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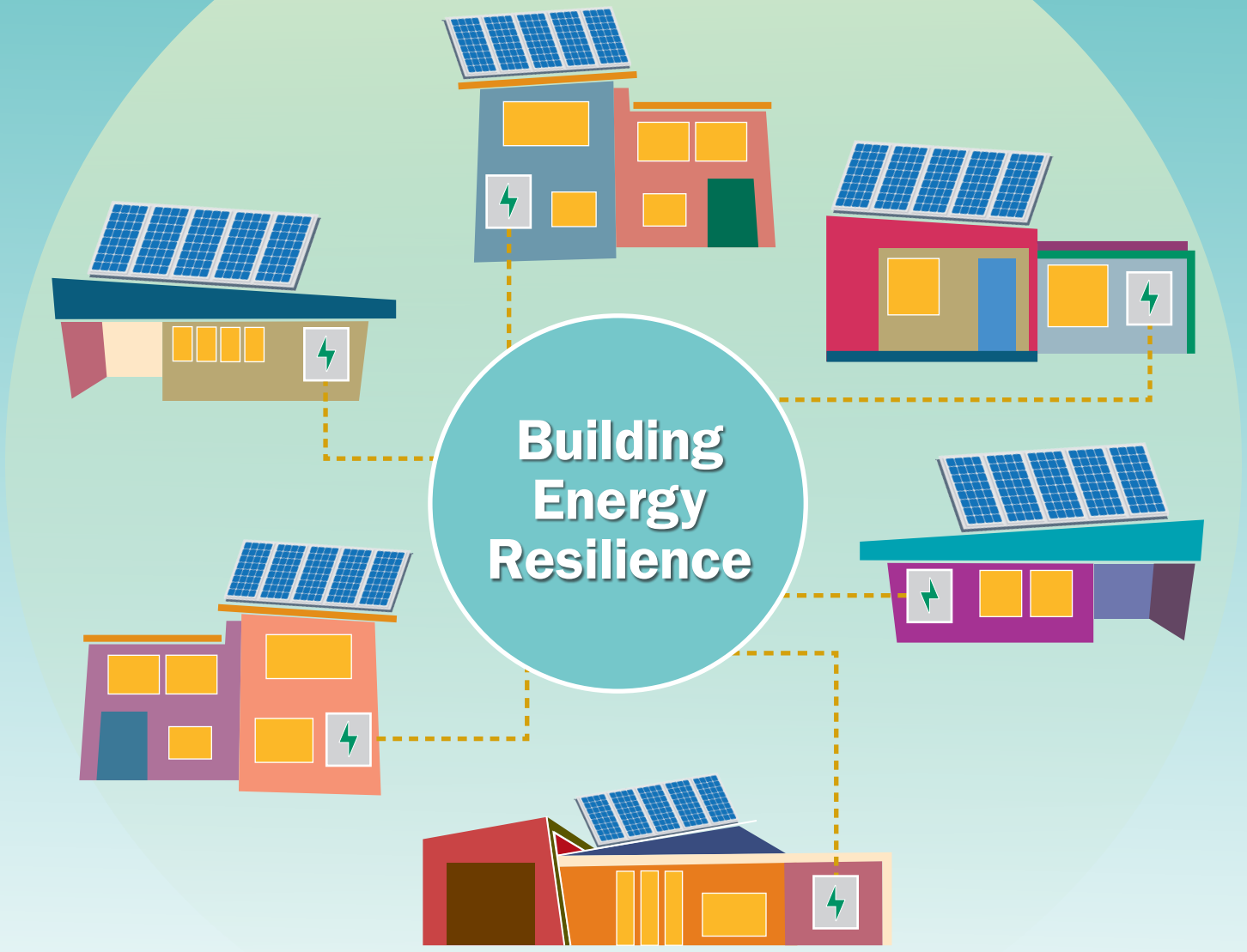
Lessons Learned from Puerto Rico's First Virtual Power Plant



CleanEnergyStatesAlliance

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About This Report

This report, prepared by the Clean Energy States Alliance (CESA), describes LUMA Energy's Customer Battery Energy Sharing (CBES) program, the first virtual power plant (VPP) program in Puerto Rico. This program provides a model for how distributed energy resources can be aggregated to enhance grid resilience, reduce peak demand, and deliver community-wide benefits. Customer-centered program design and collaborative efforts between the utility, program aggregators, and end users helped bring the CBES pilot to life and scale it into a model for resilient power. This case study highlights PowerOn Puerto Rico, which is Sunrun's CBES program. Report author Hanna Jones previously worked for Sunrun as a Senior Program Manager and played a key role in launching and managing PowerOn Puerto Rico. The information presented in this case study reflects her direct experiences. It is important to note that while core program guidelines are set by regulators and LUMA, each aggregator participating in CBES has flexibility in how they operate and manage their customer experience, outreach, payment, and technical delivery.

Acknowledgements

The author would like to thank the teams at Sunrun, Telsa, and LUMA Energy for their leadership in launching Puerto Rico's first VPP and for contributing to this report by sharing program data, operational insights, and lessons learned from the CBES program and PowerOn Puerto Rico.

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Introduction

IN THE FACE OF PERSISTENT POWER OUTAGES AND A FRAGILE ELECTRICAL GRID, Puerto Rico launched its first-ever virtual power plant (VPP) program in November 2023. The Customer Battery Energy Sharing (CBES) program is administered by LUMA Energy, a private power distribution and transmission company. The CBES program is structured to leverage residential and commercial solar and battery systems to stabilize the grid while rewarding participants for contributing stored energy during periods of peak electricity demand.[1]

This case study explores how customer-centered program design and collaborative efforts between the utility, program aggregators, and end users helped bring the CBES pilot to life and scale it into a model for resilient power. PowerOn Puerto Rico, Sunrun's CBES program, is highlighted as a highly successful and scalable VPP program model. The case study outlines actionable strategies including coordinated outreach, thoughtful program design, and a feedback loop that continuously improves customer experience.

What is a Virtual Power Plant?

