Prophecy’s Oosterman on being the only U.S. player for vanadium supply

June 26, 2018 — “China controls about 56% of the vanadium in the world. The other two big players are Russia and South Africa. As a result, of course, it has been deemed as a strategic metal. The United States, for example, imports about 99% of its vanadium. It is a key metal in construction. It is a key metal in the aerospace industry. Really this is where our project is poised to basically be the only player in the United States for vanadium supply.” states Danniel Oosterman, Vice President of Exploration at Prophecy Development Corp. (TSX: PCY | OTCQX: PRPCF), in an interview with InvestorIntel Corp. CEO Tracy Weslosky.

Tracy Weslosky: Vanadium is one of those critical materials with regards to a lot of sustainability issues that are currently happening today that very few people understand. Would you mind giving us kind of an introduction to vanadium?

Danniel Oosterman: Vanadium, even though it is not widely known about, it is widely used and widely applied in a number of applications. The principle application is actually steel. 92% of vanadium used in the world is used in steel. A small percentage added to steel actually doubles the strength and lightens it by 30%. As such it is ideal for, not only, rebar in construction and steel for skyscraper and such, but actually it is very useful in the aerospace industry as well.

Tracy Weslosky: Of course, we cannot forget the electric vehicles and the battery storage sector.

Danniel Oosterman: The battery space is a growing space, lots of excitement. You have a lot of big players, key players, like Robert Friedland, now are paying attention to it. That really puts us in a position where we with our project may be able to access every single one of these aspects, aerospace, chemical industry, steel industry, with our project in Nevada.

Tracy Weslosky: Respectfully, to Robert Friedland, which we all know in the resource sector, we have major players, mainstream players, like Elon Musk, that are drawing attention to the requirements for vanadium in their batteries. Give us a little bit of an overview of vanadium. We know that the Chinese control 90% of the rare earth and 80% of the graphite. What do the Chinese control of vanadium?

Danniel Oosterman: Well, Tracy, China controls about 56% of the vanadium in the world. The other two big players are Russia and South Africa. As a result, of course, it has been deemed as a strategic metal. The United States, for example, imports about 99% of its vanadium. It is a key metal in construction. It is a key metal in the aerospace industry. Really this is where our project is poised to basically be the only player in the United States for vanadium supply for the United States. That really just puts our project in an advanced position. If you look at the political landscape in the United States, with Donald Trump deregulating a lot of things, he recognizes a lot of strategic value of certain metals. Principle of that, and we have had discussions with the Federal government in the United States regarding this, our project in particular is a high priority project because vanadium is considered one of these critical metals in the strategic sense that Trump has raised concern. As such we will essentially anticipate that we would move to the front of the queue in terms of our project going ahead and eventually put it into production…to access the complete interview, click here

Vanadium – Help Yourself

A spin-off from the surge in green energy solutions in recent years (particularly wind and solar) is that the world is now awash in electricity that is not generated when it is wanted or needed but rather when the sun shines and the wind blows. This is not exactly the best way to run a grid management system. The missing part of this equation is storage devices to stash away this power for, quite literally, a rainy day.

Some bizarre suggestions for "do it yourself" story have emanated from Tesla but as with everything from that source it's more a case of form over content. What is needed is a realistic means by which either the power generator (in some cases households) or the grid operator can store up the energy for when it's really needed and thus flatten the peak load problem that has bedeviled electricity distributors since the dawn of the modern age.

