2016

Solar Plus Storage: A Resiliency and Climate Mitigation Strategy for Vulnerable Communities

Community Power Network
VA SUN, WV SUN, OH SUN,
FL SUN MD SUN, & DC SUN

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Executive Summary

Solar systems with battery backup have the potential to provide communities with much needed resiliency in the face of natural disasters. By providing power when the electric grid goes down, these systems can protect vulnerable communities from the most immediate, devastating effects of a natural disaster.

While the need for solar plus storage is clear, the question still remains: Are solar systems with battery backup a realistic option for communities seeking to improve their resiliency? What will it take to help a community deploy solar plus storage at a meaningful scale?

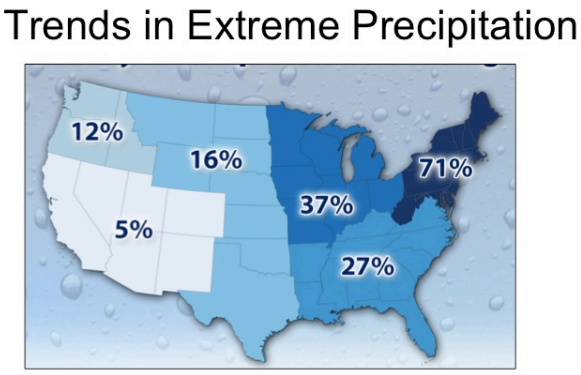
Community Power Network, a Washington DC-based nonprofit, sought to answer that question. Using a planning grant from the Aduvians Foundation, CPN conducted an in-depth analysis of the current "state of the art" of solar plus storage, seeking to determine if solar plus storage is a viable means to protect vulnerable communities from the impacts of climate change. Using the Hampton Roads, Virginia region as a test case, CPN modeled the financial feasibility of these projects and identified means to scaling up their deployment. The result is a clear framework that outlines the current state of affairs and provides a roadmap for how communities can use solar plus storage technologies to increase their resiliency.

Vulnerable Communities and the Need for Action

Preparing for natural disasters: The importance of resiliency

Throughout the country, an increasing number of communities are facing a growing threat from climate change-fueled natural disasters. Rising sea levels, increased flooding, greater annual precipitation, and more regular and intense storm events threaten communities with greater frequency each year.[1] For vulnerable communities it is no longer a matter of "if" a disruptive weather event will occur, but how soon.[2]

As climate change continues to impact weather patterns and intensify storms, communities will face increasing challenges. Disruptive weather events and natural disasters often create widespread and days-long power outages. These storms and outages are not just an inconvenience. They can have life-threatening consequences for vulnerable communities. Low-income families and people with disabilities, in particular, are disproportionately harmed by weather-related



Increase in the number of 2" rainfalls per year from 1958 to 2011

Extreme precipitation events will continue over the next 100 years as climate change continues to alter weather patterns.

[1] *Norfolk, Virginia: Identifying and Becoming More Resilient to Impacts of Climate Change,* Natural Resources Defense Council, July 2011

[2] https://www.theguardian.com/environment/blog/2014/jul/14/8-charts-climate-change-world-more-dangerous

disasters. Prior to the event, they often do not have the ability or means to temporarily relocate quickly. After the event, the resulting loss of power can be life threatening.

When in danger, people turn to their community anchor institutions for help and support. Police, fire departments, hospitals, and schools are expected to provide shelter and services after a disaster. However, if these anchor institutions themselves do not have power, or are running on limited generator power, it is impossible for them to meet to the community's need.

The lack of emergency preparedness in many communities is sobering to contemplate. A 2015 study by SmarterSafer demonstrated our lack of preparation as a nation. "Our current natural disaster policy framework focuses heavily on responding to disasters, rather than putting protective measures in place to reduce our vulnerability and limit a disaster's impact," the report reads. "This needlessly exposes Americans to greater risks to life and property and results in much higher costs to the federal government."[3] In addition to the human impacts, coastal infrastructure, fisheries and other critical habitats, income from tourism, military assets, and military readiness face severe risks from extreme weather events.[4]

Impact of climate change on the electric grid

Regional electric grids are also becoming increasingly vulnerable to the effects of climate change. Major storm events and flooding will lead to a greater number of prolonged power outages. Both the Union of Concerned Scientists (Figure 1) and the Energy Information Administration (Figure 2) have completed studies documenting a significant increase in U.S. electric grid disruptions as a result of major weather events over the last decade.[5] Weather-related disturbances are outpacing other events as the leading cause of outages in the U.S.

[3] http://www.smartersafer.org/wp-content/uploads/Bracing-for-the-Storm.pdf

[4] McGarry, James, Bill Kovarik, Rae Tyson. *Safe Coast Virginia: Climate Change Threats and Practical Solutions for Coastal Virginia.* Chesapeake Climate Action Network, 2014.

[5] http://blog.ucsusa.org/steve-clemmer/hurricanes-sandy-katrina-and-the-growing-risks-of-storm-surge-and-blackouts-936

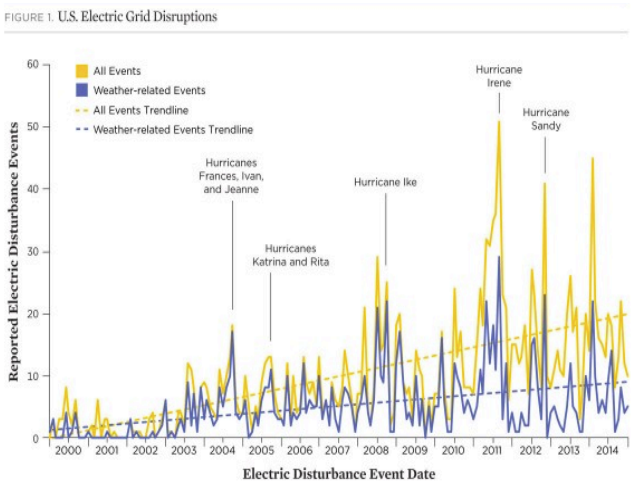


Figure 1: US Electric Grid Disturbances (2000-2014)

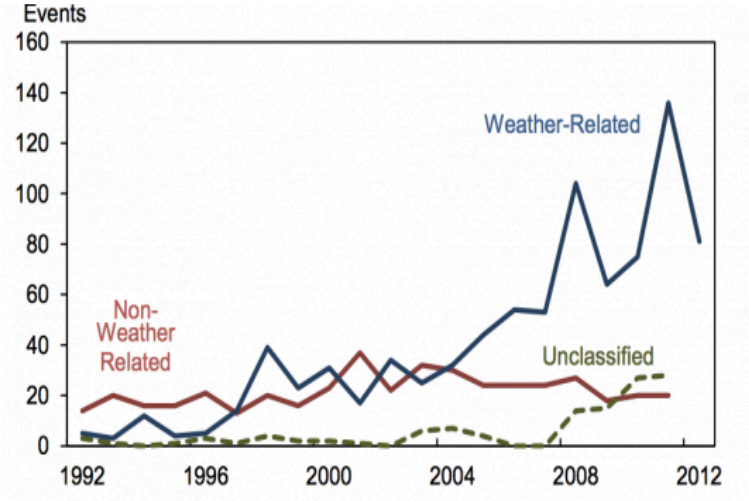
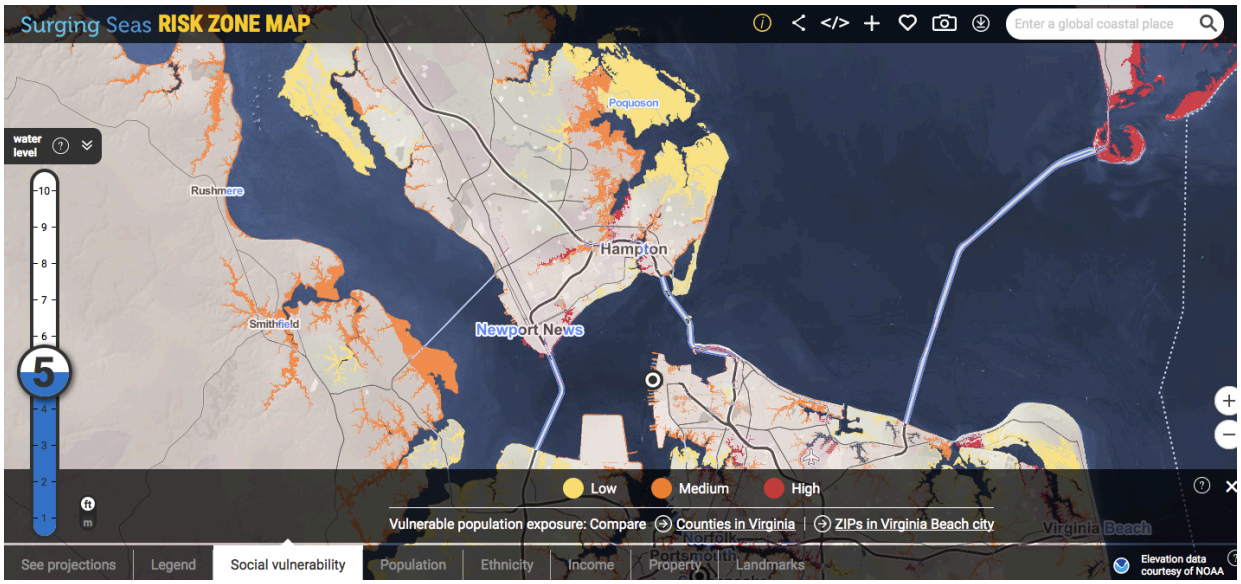


Figure 1: Observed outages to the bulk electric system (1992-2012)

According to the 2011 *Southside Hampton Roads Hazard Mitigation Plan,* even a "moderate" hurricane storm event would be expected to bring "near-total power loss with outages that could last from several days to weeks." In the increasingly likely case of more extreme storm events, "power outages [would] last for weeks to possibly months."[6] The *Peninsula Hazards Plan* also warns that, "tropical storms and hurricanes have the potential to significantly impact (impair) a wide range of sectors including transportation, utilities, and emergency management." Higher profile structures, infrastructure, and vehicles are most vulnerable to destructive hurricane winds. Damage to above-ground power and communication lines and towers could potentially lead to outages that last for days, weeks, and, in a worst-case scenario, months.[7] To exacerbate the problem, current disaster preparedness plans appear to plan for one to two feet of sea level rise in the next 100 years,[8] while current scientific projections are projecting more than five feet of sea level rise in the next century.[9]

[6] http://www.hrpdcva.gov/uploads/docs/2011%20Southside%20HR%20Hazard%20Mitigation%20Plan.pdf (pages 63,64)
[7] https://www.williamsburgva.gov/Index.aspx?page=401 (page 136)
[8] http://www.hrpdcva.gov/uploads/docs/2011%20Southside%20HR%20Hazard%20Mitigation%20Plan.pdf (pages 26-29)
[9] Stiles, William, Molly Mitchell, and Troy Hartley. *Policy Climate for Climate Change in Virginia: Overview of Adaptation Policy, Planning and Implementation Landscape.* Sea Grant Law & Policy Journal, 2012. http://nsglc.olemiss.edu/sglpj/vol5no2/3-hartley.pdf (page 21)



Flooding and major storm events threaten the stability of a significant portion of our nation's electrical grid.

Case Study: Superstorm Sandy

While it is easy to dismiss projections and models as theoretical exercises, we are already beginning to see the impact that major weather events have on unprepared communities and disadvantaged populations. Hurricane Sandy is a clear example of this. In the aftermath of Superstorm Sandy, 8.5 million people lost power for an extended period of time.[10] Sandy shut down or damaged at least 165 electric substations, several large power plants, 7,000 transformers, and 15,000 electrical poles. Many of the gas generators relied upon by critical infrastructure, such as hospitals and senior living centers, either failed or provided limited performance due to issues with siting, fuel availability and poor maintenance.[11]

During Hurricane Sandy, many of the emergency generators relied upon by critical infrastructure failed.

The storm surge caused flooding and outages that seriously impeded the ability of five hospitals and 30 residential facilities to shelter in place during and after the storm.[12] At New York University's Langone Medical Center, the auxiliary generator malfunctioned. As a result, 215 patients, some with life-threatening conditions, were transferred to other facilities during the height of the storm.[13] The American Red Cross sheltered 10,928 residents in 258 shelters throughout the region at the storm's peak.[14] However, shelters were not prepared to support special-needs residents, and turned away residents who depended on the electrical grid for various reasons, such as powering a medical

[10] *Hurricane Sandy After-Action Report*, FEMA, July 2013
[11] Sifferin, Alexandra. *Lesson from Storm Sandy: When Hospital Generators Fail.* Time Magazine, October 30, 2015
[12] *After Hurricane Sandy: Lessons Learned for Bolstering the Resiliency of Health Systems and Services,* Northeastern University and the National Center for Disaster Preparedness.
[13] Sifferin, Alexandra. *Lesson from Storm Sandy: When Hospital Generators Fail.* Time Magazine, October 30, 2015
[14] *Hurricane Sandy After-Action Report,* FEMA, July 2013

device, because shelter operators felt that these patients' needs could not be met.[15] As a result of the storm, 117 people died. It caused $65 billion in damages.[16]

Sandy and countless other recent natural disasters have again and again taught emergency managers an important lesson: traditional gas and diesel generators are not reliable. And, when the power goes out, the poor, sick and elderly are most likely to be impacted. A majority of the 117 fatalities due to Hurricane Sandy were elderly. A New Jersey report found that: "most of the New Jersey residents who died as a result of the storm were 65 or older. The leading causes of death among this age group were asphyxiation, as respirators could not work without electricity."[17]

A 2015 study summarized the importance of resiliency and backup power in the face of major weather events and natural disasters:

> *"The disaster showed that – more than an inconvenience – losing power is life threatening to those who need electricity to power elevators, mobility devices, medical equipment, and refrigeration for medicine. And once disaster strikes, low-income and vulnerable populations – those requiring supportive services – have the most difficulty dealing with the consequences. They often lack the income, savings, insurance, and access to communication channels and information to recover from the adverse impacts of disruptive weather events."*[18]

The need for resiliency

A 2013 survey by Accenture found that 83 percent of North American utilities said that recent extreme weather had directly influenced investment decisions around grid hardening and networking. "This is now a top priority," said Jack Azagury, head of Accenture's global smart grid business, "we saw Sandy give the utilities an environment to consider broader investment" in smart meters, fault detection and software tools to monitor the distribution grid. As Greentech Media put it, a new buzzword has emerged as a framework for this next round of grid investment: "resiliency."[19]

Resiliency is defined as the capacity of a community to anticipate, plan for, and mitigate the dangers associated with environmental and social change.[20] If communities are to be able to

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[15] *After Hurricane Sandy: Lessons Learned for Bolstering the Resiliency of Health Systems and Services,* Northeastern University and the National Center for Disaster Preparedness

[16] https://www.greentechmedia.com/articles/featured/resiliency-how-superstorm-sandy-changed-americas-grid

[17] *http://www.njisj.org/wp-content/uploads/2013/05/HURRICANE-SANDY-AFTER-MATH-Rebuilding-with-Social-Justice-in-New-Jersey.pdf*

[18] Mullendore, Seth, Robert Sanders, and Lewis Milford. "*Resilience for Free: How Solar+Storage Could Protect Multifamily Affordable Housing from Power Outages at Little or No Cost*," Clean Energy Group, October 2015

[19] https://www.greentechmedia.com/articles/featured/resiliency-how-superstorm-sandy-changed-americas-grid

[20] "*Bounce Forward: Urban Resilience in the Era of Climate Change,"* A Strategy Paper from Island Press and the Kresge Foundation, May 2015

withstand the impacts of climate change, and the impending threat of severe weather events, they must begin to develop resiliency.

