Smart Community Summit 2019
Session１：Against natural disasters - Strengthening disaster resilience

NEDO's Approach for Improvement of the Resiliency

June 4th, 2019

New Energy and Industrial Technology Development Organization
Smart Community Department
Director General
Nobuhiko Kusunose

Contents

1．Global Trends for Resiliency

Japan

Natural Disasters with power outage in 2018

- 28th Jun. – 8th Jul.　Heavy Rain in west Japan（0.08 million）
- 4th Sep.　Typhoon No. 21（2.4 million）
- 6th Sep.　Hokkaido Eastern Iburi Earthquake（First blackout in Japan, 2.95 million）
- 30th Sep.　Typhoon No. 24（1.8 million）

( ) number of households suffered power outage

Working Group on Electricity Resilience Interim Report

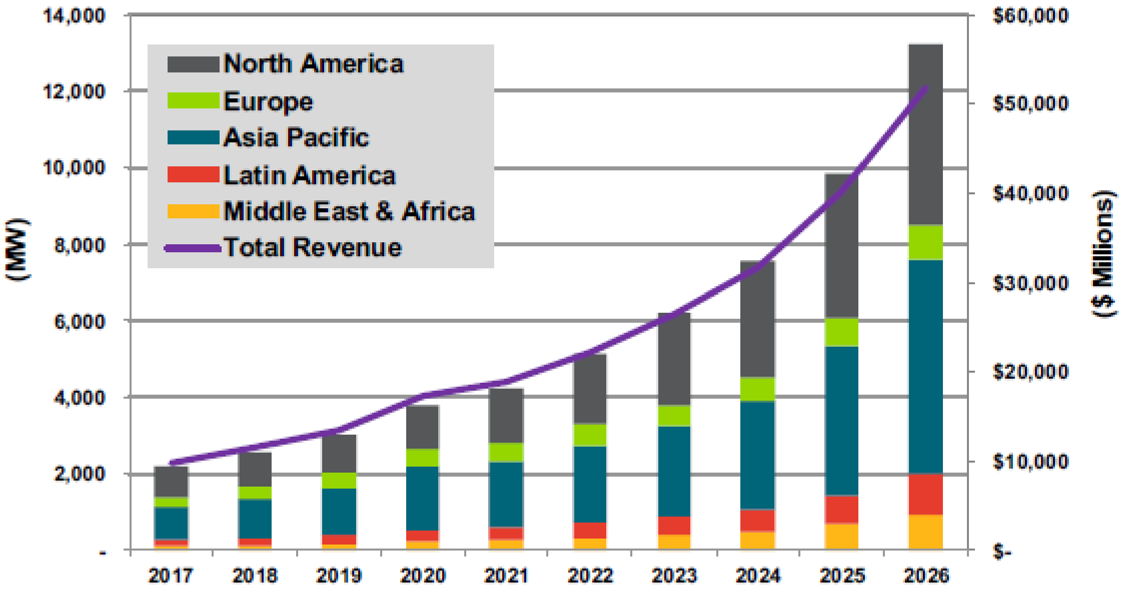
Mid & Long term Action Plan（取りまとめ後に即座に検討）

Anti-disaster measures
- 電源への投資回収スキーム等供給力等の対応力を確保する仕組みの検討
- ブラックアウトのリスクについての定期的な確認プロセスの構築
- Explore the measures to enhance and utilize interconnection lines that contribute to both improve resilience and RE expansion
- その際、レジリエンス強化と再エネ大量導入を両立させる費用負担方式やネットワーク投資の確保の在り方（託送制度改革含む）について検討
- Promote RE introduction that is resistant to natural disasters
- Explore resilience measures on the demand side
- 合理的な国民負担を踏まえた政策判断のメルクマールの検討
- 火力発電設備の耐震性の確保について、国の技術基準への明確な規定化　等

