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As we move into 2018, energy storage is key to truly realize the full potential of renewable energy technologies, and batteries are the most important component of energy storage. Battery metals are becoming more and more popular thanks to the increasing demand for portable technology and the rise of the electric vehicle market. Technological advances and cost reduction in the last two years have been remarkable and nothing short of a revolution. The main growth driver up to now has been consumer goods but what will take this sector to the next level is road transport. Every major car manufacturer has electric models and that market grew 40% in 2017. There are currently 2M+ electric vehicles on the road today, where there were virtually none 10 years ago.

The round-up of the Battery Metals Category includes:

**Lithium** - Lithium-ion batteries are found in laptops, phones, and vehicles. Lithium prices have doubled since 2008 from $4,500 a tonne to $9,000.

**Cobalt** had 100,000 tonnes mined globally in 2016. Demand is expected to exceed 120,000 tonnes by 2020. Around 60% of cobalt mined will go toward ion battery production by 2020.

**Graphite** is used in conducting material for lithium-ion batteries and its global market is projected to reach $29.05 billion by 2022.

**Nickel** can make a battery last longer. World demand increased from 907,000 tonnes in 1990 to 1.4 million tonnes in 2010.

**Vanadium** is a super-metal that can super-charge a battery of any size. As the energy industry works to grow its storage capacity and uses, vanadium will play an important role in the growth of this sector.

Battery technology has brought stability to renewables and made the electric vehicle dream a reality. The battery industry is seeing unprecedented demand as the global energy sector transitions into clean energy and electric vehicles disrupt the internal combustion engine’s conventional hold on the automotive industry. Read on for a more detailed look at this emerging sector and insight from leaders in the space.
The Biggest Change to the Car Industry in a Century

In December 2016, General Motors began selling one of the most important cars in its 108-year history, the Chevy Bolt.

In addition to being significant for the iconic American automaker, the introduction of the Bolt was a landmark event in the history of electric cars. The Bolt was the world’s first low-priced, mass-market car with a range of more than 200 miles.

For a long time, electric carmakers have seen this feature – the ability to run 200 miles before requiring a recharge – as critical to the “revolution”, the widespread adoption of clean, emission-free electric cars.

A driving range greater than 200 miles is critical because of something called “range anxiety.” Range anxiety is the fear drivers get from knowing the battery in their electric car could run out of charge... and leave them stranded far away from a charging station. As electric vehicles have grown in popularity over the past decade, the term has become an obsession in the auto industry.

In fact, you could say the race among electric carmakers like GM, Tesla, and Nissan is the race to become the world champion of overcoming range anxiety. A big breakthrough in treating this “disorder” would be worth hundreds of billions of dollars. It would set the winner up to dominate the future of cars.

Although electric cars have come a long way over the past decade, they are still light years behind internal combustion engines when it comes to fueling infrastructure. Batteries drain quickly and they must be recharged. Most gasoline-powered cars en-
joy ranges of over 300 miles, while for years, affordable electric cars had limited ranges of less than 100 miles. (Tesla’s famous Model 3 has a range greater than 200 miles, but it’s also out of the average buyer’s price range.)

A limited number of miles per battery charge is a big deal because regular gas stations are much, much more common in most places than charging stations. In most areas, the guy leaving his driveway in an electric car has a lot less options for refueling than the guy driving a Chevy Suburban.

You might want to do your part to save the Earth, but if doing that means constantly worrying about getting stranded with a low battery, you’ll probably choose the gas guzzler.

This aspect of owning electric cars is the biggest obstacle to their widespread adoption. Most folks choose not to deal with “range anxiety,” so electric cars command only a tiny percentage of the U.S. auto market.

However, some of the world’s smartest people are working on overcoming this obstacle. They have access to billions of dollars in capital to further research and development. After all, they know that a big breakthrough in EV technology will put them in a position to dominate the future of the car industry... while enjoying all the power and profit that will come with that position. While many companies are battling to become the king of electric vehicles, the face of the EV revolution is the brilliant innovator Elon Musk.

Musk has achieved fame and fortune through a career of disrupting established industries. He disrupted payment processing with his company Pay Pal. He has disrupted commercial space travel with his company Space X. He has disrupted the car industry with Tesla’s electric cars. Now, Musk and his fellow electric automakers are set to disrupt the copper industry.
With the Bolt, GM won an early battle over Musk. But this war – which will go down as one of history’s greatest business wars – is far from over.

**Electric Vehicles: On the Cusp of a Super Boom**

In addition to earning a spot in automotive history, the Chevy Bolt is getting great press. It was named the 2017 Motor Trend Car of the Year. The popular car reviewer said, “The groundbreaking Chevrolet Bolt EV is the car of tomorrow. Today.”

Another electric car to win a recent Motor Trend Car of the Year award is the Tesla Model S. Motor Trend said the Model S was a “truly remarkable automobile.”

Because of favourable press and climate change concerns, sales of electric cars are starting to boom... and they’ll continue to boom in the future.

Just 10 years ago, there were virtually no electric cars on the road. In 2017, an estimated 1 million new electric vehicles will be sold. This science experiment is now the real deal, and it is changing the car consumer mindset. Below is a chart that shows the enormous increase in global EV sales since 2010.

A driving factor in building affordable electric vehicles is a decrease in the cost of car batteries. Since 2008, the cost of an electric car battery has declined by 80%. (See Chart 1) that shows this dramatic decline.

The International Energy Agency has set a target of 12.9 million electric vehicles on the road in major markets by 2020 and 100 million by 2040.

According to Bloomberg’s New Energy Finance group, by 2025, over 5 million electric vehicles will be sold each year. This is a giant 887% increase over 2016’s level. (See Chart 2) that shows the Katusa Research electric vehicle annual sales forecast.

The seismic shift from gasoline-powered cars to electric vehicles is a generational change. Despite GM’s early win with the Bolt, Elon Musk and Tesla remain the poster children of EVs. In fact, Tesla is now comparable by market capitalization to GM and Ford... while selling a fraction of the number of cars of GM or Ford.

**The Safe, Sure Route to EV Profits**

Over the coming years, many people will make bets on who will win the great EV race.

Will it be Elon Musk and Tesla?
Will it be GM? BMW? Audi?
Nissan? Toyota?
Will it be an upstart we haven’t heard of yet?
Picking technology winners is a very tough game. It’s a constantly changing landscape. Technological innovation is accelerating at an incredible pace. Today’s dominant force is tomorrow’s loser.

I know Electric Vehicles are on the cusp of a super boom... and therefore a huge investment opportunity. But instead of trying to pick which car companies satisfy the tastes of the fickle public, I’d rather take the smarter, surer route for profiting during this boom...

I’m going to sell every EV maker copper, a metal they must consume in huge quantities for decades in the future.

Demand for this critical EV ingredient is set to boom.

