



THE MOST **RELIABLE, LONGEST-LASTING**
VANADIUM FLOW BATTERY IN THE WORLD

WWW.VRBENERGY.COM

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ABOUT VRB ENERGY

VRB Energy is a fast-growing, global clean technology innovator. We have developed the most reliable, longest-lasting vanadium flow battery in the world, with over 30 MWh of systems deployed and over 800,000 hours of demonstrated performance. VRB Energy is the technology leader in the field, and the combination of our proprietary low-cost ion-exchange membrane, long-life electrolyte formulation and innovative flow cell design sets us apart from other providers. Our vanadium redox batteries (VRB®) store energy in liquid electrolyte in a patented process based on the reduction and oxidation of ionic forms of the element vanadium. This is a nearly infinitely repeatable process that is safe, reliable, and non-toxic. Components can be nearly 100% recycled at end-of-life, dramatically improving lifecycle economics and environmental benefits compared to lead-acid, lithium and other battery systems.

VRB ENERGY OWNERSHIP

VRB Energy is majority-owned by High Power Exploration (HPX), a metals-focused exploration company that also invests in minerals-dependent, high-growth emerging technologies. HPX is a subsidiary of I-Pulse, a global leader in developing innovative commercial applications for pulsed power technologies that convert small amounts of electrical energy into limitless power to address a broad and growing suite of applications across multiple industrial markets. I-Pulse is a private company with offices in San Francisco, Toulouse, London and Singapore.

For more information on HPX and I-Pulse, please visit our websites at www.hpxploration.com, and www.ipulse-group.com.

STORAGE IS ENABLING THE RENEWABLE ENERGY REVOLUTION



RENEWABLE ENERGY INTEGRATION

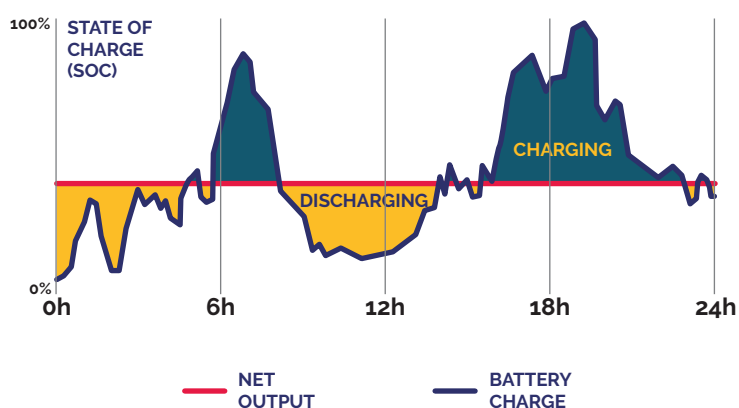
More energy from the sun reaches the earth in a single hour than humanity uses in an entire year. Photons hit the silicon in a solar panel and dislodge electrons as an electric current. The sun's rays also warm the earth, causing air to rise and generating wind currents that we can harness with wind turbines.

We can capture this variable energy with energy storage, and convert this free fuel into nearly limitless clean electricity. VRB Energy's Vanadium Redox Battery Energy Storage Systems (VRB-ESS®) are ideally suited to charge and discharge throughout the day to balance this variable output of solar and wind generation.

VRB-ESS are a type of flow battery, which are poised to dominate the utility-scale storage market for wind and solar integration. The technology is fundamentally better suited to these deep discharge applications

that require four to eight hours of storage per day. VRB-ESS deliver an almost infinite number of cycles over more than 25 years, yielding the best, most sustainable lifecycle economics.

