How Fusion Research Led to Power Management Spinoff: BNEF Q&A

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About six years ago, as California-based TAE Technologies was building Norman, its fifth-generation fusion research reactor, executives at the startup had an epiphany. While Norman needed more than 750 megawatts to be delivered in an instant, the power company that would supply that power could feed only 2 megawatts. Moreover, electricity needed to be delivered to 80,000 electrified parts in a ballet requiring different power and timing requirements.

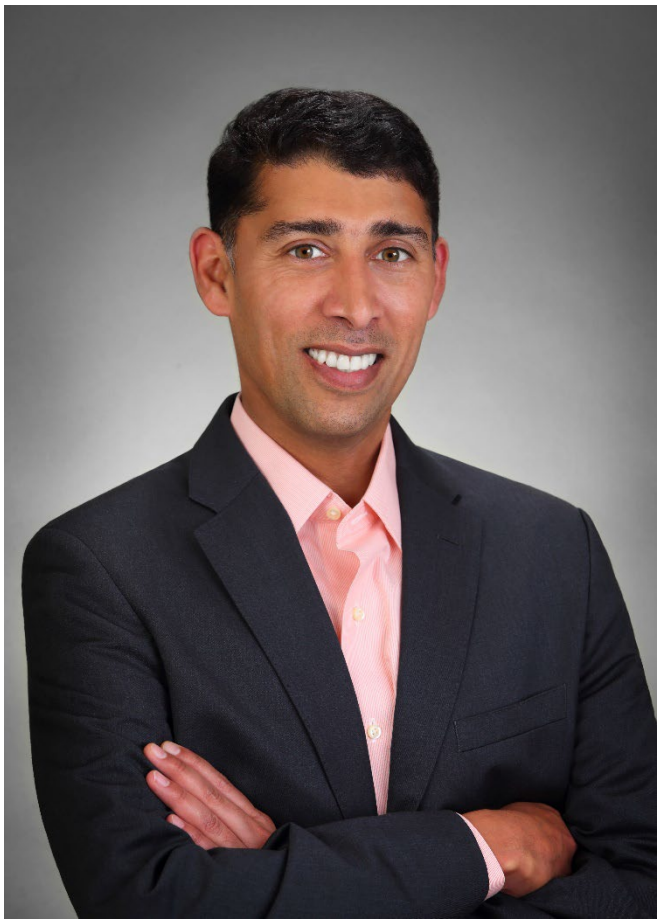
To meet Norman's power needs, TAE would have to come up with a solution — one that would involve a bespoke power supply system using a combination of algorithms and hardware. The same kinds of fluctuations required for a fusion reactor, TAE realized, were similar to the fluctuations in demand needed in electric mobility and for energy storage applications.

TAE, in meeting Norman's requirements, took it a step further, developing a spinoff called TAE Power Solutions. The spinoff has created what it calls a converter battery module to control a battery system at the modular level with low-cost converters and control systems in each module. The company has also developed a power management system for electric transportation and a pulse technology to charge battery systems two times faster with existing cell chemistries. The goal, the company says, is to provide solutions for more affordable and efficient storage, along with ultrafast charging, electric vehicle powertrains, peak shaving, buffering and second life of batteries.

"Out of both necessity and some big breakthrough innovation in ideas, we designed and developed power supplies that allowed us to take what little was available from the grid and rapidly store it and discharge it at a much higher rate," says Kedar Munipella, the chief executive officer of TAE Power Solutions. "As we deployed this novel power supply architecture, we were able to run the experiments without interruptions to our daily process."

In May, TAE Power Solutions opened a new UK facility where the spinoff will operate a new battery prototype-and-test facility as a step to manufacture modular battery packs for a variety of applications, including all forms of e-mobility including cars, trucks, buses and rail.

BloombergNEF spoke to Munipella about the lightbulb moment behind TAE Power Solutions, how TAE Technologies' work on fusion led to the spinoff, and how Munipella's experience in the solar industry is informing his work with power management. The interview, conducted in late September, has been edited for length and clarity.



TAE Power Solutions Chief Executive Officer Kedar Munipella. Photo courtesy of TAE Power Solutions.

Q: What is the work that TAE Technologies is doing that led to TAE Power Solutions?

A: As we were going through our fusion journey with TAE's experimental fusion device in 2014, we realized we needed a lot of power to run the experiments. You don't need power on a sustained basis, but you need it when you trigger an experiment. The grid can only offer a commercial building in a standard business park so much power. The gap in what the grid could offer and what the fusion experiment needed was what led to the development of our power management solution.

Out of both necessity and some big breakthrough innovation in ideas, we designed and developed power supplies that allowed us to take what little was available from the grid and rapidly store it and discharge it at a much higher rate. As we deployed this novel power supply architecture, we were able to run the experiments without interruptions to our daily process. We're now able to store from the grid sufficient energy to discharge up to 750 megawatts of power into 80,000 distinct electrified points on the machine.

Q: When did the lightbulb really turn on that connected the work TAE was doing with power management and electric vehicles?

