# WISCONSIN OFFICE OF ENERGY INNOVATION FLORENCE ELEMENTARY MICROGRID FEASIBILITY STUDY

Prepared for the Wisconsin Office of Energy Innovation (WI OEI)

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Wisconsin Office of Energy Innovation

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## About SEPA

The Smart Electric Power Alliance (SEPA) is dedicated to helping electric power stakeholders address the most pressing issues they encounter as they pursue the transformation to a carbon-free energy system. We are a trusted partner providing education, research, standards, and collaboration to help utilities, electric customers, and other industry players across three pathways: Regulatory and Business Innovation, Grid Integration, Electrification. Through educational activities, working groups, peer-to-peer engagements and custom projects, SEPA convenes interested parties to facilitate information exchange and knowledge transfer to offer the highest value for our members and partner organizations. For more information, visit www.sepapower.org.

## Acknowledgements

SEPA would like to thank the Wisconsin Office of Energy Innovation (WI OEI) for the opportunity to conduct this study. The study was made possible by WI OEI's Critical Infrastructure Microgrid and Community Resilience Centers Pilot Grant Program (CIMCRC), which focuses on innovative pre-disaster mitigation through critical infrastructure microgrids and other resilient building strategies by studying the feasibility of the deployment of distributed energy resources (DERs) and appropriately sized storage, along with a grid-interactive controls schema. This feasibility study was one of sixteen (16) grants awarded across the state.

SEPA would also like to thank its project partners at Florence Utility Commission, WPPI Energy, and the School District of Florence County.

# 0.0 Executive Summary

Extreme weather events threaten damage to the electrical system and disruption to power supply. These weather events in Wisconsin are increasing in both frequency and economic impact, causing prolonged outages, and disproportionately affecting underserved communities. This project presents an opportunity to collaborate with a Wisconsin elementary school which is designated as an American Red Cross Shelter to assess the feasibility of deploying a microgrid as a pre-disaster mitigation technique. An appropriately sized microgrid could insulate the facility from the impacts of prolonged outages and build resilience for the community. This study identifies a microgrid as a resilience solution, develops microgrid designs that incorporate varying power supply technologies, and utilizes stakeholder input to evaluate the feasibility of each microgrid design. This feasibility study was funded by a grant from WI OEI and donated funds and working time from SEPA, Florence Utility Commission (Florence Utilities), the School District of Florence County, and WPPI Energy.

The feasibility study methodology included the following primary tasks:

1. **Stakeholder Engagement** - SEPA convened a core project team of key stakeholders to discuss the feasibility of a microgrid project at Florence Elementary.
2. **Data Collection** - SEPA collected community, utility, and energy consumption data relevant to the system sizing and financial and environmental impact analysis of a potential microgrid at the emergency shelter.
3. **System Sizing and Analysis** - SEPA evaluated six (6) preliminary microgrid scenarios. Based on stakeholder feedback, the project team conducted a detailed system design of one of the modeled scenarios. The sizing and analysis considered community function as the primary resilience objective and metric.
4. **Financial and Environmental Impact Analysis** - SEPA conducted a benefit-cost analysis of the modeled scenarios to determine economic feasibility.

The project team designed the microgrid scenarios for Florence Elementary School in Florence, WI, as seen in Figure 0.1. During emergencies, the school is designated as an emergency shelter which would serve a population of 4,295. Approximately 27 percent of that population is over age 65 and could have significant energy needs such as oxygen and other medical equipment.[1] The microgrid feasibility study proposal was motivated by the failure of the 480 KW diesel generator which previously served the school.

This report provides several scenarios for the additional development and seamless integration of a microgrid. The feasibility study partners analyzed the load profiles of the elementary school and a nearby nursing home, Florence Health Services, and developed six potential microgrid designs, as seen in Table 0.1 and Figure 0.2, to serve the load of the elementary school, or the elementary school and nursing home, while utilizing solar photovoltaic, battery storage, and

[1] https://apps.psc.wi.gov/ERF/ERFview/viewdoc.aspx?docid=420888

natural gas generator technologies. Based on input from the project team, this report also briefly addresses a “baseline” scenario, which offers a high-level comparative valuation for installing a 90 kW natural gas standby generator to meet the facility’s load during an outage. Though a full BCA was not completed for the “baseline” scenario, related costs are presented in the results.

***Figure 0.1 – Florence Elementary Site Plan***

Source: Florence Elementary, 2022

To ensure the microgrid designs would serve the needs of the school and community, the core project team consisted of key project stakeholders. Each month, project team members provided information about the purpose of the microgrid, project updates and findings, and held an open dialogue for members to provide feedback. Project team members were given the opportunity to ask questions and ultimately chose six possible microgrid design scenarios that they determined would best suit the site and community.

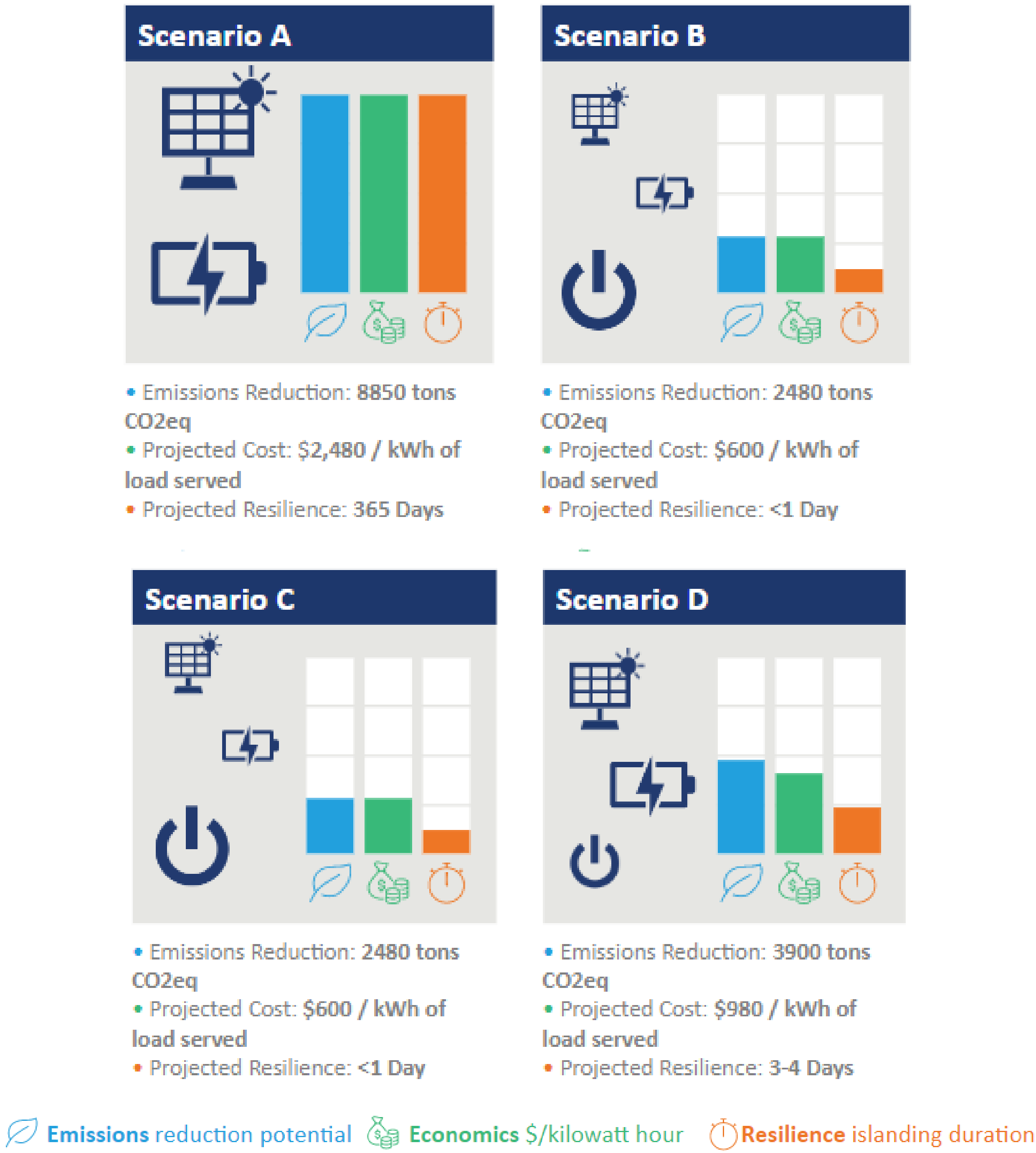
The microgrid components in this study include:

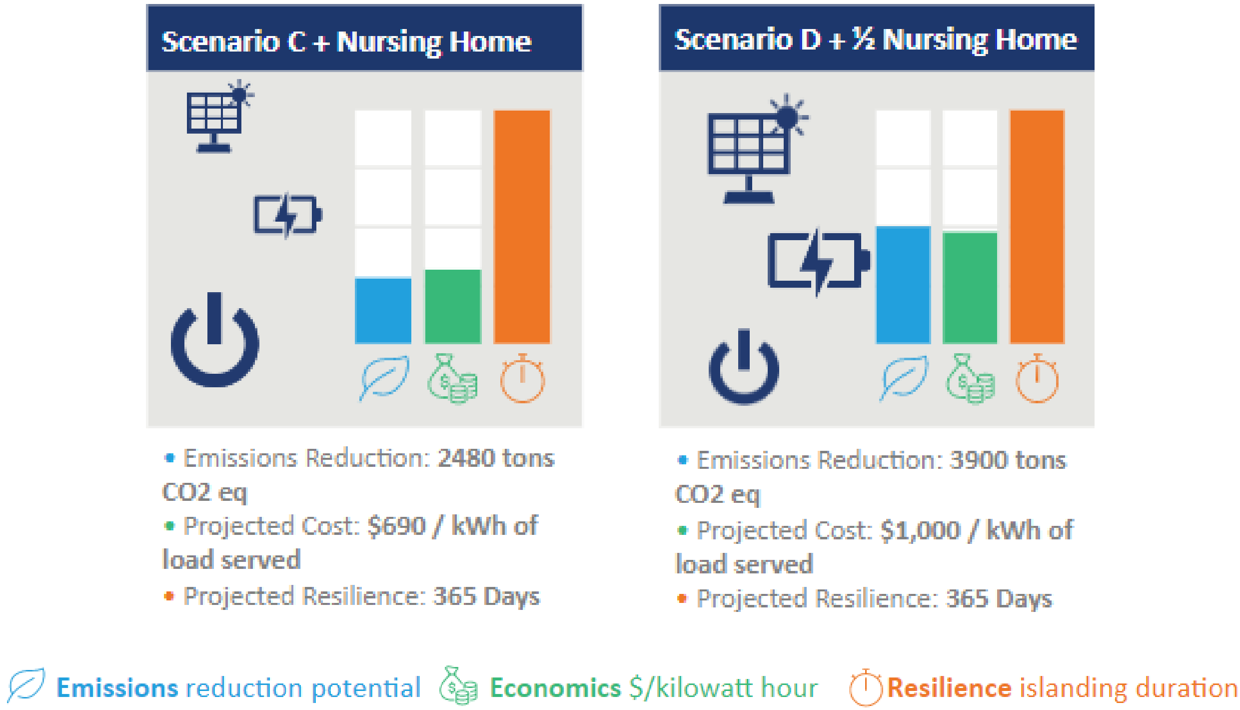
- Load: Florence Elementary School (and Florence Health Services)
- Ground-Mounted Solar PV
- Battery Energy Storage System (BESS)
- Natural Gas Standby Generation
- Microgrid Controller
- Distribution System

