

Electricity Storage: What's The Potential And When?

Five CEOs of electricity storage companies, each of which uses a different technology, participated in a panel discussion about the outlook for the storage market at the Chadbourne global energy conference in San Diego in June. The following is an edited transcript of the session. The panelists are Bob Kraft, CEO of Energy Storage & Power, Dan Vogler, CEO of GeoBattery Corporation, John Jung, CEO of GreenSmith Energy Management, Mark McGough, CEO of Pentadyne Power Corporation, and David Schramm, CEO of Maxwell Tech. The moderator is Doug Fried with Chadbourne in New York.

MR. FRIED: Each of your companies is pursuing a different technology. Tell us briefly about your company and its product, starting with you, Bob Kraft.

MR. KRAFT: We are focusing on compressed-air energy storage. My company started as an engineering and technology company and is transitioning to a technology deployment and manufacturing company.

MR. VOGLER: GeoBattery focuses on scalable grid storage. We do not make batteries, but we enable battery technology on the grid. We focus on the grid interface or the middleware. Hooking a DC battery to the AC grid is not a trivial task, and the power electronics control systems and software in the middle between the battery and the grid is of great importance. We have identified more than 12 applications for it within the energy storage space.

MR. JUNG: Our focus is distributed energy storage. Greensmith is a turnkey energy system provider to the utility industry. We believe that it is a horses-for-courses world in energy storage where centralized solutions like some of the ones represented here will be appropriate, but the industry also has to grapple with pockets of grid congestion and that is where Greensmith comes in.

We are agnostic about storage technology. We believe that there is plenty of capital being put into batteries, factories and lines, and what we do is integrate the system so that it has all the software really to store energy — not just a battery in a box but a smart grid appliance that can exchange data with the rest of the smart grid infrastructure and be controlled by a centralized system.

MR. MCGOUGH: Pentadyne is trying to make the best flywheel in the world. We sell flywheels into UPS applications with manufacturers like Toshiba and General Electric that sell their UPS products with our flywheels as a backup energy storage component. We also sell our flywheels into rail applications; we are focusing now on the rail market. We have a large contract that we just won with New York City to capture the braking energy of a train. We can turn a subway train into a hybrid electric vehicle using our product. We have gone from zero sales four years ago to about \$16 million a year today, and we are on a nice growth trajectory.

MR. SCHRAMM: Ultracapacitors store power; they don't make it. A battery makes energy, so all we do is we store it. There is no chemical reaction, so you can charge and discharge an ultra-capacitor millions of times while a battery can charge and discharge only thousands of times. Because of the lack of mass transfer, we can also upgrade from -40 to +65 centigrade, so it gives us a nice temperature range. Ultracapacitors are lightweight, very high-power, low-energy batteries. Batteries, by contrast, are typically higher energy, lower power.

Today we are into windmills for pitch control, buses for brake regeneration, automobiles for start-stop systems, computer memory backup and UPS. Studies have shown that when you couple an ultra-capacitor with a battery, you can extend the life of the battery by 30%. We are gaining traction in the marketplace. Last year, we crossed the \$100 million mark, which is about a 26% increase over 2008. Major geographic areas are Asia and Europe. We are doing very little business in the United States.

MR. MCGOUGH: If I could just add, the ultracapacitor and the flywheel are similar in the sense that they are very power-dense. Neither is an energy-dense technology; they are power-dense. We can deliver a lot of energy in a short amount of time, and we can also capture a lot of energy in a short amount of time, and that makes both products a different tool in the designer's toolbox.

MR. FRIED: Let's talk about how these technologies might be used in renewable energy projects. Dan Vogler?

MR. VOGLER: Most renewable energy / continued page 2

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projects produce electricity intermittently. Wind turbines are up and down all day, and they peak in the middle of the night, which is the opposite of the demand curve. Solar is off line in the middle of the night. Tidal energy has two cycles a day. All of these renewable energy sources beg for storage to smooth the electricity deliveries to the grid.

In Texas, we are the leader in wind production, but the wind often peaks in the middle of the night, so there would be a time arbitrage to store wind power in the middle of the night and shift it to day use when the utilities want it. That is one of the more obvious uses of storage. Base-load power plants run 24 hours a day, seven days a week. You don't shut them down. You might throttle them back at night, but they can generate two to three times more power in the middle of the night than demand at those hours for electricity. If we could just take all of the excess power available in the middle of the night and store it to day use, then we could avoid building another base-load coal or nuclear plant.

