



The 10th Energy Storage International
Conference and Expo
储能国际峰会暨展览会 2021

High-efficiency and Large-scale VRB-ESS® Supports Carbon Neutralization

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中国·北京 CHINA BEIJING

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Catalogue

Value and mission of VRB ESS
technology

01

Advantage of vanadium flow
battery

02

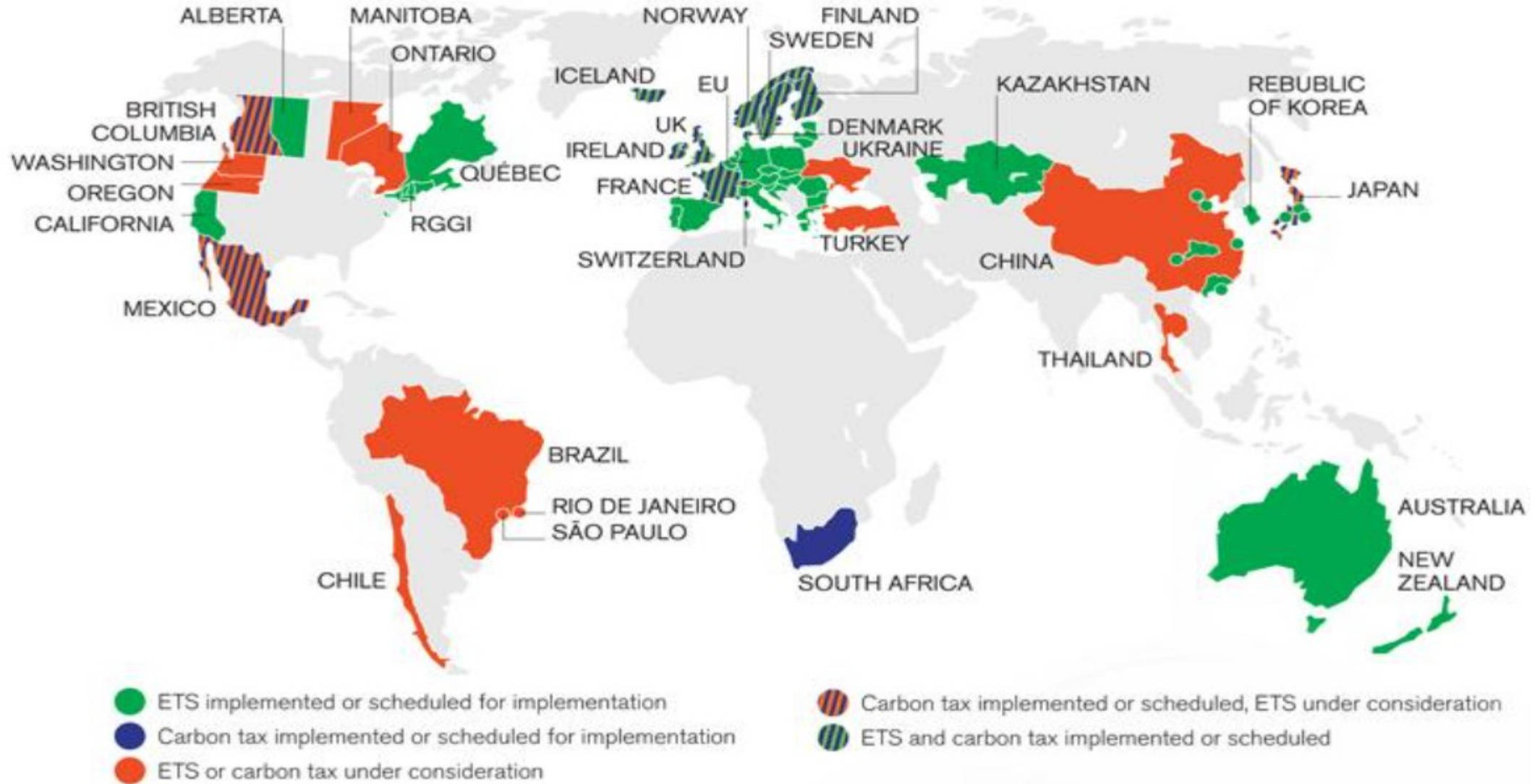
Commercial application of
large-scale projects