*Table 0.1 - Microgrid Scenario Summary*

| Scenario | Load | Solar | Solar kW-DC | Battery kW-DC | NG kW-DC |
|---|---|---|---|---|---|
| **Scenario A** | Florence Elementary | Ground Mounted Solar Only | 625 | 340 | - |
| **Scenario B** | Florence Elementary | | 175 | 50 | 45 |
| **Scenario C** | Florence Elementary | | 175 | 50 | 45 |
| **Scenario D** | Florence Elementary | | 275 | 100 | 25 |
| **Scenario C + Nursing Home** | Florence Elementary + Nursing Home | | 175 | 50 | 170 |
| **Scenario D + Nursing Home** | Florence Elementary + Nursing Home | | 275 | 100 | 90 |
| **"Baseline" Scenario** | Florence Elementary | -- | -- | -- | 90 |

***Figure 0.2 – Overview of Proposed Microgrid Scenarios***






Source: SEPA, 2022

The benefit-cost analysis (BCA) quantifies the net present value (NPV) of the benefits and costs associated with each proposed microgrid scenario as summarized in Table 0.2 below. The BCAs highlighted below assume a mid-range estimate for component costs and O&M. The benefits exceed costs over the project lifecycle if the benefit-cost ratio (BCR) is greater than 1.0. The analysis found that the BCR of each scenario was between 0.72 and 0.99, indicating that the NPV of costs outweigh the benefits in all scenarios, albeit by a very narrow margin in certain cases. It is important to note that the value of resilience was implied from the BCA but was not included in the BCA itself, so BCR values presented in this report are likely to underestimate the actual BCR in each scenario. Also note that while the team found the costs to slightly outweigh the benefits in the six scenarios, the benefits of solar generation and BESS operation could change depending on future analysis around the business model and ownership structures of a microgrid project. Conversely, note that some of the emissions reduction benefits included in the BCA may not be directly realized by Florence Elementary, effectively reducing the BCR.

*Table 0.2 - Summary of Costs and Benefits*

| Costs | Benefits* |
|---|---|
| • Generation (Solar Photovoltaic (PV) + Natural Gas Standby Generator (NG))<br>• Battery Energy Storage System (BESS)<br>• Controller and Communications<br>• Distribution Upgrades<br>• Operations & Maintenance | • Solar Generation (Demand savings, energy rate savings, and excess generation credits)<br>• BESS Economic Benefits (Energy arbitrage, demand savings)<br>• Emissions Reductions |
| **Scenario A: BCR = 0.73** | |
| **Scenario B: BCR = 0.99** | |
| **Scenario C: BCR = 0.99** | |
| **Scenario D: BCR = 0.89** | |
| **Scenario C (including Florence Health Services): BCR = 0.88** | |
| **Scenario D (including ½ Florence Health Services): BCR = 0.86** | |

*Note that an estimate of the value of resilience is implied from this BCA and noted in section 4 below, but it is not included in the BCA and is not reflected in the BCR.

Source: SEPA, 2022.

This study develops the groundwork for the School District of Florence County, Florence Utility Commission (Florence Utilities), WPPI, WI OEI, and other local stakeholders to move to a more detailed benefit-cost analysis and ultimately to the implementation phase of microgrid development. The potential next steps include a determination of ownership and operation structures, further construction coordination, identification of financing and funding, and the development of a full engineering design and construction study. The continuation of strong engagement with community stakeholders through the implementation of the microgrid will facilitate the success of the project.

# 1.0 Introduction

A resilient energy system can absorb and recover in a timely manner from unavoidable external events, such as natural disasters. In recent years, the frequency and intensity of naturally occurring threats has substantially increased. Wisconsin suffered 32 billion-dollar disaster events costing over $166 billion in damages in the last 20 years. This is more than a 50% increase from eight such events costing $104 billion from 1980 to 2000.[2] Extreme weather events threaten the stability of the grid and cause power outages with attendant economic

[2] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022).

losses. In fact, national power outage data suggests a 67% increase in outages from weather-related events since 2000.[3]

A grid without resilience measures in place may suffer prolonged outages, which may render critical services inaccessible, such as communications, public safety, water treatment, healthcare, and emergency shelters. Grid instability disproportionately affects communities with higher elderly populations, as those demographics face a higher risk of fatality during outage events without backup power for oxygen or other critical medical devices. This microgrid project in Florence, Wisconsin would bolster resilience for the school's shelter functions during emergency events, utilize renewable power sources, and provide energy savings and increase affordability for the facility.

## 1.1 Project Overview

### Site and Customer Background

This report assesses the feasibility of utilizing a microgrid in building resilience for Florence Elementary School, a public school and American Red Cross disaster shelter in Florence, Wisconsin.

### Existing Infrastructure

The site consists of a 35.6 acre parcel containing a 54,000 square foot school building, parking lot, playground and blacktop, areas of green space, road that cuts through the green space and connects to the middle/high school, and an existing diesel generator which will be removed from the site. The site hosts an interconnection point to Florence Utilities' electric distribution grid and natural gas distribution system.

### Rationale for Microgrid

This report was commissioned by WI OEI through the CIMCRC to study the feasibility of including a critical infrastructure microgrid for the site as a means for innovative pre-disaster mitigation given its shelter designation and documented failure of existing backup generation. Such a microgrid might incorporate DERs, appropriately sized energy storage, and a grid-interactive controls schema which would allow the introduction of locally generated solar energy and increased resilience (i.e., the ability to operate independently even when the public grid is temporarily inoperable). This feasibility study included engagement with key stakeholders, energy, disaster, and site-specific data collection, preliminary microgrid system sizing and analysis, and financial and environmental impact analysis.

WI OEI defines a microgrid as "a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity

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[3] SEPA, Commonwealth of Kentucky Regional Microgrids for Resilience Study, p. 7 (2021).

with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode."[4]

## Identification of Critical Infrastructure

Florence Elementary agreed upon a Memorandum of Understanding (MOU) with the American Red Cross to use parts of the facility as a shelter during an emergency, including the gymnasium, locker rooms, and some rooms in the west wing of the facility. The MOU can be found in Appendix 3.

Additionally, project team members suggested that some proposed scenarios include the load of a nearby nursing home, Florence Health Services. During two occasions in the past decade, nursing home residents used the elementary school facility as a shelter during extended outages. Given this history, team members suggested that providing resilience services to the nursing home by increasing the capacity of standby generation at the school could limit the burden on the school during an emergency.

## Key Partners and Stakeholders

Within this report, the core project team comprises stakeholders who supported the evaluation of preliminary microgrid scenarios to best support Florence Elementary and analyze the financial, societal, and environmental benefits of the microgrid. The findings of this report may support future endeavors by the WI OEI to build energy resilience at sites similar to Florence Elementary.

SEPA, the School District of Florence County, WPPI, and Florence Utilities are the primary partners leading the project. Table 1.1.1 summarizes the role of each organization in carrying out the project.

***Table 1.1.1 - Core Project Team and Responsibilities***

| Project Partners | Responsibility | Role |
|---|---|---|
| Florence Utilities | Technical and strategic support | Local electric distribution utility and applicant |
| School District of Florence County | Technical and strategic support | End-use customer |
| Smart Electric Power Alliance (SEPA) | Stakeholder engagement and technical assistance | Microgrid feasibility study lead |
| WPPI | Technical and strategic support | Electric wholesale supplier |

Source: Smart Electric Power Alliance, 2022

[4] https://apps.psc.wi.gov/ERF/ERFview/viewdoc.aspx?docid=420888

## Financial and Environmental Impact Analysis

This study includes a financial and environmental impact analysis of six proposed microgrid scenarios that serve the elementary school through different asset mixes including solar PV, battery storage, and natural gas standby generation. The scenarios represent a range of renewable resource intensities, islanding capabilities, and related costs and benefit propositions. The analysis aims to quantify the net present value costs and benefits associated with each scenario to determine a BCR for each. The specific costs and benefits of the analysis are detailed fully in 4.2 Financial and Environmental Impact, including costs associated with the development, design, components, and operation of the microgrids, and benefits associated with emissions reductions, demand and energy rate benefits, and solar generation credits.

# 1.2 Feasibility Study Methodology and Assumptions

## Stakeholder Engagement

The core project team, composed of SEPA, WPPI, Florence Utilities, and the School District of Florence County discussed the resilience needs of the Florence Elementary site, and assessed feasibility in the development of a microgrid project. Each month, beginning in January of 2022, SEPA hosted virtual check-in meetings to build connections with the entire team, foster a collaborative project environment, and maximize engagement throughout the project. For summaries of each monthly check-in discussion, see Appendix 1: Project Team Check-In Summaries.

Fostering a collaborative relationship between project team members encouraged productive conversations and provided SEPA with key input regarding the study, microgrid site, and the microgrid design that would best serve the site's needs. Furthermore, the project team engagement provided members with the information they needed to engage in meaningful conversation, and communicate, via feedback, their input on project design.

## Data Collection

The team collected data from a variety of sources to model preliminary microgrid scenarios. While the team was unable to gather detailed load profile data from the site, SEPA estimated Florence Elementary's hourly load profile based on a historical hourly kW load profile that WPPI Energy provided for Forest Park School, in a nearby district. SEPA assumed that Florence Elementary had a similar load shape, and adjusted the proxy load profile to match the monthly demand peaks (kW) and consumption (kWh) of Florence Elementary, as provided by Florence Utilities. The estimated load data helped to quantify a load duration curve, which determines how much designed load the microgrid scenarios should serve.

To plan where to construct the microgrid at Florence Elementary, the School District of Florence County provided a site map and additional information regarding land availability for storage systems, standby generators, and solar PV. Florence Utilities provided maps of existing natural gas supply and electric distribution infrastructure. Multiple contributors supported the data collection effort, which was valuable in developing model assumptions and designing the microgrid scenarios.

## System Sizing and Analysis

SEPA considered site area limitations identified in the site map provided by Florence Elementary, preferences vocalized by project team members, and internal expertise to inform the fuel source mix for each scenario. SEPA ensured that the scenarios reflected a range of options with respect to renewable assets, islanding capabilities, and project costs that adhered to site area limitations.

To determine solar PV site constraints, SEPA referenced a 2013 NREL study on land-use requirements for solar power plants which estimated the direct area capacity-weighted average land use of solar PV at 5.5 acres/MWac for a fixed-axis system. This value and the land available from the site assessment determined the maximum buildable solar capacity (kWac) on the site. To estimate the maximum buildable DC solar capacity, SEPA multiplied the maximum AC solar capacity by the conservative DC-to-AC ratio of 1.3 that was used in the study, instead of the ~1.18 value that was used in the NREL study.[5] As a result, estimates for maximum DC solar capacity might be slightly high, though this estimate would potentially only impact scenario A which proposes solar PV in excess of 600 kWDC.[6] Additionally, land availability at Florence High School could bridge that small gap.

