SUMITOMO ELECTRIC

IERE Electric Power Technology Platform

9th IERE Webinar, April 2, 2025

Webinar on Rechargeable Battery Development and Evaluation for Energy Storage

Advancements & Deployment of Sumitomo's Flow Battery Technology

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SVP, Chief Engineer of Energy Storage System

Sumitomo Electric U.S.A., Inc.

SUMITOMO ELECTRIC GROUP

1. “Sumitomo Electric” Company Profile

Company Name	Sumitomo Electric Industries, Ltd.
Established	April 1897
Capital Stock	¥99,737 million
President	Osamu Inoue
Employees	293,266 consolidated
Subsidiaries & Affiliates	415 Domestic(Japan):104, Overseas:311
Consolidated Business Results	Net Sales ¥4,402,814 million Operating Income ¥226,618 million
Credit Ratings	A2 (Moody’s), A (S&P)

(As of March 31, 2024)

Automotive (53%)	◆ Wiring Harness ◆ Vibration-proof rubber ◆ Automotive hoses ◆ Car electrical equipment
Environment & Energy (23%)	◆ Electric wires & cables; Power transmission cables ◆ **Flow Battery System** ◆ Power line engineering
Industrial Materials (9%)	◆ Cutting tools ◆ Diamond tools ◆ Cemented carbide tools ◆ Special steel wires
Electronics (9%)	◆ Electronic wire products ◆ Flexible printed circuits ◆ Semiconductors
Info-communications (6%)	◆ Optical fibers, and cables ◆ Optical devices ◆ Traffic control systems etc.

Founder of the Sumitomo Family
Masatomo Sumitomo
(1585-1652)

Around 1600
Perfected nanban-buki, a copper refining technique for separating silver from copper ore containing silver

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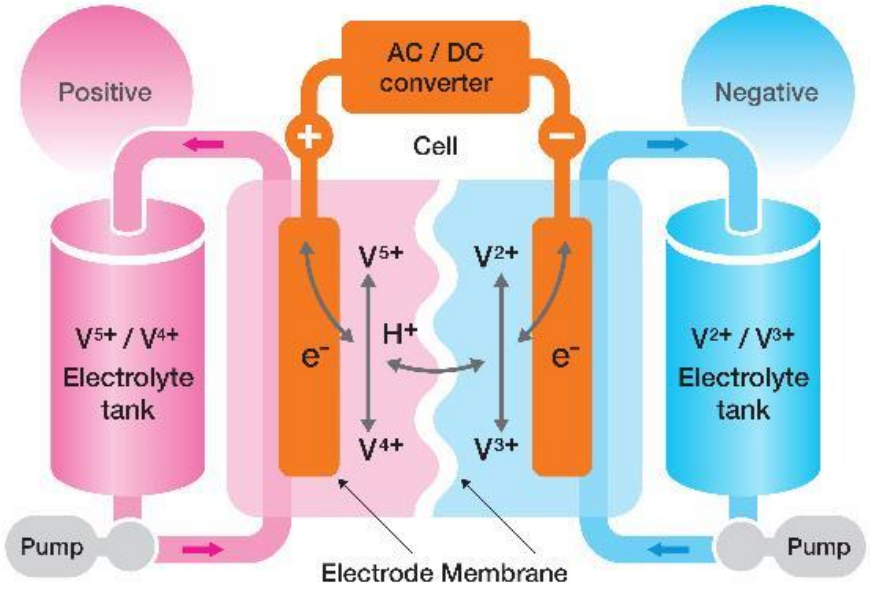
2. Principle of Flow Battery

