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Smart Community Summit 2021

Smart Grid Demonstration Project in Poland

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This presentation is based on results obtained from a project commissioned by the New Energy and Industrial Technology Development Organization (NEDO)

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Contents

1. Hitachi Activities: Social Innovation Business

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1. Hitachi Activities: Smart community initiatives

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UK:
NEDO Manchester
Smart Grid Demonstration Project

Japan:
Kashiwa-no-ha Smart City

U.S.: New Jersey
Energy Storage System (BESS)
Demonstration Project

Poland
NEDO SPS/BESS
Demonstration Project

U.S.:
BPA SPS
FS Project

Slovenia:
NEDO DMS
Demonstration Project

U.S.:
New York State
Microgrid FS Project

India:
Capacity Building
Demonstration Project

Thailand:
NEDO
Optimized Performance Enabling
Network for Volt/Var(Q)
(OPENVQ)

Japan:
NEDO Izu Oshima
Large Hybrid Energy Storage System
(BESS) Demonstration Project

U.S.:
NEDO Hawaii
Smart Grid
Demonstration Project

NEDO: New Energy and Industrial Technology Development Organization
BESS: Battery Energy Storage System SPS: Special Protection Scheme FS: Feasibility Study
BPA: Bonneville Power Administration DMS: Distribution Management System
OPENVQ: Optimized Performance Enabling Network for Volt／var（Q）

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2. Background of Demonstration
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4. Results of Demonstration

2. Background of Demonstration in Europe

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■ Politics : Clean Energy Package

<2030's Target>
・RES ・Energy Efficiency ・Interconnection
・Electricity market design

<Efforts of Regulatory agency and ENSTO-E>
・TYNDP ・Electricity market integration ・TSOs Regional coordination

■ Industrial :

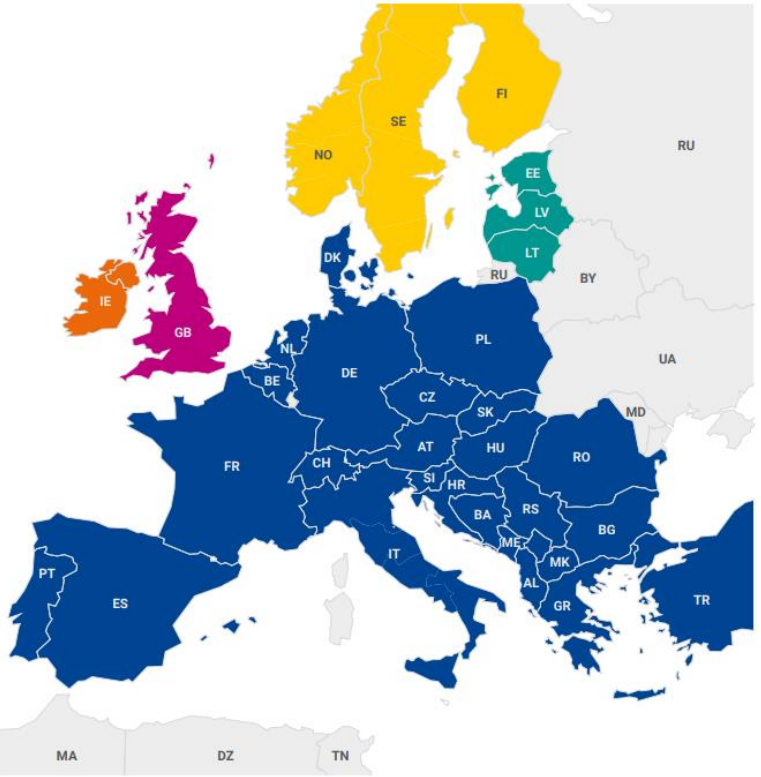
・RES/DER introduction
・Electrification, HVDC
・Power flow in intra region

■ Other factors:

・Exits of Aging plants
・Exits of nuclear plants
・Digitalization

■ Long/Mid term (2025-2030) Challenges in Grid Operation:

・Frequency related issue (low-inertia caused by RES, HVDC, Electrification)
・Transient stability/Voltage issue (caused by RES)
・Congestion management (unexpected power flow)
・Dynamic operation (incl. regulation change)



Source : ENTSO-e TYNDP2020, System dynamic and operational challenges, TSO development plans

2. Overview of Poland

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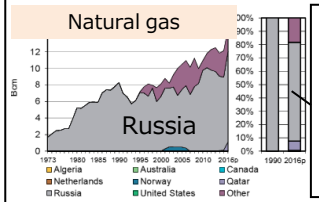
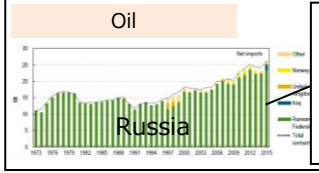
■ Expansion of wind power generation in Poland
Poland aims to increase wind power generation in order to reduce its dependence on energy imports and to meet the EU Renewable Energy Directive.

