

**U.S. Department of Energy
State Energy Strategies
Community Solar in the Southeast Project**

**Fayetteville Public Works Commission
Community Solar in Practice Case Study**



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Preface

The N.C. Clean Energy Technology Center (NCCETC) advances a sustainable energy economy by educating, demonstrating and providing support for clean energy technologies, practices, and policies. The NCCETC helps large industrial, institutional and commercial energy users to reach their energy-related goals. Whether your objectives are to achieve cost reductions, sustainability initiatives, or improve energy resiliency, the Center provides direct support and access to resources.

The Clean Power and Efficiency / Renewable Energy Programs at the Center are staffed by experienced specialists and engineers. Our services include site-specific energy assessments, economic feasibility studies and project development support. We often assist by helping clients to improve energy efficiency of building systems and / or industrial processes or deploy distributed generation systems.

The Center is a public service center in the College of Engineering at North Carolina State University. The North Carolina General Assembly generously provides core funding for the Center by direct appropriation through the Department of Environmental Quality. The Center receives additional funding from fees for training and technical assistance and from numerous federal, state and private research grants. The Center is also supported by the N.C. Clean Energy Technology Center Foundation, a part of the NC State Engineering Foundation.

The estimates contained herein serve as a reasonable basis for future decision-making plans and improvements. The recommendations are based on conditions existing at the time of the survey, information provided by client personnel, short-term measurements taken by the surveyors, or estimates made, and average yearly data. Actual savings will depend on factors such as, varying energy prices, specific energy use patterns and conservation plans implemented. The specific savings cannot be guaranteed.

Any opinions, findings, conclusions, or recommendations expressed herein are those of the author and do not necessarily reflect the views of the NCDEQ or NC State University.

The NCCETC would like to thank Ms. Kathy Miller, Marketing Manager, for working with our team through each phase of this innovative and complex project.

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Description of Project

In late 2019, the Fayetteville Public Works Commission (PWC), a public power provider in North Carolina, became the first to implement a community solar plus storage system at a municipal utility within the state with a 1MW solar photovoltaic (PV) + 560 kW/2-hour battery project. PWC turned to this shared, or community solar model in order to meet three key needs of the utility, which serves about 83,000 customers in Cumberland County. First, the project would help PWC meet its requirements under the state's Renewable Energy Portfolio Standard (REPS), which mandates that as a municipal utility, 10 percent of their power come from renewable energy. Secondly, the project was scaled to provide cost savings through renewable energy generation and energy storage to reduce coincident peak demand and lastly, it would allow them to offer a green energy option to their customers.

The Public Works Commission partnered with the North Carolina Clean Energy Technology Center (NCCETC) to investigate the viability of solar PV and storage at their Butler Warner Generation Plant under the U.S. Department of Energy's *Community Solar for the Southeast* project. The Center provided a technical and economic analysis as well as RFQ and RFP development and program design, to help PWC assess vendors and project developers to meet the procurement parameters stipulated by the utility. The construction for the community solar project began in December of 2018 and it was completed September 2019.

This study serves as a follow-up to the Municipal Utility Case Study and provides information relevant to PWC's implementation of the community solar project including:

- Benefits for PWC and Customers
- Project Design and Performance
- Procurement Process
- Start-up and Operation
- Program Marketing and Communication
- Future Opportunities
- Conclusion

About *Community Solar in the Southeast*

In 2016, the NC Clean Energy Technology Center received a federal grant from the Solar Energy Technologies Office of the U.S. Department of Energy to provide no-cost technical assistance, program design, policy support and resource development aimed at making solar more affordable and accessible through shared solar projects developed by cooperatives and municipal utilities across the Southeast. The project, *Community Solar for the Southeast*, led multiple stakeholder engagements with rural public power utilities to determine solutions needed to increase development of community solar projects. The team provided technical assistance to analyze, design, and implement community solar projects, as well as published resources for other interested utilities to use. The project, which concluded in June of 2020, has helped nine municipal utilities and cooperatives with technical assistance and produced more than seven resources.

