Recent examples of efforts by low-carbon countries to expand their renewable energy growth rate.

21st November 2017

Japan Electric Power Information Center (JEPIC)

Joji Kawano

Introduction

Advantages of renewable energy installation to the grid

- Environment-friendly
- Low running costs

- Renewable energy installation is expected to increase to realize a low-carbon society.

Problems of renewable energy installation to the grid

- Intermittent power generation (Strongly depends on the weather conditions)
- Reducing reliability of the grid

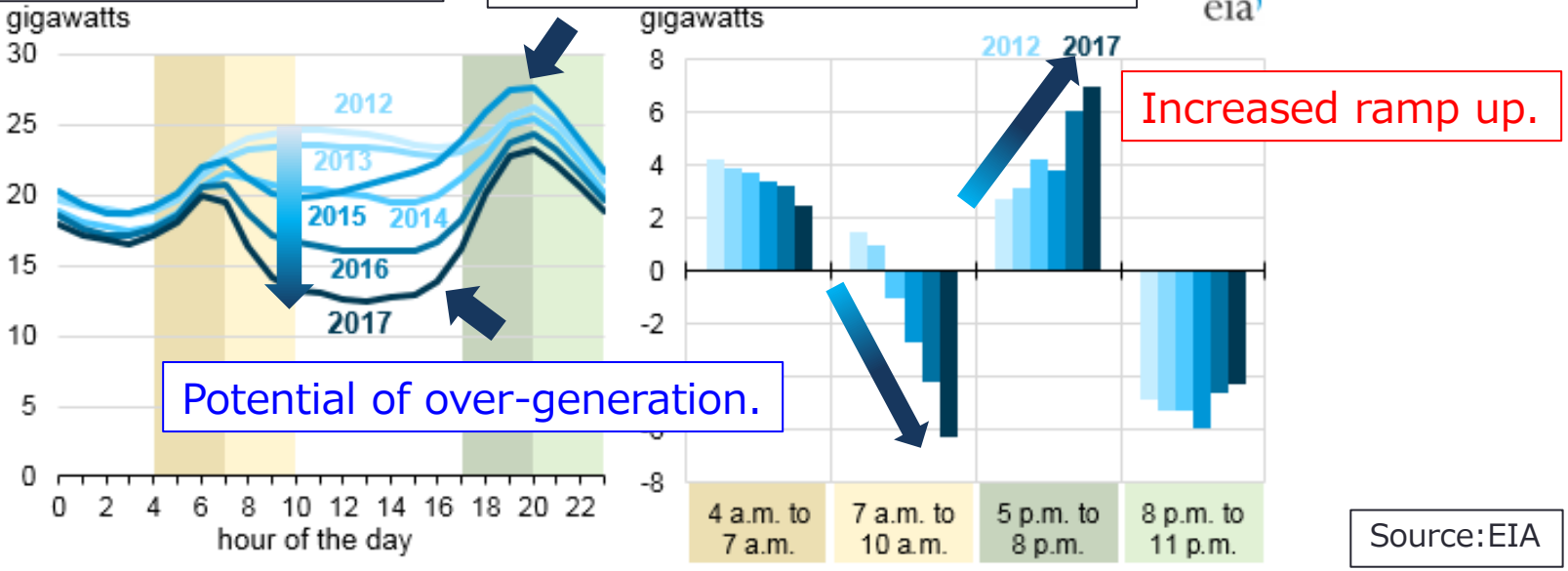
- A solution is needed to increase renewable energy installation to the grid.

Introduction

Example of reduced reliability of the grid #1

Power generation suppression of thermal power generation by PV mass installation.

A maximum (peak) volume of demand is observed around sunset.



Potential of over-generation.

Increased ramp up.

Source:EIA

(Comment)

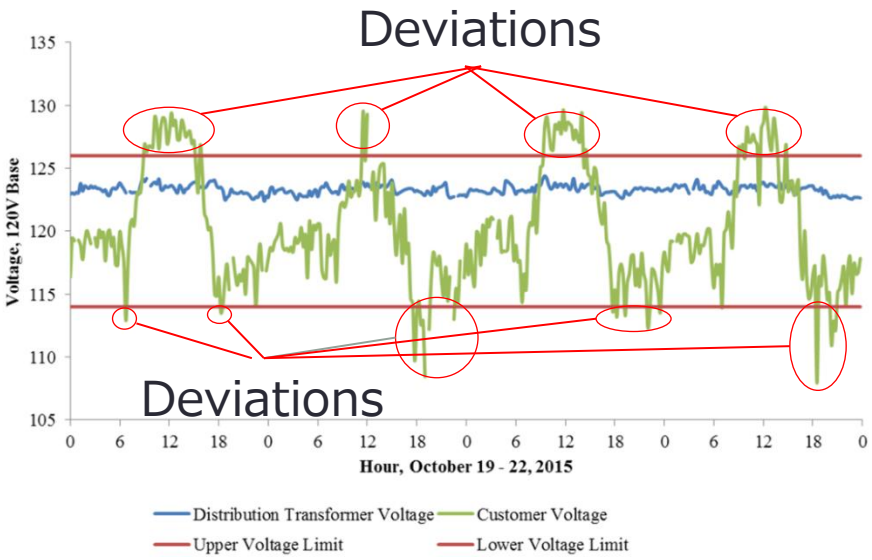
- The results listed above cause a reduction in the value of the base load generation.
- A sudden increase of demand will be observed around dusk.

(Solution)

- Expansion of pumped Hydro.
- Reduction in the volume of interconnectivity.

