IIS Technical Forum
"Rehabilitation after the Great East Japan Earthquake Disaster"

Energy demand and supply, from now to the future

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Main Massages

1. What happened in the power system?
   Huge loss of supply
2. What has been done?
   Support through interconnection lines
3. What are being/will be done?
   Rolling blackout, Restoration of demand-supply gap
4. What should we do now?
   Planning of strategy
5. What are short-term countermeasures?
   Monitoring of power usage,
   Energy saving (methodology and effectiveness)
6. What are mid/long-term countermeasures?
   Optimization under maximum alternatives,
   Energy integration

1. What happened to the power system?

- Generation plants along the pacific coast in north from Chiba have been heavily damaged by the quakes and the tsunami.

- The damaged plants are:

In the Tohoku area,		In the Tokyo area,	
Hachinohe	250MW	Fukushima(1F)	4700MW
Sendai	440MW	Fukushima(2F)	4400MW
Shin-Sendai	950MW	Hirono	3800MW
Haramachi	2000MW	Nakoso*	1630MW
Shinchi*	2000MW	Hiatchinaka	1000MW
		Kashima	4400MW
		Kashima*	1400MW
		SumikinKashima	630MW

* Cooperative Thermal Power Company

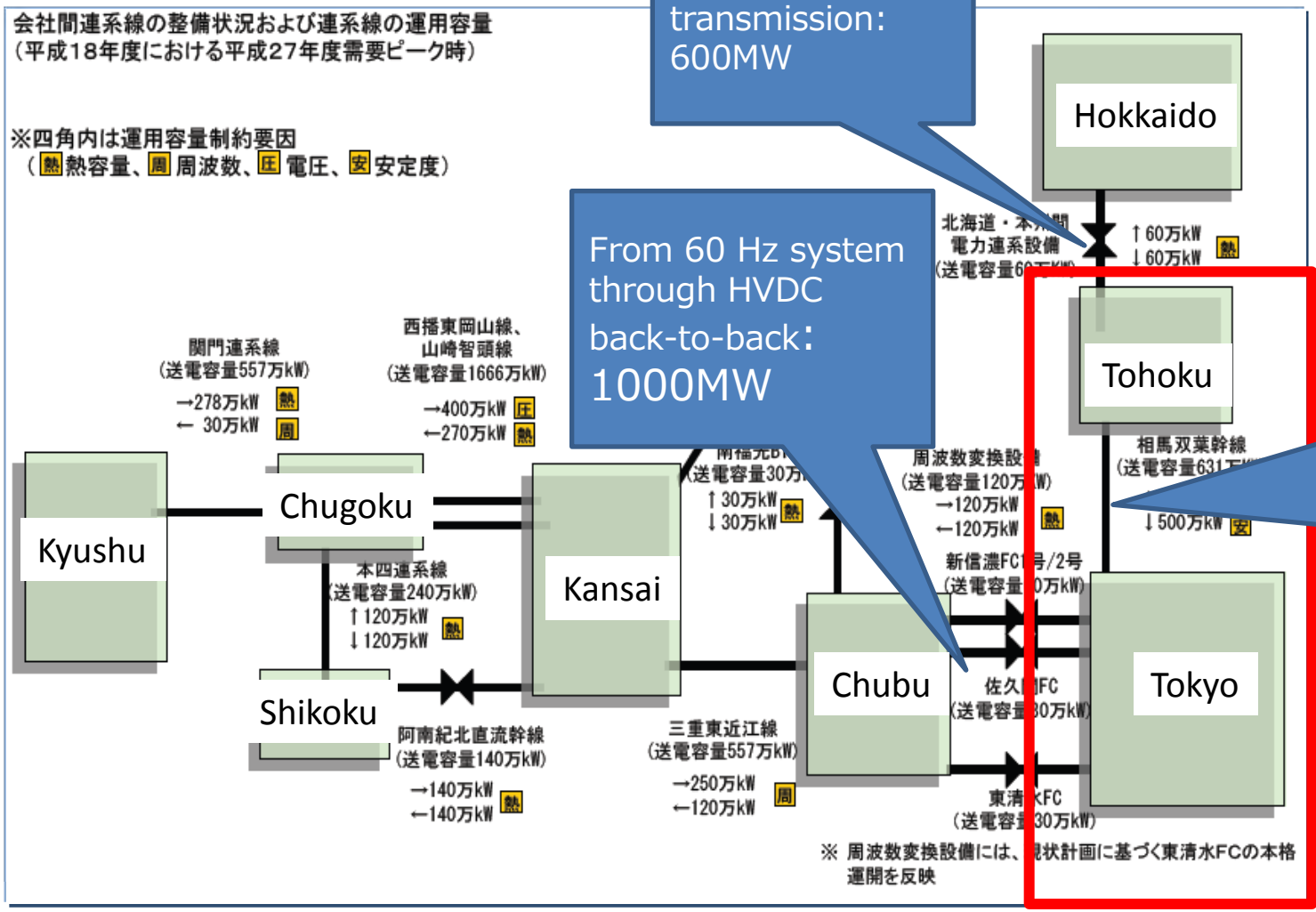
- After March 11, we had severe shortage of power supply when the power demand was still high du to remaining winter demand for heating.

2. What has been done?

Support through Interconnections

From Hokkaido through HVDC transmission: 600MW

From 60 Hz system through HVDC back-to-back: 1000MW



Although capacity of the tie- line between Tokyo and Tohoku is enough, the stable operation was quite difficult and is still difficult.

