Behind the scenes of Aquion Energy's battery factory & the future of solar storage

Katie Fehrenbacher Jul 20, 2014 - 9:00 PM CDT

Blog Post

- **Science & Energy**

Credit: Image courtesy of Katie Fehrenbacher, Gigaom

Drive about 45 minutes southeast of downtown Pittsburgh, out to the edge of Westmoreland County, and you'll reach a sprawling, cavernous factory whose history shadows the ebb and flow of technology trends and American manufacturing.

In the late 1960s, Chrysler, fresh off the American muscle car wave, started building the plant, but as the seventies approached and the price of oil rose, it suspended construction without making a single car. Fast forward a decade and German car company Volkswagen stepped in — rolling the boxy Rabbit off the line — but that era was hit with a lethal combo of worker unrest, awkward car designs and dropping oil prices that took the sheen off Volkswagen's small-car edge.

The 2.3-million-square-foot factory in Westmoreland County, PA. Image courtesy of Katie Fehrenbacher, Gigaom.

In the nineties, it was Japanese giant Sony's turn and the company used the site to make rear-projection televisions, but a few years later LCD and plasma screens made that tech obsolete. As low-cost production moved to Asia, Sony's plans for most of its U.S. factories were canned.

It's as if the two-million-square-foot factory that sits in the city of Mount Pleasant has always been home to a series of downward-trending tech cycles. But perhaps this year will see the end of that industrial version of *Groundhog Day*.

The factory, owned by the state and now leased to a variety of tenants, is the brand-new home to a company that could be a leader in the emerging market for low-cost batteries that can be plugged into the power grid and paired with solar panels.

Aquion Energy's new factory in Westmoreland County, PA. Image courtesy of Katie Fehrenbacher,Gigaom.

The new tenant is young battery startup Aquion Energy, which has set up shop in a small section of the huge factory. It's churning out ultra-simple, low-cost and non-toxic batteries made from a combination of salt water, carbon and manganese oxide.

Aquion is farther head than most of its competitors, many of which are still in the R&D and prototyping stage: It's made, and is in the process of shipping, about 2 MWh worth of batteries to customers since the beginning of 2014 and plans to ship several more multiple MWh this year. In terms of individual battery units, that means it will ship somewhere between 5,000 and 10,000 batteries this year.

The energy storage market will potentially be worth some tens of billions of dollars in the coming years and Aquion's factory is the first of its kind at this scale. Solar companies are starting to install battery banks next to solar farms so that the batteries can store solar energy during the day to be used after the sun goes down. Remote communities are beginning to pair batteries and solar panels to disconnect from the grid. Down the road, utilities will more commonly buy these types of batteries to better manage the grid.

On a tour of the factory last week, Jay Whitacre, Aquion Energy founder and CTO — a Professor of materials science at Carnegie Mellon University who invented the chemistry used in these batteries — showed me the first installed manufacturing line and walked me through the process of how an Aquion Energy battery gets made. Along the way, he could barely contain his excitement over the fact that a venture that was once just an idea in his head is now shipping product and bringing in revenue.

Aquion Energy founder and CTO Jay Whitacre inspects a battery that's ready to ship to a customer. He invented the battery chemistry at Carnegie Mellon University. Image courtesy of Katie Fehrenbacher, Gigaom.