Energy import dependence



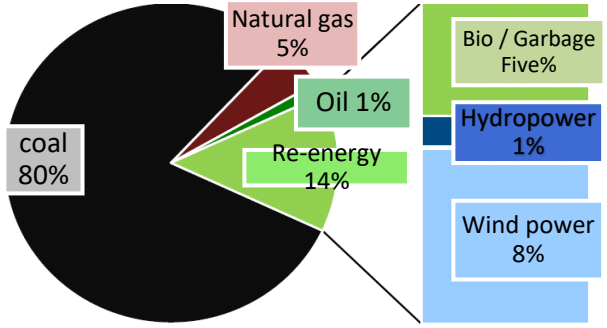
Poland's dependence on natural gas overseas is 70%. 70% of them depend on Russia * 1 (about 100% in 1990)



Most of the crude oil depends on imports, of which more than 80% depends on Russia. * 2

Poland

Energy Mix *3



80% of electricity comes from coal (including lignite)

Need to increase energy self-sufficiency to reduce dependence on energy imports.

Need to expand Renewable energy to meet the EU Renewable Energy Directive

Aiming to increase the amount of wind power generation

Source: * 1 IEA「Natural Gas Information」2017
* 2 IEA「2017Poland - Energy System Overview」2017
* 3 IEA「2017Poland - Energy System Overview」2017

2. Enhancement of transmission lines

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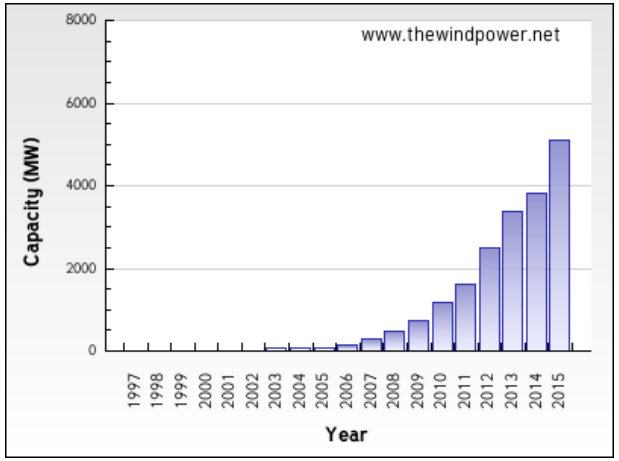
- In Poland, the amount of wind power is expanding, especially in the northern regions.
- However, there are challenges in grid operation because the areas suitable for wind power and the demand areas are far apart.

Introduction of wind power in Poland

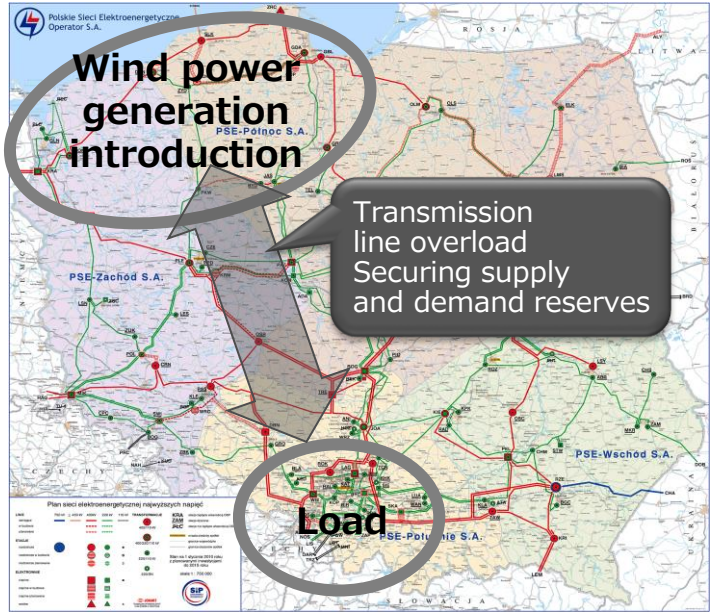


Source: www.thewindpower.net

2016 wind power introduction About 5,298 MW → 2021 Wind power introduction 9,848MW(Plan)

Source: PSE (Polskie Sieci Elektroenergetyczne)

Wind power expansion area



2. Securing supply and demand reserve

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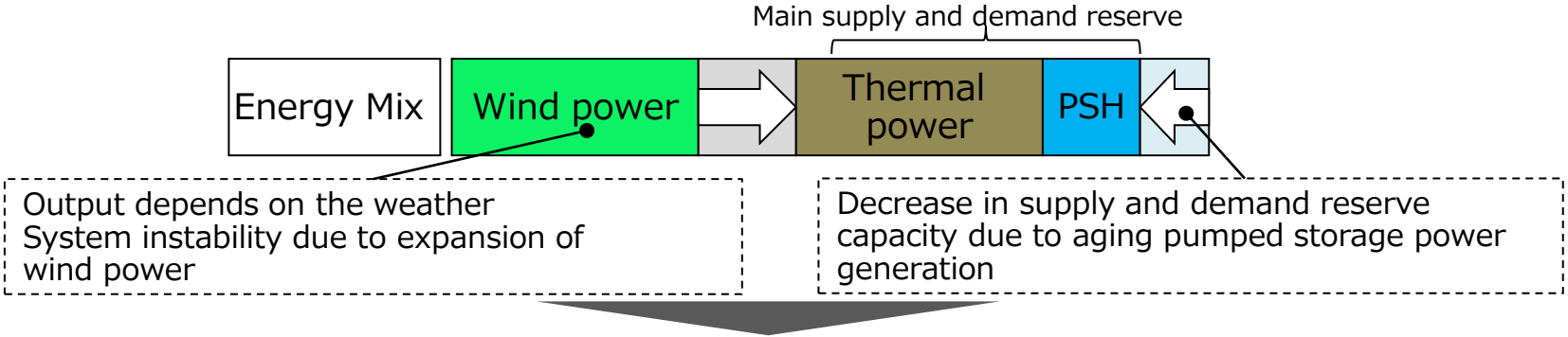
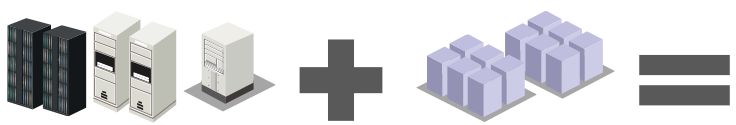
- The grid operator is facing the challenge of decreasing reserve power to keep the grid stable as the introduction of wind power, which has unstable output, and is studying the introduction of battery storage systems in parallel with gas turbines.
- Mitigation of short-term fluctuations and provision of reserve power by battery storage systems .