2. What has been done?
Additional Generation

- Some hydro power plants, which are normally in 60Hz operation, are connected to Tokyo system in 50Hz operation.
  - Sakuma I, II (Shizuoka pref.) 175MW
  - Akiba I, II, III (Shizuoka pref.) 130MW
  - Ontake, Nezame (Nagano pref.) 70MW
  - Yasuoka (Nagano pref.) 20MW

  (Above Supply capacities depend on water dosage)

- Purchasing of existing private power generators in utility companies

  (1000MW in the middle of March, several 1000 MW in April)
- Purchasing of existing numerous small(a few kW)-, medium(a few hundred kW)- private generators in the demand side

2. What has been done?

Rolling Blackout (1)

- In order to avoid unmanageable blackout, power supply to each area has been alternatively suspended in a scheduled manner.
- How does this done?
  - An operator switches-off 66kV transmission lines in 275kV/154kV substation to black-out the connected distribution substations for 6.6kV power supply.
  - As a result, 6.6kV distribution line on poles are de-energized and all the power supply to the demand are suspended.

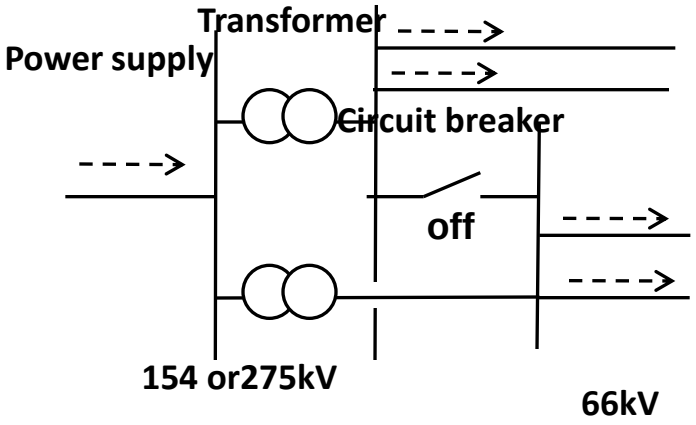


Fig. Normal sub-station operation

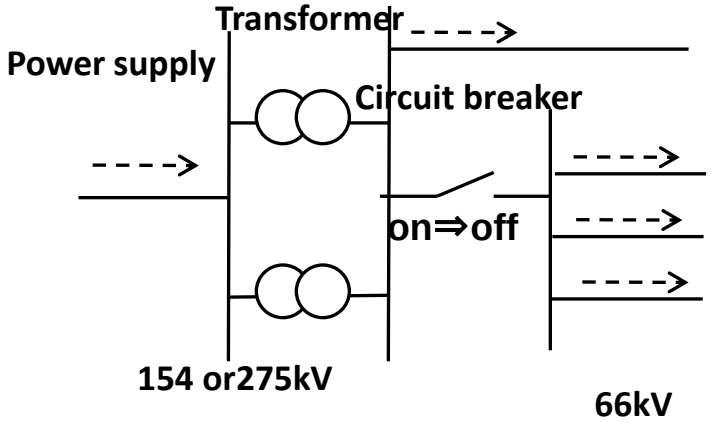


Fig. Sub-station operation in rolling-blackout

2. What has been done?
Rolling blackout (2)

- A supply area of a distribution substation is sometimes largely different from an administration area. The power company tries to avoid a rolling blackout. Those make customers difficult to predict when blackout takes place.
- The rolling black out, even being managed, might cause serious damage to all the social and economic activities including medical facilities such as hospitals.
- At the beginning of the blackout, the operator had to concentrate on secure supply only, because they had no experience. It is however possible to expect the better operation from this day onward.
- Rolling blackouts in the past were small scale and short duration. Nobody has experienced that the large scale and long duration rolling-blackout in the Tokyo area.

2. What has been done?
Rolling blackout (3)

- What is a black-out other than the rolling blackout?

- When the supplied power is smaller than demand, the frequency of the power system decreases. Then under-frequency relays automatically disconnect demands in the system, in order to avoid the whole system down. This causes that timing and areas of the blackout unpredictable. This is called an unmanaged blackout.
- Once an unmanaged blackout happens, many consumers and generators are disconnected from the power system. The restoration of the system often requires from few hours to days.

3. What will be done ?

Demand side

The operation of the two interconnected power systems needs to be stabilized through restoration of supply capacity, energy efficiency, and demand suppression.

TEPCO's Announced that the supply capacity in this July, including reserve capacity for balancing and unpredicted failure, is reserved. For pumped storage, operation during night time should be secured.

