Solar Integration Workshop
Pleanaly

RES integration in Japan

October 16th, 2018

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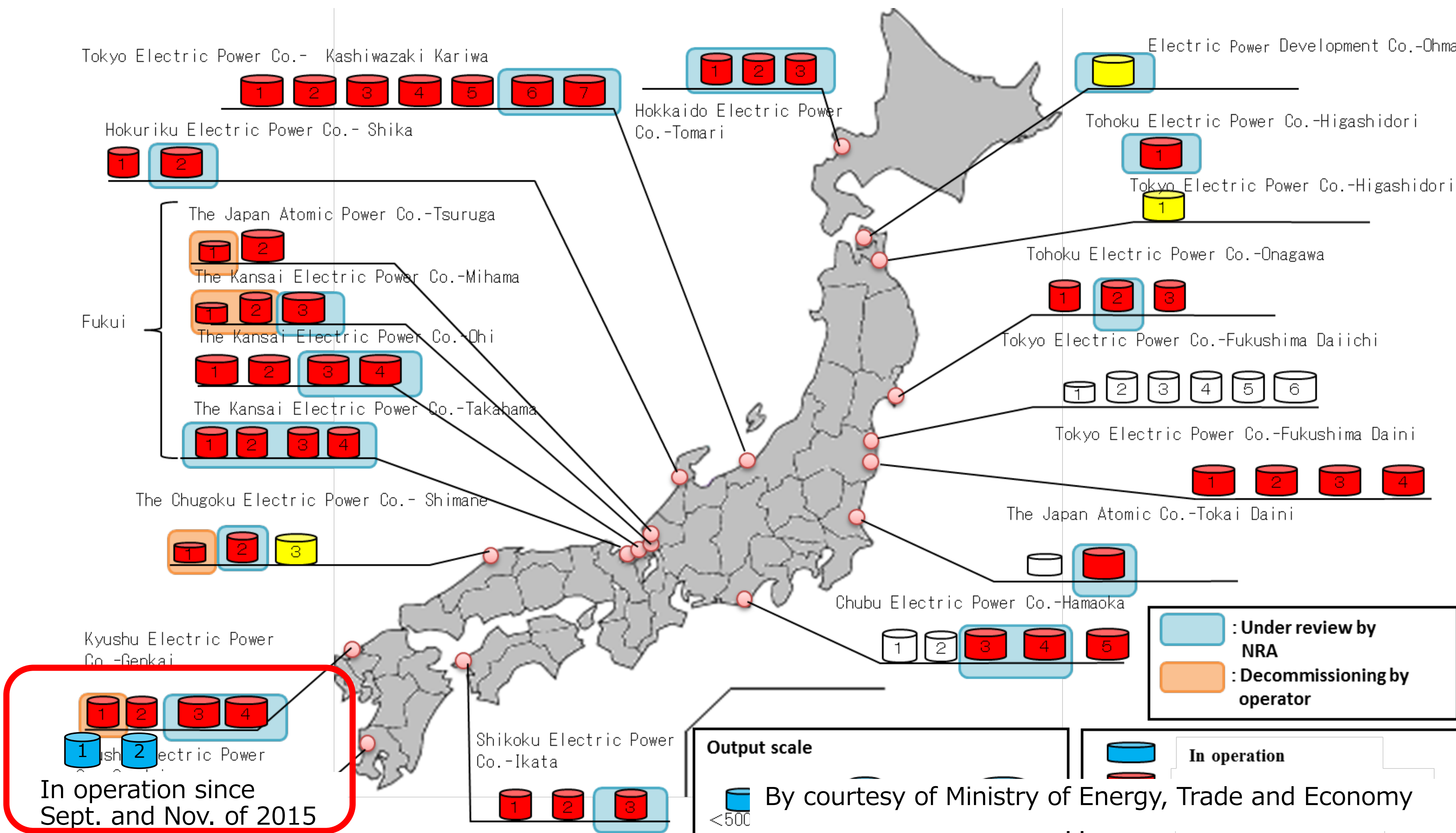
the University of Tokyo

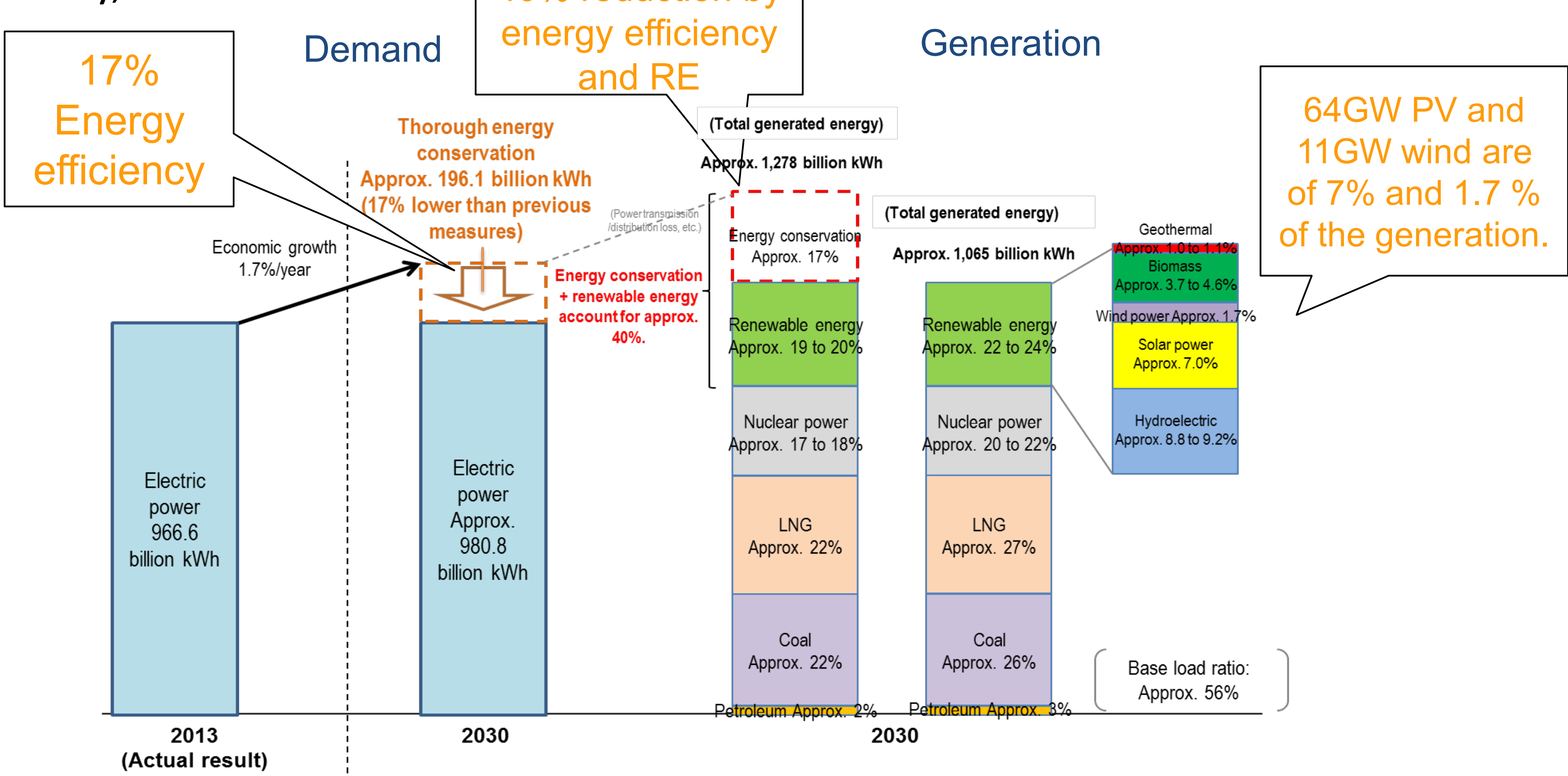
After the Earthquake: Deregulation of Power Market

As of 2015



Japan's Long-term Energy Demand and Supply Outlook

- After 4 years from the Earthquake in 2011, the Government of Japan published "Long-term Energy Demand and Supply Outlook (the Outlook)" in July, 2015.



FIT Tariffs

<table>
<tr><th></th><th>FY2012</th><th>FY2013</th><th>FY2014</th><th>FY2015</th><th>FY2016</th><th>FY2017</th><th>FY2018</th><th>FY2019</th><th>FY2020</th><th>Price targets for 2030</th></tr>
<tr><td>Solar (commercial) (10 kW or more)</td><td>\40</td><td>\36</td><td>\32</td><td>\29
\27 *
* From July 1 (after profit consideration period)</td><td>\24</td><td>\21
(10 kW or but under 2 MW)</td><td>\18
(10 kW or more but under 2 MW)</td><td></td><td></td><td>\7</td></tr>
<tr><td>Solar (residential) (Under 10 kW)</td><td>\42</td><td>\38</td><td>\37</td><td>\33
\35 **
** Subject to the installation of a power</td><td>\31
\33 **</td><td>\28
\30 **</td><td>\26
\28 **</td><td>\24
\26 **</td><td></td><td>Market price
(Target for 2020 and beyond)</td></tr>
<tr><td rowspan="4">Wind</td><td colspan="5">\22 (20 kW or more) ****</td><td>21 ****
(20 kW or more)</td><td rowspan="2">\20 ****</td><td rowspan="2">\19 ****</td><td rowspan="2">\18</td><td rowspan="2">\8-9</td></tr>
<tr><td colspan="6">\55 (under 20 kW) ***</td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td colspan="4" rowspan="2">\36 (offshore wind)</td><td colspan="2">\36(fixed) *****</td><td></td><td>\8-9</td></tr>
<tr><td colspan="2">\36(floating)</td><td>\36 (floating (floating)</td><td rowspan="16">Aiming for independence from the FIT system over a mid- to long term</td></tr>
<tr><td rowspan="2">Geothermal</td><td colspan="8">\26 (15 MW or more) ****</td><td>\26</td></tr>
<tr><td colspan="8">\40 (under 15 MW) ****</td><td>\40</td></tr>
<tr><td rowspan="4">Hydro</td><td colspan="5" rowspan="2">\24 (1 MW or more but under 30 MW) ****</td><td>\24</td><td colspan="2">\20 (5 MW or more but under 30 MW)</td><td>\20</td></tr>
<tr><td colspan="3">\27 (1 MW or more but under 5 MW) ****</td><td>\27</td></tr>
<tr><td colspan="8">\29 (200 kW or more but 1 MW) ****</td><td>\29</td></tr>
<tr><td colspan="8">\34 (under 200 kW) ****</td><td>\34</td></tr>
<tr><td rowspan="10">Biomass</td><td colspan="8">\39 (fermented methane gas)</td><td>\39</td></tr>
<tr><td colspan="3" rowspan="2">\32 (wood biomass derived from thinned wood)</td><td colspan="5">\40 (under 2 MW)</td><td>\40</td></tr>
<tr><td colspan="5">\32 (2 MW or more)</td><td>\32</td></tr>
<tr><td colspan="5" rowspan="2">\24 (general wood biomass)</td><td>\24 | \21
(20 MW or more)</td><td>Shift to the auction system (10 MW or more)</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>\24
(Under 20 MW)</td><td>\24
(Under 10 MW)</td></tr>
<tr><td colspan="5" rowspan="2">\24 (biomass liquid fuel)</td><td>\24 | \21
(20 MW or more)</td><td rowspan="2">Shift to the auction system</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>\24
(Under 20 MW)</td></tr>
<tr><td colspan="8">\13 (building material waste)</td><td>\13</td></tr>
<tr><td colspan="8">\17 (municipal waste; other biomass)</td><td>\17</td></tr>
</table>

*** A transitional measure is applied only to wind power projects that are truly being developed. **** Replaced equipment for wind, geothermal and hydro power generation are subject to a tariff lower than that for newly-approved equipment. ***** The conditions for applying the rules on the use of general sea areas are will be to the auction system when the rules come in force.

By courtesy of Ministry of Economy, Trade and Industry

Progress of RE Deployment after the launch of FIT

- The FIT began in July 2012 after the East Japan Earthquake in 2011.
- Due to the favorable FIT tariffs, investment in RE has been stimulated. PV which require short planning and construction period has shown remarkable increase of FIT permission and actual deployment.

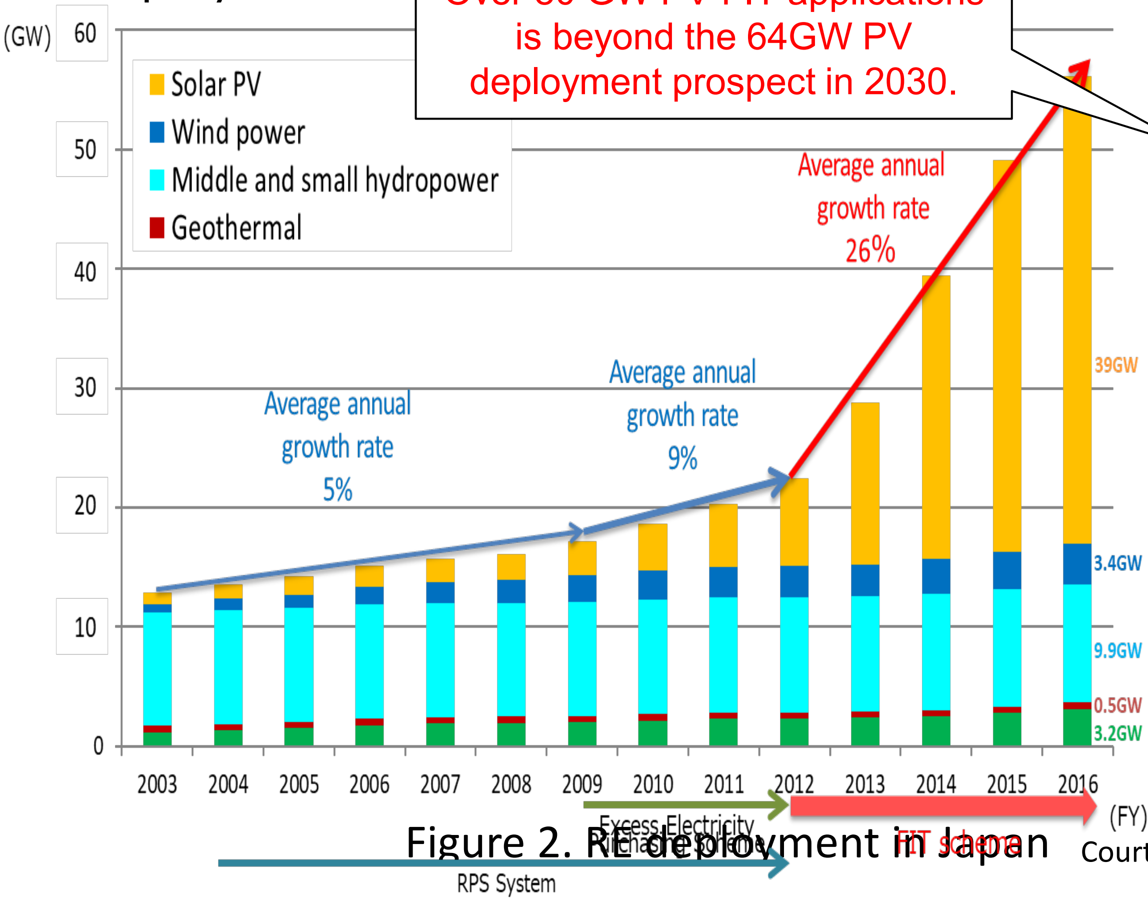
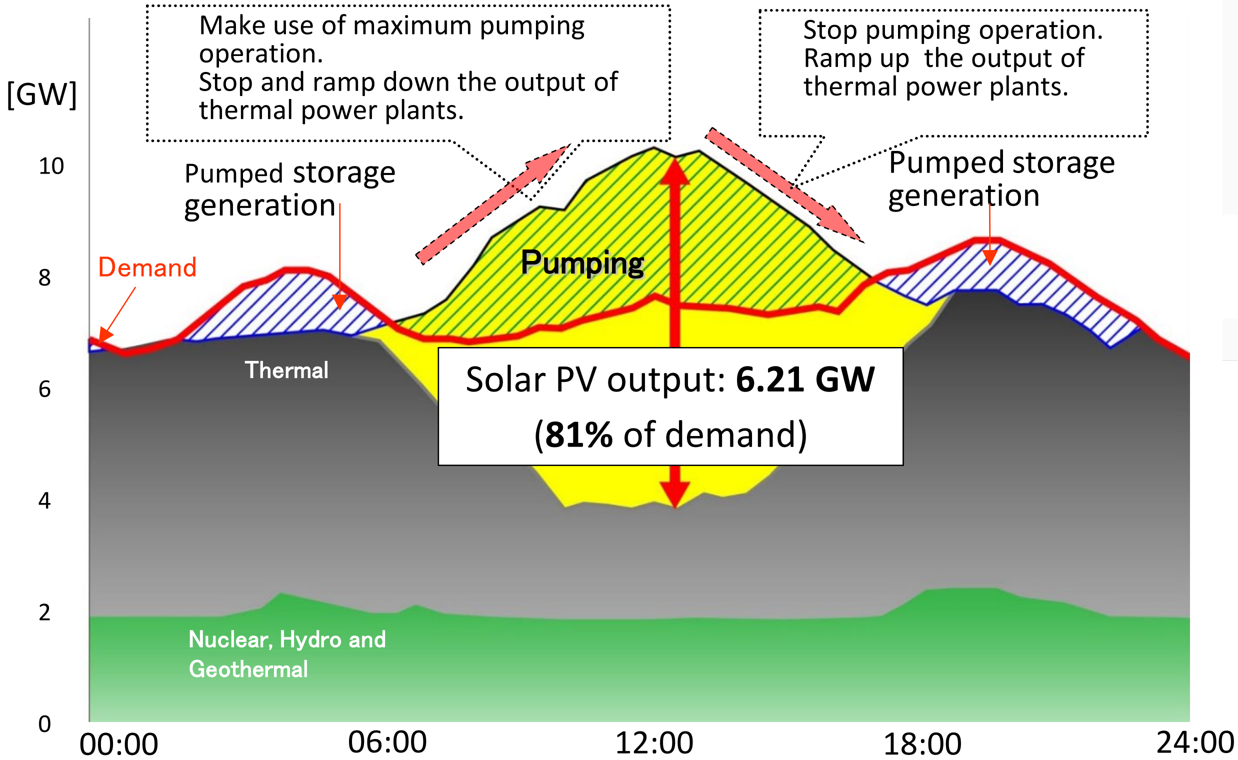


