Safeguarding Pennsylvania

Resilient Microgrids in Our Communities

Prepared for Pennsylvania Department of Environmental Protection (DEP)

Energy Programs Office

February 2025

Foreword

Pennsylvania is an energy generation powerhouse with a strong history of delivering reliable and resilient energy to its residents and to neighboring states. While we remain a provider of reliable and resilient bulk power, the impacts of climate change such as the increased frequency of severe weather is resulting in more frequent community-level energy supply disruptions. Increasing powerful storms has challenged our ride-through capabilities of not only the energy supply but also the distribution and delivery of energy at the local level.

When examining how to harden our distribution infrastructure for resilience, one of the first areas to look is at our energy supply systems which feed and support critical facilities in our communities. One solution to reduce disruptions is to deploy onsite resilient power generation and energy storage. This ability to self-support until the distribution system is restored can provide critical services when those services are of the utmost value. Examples of critical facilities include assisted care living, hospitals, fire and police, grocery stores, shelters and pharmacies which serve as lifelines, locations to assemble and launching pads to recover during and after an emergency.

The Pennsylvania Department of Environmental Protection's (DEP) Energy Programs Office (EPO) commissioned this Statewide Microgrid Study to highlight opportunities to increase energy resilience solutions via the deployment of microgrids. We want to ensure that all Pennsylvanians, especially those in communities historically affected by energy insecurity and injustice, can consider opportunities to upgrade critical facilities to increase security and recover from energy disruptions quickly.

Stakeholders provided essential data to inform the findings. I hope the following information highlights the need to invest in, and create a centralized, focused endeavor for, targeted microgrid deployment throughout Pennsylvania. I invite you to explore this study and join us in supporting the deployment of resilient energy solutions for the equitable benefit of all our residents.

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About SEPA

The Smart Electric Power Alliance (SEPA) helps all electric power stakeholders accelerate the transformation to a carbon free electricity system. SEPA concentrates our focus on the following areas to maximize impact: Transportation, Storage, Resilience, Emerging Technology, Policy, and Energy Equity. SEPA delivers value to members through research, education, events, working groups, peer engagements, and member projects. We facilitate collaboration, develop innovative strategies and guidance for regulatory and business innovation, and provide actionable solutions for its members and partner organizations. For more information, visit www.sepapower.org.

Acknowledgments

This material was prepared with support and funding from Pennsylvania's Department of Environmental Protection (DEP) and the U.S. Department of Energy's (DOE) State Energy Program which provides funding and technical assistance to enhance energy security, advance state-led energy initiatives, and maximize the benefits of decreasing energy waste. Any opinions, findings, conclusions, or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the DEP or DOE.

SEPA thanks its key stakeholders' organizations who provided input throughout the course of the study: Pennsylvania Public Utility Commission (PUC), Pennsylvania Emergency Management Agency (PEMA), PA Governor's Office of Critical Investments (OCI), Pennsylvania Rural Electric Association (PREA), Pennsylvania Municipal Electric Association (PMEA), PECO Energy Company (PECO), FirstEnergy Corporation (FirstEnergy), PPL Electric Utilities (PPL), and Duquesne Light Company (DLC).

SEPA would like to thank members of Pennsylvania Energy Programs Office that informed and shaped the direction of this project including; David A. Althoff, Jr, Kerry Campbell, Sarah Pinter, Daniel Eitzman, Amanda Eyer, Tristyne Youngbluth, Garrett Strunk, Tedd Johns, and Abbey Cadden. We would also like to thank the following SEPA staff for their support throughout the life of this project: Carina Wallack, Janne Knieke, Andrew Hennessy, Andrew Whiteman, Ella Rohn, Lauren Borkowski, Trevor Gibson, and Lynsey Callahan.

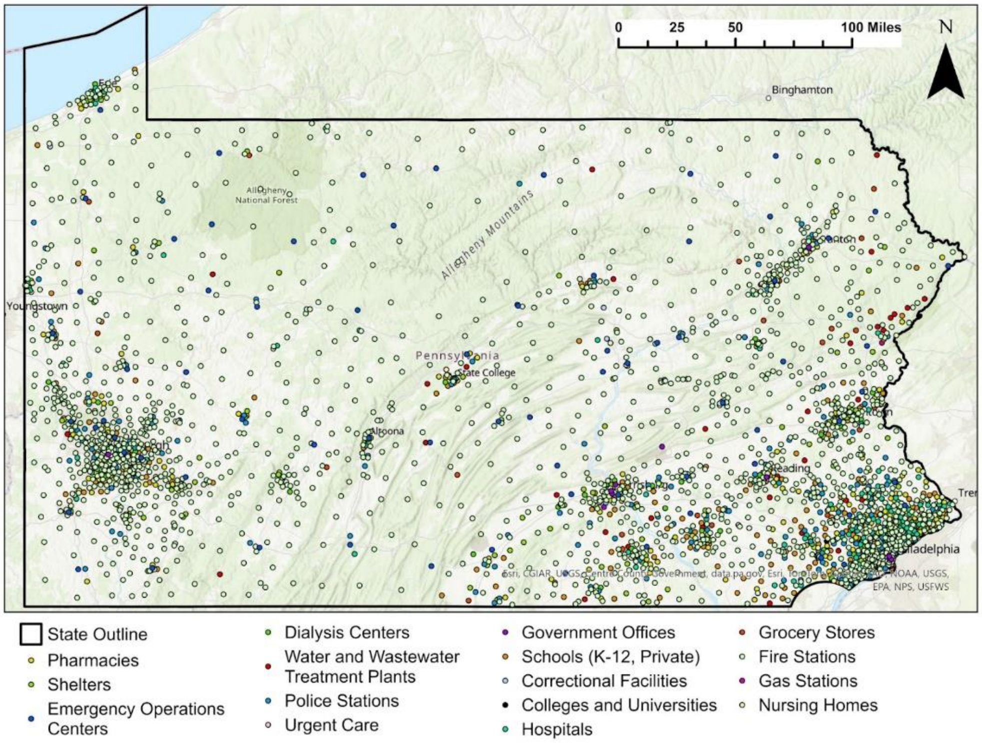
Preface

Scope of the Statewide Study

***This Safeguarding Pennsylvania: Resilient Microgrids in our Communities* study is focused on identifying prioritized opportunities for deploying microgrids in the Commonwealth of Pennsylvania.** This scope was developed based on the growing need for rapid deployment of solutions that can improve community resilience in the face of rising extreme weather conditions and electric disruptive events. Additionally, the Pennsylvania Department of Environmental Protection identified a need for state leadership and coordination in microgrid deployment initiatives. This study is focused on engaging electric utility and state representatives to collect distribution system, natural hazard, population and demographic, and critical infrastructure data to prioritize and evaluate microgrids.

Siting locations for microgrid deployment were limited to the 23,937 critical facilities across Pennsylvania canvased for the study (Figure P1). These facilities, including grocery stores, schools (K-12, private), pharmacies, shelters, dialysis centers, hospitals, police stations, water and wastewater treatment facilities, emergency operations centers, government offices, gas stations, urgent care, correctional facilities, fire stations, nursing homes, and college and universities, are integral to the state and local community hazard recovery strategies.

Figure 1: Pennsylvania Critical Facilities



Source: Smart Electric Power Alliance, 2024

The U.S. Department of Energy (DOE) defines a microgrid as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected and islanded modes." While no two microgrids are the same, this study is focused on two broad categories of Front-of-the-Meter (FTM) and Behind-the-Meter (BTM) applications (referred both to as a "microgrid" throughout this study for simplicity) (see "Microgrid Deployment Strategies").

The study's primary focus is to identify opportunities and prioritize site selections for evaluating the potential for microgrid implementation. While the study may provide prioritized site selections, general microgrid sizing recommendations, and capital expense models for low, mid, and high levels of renewable energy integration, it is not a substitute for a detailed engineering review. A full microgrid feasibility and engineering study will need to be conducted at each identified critical facility to assess the specific requirements and conditions for implementation.

This study is not published in a vacuum. Various considerations, such as legislation, utility regulation, and ownership models, are critical to the successful deployment of microgrids throughout Pennsylvania. While this study may touch on some of these topics, the authors will not be making any specific recommendations regarding policy, regulatory frameworks, or ownership structures. These aspects are complex and require further exploration and dialogue among stakeholders, including policymakers, utility companies, and community representatives, to determine the best path forward.

Executive Summary

Safeguarding Pennsylvania: Resilient Microgrids in our Communities, initiated by the Pennsylvania Department of Environmental Protection (DEP) and executed by the Smart Electric Power Alliance (SEPA), presents an in-depth approach aimed at ensuring grid resilience throughout Pennsylvania. As extreme weather events become more frequent, the resilience of the state's energy infrastructure (i.e. its ability to withstand and quickly recover from operational disruptions) is increasingly critical. In partnership with DEP's Energy Programs Office (EPO), SEPA identified and prioritized customers and communities across Pennsylvania for microgrid deployment using data-driven and stakeholder-informed site selection criteria. SEPA and DEP also developed a publicly available mapping tool and produced an associated data package as part of this effort.

Pennsylvania is an energy powerhouse in the United States. As the nation's second-largest producer of natural gas—trailing only Texas—Pennsylvania generated 7.5 trillion cubic feet of natural gas in 2022. This high production level not only fuels the Commonwealth's domestic energy demand, but also drives its role as a critical energy supplier to neighboring regions, with Pennsylvania ranking as the second-largest net energy supplier to other states. Natural gas accounts for 54% of PA's electricity generation. Nuclear power also plays a vital role in the state's electricity generation portfolio, providing around 32% of all in-state electricity in 2022.

Though the Commonwealth's energy profile is robust, it lacks significant energy source diversity. Most energy is generated by natural gas, nuclear, and coal, while renewable energy sources accounted for nearly 4%[1].

Climate change is already impacting Pennsylvania as worsening heat waves, severe winter storms, increased flooding, and other impacts are affecting the PA's energy sector vulnerability resulting in increasing costs. The bulk electric power system continues to face growing electric demand as well as peak demand in part due to climate impacts:

- *Winter Storm Elliot in December 2022* had significant impacts on Pennsylvania's electricity grid, as extreme cold and high winds created a surge in demand for heating and power across the state. Several natural gas and coal-fired plants struggled to maintain output, and pipelines faced constraints, partly due to equipment freezes[2].
- *Summer Heat Waves in July 2022* strained energy supply as high temperatures lead to record demand for electricity, especially for air conditioning. Temperatures exceeded 100 degrees Fahrenheit in some areas forcing grid operators to issue hot weather alerts and conservation notices[3].
- *Severe Flooding in July 2023* impacted local energy infrastructure and led to power outages in certain areas of Bucks County. Torrential rains overwhelmed rivers and drainage systems, causing flash floods that damaged homes, business, and access roads to rural communities[4].

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[1] EIA, Pennsylvania Profile Analysis (2024)
[2] PJM, Winter Storm Elliott Event Analysis and Recommendation Report (2023)
[3] PJM, Inside Lines, July 22 Update: Hot Weather Alerts to Continue Through Weekend (2022)
[4] PBS, WHYY, 5 People Killed, 2 Children Missing After Flash Floods in Upper Makefield Twp. (2023)

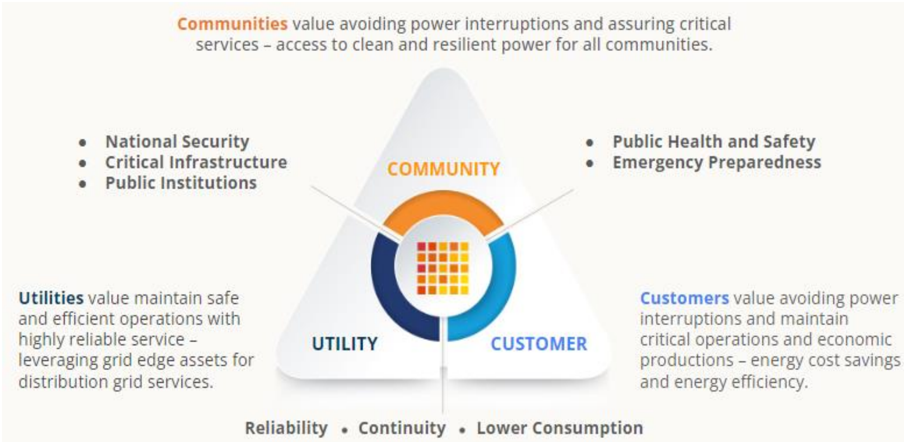
Certain communities in Pennsylvania are more vulnerable to the negative impacts of extreme weather on the electric power system, facing increased exposure to prolonged outages and hazardous conditions during restoration periods. These vulnerabilities are often tied to socioeconomic factors, such as energy burden and limited access to resources, which can lead to disproportionate impacts during such events. These challenges underscore the importance of a holistic resilience planning approach that prioritizes energy equity, environmental justice, natural hazard risk management, and energy reliability. By incorporating modern mapping tools and focusing on critical infrastructure services, planners can better address these disparities to protect and empower vulnerable populations.

Microgrids can be a solution in the energy resilience toolbox to support critical facilities, customers, and communities by providing uninterrupted power to critical functions during grid outages. While no two microgrids are the same, generally this innovative energy system provides a local community with independent energy supply while the traditional grid is being restored. Microgrids are an investment that can provide benefits to the grid and to end-use customers during normal grid operations, such as energy savings for the customer or capacity and reliability services for the utility, while enabling those customers to leverage savings from benefits to the grid. These systems could enable a rural hospital to continue providing essential care for patients and serve as an emergency response center during power outages, helping the community respond and recover quicker from natural hazards. Incorporated in these deployments, this study additionally evaluates solar photovoltaic (PV) and battery energy storage system technology applications.

As a part of the *Resilient Microgrids in our Communities* project 'the study', SEPA and DEP convened stakeholders from across the energy sector to ensure that the prioritization of critical facilities align with community resilience needs Stakeholders included Pennsylvania Electric Distribution Companies, Pennsylvania Rural Electric Association, Pennsylvania Municipal Electric Association, Pennsylvania Emergency Management Agency, Pennsylvania Office of Consumer Advocate, Pennsylvania Governor's Office of Critical Investment, Pennsylvania Public Utility Commission, etc. SEPA and DEP convened three virtual stakeholder meetings in December 2023, March 2024, and August 2024.

Understanding how to define and value resilience is essential for developing strategies that not only strengthen the grid but also benefit the communities, customers, and utilities that depend on it. The DOE Office of Energy Efficiency and Renewable Energy defines resilience as the "ability of the grid, buildings, and communities to withstand and rapidly recover from power outages and continue operating with electricity heating, cooling, ventilation, and other energy-dependent services." Despite this definition, there is not a universally accepted method for valuing resilience. The ability to recover quickly has different values depending on the electric customer (Figure 1):

Figure 1: SEPA's Resilience Triangle



To facilitate cost-effective and mutually beneficial projects, stakeholders in microgrid projects must align on direct benefits for all involved parties. When a microgrid is implemented at a critical facility, the community benefits as the essential services remain operational during extreme weather event emergencies. The critical facility itself benefits as it maintains operations during outages, reducing economic and life safety impacts of energy disruptions. The local utility benefits from the integration of renewable energy resources achieving decarbonization targets and providing localized control during outages.

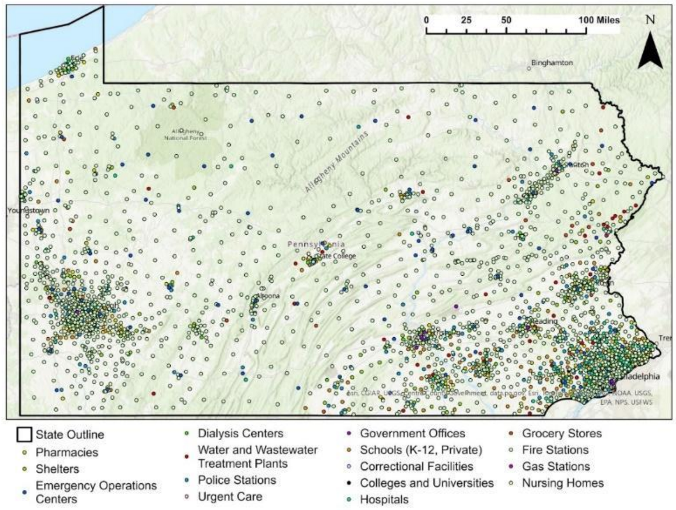
SEPA and DEP identified **23,937 critical facilities across Pennsylvania** and reviewed each facility type for microgrid development prioritization. These facilities, including grocery stores, schools (K-12, private), pharmacies, shelters, dialysis centers, hospitals, police stations, water and wastewater treatment facilities, emergency operations centers, government offices, gas stations, urgent care, correctional facilities, fire stations, nursing homes, and college and universities, are integral to the state and local community's hazard recovery strategies. To prioritize site selection, scoring was developed which comprised four categories: utility planning and operations, critical infrastructure and services, natural hazards, and energy equity and environmental justice (Figure 2).

Figure 2: Scoring Categories

Critical Infrastructure and services were identified according to state, federal, and electric distribution company definitions. Facilities that also serve as emergency shelters or emergency operation centers received higher scores due to their dual purpose in providing critical services during emergencies (Figure 3).

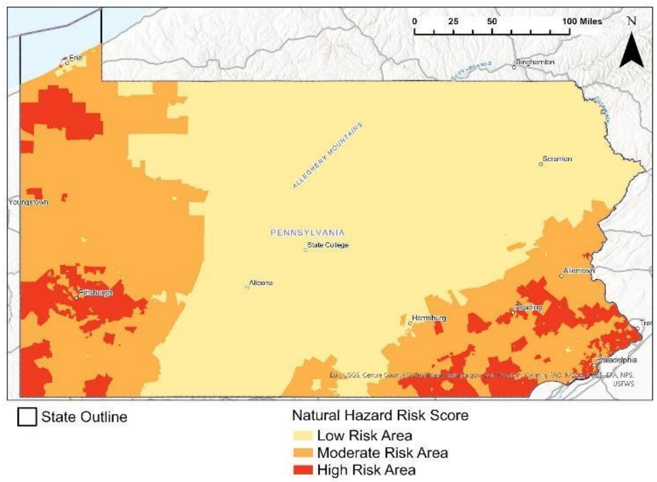
Utility planning and operations were assessed by examining utility distribution circuit reliability performance and hosting capacity constraints, considering historical outages, projected loads, and circuit voltage levels. Data provided by Electric Distribution Companies (EDCs) across the state informed this evaluation, though the availability of data varied by service territory. In areas where EDC-provided data was unavailable, scoring was based on other factors such as critical infrastructure, natural hazard risk, energy equity, and environmental justice.

Figure 3: Critical Facilities



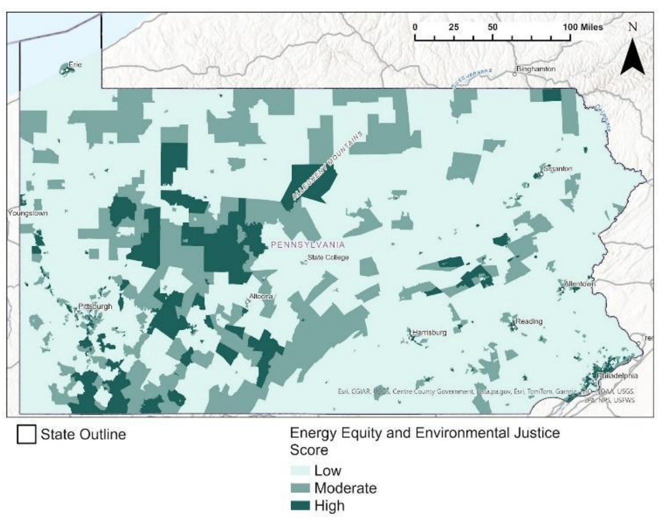
Natural hazards were identified based on criteria from the Federal Emergency Management Agency (FEMA) and the Pennsylvania Emergency Management Agency (PEMA) 2023 State Hazard Mitigation Plan. Additionally, an extra weighting is applied if a facility is located within a FEMA-designated Community Disaster Resilience Zone, further indicating the need for resilience investments (Figure 4).

Figure 4: Census Tract Natural Hazard Risk Scores



Energy equity and environmental justice (EJ) was assessed using widely recognized federal and state definitions of vulnerable populations and EJ communities. These definitions helped identify areas where resilience investments, such as microgrids, are most needed to protect and empower these communities (Figure 5).

Figure 5: Census Tract Energy Equity and Environmental Justice Scores



Using data from state and federal agencies, SEPA and DEP worked closely with stakeholders to refine the resilience scoring formula for microgrid site selection prioritization. Scores were assigned based on the concentration of critical facilities, natural hazard risk, grid reliability, hosting capacity, and energy equity and environmental justice. SEPA and DEP ranked sites for microgrid deployment, offering a clear prioritization of locations most in need of resilience investments (Table 1).

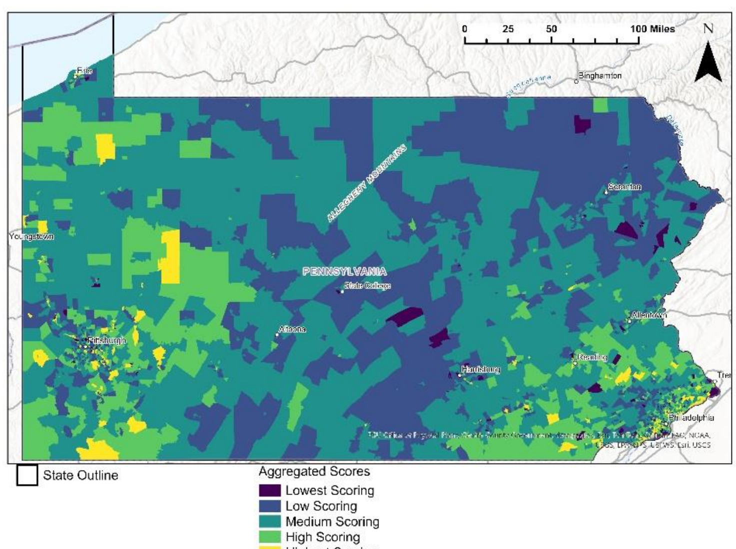
Table 1: Site Selection Criteria

Site Selection Criteria	Sub Criteria
Critical Infrastructure and Services (Up to 30 points)	• Criticality of facilities • Dual purpose as an emergency shelter • Concentration
Utility Planning and Operations (Up to 25 points)	• Electricity circuit reliability • Hosting capacity constraints
Natural Hazards (Up to 20 points)	• Natural hazard risk • FEMA Community Disaster Resilience Zone
Energy Equity and Environmental Justice (Up to 25 points)	• Environmental Justice Area • Disadvantaged Community • Energy Burden • Energy Community • Medicare Beneficiaries • Low-Income Community • Persistent Poverty

Source: Smart Electric Power Alliance, 2024

Figure 6 displays the combined site selection scores by census tract across the state, highlighting areas where microgrid deployment could significantly enhance resilience and support vulnerable populations.

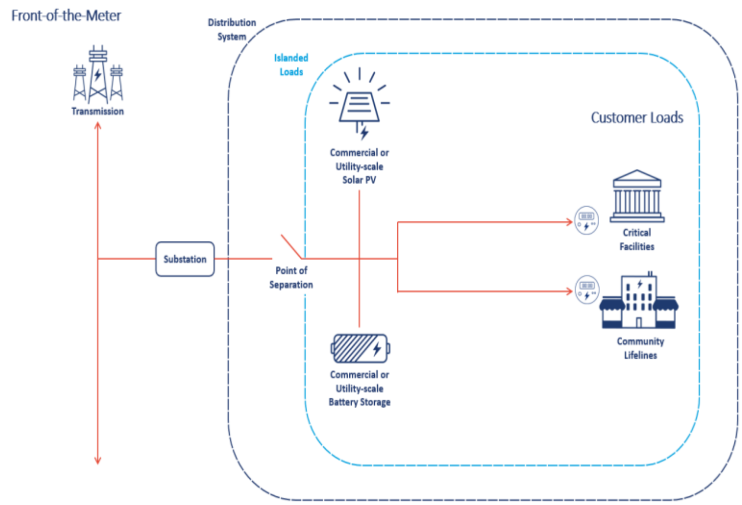
Figure 6: Census Tract Combined Site Selection Scores



The scoring process resulted in a prioritized list of microgrid locations across the Commonwealth. To make these results accessible and actionable, SEPA and DEP further developed a visualization tool mapping prioritized microgrid locations and all associated resilience factors through the [Safeguarding Pennsylvania: Resilient Microgrids in our Communities Study Mapping Tool.] The tool enhances stakeholders ability to gain a deep understanding of the resilience analysis results, which are essential for guiding planning efforts.

The study identifies 28 potential community microgrid systems and 240 priority sites for behind-the-meter (BTM) microgrids, all strategically chosen to improve grid reliability and resilience. Community microgrids integrate Distributed Energy Resources (DERs) like solar PV, battery storage, and backup generators in front of customer meters, offering direct energy and resilience benefits to several critical facilities or sections of the distribution grid (Figure 7). BTM microgrids offer comparable benefits tailored to single customers by incorporating DERs behind their meters (Figure 8).

Figure 7: Community Microgrid Deployment Strategies



SEPA also modeled three conceptual microgrid design scenarios—Low, Mid, and High Renewable—across 16 critical facility use cases using Xendee, an industry leading microgrid design and economic analysis tool (Figure 9). These scenarios included upfront capital expenditure (CAPEX) and yearly operating expenditures (OPEX). These scenarios allow Pennsylvania stakeholders to develop deployment plans that align with their specific goals, balancing cost, sustainability, and resilience. The study then lays out key partnerships and stakeholder engagement necessary to leverage the findings of the study to strengthen community resilience. For implementation, this study recommends targeting high-priority sites with tailored microgrid designs, backed by detailed engineering studies to assess technical and economic viability.

Figure 8: BTM Microgrid Deployment Strategies

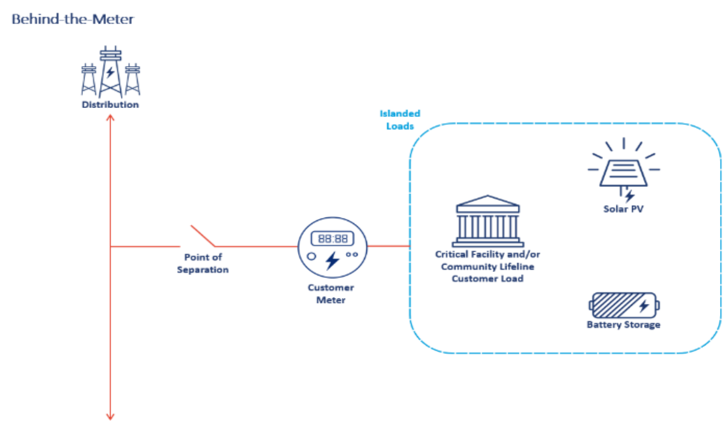
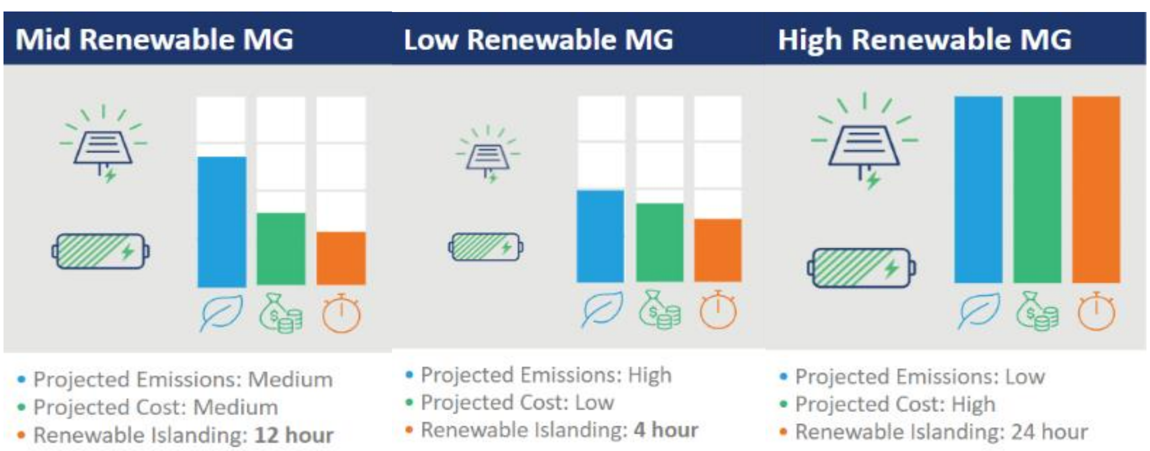


Figure 9: BTM Microgrid Deployment Strategies



By applying data-driven site prioritization with input from key electric power sector and policy stakeholders, this study provides a valuable resource for energy planners, utilities, and community leaders in Pennsylvania to identify and develop projects that build resilience in their communities. This study serves as a clear roadmap toward a more resilient, equitable, and sustainable energy future for the state. It is meant to inform and advance partnerships between the Commonwealth, other public sector stakeholders, and the private sector to accelerate near-term investment in microgrid technologies and applications. Sustained action will be required to simultaneously scale up the adoption of energy resilience applications, communicate the value proposition to critical facilities and communities, and capture sustainable funding sources that unlock meaningful near-term investments.