STORAGE SMOOTHS VARIABLE WIND OUTPUT TO KEEP THE GRID STABLE



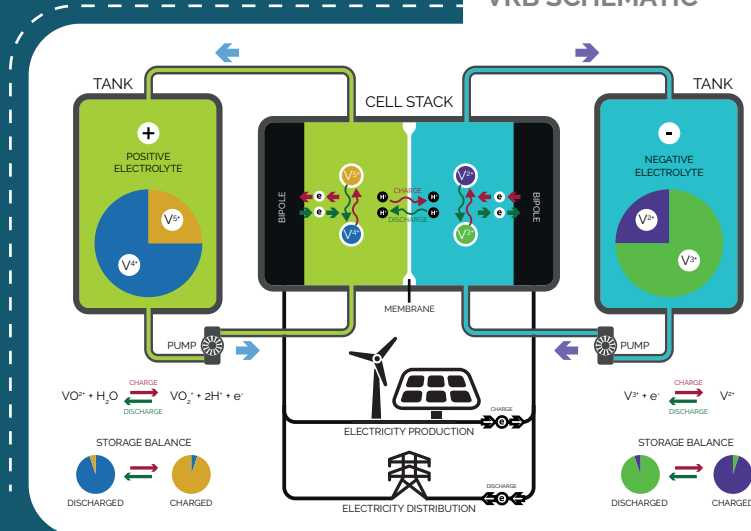
PROPRIETARY **LOW-COST** ION-EXCHANGE MEMBRANE, **LONG-LIFE** ELECTROLYTE FORMULATION, **INNOVATIVE** FLOW CELL DESIGN

PRODUCT PERFORMANCE

MODULAR DESIGN

The standard VRB-ESS power module is rated at 10kW for the kW-Class product, and 250 kW for MW-Class systems. These power modules are combined with electrolyte storage tanks and power conversion systems (PCS) to form systems from 10 kW / 40 kWh to 250 MW / 1 GWh.

VRB SCHEMATIC



KW-CLASS

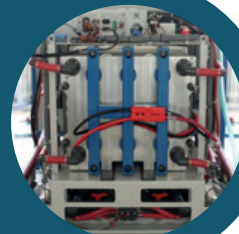
Based on a 10kW stack building block, these systems are typically deployed at remote telecom or village locations, integrating wind and solar power with 8 hours or more of energy storage.

MW-CLASS

Based on a 250kW containerized module, these systems are typically 1 MW / 4 MWh up to 10 MW / 80 MWh in size installed at utility, commercial and industrial sites, in support of solar or wind farms, or in isolated microgrids.

GW-CLASS

These systems are specially engineered to deliver 100 MW or 250 MW of power for 4 to 10 hours to meet the needs of large-scale solar and wind farms, as well as to replace utility peak power plants.



A NEARLY **INFINITELY REPEATABLE** PROCESS,
SAFE, RELIABLE, NON-TOXIC,
AND NEARLY **100% RECYCLED** AT END-OF-LIFE

APPLICATIONS

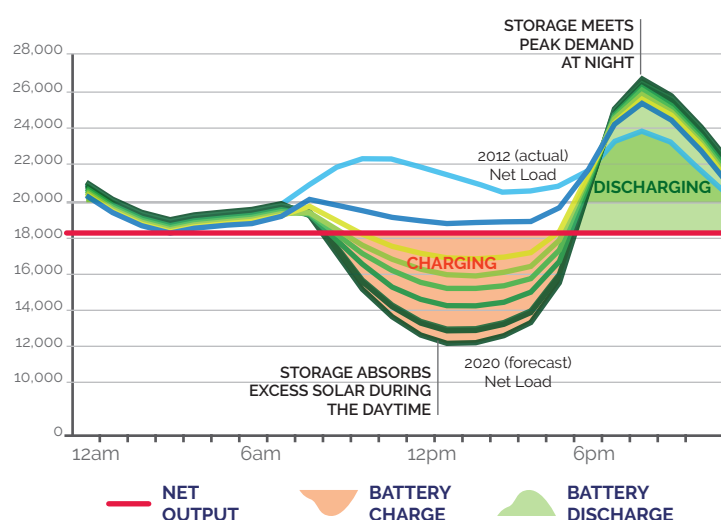
UTILITY OPTIMIZATION

Peaker Plant Replacement and T&D Deferral

VRB-ESS can respond to grid conditions within $\frac{1}{2}$ cycle, providing frequency and voltage support in real time, while simultaneously serving longer-duration energy needs.

VRB-ESS enable utilities to balance loads, make more efficient use of existing infrastructure and operate smart microgrids. VRB-ESS can replace peaker plants, and investments in transmission and distribution (T&D) can be deferred.

