Applications of secondary-battery technologies to realizing a low-carbon society

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CRIEPI

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Applications of secondary battery technologies for low carbon social realization

1. Background: Realizing a low-carbon society
2. Popularization of EVs to lower CO2 emission in transport sector
3. Stabilization of power grid connected with unstable renewable energy sources of PV and WF
4. Li ion battery Energy Storage System for energy storage system and Evs
5. Summery

1. Realizing a low-carbon society

- Carbon dioxide (CO_2) emissions from power supply systems and energy demand must be reduced.
- Renewable energy power generation often provides a low-carbon but unstable electric power supply.
- Energy storage is essential for a resilient and efficient power grid connected with renewable energy sources uncontrolable
- Combining low-carbon electric power and high-efficiency electric technologies enhances CO_2 emission reductions.

Reduction targets for CO_2 emissions in various sectors in Japan

(set in July 2015, before the COP21 meeting)

	Emissions target in 2030 (M ton-CO_2)	Estimated emissions in 2013 (M ton-CO_2)	Emission reductions (M ton-CO_2)	Reduction ratio (%)
CO_2 emissions from energy sources	927	1235	308	25%
Industrial	401	429	28	7%
Commercial and others	168	279	111	40%
Residential	122	201	79	39%
Transportation	163	225	62	**28%**
Energy conversion	73	101	28	**28%**

- Emissions in Energy conversion and Transportation sector are expected to be reduced by 28%. Popularization of EV & PHV should be accelerated by improvements in energy efficiency to reduce CO_2 emissions.

