



EcoMotion – Sustainability Solutions

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White Paper

Creating and Financing Six, Carbon-Free Microgrids for Santa Rita Union School District

The Genesis of PERCs: Powered Emergency Response Centers

September 14, 2018

Outline

1. Energy Resilience
2. Hardening Facilities
3. Crafting the SRUSD Deal
4. Financing the Deal
5. Construction and System Components
6. Permitting and Interconnection
7. Scaling the Model
8. Conclusion

1. Energy Resilience

A voice I'd never heard, but would come to know well was bluntly inquisitive and curiously emphatic. It belonged to Nancy Pfeiffer, Chief Business Officer for a school district that I'd never heard of, the Santa Rita Union School District (SRUSD) in Salinas, California.

"We want you to help us get batteries for our campuses," she said. She mentioned Elon Musk and the Gigafactory. "Can't we use our Prop 39 funds? We want 7-hour battery storage." Why?

"So that we can keep our campuses running during power outages." Really? That's not what our industry is doing with batteries. They're expensive assets. I encouraged Ms. Pfeiffer to contact able consultants in Northern California. But she wanted EcoMotion's help. We recommended gen-sets for infrequent use, but soon became clear about the District's resolve.

EcoMotion began working on a Power Outage Protection Program (POPP) for SRUSD in October 2015. The charge was to tap Prop 39 monies to "harden" these campuses with battery storage. The District needed to be able to keep its students in school. No, the District did not the "two-hour, garden variety" storage that dominates California's behind-the-meter storage market. SRUSD wanted students to be able to shelter in place, to continue with their studies throughout the entire 7-hour school day. That's a lot of batteries.¹

Fast forward: On May 14th, 2018 – and after 2.5 years of planning and development, EcoMotion facilitated the ribbon-cutting ceremony for the nation's first solar-powered Powered Emergency Response Centers (PERCs). All six school sites now feature solar systems sized to eliminate their PG&E bills. Batteries are in place; with solar and controls SRUSD now has 7-hour energy storage capabilities. All done with no money down. The systems were fully financed at parity, meaning that the District pays no more for clean power plus resiliency now than it did for "dirty power" before.²

These are the prototype PERCs EcoMotion is developing. PERCs provide deep levels of energy resiliency. They are fully financed and carbon-free. The PERCs will serve their schools and their communities during both short-term and prolonged power outages. Solar plus storage with controls allow each of six campuses to become microgrids, to "island" from the grid in the event of an outage. During prolonged outages, the sites will serve community first responders such as the Red Cross, and will be available for cell phone charging, etc.

After much planning and development, a rigorous competitive solicitation, challenges with financing the package, a short timeline to secure the PG&E A6 rate option, by September 2018, and after nearly three years of development, the PERCs are built and have received their final PTOs (Permission to Operate notices) from PG&E. The solar systems are up, energy management systems have been put in place to control loads during "rainy-day scenarios," and given approved interconnection agreements, the nation's first carbon-free PERCs are poised to function. EcoMotion's PERCs in Salinas effectively blend solar and storage and controls to create energy resilience.

¹ This white paper builds on a previous EcoMotion white paper: "Creating Microgrids and PERCs: Powered Emergency Response Centers," April 27, 2017. To access, please visit www.EcoMotion.us, then "Media," then "White Papers."

² A constant in the electric utility arena, is that rates always change. Since designing the PERCs at SRUSD – a deal financed at parity with rates at the time – PG&E's A6 rate has changed values cutting 10 - 20% of the value of the solar deal to SRUSD.

2. Hardening Facilities

The motivation for what became six PERCs at SRUSD was a simple one. The District had been experiencing frequent power outages. With its high number of English-as-Second-Language (ESL) and Free-and-Reduced-Price Meal (FRPM) students, SRUSD has a profound need for its kids to be in school, learning. Students use tablets at SRUSD, no more heaving heavy backpacks laden with text books that can't be updated, but the tablets are dependent on electricity. Furthermore, in the event of an emergency, it's often tough to reach parents in this farming community to get them to take their kids home. And the District is usually uncertain how long outages will take. Should students be sent home given the uncertainty?

