SOLAR TODAY

An American Solar Energy Society Magazine
Expert Perspectives on Achieving a 100%-Renewable Energy Society

Summer 2022
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Virtual Solar Storage Benefits All Ratepayers and Utilities

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Community Solar: Is it Inevitable... Or Not?

An Albuquerque Gem: The Rio Grande Conservatory Greenhouse

Solar Energy Panels: Blind Spots and Risks for Insurers and Owners

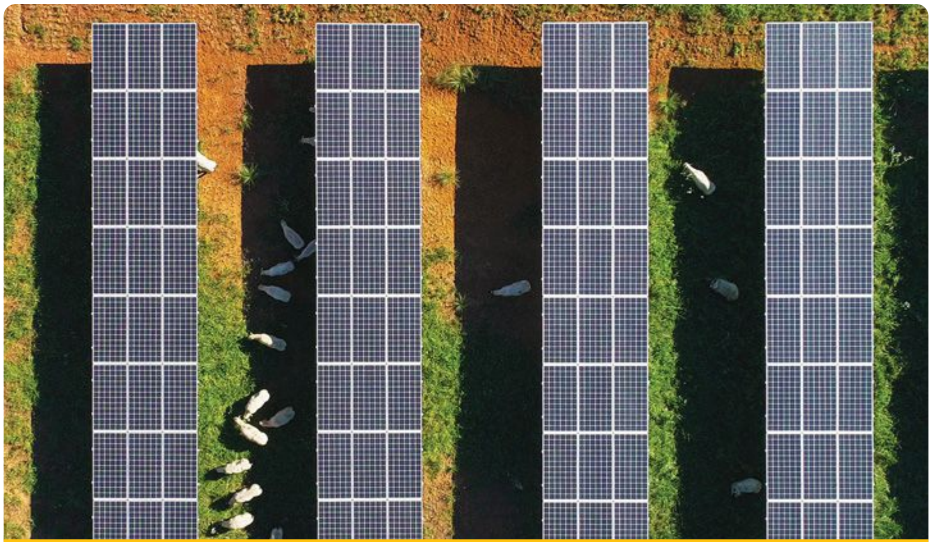
AMERICAN SOLAR ENERGY SOCIETY

Solar Today magazine is published by the American Solar Energy Society (ases.org), the U.S. section of the International Solar Energy Society, providing reporting on progress to a 100%-renewable energy society.

SOLAR TODAY

Summer 2022
Vol. 36, No. 2
solartoday.org

IN EVERY ISSUE



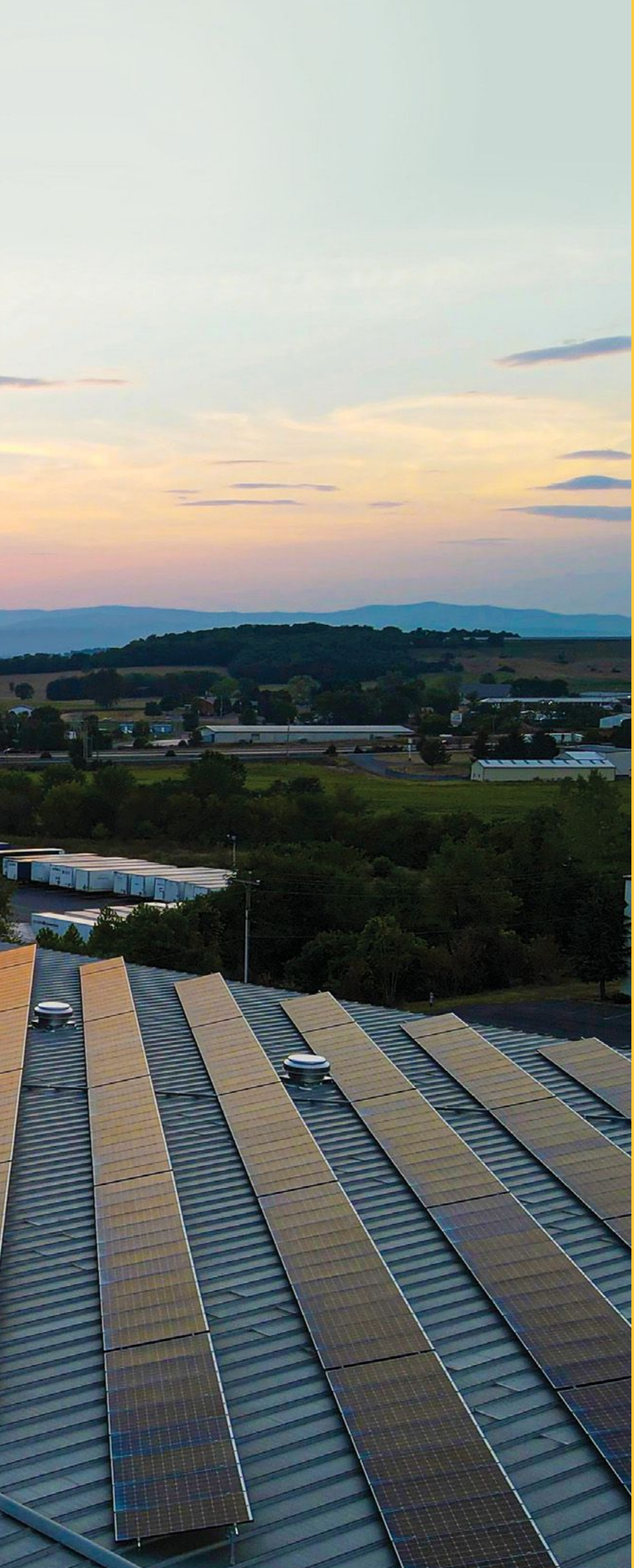
Cover Photo and this page: Carilion New River Medical Center 1-MW solar array. © Secure Futures