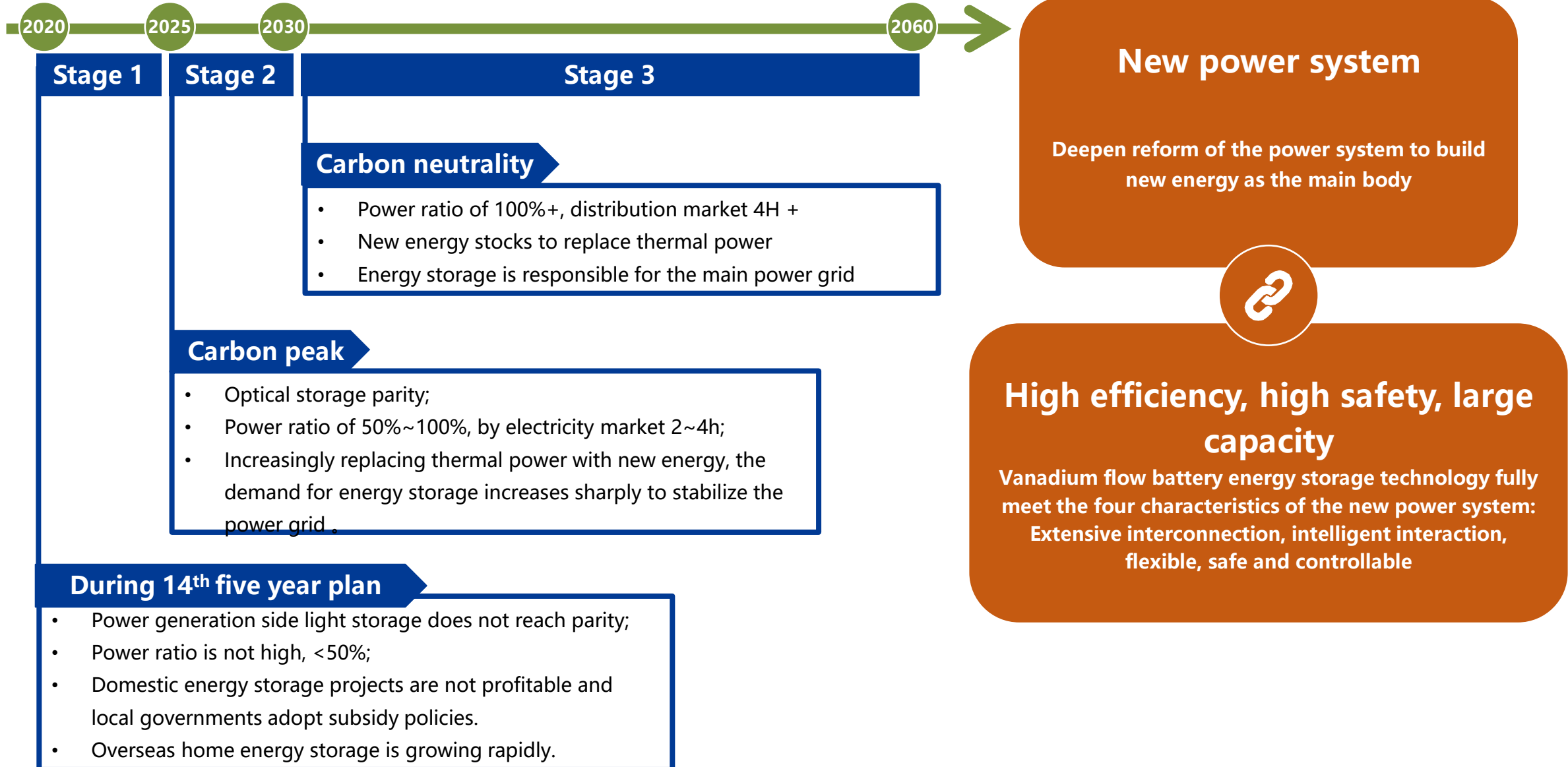
03



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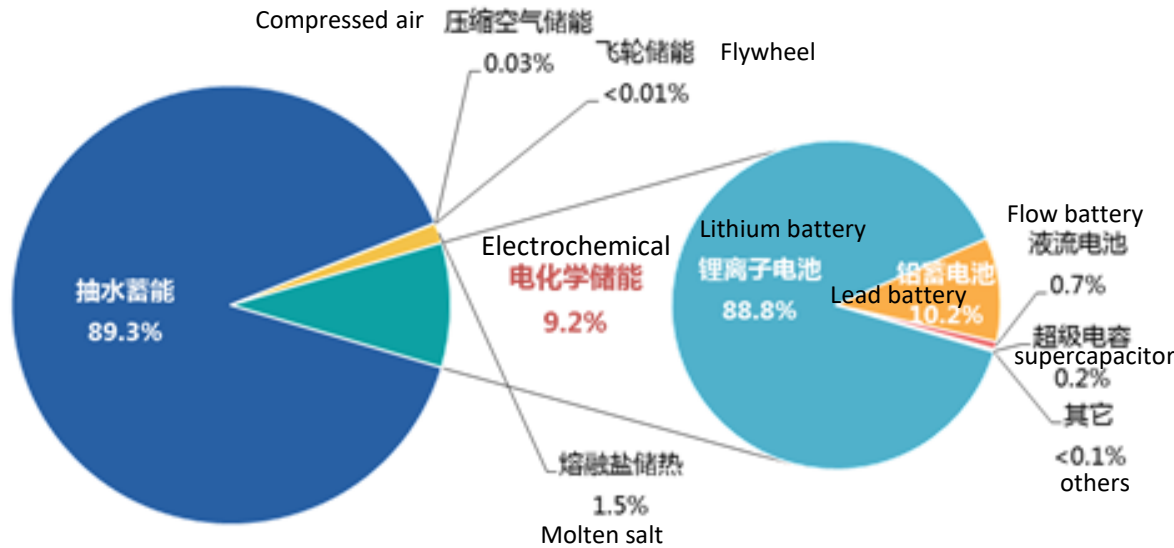
Value And Mission of VRB ESS Technology



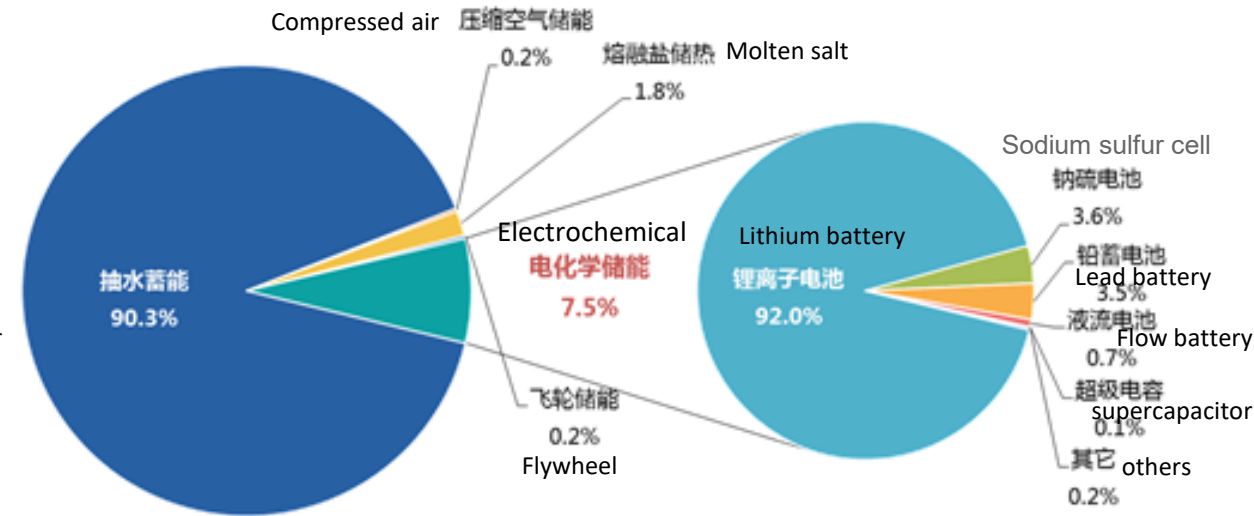


2020 Total installed capacity of the global electrochemical energy storage projects is 14,247.3MW, newly put into operation scale is 4726.8MW. Total installed capacity of electrochemical energy storage projects in China is 3269.2MW, newly installed capacity is 1559.6MW.

Installed capacity of energy storage in China (2000-2020)



Installed capacity of energy storage in global (2000-2020)





2 Advancement Technology of Flow Battery System

Advantage



Flexible configuration from KW level to MW level facilitates rapid expansion.



Charged and discharged quickly, frequently and with large current, charged and discharged in depth without damaging the battery



Charge and discharge cycles can reach more than 10,000 times(100% DOD)



Vanadium electrolyte can be completely recycled without environmental pollution



Safe, normal temperature and pressure operation, active heat management, no risk of fire or explosion



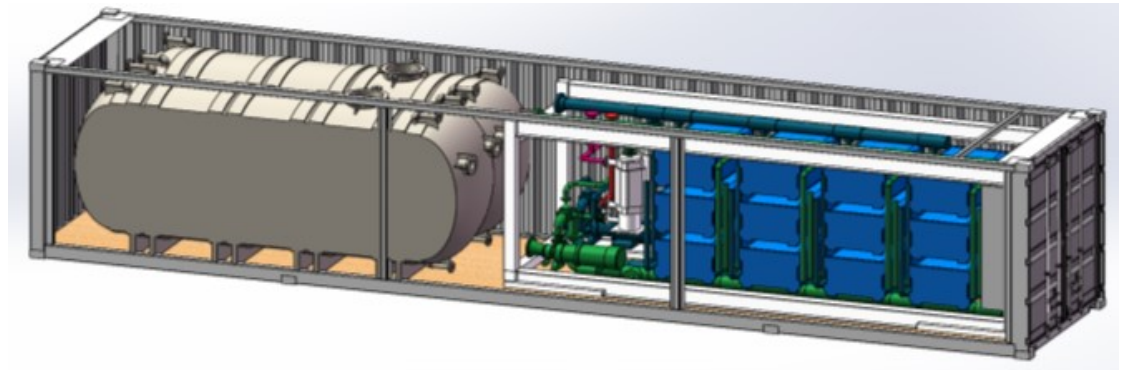
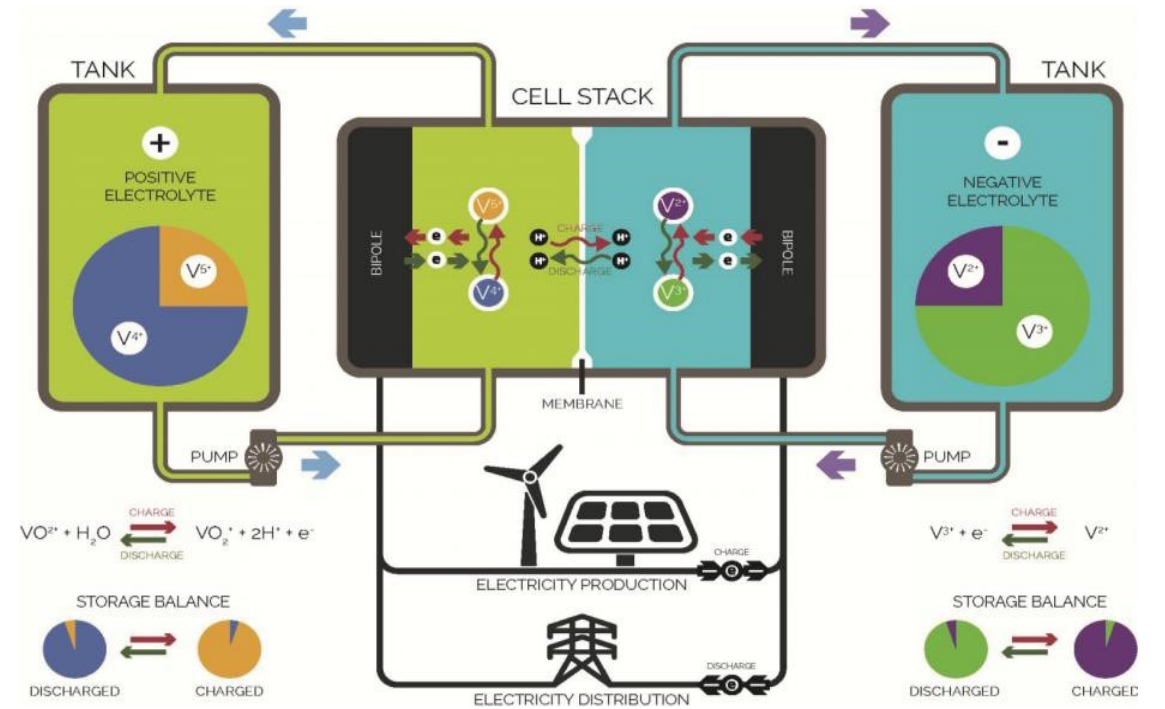
Vanadium reserves and supply are abundant