A VPP aggregates distributed energy resources (DERs) like customer-sited solar+storage systems and coordinates those resources in a way that provides reliable and sustainable power to the grid when demand is high. Through Distributed Energy Resource Management (DERM) software, a VPP can connect, monitor, and control DERs so they can operate together as a single, coordinated system. By aggregating thousands of individual devices into a unified platform, DERMs allow grid operators to see real-time performance, forecast energy production and demand, and send commands, such as when to charge or discharge batteries. In simple terms, a VPP stores energy from DERs when it is plentiful and delivers it back to the grid when it is most needed.

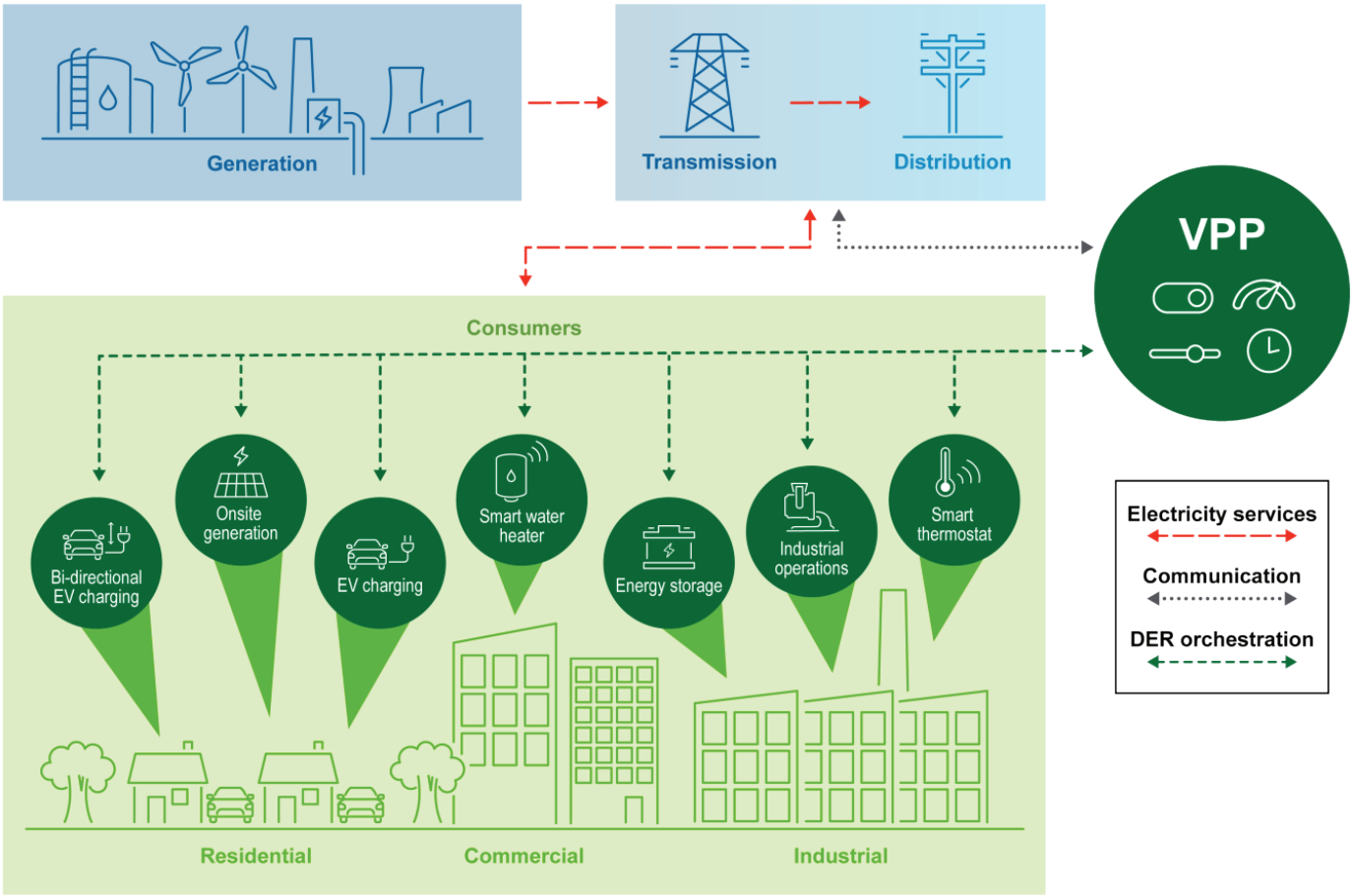
The benefits of a VPP include enhanced grid stability, cost savings, and improved resilience. By coordinating distributed resources, VPPs can reduce electricity demand during peak periods, increase supply power when the grid is strained, and minimize reliance on expensive and polluting fossil fuel plants. For customers participating in VPP programs,

1 Source: "Virtual Power Plants Projects," U.S. Department of Energy Loan Programs Office, accessed January 2026, www.energy.gov/edf/virtual-power-plants-projects.

this can provide lower energy costs, backup power during outages, and opportunities to participate directly in the energy transition. For utilities and grid operators, VPPs provide a cost-effective way to manage supply and demand, integrate more renewable energy onto the grid, and defer or avoid expensive investments in traditional energy infrastructure. Through the integration of solar+storage and advanced DERM software, VPPs transform distributed resources into a scalable solution that directly addresses the urgent challenge of extreme load growth.

Figure 1 illustrates how a VPP coordinates various distributed energy resources—such as EV charging, onsite generation, energy storage, smart appliances, and industrial operations—across residential, commercial, and industrial consumers to interact with the traditional electricity system of generation, transmission, and distribution.

Figure 1: **How Virtual Power Plants Integrate Distributed Energy Resources into the Electric Grid**



Source: "Virtual Power Plants Projects," U.S. Department of Energy Loan Programs Office, accessed January 2026, www.energy.gov/edf/virtual-power-plants-projects.

A Brief History of Puerto Rico's Energy Landscape

Puerto Rico's electric grid has long struggled with reliability, grappling with the compounded effects of extreme weather events like Hurricane Maria in 2017 and systemic issues within its aging infrastructure. According to LUMA's *2025 Resource Adequacy Repor*t, only 53 percent of the island's total generation capacity is expected to be available at any given time, due to scheduled maintenance and forced outages from failing or damaged equipment. A lack of proper maintenance has left many power plants unable to meet demand during peak periods, and some aging units are so degraded that they can produce only a fraction of their intended output.[2] As a result, LUMA estimated there would be 36 days between July 2024 and June 2025 when electricity service will be interrupted due to insufficient generation. This is 362 times higher than the industry planning standard of one day in 10 years.

