slipstream

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Downtown La Crosse
Microgrid Feasibility Analysis & Resilience Planning

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ACRONYMS

Acronym	Definition
ATS	Automatic Transfer Switch
AVERT	Avoided Emissions and Generation Tool
BAS	Building Automation System
BESS	Battery Energy Storage System
CO_2	Carbon Dioxide
CRC	Community Resilience Center
CRB	Commercial Reference Building
DER	Distributed Energy Resource
DOE	U.S. Department of Energy
DP	Distribution Panel
EASIUR	Estimating Air Pollution Social Impact Using Regression
EIGP	Energy Innovation Grant Program
EM	Emergency (electrical panel designation)
EPA	U.S. Environmental Protection Agency
EOC	Emergency Operations Center
ERS	Essential Reliability Services
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
HHS	Health & Human Services
HVAC	Heating, Ventilation, and Air Conditioning
IEEE	Institute of Electrical and Electronics Engineers
IRA	Inflation Reduction Act
ITC	Investment Tax Credit
kW	Kilowatt
kWh	Kilowatt-hour
LBNL	Lawrence Berkeley National Laboratory
LEC	Law Enforcement Center
LFP	Lithium Iron Phosphate
MISO	Midcontinent Independent System Operator
NFPA	National Fire Protection Association
NIST	National Institute of Standards and Technology
NLR	National Laboratory of the Rockies (formerly NREL)
NOx	Nitrogen Oxides
NPV	Net Present Value
OEI	Office of Energy Innovation
O&M	Operations and Maintenance
OPT	Optional Standby (electrical panel designation)
PSC	Public Service Commission
PTC	Production Tax Credit

PV	Photovoltaic
REQ	Required Standby (electrical panel designation)
REopt	Renewable Energy Integration & Optimization Tool
ROI	Return on Investment
RTO	Recovery Time Objective
SO_2	Sulfur Dioxide
TOU	Time-of-Use
UL	Underwriters Laboratories
USDN	Urban Sustainability Directors Network
UPS	Uninterruptible Power Supply
VOR	Value of Resilience

GLOSSARY OF TERMS

AVERT (Avoided Emissions and Generation Tool): A tool developed by the U.S. Environmental Protection Agency (EPA) to estimate the emissions benefits of energy efficiency and renewable energy programs by analyzing how changes in energy generation affect emissions at the regional level.

BESS (Battery Energy Storage Systems): Systems that store energy in rechargeable batteries for later use. BESS can help balance electricity supply and demand, enhance grid stability, and provide backup power during outages.

CO_2 (Carbon Dioxide): A greenhouse gas that is a primary contributor to climate change. It is emitted from burning fossil fuels, deforestation, and other industrial processes.

Community Lifelines: Fundamental services in a community that a functioning society, identified by FEMA as seven essential categories: Safety and Security, Food, Hydration, and Shelter, Health and Medical, Energy, Communications, Transportation, and Hazardous Materials.

DER (Distributed Energy Resource): Small-scale electricity generation or storage technologies, such as solar PV, wind, battery storage, and demand response, that are located close to end-users and can operate independently or in coordination with the grid.

GHG (Greenhouse Gases): Heat-trapping gases like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) that are released into the air primarily from burning fossil fuels, deforestation, and agriculture. These gases are making Earth warmer and causing climate changes.

HVAC (Heating, Ventilation, and Air Conditioning): A system that regulates indoor climate conditions, providing heating, cooling, and air circulation for buildings.

kW (Kilowatt): A unit of power equal to 1,000 watts, often used to measure the capacity of electrical appliances, solar PV systems, and generators.

kWh (Kilowatt-Hour): A unit of energy equivalent to using one kilowatt of power for one hour. It is commonly used in electricity billing to measure energy consumption.

NRL (National Laboratory of the Rockies): Formerly known as NREL (National Renewable Energy Laboratory). A U.S. Department of Energy laboratory that conducts research and development on renewable energy, energy efficiency, and energy systems integration.

NPV (Net Present Value): A financial metric used to assess the profitability of an investment by calculating the present value of capital investments when all future returns and costs are accounted for, minus the initial investment and adjusted for time and risk.

PSC (Public Service Commission): A regulatory body that oversees utilities and ensures fair pricing, reliability, and compliance with energy policies in each jurisdiction.

PV (Photovoltaics): A technology that converts sunlight directly into electricity using semiconductor materials, commonly used in solar panels for residential, commercial, and utility-scale applications.

EXECUTIVE SUMMARY

As climate change drives more frequent and severe extreme weather events, grid and community resiliency are put to the test. To respond to this growing need, La Crosse has been making concerted efforts to prioritized climate action, sustainability, and resilience through long-term planning initiatives. These efforts are grounded in the city's Climate Action Plan which emphasizes energy efficiency, renewable energy adoption, and greenhouse gas (GHG) emissions reduction. Parallel to this, the La Crosse County Comprehensive Plan and Climate Action Plan lay a strong foundation for sustainable growth integrating climate action, land preservation, and social equity into county government administration and planning. Microgrids, localized energy systems capable of operating independently from the broader electric grid, offer a compelling strategy to support these objectives.

Slipstream partnered with La Crosse County, the City of La Crosse, and Western Technical College (Western) to evaluate the feasibility of deploying microgrids at a cluster of essential facilities in Downtown La Crosse. This research addresses the community's growing need to enhance energy resilience and sustainability in response to increasing climate vulnerability. It also establishes a replicable model for urban clusters and demonstrates how local public institutions can lead energy innovation while meeting community resilience and decarbonization commitments.

Project Scope and Objectives

This study encompasses seven strategically clustered buildings spanning the three partner organizations: the County Administrative Center, Law Enforcement Center, and Health & Human Services (La Crosse County); City Hall and Main Public Library (City of La Crosse); and Kumm Center and Coleman Center (Western Technical College). Collectively, these facilities use approximately 6.77 million kWh of electricity annually and serve as essential community lifelines providing safety, security, shelter, health services, and emergency operations functions. The primary goals include:

- Evaluate the technical and economic feasibility of microgrids across individual buildings and small campus configurations, analyzing distributed energy resource (DER) configurations
- Assess the ability of microgrids to maintain critical operations during grid outages and establishing a Community Resilience Center (CRC) to support long-term community energy security.
- Quantify environmental and public health benefits, including emissions reductions
- Identify regulatory, ownership, and operational considerations that affect implementation feasibility
- Provide actionable design, financing, and implementation recommendations to guide next steps.

Key Findings

Our analysis examined various microgrid scenarios incorporating solar photovoltaic (PV) systems (new and existing), battery energy storage systems (BESS), and existing backup generators. Financial results indicate significant economic tradeoffs depending on system configuration. When evaluated using conventional financial metrics that reflect only utility bill savings and capital costs, results show mixed net present value (NPV) outcomes due to low retail electricity rates and the relatively infrequent occurrence of outages. However, these metrics do not capture several core value streams that microgrids are designed to provide, including avoided outage costs (resilience) and reduced emissions and associated health impacts. For example, the Western Technical College Small Campus Scenario 1 achieves an NPV of approximately $297,000 when resilience and emissions benefits are accounted for, compared to near break-even economics under utility savings alone.

Emissions reductions are substantial across all scenarios, ranging from 250 to 12,600 tons of CO_2 emissions throughout the 25-year analysis period, with associated carbon and air-quality health benefits valued in the tens to hundreds of thousands of dollars per site. Additional health benefits from reduced criteria pollutants (nitrogen oxides, sulfur dioxide, particulate matter) range from $80,000 to $440,000 per scenario, underscoring significant public health improvements.

Campus-scale microgrids, which interconnect buildings under the same ownership and meter, demonstrate improved economics relative to single-building systems by leveraging larger PV systems to support shared storage. These configurations also align well with regulatory constraints in Wisconsin, which currently make multi-owner microgrids difficult to implement.

Technical Feasibility

From a technical perspective, the study confirms that microgrids can reliably support critical loads during modeled outage conditions, including winter and summer peak events lasting four to eight hours. Properly sized PV and BESS systems, coupled with existing generators, can sustain essential services such as public safety operations, detention facilities, health and human services, and community sheltering. The analysis also shows that microgrids can provide additional grid benefits, including peak demand reduction, time-of-use optimization, and voltage and frequency support.

The designation of the Kumm Center at Western Technical College as a Community Resilience Center is a particularly strong outcome of the study. With appropriate microgrid support, the facility could provide heating and cooling, food services, medical support, device charging, and shelter during extended outages. Serving as a lifeline for vulnerable populations disproportionately affected by grid outages.

Implementation Recommendations and Financing Strategy

The study recommends a phased approach prioritizing microgrid-ready design during building renovations, sizing systems for forecasted growth while planning for expansion, and establishing clear recovery time objectives aligned with NIST community resilience guidelines. Individual building or small campus microgrids are more feasible than a unified multi-owner system under current Wisconsin regulatory frameworks, as they avoid complex cross-owner energy transactions and regulatory complications.

Multiple funding pathways can substantially improve project economics. The Inflation Reduction Act's 30% Investment Tax Credit, potentially increased to 50–60% with domestic content and low-income community bonuses, directly reduces capital costs. The Wisconsin Public Service Commission's Energy Innovation Grant Program (historically funding up to $750,000 for Level 3 microgrid projects), Focus on Energy rebates for solar and efficient equipment, and strategic financing structures are options that may enable project partners to achieve positive financial returns while advancing climate and resilience objective.

1 INTRODUCTION

As climate change normalizes extreme weather events, grid and community resiliency are put to the test. To respond to this growing need, La Crosse has been making concerted efforts to enhance its energy resilience and sustainability as part of its long-term development strategy. These efforts are grounded in the city's Climate Action Plan[1] which emphasizes energy efficiency, renewable energy adoption, and greenhouse gas (GHG) emissions reduction. Parallel to this, the La Crosse County Comprehensive Plan, Envision 2050[2] lays a strong foundation for sustainable growth integrating climate action, land preservation, social equity, and economic development into county planning. Meanwhile, La Crosse County's new Climate Action Plan[3] recommends the County to assess the feasibility of a downtown microgrid.

Supported by the Wisconsin Public Service Commission's (PSC) Office of Energy Innovation (OEI), Slipstream partnered with La Crosse County, the City of La Crosse, and Western Technical College (Western) to assess the feasibility of establishing microgrids at several essential government facilities (County Administrative Center, Law Enforcement Center, Health & Human Services, City Hall, and the Main Public Library) and a few Western buildings (Kumm Center and Coleman Center) that will become a designated community resilience center (CRC), all in the Downtown La Crosse area. These microgrids aim to ensure energy security, enable climate adaptation, and provide long-term economic benefits. Specifically, the study focuses on developing a variety of microgrid scenarios that align with the resilience goals of each project partner while optimizing for cost-effectiveness. Initial partner conversations revealed a unified primary goal: resilience. Consequently, the project emphasizes resilience planning, highlighting the role of these facilities in maintaining community services and the benefits of a designated CRC.

The microgrid feasibility study's goals include:

- **Evaluating the costs and benefits associated with implementing microgrids:** Developing various microgrid scenarios to associate and compare costs and benefits with different designs.
- **Promoting resilience:** Planning microgrids that can sustain critical operations during outages.
- **Supporting sustainability:** Incorporating renewable energy and energy efficiency strategies.
- **Fostering economic viability:** Identifying funding strategies and partnerships to provide positive net present value for microgrid feasibility.
- **Defining ownership structure and business model:** Establishing clear roles and responsibilities for partners in owning, operating, and managing the microgrid, ensuring long-term financial and operational sustainability.

The report starts with providing project background and details on La Crosse and the various sites that form part of the study. We then describe the methodology and results of the microgrid planning. The results highlight the tradeoffs between different system sizes and configurations to inform future microgrid planning, but a more in-depth design and analysis would be needed if the project partners decided to proceed with a microgrid installation. Finally, we provide a list of microgrid development recommendations for the sites and the eventual development of microgrids at each of them.

[1] paleBLUEdot LLC, "La Crosse Climate Action Plan."
[2] La Crosse County, "Envision 2050 La Crosse County Comprehensive Plan (2022-2050)."
[3] Constant and Key, "La Crosse County Climate Action Plan - Part 1 Government Operations Plan."

1.1 Background

La Crosse County, with a population of approximately 120,000 people, serves as a regional hub for government, health care, education, and public safety located along the Mississippi River. Within it, the City of La Crosse has a population of about 52,000 and anchors the dense downtown area where all study sites are located. Both jurisdictions have adopted ambitious long-term climate and resilience goals: the City's Climate Action Plan commits to reducing community-wide greenhouse gas emissions 40–50% by 2030 and achieving carbon neutrality by 2050. The County's Climate Action Plan aims to achieve carbon neutral county government emissions by 2050. Together, these plans highlight the region's increasing vulnerability to extreme weather and the need to strengthen continuity of operations across essential government and community-serving facilities.

The microgrid feasibility focuses on three key institutions whose facilities form the civic and operational backbone of La Crosse's downtown area: La Crosse County, the City of La Crosse, and Western Technical College. Each partner owns facilities that play a central role in delivering public services, maintaining governmental functions, and supporting community well-being during both normal operations and emergency conditions. Their shared priority of strengthening energy resilience provides a unified foundation for evaluating microgrid opportunities. Figure 1 shows and describes the seven buildings clustered within a walkable portion of Downtown La Crosse. Their proximity creates a strategic advantage for microgrid development, enabling coordinated resilience across institutions and supporting uninterrupted delivery of critical public services during grid outages.

Figure 1. Downtown La Crosse map.

