Vanadium Redox-Flow Battery (VRB) for a Variety of Applications

SUMITOMO ELECTRIC INDUSTRIES, Ltd.

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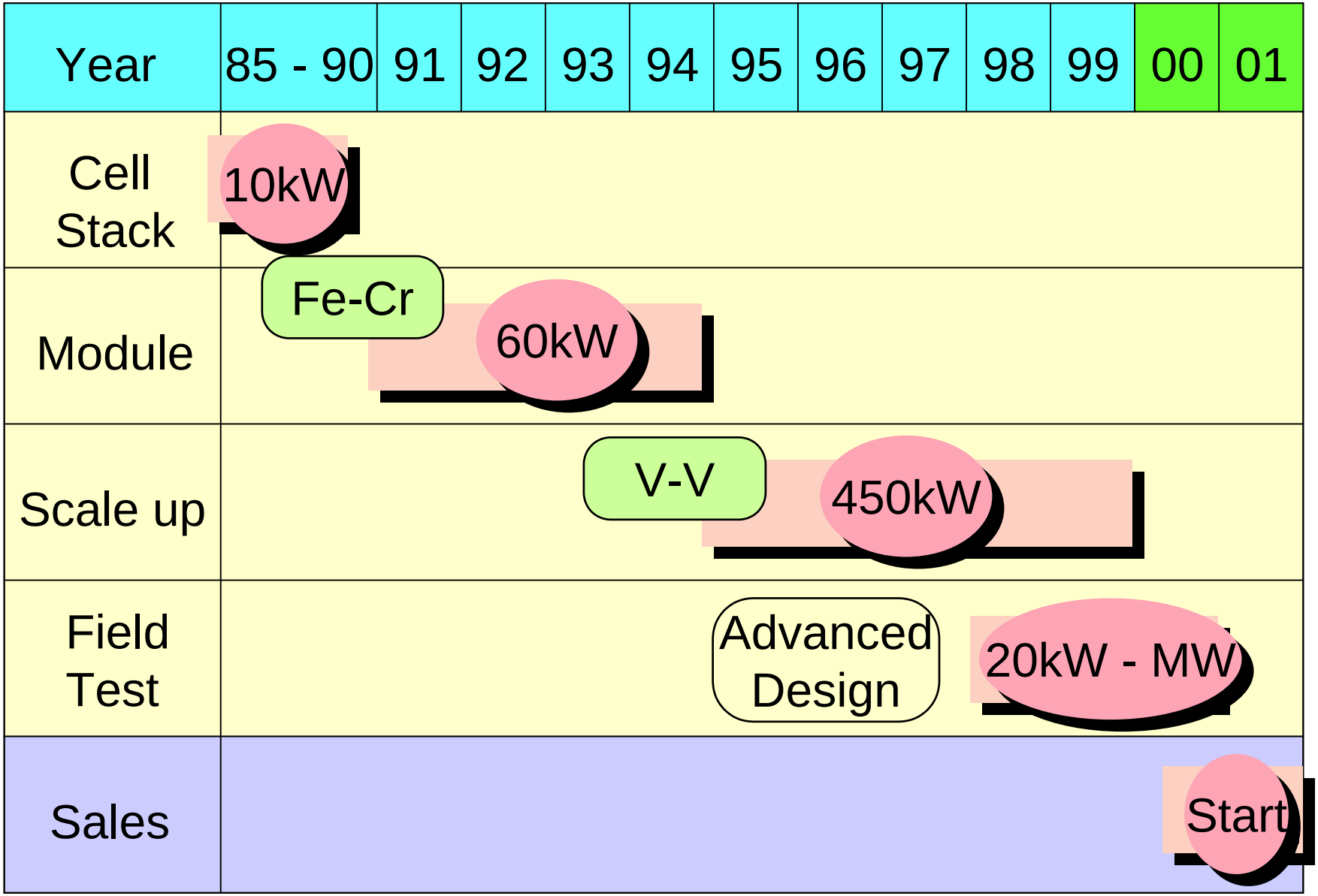
Vanadium Redox Flow Battery Development Program



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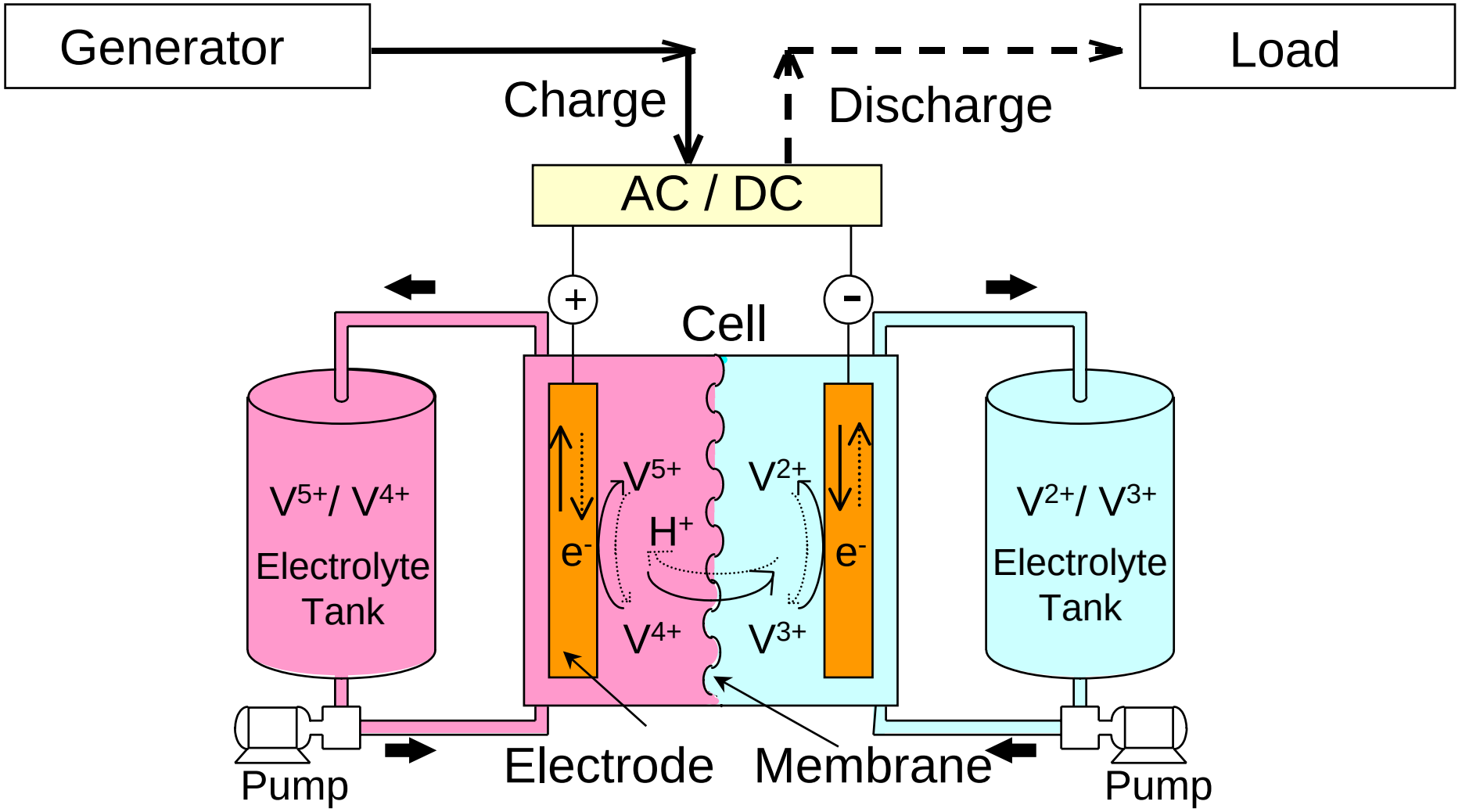
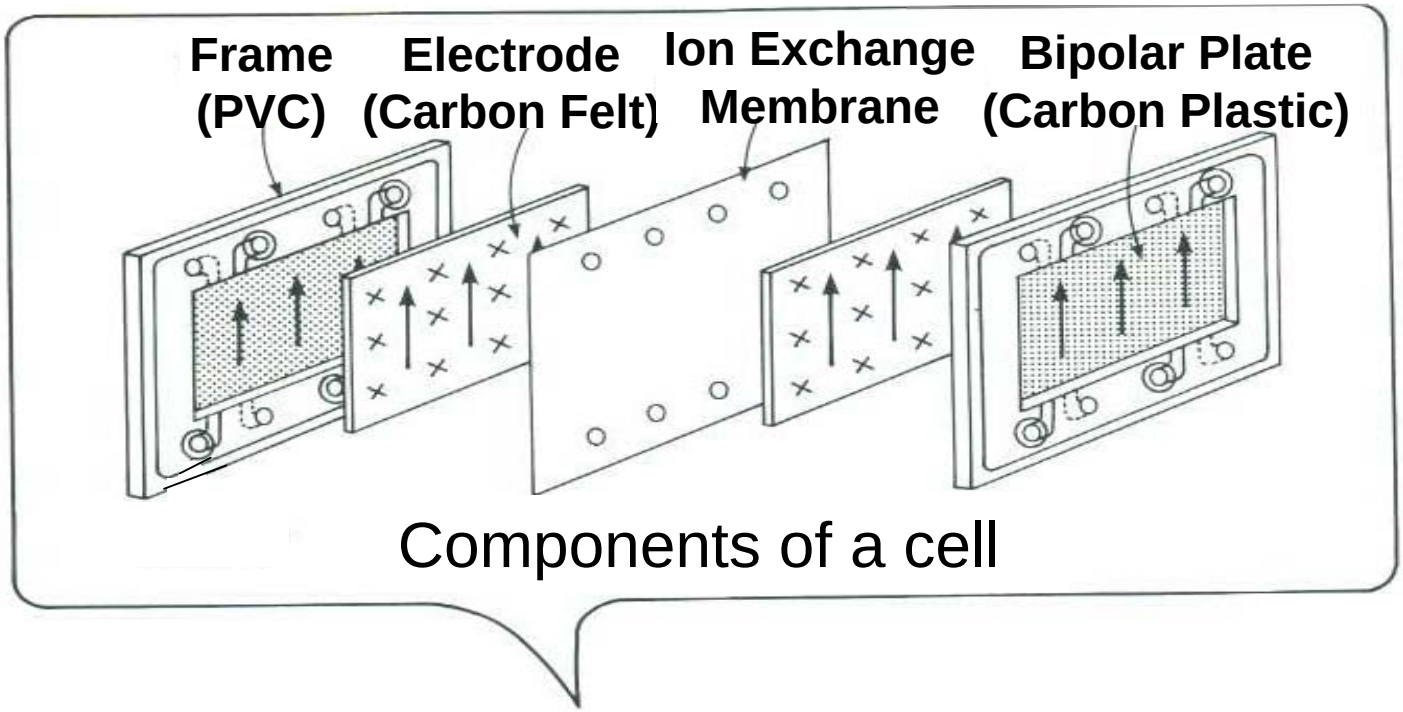
Principle of Vanadium Redox Flow Battery