As the realities and the effects of climate change become more common, and the connection to anthropocentric emissions becomes clear, schools, other institutions, and even our homes can attain energy resilience – or can be “self-sufficient” -- in a number of ways. Diesel-powered generator sets with a reserve fuel tank are standard and relatively inexpensive, and have been a favored option given the low probability of an outage on any given day. They've been used for decades for “mission-critical installations” such as fire and police stations, military facilities, and airports. But the solution only lasts as long as the fuel.

SRUSD's officials had never heard the term “microgrid.” The District simply wanted batteries but didn't know how they might be wired. To be able to operate when the grid goes down, EcoMotion informed the District that it would need more than batteries. It needed to set up an operating environment. Technically, it needed to establish a small grid – a microgrid -- that would independently maintain system frequency. This would enable solar arrays and inverters to operate when the macro, utility grid goes down.

After learning the options, SRUSD's Board was both intrigued and enticed by the idea of financing microgrids on its six campuses. It couldn't afford batteries, but might be able to finance a combination of solar and storage. This was way more than was ever imagined. Instead of investing SRUSD's precious Prop 39 funds, the entire deal would be financed separately and repaid as a utility expense. Over \$5 million dollars of energy management equipment was ultimately installed at SRUSD.

The SRUSD model is appealing and replicable. Thanks to the lithium-ion revolution³ campuses and all manner of facilities can invest in solar plus storage, achieving both carbon-free power and energy resilience. The SRUSD model can scale on campuses with or without solar. Hundreds of California school sites now have solar. However, in the event of a power outage, the systems will be rendered useless as their inverters need grid power to operate. Our job now is to “re-wire” these campuses, adding batteries and controls so that they can operate indefinitely as school and community assets.

³ Ted Flanigan, EcoMotion White Paper: “The Lithium-Ion, Hybrid-Electric Building Revolution,” February 23, 2016.

3. Crafting the Deal

The process of crafting the SRUSD deal began with EcoMotion's analysis of the average loads on SRUSD's six campuses. Our team assembled a year's worth of power bills for each campus, then examined seasonal and campus-specific usage patterns to determine average loads. We worked collaboratively with SRUSD officials to determine which loads are indeed "critical" -- such as communications, refrigeration, the bell schedule, lighting -- and which loads can be curtailed in the event of an outage... things like air conditioning and most plug loads.

Solar Savings Finance Storage

At the onset of the project there was no discussion of solar. It wasn't the District's priority; battery backup was. The District believed that solar was untenable from a cost standpoint. But EcoMotion Senior Solar Specialist Michael Ware took the initiative to investigate SRUSD's solar options. His most exciting discovery was the potential for a highly beneficial rate switch.

If SRUSD installed solar, then switched to PG&E's "solar-friendly" A6 rate which largely forgave demand charges in exchange for significantly higher energy charges, the savings realized from forgiven demand charges and the net metering from solar could potentially pay for batteries. Net metering would allow SRUSD to generate solar power in summer when students are not in session, and to get credit and bank peak kilowatt-hour prices. It appeared that the District might be able to get batteries to cover District-wide average operations, enabled by solar savings.⁴ The initial analysis found that the District might be able to finance solar and batteries at parity, the same price it had been paying for grid-powered electricity each year.

Soliciting Vendors

With a firm game plan in hand, and SRUSD's commitment to test the market, EcoMotion was poised to bundle of solar plus storage. With Board approval, EcoMotion wrote a Request for Proposals (RFP) for microgrids on behalf of SRUSD, specifically, six microgrids that combined solar and storage to achieve energy resilience.

The RFP went out to 12 firms. Only three bids came back: One for solar and storage in isolation, one for ground-mount solar only, and a third presented by SolEd Benefit Corporation⁵ of San Rafael expressing willingness to innovate and to "feather together" solar and storage to achieve the 7-hour program parameter. SolEd, working with EcoMotion, is credited with developing the

⁴ SRUSD's financial advantage was using the A6 rate that places a higher value on energy costs than demand charges. New rates proposed would cut the summer peak value for each kWh from over 50 cents per kWh, to about half that. Doing so will cause SRUSD to lose part of its summer-time net energy metering value.

