Proposal for the stability of power grid system

SUMITOMO ELECTRIC INDUSTRIES, LTD.

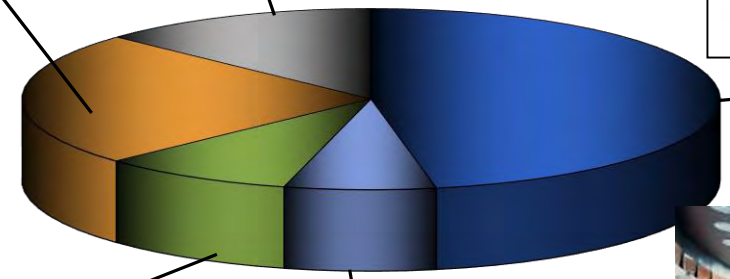
August 17, 2016

Sumitomo Electric present in Gurgaon, city of 1st Smart-Grid project in India.

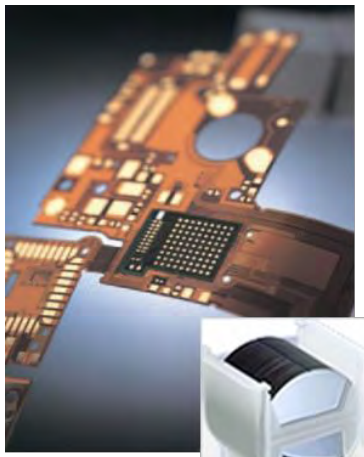
Product Portfolio and Share in Sales

Industrial Materials Group 11%

Environment & Energy Group 21%



Automotive Group 52%



Electronics Group 10%

Info-Communication Group 6%

(as of Mar. 31, 2015)

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Value Chain in Energy Solutions Offered by SEI Group

Generation	Transmission and Distribution	Storage	Demand Side

Photovoltaic Systmes
(Photo credit: Tokyo International Air Cargo Terminal Ltd.)

Superconducting Cable
(in the Asahi substation of Tokyo Electric Power Co., Ltd.)

Redox Flow (RF) Battery System

Megawatt Class Large-scale Thermal Storage System
Yokohama plant of Sumitomo Electric Industries Co., Ltd.

Submarine cables
(OF, XLPE, MI)

Capacitor Voltage Transformer

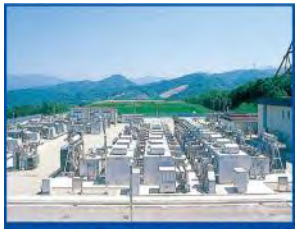
Concentrator Photovoltaic (CPV) Systems

Molten Salt Electrolysis Battery

Smart Distribution Board

Energy Management System (EMS)

Power Capacitor



Harmonic Filter Equipment

Power Conditioner for Photovoltaic System

Small Battery "POWER DEPO®"

Maritime Wind Powered Generators

Oil Filled Transformer

Static Var Compensator

Power Conditioner for Photovoltaic System

Voltage Dip Compensator

Home Gateway

Superconductor Electric Vehicle

Key Features of SEI's Flow Battery Systems

1. Long Life

- **Unlimited Charge/Discharge cycle life**
- **Electrolyte is reusable after decommissioning**

2. Multi-Purpose

- **Fast Response & Long duration Applications**

→ **Hybrid Uses for more Flexibility and Revenue**

3. Easy Operation

- **Accurate and Real-time SOC Acquisition**
- **No Operational Constraint on cycle life**
- **Operational DOD : 0~100%**

4. Safety

- **Non-flammable Electrolyte**
- **Flame Retardant Materials**
- **Accurate and Reliable SOC Management**

5. Design Flexibility

- **Separation of Power (MW) and Energy (MWh)**
- **Easy to build long-duration and large-scale systems**