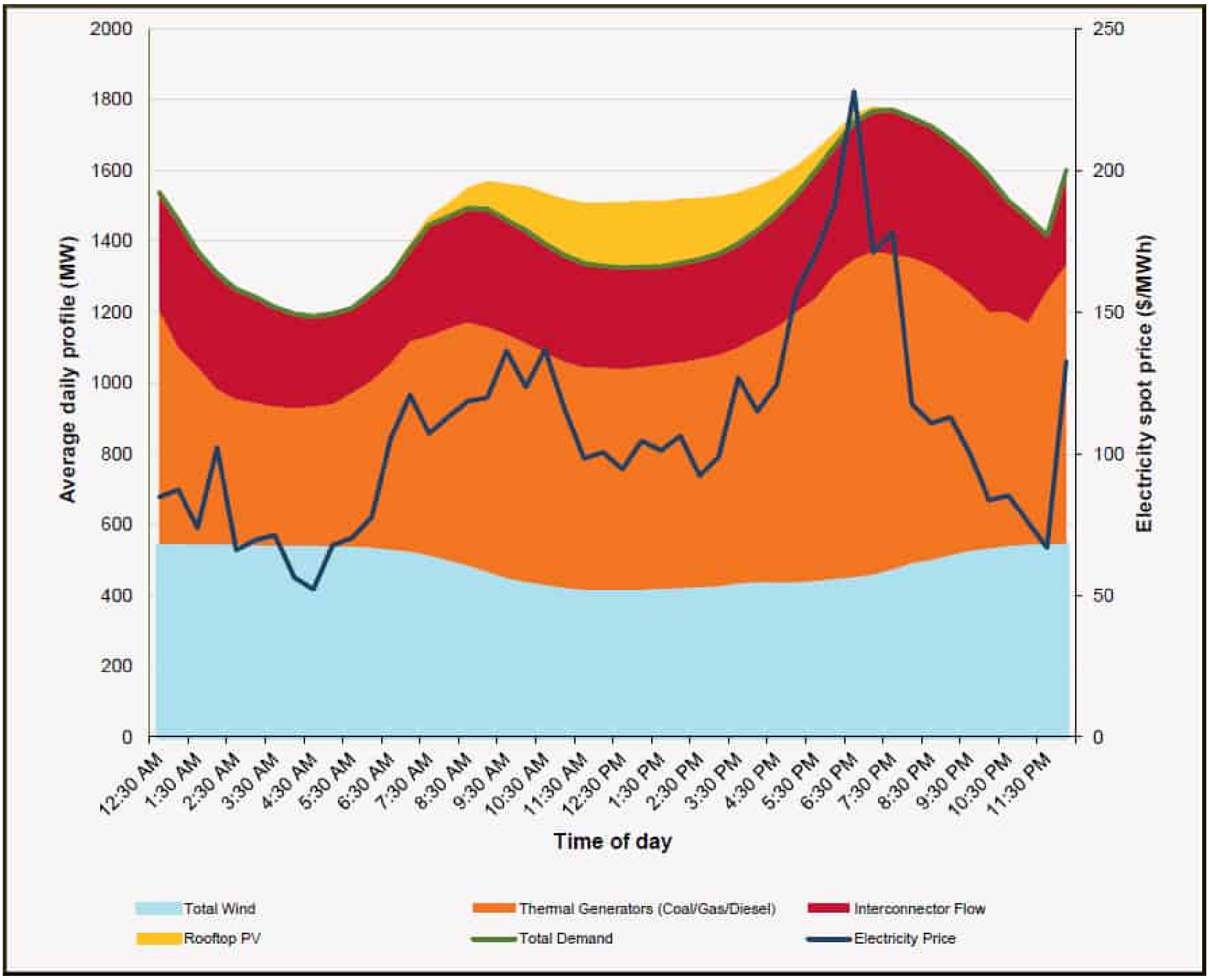
The solution, many knowledgeable observers believe, may very well lie in the Vanadium Redox Battery (VRB).

The South Australian Experience

The Australian state of South Australia is not exactly a place that is seen as being very innovative. If the rest of the world knows about it then it's primarily for its wine production. What the state does have in abundance is sunshine and this led to high levels of uptake of solar panels. However to put this in perspective the southern part of the state (where the bulk of the people live in the city of Adelaide) has nowhere near as many cloudless days as say, Nevada or Arizona.

There are solar panels everywhere these days (though not as many as there might be) and yet few places have come up with as comprehensive a policy as to exploit them as South Australia has. As a result the state is already being hailed for its leadership on renewable energy technology. Its efforts have been styled as “a consumer-powered grid”.

A report from the Australian Energy Market Operator highlights that 9.2% of the electricity generated in the state over the last financial year came from small-scale (sub 100kW) solar PV on the rooftops of households and businesses in the state. The graphic below shows the sourcing of energy an average day in South Australia over the last year.



This new style of electricity sourcing is called “distributed generation”.

The level of rooftop solar penetration in South Australia is a record for any major grid in the world, and the contribution of rooftop solar is likely to have been well over 10% in the last year (when larger rooftop solar installations of more than 100kW are included).

According to AEMO forecasts, the total will likely at least double over the next 10 years to more than 20%, at which time rooftop solar will be pushing "minimum demand" from the grid to zero on occasions.