1.2 Challenges and Vulnerabilities of the City

La Crosse faces a combination of climate, infrastructure, and socio-economic challenges that affect the City's ability to ensure energy resilience and community well-being. Below we provide an overview of the challenges that were assessed through project partner input. These challenges align with findings from the City's Climate Change Vulnerability Assessment[4] and Climate Action Plan.

Climate and Weather-Related Vulnerabilities

- **Storms and Flooding**: La Crosse is vulnerable to increasingly frequent and intense precipitation. As a river city located along the Mississippi, increasing precipitation intensity and fluctuating river levels could lead to localized flooding, infrastructure damage, and service disruptions.
- **Extreme Heat and Cold:** Partners expressed concern about growing exposure to extreme temperature events. Projections show a rise in the number of days above 90°F, increasing the risk of heat stress, particularly for seniors, children, and individuals with pre-existing health conditions. Meanwhile, severe cold weather events challenge heating systems, increase peak energy demand, and can cause prolonged outages, dangerous road conditions, and interruptions to critical services.

Infrastructure and Energy System Vulnerabilities

- **Electrical Grid Reliability:** Outages caused by storm damage, high load events, and aging infrastructure highlight the need for localized energy resilience. Many buildings and utility systems are not designed for climate extremes or rapid recovery.
- **Critical Facility Dependence:** Key government buildings like the ones in this study (City Hall, County Administrative Center, County Law Enforcement Center, Health & Human Services, Main Public Library) lack integrated backup beyond emergency panels. Loss of these lifelines during outages threatens community safety and recovery.

Social and Community Vulnerabilities

- **Vulnerable Populations:** Homeless residents, low-income households, the elderly, and disabled individuals are disproportionately at risk from extreme weather and service disruptions. They face higher exposure to health and safety risks and often have fewer resources for recovery.
- **Public Health Risks:** Climate change is increasing risks from poor air quality (allergens, ozone, wildfire smoke), spreading of diseases, and mental health stressors during extreme events.

The proposed microgrid and CRC can address and mitigate these risks and vulnerabilities, ensure continuity of essential services, and enhance overall community resilience.

[4] EcoAdapt, *City of La Crosse Climate Change Vulnerability Assessment*.

2 RESILIENCE PLANNING

Collaboration with the project partners during the resilience planning phase yielded performance metrics, infrastructure requirements, and implementation recommendations that formed the analytical foundation for this study. Planning efforts also evaluated the establishment of a Community Resilience Center (CRC), supported by standalone or small campus microgrids and co-located with other essential government facilities designated as Community Lifeline Facilities, to enhance community-wide resilience via uninterrupted delivery of vital services. The subsequent sections describe the process and overall framework for how La Crosse can build stronger community resilience through microgrids and a designated CRC.

2.1 Electrical Grid Status in the Area

Electric reliability in the City of La Crosse is influenced primarily by the same climate and weather-related hazards described above. Climate and weather-related events can result in localized voltage drops, equipment overloads, and longer restoration times, particularly in older distribution circuits that lack sectionalization or redundancy. Collectively, these factors underscore the need for localized resilience measures such as distributed generation, energy storage, and microgrid functionality.

Across the Midcontinent Independent System Operator (MISO) footprint, reliability risk is evolving due to a combination of load growth, resource mix changes, and extreme weather exposure[5]. Key considerations include:

- **Rising peak demand** over the next decade, with pronounced summer and growing winter risk as electrification and large new loads (e.g., data centers/industrial) materialize. This tightens reserve margins and increases the probability of supply shortfalls during extreme conditions.
- **Resource adequacy shifting from capacity to energy sufficiency**: greater dependence on weather-sensitive energy resources heightens uncertainty in hours outside the traditional peak, requiring more flexible, dispatchable and long-duration resources.
- **Transmission development and deliverability constraints**: significant new transmission is planned but faces siting/permitting and timing challenges; interregional transfer capability is increasingly important under extreme weather stress.
- **Essential Reliability Services (ERS) and flexibility**: retirements of conventional generation can reduce voltage/frequency support; batteries and flexible load can help but need sufficient scale and duration.

Developing microgrids and designating a CRC across key government and community facilities directly addresses many of the local outage drivers. By incorporating distributed energy resources such as solar PV, battery storage, and backup generation, these systems can operate independently of vulnerable feeder segments and maintain power to critical loads during extended outages. Localized generation and load management can also alleviate feeder congestion during extreme temperature events, reducing strain on transformers and minimizing outage propagation.

[5] North American Electric Reliability Corporation, "2024 Long Term Reliability Assessment."

2.2 Energy Resilience Metrics

To track resilience improvements, the project team applied a three-layered framework: engineering-designed, operational, and community resilience.[6] This approach provides a comprehensive perspective on resilience, recognizing the importance of robust physical infrastructure (engineering-designed resilience), adaptive management strategies and responsiveness during disruptions (operational resilience), and the critical role of social factors and community engagement (community resilience). By addressing each layer explicitly, this plan ensures that resilience improvements are measurable, strategically targeted, and directly linked to tangible community benefits.

Table 1. Resilience metrics.

Framework Layer	Performance Objectives	Metrics
Engineering-designed Resilience	**Critical load support by DERs during extended power outage.** The capability of using local Distributed Energy Resources (PV, BESS, and/or generator) to support critical loads.	Metric 1: Percentage of critical loads backed by DERs.
		Metric 2: PV + BESS capacity to support critical loads, in hours, during extended power outage in each building.
		Metric 3: Generator capacity to support critical loads, in hours, during extended power outage in each building.
Operational Resilience	**Recovery time objectives (RTOs).** Ensure critical systems and community services are restored within target recovery timeframes following an outage or disruption.	Metric: Average recovery time (hours) required to restore critical functions to operational status compared to established RTO targets.
Community Resilience	**Critical service availability.** The availability of critical services at the CRC**.**	Metric 1: Shelter capacity. Total number of community members that can be sheltered during an emergency.
		Metric 2: Food storage. Refrigerated storage capacity for food.
		Metric 3: Medical services availability (Basic medical care provision and storage of medications).
		Metric 4: Plug charging capacity. Total number of plugs that can be offered for charging phones, medical devices, or essential electronics.
		Metric 5: Heating and cooling availability. Areas with heating and cooling available to community members.
	Community Accessibility and Equity. Accessibility to CRC services for all**.**	Metric 1: Accessibility rating (e.g., walkability, public transportation access, etc.) to the Community Resilience Center.
		Metric 2: Percentage of underserved, disadvantaged, or vulnerable populations (elderly, economically disadvantaged, disabled) within immediate access radius supported by microgrid services.

[6] Charani Shandiz et al., "Resilience Framework and Metrics for Energy Master Planning of Communities."

Framework Layer	Performance Objectives	Metrics
	Community Engagement. Community member awareness of CRC and its services.	Metric 1: Level of community awareness regarding resilience center and its services.
		Metric 2: Community engagement activities frequency related to resilience and microgrids.
	Communication services reliability. Reliability of communication services during a power outage.	Metric: Reliability of communication services across the community lifelines facilities.
	Community safety and essential services. The community's essential infrastructure and resources.	Metric 1: Community lifeline facilities identified and supported by DERs.
		Metric 2: Designated Community Resilience Centers (CRCs).

2.3 Essential Facilities and Resources for Community Resilience

Below we describe the critical infrastructure and resources that directly enhance the community's resilience through the proposed microgrid project. This includes Community Lifeline Facilities, the designated Community Resilience Center, and supporting energy assets.

Community Lifeline Facilities

According to FEMA, Community Lifelines are "the most fundamental services in the community that, when stabilized, enable all other aspects of society to function."[7] They provide day-to-day services to support the recurring needs of the community. All the buildings included in this microgrid study, including essential government facilities and a future CRC, can be considered Community Lifeline Facilities, since they provide various essential community services including safety and security, food, hydration, shelter, health and medical, and communications.

Furthermore, the National Institute of Standards and Technology (NIST) in their Community Resilience Planning Guide for Buildings and Infrastructure Systems[8], categorizes a community's built environment into building clusters that make up four functional categories: Critical Facilities, Emergency Housing (Shelters, Housing/Neighborhoods), and Community Recovery. The essential government buildings and the CRC in this study all fall under the Critical Facilities category, since they provide public safety services (security, 9-1-1 dispatch, and incident response coordination), emergency operations, shelter, and care. Table 2 presents the essential government buildings that form part of the study, and the essential services they provide.

Table 2. Essential government facilities and their resilience function.

Government building	Resilience function
City Hall	It houses the La Crosse Police Department, which provides essential public safety and security services.
County Administrative Center	Supports administrative continuity and resource management, including land resources and infrastructure.

[7] "Community Lifelines | FEMA.Gov."

[8] NIST Community Resilience Program, *Community Resilience Planning Guide For Buildings and Infrastructure Systems: A Playbook*.

Government building	Resilience function
Law Enforcement Center	Ensures public safety and emergency response coordination (9-1-1 dispatch) through the County Sheriff's Department and Emergency Services Department respectively. It also houses the County Jail, which needs to be backed up in the event of an outage as it provides long-term housing.
Health & Human Services	Offers critical social services and resource distribution. Providing support to many of the most vulnerable populations, including the homeless, the disabled, and the WIC (women, infants, and children). It also houses the Juvenile Detention Facility, which needs to be backed up in the event of an outage as it provides long-term housing.
Main Public Library	Serves as an information hub and could function as a secondary short term shelter location with the appropriate back-up energy system.

Community Resilience Center (CRC):

According to the Public Service Commission (PSC) of Wisconsin, a Community Resilience Center is a facility "designed to provide emergency heating and cooling capability; refrigeration of temperature-sensitive medications, vaccines, and milk from nursing mothers; plug power for durable medical equipment (to include dialysis equipment and continuous positive airway pressure (CPAP) machines); plug power for charging of cell phone and computer batteries; and/or emergency lighting. A CRC may also be a designated location (by the city, county, or State of Wisconsin) for the distribution of emergency services during extended grid outages."[9]

When considering which sites to use as a CRC, the Urban Sustainability Directors Network (USDN) identifies in their Guide to Developing Resilience Hubs[10] several criteria which should be evaluated:

- **Site size and capacity**. The facility should be large enough to accommodate all the services identified as needed, as well as the influx of community members that might be expected during an emergency.
- **Transportation and access**. The site should be accessible to community members and emergency services, and located near as many community members as possible, considering other options they may seek during an emergency.
- **Building condition**. For cost-effectiveness, consider a building that is in good condition or for which upgrades are already planned or underway. This will reduce the cost to maintain the building and ensure the building is usable and operable during unplanned events.
- **Resilience capacity**. Prioritize buildings staffed by community members who are trained and empowered to provide resiliency services. This might include buildings that are located close to first responders, medical personnel, etc.

Based on this criteria, Western Technical College's Kumm Center is a prime candidate to be developed into a CRC. It hosts the college's health programs, giving it the ability to provide basic medical services. The first

[9] PSC of Wisconsin, "Docket 9709-FG-2023 Energy Innovation Grant Program 2023 Application Instructions."
[10] Baja et al., *Guide to Developing Resilience Hubs*.

floor of the building is home to the Union Market, the main on-campus dining service, with kitchens located in the basement level. The school can provide refrigerated space for food storage and potentially meals for people in need during an emergency. A microgrid at this site gives the college the ability to shelter residents in need, provide heating or cooling comfort, and equipment charging (phones, medical devices, or essential electronics).

Back-up CRC considerations:

City of La Crosse's Main Public Library has previously functioned as a support facility in emergencies. The library currently has a rooftop PV system and a back-up generator that supports emergency and life safety electrical panels, providing power to emergency systems and lighting. With the development of a microgrid at this site that serves as back-up support to critical facility loads, the library can function as a short-term shelter and provide charging capabilities for medical devices and essential electronics.

Emergency Operations Center (EOC):

According to FEMA in their Emergency Operations Center How-to Quick Reference Guide, an EOC is "a central command and control system responsible for carrying out the principles of emergency preparedness and emergency management."[11] It can be a physical, virtual or hybrid location. The main functions of EOC include: (1) collecting, analyzing and sharing information; (2) supporting resource needs and requests, including allocation and tracking; (3) coordinating plans and determining current and future needs; and (4) in some cases, providing coordination and policy direction.

The County Administrative building once served as an established center for emergency operations organization. Currently, the emergency functions provided by an EOC are mainly served from the county Law Enforcement Center. With feedback from the County Sheriff's department Emergency Operations Manager, we learned that the EOC needs to be able to move from location depending on where the emergency is. For example, if the downtown area is within the emergency zone, then the EOC would need to be able to relocate to a secure location. Therefore, this plan excludes an EOC because the county requires a mobile/hybrid EOC.

Energy generation and storage assets:

All buildings in this study have back-up generators that mainly support emergency and life safety electrical panels which distribute power for emergency lighting and essential systems like fire alarms, elevators, smoke dampers, or Uninterruptible Power Supply (UPS) systems. Also, most of the buildings, excluding the Western Technical College sites, already have PV systems installed. Giving them the means of generating electricity in the day during normal operations. Expanding existing systems, installing new PV in buildings that currently do not have them, and adding battery energy storage for critical loads will improve building resilience and, by extension, the community they support.

2.4 Resilience Goals and Recommended Actions

To address some of the resilience challenges that the City of La Crosse faces and improve on many of the resilience metrics identified in this study, this subsection specifies resilience goals and provides recommended actions to realize these goals effectively through strategic planning and implementation.

[11] FEMA, *Emergency Operations Center How To Quick Reference Guide*.

Goals:

- **Enhance energy reliability** and minimize disruptions to essential community services during grid outages.
- **Strengthen community preparedness** and adaptability to energy-related disruptions.
- **Foster equitable access** to resilience resources across the community.
- **Promote sustainable energy practices** and reduce community carbon footprint.