From idea to product

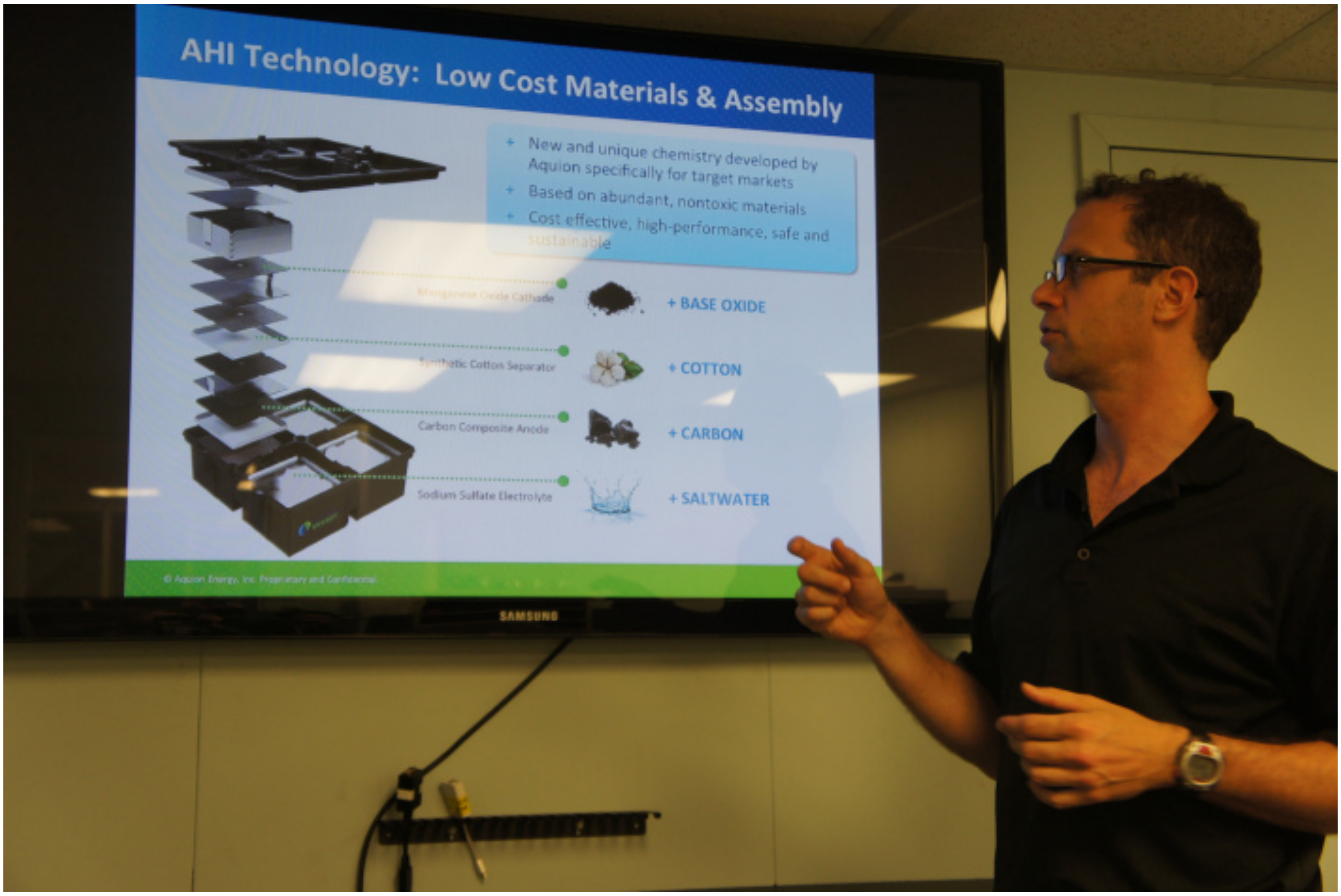
Whitacre started investigating the battery tech in 2007 in his Carnegie Mellon lab, using a rigorous "economic-first" analysis. The energy industry is "dominated by economics," and any energy storage battery product has to make the economics work first and foremost, explains Whitacre.

Lead acid batteries, which have been on the market for decades, are relatively inexpensive but degrade fairly quickly. Their energy density (the amount of energy they can store) is relatively low, they don't operate very well under hot temperatures and — of course — they contain lead. Still, lead acid batteries are commonly used in off-grid solar systems.

Lithium ion batteries are starting to be used more frequently for the power grid. They provide much more energy density than lead acid batteries, but historically they've been pretty expensive, and also don't last that long without degrading. Electric car maker Tesla (s TSLA) says it can lower the price of lithium ion batteries significantly through its massive battery factory, but whether that's true remains to be seen.