Future Polish Power System Challenge



How to deal with challenge



Mitigation of short-term fluctuations

Providing supply and demand reserves

PSH: Pumped-storage Hydropower

2. Challenges and goals of project

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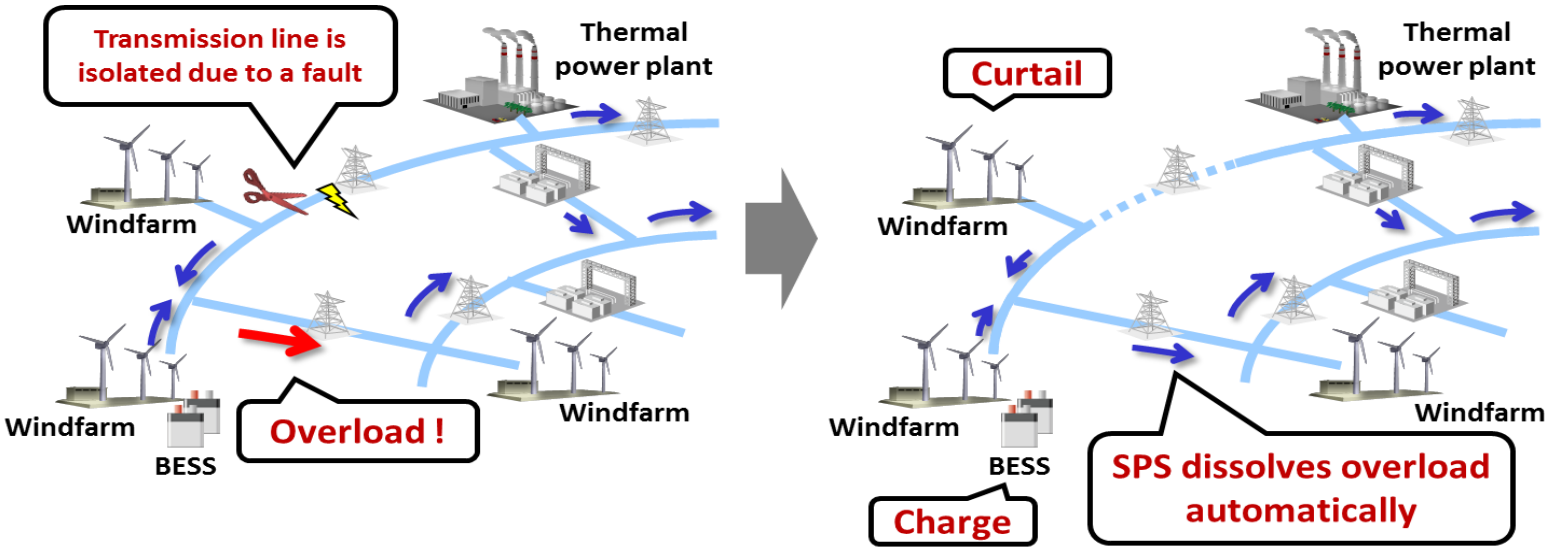
Challenges in normal condition	■Enhancement of transmission lines ■Securing supply and demand reserve	Challenge in fault condition	■Overload of transmission line
Goals	■SPS（Special Protection Scheme） ■Hybrid BESS（Battery Energy Storage System）	Challenges resolution	

Image of overload elimination by SPS



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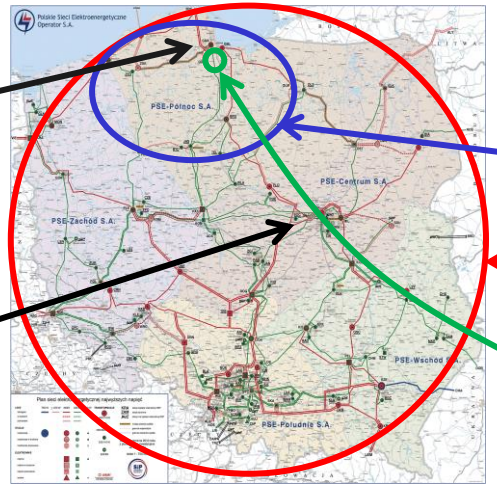
3. Demonstration Goals