In response to these persistent challenges, residents across Puerto Rico have increasingly embraced rooftop solar and battery storage (solar+storage) as a more reliable alternative to the centralized grid. This shift has not only empowered customers to take control of their energy needs, but it has also reshaped the island's energy landscape. LUMA currently connects approximately 3,650 customers to rooftop solar each month and has helped connect over 118,000 solar customers to date, contributing more than 860 megawatts (MW) of renewable energy to the grid.[3] This rapid growth has propelled Puerto Rico to rank fifth in solar adoption per capita among all US states and territories.[4] Today, solar+storage is no longer a niche solution; it has become a standard, decentralized approach to energy resilience.

In 2019, two years after Hurricane Maria dismantled the island's electric grid, the Puerto Rico Legislature passed the Energy Public Policy Act to establish parameters for a forward-looking energy system that maximizes distributed generation. The Puerto Rico Energy Bureau (PREB) determined that VPPs are critical to achieving the goals of the Energy Public Policy Act by increasing the supply of energy during peak demand periods, improving day-to-day service reliability, minimizing the impacts of potential load shedding, and supporting resilient, renewable energy systems.

2 "Press Release - New Resource Adequacy Report: Lack of Reliable Power Supply From Generators Will Pose Ongoing Threat to Service," LUMA Energy, October 31, 2024, https://lumapr.com/news/new-resource-adequacy-report-lack-of-reliable-power-supply-from-generators-will-pose-ongoing-threat-to-service-reliability-in-2025/?lang=en.

3 Ibid.

4 "Puerto Rico Territory Energy Profile," U.S. Energy Information Administration, accessed July 2025, www.eia.gov/states/RQ/overview.

To enable the deployment of VPPs at scale, significant policy groundwork was laid in Puerto Rico. In 2022, PREB approved the first-ever tariffs for VPP participation under the CBES program. These regulations established the framework for enrolling solar+storage systems in aggregated programs, setting eligibility criteria, compensation mechanisms, and technical requirements for program participation. The PREB also required transparent reporting and consumer protections to ensure fair participation and benefits to customers. Without clear and supportive regulations, coordination between utilities, aggregators, and customers would have been far more difficult, if not impossible.

LUMA's Customer Battery Energy Sharing Program

In November 2023, LUMA launched a groundbreaking demand response initiative—the Customer Battery Energy Sharing (CBES) program—designed to address persistent reliability challenges across Puerto Rico. CBES compensates residential and commercial customers with solar+storage systems that support the electric grid by discharging stored energy during times of peak energy demand or generation shortfalls, otherwise known as a "grid event." CBES is part of LUMA's broader "Building a Better Energy Future" strategy, aimed at improving reliability, customer service, and community resilience.

When LUMA forecasts that a grid event will take place and energy demand will not meet energy supply, participating CBES systems are activated in a coordinated dispatch. Electricity from customers' batteries is automatically discharged during the grid event, first to the customer's home or business and then to the grid, helping to stabilize electrical supply and prevent grid-wide power outages.

Customers who participate in the CBES program receive compensation through their aggregator, the company from which they purchased their solar+storage system or with whom they have a third-party ownership agreement. Aggregators manage and coordinate groups of customer-sited battery systems, enabling them to participate in the VPP as a single, reliable energy resource. LUMA pays each aggregator $1.25 per kilowatt-hour (kWh), and each aggregator can individually determine what price they will pay their enrolled and participating customers.

LUMA has partnered with several leading aggregators to implement the CBES program and enroll eligible customers, including Fortress Power, Sonnen, Sunrun, Sunnova,[5] Tesla, and Virtual Peaker. These aggregators manage enrollment, notify customers of upcoming events, and coordinate the seamless export of energy from distributed batteries.

By August 2024, just nine months after its launch, 5,726 customers had enrolled in the CBES program and participated in 53 grid events. The program's strong performance prompted PREB to approve its transition from a pilot to a permanent offering by the end of 2024. This marked a major milestone in the island's energy transformation, positioning solar+storage as a critical resource for day-to-day grid support.

The Customer Battery Energy Sharing program represents a next-generation approach to grid reliability. As Puerto Rico continues to face frequent generation shortfalls, often driven by aging infrastructure and insufficient generation capacity, programs like CBES will play a key role in reducing outages, integrating renewable energy, and empowering customers to be part of the solution.

VPP Aggregator: Sunrun

Sunrun Inc. is a residential solar and battery storage company that provides energy, often through a subscription-based model. Founded in 2007, Sunrun offers solar and battery storage systems to households across the United States and Puerto Rico. The company also participates in grid services programs like CBES by aggregating distributed energy resources and coordinating their use to support electric grid reliability.

Sunrun began working in Puerto Rico in 2018 and launched PowerOn Puerto Rico (their customer-facing name for the CBES program) in the fall of 2023. They partnered with local installers to train their workforce and spent time connecting with the team at LUMA to launch the CBES demand response program. Sunrun worked closely with internal teams to ensure they were launching a program that would benefit both Puerto Ricans and the company. After extensive internal and external coordination, Sunrun began the work to educate and enroll customers.

5 Sunnova Energy International Inc. filed for Chapter 11 bankruptcy protection in 2025. As part of the court-approved restructuring process, substantially all of Sunnova's residential solar and battery assets were acquired by entities affiliated with GoodFinch Management, with SunStrong Management, LLC assuming responsibility for servicing and operations of the legacy portfolio. Sunnova is no longer an active aggregator. Participation of the former Sunnova fleet in the CBES program has been paused pending regulatory approval and certification of the successor operator, and the fleet is not currently dispatching under CBES.