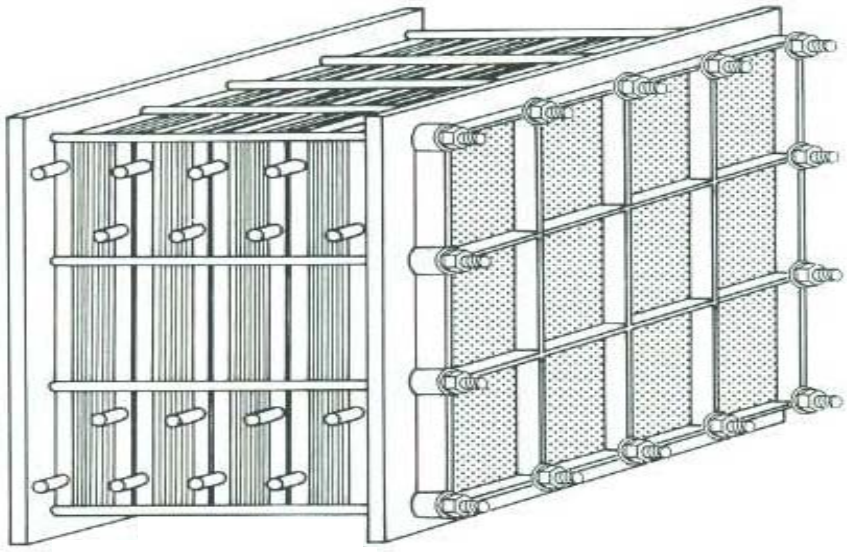
$$\oplus \quad V^{4+} \rightleftharpoons V^{5+} + e^-$$

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

Construction of Cell Stack



Components of a cell



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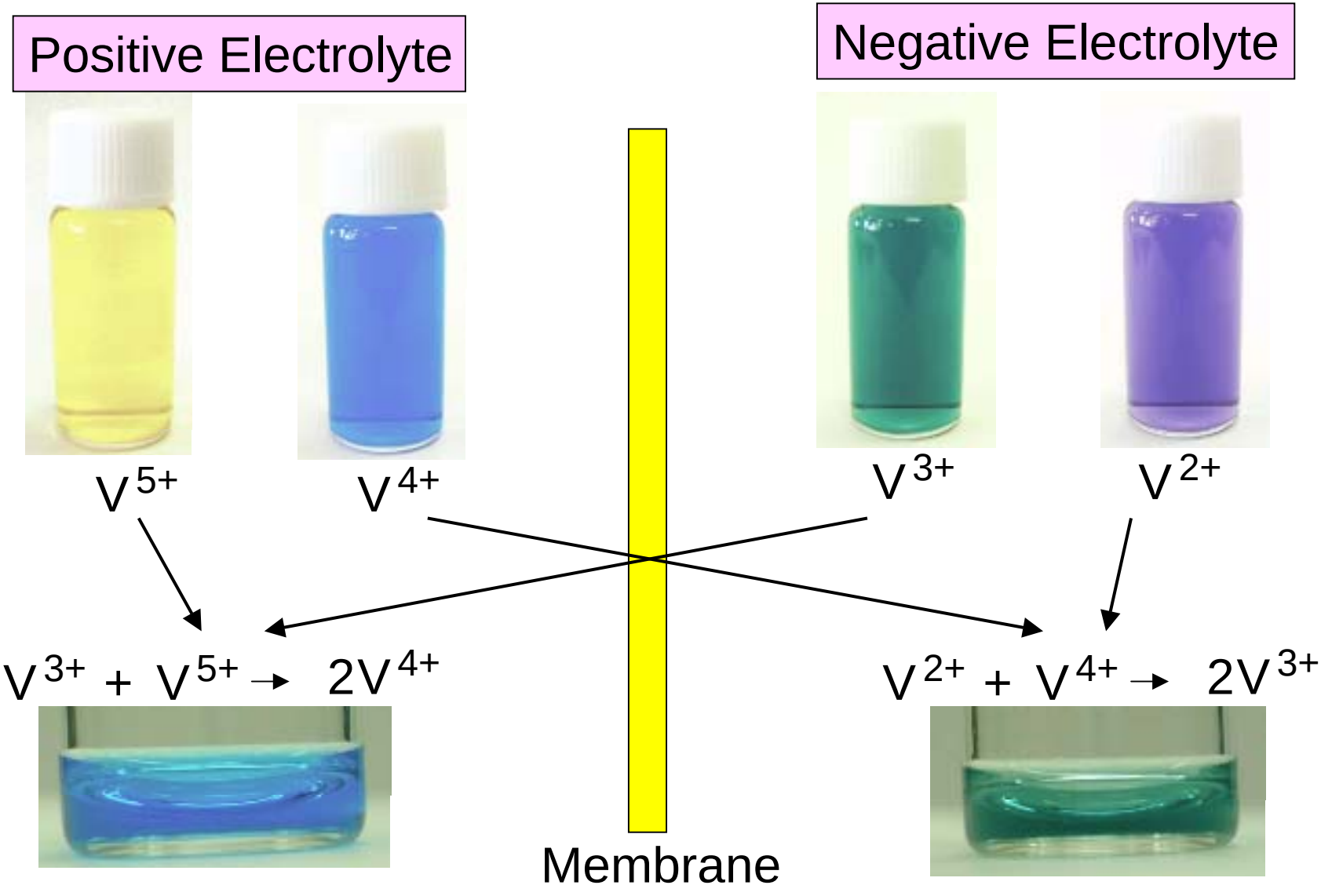
Why Vanadium ?