As can be noted from the graphic the solar component is, unsurprisingly, during the core daylight hours yet the peak of demand for power (and peak in pricing) is just after the solar ceases to be a factor. Indeed one might even interpret that the absence of solar at that point prompts the price spike, but that is a chicken-and-egg debate.

It is here that VRB's can potentially play a part. The ability to store power from the low usage periods and then spill it back into the grid at peak demand periods would be a major advantage. This prompts another thought. With grid operators paying peanuts to solar "vendors" then it is not really in the public's interest to invest in storage devices to stash the power, but seemingly the grid operators are not doing so either. One or the other needs to make this investment. For the grid to do so would require massive "battery farms" with VRBs spreading in all directions. For the householders to do it would require a small VRB at each solar producer's home. The latter raises the interesting possibility that the householder might then be able to use in the evening the power they produced during the day and lessen their own dependency on the grid. This might ironically result in more householders going *off-grid* for longer periods in the day. They would thus avoid the generators' peak usage fees. The lesson in all this is "Embrace the VRB, it will set you free".

China Embraces the VRB

Aficionados of VRBs have long wondered what the trigger might be for mass adoption of the technology and the answer is to look to the country that specializes in “mass adoption” and that is China. Recent news has shown the process is moving rapidly now. In late September 2017, the China National Development and Reform Commission (NDRC) released Document 1701, “Guidance on the Promotion of Energy Storage Technology and Industry Development” aimed at accelerating the deployment of energy storage. The policy calls for the launch of pilot projects, including deployment of multiple 100MW-scale vanadium flow batteries, by the end of 2020, with the aim of large-scale deployment over the ensuing five years.

Not one to be backward in coming forward, Robert Friedland has now jumped on the Vanadium bandwagon in China, hence his many and various allusions to the metal at the presentation he made at the London Stock Exchange a few months back. His play in the space is a private Chinese company called Pu Neng, which styles itself as “the leading provider of vanadium flow battery technology in the world” with more than 800,000 hours of demonstrated performance. The claimed USP of Pu Neng is its combination of proprietary low-cost ion-exchange membrane, long-life electrolyte formulation and innovative flow cell design.

In early November, Pu Neng announced that it had been awarded a contract for a 3 MW – 12 MWh VRB as Phase 1 of the Hubei Zaoyang 10MW 40MWh Storage Integration Demonstration Project. This first phase will be installed in Zaoyang, Hubei to integrate a large solar photovoltaic system into the grid. Following this 10MW 40MWh project, there will be a larger 100MW 500MWh energy storage project that will be the cornerstone of a new smart energy grid in Hubei Province. This large project will serve as a critical peak power plant, delivering reliability and emissions reductions.

The project will be located in Zaoyang, and installation of the VRB system will commence in November 2017. When Phase 1 is completed in early 2018, Pu Neng's VRB will be the largest flow battery installed in China. As part of the initial agreement, Pu Neng and Hubei Vanadium will jointly develop a vanadium electrolyte supply from local vanadium sources. This however is easier said than done. Vanadium mines do not "grow on trees" and its sources as a by-product of petroleum refining are relatively inelastic to the Vanadium price. If Vanadium is the New Lithium, then China is not that well-positioned (yet again) but then again who is?

Conclusion

It would seem that the need for mass storage has come upon those areas with significant alternative energy efforts as somewhat of a surprise. Power is quite literally being wasted and residential "producers" are not maximizing their revenue from what they generate due to lack of a means of storage.

Thus a focus on solar and wind generation does not reward the producers thereof if it's at the wrong time (or day) and place. For example, the low levels of grid demand on both Sunday and Saturday in South Australia pushed prices firmly into negative territory. Prices were as low as minus $1,000/MWh on some occasions and averaged minus $120/MWh for two hours on a Saturday. It also created record low demand on the grid.

VRB technology would seem to hold the solution to this problem. If the householder owns the VRB then they get the whiphand. If the grid operator owns it then they can "buy low and sell high" leaving the householder (i.e. generator) with mere scrapings. The first party that is able to make the "not too big, not too small but just right" VRB for domestic storage should be able to clean up.

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.