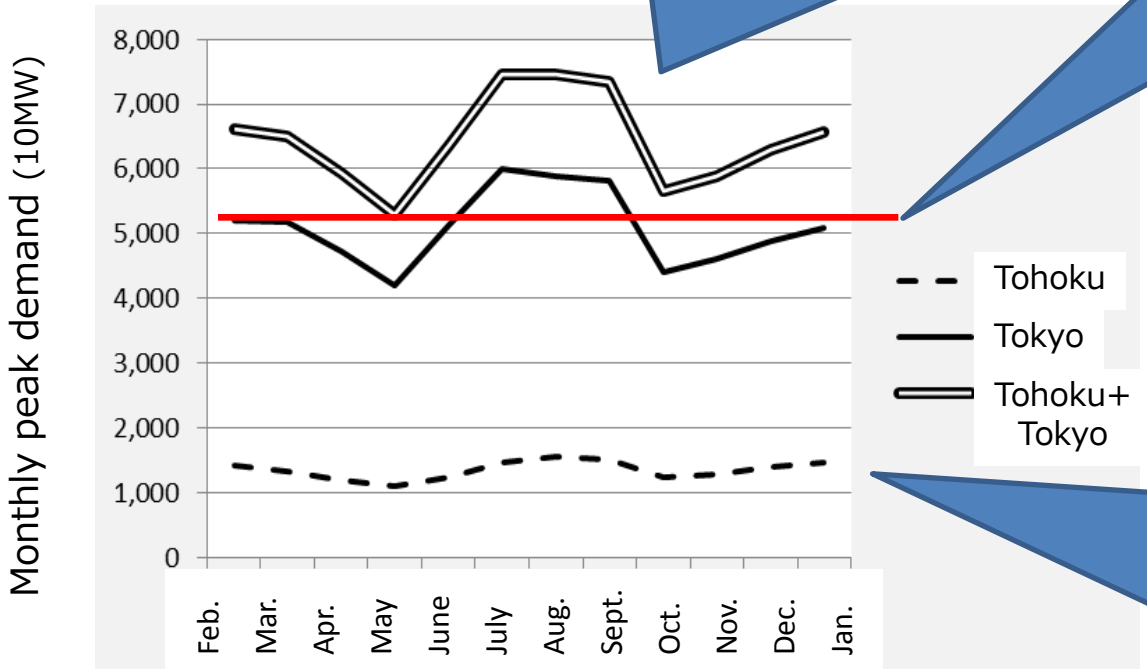


Fig. Monthly peak demand of last one year

Tohoku system, where there is large demand loss due to the quake, did not experienced the rolling blackout.
However, load restoration in coming summer and winter peak is critical.

3. What are being/will be done?
Supply side and balance

- Many thermal power plants are being restored from maintenance, long-term cold reserve and failure in weeks, months, and years. Kashima and Hitachinaka is expected to restore quickly. Note that the restoration schedule of some other quake-damaged plants is still unclear.
- In May, when air-conditioning load is minimum, the supply will cover the demand.

(Tokyo area)

- n summer, when air-conditioning load is maximum, the peak demand will rise to 60GW.
- This summer, more than 15GW will be unavailable because of the damaged nuclear power plants and long-term cold reserve units in restoration.

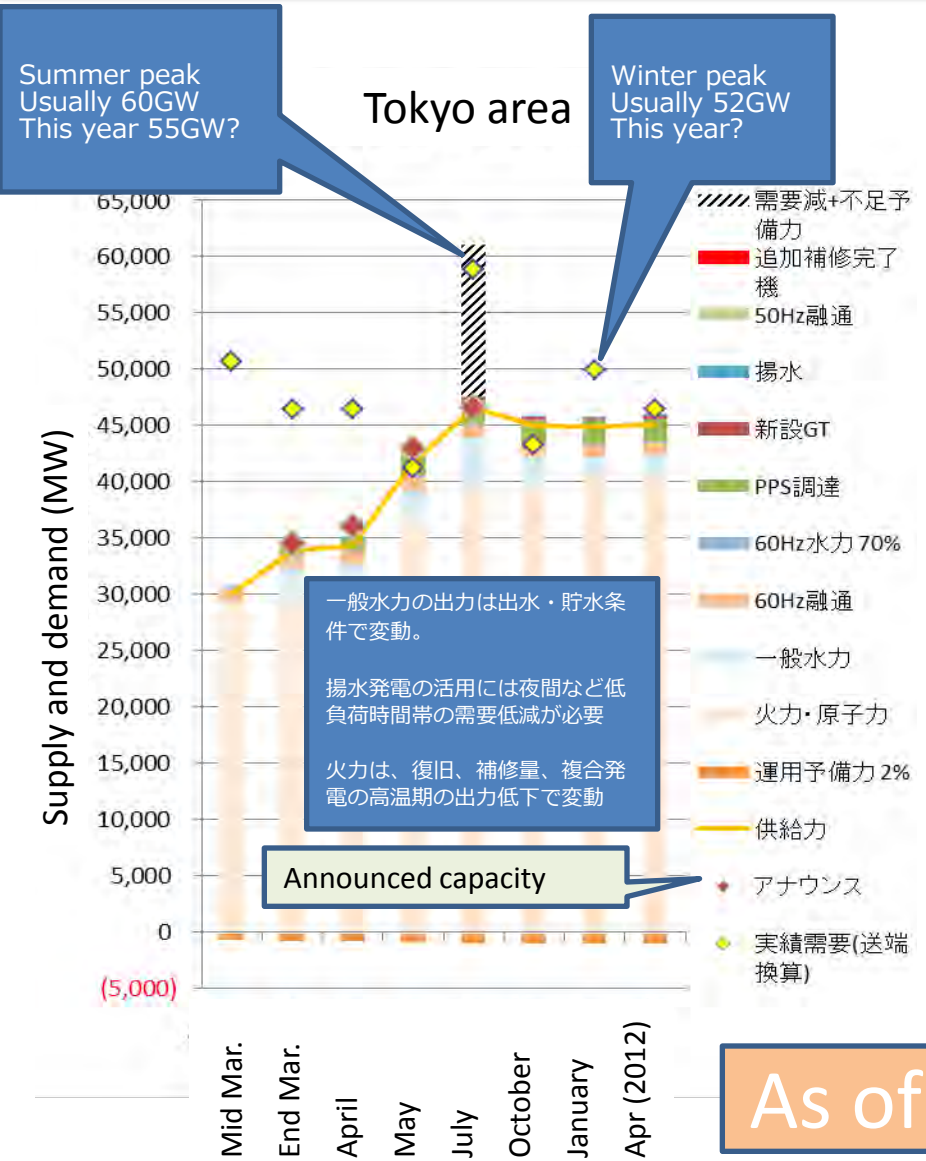
End of July: Demand 55GW ＞ Supply 52GW (including pumped hydro 4GW)