To a lesser extent, SEPA also considered land availability to site a BESS and standby generator, noting that the footprint of each is fairly insignificant compared to the requirements for solar PV. For a BESS, SEPA used reference data from a publicly available SCE battery storage project which assumed a footprint of ~0.2 sq ft/kWh.[7] For a standby generator, SEPA used a Generac 24 kW unit as a reference, which has a footprint of 3kW/sqft.[8]

## Financial and Environmental Impact Analysis

SEPA carried out a financial and environmental impact analysis for each of the six scenarios that compared the net present values of project costs and benefits, including emissions reduction benefits, over a presumed 20-year lifespan. This report shares the net present values of costs and benefits associated with each of the six scenarios and includes low-, medium-, and high- cost estimates for each scenario to compare to actual component costs in further analysis.

[5] The NREL study used a weighted-average PV derate factor of 0.85 that was calculated by dividing the AC reported capacity by the DC reported capacity for each project that was included in the study. This value implies a DC-to-AC ratio of 1 / (0.085) = 1.176.
[6] Using a DC-to-AC ratio of 1.176 instead of 1.3 would reduce the maximum DC solar capacity at Florence Elementary from 655 kWdc to 592 kW DC. While this situation would require a reduction of the solar capacity in Scenario A, it is likely that the site would have an AC-to-DC ratio closer to the 1.176 implied by the NREL study, and Florence would be able to achieve the same amount of generation modeled in the scenario with reduced solar capacity that could fit at the site.
[7] https://insideevs.com/news/323829/sce-unveils-americas-largest-battery-energy-storage-site/
[8] https://www.generac.com/all-products/generators/home-backup-generators/guardian-series/24kw-7210-with-200amp-ser-transfer-switch

This report also shares the BCR values related to each scenario and cost estimate to demonstrate whether each scenario would be cost-effective given the estimated costs and benefits over the life of the microgrid.

Costs in the financial impact analysis include component costs, microgrid design and construction costs, and long-term operating and maintenance costs for solar and BESS. Economic and environmental impact benefits included demand reduction, energy rate savings, and excess generation credits from solar and BESS, as well as emissions reduction benefits from solar. SEPA's processes for estimating specific microgrid costs and benefits for the financial and environmental impact analysis can be found in 4.2 Financial and Environmental Impact and Appendix 2: Detailed Benefits.

# 2.0 Site Assessment

## 2.1 Site Overview

Florence Elementary School is located on a 35.6 acre lot. Solar will not be installed on the school building, which is 54,000 square feet, but instead will be deployed on the surrounding property. The site assets and parcel outline are shown in an aerial image below.

*Figure 2.1.1 -* ***Site Boundaries and Aerial Imagery***

Source: Statewide Parcel Map Initiative, V7 Statewide Parcel Data (2021) and GeoData@Wisconsin, WROC Aerial Mosaic (WTM) Florence County, WI 2020 (2020)

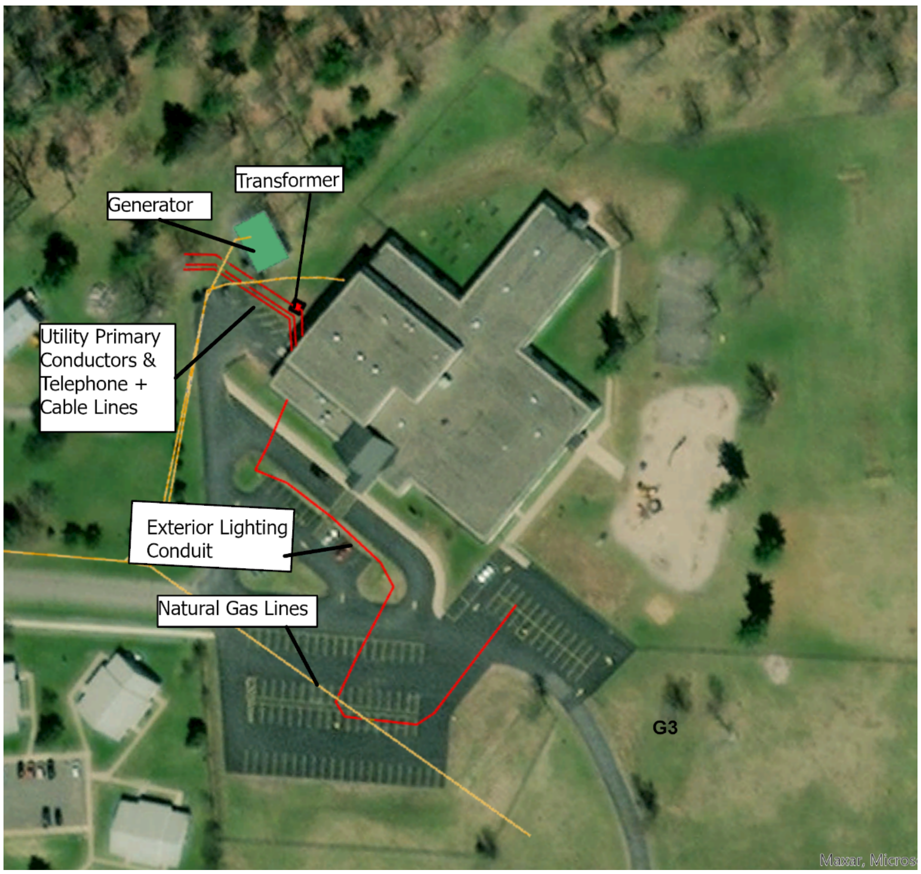
Available areas of the property are being considered for solar PV, battery energy storage, and natural gas standby back-up generation, along with microgrid controller functionality to allow for sustained islanding capabilities during a grid outage.

## Detail infrastructure

Previously, a 480 kilowatt (kW) diesel generator was installed at the elementary school to provide emergency power generation and to serve the emergency shelter described above. However, the generator has failed and Florence Utilities along with the School District of Florence County is interested in pursuing a feasibility investigation to evaluate a microgrid system to serve the emergency shelter.

Existing generator, transformer, utility primary conductors, telephone and cable lines, natural gas lines, and exterior lighting conduit are displayed on the map below.

*Figure 2.1.2 - **Site Infrastructure***

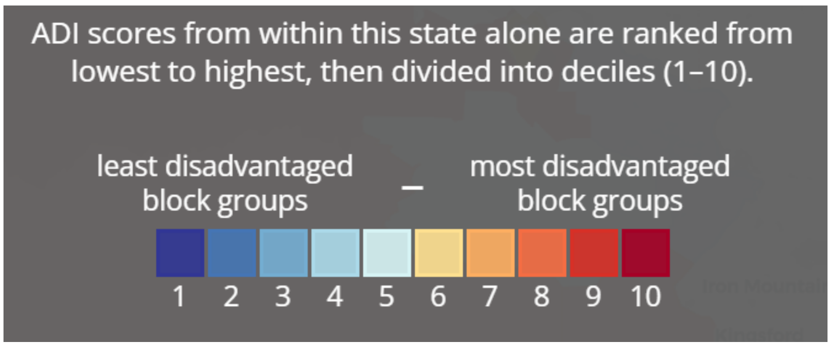



Source: SEPA, 2022

## Community vulnerability indicators

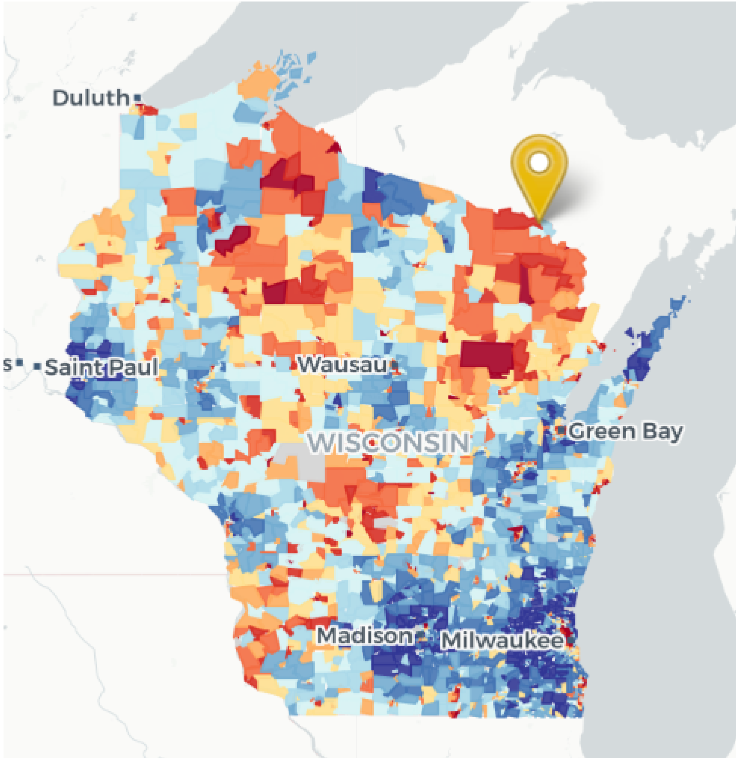
Figure 2.1.4 and 2.1.5 below show census block groups in Wisconsin categorized by their Area Deprivation Index score. The yellow marker on the map indicates the location of the site. The emergency shelter site is near some of the most disadvantaged census block groups in the state. The legend in Figure 2.1.3 can be used to read the following maps.

*Figure 2.1.3 -* ***Area Deprivation Index Legend***



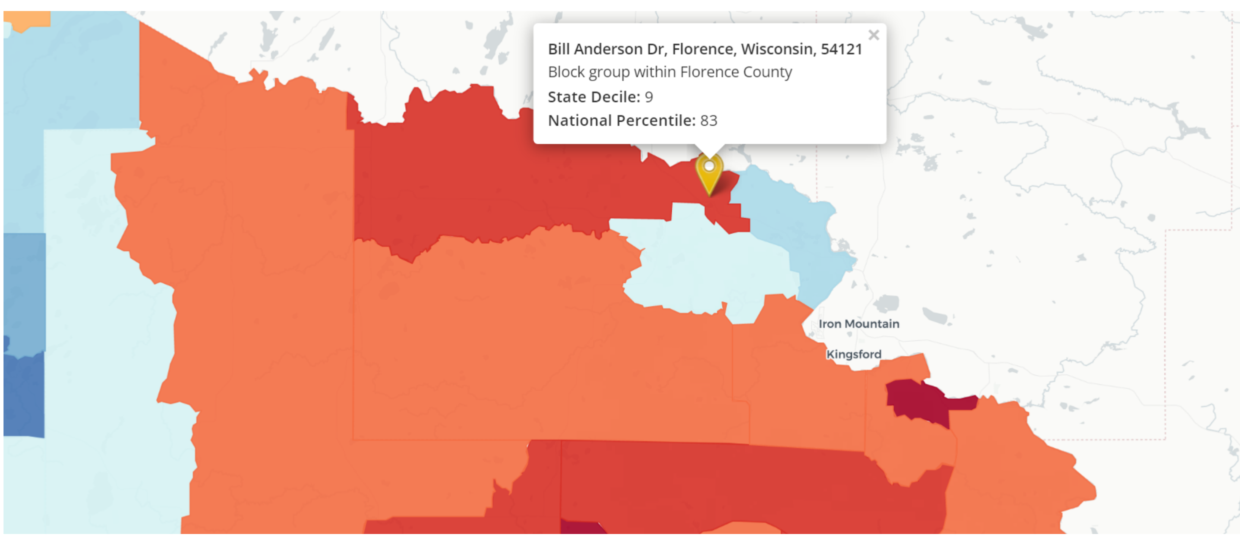

Source: University of Wisconsin-Madison, Neighborhood Atlas Map (2021)