1. Same Redox Ion for Positive and Negative
2. Aqueous Reaction (No phase change)
3. Large Open Circuit Voltage
4. Fast Response
5. Overload Capacity

Electrolytes of Vanadium Redox Battery



Electrolytes of Vanadium Redox Battery

Electrolytes are recyclable
even if positive and negative electrolytes are mixed

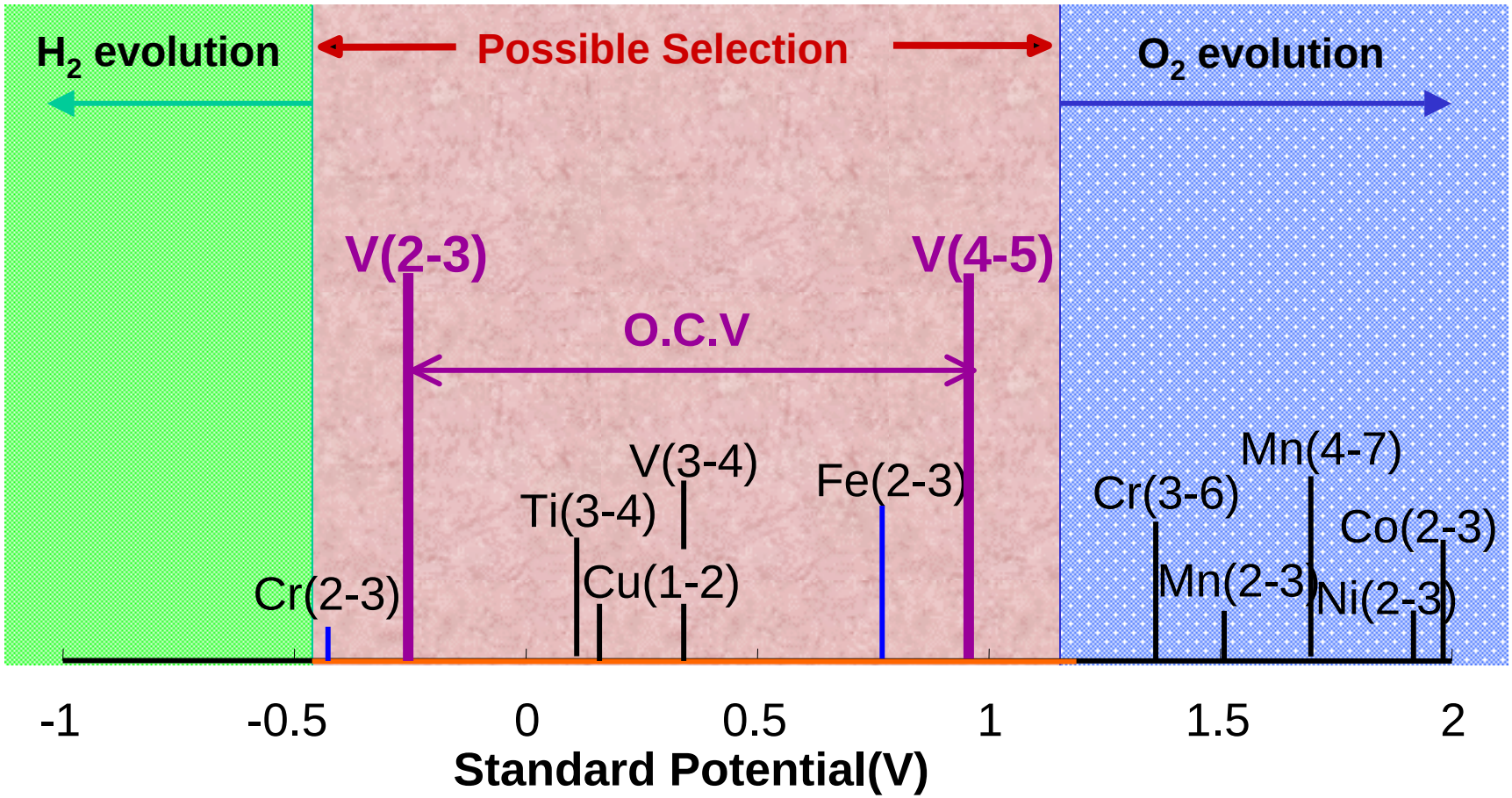
Positive Electrolyte (a >> c, d)

$$a\,V^{5+} + b\,V^{4+} + c\,V^{3+} + d\,V^{2+} \longrightarrow (a-c-2d)\,V^{5+} + b\,V^{4+}$$

Negative Electrolyte (a, b << d)

$$a\,V^{5+} + b\,V^{4+} + c\,V^{3+} + d\,V^{2+} \longrightarrow c\,V^{3+} + (d-2a-b)\,V^{2+}$$