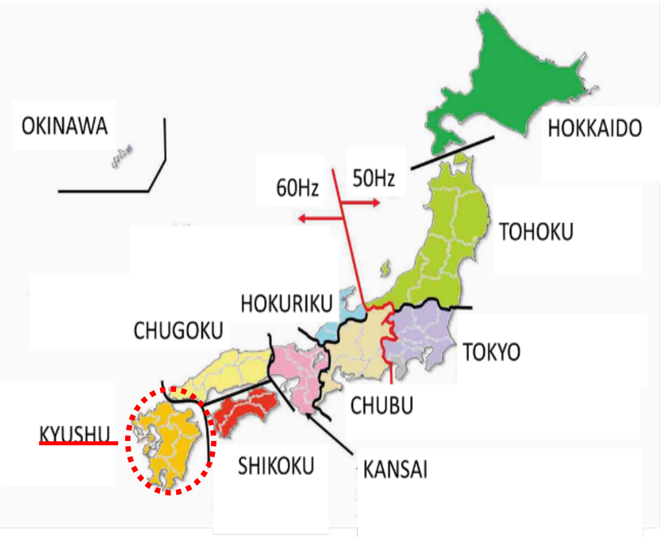
Figure 2. RE deployment in Japan

	Authorized (up to the end of 2014FY)	Already installed before 2014FY
PV (residential)	3.79GW	3.1GW
PV (non-residential)	78.84GW	15.01GW
Wind	2.29GW	0.33GW
Hydraulic	0.66GW	0.09GW
Geothermal	0.07GW	0.01GW
Biomass	2.03GW	0.22GW
Total	87.68GW	18.76GW

Courtesy by Agency for Natural Resources and Energy

Supply and demand operation in Kyushu (May 3, 2018)

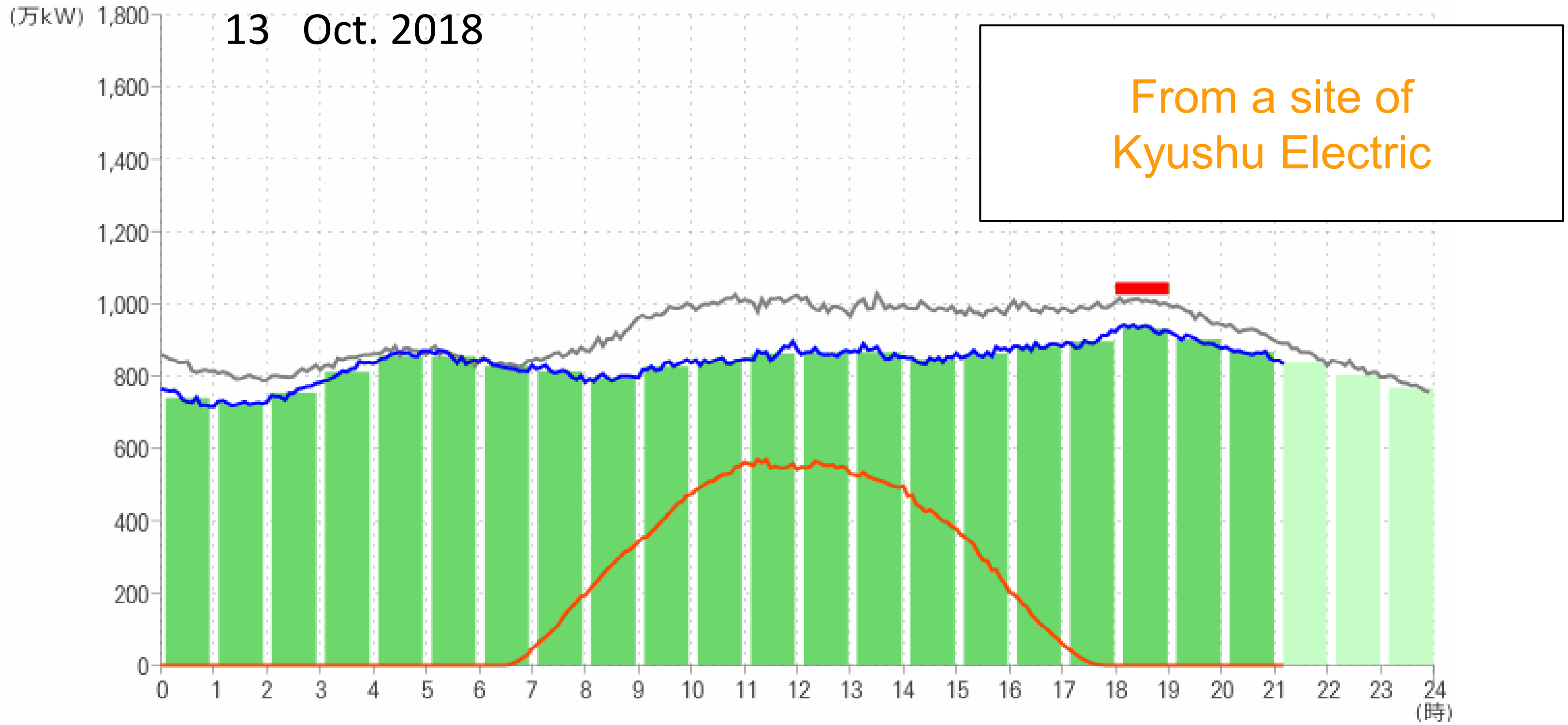




By courtesy of Ministry of Economy, Trade and Industry

First TSO-wide PV curtailment in Kyushu Oct. 13th (Sat.) and 14th (Sun)

電力使用状況の推移



本日実績（5分値） 本日実績（1時間値） 予測値 ピーク時供給力

本日の太陽光発電実績（5分値）

前日実績（5分値）※土・日曜日については前週実績、月曜日については前週金曜日実績を参考値として表示します。

・数値は送電端の値です。
・0時から0時10分頃は、データが更新されません。予めご了承下さい。
・太陽光発電実績は、日射量による推計値を含む九州エリア（本土、離島）の値です。

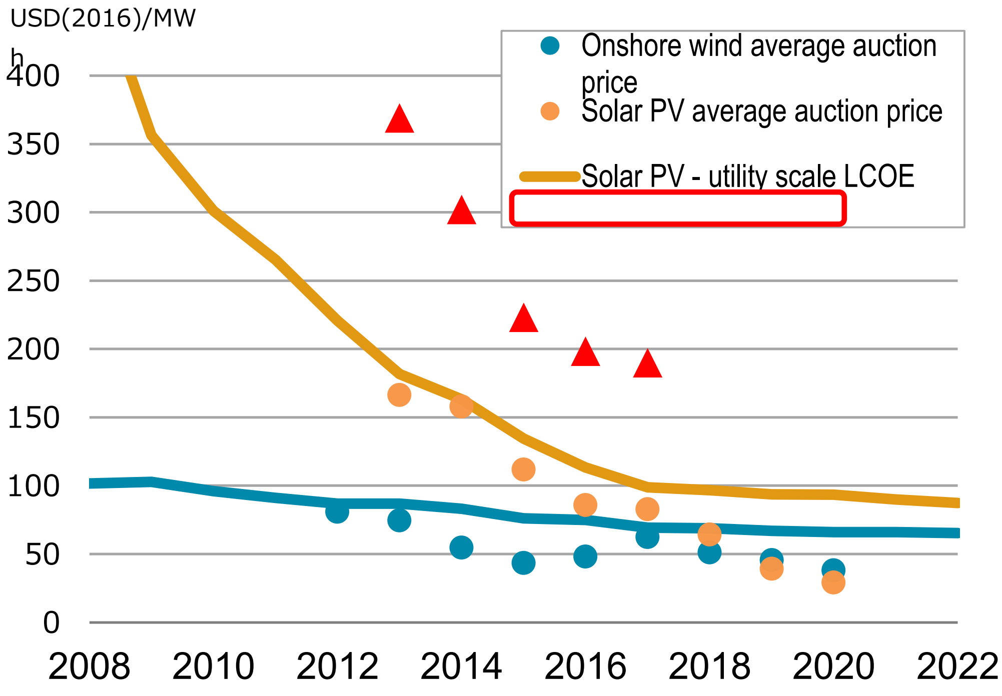
https://www.kyuden.co.jp/power_usages/pc.html

Rapid integration of solar PV in the Kyushu

http://himawari8.nict.go.jp/

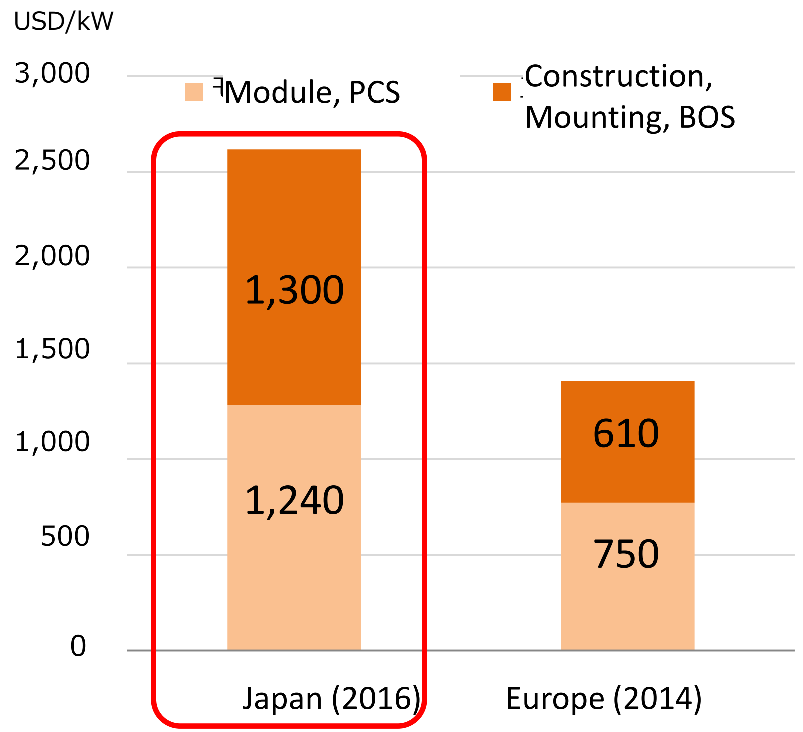
Higher cost of PV: Investment

Wind and solar PV average LCOEs and auction results by commissioning date



(Source: IEA Renewables 2017)

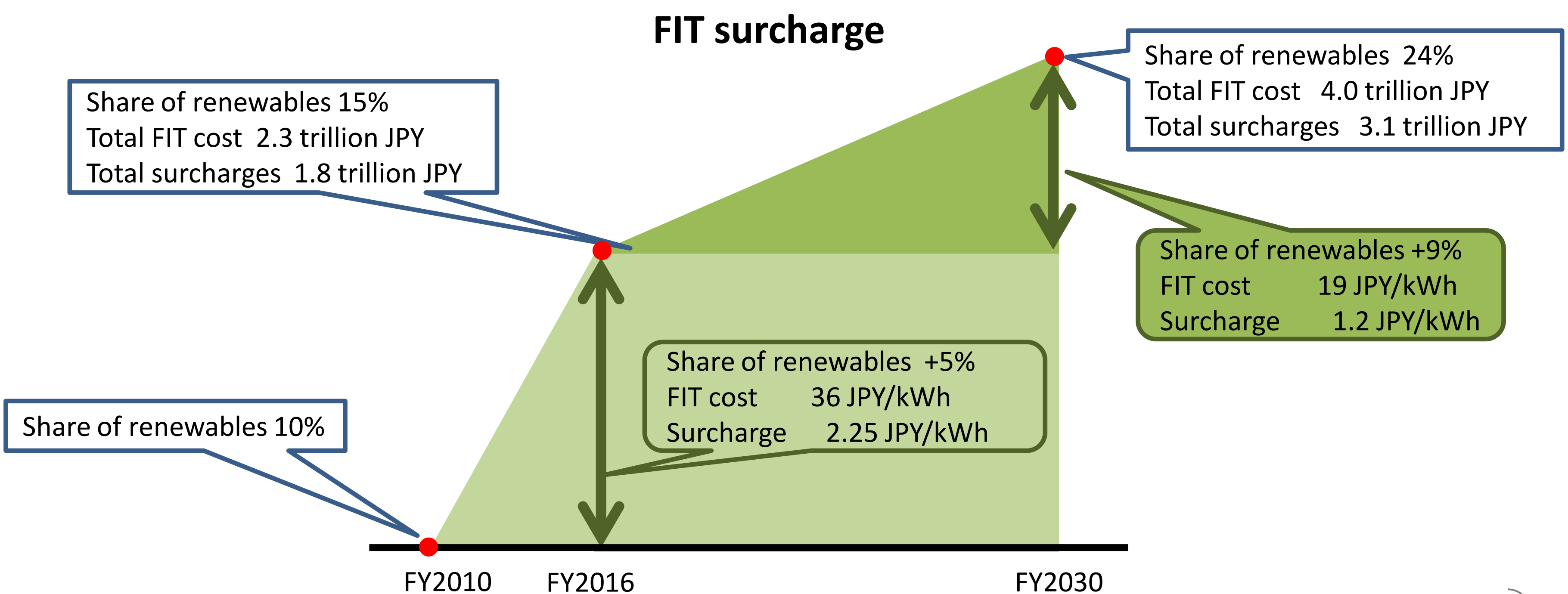
PV system cost for non-residential



(Source: METI survey)

By courtesy of Ministry of Economy, Trade and Industry

Higher cost of RE: Surcharge for electricity

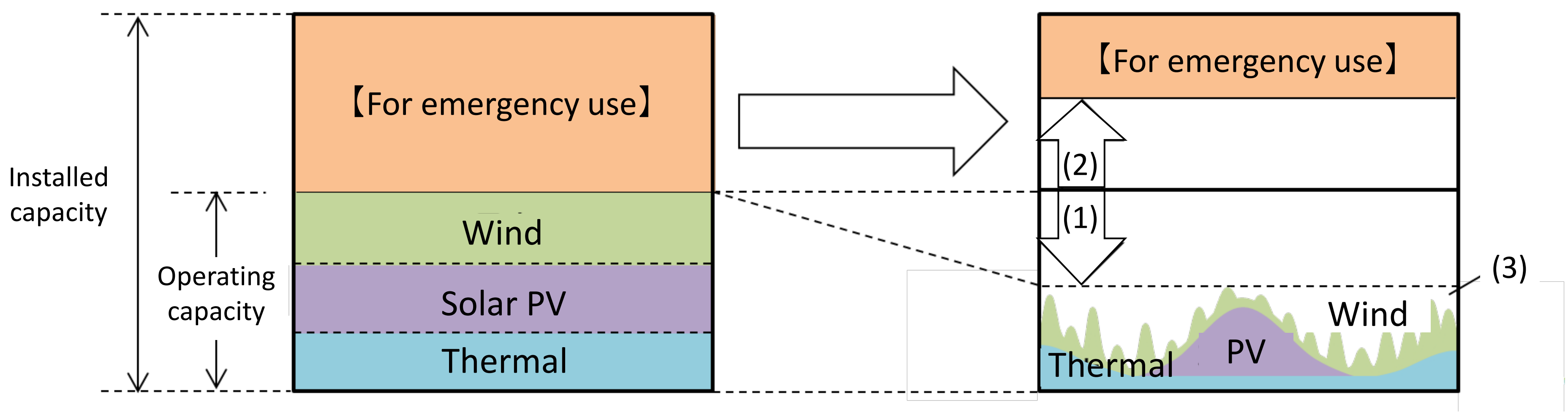


Note: The total FIT cost/ and total surcharges for FY2016 are estimates. Total surcharges for FY2030 are calculated on the assumption that the ratio of total FIT cost to total surcharges for FY2030 is the same for FY2016.
The total amount of the FIT cost and total surcharges per kWh is calculated as follows: (1) The amount for FY2016 is calculated based on the actual FIT cost and total surcharges. (2) Increments up to FY2030 are mechanically calculated on the assumption that additional power generation from renewables is all subject to FIT, where (i) the FIT cost represents the total FIT cost divided by total electricity generated from renewables; and (ii) the amount of surcharges represents total surcharges divided by total amount of electricity.