Redox: Reduction/Oxidation
Flow: Flowing active material

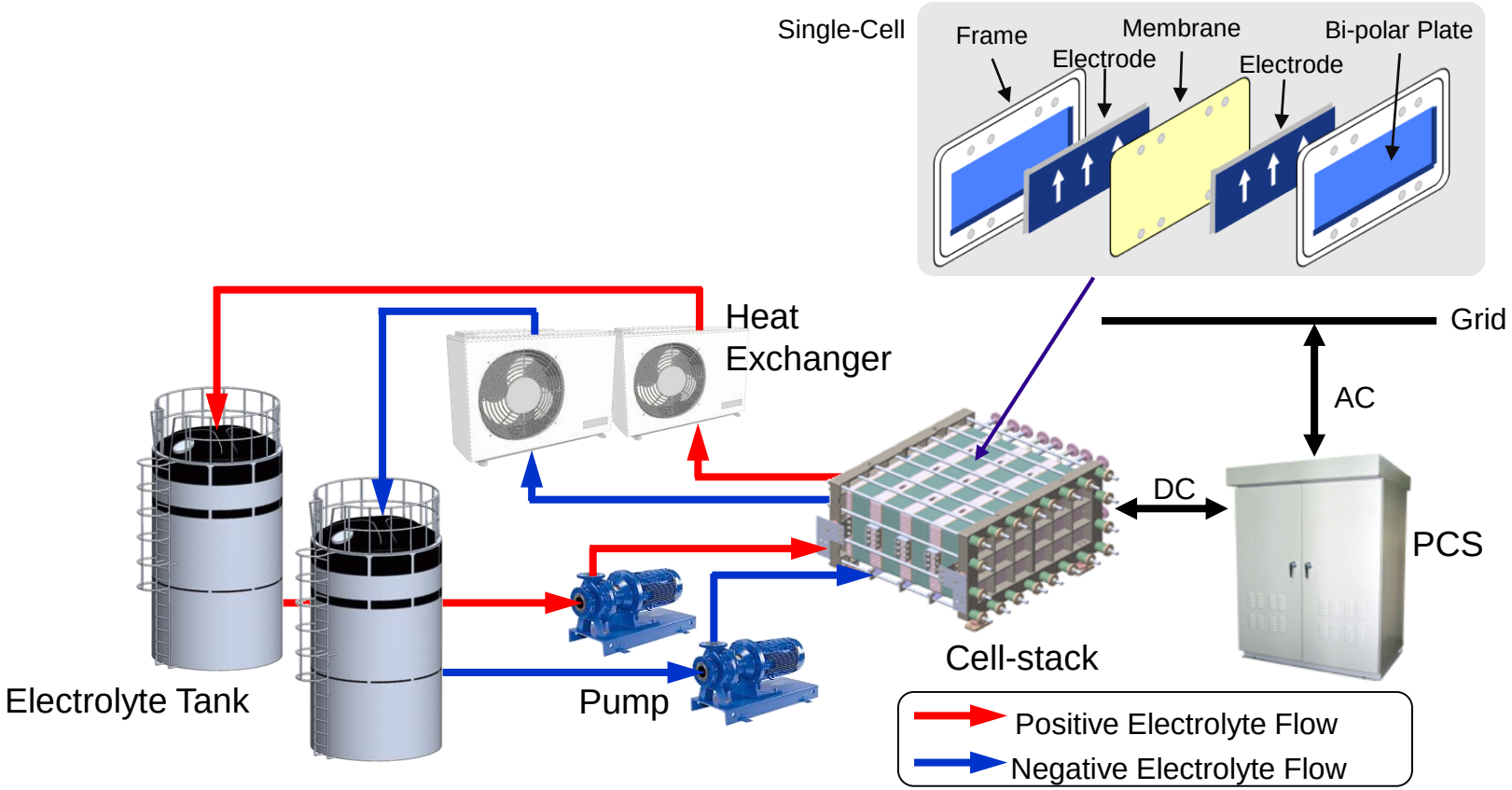
- ✓ The reactions are associated with only the changes in valences of the vanadium ions.
- ✓ Electrolyte can be used semi-permanently, because the valence changes do not deteriorate the electrolyte.



Positive Reaction $V^{4+} \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} V^{5+} + e^-$

$V^{3+} + e^- \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftharpoons}} V^{2+}$ **Negative Reaction**

3. Module Configuration of Sumitomo's Flow Battery



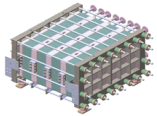
4. Two Types of Module Configuration

System @2016 → Now

- ✓ Plant Type
- ✓ 1MWh (250kW x 4h)
- ✓ 40ft Container + Heat Exchanger Unit + Tanks

Heat Exchanger

Cell stack

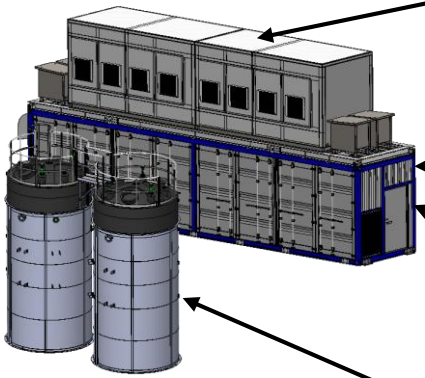


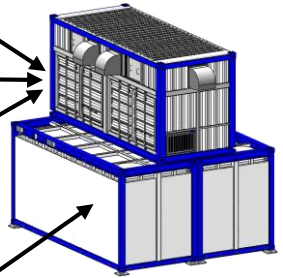
DC38kW x 8

DC150kW x 2

Pump

Tank





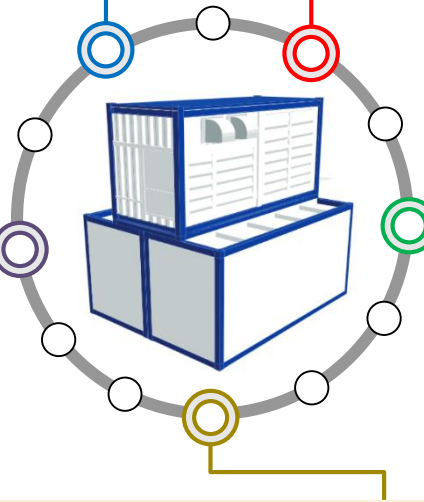
- ✓ Container Type
- ✓ 1MWh (250kW x 4h)
- ✓ 20ft Container x 3

- ✓ Compact !
- ✓ Low Transportation Cost !
- ✓ Low Construction Cost !