Introduction

Example of reduced reliability of the grid #2



(Comment)

- Voltage fluctuation in a transformer bank increases with the installation of massive PV current.
- Massive PV current increases the risk of deviating from the standard range of voltage.

(Conventional solution)

- Installation of additional transformers.
- Reduction in the volume of interconnectivity.

"Deviations" are caused by the attribute of electricity, therefore a new solution is needed to increase renewable energy development.

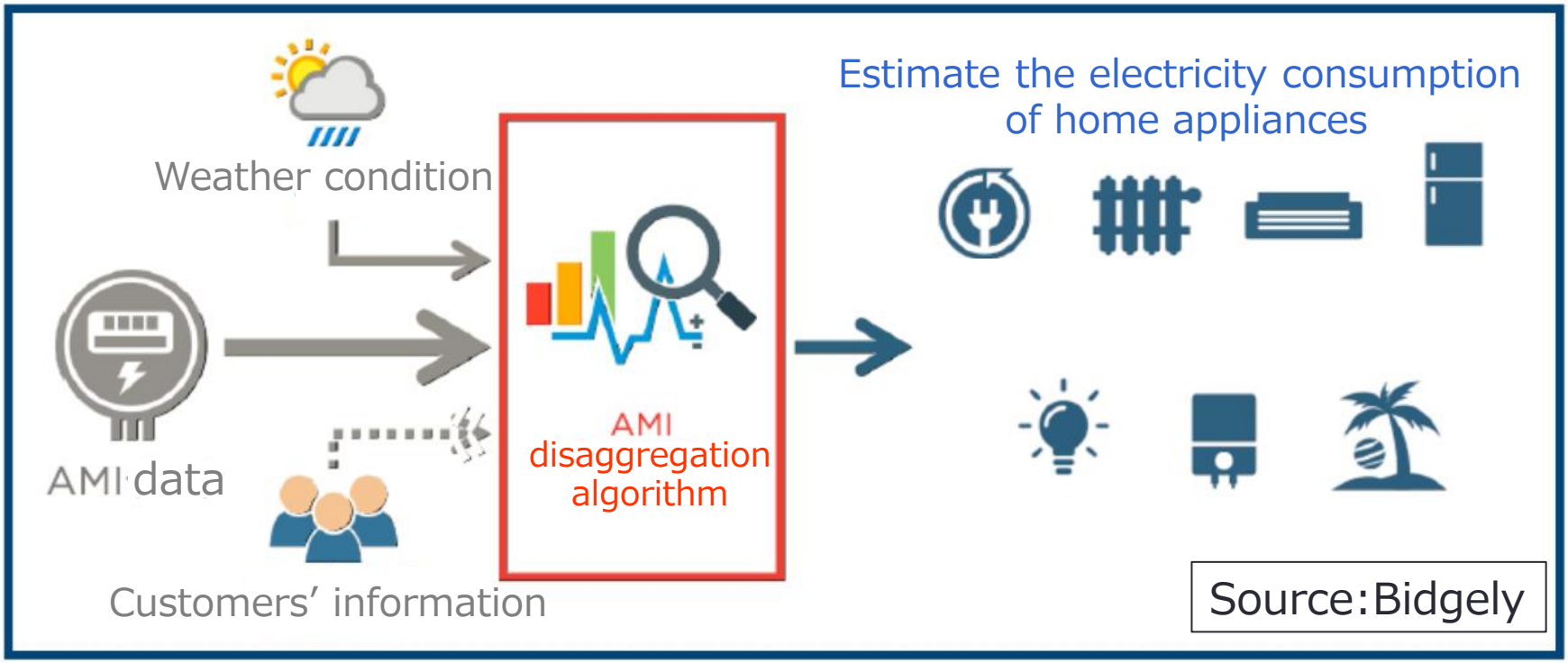
And one of the solutions is "energy storage batteries" that make it possible to store electricity. We will introduce Japan and U.S. initiatives in energy storage batteries as case examples.

Today's topics

- We will introduce the advanced efforts each country will carry out in order to increase the interconnected amount of renewable energy.
- The topics can be sorted into 2 categories.
  ① Peak demand management applying IoT or/and SNS technologies.
  ② Installation of an advanced energy storage system.

① Peak demand management applying IoT or/and SNS technologies

①- 1 Energy disaggregation through analyzed AMI data.



- ✓ Disaggregation startup "Bidgely" provides a visualizing service for home energy use.

① Peak demand management applying IoT or/and SNS technologies

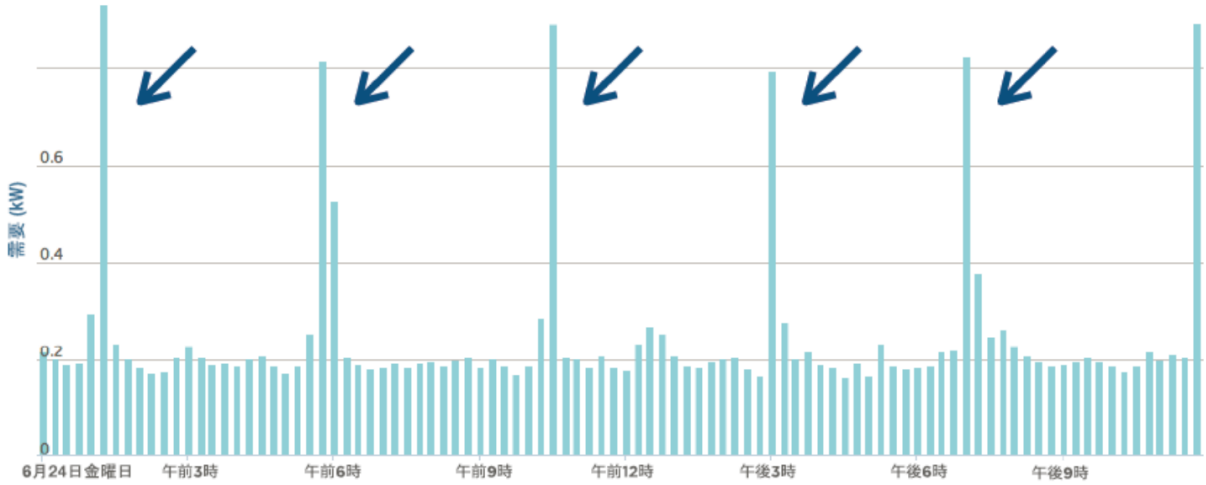
①- 1 Energy disaggregation through analyzed AMI data.