No	Area	Goal	System / function	Control target
1	Northern Poland area	・Verify the effect of increasing the connectable amount of wind power generation by SPS	SPS Overload measures (Automatic control)	1) Wind farm connected to the transmission and distribution network. 2) BESS
2	All over Poland	・Visualization of transmission line overload risk and countermeasure	SPS Overload measures (DSS)	No control * Calculations include wind farms and thermal power plants throughout Poland. Aim to expand as a control target in the future
3	Bystra wind farm	・Mitigate short-term fluctuations in wind power and provide reserve power	Hybrid BESS	1) BESS

Gdansk /Bystra

Warsaw



Demonstration area

No.1 : Verify the effect of increasing the connectable amount of wind power generation by SPS

No.2 : Visualization of transmission line overload risk and countermeasure

No.3 : Mitigate short-term fluctuations in wind power and provide reserve power

DSS : Decision Support System

3. System Overview

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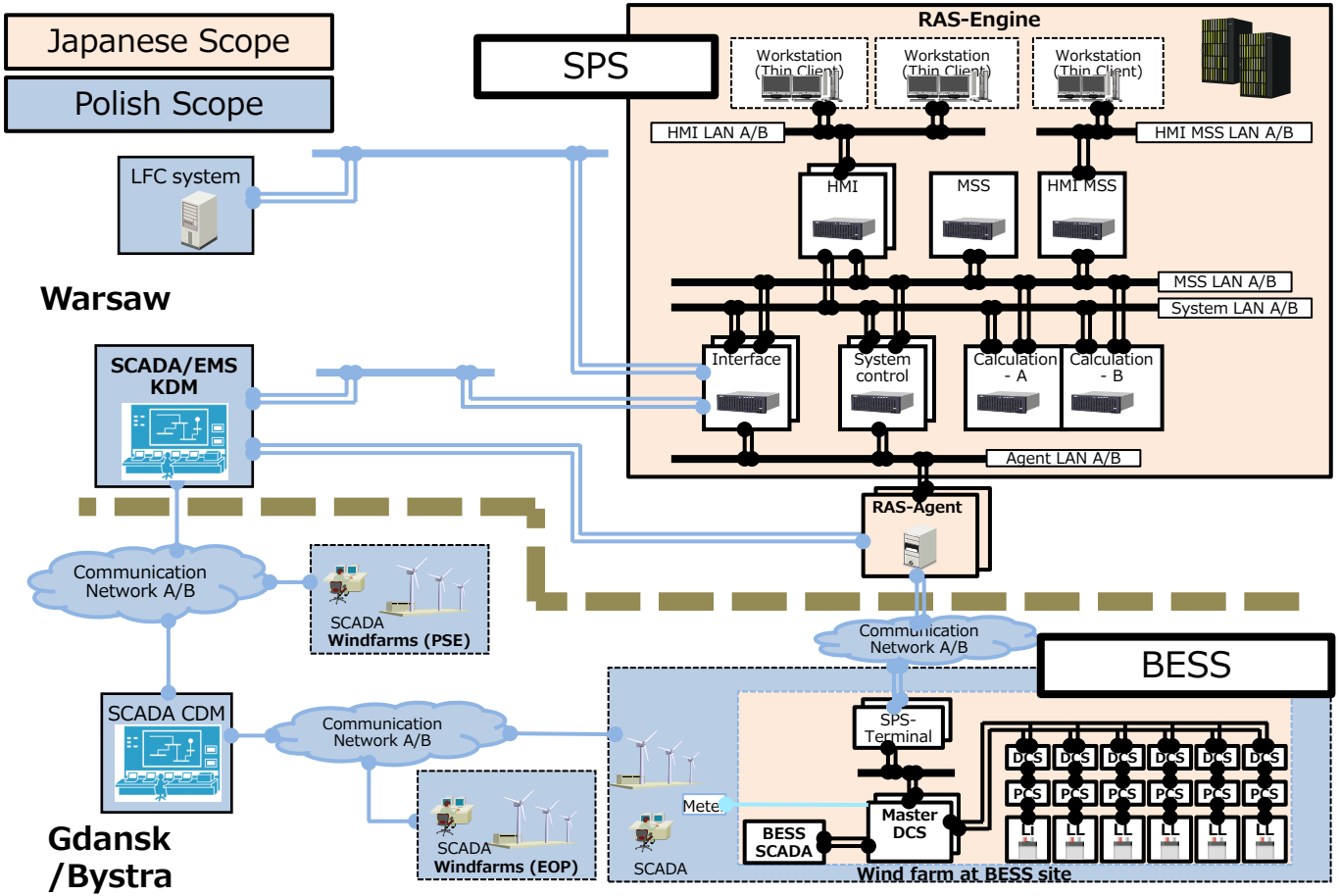

LFC :Load Frequency Control
SCADA/EMS KDM: Supervisory Control and Data Acquisition /Energy Management System Krajowej Dyspozycji Mocy
SCADA CDM: Supervisory Control and Data Acquisition Centralnej Dyspozycji Mocy
EOP : ENERGA OPERATOR
RAS: Remedial Action Scheme
DCS: Distributed Control System
PCS: Power Conditioning System
Li: Lithium ion battery
LL: Lead-acid battery