Figure 10: Partnerships and Stakeholder Engagement Cycle

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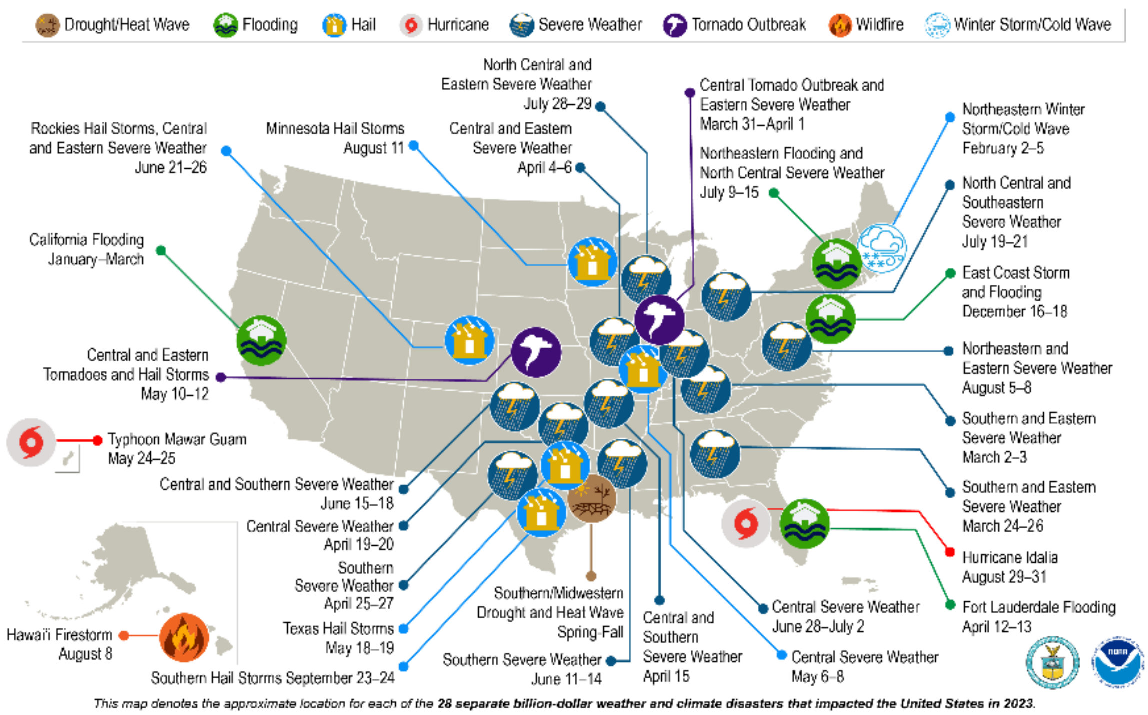
Study Overview

As the frequency and intensity of extreme weather events increase across Pennsylvania, electric distribution system operators, customers, and regulators are more focused than ever on energy system resilience. Investments in critical infrastructure and the distribution grid will enhance the system's ability to withstand, respond to, and recover from disruptions. Environmental Justice Communities (EJ communities) are often disproportionately affected by these events, facing prolonged power outages, limited access to emergency response resources, and slower recovery times.

Figure 2: U.S. 2023 Billion-Dollar Weather and Climate Disasters



Source: U.S. National Oceanic and Atmospheric Administration, Billion-Dollar Weather and Climate Disasters (2024)

These challenges underscore the need for a holistic approach to resilience planning that incorporates energy equity, environmental justice, natural hazard risk management, energy reliability, critical infrastructure services, and the use of modern mapping tools. This approach identifies where equitable resilience investments are most needed, considering both system impacts and customer benefits.

The purpose of this study is to provide stakeholders in Pennsylvania with a statewide deployment strategy, outlining prioritized customer and community sites along with microgrid use cases to enhance customer and grid resilience to be utilized for the deployment of microgrids. By identifying prioritized customers and community sites for resilience investment, stakeholders in Pennsylvania are better equipped to implement microgrids across the state.

A Summary of Microgrids in Resilience Planning

Microgrids are an essential tool in the resilience planning toolbox for states, utilities, communities, and customers to respond to and recover from grid outages. The U.S. Department of Energy (DOE) defines a microgrid as “a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected and islanded modes.” As more customers integrate distributed energy resources (DERs), microgrid integration can help communities meet their resilience and sustainability goals.

In partnership with DEP’s Energy Programs Office (EPO), SEPA identified and prioritized customers and communities across Pennsylvania using data-driven and stakeholder-informed site selection criteria. SEPA and DEP also developed a publicly available mapping tool and associated data package as part of these efforts.

Highlighted Activities of the Safeguarding Pennsylvania: Resilient Microgrids in our Communities Study

- Identified opportunities for deploying microgrids to increase resilience.
- Engaged electric utility and state representatives to collect distribution system, natural hazard, population and demographic, and critical infrastructure data to prioritize and evaluate microgrids.
- Prioritized customer and community resilience needs and potential microgrid projects.
- Evaluated the conceptual design and preliminary economics of various microgrid use cases and applications.

Energy Landscape in Pennsylvania

State Profile

Pennsylvania ranks second only to Texas as the largest net energy supplier to other states. In 2022, natural gas-fired power plants accounted for 54% of Pennsylvania's in-state electricity generation with nuclear power plants having provided 32%, coal 10%, and renewable energy sources nearly 4%.[5] Despite the state's significant fossil fuel generation assets, Pennsylvania, through its Climate Action Planning, has remained committed to reducing greenhouse gas emissions. The DEP is currently finalizing its 2024 Climate Action Plans identifying further GHG reduction strategies as well as new strategies for adapting to the impacts of climate change.

Several utilities in Pennsylvania have established carbon reduction targets as part of their commitment to reducing GHG emissions and achieving long-term sustainability goals. The table below outlines these targets, along with their corresponding baselines and timelines.

Table 1: Pennsylvania Utility Carbon Reduction Tracking

Utility	Carbon Reduction Target	Target	Baseline
Duquesne Light Company	10% reduction in combined Scope 1 & 2 GHG emissions	2027	2022
PECO	50% reduction in Scope 1 GHG emissions	2030	2015
	Net zero carbon emissions in Scope 1	2050	
West Penn Power Company[6]	30% reduction in the GHG emissions	2030	2010
	Carbon-neutral	2050	
PPL	70% carbon emission reduction	2035	2010
	80% carbon emission reduction	2040	
	Net-zero carbon emissions	2050	
UGI Utilities Inc.	55% reduction in Scope 1 GHG emissions	2025	2020

Source: SEPA's Utility Carbon Reduction Tracker, 2024

The DEP Energy Program's Office plays a pivotal role in advancing resilience and clean energy across the state. Key activities include:

- Promoting and encouraging energy conservation and efficiency.

[5] EIA, Pennsylvania Profile Analysis (2024)

[6] FirstEnergy is the parent company of West Penn Power. FirstEnergy has a carbon neutral by 2050 goal for scope 1 emissions across all of its territories.

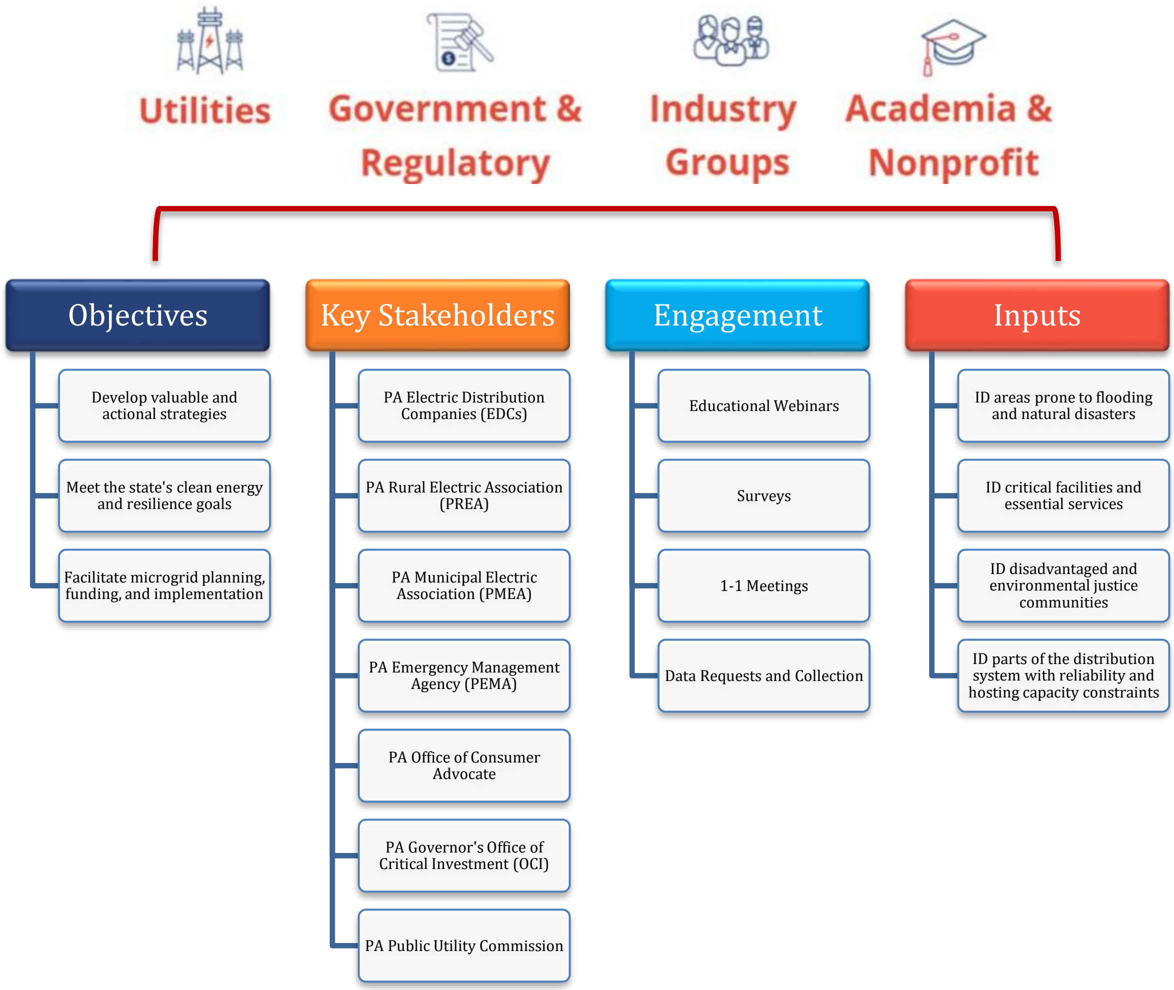
- Deploying advanced energy technologies.
- Ensuring energy security and resilience.
- Reducing GHG emissions and adapting to climate change impacts.
- Performing energy education and outreach.

Through this work, EPO helps Pennsylvanians make smarter energy choices that reduce pollution and energy use and expand the use of renewable and other clean energy solutions. A central focus of EPO's work is helping government leaders and stakeholders understand the current and potential future landscape of energy programs and initiatives, as well as the social equity, health, and economic benefits of these programs for Pennsylvania's residents.

Stakeholder Engagement

Achieving carbon reduction goals and adapting to the impacts of climate change require focused education and collaboration. Various stakeholders from across the energy sector were convened to ensure that the results of this study align with Pennsylvania's goals to support grid resilience. The following graphic outlines the objectives, key stakeholders, engagement methods, and inputs that guided this effort.

Figure 3: Engaging Stakeholders for Microgrids for Resilience and Decarbonization



Source: Smart Electric Power Alliance, 2024

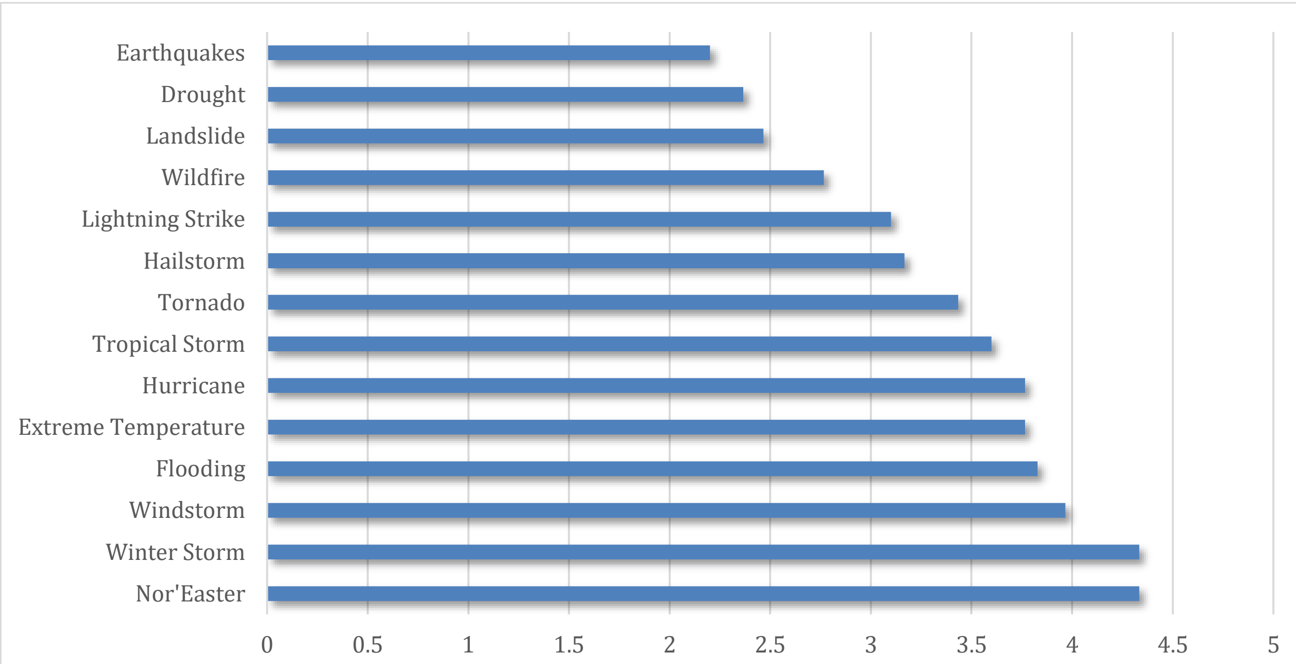
To select locations that best serve the customers and communities in Pennsylvania, SEPA organized three stakeholder-wide webinars and several individual stakeholder meetings with key stakeholder groups to collect input on the needs and preferences of the people of Pennsylvania and keep them informed of the progress of the project. The main objectives when engaging stakeholders were to:

- Present a summary of data inputs to inform prioritization.
- Identify additional data sources to inform our analysis.
- Collect feedback on establishing site selection suitability criteria.
- Provide stakeholders with a list of prioritized locations and areas most in need of resilience investments.

Stakeholder Meeting #1: Landscape Review

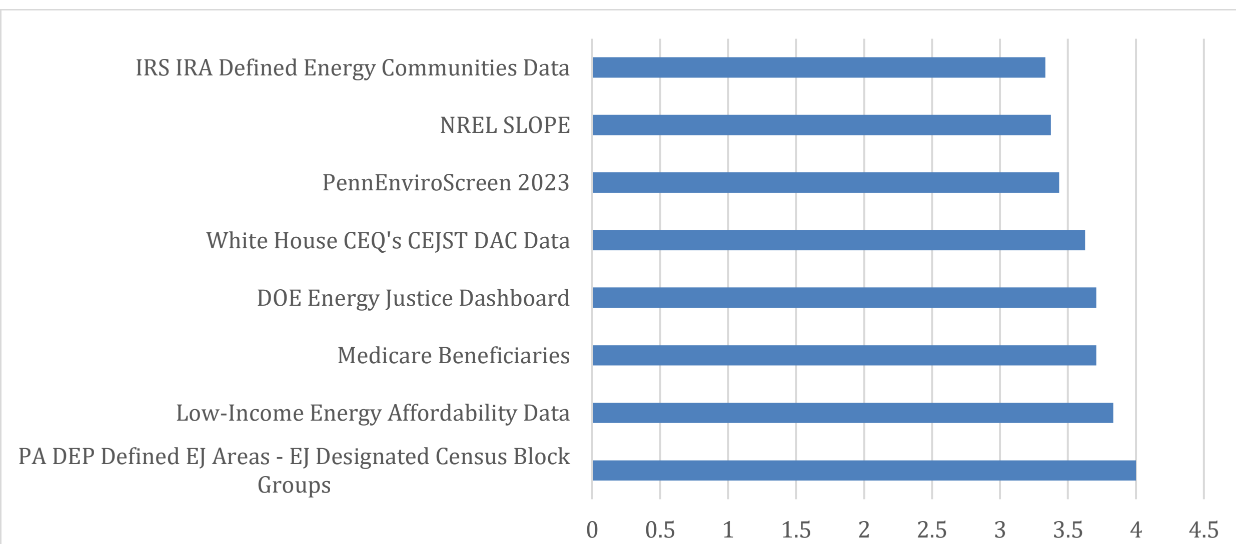
The first stakeholder meeting was held on December 4, 2023, to kick off the project to external stakeholders. During the meeting SEPA walked through what a microgrid is and how it fits into the larger grid. SEPA also walked through the objectives of the study and the criteria that would be layered on top of critical facilities to identify areas of resilience need. SEPA circulated a survey to gauge stakeholder prioritization of critical facilities, energy equity and environmental justice metrics, and natural hazard risks in Pennsylvania. The charts below show the average scores for how stakeholders prioritized the various metrics that made up the site selection criteria.

Figure 4: Average Impact of Natural Hazard Risks on Electric Grid Stability (1 = Least Impact, 5 = Most Impact)



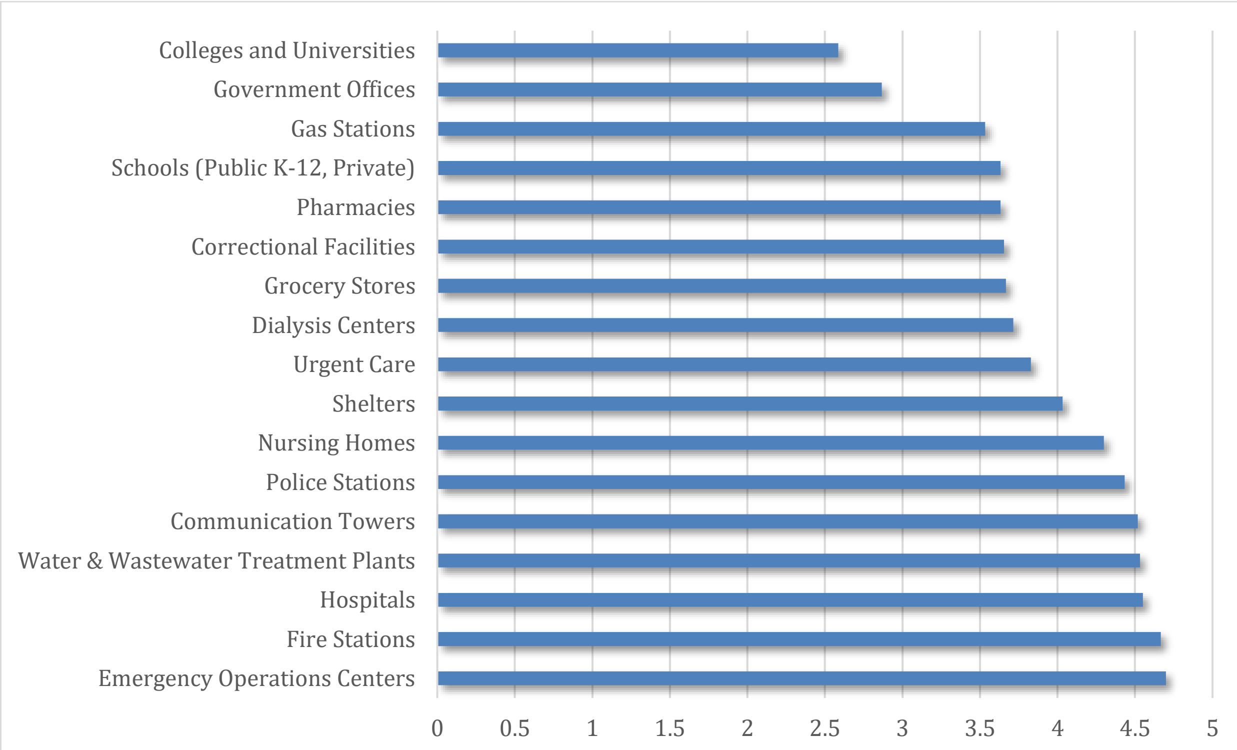
Source: Smart Electric Power Alliance, 2024

Figure 5: Average Importance of EJ and EE Definitions in Prioritizing Energy Investments (1 = Least Impact, 5 = Most Impact)



Source: Smart Electric Power Alliance, 2024

Figure 6: Average Criticality of Services Provided to the Community (1 = Least Impact, 5 = Most Impact)



Source: Smart Electric Power Alliance, 2024

Stakeholder Meeting #2: Microgrid Deployment Strategy

The second stakeholder meeting was held on March 6, 2024. The meeting walked through results from the stakeholder survey. During the meeting, representatives from the City of Erie and Groundswell presented on microgrids that have been deployed in Pennsylvania and the broader Mid-Atlantic region.

Stakeholder Meeting #3: Results Presentation

The final stakeholder meeting was held on August 26, 2024, to present the results of the study, including an analysis of various microgrid configurations and their potential to support grid resilience. SEPA also discussed the geospatial data tool developed as part of the study. During the meeting, SEPA and DEP highlighted the necessity of stakeholder engagement to build capacity and rapidly deploy microgrid projects across the state and walked through an action plan to leverage the study's findings as a strategic planning resource for stakeholders.

Electricity Regulation[7]

Pennsylvania's electricity regulatory framework is essential in shaping how Distributed Energy Resources (DERs), like microgrids, are owned and operated. The Pennsylvania Public Utility Commission (PA PUC) oversees the regulation of Electric Distribution Companies (EDCs), ensuring that they provide safe, reliable, and affordable services while also advancing the integration of renewable energy sources and modernizing grid infrastructure. The PA PUC also oversees and approves the long-term plans that EDCs must develop to ensure the reliability and resilience of the electric distribution system. These plans typically include investments in grid modernization, infrastructure upgrades, and the integration of DERs, like microgrids. As a deregulated state, Pennsylvania allows customers to choose their electricity suppliers while EDCs are responsible for maintaining the distribution network and ensuring reliable service. Additionally, Pennsylvania's electricity market operates within the PJM Interconnection, a regional transmission organization that coordinates the wholesale electricity market across several states and District of Columbia.

[7] For a full map of Pennsylvania Electric Distribution Companies' (EDCs) approximate service territory and PJM Interconnection's service territory, See Electric Power Outlook for Pennsylvania 2022-2027, Pennsylvania Public Utility Commission.

Relevant Energy Policy in Pennsylvania

- In **September 2021**, Pennsylvania published its Climate Action Plan, which identifies the potential resilience benefits of microgrids, and some of Pennsylvania utilities' Long-Term Infrastructure Investment Plans similarly address microgrids without providing a basis for facilitating development.
- In response to FERC Order 2222, which requires grid operators to plan for the participation and aggregation of DERs in wholesale markets, the PUC issued an advance notice of proposed rulemaking order (ANOPR) in **January 2024** to gather feedback on complying with this directive. As of August 2024, the proposed implementation timeline for participation in the energy and ancillary services market is the first quarter of 2026.
- In **February 2024**, the PUC sought comments on the aggregation of DERs into Virtual Power Plants (VPPs) to enhance energy efficiency, improve service, and reduce costs.
- In **April 2024**, the PUC approved a final policy statement establishing guidelines for the use of electricity storage by EDCs. This policy clarifies that electricity storage technology, particularly batteries, can be used by EDCs in place of, or alongside, more traditional wired solutions to maintain or enhance the reliability and resilience of the electric distribution system, while also offering potential benefits.
- In **May 2024**, the PUC defined energy storage assets and took a neutral stance on ownership, stating that ownership should depend on the circumstances and that third parties should be considered, while avoiding prescribing specific ownership models.

Integrating Resilience in Energy and Utility Planning

Following our detailed review of Pennsylvania's energy landscape and regulatory environment, it is crucial to explore the concept of resilience—a key element in both state energy planning and utility distribution system planning. Understanding how to define and value resilience is essential for developing strategies that not only strengthen the grid but also benefit the communities, customers, and utilities that depend on it.

One tool available to states and utilities for enhancing resilience are microgrids. Microgrids can play a pivotal role in integrating DERs, supporting decarbonization goals, strengthening community resilience, protecting critical customers, and even reducing customer costs. Their value proposition lies in their ability to island loads during a grid outage, thereby providing both customer and system resilience, as well as delivering benefits during normal grid operations.

Energy Resilience vs Energy Reliability

The DOE Office of Energy Efficiency and Renewable Energy (EERE) defines resilience as the "ability of the grid, buildings, and communities to withstand and rapidly recover from power outages and continue operating with electricity, heating, cooling, ventilation, and other energy-dependent services.". Reliability, on the other hand, is "the ability of a power system to withstand instability, uncontrolled events, cascading failures, or unanticipated loss of system components".

Despite the EERE definition of resilience, there isn't a universally accepted method for valuing resilience that can guide state regulatory or policy decisions. The PA PUC regulates utilities and oversees the implementation of policies and programs that impact grid reliability by requiring the reporting of utility reliability metrics that measure the average duration of an outage or the number of outages felt by a utility. With that said, resilience can vary across customer types, highlighting the importance of conducting a state-specific and community assessments to understand the value that different customers and communities place on resilience. For example, in a data center or manufacturing facility, the value of lost load during a disruption can be readily calculated by assessing the lost revenue or the cost of halted production. In contrast, valuing resilience for critical facilities like fire stations, hospitals, or schools is more complex due to the less tangible nature of their services.

In 2022, the National Association of Regulatory Utility Commissioners (NARUC), the National Association of State Energy Officials (NASEO), and Converge Strategies collaborated on the report Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs, which highlights various methods for valuing resilience. The table below outlines a list of resilience valuation tools identified in the report and their applications.[8]

Table 2: Resilience Valuation Approaches

Method/Tool	Developers	Advantages and New Additions	Available
Interruption Cost Estimator 2.0 Tool	• Lawrence Berkeley National Laboratory • Edison Electric Institute	• Updated calculations of power interruption costs. • New willingness-to-pay surveys that will populate the tool with more recent data and more geographic specificity for power interruption cost estimates. • New data on customer responses to longer-duration power interruptions.	Late 2024/early 2025
Customer Damage Function Calculator Tool	• National Renewable Energy Laboratory	• Helps individual facilities (or groups of similar facilities) calculate power interruption costs, based on the specific losses that they project will occur. • Guided questions lead facilities through their own assessments. • Graphical summary of initial damage costs, and costs over time.	2021
Social Burden Method	• Sandia National Laboratories • University of Buffalo	• Provides a metric for the social burden of power outages that emphasizes the needs of communities during power outages, instead of emphasizing protecting critical infrastructure for its own sake. • Adopts a more neutral treatment of the willingness to pay vs. the ability to pay for resilience.	Pilot 2021-2022
FEMA Benefit-Cost Analysis Tool	• Federal Emergency Management Agency	• Provides quantitative values for lost emergency services, such as police, fire, and emergency medical response. • New pre-calculated values specifically for hospitals published in 2021. • The use of FEMA values aligns with the application. requirements of FEMA grant programs.	2021
Power Outage Economics Tool (POET)	• Lawrence Berkeley National Laboratory • Commonwealth Edison	• Estimates the economic impacts of longer-duration power outages. • Takes into account how utility customers adapt their behavior during longer duration power interruptions. • Uses surveys of utility customers to collect data on how they would actually behave during a power outage.	Pilot 2021-2022

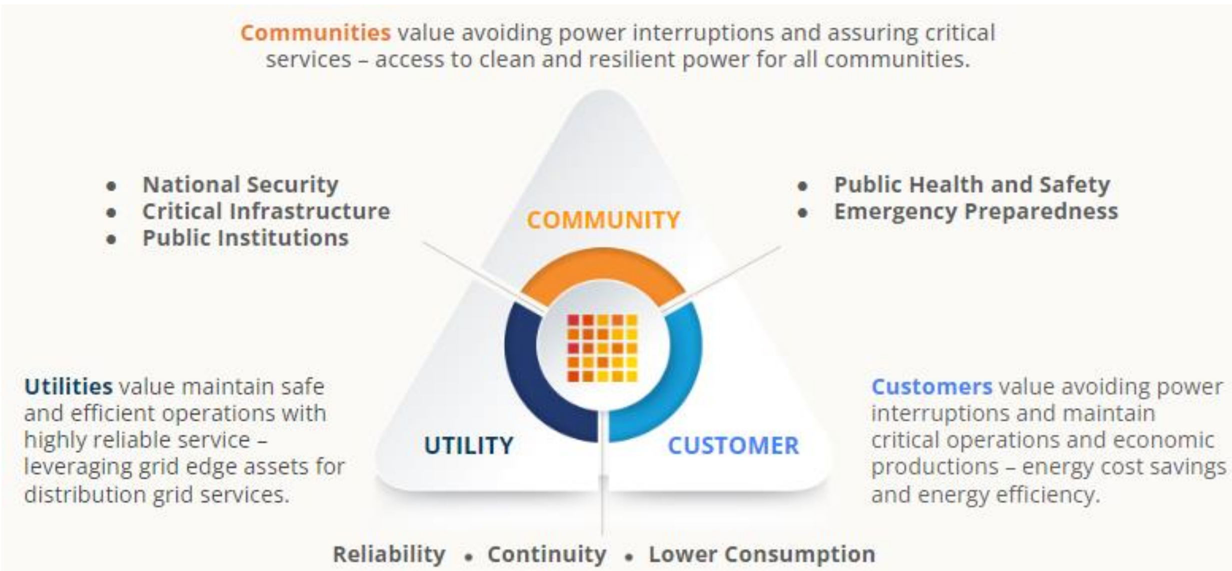
Source: Converge Strategies, NARUC, NASEO Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs (2022)

[8] Converge Strategies, NARUC, NASEO Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs (2022)

SEPA's Resilience Triangle

An important part of the resilience valuation equation is recognizing the value that stakeholders place on resilience. By identifying compatible and overlapping value streams of resilience across different stakeholders, solutions can be developed that meet the needs of multiple parties and provide added benefits. SEPA's Resilience Triangle, below, identifies the three primary representatives in a project team and their core values and priorities for resilience.