Despite being widely available, neither lead acid nor lithium ion batteries appear to be a great fit for the power grid and solar panels. In particular, they're not all that great at storing solar energy from a solar farm. Lithium ion batteries might be pretty good at moving a vehicle, using high power and providing short, shallow bursts of energy, but clean power applications generally need several hours' worth of sustained, lower-power energy.

The energy storage industry needed an entirely new way of looking at the problem.



Aquion Energy founder Jay Whitacre explains the architecture of the battery. Image courtesy of Katie Fehrenbacher, Gigaom.

Whitacre began testing combinations of low-cost materials and simple battery designs in the hopes of coming up with a product that would be as cheap as possible, easy to manufacture and able to be operated for a long time without degrading at any temperature. He threw out materials that didn't work and sought to "fail fast" with his iterations.

Early on he met David Wells, a partner with Valley venture firm Kleiner Perkins, who told him something like, "If you ever see great results, let me know." About a year later, Whitacre came up with a promising combination and Wells, true to his word, led Kleiner to incubate the company in its early life.

Around that time Ted Wiley, who is now Aquion's now VP of product and corporate strategy, was fresh out of business school and began working on a field study of the battery tech for Kleiner Perkins. Whitacre ultimately asked Wiley to join him as Aquion's first employee. Wiley says joining the company early on was "total luck." He ran its operations for the first two years and led the spin-out of the company from Carnegie Mellon.

The rise and fall of cleantech in Silicon Valley

At first, venture capital funding for Aquion was readily available. With Kleiner in early, and the cleantech Valley bubble inflating between 2008 and 2011, Whitacre says he saw a surge of attention: "At the time I didn't really understand what drove all the interest from Silicon Valley, but I was happy to take the money." Following Kleiner Perkins' early rounds and a small amount of Department of Energy funding, Valley firm Foundation Capital led a $30 million round in 2011. The round, which also included Advanced Technology Ventures and TriplePoint Capital, was oversubscribed, says Whitacre.

But by 2012, Silicon Valley sentiment around cleantech had started to sour. The term and industry had become politicized, there had been a series of high- profile Valley-backed bankruptcies like Solyndra and Fisker, and many venture capitalists ended up losing money and faith in the sector. Today, venture funding for cleantech startups is below what it was during the bubble years.

Solyndra's groundbreaking ceremony in 2009, featuring a live video feed of Vice President Joe Biden. Image courtesy of Katie Fehrenbacher, Gigaom.

Aquion needed more funds to continue to grow its business and to move into manufacturing. The company wanted to start commercializing its tech in 2014 and 2015 in order to capitalize on a growing energy storage market and get to market faster than competitors. Complicating the difficult funding environment further, Aquion had recently switched its anode-materials blend to a higher-energy, better-performing one. That was great, but if there's one thing all investors worry about, it's technology uncertainty and risk.

"Early 2013 was tough. There was an about-face in the investing community. They realized they needed to be more cautious and that this sector can have longer-term ventures," says Whitacre.

In 2013, Aquion Energy didn't target new Valley investors. It instead closed funds from family offices and international investors. Tao Invest — the fund of billionaire family the Prizkers, who also own Hyatt hotels —

joined. Hong Kong–based fund [Yung's Enterprise] came in, as did Russian firm Bright Capital. Aquion also raised money from high-profile billionaire and Microsoft co-founder Bill Gates, who has backed other battery startups, too.

That round "was a huge deal for us. I don't know where we would be without it," says Whitacre. In all, Aquion has raised over $100 million to get its batteries to market.

Aquion Energy founder Jay Whitacre standing next to a battery stack. Image courtesy of Katie Fehrenbacher, Gigaom.

Aquion is now selling its first battery stack product, the S-10, for $850 per stack (2 kWh each). Seven or eight battery units make up a stack. Twelve stacks make up a module, which runs for around $11,000. At those prices out of the gate, Aquion is selling its batteries for below $500 per kWh — on par with lead acid batteries, but they last longer without degrading and are guaranteed for at least 3,000 cycles. If the batteries are charged and discharged, say, once a day, they should last for more than eight years.

Those prices are just the beginning. Aquion's goal is to drop its prices below $350 per kWh by the end of 2015 and to make them progressively cheaper after that, getting the cost under $200 per kWh by 2020.