*Figure 2.1.4 -* ***State View: Area Deprivation Index by Census Block Group***




Source: University of Wisconsin-Madison, [Neighborhood Atlas Map ](2021)

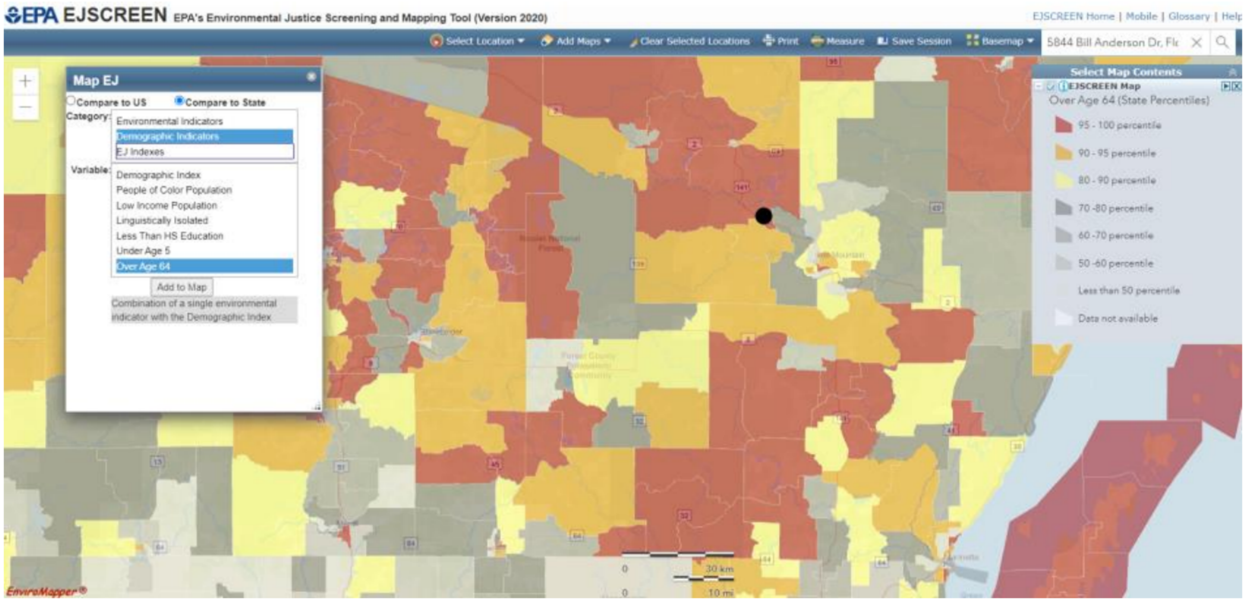
*Figure 2.1.5 -* ***Local View: Area Deprivation Index***




Source: University of Wisconsin-Madison, [Neighborhood Atlas Map ](2021)

The EPA's Environmental Justice Screening and Mapping tool, highlighted in Figure 2.1.6 below, shows that the emergency shelter site is located in an area where the percent of the population that is over the age of 64 is in the 90-100th percentile of the state.

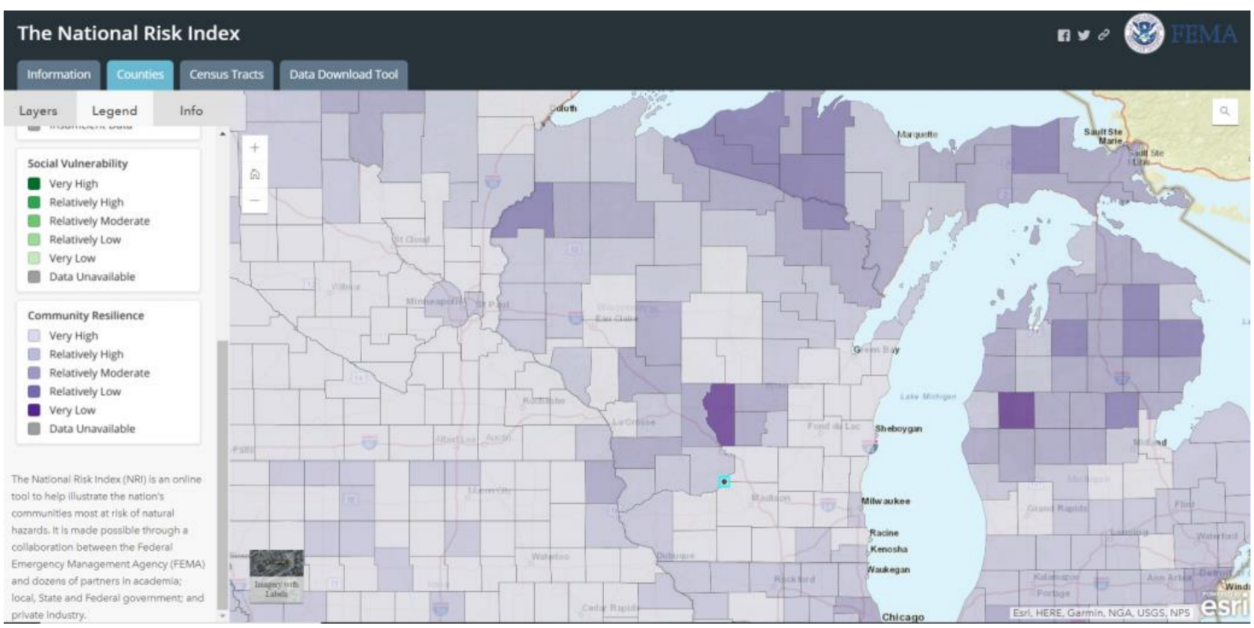
*Figure 2.1.6 -* ***Percentile of Population over 64 by Census Block***




Source: Environmental Protection Agency, [EJSCREEN](EJSCREEN) (2020)

Figure 2.1.7 below indicates that the emergency shelter site is located in an area that has relatively low to relatively moderate community resilience risk.

*Figure 2.1.7 -* ***Level of Community Resilience by County***

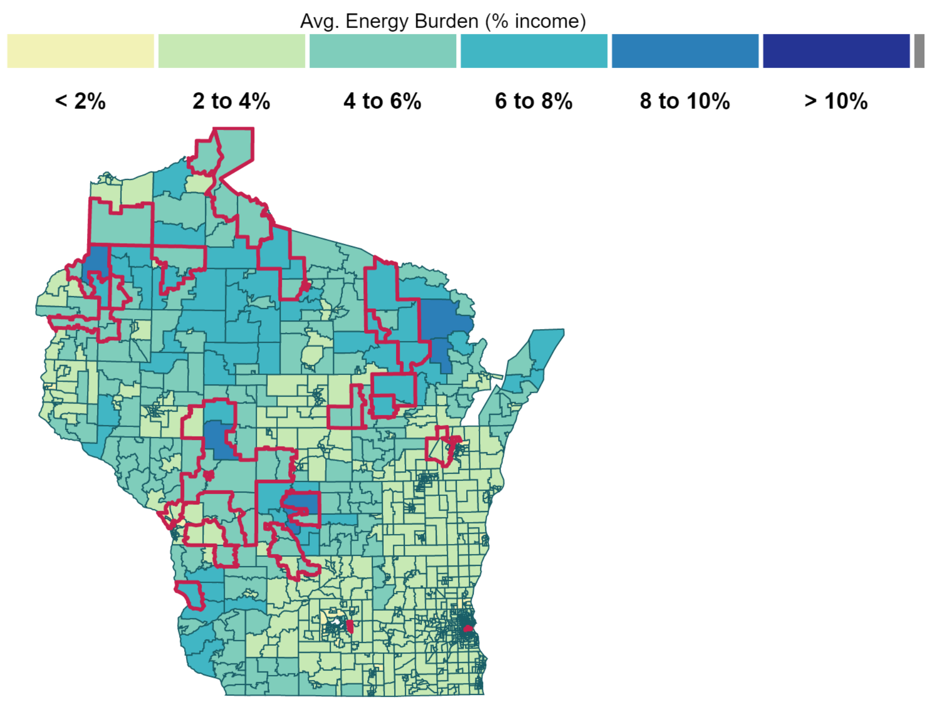



Source: FEMA, [The National Risk Index](The National Risk Index) (2021)

Below, Figure 2.1.8 indicates that the emergency shelter site is located in an area where the energy burden is significant (>5%). The red outline on Figure 2.1.8 also delineates indigienous land, which is adjacent to the emergency shelter.

The prevalence of vulnerable populations, such as elderly communities, indigienous tribes, and low-moderate income customers, make an emergency shelter at Florence Elementary all the more important to have resilient power. Therefore a microgrid solution could benefit the community tremendously by providing uninterrupted power during grid power outages.

*Figure 2.1.8 -* ***Average Energy Burden Near Proposed Site***




**Low-Income Energy Affordability Data Tool Map Export (https://lead.openei.org/)**
Exported On: 4/27/2022
SMI: 0% - 30%, 30% - 60%, 60% - 80%, 80% - 100%, 100%+
Building Age: Before 1940, 1940 - 59, 1960 - 79, 1980 - 99, 2000 - 09, 2010+
Heating Fuel Type: Utility Gas, Bottled Gas, Electricity, Fuel Oil, Coal, Wood, Solar, Other, None
Building Type: 1 unit detached, 1 unit attached, 2 units, 3 - 4 units, 5 - 9 units, 10 - 19 units, 20 - 49 units, 50+ units, Boat/RV/Van, Mobile/Trailer
Rent/Own: Renter-occupied, Owner-occupied

Source: Department of Energy, Low-Income Energy Affordability Data (LEAD) Tool

(2021)

## Site application and functionality

Florence Utilities is interested in improving resilience for the designated emergency shelter at Florence Elementary School. The shelter at the elementary school serves a population of 4,295. The elementary school is equipped with a full kitchen that could feed a large number of people in the event of an emergency as well as a number of classrooms and larger spaces for the American Red Cross to provide other shelter services. In Florence County, roughly 27% of the population is age 65 and over. This heightened the importance of designating a shelter to serve elderly customers, while giving these individuals a safe place to access medical equipment such as oxygen. The elementary school can also provide shelter for the following emergency services during a power outage event:

- Shelter for lineman restoring power
- Aid emergency response organizations
- Offer a place for refueling if gas pumps are down
- Provide a registered nurse for any minor medical care needs
- Shelter for special needs individuals

## Critical services

The elementary school will be utilized by Florence County and the Village of Florence as an emergency shelter during grid outages and other events. Examples of critical services to be provided by the emergency shelter are as follows:

- Phone charging
- Cook stoves
- Space heating
- Air conditioning
- Food preparation and storage
- Medical
- Refrigeration
- Oxygen
- WiFi
- Server storage
- Charge critical tools
- Emergency response capabilities

A microgrid may also replace the obsolete diesel generator on-site to provide the community with a source of cleaner back-up electricity to provide the above critical power services to the school as a shelter for area residents when evacuations are necessary.

## Customer information and historical outage information

Florence Elementary School requires a source of backup power generation due to its role as a Red Cross shelter in the event of an emergency or disaster. The local nursing home, Florence Health Services, which does not have a source of backup power generation, has been impacted by two emergencies within two years of each other that have forced residents to evacuate to Florence Elementary for more than one day. One emergency resulted from a lightning strike that caused a fire at the nursing home and another resulted from a building outage. Currently, the elementary school only has battery-powered emergency lights that would operate in the event of a power outage. Without backup power, the facility could be unable to operate as a shelter in the event of a widespread outage impacting the community.

