U.S. Virgin Islands Virtual Power Plant Analysis Executive Summary

November XX, 2024

Prepared for: The Government of the US Virgin Islands and the Virgin Islands Energy Office (VIEO)

Summary: Since 2009, the USVI has seen rapid growth in distributed solar and battery storage, now totaling 30.5 MW and 52.5 MWh, respectively. With a goal of reaching 30% renewable generation by 2030, Virtual Power Plants (VPPs) that integrate and control this distributed fleet represent a key solution. VPPs coordinate individual, residential batteries to mimic the functionality of a utility-scale battery, providing grid services like distributed energy capacity, load balancing, and voltage and frequency regulation across the territory. This approach yields substantial financial and operational benefits, estimated at upwards of $22.5 million annually, by offsetting costly fossil fuel use and lowering daily energy expenses by 12.3% on average. VPPs also strengthen grid resilience, reducing unserved energy—and customer experiences of rotating blackouts—by 79% in events like the loss of the two largest generators. In this way, VPPs offer a flexible, resilient pathway toward the USVI's renewable energy goals. Lessons from VPP implementations in Hawaii, Puerto Rico, Vermont, and Western Australia highlight best practices that can guide the USVI's strategy for cost-effective, resilient, and secure energy transition.

1 Overview

The US Virgin Islands (USVI) is home to a growing number of distributed energy resources (DERs). Since the introduction of net metering in 2009, the US Virgin Islands (USVI) has experienced significant growth in distributed solar and battery storage systems. By 2017, before hurricanes Irma and Maria, the net metering program had maxed out its capacity limits of 15 MW. After these unprecedented storms, the power sector faced large-scale recovery efforts and a challenged grid for many months, further prompting the rapid uptake in distributed solar and storage systems. In 2021, a net-billing program was introduced to continue to re-incentivize the use of these systems. Between 2017 and now, distributed solar capacity has increased at a rate of 3.4 MW per year, and distributed battery storage at a rate of 7.0 MWh per year. Today, there are an estimated 2,928 distributed energy resource (DER) systems across the three main USVI islands – St. Croix, St. Thomas, and St. John. The total distributed solar PV capacity across the territory is 30.5 MW, while the total distributed battery storage capacity is 52.5 MWh, as shown in Figure 1. To put this into perspective, distributed solar capacity accounts for 11.1% of utility-installed capacity and 27% of peak demand, making these systems critical to USVI's goal of reaching 30% renewable energy generation by 2030.

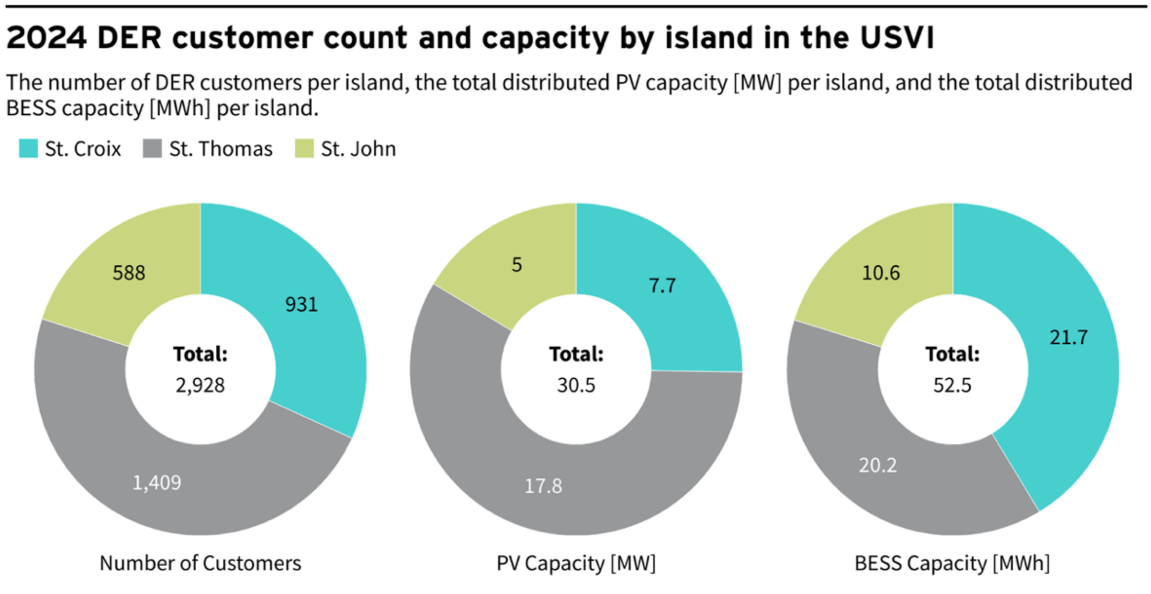

Figure 1 – 2024 estimated DER customer count and distributed solar and battery capacity in USVI by island.