OUR ENVIRONMENTAL STATEMENT

Solar Today is printed with vegetable ink on paper containing 100% post-consumer waste. The paper is produced at a biomass-powered mill. This issue saves:

Trees	**182**
Energy	**121 million Btu**
Water	**27,574 gallons**
Greenhouse Gases	**8.9 tons**
Solid Waste	**7.2 tons**

Virtual Solar Storage Benefits All Ratepayers and Utilities



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By Anthony E. Smith, Ph.D., and Andre Eanes

Our research on large solar arrays debunks the myth perpetuated by utilities that solar only benefits solar customers at the expense of all other ratepayers.

Based on instrumented readings from utility meters and arrays that we own and operate as a solar developer, our analysis provides empirical evidence that commercial behind-the-meter solar PV generation consistently offsets customer peak demand and utility coincident-peak demand.

While solar is intermittent, it is **predictably** intermittent in a way that can reliably offset customer and utility peak demand in a manner comparable to adding battery storage, which is why we refer to this phenomenon as "Virtual Solar Storage."

The common myth perpetuated by utility companies, fossil fuel lobbyists and their apologists, especially the bill-generating American Legislative Exchange Council funded by the gas-and-oil-producer Koch Industries,[1,2,3] is that solar power is an intermittent daytime resource due to passing cloud cover and therefore requires full backup by nuclear, coal and natural gas plants. These same voices call on policymakers to roll back incentives for solar (ignoring the massive subsidies that keep fossil fuels afloat) and allow "market forces" to support "all-of-the-above" energy sources, particularly including nuclear power and fossil fuel generation.

An extension of this argument is that existing policies such as net metering and federal tax incentives, which help make solar economically viable, represent a subsidy from non-participants (implied to be "low-income households who cannot afford solar") to participants (read as "wealthy households and businesses who benefit from the subsidies paid for by the poor").[4]

Black Ice Cold Storage solar array.

© Secure Futures

Grazing sheep under the Carilion New River Medical Center 1-MW solar array

Others note that solar will be able to offset the intermittency issue when paired with battery storage.[5] However, current battery technologies require far greater inputs of rare-earth metals than that of solar PV, placing greater reliance on exploitative mining practices that disproportionately occur in the global South.[6] Additionally, battery storage will likely not be economically viable in the near term and is heavily reliant on China, which is already constrained in refining raw material for and assembling the majority of the world's lithium ion batteries.[7]

> *Our senior management team is thrilled about the energy savings that translate to lower costs for our community healthcare services. We also take delight in having the solar sheep mowing the vegetation as a further statement about our commitment to sustainability and support for our farming community.*
>
> – Scott Blankenship, Senior Director of Facility Support Services, Carilion New River Medical Center

Research Study

Empirical research on the peak-demand-reduction attributes of commercial solar has to date been limited to a handful of studies.[8,9] In addition, simulated studies on demand savings from solar PV and battery storage[10] have also noted the net metering benefits to all stakeholders[11] that indirectly support our findings about Virtual Solar Storage.

We suggest ways in which solar PV effectively combines the attributes of solar and battery storage and that these savings can be passed along to all ratepayers and utilities, supporting a more-rapid and less-costly transition away from fossil fuels.

Our research focuses exclusively on commercial-scale solar for customers with summer-daytime-peak demand ("Qualifying Customers"). Our research builds off actual interval data for our customers and compares demand with and without solar. In addition, we also review coincident peak data published by PJM, the regional transmission organization that covers Virginia and much of the Mid-Atlantic region. Our analysis of solar contributions during coincident peak periods reveals how utilities and all their ratepayers consistently benefit from commercial solar.