5. Key Features

Long Lifetime
- ✓ >20-year design life
- ✓ Unlimited charging/discharging cycle
- ✓ Significantly low degradation of capacity
- ✓ Reusable electrolyte after decommissioning

Fire Safety
- ✓ No thermal runaway
- ✓ Non-flammable electrolyte



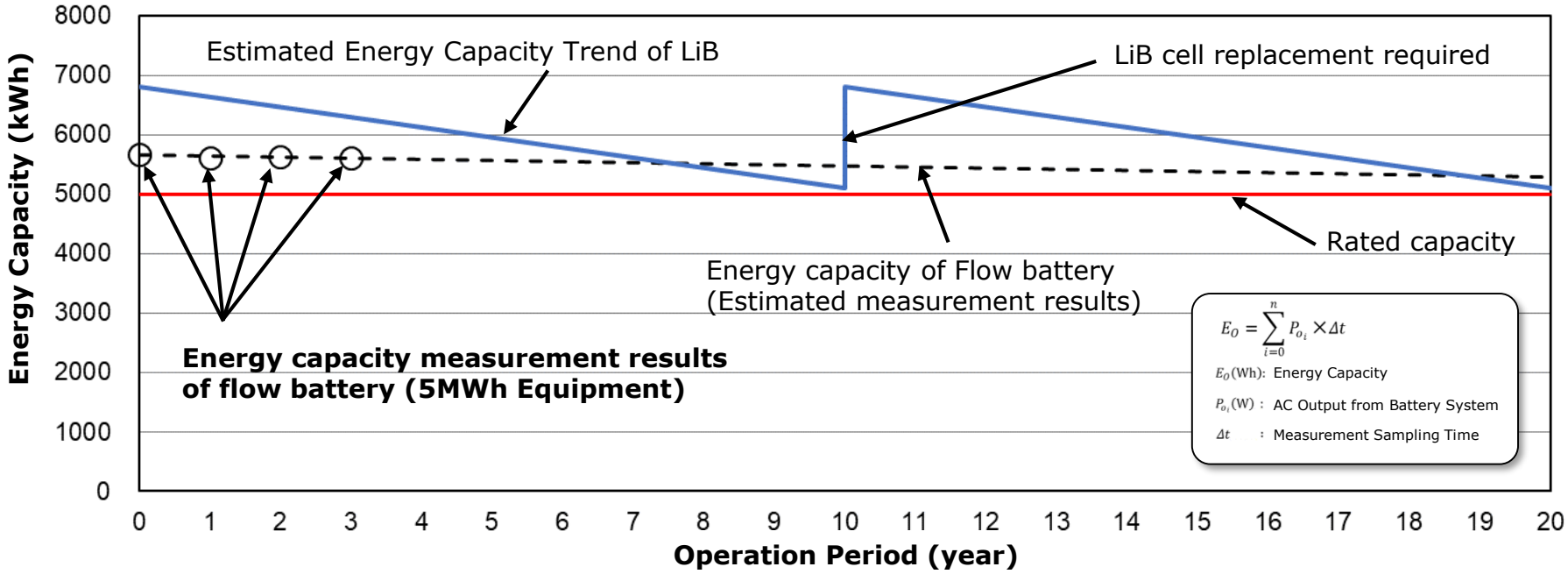
Eco Friendly
- ✓ Reusable Electrolyte
- ✓ Recyclable Electrolyte
- ✓ More than 99% weight of the materials used in the system are recyclable

Easy Operation / Operability
- ✓ Available State of Charge (SoC): 0 – 100%
- ✓ No unbalanced capacity across the cell stacks
- ✓ Accurate & real-time SoC monitoring

Low Life-Cycle Cost
- ✓ Low CAPEX per kWh: Lower unit cost ($/kWh) for longer duration systems
- ✓ Low OPEX: No need for replacement of cell stacks or electrolyte
- ✓ Significant salvage value: Reusable electrolyte of long duration systems

5.1. (Key Features) Long Lifetime

- ✓ Battery reaction (Charging/Discharging) is only change of vanadium ion valence in electrolyte.
- ✓ No chemical reaction in electrode ➡ Charge/discharge cycles are not a degradation factor



5.2. (Key Features) Non-Flammable

Very high resistance to fire incident
Fewer restrictions on installation location