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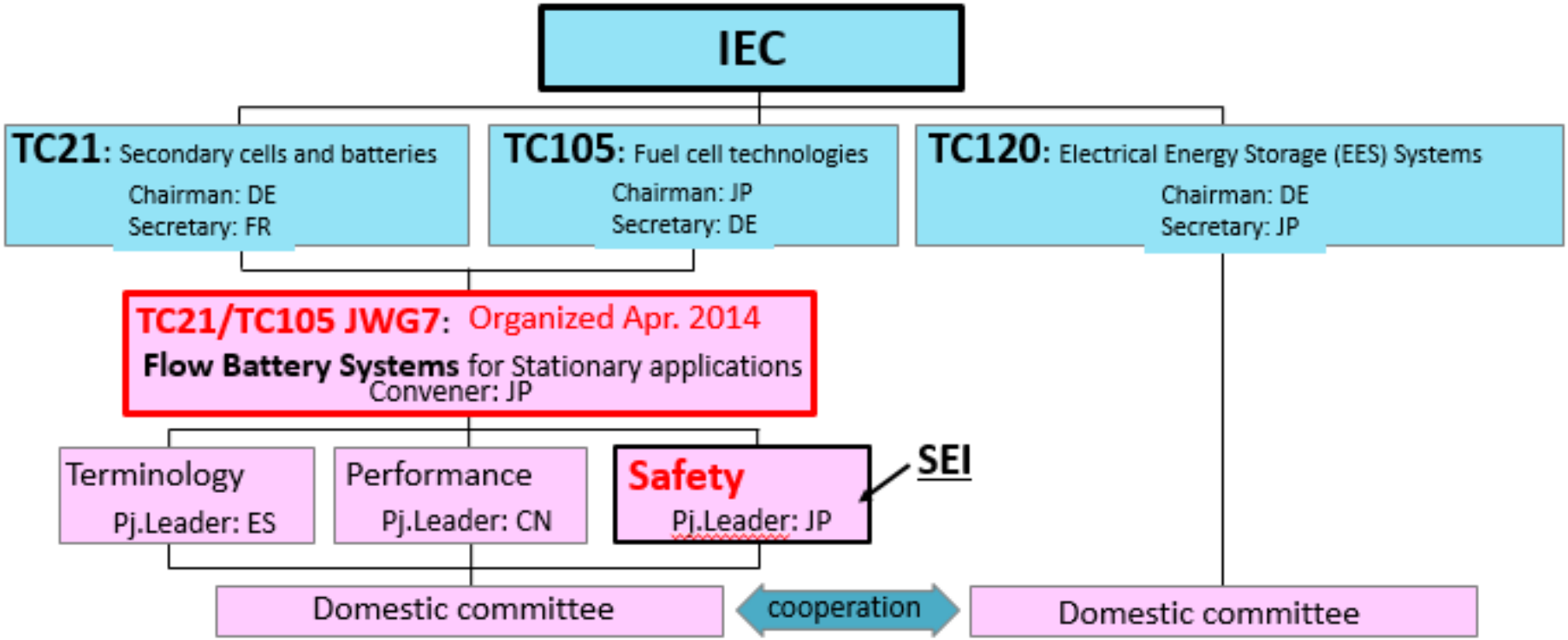
Contribution to International Standardization Activity

Sumitomo Electric has been contributing to international standardization activity of flow battery systems in **I**nternational **E**lectrotechnical **C**ommission (IEC).



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Wide Variety of Applications of Flow Battery systems

Operation	2003-2008	2012 ～	Dec., 2015～
Application	**Co-located with WT**	**Behind the meter**	**T&D**
Location	Tomamae Wind Villa (NEDO PJ)	Sumitomo Electric Yokohama Works	Hokkaido Electric Power Co. (METI PJ)
Application	・Stabilizing Wind Farm Output for Grid Integration	・Renewable Integration ・Demand Side Management ・Demand Response	・Frequency Regulation ・Mitigation of surplus Renewable generation
Capacity	**6MW x 1hr**	**1MW x 5hr**	**15MW x 4hr**
Notes	・Wind farm: 31MW ・**270,000 cycles/3 yrs.** 	・Gas generator: 3.6MW ・CPV : 100kW ・**EVERYDAY DSM** 	・Controlled by utility's control center ・**Multi-applications** 

