SUMITOMO ELECTRIC

40th Anniversary Flow Battery Symposium | 15-16 Oct., 2024 | UNSW Sydney

Advancements & Deployment of Sumitomo's Flow Battery Technology

Sumitomo Electric Industries, Ltd.

Toshikazu SHIBATA

15th Oct., 2024

SUMITOMO ELECTRIC GROUP

1.1. “Sumitomo Electric” Company Profile

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

Company Name	**Sumitomo Electric Industries, Ltd.**
Established	**April 1897**
Capital Stock	**¥99,737 million**
President	**Osamu Inoue**
Employees	**293,266**
Subsidiaries & Affiliates	**415** (Domestic [JAPAN] 104, Overseas 311)
Consolidated Business Results	Net Sales **\4,402,814 million** Operating Income **\226,618 million**

(As of March 31, 2024)

1.2. Business Development of “Sumitomo Electric”

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

Electric wire & cable

Copper

- Wiring harnesses
- Car electrical equipment
- Wire insulation — Anti-vibration rubber, automotive hoses
- Control / Transmission — System products (traffic control system, telematics, etc.)
- Electric conductors — Flexible printed circuits (FPCs)
- Electric wire products
- Electric beam irradiation products (heat-shrinkable tubes, etc.)
- Wire insulation — Fluorine resin products
- Cable installation (Power line construction) — Power line engineering, power line information systems
- (Power cables) — Electric wires and cables for power transmission and distribution
- (Copper wires) — Electronic conductors (copper wire rods, trolley wires)
- (Enamel wires) — Magnetic wires
- Wire insulation — Hybrid products (air cushions, etc.)
- Electric conductors — Metal materials for electronic parts
- Cable installation (Communication network construction) — Information communication engineering
- (Telecommunication cables) — Optical fibers, optical fiber cables, optical-related equipment
- Transmission — Semiconductor device products
- Control — Network systems and equipment
- CATV-related products
- Electric conductors — Compound semiconductors (GaAs, InP)
- Wire-drawing (Steel wires for valve springs) — Special steel wires (prestressing steel wires, steel tire cords, etc.)
- (Cemented carbide alloys for wire-drawing dies) — Cemented carbide tools (cutting tools, drills, etc.)
- Powder metallurgy — Sintered powder metal products (various parts for automobiles, home appliances, etc.)
- Diamond products (cutting tools, precision machining tools, etc.)

Automotive

Electronics

Environment & Energy

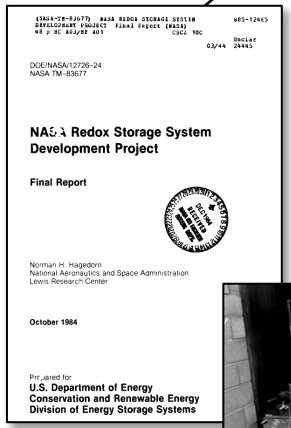
Info-communications

Industrial Materials

2. History of Flow Battery

1950 1974 1980 1985 1989 2001 2010 2020

- Dr. W.Kangro(Germany) 1st demonstration of Flow Battery (Ti/Fe, Cr/Fe)
- Dr. L.Thaller (NASA Redox Storage System Project)


(NASA-TM-83677) NASA REDOX STORAGE SYSTEM DEVELOPMENT PROJECT Final Report (NASA) 46 p HC A03/MF A01 CSCL 10C N85-12445 Unclas G3/44 24983

DOE/NASA/12726-24
NASA TM-83677

NASA Redox Storage System Development Project

Final Report

Norman H. Hagedorn
National Aeronautics and Space Administration
Lewis Research Center

October 1984

Prepared for
U.S. Department of Energy
Conservation and Renewable Energy
Division of Energy Storage Systems

- NEDO (Japan) Moonlight Project "New Energy Storage System"
  Electro Technical Laboratory, Mitsui Engineering & Shipbuilding,
- NEDO (Japan) Sunshine Project "Energy Storage System for PVs"
  Mitsui Engineering & Shipbuilding, Ebara Tech.
- Dr. M.S-Kazcos (UNSW) V/V Patent
- Kansai EPCO/Sumitomo Electric
  Fe/Cr系60kW('89), V/V系450kW('96)

- Japan Flow Battery Projects
  Mitsui 10kW('91), Kashima Kita 200kW('97)

- Regenesys Large Scale Project
- Sumitomo Electric Commercialization
- Many vendors appear after V/V Patent expired