Non-Combustible Material

- ✓ Electrolyte : Vanadium Sulfate Aqueous
  - ➡ Non-Flammable
- ✓ Material for Piping, Cell-stack
  - ➡ Flame retardant

No Thermal Runaway

- ✓ Operation Temp. : 30~45 deg.C
- ✓ Large Heat Capacity
- ✓ UL 1973, UL9540A Certificated

CERTIFICATE OF COMPLIANCE

Certificate Number 20150722-MH59980
Report Reference MH59980-20150721
Issue Date 2015-JULY-22

Issued to: SUMITOMO ELECTRIC INDUSTRIES LTD
1-1-3 Shimaya
Konohana
Osaka 554-0024 JAPAN

This is to certify that representative samples of: COMPONENT - BATTERIES FOR USE IN LIGHT ELECTRIC RAIL AND STATIONARY APPLICATIONS
Components - Redox Flow Batteries for Use in Stationary Applications,
Model RA1500-00

Have been investigated by UL in accordance with the Standard(s) indicated on this Certificate.

Standard(s) for Safety: UL 1973, STANDARD FOR BATTERIES FOR USE IN LIGHT ELECTRIC RAIL (LER) APPLICATIONS AND STATIONARY APPLICATION

Additional Information: See the UL Online Certifications Directory at www.ul.com/database for additional information

Only those products bearing the UL Certification Mark should be considered as being covered by UL's Certification and Follow-Up Service.

Recognized components are incomplete in certain constructional features or restricted in performance capabilities and are intended for use as components of complete equipment submitted for investigation rather than for direct separate installation in the field. The final acceptance of the component is dependent upon its installation and use in complete equipment submitted to UL LLC.

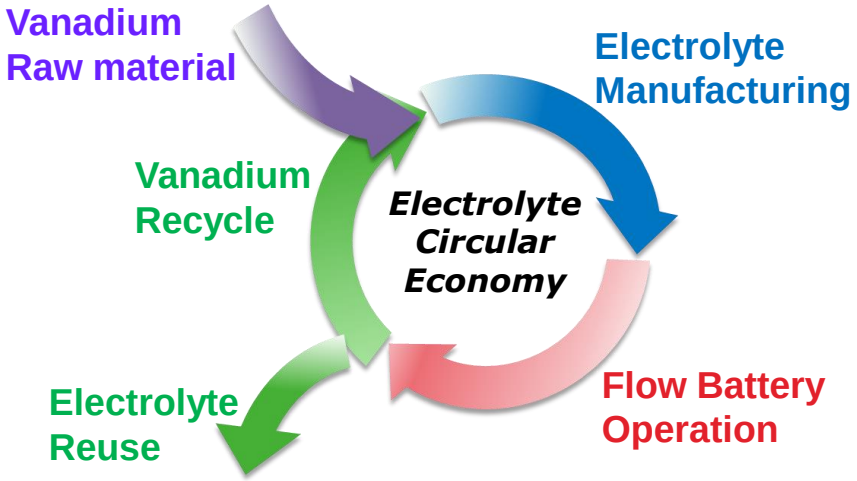
Look for the UL Certification Mark on the product.

Example of indoor installation

Example of underground installation

5.3. (Key Features) Electrolyte Circular Economy

- ✓ Battery reaction (Charging/Discharging) is only change of vanadium ion valence in electrolyte.
- ✓ The electrolyte does not decrease in quantity or degrade over 20 years of use.
- ✓ The electrolyte can be reusable, recyclable.



Example of Electrolyte Reuse

Electrolyte Reuse
after 10-year operation

5.4. (Key Features) High Recyclable/Reusable Rate

- Reuse/recycle rate : > 99.2%weight (less than 1% waste) ※
- Minimizing industrial waste generation rate when dismantling after long-term operation