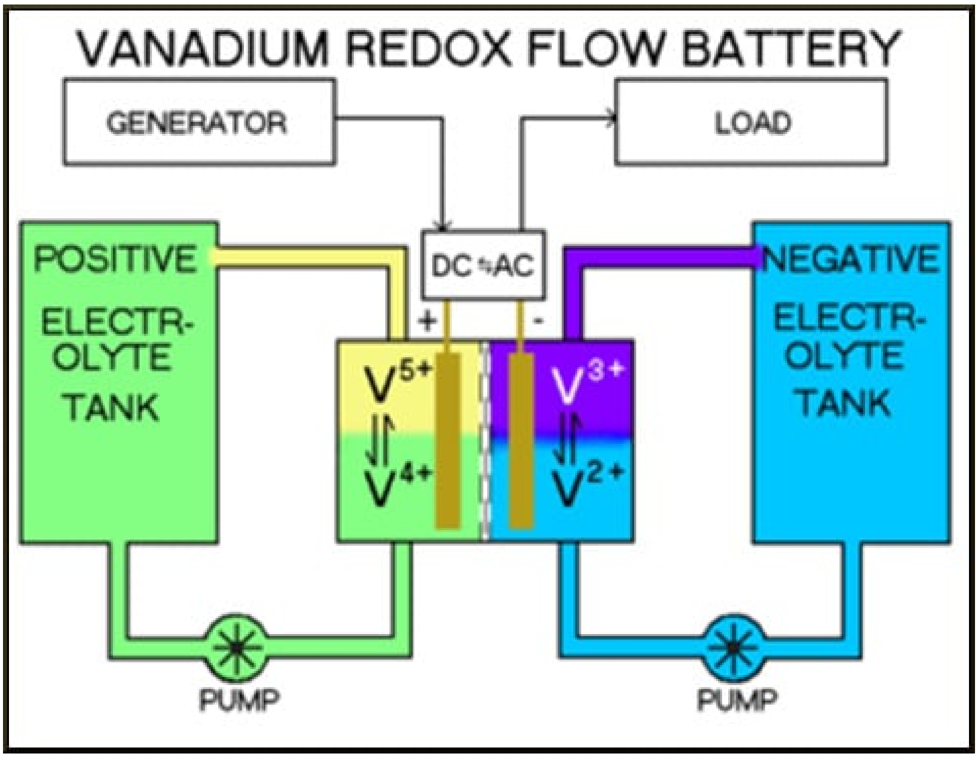
Chief amongst these is the Vanadium Redox (and redox flow) battery (VRB), which is a type of rechargeable flow battery that employs Vanadium ions in different oxidation states to store chemical potential energy. The present form (with sulfuric acid electrolytes) was patented by the University of New 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.

Scandium – The Technology Metals Race Where All are Winners

Australians are such aficionados of gambling that there is an old adage that they will bet upon two flies crawling up a wall. There are two Scandium (Sc) stories of note in Australia and both are in New South Wales and both are separated by a mere 90 miles. The first is Scandium International Mining Corp. (TSX: SCY) (which we have covered before and has had a stellar run this year) and the other is Clean TeQ Holdings Limited (ASX: CLQ |OTCQX: CTEQF) which, despite its name, is a Scandium developer as a by-product from a Nickel-Cobalt project. With Cobalt as the word on everyone's lips and Scandium the word on ours, it scores a very respectable two out of three.

Getting Informed

At the start of the Rare Earth boom, many misinformed observers referred to Scandium as a Rare Earth, this was despite it not being in the Lanthanide series at all and rarely even appearing with other REEs in mineralsiations. This was just blatant false news. Indeed Scandium is twice as prevalent in the Earth's crust as Lead. Rarity should be made of sterner stuff.

The thing that is rare is Scandium production. What production there is (and it amounts to between 10-25 tonnes per annum and even that is a shaky statistic) comes as a by-product of refining of mainly base metals. Indeed Scandium metal is very difficult to reduce to its pure elemental state. In fact, it was not isolated in pure form until 1937 and the first pound of pure elemental scandium metal was not produced until 1960.

The potential of Scandium as an alloying element in aluminium (Al) alloys has been a long-simmering desire of many informed observers over the last two decades. Hundreds of scientific papers have been published describing various improvements in properties that can be achieved, and one text book and a string of reviews or other overview articles are written on this subject.

The use of Scandium as an alloying element in aluminium alloys was first investigated by scientists of the former Soviet Union, who developed several Sc-containing Al-alloys during the 1980's and 1990's.

Aeronautics

Much of the alloy development that took place in the USSR appears to have been intended for aerospace applications. One alloy, 1421, is used for fuselage stringers of large cargo aircrafts, and some parts of the MiG 29 military aircrafts are also made of Sc-containing Al-Li based alloys. It is also claimed that some parts of the international space station (ISS) are made from alloys with Sc.