Shortcoming

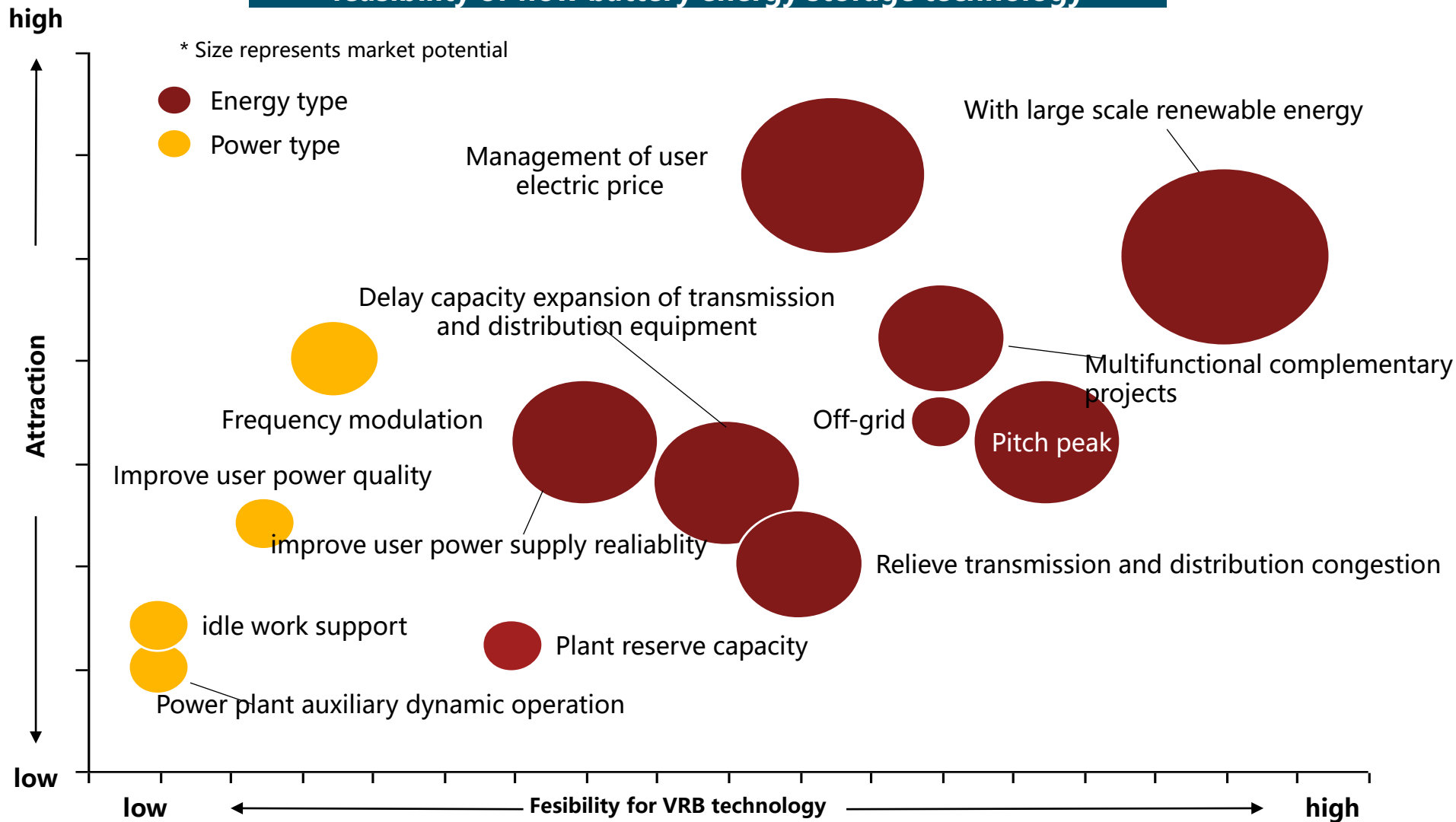


Energy density are lower than Lithium battery

Working principle of vanadium flow battery system

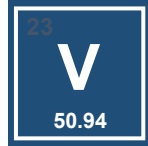


The attraction of domestic energy storage market and the feasibility of flow battery energy storage technology



VANADIUM IS THE SUPERIOR STORAGE SOLUTION

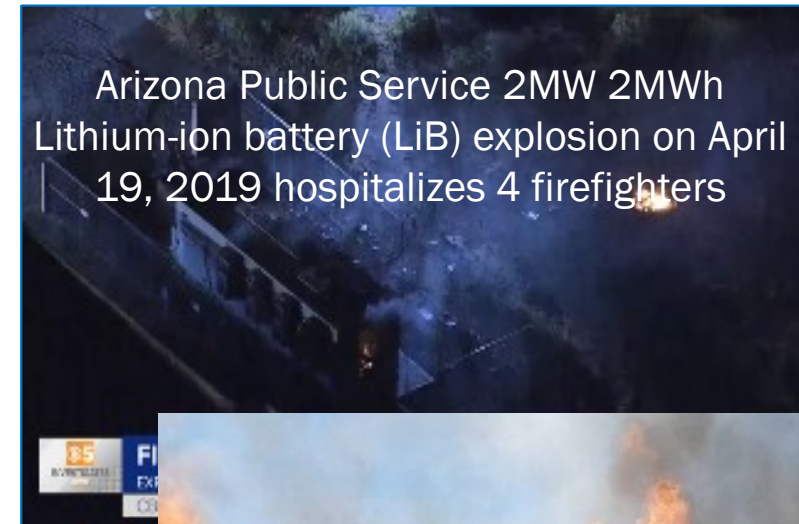
Vanadium



Lithium



Cycle-Life	Infinite	2,000-5,000
Usable Capacity	100%	80%
Safety	Inherently safe	Fire risk
Recyclability	100%	Disposal liability
Scalability	GWh projects	MWh projects
Duration	> 4 hours	1-4 hours
Efficiency	70-85%	80-95%
Lifetime	30 yrs	5-10 yrs
Raw Material Sourcing	Unconstrained, waste sources available	Li, Ni, Co constrained
LCOE	Lowest	Limited



Arizona Public Service 2MW 2MWh Lithium-ion battery (LiB) explosion on April 19, 2019 hospitalizes 4 firefighters



Chungnam, Korea LiB Fire

“The system caught fire two days after increasing the state-of-charge to 95% from 70%. LG Chem requested all storage sites equipped with their batteries lower the SOC back to 70%.”