Regards,
Marin

P.S. In my next essay, I’ll explain why copper is the single best bet on the coming super boom in Electric Vehicles. *More to come.*

*Article contributed by: Marin Katusa, Founder of Katusa Research, Bestselling Author and Investor*  
*For more information on how to profit from the coming boom in electric vehicles, check out [katusaresearch.com](http://katusaresearch.com)*
Cobalt Overview

Vulnerable Cobalt

PETER M. CLAUSI, CEO, CBLT INC.

Cobalt on the London Metal Exchange is up from USD$10 a pound in February, 2016 to almost $30 today. To determine what’s next for #27 on the periodic table, disregard the LME for a moment and look at the fundamentals. Cobalt is a small market. In 2016, global production of cobalt was roughly 100,000 tonnes. Compare that to 2016’s global copper production of over 18,000,000 tonnes, and to the 11,900,000 tonnes of zinc. That small size makes cobalt extremely vulnerable to any supply chain disruption.

That already-fragile supply chain is further imperilled because roughly 60% of the world’s cobalt comes from the Congo, one of the most unfortunate places on the planet. Since King Leopold II of Belgium (aka, The Butcher of the Congo) invaded in the late 1880’s, the only consistencies for the long-suffering Congolese have been war, human rights abuses, disease, slavery, child labour, shortened life spans and famine. The Four Horsemen of the Apocalypse graze their horses in the Congo.

Those horrors are compounded by foreign interference and political instability. As just one example, the 2016 presidential election are scheduled be held in December, 2018.

It’s extremely difficult to efficiently operate any business in such an environment, let alone one as complex as a mine.

Then consider that 98% of the world’s cobalt is a byproduct of nickel or copper mining. There is no such thing as a pure cobalt mine. Without the other metals in the deposit being economic, the cobalt won’t be developed. Globally, there are very few projects capable of near-term injection of any significant amount of cobalt into the supply chain until at least 2020.

Finally note that there no significant stockpiles, that no black market for cobalt exists, and that as of yet there is no proven recycling technology. The supply of cobalt is dependent almost entirely upon new production.

(continued on page 8)

Top 10 Cobalt-producing Countries 2016

Democratic Republic of Congo was the top cobalt producer in 2016 by a long shot, followed by smaller producers including China, Canada, Russia, Australia, Zambia, Cuba, Philippines, Madagascar and New Caledonia.

1. DR of Congo 66,000 MT
2. China 7,700 MT
3. Canada 7,300 MT
4. Russia 6,200 MT
5. Australia 5,100 MT
6. Zambia 4,600 MT
7. Cuba 4,200 MT
8. Philippines 3,500 MT
9. Madagascar 3,300 MT
10. New Caledonia 3,680 MT

Source: https://investingnews.com
Cobalt Companies

Global Energy Metals
Engaged in the exploration of resource properties. It conducts all of its operations in Canada. It projects includes Millennium Cobalt Project and Werner Lake Cobalt Project.
www.globalenergymetals.com

Cobalt Power Group
An exploration company focused on exploring and developing mineral properties in Canada. Its properties are Brownell Lake Property, Laurier Graphite Property, Rambo Property and Smith-Cobalt Property.
www.cobaltpowergroup.com

CBLT Inc.
Engaged in the business of acquiring, exploring and dealing in mineral properties in Canada.
www.cbltinc.com

(Vulnerable Cobalt, continued from page 7)

Against that limited supply the world is experiencing unprecedented demand growth for cobalt. It is needed for the cathode in rapid charge/discharge lithium-ion batteries. For almost every current configuration of rapid charge/discharge lithium-ion batteries, there is more cobalt than lithium in the battery.

It’s not just cell phones, laptops, toothbrushes and power tools. The movement to electric vehicles is a large part of the demand. For example, each Tesla Model 3 (batteries made by Panasonic) requires roughly 15 kilograms of cobalt per car, which at 500,000 cars will consume over 8% of the world’s annual supply. This would be incremental consumption on top of the existing market.

Estimates for global EV production for 2019 average around 3,000,000 units. Each one will need cobalt. Even assuming conservatively that each vehicle needs ‘only’ 10 kg of cobalt, that’s 30 million kg or roughly 13,000 tonnes of incremental demand from the battery manufacturers. That would strain the supply chain further. Volkswagen knows this and has been actively searching the globe for downstream investments into cobalt projects so as to secure a reliable source of this crucial metal. So far, it’s been an unsuccessful search.

The battery manufacturers and the end retailers like Volkswagen are distinct entities. For example, none of Apple, Tesla, DeWalt or Johnson&Johnson make their own lithium-ion batteries yet each of them sells products powered by lithium-ion batteries. Those retailers are public-facing and depend on a continued social licence with the public to operate.

That social licence may soon be impaired due to a growing movement to force those retailers to honour an ethical supply chain on cobalt. They would have to trace all cobalt back to source to prove it was not sourced from human rights abuses, child labour or slavery. If they can’t prove it, they can’t use the cobalt. If Amnesty International is successful in this campaign, expect to lose at least 10% of the world’s cobalt supply due to an inability to prove the integrity of the supply.

What does all that mean for cobalt? Economics101 has already taken cobalt from its Feb/16 low to today’s pricing, and there’s no fact to suggest that rise won’t continue. Expect continued price increases until at least 2020. The wildcard of an ethical supply chain could be a multiplier of the price.

Article contributed by: Peter M. Clausi, CEO, CBLT Inc.
Total cobalt demand to exceed 120,000 tonnes per annum by 2020, up approximately 30% from the 93,950 tonnes consumed in 2016 (Darton Commodities, 2016).

Expectation for projected battery consumption will account for ~60% of all cobalt demand in 2020, representing a 58% increase in battery demand from 2016 levels (Darton Commodities, 2016).

75% of all Lithium Batteries will contain Cobalt
1/5 of Cobalt demand will be driven by Electric Vehicles

### The Cost of Cobalt

Sources: [www.globalenergymetals.com](http://www.globalenergymetals.com) and [https://www.energyandcapital.com](https://www.energyandcapital.com)
Graphite Overview

Special Report: How to Invest in the Graphene Revolution

NICK HODGE, OUTSIDER CLUB RESEARCH

You might’ve seen graphene in the news lately because of the incredible advances it’s bringing about in the medical field, the energy sector, defense, and so on.

And here’s why: It’s 200 times stronger than steel, thinner than a sheet of paper, and more conductive than copper.

Researchers at the UK’s University of Manchester note it’s “almost one million times thinner than a human hair.”

“It is not only the thinnest material in the world,” says the New York Times, “but also the strongest: a sheet of it stretched over a coffee cup could support the weight of a truck bearing down on a pencil point.”

Bloomberg adds: “Lighter than a feather, stronger than steel, a superior electrical conductor to copper: According to its champions, graphene could unlock a new era of super energy-efficient gadgets, cheap quick-charge batteries, wafer-thin flexible touchscreen computing, and a sturdier light-weight automobile chassis.”

Bottom line: Graphene has the potential to completely revolutionize entire industries, creating bendable phones and touch screens... tiny self-powered oil and gas sensors... even synthetic blood that can be used in any person on the planet. Graphene Image

Incredible, isn’t it?