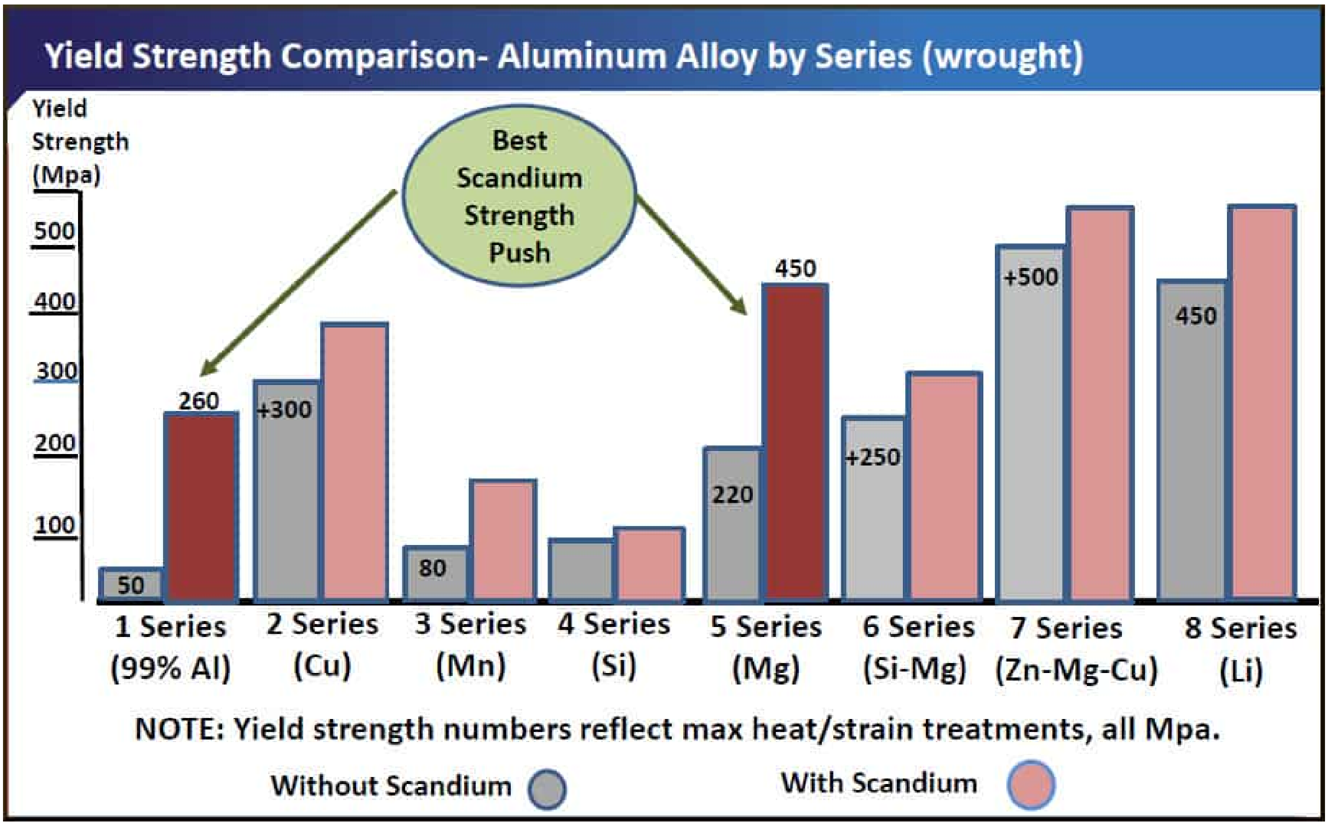
Aircraft manufacturers have been particularly interested in scandium alloyed aluminum materials. Aircraft designers believe use of Al-Sc alloys can reduce aircraft weights by 15%-20%. In addition, the ability to employ weldable structures promises similar cost reduction potential.

The three principle effects that can be obtained by adding scandium to aluminium alloys are

- grain refinement during casting or welding
- precipitation hardening from Al3Sc particles
- grain structure control from Al3Sc dispersoids

Addition of scandium in combination with zirconium is particularly effective (which gives us a chance to mention Alkane, which is in close proximity to both the projects in NSW).