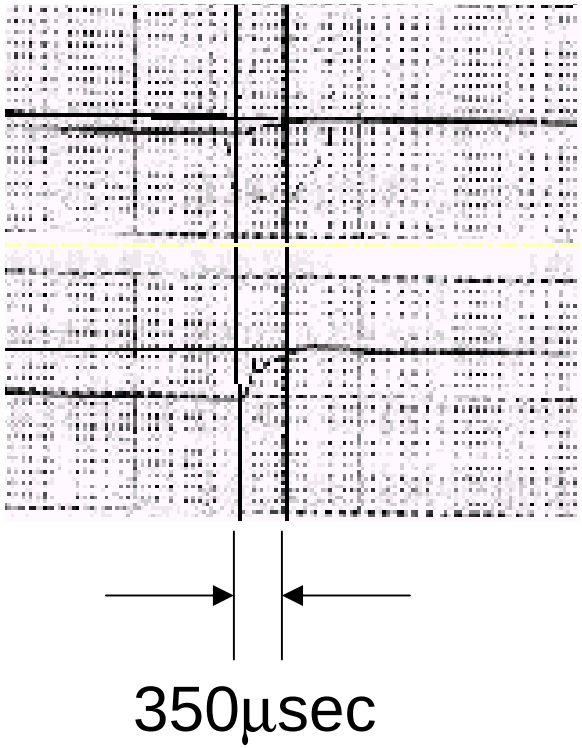
Open Circuit Voltage of VRB



VRB Response

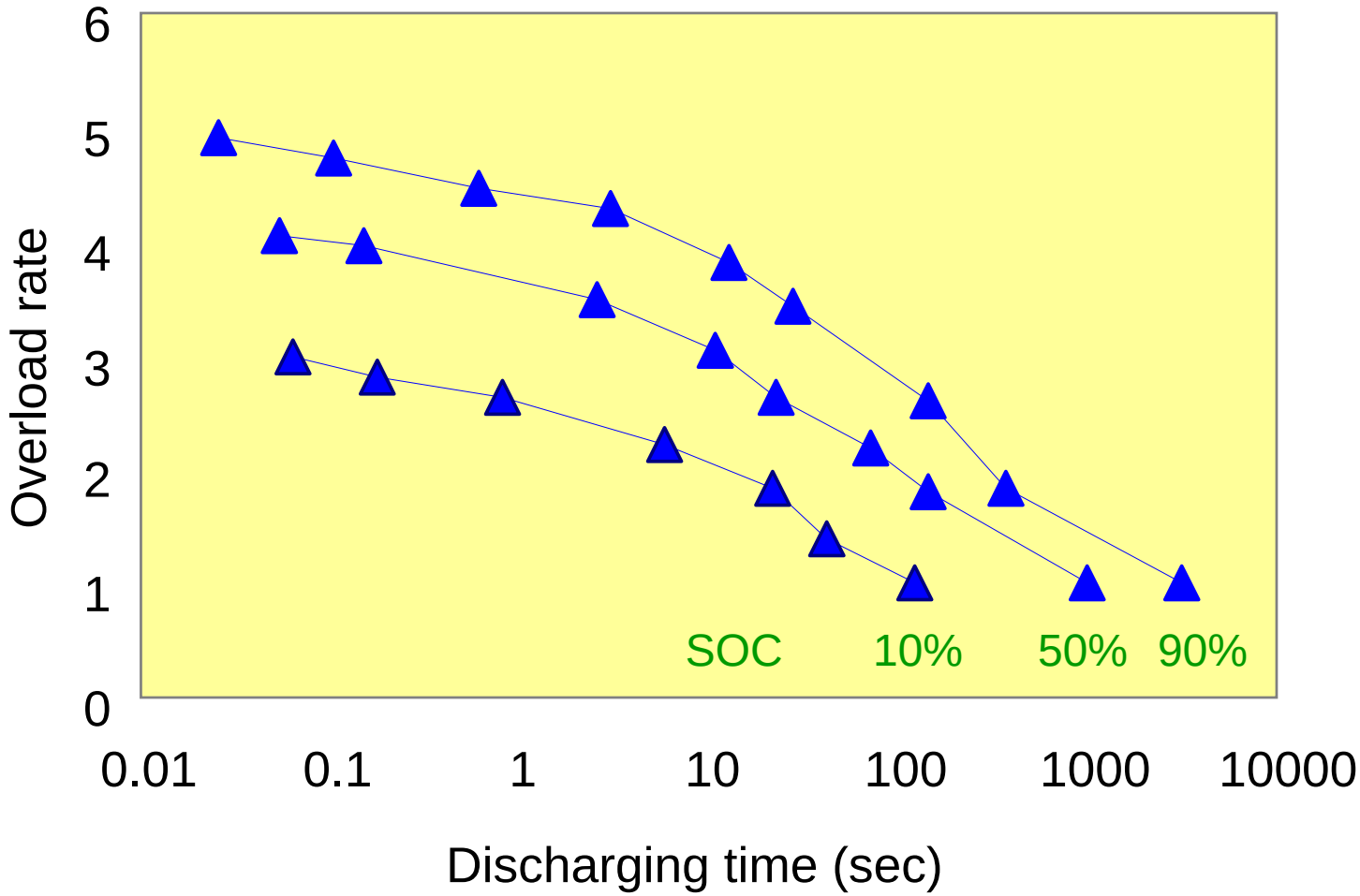
DC Voltage

DC Current



Response time of Battery is veryfied as 350µsec

VRB Overload Capacity



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Characteristic Advantage of VRB

1. High-rate Overload Capacity
2. Quick Response

→ UPS,
LFC
Stabilization of Wind
Turbine Output

3. Long Cycle Lifetime
in Deep Charge/Discharge

→ Load Leveling

4. Easy Increase of Capacity

→ Large Storage
Capacity System

5. Normal Temperature Operation
6. Environmentally Friendly

→ Safe and
Green

VRB Projects in Japan

Place	Applications	Specifications	Start of operation
Office building	Load leveling (Demonstration)	100kW x 8h	2000/02
Semi-conductor factory	1) Voltage sag protection 2) Load leveling	1) 3000kW x 1.5sec. 2) 1500kW x 1h	2001/04
Wind power station	Stabilization of wind turbine output (Field test)	170kW x 6h	2001/04
Golf course	Load leveling (Photovoltaic hybrid system)	30kW x 8h	2001/04
University	Load leveling	500kW x 10h	2001/07

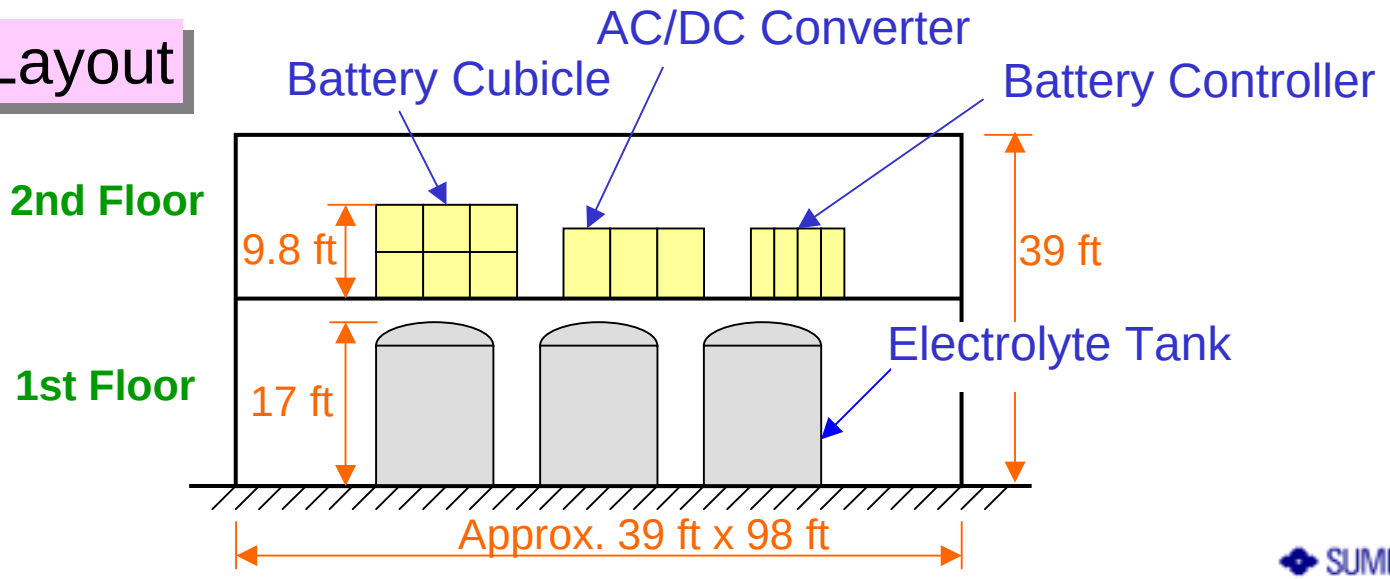
Application to Semi-Conductor Factory

Specifications

(Operation : First of April 2001)

Function	Purpose	Output	Operation
(1) Voltage Sag Protection	Protection of Important Load	3MW x 1.5sec	At the Occurrence of Voltage Sag (5-20 times /year)
(2)Load leveling	Reduction of Electricity Charge	1.5MW x 1hour	Everyday

System Layout



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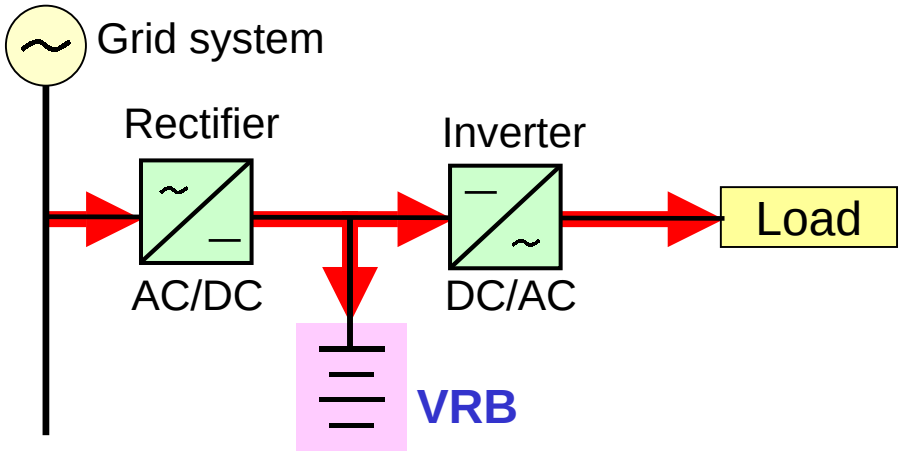
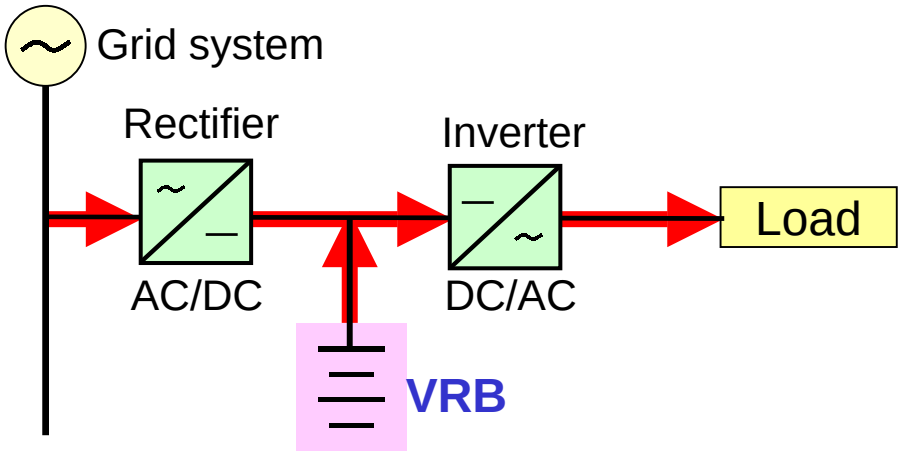
Operation Sequence