Based on customers' demand data (AMI data) measured by smart meters, it is possible to identify the type of household electric appliance.

⇒ No need for other measuring devices.

⇒ Estimate the electricity consumption of home appliances though analyzed AMI data.

⇒ Customers have access to energy saving advice.



Source: Bidgely

Ex: Load curve of thermal storage (water heating)

① Peak demand management applying IoT or/and SNS technologies

①- 1 Energy disaggregation thorough analyzed AMI data.

- ✓ Breakdown of the electricity consumption of each appliance is automatically calculated.
- ✓ Customers can always refer to the result of the calculations through the internet.
- ✓ In the case of a sudden increase in energy use, an alert can be sent.

Such kind of services or advice, improves the customer satisfaction.

Source: Bidgely

Ex: image of electricity consumption breakdown

② Installation of advanced energy storage systems

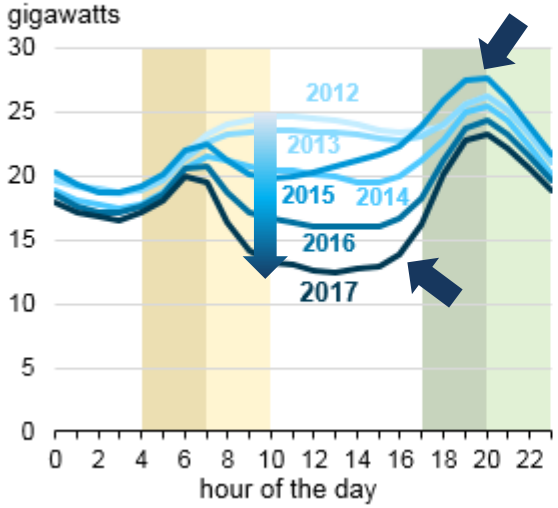
In California, the following changes are emerging as the installation of distributed energy resources into the power system.

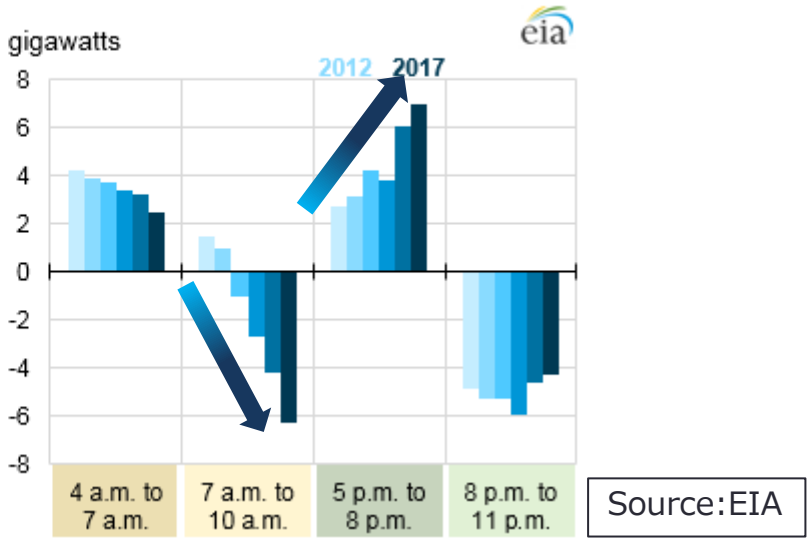
① A maximum (peak) volume of demand is observed around sunset.

② Power generation suppression of thermal power generation by PV mass introduction.

③ A sudden increase in demand will be observed around dusk.
7:00-10:00、17:00-20:00

⇒ Demonstrations of advanced energy storage system are implemented.