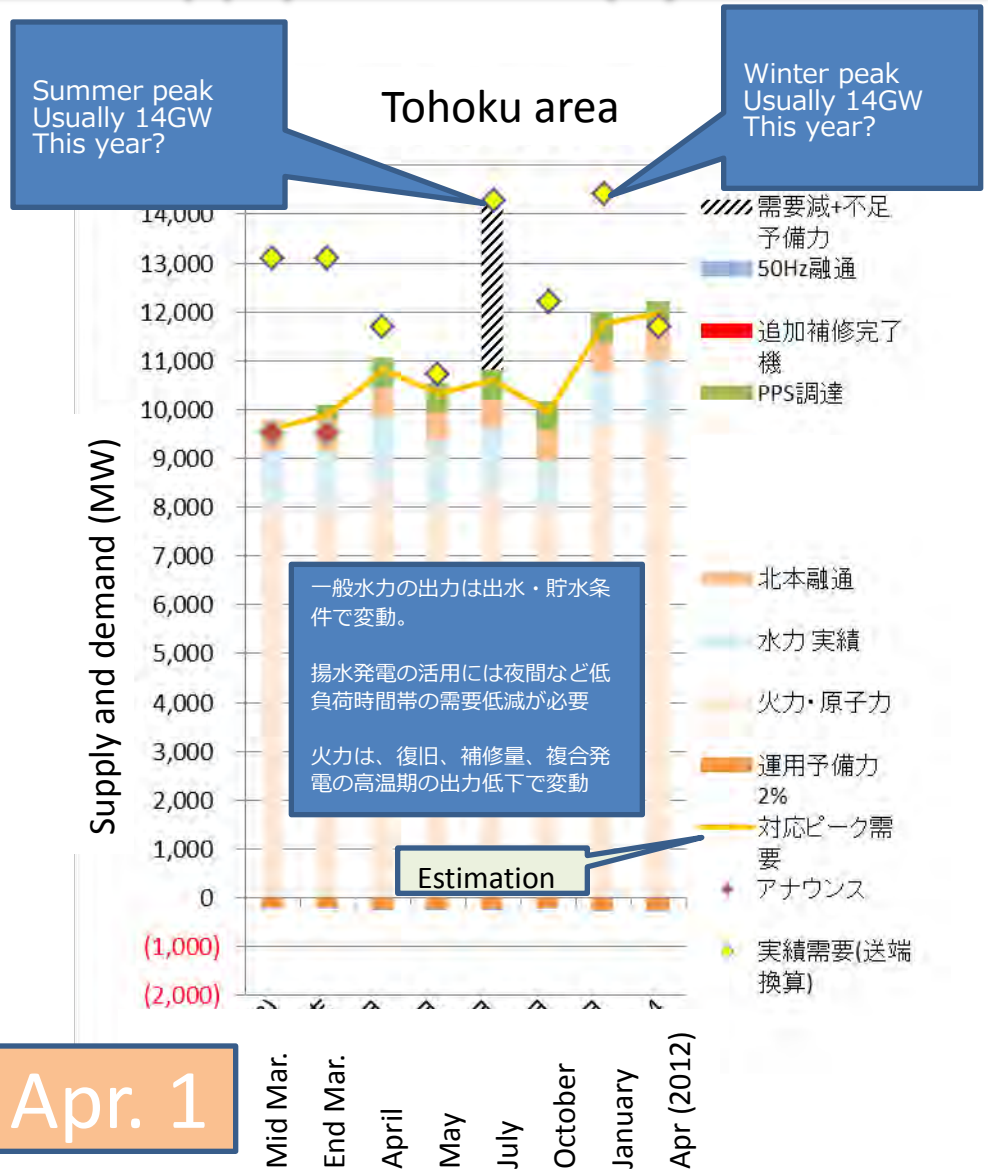
End of August: Demand 55GW ＞ Supply50.7GW (Kashiwazaki nuclear plants in maintenance)

- In winter, when heating load is maximum, demand may be larger than supply.

4. What should we do now?

Restoration of demand-supply balance (1)