R. David Gibbs of the nonprofit group Solar One directed volunteers in an installation at the Rockaway Beach Surf Club. Robert Stolarik for The New York Times

After Sandy, Solar One, a New York-based nonprofit, installed solar systems to provide power to communities in the event of future natural disasters.

A Resiliency Solution: Solar Plus Storage

Solar systems with battery backup are one effective means to provide resiliency. These systems offer sustained, on-demand power after emergencies without the need for fuel. Because of the extensive damage to electrical systems and the failure of backup generators, solar plus storage was the only power source in many areas after Sandy. Outside of emergency situations, solar systems have the added benefit of enabling communities to produce their own power, and to reap the rewards of local energy production, such as lower utility bills and employment opportunities for local contractors.[21] Furthermore, solar plus storage deployment at scale has the potential to significantly reduce greenhouse gas emissions, serving the dual roles of climate mitigation and climate resilience.

Understanding this, Community Power Network (CPN) and our on-the-ground state SUN programs have sought to determine the potential challenges and opportunities to use solar plus storage projects to mitigate the danger to at-risk communities during power outages. We envisioned solar plus storage systems on critical community buildings, such as shelters, schools,

[21] Mullendore, Seth, Robert Sanders, and Lewis Milford. "*Resilience for Free: How Solar+Storage Could Protect Multifamily Affordable Housing from Power Outages at Little or No Cost*," Clean Energy Group, October 2015.

emergency service providers, and hospitals. This would provide power immediately when the grid is down, as well as help the institutions reduce their energy bills throughout the year.

We also explored the potential of pairing solar projects on anchor institutions with neighborhood solar co-ops to enable surrounding residents to put solar on their homes. The co-ops would scale the project's impact in multiple ways: increasing emissions reductions, creating the basis for distributed solar plus storage microgrids, and providing profound opportunities for education and communication on the benefits of solar. By combining solar co-ops with battery-tied resiliency pilot projects we can build resilience in residential communities, while raising awareness about the social, ecological, and economic benefits of renewable energy.

This approach is preferable to other options because it is comprehensive and tackles the problem from both sides. Resiliency on its own does not address the root cause of these extreme storms. And solar co-ops by themselves, while an excellent way to reduce carbon dioxide emissions, do not help communities prepare for inevitable disasters. Our approach simultaneously increases the resilience of critical institutions and fosters sustained solar deployment in the region. Rather than a one-off project, our goal is to build long-term resilience and climate change action in communities. **By providing a holistic approach based on proven project models, capacity building, and education we can offer communities a practical model for addressing the multi-faceted challenges of adapting to and mitigating climate change.**

Planning grant experience and findings

Overview

In 2016, CPN's VA SUN program received a planning grant to evaluate the feasibility of using solar with storage to mitigate the dangers at-risk communities face during power outages, and to develop an implementation plan for this concept. Our central question during this period was: is installing solar plus storage systems at critical community facilities in vulnerable communities economically possible and scalable?

Solar plus storage is a complex topic within a rapidly evolving market sector. In order to determine whether our plan to develop these model pilot projects was feasible, we broke down our investigation into five areas (outlined below). We conducted extensive technical research on solar plus storage; analyzed the current resiliency policy framework in the test community of Hampton Roads, VA; built relationships with potential project partners; and developed a roadmap for how we would deploy solar plus storage systems to increase resiliency in the community. By answering these questions, and basing our research on actual project numbers in a test community, we felt we could adequately judge the feasibility of using solar plus storage to increase the resiliency of communities.

Findings

Central Research Question	
Is putting solar plus storage systems on critical community buildings economically possible? Is it scalable?	
Sub-questions	Findings
Question #1: Is battery technology ready for widespread use in resiliency applications? And does solar plus storage have the capacity to scale?	**Yes**
Question #2: Do solar plus storage projects "pencil out" financially?	**Yes**
Question #3: Is there existing demand for solar plus storage projects?	**No**
Question #4: Is solar plus storage already included in resiliency planning currently in place?	**No**
Question #5: Does the existing policy environment support widespread deployment of solar plus storage projects?	**No**

Question #1: Is battery technology ready for wide scale use in resiliency applications?

Developing successful battery pilot projects requires that the technology has achieved market readiness and is available for widespread use. We sought to analyze the market viability of current battery technologies for solar plus storage applications.

Approach

To answer this question, we spoke extensively with industry representatives and consultants, reviewed existing and emerging data and literature, and spoke with solar installers and other vendors in our network who have on-the-ground, practical experience with residential and commercial battery applications. VA SUN's Program Director, Aaron Sutch, also attended the 2016 Energy Storage Conference in Charlotte, North Carolina, where he learned about storage technology and applications, and made connections within the industry. Our objective was to ground truth much of the "hype" in the sector, and to better understand emerging trends.

Jeff Kirschbaum of Solar Panels Plus, a Chesapeake-based distributor for Aqueon batteries

Findings

The current state of battery technology makes solar plus storage feasible, and given the market's rapid development, large improvements will continue to arise in coming years.

The two most common battery types are lead acid and lithium-ion. Lead acid batteries are toxic, require maintenance, have limited discharges per battery, and do not discharge as quickly as required to be used for ancillary services. However, they are very inexpensive, reliable, and well known in the market. They are most applicable and cost effective, for example, for use for in an off-grid cabin or for use purely as backup power. Lithium-ion batteries have faster reaction times,

tolerate many more charging cycles over the life of the battery, but are more expensive and flammable. Lithium-ion batteries have received much attention in recent years, especially owing to their use in highly publicized technologies like the Tesla Powerwall. Owing to their ability to discharge frequently and rapidly, lithium-ion technology is key to using batteries to tap into additional income streams, such as demand management, peak-load shaving, or ancillary services (explained further in detail below).

CPN also spent considerable time exploring the many new batteries coming onto the market. One exciting new technology that has garnered media attention is the Aqueon™ saltwater battery. CNBC heralded it as a "relatively cheap and environmentally friendly battery that uses saltwater and other commonly available materials to solve one of the biggest technical challenges facing renewable energy technologies."[22]

We had the opportunity to speak with Jeff Kirschbaum of Solar Panels Plus, a Chesapeake-based distributor of Aqueon batteries, who provided a helpful explanation of the market perspective on battery sales, including the benefits and drawbacks of various battery and solar technologies, pricing and product availability. Although excited about the opportunities, Jeff was reticent to pick a clear technological winner moving forward. According to Jeff:

> *"With the Aqueon battery we have a non-toxic storage medium with the potential to demonstrate benefits in a wide variety of applications including resilience."*

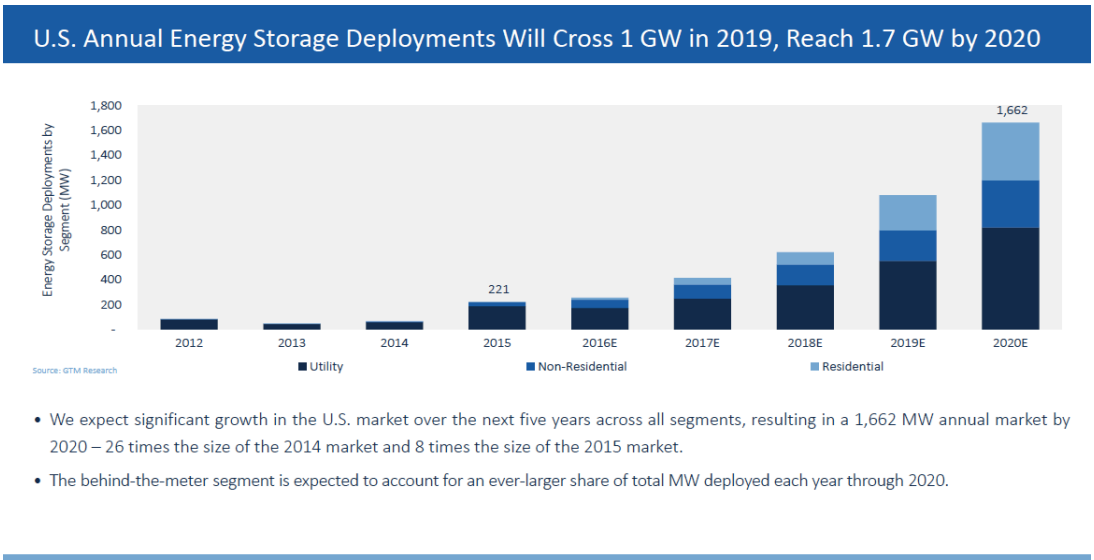
He was also careful to explain that:

> *"These applications are constantly changing…The important part is that we get the technology out there in proof of concept situations, and collect lessons learned to scale the industry...We need to constantly evolve."*

Based on our research, the Aqueon battery seems to offer the "best of both worlds" from a technology standpoint, but has the drawback of being in very limited supply at the moment. However, they are interested in collaborating with us and launching a pilot test project on the East Coast. This will be an important asset for the project from a logistical standpoint, and has the added advantage of appealing to local elected officials interested in promoting technology with direct local jobs impacts.

From an engineering perspective, the project design for a battery storage system with three separate objectives (backup power, reduction of peak demand, and engagement in the ancillary services market) is quite complex. Backup power calls for different qualities in a battery than ancillary services, so systems designed for both functions require complex software, engineering, and inverters. This will add to project complexity and cost, but is technologically feasible.

[22] http://www.cnbc.com/2015/09/15/low-cost-saltwater-battery-wins-500000-award.html



Industry experts anticipate that the storage market is on the verge of enormous growth.

It is important to note that, while battery systems are currently viable, the storage market is growing steadily and will continue to be radically transformed in the coming years. This growth is due to a number of factors, including new incentive programs in California and the PJM Interconnection (which includes Virginia, West Virginia, Ohio, Maryland, and the District of Columbia), the need for storage to help balance the grid in places like Hawaii (where solar PV comprises 29 percent of the electricity supply), and large federal investments (including a recent White House Initiative on Scaling Renewables with Storage), and a recent announcement by the United States Navy.[23] The Navy's investment may prove to be one of the most fortuitous alignments in this emerging sector contributing to the long-term success of this initiative. For more details on the Navy's commitment, see the insert below.

An increasing number of well-known companies are joining the market. *Utility Dive* recently reported that Caterpillar, best known for bulldozers and generators, has entered the storage and microgrid markets, building on its strategic alliance with First Solar to bundle solar panels and batteries for "Cat-branded microgrids.[24] Aerospace firm Lockheed Martin is producing lithium-ion batteries and developing a new flow battery design. These companies joined the ranks of other large industrial companies like ABB, General Electric, LG Chem, Panasonic, Samsung, and Tesla Motors.

[23] https://www.whitehouse.gov/the-press-office/2016/06/16/fact-sheet-obama-administration-announces-federal-and-private-sector

[24] http://www.utilitydive.com/news/construction-manufacturer-caterpillar-enters-microgrid-and-storage-market/418791/

The market is also aggressively exploring use of electric vehicles (EVs) as a "battery" to provide backup power in outages. Companies like Honda are working to develop devices to allow EV owners to use their cars to power appliances in their homes.[25] This is especially appealing to homeowners because it would allow them to have both a vehicle and the benefits of backup power without significant additional upfront cost. As investment and innovation continues in this market, there will be great demand for demonstration projects and trusted partners to help companies evaluate the efficacy of their products in real-world settings.

The solar plus storage sector is a vast landscape consisting of multiple players and technologies, from batteries to energy management software. This landscape is likely to change rapidly over the coming years. **Public demonstration projects are critical for creating transparency, disseminating best practices, and enabling solar plus storage to become a vibrant and scalable resiliency strategy for vulnerable communities.**

It is clear that solar plus storage will become cheaper, more robust, and more powerful over the coming years, in both centralized and distributed applications. However, it is unclear how the benefits of the technology will be shared and whether it will be used to increase community resiliency and sustainability. Will the poorest and most vulnerable have access to solar plus storage for life-saving medical equipment when the grid goes down? Or will those benefits mostly reside at corporate headquarters and on university campuses? The path we seek to develop will put this technology to work for the community, making its benefits accessible to the most vulnerable and under-served populations.

June 16th Announcement by United States Navy

Making Our Military Facilities More Resilient: The Navy's Renewable Energy Program Office (REPO) and U.S. Air Force announce the following new projects and activities.

- A new 50-100 MW grid-scale battery project that will be developed by a third-party developer at Naval Weapons Station Seal Beach in California.
- A new 7 MW solar photovoltaic (PV) system with a 6 MW (18 MWh) battery system that will be developed by a third-party developer on the local grid at Naval Base Ventura County (NBVC) in California. The project will serve NBVC during electric outages, covering over 65% of the base's peak loads for up to 3 hours.
- A battery second use (B2U) pilot project in Indiana with Naval Support Activity Crane, Duke Energy, and other stakeholders. The project will repurpose the Navy's fleet of decommissioned submarine batteries into distributed energy resources to serve mission-critical loads. If the battery fleet is repurposed rather than recycled, the Navy's overall battery capacity is projected to grow to 44 MWh by 2019.

Conclusion

Based on our research, we have identified that the current market for state-of-the-art batteries is robust enough to support solar plus storage applications. This does not mean that there are no current limitations, but it is feasible to deploy solar plus storage pilot projects. In particular, the fact that Aqueon saltwater batteries are distributed for the East Coast exclusively from

[25] http://evobsession.com/use-your-electric-car-to-power-your-home-with-honda-power-exporter/

Norfolk is a huge asset to the project. This will allow us to partner with Solar Panels Plus, and implement a demonstration project that has a direct connection to local job creation.

There will continue to be breakthroughs in the market in coming years as technology improves. Having pilot projects in their community will provide institutions and local governments with a baseline knowledge (i.e. solar plus storage "literacy") that will be especially helpful for navigating these changes and identifying future projects that will improve upon the pilots. As with any new technology, it is important that individuals and institutions can communicate the benefits of energy storage to the general public, decision makers, and potential customers. Pilot projects provide an important opportunity to learn about the new technology and lay the groundwork for scaling up deployment in the future.