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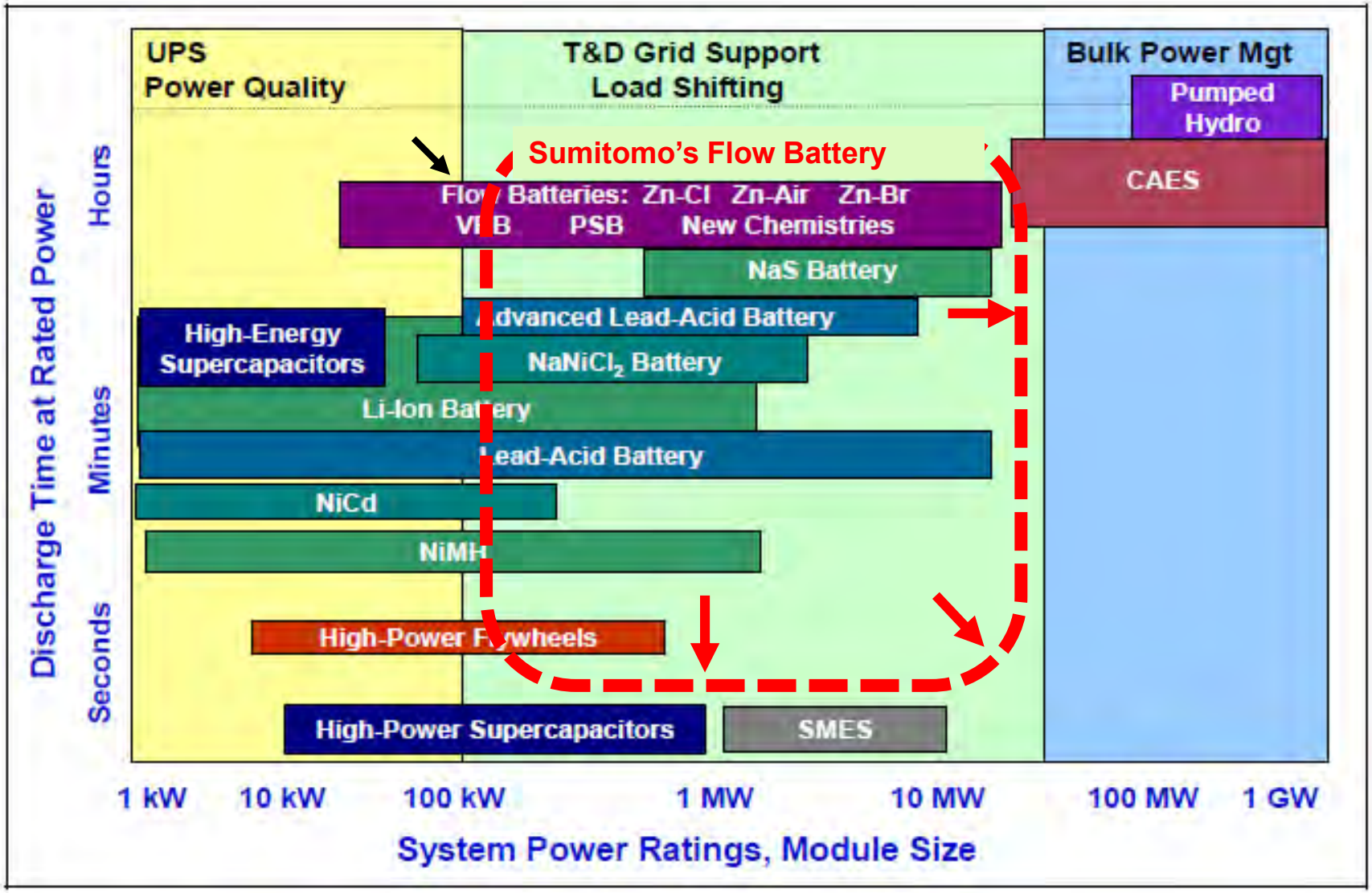
Evolution of BESS and Positioning of SEI's Flow Battery