Realization of a low-carbon society

① Use of low-carbon electricity

② Use of energy-saving technologies

Demand side

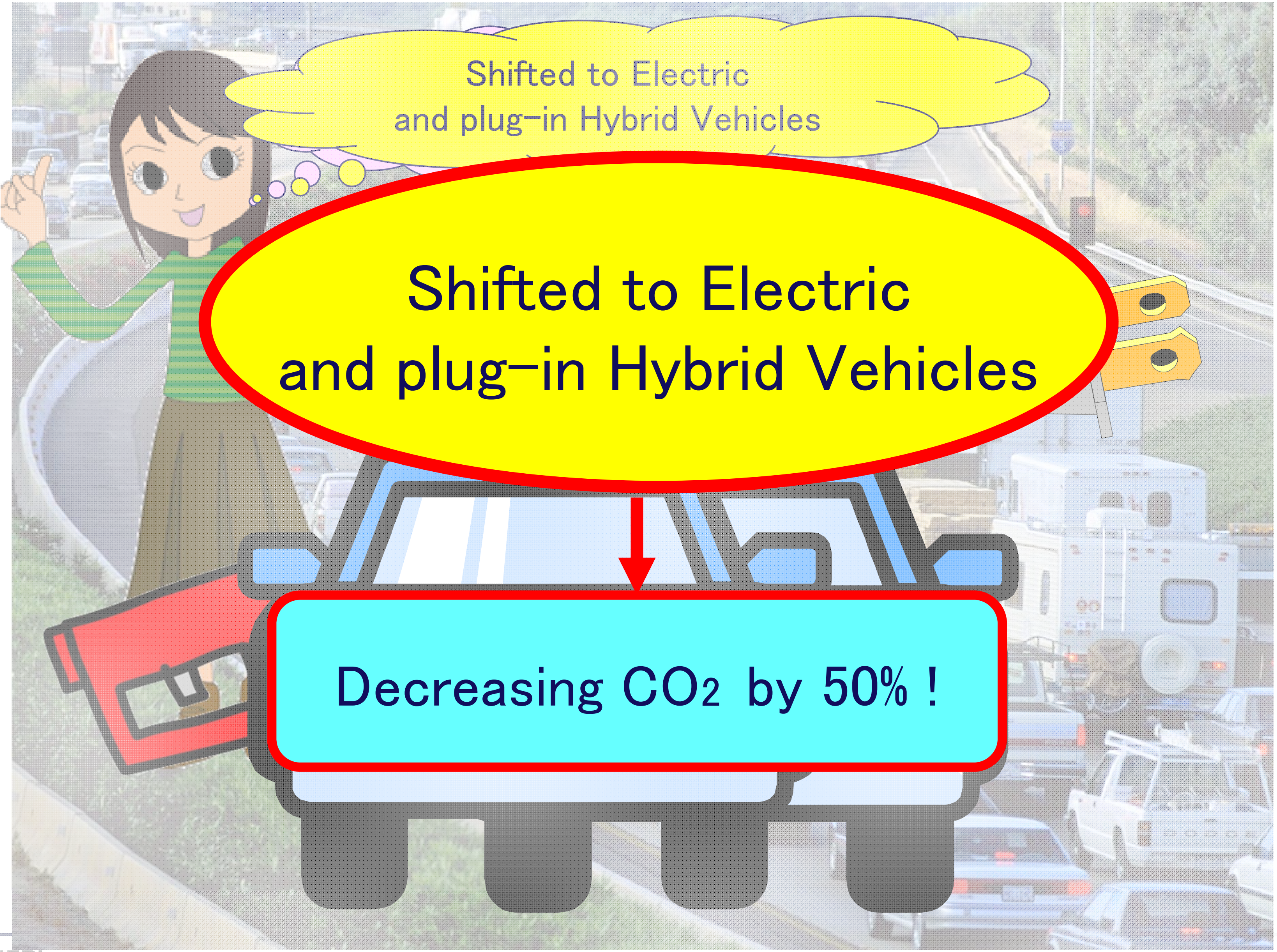
Supply side

High−efficiency technology

Low CO_2 energy

Significant reduction of CO_2 emissions

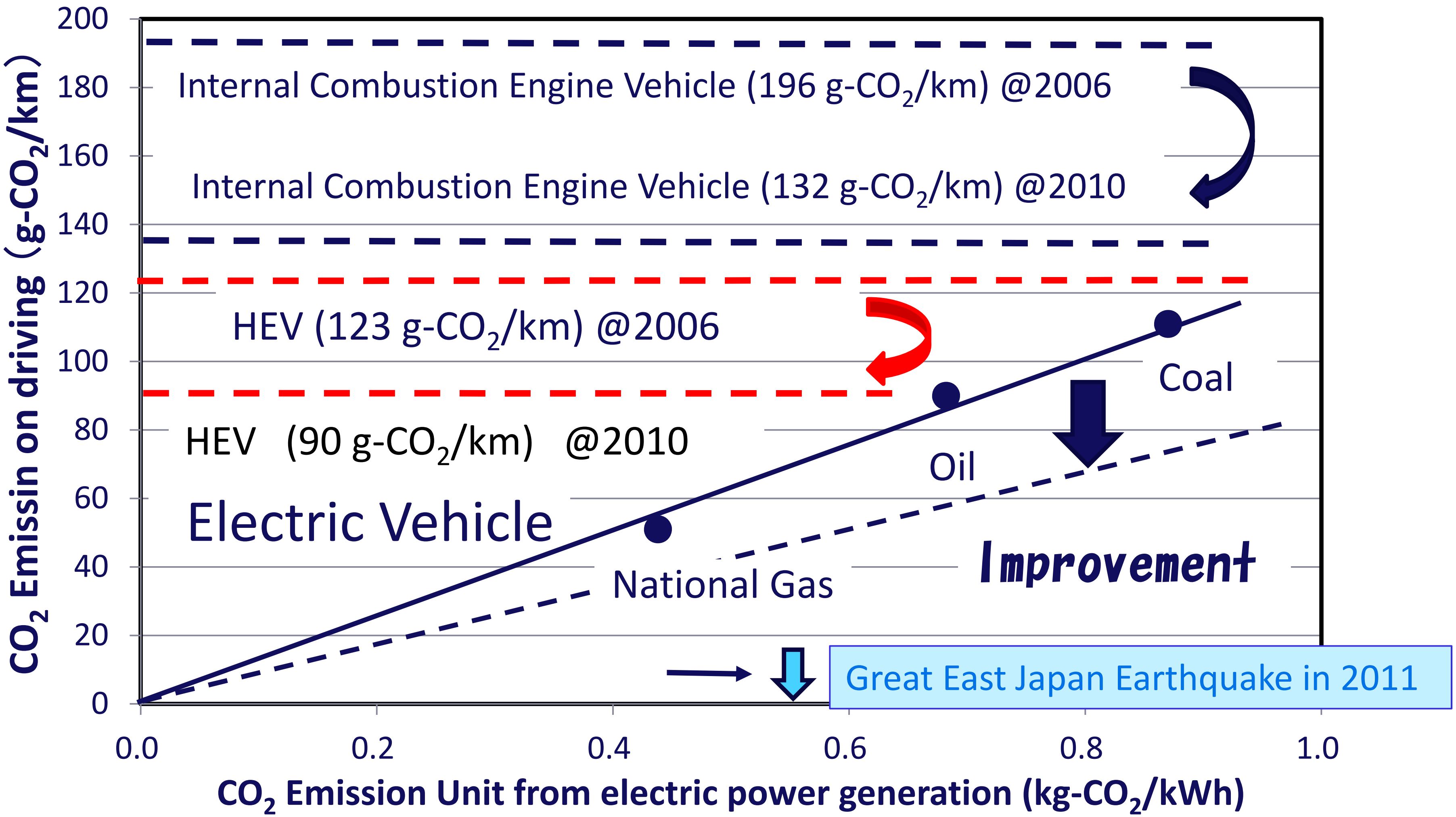
High-efficient electrification



2. Popularization of EVs for lower CO_2 emission

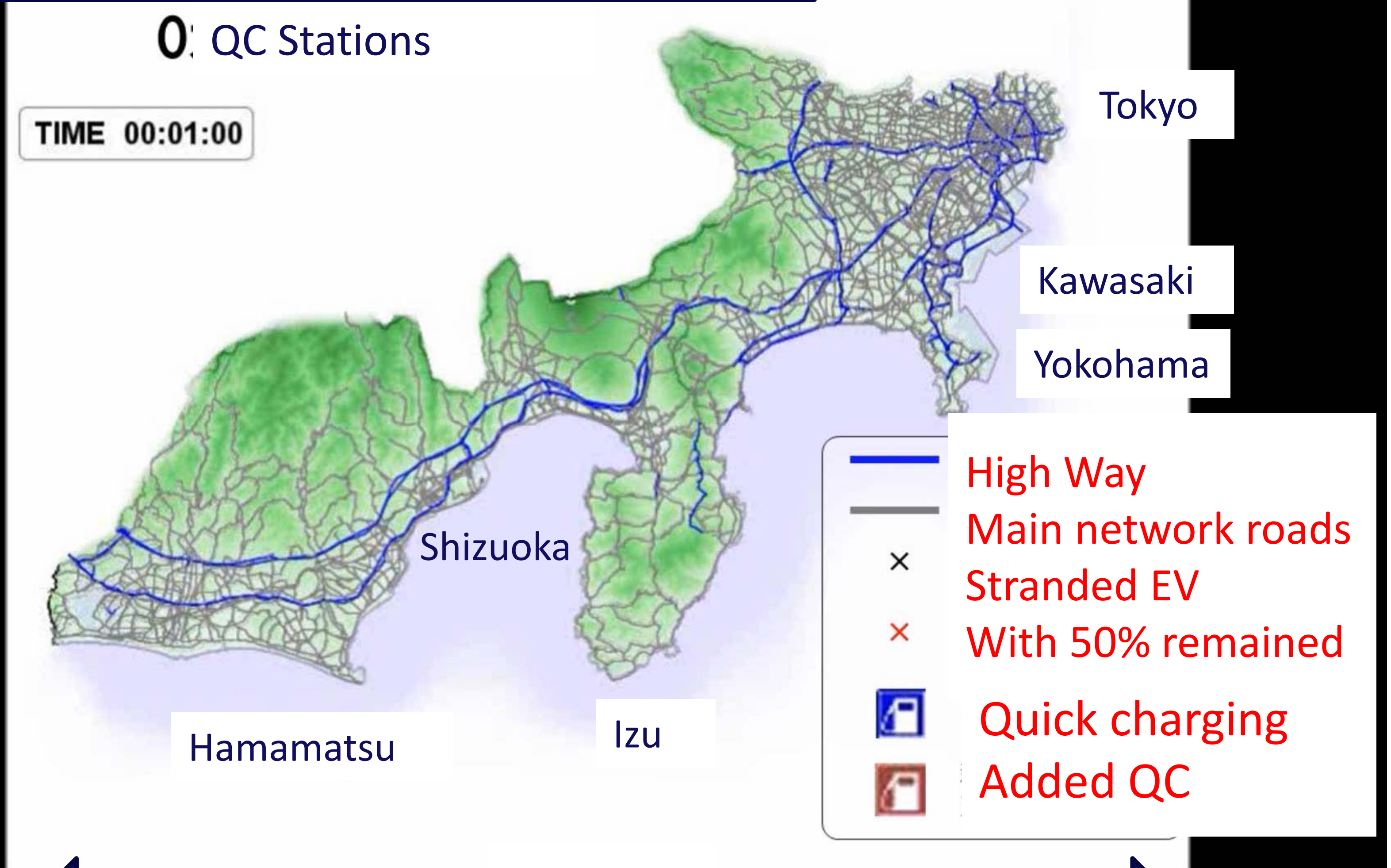
- An EV is expected to be improved to extend a mileage per a charge.
- The performances of secondary batteries should be improved, on the energy density, cycle life, safety, cost and so on.
- An EV is too expensive, not cheap.
- It is necessary to make charge time shortened.
- Preparation of charge infrastructure is required against EV stranded.