⁵ SolEd Benefit Corporation, 990 A Street, Suite 403, San Rafael, California 94901; contact David Kunhardt, Chief Executive Officer, (415) 609 – 7893.

cost-effective solution that was ultimately built. Instead of having 7 hours of battery storage, couldn't each site have about half of that since solar could make up the rest?

Sizing Storage Based on the Probability Matrix

Avalon Battery⁶ was on the SolEd team and made several important contributions to designing the PERCs at SRUSD. While more batteries would assure greater probability of normal operations during power outages, that would increase costs, making the deal less cost-effective. In fact, a 100% battery solution would likely make SRUSD "upside down," meaning that the District would have to pay more for the microgrids than it was paying for grid power alone. That was unacceptable.

Recognizing that providing 7 hours of battery storage at all times and in all situations would be prohibitively expensive, Avalon and SolEd developed a probability matrix that combined solar and limited storage for each month and hour of the day. Naturally there is less sunlight in winter. Using NREL weather data, Avalon determined the chances of insufficient power from a combination of solar and storage at any given time.

The probability matrix allowed for pragmatic sizing of the amount of storage on site. Providing resilience 100% of the time exclusively with storage would be cost prohibitive. The Power Purchase Agreement (PPA) price would certainly be considerably higher than the current PG&E price. Since solar will contribute to normal power operations much of the time, smaller battery banks could be deployed. This construct allowed for the SRUSD deal to be financed at parity.

There is some liability to this blended, solar plus storage model: At those times when the grid goes down and when there is insufficient power between solar and storage, the District has to take action. In short, it needs to cut loads. With its wireless thermostat controls it can instantaneously and remotely cut HVAC loads. Its Energy Wardens will monitor and reduce plug and lighting loads if need be. The District can cut the charging of its first electric bus -- all to operate at power levels that reflect the daily conditions.

Ready for the Perfect Storm

But now imagine "the perfect storm!" It's 8:05. All the teachers, staff, and students have arrived, the schools are in full operation... and it's raining. There is no solar generation. Now the schools have only battery power with which to operate.

⁶ *Avalon Battery, 426 17th Street, Suite 700, Oakland, California 94612. Contact: Matt Harper Chief Technology Officer, (604) 866 – 3833.*

To address this issue, EcoMotion recommended that SRUSD's Prop 39 funds be used to invest in smart energy management,⁷ notably buying wireless thermostat controls. By doing so, SRUSD can readily control its largest use – HVAC – with the remote click of a mouse. As such, in the future, when the grid goes down on a rainy day, all HVAC will be immediately cut to reduce the load served by the microgrids.⁸ This involved special coordination with the EMS vendor – Capital E Systems -- to program the systems for “Battery Mode.”

Day 2+ Operations

The great value of the PERCs is that they can operate to cover short-term power outages, as well as long-term prolonged power outages. Imagine an earthquake hits Northern California and the grid is down for a month or more.

Day 1 microgrid operations are rather straightforward: The macro-grid goes down. After the shut-down procedure to lock-out the utility from the SRUSD microgrid, the microgrid comes to life. Loads are monitored and controlled if need be, and the school sites maintain normal operations. SRUSD schools are expected to be up and running within 15 minutes.

When in Battery Mode, care must be taken not to run the battery power to zero, but to leave sufficient capacity in the batteries to maintain microgrid frequency control so that the solar inverters will be able to operate on Day 2, and for that matter indefinitely. Basically, the microgrid cannot go down or it will never be able to recover and to provide value for as long as the macrogrid is down.

The Human Element and Battery Mode

One of the great benefits of SRUSD's progressive energy management infrastructure is the effect that microgrids have on students, teachers, and the entire school community. Schools are vibrant centers for learning that influence young minds and their families.

At SRUSD, every student now knows that its schools are solar powered. Soon every student will learn about “Battery Mode” and what to do and what not to do when SRUSD campuses are operating as microgrids. SRUSD has created living laboratories for smart energy management. At Santa Rita, the Superintendent's Office, Facilities, and the staff, teachers, and students all have active and defined roles during outages. They'll take action to cut non-essential loads to maintain operations. It's a team effort.