The table below shows graphically the eight major series of Aluminium alloys. As can be noted all of them provide aluminium with a strength push when combined with Scandium in an alloy. The two that show the greatest benefits are with pire aluminium and in alloys with Aluminium and Magnesium.



Source: Scandium International

A little goes a long way with Scandium in alloys. Small additions of the metal to an alloy can produce a quantum benefit in strength for a relatively low cost (in many cases the Sc added to the alloy master mixes is a fraction of a percent of the total metal). The effect though is massive in lowering the weight of the plane and thus the fuel costs of operating the plane. The stronger the aluminium the less than needs to be used.

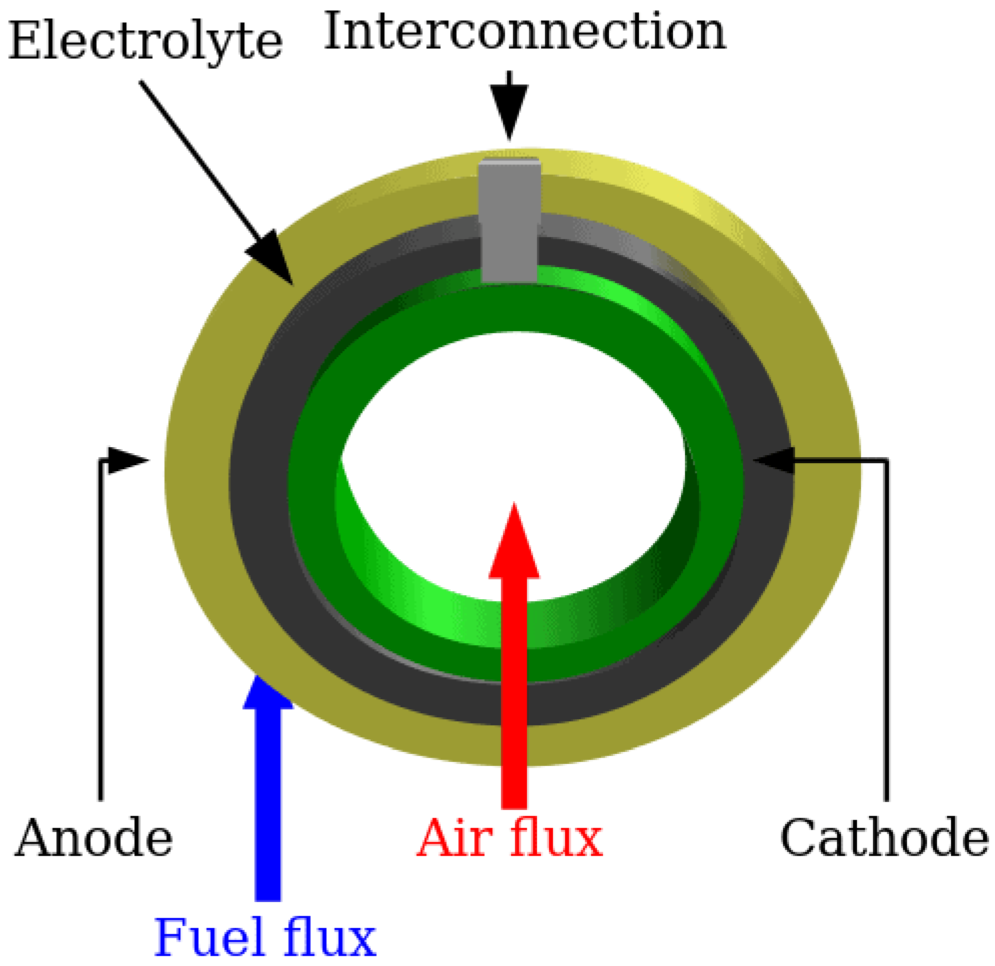
The problem the aircraft manufacturers face in adoption of Scandium alloys *en masse* is not one of price or desirability it is of supply. With no primary mines and no sizeable supply there could at some point be an absolute absence of Scandium supply for either competition reasons or geopolitical considerations. Boeing going to the storage division and finding no Scandium for that day's production would effectively shut down operations. Only with a largish, stable supply from a politically friendly jurisdiction can a wholesale adoption of Scandium in aeronautical applications be considered. For the first time since 1960, this possibility can be realistically contemplated.