CO_2 emissions reduction by combining high-efficiency technologies and low-carbon power generation



Three prefectures spanning about 200 km: Tokyo, Kanagawa and Shizuoka

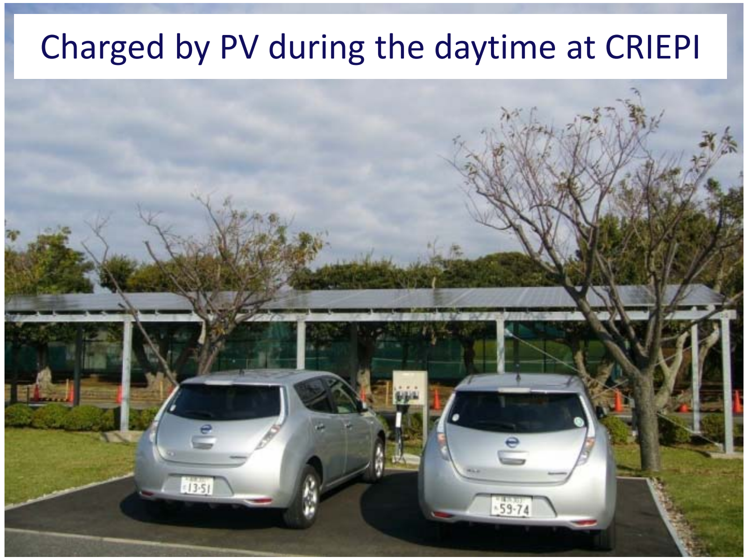
Numbers of Quick Charging Stations:



200km

“Basic & destination charges at workplaces” and “Application of EVs & PHVs to V2X”

- Using EVs for **commuting** can reduce CO_2 emissions. EVs parked at workplaces can be charged by **photovoltaics** (PV) during the day.
- EVs parked at workplaces can be used **for battery energy storage systems** for load-leveling or preventing blackouts.
- EVs parked at workplaces can be used for V2X, and managed and controlled for use as VPPs. **Wireless charging technology** is expected to be used for VPPs.