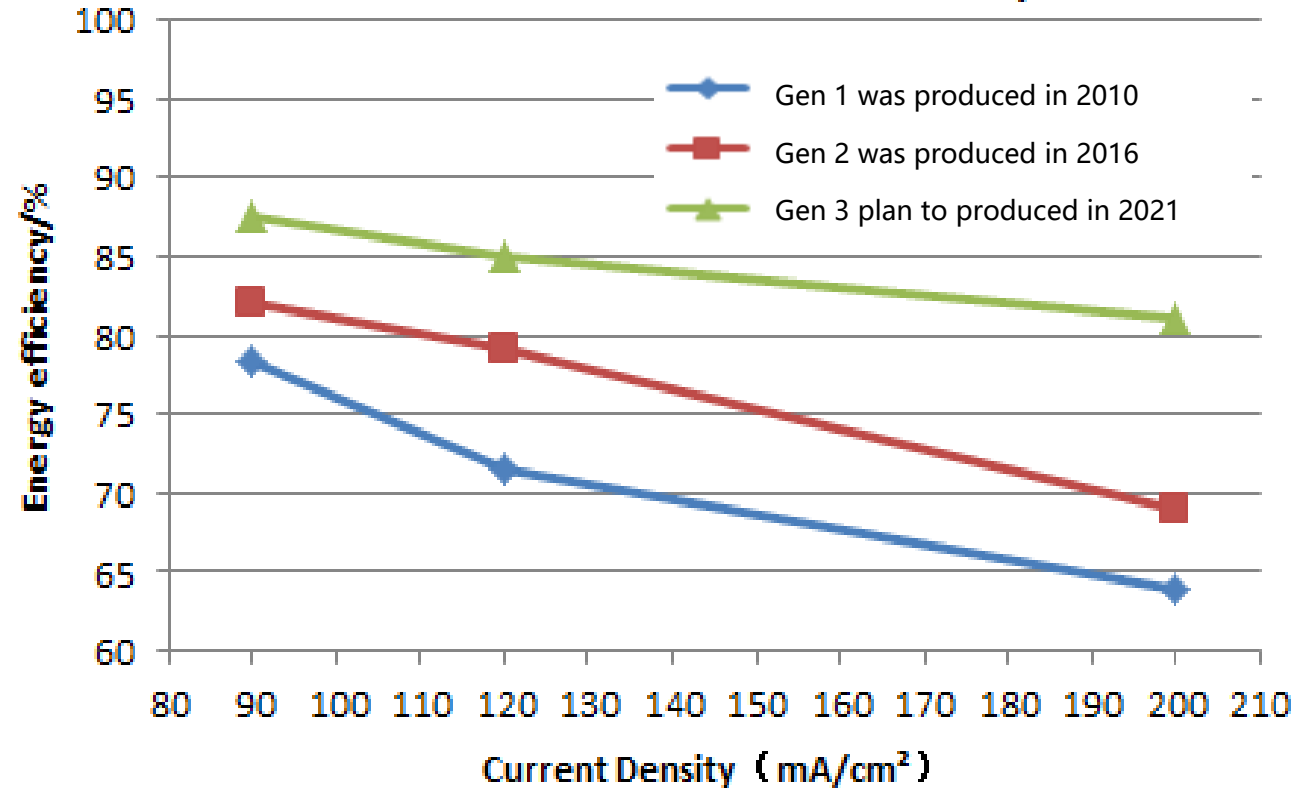
Occurred Possibility of fire or Explosion in Lithium ESS projects: ~2% in China and South Korea; 29 out of about 1000 projects in South Korea caught fire in last few years



The world leading product of Gen 3 VRB-ESS

Parameter	Gen 2 MW ESS	Gen 3 MW ESS
Specific energy (Wh/kg)	10-20	10-20
Energy density(Wh/L)	15-25	15-25
Charge/discharge efficiency	70-75%	75-80%
Normal cell voltage(V)	1.15-1.55	1.15-1.55
Cycle life time	~20000	~20000
Time durability(year)	>25	>25
Response time	<100ms	<100ms
temperature range (°C)	-20 to 45	-20 to 50

Stack developing route of VRB MW-ESS



Xinjiang

- Vanadium flow battery energy storage power station 7.5MW/22.5MWh (phase 1)

Hebei

- Wind power and energy storage project phase 1 in Hebei

Liaoning

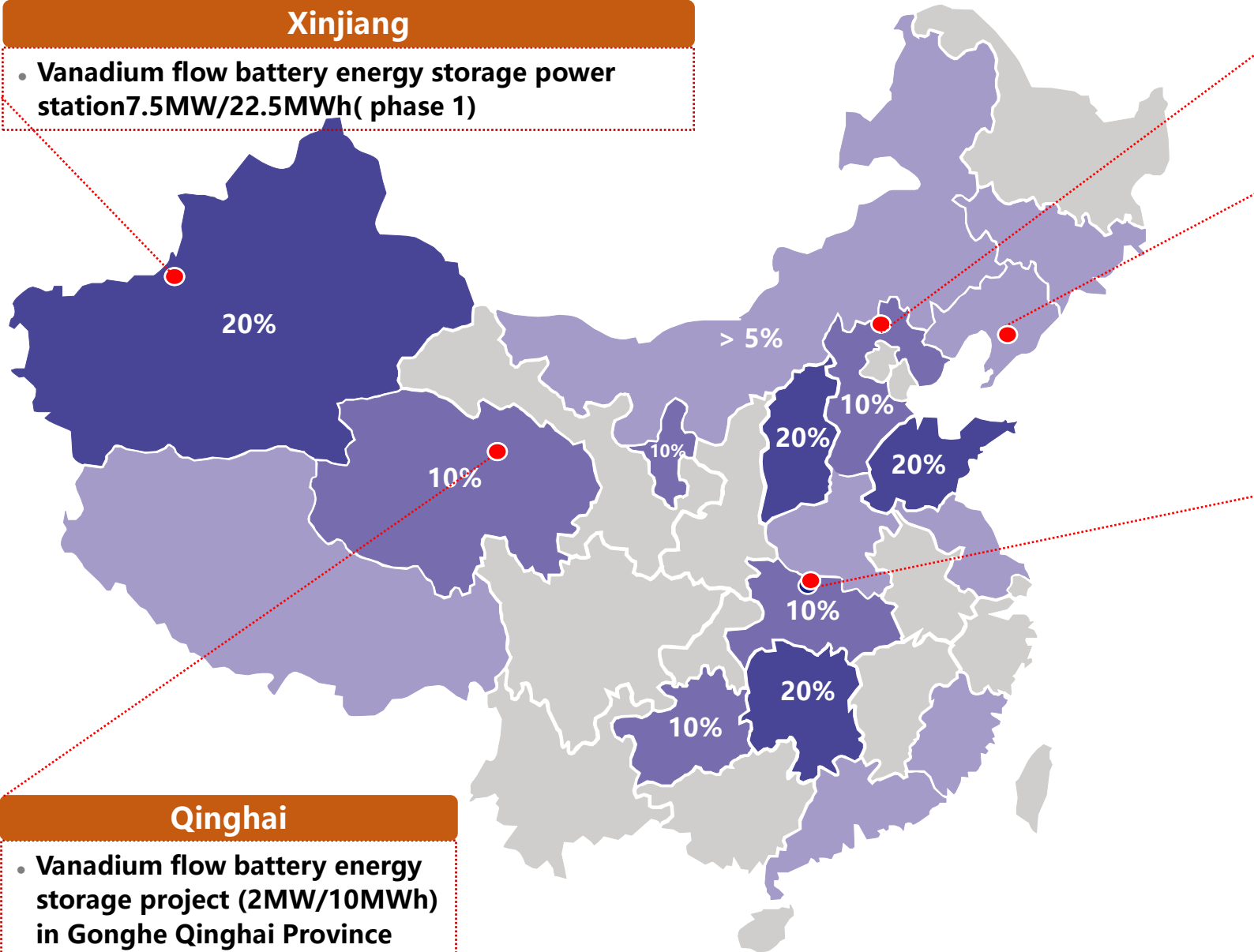
- Wind Farm with energy storage demonstration Project in Wafangdian
- Wind Farm with energy storage 10MW/40MWh Project in Toudaohang invested by State Power Investment Corporation
- Dalian 200MW/ 800MWh flow battery energy storage and peak regulation power station

