

# Vanadium in the Energy Storage Market

## The Energy Storage Market

As demand for renewable energy continues to grow, so does demand for solutions which can help control the flow of this energy generated. Energy Storage technologies are a key part of those solution.

Renewable energy is, by nature, inconsistent. However, it's imperative that energy is available for consumption 24 hours per day. Therefore, consumers relying on renewable energy face a challenge in how to regulate the flow of that energy.

Battery storage is fast becoming a popular answer to this problem. In fact, the market is predicted to grow to capacity of 185 Gwh in the next few years.

Yellow Rock Resources has been assessing the potential of this market and launched a strategy to take advantage of the growth of the storage technology market.

## Vanadium Batteries

Flow batteries using vanadium as the primary element are becoming a preferred commercial-scale energy storage solution within the storage technology market. A number of global companies, such as Schmid Energy Solutions and Gildemeister, are involved in rapidly commercialising the technology, which was originally developed at the UNSW in the 1980's.

Vanadium Redox Flow Batteries (VRFB) are a preferred solution for a number of reason including;

- Scalability
- Lifespan of 20 years
- Immediate energy release
- Excellent charge retention (up to 1 year)
- Suitability for grid connection
- Ability to discharge 100% with no damage
- Multiple cycling (000's of cycles)
- Key feature of using only one element in electrolyte; V2O5.

VRFB employ vanadium ions in different oxidation states to store chemical potential energy. To make the batteries, vanadium pentoxide ( $V_2O_5$ ) as a raw source is processed into an electrolyte (solution).

The batteries have unlimited capacity simply by using larger and larger storage tanks. They can also be left completely discharged for long periods with no ill effects. The battery can be charged and discharged at the same time, and has the additional ability to cycle often and deeply, differentiating it from its solid state (Li) based cousins.

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Fields of application include;

- Backup as Grid support: to stabilise low and medium voltage systems, as an energy reserve, or to smooth out output spikes (management of load and production peaks)
- Backup: as inline uninterruptible power supply system with frequency and amplitude decoupling, equipped with the latest system safety features
- Wind and solar parks: as a buffer to stabilise energy output and fluctuations, higher contractual security through energy reserves in times of reduced performance
- Repowering: Investment protection: VRFBs ensure constant energy feed even after the wind or solar park has been written off.
- Increase in self-consumption of renewable energies and substitution of diesel generators (Source; Schmid Energy Solutions)

Vanadium batteries are forecast to account for around 30 per cent of the future capacity growth over the next few years – equating to capacity of 62 Gwh.

To cater to this increase in battery storage capacity there needs to be growth in the production of vanadium. The 62Gwh capacity growth over the next few years alone equates to new demand of 300,000 tonnes of vanadium – more than three times what is currently produced.