In addition to reshaping policy, the practical application of these findings is to revamp our approach to sizing solar arrays for this class of Qualifying Customers. This comes primarily from the peak-shaving potential via Virtual Solar Storage (as opposed to focusing on kWh-usage reduction) in order to capture the highest dollar savings per installed Watt of solar. As a complementary strategy, we also review the customer's contract demand with the utility company to assess potential savings made possible with Virtual Solar Storage, as discussed in the companion article on contract demand and Virtual Solar Storage. Lastly, we identify ways in which public entities and policy-makers can make more informed decisions about how to leverage solar as an important component of a smart, diversified and resilient energy grid.

Methodology

This analysis covers a diverse selection of Secure Futures' summer-daytime-peaking commercial customers who stand to benefit the most from peak demand reduction by solar. This included three separate public school facilities, two cold-storage facilities, one hospital and two university facilities, which are served by four different utilities.

For each facility, we matched 12 months of utility-interval data with solar-production data. The utility data alone reflects each customer's demand with solar (i.e., including the demand reduction by solar). The solar-production data enabled us to extrapolate the customer's combined demand including solar production, (i.e. all of the customer's demand) as a representation of what the demand would have been without solar.

We used this dataset to determine the offsets to each customer's peak demand as well as during the five summertime coincident peak (5CP) times for member utilities, determined by PJM, which almost always occur on summer weekdays in the late afternoon. Once this process was completed for each summer- and daytime-peaking customer, the data was aggregated across facilities to analyze solar performance overall.

Results

Two groups stand to benefit in different ways from these findings: commercial solar customers and their utilities, which by rights should encompass all their ratepayers, notably including their non-solar customers.

Benefits to commercial solar customers center around the reductions in peak demand billed from the utilities, while non-solar participants can theoretically save money due to reduced need for higher-cost-peaker-plant generation during 5CP periods.

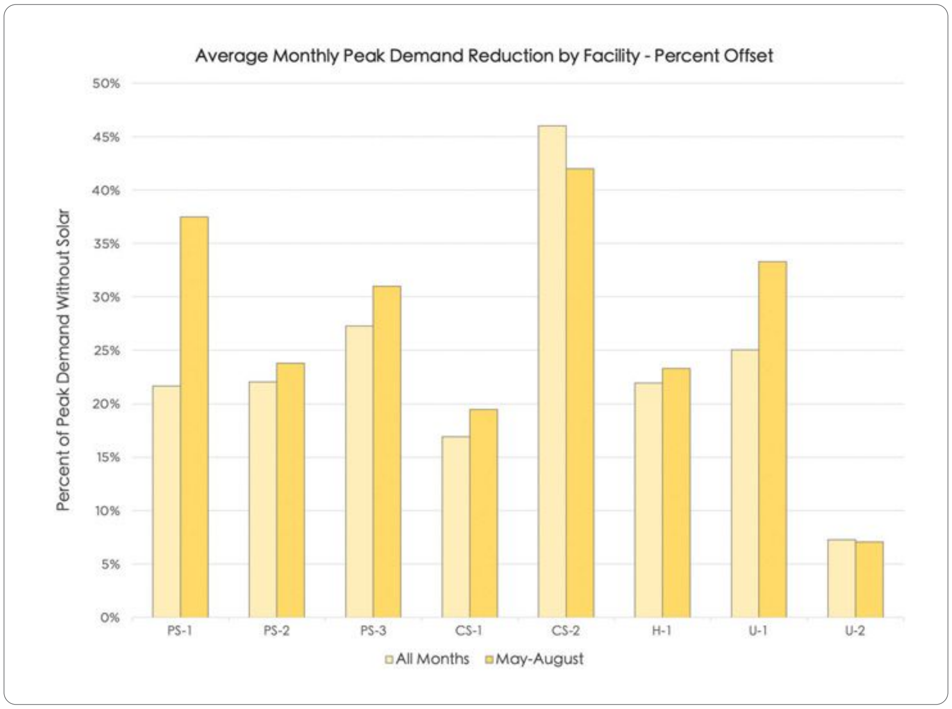
The consistency and reliability of these demand reductions benefits all stakeholders. Additionally, it should be noted that while this analysis only includes commercial customers, the net effect of residential, community and utility solar generation on the grid could theoretically be comparable.

Customer Peak-Demand Reduction. Peak-demand reduction by solar varied depending on the size of the array at each facility. These offsets averaged 25% of peak demand during the summer and 22% of peak demand annually across all facilities. The percent peak demand offset by facility is shown in Figure 1.

Our analysis found that solar-peak-demand reduction relative to peak-demand before solar is primarily driven

> *We are proud to highlight Shenandoah University's belief in and dedication to environmental stewardship. With this installation, Shenandoah demonstrates not only the power of solar energy, but also the power of people working together to create a better tomorrow.*
>
> – Tracy Fitzsimmons, Ph.D.
> President of Shenandoah University

Fig. 1: Average peak-demand reduction by solar at each of eight facilities, both for all months and only during May through August.



by the capacity of the array, which is often limited by available rooftop or land area.