Source: METI, Subcommittee on Massive Integration of RE and Next-Generation Electric Power Network (2018)
http://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/pdf/20180522001_01.pdf

Transmission and Distribution Japanese "Connect & Manage"

	Current operation	Direction of revision
(1) Probabilistic evaluation of power flow	Full capacity operation of all generators	Probabilistic evaluation for each generator
(2) N-1 inter-trip	Always secure free capacity for emergency	Release the capacity by inter-tripping in emergency condition
(3) Non-firm access	(Not considered)	Regardless of available transmission capacity, new gird connection is accepted with the condition of curtailment



By courtesy of Ministry of Economy, Trade and Industry

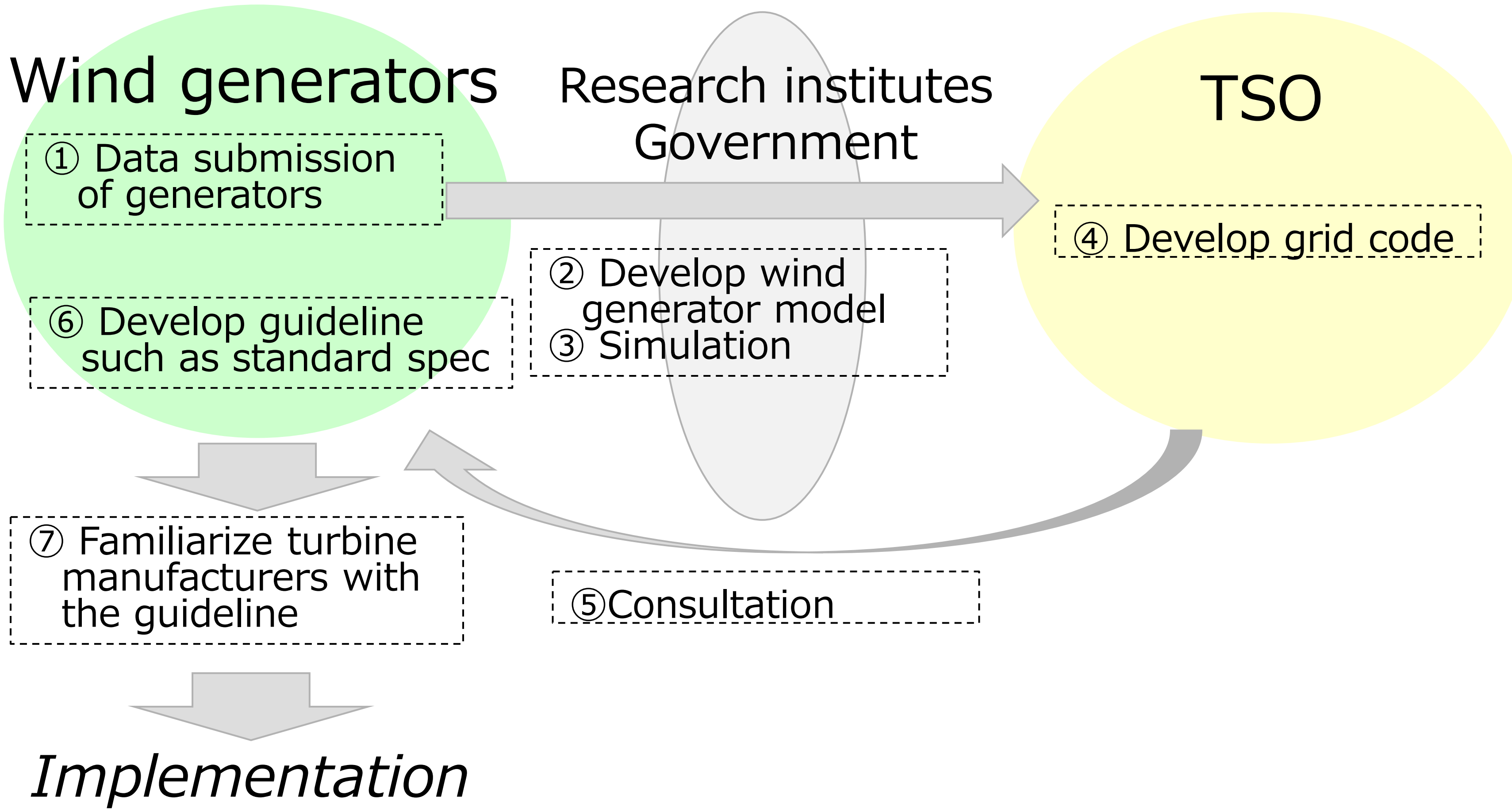
Schedule of developing advanced grid code for RE
Ancillary services from RE

June 2018, in a government committee, it was agreed to improve the existing grid code to include advanced ancillary service such as Frequency – Watt control for WIND.

No.	Measures	FY2017 2nd half	FY2018 1st half	FY2018 2nd half	FY2019 1st half	FY2019 2nd half	FY2020-	Note
1	Test of control functions							・Measurement of active power control and frequency contro by using existing wind generators
2	Effectivity evaluation by frequency simulation							・Implemented by the wind association and research institutes ・Measurement based on IEC61400-21-1 ・Confirmation of each function's contribution to frequency stability
3	Report of the effectivity of each function Consultation with stakeholders	Small Renewable introduction Large						・Decision of standard functions and specification by the wind association
				Developing wind generation model Simulation	Rule-making			① Normal case analysis
					Developing wind generation model Simulation	Rule-making		② Emergency case analysis
					Developing wind generation model Simulation		Rule-making	③ Instantaneous case analysis
4	Introduction of active power control and frequency control							・The wind association will consult with wind generators to facilitate active power control and frequency control
5	Practical use of the function							・Practical use from 2021 sequentially

Source: METI, Subcommittee on Massive Integration of RE and Next-Generation Electric Power Network (2018)
http://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/pdf/003_02_00.pdf

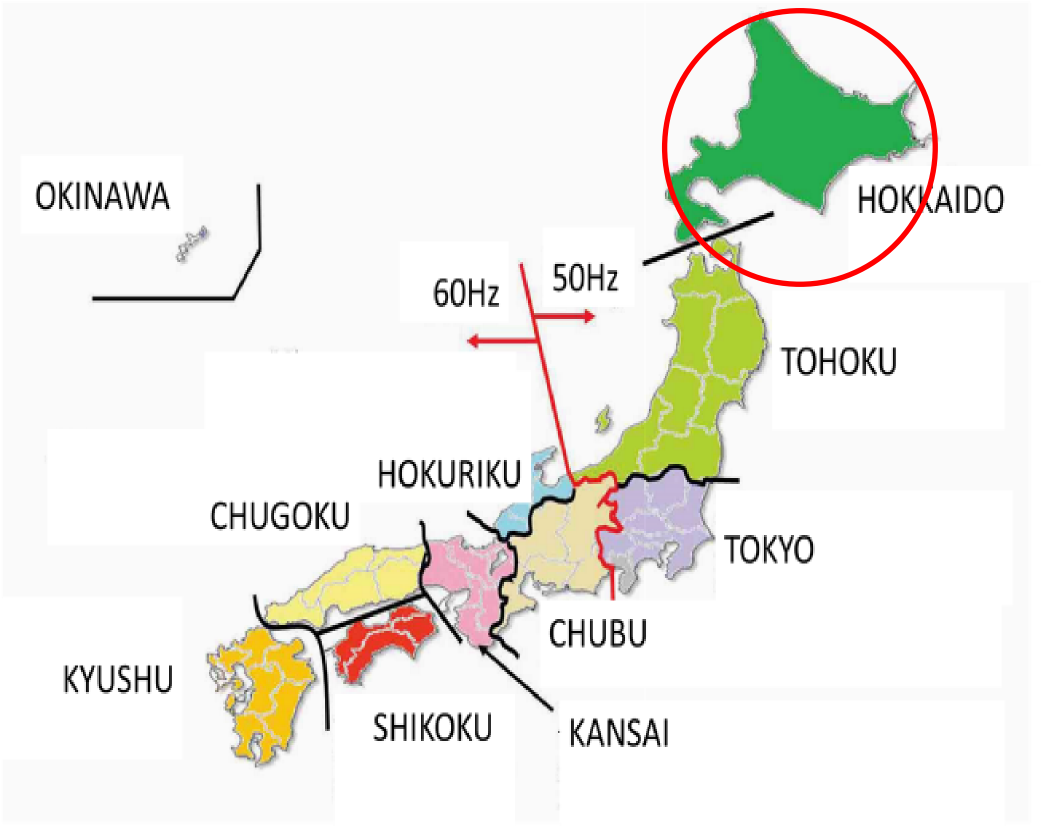
Toward developing grid code for wind power



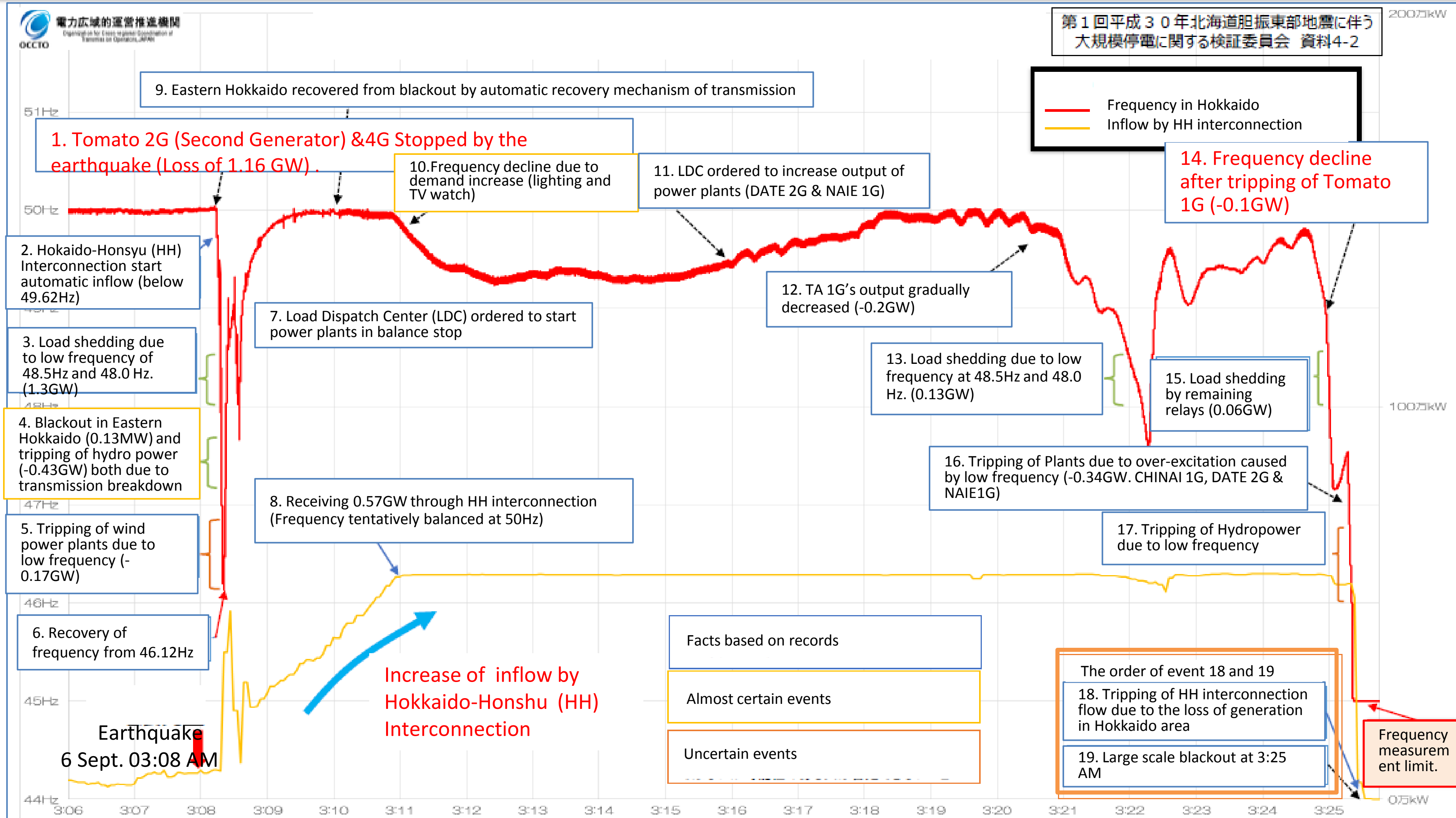
Source: METI, Subcommittee on Massive Integration of RE and Next-Generation Electric Power Network (2018)
http://www.meti.go.jp/shingikai/enecho/denryoku_gas/saisei_kano/pdf/003_02_00.pdf

Blackout event in Hokkaido (Sep. 6th) Frequency change and transmission level events

- Early in a morning on Sep. 6th , in Hokkaido, an earthquake destroyed several towers of transmission lines and 3 three coal-fired units in Hokkaido.
- The loss of 1600MW of the thermal generation which is around 50% of the load induced the first blackout in Japan.