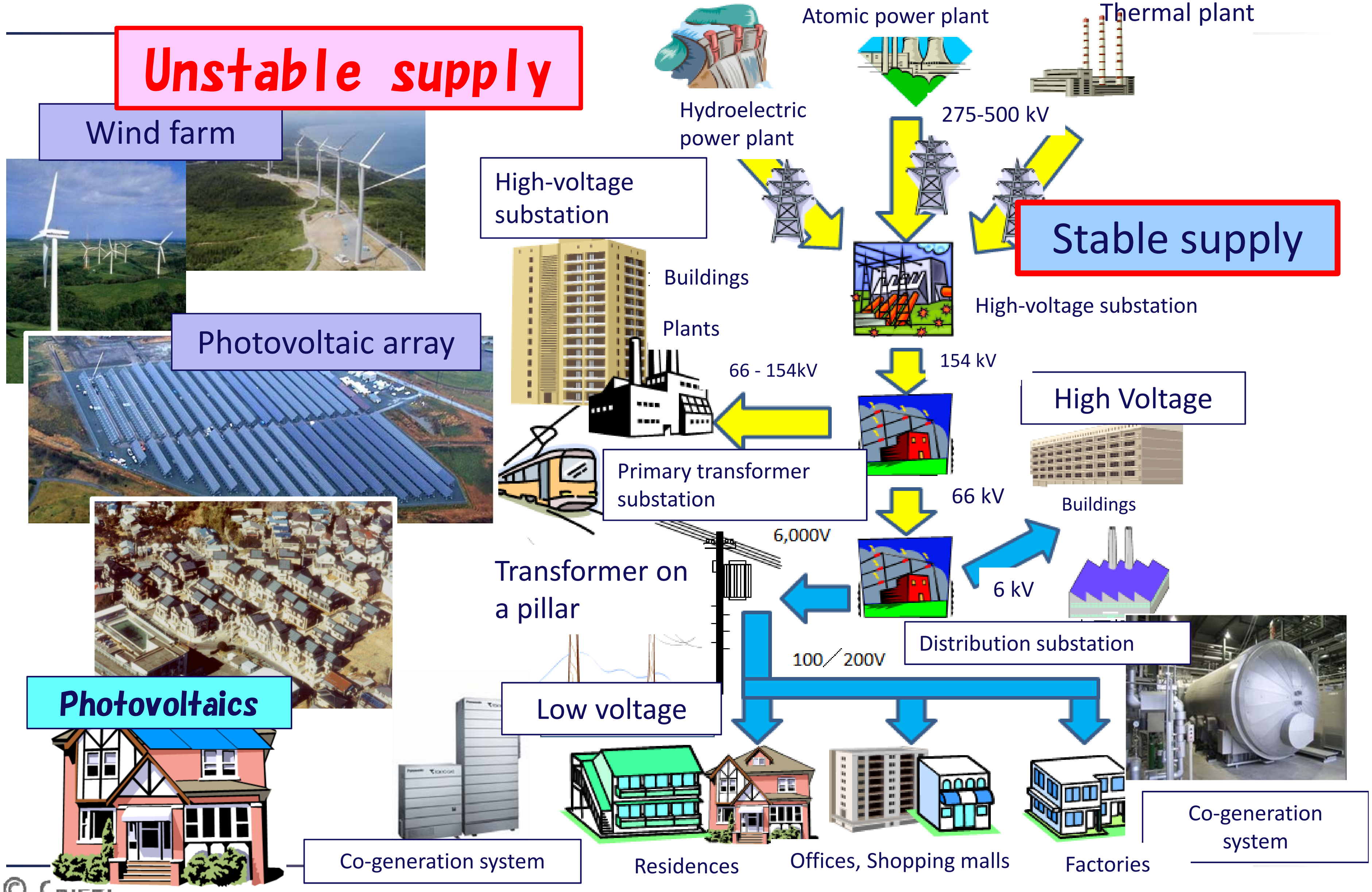

Charged by PV during the daytime at CRIEPI


Workplace charging and application to V2X at Mitsubishi

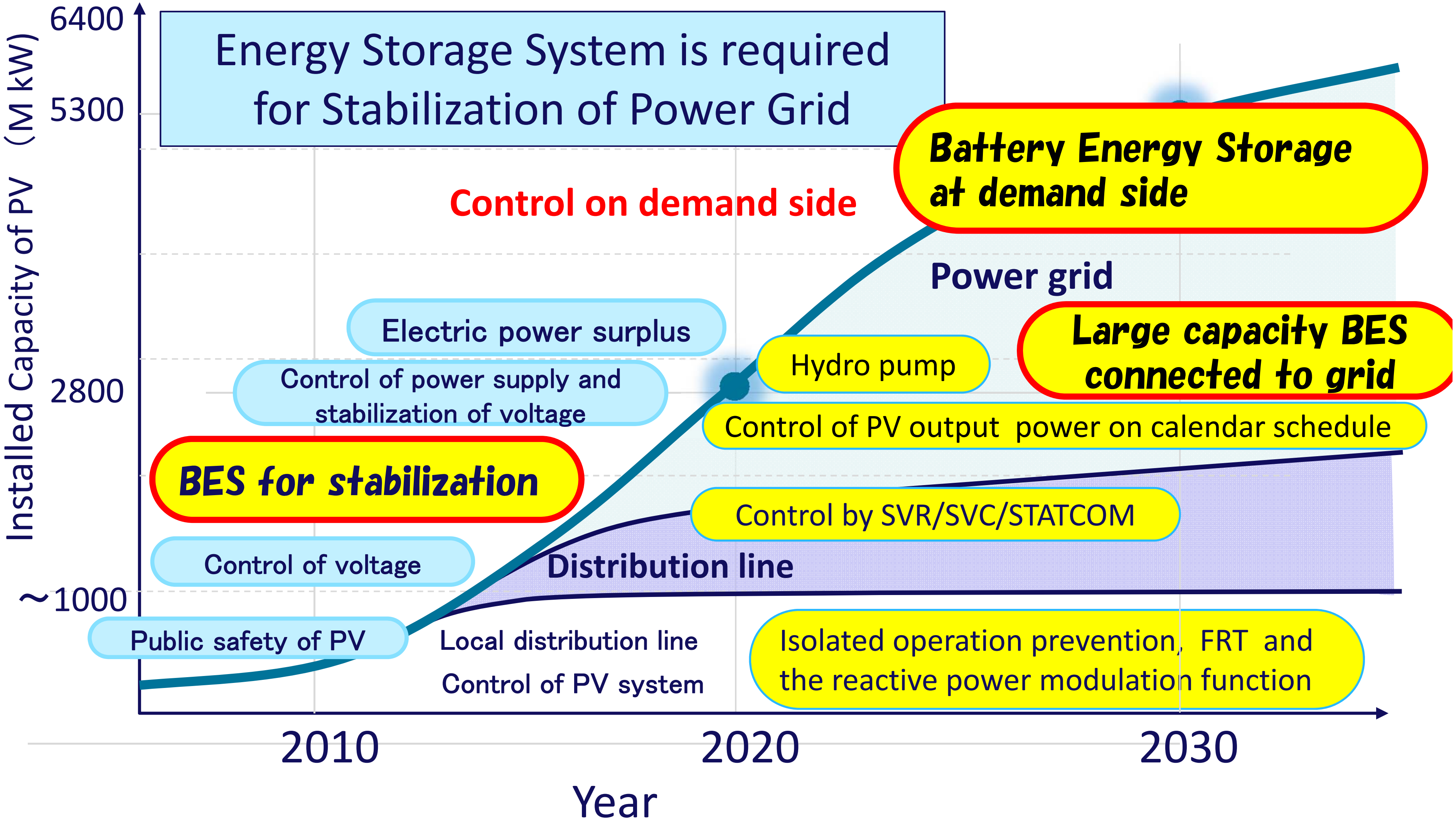
Obstacles to popularizing EVs and PHVs

- Improve **battery performance** for EVs to increase mileage per charge and cycle life to reduce EV cost.
- Create **used car and re-use markets for energy storage systems** to reduce cost of EV.
- These markets need a measure to estimate **state of health and battery degradation.**
- Install normal and quick charging stations to make driving EVs in cities more convenient.