Question #2: Do solar plus storage projects "pencil out" financially?

Deploying pilot projects, particularly in the private sector, will be much more feasible if they are cost effective. We sought to determine the economic feasibility of solar plus storage installations.

Approach

We dug deep into the business model of solar plus storage projects and explored to what extent installations with solar plus storage can "pencil out," thereby becoming a highly scalable model for deployment in the area. As a baseline we modeled the feasibility of a project located in Virginia. We determined that the sample community of Hampton Roads in Virginia is a reasonable economic proxy for a wide variety of communities around the country. This is the case because the state of Virginia has relatively low electricity prices, a conservative utility company (Dominion Power) that does not champion distributed renewable energy projects, and there are not any state-level incentives for solar or storage. Thus, if a project is economically feasibly in Virginia, it will likely be very possible in a wide range of other communities as well.

In our investigation process we examined the current economics of solar plus storage projects by working with private sector partners and vendors to model several actual sites. These models used real buildings, energy loads, and current market prices. We examined whether the combination of lowering total demand through net metering and lowering utility demand charges by load shifting with batteries would confirm a business case for the technology. Furthermore, we examined the pros and cons of adding a "frequency regulation/grid services" income stream to the project through participation in the PJM market. We sought to understand the opportunities, risks, and limitations of that market, and to identify a profitable business model by which solar plus storage could become an important part of the resiliency framework.

In order to accurately test the financial feasibility of a project, we first had to develop financial models for a number of actual solar plus storage projects. Our biggest challenge was identifying private sector partners interested in participating in the modeling study. Even though we were offering a "free study" we had a hard time convincing companies to participate. We reached

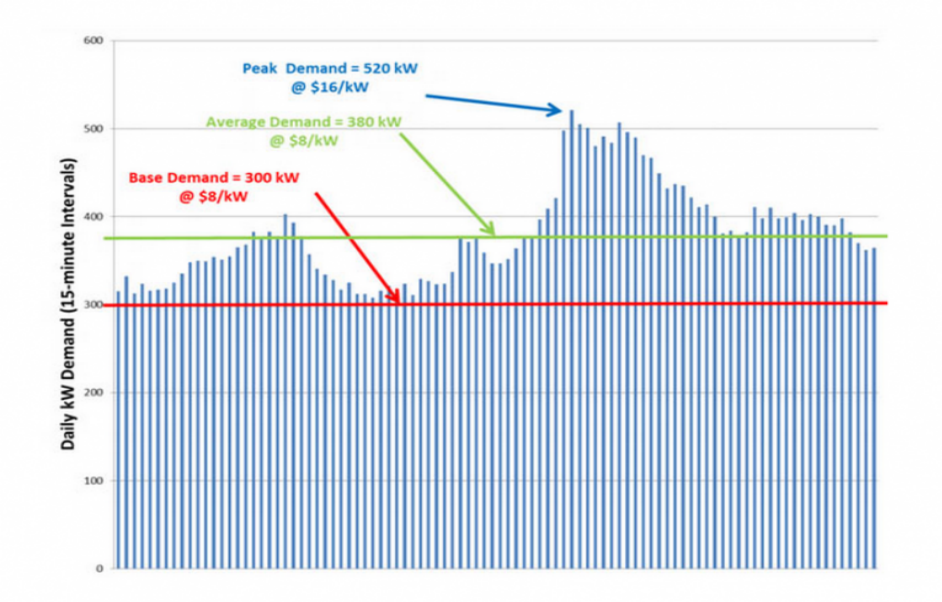
out extensively by phone, especially to grocery stories and assisted-living facilities. We posited that these facilities would be a good fit for a solar plus storage resiliency project because of their need for emergency power to protect food supplies and vulnerable seniors, combined with the fact that these sectors are largely for-profit commercial entities that could utilize federal tax credits available for solar plus storage projects. We found these sectors to have excellent solar potential and the ability for scale (see Appendix 2 and 3), but a lack of motivation to address resiliency. They are required by law to have limited backup generation, and they are not currently interested in going beyond that.

Only after a series of face-to-face meetings were we able to find project partners willing to take the time to model their building's potential for solar plus storage. The city of Newport News was the most interested partner. They identified two critical buildings for a preliminary study and expressed interest in a long-term partnership on the topic. After conducting our own solar analysis and feasibility study, we solicited bids and received proposals from two companies specializing in detailed financial and site analysis of battery storage systems: GreeNEWit and Tumalow. In addition to soliciting bids, we interviewed key players in the financing sector, conducted an exhaustive literature search, and attended the 2016 Energy Storage Conference in Charlotte, North Carolina.

Findings

Our modeling and conversations with practitioners revealed that solar plus storage can indeed "pencil out," and that demand charge reduction is a central driver of this.

Demand charges represent a monthly fixed cost. They make up a significant portion of commercial and industrial customers' total electricity costs, typically between 30 and 70 percent. With demand charges, a company with a very uneven load profile can end up paying considerably more for their energy than a company with higher energy consumption but an even load profile.



With demand charges, a company with a very uneven load profile can end up paying considerably more for their energy than a company with higher energy consumption but an

Across the U.S., demand charges are increasing even while overall energy prices are decreasing.[26] As more solar and wind capacity is added to the grid, usage profiles across the grid are becoming more uneven. Therefore, it is foreseeable that electricity prices could continue to decrease and demand charges to increase with the addition of more renewable power. This would create a very positive feedback loop encouraging solar plus storage.

In places like California, where there are high energy charges *and* high demand charges, the business case for solar plus storage is already well established. As Virginia has lower energy costs and less incentives for solar, the market is less well developed, but projects are still financially feasible. Our preliminary proposal from Tumalow showed that both Newport News buildings could significantly reduce demand charges by using a battery system to reduce the instantaneous peak demand of the building's electric load. We modeled several scenarios, and in both cases the potential monthly savings ranged from $121 to $372 due to this demand charge reduction.

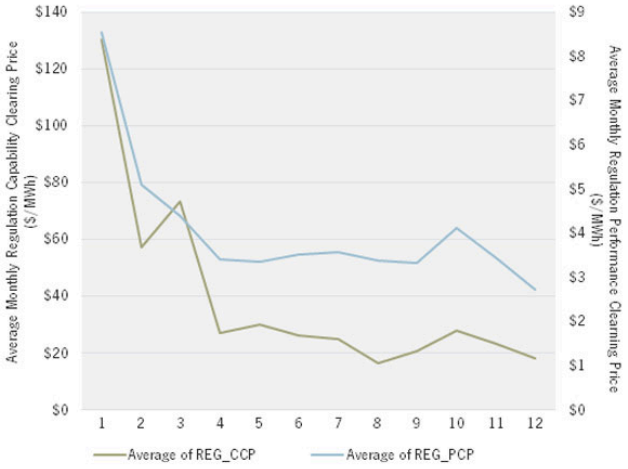
[26] http://www.carterservices.com/electrical-services/demand-charges-101/

Purchased Storage Option – Customer owns the assets		
Cost/Benefit Component		**Value**
Outright Purchase		
Upfront Capital Cost	**$**	**(40,688)**
System Equipment Refresh Capital Cost	**$**	**(5,756)**
Project Payback Period (year)		**4**
Finance		
Cumulative Financing Cost	**$**	**(61,314)**
Debt Fully Funded		**Yes**
20 year Cumulative Net Cash Flow	**$**	**136,237**
Total Cost of Ownership	**$**	**(74,064)**
Project NPV	***$***	***68,655***
Projected Average Monthly Savings	**$**	**372**
Peak Shaving Savings	$	372
Time of Use Savings	$	-
Projected Average Monthly Revenue	**$**	**624**
Demand Response Payments	$	-
Frequency Regulation	$	624
Other (TBD)		
Monthly Tumalow Energy Management Contract	**$**	**(197)**
Projected Average Net Monthly Benefit	***$***	***799***

Snapshot from a preliminary analysis of the potential revenue from storage on the Newport News emergency staging area shows a positive net present value. Complete analyses included in Appendix 1.

In addition to demand charge reduction, our modeling showed that projects could simultaneously generate income by participating in PJM's ancillary services market. Ancillary services are defined as grid support functions that help balance the power availability and power quality of the electric grid. These services include providing power during peak usage periods and balancing electric voltage and frequency to maintain optimum power quality. These services are very valuable and until very recently been provided only by power plants. However, battery technologies have now reached the point of technical maturity and cost-effectiveness allowing them to participate in this space. Battery system owners can thus be compensated for the value their systems provide to the grid.

Virginia is part of the PJM Interconnection, and thus eligible to participate in its lucrative ancillary services market. The revenue potential is quite appealing: $40/MWh x 15 hours per day x 365 days per year = $219,000 income per year per MW of storage – but prices are volatile.



Prices for ancillary services on the PJM grid are highly volatile

They generally require large-scale battery installations and depend on the opportunities used by the investor, ranging from frequency regulation to demand management or spot markets for power.[27] As an investment, it is not for the faint of heart. In fact, several of the investors we consulted concluded that they were not planning to continue to engage in these markets, as they were too hard to predict.[28] However, approaching ancillary services as a potential *additional* revenue stream of a project primarily intended to increase community resilience may provide an added incentive sufficient to push a project well into the black. It may also be important to aggregate multiple stakeholders in order to achieve battery systems large enough to take advantage of ancillary services markets.

One central thrust of this three-year project is to develop projects and policies with an eye toward building the foundation for a region-wide network of solar plus storage. It is essential to start with individual projects for proof of concept, but the twin objectives of scaling the solar market and profoundly improving regional resilience ultimately will require the creation of a network of strategically placed projects.

Another risk to financial feasibility we identified early in the planning grant process is the threat of Dominion Virginia Power, the state's largest utility, squashing development of this sector via onerous rules or excessive fees. However, while there will certainly be conflicts with Dominion over who has the right to develop and benefit from solar plus storage and microgrid solutions, there are strong signs that Dominion is not moving to immediately shut down this new sector. Dominion recognizes that profound changes in grid design and management, including solar plus storage, are on the horizon. It appears the company hopes to profit from these changes rather than stop them. While this a benefit for the feasibility of a project in Virginia, it's important that other communities conduct sufficient due diligence into the potential impact a local utility may have on a proposed project, particularly if the utility views the project as a threat.

Conclusion

While the economic model for solar plus storage is complex, and still evolving, our preliminary analysis shows that there are already a number of positive net present value (NPV) project models for solar plus storage in Virginia. The fact that the sector is still rapidly evolving means it is a good time for demonstration projects and information dissemination. It is also likely that

[27] http://www.greentechmedia.com/articles/read/battery-storage-pays-back-in-less-than-five-years-sc-finds
[28] Ben Margolis at SolSystems, and Bernie Zahren at Clean Feet Investors

additional compelling financial models for the sector will develop in the next 2-5 years. Our research validates that projects "pencil out" and there is real potential to scale up this sector. However, the projects require relatively sophisticated financial structures and specialized knowledge**. Therefore, we estimate that, at the moment, only an organization that prioritizes *both* emergency preparation and sustainability will be willing to take on the project risks and complexity**. Once we have addressed these complexities with a proven project model, private organizations will be very ready to jump in and develop their own projects. Taking on a pilot project at this point in the market's development will have a significant positive impact on market maturation. With the right foundation of support from the beginning, solar plus storage projects can become standardized and widespread.

We know that the time is ripe for solar plus storage pilot projects. The U.S. energy storage market is currently poised for an explosion: in 2015 the market grew 243 percent and had the largest year on record.[29] According to Andrew Slaughter, Executive Director of Deloitte's Center for Energy Solutions, "the emergence of battery storage is happening now, is accelerating, and it will get bigger in the next two to five years." [30] As we move closer to the battery storage technology "sweet spot" at the end of this decade we'll begin to see rapidly falling prices and accelerating deployment.[31] It is no longer a question of whether or not solar plus storage will take off, but how quickly. As with any new sector, however, there is a real possibility that those who could benefit most – low-income residents, the elderly, and other vulnerable populations – will be ignored in the process.

Question #3: Is there existing demand for these projects?

Deploying a number of pilot projects over a three year period requires that there is existing demand for solar plus storage projects. We therefore sought to determine the feasibility of partnering with community anchor institutions and/or private companies to implement pilot projects.

Approach

We conducted exhaustive review of FEMA and local emergency preparedness documents to identify specific community entities and institutions that play a role in emergency preparedness (e.g. fire and emergency services, hospitals, schools, grocery stores, emergency shelters, and elder care facilities). We focused our outreach on these partners because they are most likely to be interested in developing pilot solar plus storage projects as a means to improve their emergency preparedness. We also targeted private sector companies in these areas, as their ability to utilize federal tax credits for solar would allow the project economics to pencil out more easily. Our goal was to develop relationships with these entities and line up partnerships for the scoping study and three-year implementation program.

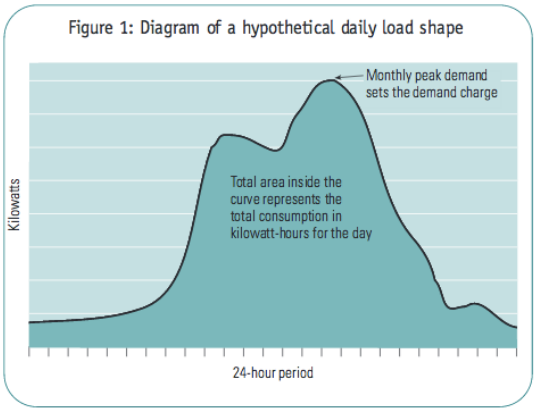
Findings: Private Facilities

[29] http://www.greentechmedia.com/articles/read/us-energy-storage-market-grew-243-in-2015-largest-year-on-record

[30] http://www.utilitydive.com/news/why-battery-storage-is-just-about-ready-to-take-off/407096/

[31] http://cleantechnica.com/2015/12/09/falling-costs-rising-applications-will-boost-us-energy-storage-market/

We took a deep dive examining the market potential in two sectors: grocery stores and assisted living facilities. Models of daily grocery store load convinced us that grocery stores might be a good place to look for financially compelling projects. American grocery stores spend an average of $3.95 on electricity and 24 cents on natural gas per square foot annually. Although energy only represents about 1 percent of total grocery store costs, it is about equal to a typical grocery's profit margin. Therefore, a 10 percent reduction in energy costs can mean a 10 percent increase in profits.[32] And, because the majority of the power is used during the day, solar plus storage could easily replace daytime peak demand without relying on net metering.



Solar plus storage could be an important value proposition for grocery stores, as they typically have excellent roof space for solar and often have high electricity bills.

We also found that many grocery stores have excellent roofs for solar (for detailed evaluations please see Appendix 2 and 3). We identified 44 different grocery stores in our test community of Hampton Roads with a solar potential of 13.7 MW of solar potential in the area. To put this in perspective, according to the U.S. Solar Energy Industries Association (SEIA), there are currently 21 MW of solar currently installed in the entire state of Virginia.[33] When interviewing the grocery store managers we discovered that most has some sort of backup power, but it was not for food or medicine protection – only for "cash registers and emergency lights and exits." Current regulations do not require stores to provide resiliency for food or medicine.