Blackout event in Hokkaido (Sep. 6th)
Frequency change and transmission level events



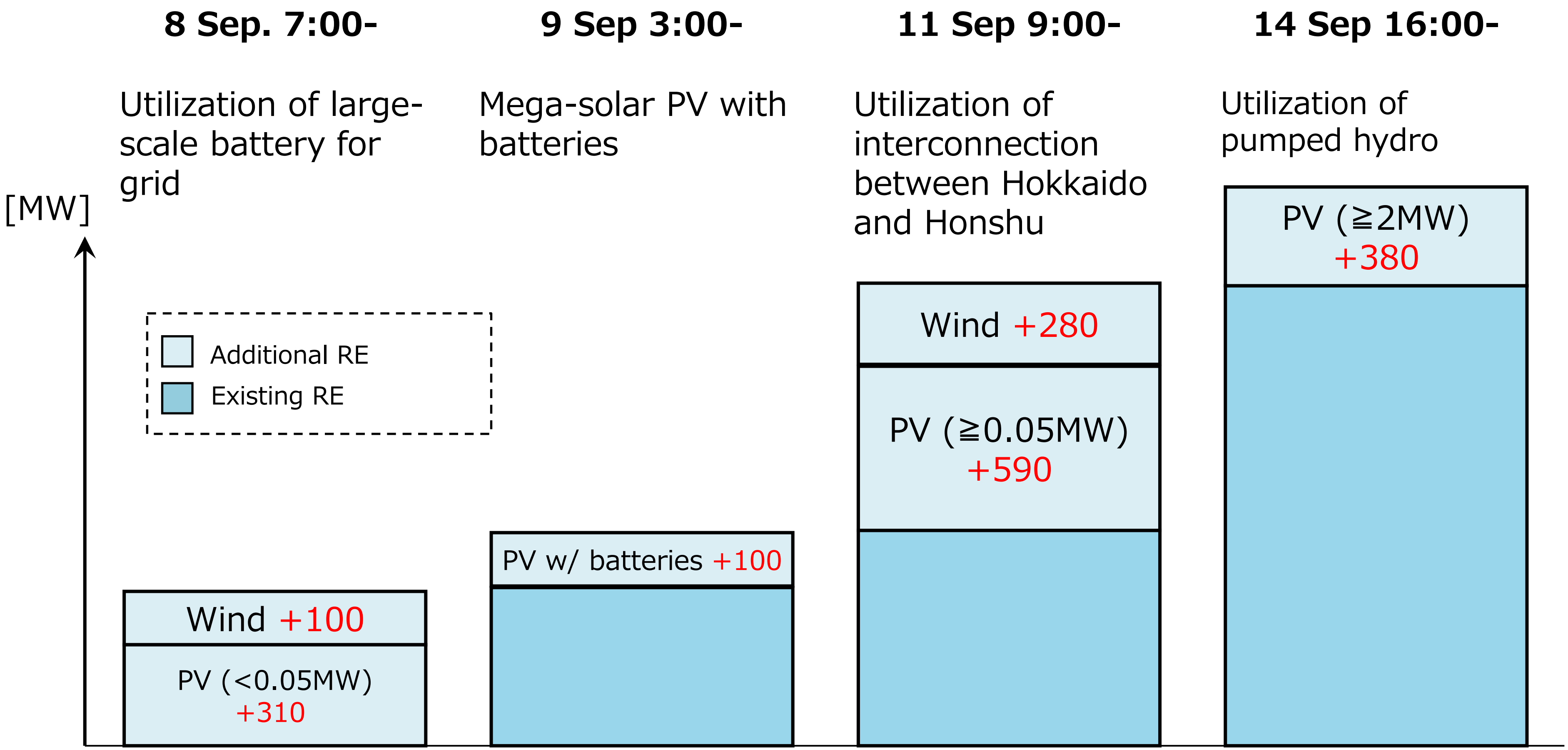
Translated from OCCTO: The Investigation Committee on the Major Blackout by the 2018 Hokkaido Eastern Iburi Earthquake

https://www.occto.or.jp/en/pressrelease/2018/180919_hokkaidoearthquake_investigation.html

https://www.occto.or.jp/iinkai/hokkaido_kensho/files/hokkaido_kensho_01_04_2.pdf

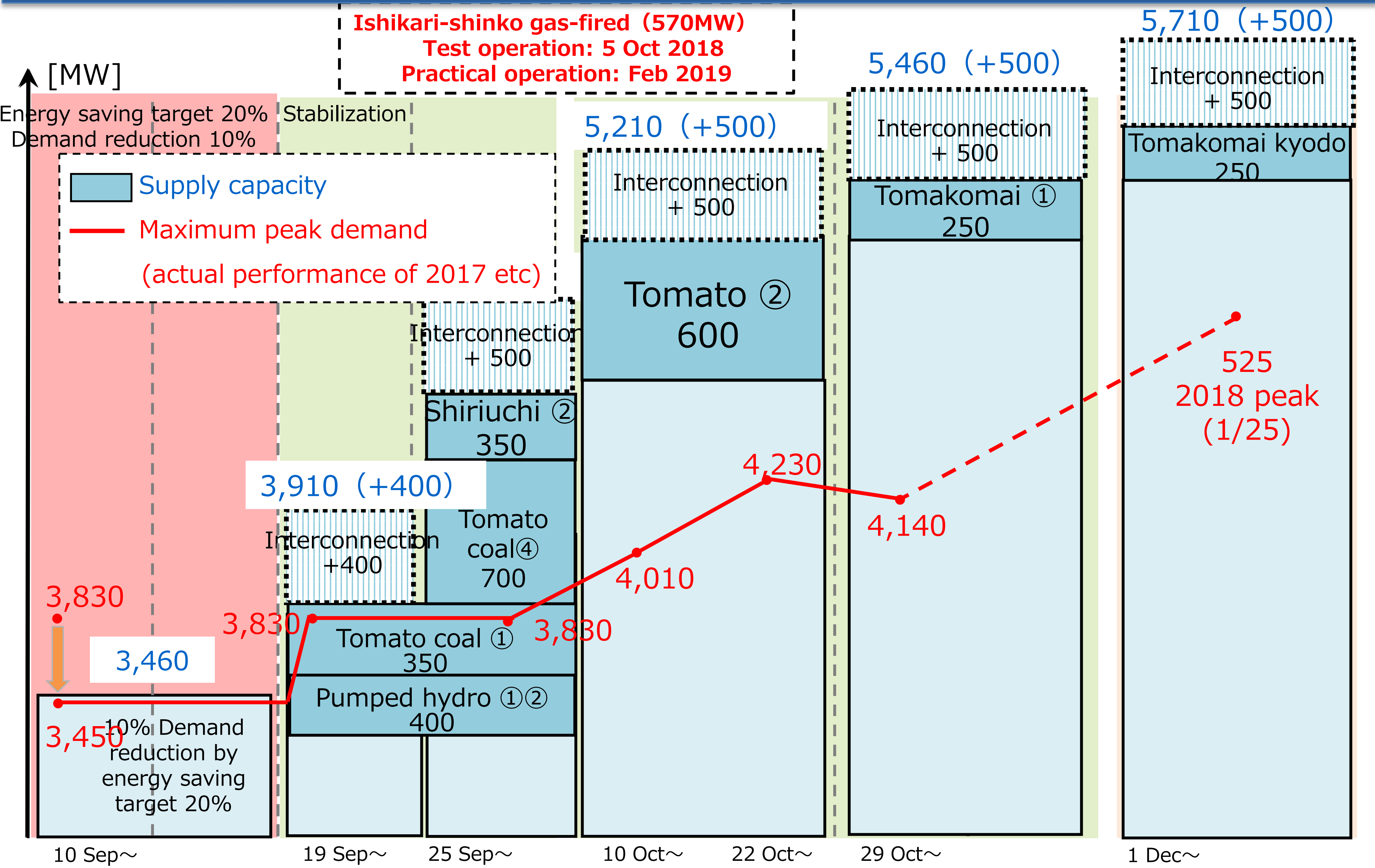
Blackout event in Hokkaido
Recovery and utilization of RE

- Flexibility is required to address variability of VRE
- Hokkaido was lack of flexibility after the earthquake, and Hokkaido Electric Power Company reconnected VRE in response to securing flexibility



Source:- METI, 17the meeting of Working Group on Grid Connection of Renewable Energy (Sep. 2018)
http://www.meti.go.jp/shingikai/enecho/shoene_shinene/shin_energy/keito_wg/pdf/017_06_00.pdf

Blackout event in Hokkaido
Recovery schedule of Supply demand balance (As of 10 Oct)



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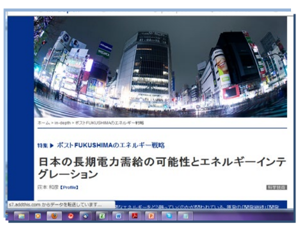
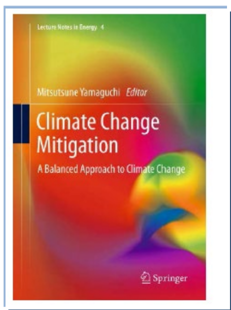
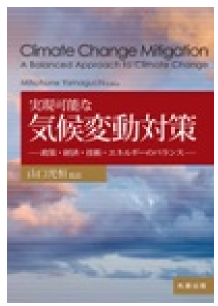
http://www.meti.go.jp/shingikai/enecho/shoene_shinene/shin_energy/keito_wg/pdf/017_06_00.pdf

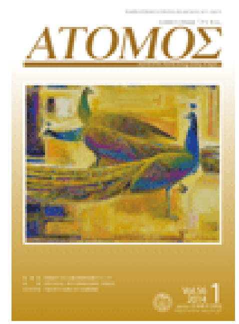
Thank you

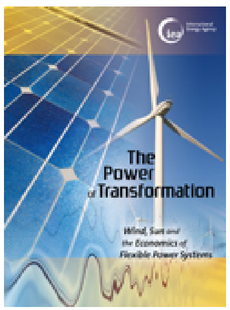
Ogimoto Laboratory, Institute of Industrial Science, the University of Tokyo
http://www.ogimotolab.iis.u-tokyo.ac.jp/

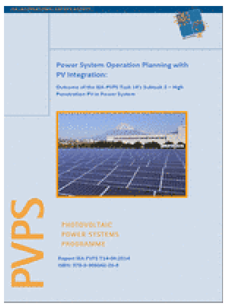












In nippon.com Your Doorway to Japan, related contents are available in English and Japanese.
http://nippon.com/en/in-depth/a00302/

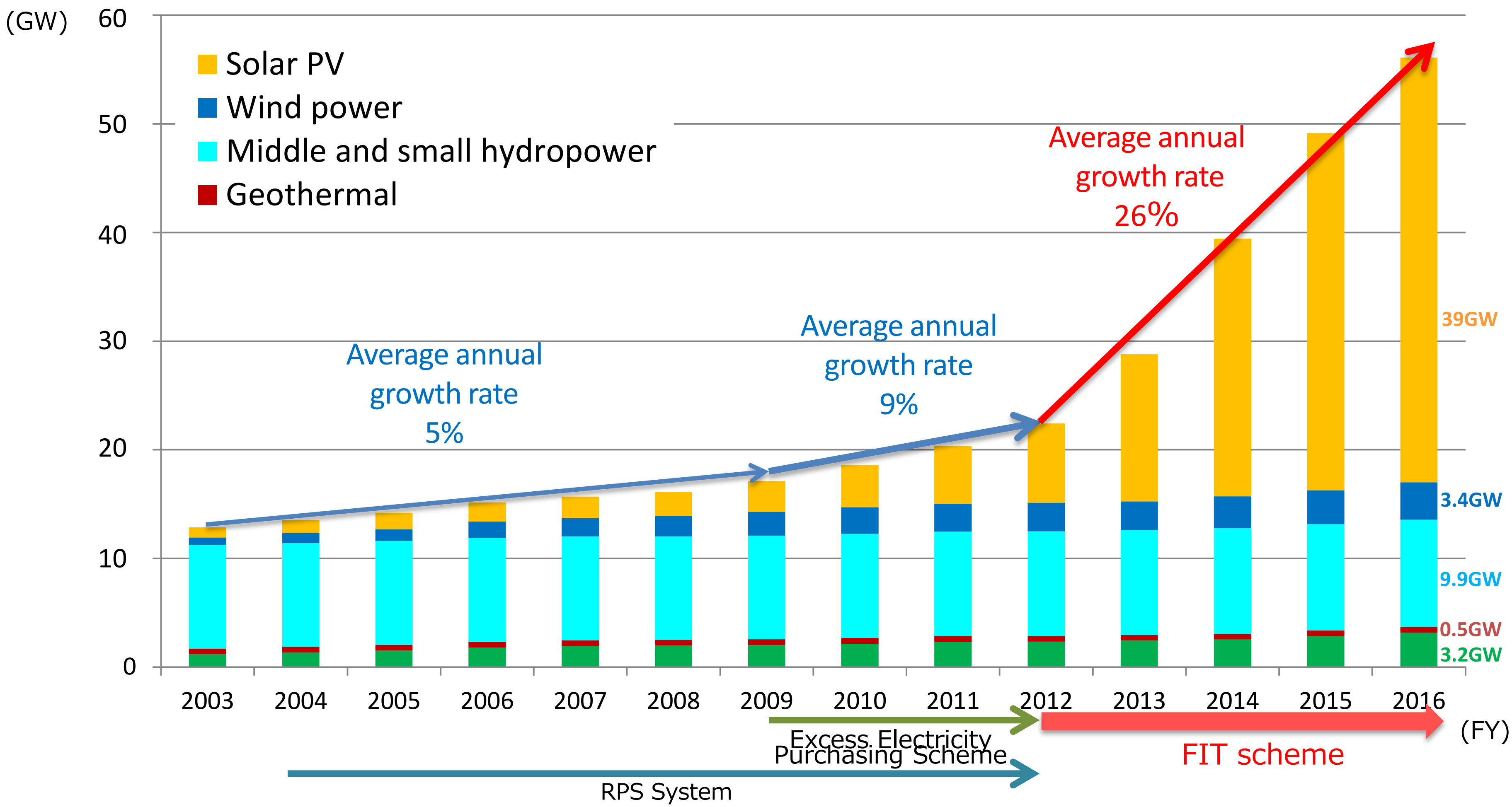
The description of "1. Impact of Scenario Selection" is available in this book which is just published July, 2012.

"The integration of variable renewable generation and the evolution of power system" is published in the Magazine of Atomic Energy Society of Japan.(Jan., Feb. and May in 2015)
http://www.aesj.or.jp/atomos/tachiyomi/mihon.html

With NEDO, translated IEA "The Power of Translation" into Japanese.
http://www.nedo.go.jp/library/denryoku_henkaku.html

IEA PVPS Task 14 Report " Power System Operation and Augmentation Planning with PV Integration" has been published
http://www.iea-pvps.org/index.php?id=322