This emphasizes the importance of implementing Resilient Solar Right-Sizing™ wherever possible, as is discussed later in this article. Additionally, variations in peak-demand reduction may also reflect occasional spikes in customer demand and occasional dips in solar production. However, these dips in coverage are not consistent enough to reduce the reliability of a properly right-sized system in predictably offsetting peak demand.

Customer Peak-Load Shifting. Solar facilities we examined saw significantly fewer demand peaks with solar during midday hours due to peak-load shifting. While this can vary due to system size and customer consumption, 85% of months analyzed saw a net positive shift in peak occurrence away from the afternoon. This means that customers experienced their peak demand on the grid much later in the day or earlier in the morning compared to when it would have occurred without solar in the vast majority of cases. Figure 2 shows this pattern for all facilities and Figure 3 shows an example time-of-day view of peak-demand reduction.

Customer Peak-Demand Reduction as a Percentage of Solar Nameplate Capacity. Nameplate capacity (kWp) is the theoretical maximum kilowatt output of a solar array in optimal conditions, representing the standard metric for the scale of a solar project. This comes into play when trying to quantify the performance of an array. While it is more tangible for customers to think of solar performance directly in terms of demand reduction they see, this does not account for varying system sizes. By dividing peak-demand-kW reduction by the nameplate capacity of

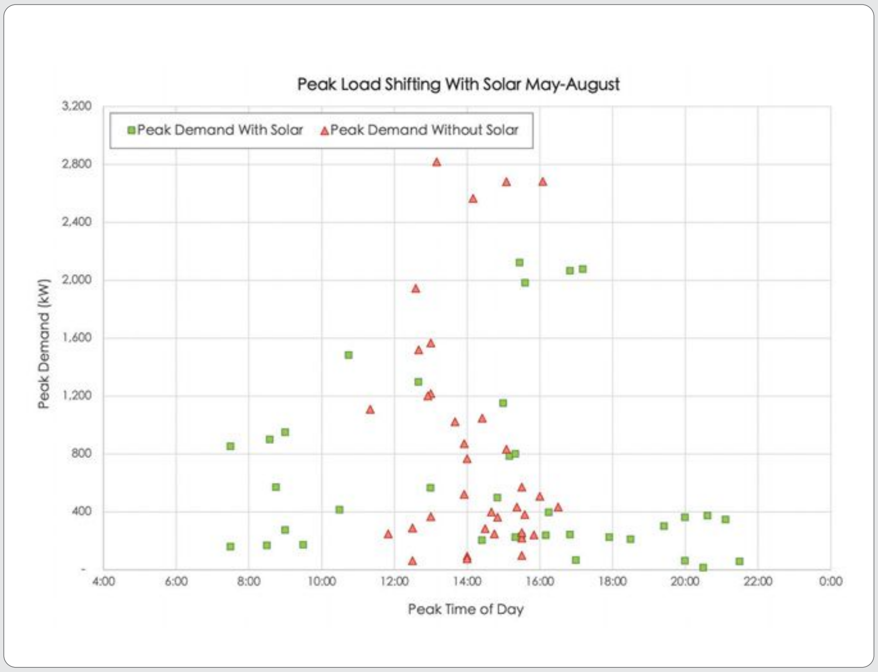
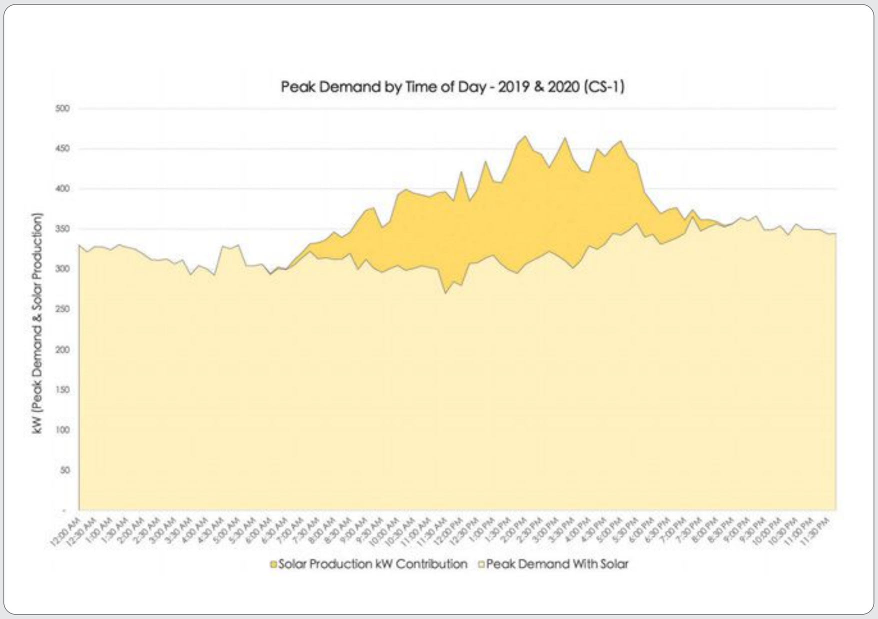


Fig. 2: Solar contributed to summer peak-load shifting from midday to mornings and evenings, primarily during weekdays. The points shown above represent monthly demand peaks for all facilities analyzed, including when they occurred. Summer months (May-August) are shown above, but similar patterns were found with annual peak-load shifting.