## Rate schedule

Florence Utilities currently serves Florence Elementary under the Small Power Service – Cp-1 electric rate (Figure 2.1.9), though Florence Elementary may want to consider a transition to the Small Power Service-Optional Time-of-Day – Cp-1 TOD electric rate (Figure 2.1.10) to optimize the economic benefits of battery storage proposed in each scenario. This analysis assumes a transition to the TOD rate in order to optimize the value of battery dispatch for peak shaving and energy arbitrage.

***Figure 2.1.9 - Florence Utilities Small Power Service (Cp-1) Rate Structure***

**SMALL POWER SERVICE – Cp-1**

**Application:**

This rate will be applied to customers for all types of service if their monthly Maximum Measured Demand is in excess of 50 kilowatts (kW) per month for three or more months in a consecutive 12-month period, but not greater than 200 kW per month for three or more months in a consecutive 12-month period. Customers billed on this rate shall continue to be billed on this rate until their monthly Maximum Measured Demand is less than 50 kW per month for 12 consecutive months. The utility shall offer customers billed on this rate a one-time option to continue to be billed on this rate for another 12 months if their monthly Maximum Measured Demand is less than 50 kW per month. However, this option shall be offered with the provision that the customer waives all rights to billing adjustments arising from a claim that the bill for service would be less on another rate schedule than under this rate schedule.

**ELECTRIC RATES - Effective 04/01/2021 - Continued**

**SMALL POWER SERVICE – Cp-1 - continued**

**Determination of Billed Demand:**

The Billed Demand shall be the Maximum Measured Demand.

**Determination of Maximum Measured Demand:**

The Maximum Measured Demand in any month shall be that demand in kilowatts necessary to supply the average kilowatt-hours in 15 consecutive minutes of greatest consumption of electricity during each month.

**Determination of Distribution Demand:**

The Distribution Demand shall be the highest monthly Maximum Measured Demand occurring in the current month or preceding 11-month period.

**Rate:**

| | |
|---|---|
| Customer Charge: | $65.00 per month |
| Distribution Demand Charge: | $2.00 per kW of distribution demand |
| Demand Charge: | $9.00 per kW of billed demand |
| Energy Charge: | $0.0863 per kilowatt-hour (kWh) |

Energy is subject to Power Cost Adjustment Clause (PCAC) which varies monthly.

*Figure 2.1.10 - Florence Utilities Small Power Service (Cp-1) TOD Rate Structure*

**SMALL POWER SERVICE-Optional Time-of-Day – Cp-1 TOD**

**Application:**

This rate schedule is optional to all Cp-1 customers. Customers that wish to be served on this rate schedule must apply to the utility for service. Once an optional customer begins service on this rate schedule, the customer shall remain on the rate for a minimum of one year. Any customer choosing to be served on this rate schedule waives all rights to billing adjustments arising from a claim that the bill for service would be less on another rate schedule than under this rate schedule. Once on this rate, the utility will review billing annually according to Wis. Admin. Code ch. PSC 113.

**Rate:**

| | | | | |
|---|---|---|---|---|
| Customer Charge: | $65.00 per month | | | |
| Distribution Demand Charge: | $2.00 per kW of distribution demand | | | |
| Demand Charge: | $9.00 per kW of on-peak billed demand | | | |
| Energy Charge: | On-Peak | $0.0955 per kilowatt-hour (kWh) | Off-Peak | $0.0725 per kWh |

Energy is subject to Power Cost Adjustment Clause (PCAC) which varies monthly.

Pricing Period: On-peak: 8:00 am to 8:00 pm Monday thru Friday, excluding holidays specified below.
Off-peak: All times not specified as on-peak including Saturday and Sunday, and the following holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day or the day designated to be celebrated as such.

**Determination of Maximum Measured Demand and On-Peak Maximum Demand:**

The Maximum Measured Demand in any month shall be that demand in kilowatts necessary to supply the average kilowatt-hours in 15 consecutive minutes of greatest consumption of electricity during each month. Such Maximum Measured Demand shall be determined from readings of permanently installed meters or, at the option of the utility, by any standard methods or meters. Said demand meter shall be reset to zero when the meter is read each month. The Maximum Measured Demand that occurs during the On-peak period shall be the On-peak Maximum Demand.

**Determination of Distribution Demand:**

The Distribution Demand shall be the highest monthly Maximum Measured Demand occurring in the current month or preceding 11-month period.

**Determination of On-Peak Billed Demand:**

The Maximum Measured Demand that occurs during the On-peak period shall be the On-peak Billed Demand.

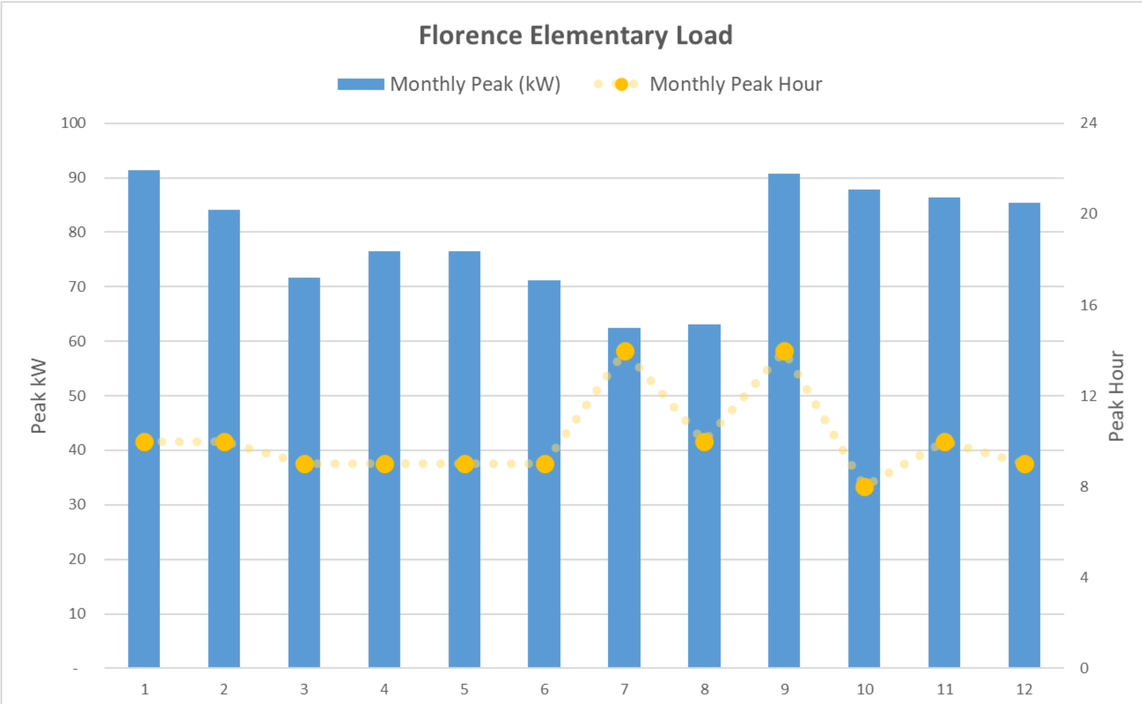
## 2.2 Initial Load and Solar Analysis

### Load Analysis

Several different load and asset mix scenarios served as additional inputs in the microgrid sizing, siting, and financial analysis processes. For this study, SEPA considered three load scenarios. In the first scenario, the microgrid would serve the elementary school's load only. In the second and third scenarios, the microgrid would serve the elementary school's load, and backup generation would be sized to serve either all or half of Florence Health Services, the nursing home next door to the school.

The load depends on the time of year and time of day. The elementary school's load clearly peaks in the winter. Throughout the year, the load peaks in the mid-morning, though in July and September, it peaks in the early afternoon. Figure 2.2.1 illustrates the variation of the school's load throughout the year.

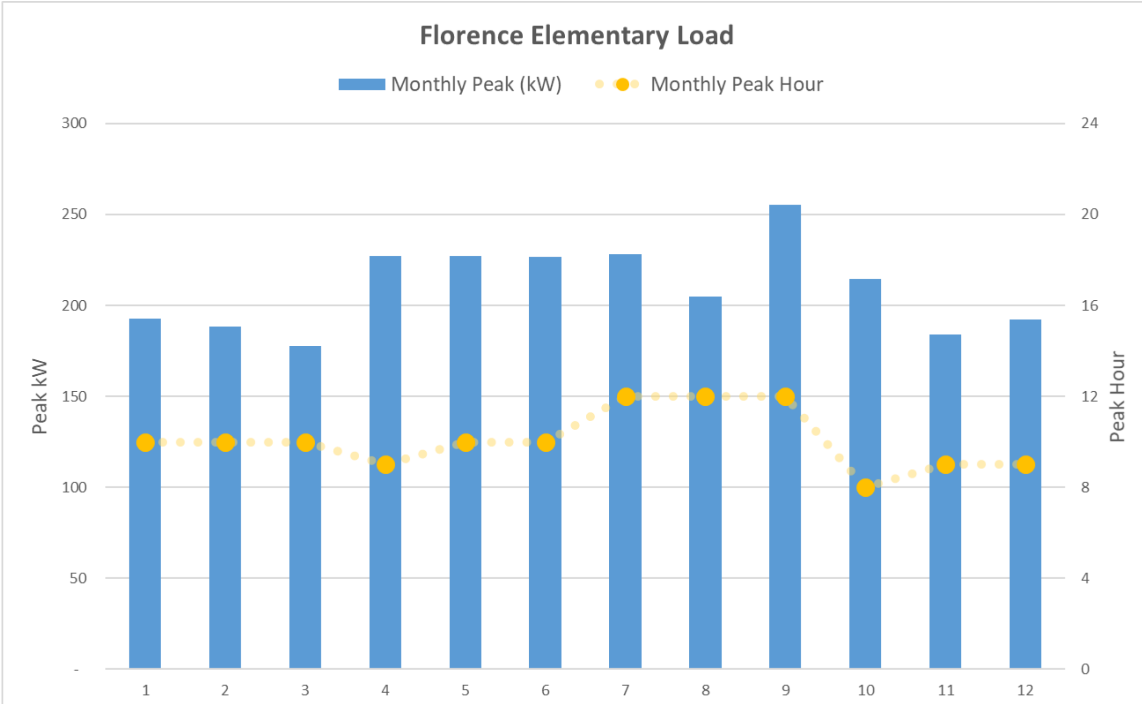
*Figure 2.2.1 - Florence Elementary Load by Month*




Source: Smart Electric Power Alliance, 2022

With the addition of the nursing home facility, the new combined load, as shown in Figure 2.2.2, always peaks in the morning between 8:00 AM and noon. Additionally, the monthly load peaks more than double with the introduction of the nursing home's load, and the highest monthly peaks shift to occur during the summer.