Example: Net system load in California drops dramatically mid-day due to increasing solar penetration. Storage is needed to balance and stabilize.



SOURCE: CALIFORNIA CAISO

COMMERCIAL AND INDUSTRIAL (C&I)

On-Site Energy Optimization

Installed "behind-the-meter" at C&I facilities, VRB-ESS reduce operating expenses through multiple benefit streams:

- Reduction of peak demand charges from utilities.
- Integration and optimization of on-site renewable energy.
- Provision of backup power that reduces losses in the event of utility outages.
- Reduction of wear on equipment through improvement of power quality.

MICROGRIDS

System Balancing and Energy Optimization

Microgrids combine a diverse set of generation and loads on a system isolated from the main utility grid. They are typically either remote, islanded systems or special zones designed to connect or disconnect from the main utility grid for economic or power quality reasons.

On isolated diesel grids, VRB-ESS balance loads, maintain power quality, and reduce fuel use. On grid-connected systems, VRB-ESS allow seamless connect/disconnect from the main utility grid on-command. With the dramatically reduced cost of solar power, the combination of photovoltaics and VRB ("PV + VRB") is now three to five times cheaper than traditional diesel generation.

CHINA STATE GRID'S ZHANGBEI DEMONSTRATION SITE, THE **LARGEST FLOW BATTERY** FOR THE **LARGEST UTILITY IN THE WORLD**



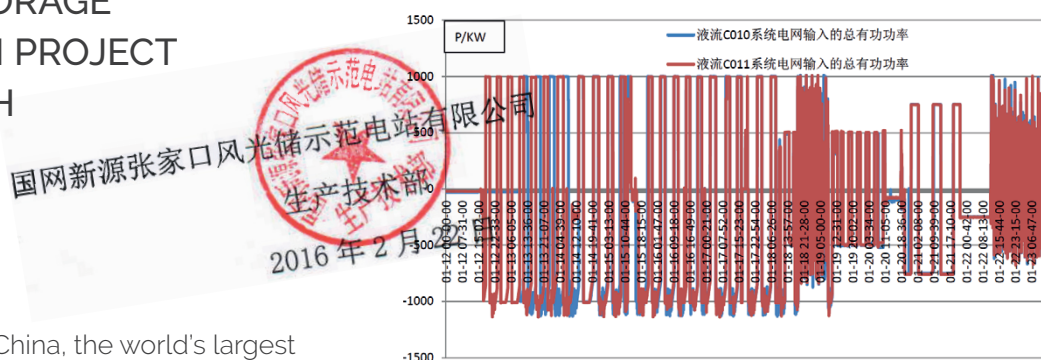
SOLAR-WIND-STORAGE DEMONSTRATION PROJECT AT 2 MW X 8 MWH

VRB Energy has completed the rigorous acceptance testing and approval process administered by State Grid Corporation of China, the world's largest electric utility company.

The 8 MWh VRB-ESS installed at State Grid's cutting-edge 500 MW solar-wind-storage project in Zhangbei achieved all of the performance test requirements for:

- Renewable smoothing
- Frequency regulation
- Peak shifting
- Microgrid support

The system achieved 100% availability during the rigorous 240-hour acceptance test, and has since demonstrated over two years of reliable performance.



Two 1 MW units, C010 (red line) and C011 (blue line): power-time curve throughout the 240 hour test.

PERFORMANCE EXCEEDED EXPECTATIONS ACROSS ALL MAJOR METRICS:

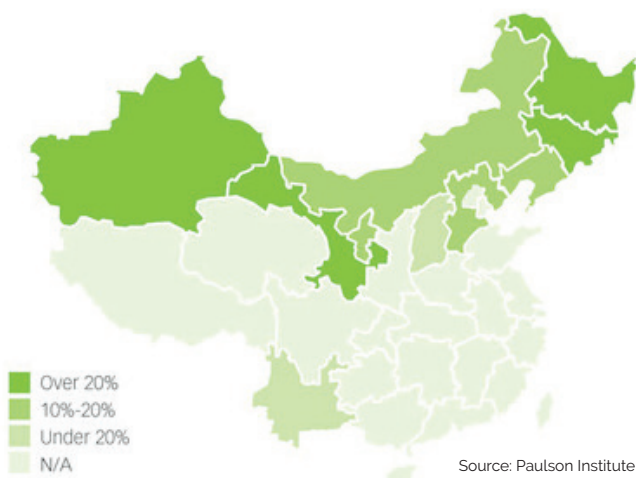
AVAILABILITY:	100% of Test Hours
POWER RATING:	120% of Target
EFFICIENCY:	110% of Target
RESPONSE TIME:	< 20 ms Target