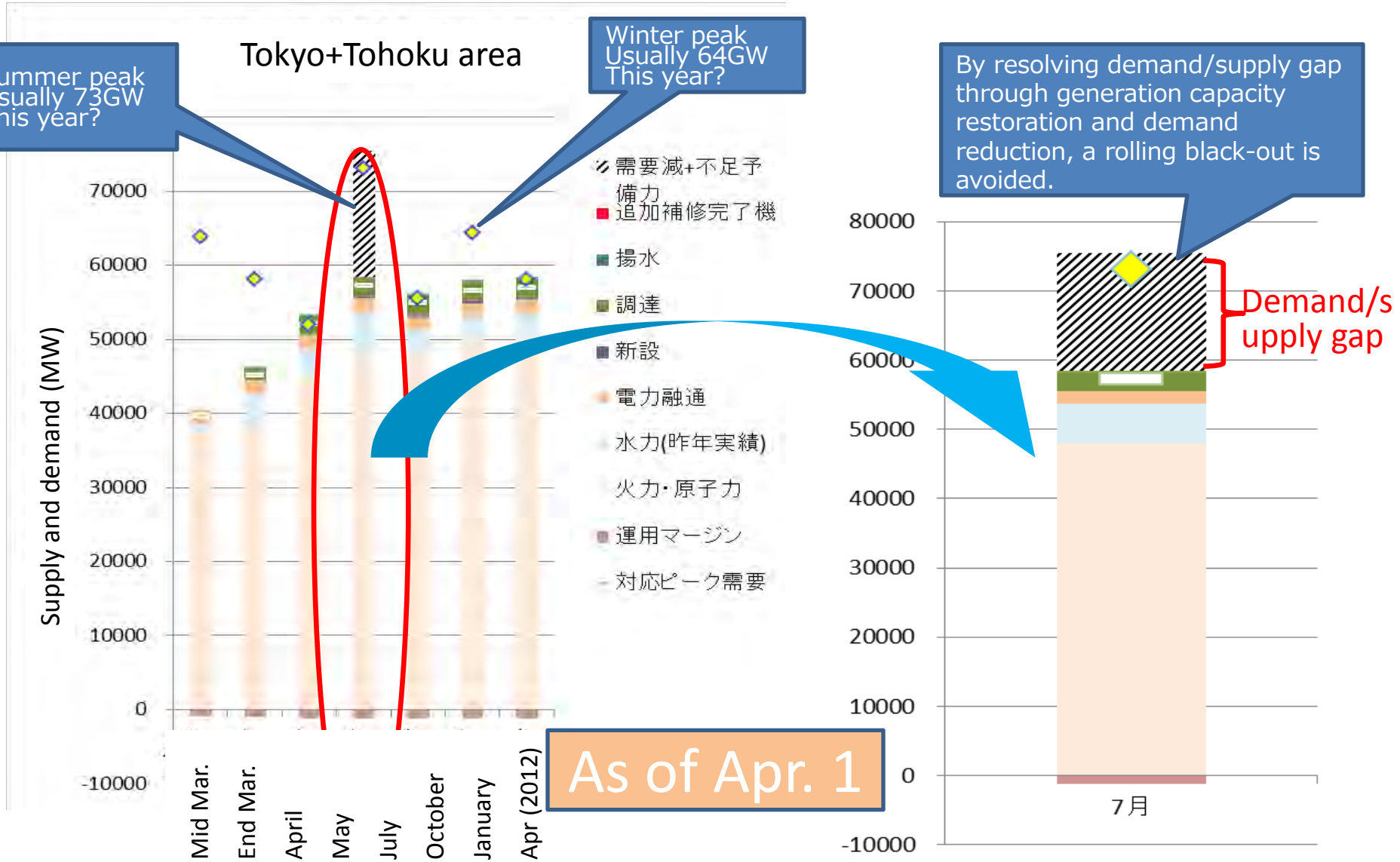




As of Apr. 1

4. What should we do now?

Restoration of demand-supply balance (2)



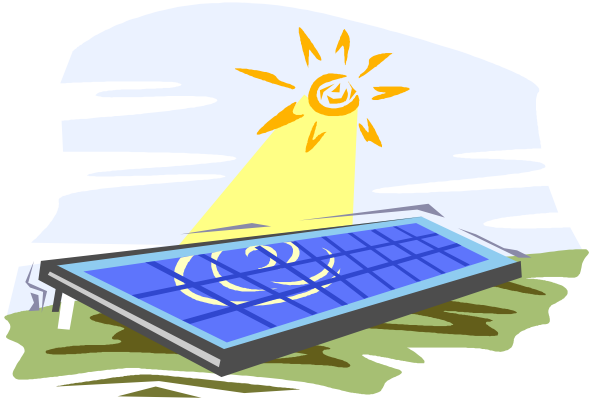
4. What should we do now?
Planning of Strategy

- To clarify the short (this summer), mid (a few years) , and long (10 years) term goal and strategy
  - Should avoid to discuss the strategy which dose not match the short term goal
  - Too much emergency strategy might cause negative effect, if the strategy dose not match the mid/long term goal

- To restoration from the “bleeding status”
  - To secure the supply to match the peak load, in order to avoid “economic meltdown” due to a power supply interruption.
  - To minimize additional fuel cost (Loss of one 1350MW nuclear annually requires 100 billion yen (or 1b$) for fuel.

5. What are short term efforts?
What CANNOT we do for in one?

- To increase the interconnection capacity between 50Hz and 60Hz or others relating frequency.
- Need several years to commission new major thermal plants, excluding low efficiency G/T
- Install of new distributed generation including PV and wind as major supply capacity



- One 1350MW nuclear unit is comparable with 10GW PV, while existing PV accumulated deployment in Japan is 2GW.
- When the demand-supply balance is improved as a total, the kW of PV will be effective to reduce a summer peak load.

5. What are short term efforts?
What we can do

- Reduction of demand: energy efficiency and demand suppression
- Install of New generation capacity: limited to quickly deliverable ones such as G/Ts and combustion engines
- Utilization of existing non-utility generators
- New deployment of distributed generation including PV and wind, in line with long-term goal
- Advanced commissioning of planned new generation, if any.
- Temporary hand-over of works to outside 50Hz area.
- Resume operation of existing nuclear plants of temporary off-line maintenance

➢ Kashiwazaki-Kariha II, III, IV can supply 3300MW this summer. Combination with pumped hydro plants offers us more than 5000MW peak supply.

6. What are mid/long-term efforts?
Example of countermeasure

<Supply side>

- Planning including lessons learned
- Reinforcement of the interconnection between 50Hz and 60Hz
- Deployment of 50Hz/60Hz generator between 50Hz and 60Hz systems
- Diversification of generation including PV and wind
- Reinforcement of transmission system to support generation diversification

Countermeasures only by supply side is economically inefficient.