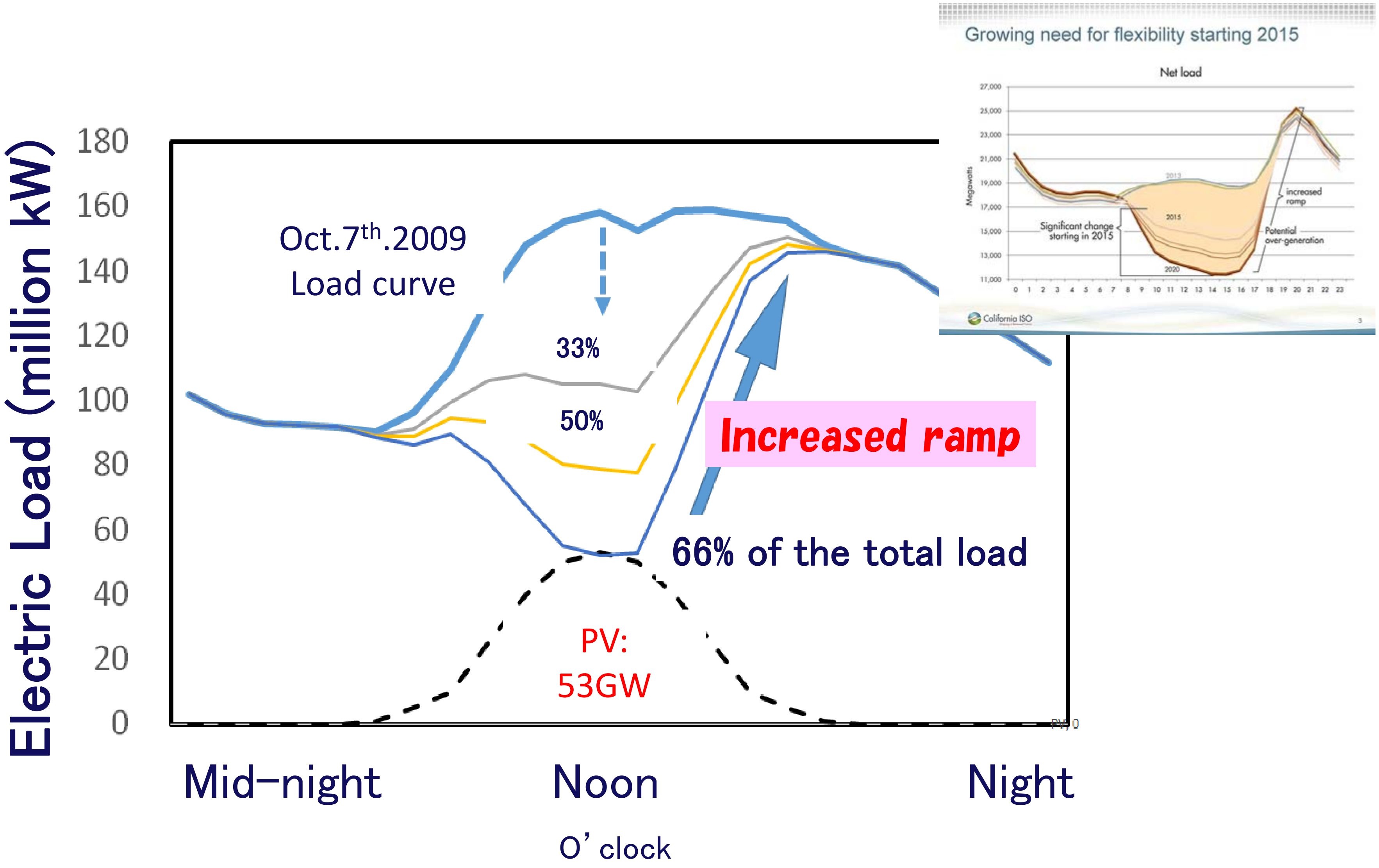
3.Power grid connected with PV and WF



Issues and measurements for mass introduction of PV



Japanese Duck-curve in load curve



Differences between conventional power plants, and photovoltaics & windfarms

Conventional power plants

- **Can control** output power
- **Governor-free** because of revolving generators
- **CO_2 emissions** from fossil fuels

Photovoltaics & wind farms

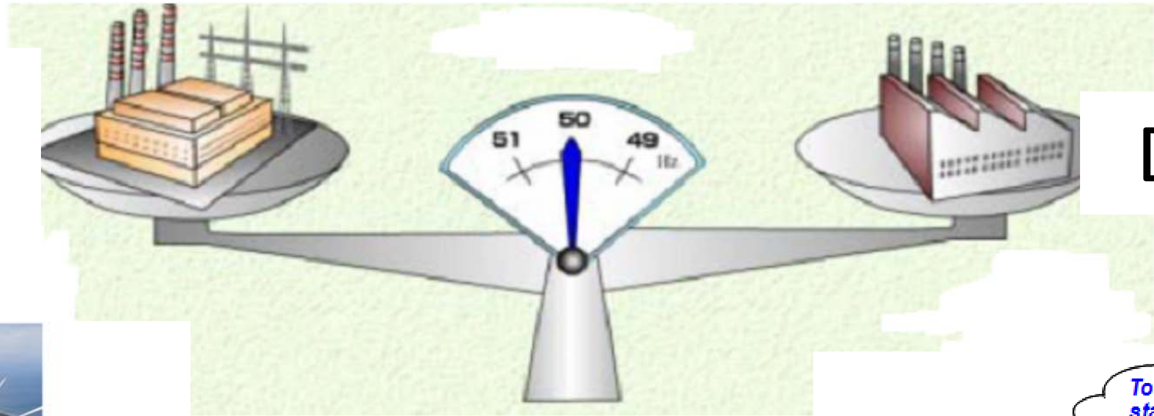
- **Large variation and uncontrolled output power**
- **Dependent on weather and daylight**
- Dependent on season
- Carbon-free