Recommended Actions:

- **Establish the proposed microgrids at the identified community lifeline facilities** (City Hall, County Administrative Center, County Law Enforcement Center, Health & Human Services, and Main Library) to ensure continuity of critical services during outages.
- **Implement the Community Resilience Center (CRC)** at the Western Technical College's Kumm and Coleman Centers, leveraging their existing kitchens, medical program spaces, and shelter capacity to provide food and water, basic medical services, emergency shelter, and community support during extended outages.
- **Establish recovery time objectives (RTOs) for critical facilities.** Using the NIST *Community Resilience Planning Guide for Buildings and Infrastructure Systems* as a reference, develop clear recovery time goals for each facility type included in the microgrid study. The NIST example table below will serve as a guiding reference for defining performance expectations across recovery phases: short-term, intermediate, and long-term. These RTOs will help align microgrid design and control strategies to ensure critical facilities such as emergency operations, public safety, and community shelters can meet their targeted operational performance following an outage.

Figure 2. Example building cluster table: Desired performance goals.[12]

Building Clusters	Design Hazard Performance								
	Phase 1: Short-Term			Phase 2: Intermediate			Phase 3: Long-Term		
	Days			Weeks			Months		
	0	1	1-3	1-4	4-8	8-12	4	4-24	24+
Critical Facilities									
Emergency Operation Centers	90%								
First Responder Facilities	90%								
Hospitals	90%								
Buildings with Non-ambulatory Occupants (prisons, nursing homes, etc.)	90%								
Critical Factory	90%								
Emergency Housing									
Temporary Emergency Shelters	30%	90%							
Single and Multi-family Housing (shelter in place)	60%			90%					
Housing/Neighborhoods									
Critical Retail		30%	60%	90%					
Religious and Spiritual Centers			30%	60%	90%				
Single and Multi-family Housing (Full Function)			30%		60%		90%		
Schools			30%	60%	90%				
Hotels & Motels			30%		60%	90%			
Community Recovery									
Businesses – Non-critical Factory				30%	60%	90%			
Businesses - Commodity Services				30%	60%		90%		
Businesses - Service Professions				30%		60%		90%	
Conference and Event Venues				30%		60%		90%	

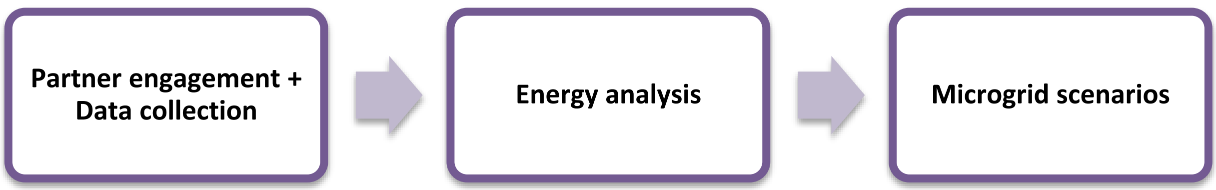
- Utilizing the design framework and recommendations provided in this study, **develop feasibility studies that will lead to implementing microgrids at other community lifeline facilities and develop more resilience hubs**. The investment strategy for this needs to be aligned with community priorities and available funding opportunities.
- **Conduct regular resilience and operational assessments** to evaluate and optimize microgrid performance. These assessments will help identify vulnerabilities and necessary technology upgrades, measure progress toward resilience goals, and ensure that operations of these systems are aligned with community needs.
- **Implement community outreach and education programs** to build awareness and preparedness related to energy resilience. These programs increase public understanding of available services (including the CRC), empower individuals to prepare for outages, and strengthen trust in local institutions.
- Establish partnerships with other local government representatives, utilities, and community-based organizations to **form a collaborative resilience planning team** to enhance resilience planning and resource sharing. The team's role will be to guide implementation of resilience actions, monitor progress, and ensure that decision-making is inclusive and reflective of community priorities.

[12] NIST Community Resilience Program, *Community Resilience Planning Guide For Buildings and Infrastructure Systems: A Playbook*.

3 METHODOLOGY

We conducted the feasibility study through a structured and iterative process, combining a three-stage methodology (Figure 3) with ongoing partner engagement. These processes were supported by carefully selected tools designed to assess building energy demands, evaluate distributed energy resources (DERs), and optimize microgrid configurations, costs, and benefits. We collected energy, cost, technology, and site infrastructure data to use as inputs in the analysis. This methodology provided a robust technical, economic, and environmental assessment of each potential microgrid scenario, while continuous project partner engagement ensured alignment with project partner goals. The three stages of the methodology are described in detail in the following sections

Figure 3. Feasibility study methodology stages.



3.1 Partner Engagement

Partner engagement was a critical, ongoing task throughout the study. A partner advisory team was created, which consisted of representatives from the three organizations integral to the project: La Crosse County, City of La Crosse, and Western Technical College. Key staff from each organization, including sustainability planners, facility directors, emergency operations managers, and other relevant department leaders, provided critical data on the infrastructure, energy consumption, and resiliency needs of the seven sites included in this study. This was done through regular recurring meetings and by providing the following specific data:

- Building architectural, mechanical, and electrical drawings.
- Monthly electricity and gas usage and cost data.
- Back-up generator information
- Photovoltaic (PV) system size, equipment, and cost data for the buildings that have one.

Having continuous engagement with these partners facilitated the collection of high-quality data, guided the alignment of microgrid scenarios with each partner’s specific needs and ensured that the proposed solutions were both technically feasible and economically viable. Regular meetings and collaborative discussions with the project partners helped refine the assumptions and parameters used in the analysis, ensuring that the project addressed resiliency goals, sustainability targets, and project partner priorities.

3.2 Energy Analysis

The following sections describe the data and methodology used throughout the energy analysis stage.

3.2.1 Building Load Profiles

The building electric load profiles for each site were created using two methods. For office type buildings (County Administrative Center, LEC, HHS, and City Hall) and secondary school type buildings (Western’s Kumm Center), the hourly load profiles were simulated based on standard load profiles from the Department of Energy’s (DOE) Commercial Reference Building (CRB) models accessed through the National

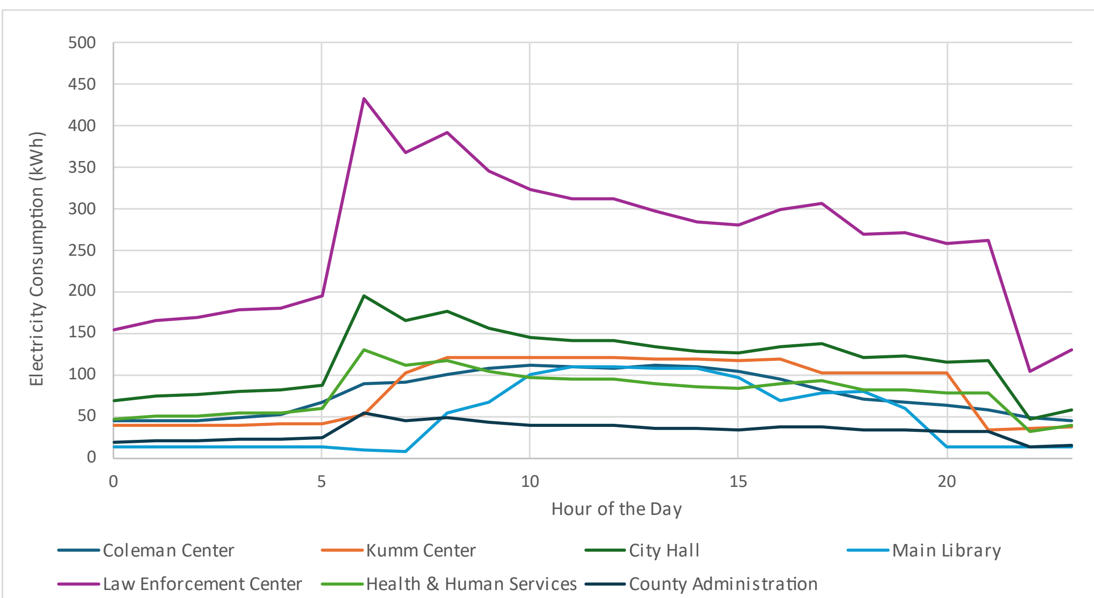
Laboratory of the Rockies' (NLR)[13] REopt (Renewable Energy Integration & Optimization) web tool[14], and using real monthly electricity consumption data. Because standard load profiles were unavailable for the Main Public Library, we created a custom model using Slipstream's Sketchbox energy modeling tool[15], scaling the resulting hourly profile to match real monthly electricity consumption data. Finally, the load profile for Western's Coleman Center did not have to be simulated since real 15-minute electricity demand data was provided. Table 3 below shows the annual electricity consumption and peak electricity demand data for all seven buildings involved in the study.

Table 3. Electricity data of each building.

Building Owner	Building Name	Annual electricity usage (kWh/year)	Peak electricity demand (kW)
La Crosse County	County Administrative Center	360,059	unknown
	Law Enforcement Center	2,458,206	unknown
	Health and Human Services	887,636	unknown
City of La Crosse	City Hall	960,320	202
	Main Public Library	687,800	222
Western Technical College	Kumm Center	734,741	381
	Coleman Center	680,702	336

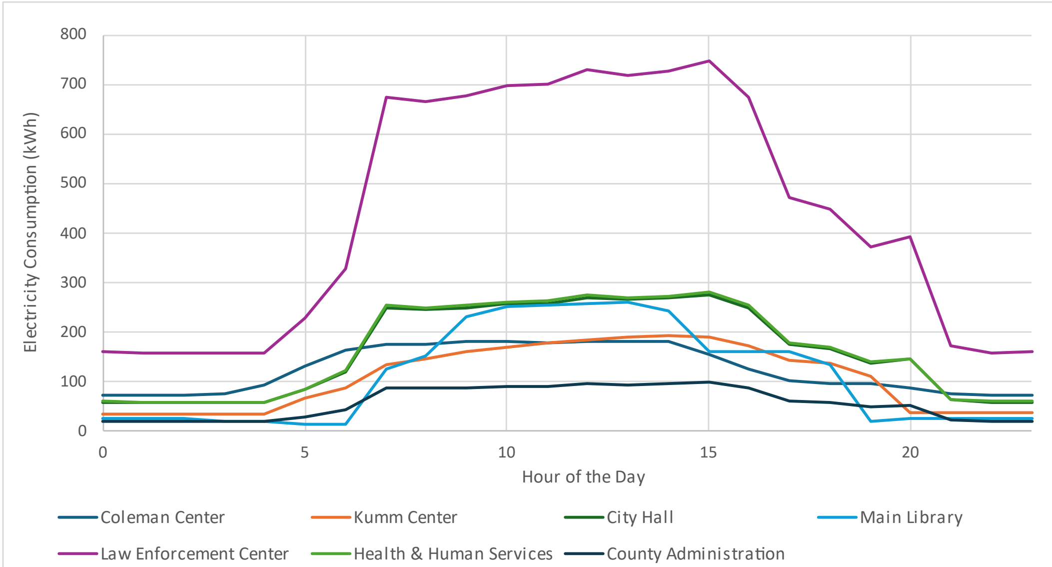
Figure 4 and Figure 5 below compare typical daily electricity consumption by building (in kWh) across typical winter and summer weekdays respectively. Based on the peak consumption shown in the summer months, these buildings have gas-fired heating and electric cooling. Since these are all commercial buildings, the bulk of their consumption occurs during the day, between 5:00 AM to 6:00 PM. Therefore, PV systems will significantly reduce energy and demand costs.

Figure 4. Winter day load curves



[13] Formerly known as NREL (National Renewable Energy Laboratory).
[14] Anderson et al., *The REopt Web Tool User Manual*.
[15] YouTube, "Sketchbox."

Figure 5. Summer day load curves



The distributed energy resources (DERs) considered in this study are solar PV (new and existing) and battery energy storage systems (BESS), all of which are subject to Xcel Energy's interconnection application and interconnection process. The REopt tool was used to evaluate the performance and economic feasibility of these DERs, balancing energy generation, storage, and cost-effectiveness to meet each buildings energy needs. In the following sections we will describe each of the DERs considered, the analysis process for applying them to the study sites, and their respective considerations and inputs for the tool used.

3.2.2 Solar Photovoltaics (PV)

The solar PV analysis was conducted using REopt to evaluate the potential for integrating behind-the-meter rooftop PV systems to the buildings that do not currently have one of these systems installed. Table 4 details the capacities of the PV systems currently installed at the La Crosse County and City owned sites.

Table 4. Existing PV systems in the study sites.

Building name	PV panels capacity (kW_{DC})	PV inverters capacity (kW_{AC})
County Administrative Center	133	100
Law Enforcement Center	255	200
Health and Human Services	100	75
City Hall	113	100
Main Public Library	112	100

For the buildings that do not currently have a PV system installed, Western's Kumm Center and Coleman Center, we began by estimating the available area for solar panel installations based on roof configuration using Google Earth as a measurement tool. Figure 6 and Figure 7 show how each building's rooftop area was measured. Between the two buildings, the total area available for PV panels is 33,255 ft^2, which amounts to a maximum PV system capacity of 333 kW_{DC}. To optimize solar generation, the tilt and orientation of the panels were specified based on the building's roof configuration. Since these buildings have flat roofs, the PV panels were modeled with a tilt angle of 20° and oriented towards the south, a common configuration for cost-effective rooftop racking systems and optimal performance.

Figure 6. Kumm Center rooftop area measured for PV installation.