Figure 7: SEPA's Resilience Triangle



Source: Smart Electric Power Alliance, 2024

Benefits of Microgrids for Utilities, Customers, and Communities

As part of this study, SEPA identified microgrid scenarios that benefit critical facility customers, utilities, and communities, aligning incentives across stakeholder groups. Ensuring that all resilience project stakeholders achieve direct benefits from a microgrid project increases the overall likelihood of project success.

Community Benefits

Emergency Response and Preparedness: Ensures critical facilities and essential community services remain operational during extreme weather event emergencies.
Environmental Benefits: Reduces carbon emissions through renewable energy integration.

Customer Benefits

Reliability and Resilience: Enables critical facilities to maintain operations during outages, reducing economic and life safety impacts of energy disruptions.

Cost Savings and Emissions Reduction: On-site renewable generation with energy export options helps manage peak demand and shift energy usage to off-peak hours.

Utility Benefits

Modernizing the Grid: Localized control during outages enhances resilience while leveraging dispatchable DERs to improve system efficiency.
Integrating Renewables: Facilitates solar PV and battery storage grid integration which can support achieving decarbonization targets.
Managing Costs: Defer costly infrastructure investments and lower operational costs while maintaining grid stability.
Supporting Customers: Offers a solution to meet the changing demands of electricity customers.

Microgrid Suitability

The microgrid suitability assessment in Pennsylvania, conducted in partnership with DEP, is a comprehensive and stakeholder-driven process that includes scoring potential sites for customer and community microgrids across the Commonwealth. This effort was grounded in high-quality data and leveraged advanced geospatial analysis techniques. SEPA and DEP drew on years of experience to integrate traditional distribution system planning elements—such as hosting capacity analysis, distribution system reliability, and the identification of priority customers and circuits—with crucial considerations for energy equity, environmental justice, and natural hazard risks.

The scoring, as illustrated in the graphic below, is comprised of four categories: utility planning and operations, critical infrastructure and services, natural hazards, and energy equity and environmental justice.

Figure 8: Scoring Categories for Microgrid Suitability

Utility Planning and Operation Criteria

- Hosting Capacity Constraint (constrained, not constrained)
- Circuit Reliability Performance (high, moderate, low)

Critical Infrastructure and Services Criteria

- Serves a federal, state, and/or utility defined critical customer and/or facility.
- Serves a dual purpose as an emergency shelter and/or emergency operations center (Y/N)
- Concentration of critical facilities (high, moderate, limited)

Natural Hazards Criteria

- Natural hazard risk (high, medium, low)
- Located within a FEMA-designated Community Disaster Resilience Zone

Energy Equity and Environmental Justice Criteria

- Located within an Environmental Justice Area as defined by PennEnviroScreen 2023
- Located within a Disadvantaged Community (census tract) as defined by the Climate and Economic Justice Screening Tool (CEJST) developed by the White House CEQ
- Located within a census tract that has an energy burden of at least 5%.
- Located within an Inflation Reduction Act-defined energy community.
- Located within a county with Medicare beneficiaries that rely upon power-dependent medical equipment.
- Located in a census tract that meets the CDFI's New Market Tax Credit Program's threshold for Low Income, and thereby are able to apply to Category 1 of the IRA Low-Income Communities Bonus Credit Program
- Located in a county that meets the USDA's threshold for Persistent Poverty

Source: Smart Electric Power Alliance, 2024

Site selection criteria are developed based on utility and non-utility datasets identified by DEP and key stakeholders, with each criterion associated with a specific geospatial information systems (GIS) layer and data source.

Data Collection for Site Selection Criteria

Critical Infrastructure & Services

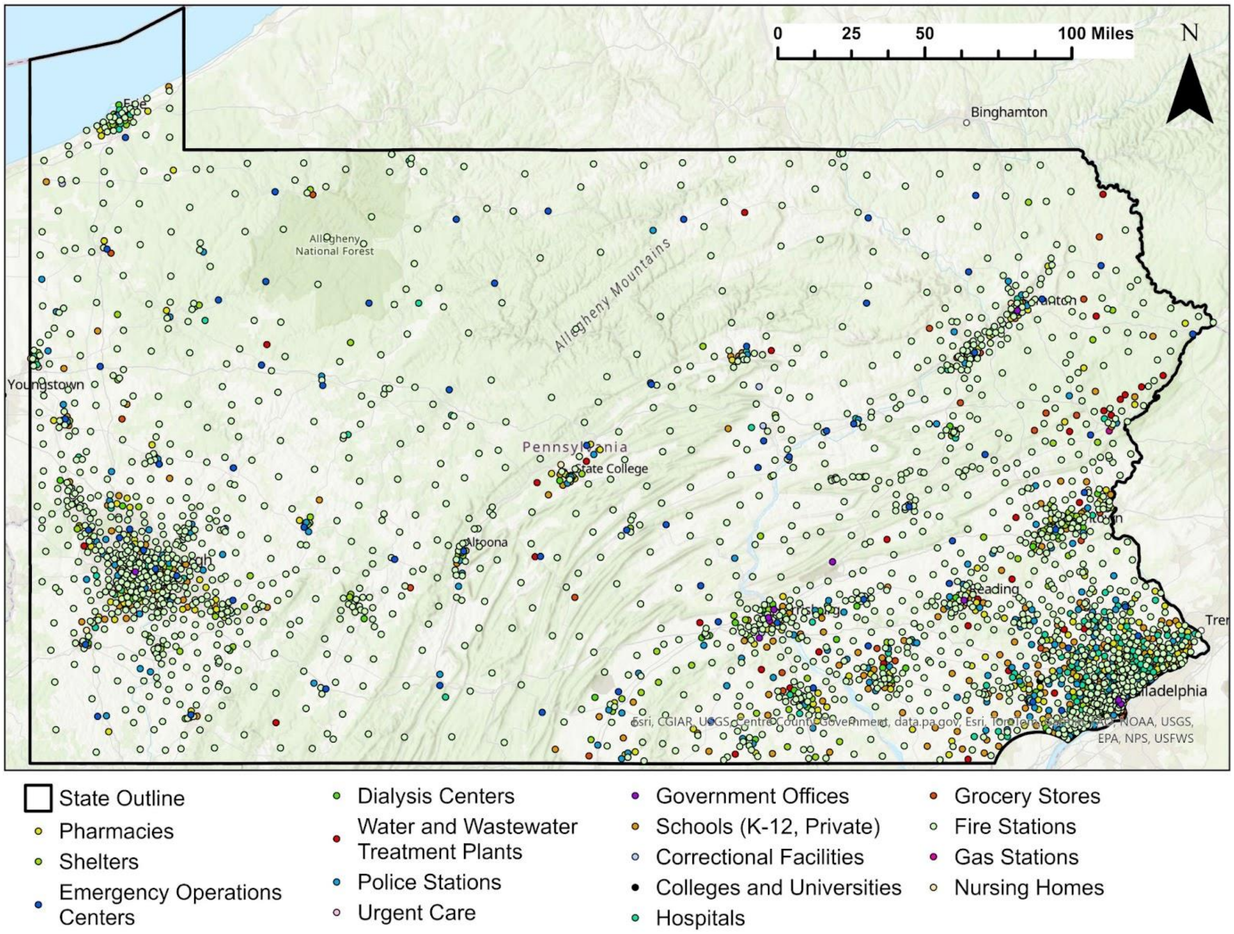
Critical infrastructure and services are identified according to state, federal, and EDC definitions. This category includes facilities such as fire stations, hospitals, water and wastewater treatment plants, communication towers, police stations, nursing homes, urgent care centers, dialysis centers, grocery stores, correctional facilities, pharmacies, schools, gas stations, and government offices. Places of worship were identified as well but were included under shelters due to their potential to act community meeting places. Facilities that also serve as emergency shelters or emergency operations centers receive higher scores due to their dual purpose in providing critical services during emergencies. As part of the data collection process, SEPA cleaned the critical infrastructure data to ensure that the sites corresponded to verifiable geographic locations.[9] In the process of cleaning and consolidating critical facility data from HIFLD, SEPA found that many addresses and locations were incomplete. As a result, communication towers were excluded from the scope of the analysis of the study as there were no identifiable names or addresses in the HIFLD database. SEPA recommends that PA DEP and stakeholders work together to compile an updated and accurate dataset so this analysis can be applied to all critical facilities across the state.

Table 3: Critical Infrastructure Data Layers

Critical Infrastructure and Services	
Site Selection Criteria	**GIS Layers and Data Sources Layer**
Critical Facility. Serves a federal, state, and/or utility-defined critical customer and/or facility	*Examples*. PA DEP's scored critical facilities dataset, state databases, utility databases, national databases
Dual Purpose. Serves a dual purpose as an emergency shelter and/or emergency operations center	*Examples*. Homeland Infrastructure Foundation-Level Data (HIFLD), American Red Cross, Utility Data
Critical Facility Concentration. Concentration of critical facilities (high, moderate, limited)	*Examples*. Number of critical facilities located on a single circuit

[9] SEPA collected data on communication towers as well but in the process of data cleaning, none of the identified communication towers across the state had verifiable location information so they were not included in the microgrid deployment scenarios. The communication tower data sets that were collected were not complete and one of the findings of the study is that they state

Figure 9: Pennsylvania Critical Facilities



Source: Smart Electric Power Alliance, 2024

Utility Planning and Operations

Evaluating utility system data such as reliability metrics, hosting capacity analysis, and load forecasts helps identify system vulnerabilities where resilience investments can provide significant value.

Utility planning and operations are assessed by examining utility distribution circuit reliability performance and hosting capacity constraints, considering historical outages, projected loads, and circuit voltage levels. Data provided by EDCs across the state inform this evaluation, though the availability of data varies by service territory. In areas where EDC-provided data is unavailable, scoring is based on other factors such as critical infrastructure, natural hazard risk, energy equity, and environmental justice.

The table below illustrates the utility operations and planning data incorporated into the resilience needs score. Capacity-constrained circuits and those with low reliability performance are identified as areas with high suitability for microgrid deployment.

Table 4: Utility Operations and Planning Data Layers

Utility Operations and Planning	
Site Selection Criteria	**GIS Layers and Data Sources**
Hosting Capacity Constraints: Whether a circuit is constrained or not constrained in its hosting capacity.	*Examples*: Constrained hosting capacity by circuit; low voltage circuits at risk of hosting capacity constraints.
Circuit Reliability Performance: The reliability performance of utility circuits, categorized as high, moderate, or low.	*Examples*: Historical Customer Average Interruption Duration Index (CAIDI) statistics by utility circuit

Natural Hazards

Natural hazards such as drought, floods, freezing temperatures, severe storms, tropical cyclones, wildfires, and winter storms continue to cause significant damage and loss of life. The parts of the system and communities most at risk from these extreme weather events stand to benefit the most from increased resilience measures.

In Pennsylvania, the most relevant natural hazards are identified based on criteria from the Federal Emergency Management Agency (FEMA) and the Pennsylvania Emergency Management Agency (PEMA) 2023 State Hazard Mitigation Plan. Additionally, an extra weighting is applied if a facility is located within a FEMA-designated Community Disaster Resilience Zone, further indicating the need for resilience investments.

The table below outlines the natural hazard data incorporated into the resilience needs score. Areas with high natural hazard risk and those within a Community Disaster Resilience Zone are prioritized for microgrid suitability, as they represent locations where resilience improvements can have the most significant impact.

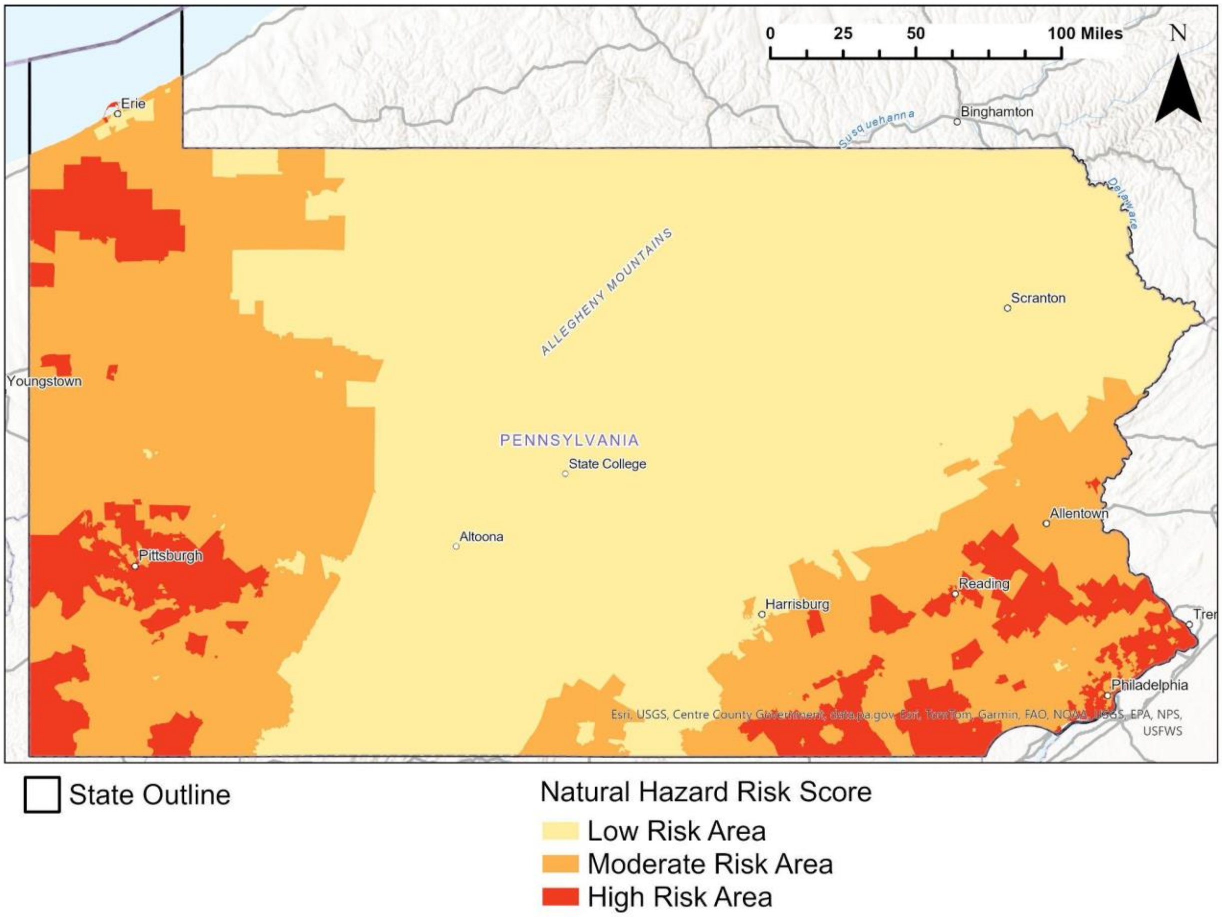
Table 5: Natural Hazard Risk Data Layers

Natural Hazard Risks	
Site Selection Criteria	**GIS Layers and Data Sources Layer**
Natural Hazard Risk: The level of risk from natural hazards, categorized as high, medium, or low.	*Examples*: Federal Emergency Management Agency (FEMA) Overall Natural Hazard Frequency[10] from FEMA NRI Database FEMA NRI Database, National Oceanic and Atmospheric Administration (NOAA)'s National Centers for Environmental Information (NCEI) Database), FEMA's National Flood Hazard Layer, via HIFLD
Community Disaster Resilience Zone: Whether the facility is located within a FEMA-designated Community Disaster Resilience Zone	*Examples*: FEMA Community Disaster Resilience Zones platform

[10] Annualized Frequency by Natural Hazard Risk by probability (low, medium, high). Hazards included in the ranking are drought, cold wave, heat wave, hail, hurricane, landslide, lightning, tornado, strong wind, wildfire, winter weather, earthquake, riverine flooding, and coastal flooding.

The map below shows natural hazard scores by census tract across the state, highlighting areas where microgrid deployment may be most beneficial due to high natural hazard risks.

Figure 10: Pennsylvania Census Tract Natural Hazard Risk Scores



Source: Smart Electric Power Alliance, 2024

Energy Equity & Environmental Justice

Energy equity and environmental justice have become central to energy planning at both the state and federal levels, with a focus on prioritizing clean and resilient investments in EJ communities that are often disproportionately affected by power disruptions.

These communities face disproportionate environmental and financial burdens as a result of historic socioeconomic inequities and discriminatory policy decisions, that disenfranchise specific groups to the benefit of another. Legacy impacts of these practices typically persist long after the statutes which created them are repealed or replaced. Often, these socioeconomic inequities lead to increased exposure to environmental hazards, where the community may not have the political sway to push for better protection/services, or in instances where the threat is caused by a critical source of economic activity and employment for the region.

As a result, some Pennsylvanians are more vulnerable to environmental and energy system threats because of where they live, the type of home they live in, their income level and degree of mobility, among other factors. At the same time, they have limited access to tools to adapt to impacts and transition to cleaner energy. As the climate continues to heat up, this vulnerability will deepen, unless environmental justice actions are prioritized.

In Pennsylvania, energy equity and environmental justice are assessed using widely recognized federal and state definitions of vulnerable populations and EJ communities. These definitions help identify areas where resilience investments, such as microgrids, are most needed to protect and empower these communities.

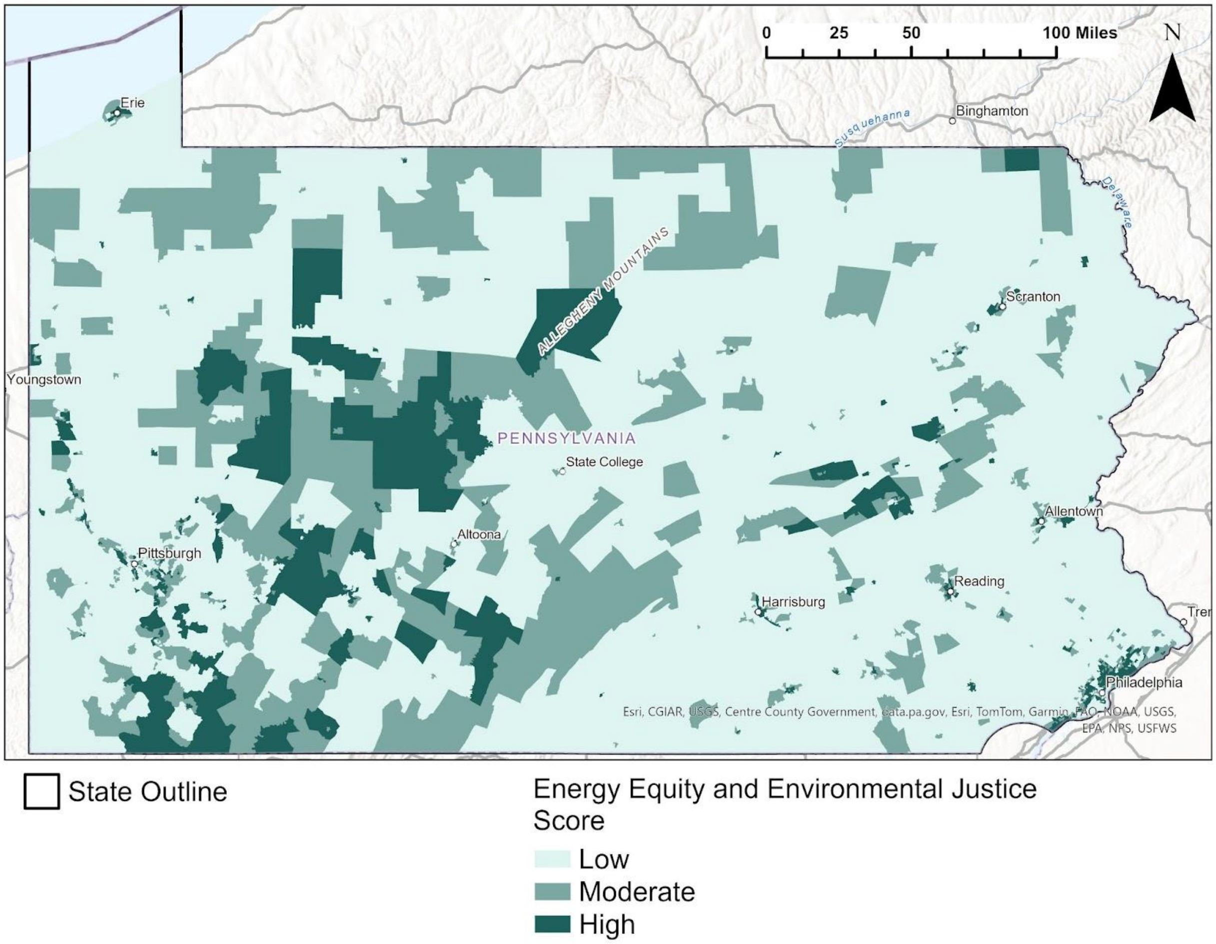
The table below outlines the energy equity and environmental justice criteria incorporated into the resilience needs score. Areas with high scores in these categories are considered highly suitable for microgrid implementation due to their increased vulnerability and the potential benefits of resilience investments.

Table 6: Energy Equity and Environmental Justice Data Layers

Energy Equity and Environmental Justice	
Site Selection Criteria	**GIS Layers and Data Sources Layer**
Environmental Justice Area: Located within an Environmental Justice Area as defined by PennEnviroScreen 2023	*Examples*. PennEnviroScreen 2023 Environmental Justice Areas (PA DEP)
Disadvantaged Community: Located within a Disadvantaged Community (census tract) as defined by the Climate and Economic Justice Screening Tool (CEJST) developed by the White House Council on Environmental Quality (CEQ)	*Examples*. White House CEQ's CEJST-defined DACs (Climate and Economic Justice Screening Tool, November 2022)
Energy Burden. Located within a census tract that has an energy burden of at least 5%	*Examples*. US Department of Energy's LEAD TOOL
Energy Community. Located within an Inflation Reduction Act-defined energy community	*Examples*. U.S. DOE Energy Community Tax Credit Bonus Map
Medicare Beneficiaries. Located within a county with Medicare beneficiaries that rely on power-dependent medical equipment.	*Examples*. US Department of Health and Human Services
Low-Income Community: Located in a census tract that meets the Community Development Financial Institutions Fund (CDFI)'s New Market Tax Credit Program's threshold for Low Income, qualifying for the IRA Low-Income Communities Bonus Credit Program.	*Examples*. CDFI's New Market Tax Credit Program (NREL's Data Catalog
Persistent Poverty: Located in a county that meets the United States Department of Agriculture (USDA)'s threshold for Persistent Poverty	*Examples*. USDA Persistent Poverty Counties (NREL's Data Catalog)

The map below displays energy equity and environmental justice scores by census tract across the state, highlighting areas where microgrid deployment could significantly enhance resilience and support vulnerable populations.

Figure 11: Pennsylvania Census Tract Energy Equity and Environmental Justice Scores



Source: Smart Electric Power Alliance, 2024

Stakeholder Engagement for Site Selection Criteria

After gathering data from state and federal agencies, SEPA and DEP worked closely with stakeholders to refine the resilience scoring formula. Through a comprehensive survey, stakeholders assigned quantitative resilience scores to each key criterion: criticality of facilities, severity of natural hazards, and the priority of energy equity and environmental justice metrics. These scores were then used to establish weightings for each criterion, forming the basis for evaluating a site's potential for microgrid deployment.

Ranking Critical Facilities and Distribution Circuits

Using this scoring method, SEPA and DEP ranked critical facilities across Pennsylvania by drawing on data from EDCs and publicly available federal and state datasets. Each critical facility was assessed based on its criticality, natural hazard risk, grid reliability, distributed energy resource hosting capacity, and considerations of energy equity and environmental justice. This approach ensured a comprehensive and geographically consistent evaluation across different areas.

For potential microgrid projects located in front of the customer's meter on distribution circuits, SEPA extended this scoring to include distribution circuits themselves. Scores were assigned based on the concentration of critical facilities, natural hazard risk, grid reliability, hosting capacity, and energy equity and environmental justice. This allowed SEPA to thoroughly rank sites according to their suitability for microgrid deployment, offering a clear prioritization of locations most in need of resilience investments.

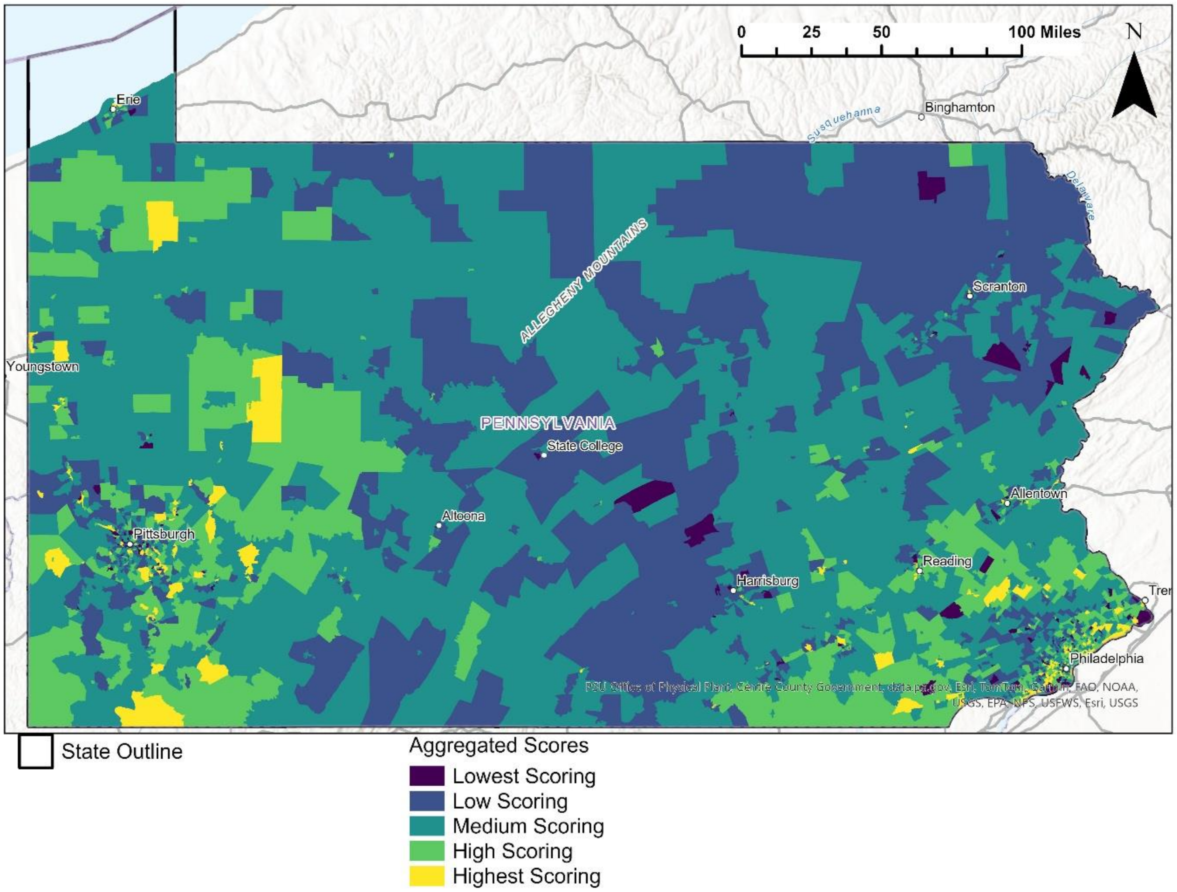
Table 7: Site Selection Criteria

Site Suitability Criteria	Sub Criteria
Critical Infrastructure and Services (Up to 30 points)	• Criticality of facilities • Dual purpose as an emergency shelter • Concentration
Utility Planning and Operations (Up to 25 points)	• Electricity circuit reliability • Hosting capacity constraints
Natural Hazards (Up to 20 points)	• Natural hazard risk • FEMA Community Disaster Resilience Zone
Energy Equity and Environmental Justice (Up to 25 points)	• Environmental Justice Area • Disadvantaged Community • Energy Burden • Energy Community • Medicare Beneficiaries • Low-Income Community • Persistent Poverty

Source: Smart Electric Power Alliance, 2024

The map below displays the combined site selection scores by census tract across the state, highlighting areas where microgrid deployment could significantly enhance resilience and support vulnerable populations.

Figure 12: Pennsylvania Census Tract Combined Site Selection Scores



Source: Smart Electric Power Alliance, 2024

Visualization and Mapping Tools

The scoring process resulted in a prioritized list of microgrid locations across the state. To make these results accessible and actionable, the project team visualized the prioritized microgrid locations and all associated resilience factors using Esri's ArcGIS StoryMaps platform.[11]

This StoryMap guides users through the analysis, providing relevant information and interactive maps that allow stakeholders to explore each criterion used in calculating resilience needs scores. Stakeholders can view a final map of prioritized microgrid locations and all of their associated resilience factor layers and have the option to download the geospatial data directly from Esri's platform. This capability enables the integration of resilience data into planning processes, empowering stakeholders to make informed decisions and implement resilience strategies effectively. By using the StoryMap, stakeholders can gain a deep understanding of the resilience analysis results, which are essential for guiding their planning efforts.