And because of its possible future applications in technology, it has been generating significant buzz among scientists worldwide since its discovery.

Strategic metal experts are already calling graphene the “… most important substance created since synthetic plastic a century ago”

It’s no wonder the two Russian scientists who discovered it were awarded the Nobel Prize in physics — as well as knighthoods.

(continued on page 11)

Top 10 Graphite-producing Countries 2016

China was the top graphite producer in 2016 by a long shot, followed by India, Brazil, Turkey, North Korea, Mexico, Canada, Russia, Norway and Madagascar.

1. China 780,000 MT
2. India 170,000 MT
3. Brazil 80,000 MT
4. Turkey 32,000 MT
5. North Korea 30,000 MT
6. Mexico 22,000 MT
7. Canada 21,000 MT
8. Russia 15,000 MT
9. Norway 8,000 MT
10. Madagascar 8,000 MT

Source: https://investingnews.com
“Graphene doesn’t just have one application,” says Andre Geim, the Russian scientist who made the find along with Konstantin Novoselov.

“It is not even one material. It is a huge range of materials. A good comparison would be to how plastics are used.”

I’d say plastics is a conservative comparison. Graphene has far more high-tech uses than plastic — and is poised to be much more lucrative...

Scientists are hailing it as a miracle cure for industries ranging from fiber optic data transmission to nuclear energy to lithium-ion batteries.

Since graphene has a high strength-to-weight ratio, it’s the perfect material for use in automobiles, rockets, boats, turbine blades, airplanes, and more.

Take a look at what hundreds of researchers, companies, and governments are already doing with the strongest, thinnest, most conductive material ever discovered:

- Engineers at Northwestern University have made a graphene electrode that allows lithium-ion batteries to store **10 times as much power and charge 10 times faster.**
- MIT Engineering Professor Jeffrey Grossman believes solar cells made from graphene could produce **10,000 times more energy from a given amount of carbon than fossil fuels.**
- University of Manchester researchers have created a device that “could help detect the presence of drugs or toxins in the body or dramatically improve airport security.”

According to the *Daily Mail:* “A graphene credit card could store as much information as today’s computers,” and that "will lead to gadgets that make the iPhone and Kindle seem like toys from the age of steam trains."

The BBC says: “It could spell the end for silicon and change the future of computers and other devices forever.”

Amazingly, the Israeli Army is even using the material to make invisible missiles.

Fact is graphene makes:

- **Solar** — 50x-100x more efficient
- **Semiconductors** — 50x-100x faster
- **Aircraft** — 70% lighter

The applications for this “wonder material” appear endless.

*This Super Material “Will Change the World.”* — Huffington Post

I’m extremely bullish on graphene’s future prospects, and so is one of the men who discovered it, Nobel recipient Konstantin Novoselov:

“I don’t think it has been over-hyped... It has attracted a lot of attention because it is so simple — it is the thinnest possible matter — and yet it has so many unique properties. There are hundreds of properties which are unique or superior to other materials. Because it is only one atom thick it is quite transparent — not many materials that can conduct electricity are transparent.”

And speaking of transparent, scientists at the University of Texas, Dallas have made a graphene invisibility cloak by heating up a sheet of the material with electrical stimulation.

Again, this isn't science fiction. This is happening right now.

Novoselov says, “It’s a big claim, but it’s not bold. That’s exactly why there are so many researchers working on it.”

So many, indeed: Over 200 companies are pursuing graphene opportunities, and it’s been the subject of thousands of peer-reviewed research papers.

Just recently, *Bloomberg* reported: “University-led research projects to investigate graphene won $1.35 billion in European Union funding.”

That’s a true testament of faith in this “wonder material.”

“Analysts say the first graphene-intensive products should come to market within 18 months,” says Businessweek, “with IBM, Samsung, and Nokia among those racing to be first.”

And now the global race is on — with a huge increase in patents filed to claim rights over different aspects of graphene...

The BBC reports: “A surge in research into the novel material graphene reveals an intensifying global contest to
lead a potential industrial revolution.”

**Graphite’s “Rare Earth” Moment**

There are two ways to make graphene. One is done in a lab, similar to how solar cells are made, with a process called chemical vapor deposition. Most of today’s graphene is made this way. It’s ultra-pure and the process can be easily controlled.

But it’s expensive and often cost-prohibitive.

The lower cost way to make graphene is by using naturally occurring graphite. This market is developing now and will be much larger than the synthetic graphene market because it can be used in high-volume consumer electronics.

Yet only a few companies around the world have access to mineral graphite, which is the resource required to make graphene...

And up to this point, China has had a tight grip on the worldwide graphite supply, controlling over 70% of it.

Like it did with rare earths, China has limited graphite exports with quotas — imposing a 20% export tariff and a 17% value added tax (VAT), causing graphite prices to rise. What’s more, due to environmental concerns, China has ordered restrictions on any further graphite mines in two of its largest graphite-producing regions.

All this has set the stage for non-Chinese based production to come online...

Leaving the door open for graphite mining operations in other parts of the globe as most of the world’s major economies perceive the mineral as being necessary for technological and industrial progression.

“China has a stranglehold on natural graphite supply,” says Simon Moores of Industrial Minerals. “This, together with a generation of under-investment in mines around the world, is creating a very tight supply situation.”

Already, Future Markets, Inc. reports a 4,000% increase in demand for graphene-based materials...

Which could send graphite prices higher as demand for this mineral starts outpacing supply as is forecast.

That’s why graphite has been named a “supply critical mineral” and a “strategic mineral” by the United States and the European Union.

This created sort of a “graphite bubble” from 2010-2013, when prices for large flake graphite tripled, from just under $1,000 per metric ton to over $2,700.

All of a sudden there were graphite companies coming out of the wood work, just like there were new rare earth companies during the rare earth boom.

But what most failed to realize is that graphite is a relatively tiny market in terms of both amount of graphite used and its cost. The world uses about 1.1 million met-
ric tonnes of graphite annually at a value of around $1.1 billion. The synthetic market is worth about $13 billion annually.

In size terms, that’s much smaller than zinc or nickel or aluminium. And in dollar terms, the annual market for cobalt at $3.5 billion is three times larger than for natural graphite. The zinc market, at $26 billion is 26X larger than the graphite market.

As the world realized it didn’t need ten new graphite mines to come online, but more likely one or two, prices started to come back to earth.

Graphite prices have now gone full circle inside of seven years.

A lot of “would be” graphite miners have gone by the wayside as well.

And now that the graphene and graphite markets have passed “mania stage,” there are a few ways to invest in it.

**Background**

We’ve all seen what the commodity supercycle has done to copper, gold, and many other resources.

Copper traded between $0.50 and $1.00 per pound for decades. And then, because of the commodity supercycle, it went over $4.00.

Same with gold. It used to sell for between $250 and $500 per ounce. It went over $1,800 in 2011.

That isn’t inflation. That’s the commodity supercycle.