Source：METI Working Group on Electricity Resilience

Global

Total Microgrid Capacity and Revenue, World Markets: 2017-2026



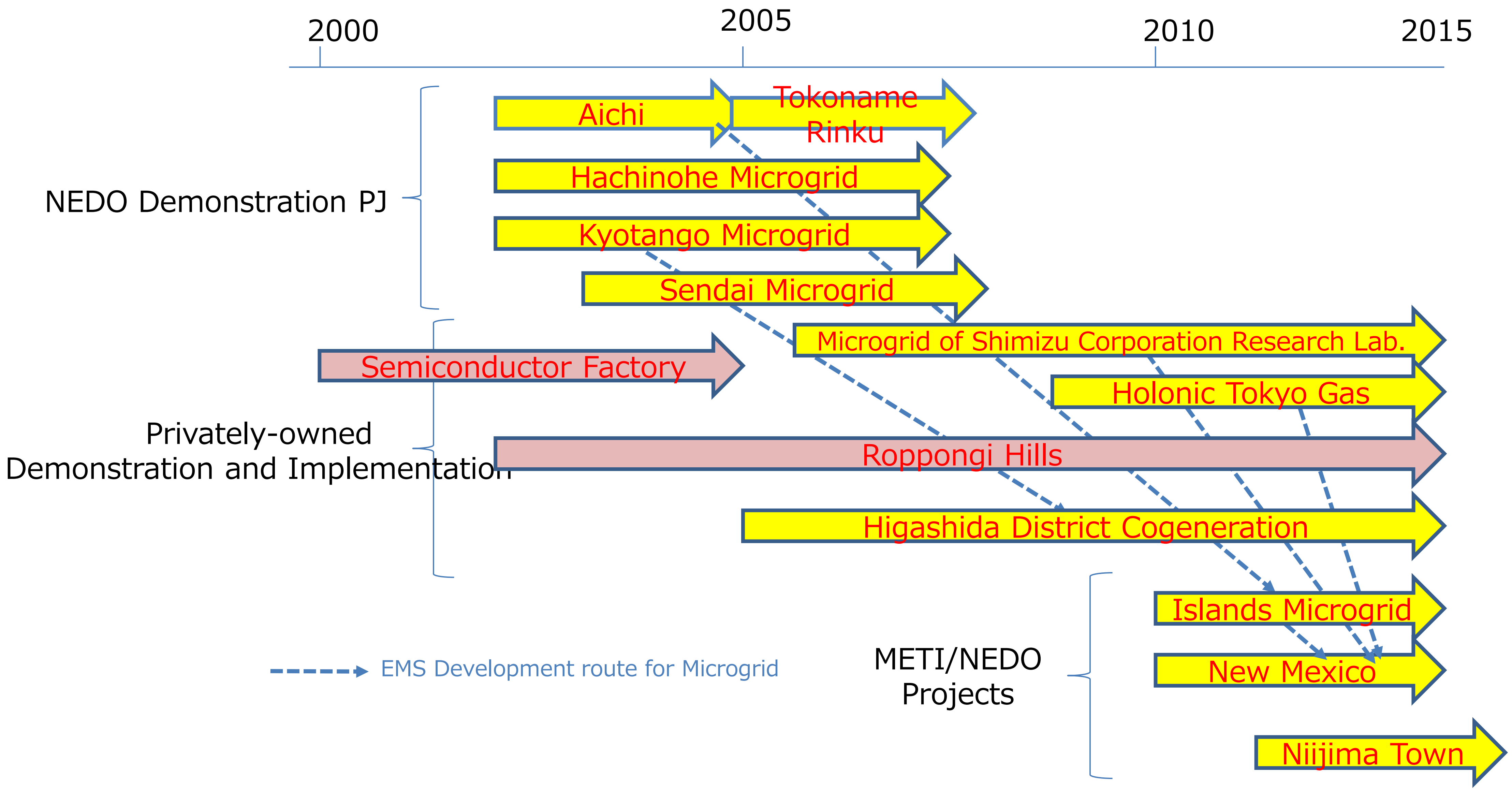
出典：Navigant Research

- In the United States, after being affected by Hurricane Sandy in 2012, microgrids are expected to play a role as an emergency power source during disasters.
- Some areas in Southeast Asia and islands where power transmission systems are not well developed, power supply from conventional DG is being replaced to microgrids based on renewable energy.

How to improve the resiliency of energy supply

1. -1) Microgrids of community/specific area
2. -2) Stand alone system for residential households
3. Quick recovery from power grid failures
4. Optimization on transmission utilization (Maximum utilization of existing transmission line)

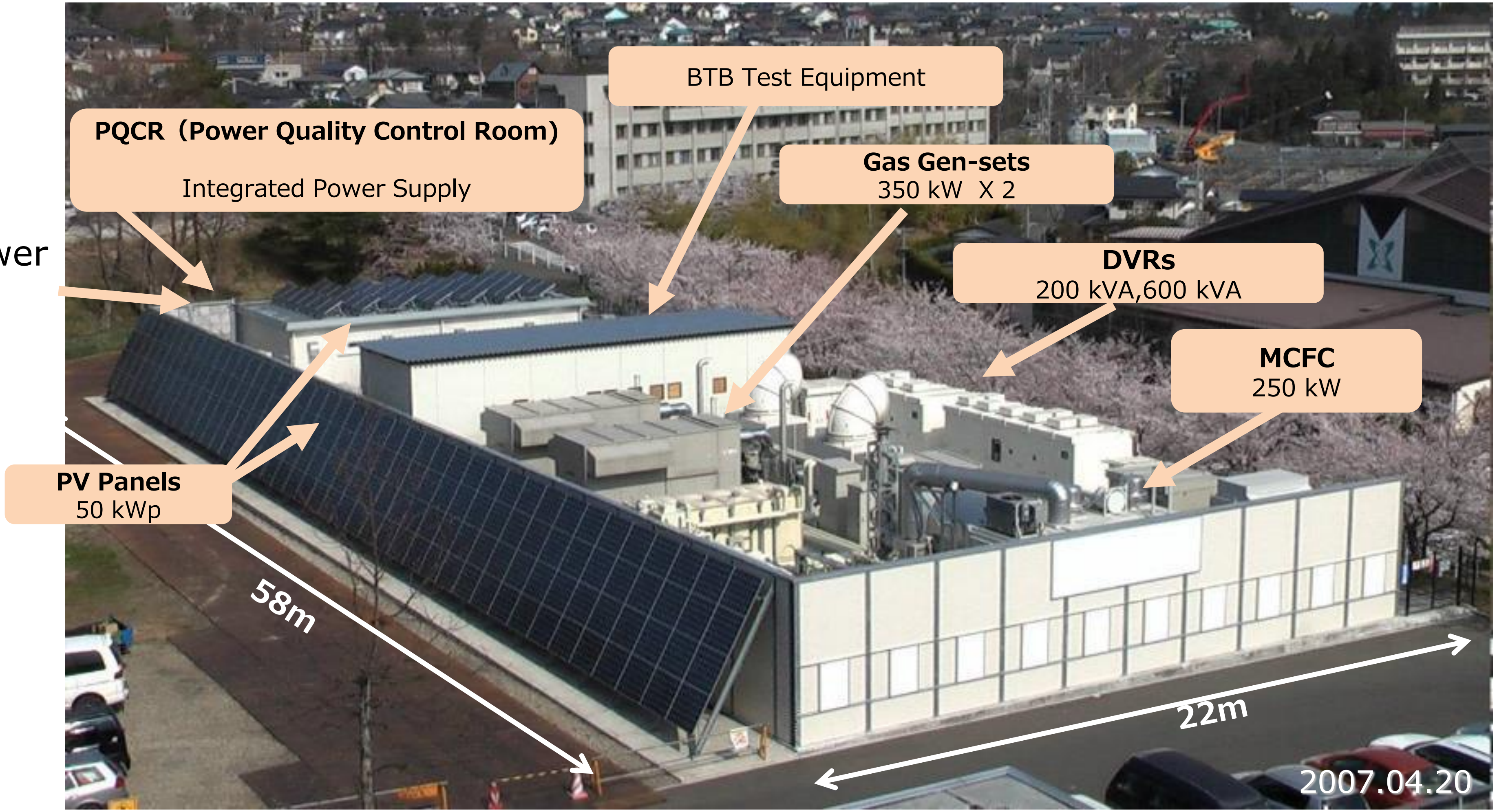
2．Domestic Demonstration Projects of NEDO: History of Microgrid Demonstration Projects in Japan



Sendai Microgrid Demonstration PJ

- Sendai Maicrogrid demonstration project, located on the campus of Tohoku Fukushi University in Sendai City from 2004-2008 (capable of supplying various classes of power quality within a microgrid)
- After completed the project in 2008, the microgrid system continued in operation.

Here is DC Power system in this building.