Solid Oxide Fuel Cells

A solid oxide fuel cell (or SOFC) is an electrochemical conversion device that produces electricity directly from oxidizing a fuel. Fuel cells are characterized by their electrolyte material; the SOFC has a solid oxide or ceramic electrolyte. Advantages of this class of fuel cells include high efficiency, long-term stability, fuel flexibility, low emissions, and relatively low cost.

Scandium's usefulness for SOFCs is that it exhibits exceptional electrical conductivity and heat stabilization qualities and therefore the largest volume current use for the metal is in SOFCs.

Scandium is used as the electrolyte component in the fuel cell, most commonly as scandia stabilized zirconia (ScSZ). Below can be seen a conceptualization of how these fuel cells work, with the electrolyte (containing the Scandium) being the dark grey layer.



Incorporation of scandium in SOFCs enables a lower operating temperature resulting in longer lived equipment and less costly materials of construction. Bloom Energy in the US is the leading SOFC manufacturer and currently the single largest scandium user. The fuel cells are massed into stacks to match the energy required so the potential is enormous and once again limited only by the reliable supply of Scandium rather than any lack of potential end demand.

Conclusion

Scandium is the example, par excellence, for our thesis of "Build it and they will come". In the aeronautics industry in particular tooling up for a different mode of manufacturing or input can be a massive cost running into the hundreds of millions of dollars if not billions. It is clear that the industry wants to apply the benefits that Scandium brings but it is not going to go out on the limb and hope that the adage "Build it and they will supply us" proves to be true. As we all know that train is heading down the track fullspeed towards Tesla that has foolishly failed to secure its supply of Cobalt and Lithium for the future. The likes of Boeing and Airbus are not so naïve.

Thus when a significant supply of Scandium is guaranteed then the synergies between aeronautics and Scandium mining will come into play and the uptake of product will be potentially enormous. That in itself will trigger more realistic and workable pricing and in turn that will feed greater uptake (beyond the aeronautical industry into those with more sensitive price points, such as lighting and fuel cells). Scandium International is well positioned to do this as a primary mine and potentially Clean Teq will be able to follow with its sizeable by-product credit of Scandium from a Nickel/Cobalt production facility.

It also seems that Australia and most specifically New South Wales will be the epicentre of Scandium activity for the short term and maybe even farther into the future. This in some dusty pub in the Australian pub in the outback will find that betting on either, or both, of those flies will pay off.

Note from the assistant publisher: George Putnam, President and CEO of Scandium International will be presenting at InvestorIntel's 6th annual Cleantech and Technology Metals Summit, and is scheduled to speak on Monday 15th from 1:50 – 2:05 PM (EST).

Core Consultants on a Lithium Market Reality Check

To quote Robert Friedland at the 2016 121 Mining Convention held in Cape Town, “The lithium market will end in tears.”

Lithium carbonate prices in China have surged by 253% over the last year alone. Forecasts for lithium prices exhibit uncapped exponential growth. Against this backdrop, Mr. Friedland’s sentiments seem completely misplaced.

The main reason for all the fanfare surrounding the potential for lithium, is the fact that it seems to be the battery of choice for the impending surge in electric vehicles. Whilst this is true, we feel that current forecasts neglect to take into account a few fundamental factors, namely:

1) Peak Oil – is this still a thing?
Who remembers about 7 years ago, when “peak oil” was the new buzz word? Peak oil is defined as that point when worldwide daily production starts to decline. The premise was that new oil reserves were not offsetting the declining production, while the demand for oil was expected to keep rising.

If the cost of gasoline rose to $7/gallon, the cost comparison of purchasing an internal combustion engine vehicle (ICE) vs. an HEV/EV model, quickly favours the uptake of electric vehicles. This fact was demonstrated in the chart below, which indicates that when oil hit an all-time high of $134/bbl in 2008, HEV sales rose. The correlation between these two factors, oil prices and EV/HEV sales was 78%.

Source 1: OPEC, Marklines, Core Consultants’ Research

Oil prices have reached a new low, in part, caused by the overall slowdown in global growth and industrial production, but also due to the increased supply from OPEC (demonstrating that economists may have called “peak oil” prematurely).

In 2015, there appeared to be a divergence in the oil/vehicle relationship in that oil prices declined sharply, whilst hybrid sales increased rapidly.

Source 2: OPEC, Marklines, Core Consultants’ Research

If the consensus is that oil prices will not recover for some time, then the question lithium analysts need to ask is whether the relationship between oil and electric vehicle demand has disassociated for now due to policies that support electric vehicle development or whether this is a relationship that should hold true over the long term, in which case low oil prices could constrain electric vehicle and therefore lithium demand.