Many things have caused this change, the big one being China, with India soon to follow.

And in the mining industry, the deposits we’ve lived off for years have been the big, low-cost, easy-to-find mines. Just like with oil.

But those mines are all getting deeper and older, so costs are increasing. Engineering and environmental standards have gone up and there’s been capital and cost inflation.

So gold can’t go back to $400 per ounce. And copper can’t go back to $1.00 per pound.

Graphite has been one of the last minerals to respond to this commodity supercycle. And the reason for that is there was excess production capacity from China.

There is still plenty production in China, which accounts for 75% of the world’s graphite production.

But it’s that very monopoly that has governments and investors looking for quality non-Chinese graphite supply.

**Nick Hodge** is an American financial author, publisher and commentator. He is the author of *Energy Investing for Dummies* along with Keith Kohl and co-author of the bestselling *Investing in Renewable Energy: Making Money on Green Chip Stocks*.

Hodge is also the founder of the **Outsider Club**.
Battery Metals are definitely a sector that we’ve been quite active in for the last couple years, and will continue to be. Looking at commodity pricing, Natural Gas is a disaster, Oil has already come up a little - I prefer some of these battery metals – the sky’s the limit on some of those. We have investments in Vanadium, Cobalt, Lithium, Graphite- one thing I’ve done differently this cycle is invest in more secure jurisdictions. I don’t really have much interest in going to see a Graphite mine in the Congo or somewhere in Africa when there are a lot of quality assets in First World countries that have lower risk, so a lot of our focus right now is North America.

Steve Palmer, President and Chief Investment Officer
Alpha North Asset Management

Graphite Company

Berkwood Resources Ltd.
Berkwood Resources Ltd is engaged in the exploration and development of natural resource properties. Its portfolio includes Lac Gueret extensions graphite project and Cobalt ford project.
www.berkwoodresources.com

"The battery metals space is one that is about to grow exponentially! The writing is on the wall as we read every day how another existing major car manufacturer announces that it too will be converting half or all of its model of cars by such and such a date. Once the big boys, VW, GM, Ford, Mercedes, BMW, etc. really get in the electric vehicle game, Tesla may seem like the small fish in a very big ocean."

Thomas Yingling, President, CEO and Director
Berkwood Resources Ltd.
Companies with graphite potential, have tried to treat graphite projects like gold, copper, or nickel projects. Buy a piece of land, drill it, get a resource, complete a feasibility study, and sell the product. In most cases they have convinced the stock market that the bigger the resource, and the higher production numbers, they will create value, by providing huge NAV and IRR numbers and will produce 50,000 to 350,000 tonnes a year. Currently the largest mine in the world is 40,000 tonnes per year, and its not one big mine but multiple pits, with a centralized processing plant. It took 60 years to get this level of production. The biggest mine in China is 20,000 tonnes, and China produces 60-70% of the worlds graphite. An Australian public company, has built a mine that was designed to produce 350,000 tonnes a year, but without the 350,000 tonnes of offtake, earnings will be challenging. Many projects will fail or never see production, since the building of a business takes time, and a graphite mine must be able to start small and build up with its customer base. The 50,000 tonne per year model does not work.

It is true the demand for graphite for lithium Ion batteries and the expandable market is exploding. Bloomberg recently stated, "The world may need the equivalent of 35 of the so-called Gigafactories like the one built by Tesla founder Elon Musk in Nevada over the next 13 years to meet the power demands of electric cars." Bloomberg also stated, in reference to lithium ion batteries that, "Graphite demand will soar to 852,000 tons a year in 2030 from just 13,000 tons in 2015."

The winning formula is to start as a small, (10-20,000 tonne) low cost, high quality produce, and build up. How does a company do that?

Low cost – the largest mine in the world produces for weathered rock, Saprolite. They can dig up the material with an excavator. Saprolite is found in hot wet climates, found in certain parts of Madagascar, Brazil, and other parts of Africa.

Low cost – infrastructure. John Hykawy of Stormcrow capital was asked, "How do you think junior graphite companies will be able to compete with Chinese pricing?"

He responded, "The only way they’re going to be able to do it is two factors, really. It’s type of deposit and the old adage of location, location, location. So, producing in a very remote location, even with a deposit that’s really high-quality but in hard rock is probably a lost cause. What we’re going to be looking for are fairly high-grade deposits, hosted in friable rock or in sediments, in clays, so that the mining required is very inexpensive, the processing is available, and hopefully this deposit is also close to the coast or close to highways so it can be transported out relatively simply and relatively inexpensively."

Start small – hard rock deposits are not profitable at 10-20,000 tonnes per year.

High quality – According to Caesars report, "Among the global graphite buyers, Madagascar is renowned for its large size and high-quality flake."

DNI Metals, two low-cost Saprolitic deposits, 50 kms to a world-class port, on a paved highway. High quality, jumbo flake in Madagascar. Low cap-ex, experienced team (built operated graphite processing plants). And most important, DNI has customers.

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**Expected New Lithium Ion Battery Capacity in 2020**

- **US**: 30%
- **China**: 60%
- **Other**: 10%

Includes Korea, Europe and Taiwan

Source: Benchmark Mineral Intelligence

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**Graphite Company**

**DNI Metals Inc.**

DNI Metals Inc is an exploration stage company. The Company is engaged in exploration and evaluation of mineral properties.

www.dnimetals.com

View Quote: C.DNI
Top 8 Lithium-producing Countries 2016
Australia was the top lithium producer in 2016, followed closely by Chile. Argentina, China, Zimbabwe, Portugal, Brazil and the United States are contributed with significantly lower amounts.

1. Australia 14,300 MT
2. Chile 12,000 MT
3. Argentina 5,700 MT
4. China 2,000 MT
5. Zimbabwe 900 MT
6. Portugal 200 MT
7. Brazil 200 MT
8. United States Unknown

Source: https://investingnews.com

Lithium Companies
American Manganese Inc.
Engaged in recycling of Lithium Ion Electric Vehicle Batteries based on the company’s patented process for producing electrolytic metals (EMD), (CMD) and (EMM) from ultra-low grade manganese deposits.
www.americanmanganeseinc.com

“"If you can’t recycle 100% of the cathode metals you do not have a green and environmentally closed circuit for EV production.”
Larry W. Reaugh, President and C.E.O. American Manganese Inc.

Lithium Overview
Why lithium, why now?

RICHARD (RICK) MILLS
As a general rule, the most successful man in life is the man who has the best information.

Our ‘who cares’ attitude towards pollution and habitat destruction are all increasing what were once tolerable pressures towards, and sometimes already beyond, the breaking point in ecosystems all over the world.

Fortunately, people, governments, and corporations are waking up and trying to reduce their carbon footprint.

Our attitude towards environmental issues is changing, we are responding to potentially catastrophic climate change and to global (and all the way down to the micro-local and individual levels of), environmental degradation.