At those prices, Aquion could see a whole new market open up for utility-scale power grid management. Right now, most customers are buying the batteries for offgrid solar and are willing to pay the higher prices partly because they want to be among the first to use the tech.

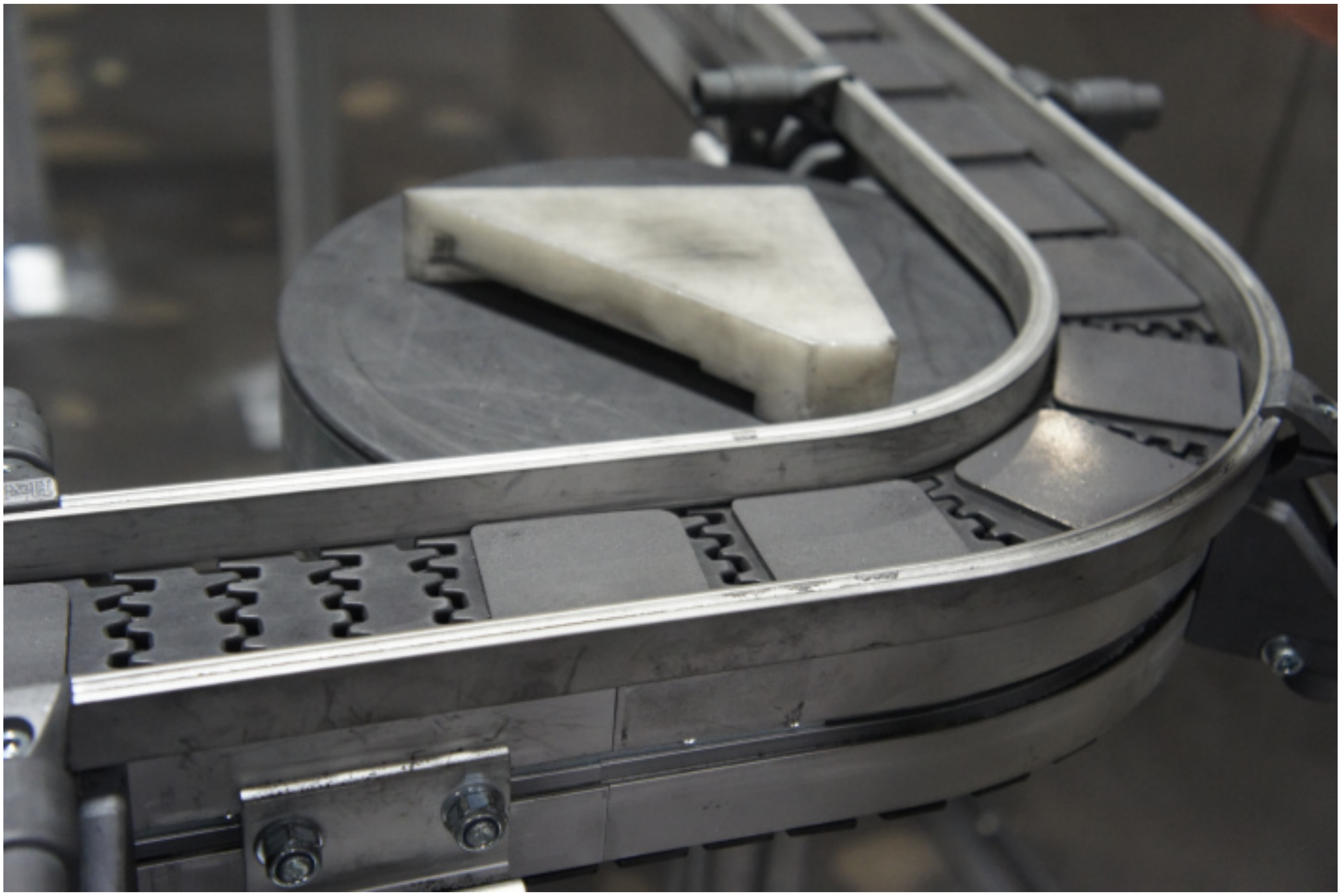
Battery stacks and modules in Aquion Energy's factory. Image courtesy of Katie Fehrenbacher, Gigaom.

