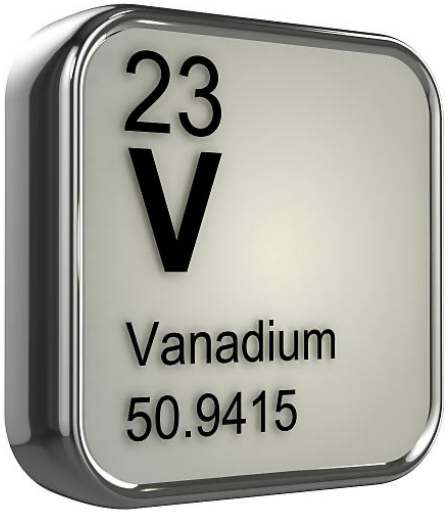
ACEMIL

INTRODUCTION

VANADIUM REDOX FLOW BATTERY (VRFB)

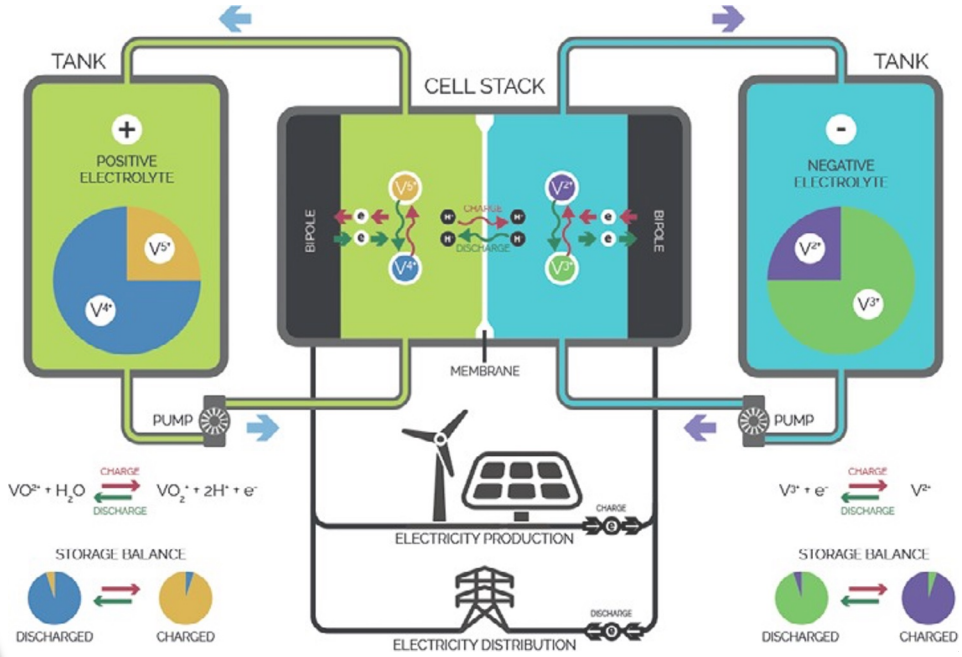


INTRODUCTION

- The vanadium redox battery (VRB), also known as the vanadium flow battery (VFB) or vanadium redox flow battery (VRFB), is a type of rechargeable flow battery. It employs vanadium ions as charge carriers. The battery uses vanadium's ability to exist in a solution in four different oxidation states to make a battery with a single electroactive element instead of two. For several reasons, including their relative bulkiness, vanadium batteries are typically used for grid energy storage, i.e., attached to power plants / electrical grids.
- The fundamentals of VFB technology are not new, having been first developed in the late 1980s. In contrast to lithium-ion batteries which store electrochemical energy in solid forms of lithium, flow batteries use a liquid electrolyte instead, stored in large tanks. In VFBs, this electrolyte is composed of vanadium dissolved in a stable, non-flammable, water-based solution.

HOW DOES IT WORK?

- Vanadium is a non-toxic, widely-available metal that is typically used for making steel more ductile, strengthening titanium and even as a dietary supplement. Vanadium is produced globally, either from primary mining operations or by secondary processing of wastes from power generation or steel manu- facturing. Significant vanadium reserves are present in the USA, Canada, China, Brazil and South Africa.
- Inside the VFB, two separate tanks of vanadium electrolyte with different charges are connected to a central fuel cell stack. Electrolyte from the tanks is pumped through the fuel cell stack, where an ion exchange occurs across a membrane. When this exchange occurs, a reversible electrochemical reaction takes place, allowing electrical energy to be stored and subsequently returned. The technology relies on the ability of vanadium to exist in four different oxidation states (V2+, V3+, V4+ and V5+), each of which holds a different electrical charge.