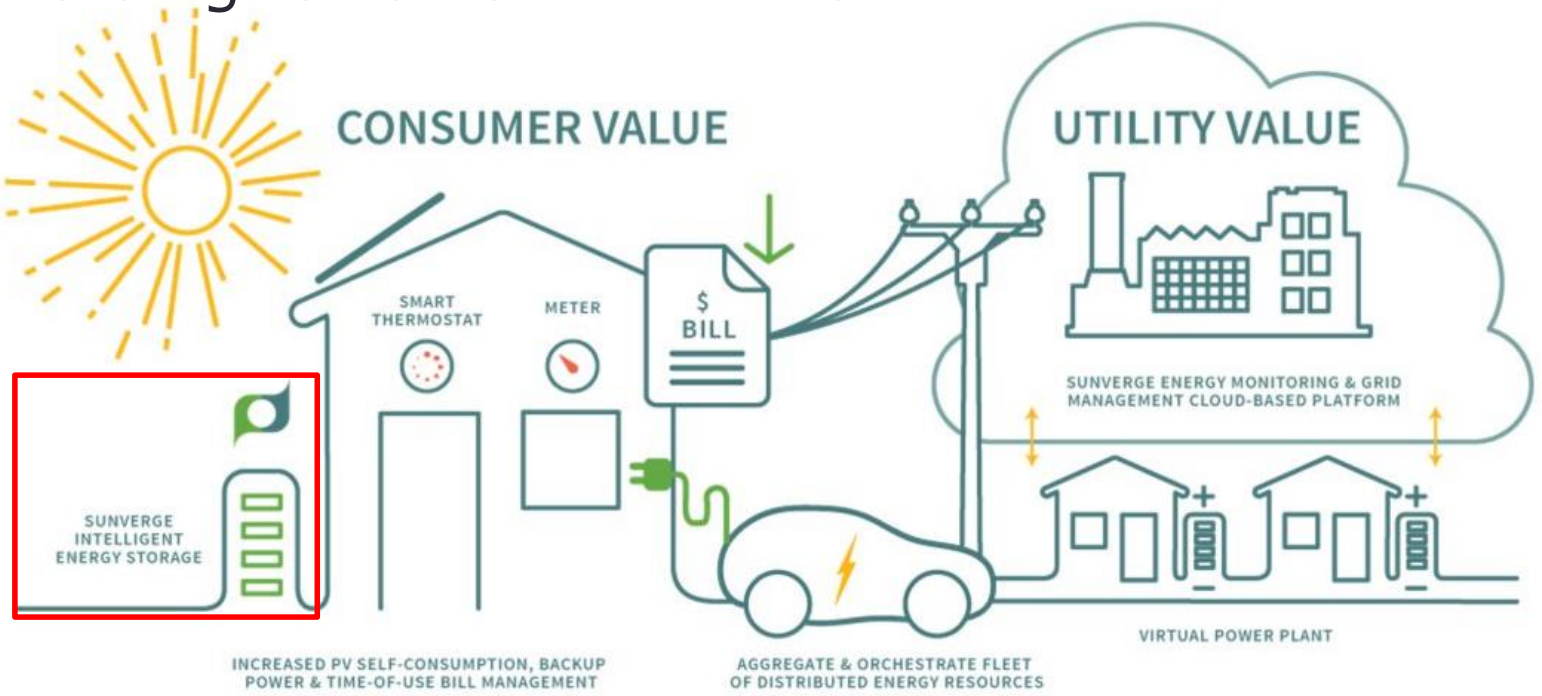


Source:EIA

② Installation of advanced energy storage systems

Ex: Advanced aggregator: Sunverge (U.S.)

⇒ Advanced energy storage systems transfers surplus PV power to battery and discharges them according to customer's needs.



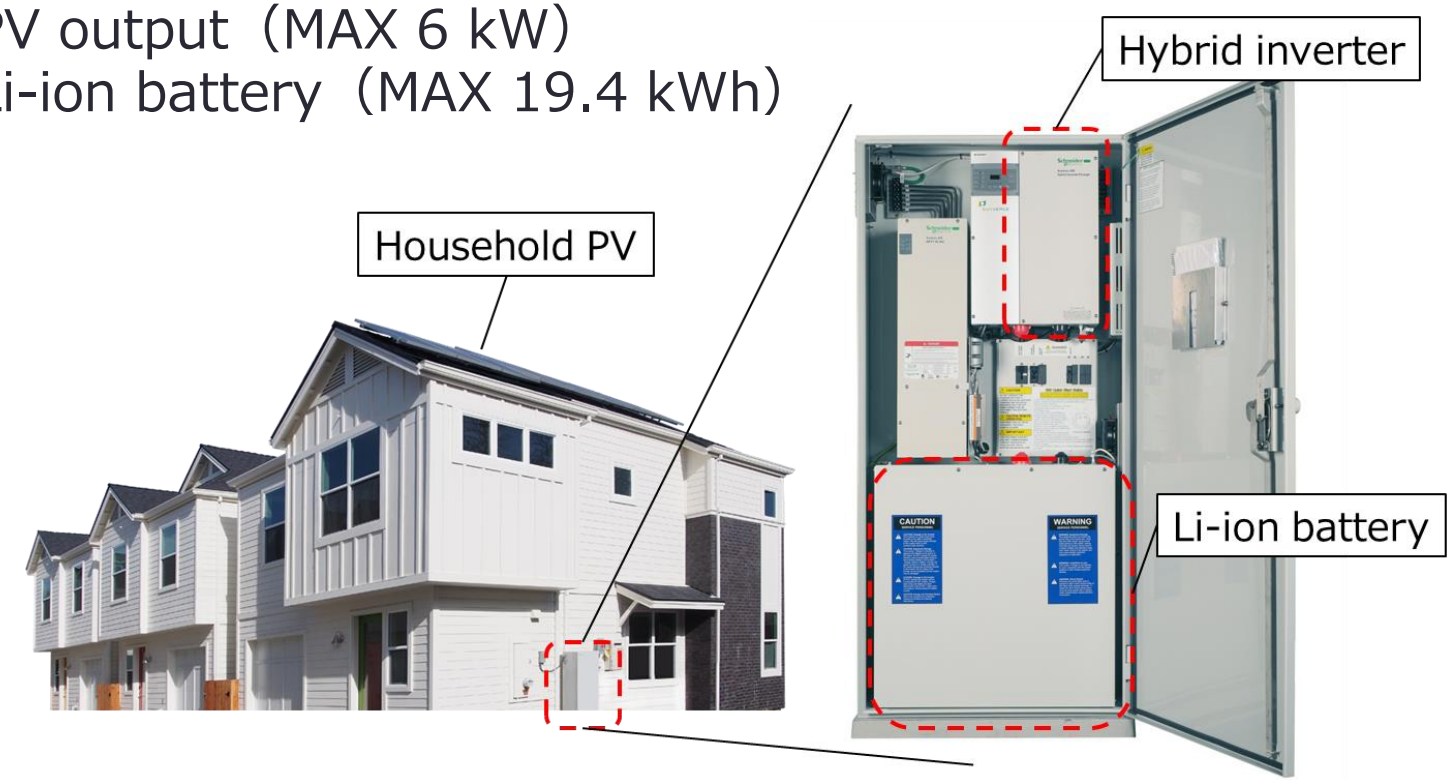
Source: Sunverge

② Installation of advanced energy storage systems

➢ The aggregator bundles multiple customers consisting of household PV and battery devices, and sells the electricity.