These DERs currently operate as individual assets independent of each other and not optimized to support the grid's needs. This means that their capacity remains underutilized. There is, however, an innovative solution which can increase the utility of these resources and bring significant benefits to the USVI's electricity system. A Virtual Power Plant (VPP) can aggregate these separate DER systems into a single, coordinated network, allowing them to function as a unified asset, resulting in improved grid reliability, reduced fossil fuel dependence, and economic benefits to both the utility and VPP participants. This Executive Summary provides a concise analysis of how a VPP could function in the USVI, based on different levels of DER penetration and participation and deliver these benefits to the territory.

2 Current Situation: Underutilized Distributed Energy Resources

Despite their growth in capacity over the years, DER systems in the USVI function independently, with no interaction between each other and no coordination with the grid. Solar and battery storage systems, installed primarily at residential properties, operate behind the meter wherein the solar systems generate electricity to provide self-consumption to the household during peak solar hours, charge the battery systems that provide self-consumption during off-peak solar hours, and export any excess power to the grid. This results in highly independent and self-sufficient DER systems, as shown in Figure 2, that are used to provide maximum value to the households but are not optimized to provide value to the grid.

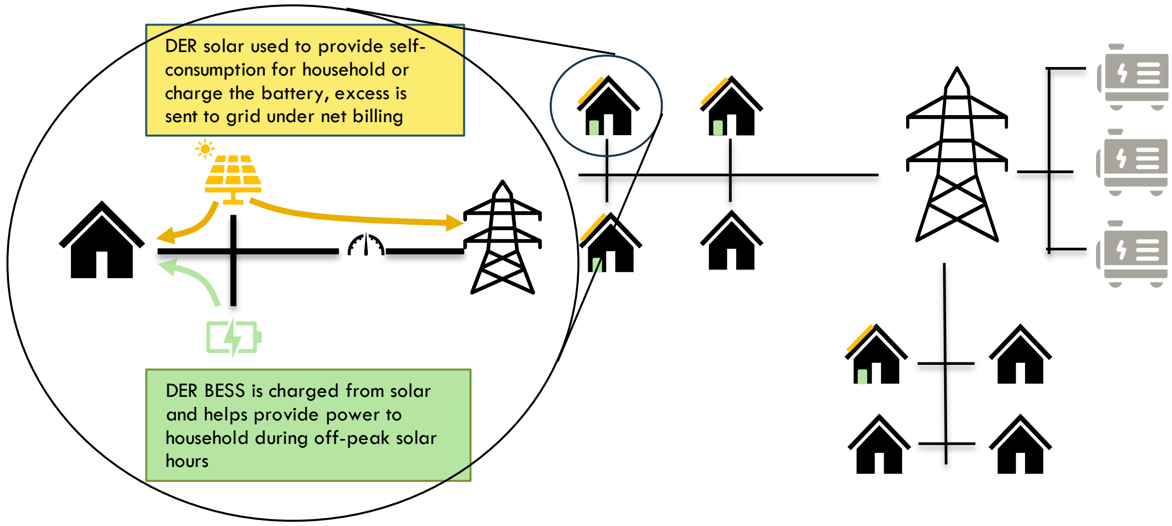

Figure 2 - Current operation of DER solar and BESS assets

Excess and intermittent distributed solar generation is sent to the grid when the solar systems are overproducing, but the more controllable battery assets are not currently supplying capacity to the grid. There is currently no mechanism in place for the battery assets to be dispatched in response to grid needs, such as reducing peak demand or enhancing grid reliability. In other words, without coordination DER systems contribute excess generation only when available, which reduces their collective impact. Furthermore, this excess generation may be available at times when it is not needed, such as the peak solar hours, leading to curtailment and essentially a waste of energy. A VPP would change this by allowing the batteries to operate in a more connected and strategic way, providing essential services like capacity reserves, peak load reduction and grid stabilization.