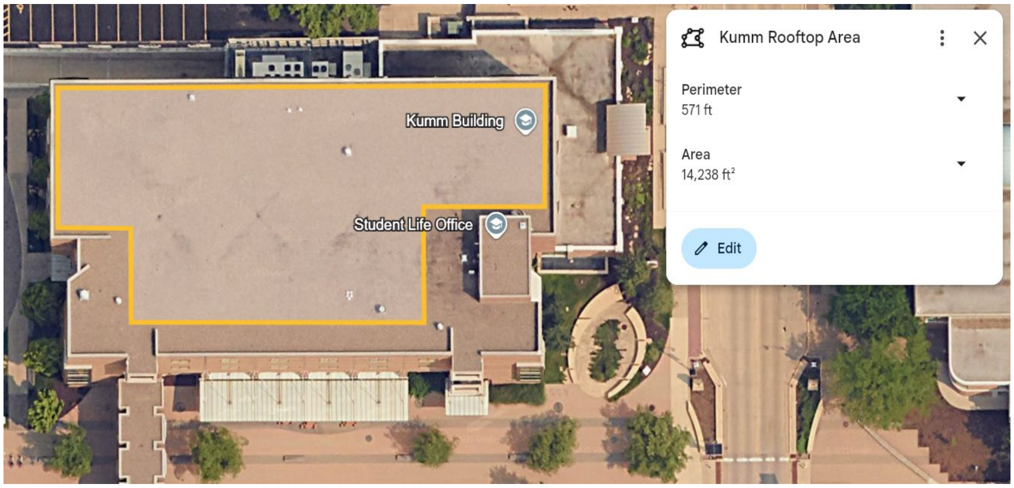
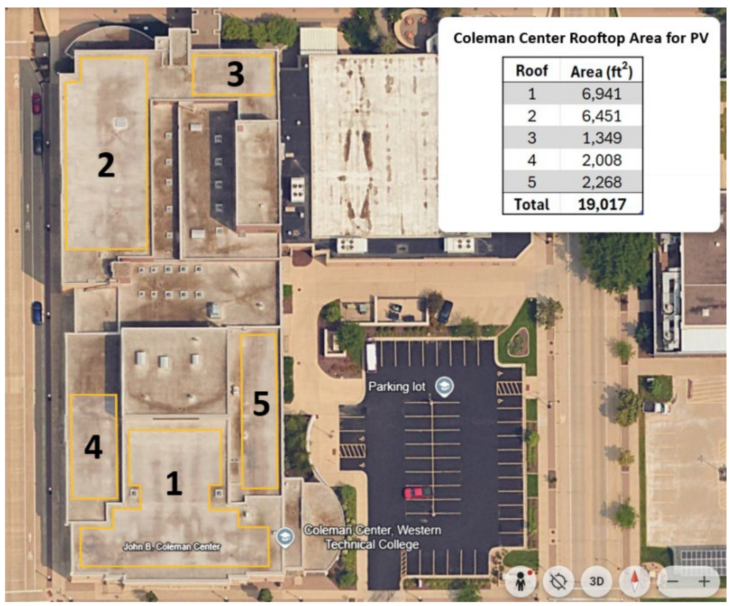


Figure 7. Coleman Center rooftop area measured for PV installation.



Integrating PV systems into a microgrid requires careful consideration of inverter compatibility and certification, as inverters play a crucial role in converting and managing solar energy output. To ensure seamless integration with future microgrid operations, all inverters specified for the project must be certified under the UL 1741[16] standard for safety and the IEEE 1547[17] standard on smart inverters and applications. This IEEE standard enables advanced inverter functionalities that are essential for microgrid operation, including voltage regulation, power factor management, and export limiting.

3.2.3 Battery Energy Storage System (BESS)

The sizing of battery energy storage systems (BESS) for each building was determined using a bottom-up approach of calculating the capacity of the building loads that need back-up power for each scenario. Conversations with partners were crucial for determining the critical loads that must be maintained during

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[16] UL Solutions, "Distributed Energy Resource Testing."

[17] *IEEE Std 1547-2018: Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*.

an outage at each site. The **County Administrative Center** and **Western's Coleman Center**, both need minimal back-up power to support emergency and life safety loads. Meanwhile, buildings like **City Hall**, which houses the City's police department, the **Law Enforcement Center**, which houses the County Jail, and the **Health & Human Services building**, which houses a juvenile detention facility, all have very specific needs to keep their operations ongoing and continue providing their public safety services. Finally, **Western's Kumm Center**, which is meant to become a CRC, and the **Main Public Library**, which could function as supporting day-shelter or cooling center if specific cooling loads are supported by the microgrid, have varying back-up power needs depending on the service function that they will provide. Specifically, for the **Kumm Center** to be considered a resilience center, the building would need to provide space conditioning, equipment charging capacity, and refrigerated food storage. This is further explained in the Resilience Planning section later in this document. Table 5 below lists the types of loads that will be prioritized at each site, including the electrical panels that feed them. Emergency and life safety systems include emergency lighting, fire alarm and suppression system, and other emergency pumps or air exhausts. Required standby systems include door controls, IT equipment, building automation system, and other uninterruptible power systems.

Table 5. Critical loads.

Building name	Critical loads and electrical panels
County Administrative Center	• Emergency and life safety systems • Required standby systems • Loads fed from transfer switches & panels such as ATS-EM [EMB, other downstream loads], ATS-OPT [OPT, UPS CR, IT, other downstream loads]
Law Enforcement Center	• Emergency and life safety systems • Required standby systems • County jail systems • Loads fed from transfer switches & panels such as ATS-EM [EMH1, EML1, EMH3], ATS-OPT [OPTH1, OPTLG], ATS-REQ [DP-REQ to REQHG, REQH1, REQH3, RECL3, TG, T1, T3, Elev B/C/D, etc.)
Health & Human Services	• Emergency and life safety systems • Required standby systems • Juvenile detention facility • Loads fed from transfer switches & panels such as ATS-EM [downstream loads in SWB/2]; ATS-OPT [downstream loads in DP/OPTA] and DP/OPTB [air handlers, HWP, SSP, WWHP, and VME loads];
City Hall	• Emergency and life safety systems • Required standby systems • Police department systems • Loads fed from panels in basement, 1st floor, and garage such as SM-[1, 2, 3]; EM-B-1; A-B-[1, 2, 3]; C-B-[1, 2]; D-B-[1, 2]; EM-A-1; EM-C-1; EM-D-1; E-G-1; A-1-[1, 2]; B-1-[1, 2]; C-1-[1, 2]; D-1-[1, 2]

Main Public Library	• Emergency and life safety systems
	• Required standby systems
	• Optional for day-shelter:
	  ○ Lighting and receptacles to first floor
	  ○ HVAC at reduced output
	• Loads fed from panels in switchboard schedules such as D, E, and Motor #12 [Chiller]

Kumm Center	• Emergency and life safety systems • Required standby systems • Needed for resilience center:

Building name	Critical loads and electrical panels
	○ Refrigerators and freezers in basement and first floor ○ Lighting and receptacles for basement, first and second floors ○ HVAC at reduced output • Loads fed from transfer switches & panels such as EE [1LS, other downstream loads]; ED [E]; D-1 [S, A, R, G]; D2 [A2, M, N1]
Coleman Center	• Emergency and life safety systems • Required standby systems • Loads fed from transfer switches & panels such as D [EQP, EQK, other downstream loads]; EM [ELSH, other downstream loads]

After the critical loads for each building were identified, energy needs were determined by analyzing panelboard schedules, motor and power schedules, one-line riser diagrams and overall electrical and mechanical building drawings provided by each project partner and estimating the energy needs of specific loads and electrical panels using demand and coincidence factors respectively. Once the critical load needs were determined, various BESS sizes were selected to build microgrid scenarios for each site. These scenarios were then simulated using the REopt tool to determine the economic and environmental implications of implementing these microgrid systems. This tool determines the optimal size and operations of the DERs based on a combination of inputs, including load profiles, electricity tariffs, and system performance constraints. For the analysis we allowed the BESS to be charged from the grid as needed, to ensure sufficient energy availability for covering outages. REopt constrains the BESS to a minimum state of charge of 20%, as discharging the battery below 20% on a regular basis would reduce the lifespan[18]. The analysis incorporated assumptions regarding outage durations and critical load priorities, ensuring that battery storage could meet resiliency targets while maintaining economic feasibility. We assume the battery modules are replaced at 10 years as the functional capacity of the battery would degrade over this time. Power components, including inverter and balance of system equipment (battery management system, electrical cabling, switchgear, thermal management, fire suppression, enclosure, etc.), are replaced at 15 years. While component replacement is the simplest BESS management strategy, other strategies such as augmentation, oversizing, or modular implementation are also possible and may result in reduced total costs.[19]

All these buildings currently have back-up generators that support many of their most important loads. These back-up generators were not included in the financial analysis using REopt, but we recommend coupling these generators to the implemented microgrids to be able to supply back-up generation to the loads if further back-up load is needed or if a longer outage than what the battery storage systems were sized for occurs.

3.2.4 Cost Variables

Upfront and ongoing costs of the microgrid, as well as the energy, wholesale and demand charge rates are a significant influence on the identification of a least- cost solution. Table 6 details the upfront costs for the PV and BESS, including PV operations and maintenance cost (O&M), both the storage and power capacity costs, and the replacement cost of the BESS.[20] A key consideration is that a 30% upfront cost incentive was considered, as initial results showed that it would be difficult to arrive at a positive net present value (NPV).

[18] Anderson et al., *The REopt Web Tool User Manual*.
[19] Shin and Hur, "Optimal Energy Storage Sizing with Battery Augmentation for Renewable-Plus-Storage Power Plants."
[20] NREL, "2024 Electricity ATB Technologies and Data Overview."

For the analysis, the upfront cost considers PV for the sites that do not currently have or could be expanded, and BESS costs.

Table 6. PV and BESS system costs: upfront capital, O&M, and replacement.

Variable	Unit Cost
PV system capital cost ($/kW)	$1,920
PV O&M cost ($/kW per year)	$20
BESS storage capacity cost ($/kWh)	$253
BESS power capacity cost ($/kW)	$968
BESS storage capacity replacement cost ($/kWh)	$177
BESS power capacity replacement cost ($/kW)	$744

Table 7 shows the utility rate utilized in the analysis. Under Xcel Energy's Wisconsin rate structure, we considered their large general time-of-day service rate for all buildings[21]. This rate is for retail customers that have a measured demand equal to or greater than 200 kW for at least 4 months of the year. In the timing column, summer refers to the months of June to September, while winter refers to all other months (October to May). On-peak times are weekdays from 9:00 AM to 9:00 PM. As the limit for net metering is 100 kW, excess solar generation is sold back at Xcel's forecast locational marginal price of $0.02923 per kWh. For NPV calculations, we assume a 2.5 percent escalation rate for O&M costs, a 1.7 percent increase in electricity rates, and a 6.2 percent discount rate.[22]

Table 7. Xcel Energy's Wisconsin large general time-of-day service rate.

Variable	Timing	Utility rates
Customer charge	Monthly	$180.00
Energy rate ($/kWh)	Summer On-Peak	$0.0982
	Winter On-Peak	$0.0881
	Off-Peak	$0.0594
Demand charge ($/kW per month)	Summer	$13.00
	Winter	$11.00

3.2.5 Resiliency Inputs

There are two resiliency inputs of interest for this analysis: (1) length of outage for the system to withstand and (2) monetary value to assign to increased resiliency.

Length of outage

Due to a lack of data on the reliability of the distribution system that supports the cluster of buildings in the Downtown La Crosse area, we identified the outage lengths of interest based on our understanding of the current and future climate vulnerabilities of the area, as described in the "Challenges and Vulnerabilities of the City" section. Although outages in the area are generally infrequent and short in duration, given the increasing frequency and intensity of extreme weather events caused by climate change, there is a higher vulnerability to natural disasters that could result in longer and more frequent outages. Therefore, we modeled two outage durations: 4-hour and 8-hour outages. This decision reflects the need to plan for both short-term and moderate-duration outages, particularly under future climate conditions.

[21] "Rate Books | Xcel Energy."

[22] Anderson et al., *The REopt Web Tool User Manual*.

To ensure the analysis accounts for critical seasonal variations in energy demand, we simulated outages during peak winter days and peak summer days. Modeling outages during peak demand seasons provides a conservative approach to evaluating the resiliency needs of each site.

Resiliency monetary value

Installation of microgrids has resiliency benefits, which often make the difference between the systems being cost-effective or not.[23] Although these benefits are widely acknowledged, there is not a standardized way to monetize the benefits.[24] Previous methods to quantify the value include willingness-to-pay surveys and tools to help facilities develop bottom-up monetary estimates for lost time spent on critical functions.

There are limited studies that quantify the financial benefit of lowered customer interruption costs. Studies show costs vary by season and time of day for different utility customers - from residential, small and large C&I, and industrial. The reference we used for these values is a study from Lawrence Berkeley National Lab that includes estimates from willingness-to-pay studies for the residential and commercial sector.[25] Table 8 illustrates the study's findings on the value of resiliency across outage lengths and building types. In this context, all buildings in this study are considered large commercial.

Table 8. Value of resiliency across outage lengths.

Cost per kW	Less than 15 minutes	1 hour	4 hours	8 hours	16 hours
Large Commercial	$15.9	$21.8	$48.4	$103.2	$203.0
Small Commercial	$187.9	$295.0	$857.1	$2,138.1	$4,128.3

3.2.6 Emissions Data and Costs

We applied hourly emissions data to estimate the impact of each microgrid system on the environment. The emissions data includes carbon dioxide emissions and criteria pollutants, including nitrogen oxides, sulfur dioxide, and particulate matter. The hourly emissions data for each comes from EPA's Avoided Emissions and Generation Tool (AVERT), which models marginal emissions rates for the region based on historical dispatch data.[26] The data assumes a gradual greening of the grid and reduces emissions factors by 4.5 percent annually.[27]

To estimate the monetary impact of the emissions savings, we apply pollutant removal cost per ton estimates to each. Table 9 lists the cost per ton for removing each of the major pollutants.[28] The Estimating Air Pollution Social Impact Using Regression (EASIUR) model from the Center for Air, Climate and Clean Energy Solutions (CACES)[29] provided the cost of the criteria pollutants (NO_x, SO_2, and $PM_{2.5}$). The pollutant removal cost for each is assumed to increase gradually over the analysis lifetime.