✓ Controllable PV output and battery capacity:
1.5 MW, 4.5 MWh (300 of customers)

✓ Energy storage system (Each house)
PV output （MAX 6 kW）
Li-ion battery （MAX 19.4 kWh）



Installation image on the house

Source: Sunverge

②Installation of advanced energy storage systems

In California, a power company (PG & E) conducted a demonstration project to utilize EVs as a flexible power source with customers and an automobile company (BMW).

BMW i3

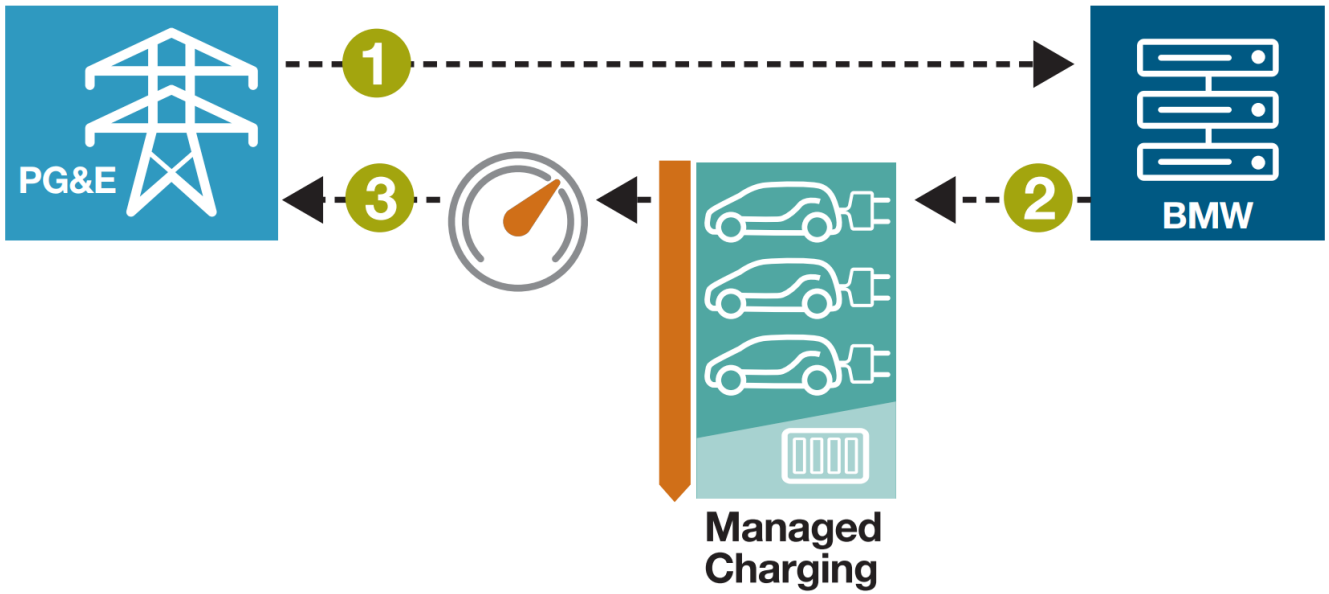
Project profile

	Note
Objectives	Verification of the possibility of utilizing EVs for energy storage that absorbs surplus renewable energy.
EV	BMW i3
Number of EVs	100 cars
Test period	2015.7~2016.12 (18 months)
Grid resources	100 kW

Source: PGE-BMW-iChargeForward-Final-Report

②Installation of advanced energy storage systems

BMW i Charge Forward System Architecture



Source: PGE-BMW-iChargeForward-Final-Report

① PG&E initiates a DR event to the BMW by sending a signal.

② Once the event has been triggered, BMW's aggregation software determines how much of the 100 kW load drop will be met by managed charging.*

③ Grid resources from DR are supplied to the grid.

*Participants were selected to participate in an event if their vehicle was available, but were always given the option to opt out.