The project led by the NC Clean Energy Technology Center, included multiple partners including Rocky Mountain Institute, Fayetteville Public Works Commission, NC Justice Center, National Rural Electric Cooperative Association, Roanoke Electric, Strata Solar, EcoPlexus, Geenex, and GreenLink. The project was funded by the Department of Energy SunShot program under Solar Energy Evolution and Diffusion Studies-2State Energy Strategies (SEEDS2SES).

Applicability to other utilities in NC

Since municipal and cooperative electric utilities in North Carolina operate under a different set of regulations than independently owned utilities (IOUs), they benefit from a certain level of autonomy when considering shared or community solar projects for their respective territories. Municipal and cooperative electric utilities purchase the majority of their power under wholesale power contracts which often have a flat energy charge (per kWh) and a coincident peak demand charge (per kW).

Depending on the wholesale contract terms and limitations, a community solar project should be analyzed taking into consideration both the energy and demand charges to assess all opportunities for shared savings and benefits.

This study will demonstrate how the collective team was able to build a program that benefits the utility, the subscribers, and all PWC ratepayers.

Benefits for PWC and Customers

In August of 2007, North Carolina Senate Bill 3 was passed establishing the North Carolina Renewables and Efficiency Portfolio Standard (NCREPS) requiring utilities to generate or obtain a percentage of their retail electric sales from renewable energy. Municipal utilities and electric cooperatives must meet an overall target of 10 percent and can use demand-side management to satisfy the requirement. Under their wholesale power supply contract, PWC's ownership of fossil fuel generation is limited, however PWC is allowed to develop projects that generate renewable energy credits (RECs) to comply with NCREPS, such as this solar PV and storage project. The system was designed to maximize financial returns while remaining compliant with regulatory constraints. The battery allows PWC to store a portion of the energy generated and discharge it during critical peak or coincident peak periods to help reduce the utility's wholesale electricity cost.

Customers who are interested in supporting renewable energy can receive a net credit from participating in the program. Each subscriber to the community solar program pays a one-time enrollment fee for each panel under, along with a fixed monthly fee per panel. The subscriber will see a net positive return on their investment in less than 2 years.

This value-based approach considers multiple streams of the energy generation including avoided cost, renewable energy value and demand reduction. It also provides all PWC customers, including renters, access to an opportunity to support clean, renewable energy without having to install and maintain their own rooftop solar PV arrays.

Project Design and Performance

The original concept for the project was based on a 1 MW solar PV array, which was in alignment with PWC's wholesale power supply agreement. Based on a study conducted by the NCCETC, it was determined that the optimal size for the battery would be 500kW of capacity,

with two hours of discharge time, for a total installed capacity of 1 MWh of energy storage. The battery storage system was designed to discharge during forecasted monthly coincident peak demand calls, to reduce Fayetteville's monthly wholesale cost for electricity and improve the payback rate for the entire system installation.

The system as installed consists of 3,384 solar PV modules, each rated at 330W for a total installed capacity of 1,100 kW_{DC}. There are 19 PV inverters providing a peak output of approximately 880 kW_{AC} to the grid. The battery system has a total storage capacity of 11,58 kWh, connected to two DC-AC inverters rated at 280 kW_{AC} each. Each inverter is individually connected to the site's main switchgear for a design peak output capacity of 560 kW_{AC}. The designed capacity is for two hours discharge with a design depth of discharge of 80%. In practice, however, the battery system's output is limited by the AC inverters, which, along with conversion losses between the DC and AC sides of the system, means the battery can be discharged for coincident peak calls at a sustained output of 495 kW_{AC} for two hours.

The original design for the solar array called for a single-axis tracking layout to maximize potential solar generation and coincident peak output at the chosen site. Late in the design process the planned design had to be changed to a fixed array to allow a right of way for an overhead transmission line, which reduced the area allowed for solar. While the change from a tracking to fixed array lowered the amount of coincident peak potential from the solar PV, the peak capacity of the solar array was not significantly changed.

PWC's wholesale power cost is based on a monthly coincident peak charge and a flat energy charge. Coincident peak (CP) is defined as the hour of each month when the electrical demand for the servicing utility, in this case, the eastern portion of Duke Energy's grid, is the highest. Under the current rate structure applied to Fayetteville Public Works from Duke Energy, the charge associated with this monthly peak is currently \$21.09/ kW. In order to accurately predict when this peak hour was going to occur, the NCCETC used nine years of Duke Energy Progress (DEP) hour demand data, corresponding ambient temperature measurements, and solar radiation data.