Load leveling (Normal operation)

Charge

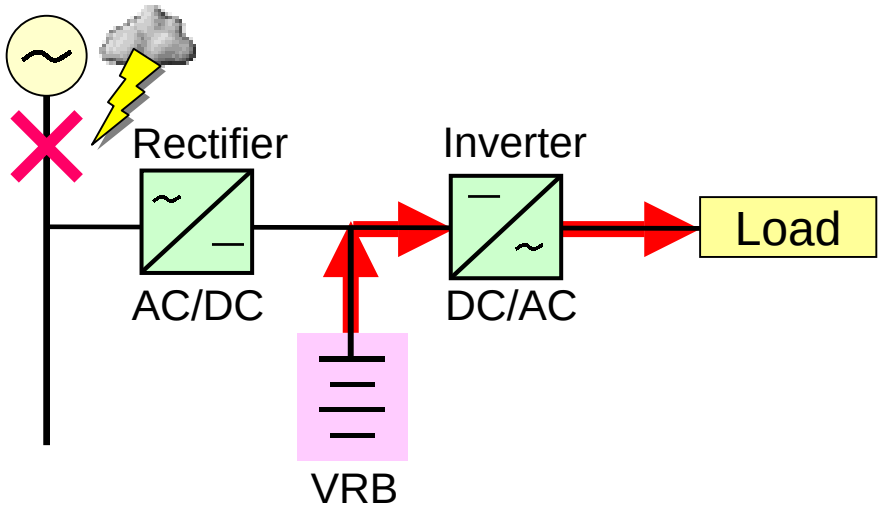


Discharge



UPS function

Voltage sag protection



Voltage Sag Protection

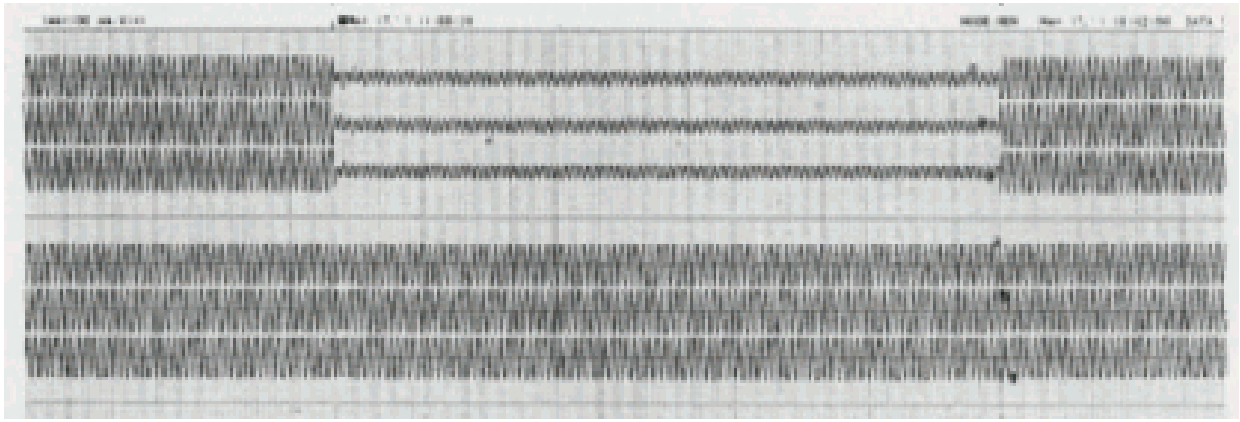
Test result for voltage sag

Voltage Sag

1.5sec

Grid System (6.6kV)

Load (6.6kV)



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1.5MW-1Hrs/3.0MW-1.5sec VRB System

Battery boxes

Electrolyte Tanks

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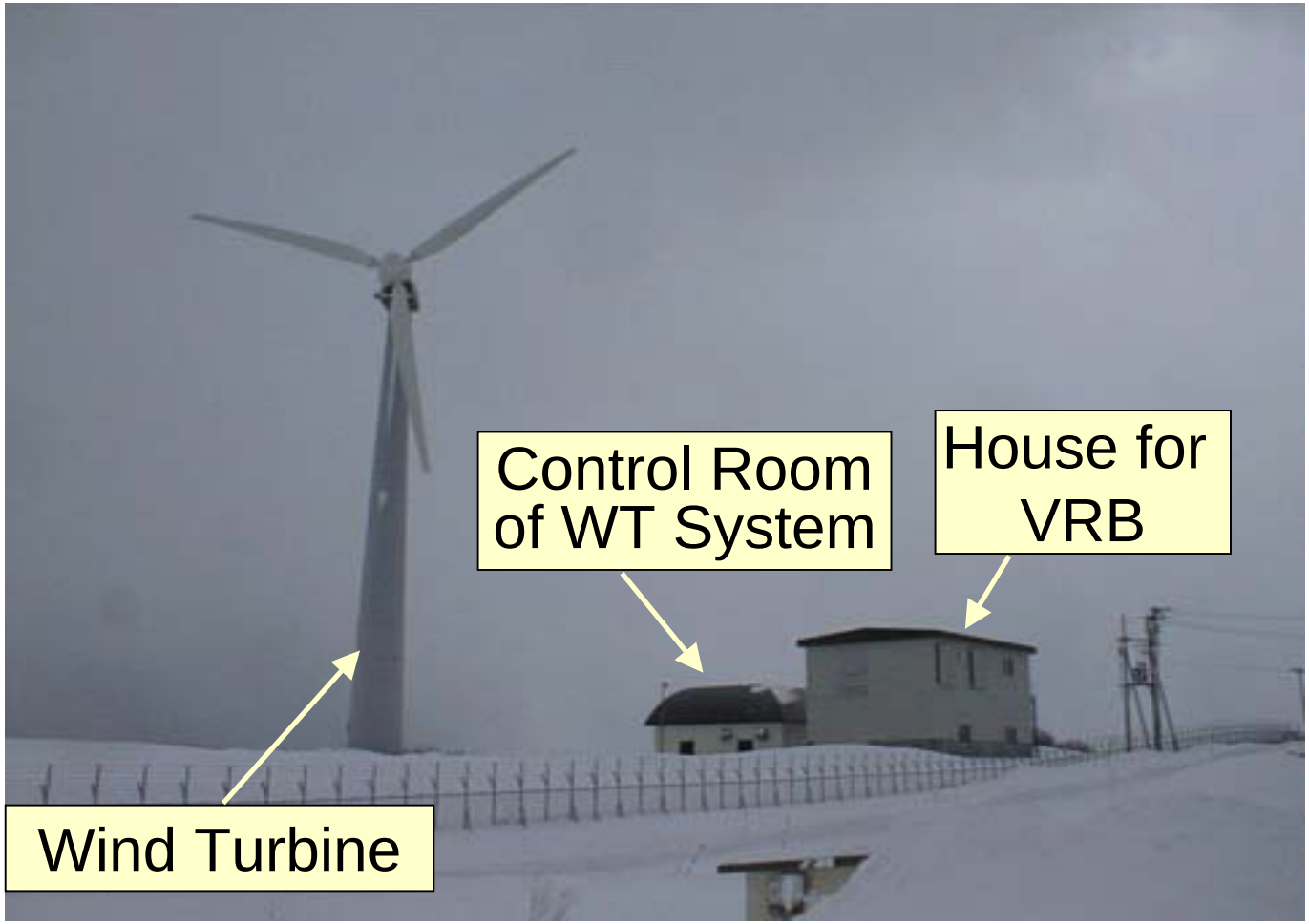
Application to Wind Power Station (NEDO Project)