LOWEST LIFECYCLE COST OF ENERGY (LCOE) WITH PROVEN PERFORMANCE AND SAFETY

ENVIRONMENTAL BENEFITS

Air emissions from coal-fired power generation are a major source of environmental degradation in China and worldwide, and air pollution has significant costs in terms of human health. However, the power from wind and solar farms in China is frequently curtailed to maintain balance on the grid.

Wind curtailment rates in China average more than 20% in key wind locations.



VRB-ESS help solve this problem by absorbing extra power, ensuring that the clean power is not wasted. In addition, VRB-ESS improve the stability and reliability of renewable power sources for utility-scale generators by implementing ramp rate control and providing reactive power support to the grid.

Adding VRB-ESS equal to 20% to 50% of the capacity of a typical wind or solar farm can eliminate this loss of "free" and clean energy, helping reduce global carbon dioxide emissions and harmful local air pollution.

LIFECYCLE BENEFITS

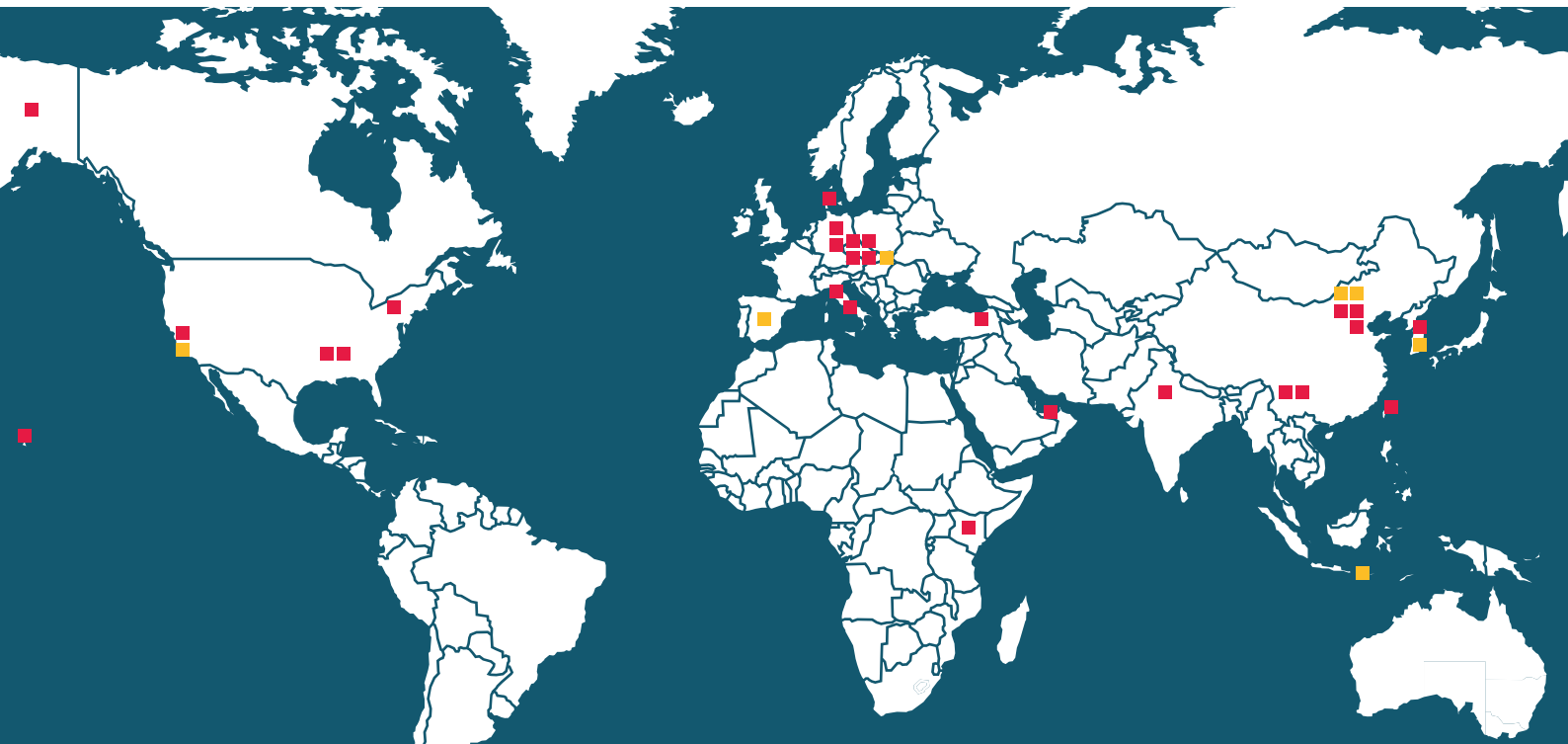
VRB Energy's proprietary all-vanadium electrolyte is the same on both the positive and negative sides of the battery. It is safe, non-combustible, and never wears out.