Hubei

- Solar and Vanadium flow battery project 10MW/40MWh (phase 1)
- Vanadium flow battery peak shaving plant 100MW/400MWh (phase 2)

Qinghai

- Vanadium flow battery energy storage project (2MW/10MWh) in Gonghe Qinghai Province



*Note:
18 of 34 provinces in China has required that all new solar and wind generation projects need to install energy storage system.*

Country	VRFBs	kW	kWh
Australia	7	945	4,629.90
Barbuda	1	3,000	12,000.00
Botswana	1	112	560.00
Canada	3	2,500	10,000.00
China	17	15,825	48,005.00
Czech Rep.	3	47	209.90
Denmark	3	40	260.00
Germany	15	1,530	86,190.00
India	4	155	740.15
Indonesia	2	400	500.00
Italy	5	631	2,610.00
Japan	5	2,330	7,481.00
Netherlands	1	10	80.00
Portugal	5	5	60.00
Singapore	1	250	2,000.00
Slovenia	1	10	45.00
South Africa	2	745	2,950.00
South Korea	5	1,250	4,900.00
Spain	4	220	800.00
Sweden	1	800	1,800.00
Switzerland	2	210	460.00
U. Kingdom	5	805	5,180.00
USA	17	7,418	33,173.70
Austria	1	14	84.00
Kenya	1	140	84.00
Slovakia	2	107	640.00
UAE	1	10	40.00
Taiwan	1	125	750.00
Turkey	1	10	40.00

Vanadium Redox Flow Battery (VRFB) technology is increasingly being tested or deployed across the globe

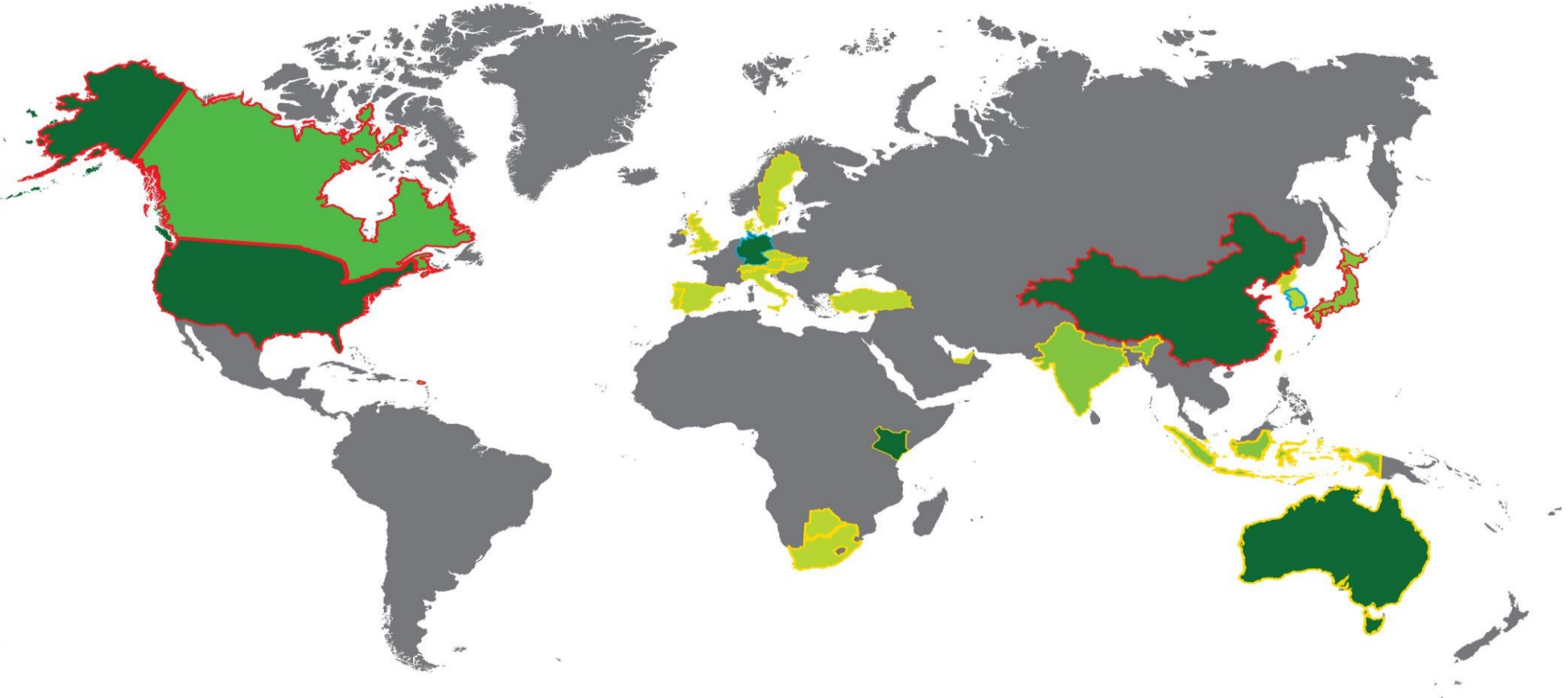


Number of VRFBs

- 1 - 5 VRFBs
- 6 - 10 VRFBs
- > 11 VRFBs

Size of VRFBs in Kilowatts

- 1 - 1000 kW
- 1001 - 2000 kW
- > 2000 kW



Last updated: 30 - 04 - 2019

113 VRFB Installations globally

39,664 kW of power

209,800 kWh of energy

- More than 25 years of service life (match the service life of wind power and photovoltaic facilities)
- Depth charge and discharge in infinite cycles (no redundant design extensions required)
- Obvious advantages when the storage time exceeds 4 hours (used for peak shifting of photovoltaic power generation and balance of wind power output)
- Power (MW) and capacity (MWH) can be configured independently (easy to expand capacity at any time)



3 Industrial Innovation Promote Large-scale Commercial Project Application

Company Overview

- VRB Energy was founded in January 2007 and base in Beijing.
- VRB Energy holds multiple key patents in vanadium redox flow battery around the world, installed over 60 storage project in 12 countries, install capacity over 40MWh.
- Rapidly grew into the world' s leading vanadium redox flow energy storage technology firm by acquiring patents, trademarks, technologies, equipment, and material from Canada' s VRB Power Systems.

Enterprise honor

- Leading unit of the National 863 Program in the field of advanced energy technology projects.
- In August 2010, it was approved by the Ministry of Industry and Information Technology to undertake the industrialization project of vanadium battery with major equipment and technology transformation.
- Vice Chairman of China Fuel Cell and Flow Cell Standardization Technical Committee.
- National high and new technology enterprises.
- Zhongguancun "gazelle plan" enterprise.
- Qing - China top 50 most investment potential.