Enrollment: Make It Easy and Help Customers Along the Way

Sunrun understood that it was critical to demonstrate the value of CBES in a way that resonated with its customers. From the outset, Sunrun deployed a customer-centered enrollment strategy that focused on showing how the program would benefit both individual households and Puerto Rico as a whole. Email campaigns targeted eligible customers in their preferred language, highlighting the program incentives, community benefits, and environmental impacts. With education in mind, Sunrun invested in its local installation partners by training thousands of sales representatives from the island's leading solar companies on VPPs, the CBES program, and the impacts on their customers if they chose to enroll.

As enrollment efforts began, Sunrun launched a Spanish-first customer support team, offering phone and email assistance five days a week and proactively reached out to guide customers through the enrollment process. They also produced step-by-step videos in both English and Spanish to explain enrollment from start to finish.

Soon after launching the program, Sunrun identified a common enrollment barrier: inputting utility account details correctly. LUMA required customers to enter their address, account number, and ID localidad during the application process. An incorrect ID localidad, an obscure municipal code identifier that is unfamiliar to most customers, often led to rejected applications. Sunrun responded by creating tailored resources and direct outreach campaigns to help customers re-enroll successfully. Through a direct partnership with Tesla, Sunrun was able to pre-populate customer information during enrollment, reducing data entry errors and application rejections over time. Customer concerns were typically resolved through direct follow up by the program manager or customer care team members. These one-on-one interactions provided both technical support and insight into common customer experience issues, which informed updates to communication strategies and support materials.

Customer Payments: Build Trust and Prove Value

One of the major selling points of the CBES program is that customers get paid for participating. However, with VPPs being a new concept and at times sounding too good to be true, Sunrun knew clarity and transparency around payments were key to building trust in the program. Sunrun chose to return 80 percent of program revenue to participants and made payment disbursement a top priority by paying out rewards in the form of Visa

gift cards to customers every six months. This timeframe was determined to ensure that customers who participated in events received a reward that felt meaningful.

Participants in Sunrun's PowerOn Puerto Rico program earn $1.00/kWh during grid events. Sunrun wanted to make it easy for customers to understand how energy stored in batteries could turn into dollars earned. Table 1 shows that customers can earn more rewards when they set a lower backup power reserve percentage for their home, and when LUMA calls more grid events.

Table 1: **PowerOn Puerto Rico Participant Earnings Table**

Backup Reserve†	Total Estimated Earnings (75 Events)	Total Estimated Earnings (125 Events)
20%	$750	$1,200
30%	$650	$1,100
40%	$550	$930
50%	$450	$750
60%	$350	$580

Source: Image from Sunrun's "Power On Puerto Rico" website (www.sunrun.com/poweron-puerto-rico), accessed January 2025; page since updated and image no longer available.

As an example, if a customer selected a backup reserve of 40 percent for themselves during grid events, their Powerwall battery would discharge the remaining 60 percent of stored energy. By discharging 7.4 kWh of stored energy during a single grid event, a customer could earn $7.40. At this rate, 75 grid events could earn a PowerOn Puerto Rico participant $550, and 125 grid events could earn them $930.

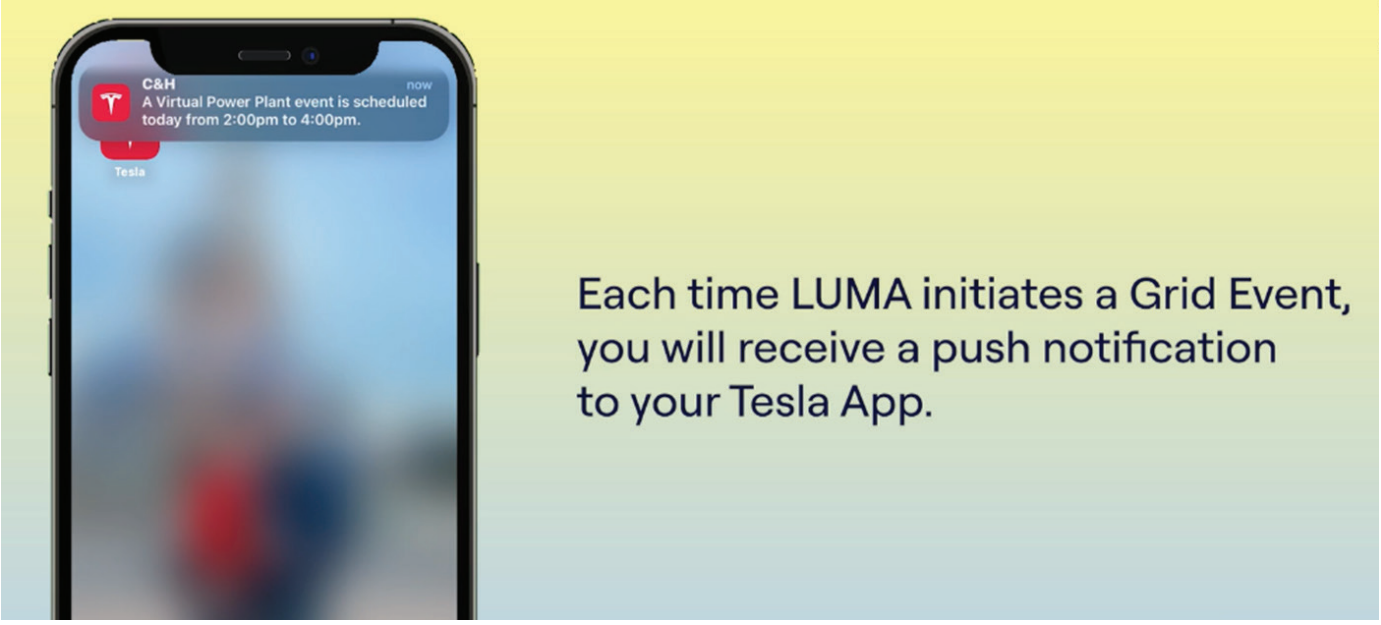
Sunrun became the first major aggregator in Puerto Rico to issue customer payments. This early delivery of tangible value proved critical in reinforcing the legitimacy of the program, with some participants earning over $300 in just six months. Customer feedback was consistently collected through Customer Care interactions and the dedicated Grid Services inbox and regularly reviewed to identify common themes and opportunities for improving the payment experience. Trends observed included a strong interest in having the option to apply earnings toward Sunrun bills instead of receiving Visa gift cards. In response, Sunrun began evaluating alternative disbursement methods to accommodate this preference and improve the overall customer experience.