Early Stage

MR. FRIED: Why haven't these storage technologies been deployed more widely already?

MR. VOGLER: It takes time for new technologies to be accepted and to reach scale. Large battery prices are now falling, and utilities are gaining a better understanding of how they work. It has been the last two years when one could make a business out of a storage company. The few storage projects in the United States are still pilot projects. We are on the cusp of moving from the pilot stage to wider commercial acceptance.

MR. FRIED: So you are at the start of what could be a rapidly-growing business.

MR. VOGLER: We are at the beginning of a huge business cycle that I believe has at least 10 years to go before it slows down. In time, storage will be the largest sector of the renewable energy market, larger than solar and wind combined because it applies to all of those technologies and really everywhere else within the grid, from underneath generation, transmission, distribution, all the way to the grid edge in the customer premises.

MR. SCHRAMM: I read a good book called *The Bottomless Well*. The author goes through a lot of data to suggest that our need for energy per person goes up every year as it has for the last 150 years. Everyone used to have 40 acres of ground, and we were a carbohydrate-based society. Ten acres was to grow the feed for the horse. We have transitioned from that. At the

turn of the last century, New York had a pollution problem, and it was horse manure. At the dawn of this century, its pollution problem is CO2. The problem has not really changed; it is still energy related. It is just a question how we address it. We need more power plants to meet growing electricity demand, but nobody wants them built in his backyard. Energy storage will give us a little bit of a cushion, but it will not significantly reduce the need to build more power plants.

MR. FRIED: David Schramm, do you see energy storage supplementing renewables or competing with them?

MR. SCHRAMM: Supplementing. We have ultracapacitors today in about 12,000 windmills. They are used today as a safety device for pitch control. The windmills at which ultracapacitors are used today can be up to seven megawatts in capacity, and they are up to 500 feet tall. I had the distinction of taking something off my bucket list a year ago. I climbed to the top of one of those windmills and vowed never to do it again. [Laughter]

If the wind is blowing too strongly, the ultracapacitor alters the pitch of the blades so the windmill doesn't destroy itself, like adjusting the sails on a sailboat so that the boat doesn't tip over. Batteries are required in this application. The problem is maintenance: replacing the batteries 500 feet above ground. The ultracapacitors extend the life of the batteries so that they do not have to be replaced as often.

MR. FRIED: Mark McGough, how long will it be before electricity storage is widely used? Where are we now in the process? What has to happen to make widespread use of storage a reality?

MR. MCGOUGH: There are several types of energy storage. There are grid scale technologies: compressed air, pumped hydro, molten salt, large batteries. There is also the kind of energy storage about which David Schramm and I spoke: fast response, very powerful, but not a high amount of energy storage. It is used for tactical applications.

An investor used a metaphor with me the other day. It was RAM and ROM memory. They serve different purposes and cost different amounts on a per-unit basis, but they are both important. One of the key impediments to rapid growth of energy storage is the cost. David Schramm and I were joking before this panel: storage will be a better business proposition when we are able to stop wrapping dollar bills around everything we ship out the door.

We have gone at Pentadyne from negative margin just a few years ago to a 19% to 20% margin to a 30% margin on everything we ship today. / *continued page 3*

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Our goal is to get to a 45% to 50% margin product, because that's where it gets interesting. We can get volume and scale and bring our prices down. I think that is less than a decade away.

The demand is being driven partly by renewable portfolio standards at the state level. The demand for energy storage should increase over time as the RPS targets increase. There is still a lot of government funding for development of these technologies. We are a finalist for an ARPA-E energy research grant that would be used for development of a storage technology that is very high-volume and low-cost — less than \$100 per kilowatt. If we can get the cost down to that level, then the industry will truly take off.

MR. FRIED: So we are really in the infancy now, really at the early stage, before storage is widely used?

MR. MCGOUGH: I think we are a petulant teenager.

[Laughter] We are making progress.

MR. VOGLER: When I said 10 years, that is for storage to become a pervasive technology and find its way into everyone's home. Residential energy storage and community storage promise to do a demand price arbitrage in the customer's home. That will probably not be flywheels though. I think it will be ultracapacitors.