Source: Electricity Energy Storage Technology Options, EPRI: 2010

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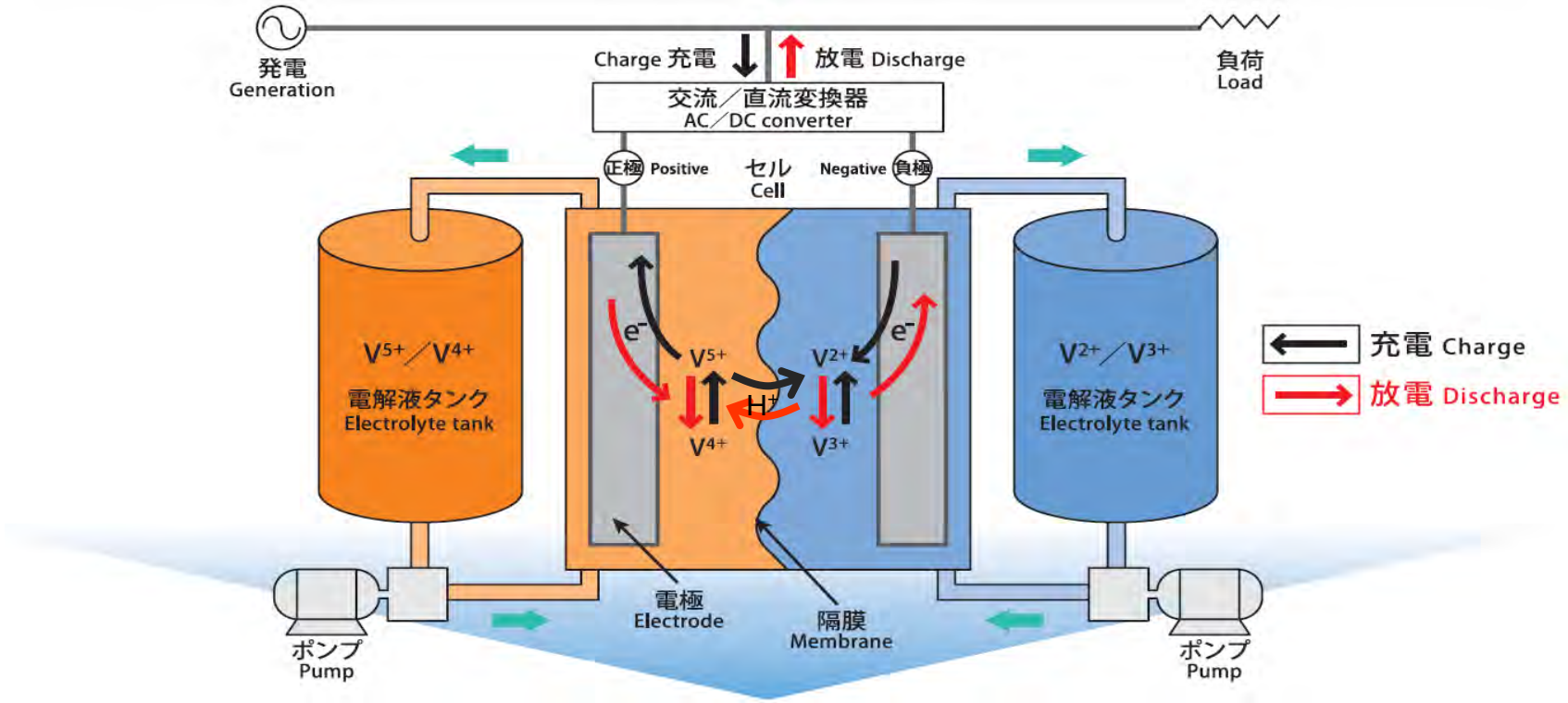
Principle of Flow Battery System