Redox Flow Battery (250kW x 3h) 90t/ Base

Collection

Sorting, crushing, and disconnect

Electrolyte 70%

Filling to other system

Iron Materials 22.7%

Equipment 1.5%

Plastic Material 4.7%

Cupper Material 0.2%

Insulated Wire 0.1%

Thermal Insulation 0.8%

Sorting and crushing

Sorting and crushing

Iron raw material 23.7%

Plastic raw materials 5.2%

Copper raw material 0.3%

Reuse 70%

Recycle 29.2%

Disposal 0.8%

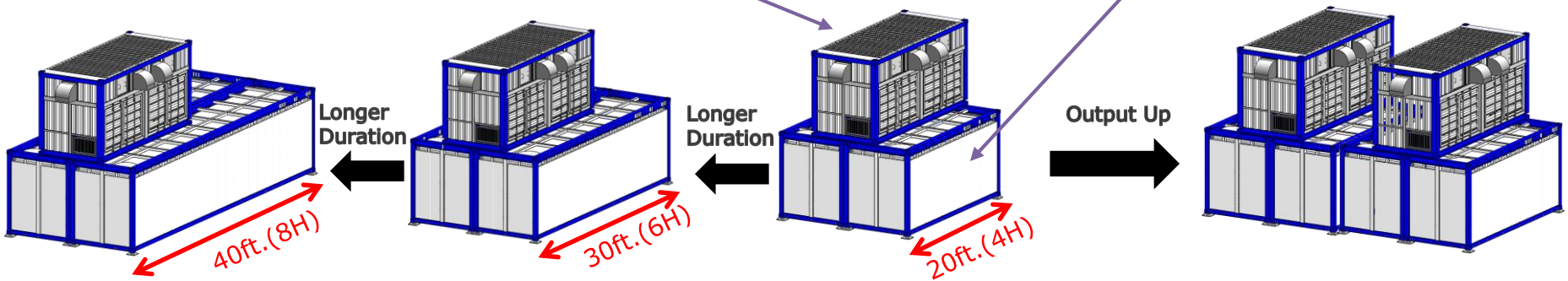
5.5. (Key Features) Suitable for LDES (Long Duration Energy Storage)

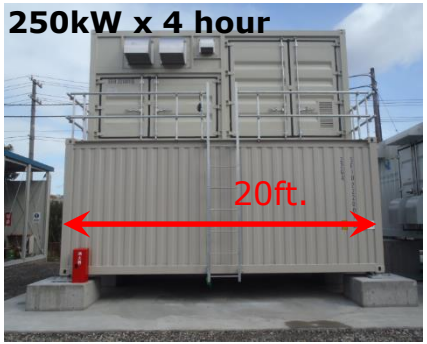
Battery Container: 250kW

- ✓ Cell stacks, pumps, sensors etc. are layout.
- ✓ Power (kW) is designed by the number of battery containers (number of Cell stacks).

Tank Containers: expandable duration

- ✓ Electrolyte is stored in the tanks inside the containers.
- ✓ Energy (kWh) is designed by the size of tank containers (electrolyte volume).



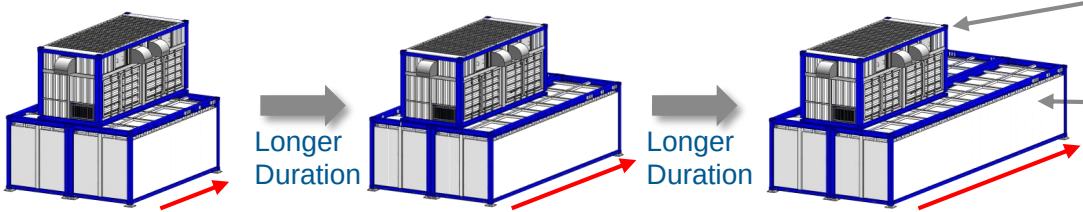


Capable of providing a 10-hour duration system to meet LDES!

5.6. (Key Features) Low Life Cycle-Cost (LCC) for LDES

CAPEX Advantage for LDES

The longer duration the lower kWh unit cost.



(Cost increase is only for the electrolyte part)

Low OPEX

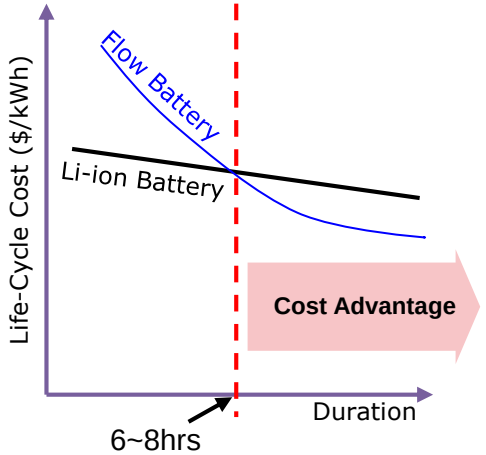
Long Life Time

➡ No replacement cost for cell-stacks and electrolyte.

Low Removal Cost

Electrolyte can be reusable, recyclable

➡ No disposal cost for electrolyte.



6. Easy Operation

Continuous rated power output at SoC 0～100%

- ✓ Rated power charging/discharging available in full SOC range (0~10%)
- ✓ Continuous discharging at the rated power for the rated duration time.

Less operational restriction

- ✓ Cycle number of charging/discharging does not become a factor of life.
- ✓ No restriction on the charging/discharging pattern.
- ✓ The cell stack has been tested for over 50,000 starts/stops cycle.
- ✓ No limit on the number of shutdowns.

State of charge monitoring

- ✓ Direct monitoring SoC is available by measuring the electromotive force of a monitor cell.
- ✓ Electrolyte of the same SoC flows into several cells, then SoC of the cells is always equal.