[23] Anderson et al., *Valuing Resilience in Electricity Systems*.
[24] Rickerson et al., *Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs*.
[25] Sullivan et al., *Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States*.
[26] US EPA, "AVoided Emissions and geneRation Tool (AVERT)."
[27] Anderson et al., *The REopt Web Tool User Manual*.
[28] Interagency Working Group on Social Cost of Greenhouse Gases, "Technical Support Document: Social Cost of Carbon, Methane."
[29] CACES, "CACES | EASIUR."

Table 9. Pollutant costs per ton.

Pollutant	Removal cost per ton	Source
Carbon dioxide (CO_2)	$51	Federal value
Nitrogen oxides (NO_x)	$20,505	CACES EASIUR model
Sulfur dioxide (SO_2)	$48,835	CACES EASIUR model
Particulate matter ($PM_{2.5}$)	$147,978	CACES EASIUR model

3.3 Microgrid Scenarios

Based on the variety of buildings in this study and the services that they provide, this project presented a unique opportunity to analyze multiple microgrid scenarios tailored to different resilience needs. This section presents the variety of microgrid configurations selected for the sites owned by each of the three partners. Small campus microgrids interconnecting buildings under a single owner were considered where possible, but multi-owner microgrids (connecting buildings with different owners) were not included because of the regulatory complexities explained in section 6.1 Ownership. By comparing the scenarios presented below, the study aims to inform project partners about the trade-offs and opportunities associated with each configuration, paving the way for informed decision-making and sustainable development. The analysis period considered in the analysis is 25 years, which is related to the expected lifespan of PV panels.

3.3.1 Western Technical College

Three microgrid scenarios with varying size configurations were considered for the Western Technical College. These include individual microgrids at each site, Coleman Center and Kumm Center, and a small campus microgrid interconnecting the two buildings. Table 10 presents the some of the main inputs to the REopt software (rooftop PV capacities, BESS power capacities, and resilience hours) for analyzing the different microgrid configurations considered at each site. Other inputs also include building location, load profile, equipment costs for PV and BESS, and the electricity rate.

Table 10. Western Technical College microgrid scenarios.

Building	Rooftop area for PV (ft^2)	PV capacity (kW_{DC})	BESS power capacity (kW)			Resilience hours
Coleman Center	19,017	142	65	130		4 and 8 hours
Kumm Center	14,238	190	75	125	230	
Small Campus	33,255	333	135	255	290	

For the Coleman Center, two configurations (BESS sizes) were considered. First, a microgrid with minimum BESS capacity needed to support emergency and life safety loads that are currently supported by the site's natural gas generator, which has a capacity of 130 kW. The second configuration includes a BESS sized to the same capacity of the current generator, which is intended to cover beyond emergency loads and support other essential loads including hot water heaters, boilers, and some of the lighting and receptacles for the first floor.

For the Kumm Center, three configurations were considered including two with similar sizing as the Coleman Center configurations. The first would be a microgrid with minimum BESS capacity to support loads currently connected to the generator including emergency and life safety loads, and a few walk-in coolers and freezers that are in the basement. While the second is a BESS sized to the same capacity as the building's current gas generator and would be able to add support to other essential loads like door controls, IT equipment, building automation, and some lighting and receptables to specific rooms in the basement, first, and second floors. The third configuration presents a high-capacity BESS sized to 68% of the sites peak load, which would support enough loads for the building to be established as a resilience center including the boiler, the chiller at reduced capacity, and more lighting and receptacles to the first and second floors.

Finally, three configurations were considered for the "Small Campus" microgrid: minimum BESS capacity which adds the capacities of the first configuration for both individual buildings, BESS for critical loads which adds the capacities of the second configuration for both individual buildings, and the resilience center which adds the first configuration of the Coleman Center with the third configuration of the Kumm center.

3.3.2 City of La Crosse

For the City of La Crosse sites (City Hall and the Main Public Library) only individual microgrids were considered because of how far apart both buildings are. Table 11 below presents some of the main inputs to the REopt software (Existing PV capacities, BESS power capacities, and resilience hours) for analyzing the different microgrid configurations considered at each site. Both building's rooftops were evaluated for potential to expand their current PV systems, but the available surface areas either receive too much shade during the year, and therefore PV panels would not produce much energy, or simply are not enough in size to sustain sufficient panels to for their annual generation to be a significant economic improvement.

Table 11. City of La Crosse microgrid scenarios.

Building	Existing PV capacity (kW_{DC})	BESS Capacities (kW)		Resilience hours
City Hall	112	80	150	4 and 8 hours
Main Library	113	35	135	

For City Hall, we considered two configurations. The first is a BESS sized to the same capacity as the building's current generator, which supports the building's typical emergency and life safety loads. The second configuration more than doubles the power capacity of the BESS to be able to support the operations of the City's police department, including loads like lighting, doors, and communications equipment (phones, computers, etc.) to the following areas: locker rooms, command rooms, officer's report room, classroom, emergency response team room, and other offices. As well as to the department's external garages which contain vehicles and equipment.

We considered two configurations for the Main Library as well. Starting with a minimum capacity BESS that would support the emergency and life safety loads currently connected to the generator. The second configuration includes a much higher capacity BESS. This larger battery is sized to 67% of the site's peak load and is intended to be able to support enough loads for an area of the library to function as a day-shelter providing lighting, receptacles for charging, and climatization.

3.3.3 La Crosse County

For the La Crosse County sites (Administrative Center, LEC, and HHS), individual microgrids were considered for each building, and an interconnected system combining the Law Enforcement Center and the Health & Human Services building. Much like in the previous sub-sections, Table 12 presents some of the main inputs to the REopt software (existing PV capacities, BESS power capacities, and resilience hours) for analyzing the different microgrid configurations considered. The three buildings' rooftops were evaluated for potential to expand their current PV systems. Only the Law Enforcement Center, which has an existing PV system that covers half of the building's rooftop, was found to have sufficient rooftop surface area (24,640 ft^2) to significantly expand their current system. This available surface area was another main input for the LEC and Campus microgrid scenarios.

Table 12. La Crosse County microgrid scenarios.

Building	Existing PV Capacity (kW_{DC})	Potential added PV capacity (kW_{DC})	BESS power capacity (kW)		Resilience hours
County Admin	133	0	60		4 and 8 hours
LEC	255	246	400	600	
HHS	100	0	100	350	
LEC + HHS Campus	355	246	500	950	

For the Administrative Center, during the load analysis it was found that the needed capacity to support the building's critical loads is just below the capacity of the building's existing generator. Therefore, only one configuration with a BESS sized to the same capacity as the generator was analyzed for this building. Since no further wiring needs to be done to connect other loads to the panel served by the generator, this addition of connecting the microgrid's battery storage to that same circuit adds simplicity and would save money.

For both the LEC and HHS, the critical loads that require backup are those that support the operations of the county jail and the juvenile detention facility respectively, including lighting, receptacles, access controls, communications equipment, IT equipment, and HVAC. With these considerations, the two configurations that were analyzed for each site follow similar considerations. The BESS capacity for the first scenarios was sized directly to support these critical loads with the HVAC functioning at elevated cooling and reduced heating temperature setpoints as to reduce kWh requirements by 50%. The second scenarios are more conservative, where the BESS was sized to the capacity of each building's current generator. We can assume that in these scenarios the HVAC would not need to be used at a reduced output, but doing so would help the BESS last longer.

Finally, we considered two scenarios for an interconnected microgrid connecting the LEC and HHS buildings. Each scenario's BESS capacity is simply a sum of the BESS capacities for each building individually, ensuring that the combined capacity could be supported. It's important to note that interconnected system connecting two buildings, like this one and Western's small campus microgrid, will have significant other costs involving the extensive wiring updates needed to be made to implement these configurations.

All these microgrid scenarios considered for each site should be coupled with each building's existing generator to ensure the resilience goals are met and that essential loads can be kept operational during longer term outages.

4 RESULTS

This section presents the results of each microgrid configuration including DER sizes, upfront costs, energy savings, utility cost savings, avoided emissions, and net present value (NPV). Initial financial results reveal that most microgrid scenarios are not cost-effective (negative NPV) based on conventional financial metrics (utility cost savings). This is mainly due to the current low utility rates and the high costs of battery storage systems. It's important to consider that this microgrid feasibility study represents a snapshot in time. Projections show that power and energy needs could double by 2035 or 2050, depending on the source. With these growing demands, utility prices are anticipated to increase. Consequently, the net present value (NPV), payback period, and other financial metrics are expected to improve dynamically with the forecasting rise in electricity costs.

Conventional financial metrics do not capture several core value streams that microgrids are designed to provide, including avoided outage costs (resilience) and reduced emissions and associated health impacts. If these additional benefits are considered, as shown in the following sub-sections, many of these microgrid scenarios can achieve a positive NPV.

Western Technical College

The Western analysis included microgrid configurations for the Kumm Center, the Coleman Center, and a Small Campus microgrid interconnecting both buildings under a single meter. The scenarios ranged from PV-only systems to BESS sized for minimum emergency loads, essential critical loads, and full resilience-center functionality. Across all configurations, results show strong resilience benefits but limited financial returns when large BESS systems are included.

The results for the Kumm Center microgrid are presented in Table 13, which shows the tradeoffs between system size, resilience capability, and economic performance. Financially, only the PV-only system shows positive returns. However, the larger BESS configurations correspond with Western's long-term resilience and community-support goals, especially establishing Kumm Center as the designated Community Resilience Center (CRC). The annual energy generation of the sized PV system is 179,581 kWh, which amounts to 26% of the buildings annual electricity consumption.

Table 13. Kumm Center microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Only PV	142	0	0	$273,370	$18,437	$24,727	10.4 yrs
Scenario 1: Minimum BESS Capacity		75	300	$421,870	$27,898	*-$28,149*	15.9 yrs
			600	$497,770	$31,604	*-$70,401*	18.4 yrs
Scenario 2: Mid-size BESS		125	500	$520,870	$31,072	*-$98,889*	20.5 yrs
			1,000	$647,370	$37,426	*-$167,375*	23.5 yrs
Scenario 3: Resilience Center		230	920	$728,770	$36,735	*-$258,466*	>25 yrs
			1,840	$961,530	$46,718	*-$403,207*	>25 yrs

Utility cost savings include energy and demand savings and export credits, which are a function of how much excess solar generation is sold back to the grid. The net present value (NPV) shows the current value of capital investment when all future returns & costs are accounted for, minus the initial investment. Major factors include the analysis period (in years), discount rate (require rate of return to account for inflation), and cost escalation rates. The payback period is the amount of time, in years, required to recover the capital cost of the optimized energy system. It accounts for the value of avoided utility costs realized by the system, installation and operating costs, incentives, and depreciation. It is how many years it takes for the microgrid's positive financial value to add up to the same amount as the upfront costs.

Positive NPV means dollars invested in the capital expenditure provide greater return than remaining idle. Negative NPV means lower return than investments delivered elsewhere; however, value-adds like health impacts, resilience costs (avoided outage costs), and carbon emissions are not included. As the project partners review these results and plan for the future of these microgrids, these factors should be considered.

The Coleman Center scenarios, shown in Table 14, demonstrate slightly stronger economics compared to Kumm Center but follow the same trend: PV-only is cost-effective, while adding storage increases resilience at the expense of financial returns. The better economic results are mainly due to the buildings capacity to have a bigger PV system that would generate 207,361 kWh annually, which is 28% of sites annual electricity consumption. Based on these results, the minimum-capacity BESS scenario is the most economically viable storage option while enhancing resilience and sustainability.

Table 14. Coleman Center microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Only PV	164	0	0	$315,659	$22,853	$45,550	9.6 yrs
Scenario 1: Minimum BESS Capacity		65	240	$488,766	$35,759	$25,721	12.8 yrs
			480	$549,633	$39,038	*-$4,751*	14.3 yrs
Scenario 2: Mid-size BESS		130	520	$622,526	$41,089	*-$58,566*	17 yrs
			1,040	$754,086	$47,642	*-$130,402*	19.7 yrs

The small campus microgrid (Table 15) combines the loads and PV potential of both buildings into a shared system, improving annual utility savings and economic viability of establishing microgrid support for both sites. By interconnecting both buildings and sizing a BEES that would provide minimum back-up support to the Coleman's critical loads but enough for the Kumm Center to function as a resilience center, Western can take advantage of the Coleman Center's capacity to host a large PV system and make establishing a CRC a more economically viable option. Together, both buildings would produce 418,649 kWh of PV generated electricity, amounting to 30% of the annual electricity consumption of both sites.

Table 15. Western Small Campus microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Only PV	333	0	0	$637,440	$44,432	$77,468	10 yrs
Scenario 1: Minimum BESS Capacity x2		135	540	$905,796	$63,410	*-$84*	14 yrs
			1,080	$1,045,314	$71,410	*-$64,184*	15.8 yrs
Scenario 2: Mid-size BESS x2		255	1,020	$1,143,396	$71,725	*-$162,239*	18.6 yrs
			2,040	$1,401,456	$84,680	*-$302,028*	21.4 yrs
Scenario 3: Resilience Center		290	1,160	$1,212,696	$73,789	*-$213,489*	19.9 yrs
			2,320	$1,506,176	$87,605	*-$382,521*	23.3 yrs

City of La Crosse

The microgrid analysis for the City of La Crosse sites included individual building configurations for City Hall and the Main Public Library. Since both buildings already have PV system, the scenarios merely incorporated two different BESS sizes to support loads for different functions as explained in the Microgrid Scenarios section. Results show strong resilience benefits but limited financial returns because energy savings from PV systems are not being considered since they are not new systems, only savings from utilizing the battery for peak demand reductions are considered.