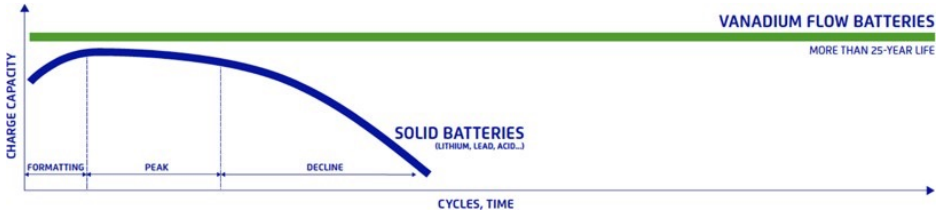


ADVANTAGES OF VANADIUM REDOX FLOW BATTERY (VRFB)

- **High flexibility and scalability**

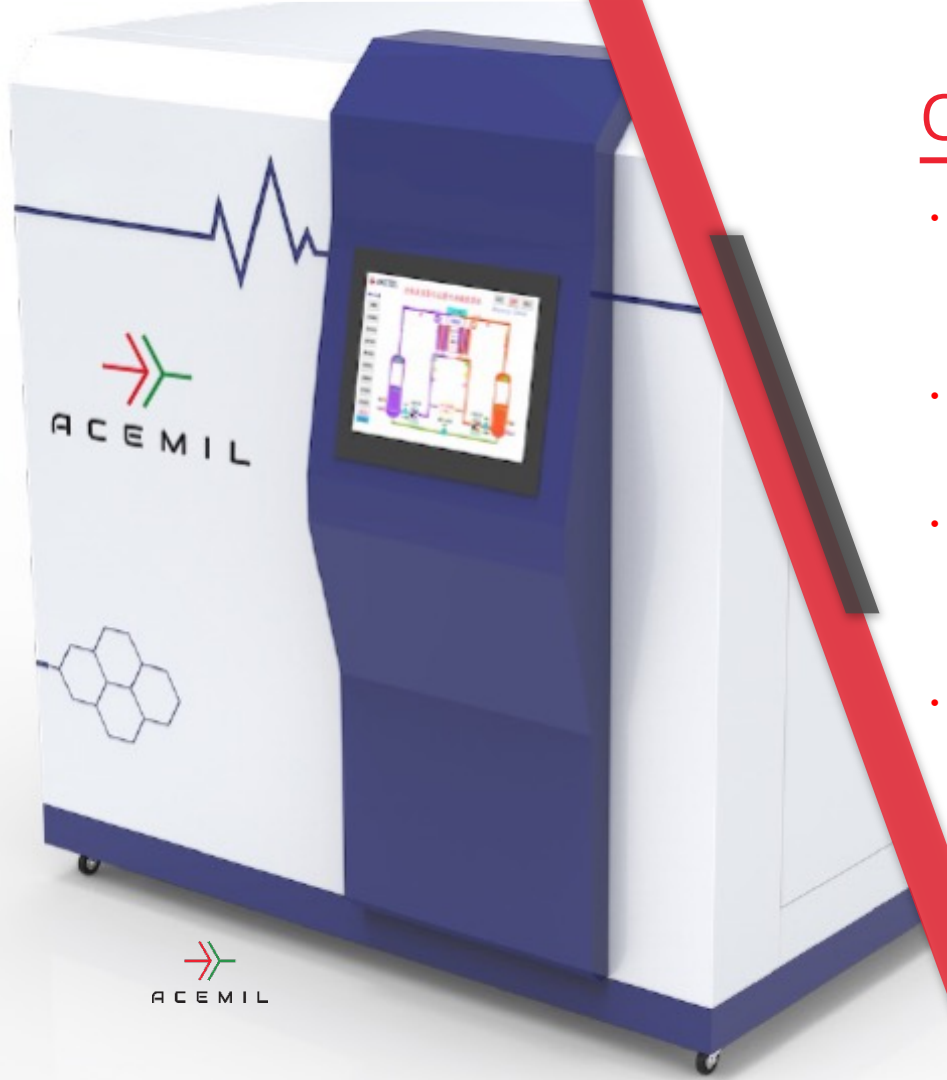
  Vanadium batteries can be easily applied in modular management, and power and capacity can be individually designed. By connecting multiple groups of energy storage units, a larger-scale energy storage system can be built. Expansion is economical and safe compare to other batteries, which makes VRFB suitable for industrial usage. It can build massive GWh size systems.