3. Sumitomo's Installation World Wide

Taiwan Power Co.
750kWh (Taiwan)
for multiuse

Hokkaido Electric Power Network 60MWh+51MWh (Japan)
for dispatch power

John Cockerille
1.7MWh (Belgium)
for increasing renewable energy ratio

Kashiwazaki IR Energy 8MWh (Japan)
for whole sale market

Nippon PS 750kWh (Japan)
for factory

National Lab.
750kWh (Taiwan)
for VPP

Energy Queensland
750kWh (Australia)
local production of electrolyte

San Diego Gas & Electric 8MWh (USA)
for wholesale market, microgrid

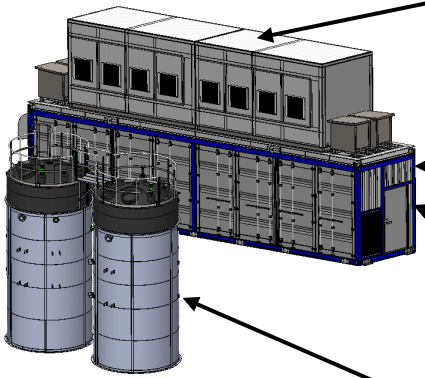
Total installation: 41 projects, 49MW, and 173 MWh across 7 countries.
7 projects (17MWh) are on going. (As of 30th September, 2024)

4. Evolution of flow battery modules

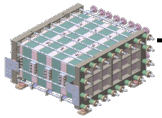
System @2016 → Now

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

Heat Exchanger



Cell stack

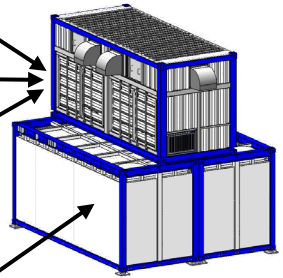


DC38kW x 8

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

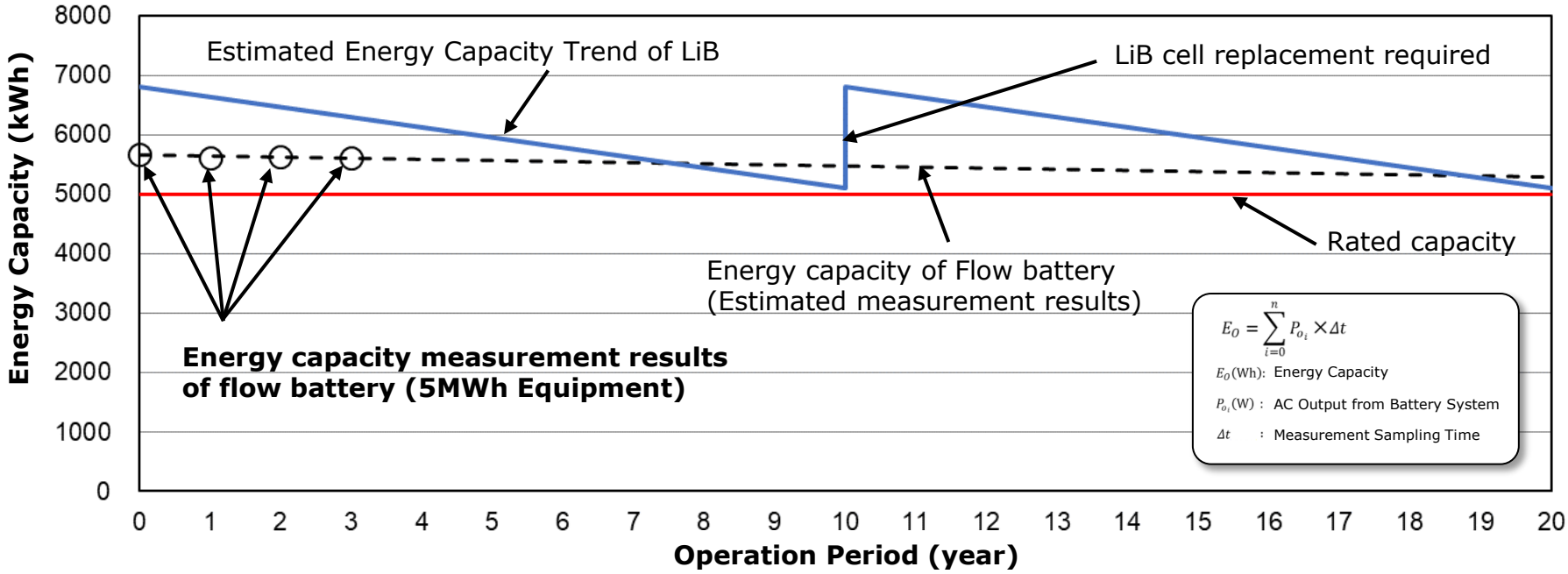
Eco Friendly
- ✓ Reusable Electrolyte
- ✓ Recyclable Electrolyte
- ✓ More than 99% weight of the materials used in the system are recyclable

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 1-00

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.