<Demand side>

- Planning including lessons learned
- Finding and eliminating unnecessary demand
- Introduction of Energy saving mode
- Energy monitoring by a distributed EMS
- Demand activation by a distributed EMS

6. What are mid/long-term efforts?
Optimization under maximum alternatives

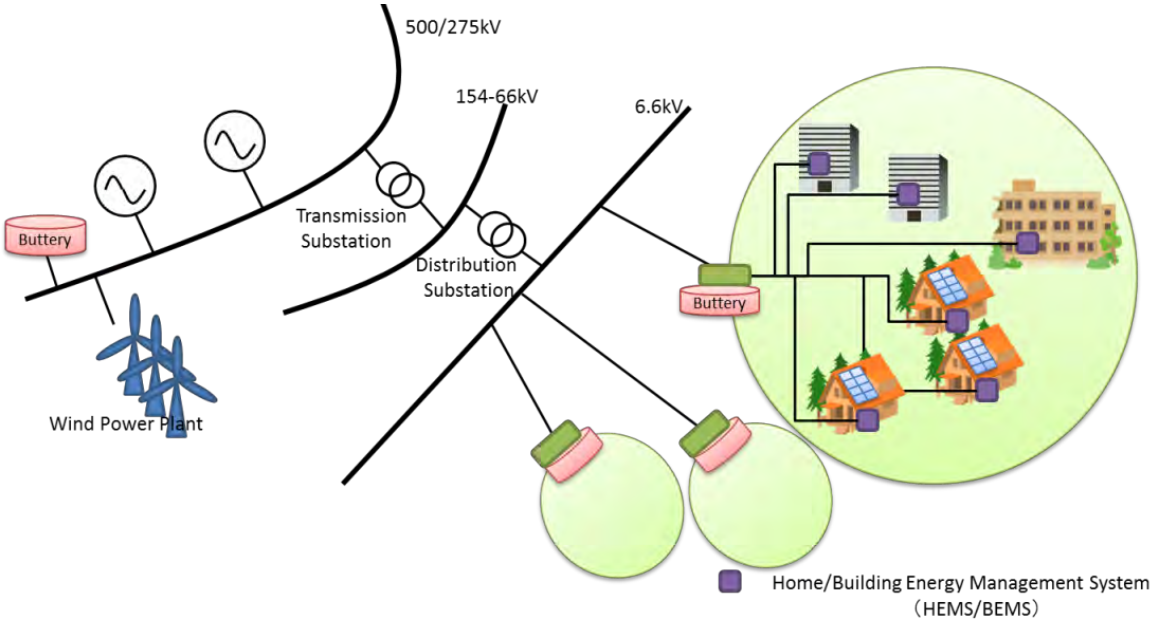
- Scope of Optimization

  ⇒ Optimization with maximum alternatives, geologically, technologically, ...

A house->a community -> an area -> a country->the world

However, there are some constraints of technology, security, economy, controllability and so on.

Reinforcement of transmission system and demand activation should be important targets.



6. What are mid/long-term efforts?
Energy Integration

- Energy provides basis for mankind's activity. Usage of energy directly affects welfare of the human activity to reduce economy and quality of life.
- Future structure of energy demand and supply has to be designed to provide stability, security, and sustainability, by taking into account resource constraint, environmental constraint, and social uncertainty.
- Key to construct sustainable energy demand and supply structure is the combination of technology, institution, and human activity.
- Long term vision is essential to establish energy technology, social institution, and better life style.
- It is highly desirable to vision the future scenario and then to make steady effort toward the its realization.

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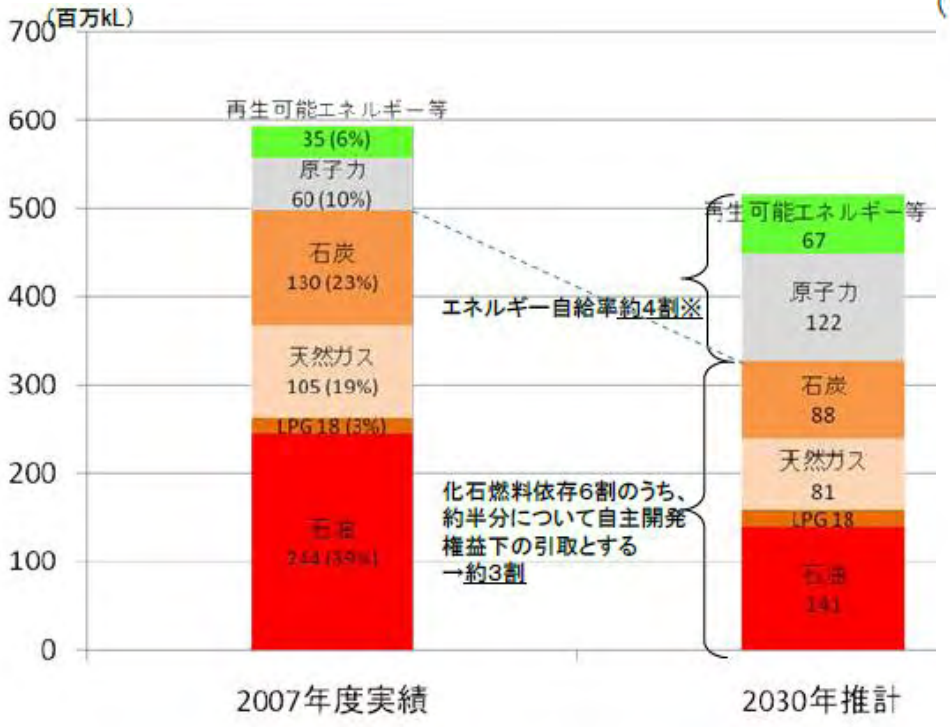
Thank you for your attention