The results for the City Hall microgrid are presented in Table 16, which shows the tradeoffs between energy storage system sizes and their economic viability. Although NPV results initially show that no scenarios pencil out, it's important to consider that the current energy savings from the building's PV systems as those economic savings would significantly improve the cost-effectiveness of all scenarios. The resilience capacity from the second scenario corresponds with City Halls's long-term resilience goals to support the city's police department. The annual energy generation of the PV system is 141,164 kWh, which amounts to 21% of the buildings annual electricity consumption.

Table 16. City Hall microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Business as Usual	113	0	0	0	0	0	0
Scenario 1: Minimum BESS Capacity		80	320	$121,367	$10,453	*-$54,255*	>25 yrs
			640	$185,505	$32,945	*-$78,890*	>25 yrs
Scenario 2: Mid-size BESS		150	600	$227,563	$32,598	*-$142,038*	>25 yrs
			1,200	$347,822	$41,558	*-$209,594*	>25 yrs

The Main Public Library's microgrid scenarios, shown in Table 17, demonstrate slightly better economic results because of the smaller sized BESS. This building has a very similar sized PV system as City Hall, resulting in a similar annual energy generation of 141,164 kWh, but because the library consumes less electricity throughout the year, this amounts to a higher renewable electricity percentage of 21%.

Table 17. Main Library microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Business as Usual	112	0	0	0	0	0	0
Scenario 1: Minimum BESS Capacity		35	140	$69,300	$6,525	*-$2,340*	17.4 yrs
			280	$104,720	$7,791	*-$27,136*	23.9 yrs
Scenario 2: Mid-size BESS		135	520	$262,240	$13,633	*-$129,980*	>25 yrs
			1,040	$393,800	$21,338	*-$189,173*	>25 yrs

La Crosse County

The microgrid analysis for the La Crosse County sites included individual microgrid configurations for each site, and a Small Campus microgrid interconnecting the LEC and the HHS building under a single meter. All three buildings have existing PV systems, with the LEC being considered for a possible expansion. The scenarios analyzed incorporated different BESS sizes to support loads for different functions and outage durations as explained in the Microgrid Scenarios section. Similarly to the City of La Crosse sites, the results show limited financial returns because energy savings from PV systems are not being considered, except for the expansion to the LEC's current system.

The results for the County Administrative Center microgrid are shown in Table 18. The existing PV system at this site produces about 167,190 kWh annually, which amounts to 47% of the buildings annual electricity usage.

Table 18. County Administrative Center microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Business as Usual	133	0	0	0	0	0	0
Scenario 1: Minimum BESS Capacity		60	240	$118,800	$6,231	*-$58,343*	>25 yrs
			480	$179,520	$8,923	*-$95,139*	>25 yrs

Table 19 summarizes the results for the microgrid scenarios at the Law Enforcement Center. This buildings existing PV system produces about 321,553 kWh annually, which amounts to 11% of the buildings annual electricity usage. By expanding this PV system with 246 kW of capacity, the site could increase solar generation up to 632,262 kWh annually, doubling its renewable electricity coverage to 22%.

Table 19. Law Enforcement Center microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Business as Usual	255	0	0	0	0	0	0
Expanded PV	501	0	0	$473,088	$34,700	$76,406	9.49 yrs
Scenario 1: Minimum BESS Capacity		400	1,600	$1,265,088	$76,512	*-$309,508*	23.3 yrs
			3,200	$1,669,888	$99,480	*-$499,774*	>25 yrs
Scenario 2: Mid-size BESS		600	2,400	$1,661,088	$88,366	*-$601,738*	>25 yrs
			4,800	$2,268,288	$118,042	*-$939,509*	>25 yrs

The results for the HHS building microgrid scenarios are presented in Table 20. This building has the smallest existing PV system of all sites. Producing about 125,707 kWh annually, which amounts to 14% of its annual electricity usage.

Table 20. Health & Human Services microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Business as Usual	100	0	0	0	0	0	0
Scenario 1: Minimum BESS Capacity		100	400	$198,000	$11,889	*-$80,725*	>25 yrs
			800	$299,200	$18,033	*-$123,889*	>25 yrs
Scenario 2: Mid-size BESS		350	1,400	$693,000	$24,823	*-$466,671*	>25 yrs
			2,800	$1,047,200	$37,128	*-$718,606*	>25 yrs

Finally, Table 21 presents the results for the Small Campus microgrid scenarios, which interconnects the LEC and HHS buildings. This existing PV systems in these two buildings produce a combined 447,217 kWh annually, which amounts to 12% of the combined annual electricity usage. By adding the PV system expansion in the LEC building, these sites could increase their combined solar generation up to 757,624 kWh annually (19% of combined annual electricity usage).

Table 21. LEC + HHS Small Campus microgrid scenario results.

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Business as Usual	355	0	0	0	0	0	0
Expanded PV	601	0	0	$473,088	$35,950	$90,114	9.1 yrs

Microgrid Scenario	PV size (kW)	BESS power capacity (kW)	BESS energy capacity (kWh)	Total upfront cost before incentives	Year 1 utility cost savings	Net present value	Payback period
Scenario 1: Minimum BESS Capacity	601	500	2,000	$1,463,088	$88,529	*-$388,841*	24 yrs
			4,000	$1,969,088	$118,291	*-$615,132*	>25 yrs
Scenario 2: Mid-size BESS		950	3,800	$2,354,088	$113,706	*-$1,062,753*	>25 yrs
			7,600	$3,315,488	$159,168	*-$1,614,273*	>25 yrs

The resilience benefits of BESS extend beyond individual buildings. By maintaining power during outages, microgrids ensures that critical facilities can continue operations, minimizing disruptions and safeguarding public health and safety. This reliability also supports economic stability, preventing revenue loss for businesses and ensuring continuity of essential services. By integrating seamlessly with other DERs and leveraging advanced optimization tools, these microgrids not only enhance community resilience but also deliver significant economic and environmental benefits.

4.1 Additional Benefits

Implementing microgrids at each site would provide significant monetary benefits beyond the energy, demand, and export savings. Additional benefits include the monetary value of resiliency and the societal benefits of reduced carbon and criteria pollutant emissions. This section will highlight those benefits and show how their inclusion impacts the NPV. Additionally, the third sub-section will explain the different ways that a microgrid could provide support to the local grid.

4.1.1 Resiliency monetary value

The monetary value of resiliency is calculated by taking the average hourly critical load for each building, multiplied by the average outage length, in this case we are just considering one hour outages, and the value of resiliency for an outage of that length for each building type (Table 6), in this case large commercial buildings, as described in the Resiliency Inputs section. The resulting value is then applied to frequency of outages throughout the project's lifetime (25 years).

The lifetime savings for resiliency depend directly on the frequency of emergency events and outages. While outage frequency and timing are unpredictable, research indicates rising frequency due to increasing extreme weather and grid generation shortages.[30] Table 17 lists the resiliency monetary value for different outage frequencies across each building systems lifetime.

Table 22. Monetary value of resiliency: comparisons depending on outage frequency.

Building	Microgrid Scenario	Average critical load (kW)	Outage Frequency				
			One year	Two years	Five years	Ten years	Once ever
Kumm Center	**1**	19	$10,589	$5,295	$2,118	$847	$424
	2	31	$16,939	$8,469	$3,388	$1,355	$678
	3	58	$31,735	$15,868	$6,347	$2,539	$1,269

[30] Robert Walton, "MISO Prepares for 'worst-Case Scenarios,' Heads into Summer with Insufficient Firm Generation."

Building	Microgrid Scenario	Average critical load (kW)	Outage Frequency				
			One year	Two years	Five years	Ten years	Once ever
Coleman Center	**1**	13	$6,856	$3,428	$1,371	$548	$274
	2	29	$16,001	$8,001	$3,200	$1,280	$640
Western Small Campus	**1**	34	$18,492	$9,246	$3,698	$1,479	$740
	2	65	$35,223	$17,612	$7,045	$2,818	$1,409
	3	73	$39,627	$19,813	$7,925	$3,170	$1,585
City Hall	**1**	24	$12,938	$6,469	$2,588	$1,035	$518
	2	45	$24,585	$12,292	$4,917	$1,967	$983
Main Library	**1**	8	$4,278	$2,139	$856	$342	$171
	2	31	$16,688	$8,344	$3,338	$1,335	$668
County Admin	**1**	19	$10,404.05	$5,202.03	$2,080.81	$832.32	$416.16
LEC	**1**	118	$64,233.70	$32,116.85	$12,846.74	$5,138.70	$2,569.35
	2	180	$97,914.70	$48,957.35	$19,582.94	$7,833.18	$3,916.59
HHS	**1**	28	$15,461.65	$7,730.83	$3,092.33	$1,236.93	$618.47
	2	96	$52,461.70	$26,230.85	$10,492.34	$4,196.94	$2,098.47
LEC + HHS Small Campus	**1**	148	$80,518.30	$40,259.15	$16,103.66	$6,441.46	$3,220.73
	2	280	$152,561.85	$76,280.93	$30,512.37	$12,204.95	$6,102.47

Utilizing the monetary values for one hour an outage occurring every year, Table 18 shows the NPV for each system when the value of resiliency is included. The microgrid scenario financials considered beyond this point are the ones sized for 4 hours of resilience. Valuing resiliency causes an increase in the NPV across all scenarios, with the most significant increase seen in microgrid scenarios with the largest BESS since they're able to support the most loads. Some scenarios that initially showed negative net present values now become economically feasible when considering the monetary value of resilience.

Table 23. Resiliency monetary value impact on net present value: Western Technical College sites.

Building	Microgrid Scenario	Total cost	NPV without resiliency	Resiliency benefit	NPV with resiliency
Kumm Center	**1**	$421,870	*-$28,149*	$10,589	*-$17,560*
	2	$520,870	*-$98,889*	$16,939	*-$81,950*
	3	$728,770	*-$258,466*	$31,735	*-$226,731*
Coleman Center	**1**	$488,766	$25,721	$6,856	$32,577
	2	$622,526	*-$58,566*	$16,001	*-$42,565*
Western Small Campus	**1**	$905,796	*-$84*	$18,492	$18,408
	2	$1,143,396	*-$162,239*	$35,223	*-$127,016*
	3	$1,212,696	*-$213,489*	$39,627	*-$173,862*
City Hall	**1**	$158,400	*-$54,255*	$12,938	*-$41,317*
	2	$297,000	*-$142,038*	$24,585	*-$117,453*
Main Library	**1**	$69,300	*-$2,340*	$4,278	$1,938
	2	$262,240	*-$129,980*	$16,688	*-$113,292*
County Admin	**1**	$118,800	*-$58,343*	$10,404	*-$47,939*

Building	Microgrid Scenario	Total cost	NPV without resiliency	Resiliency benefit	NPV with resiliency
LEC	1	$1,265,088	*-$309,508*	$64,234	*-$245,274*
	2	$1,661,088	*-$601,738*	$97,915	*-$503,823*
HHS	1	$198,000	*-$80,725*	$15,462	*-$65,263*
	2	$693,000	*-$466,671*	$52,462	*-$414,209*
LEC + HHS Small Campus	1	$1,463,088	*-$388,841*	$80,518	*-$308,323*
	2	$2,354,088	*-$1,062,753*	$152,562	*-$910,191*

4.1.2 Emissions benefits

The emissions benefits from a microgrid with PV and BESS are significant. These systems substantially reduce both criteria pollutants and carbon dioxide (CO_2) emissions. While reductions in criteria pollutants improve local air quality and public health, they are not typically assigned direct monetary value in most benefit-cost frameworks. In contrast, CO_2 reductions can be monetized using established values for the social cost of carbon, which provides a basis for estimating the broader environmental and economic benefits of lowered emissions. Table 19 summarizes the emissions reductions, in tons, throughout the project's analysis period and the associated monetary benefits.

Table 24. Emissions reductions and monetary values.

Building	Microgrid Scenario	NO_X savings (tons)	SO_2 savings (tons)	$PM_{2.5}$ savings (tons)	Health benefit	CO_2 savings (tons)	Carbon reduction benefit
Kumm Center	1	1.15	1.29	0.14	$94,357	487	$24,837
	2	1.17	1.25	0.15	$94,523	496	$25,296
	3	1.19	1.16	0.16	$92,663	469	$23,919
Coleman Center	1	1.53	1.73	0.19	$126,615	653	$33,303
	2	1.55	1.69	0.19	$125,384	643	$32,793
Western Small Campus	1	2.66	3	0.33	$219,770	1,144	$58,344
	2	2.7	2.9	0.34	$217,895	1,137	$57,987
	3	2.72	2.88	0.34	$217,474	1,127	$57,477
City Hall	1	0.92	1.01	0.12	$85,946	378	$19,278
	2	0.93	0.98	0.12	$84,686	376	$19,176
Main Library	1	0.9	1.01	0.11	$84,056	388	$19,788
	2	0.9	0.93	0.11	$80,149	372	$18,972
County Admin	1	1.08	1.2	0.13	$99,985	458	$23,358
LEC	1	4.09	4.43	0.5	$374,197	1,693	$86,343
	2	4.13	4.27	0.52	$370,163	1,620	$82,620
HHS	1	0.82	0.89	0.1	$75,076	338	$17,238
	2	0.88	0.69	0.12	$69,498	252	$12,852
LEC + HHS Small Campus	1	4.8	5.22	0.6	$442,133	12,599	$642,549
	2	4.88	4.82	0.64	$430,159	12,423	$633,573

Table 20 illustrate how adding the monetary value of the reduced air quality health impacts and reduced carbon emissions impacts NPV. By including the value of emissions savings, many scenarios achieve a positive NPV.