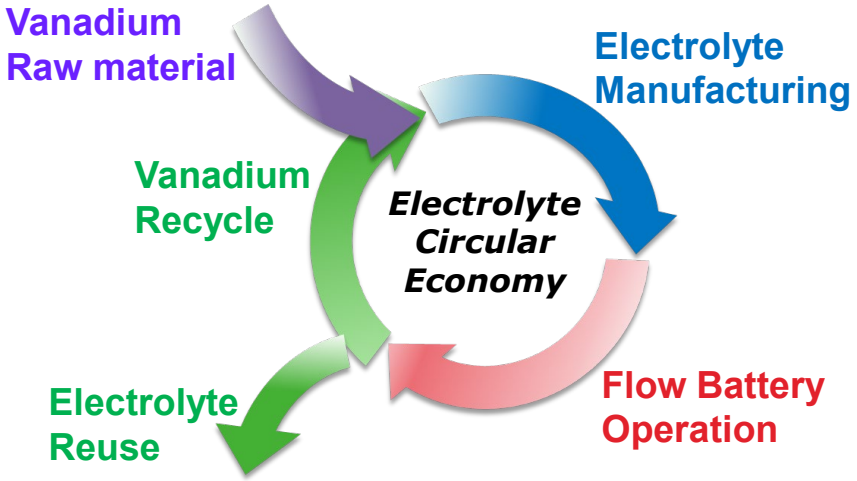
Look for the UL Certification Mark on the product.

Example of indoor installation

Example of underground installation

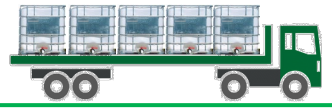
5.3. (Key Features) Electrolyte Circular Economy

- ✓ 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

Electrolyte 70%

Filling to other system

Sorting, crushing, and disconnect

Iron materials	Equipment	Waste Plastic	Cupper Material	Insulated Wire	Thermal Insulation
22.7%	1.5%	4.7%	0.2%	0.1%	0.8%

Sorting and crushing

Sorting and crushing

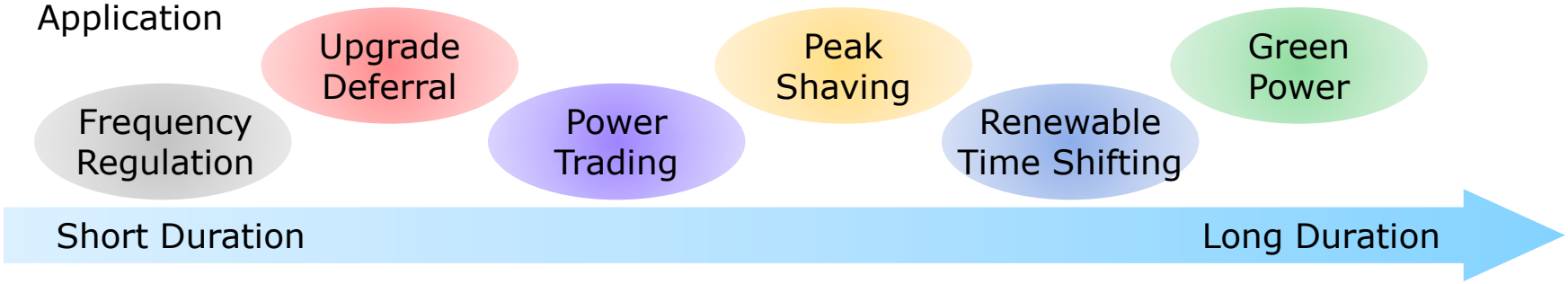
Iron raw material	Plastic raw materials	Copper raw material
23.7%	5.2%	0.3%