⁷ Ironically, after sizing solar to largely if not completely eliminate the District's power bill, SRUSD was left with little incentive for energy efficiency. Investing Prop 39 funds in sophisticated energy management provides great value by being able to cut loads when the combination of solar + storage is insufficient.

⁸ Generally, when it is raining the temperatures are mild. At these times HVAC demand will be low, and can be controlled to curb use and to stay within the schools' operating parameters.

EcoMotion has worked with SRUSD to establish protocols for action during outages. The Facilities Director will immediately contact the utility to ascertain the nature and duration of the outage. She will maintain consistent communications with the Superintendent's Office that will make all school announcements. The wireless thermostat system will be used to cut HVAC loads. Energy Wardens, established for each campus much like Earthquake and Fire Wardens, are responsible for assuring that all unnecessary appliances – for instance, photocopying and EV charging – are off during Battery Mode.

Financing the Deal

After delays, when SolEd finally signed the Power Purchase Agreement (PPA) in the summer of 2016, our project appeared to be in great shape: a done deal. But we were wrong. The PPA had a clause in it that gave the vendor (SolEd) an additional period of time to secure financing for the deal. We thought we had a deal, but we had a deal without financing. In fairness, SolEd's financial partner backed out, leaving SolEd a project without cash. At the end of the additional time, SolEd still did not have a financier for the project. SRUSD extended the PPA's terms to give more time.

Financiers are keen on financing projects that have high degrees of certainty. One of the SRUSD project's greatest barriers was that it had never been done before. Solar PPAs are common. Power Efficiency Agreements (PEAs) for storage are not uncommon and are based on avoiding ratcheting demand charges. But what EcoMotion recommended for SRUSD was novel... to wrap solar and long-term storage for resilience together in one PPA, held by one financier.

SolEd originally bid for the job with a finance partner, C2SSG. But C2SSG dropped out after SolEd won the bid, and after its analysts realized that the storage required was 7-hour storage. The more common 2-hour variety – matching SGIP incentives – has a “revenue-model,” and can provide services to utility demand response markets. On the other hand, 7-hour storage is insurance that only delivers value during crisis. SolEd reached out to 18 financial prospects, consulted with countless others, and at one point, exasperated, David Kunhardt exclaimed that, “The market is just not ready for this!”⁹

Switchgear Uncertainty

Meanwhile, the project was challenged by another uncertainty. Some of the campuses aging switchgear appeared to be too old and insufficient to land solar and storage. Clearly the PPA needed to address this cost and it was amended to include a switchgear adder of “up to

⁹ After C2SSG dropped off the SolEd team and withdrew its project financing, David Kunhardt of SolEd Benefit Corporation reached out to 18 financiers. They included Altus Power America, Avalon and its financial partner, Blue Path Finance, Brightmark Energy LLC, Candle 3, Carreden Group, CSSI, East West Bank, Ensync and its financial partner, New Island Capital, Renew Energy Partners, Security Research Association, Stem, US Bank, Wells Fargo, Zions Energy Link.

\$160,000" that would be paid by SRUSD if need be. At the end of the day, \$125,000 was required to bring the gear up to date.

PG&E's A6 Rate

The clock was ticking. PG&E's A6 rate – the rate that made the deal financially attractive – was coming to an end. Customers like SRUSD can only switch rates once a year. To secure and later grandfather the rate, we'd have to shift rates well before we would do so optimally. By shifting to the A6 rate in mid-winter, SRUSD would unfortunately have to pay high energy charges in the summer before solar was installed and operating. Given project delays, SRUSD had to pay a summer of high energy charges before they were offset by solar.