REDOX reaction: **"Red**uction" (to gain electron) & **"Ox**idation" (to lose electron)



Charge

$VO^{2+} + H_2O \rightleftharpoons VO_2^{+} + e^- + 2H^+$

Discharge

Charge

$V^{3+} + e^- \rightleftharpoons V^{2+}$

Discharge

-**Utilizing ionic state-of-charge difference of Vanadium Ions in electrolyte**
-**No degradation of electrolyte occurs during charge/discharge cycle**

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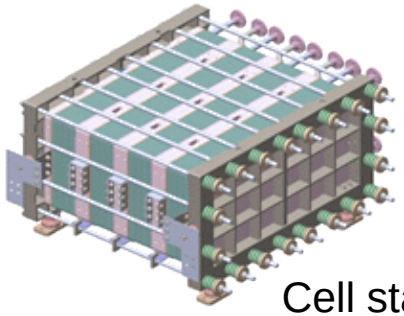
System Configuration of Flow Battery



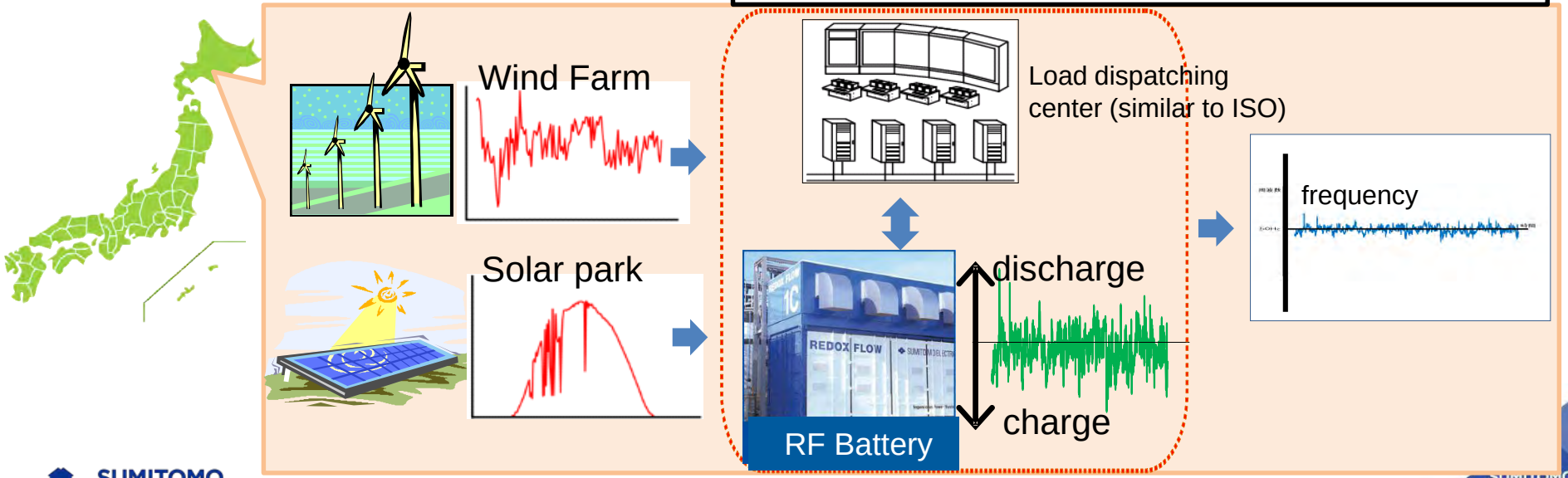
Cell stack

Electrolyte flow

BMS: Battery Management System

Use Case: Grid ESS for Hokkaido Electric Power Co.