Customer Communication: Empowering Choice in Grid Events

When LUMA forecasts that energy supply will not meet energy demand, they notify CBES aggregators of an upcoming grid event by providing the date, time, and duration. From there, aggregators schedule the dispatch of electricity from their enrolled fleet, and enrolled customers receive a notification that a grid event has been scheduled.

The Sunrun customer experience, illustrated in Figures 2–4, was designed by asking important questions about customer preferences, including communication practices, notifications, settings, and opt-out features.

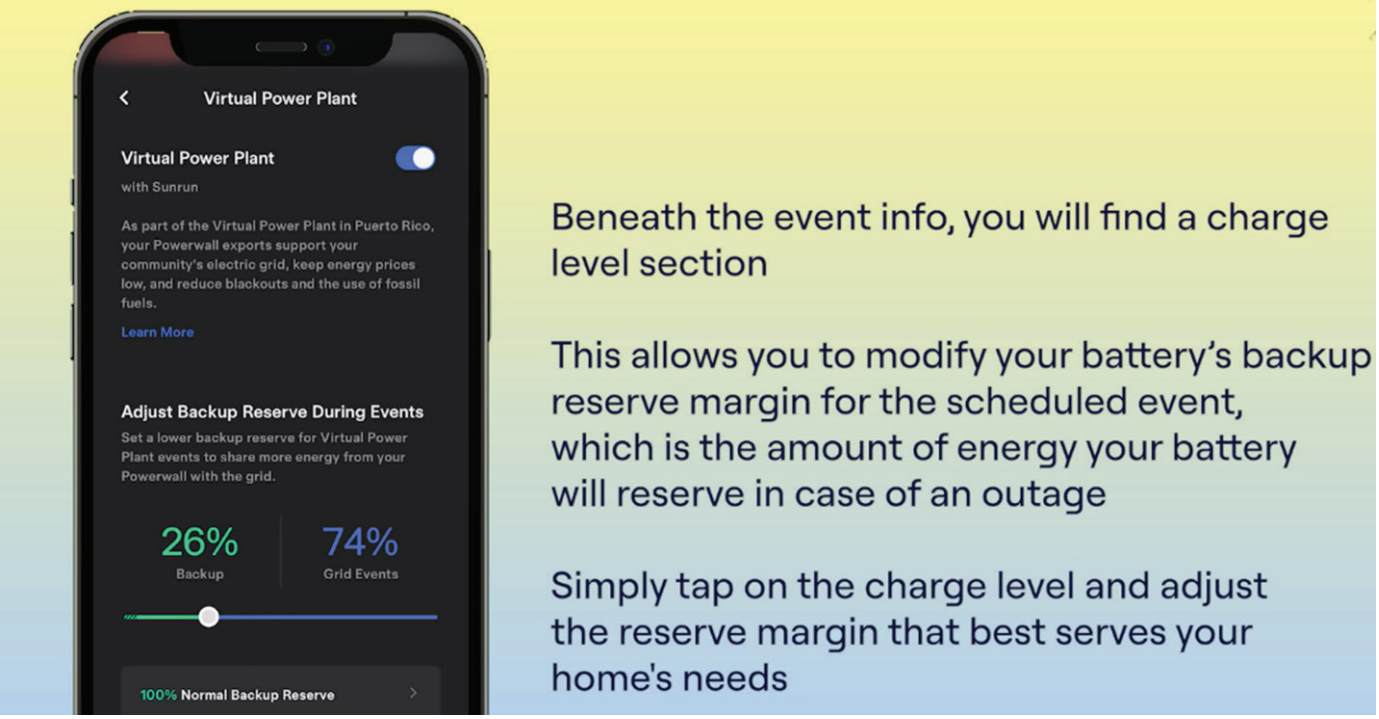
Figure 2: **Example of a Grid Event Notification to Sunrun Customers Enrolled in the CBES Program**



Source: Image from Sunrun's "Power On Puerto Rico" website (www.sunrun.com/poweron-puerto-rico), accessed January 2025; page since updated and image no longer available.

Sunrun wanted to embrace the notification capabilities that the Tesla application offered. By notifying customers on the day of a grid event on the app, customers can decide whether or not to participate, and they can adjust their reserve margin. Due to the aforementioned grid reliability issues in Puerto Rico, customers are particularly sensitive to backup battery reserve margins. It was important to allow customers to easily toggle reserve percentages in real time as they learned about and experienced the VPP program. This empowered customers to make decisions based on what was best for their home and allowed them to fully control their VPP settings.

Figure 3: **Example of How Sunrun's CBES Participants Can Adjust Their Backup Reserve Margin Prior to Grid Events Via the App**