Grocery store managers we spoke to about solar plus storage wanted to see real examples in the Virginia market before they would even consent to participate in our study. One company – Farm Fresh – has a number of large stores owned by a holding company in Minnesota. The energy manager had recently completed solar assessments for Target before moving to his current job. He was sophisticated on the economics of solar but knew nothing about the economics of storage. He was under corporate pressure to reduce energy usage but was unfamiliar with the unusually high ratio of demand charges to energy costs in Virginia. He made assumptions based on general knowledge of the solar market, and stated that when he had looked at the issue two years ago, solar did not "pencil out" in Virginia. We had similar experiences with other grocery store managers, and overall found that there was a deep lack of understanding of the opportunities in solar plus storage for the sector.

We also looked into assisted living facilities, because they are private entities and important contributors to public health. These buildings are required by law to have backup power for critical loads and are regulated at three levels of care: independent care, assisted living, and

[32] https://www9.nationalgridus.com/non_html/shared_energyeff_groceries.pdf
[33] http://www.seia.org/state-solar-policy/virginia-solar

long-term care. Independent care is the least regulated and consists mostly of retirement communities with skilled nursing services. Assisted living and long-term care fall under the supervision of the Centers for Medicare & Medicaid Services (CMS), under the U.S. Department of Health and Human Services. These facilities are required to have 72 hours of backup power in order to pass inspection standards.

CMS requires yearly inspections carried out by Virginia Department of Health (VDH). State regulations require that these facilities have an emergency preparedness plan that requires that "heating, and air conditioning systems be capable of maintaining temperatures between 70 to 80 degrees."[34] When interviewed, all claimed to have sufficient backup power and were not interested in solar plus storage, though we did find one dialysis center that was interested in exploring a feasibility assessment. Many of the facilities we interviewed had gas generators onsite, but had little additional information to share about emergency preparedness. Thus, the challenge in this sector is less a need for a regulatory lever and more a need to develop a compelling business plan for strengthening resiliency through diversification in case generators are not maintained properly or gas supply is interrupted.

Conclusion: Private Facilities

Private sector companies were generally interested in solar plus storage, but skeptical on the economics. This is likely because none of the companies, stores, or facilities were under any pressure to demonstrate emergency preparedness or resiliency, nor are there any available pilot projects that provide concrete examples of the benefits of solar plus storage. For example, assisted living facilities are required to have backup generators, but when we spoke with staff they could not answer questions about the reliability or vulnerability of said equipment. In the area of food and medicine, we could uncover no requirements for emergency preparedness that would drive demand for solar plus storage. In contrast, in Maryland we talked to a number of organizations that have been designated emergency "depots" in the case of an extended natural disaster. One such "depot" on the Eastern Shore (where both gas lines and electric supply are extremely vulnerable) was actively pursing a solar plus storage strategy.

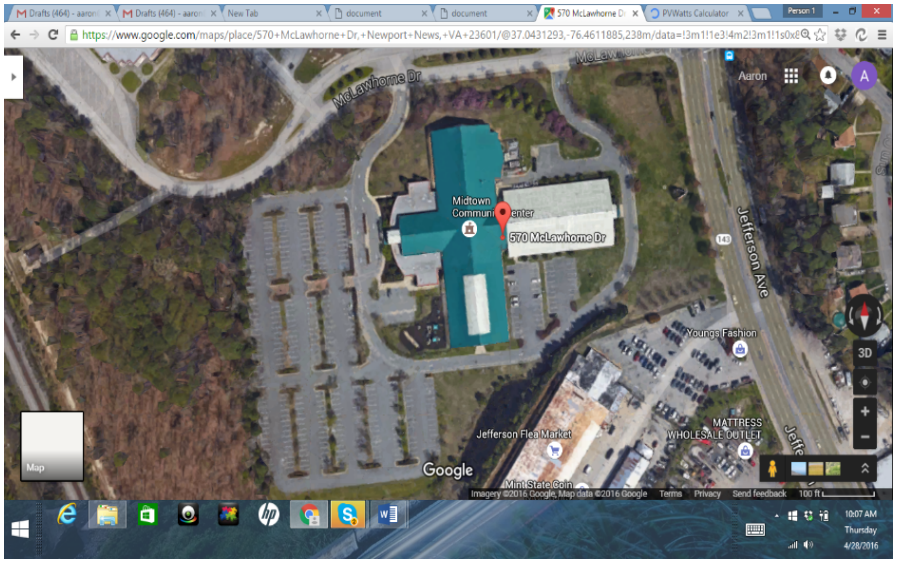
After finding it very difficult to identify willing private partners for the demonstration projects envisioned, we reached out public entities in the hope that they would express more interest in resiliency efforts from both a cost-savings and public benefits perspective.

Findings: Public Facilities

Our main breakthrough came when Newport News expressed interest in partnering to develop both a residential solar co-op and solar plus storage demonstration projects. Newport News has a unique approach in which Jennifer Privette (the city's Sustainability Director), Eddie Crockett (the Assistant Director of Public Works), and Jeffrey Strickland (Facilities Manager) work hand-in-hand to manage facility sustainability goals and emergency preparedness. We initially established a relationship with Privette to explore a Newport News residential solar co-op – validating our belief that it is helpful to start with a concrete, simple, and short term solar

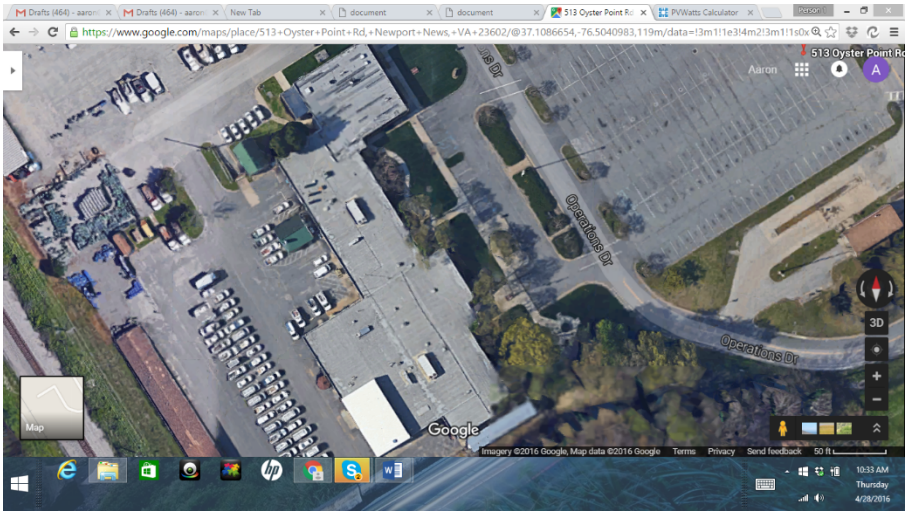
[34] http://townhall.virginia.gov/l/GetFile.cfm?File=C:%5CTownHall%5Cdocroot%5CGuidanceDocs%5C601%5CGDoc_VDH_5353_v1.pdf

project. After meeting with the city and explaining our goal of combining co-ops with storage demonstration projects, we worked with Newport News to identify two buildings for which to develop potential solar plus storage demonstration projects.



Location #1: Midtown Recreation Center

The Midtown Recreation Center (570 McLawhorne Drive, Newport News VA 23601) serves as a staging area for emergency response personnel. A PV Watts estimate indicates the building could fit over 350 kW of solar PV with multiple arrays consisting of mostly east/west access oriented and a smaller south-facing roof plane. There are also various locations to house batteries either within or outside the facility. The building currently has no backup power and a very high energy load.



Location #2: Newport News Operations Center

The Newport News operations office (513 Oyster Point Road, Newport News VA 23602) is one of many buildings at their central operations campus and serves as the main focal point for

emergency operations activities. The building has backup gas generators and gas tanks on-site, but it is the central command center for emergency response for the area and the staff is therefore interested in further increasing the facility's resilience. They are also very interested in using a pilot to learn about the technology for deployment elsewhere. The building could host an estimated 100 kW of solar and would be an excellent pilot location.

Newport News is also deeply interested in pursing a residential bulk purchase for climate mitigation, expanding the solar market, educating citizens about solar, and meeting the city's sustainability goals. The have suggested partnering with Christopher Newport University as a key project partner in both the residential solar co-op and the solar plus storage demonstration projects.

After hearing about our partnership with Newport News, the City of Norfolk's Resilience Office agreed to work with VA SUN on site assessments and feasibility analyses for their buildings. Having recently been selected as one of 100 Resilient Cities across the U.S., Norfolk is very interested in collecting data and collaborating to launch pilot projects. In many ways, this is proof of the importance of a few strategic pilot projects. A few successful pilots will generate significant interest in the region and be a major "kick-start" to the solar plus storage sector.

Conclusion: Public Facilities

We originally targeted private facilities for pilot projects based on the assumption that these projects would be welcomed by facility owners and relatively straightforward to implement (since public institutions typically have much more complicated decision-making processes) and because the private sector has a better ability to utilize federal tax credits. However, it is now clear that public entities will be at the leading edge of this effort – primarily because of their attention to community-scale benefits and desire to be seen as leaders in resilience.

Public facilities will be the best project partners to help us realize proof of concept, jumpstart solar plus storage deployment, and lay out a roadmap for private sector development. The complexity of business models, transaction barriers, and potential revenue streams requires some additional on-the-ground testing before private facilities will be ready to participate. Pilot projects on public institutions will allow us to address many of these potential barriers and complexities. They will also allow us demonstrate the range of applications for solar plus storage, and prove that the technology can benefit communities in need.

Cities like Newport News and Norfolk not only have a need to improve the resiliency of public buildings, but a desire to contribute to the public good and become thought leaders in the region. Dissemination of lessons learned about pilot projects on their properties will receive broad recognition, and is likely to open doors to additional partnerships with community leaders, institutions, local universities, and other local governments.

Question #4: Is solar plus storage already included in resiliency planning currently in place?

In addition to understanding the technological feasibility of solar plus storage, we also wanted to understand existing disaster and emergency preparedness approaches. We did this to ensure that there were not already plans for deploying solar plus storage as a resiliency measure. Although preparedness levels will vary based on jurisdiction, recent experiences with natural disasters across the country indicate that is likely a significant need for solar plus storage to be incorporated in to resiliency planning.

Approach

We conducted a deep investigation of existing FEMA guidelines for our test region and sought to understand the resiliency strategies and resource allocation in the Hampton Roads region. [35] Using our understanding of the FEMA guidelines, we looked for a comprehensive hazard mitigation plan that encompassed all sectors in the region. A hazard mitigation plan represents a community's "blueprint for how it intends to reduce the impact of natural and human-caused hazards on people and the built environment." The essential elements of a hazard mitigation plan include a risk assessment, capability assessment, and mitigation strategy resource germane to its specific case.[36]

We were unable to find a central blueprint or comprehensive, cross-sector plan, so we instead evaluated hazard plans in specific sectors and jurisdictions, municipalities, the private sector, nonprofits, and individual stakeholders. This involved reviewing disaster mitigation plans and documentation for all regional municipalities and jurisdictions, meeting and conversing with planning personnel in Virginia Beach, Norfolk, Newport News, and meeting with organizations and stakeholders representing underserved and at-risk populations. In addition, VA SUN's Program Director, Aaron Sutch, attended the Virginia Resiliency Planning Conference to further our understanding of state and national resiliency planning and mitigation strategies. Through this work, we sought to understand the current framework of resiliency planning in the region, the best leverage points for intervention, and the degree to which solar pus storage would readily integrate with existing plans.

Findings

We found that each city in the region has either its own disaster mitigation plan (for example, Chesapeake[37]) or participates in a greater regional planning effort, but there is not a consistent standard for resiliency preparation, the plans are not particularly robust, and current plans do not include solar plus storage (see Appendix 4 for specific plans). The most comprehensive plan we found is the Regional Southside Hampton Roads Hazard Mitigation Plan, encompassing the cities of Virginia Beach, Norfolk, Portsmouth, Suffolk, and Isle of Wight County.[38] Each city's

[35] http://www.fema.gov/plan-prepare

[36] http://www.cityofchesapeake.net/Assets/documents/departments/fire/em/pdf/2014-chesapeake-hazard-mitigation-plan.pdf (page 134)

[37] http://www.cityofchesapeake.net/Assets/documents/departments/fire/em/pdf/2014-chesapeake-hazard-mitigation-plan.pdf

[38] http://www.vbgov.com/government/departments/fire/emergency-mgmt/Pages/emer-mgt-reg-mit-plan.aspx

disaster mitigation plan had various levels of detail and robustness, but overall they did not appear to adequately address the significant threat posed by weather disasters.

For example, the Southside Hampton Roads plan focuses heavily on background information, such as number of lighting strikes and number of public meetings, but it does not provide actual robust contingency plans. Instead, the plan seems to lay out why the region should be eligible for Federal Disaster Assistance, rather than provide an integrated strategy to better prepare Hampton Roads for a disaster. In fact, one of the core stated objectives of the document is to "qualify for additional grant funding, in both the pre-disaster and post-disaster environment."[39] Where the plan does provide recommendations for improving resiliency it mostly focuses on hardening buildings and floodplains against potential flooding. There is a section that identifies the need to provide emergency power: in Virginia Beach it cites the need for $5 million to provide backup power to 80 critical intersections, the police department, public works buildings, the city jail, and various storm water and sewer pump stations. The plan also calls for backup power at various public schools, shelters, and neighborhood medical centers, but does not include solar plus storage as a way to meet that need.[40]

Conclusion

Overall, we discovered that the policy framework for emergency planning and response is highly fractured and poorly developed when compared to other jurisdictions of similar vulnerability. Hampton Road's planning efforts are deeply fractured due to the lack of coordination among the different jurisdictions. Although many of the emergency plans emphasize coordination and cross-jurisdictional cooperation, there appears to be a dearth of actual concrete steps and procedures to carry out this coordination. While the area faces severe threats from climate change, there is shockingly little acknowledgement of the twin threats of increasingly extreme storms and sea level rise. There is also very little integration of sophisticated resiliency planning protocols that we now see being used in places like Boston and New York. While the documents go into great detail to identify "shovel ready" projects to fund, such as hardening buildings or buying generators, none of the plans reviewed provide a deeper resiliency analysis. They failed to identify plans for supporting the sick and elderly, or provide contingencies for food, water, shelter and medicine in case of an extended event. At one meeting, an emergency manager told Aaron in confidence that, if a big storm hit, the only hope is to head for the Eastern Shore since all other roads will be blocked and the chances of evacuation are slim.