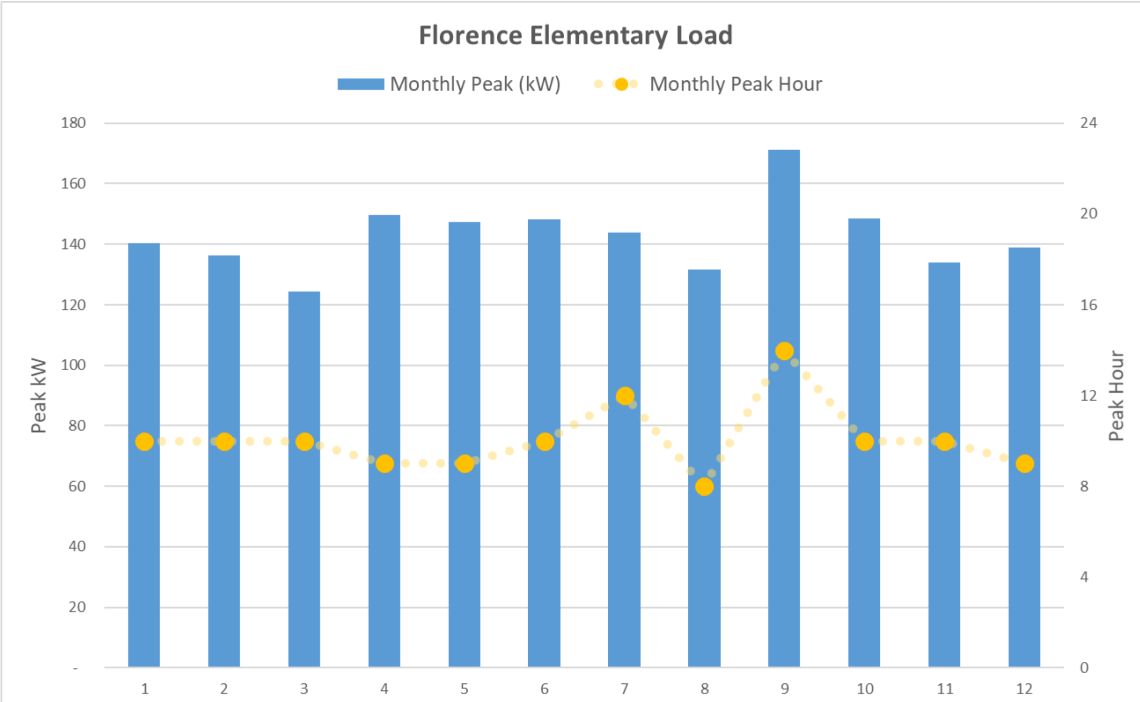
*Figure 2.2.2 - Florence Elementary and Nursing Home Combined Load by Month*




Source: Smart Electric Power Alliance, 2022

With the addition of just one-half of the nursing home facility's load, the new combined load, as shown in Figure 2.2.3, still peaks in the morning between 8:00 AM and noon. In this scenario, the monthly load peaks nearly double with the introduction of the nursing home's partial (critical) load, and the highest monthly peaks shift to occur during the summer.

*Figure 2.2.3 - Florence Elementary and ½ Nursing Home Combined Load by Month*




Source: Smart Electric Power Alliance, 2022

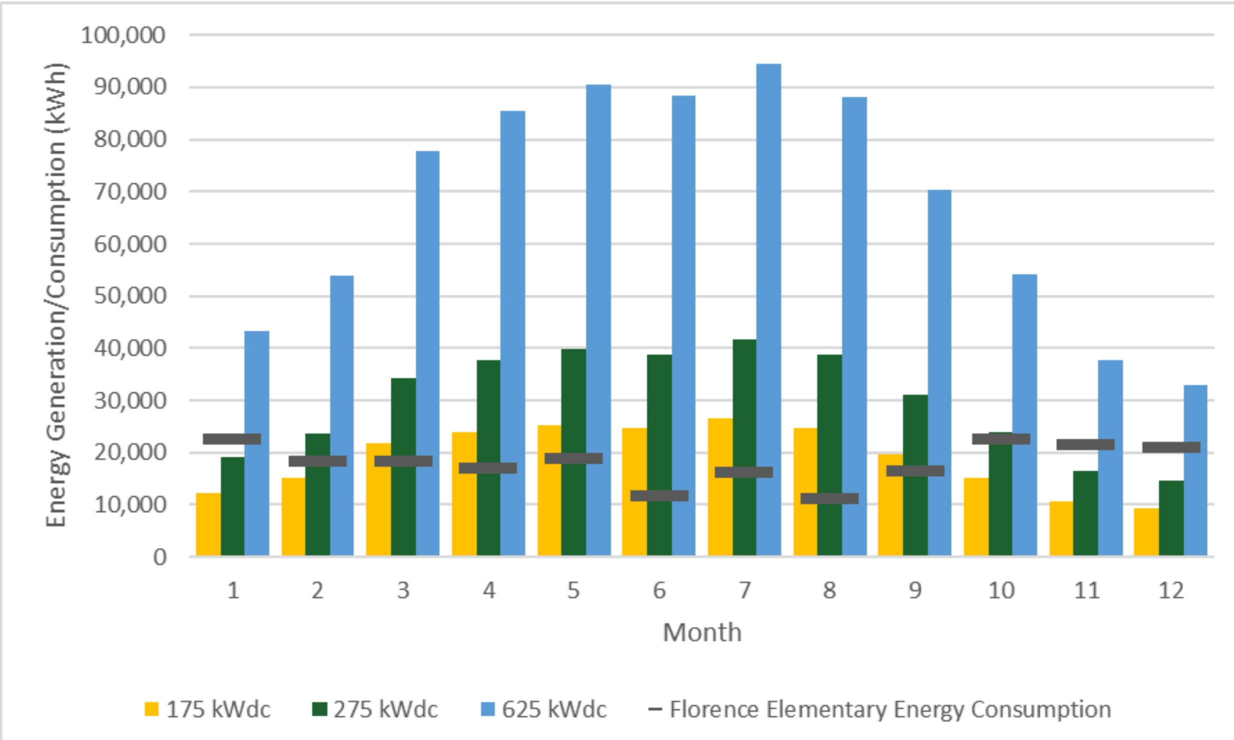
## Solar Analysis

Within the asset mix scenarios, SEPA evaluated various combinations of solar PV, battery storage, natural gas standby generation, and islanding duration. At the request of the school district, SEPA considered only ground-mounted solar, rather than roof-mounted solar which might create additional costs and challenges related to roof replacement. To estimate hourly solar production at the site throughout the year, SEPA used NREL's PV Watts Calculator and the following inputs to build an annual baseline solar generation profile:

- **Solar Resource Data Site:** Lat, Lon: 45.93, -88.26
- **DC System Size:** 1000 kW
- **Array Type:** Fixed (open rack)
- **System Losses:** 14.08%
- **Tilt:** 20°
- **Azimuth (deg):** 180°

First, SEPA adjusted the baseline solar profile to match the proposed solar capacity. SEPA then modeled each of the asset mix scenarios in order to estimate financial and environmental benefits related to that solar generation. Figure 2.2.4 highlights the average monthly solar generation for each scenario alongside monthly energy consumption at the site.

*Figure 2.2.4 - Proposed Solar Generation and Energy Consumption at Florence Elementary by Month*



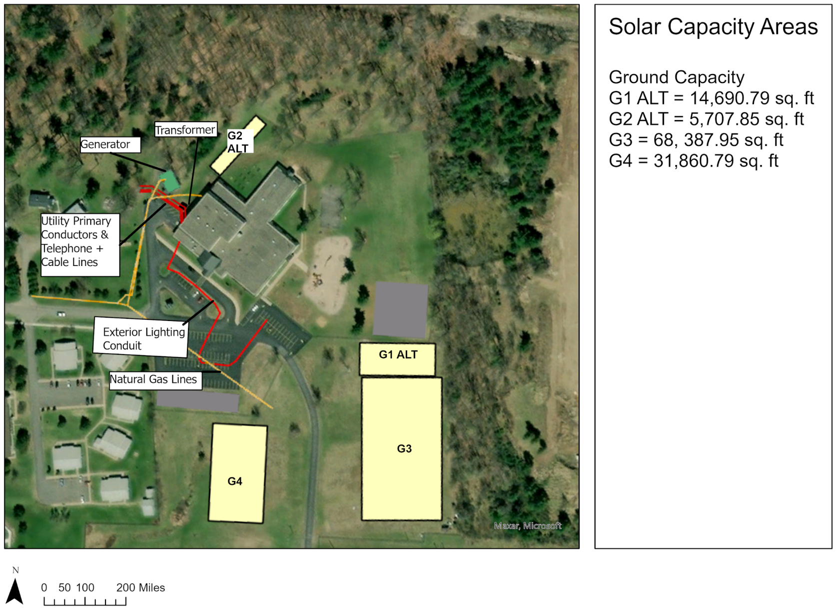

Following the initial solar and load analysis, SEPA sized different variations of battery energy storage to shape solar production and provide back-up emergency generation during outages. In cases where solar and battery storage scenarios were unable to serve the site's entire load, SEPA sized standby natural gas generators to meet the team's desired islanding duration.

## 2.3 Site Availability

The team calculated the site availability of solar energy, battery energy storage, and natural gas standby generation with the support of the School District of Florence County. As illustrated in Figure 2.3.1, Florence Elementary School and Florence Utilities provided SEPA with the site layout, electrical plans, and natural gas lines, which were used to identify four potential sections of the property that could host microgrid assets. The four sections for potential microgrid asset installation were identified in accordance with relevant building and fire codes. The site assessment considered areas free of playground equipment, located at least 10 feet away from vegetation and 100 feet from the road, and in sections of the property not demarcated with wetland soil indicators.

***Figure 2.3.1 - Florence Elementary Site Map***

Florence Elementary School Solar Capacity




Source: SEPA, 2022

## Site Assessment for Solar PV

In addition to cost and load analysis outputs, SEPA considered site availability when proposing solar capacity for each scenario. As noted in the Solar Analysis above, the team used NREL's PVWatts Calculator to estimate the anticipated solar output at the site. Ground mounted solar siting estimates are summarized in Table 2.3.1.

***Table 2.3.1 - Florence Elementary Site Map Key***

| Parcel | Usable Ground Area | Potential Solar PV (kW DC) |
|---|---|---|
| **G1 Alt** | 14,691 sq. ft | 80 |
| **G2 Alt** | 5,708 sq. ft | 31 |
| **G3** | 68,388 sq. ft | 371 |
| **G4** | 31,861 sq. ft | 173 |
| **Total** | **120,648 sq. ft** | **655** |

Source: Smart Electric Power Alliance, 2022

## Site Assessment for Microgrid Assets

Potential spacing for microgrid assets is available in the northwest corner of the site between the school building and forested area and the grassy areas south of the playground and parking lot. The feasibility of these locations are subject to review by the School District of Florence County and other stakeholders. A required site review will also assess site civil limitations and clearances to safely operate the equipment. Additionally, the facility would likely choose to install screening planting around the electrical service equipment. Screening planting was not considered in the scope of this assessment.