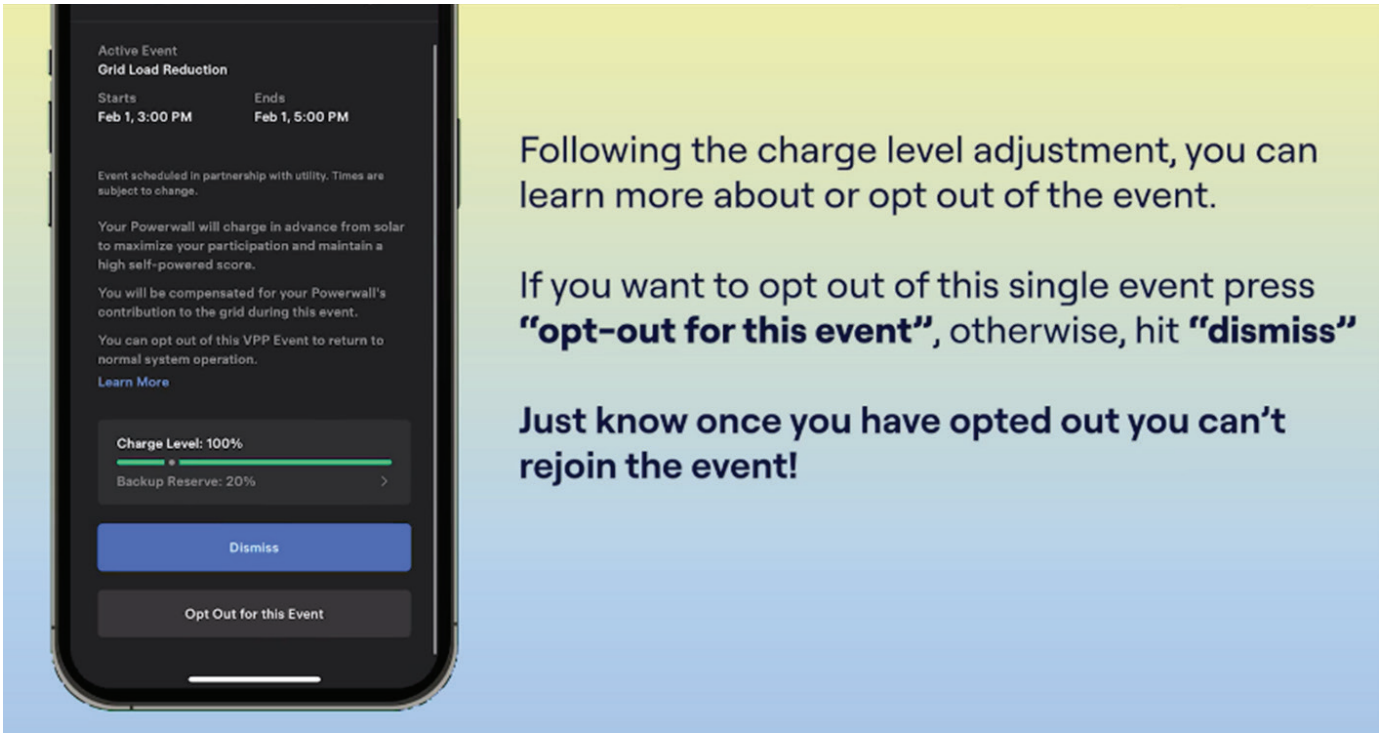


Source: Image from Sunrun's "Power On Puerto Rico" website (www.sunrun.com/poweron-puerto-rico), accessed July 2025; page since updated and image no longer available.

The system allows customers either to set their reserve margin for each specific grid event or to "set it and forget it." Sunrun recommended a 40 percent reserve on the island, because it would provide a few hours of backup if a power outage occurred directly after the grid event concluded and the sun was not out to recharge the solar+storage system. Participants also had the option to opt out of individual events. The flexibility and control of customer reserve margins, and opt-out features, even after enrollment has been approved, is critical for customers in Puerto Rico. Participants are able to build trust gradually as they become more familiar with how the program operates.

Sunrun's approach was grounded in continuous listening and responsiveness to customer feedback. For instance, customer feedback consistently emphasized a desire for more transparency around energy performance, especially how much energy was exported during individual grid events. In response, Sunrun increased its outreach cadence and began providing customers with more regular updates on their event participation and performance through email communications. By consistently integrating customer feedback into program design and communications, Sunrun strengthened participant trust and improved the overall user experience resulting in stable participation metrics, including no observed increase in opt-out rates and no significant customer-driven changes to backup reserve margin settings across the fleet.

Figure 4: **Example of How Sunrun's CBES Participants Can Easily Opt Out of Individual Grid Events**



Source: Image from Sunrun's "Power On Puerto Rico" website (www.sunrun.com/poweron-puerto-rico), accessed July 2025; page since updated and image no longer available.

From Interest to Trust: Scaling Up the VPP Program

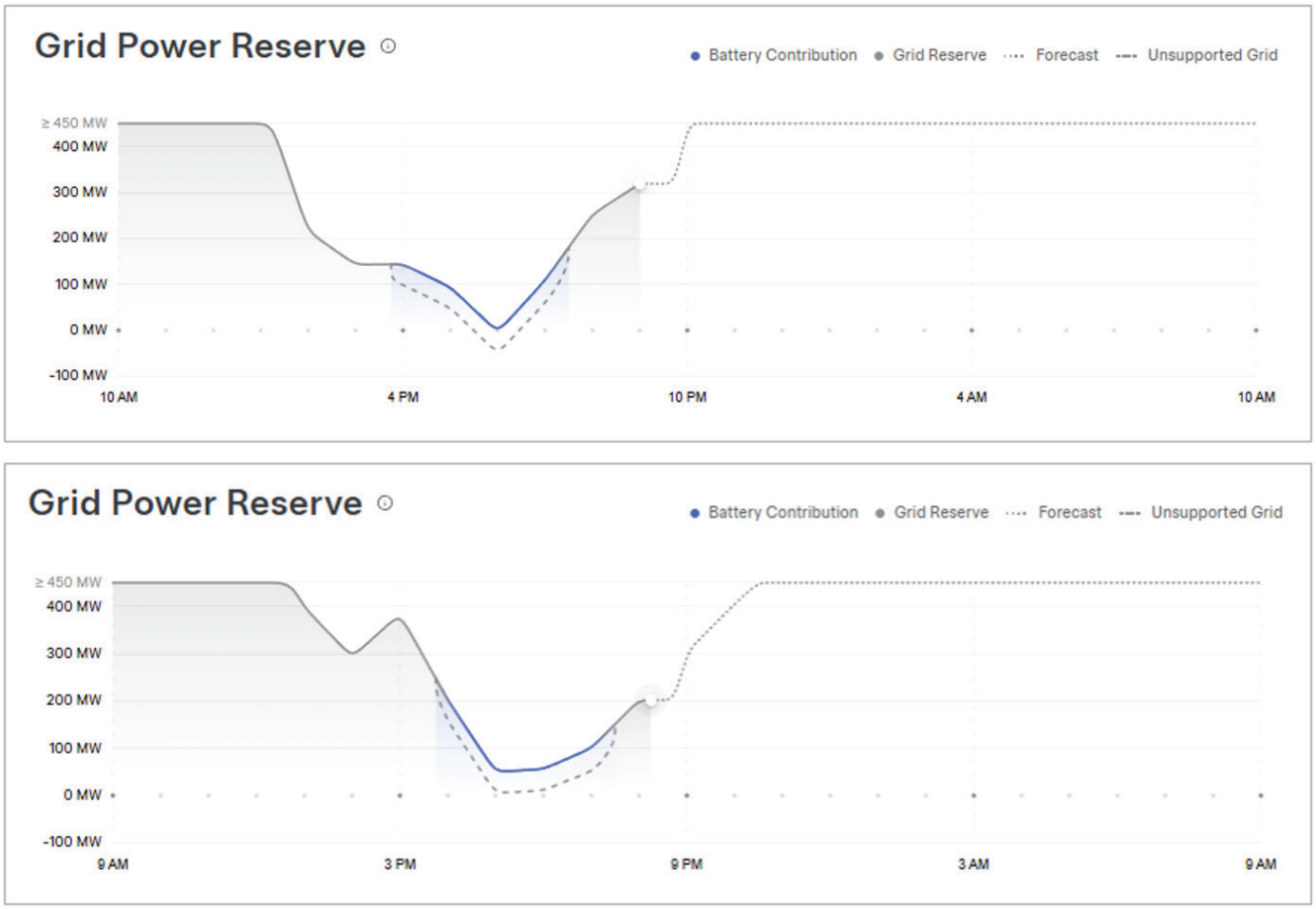
Participation in the CBES program grew because it was designed with the customer at the center. Key touchpoints build trust, from enrollment support and transparent communication to timely payouts. Participants felt empowered, valued, and connected to a larger purpose. As of May 2025, the CBES program had 11,157 customers enrolled.[6]