3 The Potential of Virtual Power Plants

A VPP offers a transformative solution by aggregating distributed solar and battery storage systems into a centrally managed, grid-responsive network, similar to what is represented in Figure 3. The VPP would enable the distributed battery systems to act as a collective resource, controlled by a central aggregator to provide decentralized energy, capacity, and/or ancillary services as needed. By coordinating these assets, the VPP allows the fleet of distributed batteries to mimic the performance of a large, utility-scale battery, delivering power during peak demand periods, reducing stress on the grid, and providing ancillary services such as voltage and frequency regulation.

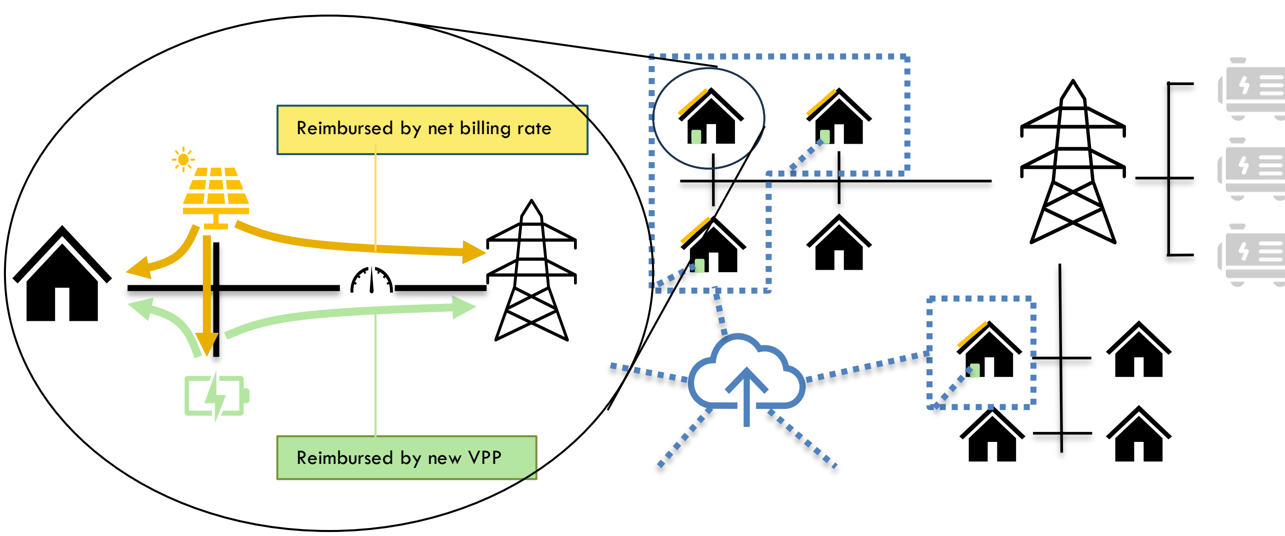

Figure 3 - Future operation of DER solar and BESS assets, connected into a VPP

The VPP would allow individual households wanting to participate in the VPP to determine how much of their battery storage they want to make available to the grid. As an example, a household could decide that they are willing to allow 40% of their battery to be used by the VPP aggregator and 60% to be reserved for self-consumption. In return for the generation they provide to the grid, they would be compensated for their contributions, creating a financial incentive for participation. This aggregation of resources can significantly reduce peak demand, improve grid reliability, and increase overall system efficiency.

4 Analysis of VPP Benefits for USVI

To assess the impact of a VPP in the USVI, a detailed simulation was conducted using the PLEXOS grid-modeling platform. This simulation assessed the USVI electricity network over a time horizon of 7 years (2025 – 2031) and considered different scenarios of DER penetration and VPP participation, including low, medium, and high DER scenarios, and compared them to a "business as usual" baseline with no VPP.

- **Low DER Scenario:** This scenario only aggregated the existing DERs in the USVI, which include approximately 30.5 MW of solar capacity and 52.5 MWh of battery storage. This storage could replace the largest generator for approximately 2.6 hours.
- **Medium DER Scenario:** This scenario included additional DERs, up to 50% of the remaining solar PV feeder capacity, with 44 MW of solar and 84 MWh of battery storage. The storage in this scenario could offset the largest generator for 4.2 hours.
- **High DER Scenario:** In this scenario, the maximum DER capacity was connected (based on current feeder capacity limits), with 57 MW of solar and 116 MWh of battery storage. This would enable the storage to match the largest generator's output for up to 5.8 hours.

The simulations produced a range of insights, including cost savings, fuel reductions, and improvements in grid performance. The key results are shown in the following table.