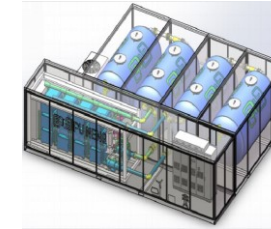
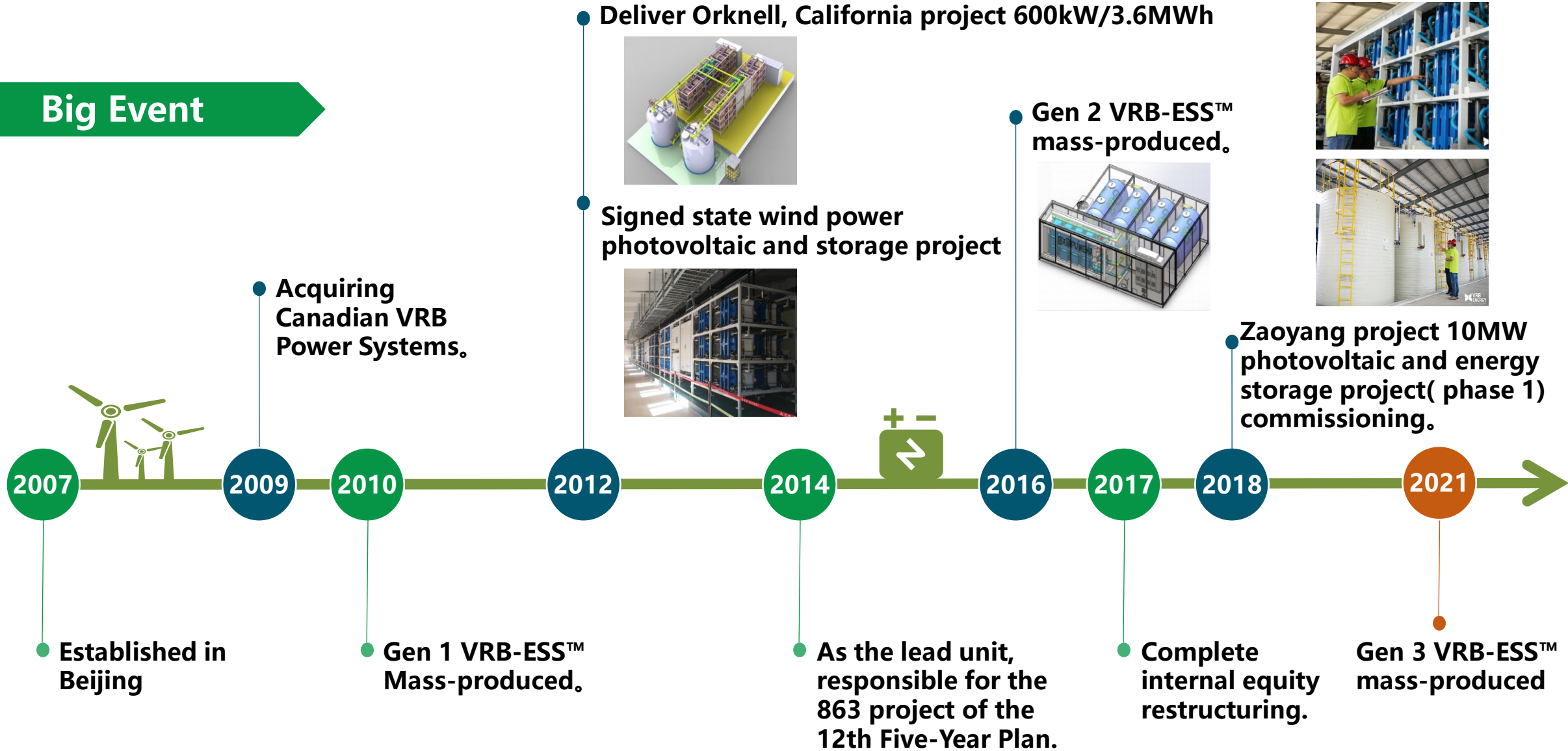
Manufacture base -Beijing



Core technical advantage

- Patented design of flow field inside the core component stack;
- No O-ring seal; Industrial mass production;
- Special formula for the electrolyte ,long life, stable performance , 100% recycled;
- Independent research and development of vanadium battery dedicated low-cost, high-performance ion exchange membrane technology, third-party verification of more than 5 years of stability; high-performance bipolar plate;
- Independent intellectual property rights of the system balance management design, can ensure that the system for a long time stable and reliable operation;
- Its own low-cost vanadium resources production and processing channels.

Big Event



VRB-ESS[®], safe ,environment friendly, low LCOE and flexible distribution energy storage technology

GW ESS with multiple modular energy storage units

10KW ~ 100KW

500KW ~ 50MW

50MW以上

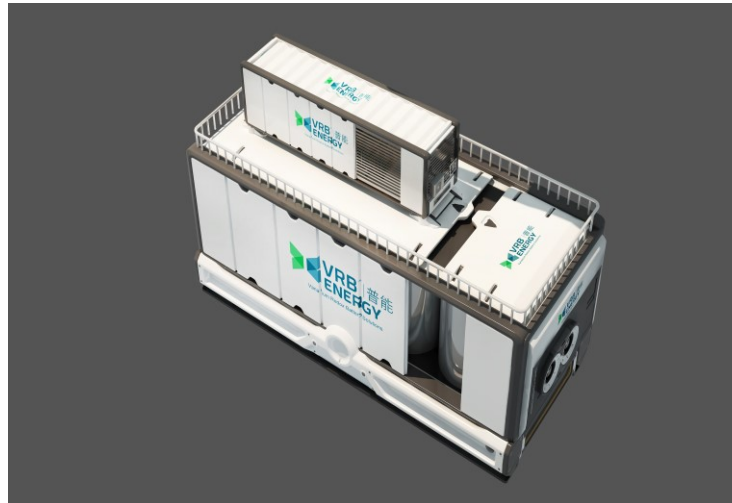
VRB KW-ESS[®]
VRB kW product

VRB MW-ESS[®]
VRB MW product

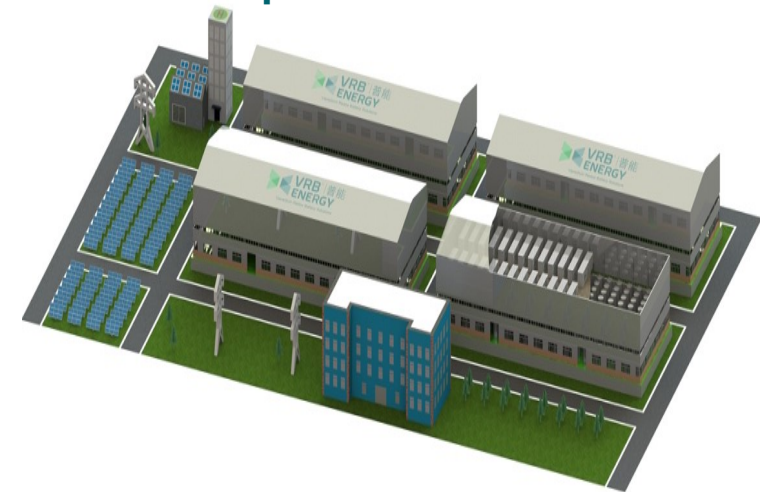
10KW/40KWh standard module



500KW/2MWh standard module



100MW peak regulation power station



Installed almost 60 energy storage project in 12 countries, installed capacity over 40MWh, over 800,000 operation hours

User side peak clipping and valley filling
USA 600kW/3.6MWh

SMART GRID
Slovakia 100kW/600kWh

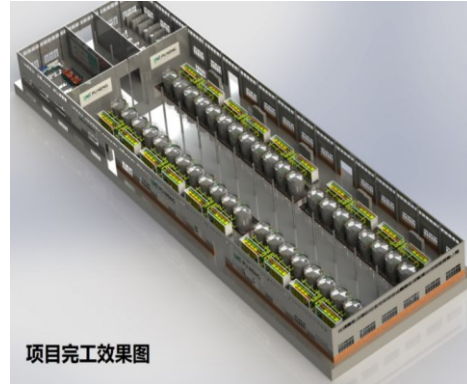
With renewable energy
State Grid 2MW/8MWh

Photovoltaic and energy storage project
Panzihua Zaoyang 10MW

Remote island
Indonesia 400kW/500kWh

System composition

First phase 3MW/12MWh vanadium flow battery power station:
6 sets of 500KW PCS
12 set of 250kW DC/DC converters)
12 sets of 250kW/1MWh vanadium flow battery units
3 sets of 1000KVA transformers



Economic feasibility study

Investment :

- Capital demand for first phase RMB55million. Include owner' s capital RMB10 million; financing RMB45 million.

