Vanadium – Heard it on the Grapevine

In the mining sector if one hangs around long enough, that which was once a subject of excitement and then fell from favour eventually comes around again. In the case of Rare Earths though one had to wait from the 1960s until the early 2000s to see them return as a talking point.

Last decade Vanadium surfaced as a subject of interest primarily tied to the fortunes of the then-booming steel industry. Now Vanadium is coming back with a vengeance for its potential in mass electricity storage devices, namely the Vanadium Redox Battery (or VRB). At the recent Natural Resources Forum event at the London Stock Exchange, which I attended, the guest speaker was Robert Friedland and he was in a Vanadium-induced ecstasy. Never could we have imagined the metal having such a euphoric effect. In any case it gave the Friedland *imprimatur* to a metal which most metals watchers have rarely paid any attention to due to it (largely) being a by-product of other mining and curiously of the petroleum refining industry.

It was not just Friedland though that has latched onto this bandwagon as we have heard Vanadium name-checked at a number of recent events recently as the next best thing now that Lithium has somewhat done its dash with promoters overcooking the soufflé.

VRB – Go with the Flow

The current end use of the bulk of Vanadium production is well-known with its strict correlation with steel consumption. New uses are potential X factor for the Vanadium space. While aerospace has been growing organically and increasing its share of the usage of the metal the area with the best potential for a quantum leap is in battery applications.

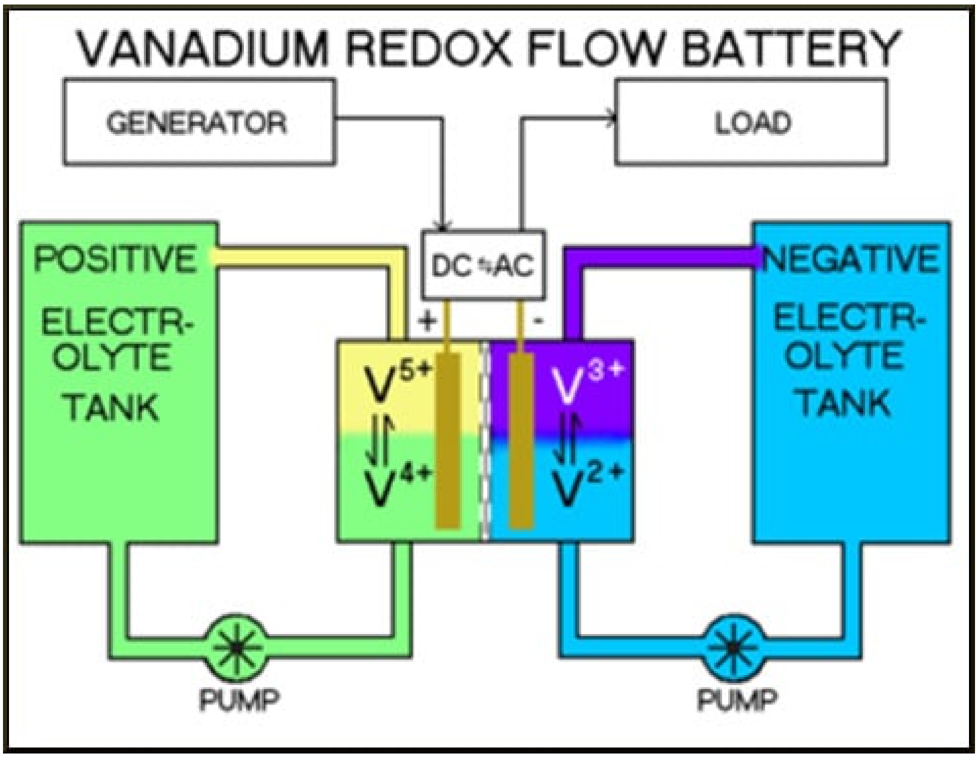
Chief amongst these is the Vanadium Redox (and redox flow) battery (VRB), which is a type of rechargeable flow battery that employs Vanadium ions in different oxidation states to store chemical potential energy. The present form (with sulfuric acid electrolytes) was patented by the University of New South Wales in Australia in 1986 where scientists carried out the first known successful demonstration and commercial development of the all-vanadium redox flow battery employing vanadium in a solution of sulfuric acid in each half in the 1980s. Although the use of vanadium in batteries had been suggested back in the 1970s by a number of scientists including some at NASA.