To maximize the savings from reducing the monthly coincident peak demand, the battery storage system and the solar PV system have been designed with separate inverters so they can both provide their maximum output and to meet other land constraints.

Based on the modeling, it is estimated that in the first year of operation the solar PV will generate an estimated 1,500,000 kWh, valued at approximately \$38,000, and provide 4,500 kW of output at CP with a value of approximately \$93,000. The battery system, if dispatched with 100% accuracy, could reduce PWC's CP by up to 5,300 kW per year, with a potential value of \$110,000.

The graph in **Figure 1** below compares the modeled monthly solar PV energy production over the first eight months of operation to the actual production for the same period.

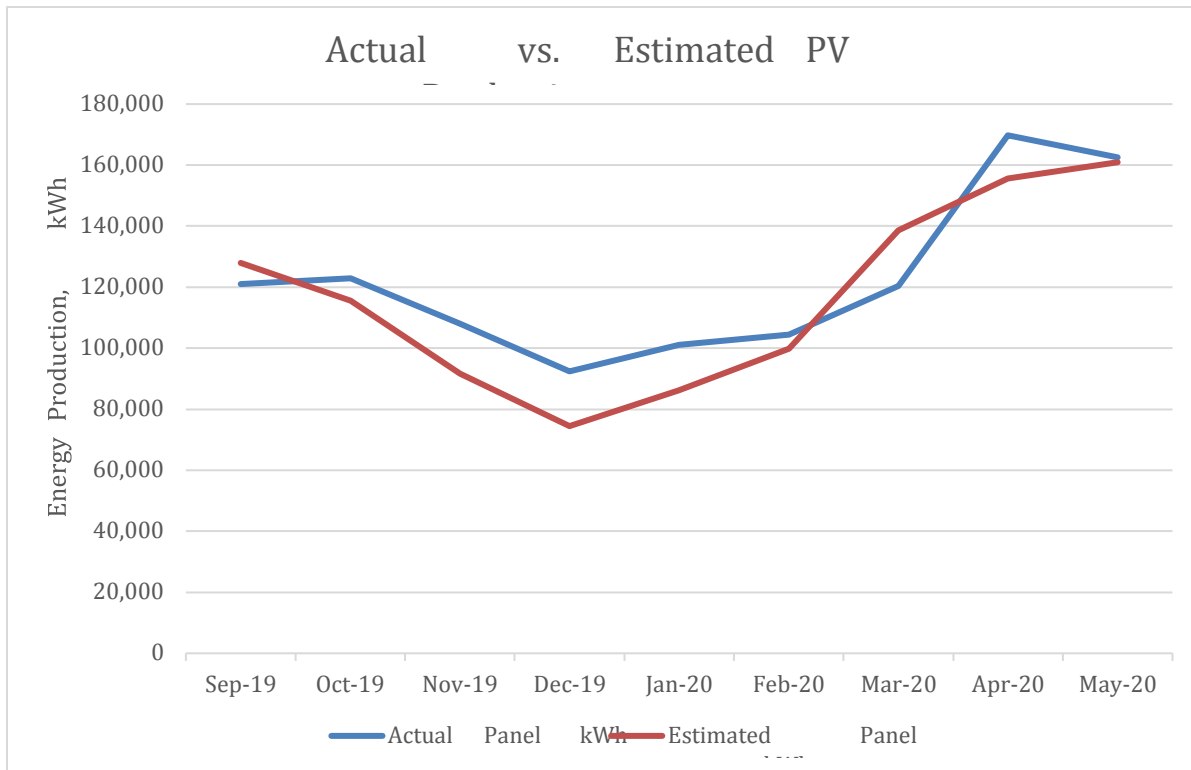


Figure 1. Estimated vs. Actual Solar PV Production, kWh

So far, solar PV generation results over the first eight of operation months have exceeded the modeled generation. Between September 2019 when the system came online, and May 2020, the total energy generated by the solar PV array was 1,102,000 kWh. The calculated value from the fixed tilt model developed by NCCETC for the same time period was 1,051,000 kWh.