Place : Tomari Wind Hills of Hokkaido Electric Power Co.,Inc.
Wind Turbine : 275 kW
VRB : 170 kW-6h

NEDO —Commission→ IAE (The Institute of Applied Energy) —Order→ SEI



VRB Equipment

Battery Cubicle

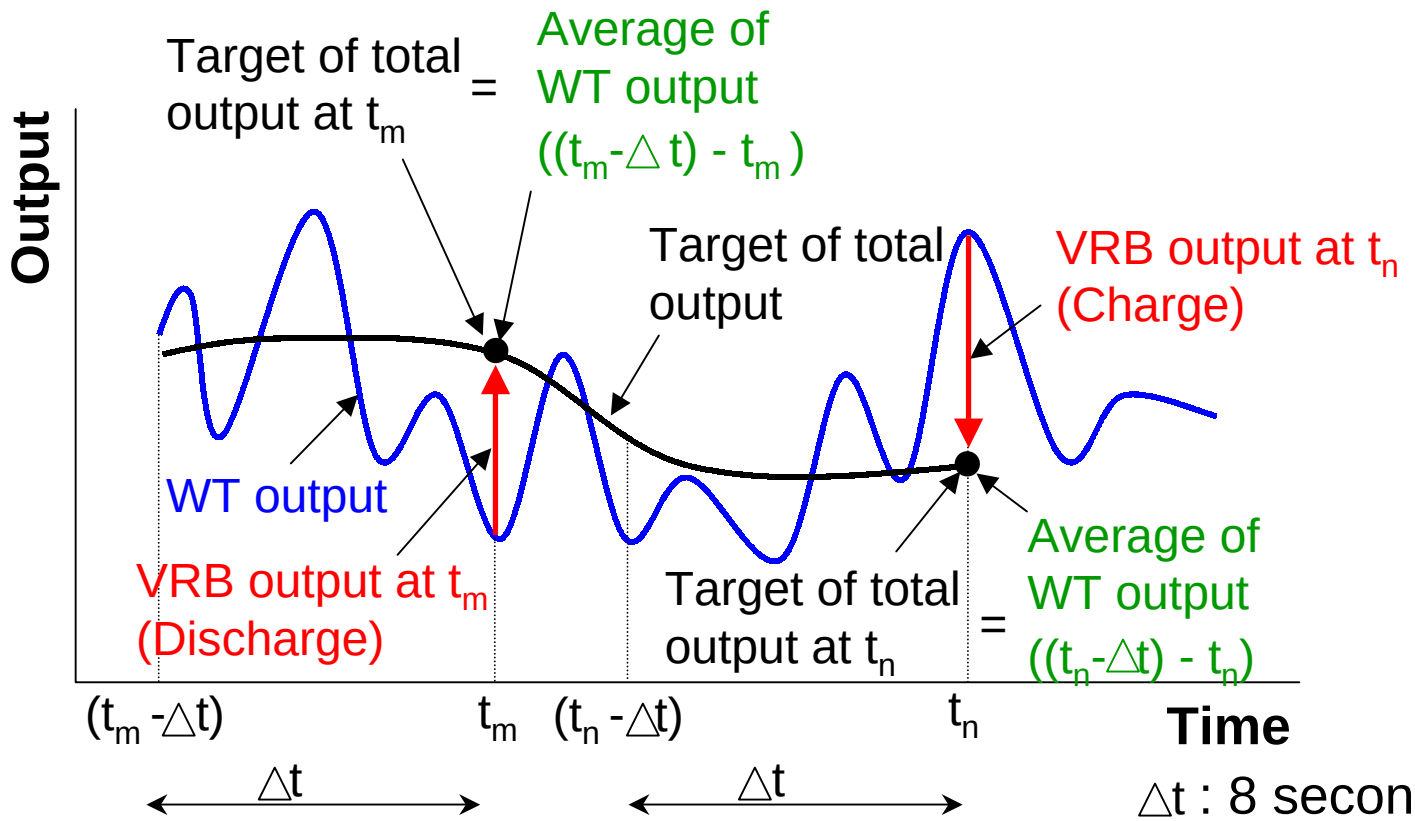
AC/DC Converter

Electrolyte Tank

Field Test for Stabilization of WT Output

<Operation Outline>

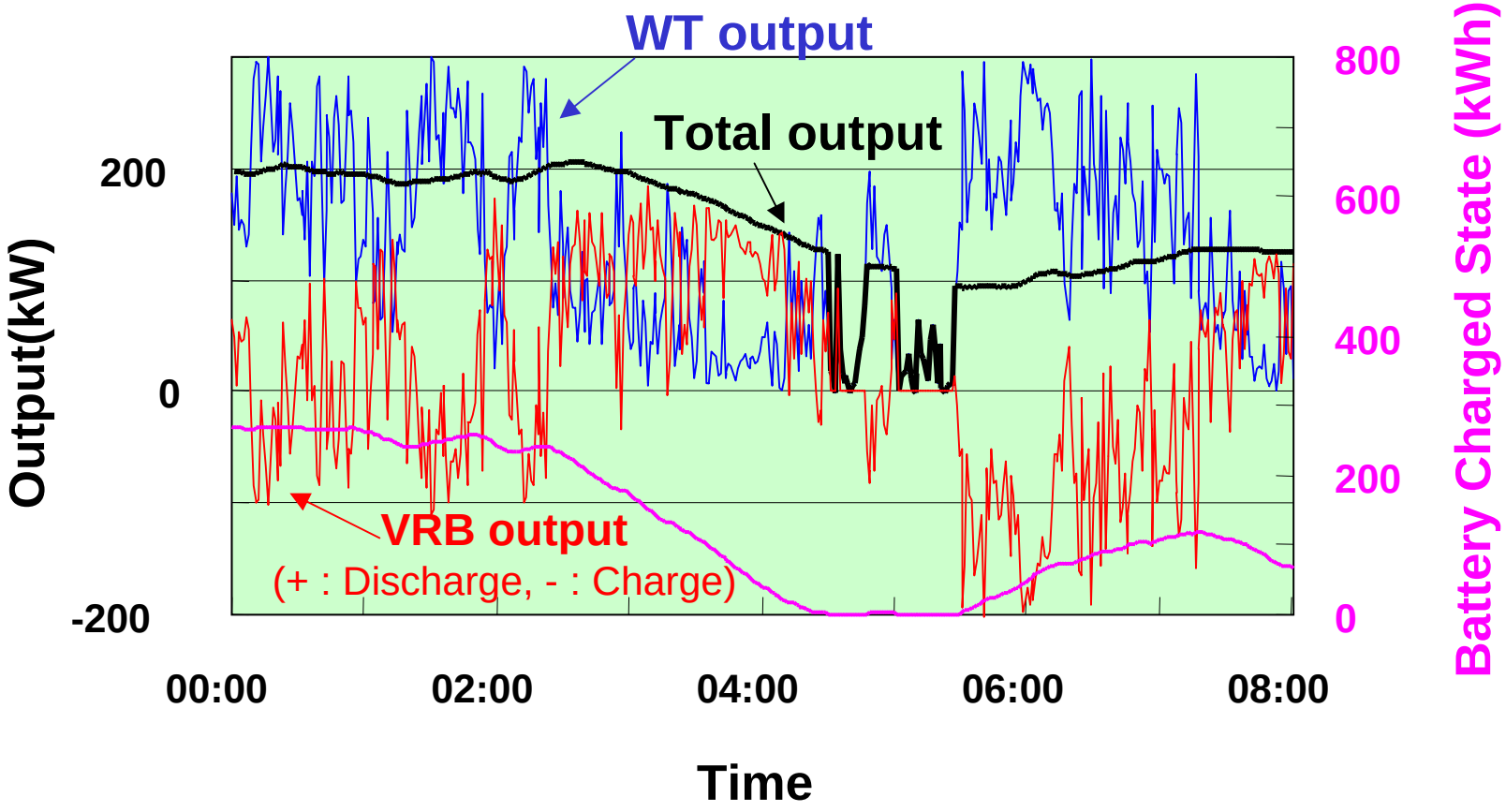
Target of total output (t) = Average of WT output ((t- △t) - t)
VRB output (t) = Target of total output (t) - WT output (t)
(+ : Discharge, - : Charge)