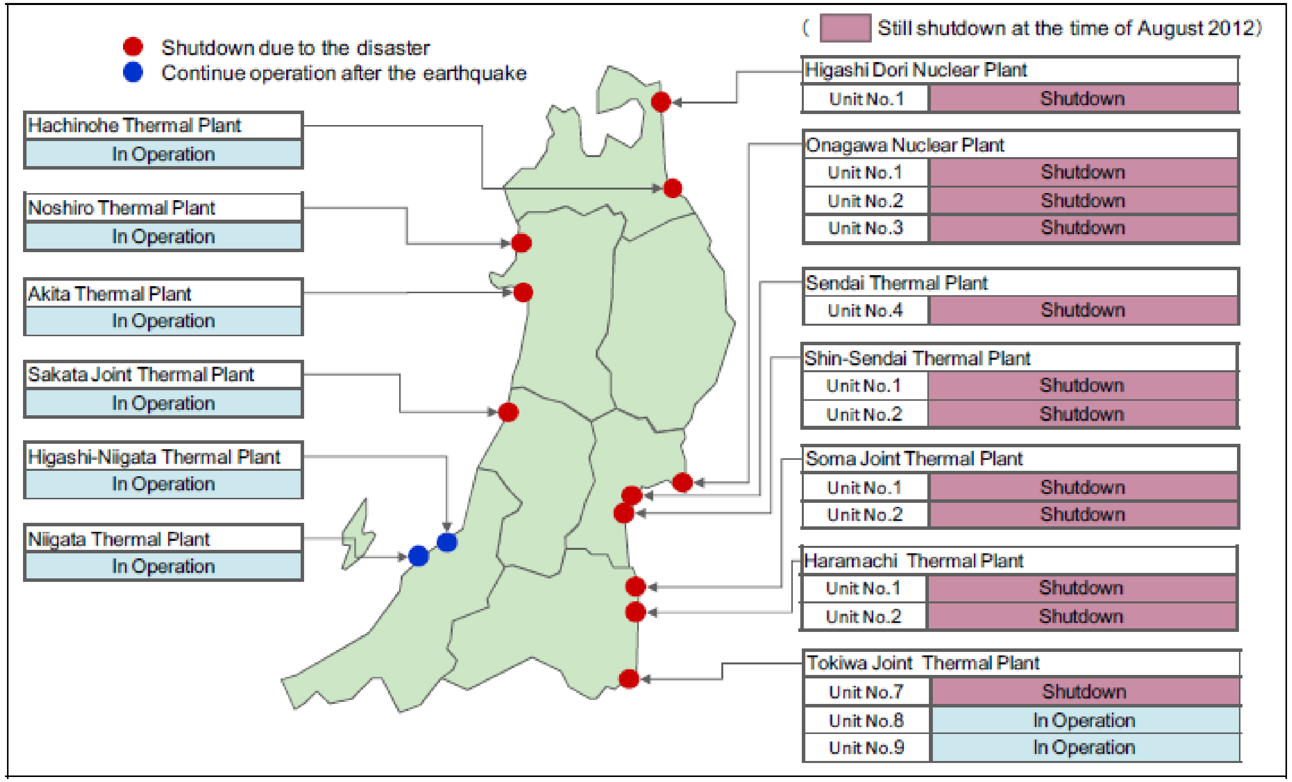
Energy Center : 1,085m^2

the Great East Japan Earthquake

- On March 11, 2011, the devastating Great East Japan Earthquake hit the Tohoku district and a blackout occurred immediately after the earthquake in most areas served by Tohoku EPC.
- **Tohoku EPC stopped supplying power to the area surrounding the Sendai Microgrid, resulting in a three-day outage.**

Kamaishi City, Iwate Prefecture

Severe damage at Minato Gas Plant

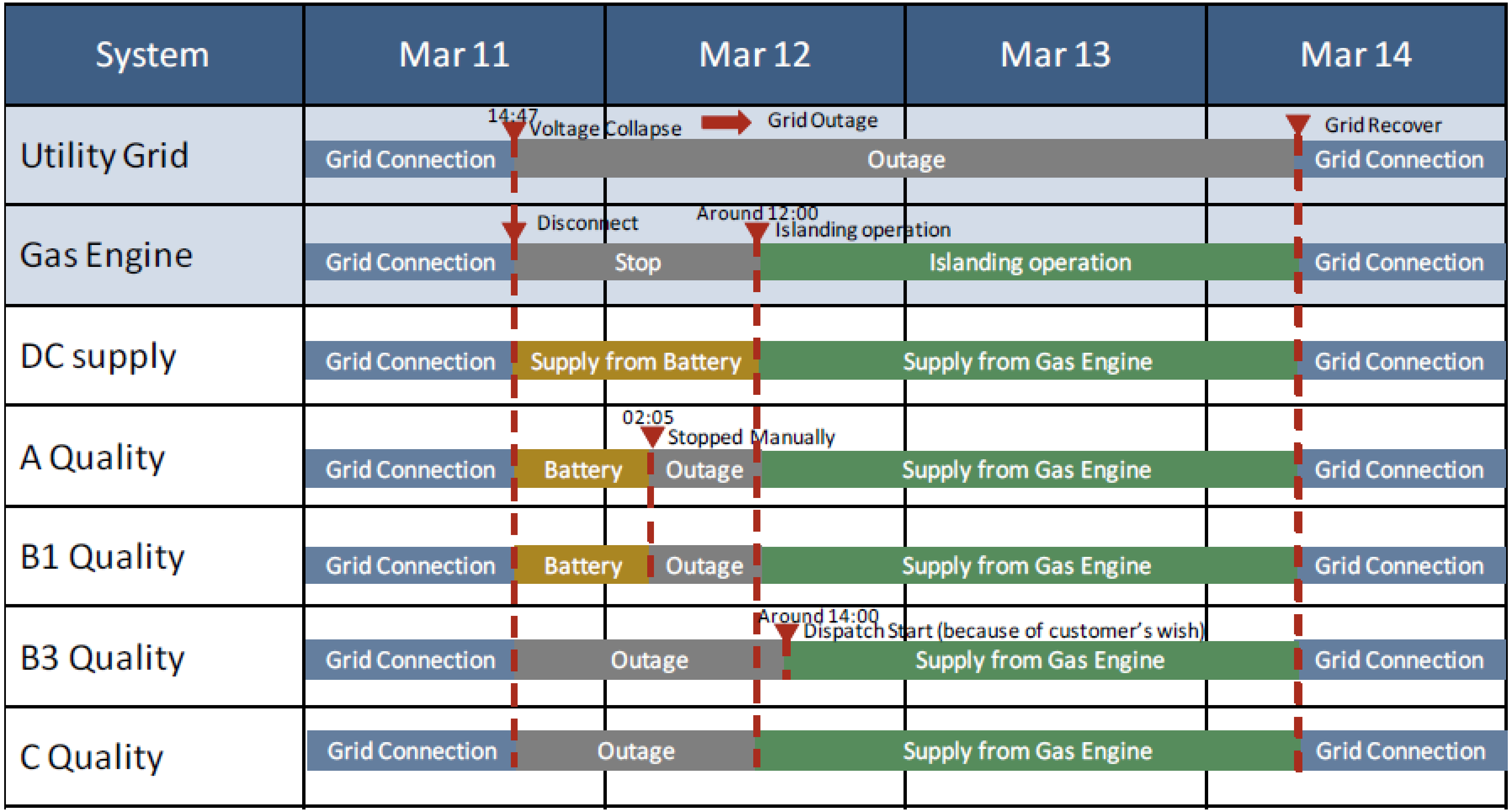


Status of Thermal and Nuclear Power Plants of Tohoku EPC

Red mark power plants as shown in above picture shutting down completely due to the earthquake.
The gas supply system suffered enormous damage as well and wide-area natural gas pipeline was used as an alternative to transmit gas from Niigata prefecture in west-north Japan, supplying mid/high-pressure gas to Sendai.