②Installation of advanced energy storage systems

➢ Incentives for project participants

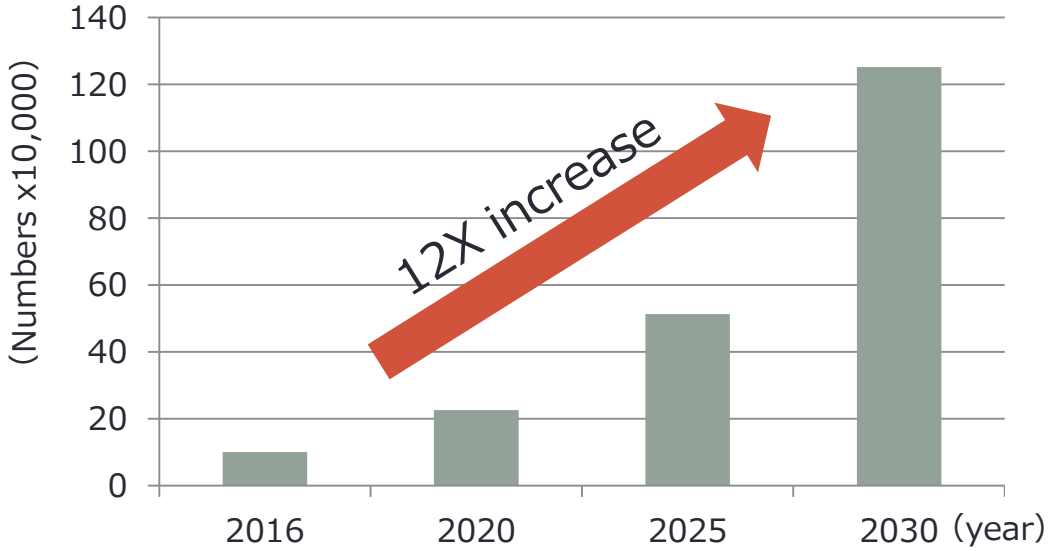
Participants	Notes
EV owners (Customers)	・Customers receive an upfront incentive of $1,000. ・An ongoing incentive for each day they do not opt-out, up to $540 that is distributed after the project has ended.
PG&E	・Attractive menu reduces customer churn. ・Utilities can increase the amount of renewable energy by using customers' batteries.
BMW	・Incentives compensate EV prices. ・Reuse of used battery.

✓ All of the participants have incentives to attend the project.

Source: PGE-BMW-iChargeForward-Final-Report

②Installation of advanced energy storage systems

Forecasted total number of EVs in PG&E's service territory



Year	Total EVs	Projected enrollment	Customer participants in an event	Load drop
2016	(100,000)	(20,000)	(1,400)	(6.2MW)
2020	226,000	45,200	3,164	14.0MW
2025	513,000	102,600	7,182	31.8MW
2030	1,251,000	250,020	17,514	77.6MW

Source:PGE-BMW-iChargeForward-Final-Report

②Installation of advanced energy storage systems

In California, the following changes are emerging as the installation of distributed energy resources into the power system.

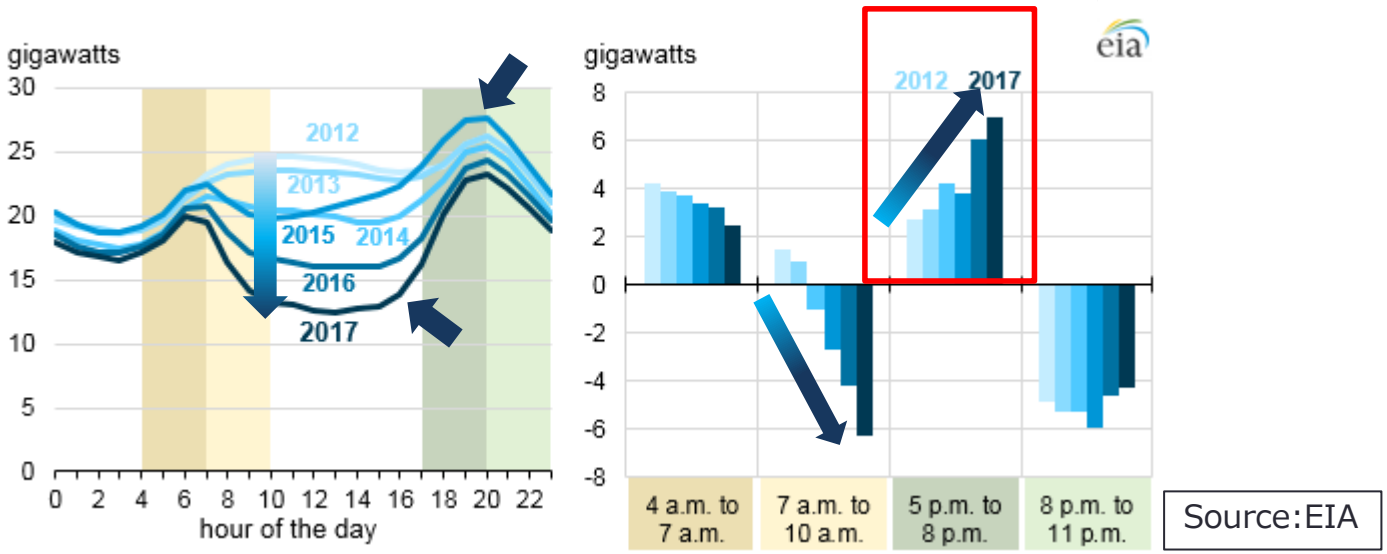
①A maximum (peak) volume of demand is observed around sunset.

②Power generation suppression of thermal power generation by PV mass introduction.

③A sudden increase of demand will be observed around dusk.

7:00-10 : 00、17 : 00-20 : 00

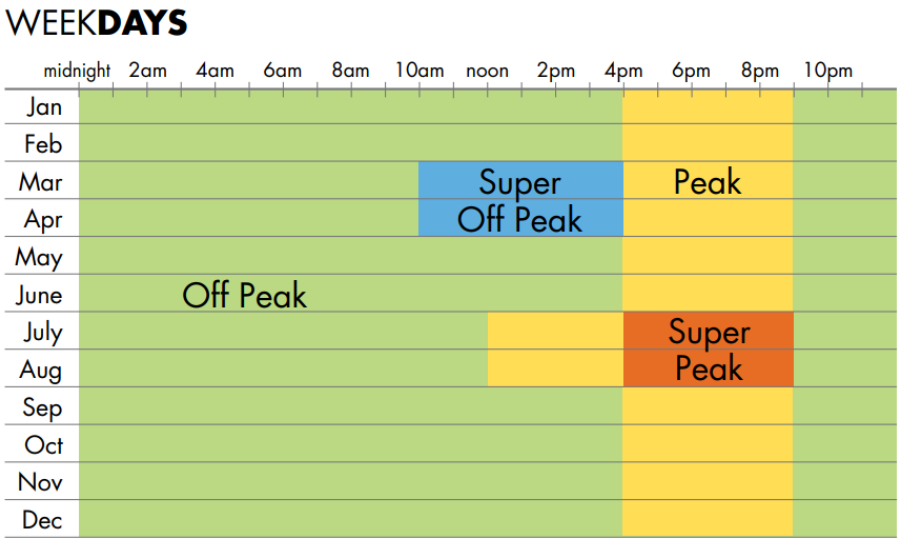
⇒Demonstrations of advanced energy storage system are implemented.