Table 25. Carbon and criteria pollutant monetary value impact on net present value.

Building	Microgrid Scenario	Total cost	NPV without added benefits	Resiliency benefit	Emissions benefit	NPV with emissions + resiliency benefits
Kumm Center	**1**	$421,870	*-$28,149*	$10,589	$119,194	$101,634
	2	$520,870	*-$98,889*	$16,939	$119,819	$37,869
	3	$728,770	*-$258,466*	$31,735	$116,582	*-$110,149*
Coleman Center	**1**	$488,766	$25,721	$6,856	$159,918	$192,495
	2	$622,526	*-$58,566*	$16,001	$158,177	$115,612
Western Small Campus	**1**	$905,796	*-$84*	$18,492	$278,114	$296,522
	2	$1,143,396	*-$162,239*	$35,223	$275,882	$148,866
	3	$1,212,696	*-$213,489*	$39,627	$274,951	$101,089
City Hall	**1**	$158,400	*-$54,255*	$12,938	$105,224	$63,907
	2	$297,000	*-$142,038*	$24,585	$103,862	*-$13,591*
Main Library	**1**	$69,300	*-$2,340*	$4,278	$103,844	$105,782
	2	$262,240	*-$129,980*	$16,688	$99,121	*-$14,171*
County Admin	**1**	$118,800	*-$58,343*	$10,404	$123,343	$75,404
LEC	**1**	$1,265,088	*-$309,508*	$64,234	$460,540	$215,265
	2	$1,661,088	*-$601,738*	$97,915	$452,783	*-$51,041*
HHS	**1**	$198,000	*-$80,725*	$15,462	$92,314	$27,050
	2	$693,000	*-$466,671*	$52,462	$82,350	*-$331,859*
LEC + HHS Small Campus	**1**	$1,463,088	*-$388,841*	$80,518	$1,084,682	$776,359
	2	$2,354,088	*-$1,062,753*	$152,562	$1,063,732	$153,540

4.1.3 Grid Support

Beyond the direct financial, resiliency, and emissions benefits described in the previous sections, the implementation of microgrids in the cluster of buildings in Downtown La Crosse could offer substantial opportunities to support the local grid. These benefits extend to grid stability, cost management, and operational flexibility. This section explores these additional benefits at a high level. Detailed analysis is not a part of the project scope.

Time-of-Use (TOU Optimization). The integration of microgrids enables these sites to respond effectively to time-of-use (TOU) pricing structures. By leveraging BESS and demand management strategies, the microgrids can shift energy consumption from high-cost periods to times when electricity prices are lower. This capability benefits both building owners, who experience reduced utility bills, and the utility, which will face lower peak demand charges from their wholesale power suppliers. For instance, the microgrid can prioritize charging BESS during off-peak hours, when electricity is cheapest, and then discharge during peak hours to supply building loads. This not only reduces energy costs but also enhances the overall economic value of the microgrid by maximizing the utilization of distributed energy resources (DERs).

Ancillary Services (Voltage and Frequency Support). By coordinating the operation of BESS, generators, and solar PV systems, microgrids can regulate voltage levels and maintain frequency stability, particularly during periods of grid disturbances. The ability to provide such services reduces the burden on the utility to invest in additional grid infrastructure or procure ancillary services from external sources. Additionally, the microgrid's advanced controls and compatible inverters enable precise voltage regulation, reactive power management, and frequency response, helping to facilitate a stable and resilient grid.

Load Flexibility (Shifting and Shedding). Load shifting and shedding capabilities within a microgrid provides additional flexibility to manage demand during critical periods. The microgrid could prioritize essential loads while shedding non-essential loads during grid emergencies or extreme peak demand events. For example, during a hot summer day with high cooling loads, the microgrid could shift non-essential energy consumption (e.g., EV charging or water heating) to off-peak hours. In more extreme scenarios, it could shed these non-essential loads entirely to ensure sufficient capacity for critical services. This proactive demand management enhances grid reliability and minimizes the risk of outages.

The Downtown La Crosse microgrids offer transformative potential not only for the community they serve but also for the local grid. By enabling TOU optimization, ancillary services, and load management, the microgrids provide a robust set of tools to enhance grid stability, reduce costs, and improve resilience. These additional benefits further underscore the value of investing in microgrid solutions as part of a comprehensive strategy for sustainable and reliable energy systems.

5 MICROGRID DESIGN RECOMMENDATIONS

Through this microgrid feasibility study, we identified best practices for evaluating and designing microgrids for a cluster of buildings in Downtown La Crosse. The following section summarizes these considerations, starting with specific design next steps to transition from feasibility analysis to the design and interconnection, followed by more general recommendations.

5.1 Next Steps: Design and Interconnection

These steps aim to ensure that the microgrid is not only technically feasible but also economically viable and prepared for future energy demands and innovations.

Microgrid design and installation. Size the microgrid for forecasted needs while designating physical space for future expansion. This recommendation is critical for BESS and solar PV arrays, which have strict clearance and land usage requirements. Planning for expansion now prevents costly future retrofits and ensures that the microgrid remains adaptable to evolving energy needs.

Generators that are currently in all the sites should be maintained and included in any microgrid design and installation. These generation assets will be important pieces of the microgrid operations in case that the PV and BESS generation are not enough to cover the necessary loads. The generator, generator controller, and all associated automatic transfer switches will require evaluation to determine how they could integrate with a future microgrid controller. In a microgrid configuration, the BESS would utilize a closed-transfer switch to prevent momentary outages during transition to island. Then as the BESS charge drops, the generator would need to come on-line in parallel with the BESS; to accomplish this, the existing generator ATS would likely need to be replaced or upgraded.

Specify microgrid-ready inverters for all PV arrays. Microgrid components that have a common communication protocol (such as SunSpec Modbus) enable microgrid readiness by facilitating interoperability and standardization, allowing different devices from different manufacturers to communicate and interact. For example, a hybrid inverter with PV can share data with a BESS, forwarding a charge and discharge plan to align with the customer's loads needs. Specifying multi-mode inverters (which can operate in grid-tied, or grid-forming modes) will ensure that there is sufficient power available to establish a stable signal during islanded operation to support the balance of the inverters. While the BESS inverter will by default be multi-mode and provide grid-forming capabilities, specifying additional PV inverters as multi-mode in addition can help support the BESS inverter and may lower the total costs.

Perform a site survey to confirm acceptable BESS installation location. The National Fire Protection Agency (NFPA) provides installation guidelines within NFPA 855 for allowable locations of a BESS, along with required enclosures and fire suppression systems.[31] For Li-ion battery systems, general installations require 10 feet setbacks, or 3 feet if the system is UL 9540 and UL 9540A[32] listed and includes advanced fire safety measures. The survey should evaluate individual building installations for smaller BESS and centralized locations for a large-scale system. Confirming allowable capacities, enclosures, and fire suppression requirements at this stage will help streamline the subsequent design and permitting processes.

Consider BESS replacement strategy in the bidding process. The battery cells used in a BESS today naturally degrade over time, a fact which must be accounted for in the design of the system. To ensure that the BESS

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[31] National Fire Protection Association, "NFPA 855: Standard for the Installation of Stationary Energy Storage Systems."
[32] UL Solutions, "Distributed Energy Resource Testing."

provides all the expected benefits for the site, there are three typical strategies which the microgrid owners could consider at installation: replacement, augmentation, and oversizing.[33] The first option is a full replacement roughly 10 years into the project lifetime. With an augmentation strategy, new cells would be added periodically to offset the degradation of older cells, and older cells would be removed as their capacity degrades below acceptable limits. The last option is to oversize the system at the onset, so that as the system degrades, it still hits the minimum usable capacity needs.

Note that the 10-year lifespan is an estimate, not a hard rule. Each battery manufacturer and its cell/module have an expected number of cycles (full charge to full discharge). For Li-ion batteries with lithium iron phosphate (LFP) chemistry, the number of cycles can range from 2,000 to 8,000. The 10-year expectancy forecasts a full cycle each day, which results in 3,650 cycles. Battery degradation also entails reduction in available capacity. As a battery ages and/or is cycled, it loses its kWh capacity non-linearly. A battery is deemed end of life when it reaches 80%, or in some manufacturer's specification sheets at 70%, available capacity. These lower available capacity batteries are the modules that cause the above three strategies: replacement, augmentation, or oversizing. If utilized elsewhere, they are termed second life batteries. Second life batteries are not in scope of this feasibility study's evaluation due to the unproven nature and current high-cost relative to new Li-ion batteries.

Specify microgrid controller requirements. The microgrid controller is the central system responsible for coordinating and optimizing the operation of all DERs, such as PV, BESS, and generators, ensuring seamless transitions between grid-tied and islanded operation modes while maintaining system stability and meeting performance objectives. The IEEE 2030.7 standard provides technical specifications and requirements for microgrid controllers to ensure that components are interoperable and have interfaces that comply with functional standards[34].

5.2 General Recommendations

Prioritize data collection and start early. The quality and quantity of primary data collected directly impacts the relevance and robustness of the results for the proposed microgrids. Key data to collect should cover each buildings energy loads (both electric and natural gas). Electric interval data should be collected where available or a robust plan for estimating an hourly load profile and calibrating this to actual usage should be developed. If electrification of vehicles or natural gas-burning heating equipment is planned, determine how to translate the available data (typically annual or monthly into hourly intervals). To meet the objectives of resilience and financial performance, a microgrid needs to carefully balance loads, sources, and storage elements, all of which fluctuate in real-time. Having robust interval data is vital for determining technology sizes when backup power is a requirement of the microgrid. After completing this exercise for the planned microgrid, it is highly recommended to implement a data collection plan for other critical facilities to aid in future resiliency planning.

Consider alternatives for natural gas-burning end uses including generators, space heating, and water heating. To achieve La Crosse's emissions reduction goals, implementing electricity consuming end uses instead of natural gas fired ones should be considered. This will add significant electric load, requiring larger batteries and PV arrays to meet critical demand at each site connected to the microgrid. However, additional electric uses, especially when implemented through a load control system, can also enhance the ability of a

[33] Shin and Hur, "Optimal Energy Storage Sizing with Battery Augmentation for Renewable-Plus-Storage Power Plants."
[34] "2030.7-2017 - IEEE Standard for the Specification of Microgrid Controllers | IEEE Standard | IEEE Xplore."

microgrid to reduce emissions and increase energy benefits.

When sizing DER components, determine the critical loads at each site. The amount of load that must be sustained during an outage is a critical factor in the size of storage required for a microgrid. Accurate determination of critical loads at each site is crucial for sizing distributed energy resources. Once all loads that need to be backed-up are identified, their energy requirements should be determined.

It may prove useful to utilize the Clean Coalition's VOR123 methodology, which tiers loads by criticality[35]. The methodology suggests that most buildings can split their load into three tiers. Tier 1 represents roughly 10 percent of load and are critical items that require power always, Tier 2 represents roughly 15 percent of total load and are all other priority loads, and Tier 3 represents the last 75 percent and all discretionary loads. To utilize this methodology, split all the major spaces in the building into Tier 1, Tier 2, and Tier 3. From there, data such as square footage, occupancy, or submetering can be used to estimate energy needs for each tier.

Utilize microgrid ready design during renovations and construction. The upfront capital costs associated with establishing a microgrid are often a deterrent. A phased approach, where components are installed progressively based on their individual value propositions while ensuring they are microgrid ready, could reduce initial financial burdens while ensuring future compatibility. For example, solar PV arrays can be installed first, with inverters confirmed to be microgrid compatible. NLR provides suggestions on RFP language to include, to ensure solar panels and inverters are microgrid-ready.[36] Language should include that inverters should comply with applicable provisions in the IEEE Series of Interconnection Standards (specifically IEEE 1547) and that the inverters should be multi-mode DC to AC inverters with islanding functionality. During planning and construction, consideration should be given as to how to create or save enough space for the future battery installation.

Consider energy efficiency and demand management to decrease solar and storage capacity needs. When sizing a solar plus storage system, the baseline load is the single most important factor. If there are ways to decrease total energy use through energy efficiency and demand management, this can allow for a smaller and less costly system. As part of an evaluation of the microgrid installation, consider if there are ways to improve efficiency in the building, such as lighting improvements or HVAC system upgrades, or ways to manage demand through plug load or lighting controls. For sites intended to provide resiliency benefits, it will be important to consider what measures can be installed that can shed or shift load to reduce the amount of energy needed during an outage.

Include resiliency benefits in calculations of cost-effectiveness. Resiliency benefits are one of the primary reasons to install a microgrid system and are often significant. It is important to consider the monetary value of these benefits when making decisions about investment. There are several methods a site could use to value resiliency:

- Utilize national estimates from LBNL. This is one of the most cited values of resiliency but is limited as it only includes values for outage durations up to 16 hours[37].
- Estimate the value using NLR's Customer Damage Function Calculator. This tool allows the user to

[35] Lewis and Mullendore, "Valuing Resilience in Solar+Storage Microgrids: A New Critical Load Tiering Approach."
[36] Booth, *Microgrid-Ready Solar PV - Planning for Resiliency*.
[37] Sullivan et al., *Updated Value of Service Reliability Estimates for Electric Utility Customers in the United States*.

input any damaged equipment costs, lost data costs, food or product spoilage costs, or any other interruption costs[38].