- Funded by Japanese government
- Size: **15 MW, 60 MWh**
- Location: Substation of HEPCO
- Application: Multi-purpose
  - Local & Central Control of ESS dispatch
  - Frequency control
  - Renewable generation mitigation, etc
- On-line: Dec.,2015



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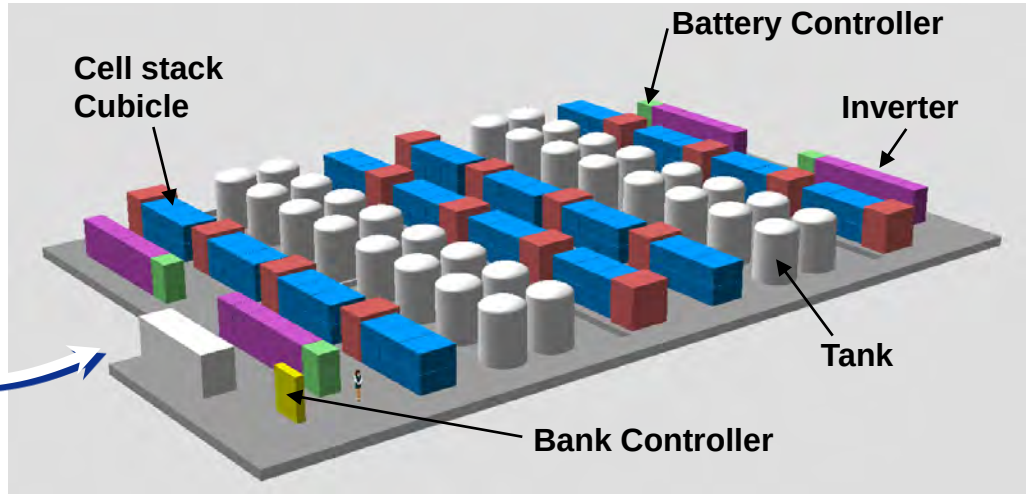
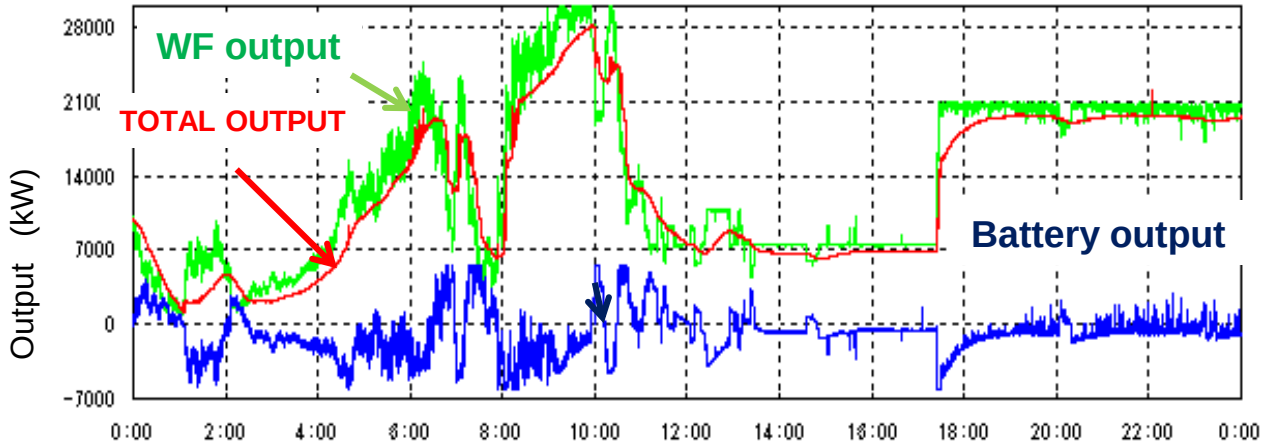
Use Case: Renewable Generation Firming

Tomamae Wind Villa National PJ (J-POWER, funded by NEDO)

- Stabilizing wind turbine's total output of 31MW
- VFB System: 6MWh (4MW x 1.5hr)