Historical trend in renewable introduction

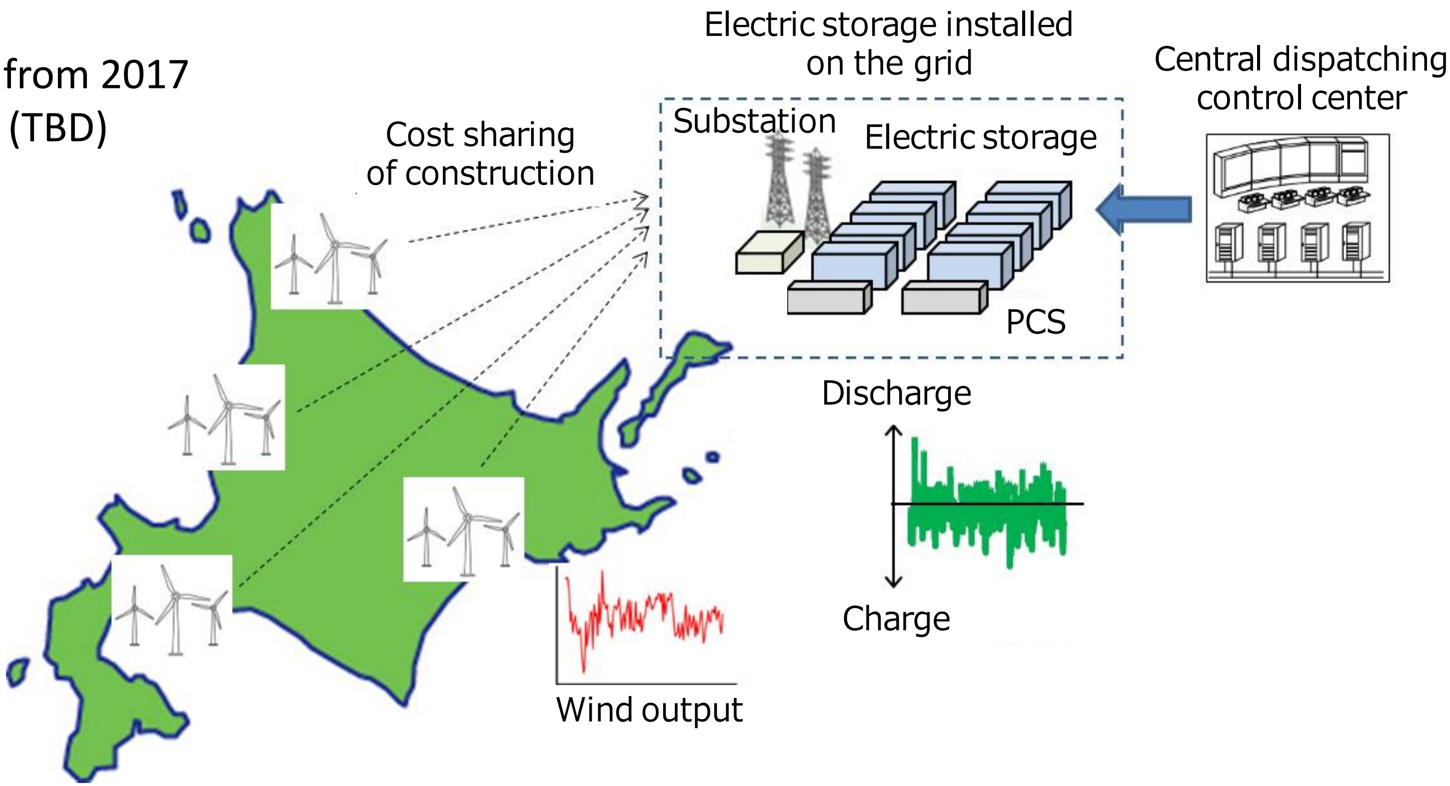


By courtesy of Ministry of Economy, Trade and Industry

Electric storage installed on the grid

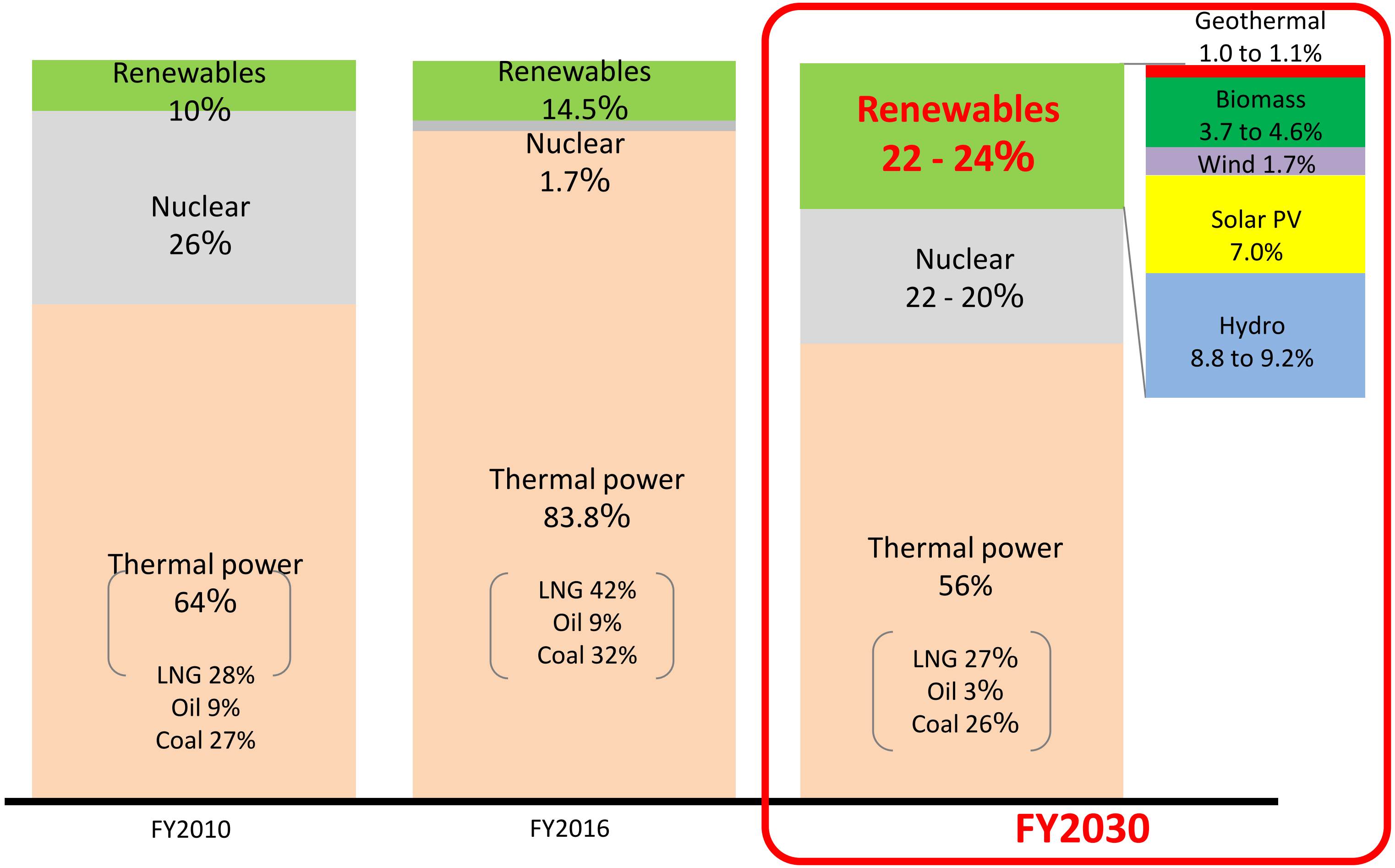
<Schedule>

- 1st bid: 600MW from 2017
- 2nd bid: 400MW (TBD)



By courtesy of Ministry of Economy, Trade and Industry

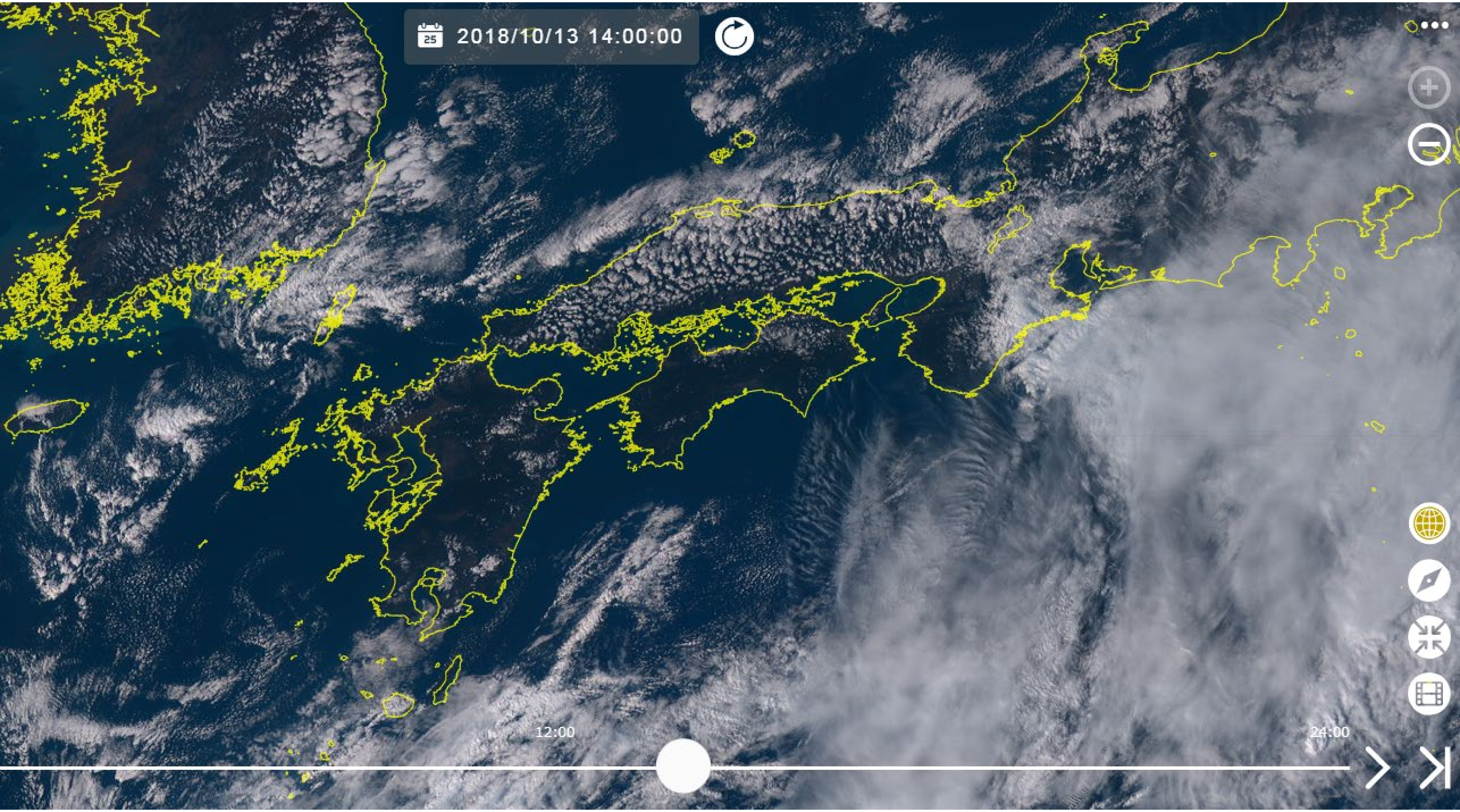
Generation mix target in 2030



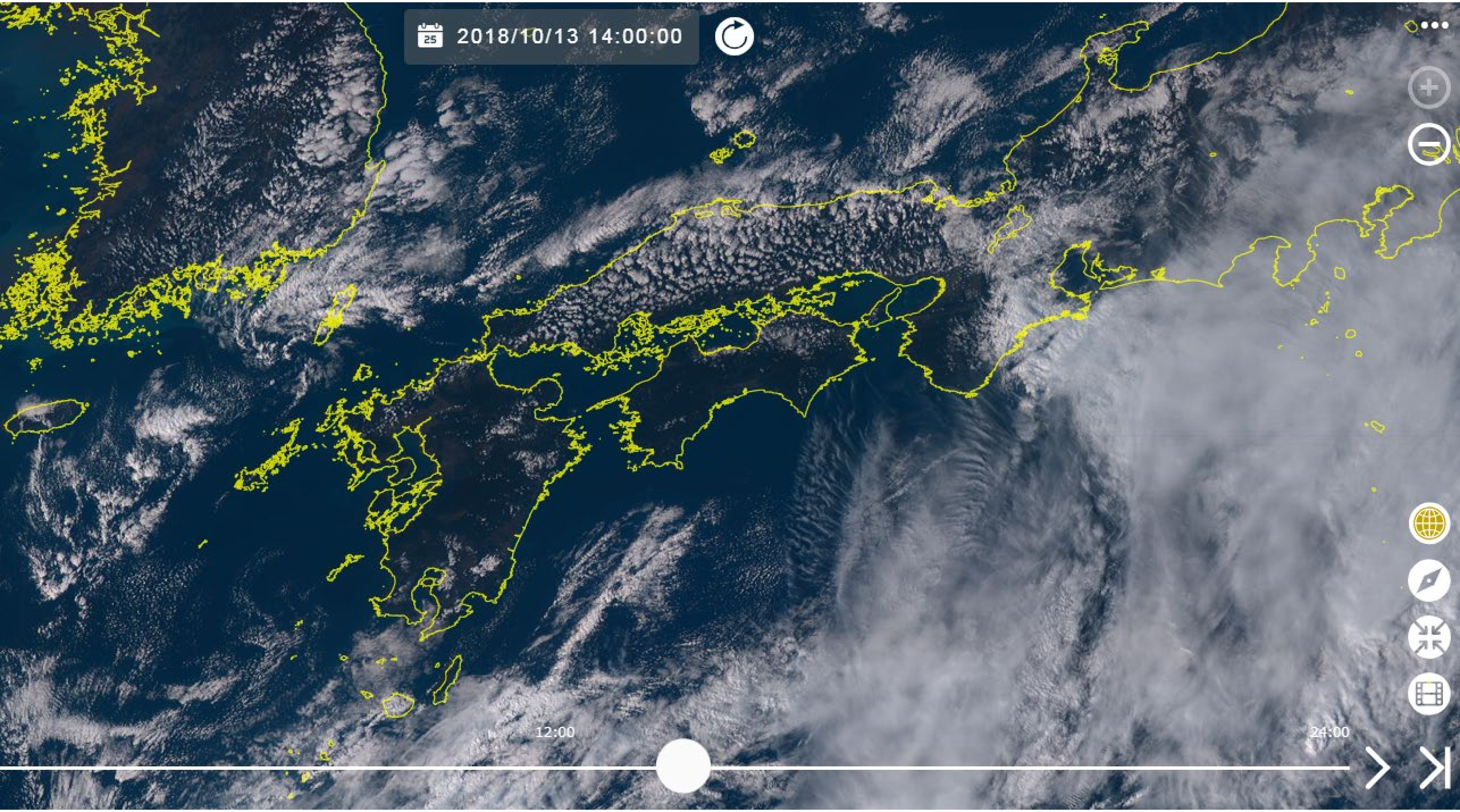
1,065 TWh
(Power demand + T&D losses, etc.)

5th Strategic Energy Plan
Energy security, economic efficiency and environment (3E+S)

By courtesy of Ministry of Economy, Trade and Industry



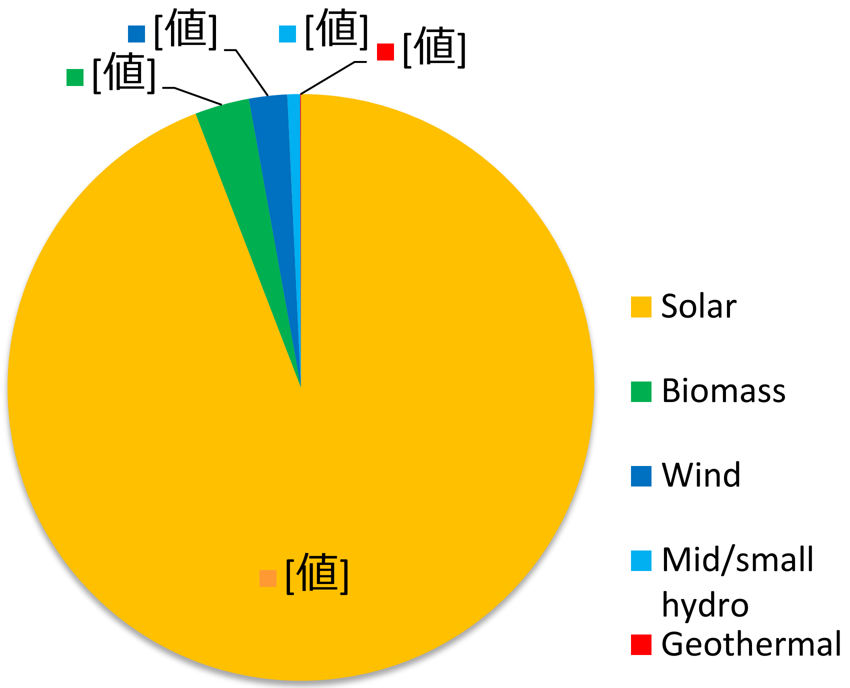
http://himawari8.nict.go.jp/



http://himawari8.nict.go.jp/

One-sided introduction of solar PV

Renewables started operation after FIT (as of Sep 2017)



Renewable introduction toward 2030 targets

	Before FIT (June 2012)	After FIT [A] (as of Sep 2017)	Target [B] (FY2030)	Progress [A]/[B]
Geothermal	0.5GW	0.5GW	1.4 - 1.6GW	33%
Biomass	2.3GW	3.5GW	6.0 - 7.3GW	53%
Wind	2.6GW	3.4GW	10GW	34%
Solar PV	5.6GW	42.4GW	64GW	66%
Hydro	48.1GW	48.4GW	48.5 - 49.3GW	99%

By courtesy of Ministry of Economy, Trade and Industry

Agenda

I. Bacground and Objectives

II. FIT and the situation of PV deployment in Japan

III. Challenges of power system operation in Kyushu-area

IV. Demand Supply analysis for Future Requirements

V. Issues and Possible Solutions for Secured System Operation under VRE Penetration

VI. Conclusion

Japan's Long-term Energy Demand and Supply Outlook

- Renewable Energy Feed-in-tariff Program (FIT) [ ] was launched in July of 2012, one year after the Great East Japan Earthquake and Tsunami.
- The heavy and rapid penetration of renewable generation, especially PV, has been affecting the power system operation of each of ten balancing area in Japan depending on the level of the penetration.
- Due to the favorable FIT tariffs, investment in RE has been stimulated. PV with short planning and construction period has shown remarkable increase in FIT permission and actual deployment.

- In this presentation, we describe
  1) FIT and the situation of PV deployment in Japan (Section II),
  2) challenges of power system operation in Kyushu-area, (Section III),
  3) demand and supply analysis of Kyushu-area (Section IV),
  4) issues and possible solutions for secured system operation (Section V) and
  5) conclusion (Section VI).

Progress of RE Deployment under FIT

- The Kyushu-area, in a southern island among four main islands of Japan as shown in Figure 1, is the most severely affected area by PV penetration.
- Its peak load is 15 GW and the minimum day-time load is 8GW, and there is 4.6 GW of nuclear power of five units, two units of those are currently in operation.