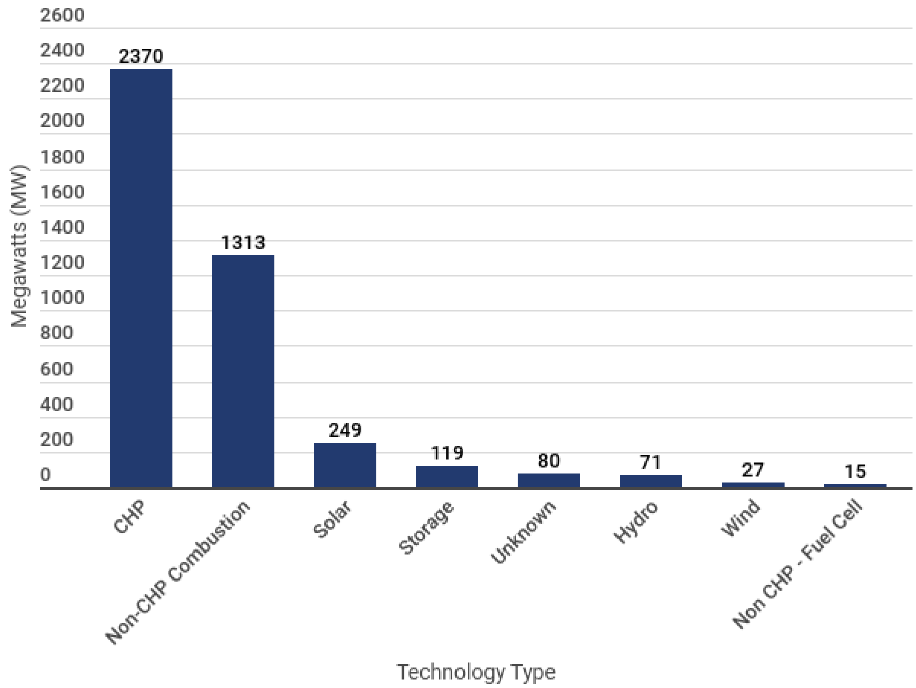
## Existing Electric and Natural Gas Feed-In

Florence Utilities identified the location of the existing natural gas main feeds and electric distribution feeder on the corner of Florence Elementary and Betsy Court to support the preliminary siting of the natural gas generator and battery storage system. These assets are tentatively sited near the northwest edge of the facility due to the proximity of both the electric distribution feeder and the natural gas line.helped with due diligence to determine that the natural gas main feeds development near the corner of Florence Elementary and Betsy Court as part of assessing site availability for a standby generator.

# 3.0 Microgrid Scenarios Development

Microgrids across the country vary significantly in both their average capacity and fuel source, as shown in Figure 3.1. According to a study by NREL in 2019, U.S. microgrid projects totaled 729 MWs in capacity. The most widely used energy source is combined-heat and power, which powers 51% of the microgrid projects. After CHP, the most widely used energy source is diesel, which powers 17% of microgrid projects. Natural gas powers 12% of microgrid projects and supports 91 MW on average, making fossil fuels the energy source of the vast majority of microgrid projects. Renewable energy fuels about 18% of microgrid projects, which may be a result of a number of factors including local regulations, budget restrictions, or preferences. Solar photovoltaic (PV) energy is the most abundantly used renewable fuel source, powering 11% of microgrid projects. Wind energy is only utilized in 1% of U.S. microgrid projects. Other microgrid fuel sources include energy storage and fuel cell technology.

***Figure 3.1 - Current Microgrid Installations by Technology***




Source: ICF International, [U.S. Department of Energy Combined Heat and Power and Microgrid Installation Databases], 2022.

## 3.1 Stakeholder Process and Findings

When determining potential asset mix and load scenarios for a Florence Elementary microgrid, SEPA engaged with the project team to adequately consider the needs of the site, WI OEI grant guidelines, and the preferences of key stakeholders.

### Process

The core team, especially members from the school district and local utility, provided input regarding project requirements to meet resilience, sustainability, and environmental goals. SEPA met with the full project team on a monthly basis to discuss scenario development considerations and study progress. During the January and February check-in meetings, the team held discussions around microgrid resilience needs at the school with respect to the percentage of load served, islanding duration, asset location and sizing, ownership models, and the use of standby back-up generation to establish microgrid scenarios. Project team members considered a number of questions as highlighted in Figure 3.1.1.

***Figure 3.1.1 - Key Microgrid Scenario Development Questions***

**What % of the site's load should be served by a microgrid?**
**Does the site have any short-term plans to reduce load?**

**Where should additional solar generation be located?**
**How much solar generation should be installed at the site?**

**How long will the site be able to operate as an island?**
**Will the site consider any backup generation options?**

**What size battery should be installed as part of the microgrid?**
**Where will the battery be located?**
**Who will own the battery energy storage system (BESS)?**
**How will the BESS be used (resilience, economic gain)?**

## Findings

From these discussions, SEPA identified several key findings.

1. A microgrid would need to replace the backup capabilities of an off-site diesel generator that currently provides backup power to the elementary school.
2. The ample space at the site makes solar PV an ideal on-site generation resource for Florence Elementary.
3. Natural gas infrastructure already exists at Florence Elementary and microgrid scenarios could potentially utilize natural gas standby generation to provide cost-effective resilience for long-term outages.
4. Long-term resilience (a week or two of islanding capability) during outages and major emergencies is suitable given the school district's agreement with the American Red Cross to use the facility as a disaster shelter.
5. Most outages are short-term (1-2 hours) and could be served by a small on-site BESS.
6. Some scenarios should also consider the load of Florence Health Service, a nearby nursing home facility, given the critical needs of its inhabitants and a history of outages at the home requiring residents to occupy the school during outages.
7. Strategic load shedding could be used to reduce the facility's energy consumption during a long-term outage.
8. The deployment of carbon-free microgrid assets or a 100% renewable scenario, including solar PV and battery storage assets, would likely provide an additional benefit to the community through public awareness and may interest the school board.

# 3.2 Microgrid Scenarios

## Overview

Scenario modeling produced the preliminary asset mix design for six microgrid scenarios, which Table 3.2.1 summarizes.

***Table 3.2.1 - Microgrid Scenario Components***

<table>
<tr><th>Scenario</th><th>Load</th><th>Solar</th><th>Solar kW-DC</th><th>Battery kW-DC</th><th>NG kW-DC</th><th>Island Days[9]</th></tr>
<tr><td>Scenario A</td><td>Florence Elementary</td><td rowspan="6">Ground Mounted Solar Only</td><td>625</td><td>340</td><td>-</td><td>365</td></tr>
<tr><td>Scenario B</td><td>Florence Elementary</td><td>175</td><td>50</td><td>45</td><td><1*</td></tr>
<tr><td>Scenario C</td><td>Florence Elementary</td><td>175</td><td>50</td><td>45</td><td><1*</td></tr>
<tr><td>Scenario D</td><td>Florence Elementary</td><td>275</td><td>100</td><td>25</td><td>3-4*</td></tr>
<tr><td>Scenario C + Nursing Home</td><td>Florence Elementary + Nursing Home</td><td>175</td><td>50</td><td>170</td><td>365**</td></tr>
<tr><td>Scenario D + Nursing Home</td><td>Florence Elementary + Nursing Home</td><td>275</td><td>100</td><td>90</td><td>365***</td></tr>
<tr><td>“Baseline” Scenario</td><td>Florence Elementary</td><td>–</td><td>–</td><td>–</td><td>90</td><td>365</td></tr>
</table>

*Battery Only - Islanding capacity only includes battery capacity, natural gas standby generator ensures that islanding is indefinite;

**Islanding capacity includes 100% of nursing home’s load;

***Islanding capacity includes 50% of nursing home’s load

Source: Smart Electric Power Alliance, 2022

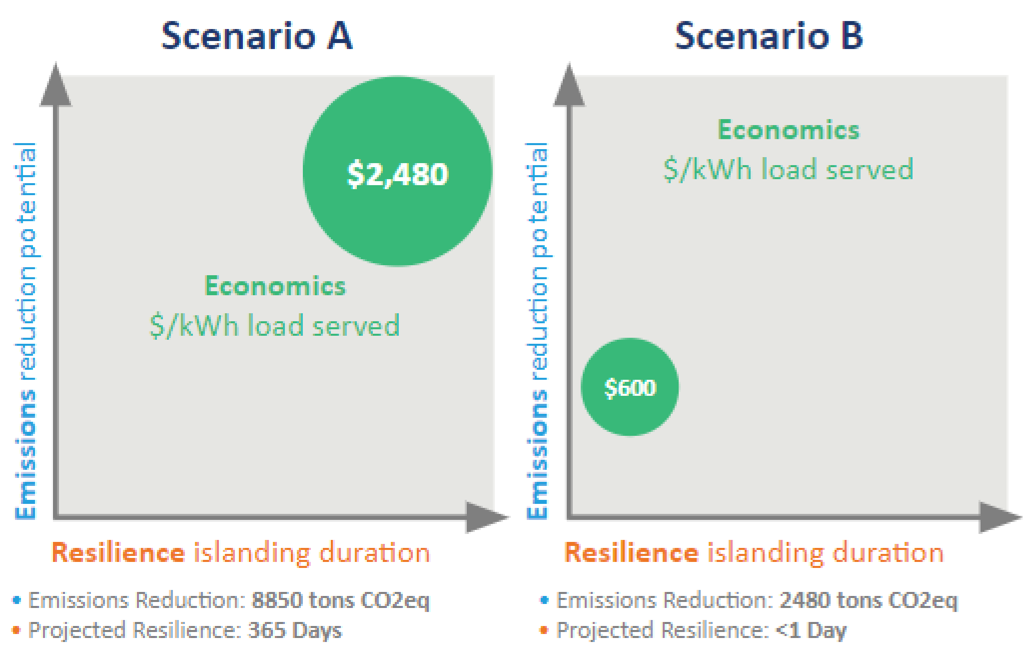
[9] This value is an estimate of the duration of islanding capability that the microgrid can provide on a typical day during the peak load month, January. Estimates may be given as a range to account for fluctuations in islanding capability based on instantaneous weather and grid conditions. Islanding duration at any given time is based on the ability of the on-site PV generation to charge the battery and meet the facility’s load, the facility’s demand during an outage event, and the time of day and year that the outage occurs. Unless otherwise stated, a natural gas standby generator ensures that the islanding capability of a scenario is indefinite.