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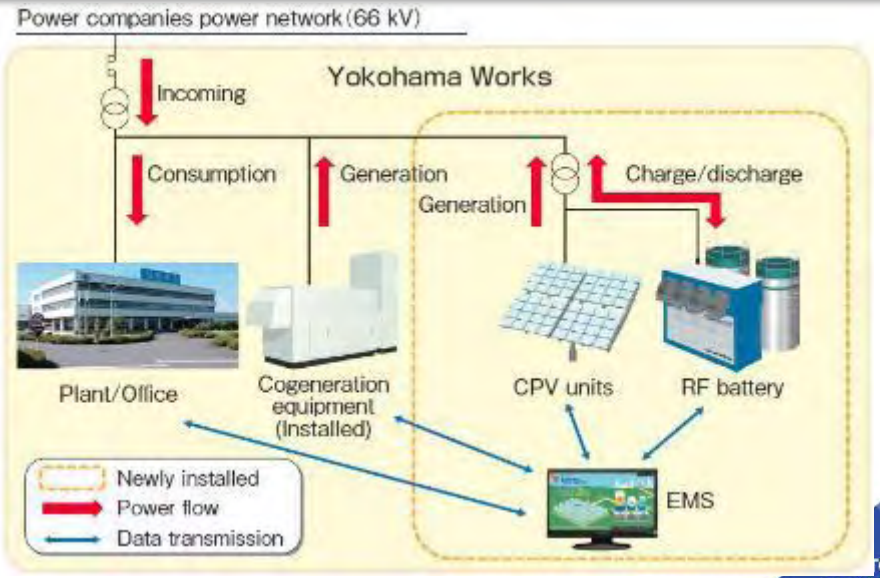
Use Case: Demand Side Management System

Flow Battery	**Max. Output : 1MW** **Capacity : 5MWh**
Concentrator photovoltaic (CPV)	**Max. Output : 100kW**
CGS	**Max. Output: 3.6MW**
EMS	**Developed by SEI**
Applications	**Renewable Firming, Peak Shaving, Demand Response(DR)**



NEDO International Demonstration Program in USA

NEDO (New Energy and Industrial Technology Development Organization)

- SEI awarded as a feasibility Study for **Flow Battery Demonstration PJ**
  Feasibility Study @2015 → **Demonstration @2016 (under const'n)**
- Purpose

  -Provide practical solution on Grid stability issues toward 2020.

  -Work together with **IOUs in California** and let Utilities know about the potential of Redox Flow Battery.

Energy Storage Workshop in 2014 in Kyoto, JAPAN

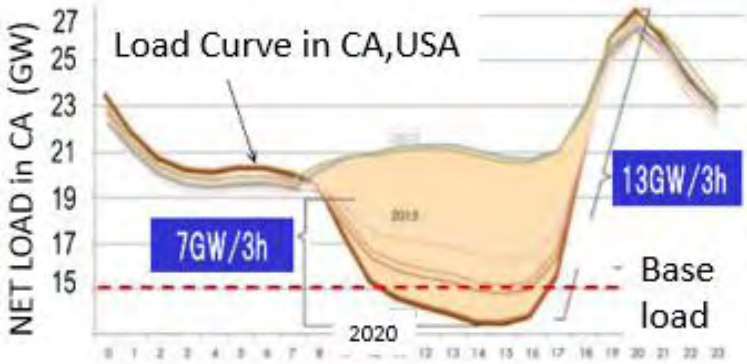
hosted by NEDO

Verde Exchange 2015 @LA

MOC* signed btw. Japan & CA on climate change, renewable energy, etc.

* Memorandum of Cooperation

http://gov.ca.gov/news.php?id=18685



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Containerized Solution (launch in 2017)

Electrolyte tank is inside 40ft container

@ SEI Osaka Works

Item	Spec
Container	40ft Standard Container
Size (L×W×H)	12.2×2.4×2.9(m)
Capacity	125 kW
Energy	4 hours (500kWh)
Ambient Temperature	-5～40℃