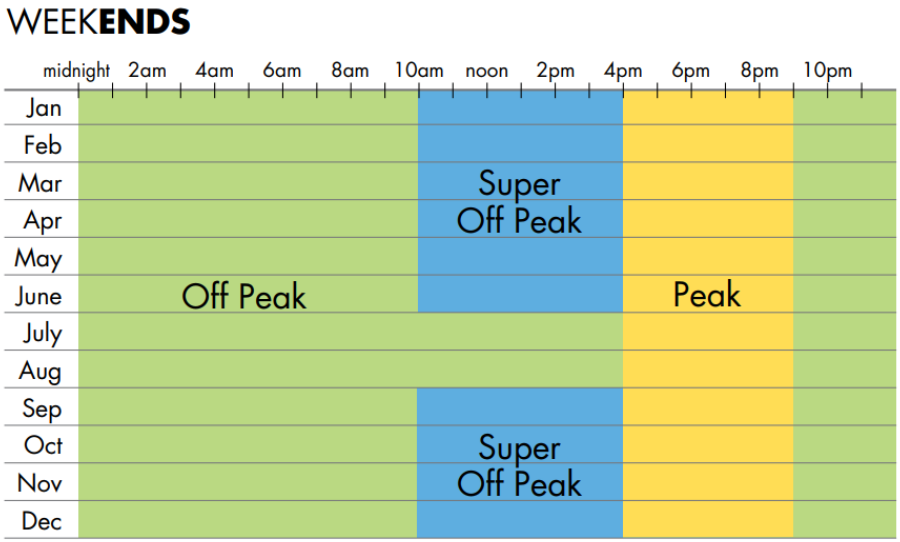


Source:EIA

②Installation of advanced energy storage systems

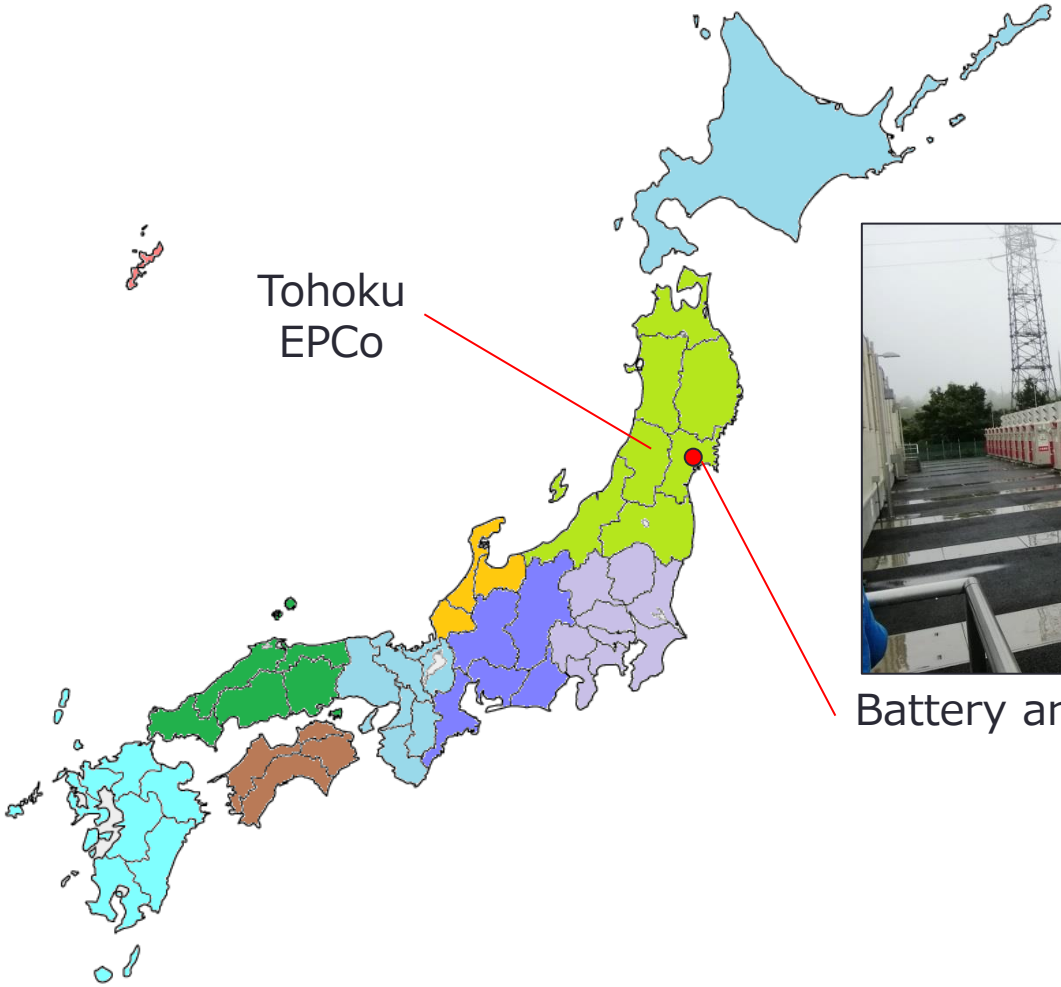
CAISO is considering the introduction of the TOU menu assuming an increase in users of power storage device such as EVs.