- Estimate human health benefits for a community resiliency center. Other studies have considered their population and estimated how many people would need electricity dependent medical care or heating and cooling centers to estimate health impacts and associated avoided costs[39].

[38] "Customer Damage Function Calculator."
[39] Rolon et al., *Solar and Energy Storage for Resiliency*.

6 MICROGRID OWNERSHIP AND OPERATIONS

6.1 Ownership

Ownership and operational structure are central factors shaping the feasibility of potential microgrid configurations. Early in the study, the project team explored a wide range of options, including a single interconnected microgrid spanning all seven facilities. However, after reviewing applicable policies and regulations, including Xcel Energy's interconnection, tariff, and service rules[40], the Wisconsin Public Service Commission's (PSC) rules for interconnecting distributed generation facilities[41], and engaging in discussions with Xcel representatives, it became clear that a multi-owner microgrid would introduce significant regulatory and contractual complexity. Specifically, interconnecting facilities with different owners requires complex energy sharing agreements across property lines, defined cost- and benefit-allocation mechanisms among multiple entities, and a joint governance structure for operations. These challenges place substantial barriers on a multi-owner, multi-facility microgrid within the current regulatory environment.

Given these constraints, the study instead focuses on microgrid scenarios for individual buildings and for small campus microgrids, in which two buildings under the same ownership are interconnected. These "small campus" scenarios are more feasible because they avoid cross-owner energy transactions and allow each entity to maintain clear financial and operational responsibility. The primary requirement for these configurations is that interconnected buildings must operate under a single electric meter to comply with utility regulations and avoid complications related to energy resale or distribution across separate customer accounts. This approach allows each partner to evaluate microgrid options that are compliant with current rules while still advancing their resilience and sustainability goals.

6.2 Operations

The successful operation of the Downtown La Crosse microgrids will require clear roles and responsibilities among participating entities to ensure grid stability, regulatory compliance, and the efficient management of distributed energy resources (DERs). Xcel Energy will serve as the Distribution Provider, responsible for overseeing the microgrid's integration with the broader electricity network, while each microgrid owner and operator will coordinate and optimize the performance of the microgrid assets. This operational framework will ensure that the microgrid functions reliably in both Blue-Sky Mode (connected to the grid) and Island Mode (disconnected from the grid during outages or emergencies).

Blue Sky Mode Operations

During normal operation, each microgrid should function as an integrated part of the broader utility grid. Each owner and operator will monitor energy generation and storage to optimize energy consumption and reduce peak demand. Solar PV assets would primarily serve on-site consumption, exporting excess energy to the grid when financially beneficial, while BESS assets will implement load shifting and peak shaving strategies to reduce demand charges and overall electricity costs. The microgrids will also provide grid services, such as frequency regulation and voltage support. Additionally, time-of-use (TOU) optimization will be used to strategically discharge stored energy during peak pricing periods, further improving economic performance.

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[40] "Interconnection | Renewable Developer Resources | Xcel Energy."

[41] "Wisconsin Legislature: Chapter PSC 119."

Island Mode Operations

In the event of a grid outage, the microgrids should transition to Island Mode, operating independently from the utility. The transition will be automatically or manually managed by the microgrid operator in coordination with the utility. Critical loads will be prioritized to maintain essential services as defined in the microgrid scenarios analyzed. Deploying BESS will provide immediate power stability to facilitate a seamless transition, while local generation will be balanced against demand to maintain reliable service. If necessary, backup generation assets may be deployed to supplement power supply during extended outages when renewable generation is insufficient.

Grid Reconnection and Resynchronization

When the external grid is restored, the microgrid must safely reconnect to Xcel Energy's distribution network. The reconnection process will involve synchronizing voltage and frequency between the microgrids and the utility grid, gradually restoring loads and distributed resources to prevent instability, and resuming participation in energy markets. Properly managing this transition is essential to ensuring seamless reintegration with the broader electricity system.

Long-Term Operational Considerations

To ensure long-term operational success, the microgrids will require ongoing system monitoring and performance evaluation. Smart metering and real-time data analytics should be used to track energy flows, detect anomalies, and optimize system efficiency. Automated microgrid controls will enable real-time decision-making, ensuring continuous optimization of energy distribution. Predictive maintenance strategies will be implemented to reduce unexpected equipment failures and extend the lifespan of DER assets. Finally, cybersecurity protocols should be established to protect against threats that could impact either grid-connected or islanded operations.

7 FINANCING OPTIONS

The upfront cost for a microgrid can be a deterrent to installation. In addition to the phased installation discussed in section 5.1 above, there are several financing options that the partners can consider. We recognize that national and federal initiatives and funding programs are subject to change, creating uncertainty in future funding availability. This uncertainty reinforces our recommendation that project partners explore additional private and state funding opportunities to ensure the successful implementation of microgrids at the Downtown La Crosse sites.

7.1 Funding Sources

Inflation Reduction Act (IRA) Tax Credits[42]

The Inflation Reduction Act (IRA) provides federal tax incentives that can significantly improve the financial feasibility of microgrid projects incorporating clean electricity generation and energy storage. The two primary incentives are the Investment Tax Credit (ITC)[43] and the Production Tax Credit (PTC)[44], which were restructured under the IRA into technology-neutral credits applicable to qualifying zero- or low-emissions electricity resources.

For projects placed in service after December 31, 2024, solar PV and BESS may be eligible for the Clean Electricity Investment Tax Credit (ITC, Internal Revenue Code §48E). The ITC provides a one-time tax credit equal to 6% of eligible project costs, which may increase to 30% if prevailing wage and apprenticeship requirements are met. Eligible technologies include solar PV, standalone and co-located BESS, and other qualified clean electricity assets used within a microgrid configuration. Additional bonus incentives can further increase the ITC amount:

- 10% domestic content bonus for meeting U.S. steel, iron, and manufactured product requirements.
- 10-20% bonus for projects located in eligible energy communities or low-income communities, subject to program definitions and capacity limits.

Alternatively, qualifying electricity-generating assets may elect the Clean Electricity Production Tax Credit (PTC) under IRC §45Y. The PTC provides a per-kilowatt-hour (kWh) tax credit for electricity generated over a ten-year period, with the credit value similarly adjusted based on prevailing wage and apprenticeship compliance. The PTC is generally more favorable for projects with high annual electricity production, while the ITC may be preferable for projects with higher upfront capital costs or where maximizing initial cost recovery is a priority.

Eligibility for IRA tax credits is subject to construction and placed-in-service deadlines that are particularly relevant for solar PV:

- Solar PV projects must generally begin construction by July 4, 2026, or be placed in service by December 31, 2027, to qualify for the ITC or PTC.
- Battery energy storage systems (BESS) are eligible under the ITC and are not subject to the same placed-in-service deadline that applies to solar generation, providing greater flexibility for storage-focused microgrid designs.

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[42] "IRS Clean Energy Tax Incentives Elective Pay Eligible Tax Credits."
[43] NC Clean Energy Technology Center, "DSIRE - Business Energy Investment Tax Credit (ITC)."
[44] NC Clean Energy Technology Center, "DSIRE - Renewable Electricity Production Tax Credit (PTC)."

- Recent federal guidance includes restrictions related to the use of equipment or material assistance from prohibited foreign entities. For projects that commence construction after December 31, 2025, eligibility for the ITC or PTC may be affected if the project includes material assistance from a prohibited foreign entity, as defined by federal statute and implementing guidance. Projects that do not rely on such assistance remain eligible, subject to other applicable construction and placed-in-service requirements.

Because the three project partners are non-taxable entities, they may elect to receive direct pay under the IRA's Elective Pay (Direct Pay) provision, which allows them to obtain a cash refund equivalent to the tax credit value in lieu of claiming the credit against tax liability. However, to receive this benefit, the project must be fully paid upfront, with the cash reimbursement received following the applicable tax filing process. As a result, interim financing, bridge funding, or grants may be required to cover initial capital costs prior to receipt of the tax credit value.

These tax credits provide a substantial funding source for microgrid development. Projects that incorporate battery storage, meet labor and domestic content requirements, and adhere to construction timing thresholds may realize significant reductions in net project cost, particularly when combined with complementary state, utility, or federal grant programs.

Wisconsin Public Service Commission (PSC) Energy Innovation Grant Program (EIGP)[45]

The Wisconsin PSC's Office of Energy Innovation (OEI) Energy Innovation Grant Program (EIGP) funds energy projects that advance innovative and clean energy technologies. This feasibility study is an example of such a project. Although this program is not currently open, if funding is reinstated in future rounds, it should be considered as a critical funding source.

The EIGP has previously awarded up to $750,000 for Level 3 microgrid implementation projects. These grants target community resilience centers, municipal microgrid initiatives, and other energy projects that provide enhanced grid reliability and emergency preparedness. To maximize the likelihood of funding, the microgrid proposals should emphasize its potential to enhance resilience, integrate renewable energy, and provide valuable data for future grid modernization efforts in Wisconsin.

Focus on Energy Rebates and Incentives[46]

Wisconsin's Focus on Energy program provides a range of financial incentives to promote energy efficiency and renewable energy adoption for residential, commercial, and industrial projects. As a statewide initiative, Focus on Energy partners with utilities, including Xcel Energy, to support energy-saving technologies that reduce emissions and improve overall energy performance.

- **Renewable Energy Rebates:** Incentives are available for solar PV installations, helping offset the costs of implementing rooftop or ground-mounted solar systems at these sites.
- **Energy-Efficient Equipment Rebates:** Commercial sites like the ones in this study can receive rebates for high-efficiency HVAC systems, water heaters, smart thermostats, and other energy-saving technologies.

Leveraging Focus on Energy's rebate programs can significantly reduce initial investment costs for

[45] "PSC Energy Innovation Grant Program."
[46] Focus on Energy, "Rebates & Incentives."

developers at these Downtown La Crosse sites. By aligning the microgrid project with these funding opportunities, partners can maximize financial savings while advancing the project's sustainability and resilience goals.

8 CONCLUSION

The Downtown La Crosse Microgrid Feasibility Study evaluated the viability of implementing microgrids across a cluster of essential government and educational facilities owned by La Crosse County, the City of La Crosse, and Western Technical College. The analysis demonstrates that integrating distributed energy resources (DERs), including solar photovoltaics (PV), battery energy storage systems (BESS), and existing backup generators, can substantially enhance energy resilience, support community services during outages, and advance local climate and sustainability goals. Collectively, the results provide a clear, data-driven foundation for informed decision-making as project partners consider next steps toward implementation.

Key findings from the study highlight important trade-offs between different microgrid configurations, particularly between economic performance and resilience capability. Across nearly all sites, PV-only systems consistently show positive net present values (NPV) and relatively short payback periods, underscoring the strong economic case for expanded onsite solar generation. In contrast, scenarios that include BESS, especially those sized to support extended outages or broader building loads, often show negative NPVs when evaluated solely using conventional financial metrics, like utility cost savings. However, campus-scale configurations demonstrate improved economics by leveraging larger PV systems to support shared storage. This is most evident in Western Technical College's Small Campus Microgrid Scenario 3, where the interconnecting the Kumm and Coleman Centers enables sufficient PV generation to economically support the large BESS needed to establish the Kumm Center as a Community Resilience Center. The same could be said for the interconnected Law Enforcement Center and Health & Human Services scenarios.

We acknowledge that with the current low utility rates and low frequency and duration of outages in the area, the economic feasibility of many microgrid scenarios do not immediately pencil out. This microgrid feasibility study represents a snapshot in time. Projections show that with load growth, driven by electrification, increasing peak demand, and evolving grid conditions, utility prices are anticipated to increase, and outages may become more frequent and longer due to the impacts of climate change. Consequently, the net present value (NPV), return on investment (ROI), and other financial metrics are expected to improve dynamically with the forecasting rise in electricity costs.

Crucially, conventional financial metrics alone do not capture the full value proposition of microgrids. When avoided outage costs (resilience value), emissions reductions, and associated public health benefits are incorporated, many scenarios that initially appear uneconomic achieve positive NPVs. These findings reinforce the importance of evaluating microgrids using a broader societal cost-benefit lens rather than relying solely on utility bill savings.

The study also underscores the importance of strategic planning and partner collaboration. The involvement of the La Crosse County, the City of La Crosse, and Western Technical College has been instrumental in defining project goals, gathering data, assessing technical feasibility, and aligning with regulatory and financial frameworks. This collaborative approach ensures that the proposed microgrids are not only technically sound but also align with the broader community's needs and priorities.

The implementation of the microgrids should follow a phased approach, as outlined in the Next Steps section. Near-term actions such as deploying microgrid-ready PV systems, upgrading inverters, improving load visibility, and planning for future BESS installation can reduce upfront costs and preserve flexibility.

Leveraging funding opportunities will be critical for reducing upfront costs and enhancing the economic viability of the microgrid. Programs such as the IRA Tax Credits, the OEI Energy Innovation Grant Program, and the range of incentive offerings from Focus on Energy could provide substantial financial support if available. By utilizing these programs, the project partners can reduce capital costs while maximizing the environmental and resilience benefits of the microgrids.

This study also offers a replicable framework for other communities seeking to integrate microgrids into resilience planning. It demonstrates how local governments and public institutions can align climate action goals, resilience planning, and infrastructure investment within a realistic regulatory and financial context. By coupling technical analysis with resilience metrics and community priorities, the approach used here can inform similar efforts across Wisconsin and the broader Midwest.

Ultimately, the Downtown La Crosse microgrids represents a transformative opportunity for the La Crosse and Western Technical College to lead in energy innovation, demonstrating how local public entities can address the challenges of climate change and energy reliability through advanced microgrid solutions. With continued partner collaboration and strategic planning, this project has the potential to become a model for sustainable and resilient community development.

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