Generate Capital

Jigar Shah, the founder of Generate Capital in New York City, saw the value of the PERC concept and how PERCs address campus resilience in a new way, and provided project financing. This was a great relief to the project team. We had a financier who had the vision -- complete with its own set of stipulations. Generate deemed that the flow batteries proposed were un-financeable. Generate also brought in MBL Construction which in turn hired both Black and Veatch – a trusted name in engineering – and Sharp Energy Systems and Services Group, part of a billion-dollar company – to round out the team

The SGIP Variable

Another variable/factor that was in play was the potential incentives from the Self Generation Incentive Program (SGIP). While we could not be certain to get this California Energy Commission (CEC) incentive, what happened if we did? Since SRUSD never expected to get SGIP incentives, at the end of the day and to secure the contract, Generate Capital was assigned the SGIP incentives by SRUSD and did indeed receive all SGIP incentives.

Remarkably, the deal was done at parity, on par with the price that SRUSD had previously paid for grid power. Thanks to a bundled PPA, financed by Generate Capital, the District has achieved its goal of being able to keep students on campus while maintaining its utility bills at parity with its current cost of grid power. Unfortunately, subsequent rate changes, and changing values to "grandfathered" rates will chip away at parity.

4. Construction and System Components

There are a number of system components that collectively spell Smart Energy Management at Santa Rita Union High School District:

Smart Energy Management at SRUSD

- Energy-Efficient Lighting

- Solar Power, 1,050 kW PV at Six Sites
- Energy Storage, 1,096 kWh Samsung Batteries
- Microgrid Controls, Sharp's Energy Systems Group
- Wireless HVAC Energy Management System
- Electric Mobility, First Electric Bus in Operation

Efficiency: The process to invest in energy efficiency at SRUSD began with lighting retrofits on each campus to develop resilience. Energy efficiency is the top of the loading order in California, and was at SRUSD. Prop 39 funding was largely used to increase the efficiency of lighting on SRUSD campuses.

Solar: As part of the PPA, each campus at SRUSD now has a sizeable solar system, designed to be large enough to eliminate its power bill when on the A6 rate. The systems range from 115 to 264 kW in size and are all mounted on top of solar-ports that serve as lunch shelters and provide shade for cars.

Storage: Each campus also has about 80 kW of battery storage, and an average of 182 kWh of energy storage ready for discharge. When the grid goes down, solar generation and/or energy stored in the batteries will keep the campuses lit and operational. The total storage capacity for the District is 1,096 kWh.

Inverters: At the heart of the microgrids are bi-directional inverters. These allow for charging and discharging battery systems, including solar to storage direct DC charging during both normal and microgrid operations.

The systems are based on net energy metered solar (green power), and storage that is designated as "non-export." Solar is used to fulfill onsite load, charge the batteries, or feed back into the grid for net energy metering credit. Storage, on the other hand, can be used to only fulfill campus needs, providing energy and frequency control in the event of grid outages. PG&E will not allow SRUSD to buy grid power at night, store it, and then to sell it at a profit during the day. And of course, that is not the District's intent.

SRUSD intends to fill up the batteries with solar and to then use the solar daily fulfill campus needs, keeping full batteries in reserve at each site for deployment in the event of an outage. Black & Veatch, the systems engineer, was required to add hardware that will open AC contacts to physically prevent back-feeding into the grid from the batteries and to assure non-export of brown electrons when in island-mode operation during power outages.

Microgrid Controls: Each campus has its own microgrid controller (MGC), software developed by Sharp and built into a microprocessor computer tucked into the battery enclosures. These are the brains of each system. The MGCs track power use, net power use, and storage levels. Smart software, which will be updated periodically, controls the flows of electrons.

Wireless Energy Management System: In addition to lighting efficiency upgrades, and at the recommendation of EcoMotion, SRUSD invested its Proposition 39 allocations in wireless, energy management of its HVAC systems to control its major loads. Since the rate switch plus solar eliminated the PG&E bill, there was no value in investing in additional energy efficiency. But investing Prop 39 funds in controls makes the world of sense.

Electric Mobility: Another element of the SRUSD story is electric mobility. SRUSD is proud to have the first electric bus in Monterey County. Given the District's interest in adding to its e-bus fleet, compounded by expectations of demand for EV charging, SRUSD is now considering how to expand its solar generation to cover all campus loads, including mobility.