Barriers

MR. FRIED: Bob Kraft, what are the main barriers to utility-scale integration of these technologies?

MR. KRAFT: One of the big ones is regulatory uncertainty — whether utilities investing in large-scale batteries will be able to put the cost into rate base. We are working on smaller-scale projects with NYSEG and PG&E that will be spread over a number of years. These will give us a chance to test the risk and establish the regulatory treatment.

The reason we haven't seen heavy use of storage in the renewables sector is the grid can handle a certain amount of intermittency. The burden of adjusting to the variability is falling heavily today on gas-fired power plants. In some parts of the country, they are really feeling the pain. Eventually, something will have to give.

MR. FRIED: John Jung, what is the next step for your company to grow?

MR. JUNG: We are along the classic adoption curve that any industry goes through. The utilities have a clearly defined one. There are good case studies about how utilities get comfortable with new technologies and how it usually requires some form

of regulatory or financial assistance. You see all those hallmarks with energy storage.

We are serving five utilities today and are growing. They are watching not just the cost per kilowatt hour of output, but also per kilowatt of capacity. They are looking at educating themselves about where energy storage can be useful — not just in the 16 or 17 different applications that EPRI and Sandia have defined, but also the potential to capture more than one value stream. At the end of the day, whatever storage device is used must be capable of being programmed to perform differently depending upon needs at the time. The utilities are becoming sophisticated enough to want more than a single dedicated custom system that sits in the ground for 10-plus years to attack a two megawatt hour problem. Maybe the system is four different boxes that, through the dimension of smart grid, can be centrally controlled to be one block of energy storage on Monday and perform different functions across the grid on Thursday.

MR. MCGOUGH: John made an important point. If you are waiting for the industry to reach scale, don't focus on technologies that are a one-trick pony. It will be tough to reach scale for technologies that have only a single application. John spoke about a device that a utility can use for one thing on Monday and another thing on Thursday. I will give you an example. Pentadyne has an array of flywheels that we use for trackside applications for mass transit authorities. Interfacing that same energy storage with a smart grid as a reservoir, if you will, for fast response gives it a second value proposition, which is very important.

I'll just make a quick advertisement for those in the audience. Senate bill 1091, sponsored by Senator Ron Wyden (D.-Oregon), would provide a 20% investment tax credit for installing energy storage devices. It would provide a huge boost to the industry if we can generate enough support for it. Congressman Mike Thompson (D.-California) introduced a companion measure in the House.

MR. FRIED: A 20% investment tax credit for storage would clearly be a help, but I should point out that there is already a 30% investment credit for some storage devices when installed at wind, solar and other renewable energy projects.

MR. MCGOUGH: The bill would provide a tax credits to broader uses of storage.

MR. SCHRAMM: Those of us who live in southern California keep reading about electricity at 5¢ to 7¢ a kilowatt hour. Our lowest rate is 15¢, and that's for the first light bulb. When the air conditioner hits,

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it goes to 34¢. So we have a reason to get into energy storage faster and try to help the power companies get that cost down.

MR. MCGOUGH: It is a tiered pricing structure. There are four tiers. As soon as you turn on the refrigerator or air conditioner, you are in tier four and it is 34¢ to 37¢ cents a kilowatt hour.

Attracting Investors

MR. FRIED: Let's talk more about the economics. David Schramm, what is the current investment climate for energy storage?

MR. SCHRAMM: Most of our business is in Asia or Europe. The Europeans have very aggressive carbon requirements for automobiles. A car today in Europe is limited to about 160 grams of CO₂ per kilometer. By law, the limit will drop to 130 grams by 2012. We are working with Continental to install a start-stop system that will help reduce carbon. The penalty for exceeding the limit is the fourth gram of CO₂ over the limit costs you €95, which is pretty hefty.

If you work the chemistry backwards, to get to 130 grams of CO₂, the Europeans will need cars that make 40-some miles to a gallon. The limit drops to just 90 grams of CO₂ by 2020. This is an example of a regulatory incentive to storage technologies that will also help make European industry very competitive in global markets. They'll have cars on the market at 60 miles per gallon. To put this into perspective, the United States has a standard that says we are going to get to 35 miles per gallon.