A: This is circa 2017 when we were building Norman, which is the fifth generation of TAE's experimental fusion reactors. We realized we needed to bridge that 750 megawatts of pent-up power. As we built these blue boxes that are sprinkled across our entire facility, which are sophisticated power supplies that allow us to store and discharge electrical energy in a unique and very rapid way, TAE Technologies' CEO Michl Binderbauer started to understand both the engineering details and the physics behind it. That's probably the moment where the lightbulb went off. He realized that if we can precisely deliver bi-directional power on a sub-millisecond timescale so effectively, then we should be able to transform the performance needed by an EV during acceleration and braking, or by an energy storage device that's connected to your home, office, industrial site, or grid-connect point when the loads keep varying. The nature of the fluctuations in demand for a fusion reactor is actually similar to the fluctuations in demand or need in automotive or for an energy storage application.

The correlation became obvious to Michl and TAE's power management division was born

to commercialize this revolutionary technology and tackle the key hurdles to rapid EV adoption, such as high cost, range anxiety, lack of quick charging, concerns about reliability and more. On the stationary side, the hurdles for the industry are cost of storage, reliability, flexibility (lack of upgrade ability), and adaptability. For suppliers or providers of storage solutions, TAE's technology reduces logistics challenges and cost of inventory. It really is a paradigm shift. For both markets, TAE Power Solutions' technology means you have one building block that, depending on how many you string together, can service residential to large grid applications and small vehicles to large trucks.

Q: What was the next step?

A: It rapidly dawned on us that outside of fusion there are these other markets that have the same need, which is a better way of storing and distributing power in a precise manner that improves efficiency of the overall process, next to costs and reliability. When you think of the two adjacent markets this applies to – the automotive side and the energy storage side – it's all about managing that energy, and in this case the energy source is a battery. As you optimize and manage that performance, how do you deploy that energy where it's needed? In the case of automotive, it's the electric motor. For energy storage, it is really where the need is across residences, commercial buildings or for utilities.

Q: Is this primarily a software challenge or a physical challenge?

A: There are elements that require advanced algorithms and sophisticated software but there's also a novel hardware component around the power electronics. The electronics at the heart of each smart battery module is based on a proprietary bi-directional power control topology, combined with sensors, networking interface logic and smart software. These innovations give us flexible and adaptable modular building blocks, connected through our proprietary software to achieve the variety of advantages across these diverse markets and application niches. In other words, our novel solution consists of a hardware layer, composed of power electronics, together with a software layer, built on highly innovative proprietary algorithms below it, that helps derive and drive those breakthrough performance benefits.

Q: Who are your potential customers?

A: On the stationary side of the business, we see the residential market as being very crowded and not one that's highly differentiated or looking for differentiation. It is, therefore, less interesting for us. The market that we're focused on is the commercial, industrial and grid-scale customers. When you look at the growth rates of those segments, you're looking at double-digit figures over the next 10 to 15 years. On the e-mobility side, the passenger car market is the biggest component of that market but it's also the most time-consuming to get into. The other markets that are entry points for us are either the light commercial, MCV (medium commercial vehicle) or HCV (heavy commercial vehicle) markets. Our current focus on the mobility side is to work with a customer or partner in each one of these market segments.

Q: Does TAE Power Solutions' success depend on TAE Technologies' success? What if TAE Technologies never achieves its goals in fusion? Does that compromise you?

A: The reason why we spun ourselves out is to address that exact question. We are independent. It is a symbiotic relationship in

that we are majority-owned by the parent and we are committed to our mutual success. But the markets we're serving and the opportunities they represent are greater than 95% of what our growth projections are. We're going to continue to grow and serve the automotive and the energy storage markets. Those markets have a spectacular growth trend independent of policy and they are now primarily consumer-led. We're committed to the success of fusion, and we'll continue to serve them. I have no doubt TAE Technologies will be successful. Independent of their success, we are on the path to serve our opportunities and achieve our success.

Q: Your background is in the solar industry. What are you applying to TAE Power Solutions that you learned from your experience in solar?

A: What we're seeing in the current transition, whether it's in EVs or in energy storage, is not dissimilar from what we saw in the PV (photovoltaic) journey. In 2005 and 2006, when polysilicon costs were greater than $400 a kilogram, the only manufacturers were either in Europe or in the US. China barely produced and barely consumed. When you think about the transition that happened just between 2007 and 2012 when the cost of polysilicon fell to less than $15 a kilogram and in subsequent years when the dollar per watt went from $7-9 a watt to less than $1 a watt, and when the conversion efficiency of a silicon cell went from 12% to greater than 24% where it is today – that journey and that transition led to the mass adoption of PV.

It was this phenomenal scale-up that China brought that drove the cost down, but it was also the maturity of the supply chain across every node all the way from polysilicon to the junction boxes and the modules that were made. What we're going through here isn't dissimilar. We're at that equivalent $400 per kilogram polysilicon price point in time. China has democratized EVs and energy storage. It's phenomenal to see how far ahead they are. When you see this journey and what consumers are demanding, which is not just better products but better in terms of affordability and range and models, it's the similar demand that consumers had with solar in 2007 and 2008.

Having been through that journey on the PV side – the technologies are different, but the fundamentals are the same, whether it's the business around scale-up and reducing the costs or addressing the technology that gets you to better efficiencies and lower cost. If we can replicate that with greater than 10% efficiency to increase range, lower costs, speed up charging, extend the life of the battery and improve overall affordability of EVs and at the same time push stationary storage performance to enable the on-demand dispatch of wind and solar, think about how quickly we can then get to not just net-zero targets but exceed every one of our expectations. We're at the bottom of that s-curve when it comes to the energy transition. It would be a shame if we forget the lessons that we already went through with PVs.

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