Integration, Engineering, Construction, and Asset Management

Black & Veatch was wisely brought in by Generate Capital to support overall project engineering. The company's engineering credibility was instrumental in assuring PG&E of safe and dependable microgrid functionality at SRUSD. Project construction was expertly provided by MBL Energy. Critical to integrating the microgrids' operation and bringing the project across the regulatory goal line to its completion has been Sharp's Energy Systems and Services Group.

Permitting and Interconnection

MBL Energy was an excellent choice for the construction of the six microgrids. MBL has completed similar solar projects at school sites throughout California, has a great reputation, and is well regarded by the Division of the State Architect in Monterey County. MBL reportedly worked with the California DSA without issue.

Kirk Stokes of Sharp Energy Systems and Services Group was the project's lead implementer and asset manager for permit application. He shouldered the responsibility of getting all permits and the interconnection initiated through PG&E. After this, Project Manager, Srujana Casturi from MBL, took the lead in seeing the permitting through to fruition.

Time-related delays were frustrating. The team chalks many of the issues to "the first-time syndrome." SRUSD was building systems, PERCs, that haven't been built and operated before. The PG&E approval process took so long that one of the parties had to file complaints with the California Public Utilities Commission (CPUC). After all, the solar systems were installed and had to sit idle for over a year prior to Permission to Operate. PG&E had refused to allow the solar to come online first, followed by the energy storage. In the end, two kinds of PG&E permits were required, one for interconnection and one for islanding.

The interconnection applications were filed in June 2017. After five months of back and forth, all were accepted after control system changes. The systems have been approved for both grid-tied (normal) and "islanded" operations during outages. Islanded operations had to be tested prior to final permission to operate. Final engineering approval was given in late July 2018, over

a year after the initial intent and applications were filed. Then two months later, after onsite inspections, SRUSD received its Permission to Operate notices from PG&E.

Scaling the Model

Energy resilience is attractive to many customer segments. Within the school segment, there are campuses without solar like SRUSD, plus hundreds of school sites in California that have solar, but no resilience. EcoMotion is currently working with Campbell Union High School District in Santa Clara County to rewire its campuses so they too can be PERCs in the event of a long-term outage. Seven years ago, CUHSD's Board authorized \$15 million to buy solar, and assumed that when the grid went down that the District would have power. But that's not the way solar systems work. Their inverters will automatically shut down, rendering their solar output useless. This frustration opens a great opportunity for rewiring.

Unfortunately, those campuses that have already installed solar have already accounted for the solar savings. Thus, the savings flow directly to the General Fund and are not available for the next logical energy management step, which is energy storage. In these instances, who or what will fund resilience? Must it become a new budget line item? A Parent Teacher Association initiative? Must schools rely on a California Energy Commission EPIC or Federal Emergency Management Agency grant?

EcoMotion is working to develop revenue models based on using a part of a district's storage capacity to "play into" automated demand response programs run by utilities, and ultimately to sell ancillary services¹⁰ to the California Independent System Operator. These are new forms of revenues that may well fund resilience. And these new forms of revenues will be reaped and realized by a new class of asset managers that tap the value of expensive energy storage elements on campus to reap secondary revenues.

Conclusion

The six SRUSD campuses, if properly operated, can operate carbon-free and in an islanded mode for decades. The systems were put together at no initial cost to the District. Now, SRUSD is creating living laboratories for its students. For these young, impressionable minds... this clean-tech innovation is their new normal.

The SRUSD case study is ripe with lessons learned. First and foremost, be patient with time-related delays. Second, bring a strong team together for maximum credibility. Third, be diligent in demanding what you need. And if shooting for the stars seems unwise, allow SRUSD's Board

¹⁰ For more information on ancillary services, please see EcoMotion's White Paper on "Ancillary Services from Distributed Storage," February 12, 2017. To access the White Paper, visit www.EcoMotion.us, go to Media, then White Papers.

to assure you that when there is no risk, there is no reward! How did a small, elementary school district in Monterey make the national press? It shot for the stars!

For More Information:

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*See also the SRUSD video titled “Microgrids, Energy Resilience, PERCs”
<https://youtu.be/82a1mRV3lTk>*

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