Based on these findings and our research into other regions, solar plus storage is not being integrated into the majority of existing emergency planning efforts, too. Therefore, in addition to developing and implementing solar plus storage projects in a region, we recommend a two-pronged approach that also takes into account the need for robust resiliency planning efforts. Specifically, we would encourage staff implementing on-the-ground projects to also participate in resiliency policy forums and public processes, with the goal of raising awareness

[39] http://www.hrpdcva.gov/uploads/docs/2011%20Southside%20HR%20Hazard%20Mitigation%20Plan.pdf
[40] http://www.hrpdcva.gov/uploads/docs/2011%20Southside%20HR%20Hazard%20Mitigation%20Plan.pdf

about the lessons of superstorm Sandy and emphasizing the need for robust resiliency. High profile profile, proof-of-concept solar plus storage projects can also demonstrate the ability of solar plus storage to be an important component of a comprehensive resiliency plan.

Question #5: Does the existing policy environment in various jurisdictions support widespread deployment of solar plus storage projects?

Implementing and then scaling solar plus storage projects will ultimately require a regulatory regime that encourages their existence in the market. We sought to identify whether there are currently jurisdictions with the policy environment necessary to support a thriving solar plus storage market. We also began to identify potential policy interventions that had the potential of helping to scale the sector and increase climate mitigation and resiliency.

Approach

We took a deeper dive to better understand the policy environments in a number of jurisdictions that support use of microgrids and solar plus storage as a resiliency and mitigation tool. We reviewed emerging microgrid and resiliency programs in other jurisdictions, focusing specifically in Boston and New York. We conducted an exhaustive literature search, interviewed key players in the sector, and met with and interviewed a number of developers in this space.

Findings

We found that several cities that have policies that support the emergence of solar plus storage are the same communities that are taking a lead in new grid resiliency planning discussion. Essentially, there is a new paradigm in electricity grid management that is emerging. In the early days of electricity, energy systems were small, localized microgrids. The Pearl Street Station in New York City, launched in 1882 by Thomas Edison, was the first of these complete systems, connecting a 100-volt generator that burned coal to power a few hundred lamps in the neighborhood with direct current electricity (DC).[41] Soon, many similar self-contained, isolated systems were built across the country. Eventually, as alternating current (AC) power became more widespread, we transitioned to very large, centralized generation systems located far away from cities and demand centers.

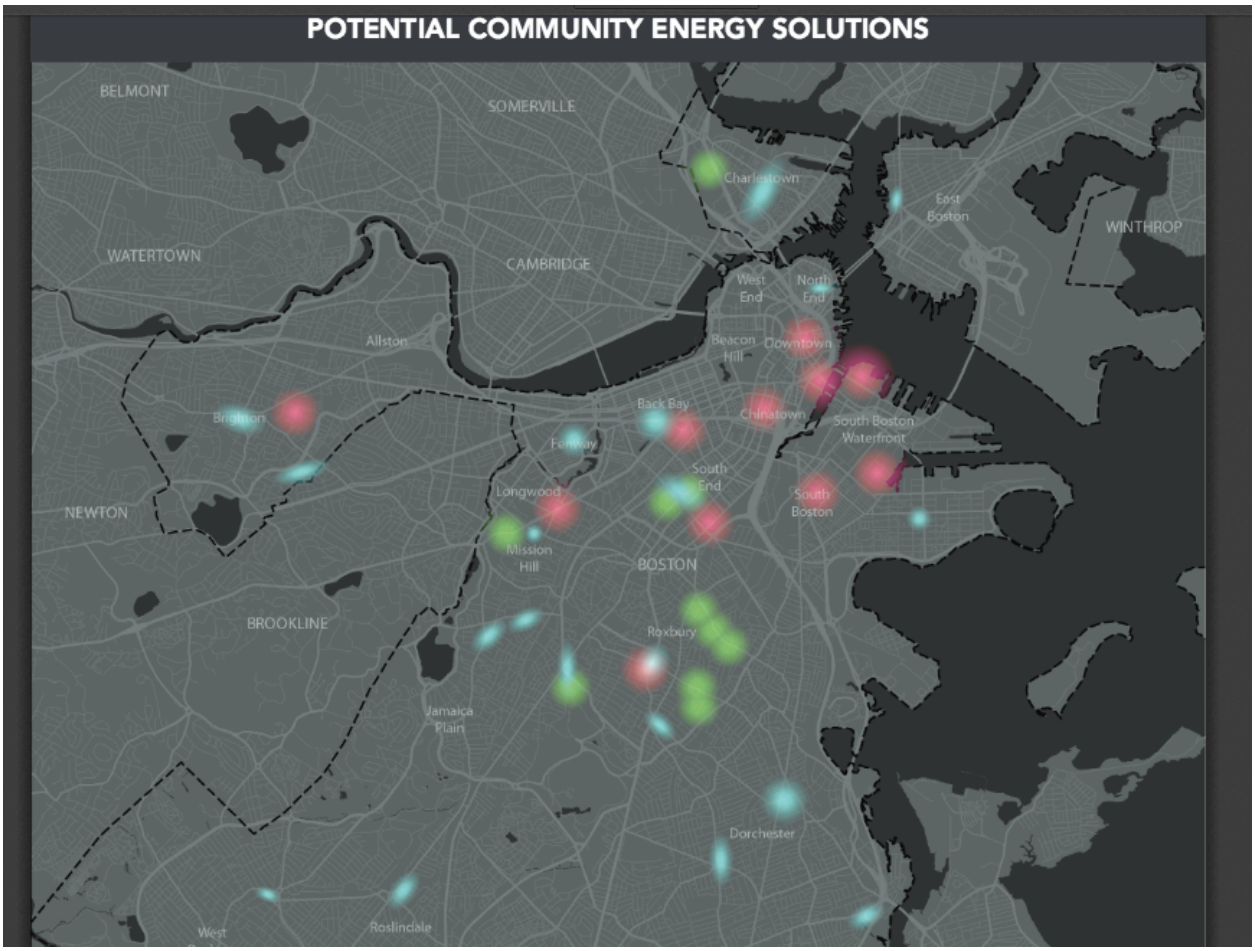
As the vulnerabilities and inefficiencies of this paradigm become evident in light of climate change and disaster mitigation, we are transitioning back to more localized power generation. Now, New York, California, Boston, and a few other jurisdictions are leading the movement to bring us back to more distributed, decentralized energy generation and distribution systems. In fact, the United States military is also relying on microgrid solutions that incorporate solar energy with battery backup systems.[42] In the age of super storms, climate change, distributed wind and solar, smart meters and computers, cities are finding that the old, centralized system is simply too wasteful, too expensive, too brittle, too vulnerable, and too polluting to survive. They are undertaking grid planning processes, often called “Grid 2.0” or “Grid of the Future” proceedings that grapple with how we legislate and plan for a more resilient energy system that

[41] http://burnanenergyjournal.com/the-electricity-grid-a-history
[42] http://www.seapowermagazine.org/stories/20160606-green.html

includes microgrids, resiliency, and decentralized energy production. Academic discussions around "grids of the future" have been happening for decades, but we are now shifting from theory to reality as cities are beginning to understand how to best implement these changes. And, in cities where these discussions are happening we are beginning to see the emergence of policies that support solar plus storage deployment. This is because solar plus storage and microgrids are extremely effective ways to achieve some of the goals of the grid of the future: decarbonization, equity, resiliency, lower costs and more flexible, effective and efficient grid management.

In many cases, cities are studying the types of resiliency improvements they can make, and the impact those new systems will have on a variety of factors. The Boston Community Energy Study is an example of the leading edge of this new sector. The researchers layered historic energy use trends, vulnerability analyses, costs savings, $C0_2$ reduction opportunities, and resiliency improvements to provide a citywide plan for the use of solar plus storage and other interventions.[43] The map below shows a detailed analysis of the potential for microgrids to achieve the complex suit of objectives delineated in the study. In the map, red dots represent opportunities for the greatest costs savings due to the mix of energy demand and needs, green dots are focused on energy justice objectives (protecting the most vulnerable), and blue dots are focused on emergency response priorities.

[43] http://www.bostonredevelopmentauthority.org/getattachment/d52c36d5-2b1a-40e3-b4cd-3d4fa01ed4e6



This study represents a profound shift in how cities are beginning to think about their energy needs in the light of increasing risks from climate change and profound new technological opportunities. One of the profoundly important aspects of this study is that, rather than start with engineering and add social concerns such as equity in as an afterthought, equity and sustainability were part of the central objectives placed before the engineers.

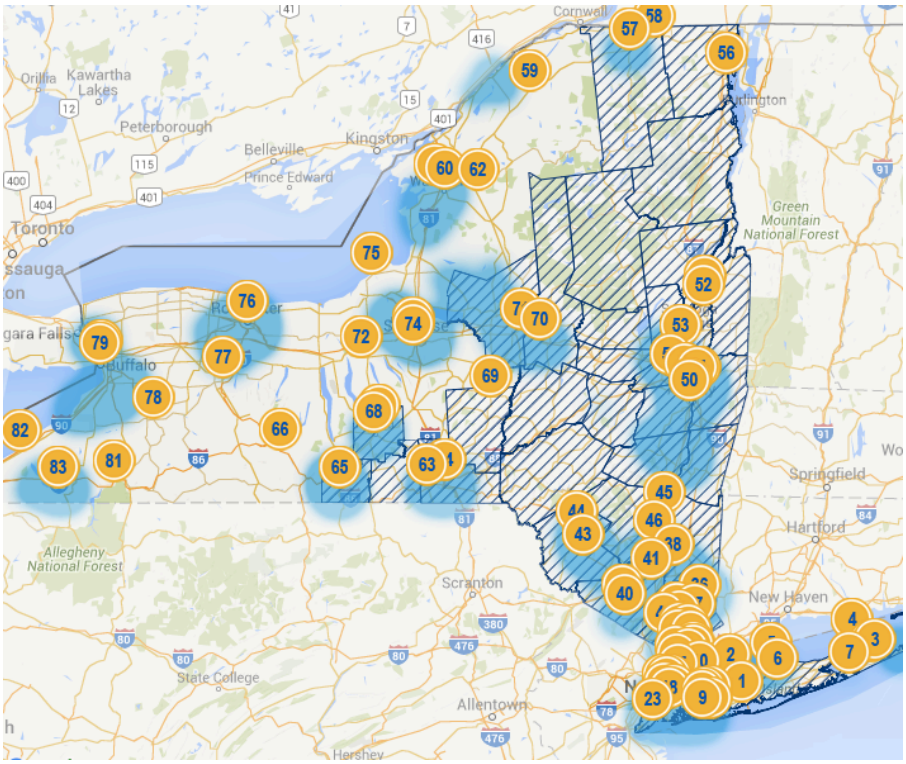
New York has also been leading much of this research and innovation. In 2014, the state agency responsible for implementation of all renewable energy programs, NYSRDA, completed the study titled "*Microgrids for Critical Facility Resiliency in NY State*." At the time, their core conclusions were:

- Microgrid investments may provide important value streams for which there are presently no mechanisms to compensate microgrid or distributed generator owners for distribution-level ancillary services, transmission and distribution investment deferral, or other socially important benefits–such as reduced environmental consequences. This may result in the underutilization of otherwise economically feasible options.
- Technology development is required to reduce the costs of engineering the microgrid, specifically the control systems and electrical infrastructure necessary to balance supply and demand that currently result in elevated system costs.

- There is a need to develop standard models/approaches to ensure effective microgrid integration with existing utility distribution networks, particularly for more complex microgrid configurations (e.g., multiple distributed energy resources (DER), multiple points of common coupling with the utility system and/or connection to urban secondary networks).

In 2016 NYSERDA announced the NY Prize, a first-in-the nation $40 million competition to help communities create microgrids. In this program the agency worked with the myriad local utilities to identify "opportunity zones," or areas the utility determined microgrids would best benefit the local grid. Priority was then given to proposals that coincided with the identified "opportunity zones." That way the larger grid benefit will be aligned with local project benefits. Here is a map of the opportunity zones in blue and phase one planning awardees in gold.[44]

During the end of the planning phase of this project CPN attended the Clinton Global Initiative Advanced Energy Economy working group and developed a "collaborative" with leading innovators in this space from New York, California, Washington, D.C., and elsewhere. Several have made formal commitments to help with the assessment and development of pilots and to make recommendations on policy as this project moves forward.



Unfortunately, these studies and conversations on grid reform or grids of the future are happening in only a limited number of jurisdictions. In the majority of the United States the conversation is still focused on the "shovel ready" mitigation plans references above, and there

[44] http://www.nyserda.ny.gov/All-Programs/Programs/NY-Prize/Opportunity-Zones-Map

is not any sort of general agreement that the region should begin investigating microgrids and solar plus storage as a means of resiliency. In short, the conversation is not taking place and policies to support its emergence do not exist.

Conclusion

Our findings show that robust resiliency planning that includes solar plus storage is taking place (and being implemented) in communities where there are policies that encourage conversations and planning around redesigning the energy grid. As a result, policies and planning around grid redesign is going to play an incredibly important role in creating demand for solar plus storage.

Therefore, we've come to realize that a policy component of this project is essential on multiple levels. While we had originally thought that development of a project pipeline would be sufficient to scale the sector, we have fundamentally shifted the proposal to focus on the fact that there is a profound need to track, analyze and disseminate emerging trends and best practices in this rapidly evolving sector. This will involve tracking and understanding the ongoing grid of the future discussions in other jurisdictions, and injecting that discussion into conversations about emergency planning and resiliency into jurisdiction-level planning efforts.

Conclusion of Planning Grant Findings

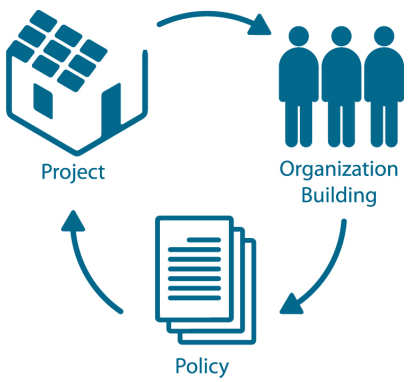
Central Research Question	
Is putting solar plus storage systems on critical community buildings economically possible? Is it scalable?	
Sub-questions	Findings
Question #1: Is battery technology ready for widespread use in resiliency applications? And does solar plus storage have the capacity to scale?	**Yes**
Question #2: Do solar plus storage projects "pencil out" financially?	**Yes**
Question #3: Is there existing demand for solar plus storage projects?	**No**
Question #4: Is solar plus storage already included in resiliency planning currently in place?	**No**
Question #5: Does the existing policy environment support widespread deployment of solar plus storage projects?	**No**

When we embarked upon our planning grant we were investigating the feasibility of implementing a series of solar plus storage pilot projects on public and private entities that could benefit from solar plus storage projects. We found that the central barrier to deploying these projects is not technological or financial: (1) The technology in its current state is able to provide both backup power *and* ancillary services to the PJM grid; and (2) the financial models

"pencil out" and demonstrate that the projects are financially feasible. They are, however, complicated and not easy to understand without clear markets or vendors.

