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## Everyone is looking for a better battery



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**CEOCFO: Mr. Moore, the first thing I see on the ZAF Energy Systems site is "Changing the way we power the world." How are you doing that at ZAF?**

**Mr. Moore:** Currently, the world is being powered by an immense grid and it is moving towards being powered by renewables. Renewables, as we have found through a decade of experience, do not work well without some sort of storage facility to go along with the renewables. Storage, up to now, has really meant lead acid batteries, and with growing popularity, lithium ion batteries. I'm not saying nickel zinc will completely displace lead acid where lowest acquisition price is paramount or completely displace lithium ion where weight is the top priority. The problem with both of these technologies is that they have either power density challenges or recycling challenges, and both of them have safety and environmental problems associated with them.

Our chemistry, nickel zinc, is environmentally friendly. We could actually legally landfill our batteries. Of course, we are not going to do that, because the elements inside are valuable and recycling is a good thing, so we are going to recycle our batteries. The nice thing about nickel zinc is that, like lead acid which is very recyclable, we are also very recyclable. The problem with lead acid is that because you have lead smelters it becomes prohibitively expensive to recycle the lead and in eighty percent of the world lead is recycled inappropriately. In other words, the batteries are cracked open manually and sulfuric acid is allowed to spill into the ground with lead in suspension and then the lead gets picked up, in many cases, by women and children and put in open air crucibles or smelters, and as I said, about eighty percent of the world recycles that way. In studies, lead has proven to be the number one and the number three world's worst polluter; the cracking process being number one and the smelting process being number three.

**CEOCFO: What is it about the combination of nickel and zinc that works so well?**

**Mr. Moore:** If you put two dissimilar metals together and put a caustic liquid between them of any sort you are going to make some electricity. In other words, you can put a copper and a steel nail in an orange and it is going to make a certain level of electricity. Therefore, every two metal pairs, if you will, on the periodic table, will generate an electrochemical reaction when they are paired together. Nickel and zinc have the advantage of being about three times more energy dense than lead and almost as energy dense as some of the lithium ions, but without the problems of lead acid's low energy density and slow recharge time or of lithium ion in terms of flammable electrolytes or managing thermal runaway.

Nickel zinc has been around for over one hundred years. Thomas Edison had the first US patent that went back to the year 1901. Actually, nickel zinc was one of the first batteries used in electric vehicles and electric vehicles predated internal combustion engine vehicles. Nickel zinc batteries were used in some of the very first electric vehicles, but the problem was that they did not cycle very well. You could only get fifty or so cycles back then. Then lead acid came along and you could get more cycles out of lead acid, and so lead acid kind of took over the battery world and nickel zinc fell by the wayside. However, modern material science has come along to solve some of the problems around nickel zinc. Now our batteries are cycling seven hundred plus cycles.

**CEOCFO: *Who is using your batteries? How and where could they be used?***

**Mr. Moore:** Almost anywhere lead acid is used, we can be a substitute. We just installed a megawatt battery backup system in a data center. Data centers are an ideal application for our batteries. We have got a couple of military contracts now. One is for an uninterruptable backup power system for the Air Force and another from the Navy for the future submarine systems. Again, anywhere lead acid is used is a good candidate for us. Now, lithium ion is catching on in popularity in certain of these applications, such as data centers. However, the problem is that lithium ion has to be maintained at a much lower operating temperature than our batteries. Therefore, almost everywhere lead acid is used, we could be a substitute and in probably twenty/thirty percent of the cases where lithium ion is used. If you want to go from zero to sixty in two point seven seconds, you will want a lithium ion battery. However, if you want to go five hundred miles in an electric rickshaw, we would be a better alternative.