Figure 2 below shows a comparison of modeled and actual coincident peak energy reduction, from both the solar PV system and the battery. The originally estimated annual peak reduction from the battery system was 2,748 kW. Actual system output over the first nine months so far has totaled 2196 kW. However, it must be noted that for the months of September and October 2019, testing and implementation of the battery dispatch and control system was still ongoing. For each of the months of January and February 2020, the metered peak output of the battery has been 495 kW. This surpasses the highest calculated value for peak reduction discharge of 468 kW.

As a result of quarantine measures due to COVID-19, many industrial customers have reduced capacity and while residential customers have shifted to being home leading to significant shifts in overall usage as well as coincident peak forecasting. This shift, along with other factors has resulted in the utility missing the opportunity to discharge the battery during coincident peak loads for both April and May. As a result, PWC is looking into alternate methods of discharge to improve the strategy of hitting the peak call during these unprecedented times.

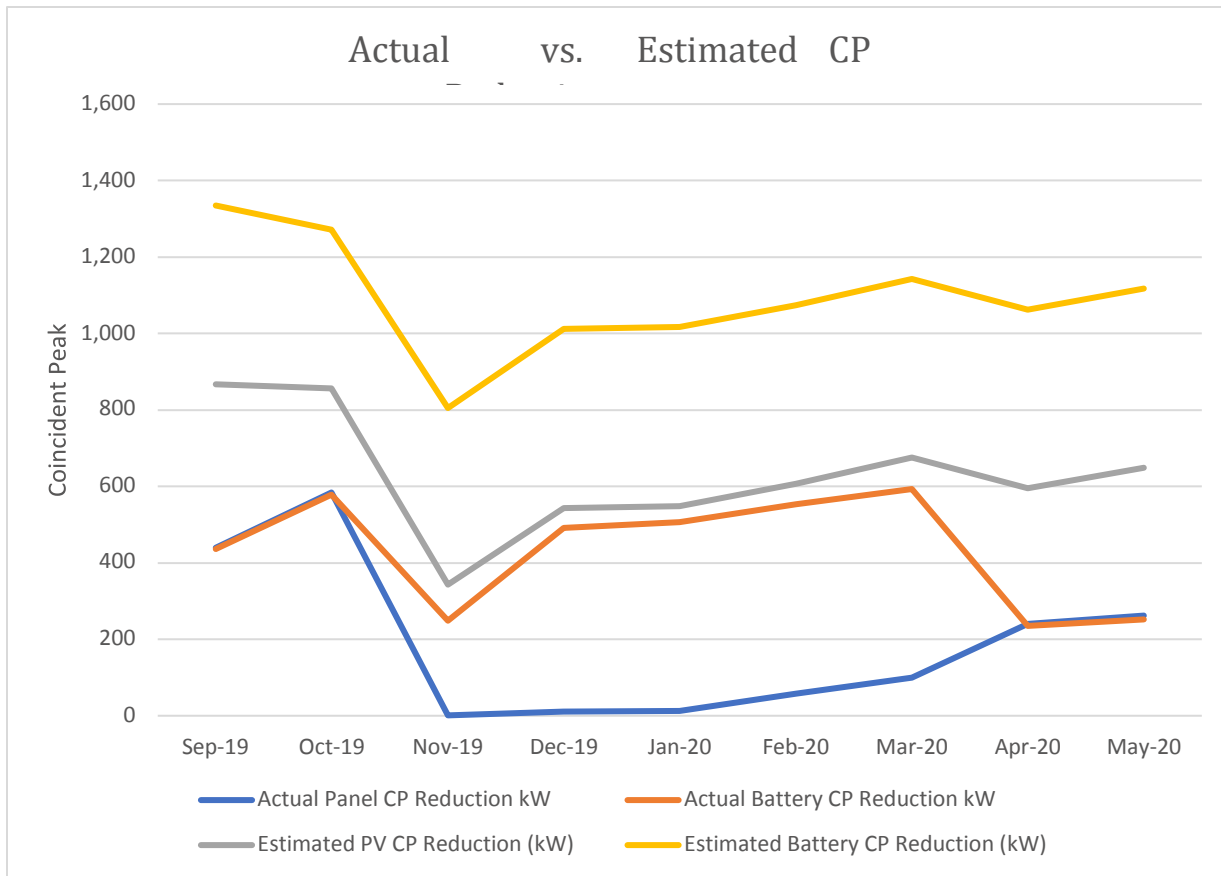


Figure 2. Estimated vs. Actual Coincident Peak Reduction, kW

The above cost and energy numbers do not take into account the extended issues with commissioning and dispatching of the system, and for the last two months, the numbers are tracking much more precisely with the calculated numbers from the initial model. It is reasonable to expect that the system will continue to track with the expected payoff rate and energy production outputs based on the original model.

Table 1 below shows the monthly solar and battery storage values used in the graphs above.

Table 1. Fayetteville PWC Solar Estimated vs Actual Performance¹

Month	Solar Generation Modeled (kWh)	Solar Generation, Actual (kWh)	Solar CP Output, Modeled (kW)	Solar CP Output, Actual (kW)	Storage CP Output, Modeled (kW)	Storage CP Output, Actual (kW)
September 2019	127,910	120,913	431	440	468	-4
October 2019	115,599	122,810	278	584	415	-6

November 2019	91,660	108,053	94	1	462	248
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December 2019	74,454	92,399	53	11	468	480
January 2020	86,268	101,157	43	12	468	494
February 2020	99,735	104,476	54	58	468	495
March 2020	138,670	120,314	82	99	468	494
April 2020	155,610	169,761	360	240	468	-5
May 2020	160,934	162,551	397	262	468	-10

¹ Meter for the site was reset on 10/6.