	Base (2024/2025)	Low DER penetration	Medium DER penetration	High DER penetration
Description	Business-as-usual: Existing DERs are <u>not</u> aggregated into a VPP.	Existing DERs are aggregated into a VPP but there is no new buildout of distributed capacity.	DER solar PV allowed to expand to **50%** of remaining feeder capacity.	DER solar PV allowed to expand to **100%** of remaining feeder capacity.
2031 DER PV Capacity *[MW]*	0	31.5	43.9	56.5
2031 DER BESS Capacity *[MW/MWh]*	0	19.8/52.5 *(can match largest gensets for 1.6 hours)*	32.4/84.1 *(can match largest gensets for 1.6 hours)*	45.0/115.5 *(can match largest gensets for 1.6 hours)*
Annual Savings *= total system cost reduction from base scenario*		**$15.4M** *(9.5% reduction)*	**$20.8M** *(12.8% reduction)*	**$26.1M** *(16.1% reduction)*
Annual Costs *= compensation to VPP participants for BESS provision at 20 cents/kWh*		**$2.3M**	**$3.0M**	**$3.6M**
Overall Benefits *= difference between savings and costs*		**$13.0M** *(~$260 per household on USVI)*	**$17.8M** *(~$356 per household on USVI)*	**$22.5M** *(~$450 per household on USVI)*

Table 1 – Key Results for long-term VPP analysis in USVI

Key findings include:

- **Cost Savings:** The low DER scenario delivered annual savings of $15.4 million, representing a 9.5% reduction in total system costs. The high DER scenario produced annual savings of $26.1 million, or a 16.1% cost reduction.

- **VPP Program Costs:** The VPP costs, largely driven by compensation for battery storage contributions, were modeled at 20 cents per kWh. These costs ranged from $2.3 million to $3.6 million annually.[1]
- **Overall Benefits:** Despite the program costs, the net annual benefits ranged from $13 million in the low DER scenario to $22.5 million in the high DER scenario. This translates to an annual benefit of $260 to $450 per household in USVI. It's also worth noting that several valuable benefits fall outside this financial analysis, such as avoided costs associated with spinning reserves, which could add an additional $100,000 to $300,000 in annual savings. Other advantages include reduced emissions, which support environmental and public health goals, and decreased load defection, helping to retain customers within the grid network. These factors strengthen the VPP's overall value proposition by providing essential grid stability, environmental, and customer engagement benefits that a traditional cost-benefit analysis may not fully capture.

5 Short-Term Operational Benefits

In addition to the long-term analysis, a short-term study modeled the impact of the VPP over a two-week period in 2031, focusing on the day-to-day benefits such as reducing fossil fuel generation. It also explored how the VPP could improve grid reliability and alleviate the situation in which the two largest generators on each system go offline during a 9-day period. The model horizons are shown in Figure 4.

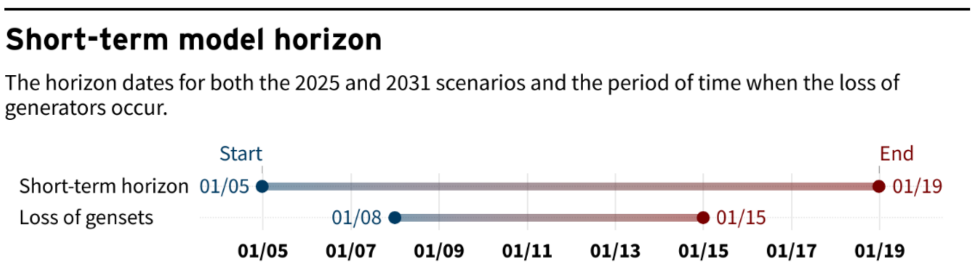

Figure 4 – Key Results for long-term VPP analysis in USVI

Dispatch order impact and fossil fuel reduction:

During a 4-day period without generator outages, the VPP reduced fossil fuel generation by 7.8%, cutting fossil fuel operating hours by nearly an hour each day, as depicted in Figure 5. This led to a 12.3% cost reduction, saving around $60,000 per day.