3. SPS System Overview

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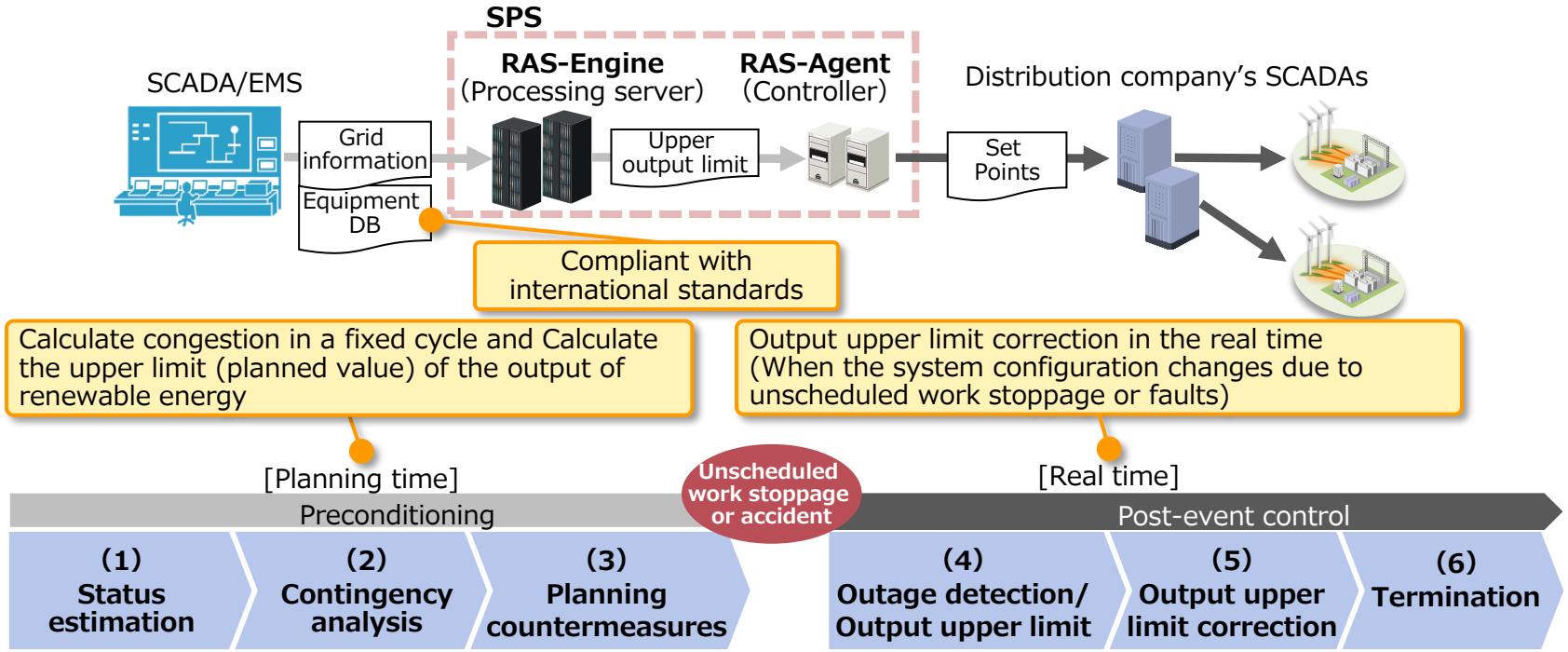
- System Objectives : Automatic elimination of overloads in transmission lines and transformers
- Control target : Output curtailment of generators (mainly wind power)



3. BESS System Overview

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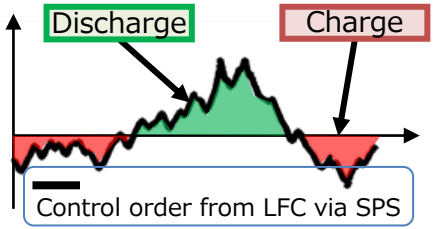
- System Objectives : Mitigate short-term fluctuations and provide reserve power
- Control target : Hybrid BESS (Lithium-ion battery and Lead-acid battery)

Lithium-ion battery : 1MW/0.47MWh / Lead-acid battery : 5MW/26.9MWh

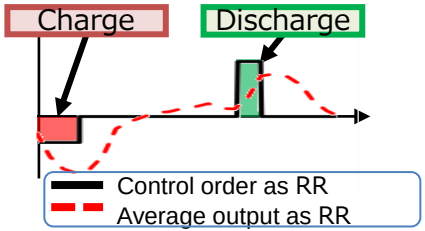
1. Normal condition : Mitigate short-term fluctuations and provide reserve power