Table 2 below tracks actual and modeled financial inputs as have been seen from both the value of electrical generation of the solar PV array, and the cost savings from timed discharge of the battery energy storage system for reducing the monthly coincident peak charge. The financial output of cost savings from the solar PV system have been adjusted to use the current rate structure PWC pays Duke Energy, to normalize the value between recent results and the historical modeled estimates for savings from both PV energy generation and coincident peak call battery discharges. The negative numbers under the storage CP values reflect losses from energy used to charge the battery in months when the controls were not yet working properly.

Table 2. Fayetteville PWC Community Solar Estimated vs Actual Financials¹

Month	<i>Solar Energy and CP Value, Modeled</i>	Solar Energy and CP Value, Actual	<i>Storage Energy and CP Value, Modeled</i>	Storage Energy and CP Value, Actual
September 2019	\$12,170	\$12,144	\$12,170	(\$161)
October 2019	\$8,810	\$15,025	\$8,810	-\$153
November 2019	\$4,503	\$3,153	\$4,504	\$4,782
December 2019	\$3,200	\$2,895	\$3,200	\$9,314
January 2020	\$3,107	\$2,833	\$3,346	\$10,318
February 2020	\$3,682	\$3,887	\$3,952	\$10,342
March 2020	\$5,265	\$5,156	\$5,631	\$10,330
April 2020	\$11,560	\$9,391	\$11,580	(\$211)
May 2020	\$12,477	\$9,671	\$12,460	(\$313)

¹ PWC's rates from DEC were updated on 1 January 2020, which updated the rates for CP demand, energy purchase from DEC, and energy resale to DEC. Value calculations for September-December were completed using the old rate structure, and Jan-May with the updated rate structure..

Procurement Process

Due to the timing, scope, and funding sources for this project, the Public Works Commission elected to pursue the project as a design-build acquisition contract to simplify the design and construction process and overall system acquisition. Design-build was expected to be more advantageous for this type of project due to several of its inherent advantages:

- Flexibility - to allow for availability of solar modules, inverters and batteries from different manufacturers at the time of procurement.
- Faster acquisition and single point of responsibility – because these projects have a single project manager from design through commissioning, there's no need for multiple rounds of bidding on contractors, suppliers, which streamlines the entire process.
- Potential cost savings – again, due to the single round of design and construction, there is the potential for savings based on less required coordination and outside specialization.

RFQ development

A Request for Qualifications (RFQ) proposal and outline specifications was issued in October of 2017. The NCCETC assisted PWC with development of the outline specs to help ensure that owner requirements and minimum performance criteria were met. The team also developed a list of local contractors with experience in similar systems to ensure a good response to the RFQ.