Sendai Microgid and the Great East Japan Earthquake

- Sendai Microgrid was able to supply power and heat within its service area continuously (**including the hospital and nursing care facilities where elderly people, dependent on ventilators for life support are residents**)



Operation of Sendai Microgrid during Grid Interruption

Ref. Timeline for Sendai Microgrid Operation after the Earthquake

11th/Mar/2011 14:47

- Beginning several tens of seconds after the occurrence of the earthquake at 14:46 on March 11, there were a series of major voltage fluctuations in Tohoku EPC's commercial grid, then a gradual drop in voltage, leading to the outage. Accordingly, the Sendai Microgrid switched over to island mode.
- The gas engines were affected by the grid's abnormal voltage. They were forced to stop generating power due to their design for preventing abnormal operation, causing the system go into an outage on the 6.6kV bus. Thus, power supply to B3 and C classes was stopped.
- Three hours later, the microgrid operator arrived at the site and attempted to restart the gas engines manually. However, the gas engines did not activate because the control system batteries were totally discharged, and did not recover until about noon onMarch 12th.
- Even after the gas engines stopped, the microgrid continuously fed power to customers of DC Supply, A class and B1 class (which are connected to the IPS) by utilizing storage batteries in the IPS and PV as the power source.

12th/Mar/2011 02:06

- As the remaining level of battery storage in the IPS fell and the voltage extended beyond the operating range, the microgrid operator stopped operation of the battery for safety reasons, resulting in the outage of A-Class and B1-Class. On the other hand, DC Supply continued feeding power even after the power interruption of A and B1 classes, because the DC Supply's minimum operating voltage was slightly lower than that of the inverters and the load was not so great.

12th/Mar/2011 approx.12:00

- The gas engines were restarted manually after the local operator implemented provisional cabling work that supplied power to the control source circuit from another power panel. The operator checked the power feeding the facility, including the gas engines, and confirmed their safe operation. The Sendai Microgrid resumed power supply to A, B1 and C classes with the gas engines operated in island mode.

12th/Mar/2011 approx. 14:00

- The Sendai Microgrid excludes B3-Class from its island system. However, at the time of the earthquake, there were four elderly people using ventilators in the nursing care facility. Considering that further interruption of the power supply would be fatal to those people (customers), Tohoku Fukushi University requested B3-Class power supply.
- Responding to this request, the microgrid operator supplied B3-Class power by switching the feeding route to the bypass route.

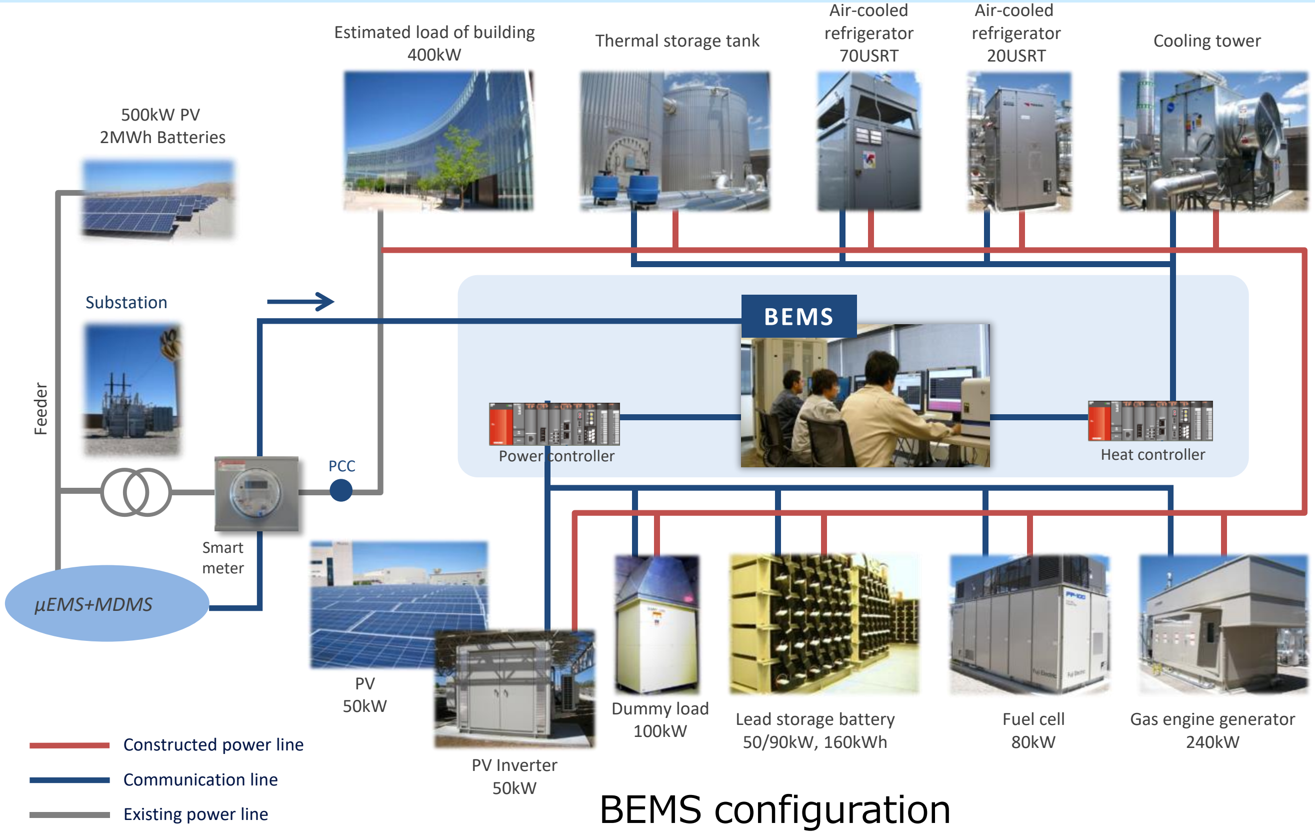
14th/Mar/2011 08:16

- Tohoku EPC's commercial grid was restored. Once all microgrid equipment for two-way power flow with the grid was checked and readied for interconnection, the Sendai Microgrid was reconnected to the distribution grid and returned to its normal operating mode.