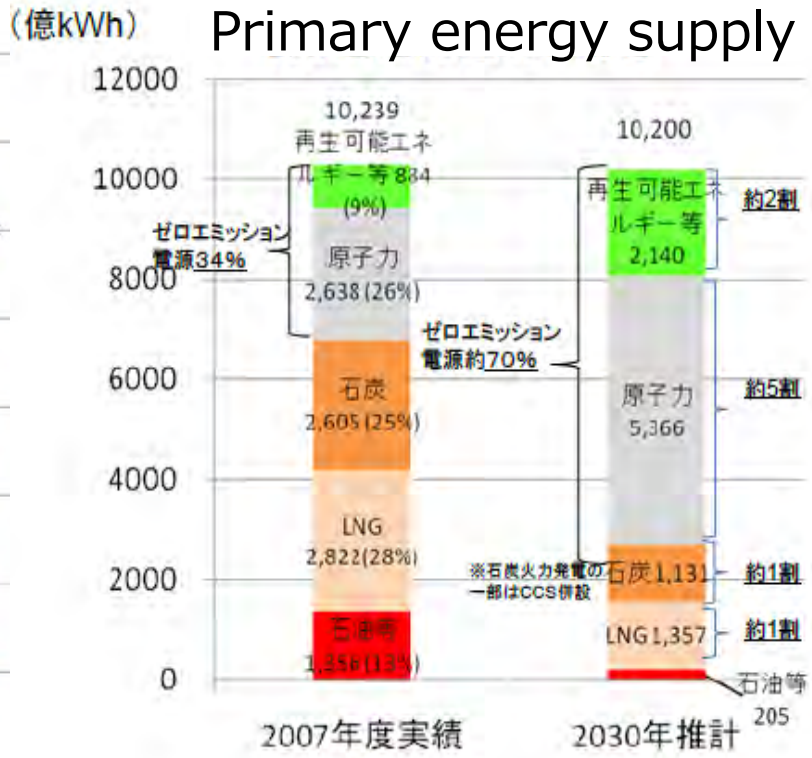
Long term goal: Energy supply at 2030

- “Energy master plan by ”Agency for Natural Resources and Energy

Primary energy supply



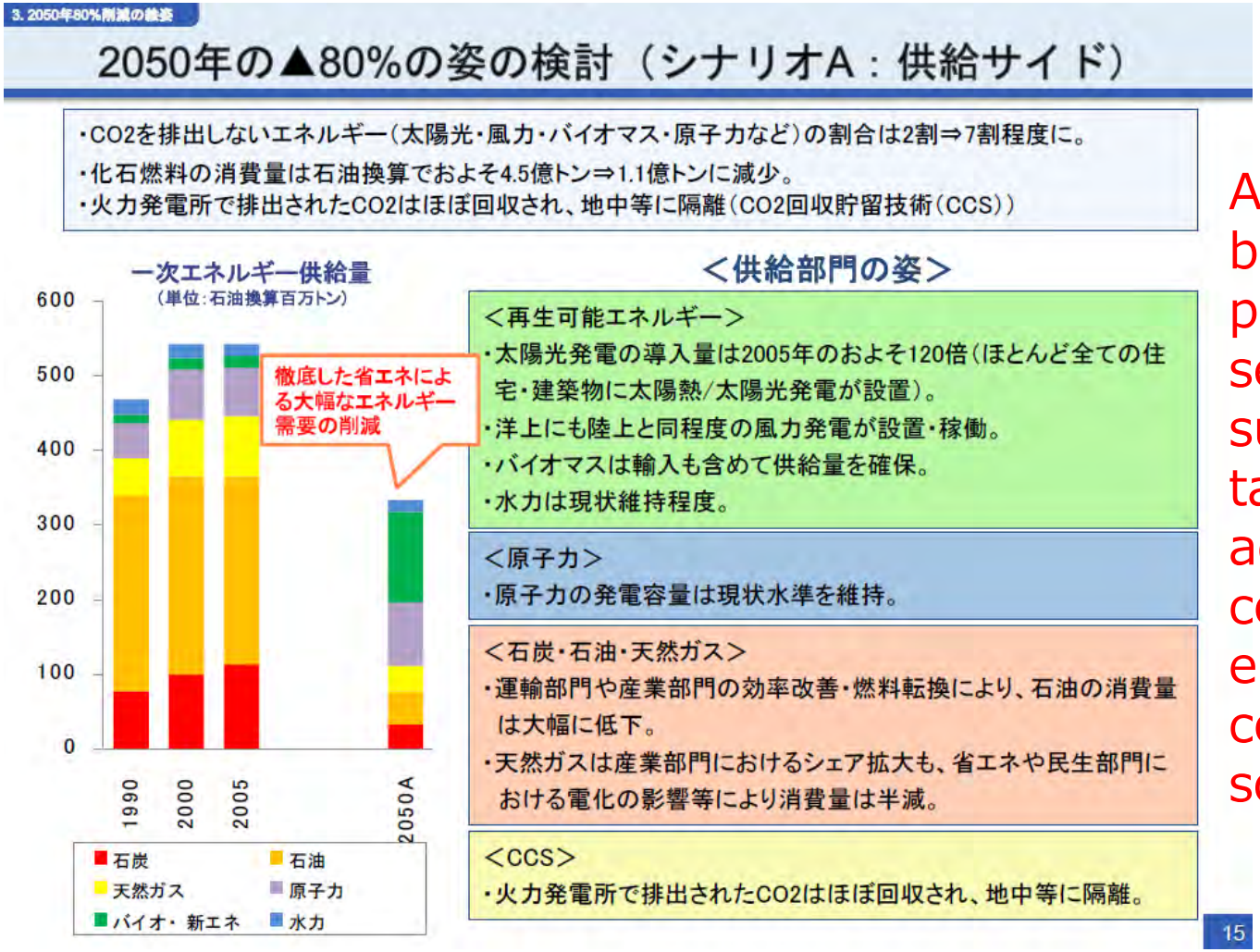
Primary energy supply



Substantial transformation is difficult to obtain within 10-20 years.
Robust plan, such as “Energy master plan” is essential.