As part of the RFQ process, a pre-proposal meeting was held for all firms planning on submitting bids in early October. It was convened in order to answer any outstanding questions and flesh out details of the project scope and requirements. PWC developed the outline site plans and specifications as part of the bid process, but there were no follow-on bridging documents that were included to provide more specific design requirements.

Due to the complexity of the specified control scheme associated with the charging and dispatch model for the battery storage system, this would have played a beneficial role in ensuring the design and control schemes met the required programming goals as specified in the initial intent of the project. PWC selected Dewberry, a firm headquarter in Raleigh, as the design-build contractor, and executed a contract in March of 2018. The detailed design phase began shortly thereafter, for which Dewberry subcontracted with an outside engineering firm.

Project Schedule

After the detailed design was approved, construction broke ground in December 2018. During development of construction documents, several challenges arose that affected the ability of the project to be completed as originally scheduled. As mentioned previously, issues with suppliers meant that lower-capacity modules had to be substituted.

The first phase of the project encompassed the installation of the solar array, and its associated racking and mounting, along with optimizers and electrical connections. This phase of construction was due to be completed in May of 2018. The second phase, the switchgear, battery storage system, and control software was due to be completed January 2019 but was not completed until the fall of 2019.

Once construction was completed, a ribbon cutting ceremony was held with the Fayetteville City Council and guests on October 23, 2019. However, as noted above the validation and testing work with the battery control system was delayed until December of 2019.

Construction Budget

The projected project budget was originally \$2.5 million dollars for engineering, construction, and commissioning of the complete system, and the final cost for construction was **\$2.56M**. However, in addition to the total system cost, additional costs were incurred due to the need for a separate contract to continue working on issues with the battery control system.

Above the construction and commissioning costs, PWC has an annual maintenance agreement with Carolina Solar for both the solar PV and battery storage system which consists of the following annual services:

- System maintenance: \$11,892
- Monitoring: \$2,382
- Vegetation management: \$6,150
- Module washing: \$2,100

Additionally, the following additional features were set up with NEC:

- Extended 4-10 battery system warranty: \$23,040
- Spare parts: \$7,767
- Training support: \$1,000

Start-up and Operation

There were challenges encountered relative to PWC's community solar project, including startup and testing delays, improper configuration of controls and unfamiliarity on the contractor's part with energy storage integration. With the support of experienced vendors and service providers, these challenges were ultimately resolved. For example, PWC had to bring in outside support from the battery's manufacturer, NEC Energy Solutions, in order to continue working through the control and dispatch issues.

During the design of a solar PV and energy storage system, it is important to document the utility's requirements, especially in terms of interconnection safety, controls and operator training. Communicating these requirements during the design, bidding and construction process

helps ensure that the solar and energy storage systems can be operated safely and provide the expected level of performance.

Testing requirements for solar PV and energy storage is necessary to ensure protection of the electrical grid and line workers, as well as to ensure that the systems operate at their maximum potential. IEEE Standard 1547, Article 11 provides a good testing and verification framework that should be first applied to evaluate the design, followed through the construction process, and culminate in a full functional performance test.

Another important consideration is for owners to engage as early as possible with vendors of essential systems, including solar inverters, storage batteries and controls, and communication hardware/software. For one, this helps confirm that equipment and controls come properly configured from the factory. As an example, the battery manufacturer for PWC's project, NEC Energy Solutions, was not informed of the intended use of the storage battery for extended peak shaving, and instead supplied the system with the battery controls configured to start recharging after 50% discharge, when they should have allowed a deeper depth of discharge.

Vendors can also provide essential training for utility staff on systems they haven't typically encountered or operated. In PWC's case, Also Energy, the monitoring and control software vendor, provided training that has helped facilitate start-up and allowed rapid customization by PWC utility engineers.

As with most complex construction projects, a commissioning process is a must for a solar PV and energy storage project. A commissioning agent is typically hired by the owner at the beginning of the project and works to ensure the owner's requirements are met. Commissioning helps reduce the likelihood of change orders, while saving time and expense by assuring things are done right the first time.