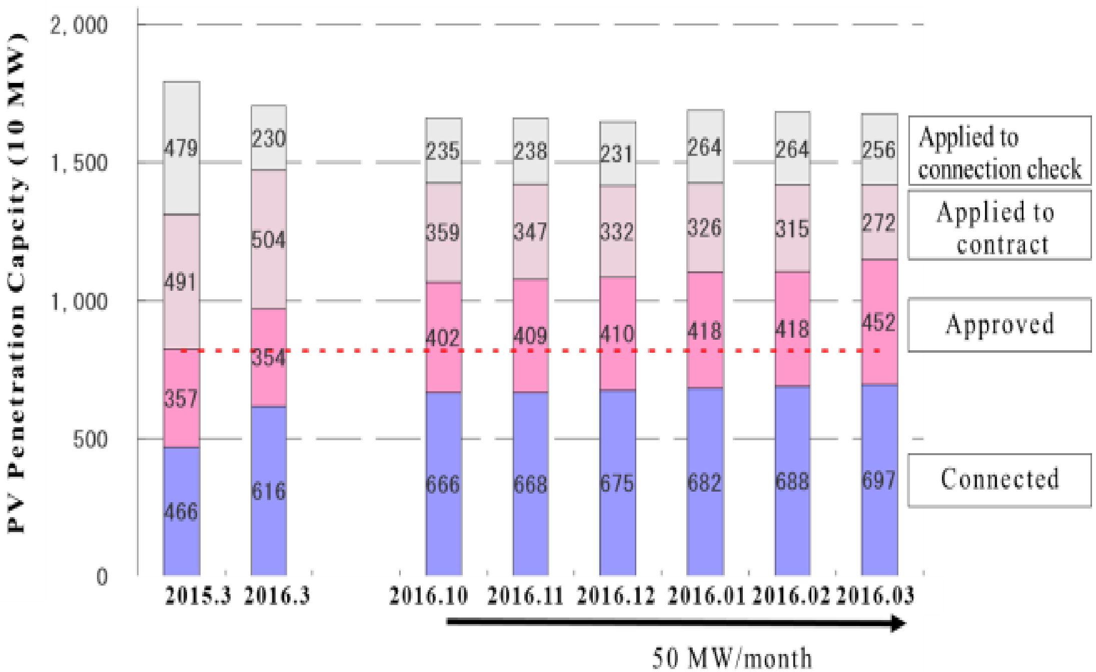


Figure 3 PV deployment in Kyushu

Figure 1. Ten balancing areas in Japan

A. Demand and Supply Situation in the G.W.

- During the G.W. of 2017 (from Apr. 29th to May 7th) the highest temperature was 25 ℃ and the daily peak demands were around 9 GW.
- Through the G.W., the Kyushu area's supply capacity was successfully secured enough to hold the occupied capacity at the level of 85%～90%.

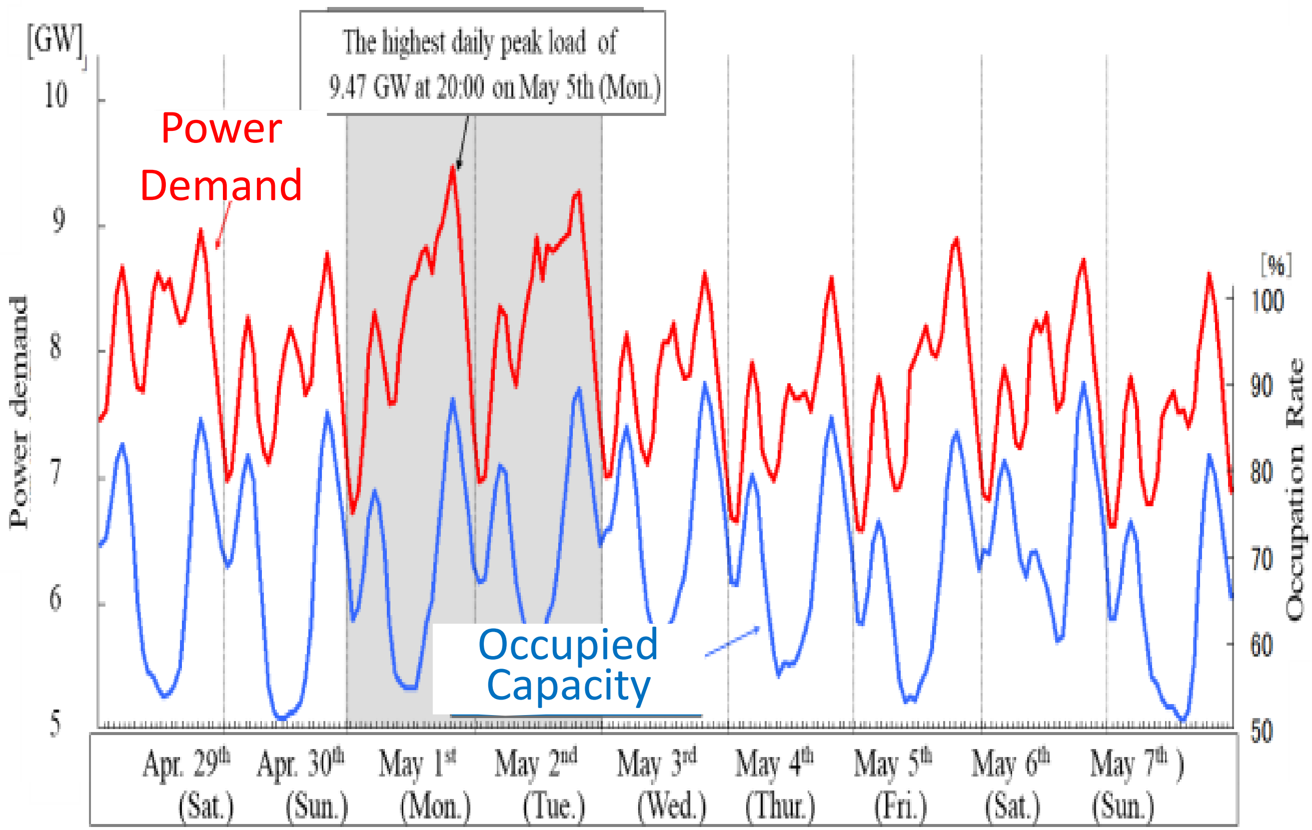


Figure 4. Power demand and capacity occupation during the GW

A. Demand and Supply Situation in the G.W.

- The lowest demand at 13:00 during the G.W. was 7.2 GW on May 4th (Thursday).
- On April 30th, the weather was fine all over the Kyushu Island, the PV output at 13:00 was 5.65 GW and PV share of the demand was 73%.

		Apr. 29th (Sat.)	Apr. 30th (Sun.)	May 1st (Mon.)	May 2nd (Tue.)	May 3rd (Wed.)	May 4th (Thur.)	May 5th (Fri.)	May 6th (Sat.)	May 7th (Sun.)	(ref.) Apr. 23rd (Sun.)
Demand (GW)		8.00	7.70	8.57	8.51	7.61	7.20	7.69	8.29	7.26	8.00
Weather (pm)	Fukuoka	F	F	F	C	F	F	F	F	F	F
	Kumamoto	F	F	F	C	F	C	F	C	F	F
	Kagoshima	F	F	F	C	C	C	C	F	C	F
PV (PV occupation)		5.38 (67%)	5.65 (73%)	4.97 (58%)	4.00 (47%)	3.51 (46%)	3.26 (45%)	4.06 (53%)	2.81 (34%)	4.12 (57%)	6.07 (76%)

Table 1. Demand and supply at 13:00 during the GW. (F: fine, C: cloudy)

B. System op. under the highest PV share on April 30

- At 13:00 when the PV output was at maximum, all the pumped storage plants were in pumping operation, while thermal power plants in low load operation.
- During ramp-up of PV generation in the morning, pumped storage plants made pumping operation (8 units at maximum) and thermal power plants ramped down the outputs and some were shut down.

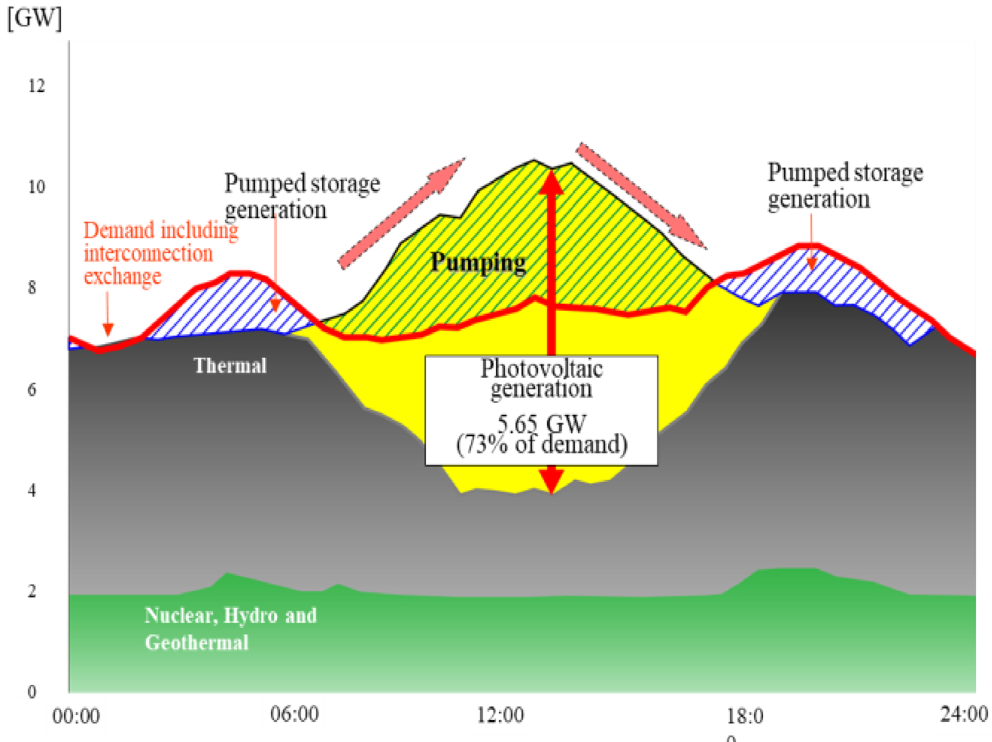


Figure 5. Demand and supply operation on April 30th

B. System op. under the highest PV share on April 30

- LNG Combined Cycke Gass Turbine (CCGT) plants with shorter start-up time picked up the increase of the residual demand.
- The existing typical start-up time is more than 10 hours for a steam turbine generator, and two hours for a typical CCGT. Four CCGT units were made on-line in 15 minutes on April 30th.

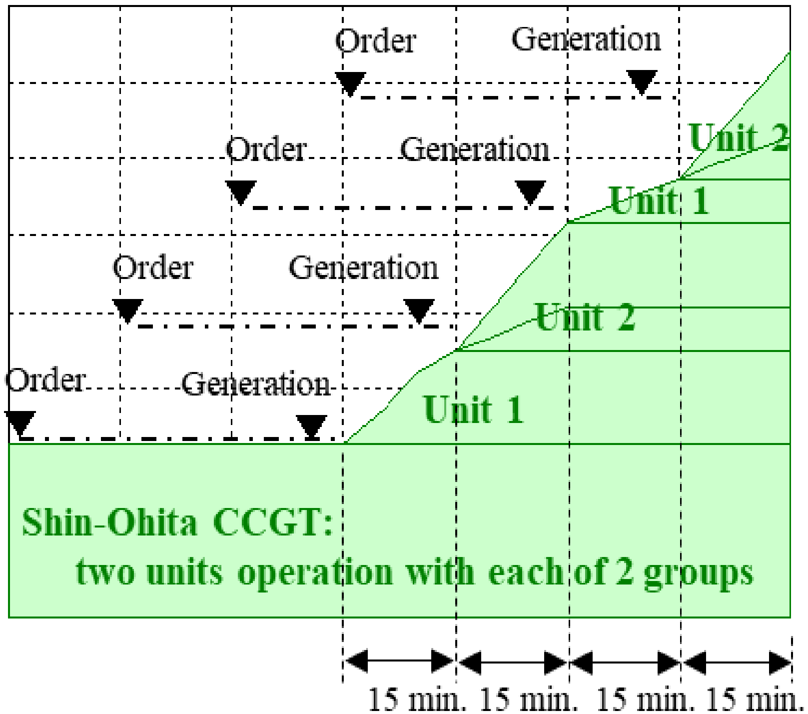


Figure 6. Generation Units Operation during a ramp-up in the evening on April 30th.

C. System Op. under the Largest PV Forecast Error on May 5th

- On May 5th, the actual PV generation was larger than the forecast by 2 GW at the maximum. As the PV generation fluctuates from the forecast

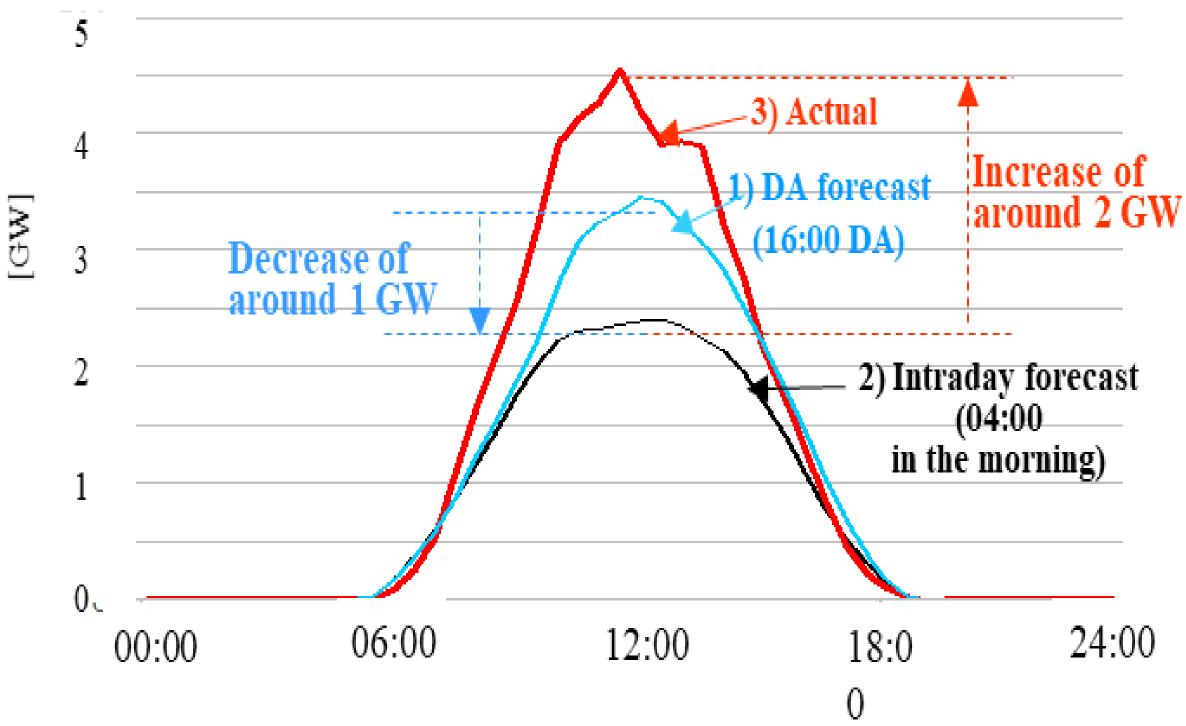


Figure 7. Generation Units Operation during a ramp-up in the evening on April 30th.

C. System Op. under the Largest PV Forecast Error on May 5th

- On May 5th, when the actual PV generation was larger than the forecast by 2 GW at the maximum, the actual system operation was modified as follows as depicted in Figure 8.