Reuse 70%

Recycle 29.2%

Disposal 0.8%

6. Project Information



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

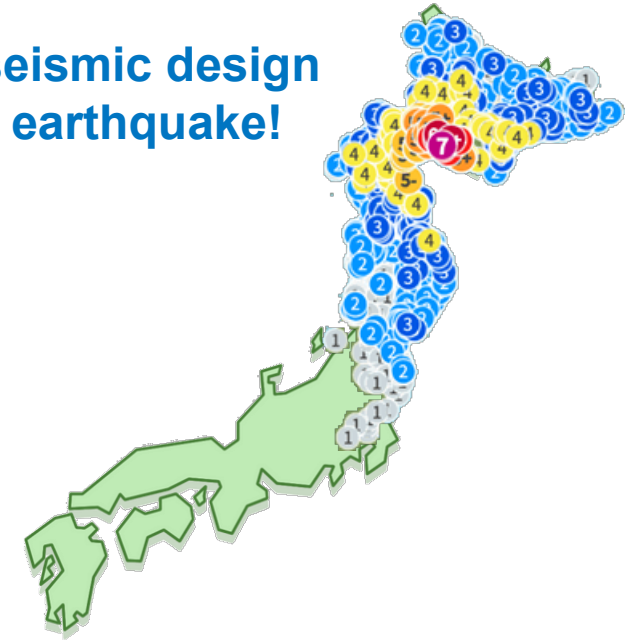
Performance verification and development of control technology as a new adjustment power resource for output change of wind turbines and PVs.

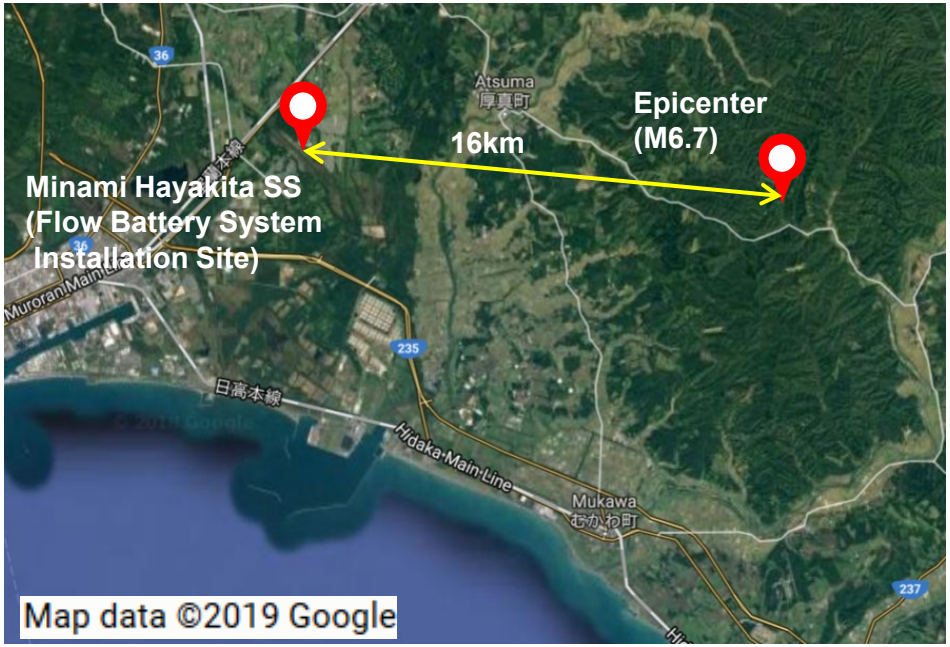
- ✓ Capacity: 60MWh (15MWx4h, Max 30MW)
- ✓ Location: Hokkaido Electric Power Network Minami-Hayakita S/S (Hokkaido, Japan)
- ✓ Use Case: Grid Use
  - ■ Suppress short-periodic fluctuations
    - Suppress WT & PV output fluctuations
    - Governor Free Equivalent Control
    - Load Frequency Control(LFC)
  - ■ 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

6.1. 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!





6.2. 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

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6.3. 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

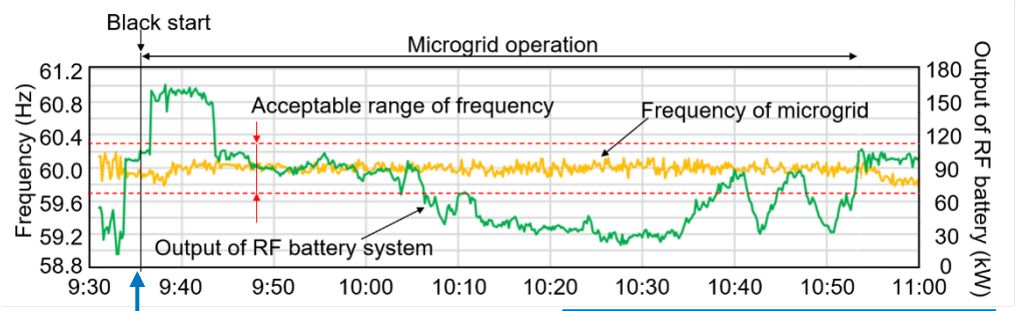
NEDO · CALIFORNIA Governor's Office of Business and Economic Development · SDGE · SUMITOMO ELECTRIC