**"Everyone is looking for a better battery. While we wait for some theoretical development in batteries to be ready for commercial adoption, many of our customers believe, for many applications, ZAF has that better battery today." Randy Moore**

**CEOCFO: *Are people actively looking for a better battery?***

**Mr. Moore:** Absolutely! I have been involved in batteries now for about twelve years. I was the president of a company called EaglePicher Technologies, LLC, for about eight years. Over those eight years, I am sure that we saw ten to twelve companies per year that came along with the new shiny widget of batteries. Out of all of that, we affectionately call it the battery company graveyard, where most startups have a hard time making it from chemistry introduction to actual commercialization. Usually, you have to survive about ten years before you can say that we made it. I am happy to say ZAF is about to cross that ten year threshold in 2021. We are certain to be around, because of the contracts we have in place now.

Everyone is looking for a better battery and there are many companies out there that are working on next generation batteries. However, in my estimation, it is going to be a new chemistry that is perfected today, that will take a decade to get into the market and that is just the way it is. There is really nothing that has been perfected that is ready to make that leap. The batteries of promise today that are being worked on are metal air batteries, but there are about seven different technical hurdles that will make a metal air battery work, such as lithium air or zinc air. Zinc air batteries, of course, a primary today in hearing aids, but if you could make reversible or rechargeable zinc air battery, it would be vastly superior to lithium ion. However, nobody has been able to actually perfect that reversibility. Lithium sulfur is another chemistry that people are working on that would be superior to lithium ion, but then again, I think we may see better batteries, but it is going to be a while.

Everyone is looking for a better battery. While we wait for some theoretical development in batteries to be ready for commercial adoption, many of our customers believe, for many applications, ZAF has that better battery today.

**CEOCFO: *With so many potential applications and industries, how do you reach out? Where do you focus your efforts?***

**Mr. Moore:** That is a very good question. Our business plan to date has been one of licensing, where we think that deploying hundreds of millions of dollars in capital to facilitate our own manufacturing capabilities would be a mistake, because most companies would do that. They get out ahead of their capital deployment and they are unable to service their investors and it takes a while for the commercial market to catch up with the capacity that is created by deploying that kind of capital.

Our business plan is different. What we are doing is we have built a very small factory, about fifty megawatt hours of production now, that is one twentieth the size of a giga factory. With that fifty megawatt hours of production, we are putting out sample batteries to the trucking industry, to the data center industry, to the industrial battery industry, to the marine industry and of course to the military, aerospace and defense markets as well. Our plan has been, since basically 2016, to feed the market with limited production capability and get customers who are excited about this battery. At the same time, we are feeding the market with battery manufacturers; existing manufacturers of both lead acid and lithium ion and nickel cadmium, for example, that want to test the batteries and see that they perform the way we say they do.

In the next year or so, we will be putting these subsets of populations together where we have the battery manufacturers we have been talking to about licensing and we have the customers who would like to adopt it. We will be putting them together and we will be generating a licensing program over the next year. Then what we will do with our fifty megawatt hours of production is we will continue to produce. We are going to focus on the much smaller and then frankly more profitable markets of aerospace and defense and medical.

**CEOCFO: *When you are talking to a prospective customer or partner, if you are talking to the right person, do they understand? Is it an easy concept?***

**Mr. Moore:** Yes, it is absolutely easy for them to understand. For example, we have been working with a trucking company that has a system, basically a battery-operated HVAC in their truck. The reason is that we have these new anti-idle regulations that are popping all over the country. In fact, more than half of the states have anti-idle regulations, so now when a trucker pulls over to get crew rest, they have to turn off their truck. For that reason, they are moving to battery to power those HVAC systems in the trucks for crew rest.

Today, one of those truckers is using eight lead acid batteries and they are getting about eight to ten hours of crew rest out of those eight lead acid batteries. They each weigh about eighty pounds, so that is six hundred and forty pounds of batteries and it takes a couple of hundred pounds of metal to hold those batteries up, so it is a significant weight drain on the truck itself. Therefore, they tested our batteries. We shipped them four of our batteries in the same exact size as the eight that they were using, called the Group 31 battery. They were able to get ten hours of crew rest out of four of our batteries and those four batteries weigh two hundred and forty pounds and needed about one hundred pounds less of steel to hold them up. This means you are gaining a significant weight advantage. It is a very simple formula for the user to say, "Okay, I can use half the batteries and they weigh less than half of the weight." So, it is a very easy value proposition. In addition, in that particular application, those lead acid batteries are only getting about two to two and one half years of battery life, because they are cycled so deeply. We are going to be able to give a five year warranty in that application.