Despite the projects being technologically viable, however, there was a lack of interest among private institutions to develop these projects. Businesses like assisted living facilities and grocery stores were not particularly interested in solar plus storage, in main part because they did not have significant external policy factors (such as laws or regional planning goals) that would motivate them to overcome the transaction barriers associated with implementing a solar plus storage project. We did find, though, that public institutions were interested in working with us on pilot projects and will be an excellent place to start.

However, based on our findings with the private sector and our researching on solar plus storage in other states, we found that it would be very difficult to truly scale solar plus storage deployment unless we also impact the region's policy environment. Specifically, that means creating demand for solar plus storage projects in resiliency planning and also driving grid modernization conversations as a means to encourage municipalities and private sector entities to think more pro-actively about how their systems could become more resilient. Fundamentally, the existing policy barriers to solar plus storage will prevent any of these pilot projects from being able to scale.



Overall, we were not too surprised at our findings from this process. In our work historically we've discovered that projects AND policy are both essential to transforming the energy sector. Projects are important because they (1) demonstrate that solar plus storage systems are technologically and financially possible, (2) provide stakeholders with an opportunity to learn about solar and battery technologies, (3) give us the chance to improve and refine financial and project models, (4) provide learning opportunities that will allow us to more quickly and effectively deploy future projects, and (5) most importantly, the pilot projects will give policymakers a real example of a successful pilot that they can point to when advocating for better policies. On the other side**,** policies are important because it will be extremely difficult to scale project deployment unless we have policies that create demand for solar plus storage. Moving forward we are therefore focused on a two-pronged approach for jumpstarting solar plus storage deployment in the Hampton Roads area.

Next Steps: Proposed Strategy and Tactics For Deploying Solar Plus Storage in Vulnerable Communities

Based on our findings we therefore propose a two-pronged approach for regions interested in facilitating solar plus storage as a resiliency option. These two lines of action, launched simultaneously, will positively reinforce each other and help us ensure that we can both implement *and* scale these projects.

Strategy #1: Implement pilot projects

We plan to implement a series of solar plus storage pilot projects to demonstrate that the technology works and is a cost effective tool to meet resilience and sustainability needs.

Using a series of pilot projects, we will educate the public and private sectors about solar plus storage. The projects will demonstrate to local officials, businesses, and citizens that solar plus storage can be an effective climate mitigation strategy AND provide safe and cost effective power during emergencies. It will demonstrate that, especially in the case of extended power outages, solar plus storage can be life saving.

Initially we will focus on partnering with the cities and municipalities to deploy pilot projects, both on an institutional and community-wide scale. Our focus on these entities is based on the fact that we've typically found these entities are initially the most interested in implementing solar plus storage projects. This will also help agencies within the government get comfortable with solar plus storage technology. It will then also provide an opportunity for peer-to-peer learning, as other government officials have an opportunity to see and copy their success. Ultimately, though, we hope these pilots will be a springboard for introducing solar plus storage to the other government agencies and private sector.

Tactic #1: Develop and deploy an effective solar plus storage project model

We will partner with municipal governments to model and deploy pilot solar plus storage projects as a means to demonstrate their feasibility. We'll create an opportunity for municipalities to learn about solar plus storage and see first hand that it is technologically feasibly. To achieve this we will:

a) **Fully model five solar plus storage pilot projects.** We will full model five pilot projects on municipal buildings and share our findings with the partners. This will include a full detailed energy analysis, detailed integrated economic modeling, full sensitivity analysis, and specific identification of critical loads for key buildings. We will conduct these analyses, prepare briefs, and present our findings to key decision makers. By providing partners with a detailed project modeling we will be able to help them better make the decision to deploy a pilot project.

b) **Deploy at least two community-anchor solar plus storage pilot projects**. Based on our project modeling we will work with our partners to implement at least two pilot projects on community anchor institutions that integrate solar with patters and provides one or more of the following benefits: backup power, peak load shaving, or PJM income generation. We will also heavily document our process and lessons learned, and develop detailed write-ups on the business model, equipment, software, and services that facilitated the project. We will then make these findings publicly available and disseminate our reports widely.

Tactic #2: Create and engage a distributed network of solar plus storage projects with homeowners, business, and small nonprofits, creating a backbone of residential solar plus storage infrastructure in the region

Widespread deployment of solar plus storage systems for resiliency will only be possible if there is broad community demand for this type of resiliency intervention. This requires communities understand and benefit from solar plus storage technologies and see the important role they provide in protecting their community from the impacts of natural disasters. We propose deploying a series of residential solar plus storage co-ops to begin creating a backbone of solar infrastructure for local citizens who will support and benefit from solar plus storage. Options to achieve this include:

a) **Implement a residential solar co-op**. Using our successful residential co-op model, we will implement a residential solar co-op in the target jurisdiction and educate the local constituency about solar. We will give homeowners and decision makers an opportunity for a hands-on learning experience with solar within a short, discreet timeframe. In this co-op we will offer the opportunity to incorporate solar plus storage, and begin to develop expertise and experience with helping residential homeowners adopt storage options. The co-op will demonstrate that solar is a cost-effective for homeowners and help lay the groundwork for solar plus storage pilot projects in the region and larger, more complex solar microgrid networks in the future. Again and again we've found that legislators and government officials are much more comfortable with solar projects when they've had a chance to either go solar themselves, or have seen a number of their constituents go solar and be able to articulate the value it provides.

b) **Implement a residential solar plus storage pilot co-op**. After implementing a residential co-op that includes optional solar plus storage, we will then explore implementing a dedicated solar plus storage co-op that provides additional community resiliency beyond just adding residential solar to the energy grid. We would explore a model of using distributed solar sites with storage that collectively play into the PJM income stream as a means to generate revenue. This would be a unique and new project model that has not yet been demonstrated, and would be an opportunity to determine whether such an approach is an effective way to scale residential solar plus storage resiliency efforts. Throughout the project we will collect data on adoption rates,

demographics, and technical project specs that can be used for future project deployment.

c) I**mplement a solar plus electric vehicle pilot co-op.** Similar to solar plus storage, solar plus electric vehicles (EVs) has the potential to support regional resiliency and accelerate decarbonization. Electric vehicles have large batteries and have the potential to act as mini-generators, powering homes and small buildings in the event of an outage. We are seeing significant changes happening in the EV market and anticipate a huge surge in EV deployment in the coming years. In our third year we will therefore explore the feasibly of implementing a solar plus EV pilot solar co-op as another effective way to scale residential solar plus storage resiliency efforts. Depending on the evolution of the market, this co-op could allow homeowners to purchase solar and EVs in bulk and receive a discounted price. This approach is similar to a project we are currently exploring in Ohio via our OH SUN program. Should the market change significantly in the next three years, however, this project would be on the cutting edge of grid integration of electric vehicles. Although there has been much speculation that pairing solar and EVs is an effective way to deploy both technologies, to-date this theory has not been tested. An EV solar co-op would further expand a network of distributed generation and resiliency in the region.

Tactic #3: Amplify our lessons learned and support the emergence of resiliency expertise throughout the state

As we implement our pilot projects we will be gaining a significant amount of expertise and knowledge about the emerging solar plus storage market. We know we cannot transform the sector alone, and therefore throughout our projects would seek to share our findings and support the emergence of a solar plus storage expertise throughout the region. To achieve this we would:

a) **Implement a community microgrid communications strategy that shares lessons learned and emerging trends with government and community leaders for resiliency planning purposes**. Building upon our findings and success in deploying at least two community-anchor pilot projects and three residential solar plus storage solar co-ops, we will then focus specifically on scaling the emergence of microgrids in vulnerable communities. We will work with an interested community to develop a deployment plan for either a network of individual solar plus storage facilities in key locations or a community based microgrid.

b) **Provide ongoing technical assistance to the private and public sector in the region.** We would provide technical assistance to public agencies, private entities, and non-profits seeking to build solar and solar plus storage. This includes providing basic information and education, facilitating procurement processes, and providing consulting support as organizations seek to develop and deploy projects. Wherever possible we would connect residential solar projects and public and institutional level projects, in order to provide learning experiences for policymakers and leaders.

We would share our findings and ensure our project models and technical support is open source, accessible, and widely disseminated.

c) **Create a state-wide solar plus storage technical advisory group.** The advisory group would be open to public or private organizations and individuals. We would meet regularly and exchange lessons learned, build technical capacity on solar plus storage projects, and create an environment where service providers and policymakers can get up-to-the-minute understanding on the emerging sector. Much of the expertise we develop internally can be immediately shared with the working group, speeding up the process by which others can take our lessons learned and build on them. This working group would be essential scaling our work, identifying policy interventions, and building a community to impact the entire state where we are operating.

d) Share our findings and lessons learned with the public, community activists, and policy audience. We would consistently document our project models, process, lessons learned, and technical expertise. We would share our findings in a series of detailed case studies, articles, blog posts, and other materials that can be used by others to replicate our successes and improve upon our approaches.

Strategy #2: Engage on policy

We would plan to also launch a solar plus storage resiliency policy initiative to encourage solar plus storage deployment in the region

While deploying pilot projects is an important step towards proving the effectiveness of solar plus storage for resiliency, these projects will not scale quickly enough if the policy environment does not support their widespread deployment. We will investigate, demonstrate, and disseminate examples of community-owned microgrids and solar plus storage initiatives being implemented across the country. We will then advocate for a resilience-planning framework that also considers equity and sustainability (not just infrastructure) in the planning framework. We will disseminate policy lessons from elsewhere and push for studies, planning exercises and policies that facilitate the resilience planning framework. We will use participation in multiple planning forums to disseminate lessons learned and outcomes from pilot projects. We will create opportunities for policy fixes at the local, regional and state level that encourage solar plus storage with equity and resiliency objectives.

Tactic #1: Engage in emergency planning processes to ensure solar plus storage is included in resiliency planning.

One of our most troubling findings was many emergency planning efforts are highly fractured, inadequate, and do not include solar plus storage. We know that it would be unrealistic to assume that a single organization could successfully overcome a region's lack of coordinated planning for a major disaster, but we do believe they could conduct focused education and outreach to ensure that solar plus storage is added to existing plans. And, their close involvement in the planning process across jurisdictions could serve to further create demand

for the types of projects (like solar plus storage) that provide more robust resiliency than basic interventions such as gas generators. To achieve better integration of solar plus storage in existing emergency planning we intend to:

a) **Participate in existing regional emergency planning initiatives and advocate for the inclusion of solar plus storage in all regional planning efforts.** We would closely follow existing regional resiliency planning efforts and push entities to incorporate solar plus storage in all plans. This will include participating in numerous resiliency policy forums, public processes, conferences, and planning events on the regional and state level. We would encourage planners to analyze vulnerabilities due to extended blackouts and push for policies that encourage a diverse, sustainable mix of resiliency strategies, including solar plus storage. We will use the knowledge we have gained to push for policies that encourage development of the solar plus storage while focusing on equity and protecting the most vulnerable and sharing the benefits. We would raise awareness about the lessons of superstorm Sandy and emphasizing the need for robust resiliency that includes solar plus storage.

b) **Work independently with jurisdictions to include solar plus storage in existing and future resiliency planning efforts**. We'd bring examples of successful solar plus storage projects that are "shovel ready" and help municipalities see that solar plus storage can be a cost effective opportunity for them to quickly improve their resiliency. We'd work directly with planners and policy makers to provide them with the information they need to be able to effectively incorporate solar plus storage into resiliency.

Tactic #2: Conduct public outreach and education to change the conversation around resiliency

While it is important that solar plus storage be incorporated into planning efforts in each jurisdiction, this piecemeal approach will on its own not be enough to help the region dramatically overhaul the resiliency of its energy systems. Such a fundamental transformation will require bigger picture discussions of the "grid of the future" and how such planning can meet the needs of communities. We would therefore seek to jumpstart the "grid 2.0" and "grid of the future" discussions in the region and encourage officials to begin having these planning conversations. To achieve this includes:

a) Investigate and disseminate emerging resiliency project models in other states. We will engage in and evaluate planning and project work throughout the country, especially community-led projects in New York, Boston, Washington D.C., California, Ohio, and elsewhere. We will share our findings with government officials and community leaders in the region and stimulate conversations about the importance of "grid of the future" planning.

b) Develop strategic partnerships with key stakeholders to better conduct public outreach and education. We would develop strategic partnerships with important stakeholders, including advocates for the elderly, local HOAs, and other key

constituencies interested in building a campaign for resiliency reform, with the goal of being better able to conduct public outreach and education around the importance of resiliency planning.

c) **Implement a solar rights campaign as an educational effort**. We will call for the right of all citizens to be able to access solar as a basic property right. This will allow us to build network of local activists that includes government officials, military personnel, and local businesses, an extremely diverse and politically powerful cross section of supporters. This will allow us to build an important base for online organizing that will ultimately be essential for advocating for the policy reforms we identify over the course of our work.

Tactic #3: Proactively engage with and intervene on policy issues to change the regulatory environment around solar plus storage and resiliency planning in the region.

In addition to participating in existing resiliency planning initiatives, we would also plan on launching proactive campaigns focused on improving demand for solar plus storage as a resiliency measure. The specific policies that we would focus on will depend in part on the policy barriers we identify as we attempt to deploy our pilot projects, but our activities would include:

d) **Identify additional policies that could help transform the sector.** Using the exercise as a tool to activate and engage stakeholders, we would conduct a policy scoping exercise that would allow us to identify key policy interventions that would aid in scaling the sector. These interventions could include improving emergency readiness for specific populations (such as the elderly or people with disabilities), improving emergency response and readiness rules, strengthening emergency preparedness legislation or ensuring sufficient support for preparedness budgets. Other opportunities include tax credits for emergency preparedness, tax credits for vulnerability assessments that would lead to infrastructure investments, designation of medicine depots, and shelter in place requirements. By actively engaging with stakeholders, including local residents and government stakeholders, we could both identify opportunities to improve policies and more quickly activate their participation.

e) **Implement legislative campaigns or local policy initiatives we've identified that will transform the sector.** Based on the barriers we identify as we engage with stakeholders and implement pilot projects, we would then conduct comprehensive campaigns to change the policy environment for solar plus storage and facilitate scaling in the sector. These could include funding resiliency studies, requiring grocery stores provide greater protections for food during power outages, providing more means for citizens to shelter in place, or providing incentives for home or business emergency preparedness. Included in our work will be sharing research findings, policy lessons learned, and major policy recommendations that would lay the groundwork for a more robust resiliency planning and implementation in the region.