No pump power required when stopped, no self-discharge

- ✓ When the pump stops, the pump power, which is the main auxiliary power, is zero.
- ✓ No self-discharge in stop condition since no electrolyte in cellstacks.
- ✓ No voltage in stop condition since no electrolyte in cell-stacks. (Low risk of electric shock)

7. Installation World Wide

John Cockerille
1.7MWh (Bergium)
Smart Factory

Nippon PS
750kWh (Japan)
Renewable Ratio Up

Kashiwazaki IR Energy
8MWh (8h) (Japan)
Wholesale Market

Hokkaido Electric Power Network
51MWh (Japan)
Grid Control for further WF Introduction

Hokkaido Electric Power Network
60MWh (Japan)
Grid Control (AFC, GF)

7
Countries

44
Project

180
MWh

50
MW

Dec. 2024

ITRI
3MWh (Taiwan)
Using Local Electrolyte

National Lab.
750kWh (Taiwan)
VPP

TICP
750kWh（Taiwan）
Multi Use

Energy Queensland
750kWh (Australia)
Using Local Electrolyte

San Diego Gas & Electric
8MWh (USA)
Wholesale Market Microgrid

Utility (Under Construction)
4MWh (8h) (USA)
Wholesale Market, Microgrid

7.1. Grid-scale Use for Frequency Regulation (1)

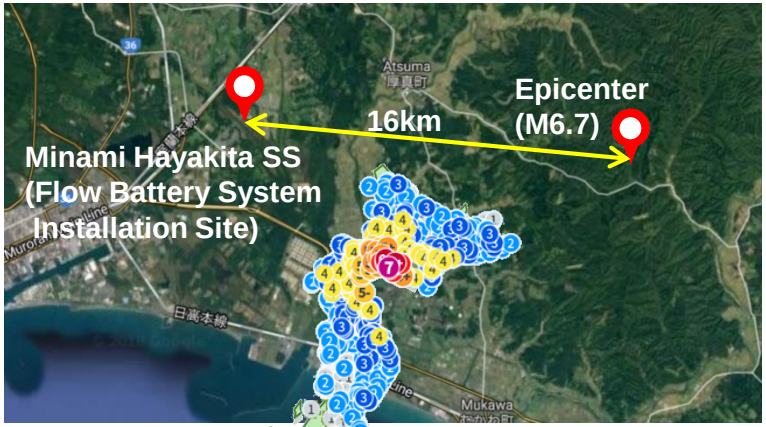
Performance verification and development of control technology as a new adjustment power resource for output change of wind turbines and PVs.

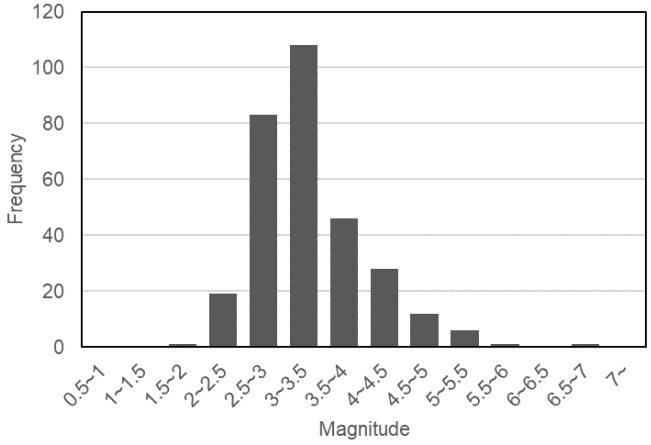
- ✓ Capacity: 60MWh (15MWx4h, Max 30MW)
- ✓ Location: Hokkaido Electric Power Network Minami-Hayakita S/S (Hokkaido, Japan)
- ✓ Use Case: Grid Use
  - ■ Suppress short-periodic fluctuations
    - Suppress WT & PV output fluctuations
    - Governor Free Equivalent Control
    - Load Frequency Control(LFC)
  - ■ Suppress Long-periodic fluctuations
  - ■ Over Generation Measures
  - ■ Hybrid Operation of Long & Short period fluctuations
- ✓ Demonstration Starts: Dec.,2015
- ✓ Commercial Operation Starts:2019
- ✓ Project Partner METI Ministry of Economy, Trade and Industry / ほくでんネットワーク / SUMITOMO ELECTRIC