There are currently a number of suppliers and developers of these battery systems including Ashlawn Energy in the United States, Renewable Energy Dynamics (RED-T) in Ireland, Cellstrom GmbH in Austria, Cellennium in Thailand, and Prudent Energy in the United States and China. The vanadium redox battery results from over 25 years of research, development, testing and evaluation in Australia, Europe, North America and elsewhere.

The image that follows gives a good idea of one of the more practical applications of such batteries. In this case the solar panels collect energy during the day and store it in the battery for release during the period when the solar panels cannot access sunlight.

Source: Cellstrom GMBH

A vanadium redox battery consists of an assembly of power cells in which two vanadium-based electrolytes are separated by a proton exchange membrane. The battery exploits the ability of vanadium to exist in solution in four different oxidation states, and uses this property to make a battery that has just one electroactive element instead of two.



Source: Vanadiumsite.com

The main advantages of the vanadium redox battery are that it can offer almost unlimited capacity simply by using larger and larger storage tanks, it can be left completely discharged for long periods with no ill effects, it can be recharged simply by replacing the electrolyte if no power source is available to charge it, and if the electrolytes are accidentally mixed the battery suffers no permanent damage. The VRB has also been shown to have the least ecological impact of all energy storage technologies.

The main disadvantages with vanadium redox technology are a relatively poor energy-to-volume ratio, and the system complexity in comparison with standard storage batteries.

Another emerging technology is the use of lithium-vanadium phosphate or fluorophosphate cathodes and lithium-vanadium oxide anodes in rechargeable lithium batteries. These batteries exhibit greater safety compared with the more generic lithium-cobalt oxide type cathodes seen in cellular telephone or laptop batteries (which have higher operating voltages and higher rates of energy storage). The vanadium phosphate cathode material can support 20% more energy storage than the conventional cobalt oxide, as much as 26% more than iron phosphate, and 56% more than manganese oxide. However, in order for such a battery to be practical, the cost of the battery is critical.

Source: Subaru

Several years ago Subaru developed a prototype of its G4e electric car (pictured above), powered by lithium-vanadium phosphate batteries. This concept car has a 200-km range that is provided by a relatively small vanadium phosphate battery pack, double what their earlier R1e concept car could achieve. However, it would appear that Subaru have done little with the concept of late. Maybe the patents need dusting off in the light of Cobalt's perilous surge in price.

Largo Resources – the Primary Exposure

The most obvious pure exposure to Vanadium mining (rather just a project is Largo Resources Ltd. (TSX: LGO | OTCQB: LGORF) with its Maracas mine in Brazil. This has been in operation for several years now and has been growing impressively in terms of production (see table below), meanwhile its production costs have been falling (helped by the weakness of the Real against the US dollar) and the Vanadium price has been rising.

Maracas Production & Pricing

	Production	Production	Cost per pound		
	Tonnes	Pounds (Equiv)	CDN$	US$	R$
1st Quarter 2017	2,062	4,545,926	$5.19	$3.90	R$12.31
4th Quarter 2016	2,304	5,079,444	$4.82	$3.60	R$11.90
3rd Quarter 2016	2,182	4,810,481	$4.67	$3.59	R$11.61
2nd Quarter 2016	2,311	5,094,877	$4.19	$3.25	R$11.40
1st Quarter 2016	1,169	2,577,201	$6.52	$4.75	R$18.51
4th Quarter 2015	1,654	3,646,441	$5.97	$4.47	R$17.20

The company has given guidance that production in FY17 should be around 9,361 tonnes (equivalent to ~ 20.6 mn lbs). The company expects monthly output of 840 tonnes of V_2O_5 from May 2017 onwards.