Fig. 3: Peak-demand reduction by time of day at a cold-storage facility (CS-1), representing the highest demand value at any 30-minute interval with and without solar during 2019 and 2020. Compared to what would have been a prominently day-peaking profile without solar, relatively level peak demand was maintained throughout the day with solar.



the array, we can control for this and derive a more objective measure of system performance, regardless of the overall scale of the project and limitations on system sizing. Figure 4 shows this for all eight facilities analyzed.

Solar peak-demand reduction as a percentage of kWp DC was greater in the summer months (43% on average) for all facilities than overall for the year (34% on average). This stands to reason given the higher expected output during summer months relative to the constant standard that is nameplate capacity.

Utility Coincident Peak-Demand Reduction. As with customer peak-demand reduction, average PJM coincident-demand reduction for the 5CP's varied by facility depending on system size. However, the average 5CP offset was consistently higher than that of monthly customer peak demand, ranging between 10% and 84% compared to between 7% and 46% respectively.

This is likely due to 5CP periods almost exclusively occurring during late afternoons in the summer when solar production is relatively high, whereas monthly peak demand could include winter months and can occasionally occur outside of peak solar-production hours. This pattern is shown by facility in Figure 5.

Utility Coincident Peak-Demand Reduction as a Percentage of Solar Nameplate Capacity. As with quantifying peak-demand reduction, the reliability of solar in reducing coincident peak demand for utilities is best represented as a percentage of nameplate capacity. 5CP demand reduction as a percentage of kWp DC ranged between 36% and 48% (averaging 44%), which is actually more consistent than the same metric for peak-demand reduction. This spread is shown in Figure 6 on the next page.

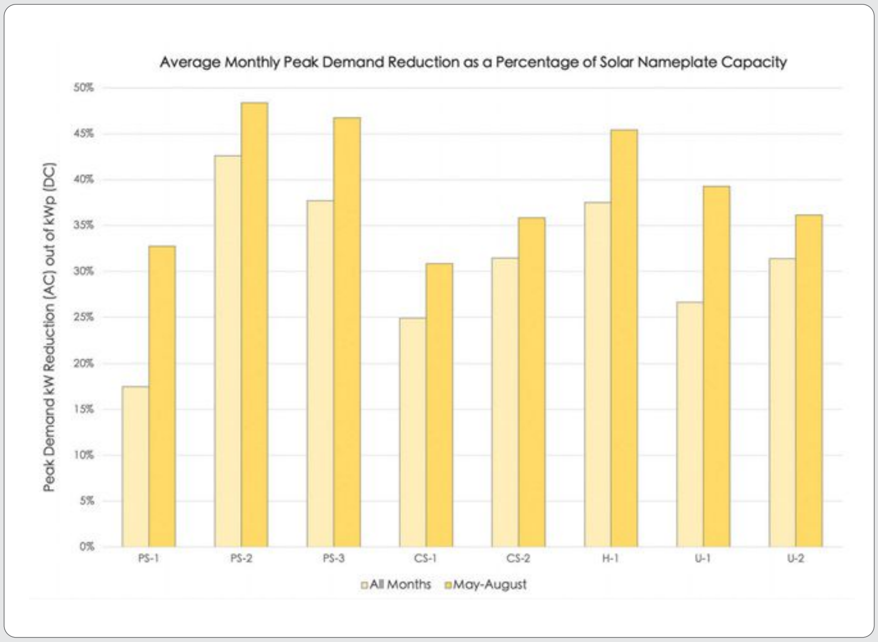
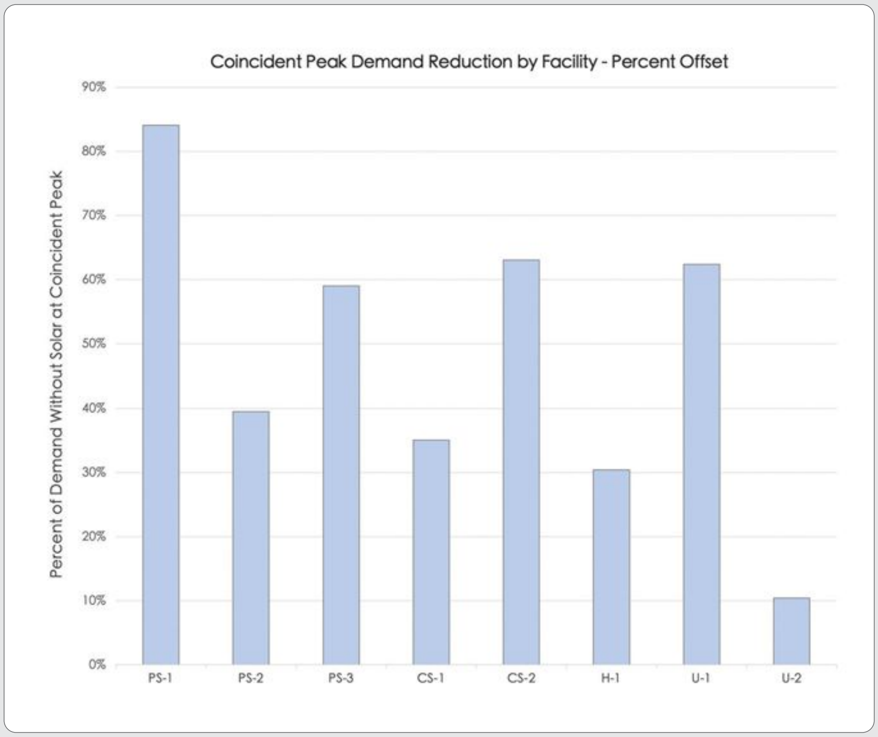