[11] Safeguarding Pennsylvania: Resilient Microgrids in our Communities Study Mapping Tool

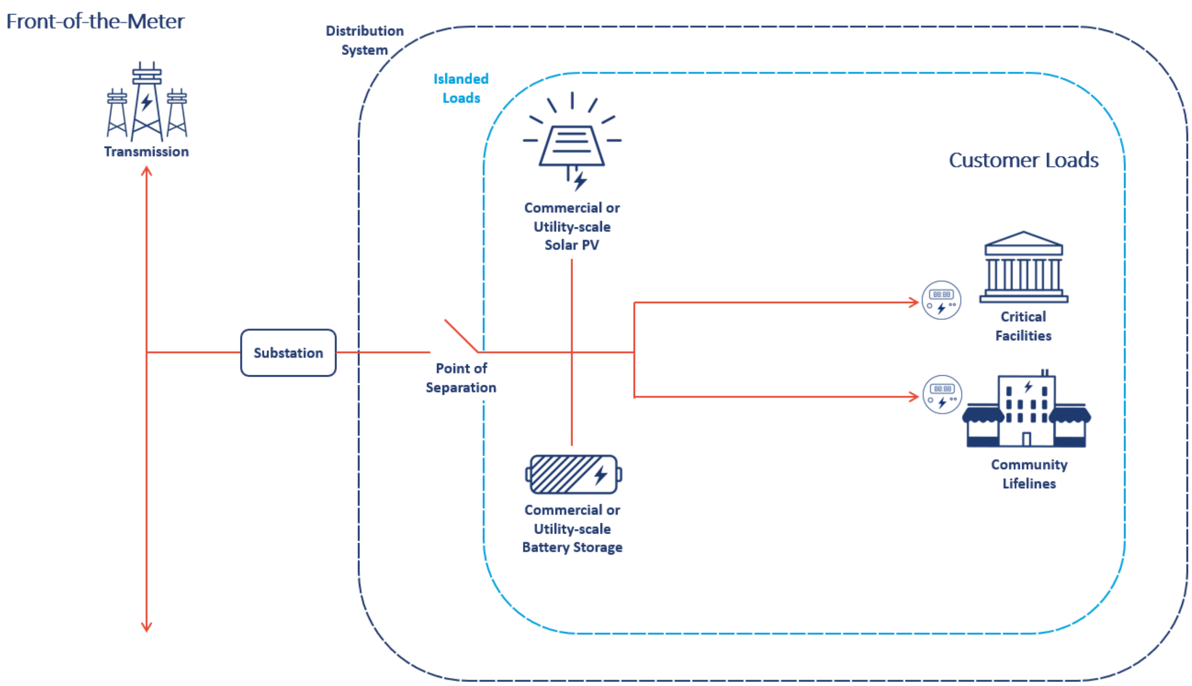
Microgrid Deployment Strategies

SEPA and DEP have identified two key microgrid deployment strategies to maximize benefits for communities, customers, and utilities: Front-of-the-Meter (FTM) Community Microgrids and Behind-the-Meter (BTM) Microgrids.

Front-of-the-Meter (FTM) Community Microgrids

Community microgrids integrate DERs like solar PV, battery storage, and backup generators in front of customers' meters, offering direct energy and resilience benefits to several critical facilities or sections of the distribution grid. Community microgrids can offer increased resilience that supports a broader group of customers by linking multiple customers to one system. Where multiple critical facilities are located within close geographic proximity of each other, it provides an opportunity to explore resilience hubs or Front-of-the-Meter Community microgrids to provide economies of scale and maximize community benefits systems can be best suited towards communities that have a high concentration of critical facilities with poor reliability, whereby various critical facilities can aggregate resources to mitigate disruptions. With that said, aggregating loads and resources from different facilities can prove complex and cost-intensive to implement, which has led to greater regulatory hurdles.

Figure 13: Community Microgrid Deployment Strategies

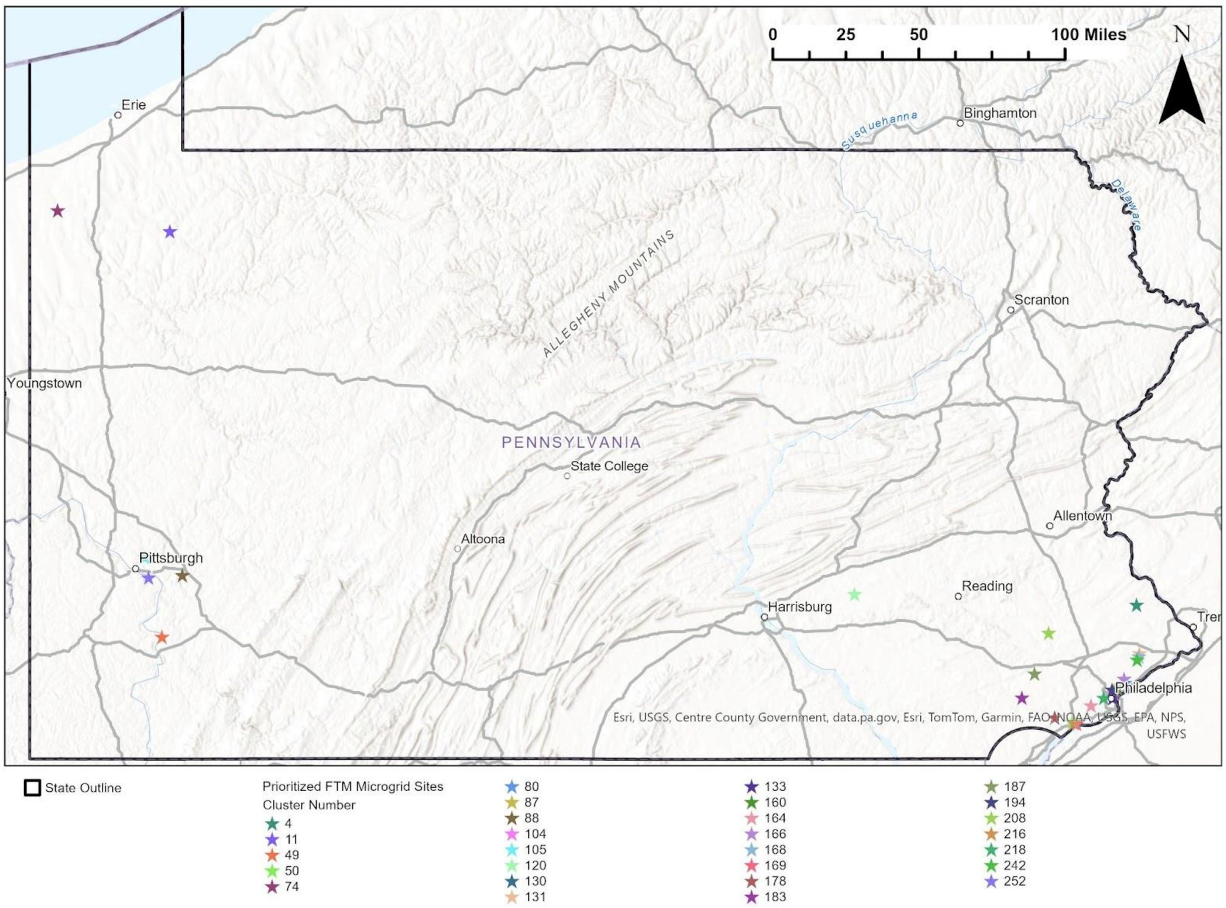


Source: Smart Electric Power Alliance, 2024

FTM Deployments

GIS-based siting analysis has pinpointed 28 potential FTM microgrid systems across Pennsylvania, each designed to enhance grid reliability and community resilience. These microgrids are strategically positioned to serve clusters of critical facilities within a 1,500-foot proximity on the same circuit, including FEMA-defined community lifelines, resilience hubs, essential businesses, and other critical infrastructure. Additionally, community microgrids may serve rural and/or remote communities at the end of a utility's feeder. Community microgrids may also be sited to defer traditional utility reliability and capacity investments by installing local power generation and energy storage to provide grid reliability, capacity, and other distribution services.

Figure 14: Prioritized Community Microgrid Deployment Locations

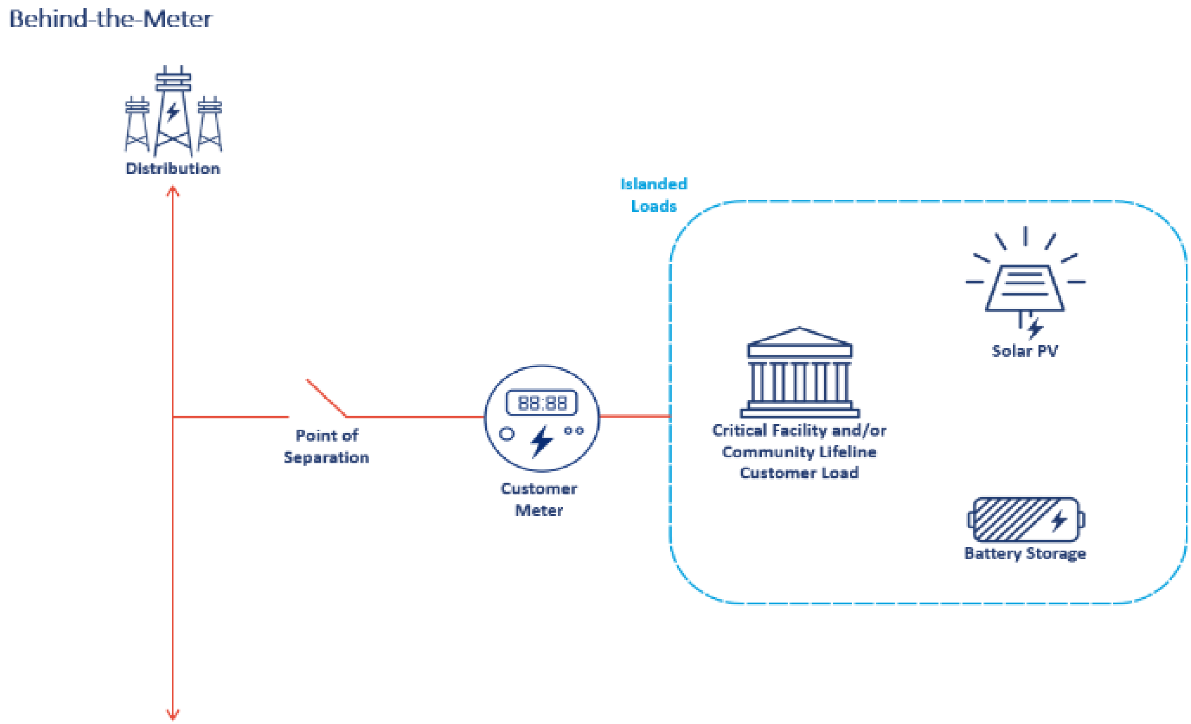


Source: Smart Electric Power Alliance, 2024

Behind-the-Meter (BTM) Microgrids

BTM microgrids offer direct energy and resilience benefits tailored to single customers by incorporating DERs behind their meters. These microgrids are ideal for large standalone facilities or geographically isolated sites, providing a cost-effective and scalable resilience solution that ensures continuity during grid disruptions. BTM microgrids are often relatively simple and easy to implement solutions as compared to community microgrids. They are best suited towards areas with a low concentration of critical facilities and for customers that are interested in lower cost solutions and that are deployed expeditiously as community microgrids can be slowed by the coordination from multiple stakeholders.

Figure 15: BTM Microgrid Deployment Strategies



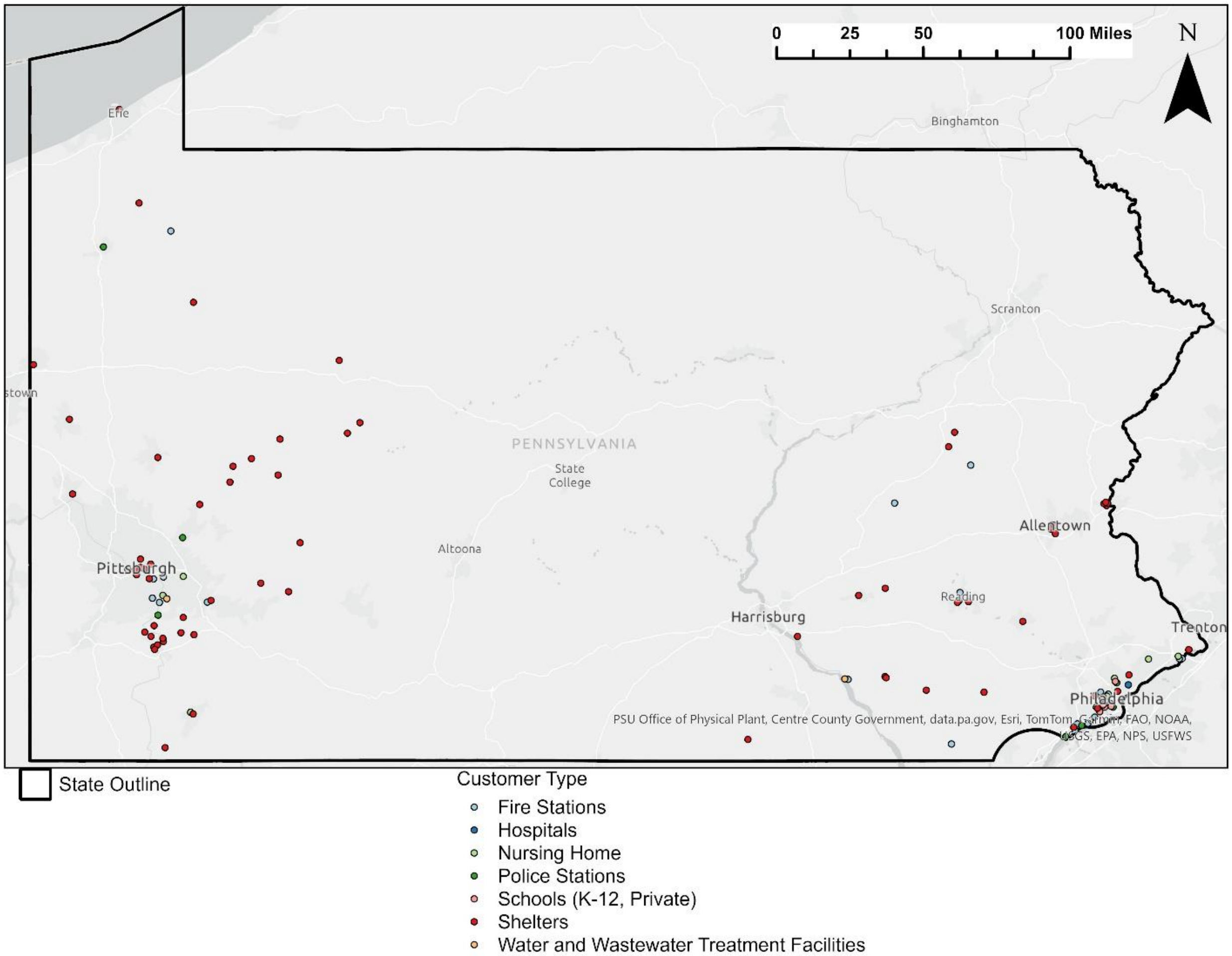
Source: Smart Electric Power Alliance, 2024

BTM Deployments

SEPA has identified priority locations for BTM microgrids at 240 critical facilities in Pennsylvania. These systems are grid-tied and are often owned and operated by the end-use customer. In certain jurisdictions, joint ownership and regulatory frameworks allow for end-use customer resilience during emergency operations, and grid reliability and capacity services during normal grid operations. On April 4th, the PUC issued a policy statement allowing the EDCs to be able to use energy storage to address reliability on their distribution systems. The notice provided important clarity around the potential for utilities to use energy storage as a tool to address/bolster system resilience and reliability.[12]

[12] PUC Finalizes Policy Statement on Use of Electric Storage to Enhance Grid Reliability and Resilience (2024)

Figure 16: Prioritized BTM Microgrid Deployment Locations



Source: Smart Electric Power Alliance, 2024

Microgrid Use Cases and Scenarios

SEPA modeled three conceptual microgrid design scenarios—Low, Mid, and High Renewable—across 16 critical facility use cases using Xendee, an industry leading microgrid design and economic analysis tool. These scenarios included upfront capital expenditure (CAPEX) and yearly operating expenditures (OPEX) of incorporating resources to meet those scenarios. These scenarios are designed to guide Pennsylvania stakeholders in developing deployment plans that align with their specific goals, balancing cost, sustainability, and resilience. SEPA's approach ensures each microgrid is optimally sized to meet the specific load requirements of each critical facility, balancing lifecycle costs and applicable investment tax credits with the resilience and sustainability needs of the customer. Appendix X: Detailed Load, Sizing, and Cost Analysis shows specific critical facility use cases for BTM microgrids.

Low Renewable Scenario

- **Resilience**: Up to 4 hours of clean energy resilience using the solar PV and a 4-hour Lithium-Ion (Li-ion) battery energy storage system (BESS) with an option to provide ongoing energy resilience if paired with a diesel or natural gas standby generator.
- **Operational Focus**: During normal grid operations, the system will prioritize reducing energy costs by using solar PV and BESS to offset grid electricity usage. In emergency situations, the battery will maintain a reserve charge, ready to provide immediate backup power. If a prolonged outage occurs, the system can seamlessly switch to a standby generator to maintain critical operation.

Mid Renewable Scenario

- **Resilience**: At least 12 hours of clean energy resilience using the solar PV and a 4-hour Li-ion BESS with an option to provide ongoing energy resilience if paired with a diesel or natural gas standby generator.
- **Operational Focus**: Under normal conditions, the solar PV and BESS will work together to reduce energy costs, with the BESS providing load-shifting and peak shaving capabilities. In the event of a grid failure, the system will ensure a longer period of resilience, maintaining essential operations for up to 12 hours using stored energy. A standby generator can extend this resilience further, ensuring continuity of operations during prolonged outages.

High Renewable Scenario

- **Resilience**: At least 24 hours of clean energy resilience using the solar PV and a 4-hour Li-ion BESS, with net-zero annual load generation.
- **Operational Focus**: During normal operations, the solar PV system will generate sufficient power to meet 100% of the critical facility's annual energy needs, with any excess stored in the BESS for later use or fed back into the grid. In a grid-down situation, the system will prioritize maintaining critical loads for at least 24 hours using the stored energy. The BESS will be optimized to manage energy flows efficiently, and in cases of extended outages, a standby generator can provide additional support to ensure uninterrupted service.

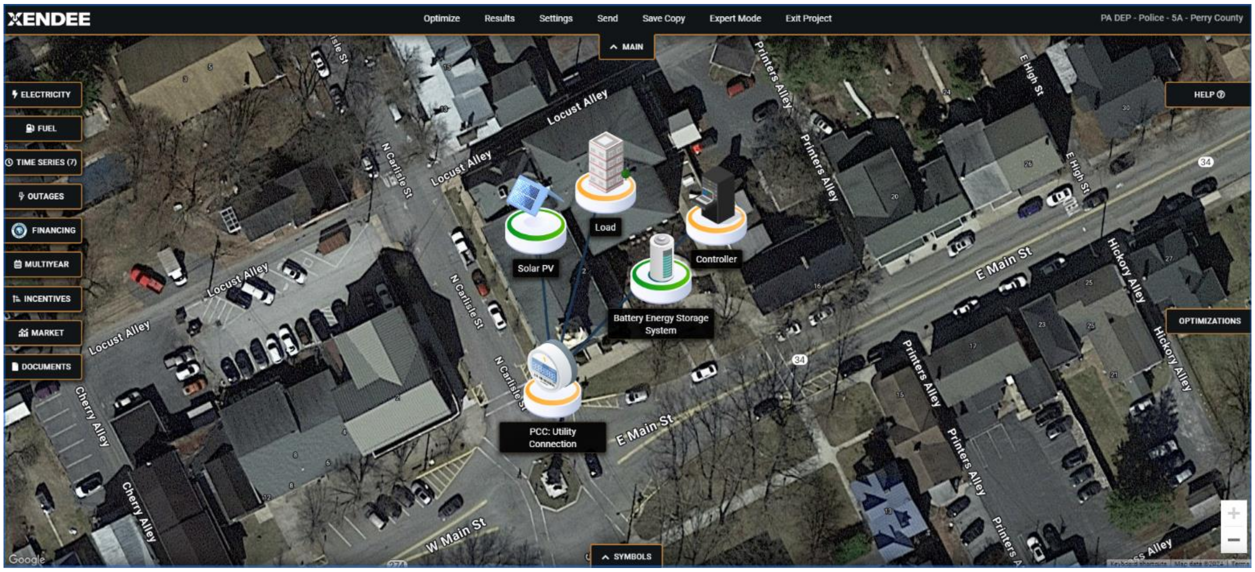
- Projected Emissions: Low
- Projected Cost: High
- Renewable Islanding: 24 hour

Appendix X: Detailed Load, Sizing, and Cost Analysis details the size and cost variability of microgrid deployments per the level of renewable integration and the type of facility. For example, the High Renewable scenario for a hospital might require a 3.36 MW solar PV system with a 4-hour 6.75 MWh Li-ion BESS and an upfront CAPEX of approximately $8.6 million. In contrast, the Low Renewable scenario for a pharmacy might require a 167-kW solar PV system with a 4-hour 322 kWh Li-Ion BESS and a CAPEX of approximately $435,000. The variability demonstrates the assumptions present in the study and the importance of tailoring microgrid solutions to meet the specific customer needs.

Illustrative Police Station Microgrid Use Case

This study identifies potential microgrid technology scenarios for 16 use cases, corresponding to 16 critical facility types. For each use case, there are three modeled technology scenarios capable of providing uninterrupted power to a facility during an outage lasting 4, 12, or 24 hours on a typical day during the month in which the facility’s annual demand peak occurs.

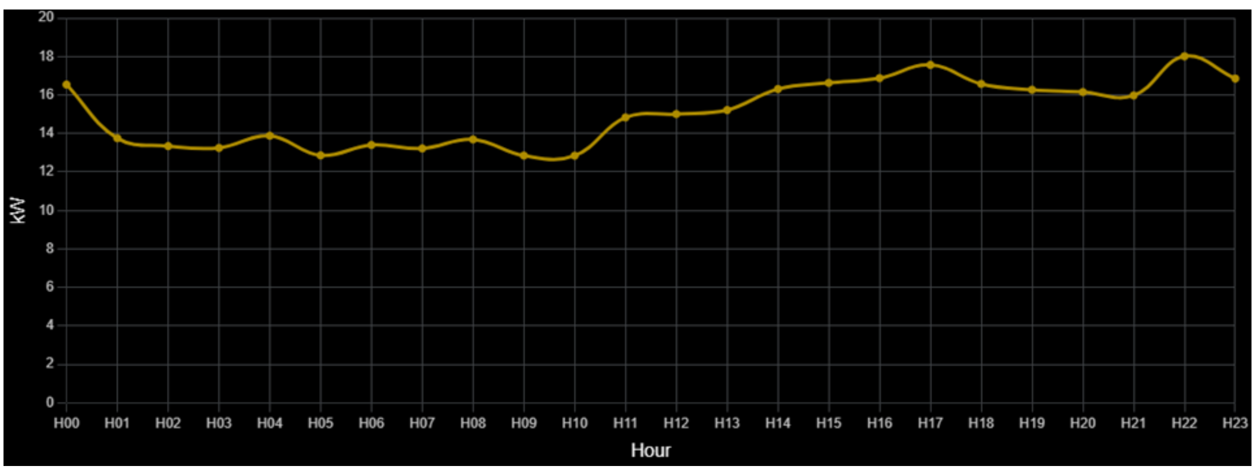
Figure 17: Xendee Screenshot of Police Station Microgrid Use Case in Perry County, PA



Source: Xendee, 2024

Each microgrid technology scenario has a unique electricity dispatch profile depending on the facility type, proposed DER assets, time of year, and type of day. As an example, the chart below shows actual the average hourly demand peaks for police station in Perry County during the month of July (e.g., the month during which the annual demand peak occurs).

Figure 18: Hourly Peak Demands of Policy Station in Perry County During July Summer Peak



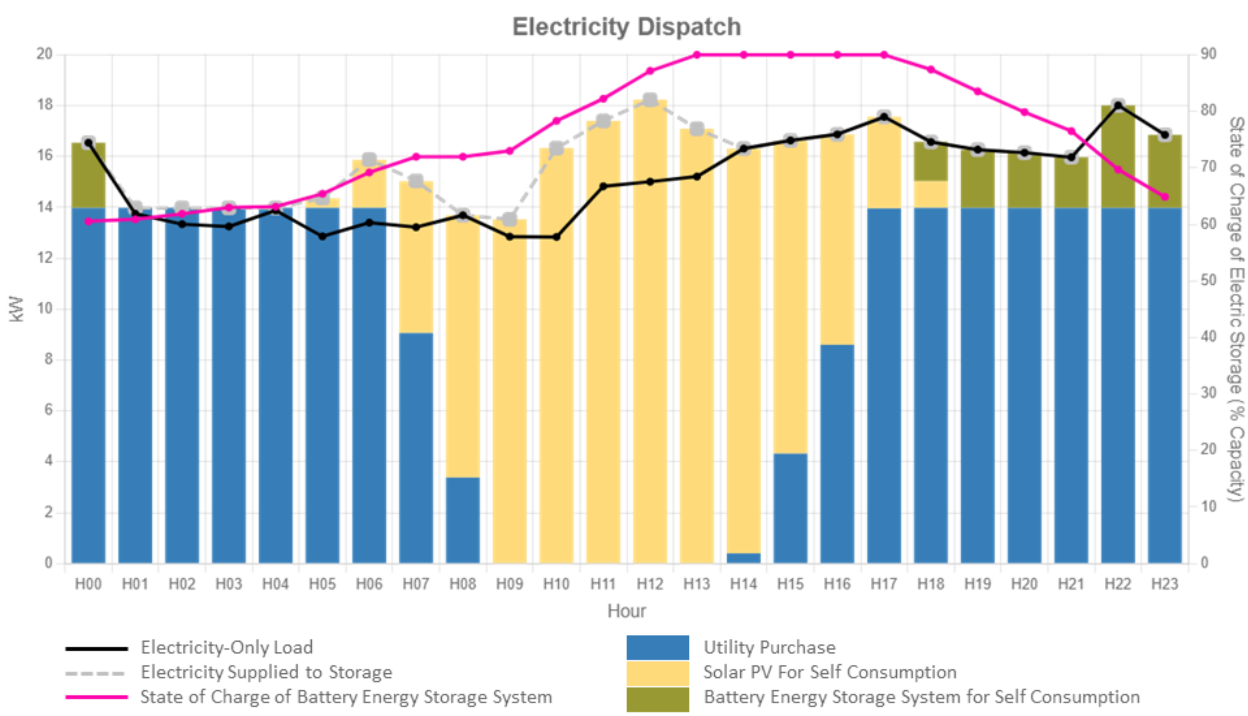
Source: Xendee, 2024

The two example electricity profiles below assume a mid-renewable scenario for the police station. This mid-renewable scenario is able to provide 12-hours of ride-through capacity to a police station during the peak month utilizing approximately 35 kW of solar PV and 62.3 kWh of BESS. To reference all 16 use cases and each microgrid scenario's detailed load, sizing, and cost analysis, see Appendix X: Detailed Load, Sizing, and Cost Analysis.

The chart below shows hourly electricity dispatch during normal operations during a theoretical peak day (i.e. each hour during the day is sized to the monthly peak for that hour) at the police station during the month of July. This example highlights the following common features of the normal operation electricity dispatch of each microgrid scenario:

- On-site solar PV generation meets a significant amount of the facility's demand during daytime outage hours.
- Excess solar PV generation is used to charge the on-site BESS for usage as the sun sets and generation wanes.
- The on-site BESS is strategically discharged to meet facility's demand during afternoon outage hours when solar PV is unable to completely meet the site's demand.
- While the BESS is only partially charged at the onset of the outage, excess solar PV generation ensures that it is fully charged during the daytime.

Figure 19: Normal Operation Hourly Electricity Dispatch for Police Station Microgrid Use Case



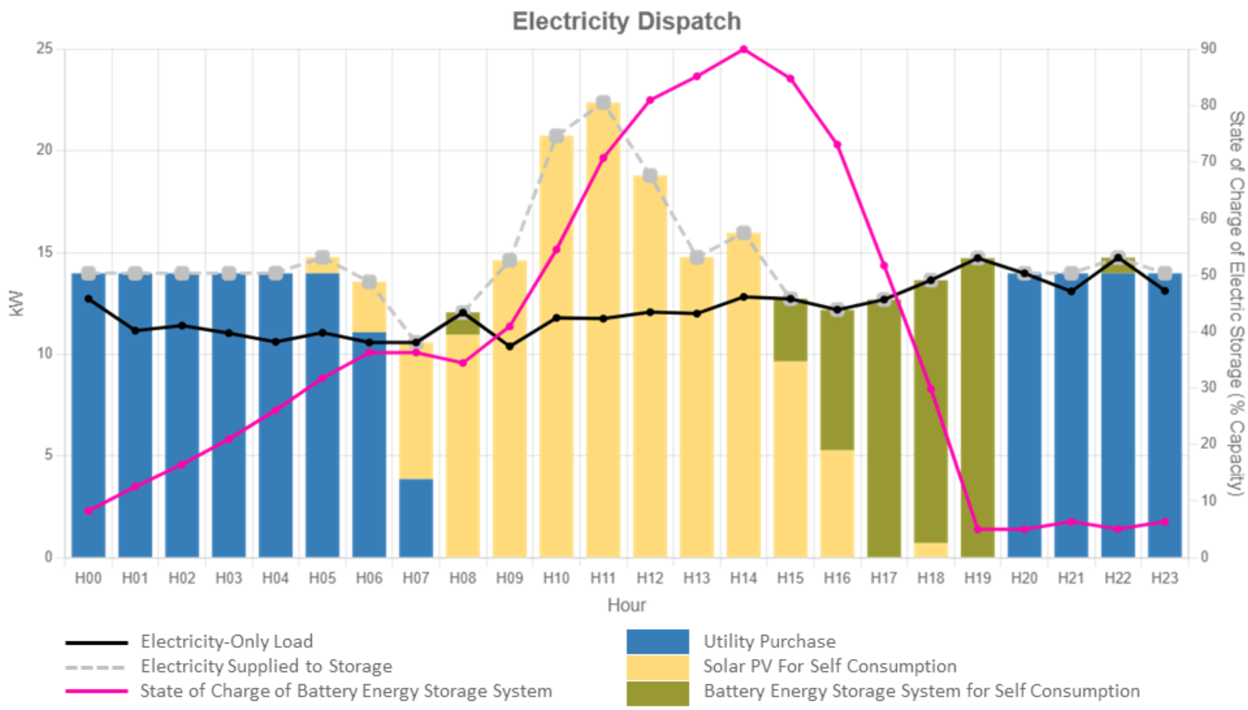
Source: Xendee, 2024

The chart below shows hourly electricity dispatch during a 12-hour emergency outage event in July lasting from 8am to 8pm at the police station in Perry County. This example highlights the following common features across the emergency operation electricity dispatch of each microgrid scenario:

- On-site solar PV generation meets a significant amount of the facility's demand during daylight hours.
- Excess solar generation can be used to charge the on-site BESS.
- Assuming regular grid operation, the on-site BESS can meet some of the facility's demand during shoulder- or nighttime hours when solar PV is unable to meet the site's demand.