Long term goal: demand and supply at 2050

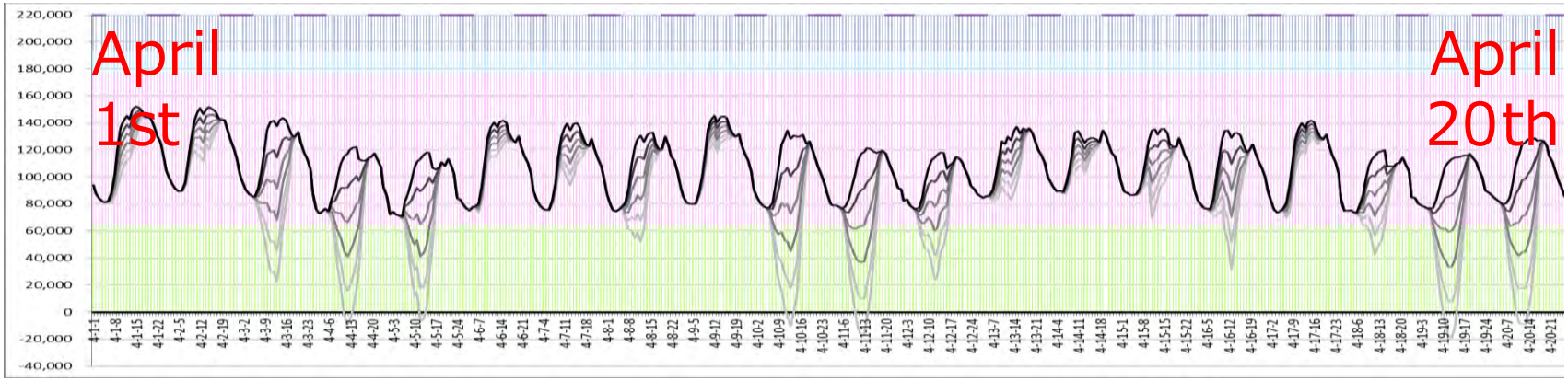
- Ministry of the Environment “mid/long term roadmap”



A strategy has to be established to provide stability, security, and sustainability, by taking into account resource constraint, environmental constraint, and social uncertainty.

Suggestion from extreme case
Need for demand activation

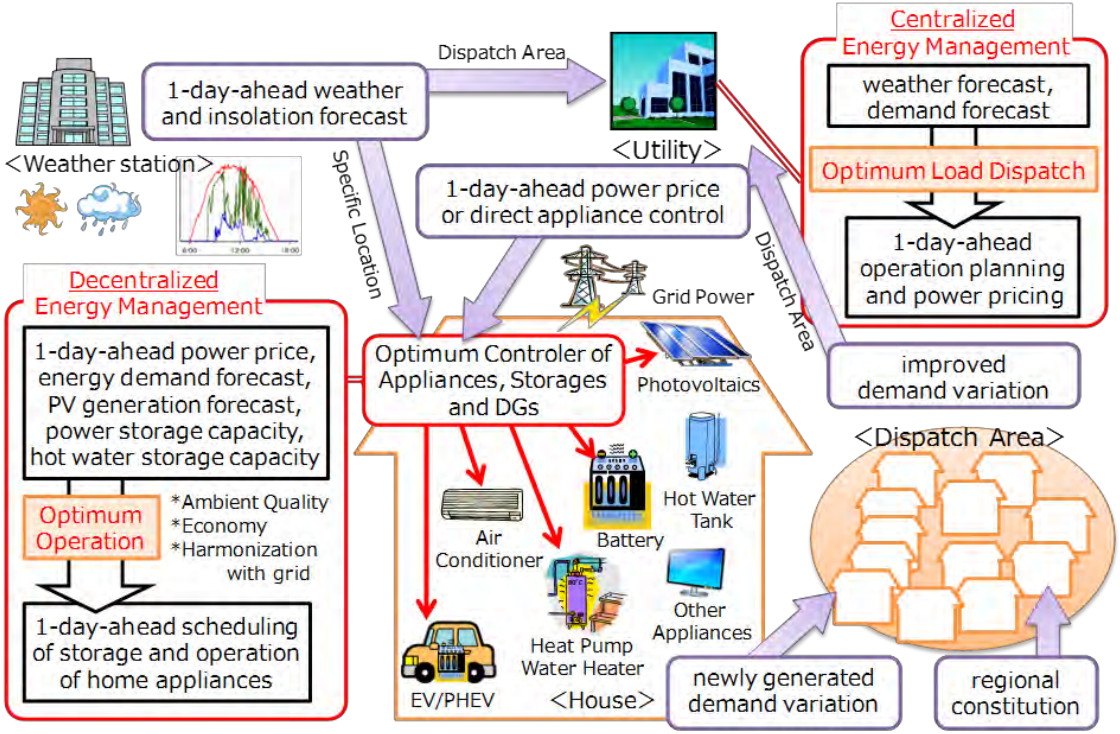
- Equivalent demands for PV share: 4, 8, 12, 16, 20% at 2030



- Balancing demand and supply is getting hard as share of variable renewable generation increases.
- Step-by-step deployment of countermeasures is needed to settle the balancing problem.
- Need for additional balancing capability can be increased firstly through utilization of existing thermal and hydro power plants, and later through demand activation.
- Energy security is re-acknowledged after the quake.

Balancing capability by demand activation

- New schedulable load: charging of EV, heat pump water heater and a battery
- These new needs will be utilized to provide more balancing capability to a power system using the distributed EMS.



- Smart meters
- HEMS, BEMS
- Control of EV charging
- Battery

⇒ Provide more flexibility even against emergency situation through the increase of balancing capability in the various situations