Fig. 4: Average monthly peak-demand reduction by solar (kW AC) as a percentage of system nameplate capacity (kWp DC) for all eight facilities. Demand reduction is averaged both across all months and only May through August, yielding the two different series shown above.

Fig. 5: Average demand reduction at coincident peak periods by solar at each of eight facilities.



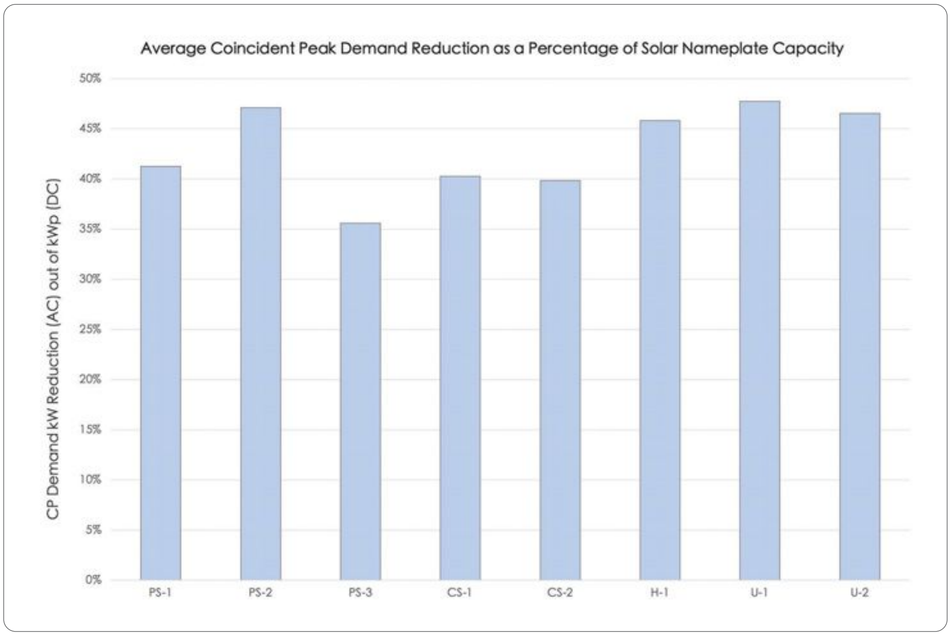


Fig. 6: Average coincident peak-demand reduction by solar (kW AC) as a percentage of solar-array nameplate capacity (kWp DC) for each of eight facilities.

This demonstrates that, given sufficient market saturation and interconnection with the grid, solar can consistently reduce coincident peak demand for energy utilities and alleviate overall strain on the grid. Given these findings, all ratepayers can benefit from solar as a result of their utilities saving on peak generation and grid upkeep, whether or not customers have solar on their roofs.

Implications for Solar Right-Sizing

For best results with peak-demand shaving by solar, facilities should be summer- and daytime- peaking. In the northern hemisphere (as all facilities analyzed are), we define summer-peaking as having the greatest monthly peak demand (before solar) between the months of May and August. Daytime-peaking is defined as having demand regularly peak between 11:00 AM and 4:00 PM with few to no demand spikes during off-production hours. All facilities reported in this analysis met these criteria.

Given that the average May-August demand offset out of kWp DC for the eight facilities analyzed is 43% (as shown in Figure 4), a realistic baseline of summer peak-demand reduction would equal at least 40% of kWp DC in most cases. This is on par with actual system performance and is used as the level of summer peak-demand reduction in Figures 7 and 8 below.