  VRFBs store their energy in two electrolyte tanks, which are connected to a stack of cells. The electrolyte is the fluid that stores the active materials dissolved in the liquid, and is pumped from the two tanks through the cell stack during charging and discharging process. The energy capacity of a VFRB battery can easily be expanded by adding more solution to the tank.



- **Longest lifecycle**

  While Vanadium Redox Flow Batteries last for 20-30 years lifespan, Lithium-ion batteries can only last for 5-7 years due to their rapid capacity and efficiency loss. Vanadium Redox Flow Batteries can reach 20.000 charge/ discharge cycles without any capacity or efficiency loss. VRFB have same lifestyle as the solar and wind energy plants and farms.



OUR VISION & MISSION

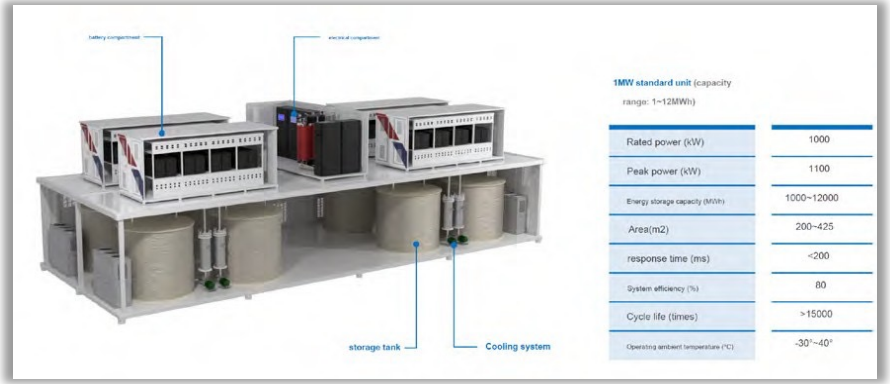
- **Low maintenance costs**
  Vanadium Redox Flow Batteries have the lowest maintenance cost. VRFB`s annual maintenance cost is just 0.5% of the initial investment costs of the system, while Lithium-ion batteries have 5-10% maintenance costs annually compared to their initial investment costs. In the long run the VRFB is much more economical than any other competitor technology.

- **Lowest LCOE (Levelized Cost of Energy)**
  While the LCOE of Lithium-ion battery is 0,090 USD/kWh, for Vanadium RFB it is only 0,050 USD/kWh, and it keeps improving. Vanadium batteries have the lowest cost over the lifecycle of the battery

- **Safest battery – can operate in high temperature environment**
  Lithium batteries are both flammable and explosive. Vanadium is a safer alternative to lithium. A vanadium flow battery is water-based, and thus non-flammable and non-explosive. Indeed, vanadium flow batteries offer the highest level of safety compared to any other battery technology on the market today. Therefore, vanadium batteries can operate in high temperature environment.

- **Low environmental impact**
  Lithium has high disposal costs, but the vanadium electrolyte in vanadium batteries can be reused, so it retains its end-of-life value. In fact, vanadium batteries are known for having the easiest end-of-life processing. Combine this with the fact that lithium batteries need to be replaced more often and lose capacity over time, a vanadium flow battery is a greener alternative to lithium that creates far less waste. VRFB has the lowest carbon footprint among batteries.

PRODUCT EXAMPLES



1MW standard unit (capacity range: 1~12MWh)

Rated power (kW)	1000
Peak power (kW)	1100
Energy storage capacity (MWh)	1000~12000
Area(m2)	200~425
response time (ms)	<200
System efficiency (%)	80
Cycle life (times)	>15000
Operating ambient temperature (°C)	-30°~40°