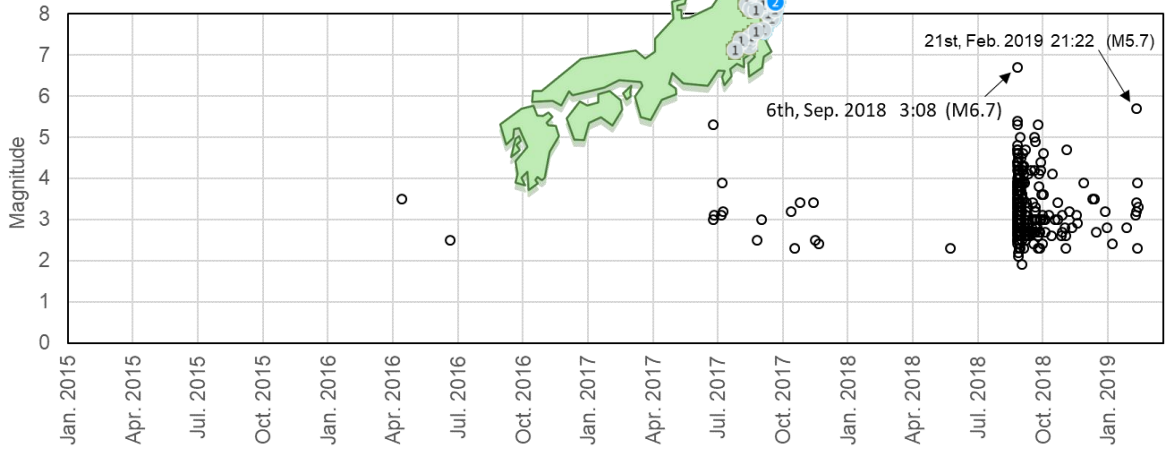
7.1. Grid-scale Use for Frequency Regulation (2)

- ✓ The large earthquake of “M6.9” occurred in Hokkaido on 6th Sep. 2018.
- ✓ There is no damage or breakdown of the battery system.
- ✓ The battery system restarted operation on the next day of the earthquake.
- ✓ Seismic design : horizontal 1.0G, vertical 0.5G

Verified seismic design by actual earthquake!







7.2. Grid-scale Use for Wind Firm Integration

Use of storage batteries to expand the introduction of wind power in Hokkaido area.

- ✓ Capacity:
  51MWh (17MWx3h)
- ✓ Location:
  Hokkaido Electric Power Network
  Minami-Hayakita S/S (Hokkaido, Japan)
- ✓ Use Case: Grid Use
  - "Wind Power Generation Offering Process with Grid-side Storage Batteries (Phase I)".
  - The flow battery energy storage system provides the regulating power required for the interconnection of new 162 MW wind power plants (15 sites).
- ✓ Operation Starts: Apr., 2022
- ✓ Project Partner

ほくでんネットワーク SUMITOMO ELECTRIC

7.3. For Multiuse on Distribution Grid (1)

Multiple use operation of VRFB system on the distribution grid of CA utility to prove economic value & potential for the use on electric grids.

- ✓ Capacity: 8MWh (2MWx4h, Max 3MW)
- ✓ Location: SDG&E, Miguel S/S (CA, USA)
- ✓ Use Cases:
  - Distribution line applications such as peak-shaving, peak-cut
  - Operation in CAISO market
  - Microgrid
- ✓ Operation Start: March 2017
- ✓ Commercial Operation Start: Jan. 2022
- ✓ Project Partners

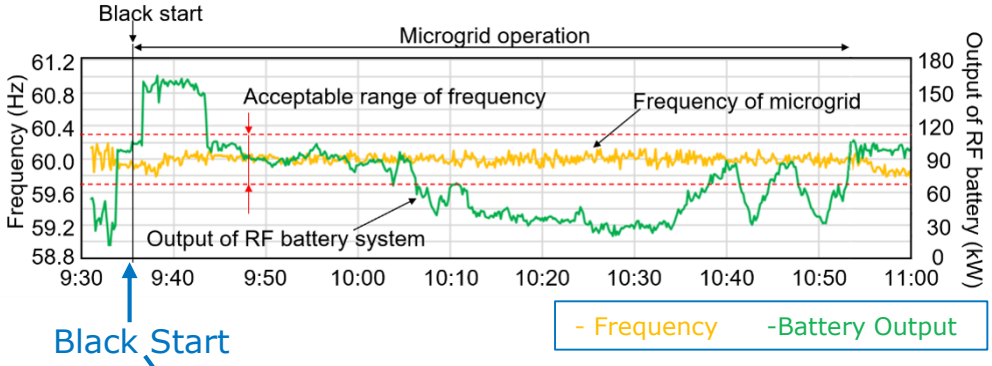
NEDO · California Governor's Office of Business and Economic Development · SDGE · SUMITOMO ELECTRIC