2) Recycling- becoming increasingly efficient
Recycling of cars and car batteries is not new, but the technology is becoming increasingly sophisticated and the recovery rates are constantly improving.

Most of the value in recycling car batteries comes from the amount of nickel, cobalt, iron and other high-value metals for reuse. The difference in battery values generally depends on the nickel and cobalt content.

However as industrial minerals gain importance and value, it becomes feasible to recycle these batteries and to extract some of these metals.

Last year witnessed the first electric vehicle to be recycled- the Chevy Spark-for its rare earth content. The car was crushed and more than 90% of the rare earth metals were recovered. Not bad going for a first time.

In 2009 The US Department of Energy awarded $9.5m to Toxco (now renamed ‘Retriev Technologies”) in order to build the first recycling facility for lithium-ion batteries. We understand that the facility is already accepting electric car batteries from major manufacturers including Tesla.

With respect to lithium batteries, the batteries degrade with time and retain around 70-80% of their original capacity. Whilst this is not enough to propel an electric vehicle, it is still valuable material and can have other uses, which reduces the requirement for virgin material.

According to Chemetall, within the next twenty years, 50% of the lithium requirement for new batteries will be provided through the recycling of electric vehicles.

3) Alternative battery choices- lithium is not the only option

Last year a client contacted us. They were a major mobile manufacturing firm seeking to extend their manufacturing capabilities into electric vehicles. To do this they needed to understand the cobalt supply chain and secure a supply-partner.

They explained to us in no uncertain terms that if Core Consultants could not find suitable suppliers for them or if our report indicated that using cobalt might tarnish their reputation, that they would move away from lithium-cobalt batteries and make use of other storage devices.

At this statement, I was taken aback and enquired if they really could develop an alternative battery without compromising their current products' quality and if so how long it might take?

The client indicated that they had several alternative storage solutions and each of them were between 4-7 months away from commercialisation and could be implemented without changes to their current service offerings or quality.

"Do you really think we haven't learned from rare earths? Or that we would allow our multibillion-dollar company to be held ransom to a single commodity?” he asked.

And this is the key – At the moment, since lithium forecasts fail to take into account substitutes and the fact that most mega-corporations have a number of options with respect to which battery they can use, this will place a cap on how high lithium prices may rise.

It is true that currently no other technology is as compelling as lithium. Furthermore, the lithium cost itself is only around 2-3% of the overall battery manufacturing cost. So indeed if lithium prices rose ten-fold It would only increase the input cost from 2% to 20% and battery users will absorb this cost. But what if prices continue to go up 200%? There is a point, whereby no matter how compelling a technology may be, end-users will source alternatives and mitigate their inflation risk.

4) Efficiency of use- the aim is use high value materials sparingly

As a chemistry major, I found experimenting fun, but the discipline itself a bit stagnant. My main concern was that our labs at the universities were always producing known substances instead of creating new substances. Where was the innovation?

This was until a professor highlighted to me that one of the major aspects of being a chemist was to try and see if we could engineer the same material faster or cheaper or by using less reagents. From that moment I was hooked on the economics of the science.

Ten years ago, lithium-ion batteries for electric cars was the dream, not the standard. Apart from technical difficulties, the cost of the lithium-ion battery stood in the way of commercialization. What we have seen over the years, is a steady decline in the amount of lithium required to propel a vehicle. This is known as the “efficiency of use.”

We use reagents more efficiently and thereby “get more bang for our buck.”

Take for example the Chevy Spark EV, which uses a lithium-ion battery manufacture by LG Chemicals. For the same power in 2015, the battery pack used 192 lithium-ion cells while the 2014 model used 226 cells. The number of cells required declined by 15% in the space of one year. This example demonstrates just how quickly technology is enabling efficiency of use principal.

Both the number of cells required and the overall cost of lithium batteries has declined with time, rendering lithium-ion batteries feasible for electric vehicles.

The aim of this article is not to be a downer, and **I do believe that the lithium market still “has legs.”** However, it seems that with all the hype surrounding this element, analysts are forgetting that lithium is just a commodity and, as is the case with most commodities, economics and profits drives technological advancements which makes way for substitutes, efficiency of use or recycling and ultimately prevents prices from going unchecked for too long.