3．International Demonstration Projects of NEDO

（1）Smart Grid Demonstration Project in New Mexico : Albuquerque site (BEMS)

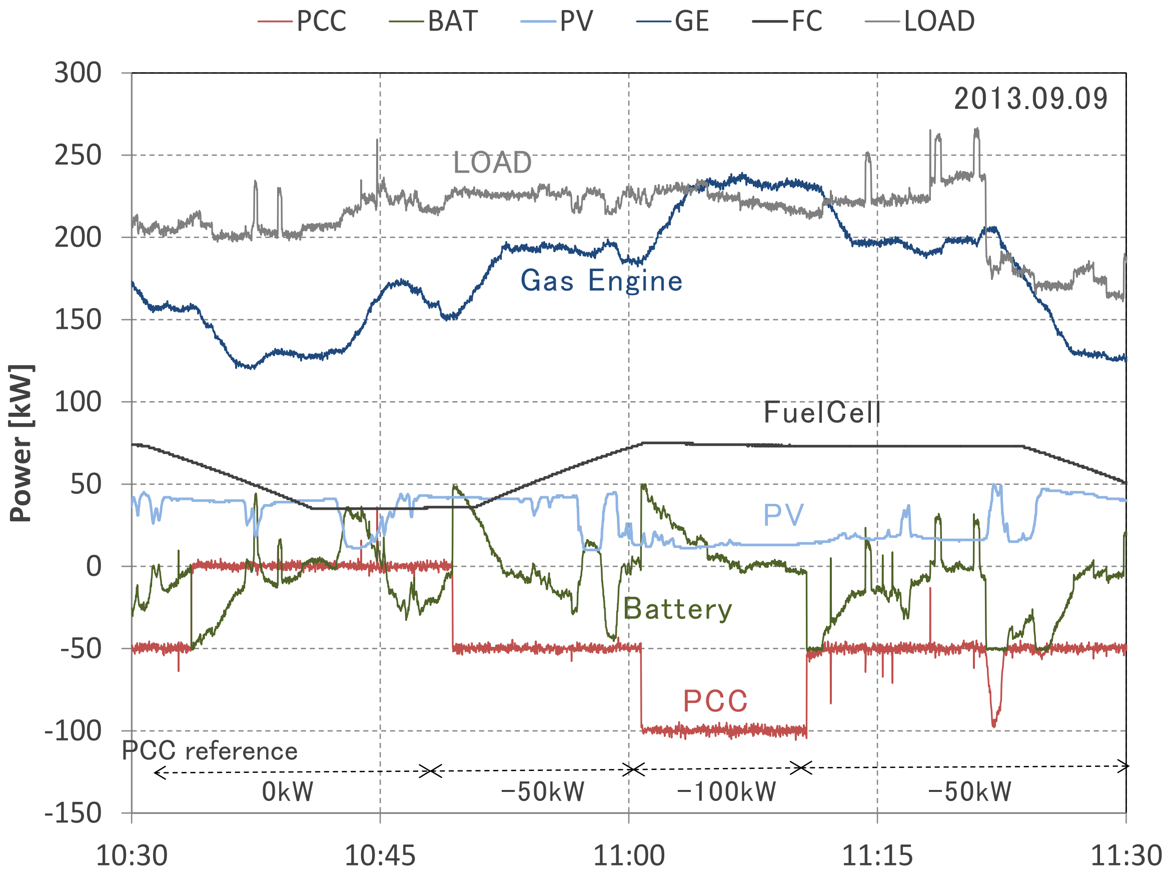
- Smart grid demonstration project in Los Alamos and Albuquerque in New Mexico from FY 2009-FY2014.
- In Albuquerque, an existing building in a new development area called Mesa Del Sol was retrofitted with a gas engine, phosphoric acid fuel cells, and thermal storage layers, changing it into a smart building that can operate as a microgrid to sustain its own power and heat supply.
- **The system for this demonstration has characteristics of contributing to the power system operation in the grid-connected mode and also shifting to the islanding mode without any instantaneous interruption at the time of power grid outage.**
- This project affected later projects such as the US Spider Project (microgrid of military facilities) through the project partner Sandia National Laboratory.



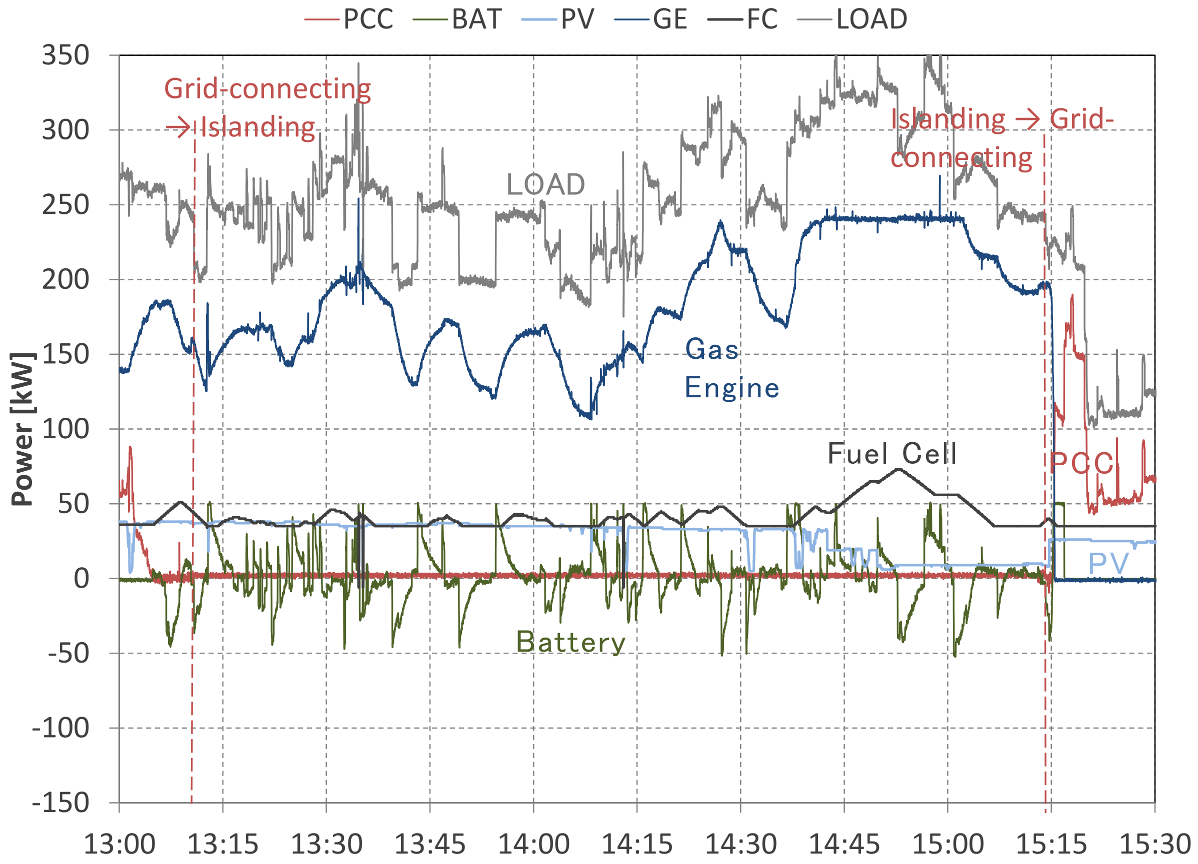
BEMS configuration

Albuquerque site (BEMS)