Benefit :

- Calculation period: 31years, construction period: 1year, operation period 25~30 years;
- Annual income from electricity sales is 3.45 million yuan, static payback period is 12 years, total power generation income (exVAT) 103 million yuan, IR 6.2%

Significance of the project

- The largest liquid flow battery energy storage project that has been put into operation in China
- The first MW class vanadium flow cell is used in the user-side PV integration project
- Commercialization demonstration and application \ Profit model exploration
- Catalyst to promote the development of local energy storage industry

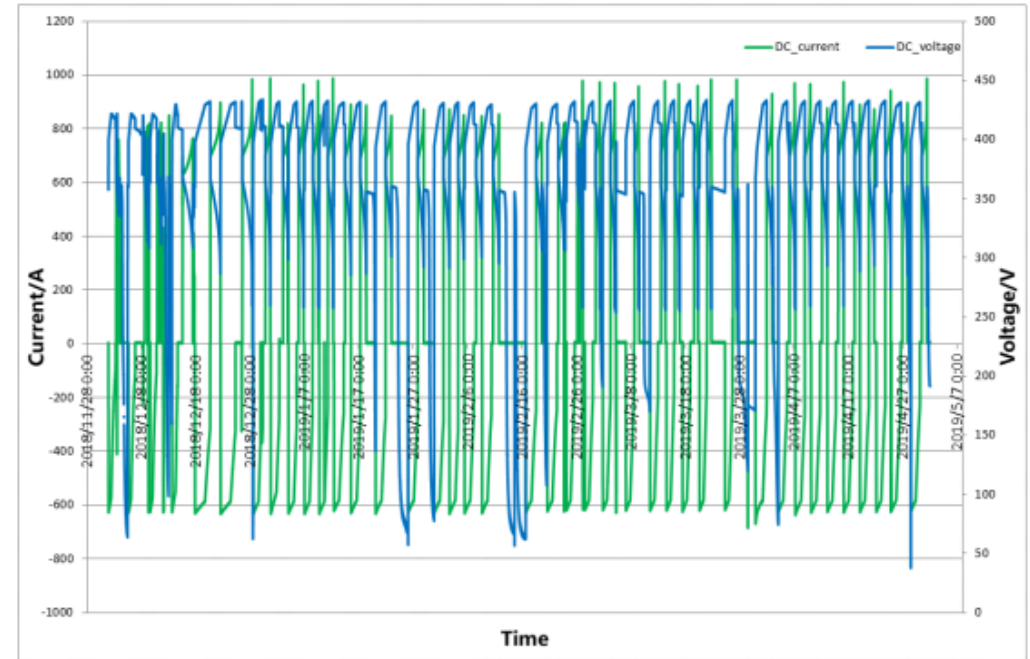


with the electrolyte leasing mode in the actual project for first time, financial capital bound with the electrolyte assets, reduce the customer's one-time investment cost

Onsite picture



Operation curve



湖北普能 3MW 储能一体化示范项目 湖北中凯储能有限公司

5.0 其他事项

甲乙双方根据测试结果一致同意以上报告内容，双方签字盖章后有效。本报告一式两份，甲乙双方各持一份。

甲方：湖北中凯储能有限公司

(盖章)

负责人签字：

日期：2018年6月28日

乙方：北京普能世纪科技有限公司

(盖章)

负责人签字：

日期：2018年6月28日

请予协助为盼！

单位名称：北京普能世纪科技有限公司

日期：2019年06月16日

结论：

<input checked="" type="checkbox"/> 同意使用数据材料。	<input type="checkbox"/> 不同意使用数据材料。
 公司名称：北京普能世纪科技有限公司 (盖章) 2019年6月16日	 公司名称：湖北中凯储能科技有限公司 (盖章) 2019年6月16日

Gen 3 product
World leading performance

- **Cost reduction 28%.**
- **Energy density increase 25%.**
- **System efficiency increase 10%, achieved 83%.**

stack and relate facility occupy 40% cost

Continue R&D to improve the system design and cost reduction

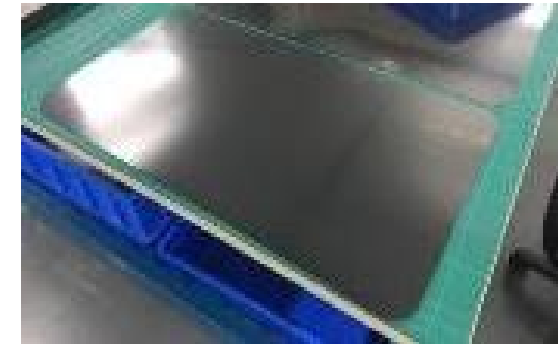


Balance V price further cost reduction

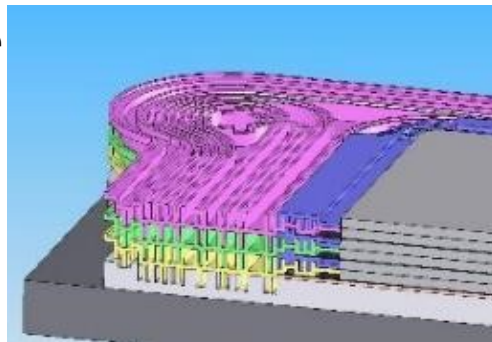
Vanadium electrolyte occupy 60% cost

Electrolyte can be 100% recyclable for other project or purpose.

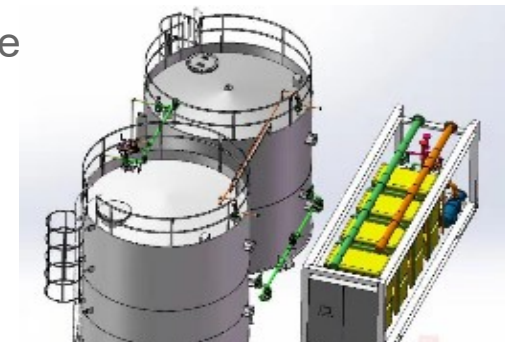
- Independent research and development of ion exchange membrane technology and high-performance bipolar plate .



- Patented design of the flow field inside the stack .



- System balance manage design .