Source: CAISO

Recent demonstrations in Japan



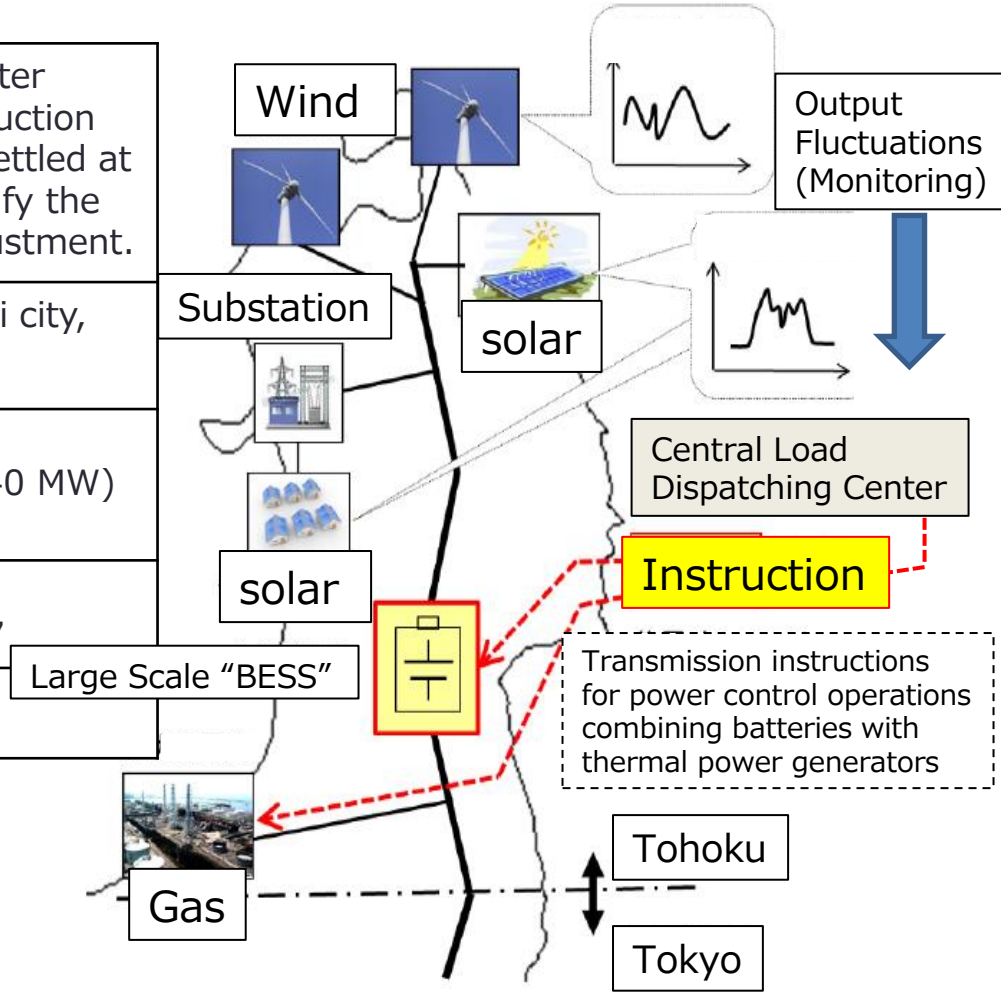
Battery arrays (Nishisendai Substation)

Source: Japanese electric power companies' web sites

Recent demonstration by Tohoku EPCo.

Nishisendai Battery Storage Verification Project

Objectives		The power system central center controls by power adjust instruction sent to the large scale BESS settled at the substation, in order to verify the BESS effect for frequency adjustment.
Details	Location	Nishisendai Substation (Sendai city, Miyagi Prefecture)
	Specifi-cations	Lithium-ion battery Output: 20 MW (short term: 40 MW) Capacity: 20 MWh
	Test period	Construction: FY 2013-2014 Demonstration: FY 2014-2017
	Support	Associations



Tohoku Electric Power Co., Inc. ANNUAL REPORT 2016 1
http://www.tohoku-epco.co.jp/ir/report/annual_report/pdf/ar2016.pdf

Recent installation example in United States.

Generation Alternative

Meeting critical local power capacity with world's largest battery

Two San Diego arrays of 37.5MW/150MWh installed in six months.

PURPOSES

- Capacity, local reliability
- Peak power mitigation
- Ramping/flexibility
- Ancillary services

IMPACT

- ✓ Rapid deployment
- ✓ Competitive & cost effective
- ✓ Meets flexibility (duck curve)

30MW Escondido Advancion Array
San Diego, California

Contains Forward Looking Statements | Confidential & Proprietary

1

- ✓ Battery storage devices were installed in the city that can not be installed in conventional thermal power generation facilities.
- ✓ Early operation was possible without strict environmental regulations being applied.

I thank AES for permission to use their articles.

Conclusion

- We have sorted advanced initiatives aimed at increasing the rate of renewable energy installation.
- By combining DR and advanced technology, such as IoT, and SNS, we can offer the following new services (For homes).

  Energy disaggregation through analyzed AMI data.

  DR by applying SNS technologies.
- By combining DR and battery technology, we can offer the following new advanced services (For homes).

  DR by applying battery technologies.

  DR by applying EV technologies.
- It is necessary to prepare for changes in circumstances on the premise that storage batteries will become popular.