500kW x 1 MWh VRB Energy VRB-ESS at the National Wind Power Integration & Research Test Center of the China Electric Power Research Institute, Zhangbei, China.



At the end of 25 or more years of successful project lifetime, the electrolyte can be reused in another battery, or recycled, and the other components can be recycled. This helps lower lifecycle costs and is a significant environmental benefit compared to other types of battery systems.

GLOBAL REACH



PROVEN PERFORMANCE

With over 30 MWh of systems deployed around the globe, and over 800,000 hours of operation, VRB Energy is the demonstrated world leader in flow battery technology.

APPLICATIONS	SYSTEMS	LOCATIONS
kW-Class		■
Telecom	10kW x 3 Units	India
	10kW / 40 kWh	Hungary
	10kW / 40 kWh	UAE
	10kW x 14 Units	Kenya
	10kW / 40 kWh	Turkey
Renewable Integration	20kW x 6 Units	USA
	10 kW x 3 Units	China
	7 kW / 40 kWh	Czech Rep.
	7 kW x 2 Units	Austria
	7 kW x 2 Units	Italy
	7 kW / 40 kWh	Slovakia
Microgrid	10 kWh x 4 Units	China
	7 kW/ 40 kWh	Italy
	10 kW x 2 Units	Germany
	20 kW / 100 kWh	Denmark
MW-Class		■
Utility Optimization	400 kW / 500 kWh	Indonesia
Renewable Integration	2 MW / 8 MWh	China
	3 MW / 12 MWh	China
	100 kW / 600 kWh	Slovakia
Commercial & Industrial	600 kW / 3.6MWh	USA
Microgrid	500 kW / 1 MWh	China
	50 kW / 200 kWh	Spain
	100 kW / 200 kWh	Korea

VRB ENERGY IS THE **TECHNOLOGY LEADER** IN THE FIELD



ECONOMICS

Lithium-based batteries have inherently shorter lifetimes and are not well suited for longer duration storage (4+ hours). Vanadium outperforms lithium on depth-of-discharge (DoD), cycle life, and end of life value (lithium carries a disposal cost). VRB-ESS are two to three times lower in LCOE.



PROPRIETARY TECHNOLOGY

VRB Energy is the technology leader in the field. The combination of our proprietary low-cost ion-exchange membrane, long-life electrolyte formulation and innovative flow cell design sets us apart from other providers.



SAFETY

Unlike other large battery systems, VRB-ESS contain no heavy metals such as lead, nickel, zinc or cadmium. The liquid electrolyte is non-toxic, non-flammable and is 100% reusable. VRB-ESS operate at low temperature and pressure and are an inherently stable and safe design.



PROVEN PERFORMANCE

With over 800,000 hours of operation, and millions of cycles on systems in our R&D labs and in the field, VRB Energy has the most proven technology and reliable products in the industry today.



SYSTEM QUALITY COMPLIANCE

VRB-ESS have been reviewed and are in compliance with European system quality and safety guidelines.



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