- Electricity is primarily purchased from the utility during off-peak hours, which can further reduce energy costs for facilities that are on a time-of-use rate.

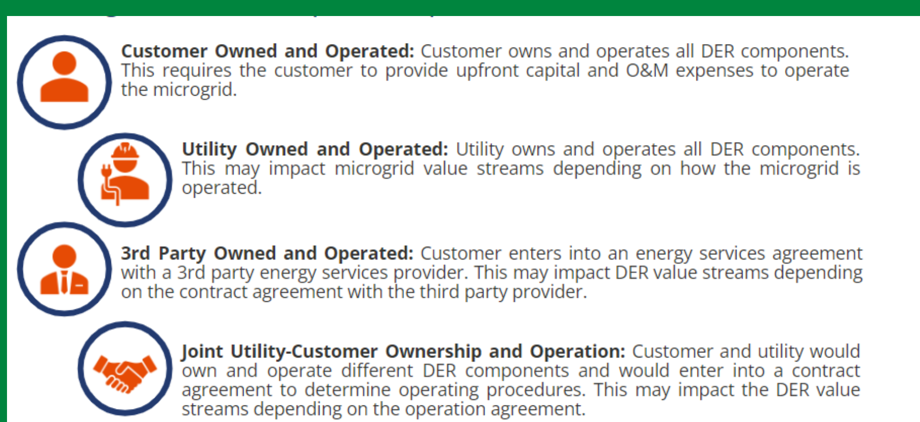
Figure 20: Emergency Operation Hourly Electricity Dispatch for Police Station Microgrid Use Case



Source: Xendee, 2024

Microgrid Ownership and Operation Structures

While determining ownership and operation structures is outside the scope of the study, various ownership and operation structures are listed below or stakeholders to consider when considering the regulatory and legal implications of microgrid implementation are listed below.



Microgrid Deployment Action Plan

SEPA and DEP created this action plan to facilitate the planning, funding, and implementation of microgrid projects across Pennsylvania. It is intended to align enhancing distribution system and customer resilience and to ensure that the proposed project sites and areas align with state policy objectives and stakeholder priorities.

Leverage the Study as a Strategic Planning Resource

- **Review the Study Findings:** Begin by reviewing the Safeguarding Pennsylvania: Resilient Microgrids in our Communities Study to understand the identified microgrid opportunities, prioritized sites, and use cases. This study offers a comprehensive analysis of Pennsylvania's energy landscape, regulatory environment, and resilience needs.
- **Integrate Study Data into Planning Processes:** Use the geospatial data, maps, and scoring criteria from the study to guide infrastructure planning and decision-making. The study's prioritized microgrid locations, along with data on critical infrastructure, natural hazard risks, and energy equity considerations, should be central to identifying where and how to allocate resources effectively.
- **Prioritize Projects Using Study Data:** Leverage the resilience needs scores developed in the study to prioritize microgrid projects that align with state policy objectives, grid reliability, resilience, ratepayer impacts, scalability, regulatory compliance, and stakeholder input. This data-driven approach ensures that proposed microgrid projects meet regulatory criteria, increasing the likelihood of their approval.

Engage Stakeholders to Drive Microgrid Project Opportunities

- **Convene Stakeholder Meetings:** Organize meetings with key stakeholders—including the PA PUC, utility companies, local governments, and community organizations—to discuss the study's findings and ensure alignment on priorities and potential win-win projects. Given the complexity of microgrid systems, continuous engagement is crucial for aligning project priorities with community needs, pooling resources, and reducing risks.
- **Collaborate on Resilience Planning:** Work with state agencies, local governments, utilities, and community organizations to integrate the study's insights into broader resilience planning efforts. The study provides a roadmap for targeting investments in areas with natural hazard risks, reliability constraints, and underserved communities. By leveraging this data and securing federal funding, stakeholders can effectively plan and implement microgrid systems that enhance the resilience of Pennsylvania's energy infrastructure.
- **Build Consortiums:** Identify key stakeholders and define each member's roles and responsibilities. Leveraging the data and stakeholder engagement from this study, collaborate to identify project opportunities and to secure funding from state and federal grants, investment tax credits, and private capital, and pool resources to optimize costs.

Figure 21: Partnerships and Key Stakeholder Cycle to Identify Project Opportunities

Source: Smart Electric Power Alliance, 2024

Develop and Implement Microgrid Projects

- **Target High-Priority Areas:** Focus on the top-ranked microgrid sites identified in the study. Utilize the study's detailed site selection criteria to choose locations with the greatest potential for enhancing resilience, particularly in areas with critical infrastructure and high natural hazard risks.
- **Design Tailored Microgrid Solutions:** Use the study's microgrid use cases and scenarios to design systems that meet the specific resilience, cost, and sustainability goals of each site. Consider the Low, Mid, and High Renewable scenarios provided in the study to determine the most appropriate configuration for each project.
- **Conduct Engineering Studies:** Carry out detailed engineering and feasibility studies at prioritized sites before implementation. These studies should include technical assessments, economic analysis, and evaluations of potential operational challenges, using the study's data as a benchmark.

Secure Funding, Incentives, and Engage Private Capital

- **Apply for State and Federal Grants:** Utilize the study's findings to evaluate and apply for state and federal funding opportunities that can reduce financial burdens and increase project feasibility. The raw data from the study, including resilience needs scores and critical infrastructure information, is ideal for justifying project benefits in funding applications. See additional information on state and federal grants in Appendix Y: Incentives, Grants, and Partnerships for Project Development.
- **Leverage Investment Tax Credits (ITC):** Maximize the financial feasibility of your projects by taking advantage of ITCs available through the Inflation Reduction Act. Ensure your projects meet the necessary requirements to qualify for these credits, which can significantly enhance the value proposition of microgrid projects. See additional information on ITC in Appendix Y: Incentives, Grants, and Partnerships for Project Development.
- **Engage Private Capital:** In addition to public funding, seek out private capital from foundations, non-profits, and financial institutions. Present a strong case using the study's data to attract private investment in microgrid projects, focusing on the potential for resilience, community benefits, and return on investment.

Appendix X: Detailed Load, Sizing, and Cost Analysis

This appendix includes the detailed load analysis, sizing, and economic analysis for site-specific microgrids. For community microgrids, load analysis, sizing, and economic analysis will vary by the types and number of facilities within the community microgrid. For both site-specific and community microgrids, engineering design and interconnection studies are recommended as a next step for further analysis. For each use-case, SEPA developed high, mid, and low renewable scenarios. The high-renewable scenario is able to provide 24-hours of ride-through capacity during the month with the highest average hourly demand. The mid-renewable scenario is able to provide 12-hours of ride-through capacity during the month with the highest average hourly demand. Lastly, the low-renewable scenario is able to provide 4-hours of ride-through capacity during the month with the highest average hourly demand. The models for each use case was determined by their average peak load.

Within each use-case, SEPA utilized Xendee to identify preliminary economic costs including the Capital Expenditures (CAPEX) and the annual Operating Expenditures (OPEX). CAPEX included the upfront costs of the solar PV and battery storage for each scenario. The annual operating costs included Utility Demand Charges, Utility Energy Charges, DER Maintenance Costs but there are other costs that might be associated with interconnection, which must be determined through separate engineering studies, and which are not included in the initial analysis. Below is a summary of the CAPEX and OPEX across the scenarios for each of the use-cases.

Use-Case Summary

Critical Facility Use Case	Utility Tariff	Critical Facility Count	Cost Range	
Grocery Stores	**Duquesne Light Co - GM**	**3,905**	CAPEX	$1,268,045 - $2,548,371
			OPEX	$69,000 - $81,000
			Total	$1,337,045 - $2,629,371
Schools (K-12, Private)	**FirstEnergy. - GS-Medium**	**5,714**	CAPEX	$782,002 - $1,286,801
			OPEX	$13,000 - $26,000
			Total	$795,002 - $1,312,801
Pharmacies	**PECO Energy Co - GS**	**2,778**	CAPEX	$201,388 - $435,117
			OPEX	$10,000 - $16,000
			Total	$217,388 - $445,117
Shelters	**Duquesne Light Co - GM**	**1,401**	CAPEX	$8,253 - $25,286
			OPEX	$0 - $1000
			Total	$9,253 - $25,286

Dialysis Centers	**FirstEnergy - GS-Medium**	**318**	CAPEX	$300,714 - $420,193
			OPEX	$13,000 - $15,000
			Total	$315,714 - $433,193
Hospitals	**PECO Energy Co - HT**	**745**	CAPEX	$4,614,815 - $8,576,791
			OPEX	$344,000 - $402,000
			Total	$5,016,815 - $8,920,791
Police Stations	**PPL Electric Utilities Corp - GS-1**	**1,298**	CAPEX	$64,342 - $156,355
			OPEX	$6,000 - $7,000
			Total	$71,342 - $162,355
Wastewater Treatment Facilities	**PECO Energy Co - GS**	**3,014**	CAPEX	$1,702,844 - $5,141,688
			OPEX	$227,000 - $308,000
			Total	$2,010,844 - $5,368,688
Water Treatment Facilities	**PECO Energy Co - GS**	**3,014**	CAPEX	$2,217,062 - $5,487,590
			OPEX	$160,000 - $187,000
			Total	$2,377,062 - $5,674,590
Emergency Operations Center	**PPL Electric Utilities Corp - GS-1**	**75**	CAPEX	$303,087 - $1,267,876
			OPEX	$35,000 - $40,000
			Total	$343,087 - $1,302,876
Government Offices	**PPL Electric Utilities Corp - GS-1**	**25**	CAPEX	$165,845 - $394,732
			OPEX	$11,000 - $12,000
			Total	$176,845 - $406,732
Gas Stations	**PECO Energy Co - GS**	**289**	CAPEX	$83,680 - $229,580
			OPEX	$11,000 - $13,000
			Total	$96,680 - $240,580
Urgent Care	**FirstEnergy - GS-Medium**	**60**	CAPEX	$74,710 - $140,084
			OPEX	$5,000 - $8,000
			Total	$82,710 - $145,084
Correctional Facilities	**PPL Electric Utilities Corp - GS-1**	**183**	CAPEX	$375,684 - $1,076,901
			OPEX	$42,000 - $58,000
			Total	$433,684 - $1,118,901
Fire Stations	**FirstEnergy - GS-Medium**	**2,895**	CAPEX	$25,406 - $54,173
			OPEX	$2,000 - $3,000
			Total	$28,406 - $56,173
Nursing Home	**Duquesne Light Co - GL**	**909**	CAPEX	$1,961,856 - $4,752,972
			OPEX	$85,000 - $95,000

			Total	$2,056,856 - $4,837,972
Colleges & Universities	**Duquesne Light Co - L**	**328**	CAPEX	$38,986,886 - $85,459,462
			OPEX	$2,078,000 - $2,190,000
			Total	$41,176,886 - $87,537,462

Net Energy Metering (NEM)

Each of the optimizations assume a net metering constraint, meaning that total annual electricity exports from solar PV cannot exceed the total annual electricity purchased from the utility. Optimal scenarios in this report assume that excess generation credits are not received for electricity exports that exceed utility electric purchases and reflect a relatively conservative size estimation. NEM credits for electricity are assumed to be equal to energy rates (per kWh) defined in the rate schedule.

Financing

Scenarios assume an upfront cash purchase of DER assets with a 5% discount rate and 20-year project length. SEPA incorporated a 5% discount rate based on the average of societal cost of capital rates(~3%) and an investor-owned utility's weighted average cost of capital rates(~5-8%).[13] Further feasibility analysis will need to be conducted on a case-by-case basis and should consider an individual customer's risk preference which may be smaller, greater, or even negative.

Market Participation

Scenarios assume that the BESS does not provide demand response, frequency regulation, capacity reserve, energy arbitrage, or other economic benefits beyond self-consumption and resilience. As a result, solar PV and BESS sizing reflects a relatively conservative size estimation and may not accurately reflect the full economic benefits of a BESS under market and operating conditions.

Base Component Costs

Estimated solar PV and BESS costs for each scenario were developed by the National Renewable Energy Laboratory (NREL) and were selected to match the expected PV system for each use case given the sites' load profiles.

Solar PV

Solar PV costs for the grocery store, pharmacy, dialysis, EOC, government facility, gas station, urgent care, and correctional facility:

[13] Turning Policy Into Performance: Determining A Discount Rate For Decarbonization Northeast Energy Efficiency Partnerships (2022)

Small Commercial PV System (NREL)
Under 500 kW

Manufacturer
Generic

Currency
USD: $

Inverter	Cost (per kW)	$80	Inverter Life (years)	15
Solar PV	Cost (per kW_{DC})	$1,750	Solar PV Life (years)	30
	Maintenance (per kW_{DC}/month)	$1.50		
	Installation	*Not set*		

Solar PV costs for the school:

0.5 MW Commercial rooftop PV
Costs in [2020 USD, US$]; Source published in 2021, p.13, available at: https://www.nrel.gov/docs/fy22osti/80694.pdf [accessed Q1/2022]

Manufacturer
generic

Part Number
generic

Currency
USD: $

Inverter	Cost (per kW)	*Not set*	Inverter Life (years)	*Not set*
Solar PV	Cost (per kW_{DC})	$1,460	Solar PV Life (years)	30
	Maintenance (per kW_{DC}/month)	*Not set*		
	Installation	*Not set*		

Solar PV costs for the shelter:

Average Residential rooftop PV 7.15 kWp
Costs in [2020 USD, US$]; Source published in 2021, p.7;43, available at: https://www.nrel.gov/docs/fy22osti/80694.pdf [accessed Q1/2022]

Manufacturer
generic

Part Number
generic

Currency
USD: $

Inverter	Cost (per kW)	*Not set*	Inverter Life (years)	*Not set*
Solar PV	Cost (per kW_{DC})	$2,650	Solar PV Life (years)	25
	Maintenance (per kW_{DC}/month)	$2.41		
	Installation	*Not set*		

Solar PV costs for the hospital, water/wastewater treatment facilities, and nursing home:

Commercial PV System (NREL)
500 kW to 1 MW system

Manufacturer
Generic

Currency
USD: $

Inverter	Cost (per kW)	$80	Inverter Life (years)	15
Solar PV	Cost (per kW_{DC})	$1,670	Solar PV Life (years)	30
	Maintenance (per kW_{DC}/month)	$1.42		
	Installation	*Not set*		

Solar costs for the police station and fire station:

11 kWp residential rooftop PV

Costs in [2020 USD, US$]; Source published in 2021, p.7, available at: https://www.nrel.gov/docs/fy22osti/80694.pdf [accessed Q1/2022]

Manufacturer
generic

Part Number
generic

Currency
USD: $

Inverter	Cost (per kW)	Not set	Inverter Life (years)	Not set
Solar PV	Cost (per kW_{DC})	$2,140	Solar PV Life (years)	25
	Maintenance (per kW_{DC}/month)	Not set		
	Installation	Not set		

Solar Costs for the college/university campus:

10 MW Utility-scale fixed-tilt PV

Costs in [2020 USD, US$]; Source published in 2021, p.19, available at: https://www.nrel.gov/docs/fy22osti/80694.pdf [accessed Q1/2022]

Manufacturer
generic

Part Number
generic

Currency
USD: $

Inverter	Cost (per kW)	Not set	Inverter Life (years)	Not set
Solar PV	Cost (per kW_{DC})	$1,030	Solar PV Life (years)	30
	Maintenance (per kW_{DC}/month)	Not set		
	Installation	Not set		

Battery Energy Storage System

BESS costs for all facilities are noted below:

4h Utility Storage [Li-Ion]

4 hour system, lifetime assumed. Source published in 2020, p.6, available at: https://www.nrel.gov/docs/fy21osti/79236.pdf [accessed Q1/2022]

Not set 10 years

Manufacturer
generic

Part Number
generic

Currency
USD: $

Installation	Not set
Inverter (per kW)	Not set
Modules (per kWh)	$345
Maintenance (per kWh per month)	Not set

CAPEX included the upfront costs of the solar PV and battery storage for each scenario. Annual operating costs include utility demand charges (per kW), utility energy charges (per kWh), and DER Maintenance Costs but there are other costs that might be associated with interconnection, which must be determined through separate engineering studies, and which are not included in the initial analysis. Below is a summary of the CAPEX and OPEX across the scenarios for each of the use-cases.

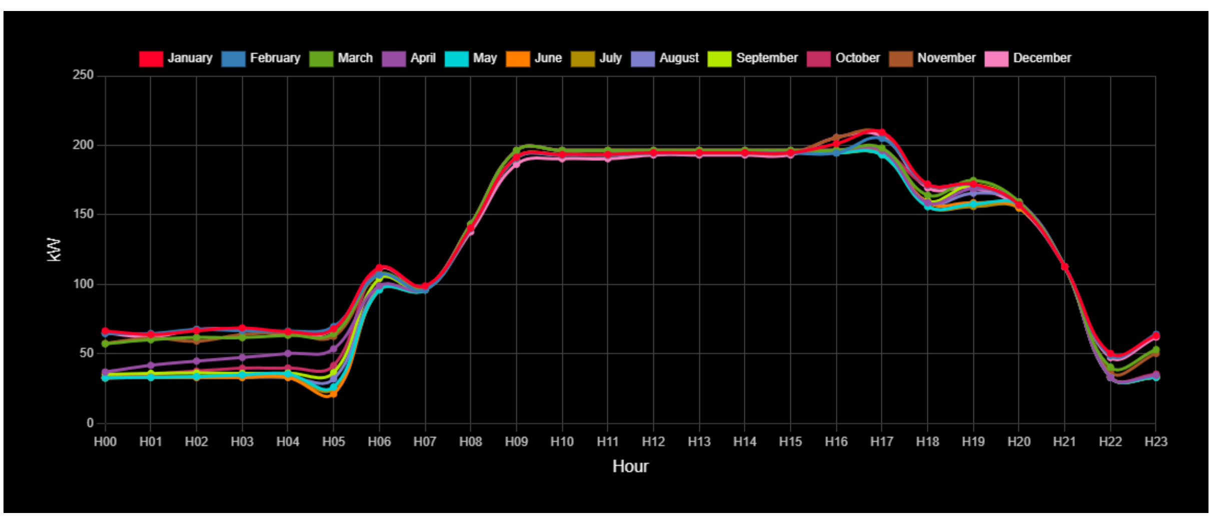
Grocery Stores

This use case demonstrates three potential design scenarios for a microgrid deployment at grocery stores in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

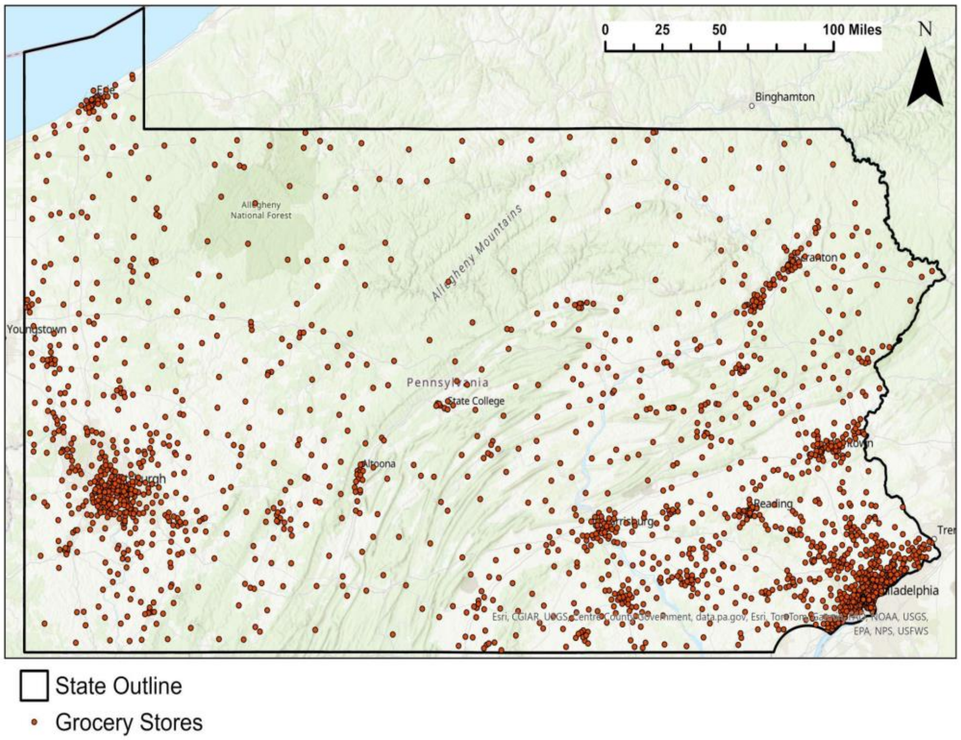
- Facility Size and Type:
    - Grocery stores include community-scale markets that provide food, beverages, and household goods to community members. Grocery store locations may also support other vital related services with on-site pharmacies, cafes, and/or ATMs. These services remain critical during outages, and some grocery stores may not have the resilience capabilities to continue operations.
    - The load profile used in this study represents the average hourly facility load for a 45,000 sq ft., one floor, rectangular building that was built after 1980. The building includes zones for sales, produce, dry storage, deli, bakery, and offices.
    - Daily operating hours are assumed to be 7am - 10pm.

Grocery Store Load Profile:



Source: The "grocery store" load profile used in this study is taken from hourly electric load data published on the National Renewable Energy Laboratory's (NREL) OpenEI site. The load profile represents the electric consumption of an average grocery store in IECC climate zone 5A near Pittsburgh, PA.

Distribution of Grocery Stores:



- Overview:
  - SEPA identified 3,905 potential grocery stores as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - SHOPRITE OF ISLAND AVE 423 - Philadelphia
    - Dollar Tree 1781 - Philadelphia
    - Family Dollar 11363 - Philadelphia
    - 8 Brother Associated Inc- Philadelphia
    - Family Dollar 8419 - Philadelphia

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Lithium Ion (Li-Ion) Battery Energy Storage System (BESS)

Benefits of a Microgrid:

A microgrid can specifically benefit grocery stores by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for food supply.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- https://www.scalemicrogrids.com/projects/grocerystoremicrogrid
- https://www.enelnorthamerica.com/about-us/newsroom/search-press/press/2022/05/enel-x-launches-microgrid-at-a-massachusetts-fresh-food-service-station-ensuring-resiliency

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Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	812.0	782.0	611.0
BESS Capacity (kW)	855.0	552.5	192.5
BESS Energy (kWh)	3,420.0	2,210.0	770.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$990,893	$1,268,731	$1,317,960
	Battery Energy Storage System	$277,152	$794,242	$1,230,411
Annual OPEX	Utility Demand Charges	$7,000	$6,000	$4,000
	Utility Energy Charges	$37,000	$19,000	$17,000
	DER Maintenance Costs	$25,000	$46,000	$60,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

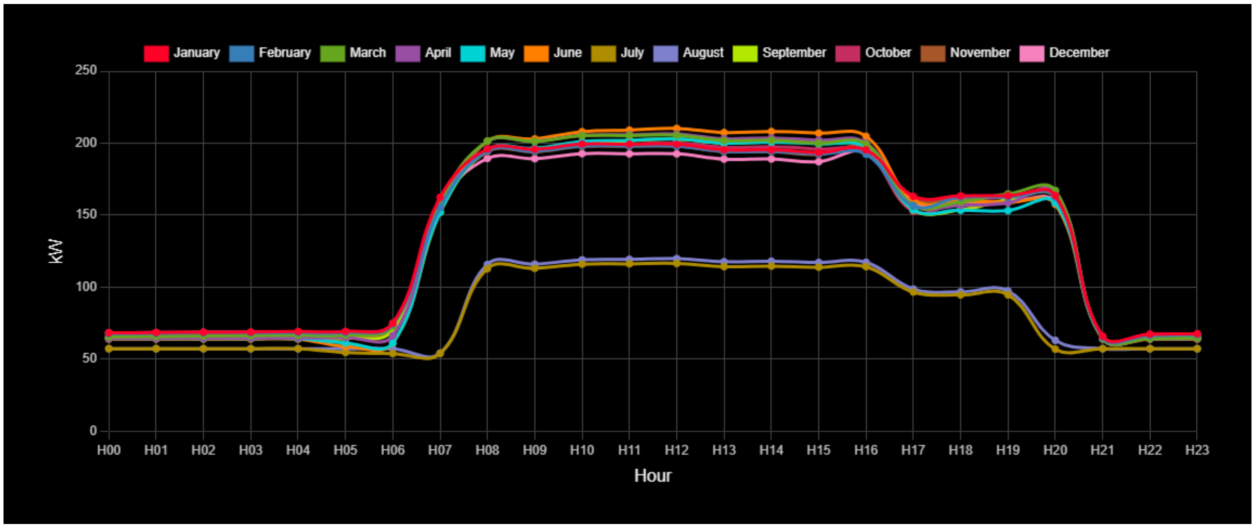
Schools (K-12, Private)

This use case demonstrates three potential design scenarios for a microgrid deployment at schools in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

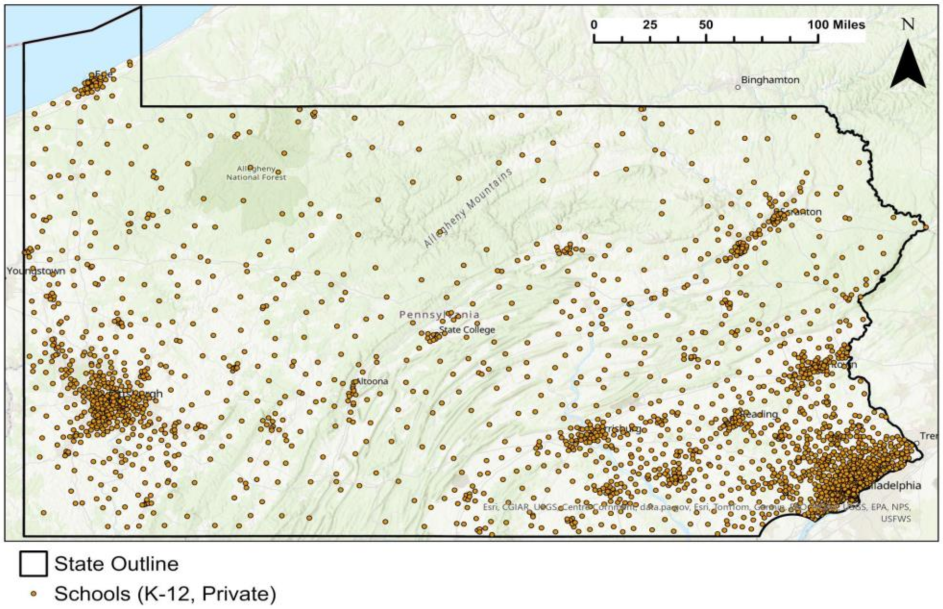
- Facility Size and Type:
    - Schools include public and private K-12 schools that provide education services to the communities they inhabit. Schools often serve their communities through after-school activities (e.g. cultural and social events, youth activities, resource use and information dissemination, health, leisure, and recreation activities, and adult learning) and sometimes serve as community shelters or other emergency facilities. Many of these services are critical during outages, and some educational facilities may not have the resilience capabilities to continue operations.
    - The load profile used in this study represents the average hourly facility load for a 73,960 sq. ft., one-story building shaped like an "E" with three pods that was built after 1980. The load includes classrooms and a main building housing the gym, cafeteria, kitchen, library, offices, lobby, bathrooms, and a main corridor.
    - Daily operating hours are assumed to be 8am - 3pm.

School Load Profile:



Source: The "Primary School" load profile used in this study is taken from hourly electric load data published on the National Renewable Energy Laboratory's (NREL) OpenEI site. The load profile represents the electric consumption of an average primary school in IECC climate zone 6A near Bradford, PA.