Performance results in grid-connected mode

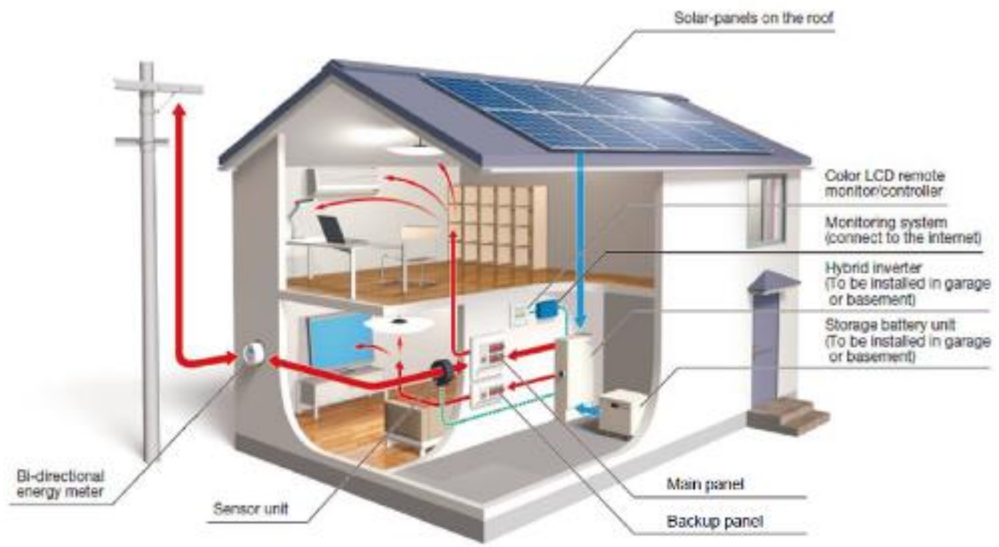


Performance results in Islanding mode



（2）Smart Community Demonstration Project in Canada

- Hybrid inverter systems for unified control of solar panels and storage batteries in 30 homes in the city of Oshawa.
- Demonstrate the system's use as an emergency power source during power outages while verifying its ability to stabilize the power grid from FY2015 – FY2017.
- **204 times power outage in the city of Oshawa in 2013,** especially Ice storm brings serious power outage.
- **116 times power outage during the demonstration.** All demonstration sites experienced power outage and **stand-alone operation was activated successfully** while power outage occurred.



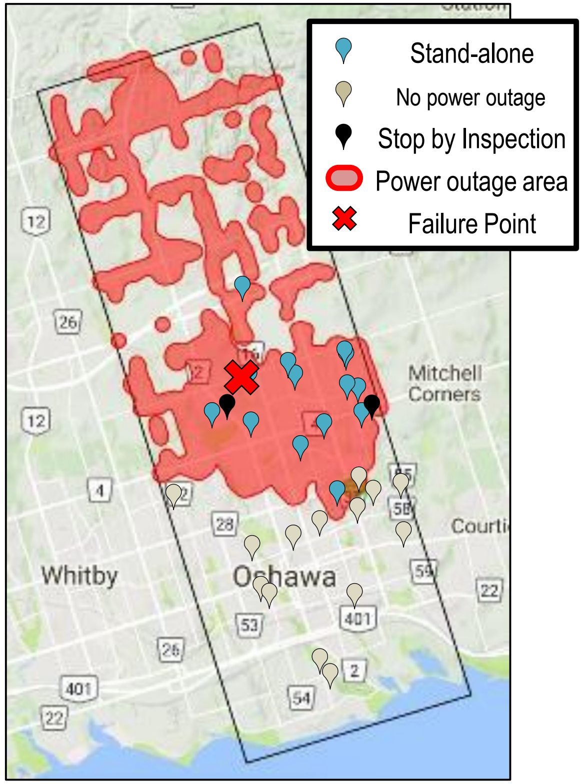
Installation Diagram

Outage duration	FY2016	FY2017	Total
< 15 min	25	16	41
15 - 60 min	20	5	25
1 – 3 hours	14	15	29
> 3 hours	17	4	21
Total	76	40	116
Max. number of outage per site	8	6	

Number or Power Outage od demonstration sites during the demonstration period

Outage Performance Case Study

- November 14, 2016, a power outage occurred in the northern part of Oshawa due to equipment failure (transformer burnout in substation).
- Stand-alone operation was activated for ~3 hours at 14 sites out of the area where power outage occurred, and electric power was supplied during the power outage.

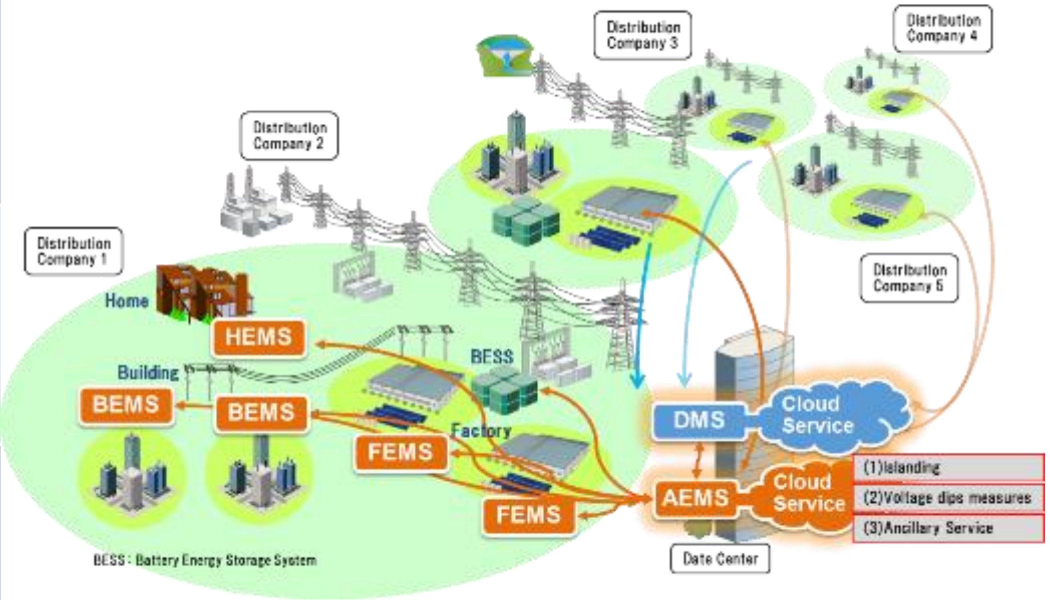


Stand-alone operation on Nov.14, 2016

（3）Smart Community Project in Slovenia

- A cloud-based integrated Distribution Management System (DMS) and Advanced Energy Management System (AEMS) linked with which provides several services including;
- **1) Quick recovery from grid failure**, **2) Voltage dips mitigation measures** for factory, and **3) Islanding** to prevents power outages in critical facilities.
- Demonstration Operation Start : 2018 – (partially)