Definition of Success

Overview

After three years, we will have been successful if the jurisdiction in which we are working is home to multiple solar plus storage demonstration projects, homeowners are beginning to integrate storage infrastructure with their personal systems, there is widespread public acknowledgement of the importance of solar in resiliency planning efforts, and local governments and elected officials are beginning to implement resiliency planning that includes solar plus storage.

Key metrics

We will be able to measure our success towards our goals via the following metrics.

Strategies	Measures of success
Strategy #1: Implement pilot projects	
Tactic #1: Develop and deploy an effective solar plus storage project model	
Fully model five solar plus storage pilot projects **(Year 1)**	Will have successfully developed spreadsheets and auxiliary documentation and will have modeled five pilot projects, to include all financial and project details necessary to implement a pilot project.
Deploy at least two community-anchor solar plus storage pilot projects in the region **(Years 2 & 3)**	Will have successfully facilitated the installation two pilot solar plus storage projects in the region. Projects will be either completed or installations well underway by end of grant period.
Tactic #2: Create backbone of residential solar plus storage infrastructure in region	
Implement a regional residential solar co-op**. (Year 1)**	Will have implemented a regional residential solar co-op with at least 50 members and 15 homeowners going solar.
Implement a residential solar plus storage pilot co-op**. (Year 2)**	Will have implemented a residential solar plus storage pilot co-op with at least 30 members and 10 homeowners implementing solar plus storage.
Implement a solar plus electric vehicle pilot co-op. **(Year 3)**	Will have implemented a solar plus electric vehicle pilot co-op with at least 30 members and 10 homeowners implementing solar plus EVs or a combination.

Tactic #3: Amplify lessons learned	
Implement a community microgrid communications strategy that shares lessons learned and emerging trends with government and community leaders for resiliency planning purposes. **(Year 3)**	Local jurisdictions and community leaders will consider solar plus storage as a resiliency strategy within local planning exercises. Case studies and other communication products will be developed. We will document dissemination of these materials.
Provide ongoing technical assistance to the private and public sector in the region **(Years 1-3)**	Will complete at least 20 preliminary solar site assessments. We will create a log to document technical assistance provided.
Create a state-wide solar plus storage technical advisory group. **(Years 1-3)**	Will have formed group and facilitated, at minimum, quarterly meetings or phone calls to exchange information and lessons learned. Will develop and deploy an online sharing platform to facilitate research dissemination and sharing.
Share our findings and lessons learned with the public, community activists and policy audience. **(Years 1-3)**	Will have deployed at least 10 blog posts, whitepapers, informational resources, webinars, or other resources to disseminate our lessons learned.
Strategy #2: Engage on Policy	
Tactic #1: Engage in emergency planning processes to ensure solar plus storage is included in resiliency planning.	
Participate in existing regional emergency planning initiatives and advocate for the inclusion of solar plus storage in all regional planning efforts. **(Years 1-3)**	Will document when solar plus storage is considered in these forums and implemented as a goal or target within regional plans.
Work independently with each jurisdiction to include solar plus storage in existing and future resiliency planning efforts**. (Years 1-3)**	Will document where solar plus storage is considered in these forums and implemented as a goal or target within local plans.
Tactic #2: Change the conversation around resiliency	
Investigate and disseminate emerging resiliency project models in other states**. (Year 1)**	Will provide examples in written report where our work is being pursued or promoted by other leaders or organizations.
Develop strategic partnerships with key stakeholders to better conduct public outreach and education. **(Year 1)**	Will document partnerships in written report and highlight important partners in blog posts and other communications

	materials.
Implement a solar rights campaign as an educational effort**. (Year 1)**	Will build on solar rights petition to reach an additional audiences. We aim to secure 2000-10,000 signatures on the petition statewide.
Tactic #3: Proactively engage with and intervene on policy issues	
Identify additional policies that could help transform the sector. **(Year 1)**	Will produce options paper for internal use and discussions with close partners
Implement legislative campaigns or local policy initiatives we've identified that will transform the sector. **(Year 2-3)**	Jurisdictions will adopt strategic policies and or legislation that will help scale the market for solar plus storage

Team Qualifications

Project Deployment

CPN got started implementing solar projects in 2007 and our project work has been the backbone of our work ever since. Thanks to our team's deep technical knowledge we have developed extensive expertise in solar project development and have helped over 1,200 homeowners and hundreds of organizations go solar. In total we have facilitated over 7.8 MW of installed capacity since 2013, which has translated into $33M in direct local spending. Many of our co-op members have commented that our technical experience is what helped them feel comfortable participating in the co-op process, as we are a reputable nonprofit that has a deep understanding of the local solar market.

Policy Engagement

We have a strong track record of engaging on policy initiatives in the state that we work. We use our project development experience to identify policy barriers to scaling up solar deployment. By basing our policy work in on-the-ground project experience, we're able to systematically build a strong solar market in the state. Some of our experience includes:

- CPN's Executive Director, Anya Schoolman, recently led a broad coalition to fight the proposed merger between Exelon and Pepco in Washington DC that was widely noted for its effectiveness in mobilizing a broad base of activists under the banner of "rates, reliability and renewables." As a leader of the PowerDC coalition, Anya developed and maintained a coalition of nearly 40 groups that covered a wide range of interest areas. She ensured the coalition stayed on message, was strategic in its approach, and presented a unified front throughout the over two-year campaign. As a result of her work, the coalition succeeded in convincing the D.C. PSC to reject the merger on two different occasions. While ultimately the deal was approved, the opposition and the PSC adopt PowerDC's framing in their decision language. The campaign also raised the specter that grassroots reaction against anti-renewable positions would limit the ability of large holding companies like Exelon to expand into new territories, and the work has been closely followed by the broader utility

community. Our involvement has already changed the dynamic in Hawaii merger case and will continue to influence mergers in the future.

- In 2015 CPN (operating as WV SUN) successfully led a campaign in West Virginia to defeat a bill that would have repealed net metering in the state. In the span of a week we successfully formed a coalition and mobilized over 1,000 comments to local legislators. The result was a defeat of the bill and statements about the importance of net metering from both democrats and republicans in both the House and the Senate.
- Since 2007, DC SUN (CPN's DC program) has passed a number of policy changes that have created one of the strongest solar markets in the country. Our successes include:
    - Passing the Community Renewables Energy Act of 2013, which now allows for community solar (virtual net metering) in the District.
    - Passing the Distributed Generation Amendment Act of 2011, which closed the DC Solar Renewable Energy Credit (SREC) market so that the market only benefits the DC ratepayers that fund the program.
    - Passing the Clean and Affordable Energy Act of 2008, which created a mechanism for the implementation of a residential DC solar rebate program.
    - Intervening on issues with the Public Services Commission such as smart meters and net-metering rules.
    - Advocating for consumer net metering and smart metering rights.
    - Working with DC SEU's solar program.
- In 2011, Anya also founded Community Power Network, a national organization that supports grassroots, local, state, and national organizations working to build, and promote locally based renewable energy projects & policies. CPN has provided technical assistance to hundreds of citizens and organizations around the country, and is also currently implementing state projects in Washington DC (DC SUN), Maryland (MD SUN), West Virginia (WV SUN) and Virginia (VA SUN). The organization focuses as well as policies and project models for bringing solar to low-income households.
- In 2009, Anya was honored as the MD, DC, and VA Solar Energy Industries Association Solar Champion and that same year, CALFinder named Anya one of its 10 Amazing Activists in the Name of Solar. In April 2014, the White House selected Anya as one of 10 White House Champions of Change for Solar Deployment for her groundbreaking work to deploy solar in the National Capital region. In her previous work, Anya served as a consultant for grantmakers and organizations on environmental strategy. She also spent nearly 10 years working for the Environmental Protection Agency and the US Department of the Interior. She has extensive campaign and programmatic experience, and has a strong understanding of the best ways to move coalitions and groups towards a shared vision.

Budget

Overview

We are seeking support for three years as we implement the project outlined in this work plan. Over time, CPN's contribution will scale up via a combination of in-kind support, earned solar co-op revenue and additional grant funding. We are currently in conversation with a number of

national funders that exploring supporting resiliency work should our project be selected. A number of our industry collaborators are also interested in providing in-kind support in exchange for participating in a groundbreaking project.

Total Project Funding Requested	Year 1	Year 2	Year 3
Total Project Budget	**$227,000**	**$237,000**	**$247,000**

Project Budget Breakdown	Year 1	Year 2	Year 3
Salary			
VA SUN Program Director (30%) VA SUN Director of Resiliency Initiatives (100%) CPN Executive Staff: Anya Schoolman, CPN Executive Director (15%) Ben Delman, Communications Manager (15%) Isabel Ricker, Director of Engagement and Development (15%)	$182,000	$195,000	$205,000
Expenses			
Legal and Technical Support	$5,000	$5,000	$6,000
Marketing and Communications Materials	$10,000	$10,000	$10,000
Travel	$6,000	$6,000	$6,000
Materials & Supplies	$6,000	$6,000	$6,000
Organizational Expenses – Rent & Overhead	$14,000	$14,000	$14,000
Total	**$227,000**	**$237,000**	**$247,000**

Appendices

Appendix 1: Analysis of Newport News buildings

Summaries of our economic modeling are below and full, detailed spreadsheets are available on Dropbox

Newport News Operations Center (513 Oyster Point Road)
Cost Benefit Analysis- With Tax Benefits

Cost/Benefit Component	Value
Lifetime Production (MWh)	**2,611**
Project Inflows	
Lifetime Energy Revenue ($)	$246,596
Lifetime REC Revenue ($)	$10,877
Lifetime Tax-Based Incentives ($)	$134,438
Total Inflows	$391,911
Project Outflows	
Outright Purchase ($)	($225,000)
Lifetime System Expenses ($)	($10,500)
Lifetime Financing Costs ($)	$0
Total Outflows	($235,500)
Project Free Cash Flow	$156,411
Summary	
Project NPV ($)	$50,421
Project IRR (%)	9.07%
Project Payback Period (Years)	8

Newport News Operations Center
(513 Oyster Point Road)
Cost Benefit Analysis-
Without Tax Benefits

Cost/Benefit Component	Value
Lifetime Production (MWh)	**2,611**
Project Inflows	
Lifetime Energy Revenue ($)	$246,596
Lifetime REC Revenue ($)	$10,877
Lifetime Tax-Based Incentives ($)	$0
Total Inflows	$257,473
Project Outflows	
Outright Purchase ($)	($225,000)
Lifetime System Expenses ($)	($10,500)
Lifetime Financing Costs ($)	$0
Total Outflows	($235,500)
Project Free Cash Flow	$21,973
Summary	
Project NPV ($)	($70,952)
Project IRR (%)	0.90%
Project Payback Period (Years)	19

Midtown Recreation Center
(570 McLawhorne Drive)
Cost Benefit Analysis- With
Tax Benefits

Cost/Benefit Component	Value
Lifetime Production (MWh)	**9,138**
Project Inflows	
Lifetime Energy Revenue ($)	$863,088
Lifetime REC Revenue ($)	$38,068
Lifetime Tax-Based Incentives ($)	$418,250
Total Inflows	$1,319,406
Project Outflows	
Outright Purchase ($)	($700,000)
Lifetime System Expenses ($)	($18,900)
Lifetime Financing Costs ($)	$0

Total Outflows	($718,900)
Project Free Cash Flow	$600,506
Summary	
Project NPV ($)	$227,966
Project IRR (%)	10.71%
Project Payback Period (Years)	7

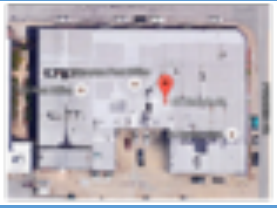
Midtown Recreation Center
(570 McLawhorne Drive)

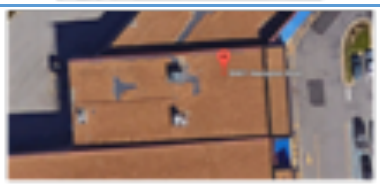
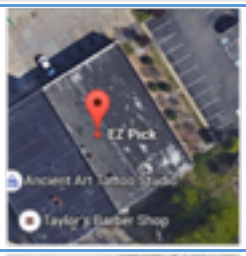
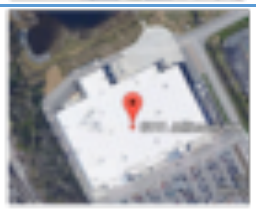
Cost Benefit Analysis-
Without Tax Benefits

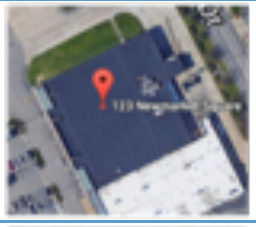
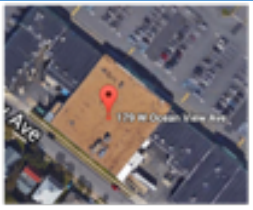
Cost/Benefit Component	Value
Lifetime Production (MWh)	**9,138**
Project Inflows	
Lifetime Energy Revenue ($)	$863,088
Lifetime REC Revenue ($)	$38,068
Lifetime Tax-Based Incentives ($)	$0
Total Inflows	$901,156
Project Outflows	
Outright Purchase ($)	($700,000)
Lifetime System Expenses ($)	($18,900)
Lifetime Financing Costs ($)	$0
Total Outflows	($718,900)
Project Free Cash Flow	$182,256
Summary	
Project NPV ($)	($149,640)
Project IRR (%)	2.31%
Project Payback Period (Years)	17

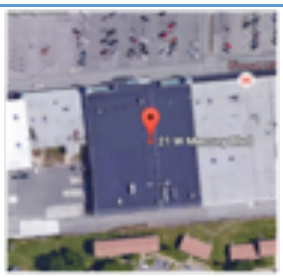
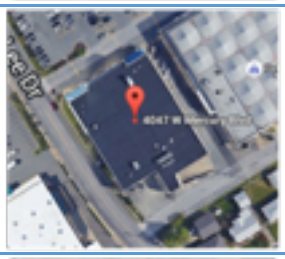
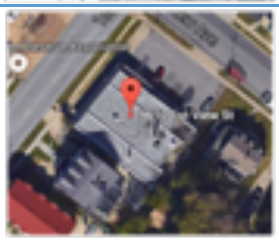
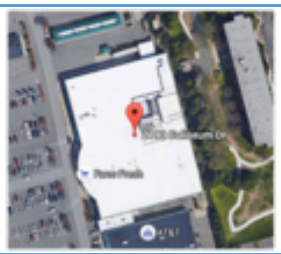
Appendix 2: Solar Analysis of Grocery Stores

Below is an example of the type of analyses we conduct to determine the feasibility and solar potential in a particular market segment. For example, in Hampton Roads, our test municipality, there is significant solar potential on grocery store facilities, as they could host over 13 MW of installed capacity.