Gen 3 product
World leading performance

stack and relate facility occupy 40% cost

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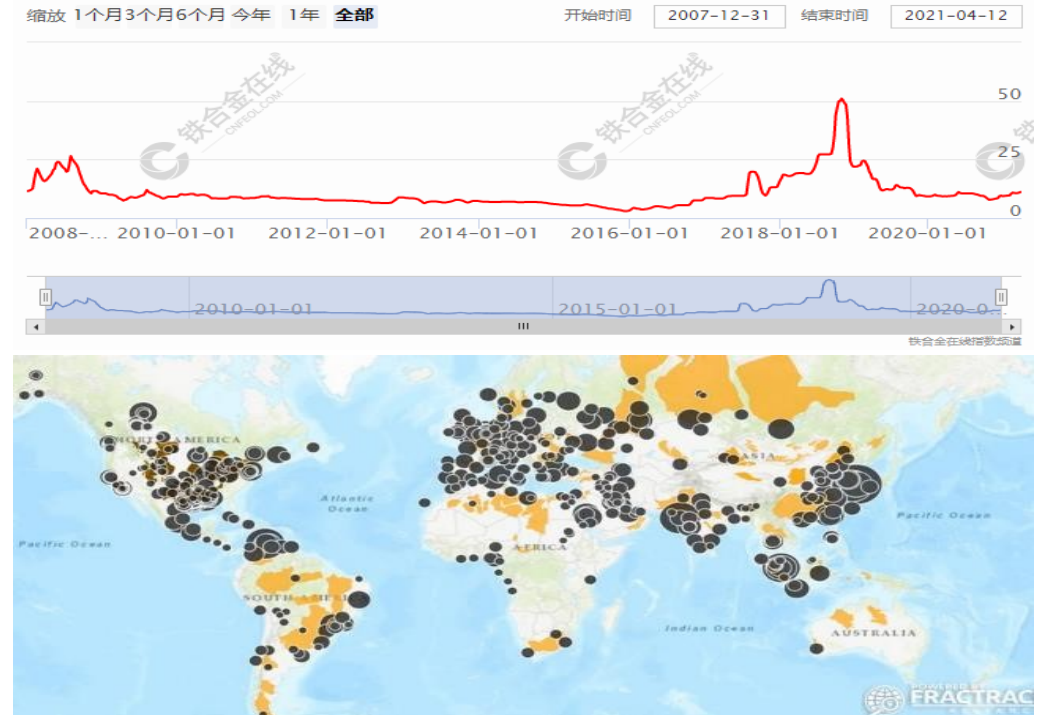
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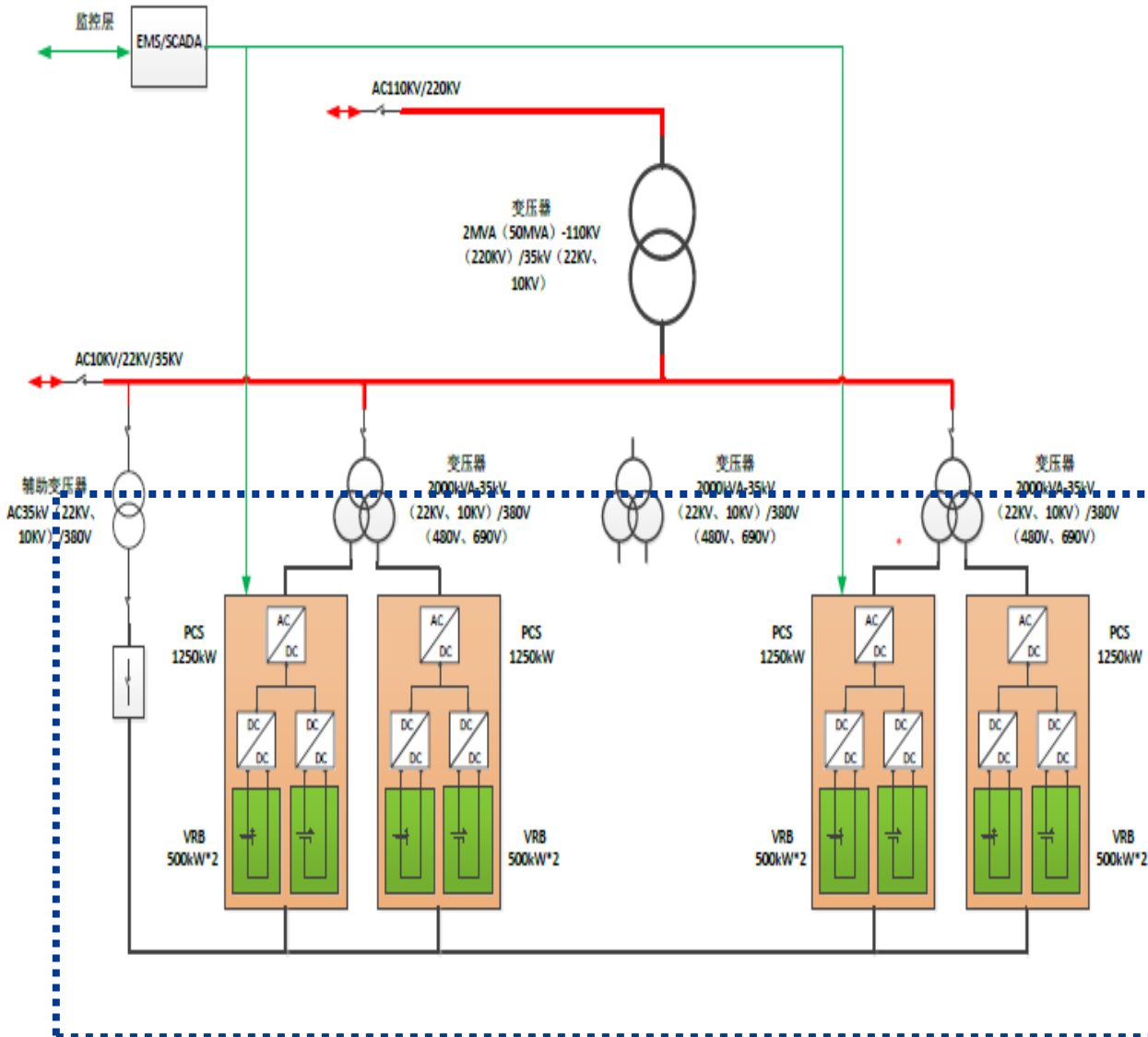
Balance V price
further cost reduction

- ➔ **Vertical integrated resource and commodity trading to obtain low cost electrolyte**
- ➔ **Unrestricted vanadium resource support the expansion and localized production of electrolyte industry**

- Have reliable low cost and certain potential appreciation space of V2O5
- Vanadium widely used for steel product , and have asset attributes as electrolyte
- Vanadium can be extracted from refinery wast and is distributed all over the world

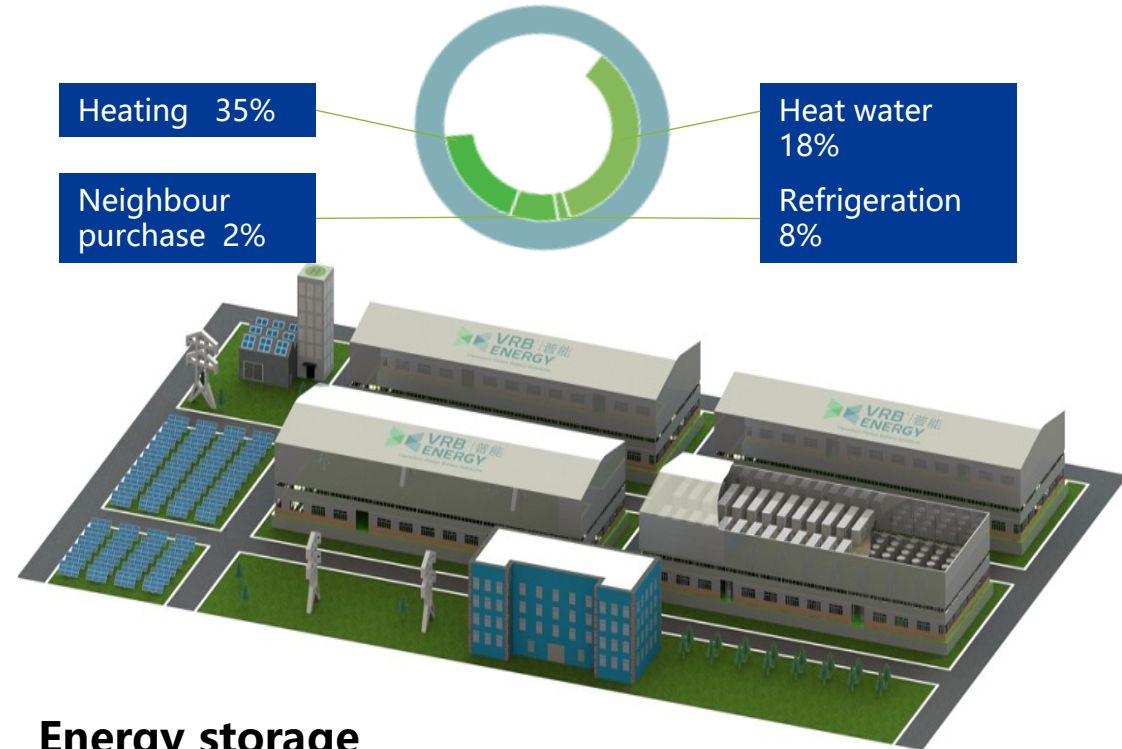


Electrical topological diagram



- Construction period: 6~12months
- Floor space: 2.66 hectare (100MW/400MWh)
- 1.5 ~2 times overload capacity
- Waste heat recovery :

system efficiency achieve 90% with waste heat recovery



Energy storage power station

- **Under the goal of carbon neutrality, the rapid development of photovoltaic and wind power generation and the rapid decline in cost bring great opportunities for energy storage technology.**
- **The vanadium flow energy storage system has become an ideal large-capacity energy storage technology in the fields of photovoltaic and wind power generation, large-scale peak-regulating power station and distributed power generation due to its characteristics of flexible power/capacity configuration, high safety and long cycle life.**
- **Through various projects, the multi-stacking value of vanadium flow battery energy storage technology has been demonstrated.**
- **By leveraging advanced technology, integrating financial and mineral resources, and providing low-cost, capitalizable VRB energy storage solutions, we are accelerating the arrival of the renewable energy/smart grid era.**



VRB ENERGY BEIJING
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Thanks for Your Time