△t : 8 seconds - 8hours

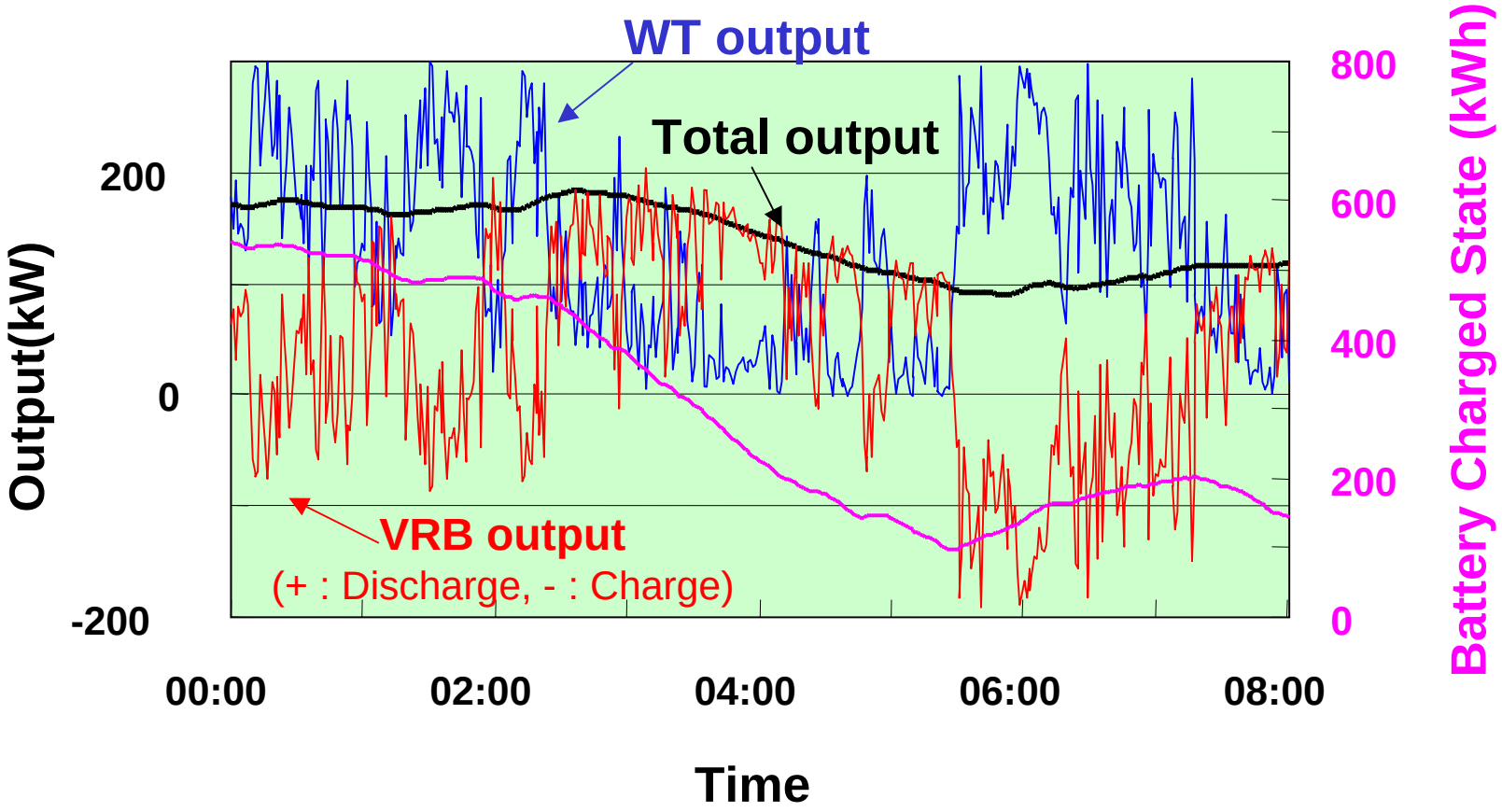
Example of Simulation Results for Stabilization of WT Output