This virtuous circle has replaced a rather vicious cycle that had previously reigned for the company producing some quite eye watering losses (see earnings table below) in the not too distant past. Producing more meant greater losses while now producing more signals that profitability is within shouting distance.

As the table shows the gross loss has shriveled to levels at which it is most likely to turn a profit at that level fairly soon and hopefully at the bottom line by the end of the current fiscal year.

Largo Resources
In Millions of CAD

	1Q17	FY16	4Q16	3Q16	2Q16	1Q16	FY15	FY14	FY13
Revenue	29.43	81.23	31.48	20.76	18.95	10.05	7.60	0.00	-
Cost of Revenue, Total	29.6	113.17	30.15	29.95	29.74	23.33	29.38	0.00	-
Gross Profit	-0.18	-31.94	1.33	-9.20	-10.79	-13.28	-21.78	0.00	-
Selling/General/Admin. Expenses	2.87	13.28	3.29	4.63	3.29	2.06	12.31	12.56	5.13
Research & Development	0	0.1	0	0	0.02	0.07	0.71	0.22	-
Depreciation/Amortisation	-	-	-	-	-	-	-	-	-
Interest Expense (Income)	-	-	-	-	-	-	-	-	-
Unusual Expense (Income)	-	0	0	-	-	-	6.75	14.76	0
Other Operating Expenses, Total	0.63	3.08	0	0	0	0	0.85	10.02	2.06
Total Operating Expense	33.1	129.63	33.44	34.59	33.05	25.46	50	37.56	7.19
Operating Income	-3.68	-48.4	-1.96	-13.83	-14.11	-15.41	-42.4	-37.56	-7.19
Gain (Loss) on Sale of Assets	-	-	-	-	-	-	-	-	-
Other, Net	-	-	-	-	-	-	-	-	-
Income Before Tax	-9.72	-55.63	-11.65	-24.7	-9.66	-9.61	-129.96	-52.62	-11.58
Tax	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Income After Tax	-9.72	-55.63	-11.65	-24.7	-9.66	-9.61	-129.96	-52.62	-11.58
Diluted Weighted Average Shares	455.57	387.03	423.98	415	412.65	296.06	167.11	100.93	89.61
Diluted EPS Excluding Extraordinary Items	-0.02	-0.14	-0.03	-0.06	-0.02	-0.03	-0.78	-0.52	-0.13
Diluted Normalised EPS	-0.02	-0.14	-0.03	-0.06	-0.02	-0.03	-0.74	-0.38	-0.13

Conclusion

It's a long while since I (at Hallgarten) wrote my *magnum opus* on Vanadium back in early 2012. Strangely the field of players has not expanded (nor contracted) too much since then. It is the same hardy group of survivors with the producer being Largo Resources (only a project back then) while others like NextSource (back then called Energizer Resources) with its Green Giant in Madagascar and the perpetual bridesmaid of the space, American Vanadium. Back in those days Neometals (then Reed Resources) was expounding on the Vanadium potential of Barrambie (now refocused as a Titanium project) and we had been talking, as far back as 2010, to Apella Resources (name changed to VanadiumCorp) about its Iron-T deposit that has now moved into the camp of Alix Resources (spoiler alert: I sit on the advisory board of Alix).

With Vanadium Redox being the intelligent chatter of the day (or year) it won't be long before these players start to reappear on the radar and others join them. Largo definitely has the jump on most of them and has had an expensive learning curve behind it. Not all Vanadium deposits are the same though so some of the lessons learnt by Largo may not translate for all wannabes on the scene. In any case, this opens up the battery metals debate to another realistic alternative. The more the merrier, we would say.