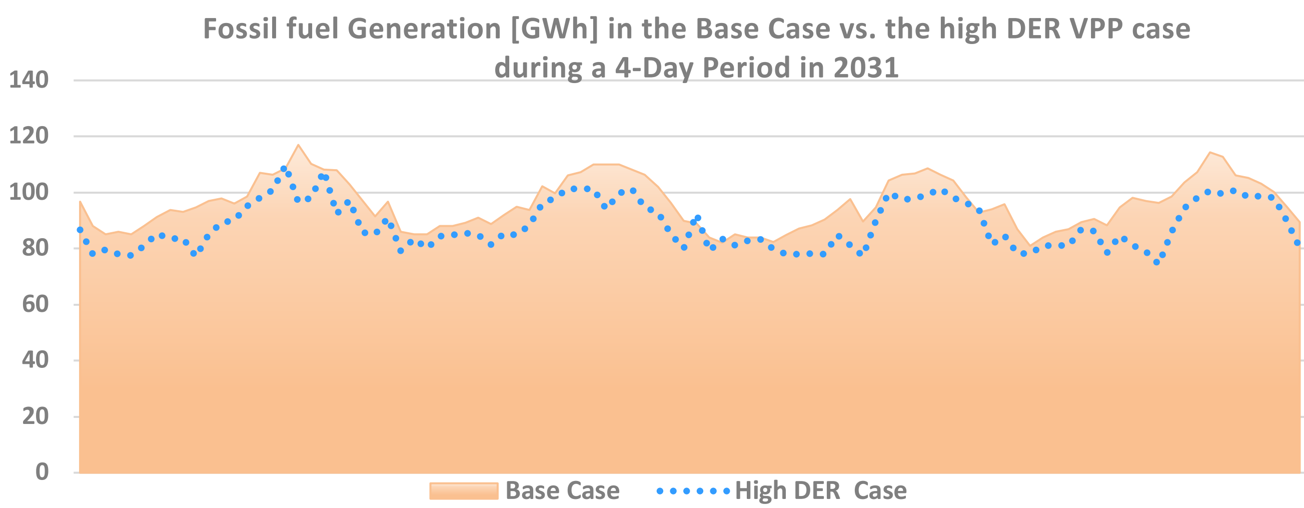

Figure 5 – Fossil fuel generation [GWh] during a 2031 4-day period for base case and high DER VPP case

[1] The VPP's cost model currently sets participant compensation at 20 cents per kWh, aligning with the solar net billing rate. However, this rate is conservatively low, especially given the territory's retail electricity rates, which are closer to 40 cents per kWh. To effectively incentivize customer participation, the compensation rate should balance utility benefits with sufficient motivation for participants. By setting a competitive rate, the VPP can ensure robust customer engagement, which is essential to maximizing its operational and financial value

Grid Support During Generator Outages:
The VPP also proved valuable during simulated generator outages, which often result in rotating blackouts in the USVI. The high DER VPP scenario reduced unserved energy (power outages) by 79%, compared to the base case, as depicted in Figure 6.

In terms of cost, the base case saw a 15% increase in total system costs during generator outages, while the high DER VPP scenario only raised costs by 5.7%, highlighting its ability to reduce the impact of generator failures.