We are attempting as a company to use a novel approach: sell your product for more than it cost and then use that money to invest in your business. [Laughter] It seems to be working so far. It let us raise money last year.

MR. FRIED: Mark McGough, where is the money coming from at this stage — friends and family, venture capital, strategic equity?

MARK MCGOUGH: Yes, from all those sources. I have been a professional beggar, all but standing on the street corner. [Laughter] I think there is an appetite for investment across the spectrum — especially in the energy storage sector which I think is a very hot area, and we are seeing that in the response we are getting from potential investors.

I also believe we are headed for industry consolidation. As some of the technologies mature and you see the economies of scale, potential synergies with other product sets appear and that will drive mergers and acquisitions. There will be the Darwinian weeding out of weak companies and, among the

survivors, there will be consolidation.

MR. FRIED: John Jung, what is the best way to finance these technologies at a utility scale? Is it direct investment by utilities, financing energy storage in conjunction with financing independent power projects, completely independent financing, what?

MR. JUNG: Ah, yes.

MR. FRIED: Thanks for clearing that up. [Laughter]

MR. JUNG: What I meant to say is we are seeing all of the above. There are utilities that want to bake storage costs into rate base. Some storage companies are landing large contracts with utilities that may provide a financeable revenue stream. NGK, a Japanese manufacturer that uses a sodium sulfur technology, sold 320 megawatts to UAE in the last 12 months or so, and it has a contract for another 150 megawatts with EdF.

MR. SCHRAMM: I think it depends on the technology. For instance, community energy storage is hard to imagine without a distribution company or utility involved.

MR. VOGLER: It is the size or scalability of the storage need that will determine where the capital comes from. A utility might pay for a small project out of its own budget without the need for special financing. A larger project at a wind farm or a time shift of all the excess power from a nuclear plant to day use is a large project that will probably have to be developed by a third party on a turnkey basis with outside financing.

One of the biggest applications within storage goes to power quality. One of the biggest problems utilities face is this. Let's say there is an industrial park with five factories all tied into a substation. The local utility has a design plan for the service area, but it cannot control what those factories do. The factors are continually adding new equipment, more conveyors, more motors, more compressors and creating quality-of-power problems not only for themselves but also for everyone else tied into the same substation.

Until now, the utility had only one option. It had to upgrade the substation with a new transformer, upgrade the transmission line into that substation and maybe even add more generating capacity 10 miles away, when in fact the problem might be intermittent. Ten minutes or 15 minutes a day the lights get dim from something the neighbor is doing next door. Storage is the answer for utilities to solve these short, intermittent problems instead of having to do a full upgrade of basic capacity.

MR. JUNG: The Allen Bradleys and the Rockwells of the world look at ways they can prevent the spikes and the harmonics that are created when they turn

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the gear on and off. So the opportunities are not just with the utilities.

Competition

MR. FRIED: You guys seem to get along with each other. Are you competing against each other or are there synergies? [Laughter]

MR. VOGLER: We're all in the storage business, but these are different technologies. In terms of the underlying storage medium itself, it's five different lessons in Newtonian physics.

MR. SHRAMM: There's a good analogy here. We had a big solution in the 1970's after the Arab oil embargo, and that was everybody was going to build a small car. What it did was destroy the US automakers because we brought in the Japanese automakers, who were already well ahead of the US companies in producing small cars. In the 1980's, we said we are now going to solve the problem a different way. We put billions of dollars into making fuel cells. Well, there are not many fuel cells in parking lots today, so that didn't work. In the 1990's, we decided we know how to grow corn, so we decided to put every car on ethanol. Ethanol takes a lot of fresh water to make, so the unintended consequence killed that. Now we are going to have all electric cars. It is 34¢ a kilowatt/hour to charge such a car in southern California.

Our society always looks for this one silver bullet, and what you need instead of one silver bullet is a collection of technologies, and the proper mix depends on the problem we are trying to fix. Between our regulators and our lawmakers, they appear to be looking for the silver bullet, and that is the wrong place to look.

MR. JUNG: Greensmith's business is to solve grid congestion issues, and whether it is zinc bromine or lithium iron phosphate or ultracapacitors doesn't matter. From the standpoint of a burgeoning industry, it is healthy to have as much competition as possible. The utilities are not looking at VHS-or-Betamax kind of judgment. They are looking at a course of strategy implementation for energy storage. Given that context, I think you will see very little babbling up here in terms of whose mousetrap is slightly faster or better or more sanitary than the other. We are in mouse management.