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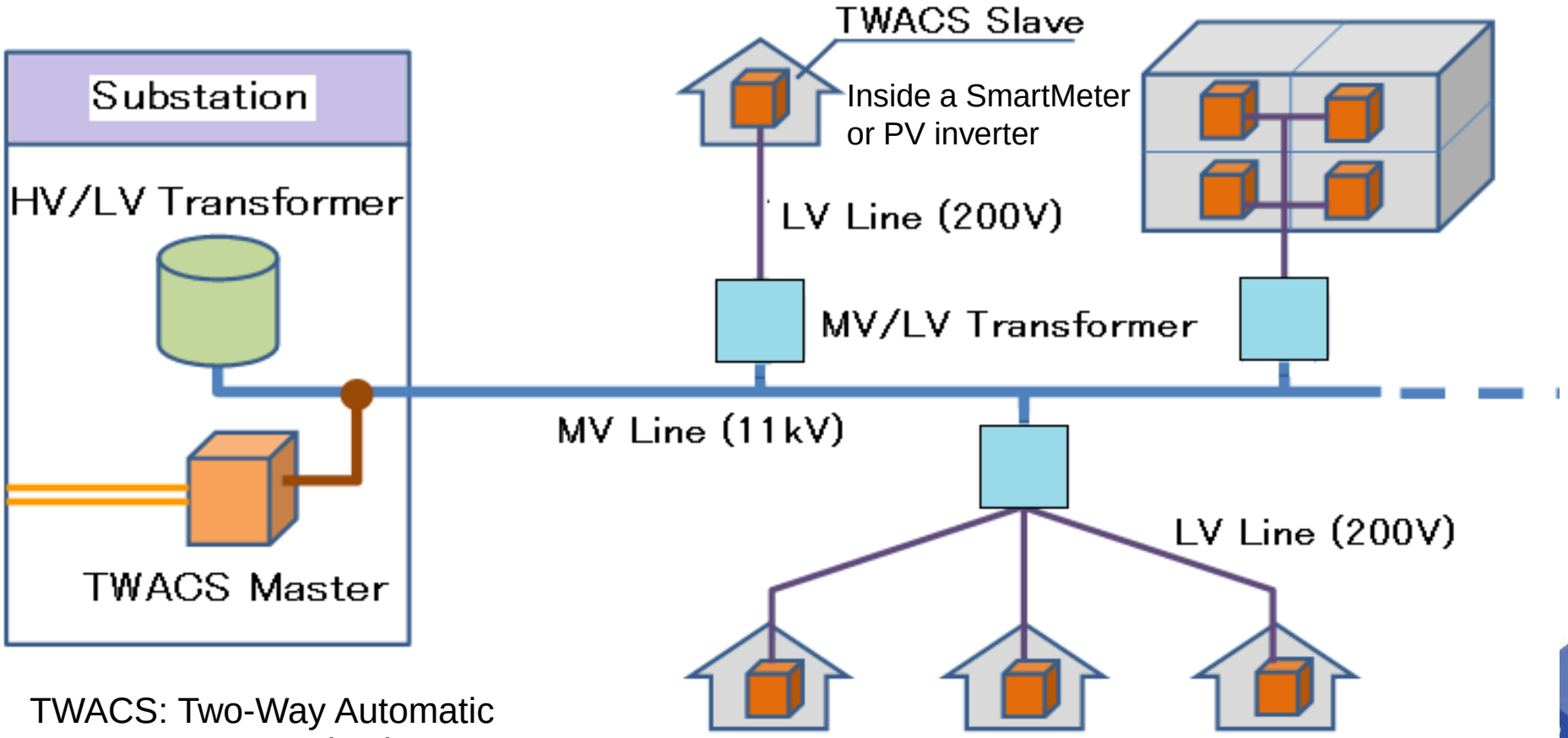
TWACS-PLC for AMI and system control

- TWACS Master installed in a substation directly communicates the Slaves through the MV/LV transformers.
- TWACS can use for AMI(Smart Meter, MV/LV Transformer) and PV inverter and Meter switch control on MV/LV line.
- Stable communication over 100km is expected.



TWACS: Two-Way Automatic Communication System