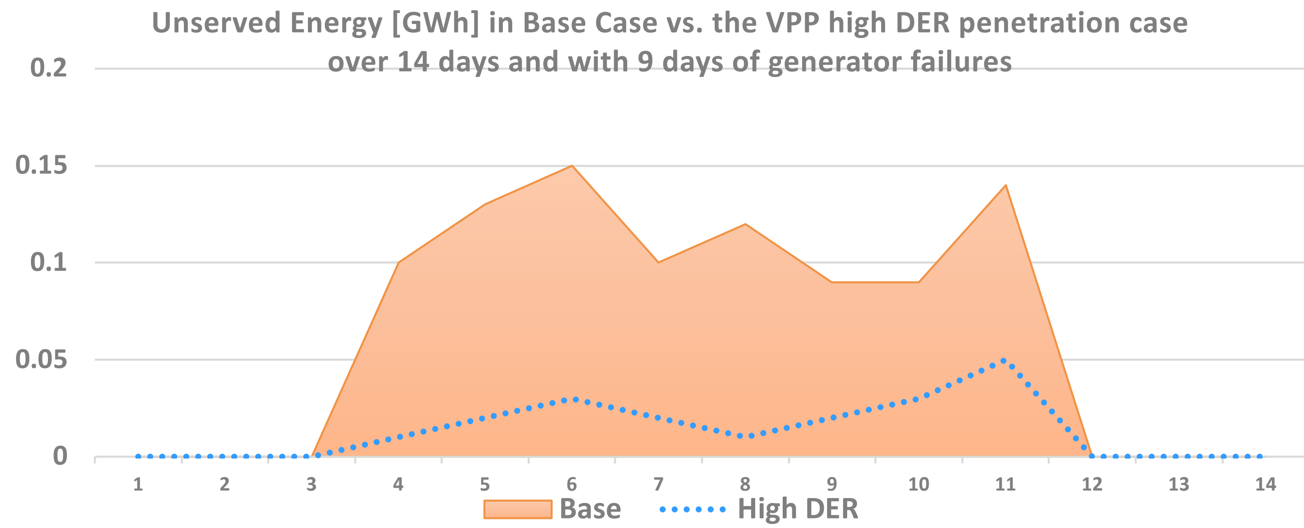

Figure 6 – Unserved energy during 2031 two-week period for base case and high DER VPP case with generator outages

6 Policy and Regulation for VPP Implementation

In researching VPP programs in the jurisdictions of Hawaii, Puerto Rico, Vermont, and Western Australia, eight key practices emerged that could guide successful VPP implementation in the USVI. The table below describes how these practices can be applied to the USVI context and develop a regulatory framework that enables VPPs.

Best Practice	Recommendation
1. Establish grid service needs	Highlight most critical grid service needs to be addressed by customer-sited DERs to inform program development. Knowing the grid service needs that are required in both the short and long term will help to ensure that any program developed is fit for purpose
2. Develop long-term DER plans	Include the need for long-term, strategic planning for DERs in regulatory framework. This planning can inform development of programs that leverage these assets and benefit both the utility and ratepayers.
3. Establish an overarching Demand Response program	The regulator, the Public Services Commission (PSC), and utility should collaborate to develop an overarching Demand Response or DER program. An overarching program will provide flexibility for different types of sub-programs or tariffs that can be used to carry out demand side management activities.
4. Develop competitive procurement processes for third-party providers or aggregators	Adapt procurement framework to allow for contracting of independent third parties to provide programs or aggregate customer DERs for use in a VPP. Having the proper frameworks in place will allow for ease of participation and faster uptake of the program.
5. Implement fair and sustainable compensation/ incentives that reflect the	Consider compensation mechanisms based on quantifiable factors such as the cost of avoided generation. Consider use of upfront incentives to allow for equitable program participation. These mechanisms will encourage new and continued

value that DERs bring to utilities	participation in programs. Premiums can also be applied to compensation for emergency grid events.
6. Determine appropriate cost recovery mechanisms	Collaborate with the relevant stakeholders (PSC, utility, general public) to determine how costs incurred by the utility can be recovered. Sufficient consultation can allow for development of solutions that are acceptable to all from the outset and hence minimize the risk of regulatory delays later in the program.
7. Regularly evaluate effectiveness of demand response/VPP programs	Consider regular use of an analysis that weighs customer benefits against costs to ensure that programs are cost-effective for both the utility and customers. Regularly assessing the cost-effectiveness of programs can allow for early detection of disparities or areas for improvement within the program.
8. Ensure cybersecurity and data protection protocols are in place	Establish requirements for cybersecurity and data protection in a customer DER program and enforce these requirements on aggregators and program providers. These requirements will assuage the privacy and security concerns of all stakeholders involved in the program. Alternatively, in the early stages, the program can avoid the cybersecurity risk through use of scheduled dispatch operation where devices do not need to be managed in real-time.

Table 2 – Best policy and regulation practices for VPP implementation and recommendations for USVI context

7 Conclusion and Key Takeaways

The analysis shows that the benefits of implementing a VPP in the USVI, are substantial across all levels of DER penetration. The VPP reduces utility fuel and generator use, offering significant cost savings. Moreover, it enhances grid reliability and resiliency, provides frequency and voltage regulation, and reduces strain on transmission and distribution infrastructure.

The analysis reveals significant potential for both economic and operational improvements:

- **Cost Savings:** A VPP could deliver substantial savings of up to $22.5 million annually in the high DER scenario.
- **Grid Resiliency:** By aggregating existing storage capacity, the VPP can provide critical support during peak demand and generator outages, reducing the reliance on fossil fuels and lowering the risk of blackouts.
- **Economic Benefits to Households:** Participating households would better utilize their home battery storage units, making the program financially attractive to consumers without additional investment on their end.

Ultimately, the cost of operating a VPP, including participant compensation and administration, is outweighed by the financial and operational benefits it brings. These results suggest that with a robust policy and regulatory framework, implementing a VPP in the USVI offers a promising pathway to a more resilient, cost-effective, and sustainable energy future.