Central control

Primary(FCR) and Secondary(FRR) reserve power equivalent

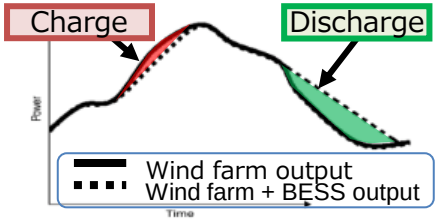


Tertiary(RR) reserve power equivalent

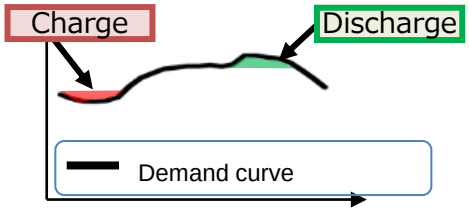


Local Control

Mitigate of short-term fluctuations



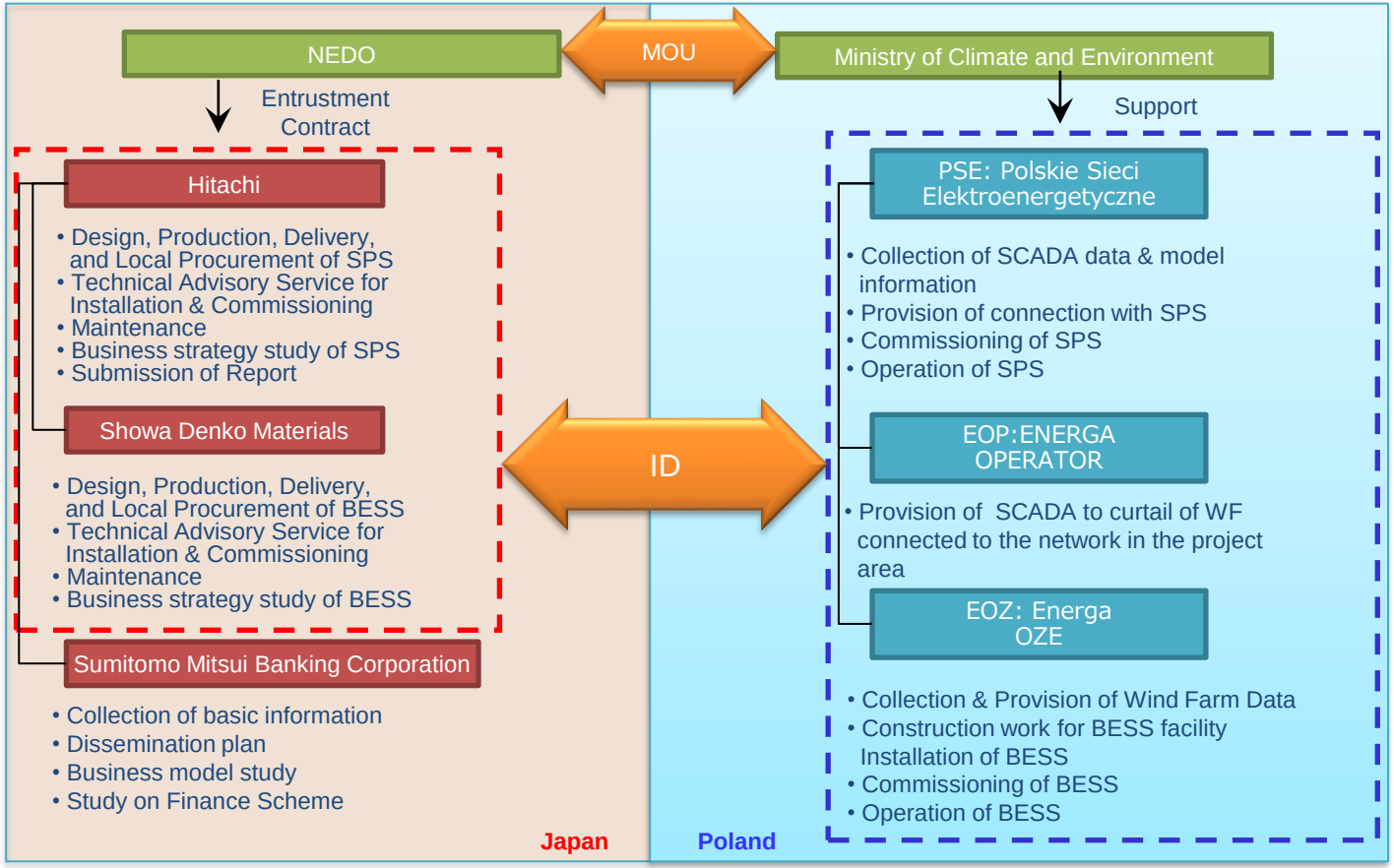
Price arbitrage



FCR: Frequency containment reserve
FRR: Frequency restoration reserves
RR: Replacement reserves