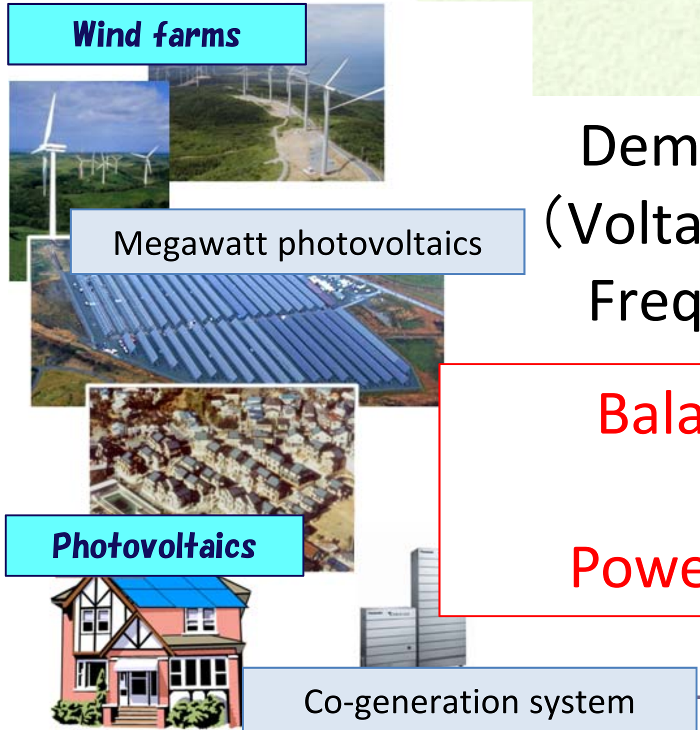
Stabilization of power grid

To provide frequency regulation and voltage support

Power supply

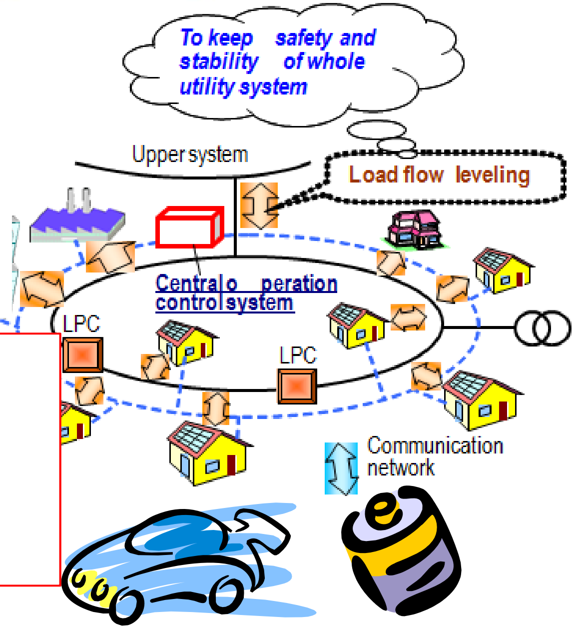
Demand





Demand & Supply Balance
（Voltage: 101 ± 6 V
Frequency: 50 ± 0.2 Hz ）

Balancing every 30 min
＋
Power control every 0.1 s



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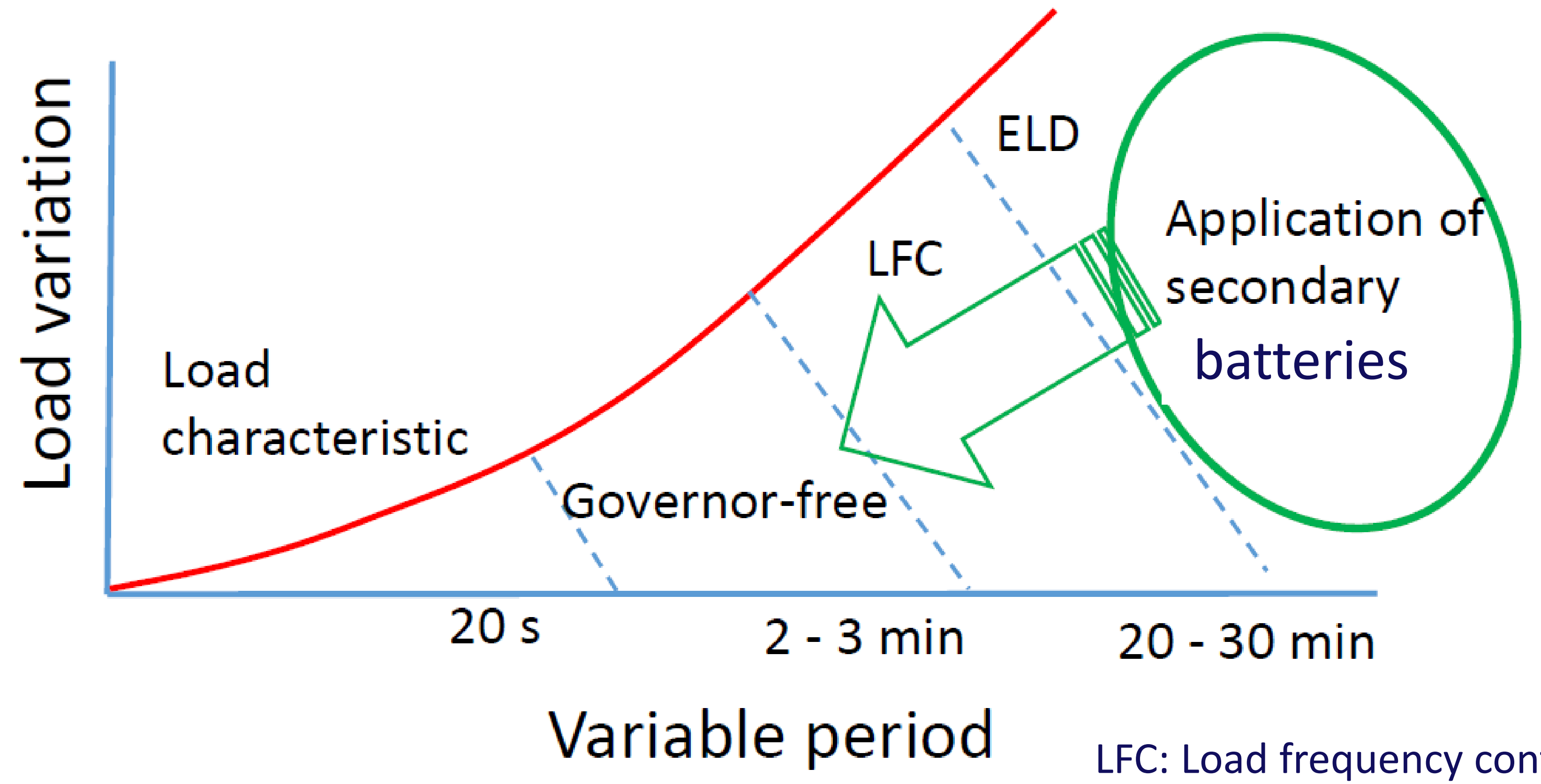
Load-up operation and power control



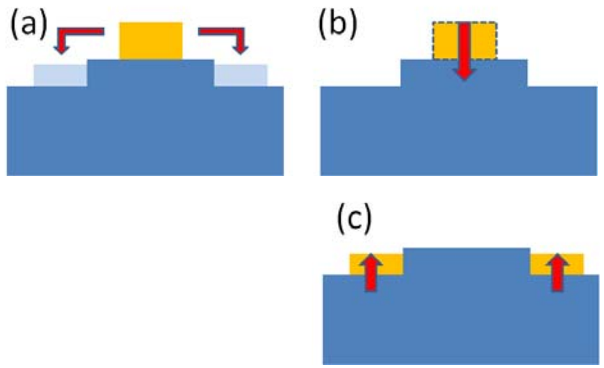
LFC: Load frequency control
ELD: Economic load dispatch

Secondary battery systems are expected to operate in the faster LFC and governor-free output area

Changing use of energy storage systems

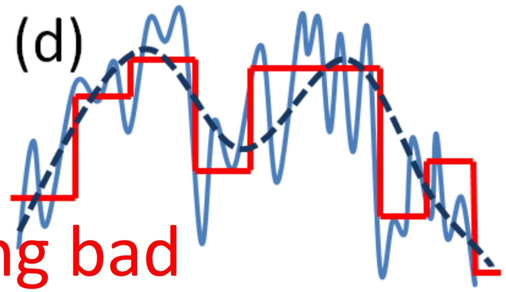
◆1980s–1990s

- ✓ **Load leveling** by peak-cut, peak shift, and bottom-up methods
- ✓ Back-up and preventing blackouts
- ✓ Improving electric load efficiency



◆ Increase in photovoltaics and wind farms

- ✓Stabilizing voltage and frequency of power grid
- ✓Supporting output power
- ✓Substituting thermal power plants for stabilization
- ✓Compensating for capacity shortages during bad weather



Issues for large-introduction of renewal energy of PV and WF

- Stabilization of power grid (Preparation of large-capacity secondary batteries, and quick-response and high-efficiency thermal power)
- Shortage of the amount of power line capacity capable to interconnect the power generated from PV & WF