One of the results of our rising awareness, and taking personal responsibility for our own actions, is that we are in the early

(continued on page 17)
stages of a major, decades-long transition in how energy is produced and stored. A global energy transition, from the burning of fossil fuels for energy and transportation, to using renewable non-polluting solar and wind energy is underway.

Lithium powers many of today's handheld tools, our modern mobile communications, our computing devices and increasingly our transportation system. Lithium-ion is the leading energy storage technology, one cannot understate its importance in transforming not only communications gadgets into marvels of handheld technology but in taking electric cars from a niche curiosity into a major clean energy revolution for the transportation sector.

“The top five lithium ion battery manufacturers are ramping up capital expenditure with a view to almost tripling capacity by 2020.” The Economist

China and India are both going to 100% electric vehicles. Every major car manufacturer has electric models. Volvo has even promised to phase out traditional internal combustion engines (ICE) from 2019.

France has promised to end the sale of gasoline and diesel vehicles by 2040, the U.K. quickly followed suit.

(continued on page 18)

“The vast majority of the cobalt mined today is done as a secondary metal to primary copper and nickel mining in places like the Democratic Republic of Congo. As the market for electric vehicles grows, It is going to be critical to create secure domestic/North American and primary source of mined cobalt to provide a stable future market for lithium ion battery production for electric vehicles.”

“The location of the specific lithium or cobalt mineral exploration properties is a critical factor when investing in mining exploration companies. If mineral exploration properties are located in safe mining jurisdictions like Chile or Canada, and in areas with known concentrations of lithium and cobalt, you have increased your chances of making a profitable investment.”

Tim Fernback, President and C.E.O.
LiCo Energy Metals Inc.
Gigafactory’s making lithium-ion batteries for electric vehicles are springing up across the globe. Tesla’s Nevada Gigafactory, to be completed in 2018, will produce more lithium-ion batteries than were produced globally in all of 2013. Elon Musk, Tesla’s CEO has already announced plans to build four more Gigafactory’s. By 2021, Chinese Gigafactory’s will provide 3.5 times more gigawatt-hours of battery cells than Tesla’s current Gigafactory. Europe recently announced five Gigafactories will be built. Bloomberg reports that global battery-making capacity is set to more than double by 2021, topping 278 gigawatt-hours a year compared to 103 gigawatt-hours at present. “Lithium isn’t a bubble, it’s a fundamental change in energy usage.” financialpost.com Morgan Stanley analysts project that by 2050, 81% of 132 million new auto sales will be electric.

Danger Will Rogers Danger

There’s a looming problem. “It’s not clear that the resource supply chains exist yet for all these factories.” David Hart, director E4tech Translation – There isn’t enough lithium currently being mined to supply all those Gigafactory’s.

“We estimate the lithium industry is going to need between $4-$5 billion of investment out to 2025.” Simon Moores, Benchmark Minerals Intelligence The potential for supply-demand gaps to open up over the coming decade is significant, a supply shortage of lithium will cause major issues in the battery supply chain. Elon Musk said, in 2016: “In order to produce half a million cars a year ... We would basically need to absorb the entire world’s lithium-ion production.”

Exposure to lithium

With the massive coming increase in demand for lithium – because of the massive swing away from burning fossil fuels to a battery fuelled transportation system still in its infancy – and a supply chain not capable of meeting the increase now is a great time to be looking at select lithium stocks. Be warned, lithium prices aren’t cheap. Lithium focused companies had a great 2016. For most, the trend continued into 2017. Some have seen a pullback in share price and in your author’s opinion are at an attractive entry point. Production and near-term production stories would seem to offer the best leverage, or exposure, to rising lithium demand. Market share for the “Big 3” lithium producers, the New York listed chemical companies Albemarle, Sociedad Quimica y Minera de Chile and FMC, has dropped from about 85 percent to 53 percent – China now has about 40 percent of the world’s market share. Also listed are several near-term producers; Lithium Americas Corp., MGX Minerals Inc., and Nemaska Lithium.

Albemarle (NYSE:$ALB)

After acquiring Rockwood Holdings in 2015 Albemarle inherited the U.S.’s only producing lithium mine, the Silver Peak lithium mine in Nevada. Tesla, with its Gigafactory in Nevada, plans to produce as many as 500,000 battery packs per year and will consume nearly all of today’s current global annual lithium supply to do it. Outside the U.S., Albemarle produces from its assets in the Salar de Atacama in Chile and from a 49% stake in the massive hard-rock Greenbushes mine in Australia where the company is planning on a doubling of production. Albemarle has asked Chile’s government to allow it to raise its lithium production quota to 180K metric tons/year from the current 80K tons/year limit. “Lithium isn’t a bubble, it’s a fundamental change in energy usage.” financialpost.com

MGX Minerals Inc. (CNX:$XMG)

Petrolithium focuses on concentrating lithium and other minerals from the abundant brine that accompanies oil
MGX has a patent pending, proprietary, low-energy process specifically designed to rapidly concentrate lithium and other minerals from highly-mineralized brines associated with oilfields. MGX’s patented technology separates heavy metals and hydrocarbons from brine, purifying the wastewater and creating a steady flow of brine feedstock for MGX’s recovery process.

The wastewater treatment industry is expected to grow into a $45 billion market annually by 2025, globally O&G producers are increasingly looking for opportunities to reduce wastewater handling costs. MGX has entered water/brine testing and analyses agreements with major oil companies across North America and has completed testing at more than 25 locations providing an initial pipeline of mineral and water handling projects.

MGX has also recently signed an agreement with Power Metals Corp. to acquire all of the company’s current U.S. petrolithium brine assets and a 20-per-cent working interest in all of the company’s current hard rock assets and any future assets that the company acquires for the next 36 months.

MGX Minerals also has magnesium and silicon projects.

**Sociedad Quimica y Minera de Chile (NYSE:$SQM)**

The company’s largest assets are in the Salar de Atacama, or the Atacama Salt Desert – considered to have the highest lithium and potassium concentrations ever recorded. Beyond its lithium business, SQM is also a significant potash producer and the world’s largest producer of iodine. SQM is the world’s lowest cost producer of lithium and is intent on greatly expanding capacity.

Many might consider SQM expensive as its stock sells for more than 40 times trailing earnings and 30 times forward earnings versus 25 times forward earnings for ALB and 18 times forward estimate for FMC Corp.

**FMC (NYSE:$FMC)**

FMC’s lithium operations are next to SQM, in the Salar del Hombre Muerto of Argentina.

FMC’s lithium segment jumped 45% in the first quarter of 2017 from the year before.

The company is fast ramping up its global lithium hydroxide production capacity to serve the growing electric vehicle market. In July, 2017 FMC Corp said it plans to expand lithium hydroxide capacity by 8,000 tonnes next

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### Lithium Company

**Argentina Lithium & Energy Corp.**

Argentina Lithium & Energy Corp, formerly Iron South Mining Corp is a natural resource company. It is a natural resource company engaged in the acquisition and exploration of resource properties in the Americas and Argentina.