Making the battery: Behind the scenes

The Aquion battery's secret sauce is its electrode blend. Traditionally, a battery is made up of a positive electrode, a negative electrode and an electrolyte that sits in the middle and shuttles ions between the two electrodes during charging. Aquion uses a dry manganese oxide powder for the positive electrode and a dry carbon powder for the negative one. Saltwater fills the battery to conduce the charging and discharging. On some of the assembled battery units I checked out, you can actually see the dried salt crystals on the outside of the packaging.

Material powders that go into Aquion's electrodes. Image courtesy of Katie Fehrenbacher, Gigaom

At one end of the factory sit stuffed sacks of powdered materials, like these shown above. On a floor above the main factory, Aquion workers mix together the electrode blend. The powders are then stamped into dry pellets that look like square hockey pucks made of pencil tips. The "hockey pucks" come off the assembly line and are assembled into the battery module.

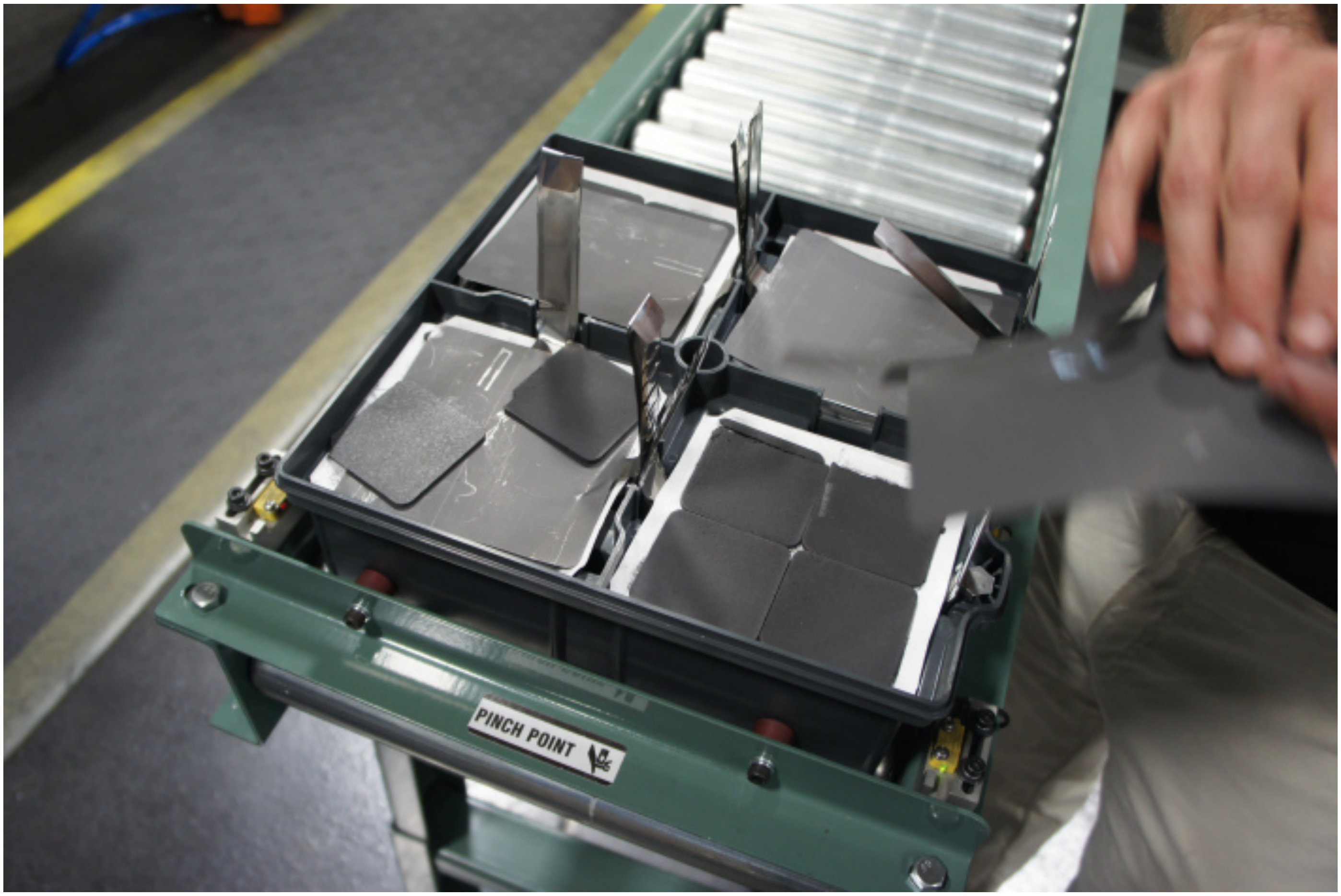


The powders get stamped into dry pellets. Image courtesy of Katie Fehrenbacher, Gigaom

The pellets are smooth to the touch, lightweight and leave a slight dark residue on your fingers when you pick them up, like the way a pencil tip does.

Machines that pick and place the electrodes into the battery units. Image courtesy of Katie Fehrenbacher, Gigaom.

Once the electrodes are made, a machine picks them up and puts them in the right place to be assembled into a battery unit. It's the same type of machine that puts chocolates into those heart-shaped Valentine's Day boxes. When the battery casing is filled, it looks like this (this is one that was put aside because the metal closure was tweaked):



Inside of an Aquion Energy battery, showing the cathode and anode pairs. Image courtesy of Katie Fehrenbacher, Gigaom.

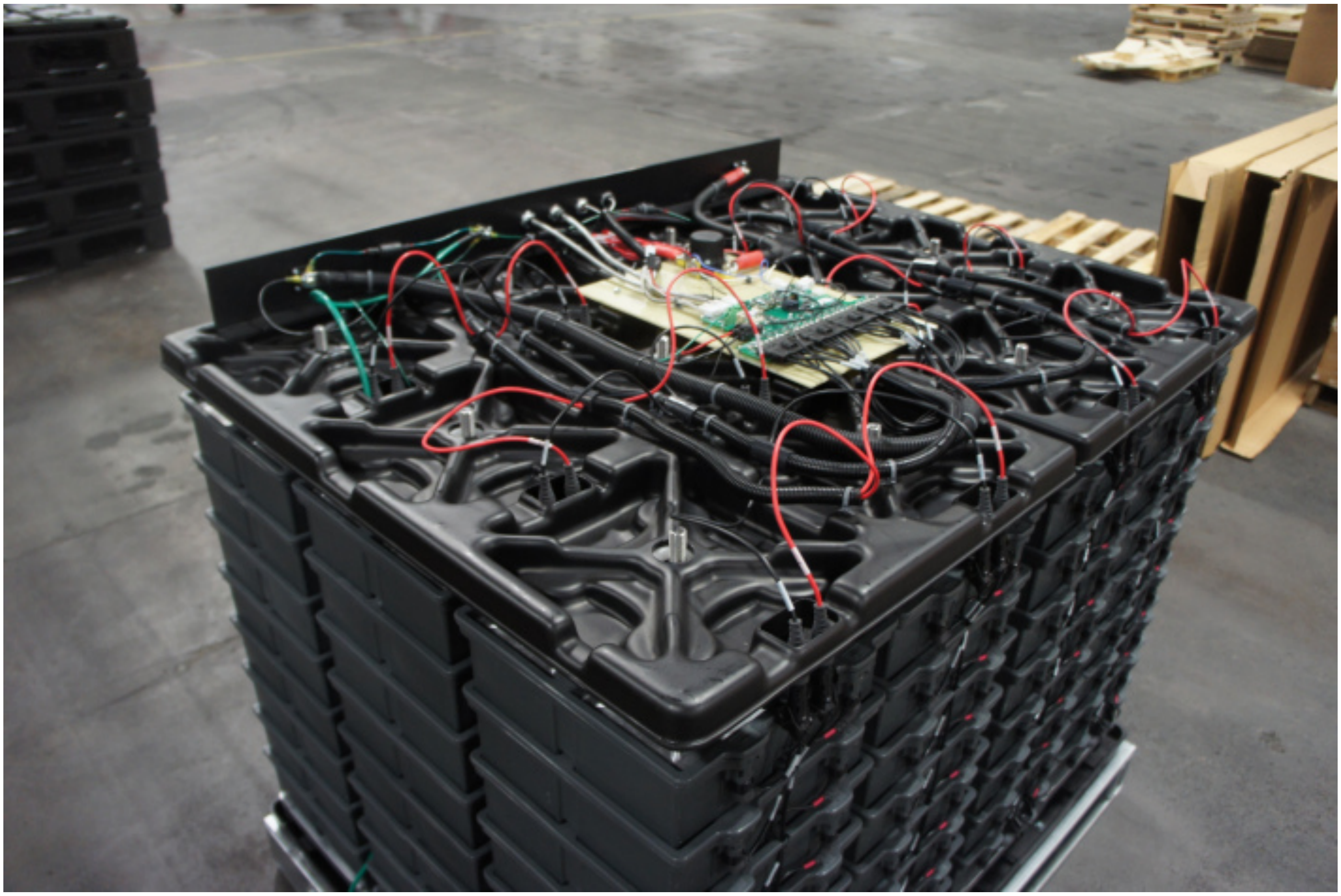
Once the battery's electrodes and separators are fully assembled, it's filled with saltwater. Then it's basically done, closed up and can be stacked with 7 or 8 more batteries.