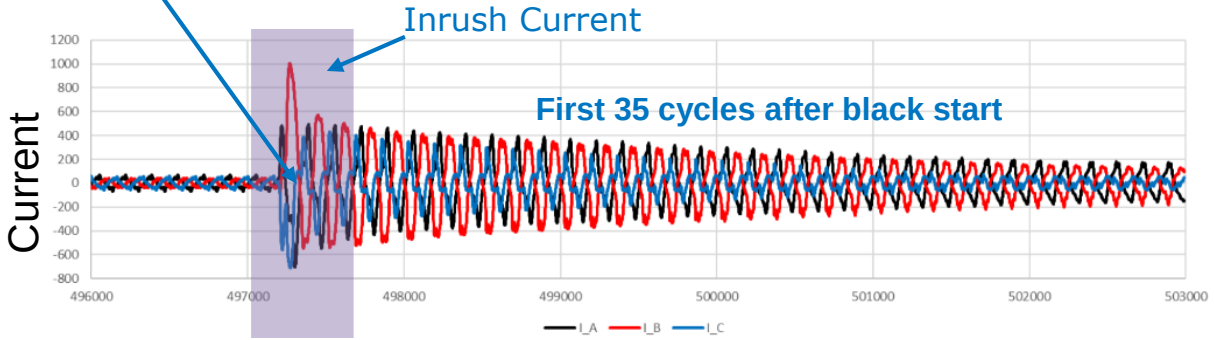
ISGAN Award of Excellence 2024

The project was awarded the 10th ISGAN* award of excellence.
*International Smart Grid Action Network

7.3. For Multiuse on Distribution Grid (2)

Microgrid using commercial distributed line





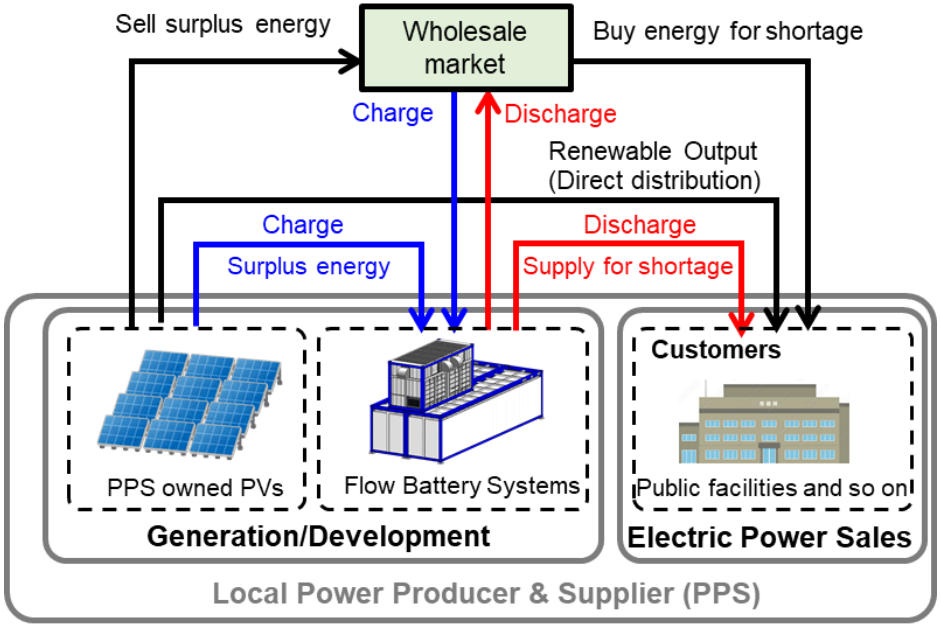
Target area: 2.2km
Number of customers: 66 consumers
Contracted load: Approx. 400kW
Others: With PV (100kW or higher)
Without generator

7.4. LDES Applications

"Long Duration Energy Storage System (LDES)" for PPS (Power Produce & Supplier). Charging electric power from both PV and Market, and discharging to both customers and Market for local electric power supply and demand adjustment.

Kashiwazaki City PPS Project

Capacity : 8MWh (1MW x 8h)
Location : Niigata, Japan
Operator : Kashiwazaki IR Energy
Application : Whole Sale market, Effective use of PV output
Operation : 2024~



In addition, two LDES project, 1MWx8h (Japan) and 500kWx8h (USA), are under construction now.

7.5. Localizing Electrolyte Production

- ✓ *Commissioning of a 250kW x 3h VRFB system is completed in QLD, Australia with the customer now finalizing integration works for their dynamic connection.*
- ✓ *Sumitomo Electric will build a cooperative framework with local companies and accelerate the vanadium redox flow battery business in the Australian market.*

- ✓ *Capacity* :750kWh (250kW x 3h)
- ✓ *Location* :Brisbane, Australia
- ✓ *Application* Demonstration (Smoothing of solar power output, Demand response, etc.)
- ✓ *Start of operation*:2024
- ✓ *Project Partner*

Energy Queensland energex VECCO Group SUMITOMO ELECTRIC

Thank you!

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SUMITOMO ELECTRIC

Connect with Innovation

for more information …

Introduction Movie YouTube JP
https://youtu.be/TSsqCazP1V0

Sumitomo Flow Battery Web
https://sumitomoelectric.com/products/flow-batteries

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