[www.argentinalithium.com](http://www.argentinalithium.com)

“We believe that the “technology metals” are poised for a strong several years as the battery market continues to expand due to the big government mandates to phase out use of gasoline vehicles in countries like China. While there are other potential methods of energy storage, we believe that lithium will continue to thrive as a proven and tested model. We see that the Lithium triangle will form the best investment thesis for low cost high margin projects that we see has the best success to adequately supplying the lithium market.”

Nikolaos Cacos, President and CEO

Argentina Lithium & Energy Corp.
year to 18,000 and further boost output to 30,000 tonnes over the next several years.

“There will be more EVs on offer than internal combustion engines 15 years from now.” Mark Fields, CEO Ford Motor Co.

Lithium Americas Corp. (TSX:$LAC)
Lithium Americas has a joint venture with Sociedad Quimica y Minera de Chile (SQM) for the Cauchari-Olaroz project in Jujuy, Argentina. Cauchari-Olaroz is believed to be the world’s third-largest lithium brine resource.

SQM and Lithium Americas plan to develop their JV Cauchari-Olaroz project with targeted production of 50,000 tpa of LCE.

The benefits of this joint venture include an opportunity for Lithium Americas to apply its recently gained operational know-how to its solely-owned Clayton Valley Lithium Nevada project.

“Lithium supply security has become a top priority for technology companies in the United States and Asia.” United States Geological Service

Nemaska Lithium (TSX:$NMX)
Nemaska Lithium is one of the only companies in the world looking to produce lithium hydroxide (the most valuable battery-grade lithium ingredient) directly instead of from lithium carbonate.

The spodumene concentrate produced at its Whabouchi mine in Quebec will be shipped to the Corporation’s lithium compounds processing plant to be built in Shawinigan, Quebec. This plant will transform the spodumene concentrate into high purity lithium hydroxide and carbonate using the proprietary methods developed by the Corporation, and for which the Corporation holds four patents.

Goldman Sachs, in 2016 said: “Every 1% increase in electric vehicle penetration would increase demand by 70k MT (LCE) per year.”

Conclusion
If, as the Financial Post says, lithium is a fundamental change in energy usage does that mean lithium is the new petroleum? Are internal combustion engines going to be replaced by more efficient energy technology much like petroleum replaced coal, and coal replaced wood?

Lithium is a strategic green metal. Grand View Research Inc., in its report, has placed the world lithium-ion battery market at $93 billion by 2025, with a 17% compound annual growth rate.

Investors should seriously consider Lithium as a long term hold with respect to this ever growing demand.

Cobalt Company
Quantum Cobalt Corp.
Quantum Cobalt Corp is engaged in acquisition, exploration and development of mineral properties including cobalt resource properties.
www.quantumcobalt.com

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StockTalk Investors Guide - The Buzz on Blockchain
Nickel Overview

Could EV demand cause a shortage of battery-grade nickel?

ANDREW TOPF

Nickel: The dark horse in the EV battery race
Without a doubt, the barn door that has been cracked open on electric vehicles (EVs) is only going to swing further. One recent projection puts EVs at 16% market penetration by 2030 and 51% by 2040. Several countries including China, France and the UK have signalled they will eventually ban gas-powered vehicles, and one auto-maker, Volvo, recently announced that starting in 2019, all models will be hybrids or electrics.

This has investors flocking to companies that mine lithium and cobalt – two key ingredients of batteries used in EVs. But it’s a lesser-known fact that nickel, a cheaper, up-to-now industrial metal used primarily in stainless steel, will also be needed for EV batteries. In fact, so much nickel could be demanded in the next few years that analysts are predicting a shortage of battery-grade nickel.

Investors who can identify companies with properties that contain this type of nickel stand to make a bundle, especially those in the early exploration stages.

Why is nickel important?
Because more nickel in the battery solves the two major impediments to mass adoption of EVs, which are range and cost. Nickel cathodes (the part through which electrons enter the battery) intrinsically have a higher energy density. The more nickel content, the longer distance you can travel and it also brings down costs. Right now the demand (a large part of it being speculation) for cobalt and lithium has spiked the prices of these two metals considerably, which ironically has made EV batteries (continued on page 22)
more expensive to produce and therefore dampens EV market growth. Since 2008 the price of lithium carbonate has doubled from around $4,500 a tonne to $9,000, while cobalt has tripled from $20,000 a tonne to $60,000 just in the last year.

Michael Fetcenko of BASF Battery Materials said during the Benchmark Minerals Cathode Conference: “You can get higher energy in two ways: you can take your existing cathode material and you can widen the operating voltage, or you can use higher nickel content.”

**Rising demand for battery-grade nickel**

The increased input costs of lithium and cobalt has battery and electric car manufacturers wanting to shift their current mix of materials to using less cobalt or lithium and more nickel, which is currently just under $12,000 a tonne. According to a recent report from UBS, if 15 million EVs are produced in 2025, it would mean an additional 300,000 to 900,000 tonnes per annum of incremental demand. That much new demand each year until 2025.

However, it is important to note that the 300 to 900 ktpa figure depends on the chemistry of EV batteries changing from the current 1:1:1 ratio of nickel-manganese-cobalt (NMC) batteries used for example in the Chevy Bolt, to 8:1:1 (eight times more nickel). UBS says the drivers for nickel are cobalt’s expected price surge, and the security of cobalt supply (65% of cobalt comes from the DRC, an unstable mining jurisdiction).

Another report from Wood Mackenzie confirms the UBS findings. Except the consultancy is more conservative than UBS, predicting that nickel uptake in all batteries including EVs "will be considerable, typically exceeding 200 kt by 2025." Wood Mackenzie also confirms that NMC batteries will be a key driver of battery-grade nickel:

“The current consensus is that NCM is likely to be the dominant battery type over the next ten years, signalling that a substantial boost to nickel demand is possible.”

To envision what would happen to battery metals demand should the world suddenly switch from gas-powered vehicles to EVs, UBS extrapolated data for a fictitious scenario where 100% of the world's automobile demand came from Chevy Bolts instead of the current auto mix.

Nickel demand would more than double, by 105%, lithium would take off by 2,898%, the need for cobalt would rise by 1,928%, rare earths demand would spike by 655%, and graphite by 524%, to name just the top five metals. The only metals that would drop are platinum and palladium, used in catalytic converters of gas- and diesel-powered engines; demand for PGMs would fall by 53%.

In this scenario, even more nickel would be demanded for Teslas, whose nickel-cobalt-aluminum (NCA) cathodes made by Panasonic are 80% nickel, versus the Bolt’s NMC batteries which use equal parts nickel, manganese and cobalt.

According to Elon Musk, Tesla’s batteries should be called “nickel-graphite” because the cathode is nickel and the anode is made of graphite and silicone oxide. In fact, nickel is the most important metal by mass for lithium-ion batteries (see infographic below).

[click on image above to view full infographic from The Visual Capitalist.com]

Indeed the future chemistry of EV batteries will play an important role in the story of how important nickel could become in this “green” auto shift.