Distribution of Schools (K-12, Private):



- Overview:
  - SEPA identified 5,714 potential schools (K-12, Private) as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Reading School District- Glenside Elementary School - Reading
    - Penrose Elementary School - Philadelphia
    - Thomas G Morton Elementary School – Philadelphia
    - Motivation High School – Philadelphia
    - John B Kelly Elementary School – Philadelphia

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit schools by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for education, shelter, and other community emergency response resources.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- https://www.ksbe.edu/article/one-of-the-largest-renewable-energy-microgrids-on-maui-is-right-here-on-campus
- https://rmi.org/press-release/public-school-renewable-microgrid-opens-in-orocovis/

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	462.0	444.0	585.0
BESS Capacity (kW)	22.7	166.8	234.0
BESS Energy (kWh)	90.7	667.0	936.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$749,337	$720,430	$949,778
	Battery Energy Storage System	$32,665	$240,100	$337,023
Annual OPEX	Utility Demand Charges	$11,000	$6,000	$4,000
	Utility Energy Charges	$61,000	$56,000	$41,000
	DER Maintenance Costs	$13,000	$19,000	$26,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Pharmacies

This use case demonstrates three potential design scenarios for a microgrid deployment at pharmacies in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

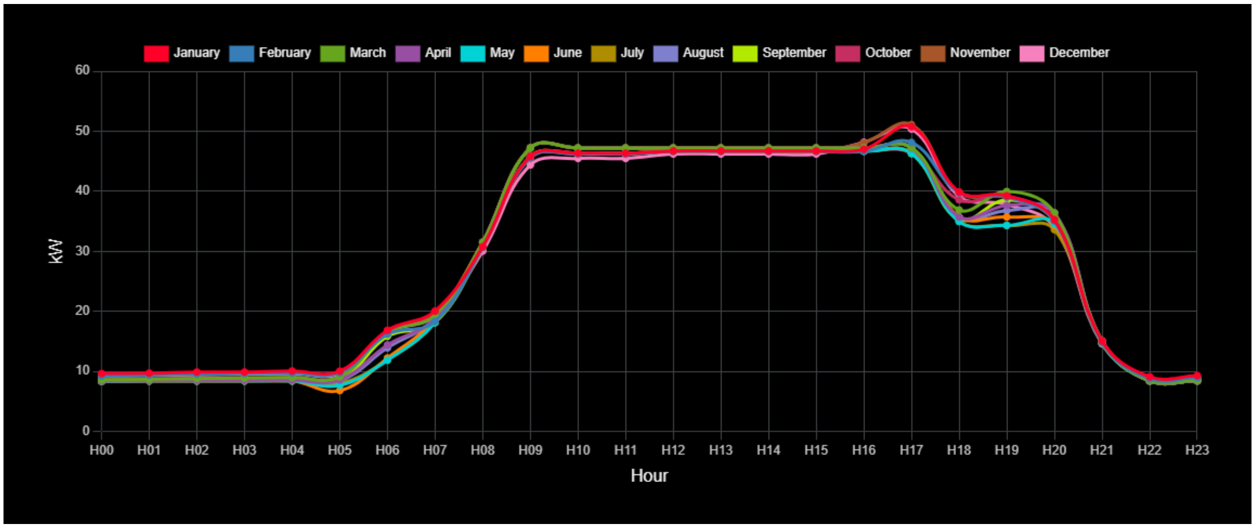
Assumptions:

- Facility Size and Type:
  - Pharmacies include local and chain convenience stores and small-scale grocers hosting a pharmacy that provides critical medical supplies to a community. Many pharmacies are collocated with small-footprint markets that stock a limited selection of household goods and staple groceries. These facilities may provide support services

to community members, such as an ATM or health care clinic. These services remain critical during outages, and many pharmacies may not have the resilience capabilities to continue operations.

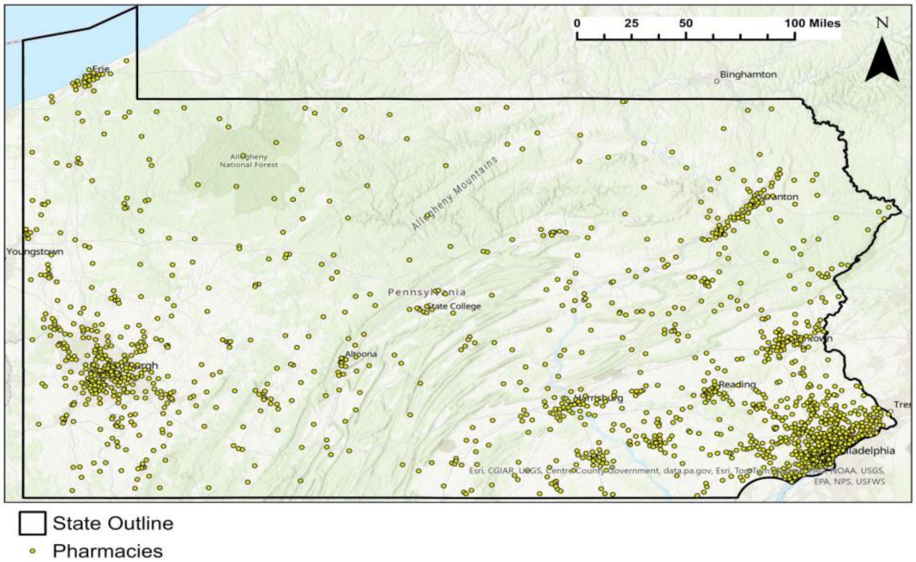
- The load profile used in this study represents the average hourly facility load for a 24,962 sq.ft., one floor rectangular building that was built after 1980. SEPA reduced the facility load profile by a factor of two to reflect a 12,481 sq. ft. one-floor facility that is more similar in size to existing pharmacies. The building includes a point-of-sale area, the front retail area, a large core retail zone, and a back zone.

Pharmacy Load Profile:



Source: The "stand-alone retail" load profile used in this study is taken from hourly electric load data published on the National Renewable Energy Laboratory's (NREL) OpenEI site. The load profile represents the electric consumption of an average pharmacy in IECC climate zone 4A near Philadelphia, PA.

Distribution of Pharmacies:



- Overview:
  - SEPA identified 2,778 potential pharmacies as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Fourstar Pharmacy - Philadelphia
    - Browns Parkside Llc - Philadelphia
    - Shoprite Pharmacy Of Island Ave - Philadelphia
    - Haverford Pharmacy – Philadelphia
    - Ritechoice Pharmacy Iv – Philadelphia

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit pharmacies by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for food and medical supplies.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- https://spectrum.ieee.org/microgrid

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	96.3	152.0	167.0
BESS Capacity (kW)	12.1	64.8	80.5
BESS Energy (kWh)	48.3	259.0	322.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$184,015	$291,189	$319,327
	Battery Energy Storage System	$17,373	$93,339	$115,790
Annual OPEX	Utility Demand Charges	$5,000	$1,000	$1,000
	Utility Energy Charges	$9,000	$3,000	$2,000
	DER Maintenance Costs	$2,000	$6,000	$7,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Shelters

This use case demonstrates three potential design scenarios for a microgrid deployment at shelters in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

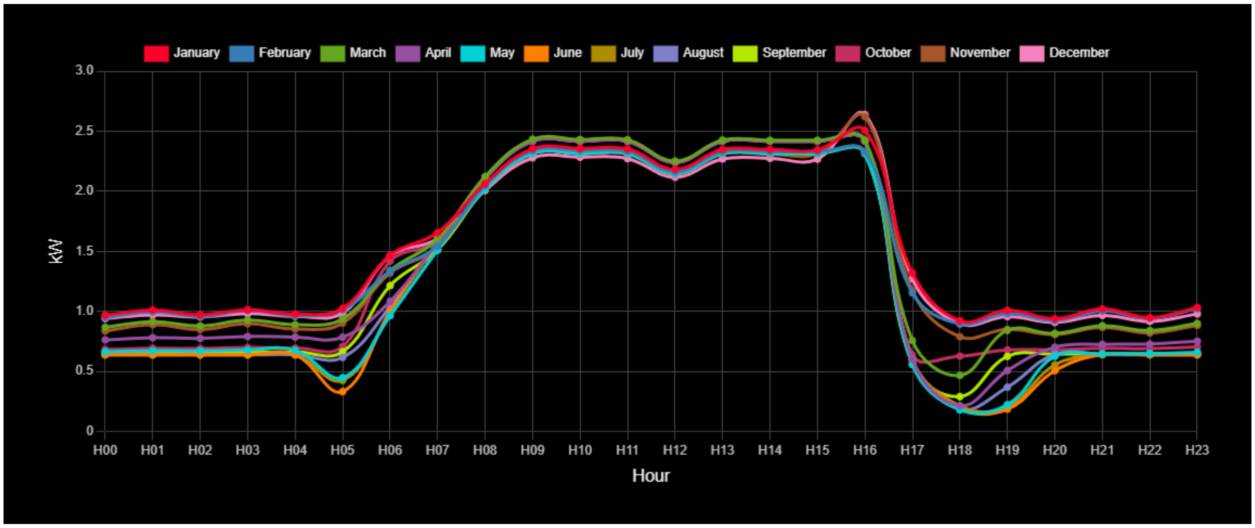
Assumptions:

- Facility Size and Type:
  - Shelters include senior and resilience centers, public and government facilities, or institutional buildings that serve as community centers. These facilities may provide services to community members to help them meet social, physical, emotional, and intellectual needs. Shelter facilities may include meeting and classroom spaces, food preparation spaces, charging outlets, sports facilities, and other amenities. During an

emergency, these facilities may serve as shelters that provide a range of critical services. Some shelters may not have the resilience capabilities to continue operations during an emergency outage.

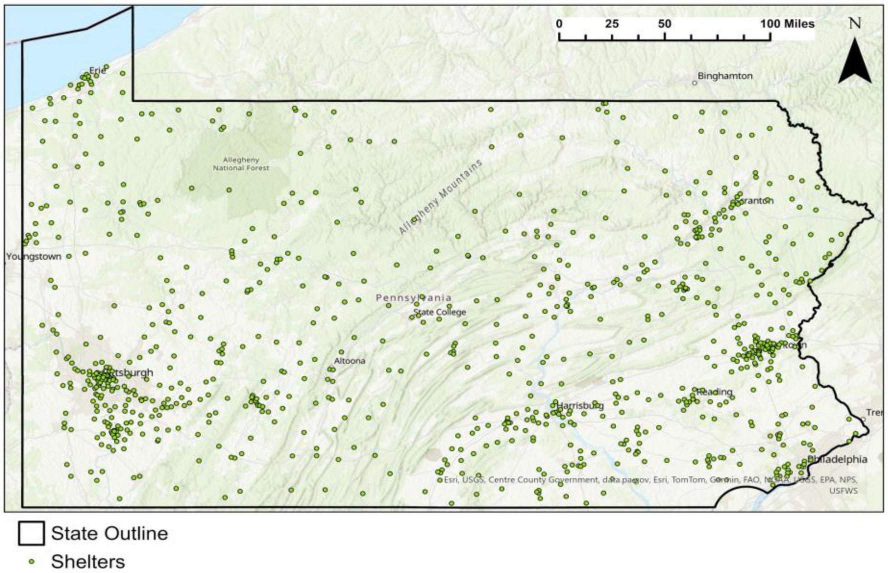
- The load profile used in this study was collected and used in the 2022 ProtoGen PA DEP Microgrid Feasibility Studies. The load profile represents historical load data for a community recreation center building that was built prior to 1980. The building includes a basketball/volleyball Court, two locker rooms, bleachers, and an office.

Shelter Load Profile:



Source: The load profile used in this study was collected during the 2022 ProtoGen PA DEP Microgrid Feasibility Studies. The load profile represents historical electric consumption for a recreation center and potential shelter facility in IECC climate zone 5A near Pittsburgh, PA.

Distribution of Shelters:



- Overview:
  - SEPA identified 1,401 potential shelters as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Emanuel Baptist Church – Donora
    - CHRISTIAN LIFE MINISTRIES – Donora
    - Saint Paul Baptist Church - Donora
    - St. Spyridon Greek Orthodox Church - Monessen
    - Um Church of Monessen - Monessen

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit shelters by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for providing critical community and emergency services.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Link to real-world examples of this microgrid use case in the U.S.:

- https://mayor.dc.gov/release/mayor-bowser-announces-new-microgrid-st-elizabeths-east-increase-resiliency-and-reliability

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Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	2.0	4.3	7.4
BESS Capacity (kW)	1.8	2.7	3.3
BESS Energy (kWh)	7.2	10.9	13.1

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$5,655	$12,006	$20,576
	Battery Energy Storage System	$2,598	$3,918	$4,710
Annual OPEX	Utility Demand Charges	<$1,000	<$1,000	<$1,000
	Utility Energy Charges	$1,000	<$1,000	<$1,000
	DER Maintenance Costs	<$1,000	<$1,000	<$1,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Dialysis Centers

This use case demonstrates three potential design scenarios for a microgrid deployment at dialysis centers in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

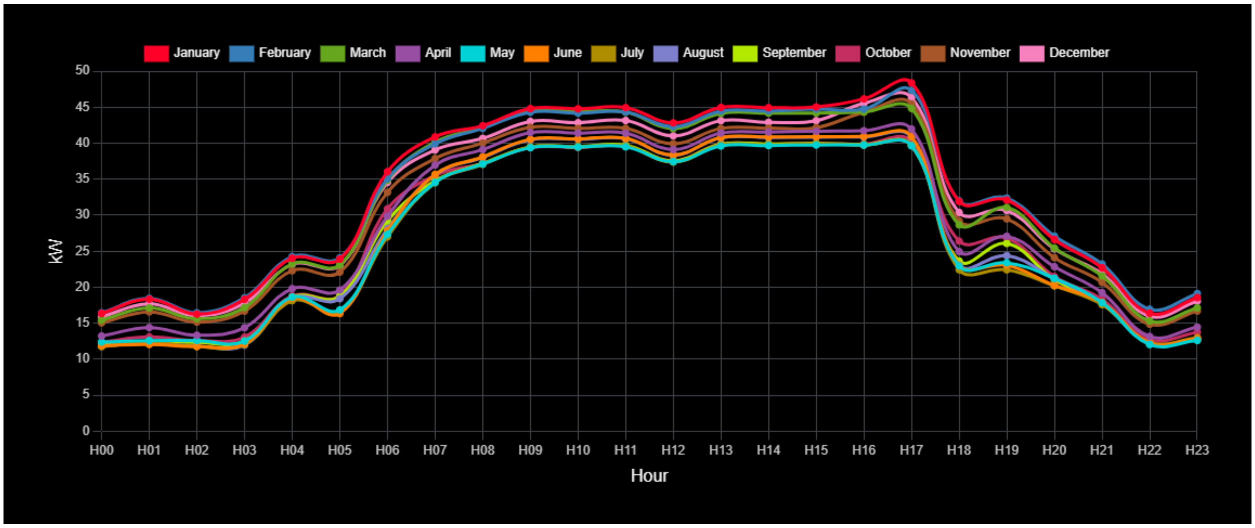
Assumptions:

- Facility Size and Type:
  - A renal dialysis center (dialysis center) is a medical facility that provides outpatient dialysis services to those with chronic kidney failure. Dialysis patients generally visit a dialysis center three times a week for between three and four hours. Dialysis services

remain a critical facility for their patients during outages, and some dialysis centers may not have the resilience capabilities to continue operations.[14]

- The load profile used in this study represents the average hourly facility load for a 40,946 sq. ft., three-story irregular-shaped building that was built after 1980. SEPA reduced the facility load profile by a factor of five to reflect an 8,189 square foot, one-floor facility that is more similar in size to existing dialysis centers. The building includes exam rooms, offices, a lobby, waiting rooms, a pre-operating room, operating rooms, storage, restrooms, physical therapy, and staff lounges.
- Daily operating hours are assumed to be 7am - 6pm.

Dialysis Center Load Profile:



Source: The "outpatient health care" load profile used in this study is taken from hourly electric load data published on the National Renewable Energy Laboratory's (NREL) OpenEI site. The load profile represents the electric consumption of an average dialysis center in IECC climate zone 5A near Allentown, PA.

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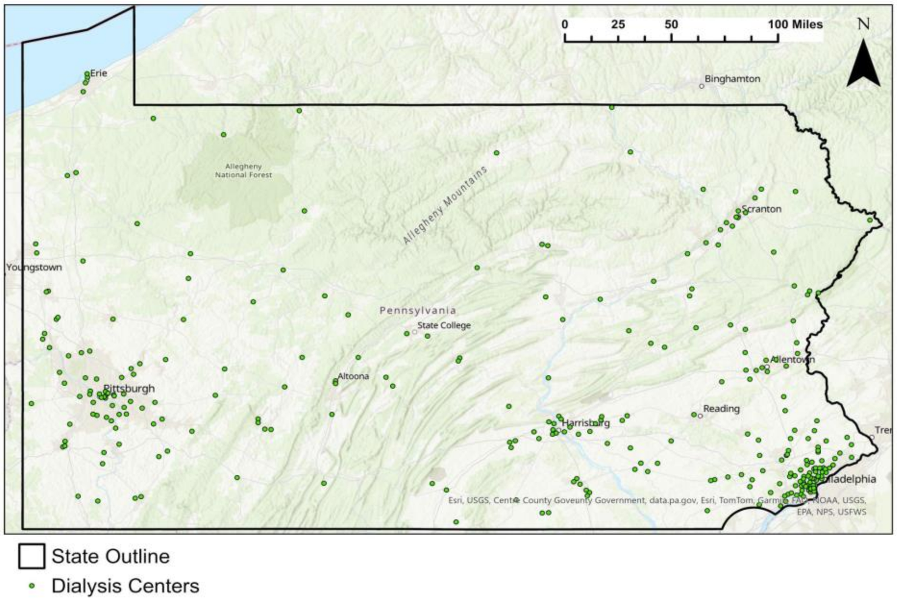
[14] https://www.definitivehc.com/resources/glossary/r/renal-dialysis-center#:~:text=A%20renal%20dialysis%20center%2C%20sometimes,as%20it%20cleanses%20the%20blood.

Distribution of Dialysis Centers:



- Overview:
    - SEPA identified 318 potential dialysis centers as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
        - U.S. Renal Care - Philadelphia
        - DaVita Cedar Grove Dialysis - Philadelphia
        - DaVita Elizabeth Dialysis - Elizabeth
        - DaVita Mckeesport West Dialysis - McKeesport
        - DaVita Memphis Street Renal Center - Philadelphia

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit dialysis centers by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for healthcare services.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- https://wpln.org/post/rural-health-centers-across-tennessee-are-getting-solar-microgrids/
- https://spectrum.ieee.org/microgrid

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	130.0	144.0	170.0
BESS Capacity (kW)	36.0	49.0	66.5
BESS Energy (kWh)	144.0	196.0	266.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$248,835	$274,217	$324,572
	Battery Energy Storage System	$51,879	$70,518	$95,621
Annual OPEX	Utility Demand Charges	$1,000	$1,000	$1,000
	Utility Energy Charges	$10,000	$9,000	$6,000
	DER Maintenance Costs	$4,000	$5,000	$6,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Hospitals

This use case demonstrates three potential design scenarios for a microgrid deployment at hospitals in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

- Facility Size and Type:
    - According to the American Hospital Association, hospitals are “licensed institutions with at least six beds whose primary function is to provide diagnostic and therapeutic patient services for medical conditions; they have an organized physician staff; and

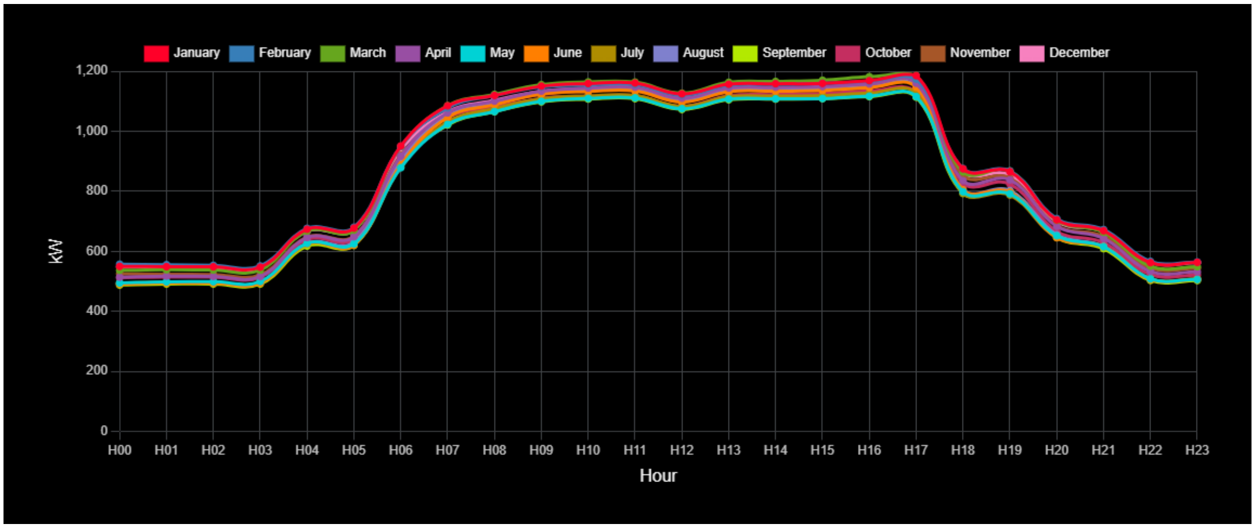
they provide continuous nursing services under the supervision of registered nurses."[15] Hospital types may include:

- Community hospitals
- General hospitals
- Registered hospitals
- Short-stay hospitals
- Special hospitals

○ The load profile used in this study represents the average hourly facility load for a 241,351 sq. ft., five-story rectangular building with a basement that was built after 1980. The building includes an emergency room, an intensive care unit, operating rooms, patient rooms, physical therapy, offices, a lobby, labs, nurse's stations, a dining hall, kitchen, and conditioned corridors.

○ Daily operating hours are assumed to be 24 hours.

Hospital Load Profile:



Source: The "hospital" load profile used in this study is taken from hourly electric load data published on the National Renewable Energy Laboratory's (NREL) OpenEI site. The load profile represents the electric consumption of an average hospital in IECC climate zone 4A near Philadelphia, PA.

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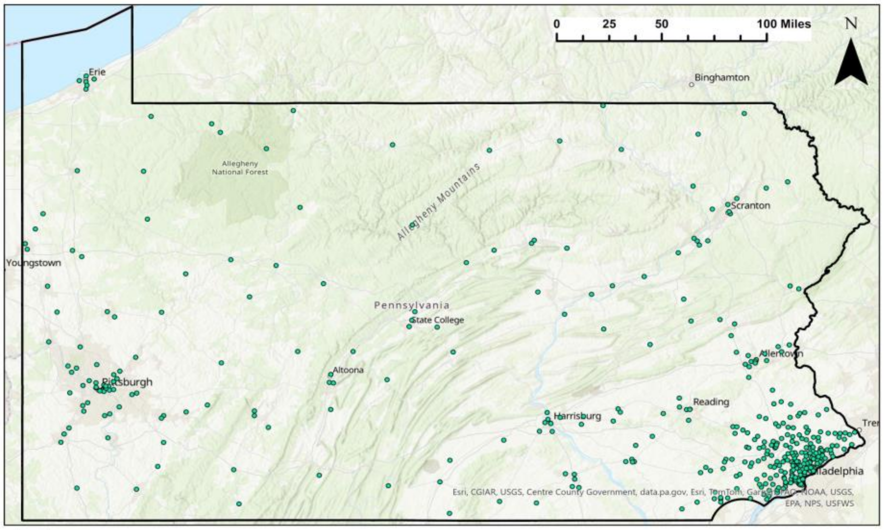
[15] https://www.cdc.gov/nchs/hus/sources-definitions/hospital.htm

Distribution of Hospitals:



State Outline
Hospitals

- Overview:
    - SEPA identified 745 potential hospitals as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
        - Temple University- Episcopal Hospital & ER - Philadelphia– Philadelphia
        - Temple University Hospital – Philadelphia
        - KINDRED HOSPITAL - Darby
        - MERCY CATHOLIC MEDICAL CENTER - Darby
        - ARIA HEALTH FRANKFORD – Philadelphia

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit hospitals by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for healthcare and emergency medical services.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- https://betterbuildingssolutioncenter.energy.gov/implementation-models/kaiser-permanente-pioneers-californias-first-medical-center-microgrid
- https://www.microgridknowledge.com/healthcare-hospitals/article/33003827/healthcare-microgrids-new-federal-ruling-marks-seismic-shift

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Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	2,360.0	2,760.0	3,360.0
BESS Capacity (kW)	210.3	1,190.0	1,687.5
BESS Energy (kWh)	841.0	4,760.0	6,750.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$4,311,933	$5,040,946	$6,146,661
	Battery Energy Storage System	$302,882	$1,714,176	$2,430,130
Annual OPEX	Utility Demand Charges	$74,000	$39,000	$32,000
	Utility Energy Charges	$278,000	$234,000	$178,000
	DER Maintenance Costs	$50,000	$101,000	$134,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Police Stations

This use case demonstrates three potential design scenarios for a microgrid deployment at police stations in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

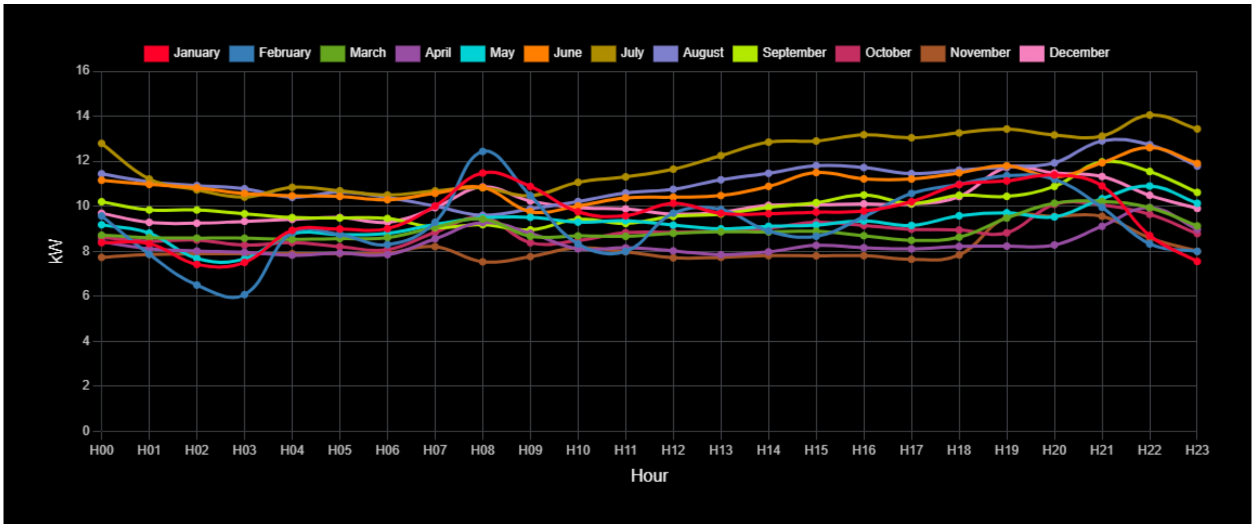
Assumptions:

- Facility Size and Type:
  - Police stations serve as a place of operation for a municipal police department, county sheriff's office or other law enforcement agency; these facilities may also support other

related emergency service roles including communications and dispatch. These emergency services remain critical during outages, and some police stations may not have the resilience capabilities to continue operations.

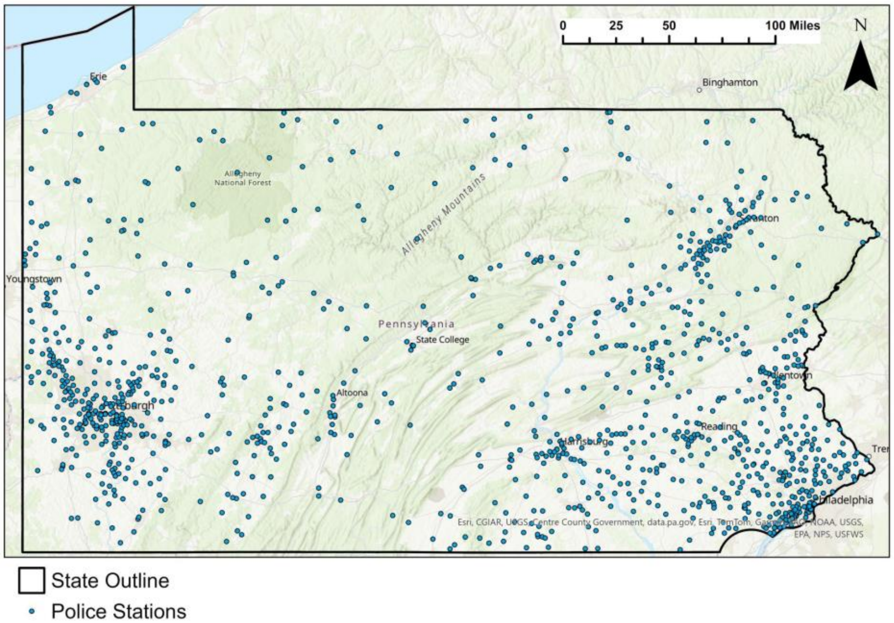
- SEPA collected the load profile from a large Investor-Owned Utility that serves the mid-Atlantic region of the U.S.

Police Station Load Profile:



Source: The load profile represents historical electric consumption for a police station in IECC climate zone 4A near Philadelphia, PA.