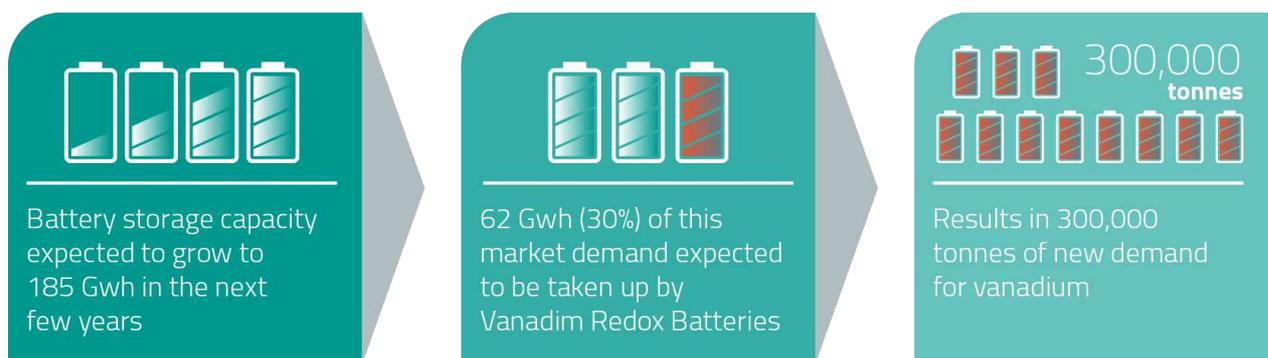
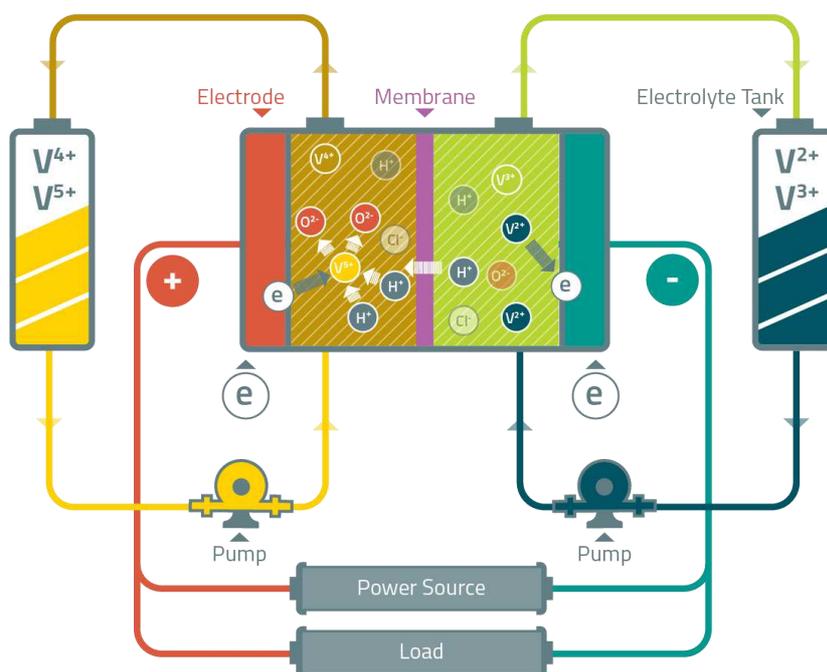


Figure 1 The Vanadium Redox Flow Battery



## Yellow Rock’s Vertical Integration Strategy

Yellow Rock has recognised the potential for involvement in the energy storage market and explored the growth of demand for VRFB. It is on this basis that the company launched its vertical integration strategy alongside its progression of the high-grade Gabanintha Vanadium Project in Western Australia.

The strategy involves the establishment of a subsidiary company which will focus on reselling vanadium batteries and assessing the commercial viability of establishing an electrolyte plant in Australia.

Once the Gabanintha Project comes into production Yellow Rock Resources will be able to supply the raw product to electrolyte producers worldwide, as well as its own plants should that option be progressed.

In the meantime, Yellow Rock Shareholders are exposed to the potential for early cash flows coming from expected sales of the vanadium batteries, which will be imported by Yellow Rock Resources and its subsidiary, VSUN Pty Ltd.

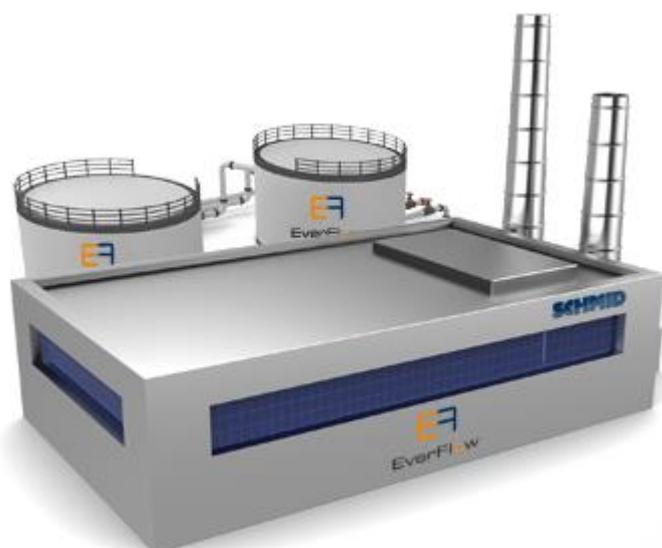
## Next Steps

Yellow Rock Resources has established a joint venture subsidiary company VSUN Pty Ltd. It is also settling final agreements with potential installers, battery suppliers and electrolyte producers, having established the right to distribute two types of batteries from international suppliers.