In the summer of 2025, Sunrun began implementing an auto-enrollment strategy, working with the government of Puerto Rico to expand the program in response to the anticipated summer energy emergencies. In early July 2025, LUMA successfully deployed 70,000 batteries contributing 48 MW during a single grid event, in partnership with the other aggregators in the program.[7]

6 Interview with LUMA's Energy Programs Director, May 12, 2025.

The summer of 2025 became a proving ground for Puerto Rico's first VPP. Amid emergency conditions driven by extreme heat and power generation shortfalls, Sunrun began dispatching more than 37,000 home batteries to provide emergency power to Puerto Rico's grid.[8] The combined efforts of Sunrun and other aggregators provided enough power to overcome substantial generation shortfalls, preventing rolling blackouts and extending electricity service to communities across the island. As LUMA publicly stated, "This collaboration helped address a generation shortfall of nearly 50 MW, assisting in preventing multiple load shedding events and keeping the lights on longer in many communities around the island."[9]

Figure 5: **Screenshots from a Live Feed on the Tesla Puerto Rico Virtual Power Plant Dashboard Show How Customer-Sited Powerwalls Consistently Helped to Meet Afternoon Peak Demand in Summer 2025**



Source: "Puerto Rico Virtual Power Plant Dashboard," Tesla, accessed July 2025, www.tesla.com/puerto-rico.

7 LUMA Puerto Rico (@lumaenergypr), "Celebramos un gran logro energético …" X, July 9, 2025, https://x.com/lumaenergypr/status/1943040048451981380.

8 "Sunrun Dispatches Emergency Power to Help Prevent Grid Blackouts During Energy Shortages," Sunrun, July 21, 2025, https://investors.sunrun.com/news-events/press-releases/detail/347/sunrun-dispatches-emergency-power-to-help-prevent-grid.

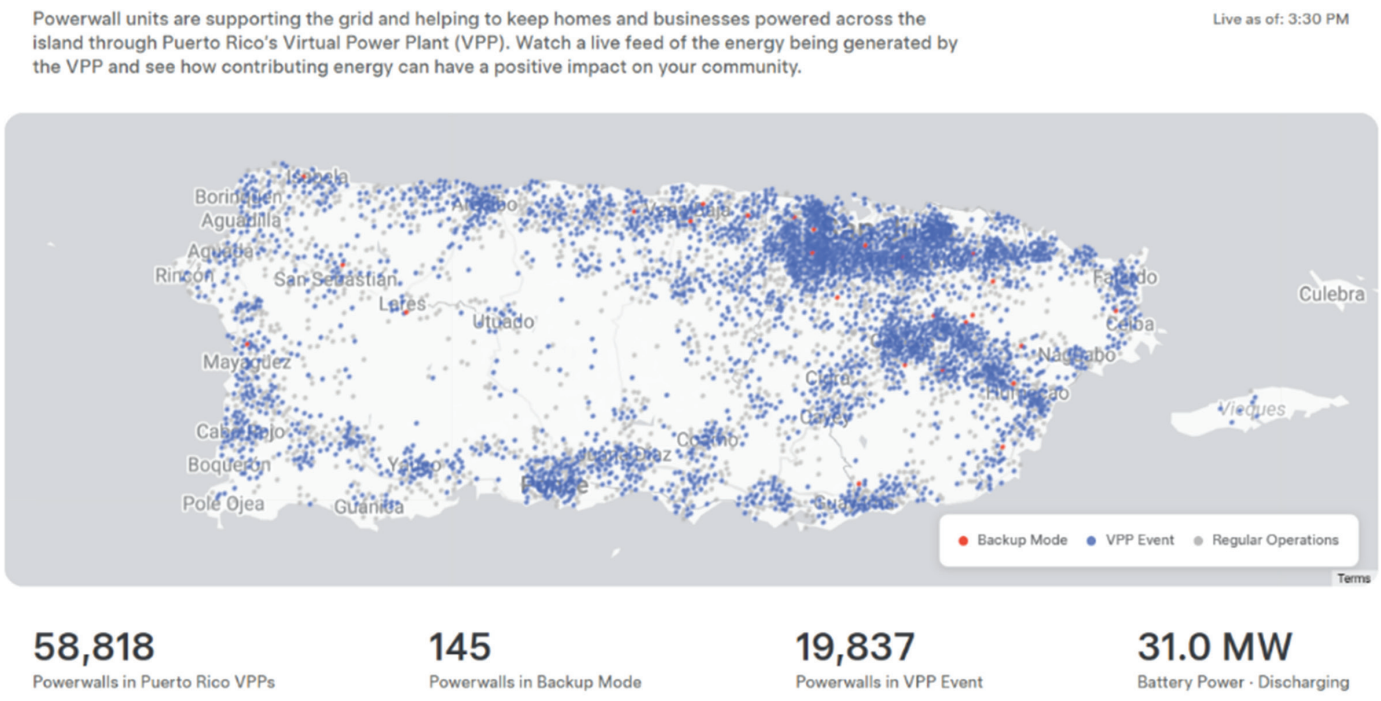
9 LUMA Puerto Rico (@lumaenergypr), "Celebramos un gran logro energético …" X, July 9, 2025, https://x.com/lumaenergypr/status/1943040048451981380.