Function	Description
Quick recovery from grid failure	When an accident involving a power outage occurs in the distribution network, accurate identification of the accident point, disconnecting the accident point from the grid, and automatically switching the non-accident point to the grid Shortened recovery time from power outage by half (target)
Voltage dips mitigation measures	The system mitigates voltage dips caused by snowfall, lightening strike or other natural disaster at factories and other consumers that require a high-quality electricity supply by using BESS installed within the area to protect consumers' critical facilities from voltage dips.
Islanding	The system is linked with the DMS and prevents huge power outages by isolating areas that contain critical facilities such as hospitals from the grid and providing electricity from BESS during power outages.

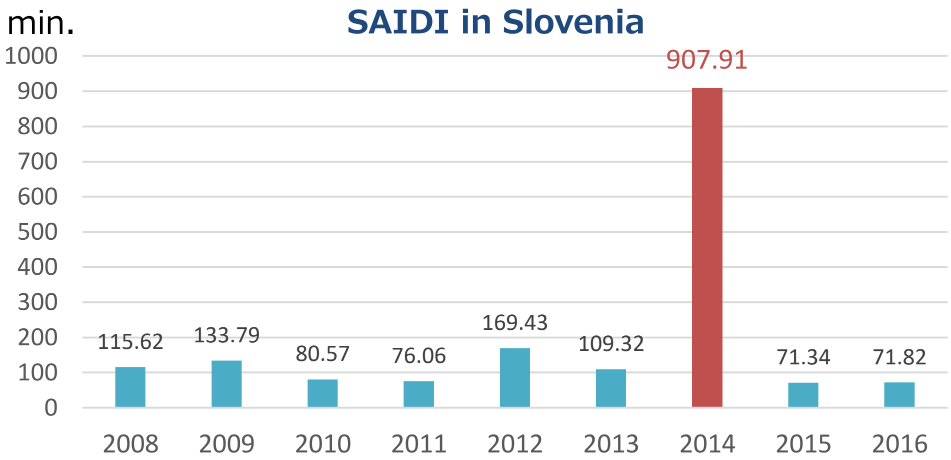


Background of the project

1. Increase renewable energy and decrease thermal power plant
   ⇒Utilize DERs to provide flexibility to the power grid

2. The amount of damage caused by power quality degradation such as voltage dip in EU is estimated more than € 150 billion per year. 90% of them was industrial customers such as factories.
   ⇒Needs for economical voltage dips mitigation measures

3. Ice storm in 2014 cuts power in Slovenia
   ⇒Shortening outage duration and protect critical facilities such as hospitals from huge outages



Source : CEER Benchmarking Report 6.1 on the Continuity of Electricity and Gas Supply (2018)

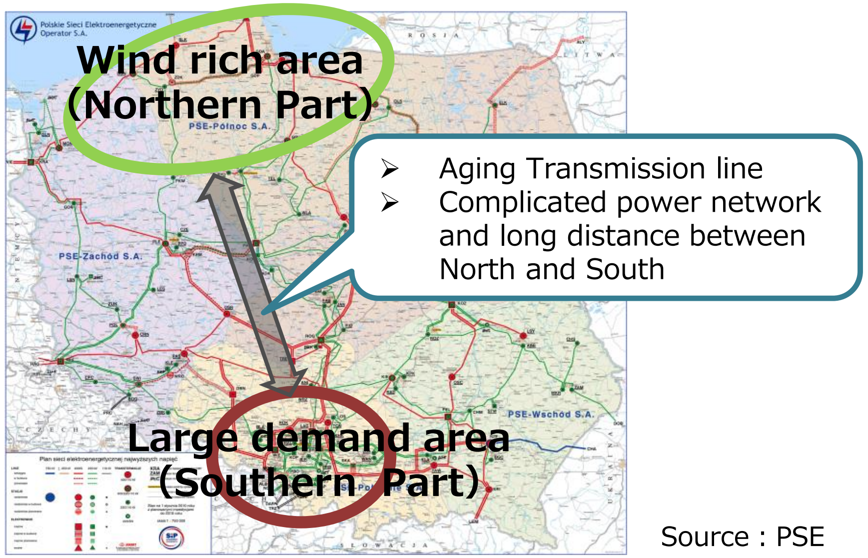
(4) Smart Grid Demonstration Project in Poland

- **On-line Special Protection Scheme (SPS)** and **hybrid BESS** in order to **increase power system security and preventing the grid overloading and allowing for optimal management of wind generation**.
- Demonstration Operation Start : 2019 Autumn

Challenges for Transmission line

- Wind power will grow from 5.8GW(2018) to 9.8GW(2021). **Transmission capacity issue** for further integration of Wind.
- **Grid overloading issue** due to the distance between suitable area for wind power (north) and large demand area (south)