At minimum, arrays should ideally be sized such that solar can offset the difference between summer (May-August) and winter (November-February) pre-solar peak kW. This is because, even in a worst-case scenario of winter solar production, peak demand can expect to remain below pre-solar winter peak levels. This sizing is shown in Figure 7.

With larger systems, solar production can even shift the annual demand peaks to winter months as shown in Figure 8, depending on the prominence of summer pre-solar demand peaks.

In the cases of both Figures 7 and 8, the kW reduction equaled 40% of their nameplate capacities. Right-sizing for a 15% to 50% reduction of pre-solar peak demand falls between the lower range for project economies of scale and the higher limit for Virtual Solar Storage.

Ultimately, it is important to note that larger systems (especially those offsetting more than 100% of kWh annually) eventually see diminishing returns in terms of both peak-demand offset and financial savings. Since kW demand costs often represent the most valuable part of the electric bill, any additional solar generation that does not noticeably reduce peak demand represents a diminishing marginal return.

Policy Implications

Assertions about the supposed unreliability of solar in reducing demand are often proclaimed as fact by the fossil fuel industry electric power utilities, who retain an outsized influence on energy policy. However, dispelling this myth undercuts lobbying efforts that attempt to leverage historical misinformation and ambiguity on this issue.

As solar captures a larger share of the energy market, the grid must evolve to accommodate solar and other distributed renewables. This means a smarter, more-responsive grid and the widespread implementation of bidirectional metering. Under this system, residential and commercial customers can take full advantage of net metering while distributed solar can be dispatched onto micro- and macro-scale grids as needed.

Finally, regulations must be put in place to properly redistribute financial savings from demand reduction by solar (and a more efficient grid overall) that can be realized by utilities.[12] Unless required to do otherwise, investor owned utilities have more incentive to internalize these savings rather than pass them onto ratepayers, especially when they retain an effective monopoly on the market. Once the necessary infrastructure is in place, this is the most critical step in dispelling the myth that non-solar ratepayers subsidize solar customers.

Suggestions for Future Research

One important area of future research surrounds the mid- to long-term implications of solar development and its impact on grid-scale load shifting. At a certain point, solar may carve out the duck curve[13] beyond what the grid can handle. Is there a saturation point of solar's market share, assuming it is not paired with storage? What does solar fulfilling a "Virtual Solar Storage" niche look like for the grid as a whole?

Another topic of research could address the financial implications of stranding fossil fuel assets such as coal plants to adopt a more diversified grid made up of solar among other renewables. Considering environmental costs and the privatized ownership of fossil-fuel, it is quite possible that transitioning to renewables before fossil fuel assets have completed their lifecycles could still be more economically beneficial overall.

Future research into solar right-sizing is essential in building industry knowledge in how to design arrays to suit differing conditions. Customers with a wide variety of demand profiles can still benefit from solar, and long-term research can help to inform and to best adapt solar design to provide the most value for them and all stakeholders.

Lastly, public entities that issue requests for proposals for solar projects should give greater consideration to the benefits of peak-demand reduction. Currently, standard practice is to only consider savings from kWh usage offset and