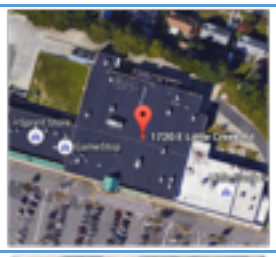
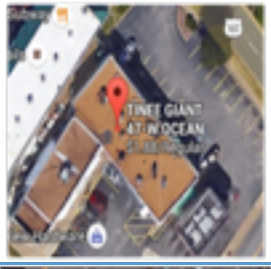
Store	Photo	Potential installed capacity
Farm Fresh 608 E Mercury Blvd (757) 723-0771		279 kW
Food Lion 3855 Kecoughtan Rd (757) 723-8802		237 kW
Save-A-Lot 2201 Kecoughtan Rd (757) 245-2061		177 kW
M&T Market Zeros Subs 2711 Kecoughtan Rd (757) 723-0711		18 kW
Best of British 555a Settlers Landing Rd (757) 723-7480		400 kW
Swami Food Store 81 Lincoln Street (757) 722-1164		260 kW

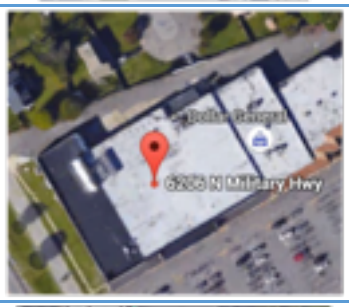
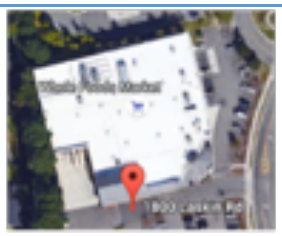
Fresh Pride 2309 Jefferson Ave (757) 244-6166		200 kW
Commissary 1588 Mall Dr (757) 423-6070		500 kW
Hampton Oriental Market 1123 N King St (757) 723-3003		75 kW
Food Lion 8401 Hampton Blvd (757) 489-2717		60 kW
EZ Pick 2607 W Mercury Blvd (757) 825-2541		68 kW
Farm Fresh 230 E Little Creek Rd (757) 587-8741		500 kW
Walmart Supercenter 6111 Jefferson Ave (757) 637-4205		1200 kW

Kroger Little Creek Gateway Shopping Center 205 E Little Creek Rd (757) 587-5945		240 kW
Food Lion 123 Newmarket Square (757) 244-7887		310 kW
Walmart Neighborhood Market 117 Marketplace Dr (757) 637-4861		350 kW
Food Lion Coliseum Crossing Shopping Center 85 Coliseum Crossing (757) 827-1304		240 kW
Farm Fresh - Ocean View 179 W Ocean View Ave (757) 587-0200		280 kW
Save-A-Lot 1933 E Pembroke Ave (757) 723-3645		290 kW
Save-A-Lot 4902 W Mercury Blvd (757) 838-4505		70 kW

Food Lion 21 W Mercury Blvd (757) 727-9001		410 kW
Little E's Grocery 313 Buckroe Ave (757) 851-9820		20 kW
Food Lion 4047 W Mercury Blvd (757) 825-8020		248 kW
Carmen's Market & Boutique 9610 1st View St (757) 216-5623		45 kW
Farm Fresh 2190 Coliseum Dr (757) 827-4816		470 kW
Walmart Supercenter 1900 Cunningham Dr (757) 826-6377		1,400 kW

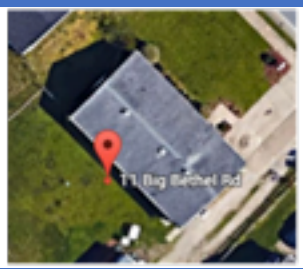
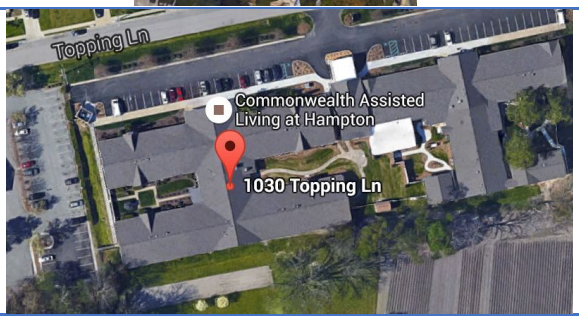
Quick Pick 9825 Jefferson Ave (757) 595-1919		150 kW
Food Lion Southern Shopping Center 7525 Tidewater Dr (757) 588-7791		29 kW
BJ's Wholesale Club 2000 Power Plant Pkwy (757) 846-2020		970 kW
Food Lion Warwick Shopping Center 10880 Warwick Blvd (757) 595-0115		410 kW
Solo Mart 4710 Marshall Ave (757) 245-2577		50 kW
7 Brothers Food City 6819 Sewells Point Rd		30 kW

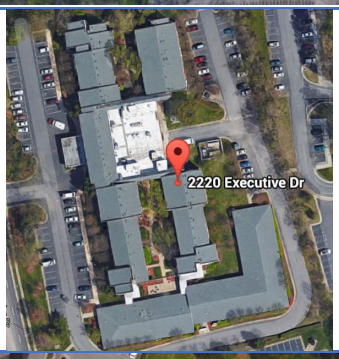
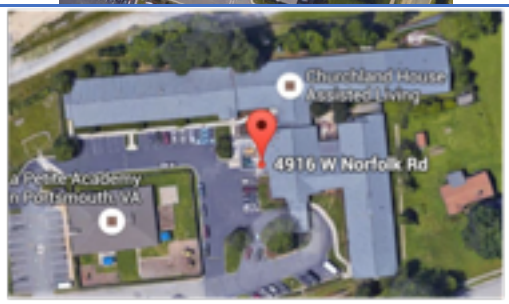
Walmart Neighborhood Market 1720 E Little Creek Rd (757) 480-0654		500 kW
Save-A-Lot Roosevelt Gardens Shopping Center 2314 E Little Creek Rd (757) 583-3476		88 kW
TINEE GIANT 47-W.OCEAN 123 W Ocean View Ave (757) 588-4469		30 kW
Food Lion Little Creek East Shopping Center 4253 E Little Creek Rd (757) 583-7817		290 kW
Food Lion 1859 E Little Creek Rd (757) 588-0423		230 kW

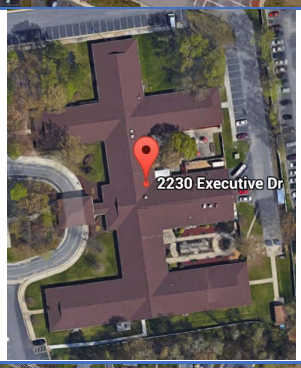
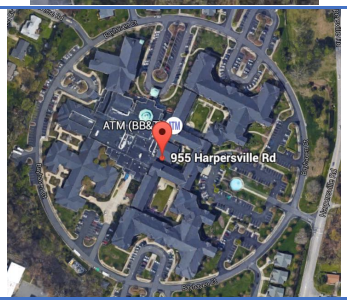
Walmart Supercenter 7530 Tidewater Dr (757) 480-0587		1,300 kW
Miller's Neighborhood Market 2129 W Mercury Blvd (757) 826-5237		44 kW
Food Lion 6206 N Military Hwy (757) 853-2850		233 kW
Miller's Neighborhood Market 1133 W Mercury Blvd (757) 896-2221		17 kW
Whole Foods Market 1800 Laskin Rd (757) 422-0444		280 kW
Whole Foods Market 12080 Jefferson Ave (757) 947-2460		330 kW
TOTAL POTENIAL CAPACITY		13,738 kW

Appendix 3: Analysis of Assisted Living Facilities

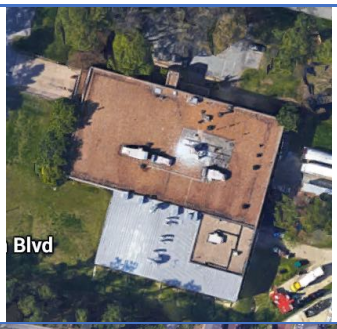
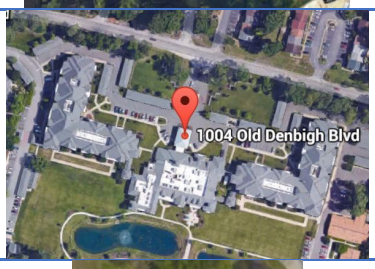
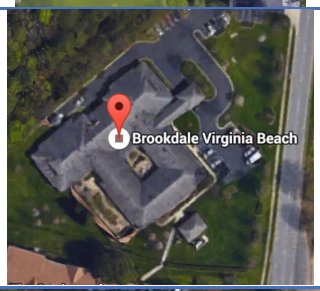
Below is an example of the type of analyses we conduct to determine the feasibility and solar potential in a particular market segment. In Hampton Roads, assisted living facilities have the potential to host over 14 MW of solar capacity.

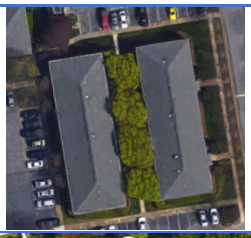
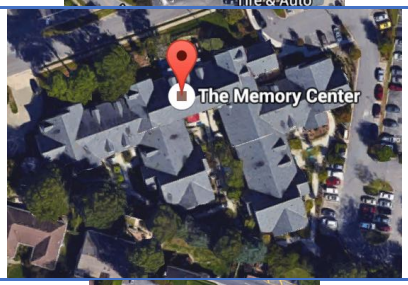
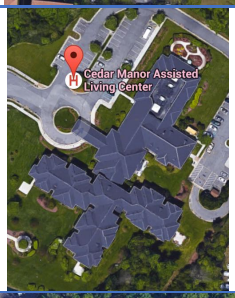
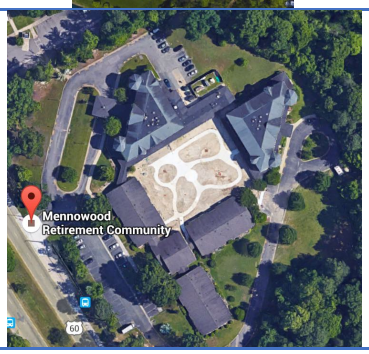
Location	Photo	Potential installed capacity
Faithlink 11 Big Bethel Rd (757) 896-8660		15 kW
Golden Care 532 Settlers Landing Rd		10 kW
The Ballentine 7211 Granby St (757) 687-0999		180 kW
Commonwealth Assisted Living at Hampton 1030 Topping Ln (757) 504-3559		300 kW

Seton Manor 215 Marcella Rd (757) 827-6512		120 kW
Eden Court Assisted Living 1034 Topping Ln		220 kW
Devonshire 2220 Executive Dr		370 kW
Province Place of DePaul 6403 Granby St		258 kW
Churchland House Assisted Living 4916 W Norfolk Rd		400 kW

Province Place of Maryview 1 Bon Secours Way (757) 686-9100		280 kW
Hilton Plaza Inc 311 Main St (757) 596-6010		60 kW
Harbor's Edge Retirement Community 1 Colley Ave (757) 616-7900		170 kW
Sentara Nursing & Rehabilitation Center 2230 Executive Dr (757) 224-2230		480 kW
The Chesapeake 955 Harpersville Rd		6,000 kW

Consulate Health Care of Norfolk 3900 Llewellyn Ave (757) 625-5363		300 kW
Commonwealth Assisted Living 1516 Harmon St (757) 588-4663		130 kW
Envoy of Thornton Hall 827 Norview Ave (757) 853-6281		324 kW
Coliseum Park 305 Marcella Rd, Hampton, VA 23666		625 kW
Riverside Convalescent Center 200 Lumar Rd 757-357-3282		470 kW

Riverside Convalescent Center 1000 Old Denbigh blvd		325 kW
Warwick Forest Retirement Community 1004 Old Denbigh		750 kW
Dominion Village at Poquoson 531 Wythe Creek Rd		210 kW
Dominion Village at Chesapeake 2856 Forehand Dr		220 kW
Brookdale Virginia Beach 937 Diamond Springs Rd		290
Leigh Hall 890 Poplar Hall Dr		42 kW

The Waterford at Virginia Beach 5500 Shore Dr		10 kW
Kings Grant House 440 N Lynnhaven Rd		280 kW
The Memory Center 1853 Old Donation Pkwy		320 kW
Greenfield Senior Living at Chesapeake 130 Great Bridge Blvd		210 kW
Cedar Manor 1324 Cedar Rd		450 kW
Mennowood Retirment Community 13030 Warwick Blvd 757-249-0355		260 kW
TOTAL POTENTIAL		**14,079 kW**

Appendix 4: Regional Planning Documentation Examples

- Southside Hampton Roads (multijurisdictional)
    - 2016 Version Awaiting Final Draft
- Chesapeake
- Norfolk
- Peninsula Hazard Mitigation Plan (multijurisdictional), includes Newport News

Appendix 5: Additional Resources

- Electric Power Research Institute - EPRI conducts research and development related to the generation, delivery and use of electricity for the benefit of the public. An independent, nonprofit organization, they bring together scientists and engineers as well as experts from academia and the industry to help address challenges in electricity.
- EPRI Energy Storage Integration Council (ESIC) - Energy Storage Integration Council (ESIC) is an open and active venue, executed via a combination of in-person meetings, webcasts, and teleconferences, for identifying key gaps and common approaches for the integration of energy storage across key technical topic areas.
- Storage Value Estimation Tool (StorageVET) - A publicly available, web-hosted, energy storage value simulation tool.
- DOE/EPRI 2013 Electricity Storage Report - Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation, The Electricity Storage Handbook is a how-to guide for utility and rural cooperative engineers, planners, and decision makers to plan and implement energy storage projects. The Handbook also serves as an information resource for investors and venture capitalists, providing the latest developments in technologies and tools to guide their evaluations of energy storage opportunities.
- Cost-Effectiveness of Energy Storage in California: Application of the EPRI Energy Storage Valuation Tool to Inform the California Public Utility Commission - EPRI has developed an innovative methodology for quantifying the value of grid energy storage opportunities
- Guide for the Interoperability of Energy Storage Systems - This document provides guidelines for discrete and hybrid energy storage systems that are integrated with the electric power infrastructure, including end-use applications and loads. This guide builds upon IEEE Std 2030 Guide for Smart Grid Interoperability of Energy Technology and Information Technology Operation With the Electric Power System (EPS), and End-Use Applications and Loads.
- The DOE Global Energy Storage Database - Provides free, up-to-date information on grid-connected energy storage projects and relevant state and federal policies.
- The Energy Storage Systems (ESS) Research Program – The goal of the ESS program is to develop advanced energy storage technologies and systems, in collaboration with industry, academia, and government institutions that will increase the reliability, performance, and competitiveness of electricity generation and transmission in the

electric grid and in standalone systems.

- Incorporating Renewables Into The Electric Grid: Expanding Opportunities For Smart Markets And Energy Storage - This report examines economic and technical considerations related to increasing integration of variable renewable energy resources onto the existing electric grid, which highlight the importance of emerging technologies and approaches in smart markets and energy storage.