MR. SHRAFT: From a compressed air energy storage standpoint, renewable stored bulk energy is different from the flywheel or the capacitor, but our product could very well compete with batteries. It is a two-megawatt, eight-hour storage device that comes on a skid mount — you drop it down

— and because it is a turbo machinery type piece of equipment, it has a very long lifetime: 30 to 40 years. We think maybe it costs half of what a battery costs up front and maybe a tenth of the cost on a kilowatt hour basis. We are really excited about it, and our joint venture partner, PSEG, is working with us to build the first product.

Risks

MR. FRIED: A number of these things sound positive, and you guys are obviously excited about it, but looking at it from the other end of the spectrum, what type of risks, Mark McGough, do investors and early adopters of an energy storage technology face?

MR. MCGOUGH: We talked about a lot of variables just in this brief conversation that have a bearing on how successful we will be.

Favorable government regulations and strong renewable portfolio standards and other incentives will be necessary for the broader adoption of our technology.

Geoffrey Moore wrote a good book called *Crossing the Chasm* in which he describes the technology adoption life cycle. Many of these technologies that are still early and have not crossed the chasm. The reliability and designs of the technology have not been tested in enough applications where there is certainty around them. We like to think that we have worked a lot of the technology risk out of our product, but still we're early and there are a lot of other companies that are even earlier in the development of technology.

It starts with technology risk, and then there are the economics. We were joking about wrapping dollar bills around everything we ship. That's a problem, so you have to get past that and then you have to find the right channels to the market, and there has to be a need that develops in the market — we are all pretty bullish about that one because of the renewable portfolio standards and some of the dynamics in smart grid and energy efficiency requirements that are driving the need for energy storage.

There is good reason to be bullish about energy storage as a category, but it is still too early to determine who will be the winners and losers. I think there will be a lot more winners than one or two winners. A lot of companies could be very successful in the next five years because of these market dynamics.

MR. FRIED: Dan Vogler, where do you see the industry moving in the next few years?

MR. VOGLER: I would estimate there are fewer than a dozen real play-

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ers in North America in the energy storage business today so there will inevitably be more competition and more variations in technology in the underlying storage medium, especially battery chemistry. It is a wide open market today.

The market opportunity in the wind business alone in the United States is \$500 million today, and the wind market is going to double in the next three years, so this is a huge looming market for us.

The challenges ahead of us are educating the customers and educating the regulators. There is no clear classification for storage among the Texas PUC accounts, and the PUC refuses to address it. It is letting the marketplace work it out. The utilities are definitely on their own, somewhere between a study phase and a pilot project.

I think the next evolution is where we move from this developmental phase to having the bugs worked out to what I call, and John Jung called, turnkey storage where the utilities order some number of megawatts and are willing to pay for that on a dollar-per-megawatt hour basis, akin to solar and wind projects.

MR. FRIED: John Jung, what's the key to successful development of this industry?

MR. JUNG: The elevator pitch that we give has to become less about a nifty technology and more about business problem-solving. I think that will be when this industry really

begins to take off. What we try to do at Greensmith is design a business where we ship units in as little as 90 days from order, where utilities feel like they're kind of ordering a transformer. It can be configured. It doesn't have to be a custom, speced-out project somewhere that takes six months to engineer, 12 months to implement and six months to certify from a safety standpoint

MR. FRIED: Mark McGough, what does the future hold?

MR. MCGOUGH: The thing to keep in mind about energy storage is that it is just that — it is storage. It is not generation. It costs money to generate the electricity, and no wants to add an incremental cost for storage. I worked for a utility. We are owned in part by a utility, and I have talked to enough utility executives who will tell you that when you are looking at grid scale, the cost is an issue because you have already had to pay to generate the electricity. The cost of storing energy can range from a few cents a kilowatt hour to half a million dollars a kilowatt hour for a hearing aid. Those are all forms of devices that store energy for different applications. What companies and investors need to do is look for the value proposition: where are the values that we can bring or the opportunities to make a profit in storing energy that fits the technology we have to offer? ☺

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