BES connected with electric power grid

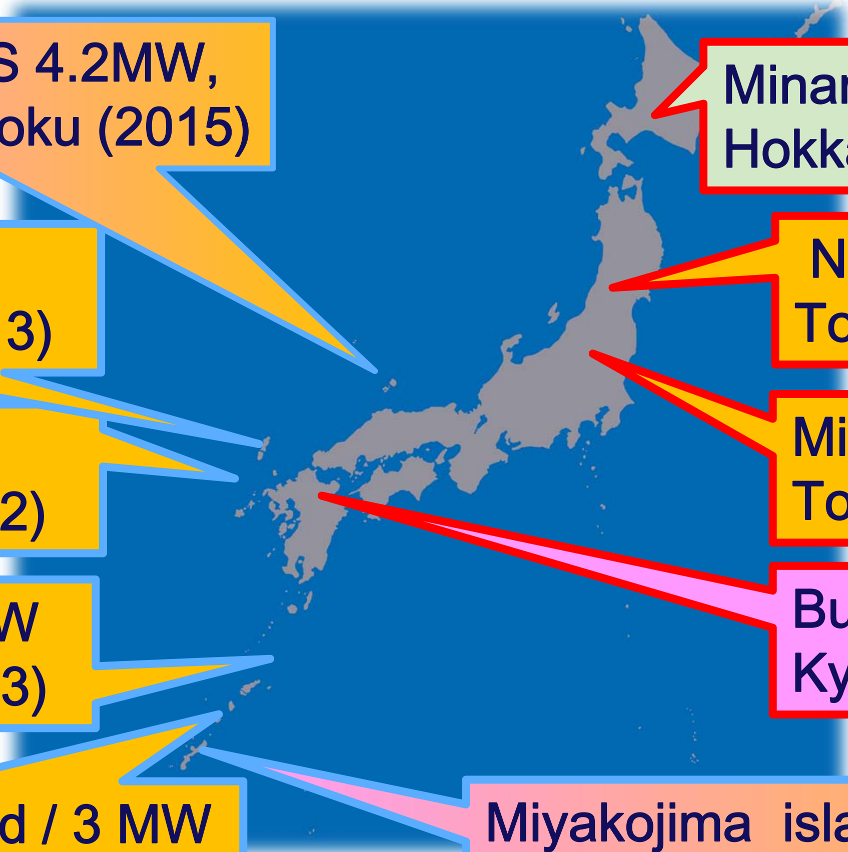
Battery type : ■: LIBs, ■: Sodium-Sulfur, ■: Redox-Flow

Stabilization in islands

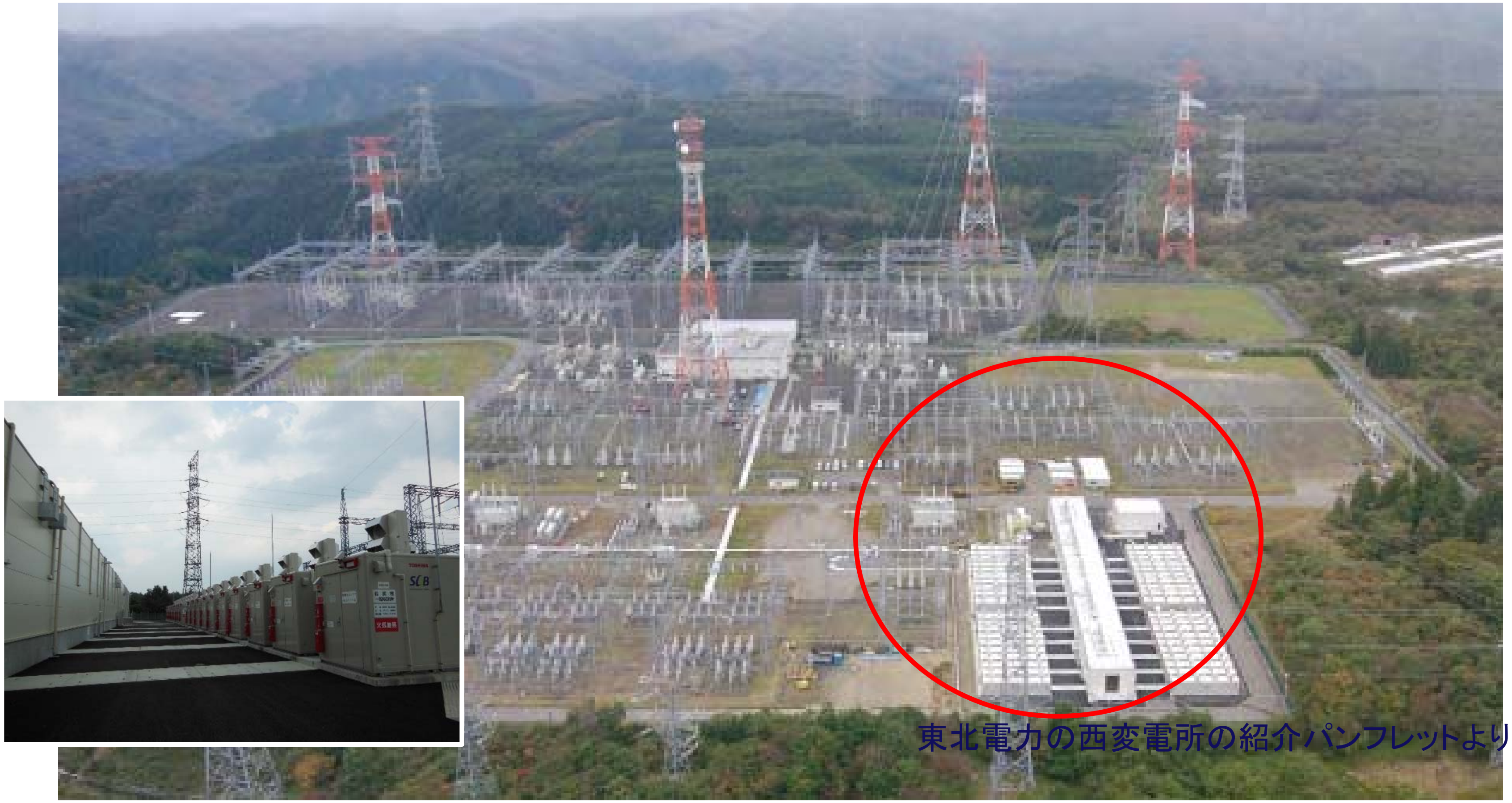
- Oki Islands / NaS 4.2MW, LIBs 2MW Chugoku (2015)
- Tsushima / 3.5 MW Kyushu EPCO (2013)
- Iki Island / 4 MW) Kyushu EPCO (2012)
- Amami island / 2 MW Kyushu EPCO (2013)
- Tanagashima island / 3 MW Kyushu EPCO (2013)
- Miyakojima island / NaS/4MW & LIBs/100kW Okinawa EPCO (2010)

Stabilization of power grid

- Minami-hayakita / 15 MW Hokkaido EPCO (2013)
- Nishi-sendai / 20 MW Tohoku EPCO (2013)
- Minami-soma / 40 MW Tohoku EPCO (2015)
- Buzen / 50 MW Kyushu EPCO (2015)



Large-scale Li battery storage system (40 MW, 20 MWh) at the Nishi Sendai substation



Battery system stabilizes the load frequency control of the power grid

Li battery energy storage system at the Nishi Sendai substation

Each container contains several Li ion batteries and is equipped with an air conditioner, lighting rod, and fire prevention equipment