For ongoing site maintenance and monitoring PWC decided to engage Carolina Solar Services, a specialty firm that provides startup and testing, 24/7 monitoring, rapid on-call service, annual inspections, landscape maintenance and inverter / module swap-outs. Such services are vital to maintaining a high level of performance and uptime, and annual costs for them should be budgeted in the project.

Program Marketing and Communication

Program design

A number of community solar program models and lengths of participation were compared and contrasted for this task, based on the needs of PWC and its customer base. Elements such as REC (renewable energy certificate) treatment, customer eligibility including minimum terms, deposits, transferability, financing, and tax considerations were included in the analysis of a suitable program for customers. The initial program design discussed in the previous case study

used a pure subscription model, with subscriber contributions recouped entirely through a monthly charge.

The final program design PWC chose includes both an upfront fee of \$20 for the first solar panel, \$10 for additional panels (up to 5 panels per customer) and a monthly subscription charge of \$1.53/month per panel. The program does not have a minimum term (although the upfront fee disincentivizes early exit for subscribers), and PWC retains all RECs, with the REC value included in the subscription credits, which are currently \$2.51/month per panel. For municipal utilities to meet the Renewable Energy Portfolio Standard requirement of 10% generation sourced from renewables, PWC chose to invest in their own generation to meet some of the requirement. A percentage of the NC renewable energy rider or fee collected from PWC customers will also be applied to a portion of the project's development, pending approval. Based on the analysis of the project's 25-year term, this design allowed PWC to create a program that provides financial benefits to subscribers much more quickly than traditional programs.

PWC has been actively promoting the community solar program through a variety of outreach initiatives including community events, social media and communications such as PWC-sponsored newsletters, podcasts and video animations. They've also participated in traditional media buys of digital billboards, print ads in the local newspaper, and appeared on radio shows. Beginning this Fall, they will offer quarterly Solar Sunday tours for subscribers and in the near future they plan to host school groups, as well.

At the writing of this case study, the program is 82% subscribed, with residential customers subscribing to 2,299 panels overall, at an average of 4-5 panels per customer. There are 484 nonresidential panels subscribed, with these subscribers including some small businesses and churches. More than 50% of the program was subscribed during the initial two months, and by month 4 the program attained 70% subscription. In order to account for customer enrollment and panel availability, as well as credits on bill statements, PWC embarked on a major modification of their billing process. To subscribe, customers need to access a portal page on the utility's website and complete an application.

PWC applied and received \$32,000 in funding from the North Carolina Department of Environmental Quality's Weatherization Assistance Program to help ten low-income qualifying residents participate in the community solar initiative. The funds were distributed through Action Pathways, a non-profit community action agency that helps families and individuals achieve and sustain economic security. Action Pathways selected eligible pre-qualified weatherization program participants to benefit from this initiative.

Future Opportunities

When speaking of future opportunities for increased peak reduction strategies, PWC is currently assessing an additional 1,500 kW of battery storage at the Butler Warner Generation Plant. Based on their wholesale contract with DEP, PWC is able to increase their capacity to store energy and dispatch it when it benefits the utility and its customers when energy is most expensive.

Lessons learned

The PWC engineering team has gained invaluable experience having implemented this community solar project, including the importance of safety and operator training for utility staff. Of equal importance is fostering relationships with the vendors of key components early in the project development phase. Vendors can provide critical information on product configuration, testing and training in order to sync with the utility's specific need and purpose. Additionally, having or acquiring a base knowledge of controls, testing variables, and interconnection would be beneficial during the implementation period. The value of a commissioning agent to oversee all aspects of the project is instrumental for success.

Conclusion

The Fayetteville PWC community solar project provides a proof of concept for community solar programs at municipal utilities in the Southeastern United States. The initial case study analysis demonstrated that it is possible in some cases to develop community solar programs that provide financial benefits to subscribers without requiring subsidization by the utility or other customers. The project in practice experienced some challenges in the development process, but was nevertheless completed, and is now performing as expected or better than the model predicted.

PWC Community Solar Project Partners

Fayetteville Public Works Commission
North Carolina Clean Energy Technology Center
Also Energy
Carolina Solar Services Dewberry
Directional Services, Inc.
Horne Brothers
NEC Energy Solutions
NC Department of Environmental Quality