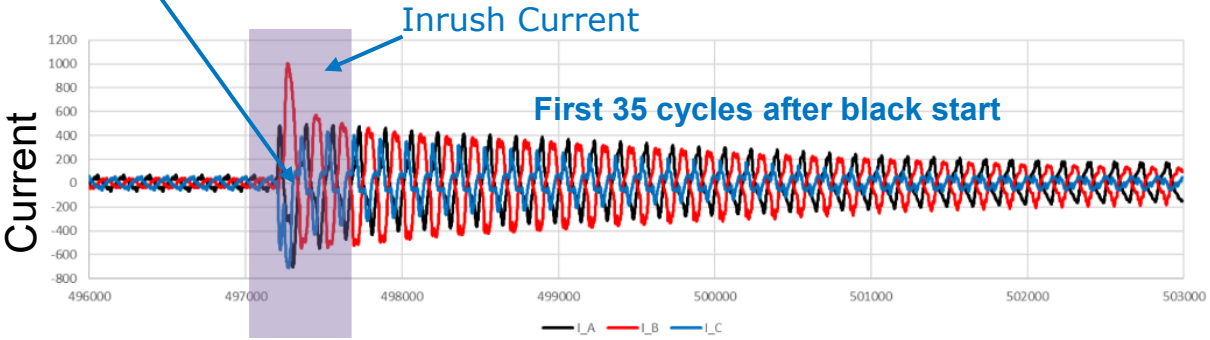
ISGAN Award of Excellence 2024

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

6.3. For Multiuse on Distribution Grid (2)

Microgrid using commercial distributed line

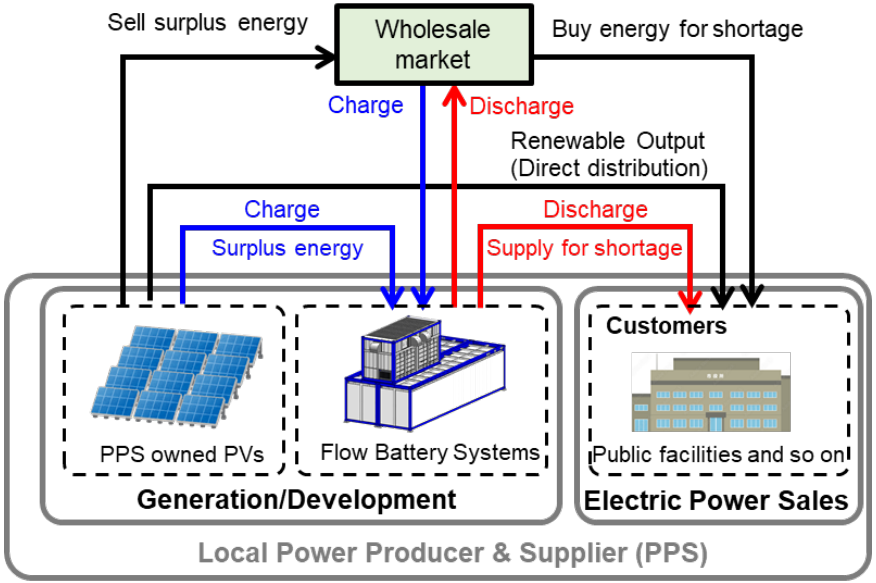




Target area: 2.2km
Number of customers: 66 consumers
Contracted load: Approx. 400kW
Others: With PV (100kW or higher)
Without generator

6.4. For Local PPS (Power Producer & Supplier)

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



- ✓ *Battery Capacity* :8MWh (1MW x 8h)
- ✓ *Location* : Kashiwazaki, Japan
- ✓ *Use Case*
  - Whole sale market operation
  - Effective use of PV output
- ✓ *Start of operation* : Oct. 2024
- ✓ *Project Partner*

Kashiwazaki Ideal & Realistic Energy

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6.5. 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: Solar soaking, and possible market trading*
- ✓ *Start of operation*:2024
- ✓ *Project Partner*

Energy Queensland, energex, yurika, VECCO Group, SUMITOMO ELECTRIC

Thank you! Any Question?