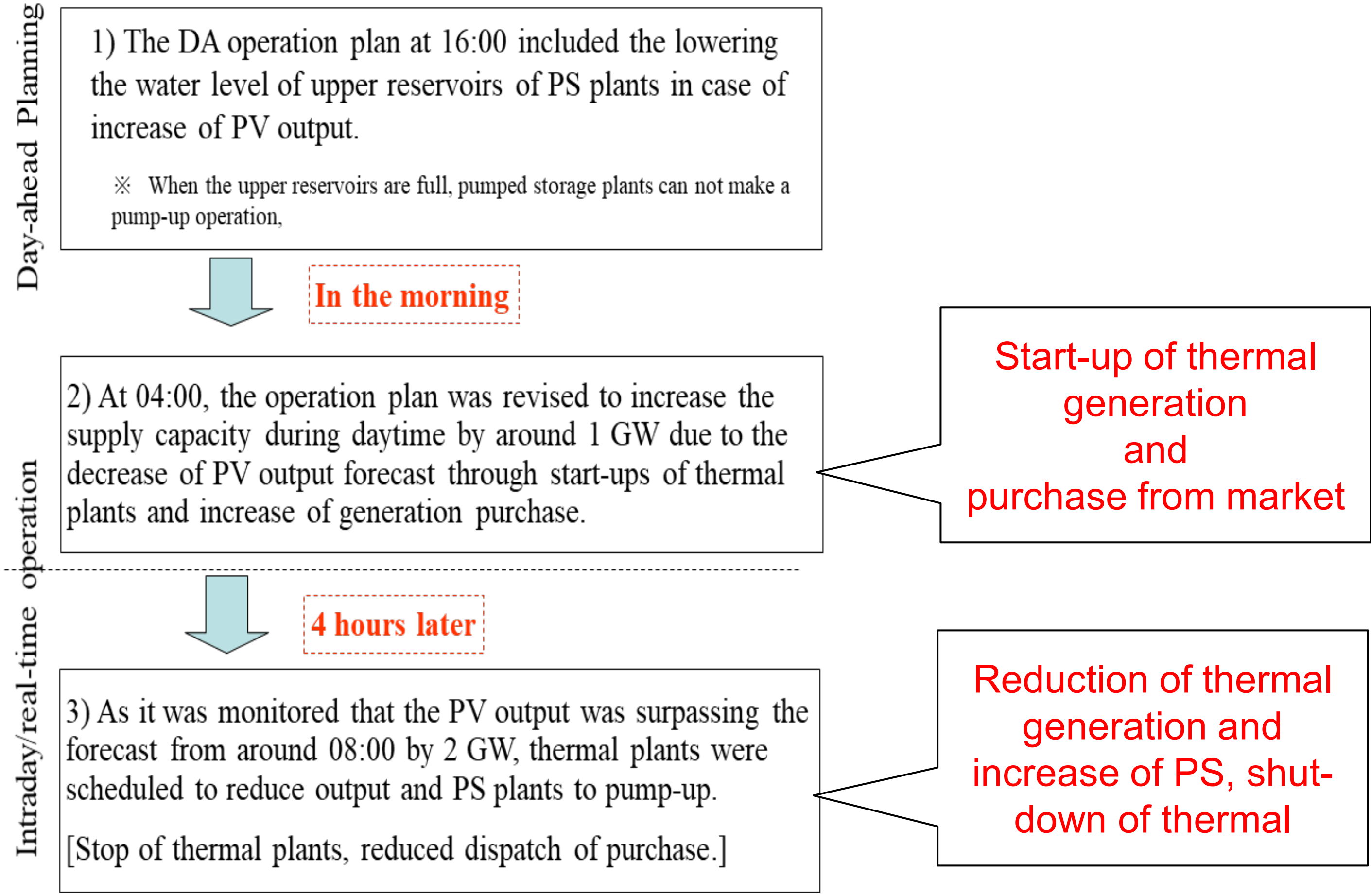


Figure 8. Operation planning from a day ahead to real-time on May 5th

C. System Op. under the Largest PV Forecast Error on May 5th

- Pumped storage plants with short start-up time were useful for the system operation near real time under PV forecast error (Figure 9).
- The large generation surplus almost filled up the upper reservoir (Fig. 10).

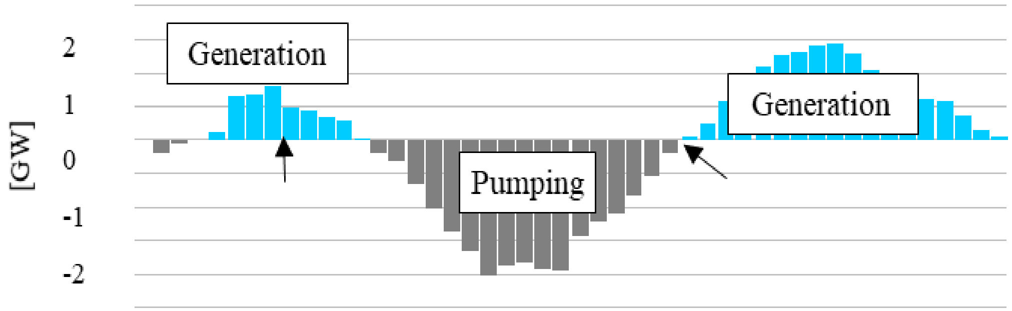


Figure 9. Pumped-storage plants

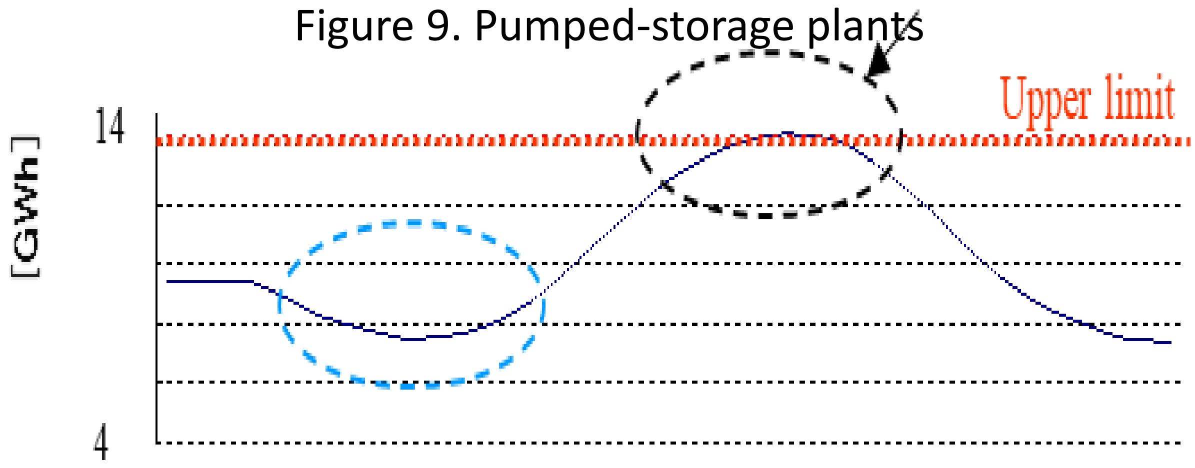


Figure 10. Stored energy of upper reservoirs

A. Assumptions

- ◆Analysis Period: 2030
- ◆Scenario toward 2030

  Japan Government's "Long term energy outlook (2015)"
- ◆Assumptions of Generation facilities and operation

  Power Supply Plans of Power utilities

  Demand: variation according to ambient temperature, EV, HPWH

  Nuclear plants: 20-22% of total generation

  Coal and Gas Power Plants:40 year life, expansion with reserve margin criteria

  Oil fired power plants: No addition, no retirement excluding announced ones

  PV and, wind: Hourly variation of generation

  Hydro: Monthly variation of generation

  Interconnection: No expansion, energy exchange

A. Assumptions: Variability and Flexibility

- Variability or Requirement for LFC capability
  - —Demand variation : 2% of demand
  - —PV generation variation: ±10% of generation output
  - —Wind generation var. : ±5% of capacity

- Supply of LFC capability
  - —Thermal generator : ±5% of capacity
  - —Pumped hydro : ±20% for generation
    ±20% for pumping
    (if variable-speed type)
  - —CHP, Load, and others : not assumed

A. Assumptions: study cases

Case	Generation Dispatch Operation	Interconnection operation	PV capacity (in Japan)	PV capacity distribution
Ei_PV108p/ Ei_PV108b	Economic Dispatch	No	108	Proportional/ Biased
Ee_PV108p/ Ee_PV108b	Economic Dispatch	Energy only	108	Proportional/ Biased
Eb_PV108p/ Eb_PV108b	Economic Dispatch	Energy and balancing capacity	108	Proportional/ Biased
Pe_PV108p/ Pe_PV108b	RE Priority Dispatch	Energy only	108	Proportional/ Biased

Note:PV capacirty in Kyushu: 10.1 GW in the propotional scenario (p)
19.8 GW with the biased scenario (b)

TABLE 2. STUDY CASES OF DEMAND AND SUPPLY ANALYSIS

B. Methodology

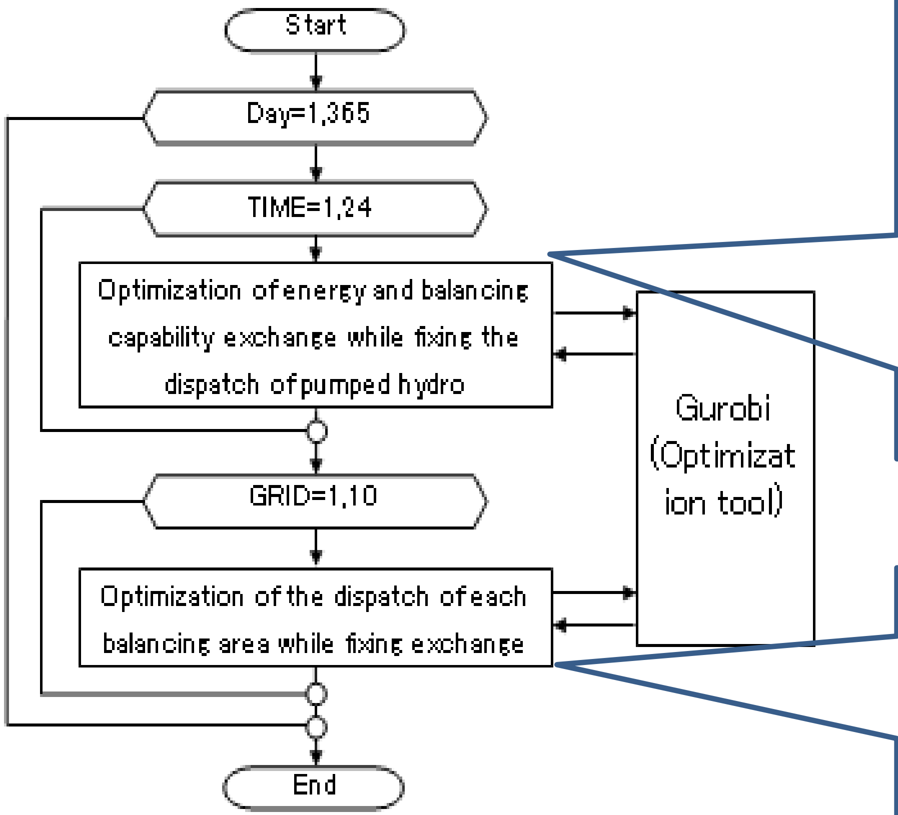
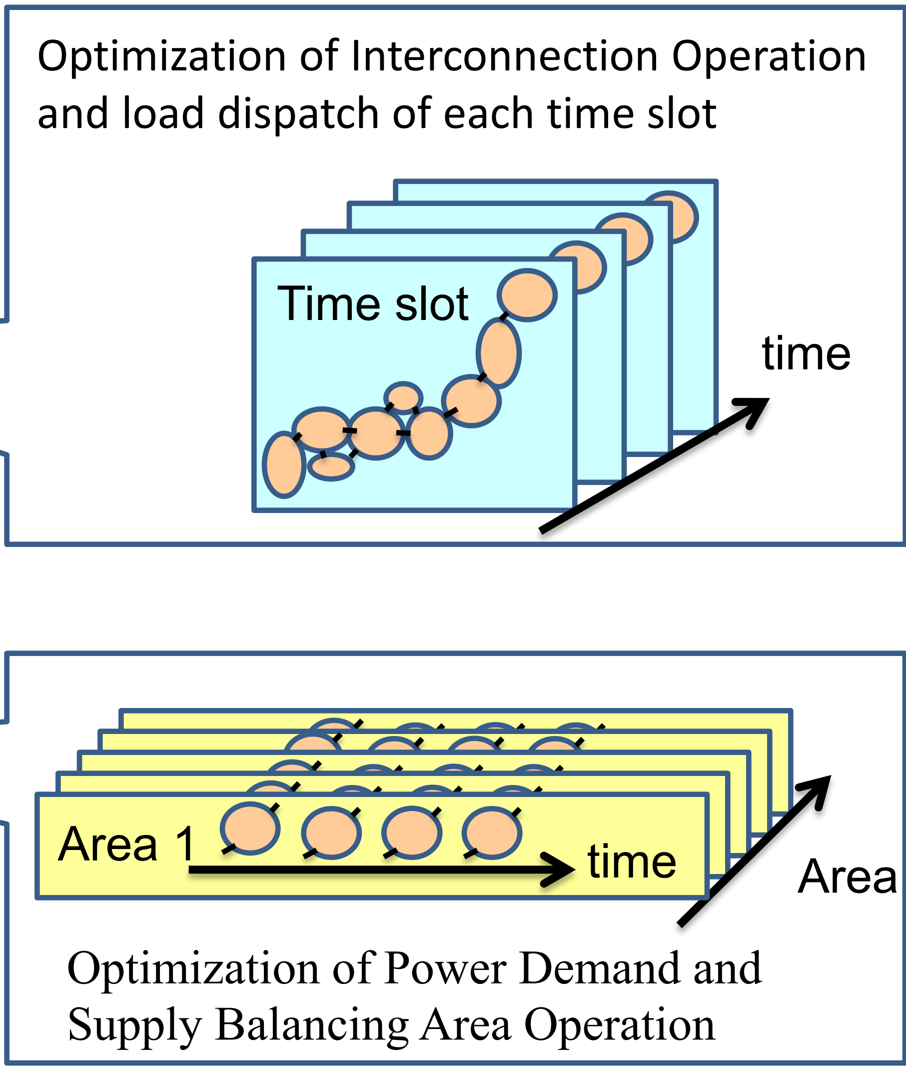
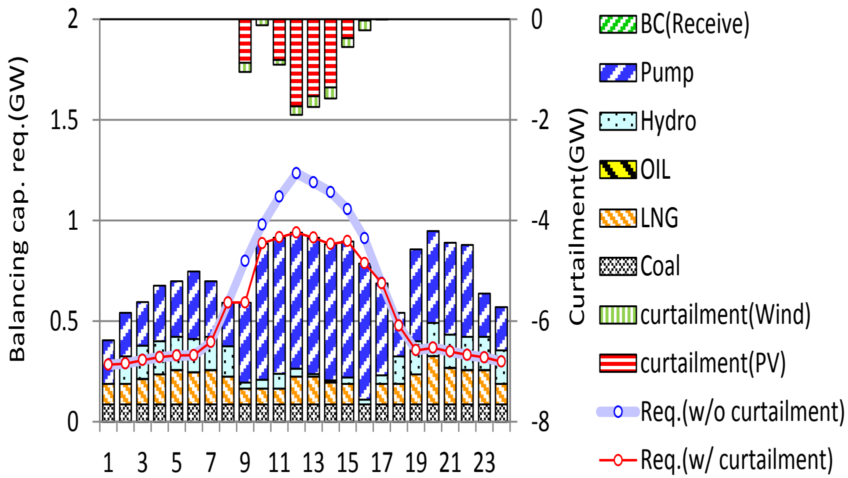


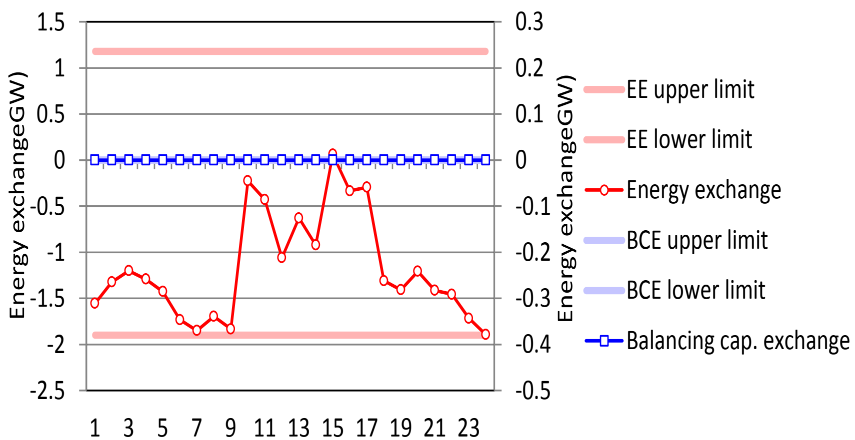
Figure11 Flowchart of power supply and demand analysis tool