Distribution of Police Stations:



- Overview:
    - SEPA identified 1,298 potential police stations as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
        - Philadelphia Police - Thirty Ninth District - Philadelphia
        - Eddystone Borough Police Department – Eddystone
        - Monessen Police Department - Monessen
        - Elizabeth Borough Police Department - Elizabeth
        - Philadelphia Police - First District - Philadelphia

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Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit police stations by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for emergency response services and public safety.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- https://www.govtech.com/smart-cities/microgrid-boosts-resiliency-for-chattanooga-police-and-fire
- https://www.energy.gov/nepa/articles/cx-030803-city-decatur-police-department-clean-energy-project

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Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	25.6	35.1	49.2
BESS Capacity (kW)	4.3	15.6	31.0
BESS Energy (kWh)	17.2	62.3	124.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$58,162	$79,954	$111,858
	Battery Energy Storage System	$6,180	$22,445	$44,497
Annual OPEX	Utility Demand Charges	$1,000	$1,000	<$1,000
	Utility Energy Charges	$5,000	$4,000	$3,000
	DER Maintenance Costs	$1,000	$2,000	$3,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Water and Wastewater Treatment Facilities

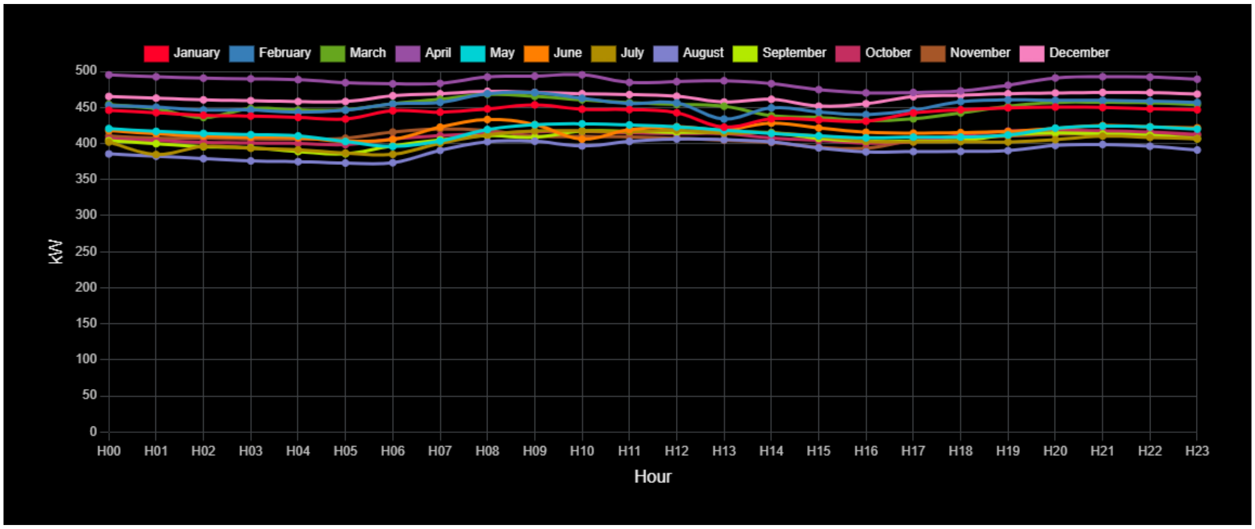
This use case demonstrates three potential design scenarios for a microgrid deployment at water and wastewater treatment facilities (WTP/WWTP) in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

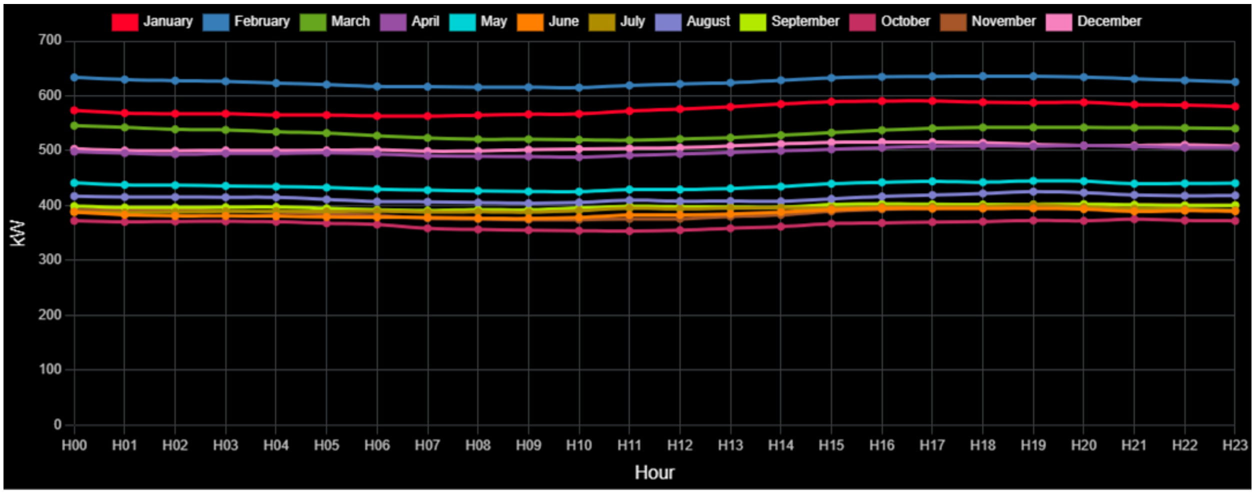
- Facility Size and Type:

- Water treatment plants are designed to treat drinking water to make it safe for human consumption. Wastewater treatment plants are designed to remove contaminants from wastewater and convert it into an effluent that can be returned to the water cycle or distributed to commercial and residential customers. WTP/WWTP are built to operate 24 hours a day and 365 days a year. These services remain critical during outages, and some treatment facilities may not have the resilience capabilities to safely continue operations.
- The WWTP plant is capable of processing 4.54 million gallons of water per day.
- The WTP plant is capable of processing 175 million gallons of water per day.

Wastewater Treatment Facility Load Profile:

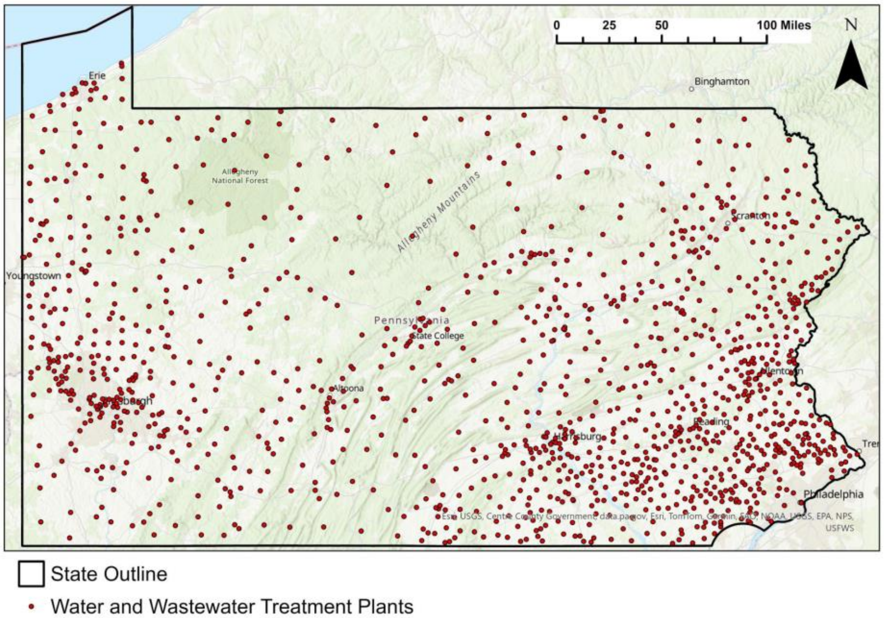


Water Treatment Facility Load Profile:



Source: The load profiles used in this study were collected during the 2022 ProtoGen PA DEP Microgrid Feasibility Studies. The load profile represents historical electric consumption for a wastewater treatment plant in IECC climate zone 5A near Allentown, PA and a water treatment plant in IECC climate zone 4A near Philadelphia, PA.

Distribution of Water and Wastewater Treatment Facilities:



- Overview:
  - SEPA identified 3,014 potential water and wastewater treatment facilities as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Columbia Water Co-Spruce St Booster – Columbia
    - West County Municipal Authority - MCKEESPORT– Verona
    - Tamaqua Wastewater Treatment Plant - Tamaqua– Sutersville
    - Midland Boro Muni Auth-Midland Water Plant - Midland
    - Nadine Pump Station Wilkinsburg-Penn – Verona

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit water and wastewater treatment facilities by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for environmental protection and water supply.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.

- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- [City of Houston Northeast Water Purification Plant]

Preliminary Solar & Storage Sizing (Wastewater):

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	883.0	1,400.0	1,970.0
BESS Capacity (kW)	61.0	517.5	1,065.0
BESS Energy (kWh)	244.0	2,070.0	4,260.0

Preliminary Solar & Storage Sizing (Water):

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	1060.0	855.0	1800.0
BESS Capacity (kW)	199.0	775.0	1528.0
BESS Energy (kWh)	796.0	3100.0	6110.0

Preliminary Economic Analysis (Wastewater):

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$1,615,067	$2,559,459	$3,609,614
	Battery Energy Storage System	$87,777	$743,889	$1,532,074
Annual OPEX	Utility Demand Charges	$68,000	$53,000	$36,000
	Utility Energy Charges	$222,000	$168,000	$109,000
	DER Maintenance Costs	$18,000	$47,000	$82,000

Preliminary Economic Analysis (Wastewater):

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$1,615,067	$2,559,459	$3,609,614
	Battery Energy Storage System	$87,777	$743,889	$1,532,074
Annual OPEX	Utility Demand Charges	$68,000	$53,000	$36,000
	Utility Energy Charges	$222,000	$168,000	$109,000
	DER Maintenance Costs	$18,000	$47,000	$82,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

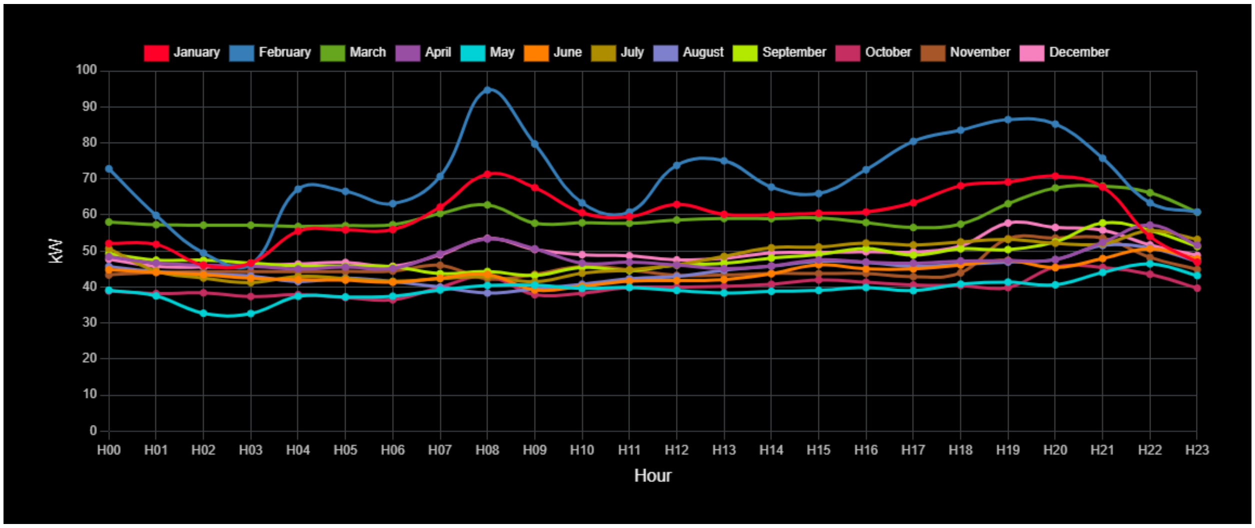
Emergency Operations Centers

This use case demonstrates three potential design scenarios for a microgrid deployment at emergency operations centers in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

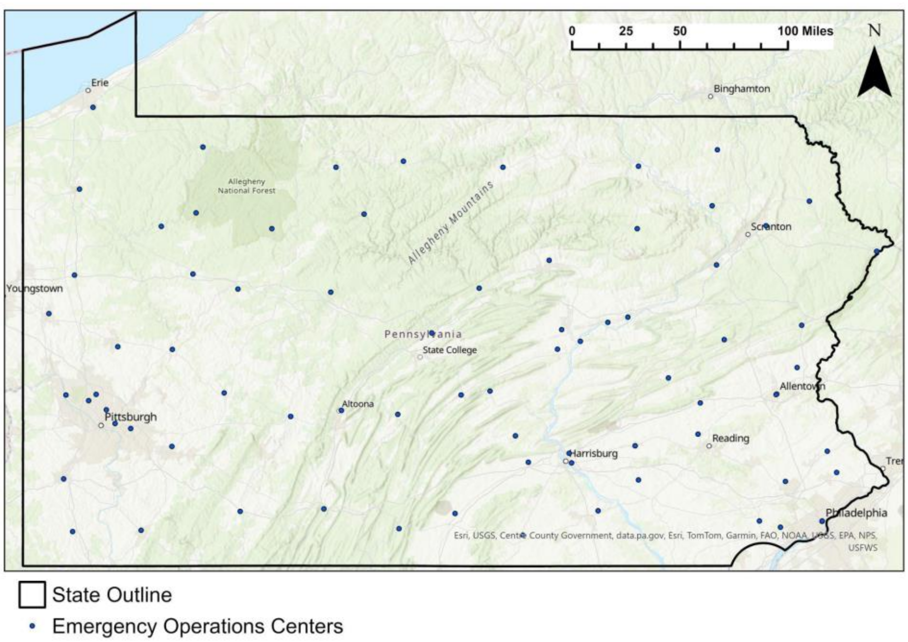
- Facility Size and Type:
    - An emergency operations center (EOC) is a centralized command and control system facility that houses strategic emergency preparedness, emergency management, and disaster management functions during an emergency. At an EOC, leaders and emergency responders can coordinate information and resources to support incident management activities. Many EOC buildings also support other government agencies or business functions. These emergency response and operations services remain critical during outages, and some EOCs may not have the resilience capabilities to continue operations.
    - The load profile represents historical load data for a municipal courthouse building which was built prior to 1980. The building includes a 24-hour 911 call center.

Emergency Operation Center Load Profile:



Source: The load profile used in this study was collected during the 2022 ProtoGen PA DEP Microgrid Feasibility Studies. The load profile represents historical electric consumption for an EOC facility in IECC climate zone 5A in Perry County, PA.

Distribution of Emergency Operations Centers:



- Overview:
  - SEPA identified 75 potential emergency operations centers as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Armstrong County Emergency Operations Center - Kittanning

- Lawrence County Emergency Operations Center - New Castle
- Washington County Emergency Operations Center - Washington
- Lebanon County Emergency Operations Center – Lebanon
- Bucks County Civil Defense Emergency Operations Center – Doylestown

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Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit EOCs by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for continuity of operations, public safety and emergency services.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Link to real-world examples of this microgrid use case in the U.S.:

- Montgomery County Government Department of General Services

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Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	88.4	314.0	316.0
BESS Capacity (kW)	93.3	210.3	462.5
BESS Energy (kWh)	373.0	841.0	1,850.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$168,749	$599,321	$603,565
	Battery Energy Storage System	$134,338	$302,607	$664,311
Annual OPEX	Utility Demand Charges	$3,000	$2,000	$1,000
	Utility Energy Charges	$31,000	$7,000	$7,000
	DER Maintenance Costs	$6,000	$15,000	$27,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

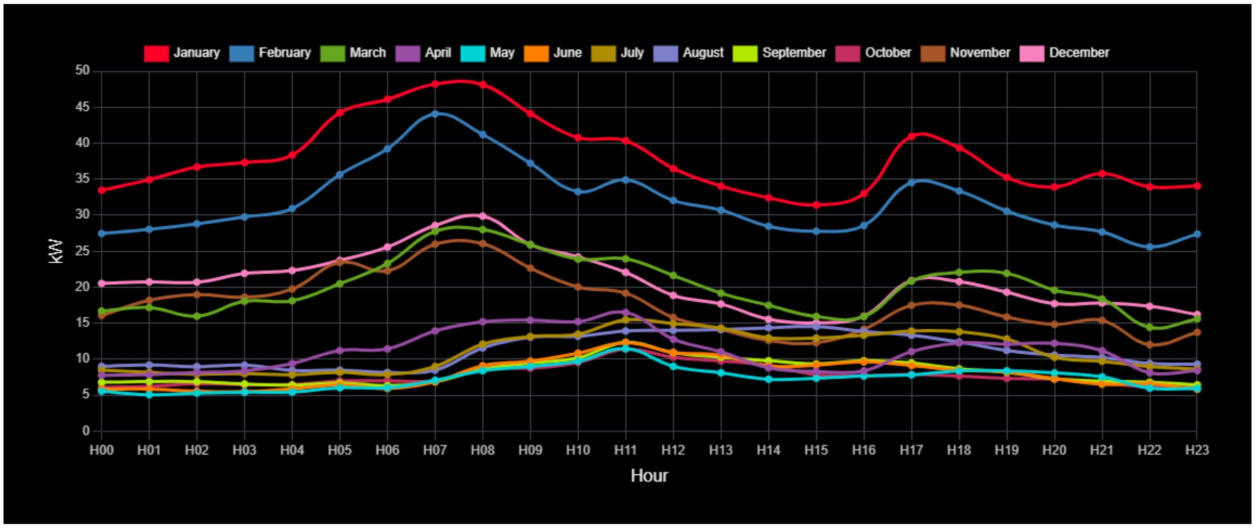
Government Offices

This use case demonstrates three potential design scenarios for a microgrid deployment at government offices in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

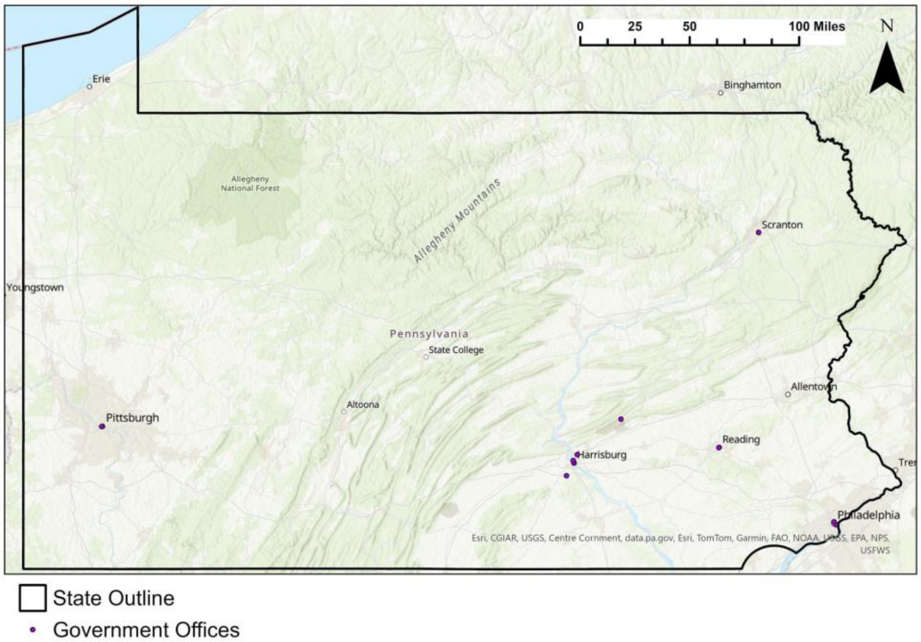
- Facility Size and Type:
    - Government offices include facilities which are owned by federal, state, local, or tribal government entities or facilities whose constriction or operations are funded by the aforementioned entities either in full or in part; facilities may include general-use office buildings, courthouses, laboratories, and structures that may house critical equipment, systems, networks, and functions. Governmental functions remain critical during outages, and some government offices may not have the resilience capabilities to continue operations.

Government Office Load Profile:



Source: The load profile used in this study was collected during the 2022 ProtoGen PA DEP Microgrid Feasibility Studies. The load profile represents historical electric consumption for a government office and town hall facility in IECC climate zone 5A in Schuylkill County, PA.

Distribution of Government Offices:



- Overview:
  - SEPA identified 25 potential government offices as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - City-County Building - Pittsburgh
    - Pittsburgh State Office Building - Pittsburgh
    - Pennsylvania State Office Building - Reading
    - Penn Mutual Building – Philadelphia
    - Philadelphia State Office Building – Philadelphia

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit government offices by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for continuity of operations.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Link to real-world examples of this microgrid use case in the U.S.:

- San Diego Government Office Microgrids

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	62.9	73.0	138.0
BESS Capacity (kW)	31.8	45.5	90.5
BESS Energy (kWh)	127.0	182.0	362.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$120,220	$139,505	$264,492
	Battery Energy Storage System	$45,625	$65,684	$130,240
Annual OPEX	Utility Demand Charges	$1,000	$1,000	$1,000
	Utility Energy Charges	$7,000	$6,000	$4,000
	DER Maintenance Costs	$3,000	$3,000	$7,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

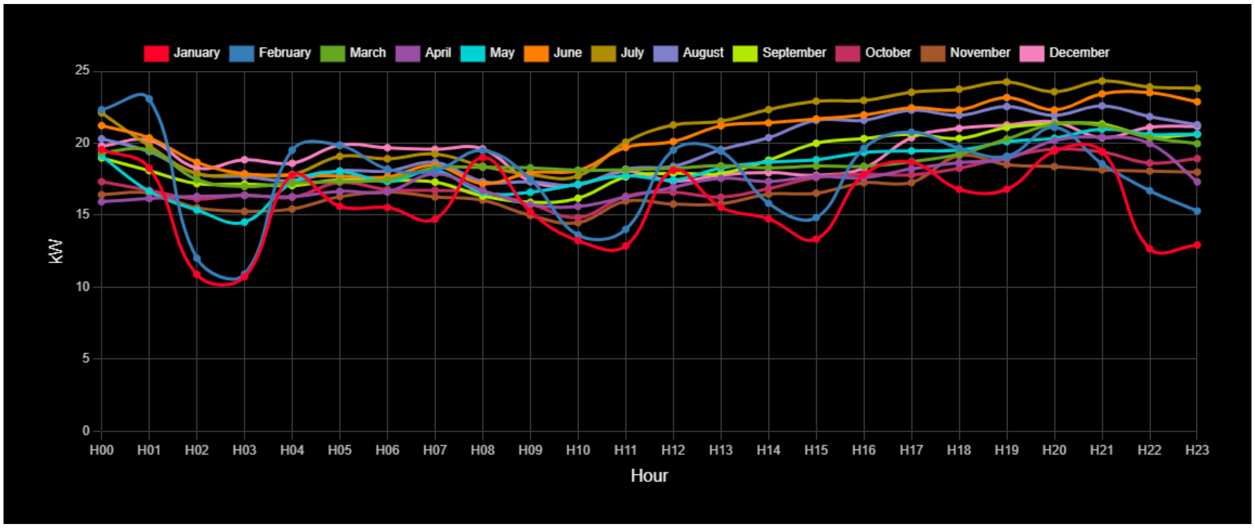
Gas Stations

This use case demonstrates three potential design scenarios for a microgrid deployment at gas stations in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

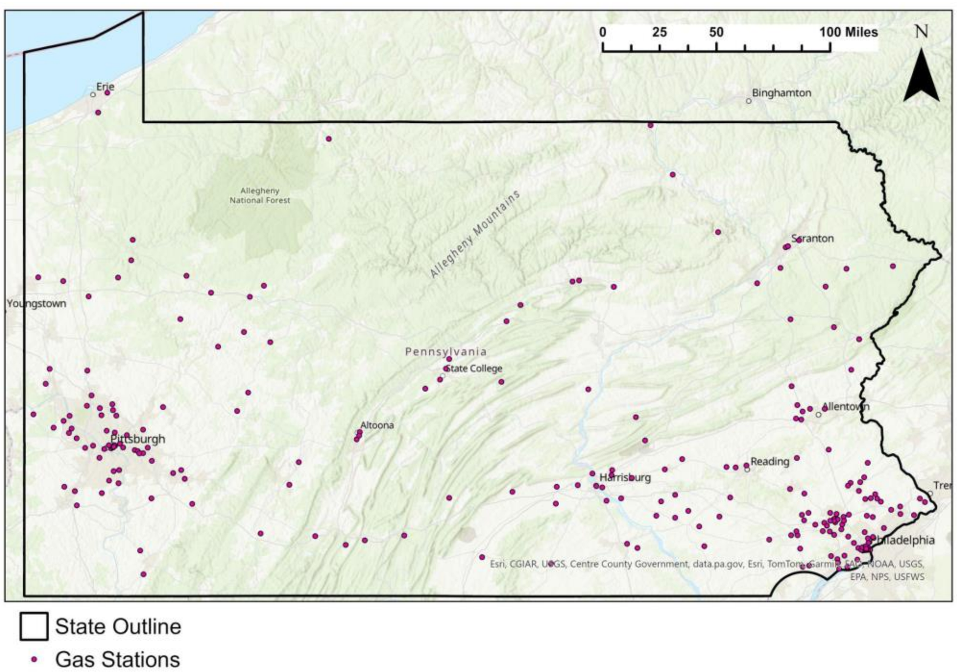
- Facility Size and Type:
  - Gas stations are retail stations for fueling motor vehicles that may include vehicle servicing and repair capabilities, convenience store offerings, and/or additional fuel sales (diesel, kerosine, CNG/LNG, EV charging, etc.). These services and offerings remain critical during outages, and some gas stations may not have the resilience capabilities to continue operations.

Gas Station Load Profile:



Source: The load profile used in this study was collected from a large Investor-Owned Utility located in the mid-Atlantic region of the U.S. The load profile represents historical electric consumption for a gas station in IECC climate zone 4A near Philadelphia, PA.

Distribution of Gas Stations:



- Overview:

- SEPA identified 289 potential gas stations as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Center City Shell - S&B Auto - Philadelphia
    - JG Service Station – Uniontown
    - Sunoco - Oakmont Service Plaza – Verona
    - Exxon - Lehigh Gas Station and Convenience Store – Landsdale
    - Woodlyn Exxon – Woodlyn

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit alternative fuel stations by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for fuel and food supply.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Link to real-world examples of this microgrid use case in the U.S.:

- https://www.enelnorthamerica.com/about-us/newsroom/search-stories/stories/2022/06/resilient-service-station

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Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	40.3	56.6	82.5
BESS Capacity (kW)	4.7	25.5	50.0
BESS Energy (kWh)	18.6	102.0	200.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$76,967	$108,038	$157,545

	Battery Energy Storage System	$6,713	$36,597	$72,035
Annual OPEX	Utility Demand Charges	$3,000	$3,000	$2,000
	Utility Energy Charges	$9,000	$2,000	$5,000
	DER Maintenance Costs	$1,000	$2,000	$4,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Urgent Care

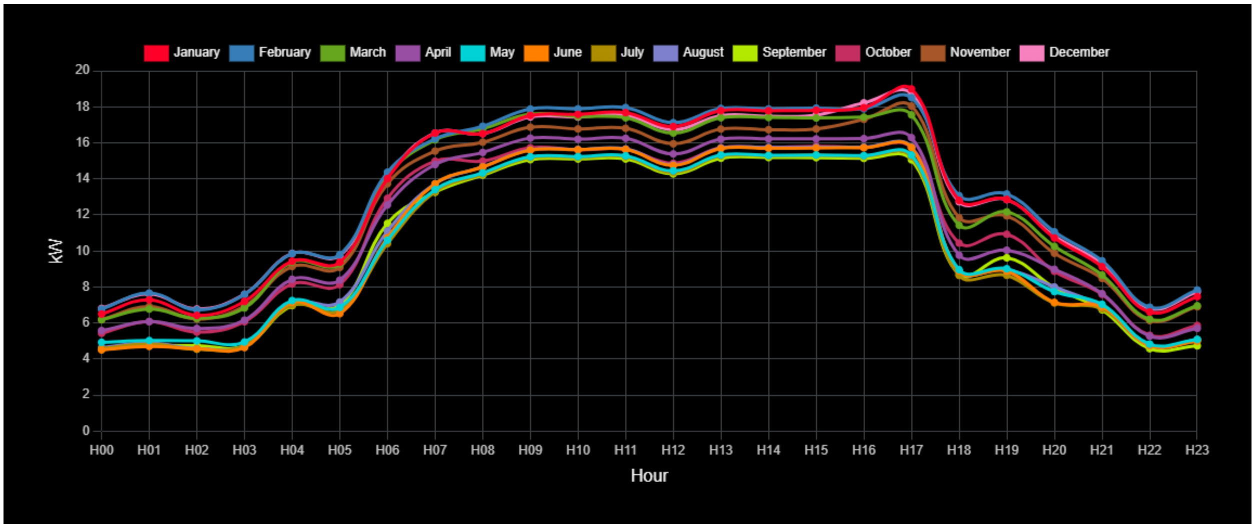
This use case demonstrates three potential design scenarios for a microgrid deployment at urgent care facilities in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

- Facility Size and Type:
  - Urgent care facilities include walk-in clinics that provide medical care for minor illnesses and injuries outside of a traditional hospital or emergency department. Urgent care facilities may also be referred to as walk-in clinics, minute clinics, quick care clinics, minor emergency centers, or minor care clinics. These healthcare services remain critical during outages, and some urgent care facilities may not have the resilience capabilities to continue operations.[16]
  - The load profile used in this study represents the average hourly facility load for a 40,946 sq. ft., three-story irregular-shaped building that was built after 1980. SEPA reduced the facility load profile by a factor of thirteen to reflect a 3,150 sq. ft., one-floor facility that is more similar in size to many existing urgent care facilities per American Academy of Urgent Care Medicine (AAUCM). The building includes exam rooms, offices, a lobby, waiting rooms, a pre-operating room, operating rooms, storage, restrooms, physical therapy, and staff lounges.
  - Daily operating hours are assumed to be 7am - 6pm.