**CEOCFO: *What has changed for you under COVID-19 right now?***

**Mr. Moore:** Actually, nothing for us. We were notified early on, by the Air Force and the Navy, that we are considered to be critical infrastructure for the defense industrial base. We did have a slight delay in some chemical product that was coming out of China, but we had enough inventory that it really did not impact us. We had a vendor who was making a tool for us who was thinking about shutting down and we needed that tool for our Air Force contract. We notified the subcontractor, the tool maker, that we were considered defense industrial base and we really needed that tool. They asked us for a copy of the letter and we sent to them and they stayed open! Therefore, we have not shut down. We had a couple of employees who had personal situations that caused them to not come to work, but we have not shut down. We have not had a disruption in our business at all.

The only difference for us really is that we have a 3D print farm that we use for rapid prototyping and during this crisis we turned our 3D print farm over to making PPE and donated a lot of PPE to local first responders.

**CEOCFO: *What about the medical area?***

**Mr. Moore:** Going forward, medical installations use batteries in many different areas. They have these things; they call them COWS in the medical world, that is Computer On Wheels that are battery operated, that basically go up to the bedside and the nurses use them for inputting vital statistics. All of those are battery powered and most of them are powered by lead acid batteries, so we can go into that market. That is a specialty market that would be very appropriate for us. We also make batteries today for external medical devices like insulin pumps and such. One of the devices is for deep vein thrombosis. The batteries provide power for pneumatic pumps that inflate air bladders that are put around the

person's leg. They fill up with air and they inflate and deflate, so that they help prevent blood clots. In hospitals these devices are plugged in. But our customer is making the device to be worn as an outpatient. We are making batteries for those after our customer was concerned about the possibility of a lithium ion fire next to a person's body. If you Google 'vape battery explodes in pocket' and watch the videos, you'll get a feel firsthand for why he was concerned.

There is another area where our batteries are really suitable for, which are the hospital backup systems. For a hospital backup system, the battery has to be able to respond to critical areas, such as operating rooms and so on, without interruption. That basically means you have to be operating on the battery and then bring the diesel generator up behind the battery. A diesel or natural gas generator actually works a lot better if you couple it with a battery, because the battery performs a shock absorber role in taking any compressor starts or if you turn on a big piece of machinery inside the hospital it will make the generator ramp, and it causes more noise and more maintenance problems with the generator. However, if you put a battery in front of the generator, between the hospital and the generator, the generator runs very smoothly, and you can run much longer and with less maintenance and with less fuel.

The only thing that I do not think our batteries are really suitable for is implantable batteries. I think you are going to see lithium ion and some of the other chemistries continue to prevail in the implantable market. In general, the medical market is a good market for us.

**CEOCFO: *What have you learned from your military experience that has been helpful running companies, both what to do and what not to do?***

**Mr. Moore:** I am a big fan of the training that you get as a military leader. You hear some of it in the commercial world, but it does not have the same emphasis as you get in the military, about the value of leadership qualities. That would have to be the number one thing that I got out of the military. It is a respect for what it means to be a leader.

**CEOCFO: *Why pay attention to ZAF Energy Systems? Why is the company important?***

**Mr. Moore:** I have worked for many different companies in many different industries and I have never felt like I had an opportunity to make an impact on the entire planet the way we do. From an energy efficiency perspective, energy storage is what is going to be what makes our planet turn green. Of all the batteries out there, there is no battery that is really good for the planet either in their manufacture or their disposal or recycling. But, of all the batteries out there, this is the one that I have had the most experience with that is the least harmful to the ecosystem. We did over thirty battery chemistries where I worked previously, and no battery that I am familiar with is as green as this battery.