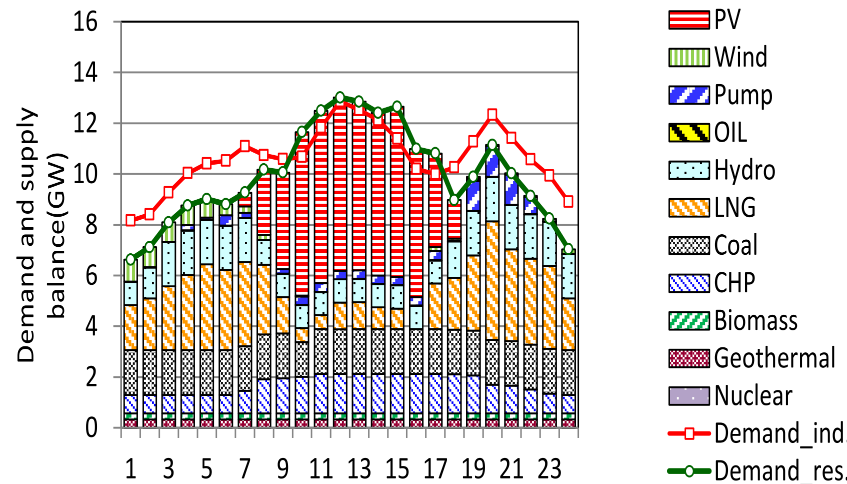
B. Methodology: Example of outputs



Example: LFC capability balance and generation curtailment



Example:Interconnection energy exchange



Example: Hourly demand and supply balance

C. Results: Generation capacity and production

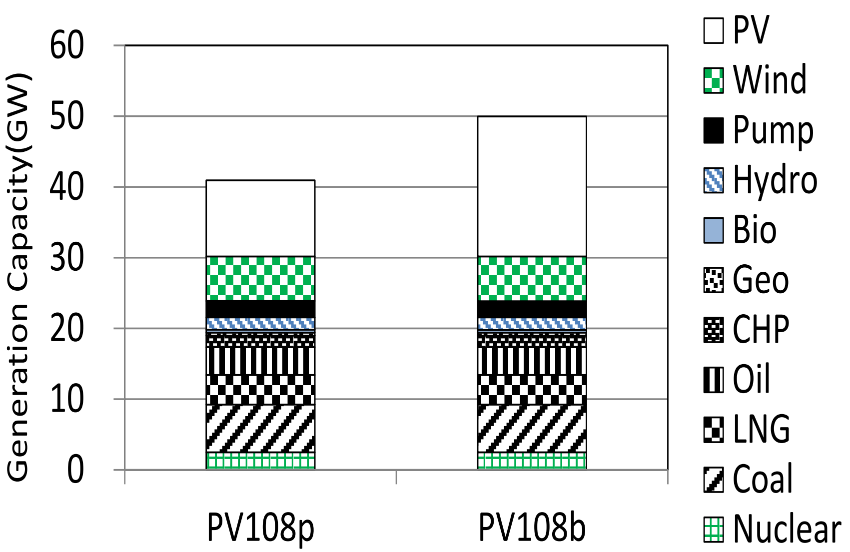


Figure.12 Assumed generation capacity portfolio in Kyushu-area in 2030

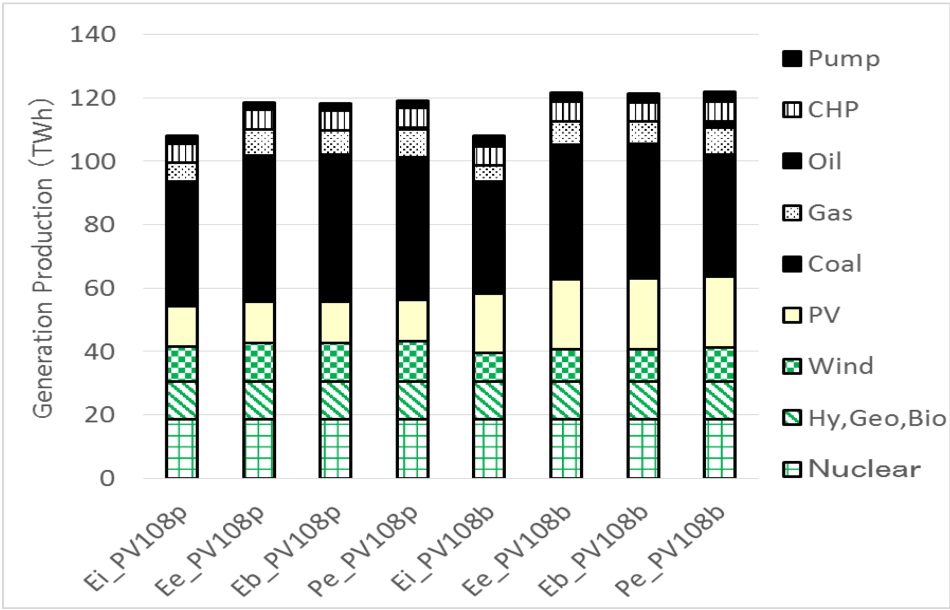


Figure 13 Annual generation by type in 2030

C. Results: Curtailment

- The cases of energy and balancing capacity interchange (Eb PV108) have less curtailment ratios than those with energy only interchange (Ee PV108).
- The cases of priority dispatch (Pe PV108) have the least curtailment ratios among all the cases.

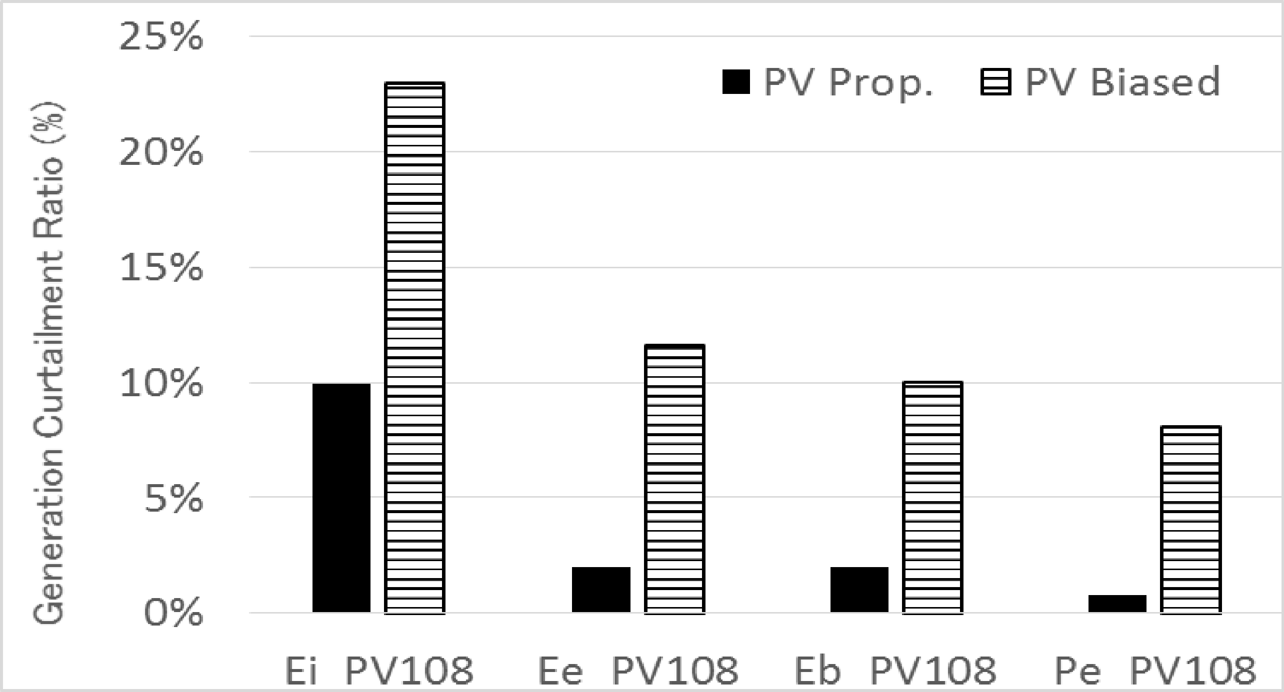


Figure 14 Annual curtailment ratios of PV + Wind generation in Kyushu in 2030

C. Results: Fuel cost and Unit Fuel Cost

- Under energy only interchange, cases with priority dispatch (Pe PV108) have less unit cost (/kWh) than those with economic dispatch (Ee PV108) due to constrained thermal dispatch.

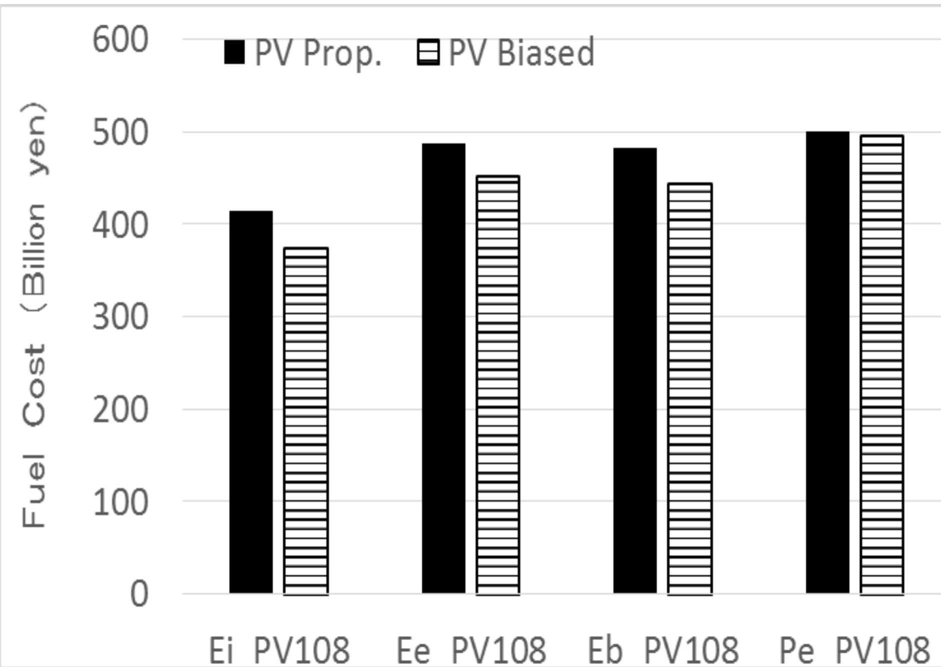


Figure 15 Annual total fuel cost in Kyushu area

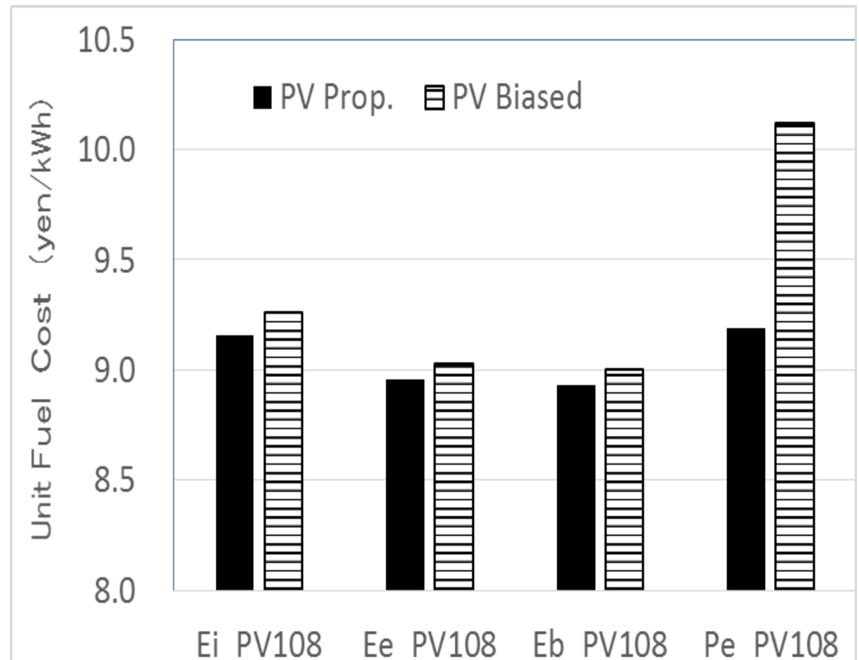


Figure 16 Annual unit fuel cost of thermal generation in Kyushu area

D. Implications from the analysis

- The proportional deployment of PV is economically superior to the biased deployment.
- The economic dispatch is economical than the RE priority dispatch.
- The energy interchange is more cost effective than no interconnection, and "energy and balancing capacity exchange" is further more cost effective.

- For evaluating reliability and stable operation of a power system, it is necessary to simulate forecast errors of power demand, PV, and wind generation forecast, dynamic phenomena including as frequency regulation and frequency dip after major disturbances.
- As the penetration of RE increases, we need more sophisticated framework of analysis and evaluation reflecting technology and institution.

Related Article:

Impact of Photovoltaic Yield Forecasting on Future Power System Operations in Japan

Y. Udagawa, K. Ogimoto, J. Gari da Silva Fonseca (University of Tokyo, Japan), H. Ohtake (National Institute of Advanced Industrial Science and Technology, Japan), S. Fukutome (JP Business Service Corporation, Japan)

A. Generation Forecast

- Although several forecast methods of RE generation are used in system operation in Japan, it is impossible to perfectly avoid large errors.
- The forecast methods are requested to offer probability information and reduce forecast errors by short-term forecast.

B. Robust System Operation

- RE priority dispatch, being logically a constraint on an operation, reduces the economy, as shown in Chapter III, and stability of the operation.
- In the stage of massive VRE penetration, it is necessary to abandon RE priority dispatch.
- It is also important to enhance the system operation by closing decision making nearer to real time utilizing best-available data and information through monitoring and forecast.

C. Enhanced Plant Operation

- Under the inevitable generation forecast error, centralized generation fleet are requested more flexible operation.
- With coal- and gas-fired plants, it is necessary to enhance their operational flexibility including a shorter start-up time, a smaller minimum load, and faster output change.
- Pumped hydro plants, which simultaneously offer larger residual load and frequency regulation service, are expected more flexible weekly operation, simultaneous pumping and generation within a plant, if necessary.

D. Essential RE Plant Operation

- Although grid codes which prescribe the required functions and performance of RE plants are gradually being established in many countries. there arise many additional issues and requirements,
- The additioanl issues should be reflected in a design of RE plant so that they can be utilized in a power system operation effectively.
- Among the issues and requirements, control/management of numerous distributed RE such as roof-top PVs is the emerging challenges.
- The challenges of the treatment of numerous and distributed resources include not only RE plants but also diversified demands and energy storages.

VI. CONCLUSION

- With the massive and geographically-biased PV penetration under the FIT program, several balancing areas are experiencing emerging difficulties of power system operation.
- Comparing the current difficulties and the results of demand and supply analysis, there are several possibilities to improve the RE integration in a sustainable manner.
- The demand and supply analysis of this time assumed a perfect forecast of RE generation and simple planning process of system operation. So as to expand the scope to evaluate security and stable system operation, the study will be continued so that it includes forecast error and multi-step system planning process.

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Thank you

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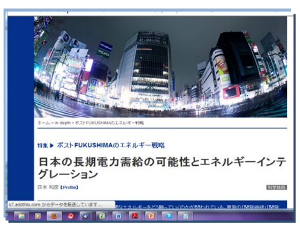

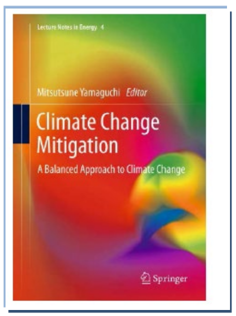

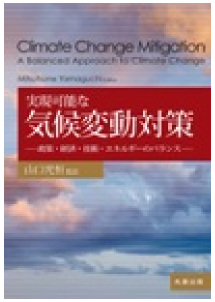

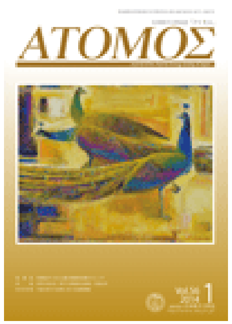

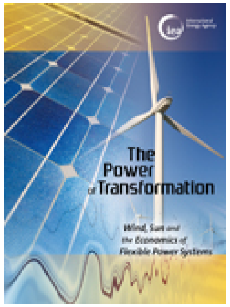

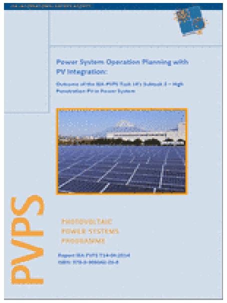

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http://nippon.com/en/in-depth/a00302/

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