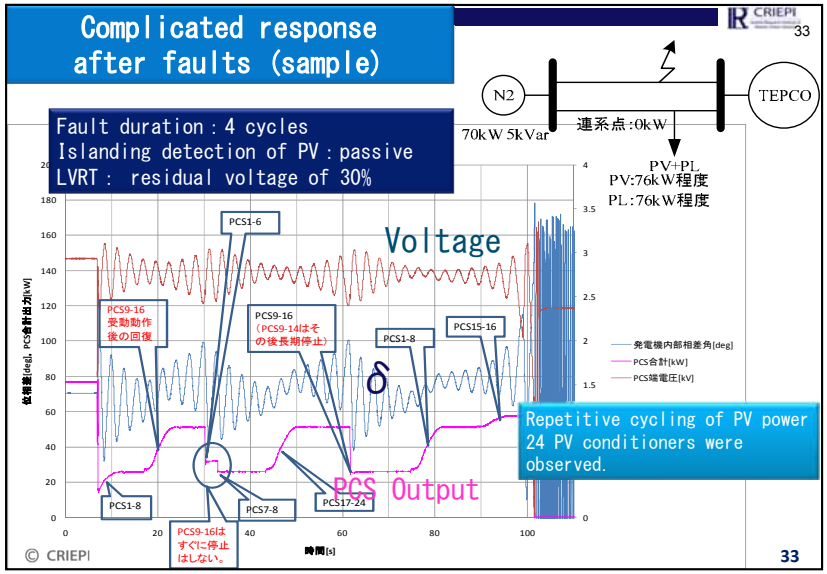
[Source]電事連：次世代送配電システム制度検討会第1ワーキンググループ第7回資料（平成22年12月27日）(in Japanese)

Power System Simulator



※経済産業省補助事業：「分散型電源大量導入系統影響評価基盤整備事業」

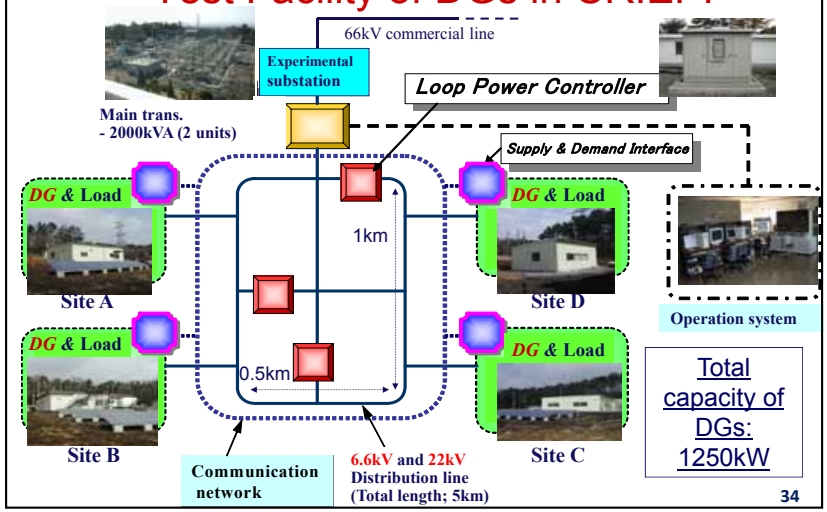
Complicated response after faults (sample)



Closing Remark

- Wind power and photovoltaic generation will be one of major power sources in the future though we face much uncertainty in energy issues.
- Large-scale penetration of the power sources will presents many unprecedented challenges to our grid.
- CRIEPI will continue the researches on the related topics: e.g., battery application, impacts on system dynamics, etc.

Test Facility of DGs in CRIEPI



Thank you very much for your attention.