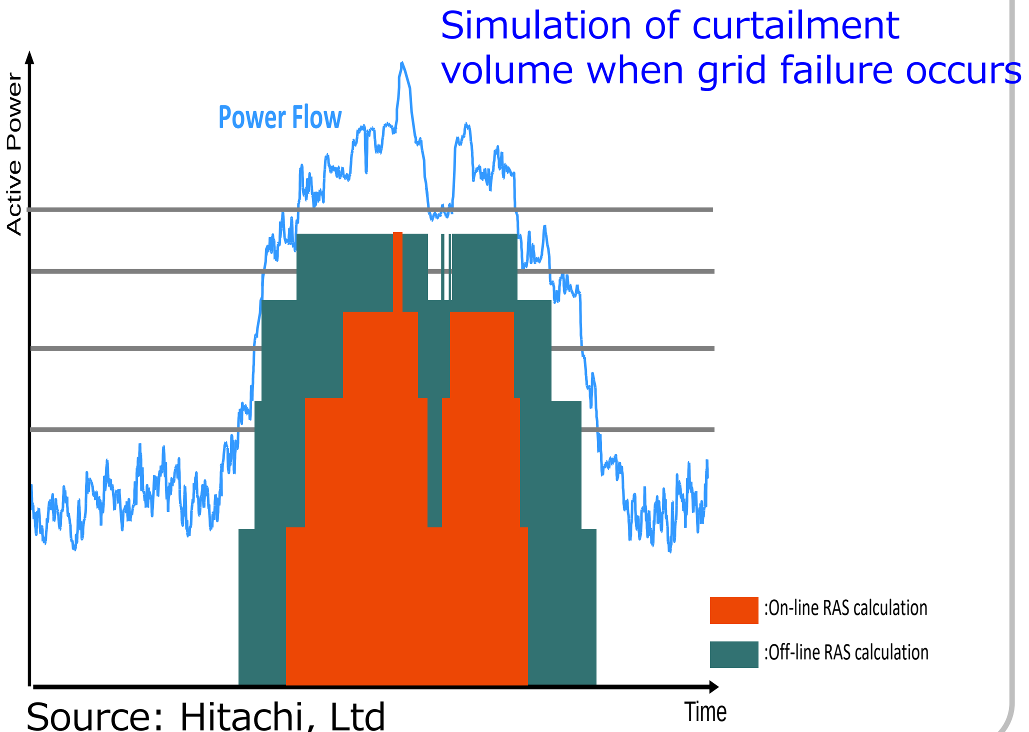
Transmission in Poland



Source : PSE

Optimization of Wind Power Curtailment

SPS will simulate the minimum curtailment volume due to minute order parameter setting.



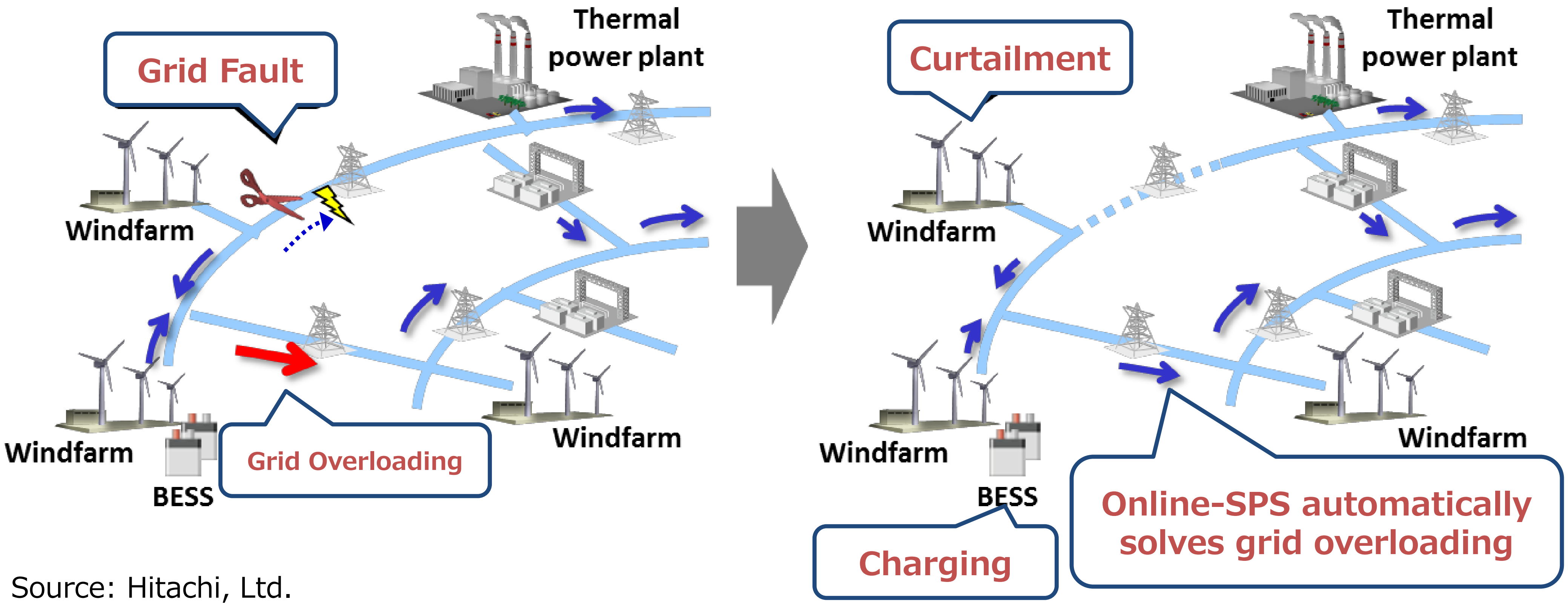
Source: Hitachi, Ltd

BESS: Battery Energy Storage System

Online-SPS solves grid overloading

- SPS system **plans real time countermeasures action (curtailment of wind power or charging the battery) for specific accidents on the power network** based on the online information extracted from SCADA. If an accident actually occurs, the SPS system carries out controls automatically in order to prevent overloads in the power system.
- Conventional offline-SPS is static parameter setting by seasonally or yearly. Transmission capacity requires some amount of margins for emergency use which limit the renewable energy connection to the grid (FS simulation shows **the grid connection available capacity of RE is 1.8 time bigger by online-SPS**.)

Image of Solving Overloading by online-SPS



Source: Hitachi, Ltd.

5. Conclusion

- Aiming to establish microgrids technologies and improve resilience of power systems, NEDO have carried out several demonstration projects in Japan and overseas since early 2000s. NEDO will continue to make efforts to contribute to address energy issues in the world with Japan’s technology.

- The recent sharp drop in the cost of DERs has reduced microgrids introduction costs and increased their cost performance. However, cost reduction of the entire system is necessary in addition to cutting costs of each equipment in order to shift microgrids from demonstration phase to commercial operation.

- To reduce the cost of the entire system, modular microgrids need to be presented as a solution for mass-production. To do so, standardization (standardization of interfaces between each equipment and different systems) and interoperability will become important.

- Municipalities/local governments, who are the system owner, will be required to deliberate what lifelines they are going to maintain in their community. There are many ways to improve resilience; therefore, the IEC and various organizations are taking steps to sort out the measures by standardization.

Ref. Case Studies of NEDO Demonstration PJ

Case study of the completed smart community demonstration projects are available from NEDO website.

- The Operational Experience of Sendai Microgrid in the Aftermath of the Great East Japan Earthquake
- Japan－U.S. Collaborative Smart Grid Demonstration Project in New Mexico
- Smart Community Demonstration in Malaga
- Japan - U.S. Collaborative Smart Grid Demonstration Project in Maui Island of Hawaii State
- Smart Community Demonstration Project in Lyon, France
- Smart Community Demonstration Project in Greater Manchester, UK

http://www.nedo.go.jp/activities/ZZJP2_100058.html
or Google “NEDO case study”

Ref. Promotion video of NEDO projects

Uploaded on 12th June, 2018

http://www.nedo.go.jp/library/nedo_channel.html

Thank you for your attention !!