Data from Tesla's Virtual Power Plant Dashboard, shown on Figure 5, illustrates how the VPP was consistently deployed around the same time each day to meet peak demand and help prevent load shedding events that would otherwise result in outages for Puerto Ricans. The graphs show a repeatable and reliable pattern of dispatch, reinforcing the value of this model in supporting grid operations during times of high stress. Puerto Rico's first VPP thus demonstrates how customer-sited batteries can collectively function like a traditional power plant, providing on-demand energy exactly when the grid needs it most.

Looking Ahead: The Role of Community in Grid Resilience

A resilient grid in Puerto Rico depends not only on technical innovation but also on community participation. Programs like CBES demonstrate that VPP customers are willing to share their stored energy when they understand the value and feel confident in the process. By prioritizing customer engagement alongside system performance, the CBES program has shown that VPPs can deliver meaningful grid support while empowering individual households.

Figure 6: **Screenshot from a Live Feed on Puerto Rico's Virtual Power Plant Dashboard Showing How Customer-Sited Powerwall Batteries Contributed Power to the Grid During a Period of High Demand in Summer 2025**



Source: "Puerto Rico Virtual Power Plant Dashboard," Tesla, accessed August 2025, www.tesla.com/puerto-rico.

Figure 6 is a screenshot from Tesla's Virtual Power Plant Dashboard showing a live feed of the energy being generated by Powerwall units participating in Puerto Rico's VPP. This screenshot was taken during a VPP event during the summer of 2025, when almost twenty thousand customer-sited Powerwall units contributed 31 MW of power to the grid during a period of high energy demand.

The path forward must remain collaborative. Stakeholder alignment, ecosystem partnerships, and clear communication will continue to be essential. As Puerto Rico moves toward a cleaner, more distributed grid, customer-driven VPP programs like CBES offer a scalable solution rooted in value, resilience, and mutual benefit.

Key Strategies for Success: Moving the CBES Model to Other Markets

The CBES model should be considered a template for future VPP deployments, not only in Puerto Rico, but in other markets seeking to balance grid reliability with distributed, customer-centered solutions. Outlined below are the intentional design features that made PowerOn Puerto Rico a success.

Proactive Marketing & Community Trust

- ✔ Email campaigns announcing the program were personalized to highlight different motivators: financial gain, environmental impact, and community resilience.
- ✔ Local sales partners were trained to promote the post-sale program, building on trusted customer relationships.
- ✔ A local public relations firm reviewed all marketing campaign materials for cultural and linguistic relevance.

Customer Education & Enrollment Support

- ✔ A dedicated customer care team provided support by phone and email five days a week to assist customers with questions and to provide information.
- ✔ Bilingual videos and how-to guides walked customers through the program's nrollment process.
- ✔ Direct outreach campaigns helped resolve enrollment issues, especially those related to LUMA's ID localidad.

Incentive Design & Financial Transparency

- ✔ Sunrun chose to issue 80 percent of grid event revenue to participants.
- ✔ Clear resources, including earning tables, helped customers make informed choices about the reserve settings on their batteries.
- ✔ Customers who enrolled early and set a lower reserve margin on their batteries earned more rewards for program participation.
- ✔ Sunrun issued grid event payments twice a year, reinforcing the value of participation in the program.

Customer Experience & Engagement

- ✔ Participants could opt out of events or adjust reserve margins for their batteries at any time.
- ✔ Regular communication kept program customers informed about events and payment timing.
- ✔ Sunrun chose to send notifications to its customers every time an event occurred. (Not all aggregators in CBES did this.)
- ✔ Direct customer care support provided solutions quickly.

VPP Design & Rapid Dispatch Capabilities

- ✔ Batteries were aggregated through a cloud-based platform, enabling near-instantaneous dispatch.
- ✔ Customers maintained control of their batteries while still allowing Sunrun to provide LUMA with a flexible, fast-responding energy resource.
- ✔ Batteries offered a quick-to-deploy, and efficient alternative to traditional fossil fuel plants.

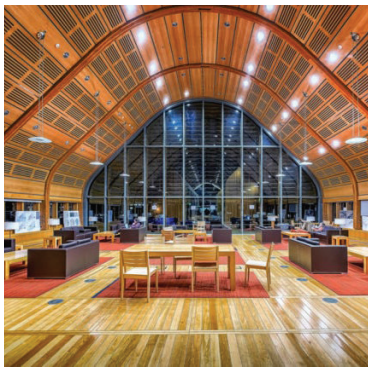












Row 1 (L-R): CESA; Resonant Energy; CESA; Bigstockphoto/DavidM199. Row 2 (L-R): Portland General Electric; CESA; Murray Carpenter/Maine Public.
Row 3 (L-R): Orsted (US Offshore Wind; CESA; Solara/California Energy Commission; iStockphoto/Fotomax. Row 4 (L-R): Tom Piorkowski; CESA; Shutterstock/Soonthorn Wongsaita

ABOUT CESA

The Clean Energy States Alliance (CESA) is a national, nonprofit coalition of public agencies and organizations working together to advance clean energy. CESA members—mostly state agencies—include many of the most innovative, successful, and influential public funders of clean energy initiatives in the country. CESA works with state leaders, federal agencies, and other stakeholders to develop and promote clean energy programs and markets, with an emphasis on renewable energy, energy equity, financing strategies, and economic development. CESA facilitates information-sharing, provides technical assistance, coordinates multi-state collaborative projects, and communicates the views and achievements of its members.

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