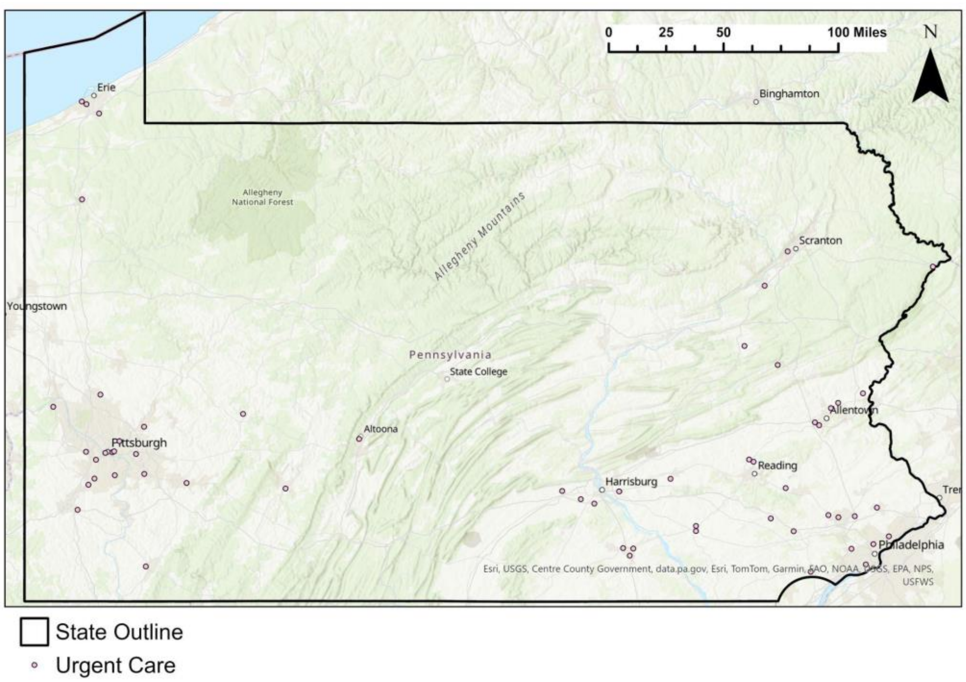
[16] https://www.acep.org/patient-care/policy-statements/urgent-care-centers

Urgent Care Load Profile:



Source: The "outpatient health care" load profile used in this study is taken from hourly electric load data published on the National Renewable Energy Laboratory's (NREL) OpenEI site. The load profile represents the electric consumption of an average urgent care facility in IECC climate zone 6A near Bradford, PA.

Distribution of Urgent Care Facilities:



- Overview:
  - SEPA identified 60 potential urgent care facilities as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:

- Urgent Care Center - New Kensington
- Water Street Urgent Care - Meadville
- Select Speciality At UPMC Montefiore – Pittsburg
- Concentra Urgent Care - Aspinwall - Pittsburgh
- Concentra Urgent Care - Philadelphia Airport - Philadelphia

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Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit urgent care facilities by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for healthcare and emergency medical services.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Link to real-world examples of this microgrid use case in the U.S.:

- [Tamalpais California Healthcare Clinic Microgrid]

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	37.1	54.0	57.0
BESS Capacity (kW)	2.6	18.7	21.7
BESS Energy (kWh)	10.4	74.7	86.7

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$70,948	$103,179	$108,873
	Battery Energy Storage System	$3,762	$26,886	$31,211
Annual OPEX	Utility Demand Charges	$1,000	<$1,000	<$1,000
	Utility Energy Charges	$6,000	$4,000	$3,000

	DER Maintenance Costs	$1,000	$2,000	$2,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

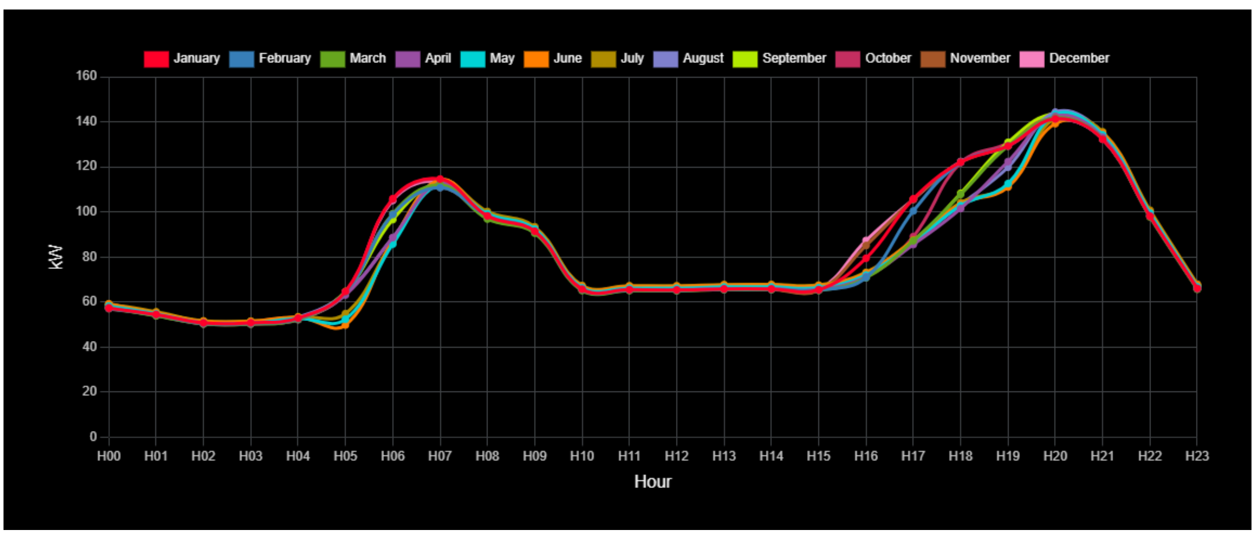
Correctional Facilities

This use case demonstrates three potential design scenarios for a microgrid deployment at correctional facilities in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

- Facility Size and Type:
    - According to the U.S. Department of Justice, "Corrections facilities include prisons and jails. Prisons are state or federal housing facilities that confine convicted felons with sentences typically longer than a year. Jails are administered by local law enforcement and hold those with shorter sentences — usually for 1 year or less — and those awaiting trial."[17] Some correctional facilities may not have the resilience capabilities to continue operations during an emergency outage.

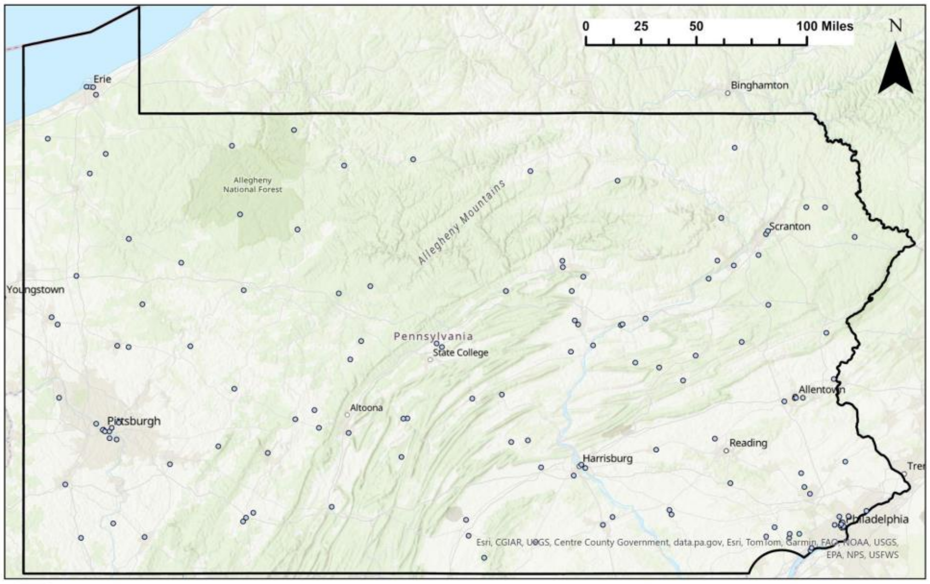
Correctional Facility Load Profile:



Source: The load profile used in this study was collected during the 2022 ProtoGen PA DEP Microgrid Feasibility Studies. The load profile represents historical electric consumption for a county prison built after 1980 in IECC climate zone 5A in Perry County, PA.

[17] https://nij.ojp.gov/topics/corrections/correctional-facilities

Distribution of Correctional Facilities:



State Outline
Correctional Facilities

- Overview:
  - SEPA identified 183 potential correctional facilities as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Philadelphia Juvenile Justice Services Center - Philadelphia
    - Curran-Fromhold Correctional Facility - Philadelphia
    - PHILADELPHIA INDUSTRIAL CORRECTIONAL Center - Philadelphia
    - Philadelphia Detention Center – Philadelphia
    - SCI Chester - Chester

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit correctional facilities by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for public safety.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Link to real-world examples of this microgrid use case in the U.S.:

- [Montgomery County Correctional Facility Microgrid]

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	181.0	302.0	397.0
BESS Capacity (kW)	21.2	128.3	221.5
BESS Energy (kWh)	84.9	513.0	886.0

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$345,104	$577,668	$757,882
	Battery Energy Storage System	$30,580	$184,747	$319,019
Annual OPEX	Utility Demand Charges	$6,000	$3,000	$2,000
	Utility Energy Charges	$48,000	$34,000	$23,000
	DER Maintenance Costs	$4,000	$11,000	$17,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

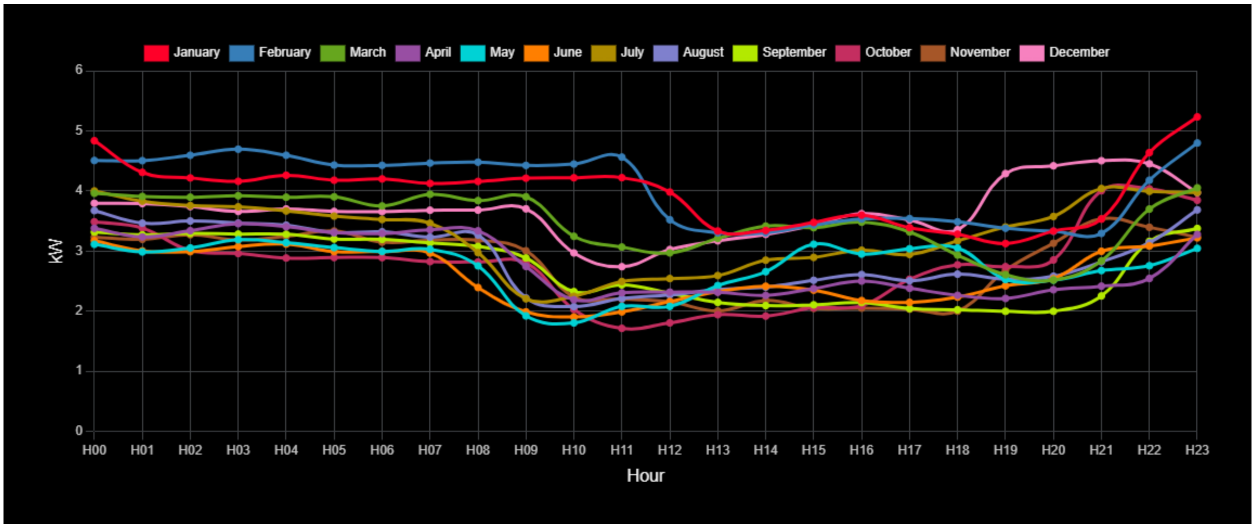
Fire Stations

This use case demonstrates three potential design scenarios for a microgrid deployment at fire stations in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

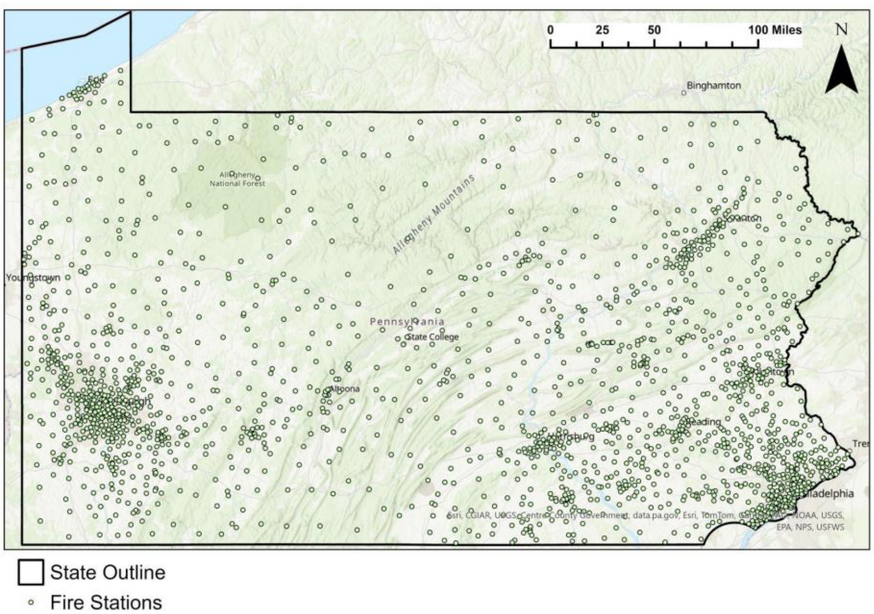
- Facility Size and Type:
  - Fire stations serve as a place of operation for a municipal fire department and may also support other related emergency service roles including communications and dispatch. Some fire stations may not have the resilience capabilities to continue operations during an emergency outage.

Fire Station Load Profile:



Source: The load profile used in this study was collected during the 2022 ProtoGen PA DEP Microgrid Feasibility Studies. The load profile represents historical electric consumption for a fire station in IECC climate zone 6A near Eldred, PA.

Distribution of Fire Stations:



- Overview:
  - SEPA identified 2,895 potential fire stations as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Folcroft Fire Company - Folcroft
    - Monongahela Fire Department - Monongahela
    - Philadelphia Fire Department Engine 16 Medic 26 - Philadelphia
    - Philadelphia Fire Department Engine 59 Ladder 18 Medic 4 - Philadelphia

- Union Fire Company #1 - Oxford

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit fire stations by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for public safety and emergency response services.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- [Solar Emergency Microgrids for Fremont Fire Stations]
- [Portland Fire Station Microgrid]
- [Erie Pennsylvania Fire Station Microgrid]

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	9.0	9.2	16.8
BESS Capacity (kW)	3.4	3.6	11.1
BESS Energy (kWh)	13.5	14.4	44.5

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$20,559	$20,942	$38,157
	Battery Energy Storage System	$4,847	$5,169	$16,016
Annual OPEX	Utility Demand Charges	$1,000	$1,000	$1,000
	Utility Energy Charges	$2,000	$2,000	<$1,000
	DER Maintenance Costs	<$1,000	<$1,000	$1,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

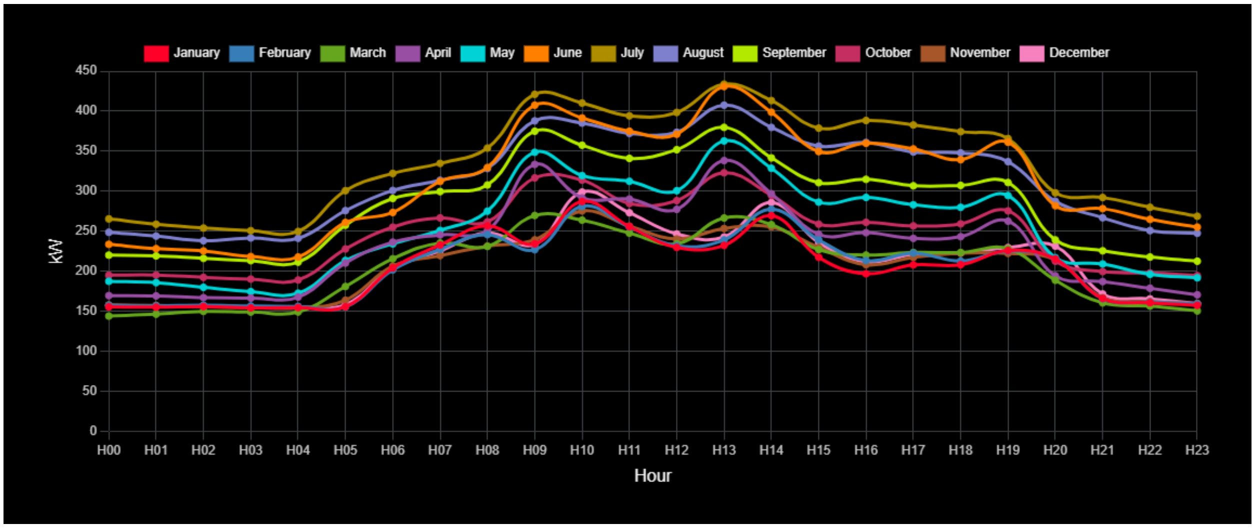
Nursing Home

This use case demonstrates three potential design scenarios for a microgrid deployment at nursing homes in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

Assumptions:

- Facility Size and Type:
    - Nursing homes and other long-term care facilities (i.e. assisted living communities, continuing care retirement communities, and other residential care facilities) provide health and personal care services for elderly or disabled residents including nursing care, 24-hour supervision, meals, assistance with everyday activities, and rehabilitation services.[18] These services remain critical for residents during outages, and some nursing homes may not have the resilience capabilities to continue operations.

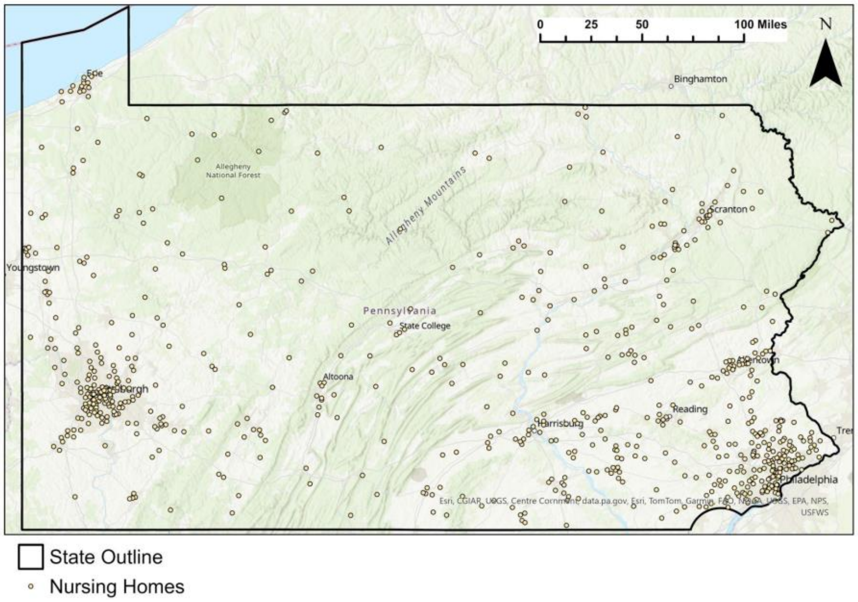
Nursing Home Load Profile:



Source: The load profile used in this study was collected during the 2022 ProtoGen PA DEP Microgrid Feasibility Studies. The load profile represents historical electric consumption for a nursing home in IECC climate zone 5A in Allegheny County, PA.

[18]https://www.nia.nih.gov/health/assisted-living-and-nursing-homes/long-term-care-facilities-assisted-living-nursing-homes

Distribution of Nursing Homes:



- Overview:
  - SEPA identified 909 potential nursing homes as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - West End Senior Community Center - Rook
    - West End Senior Center- Pittsburgh
    - Monroeville Senior Citizen Facility – Monroeville
    - Monroeville Senior Center – Monroeville
    - St Ignatius Nursing Home – Philadelphia

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit nursing homes by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for healthcare.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Link to real-world examples of this microgrid use case in the U.S.:

- New York Medical Complex Microgrid

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (kW)	917	1,300	1,980
BESS Capacity (kW)	198	565	790
BESS Energy (kWh)	790	2,260	3,160

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$1,677,451	$2,371,645	$3,615,090
	Battery Energy Storage System	$284,405	$815,042	$1,137,882
Annual OPEX	Utility Demand Charges	$1,000	$1,000	<$1,000
	Utility Energy Charges	$69,000	$41,000	$15,000
	Utility Contract Costs	$45,000	$45,000	$45,000
	DER Maintenance Costs	$25,000	$48,000	$70,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Colleges and Universities

This use case demonstrates three potential design scenarios for a microgrid deployment at colleges and universities in Pennsylvania. Each scenario is tailored to enhance the resilience, efficiency, and sustainability of the facility during grid outages and normal operations.

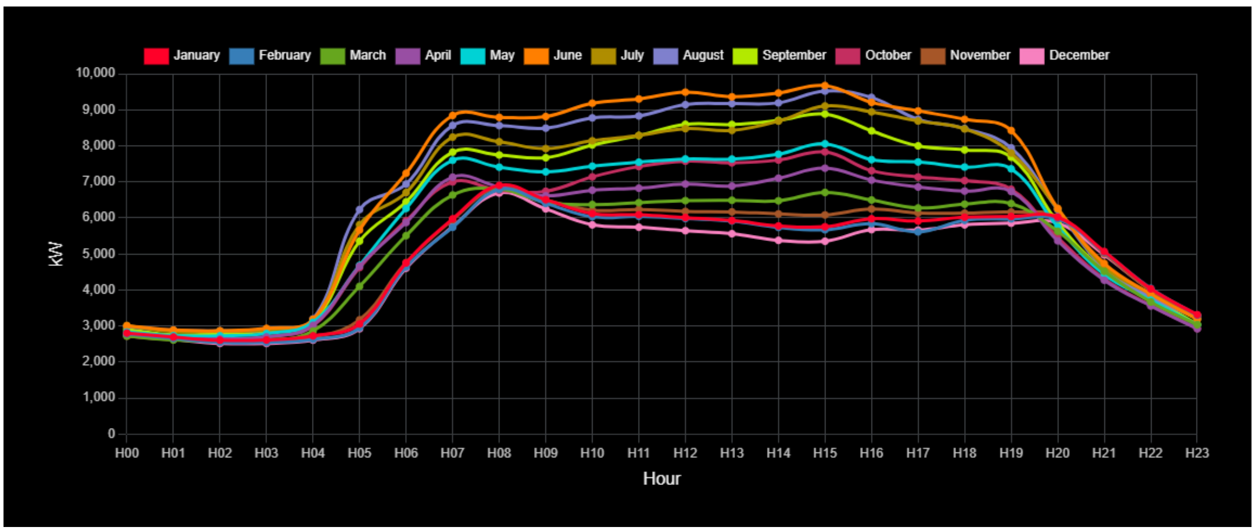
Assumptions:

- Facility Size and Type:
  - Colleges and universities are post-secondary education facilities that provide undergraduate and/or graduate degree programs and may include research institutions, athletics, and housing. During outages, colleges and universities may be

able to provide shelter, food, and other critical community services. However, some institutions may not have the resilience capabilities to continue operations.

- The load profile used in this study represents an aggregated hourly facility load for a representative list of [reference buildings] that were built after 1980. The "campus" load profile[19] includes:
  - Secondary School (x2)
  - Primary School (x3)
  - Large Office
  - Medium Office (x2)
  - Small Office (x6)
  - Mid Rise Apartment (x4)
  - Small Hotel (x3)
  - Large Hotel (x3)
  - Full-Service Restaurant (x2)
  - Quick Service Restaurant (x4)
  - Warehouse

College and University Load Profile:



Source: The "colleges and universities" load profile used in this study is aggregated from hourly electric load data published on the National Renewable Energy Laboratory's (NREL) OpenEI site. The load profile represents the electric consumption of several representative facilities comprising a "campus" in IECC climate zone 5A near Pittsburgh, PA.

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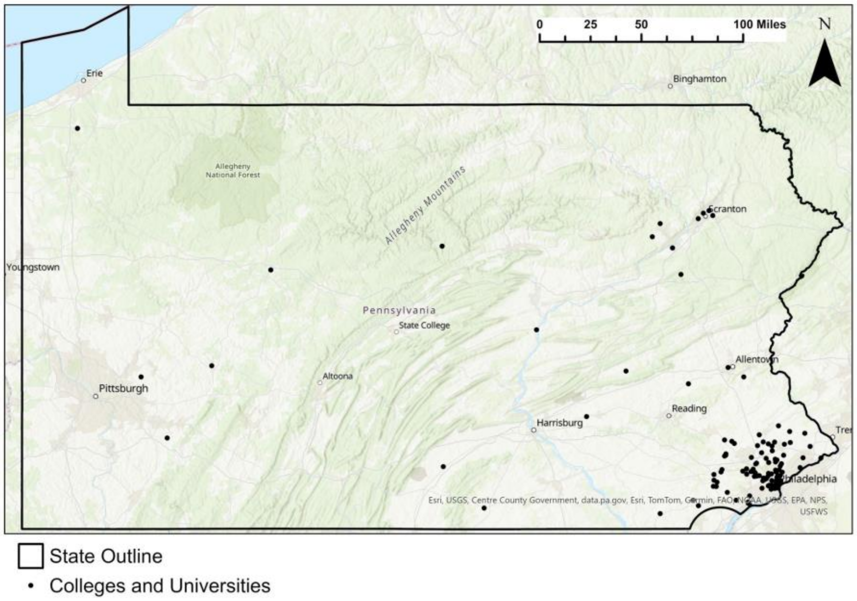
[19] Campus facilities loosely based on Chatham University's Shadyside campus facilities list.

Distribution of Colleges and Universities:



- Overview:
  - SEPA identified 328 potential colleges and universities as microgrid sites in Pennsylvania. The top 5 ranked facilities based on site prioritization are highlighted below:
    - Widener University Building 1 – Chester
    - Widener University Building 2 – Chester
    - University Of Pittsburgh At Greensburg – Greensburg
    - St Joseph's University – Merion Station
    - St Joseph's University – Merion Station

Technology Selection:

This use case includes the following technologies for consideration in each scenario:

- Commercial Rooftop Solar PV
- 4-hour Li-Ion BESS

Benefits of a Microgrid:

A microgrid can specifically benefit colleges and universities by:

- **Resilience:** Ensuring continuous operation during grid outages, which is critical for providing critical community and emergency services.
- **Sustainability:** Reducing carbon emissions by integrating renewable energy sources.
- **Cost Savings:** Lowering operational costs through demand charge reductions and savings from net-metering.

Examples:

Links to real-world examples of this microgrid use case in the U.S.:

- Gallaudet University Microgrid
- University of Kansas Welcome Center Microgrid
- Illinois Tech Microgrid

Preliminary Solar & Storage Sizing:

	Low Renewable	Mid Renewable	High Renewable
Solar (MW)	25.3	39	57.3
BESS Capacity (MW)	6.2	9.5	12
BESS Energy (MWh)	24.7	38.1	48.1

Preliminary Economic Analysis:

Simple ranges of costs (CAPEX and OPEX) for each scenario:

		Low Renewable	Mid Renewable	High Renewable
CAPEX	Solar PV	$30,087,693	$46,441,385	$68,143,415
	Battery Energy Storage System	$8,899,193	$13,706,126	$17,316,047
Annual OPEX	Utility Demand Charges	$95,000	$29,000	<$1,000
	Utility Energy Charges	$1,384,000	$830,000	$557,000
	Utility Contract Costs	$473,000	$473,000	$473,000
	DER Maintenance Costs	$711,000	$1,097,000	$1,521,000

Key Considerations:

Refer to the **Microgrid Deployment Action Plan** in the main report for key considerations and next steps with planning, funding, and implementing the microgrid.

Appendix Y: Incentives, Grants, and Partnerships for Project Development

Additional Information on State and Federal Grants:

- FEMA Building Resilient Infrastructure and Communities (BRIC) Funding. FEMA's BRIC program to support states, local governments, tribes and territories as they invest in proactive hazard mitigation solutions. In July 2024, FEMA announced 56 projects totaling $674.5 million towards hazard mitigation programs and projects. This program has a 75 percent federal and 25 percent state/local match, and for small and impoverished communities a 90 percent federal and 10 percent state/local match.
- Renewable Energy Program (REP) and Solar Energy Program (SEP). The Pennsylvania Department of Community and Economic Development (DCED) and DEP provide grant and loan funds through the REP and SEP to develop geothermal, wind, and solar energy projects. Through the REP, Pennsylvania provides loans to businesses, economic development organizations, and political subdivisions (i.e. municipalities, counties, and school districts) for geothermal systems or wind energy projects up to $5 million or 50 percent of the total project cost. The REP also provides grants for wind energy generation or distribution projects up to $1 million, or 30 percent of the total project cost. Similarly, Pennsylvania's SEP program provides loans to businesses, economic development organizations, and political subdivisions (i.e. municipalities, counties, and school districts) for solar energy generation or distribution projects up to $5 million or $3.00 per watt. The SEP also provides grants of up to $1 million or $1.50 per watt for solar energy generation or distribution projects. Microgrid projects that include wind, geothermal, or solar generation resources may be eligible to receive loan or grant funding from the REP or SEP.
- The Solar for Schools program, passed in July 2024, will provide state and federal funding to install solar systems at public K-12 schools, community colleges, and career technical schools across Pennsylvania. Schools will apply to receive funding to cover up to 50% of the total cost of a solar project. The state funds can be stacked on top of other donations, grants, or federal funds available through federal incentives through the IRA.

Additional Information on Leveraging the Federal Investment Tax Credit (ITC):

- Additional Information: ITC is available to solar and storage project stakeholders that reduce the federal income tax liability for a percentage of the cost of a system installed during the tax year. Ensure that your projects meet the necessary requirements to qualify for these credits. Through 2033, a 30% credit is available for solar and storage projects that meet prevailing wage and apprenticeship requirements. Additional 10% bonus credits are available for projects that meet domestic content requirements or are built within identified energy communities. Low-income bonus credits (10-20%) are also available for projects built in LMI communities, on Indian land, or as part of a qualified low-income residential building project or low-income economic benefit project. Microgrid projects, including solar and/or storage resources, are likely eligible for federal ITC.

- Additionally, the Inflation Reduction Act, included a “direct pay” provision that enables tax-exempt and governmental entities to receive payment equal to the full value of the ITC. Rather than creating a credit for the amount of income tax you would otherwise owe for a solar project, the IRA now enables eligible entities to directly receive the 30% credit on the cost of the solar and/or storage system.

Leveraging External Expertise & Capital to Develop Projects

- In addition to leveraging federal funding and tax credits, it is important for project teams to utilize external expertise and capital to advance microgrid projects that enhance Pennsylvania's energy grid resilience and flexibility. Private Equity firms with microgrid projects in their portfolio can provide vital financial resources for large capital projects. Microgrid developers offer important technical expertise required in designing and deploying microgrid systems. Similarly, a number of organizations are beginning to develop resilience hubs, in which a microgrid provides essential services for local members of a community. Resilience hubs offer an important solution that continues to meet the needs of a community during the event of an outage.