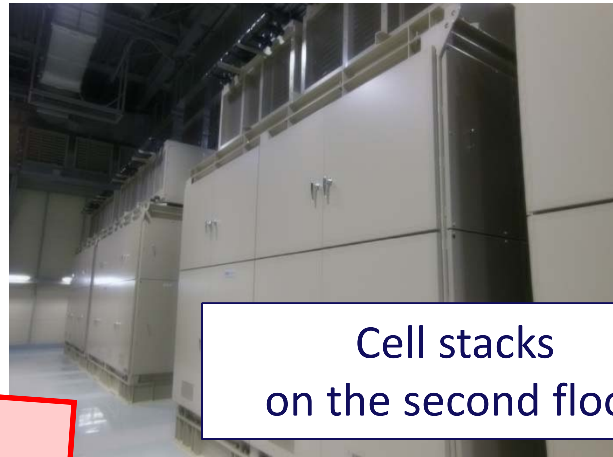
Buzen（50MW/300MWh）

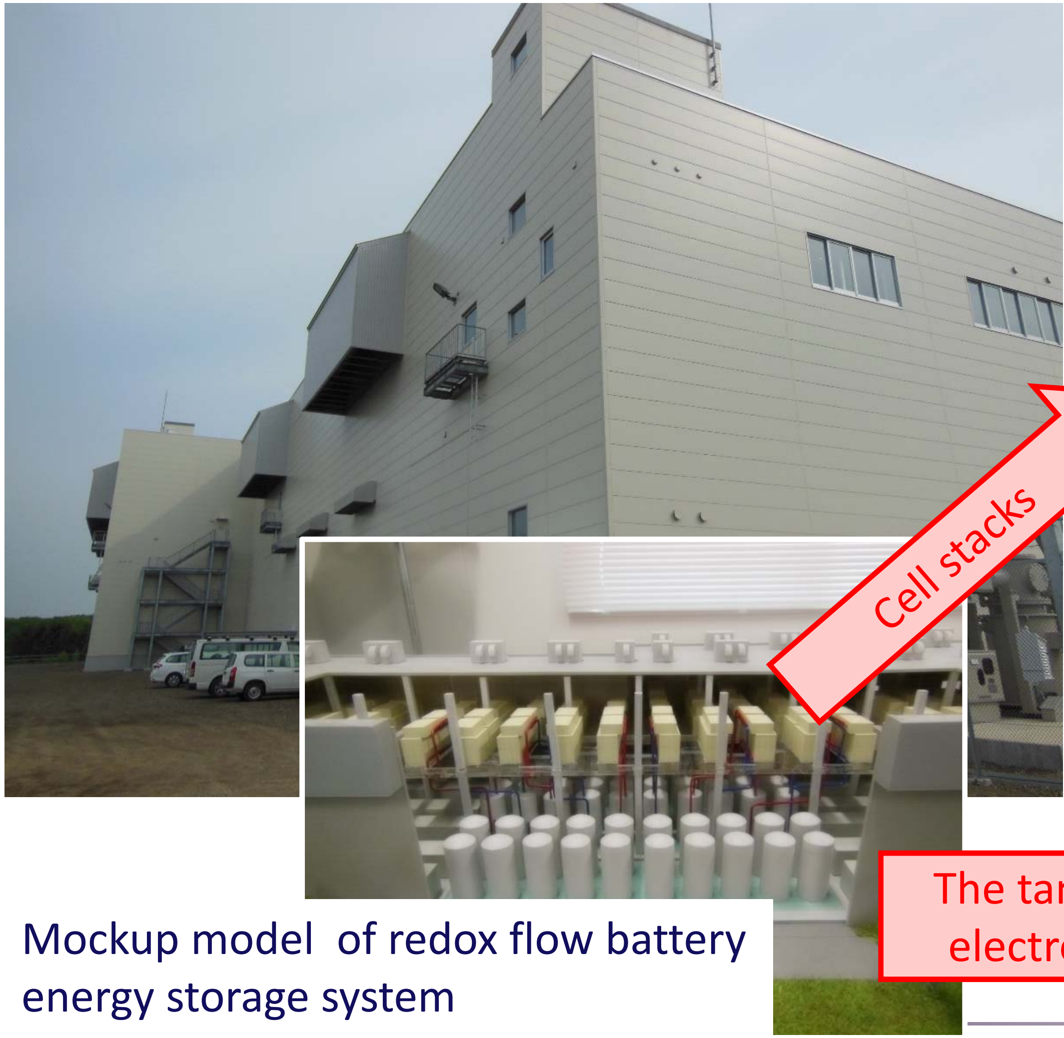
Na/S battery energy storage system

Two steps accumulated 40ft containers for more compact

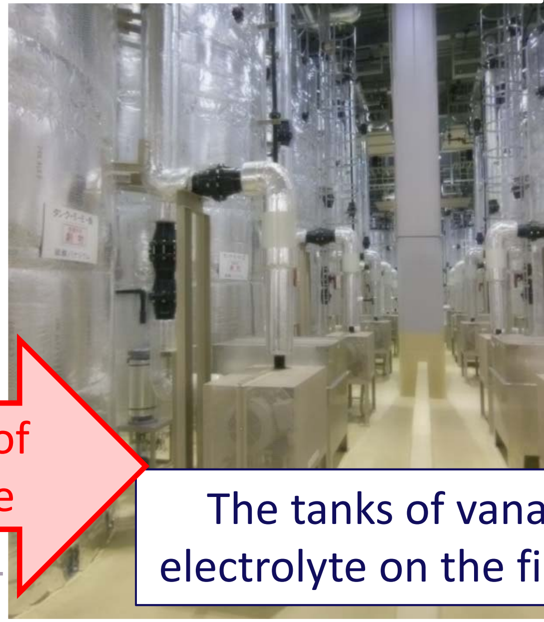
Minami hayakita power station

Vanadium Redox flow battery





Mockup model of redox flow battery energy storage system



Li ion battery Energy Storage System

- Compact energy storage system
- High energy efficient storage (Higher than 80%)
- Quick response with full power in milliseconds order
- Easy installation

Remarking points

- ✓ Limited power (W) and capacity (Wh)
- ✓ Flammability (Electrolyte: organic liquid)
- ✓ High cost (Expectation of cost reduced by mass production in near future)

Improvement of Li ion battery

- Higher energy density (weight, volume) for vehicles and stationary system
- Incombustibility, inflammability and no exposure against EV crash and distributed energy storage system on fire.
- So fast dis/charging reaction for super quick charge of EVs and control of power grid frequency
- Operation at wide range temperature for EVs and stationary system to reduce accessory and auxiliary machine for control temperature.

Summary

- Secondary batteries must be improved to stabilize power grids and commercialize EVs to build a low carbon society.
- The performance of lithium batteries must continue to be improved, and new batteries must be developed with higher energy density, durability, and safety.
- Methods for evaluating batteries during operation are required to prolong operation time.

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Thank you for your kind attention.

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APPLICATIONS OF SECONDARY-BATTERY TECHNOLOGIES TO REALIZING A LOW-CARBON SOCIETY