There are four criteria that battery makers use to determine the best mix of materials: stability, energy capacity, energy density, and cost. The more cobalt and nickel that is added to a battery, the higher the density, but these materials are also less stable and more expensive than the competing lithium-iron-phosphate battery currently most (continued on page 23)
popular in China. LFPs do not use any nickel in the cathode. According to UBS, Korea’s Samsung SDI and LG Chem are developing an NMC battery with six times more nickel than currently, starting in the first half of 2018, then moving up to 8 times more nickel (an 8:1:1 combination). SK Innovation, another Korean battery maker, is also going for an 8:1:1 split. Meanwhile Tesla and Panasonic are planning on upping their NCA battery cathode to 85% nickel from its current 80%.

The loser in this changing battery chemistry will be cobalt, according to UBS. “The shift to lower cobalt NMC cathodes will reduce cobalt use by up to 70% by early next decade (holding prices equal).”

**Not all nickel will do**

Even without EVs, nickel – used mostly to produce stainless steel - is already one of the world’s most important metals with a market value around $20 billion. How much EVs affect nickel depends on their market penetration. EVs currently only account for 3% of nickel usage. But if they were to grow from 1% penetration to 6% that would result in 167,000 more tonnes of nickel demand according to Cairn Energy Research Advisors. Push that to 10% market penetration, and the demand for nickel rises to 400,000 tonnes, an amount that would trigger a nickel supply deficit, Ivan Glasenberg, the CEO of Glencore, one of the world’s largest nickel producers, has said.

But there is a problem supplying all that nickel. Two-thirds (62.4%) of the earth’s nickel supply is found in nickel laterite deposits, while only a third (37.5%) is contained in nickel sulphide deposits which have nickel grades high enough to be used in batteries. The nickel from laterite deposits is typically used to make nickel pig iron and ferronickel, while sulphide deposits can be mined to make nickel sulphate, which is appropriate for EV cathodes.

The nickel market has long been oversupplied by the big producers – Indonesia and the Philippines – that supply cheap nickel pig iron (NPI) to China, thus keeping a lid on prices. At around $4.36 a pound, 40% of nickel miners are losing money. Switching up the mix so that more companies mine higher-grade nickel for batteries is a way out of the price conundrum, states UBS.

“The battery opportunity offers a renaissance for long suffering producers of high grade nickel products which have lost market share to NPI & FeNi.”

However, UBS notes it will take a few more years for the loose nickel market to tighten up, predicting that EV demand is not likely to have any impact until 2020.

**Prepping for more nickel**

Korea’s top two battery makers SDI and LG Chem have already been mentioned as companies looking to build more nickel into their EV battery composites; other firms are moving in that direction as well.

Wood Mackenzie notes that Umicore, of Belgium, is predicting a 60% increase in its market for cathode materials through 2020, with two-thirds of that market expected to be nickel. In June BASF signed an MOU with Russian nickel and palladium miner Norilsk to supply nickel for lithium-ion batteries. BASF plans to invest $456 million to build new cathode materials production plants in Europe.

In China, the world’s largest producer of EVs, battery manufacturers are looking to migrate to nickel-containing batteries with several including Shanshan, Nichia, L&F & Reshine producing them, according to Wood Mackenzie. CALB & Sinopoly are also starting to produce NMC batteries.

Contemporary Amperex Technology Limited (CATL), a private Chinese company, recently entered into a four-year cobalt supply contract with Glencore to allow it to develop NMC cathodes for Volkswagen.

Miners are also getting in on the action. In August BHP, one of the biggest mining companies, announced it would invest $43.2 million to build the world’s largest nickel sulphate plant in Australia. Jinchuan, China’s top nickel producer, said it will start building a project next year in Guangxi that will produce raw materials for the EV battery market. The facility expects to produce 30,000 tonnes of nickel and 3,000 tonnes of cobalt annually. Sherritt, IGO, Western Areas and Vale have all expressed interest in mining more battery-grade nickel.

One of the most exciting nickel sulphide exploration prospects is in Greenland, where North American Nickel (TSXV:NAN) is advancing its Maniitsoq project, which has multiple mineralized targets spread across the 75
by 15-kilometre Greenland Norite Belt. Norite, is a mafic igneous rock and occurs within intrusions such as the Sudbury Igneous Complex – the second largest nickel complex in the world.

Fresh results from nAn’s 2017 drill program have extended the Mikissoq nickel-copper sulphide zone, discovered in 2016, by an additional 60 metres down-dip. Assay highlights from hole MQ-17-135 featured 75.75 metres at 1.10% nickel and 0.43% copper, including 10.25 metres at 2.29% Ni and 1.33% Cu, and 19.25 metres at 1.89% Ni and 0.26% Cu. (A grade higher than 1% over 10m is considered a good sulphide nickel intersection). Two drill holes at the Spotty Hill target also extended the known mineralization and indicate further potential at depth. North American Nickel plans to release additional assay results in the near future.

Battery-grade supply crunch and higher prices

Will there be enough supply? It’s a valid question, considering the expected explosion of growth in electric vehicles as the world slowly weans itself off fossil fuels. According to the UBS report, nickel pig iron and ferronickel have dominated market share over the past decade. This type of nickel is typically mined from low-grade laterite ores either from Indonesia or the Philippines and then shipped to China where it is converted into NPI. NPI is preferred by China’s stainless industry because of its low cost. Only half of all nickel produced is appropriate for batteries.

It is possible to convert laterite nickel into battery-grade material by high-pressure acid leaching (HPAL), but this process is expensive compared to making NPI.

UBS analyzed a number of high-profile nickel mines around the world and came to the conclusion that currently 949,000 tonnes per annum would be suitable for batteries – either from sulphides or from the HPAL process – while 827,000 tonnes are currently unsuitable.

It adds that producers of high-grade nickel products “could potentially benefit from the emergence of price premiums vs FeNi and NPI products as battery demand increases.”

But given that the market is currently saturated with NPI or ferronickel which is keeping prices at an unsustainably low level – it seems apparent that at least in the next few years - barring a dramatic shift to battery-grade nickel production – there will not be enough battery nickel to go around.

“The key conclusion is that mine supply growth that has occurred & likely to occur for the next few years is in a form that is inadequate to supply the battery supply market,” states UBS.

However longer term (ie. post -2020), the analysts seem to agree that EV demand will start to make a dent in nickel supply and prices could rise further, as the demand for battery-grade nickel increases.

“Although the capacity to produce nickel sulphate (the primary starting material for NCM or NCA) is expanding rapidly, we cannot yet identify enough NiSO4 capacity to feed the projected battery forecasts,” states Wood Mackenzie, adding that even if large producers like BHP switch over, “the question remains as to whether or not there will be enough nickel units left over to feed all the other segments of consumption.

“On that basis it would seem reasonable that the EV revolution could push future nickel prices to higher levels than we currently forecast.”