2. Fault condition : Switch to overload countermeasure and charge to eliminate overload

3. Project Structure



ID : Implementation Document

3. Project Schedule

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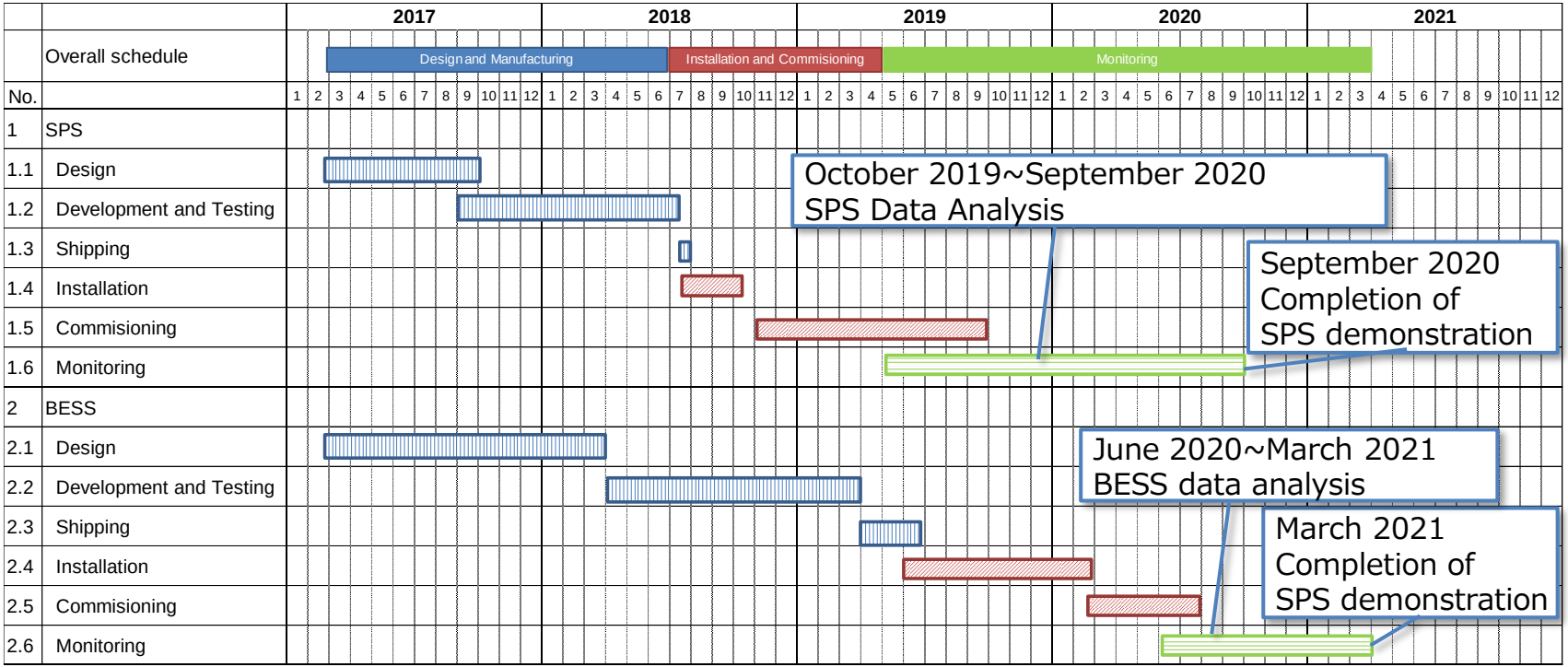
COVID-19 had an impact on the timing of the BESS demonstration,
but the demonstration was successfully completed.



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4. Results of SPS - 1

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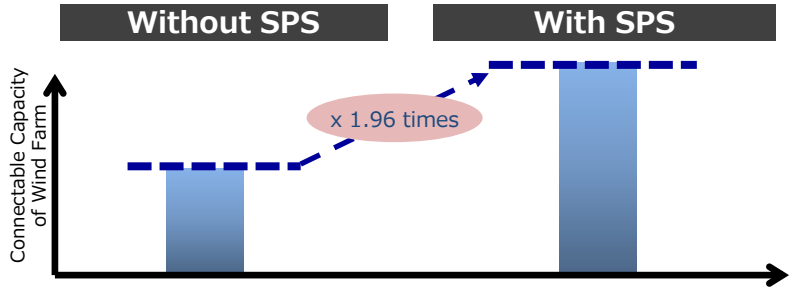
The effect of increasing the connectable amount of wind power generation by SPS was verified and confirmed.



*An example : 9pm, July 14th, 2020

- It was confirmed that SPS is more effective in areas where a large amount of wind power is installed.
- It was confirmed that the transmission capacity of the bottlenecked transmission lines could be raised.
- It was confirmed that the connectable amount of wind power generation could be increased by 1.96 times in the harshest section of the area where the SPS was effective.

4. Results of SPS - 2

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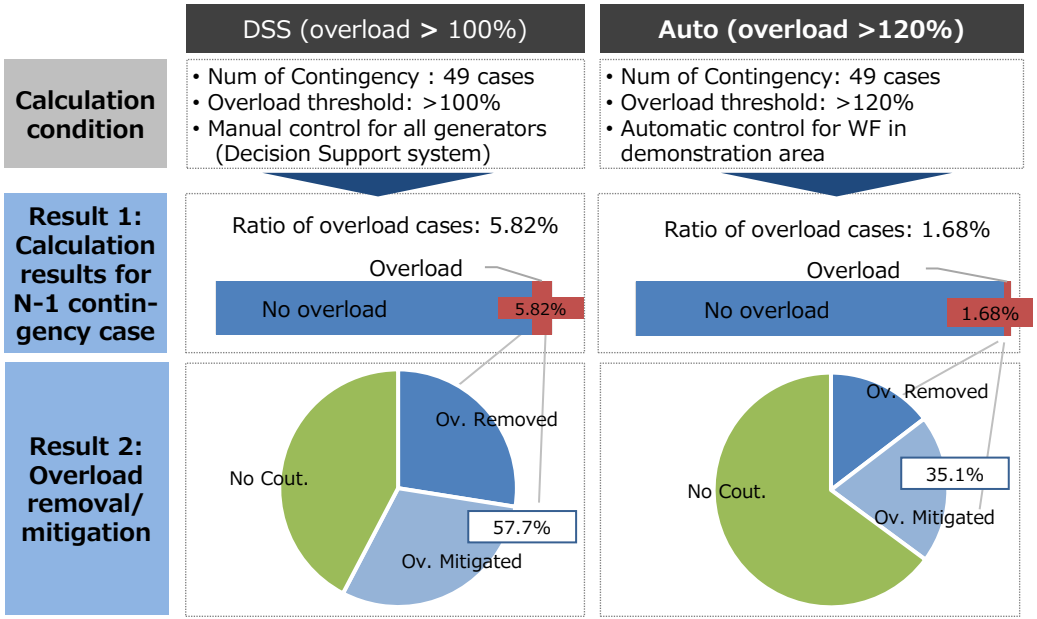
The visualization of overload risk and countermeasure by the DSS function of the SPS was verified and confirmed.