Yellow Rock’s core focus will remain on the Gabanintha Vanadium Project while the subsidiary company focuses on the battery market.

The strategy to supply vanadium to the battery market also supports the project viability of Gabanintha. There is also existing demand from the steel market, which is growing at a compound annual growth rate of 6 per cent.

## Vanadium Battery Examples



## Frequently Asked Questions

### 1. How far advanced is development of the Vanadium Redox Flow Battery (VRFB)?

Vanadium Redox Flow Batteries have been in development for decades. The technology was actually born out of the University of New South Wales, which recently commissioned an installation of a battery at its campus. Companies worldwide have been implementing large-scale batteries for a number of years – Sumitomo is one example which has completed numerous installations while Gildemeister Energy Solutions and Schmid are also leaders in the market. While in development for many years, VRFB's have never existed in a market with the current installed capacity of renewable energy as exists today. The market is now ideal for rapid commercialization of VRFBs.

### 2. What does the vertical integration strategy mean for Gabanintha?

Gabanintha is still Yellow Rock's focus. The high grade nature of the project, lending itself to low-cost production, makes it an ideal long-term feeder for an established sales strategy in the target market. Yellow Rock Resources has established a subsidiary company which will be responsible for all of the battery market-related business and will be providing sufficient resourcing for this company to manage that independently. We are continuing to hit progress milestones which are advancing Gabanintha towards development. This strategy enhances the business case for Gabanintha and is expected to expose the company to early cashflows.

### 3. Who is Yellow Rock partnering with in this strategy?

We are involved with a range of different stakeholders throughout the battery storage market. This includes battery makers, installers and electrolyte producers. We are yet to publicly announce who the official partners are however we have a firm commitment from an Australian installer who will become our joint venture partner, two prominent German battery makers and a UK company who will assist us with electrolyte plant development.

### 4. What is the structure of the joint venture and subsidiary company?

The joint venture company is a subsidiary of Yellow Rock Resources with the partner taking a minority stake. Yellow Rock Resources is confident with this arrangement in order to diversify risk and include key skills while also providing positive exposure to early cash flows and potential upside from a growing market.

### 5. When do you expect first battery sales?

Our plan is to import batteries from European developers and test them at a range of sites around Australia. This is expected to happen progressively within the next six months. Sales leads and specification will commence during that time. We have already spoken to a range of potential clients across the business spectrum including mining and exploration companies, commercial businesses who are expressing significant interest and so are confident of having sales not long after the test sites have proven successful.

### 6. Why is nobody else doing this?

The Australian market offers significant opportunity because there is not a lot of activity with battery storage currently. Most of the battery makers are located in either Asia or Europe and, therefore, Australia may not have been a priority. We are excited to have secured early mover advantage in this arena.

### 7. How is it being funded?

Yellow Rock, as a listed company, has cash on hand which will help fund the early stages of the integration strategy alongside the joint venture partner. The company is assessing other opportunities for future funding but we are confident shareholders will see the positive opportunity which exists.

### 8. Where would an electrolyte plant be constructed?

Vanadium electrolyte is a solution containing vanadium ions which goes into the batteries. Yellow Rock is assessing the viability of constructing an electrolyte plant however it is early stages. Research so far indicates that a plant would only be of small scale and may not need a new build, but rather could be co-located with another chemical lab. The first plant will be local to Western Australia so as to benefit the local economy.

### 9. When would Yellow Rock complete the vertical integration "loop" by supplying Gabanintha vanadium to the subsidiary company?

The Gabanintha project will move into development in 2016. Depending on a number of factors (including the scale of the project selected, funding and key partnerships, we are working to have the project up and running within the next three years at which time our own supply into the battery market (as well as the steel market) will be possible.