An Aquion Energy battery unit. Image courtesy of Katie Fehrenbacher, Gigaom.

The batteries are relatively heavy once they’re fully assembled. I could pick one up, but I wouldn’t want to carry it for a long distance. Remember they’re filled with saltwater.

Battery units stacked up on the metal rods. Image courtesy of Katie Fehrenbacher, Gigaom.

The modules get computing and software units that Aquion Energy is developing in-house. The market is growing for battery software, developed by startups and big companies alike. Aquion is also working with other integrators that make software, [like Princeton Power Systems](). After the computing top, the battery gets an Aquion-branded cap.



Computing units for Aquion Energy battery modules. Image courtesy of Katie Fehrenbacher, Gigaom.

All of the battery stacks and units are tested before going out the door. In hot rooms, for instance, the batteries are tested operating at 40 and 50 degrees Celsius (104 degrees F and 122 degrees F). One of the benefits of the Aquion battery is that it can run just fine in a hot environment, like a super sunny solar field.

Battery modules being tested at Aquion's factory. Image courtesy of Katie Fehrenbacher, Gigaom.

Currently, Aquion is running one manufacturing line and can make 200 MWh worth of batteries per year. It can produce 1 to 2 battery units a minute and already there are batteries in the queue ready to be shipped.

Batteries ready to ship at Aquion Energy's factory. Image courtesy of Katie Fehrenbacher, Gigaom.

Down the road, Aquion plans to expand production to five battery lines, which will be able to make over a gigawatt hour of batteries per year.

Though Aquion is charging ahead with commercial manufacturing, it won't be a large-scale factory for awhile. And of course, despite all of the good intentions and hard work already done, a lot can go wrong when it comes to scaling up this type of manufacturing. No doubt there will be future hurdles that Aquion will have to overcome.

The ultimate test of Aquion's success will come from its customers, particularly the early ones. This first set of customers is willing to pay initially higher prices for the chance to use a new and exciting technology. And they are primarily using the batteries for offgrid solar projects. Down the road, when the batteries are cheaper, utilities and grid management will be the bigger fish to catch.

While Aquion has a way to go before it can scale up enough to change the game for solar and grid power, it's an example of an emerging technology that's at the beginning of a transformational change in the energy industry. It's not a company that's riding a wave of a fading tech trend. If anything, it could be too early. But I'm predicting that it's going to be inhabiting that Pennsylvania factory for a long time, employing local workers and developing an entirely brand new type of American manufacturing.

Updated to reflect that Jay Whitacre is still a full time professor at CMU.