The conclusion for nickel investors is inescapable. While the market will remain oversupplied likely until 2020, the potential for price increases commensurate with increased EV production and demand for battery metals makes now an ideal time to take a position in an early-stage company. Those companies that are sitting on sulphide nickel deposits have a much higher growth potential than nickel laterite miners, especially the ones with management teams capable of bringing them to production. These will be the companies to watch as the EV shift kicks into high gear.

FULL DISCLOSURE: North American Nickel is a paid client of Stockhouse Publishing.
Vanadium is a super metal. It makes steel stronger.

SUPER METAL

Uses of Vanadium

50% of vanadium in the world is used in rebar

Vanadium is primarily used in rebar, but can also be found in car bodies, chassis and tools.

Source: https://investorintel.com

Top 4 Vanadium-producing Countries 2016
China was the top vanadium producer in 2016 by a long shot, followed by Russia, South Africa and Brazil.

1. China 42,000 MT
2. Russia 16,000 MT
3. South Africa 12,000 MT
4. Brazil 6,000 MT

Source: https://investingnews.com
Vanadium Overview

Is Vanadium Stealing Lithium’s Thunder?

MARC DAVIS

Lithium stocks are a hot commodity these days. We can all see that for ourselves.

This is clearly because lithium has become the undisputed poster-boy metal for the green energy revolution. And it’s in such big demand that lithium development companies (most of which are Canadian) are rushing to bring new supplies on-stream.

The pages of Stockhouse are well-populated by many of these success stories in the making.

Yet, in all this excitement, investors are overlooking an inconvenient truth: Lithium-powered batteries are not ideally suited to industrial-scale applications – the ‘Holy Grail’ of renewable energy.

Instead, it’s a much-lesser-known metal – vanadium – that is measuring-up as the best solution.

However, using clean renewable energy for grid-scale power storage is still not as sexy as using lithium ion batteries for all the electronic conveniences of our modern era. For instance, energy-dense lithium ion batteries are constantly in the news for making electric vehicles far more practical, user-friendly, and more performance-oriented. Indeed, Tesla Motors has done a fantastic job of evangelizing lithium-battery power as being super-cool. Yet lithium ion battery power has some serious limitations when it’s scaled up for brick and mortar applications that require massive amounts of stored renewable energy.

The Vanadium Imperative

Whereas the private sector is backing lithium-powered batteries in a big way, many G20 governments are taking a different tack. They are instead directing billions of dollars of grants into vanadium’s fast-emerging role in the electrification of society’s energy supplies.

That said, a small handful of publicly-traded vanadium developers are working diligently in the hope that they too will have their day in the sun, just like Canada’s many lithium start-ups.

The eventual aim of governments and corporations alike is to enable vanadium-powered batteries to provide uninterrupted solar and wind power to whole cities. That’s because vanadium can cost-effectively supercharge batteries of any size, even ones so big they have to be housed in substations for large-scale power grid usage (continued on page 27)
Most significantly, vanadium-enhanced batteries can store prolific amounts of energy, which solves the major drawback of alternative energy. For instance, solar power currently cannot be harnessed for use at night-time and when the sun doesn’t shine.

Pictured below: Likewise, the electricity generated by wind turbines presently goes to waste when the wind stops blowing or when the wind speed is too high or too low. That’s a big deal. It’s because any surplus of wind or solar power currently has nowhere to go – except to be either wasted or discharged back into the ground. So vanadium-powered forms of renewable energy are finally realizing their full potential now that they are able to provide uninterrupted supplies of electrical power on a serious scale.

In this regard, what are known as vanadium flow batteries (VFBs) are being developed to store large quantities of electricity produced during peak production periods. This energy will then be available to power grids to ensure a steady flow of energy. In fact, these batteries one day will be built next to transformers, where they can store up each community’s daily solar surplus, before releasing it back again in the evening.

Even the industrial sector will ultimately benefit. Large industrial facilities can now store energy during cheap off-hours rates and draw from the battery when rates are high, while ensuring resiliency in case of grid disruptions.

In fact, vanadium can cost-effectively supercharge batteries of any size, even ones so big they have to be housed in substations for large-scale power grid usage. This means that vast amounts of intermittent energy, namely wind and solar, can be stored with the capability of releasing it quickly on demand.

All told, vanadium flow batteries are the only type of batteries technology capable of powering everything from a single home (kilowatt hour capacity) to the storage demands of a power grid (megawatt hour capacity). They work by storing energy in a liquid electrolyte that circulates or “flows” between large holding tanks. This is what generates electricity. The bigger the tank, the more electricity can be produced.

Conversely, lithium ion batteries have their energy stored in tiny cells. You may only need several of them for your laptop computer or smart phone. However, as many as hundreds of thousands of them are needed for large industrial applications, such as powering a factory. This can be a prohibitively costly proposition.

**The Lithium vs Vanadium Comparison**

Here’s a comparison between the two competing battery technologies. And it demonstrates that each kind has its strengths and weaknesses as the world scrambles to embrace clean energy solutions:

- **Vanadium flow batteries are non-flammable and non-toxic, unlike lithium ion batteries, which can be combustible under certain circumstances and are harmful to the environment**

- **Lithium ion batteries have very short operational lives compared to vanadium batteries (1,000-2,000 recharges vs tens of thousands of cycles)**

- **Vanadium flow batteries can cost-effectively be made to store more energy simply by adding bigger tanks of electrolyte. Lithium ion batteries are not scalable in this sense. In other words, a doubling of capacity translates into a doubling of the cost**

- **Big vanadium flow batteries are bulky and expensive (and usually housed in shipping containers), whereas lithium ion batteries are small and ideal for small-scale applications, including automobiles**

- **Lithium ion batteries are solid-state, making them ideal for vehicles, whereas vanadium flow batteries are only suitable for stationary brick and mortar applications**

- **Vanadium flow batteries can charge and discharge simultaneously, unlike lithium ion ones**

- **Lithium ion batteries cannot release massive amounts of electricity instantly – over and over again – whereas vanadium flow batteries can**

- **Vanadium flow batteries can also be charged way faster than lithium ion batteries and can hold their charge far longer**

*(continued on page 28)*
The Verdict

Truth be told, neither form of battery technology is superior to the other. Lithium ion batteries and vanadium flow batteries are merely each suited to different applications.

To recap, vanadium flow batteries – which are typically housed in shipping containers – can supply on-site kilowatt-scale renewable power supplies for brick and mortar structures, like homes and factories. They can even inexpensively generate megawatts for grid-scale applications.

Conversely, lithium ion batteries work best in smaller applications and will be in huge demand with the electrification of the world’s transportation systems, especially automobiles.

Regardless, both metals play integral roles in the green energy revolution and will be in greater and greater demand going forward. So what does this mean for Canada’s publicly-listed lithium and vanadium developers? For many of them, it means a very bright future and the advent of much higher share price valuations.

Marc Davis, BNWnews.ca – Former floor trader, investment industry research analyst, journalist & CBC TV business reporter, Marc is steeped in news media & capital markets.

Image Sources: http://www.windpowerengineering.com and https://www.energyandcapital.com

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