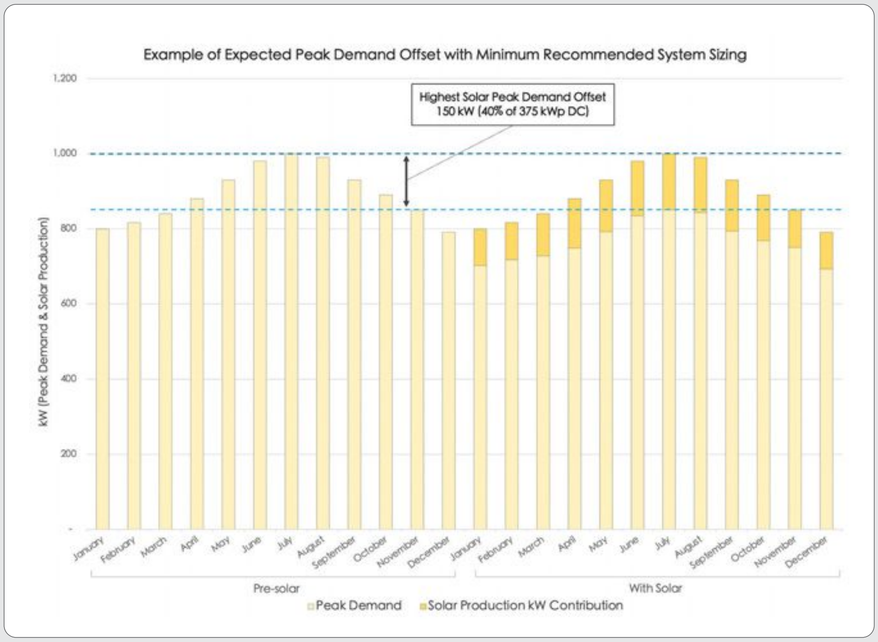
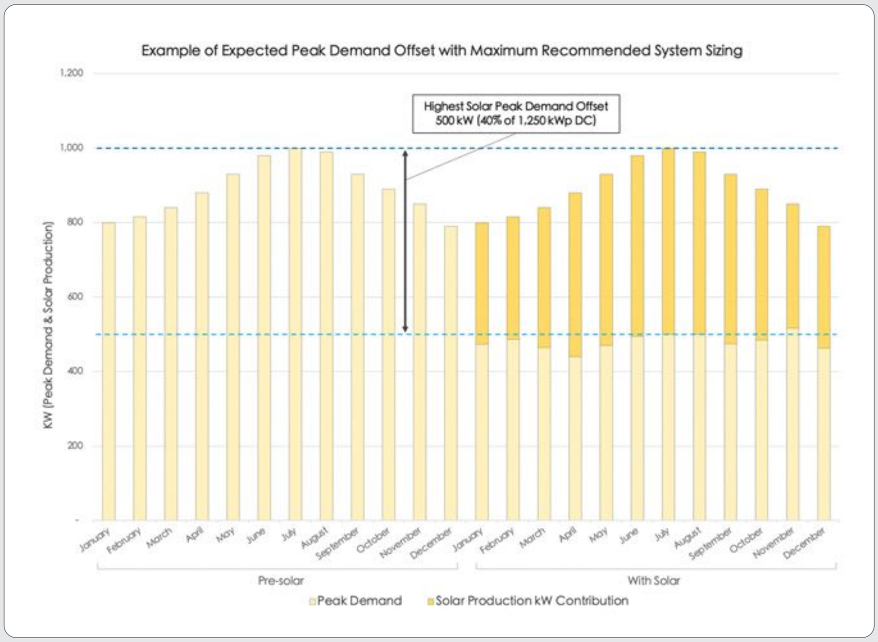


Fig. 7: This example chart shows the optimal recommended sizing, in which annual peak demand (still occurring May-August) is reduced to the levels of pre-solar winter peak demand (November-February). In this circumstance, a 500 kWp DC system achieves a 150 kW peak-demand reduction in summer months.

Fig. 8: This example chart, with the same demand profile as Figure 7, shows the maximum recommended sizing, where annual peak demand (shifted to November) is reduced enough to maintain relatively consistent peak demand throughout the year. In this circumstance, a 1,250 kWp DC system achieves a 500 kW peak-demand reduction in summer months.



> *We were at first amazed that Secure Futures recommended a solar array half the size as suggested by a competitor. The Secure Futures team advocated more solar savings, not more solar panels. Once we understood the right-sizing concept with regard to our energy and power usage patterns, it made perfect sense. We've been enjoying significant solar savings ever since as a result.*
>
> – Kevin Longenecker, CFO,
> InterChange Group, Inc.


© Secure Futures

University of Richmond solar array

assume that savings on demand charges will be negligible, but this analysis refutes that claim. ■

About the Authors

Andre Eanes serves as Project Coordinator for Secure Futures, LLC, a B-Corp certified commercial solar developer based in Virginia. He conducts technical analysis and market research with the goal of creating a more sustainable and equitable future. He received his B.S. in biology from the University of Richmond and is an Federal Aviation Administration-certified commercial drone pilot.

Anthony Smith, Ph.D., serves as President and Founder of Secure Futures, LLC. He brings over 40 years in developing and leading innovative solutions in energy efficiency and solar, with emphasis on creative financing to make energy more affordable for public-serving entities. In a previous life he traded oil futures to hedge energy costs for commercial customers. Now he applies those skill sets in hedging energy costs with solar. He received his Ph.D. from the Wharton School of Management at the University of Pennsylvania.

> *We first went solar with Secure Futures in 2018 and our board was so impressed with the savings that we completed a second stage of solar projects and roof restoration with them in 2021. The benefits also extend to the classroom, with the Secure Futures team bringing rooftop solar into the classroom with their innovative Throwing Solar Shade project-based learning program.*
>
> — Dr. Eric Bond, Superintendent,
> Augusta County Public Schools

Appendix

Facility labeling key:

PS = Public School

CS = Cold Storage Warehouse

H = Hospital

U = University

PS-1: Wilson Elementary School, Augusta County Public Schools

PS-2: Stuarts Draft Elementary School & Stuarts Draft High School, Augusta County Public Schools

PS-3: Fort Defiance High School & Clymore Elementary School, Augusta County Public Schools

CS-1: Port Services, Interchange Group

CS-2: cPad2, Interchange Group

H-1: Carilion New River Valley Medical Center

U-1: James R. Wilkins, Jr. Athletic and Events Center, Shenandoah University

U-2: Smith Library, Shenandoah University

Sources

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2 https://bit.ly/3Nl7wS1
3 https://bit.ly/3Jk8bAW
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