Battery Capacity = 3hr
DT = 240min

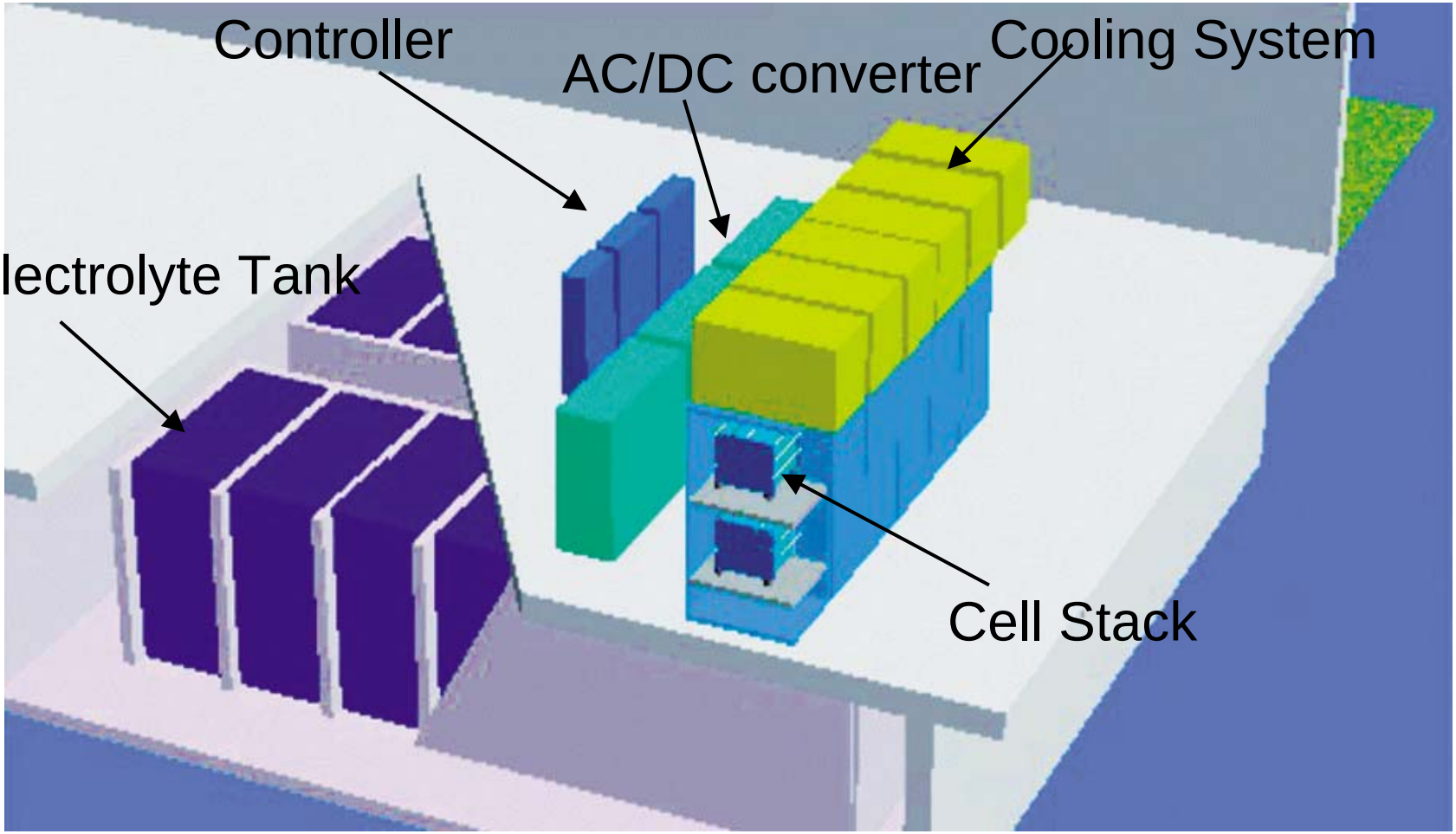


Example of Simulation Results for Stabilization of WT Output

Battery Capacity = 6hr
DT = 240min



500kW-10Hrs VRB System



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500kW-10Hrs VRB System

Electrolyte Tanks and Pipes

Battery Boxes

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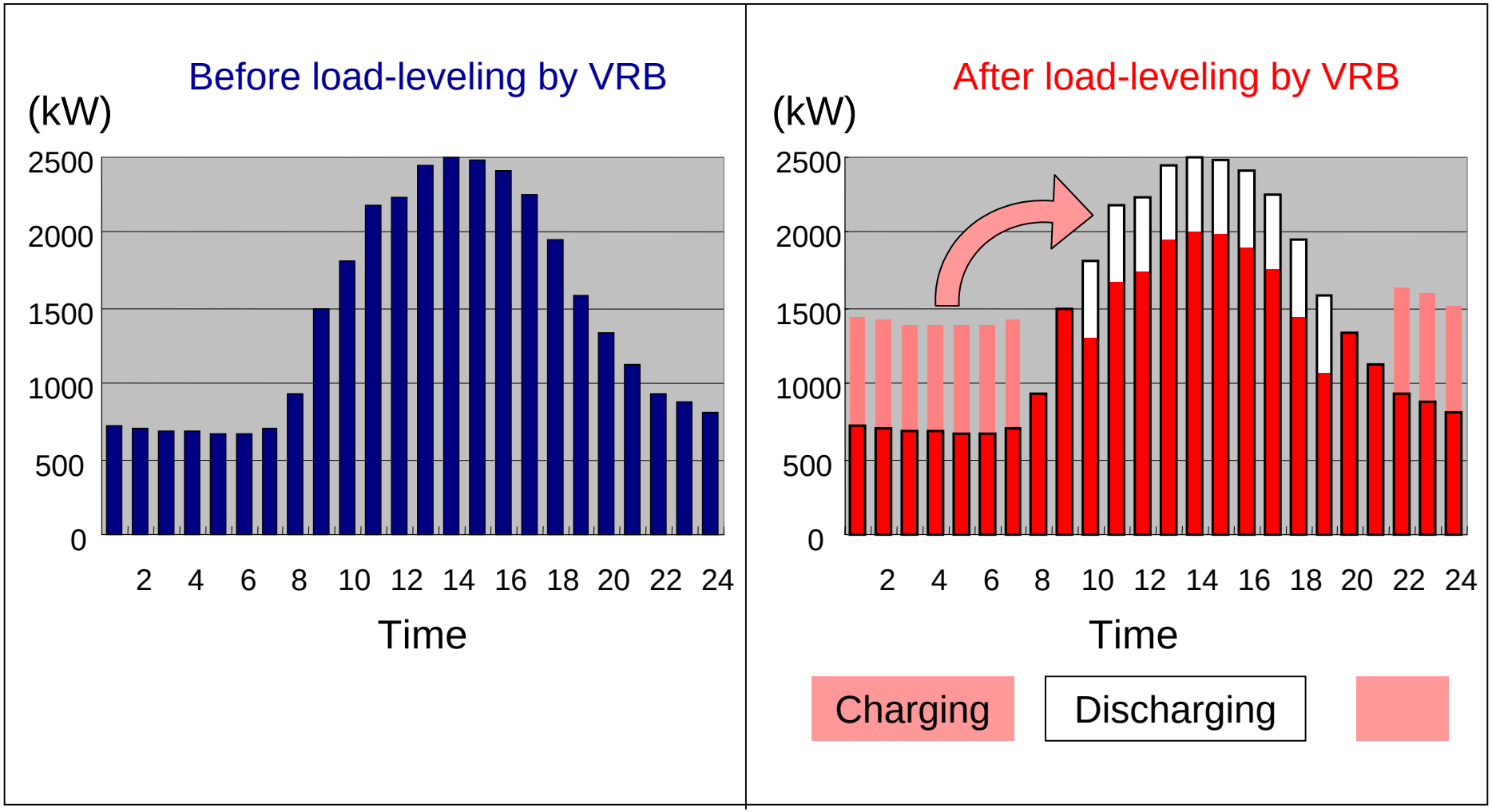
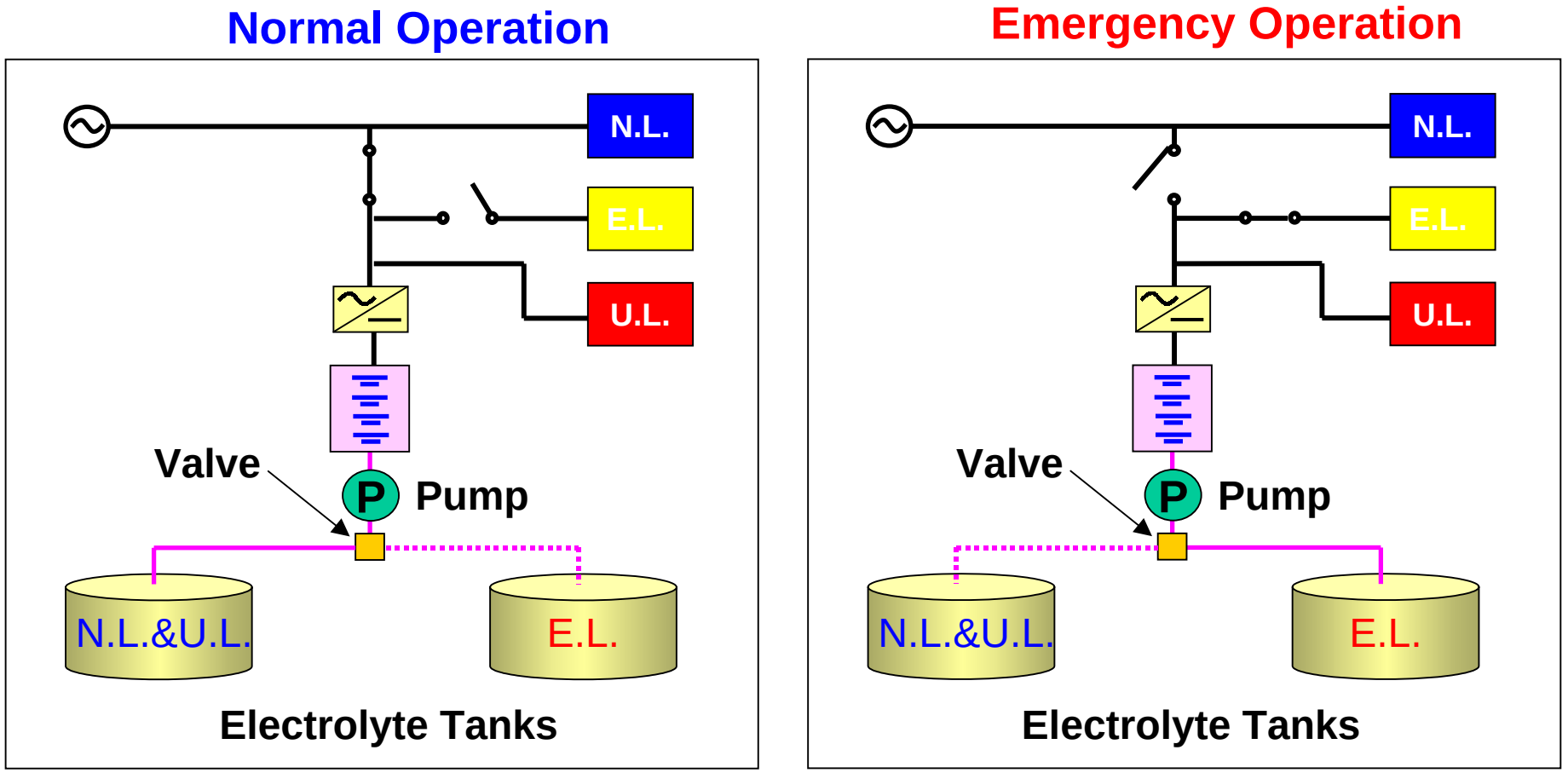
500kW-10Hrs VRB System



VRB System for Multiple Applications



N.L.: Normal Load U.L.: UPS Load E.L.: Emergency Load