*Data period: Oct, 2019- Sep, 2020
*Automatic control countermeasure could not be planned when the WF output was low or when there were no control targets. By increasing the number of control targets, it is possible to increase the rate of countermeasure planning.

- It was confirmed that overloads in 57.7% of N-1 contingency cases could be mitigated or eliminated for overload risks of more than 100%, targeting power plants throughout Poland for control.
- It was confirmed that overloads in 35.1% of N-1 contingency cases could be mitigated or eliminated for overload risks of more than 120%, targeting WF in demonstration area for control.
- In the case where countermeasures cannot be taken by the SPS, the necessity of expanding the control target and enhancing the grid was shown, and the visualization of overload risk and countermeasure was verified and confirmed.

4. Results of Hybrid BESS-3

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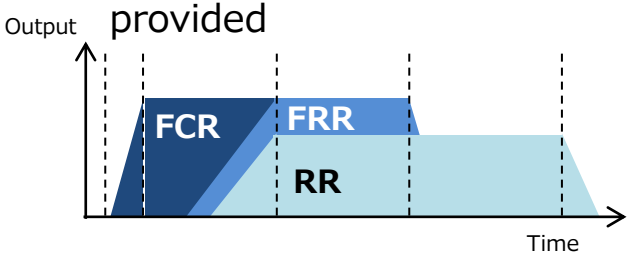
Mitigating short-term fluctuations in wind power and providing reserve power has been verified and confirmed.

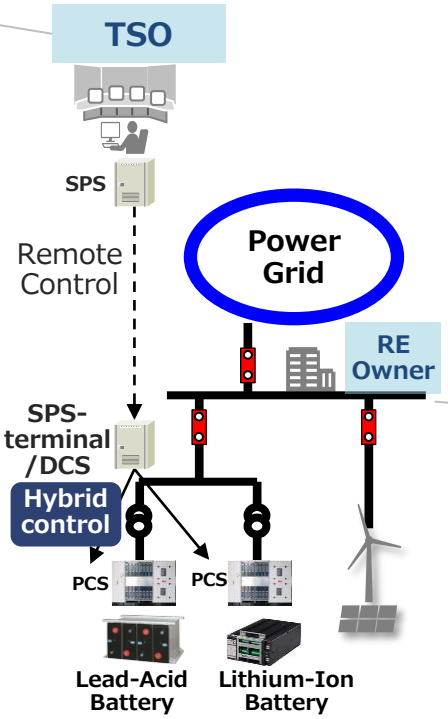
Providing reserve power

✓Primary (FCR), secondary (FRR) and tertiary (RR) reserve power equivalent provided



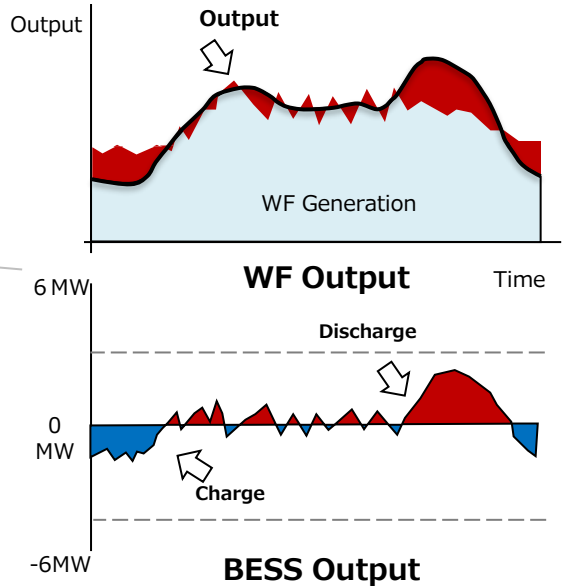
Mode	Output	Response	Capacity
FCR*	6MW	<30sec	>15min
FRR	6MW	<15min	>15min
RR	5MW	<15min	>2hours

*Verified the response time of BESS as FCR due to regulation issues.



WF fluctuation mitigation

✓Mitigate WF fluctuation keep within 10%



4. Comments from Polish Participants

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Eryk Kłossowski
CEO, PSE S.A.

"Rising integration of non-dispatchable sources of energy in energy mix constitutes a challenge for Transmission System Operator, hence PSE searches for solutions increasing the security of the Polish Power System. The SPS and BESS will contribute to improving the operation of the transmission grid in the increasing wind power environment. For this reason, I am satisfied that PSE could participate in this project and become one of the first companies in Europe to implement a system with intelligent grid functionalities."

"Energa Group owned by ORLEN Group, as the leader in the development of renewable sources of energy in Poland, spotted technical challenges related to the expansion of RES and acts for the quality and reliability of energy supply. We want to achieve that through the development of modern infrastructure for energy storage purposes. Our attention and active participation, as well as Energa Group's engagement at almost all stages of the project permitted us to acquire and develop the best world-class technical knowledge and reach unique competence. Due to another modern energy storage, we have gained experience in this type of investments and we can see further 'green' prospects, which should be beneficial for the entire Polish energy and industrial sectors."

Piotr Meler,
CEO, Energa OZE SA

Source : July 8, 2021 News Release, Website of each company

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