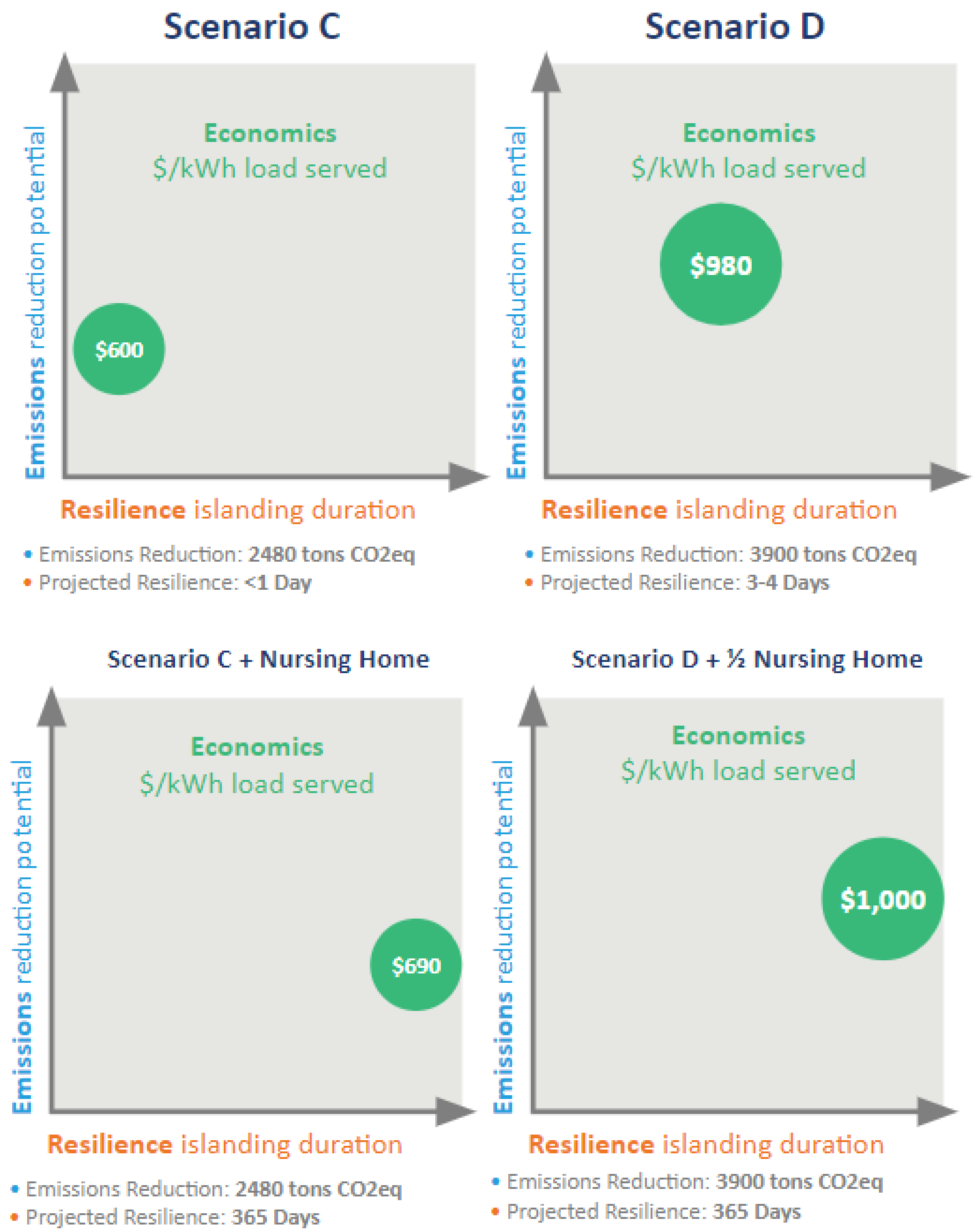
## Preliminary Economic Analysis

The preliminary economic analysis included an initial high-level look at each preliminary draft scenario. The analysis included some easy-to-calculate estimates of the costs and benefits of each scenario, especially as related to the generation and resilience characteristics of each. The preliminary economic analysis included order of magnitude estimates of solar and emissions benefits, as well as capital costs and O&M estimates. Select cost and benefit highlights were then presented to the project team to demonstrate the unique and relative value propositions of each scenario, and to validate each scenario prior to the final economic analysis.

Figure 3.2.1 summarizes relative emissions reductions, projected costs (per kWh load served), and resilience capabilities for each microgrid scenario. The costs, carbon emissions, load coverage and grid support all vary in each of the six designs. The designs range from inexpensive to most expensive, carbon free to significant natural gas generation, and load coverage that may include the nearby nursing home facility. Additionally, the islanding duration of each design is indefinite, as each scenario is designed to support the load using only the microgrid during a significant, long-term outage.

***Figure 3.2.1 - Scenario Asset, Load Coverage, Outage Capability, and Cost Overview***






Source: Smart Electric Power Alliance, 2022

The initial normative cost considerations above for the six microgrid scenarios came from the NREL 2019 Annual Technology Baseline, vendor quotes, and NREL's Phase I Microgrid Cost Study: Data Collection and Analysis of Microgrid Costs in the United States.

## Scenario Pros and Cons

The six microgrid design scenarios present their own benefits and drawbacks. A key finding is that the significant space at the school makes it cost-effective to deploy solar as a microgrid asset. Each of the scenarios features solar PV that brings the site to at least net-zero energy consumption year over year.

**Scenario A**, the most costly and only 100% renewable design, serves the load of the entire site and maximizes on-site generation by deploying ground-mounted solar PV over a significant portion of free space. Additionally, the scenario takes advantage of a fairly large battery energy storage system to allow the site to island indefinitely without a need for a natural gas standby generator.

**Scenarios B and C** represent more economical microgrid designs that serve the load of the entire site while minimizing costs and optimizing the economic benefits of a battery energy storage system. These scenarios suggest deploying enough solar to reach net-zero energy consumption, but include significantly smaller battery energy storage systems that are supplemented with natural gas standby generators to allow the facility to island indefinitely during an outage. These two scenarios compare the benefits of using the battery for demand reduction versus energy arbitrage.

**Scenario D** represents a middle ground between the 100% renewable Scenario A and the economical scenarios B and C. The scenario incorporates minimal natural gas generation by doubling the capacity of the battery in scenarios B and C to provide longer term resilience and oversizing the solar to charge the battery while islanding.

SEPA also included two additional scenarios that augment scenarios C and D to meet all or half of the nearby nursing home's load, respectively, by increasing the size of the standby natural gas generation in each scenario. A "baseline" scenario, which proposes a 90 kW natural gas standby generator in lieu of a microgrid is also presented for comparison.

It is worth noting that scenarios which propose a more renewable or 100% carbon-free microgrid, such as scenarios A and D, require a significant amount of solar PV and battery storage, which can substantially increase the cost of a project. While the supplementation of a microgrid with natural gas prevents the project from being powered entirely by renewable energy, its inclusion in the form of back-up generation is often necessary to serve the load of the entire site while reducing project cost and increasing resilience.

# 4.0 Microgrid Feasibility

## 4.1 Preliminary Engineering Considerations

In addition to the loads and DER assets noted in the scenarios above, several other factors must be considered during the engineering design phase of a microgrid project including a microgrid controller, the distribution system, and natural gas feed-in. The components of a microgrid include facility load (Florence Elementary and Florence Health Services), generation (solar PV or standby generation), battery energy storage, a microgrid controller, and interconnection to an existing distribution line.

For the purposes of this analysis, it is assumed that Florence Utilities will own and operate the medium voltage distribution infrastructure, while the other infrastructure including solar facilities, battery storage and natural gas generation would be owned by the School District of Florence County. In general, the scope of the necessary fieldwork is largely agnostic to the ownership model.

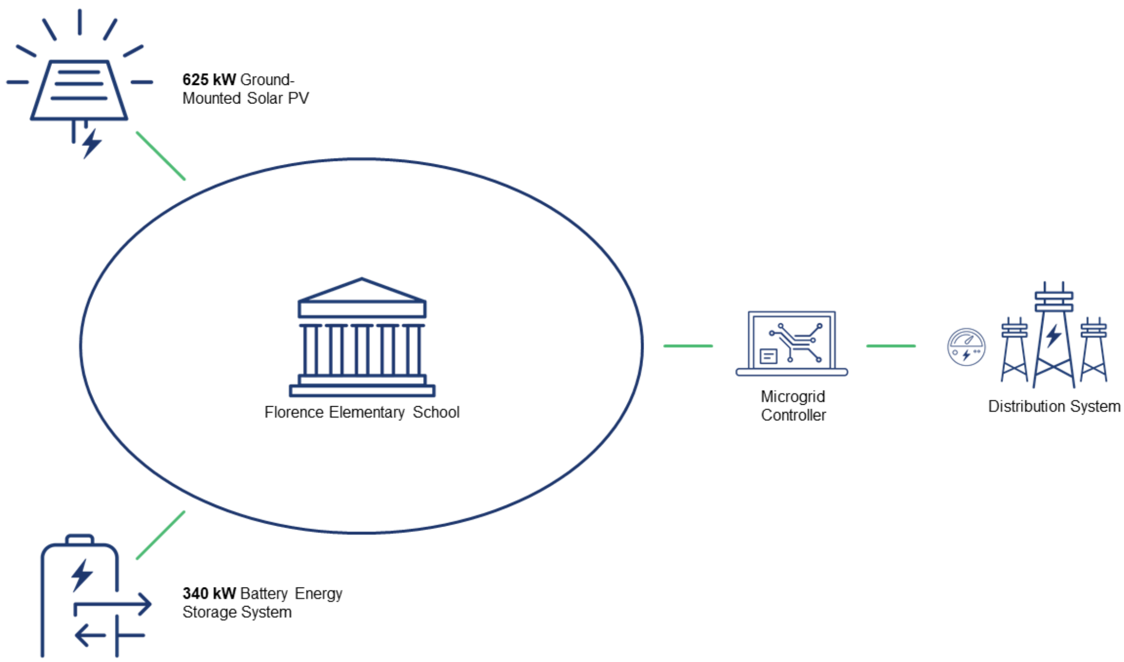
SEPA designed scenarios A-D to serve Florence Elementary, and two additional scenarios to serve both the elementary school and Florence Health Services through a mix of ground-mounted solar, battery storage, and natural gas generation. Each of the preliminary sizing estimates for each scenario enable the microgrid to rely significantly on generation from solar PV during the summer, and utilize battery storage and the natural gas generator for islanding during periods of low solar output.

Note that SEPA estimated Florence Elementary's loads using the historic load profile data for a nearby school district and, therefore, the site's load could change once real-world data becomes available. This could lead to different results for the load analysis, especially if the facility increases energy efficiency efforts.

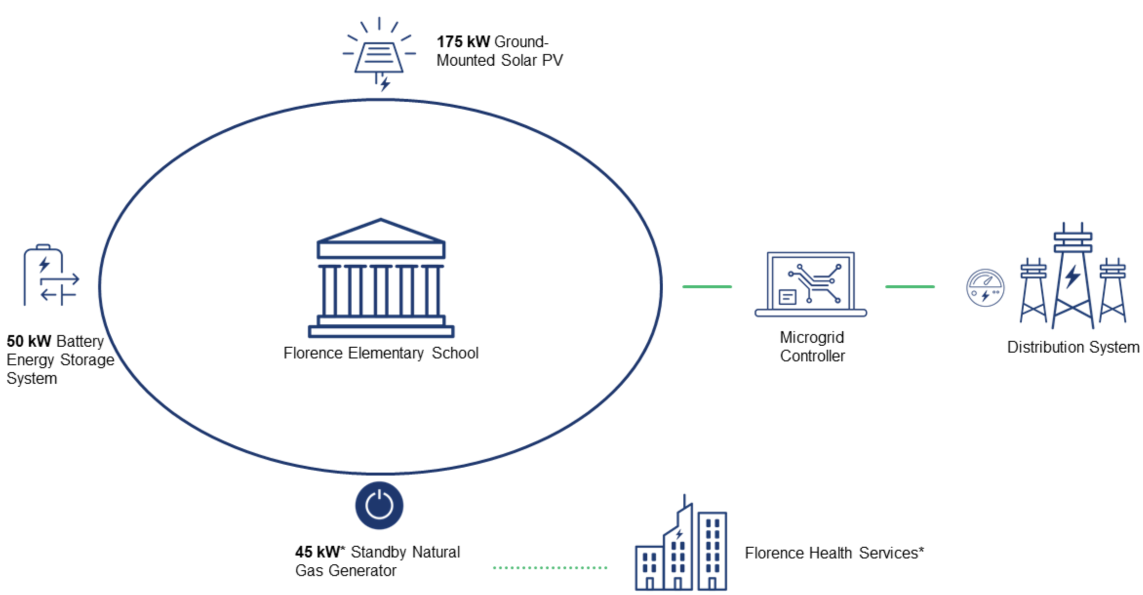
### Site Layout

SEPA developed a conceptual microgrid configuration for each scenario, but suggests that stakeholders reference 2.3 Site Availability and coordinate with an engineering design team to develop a site layout that best suits the final project. Microgrid configurations are noted below for each scenario.

### Scenario A

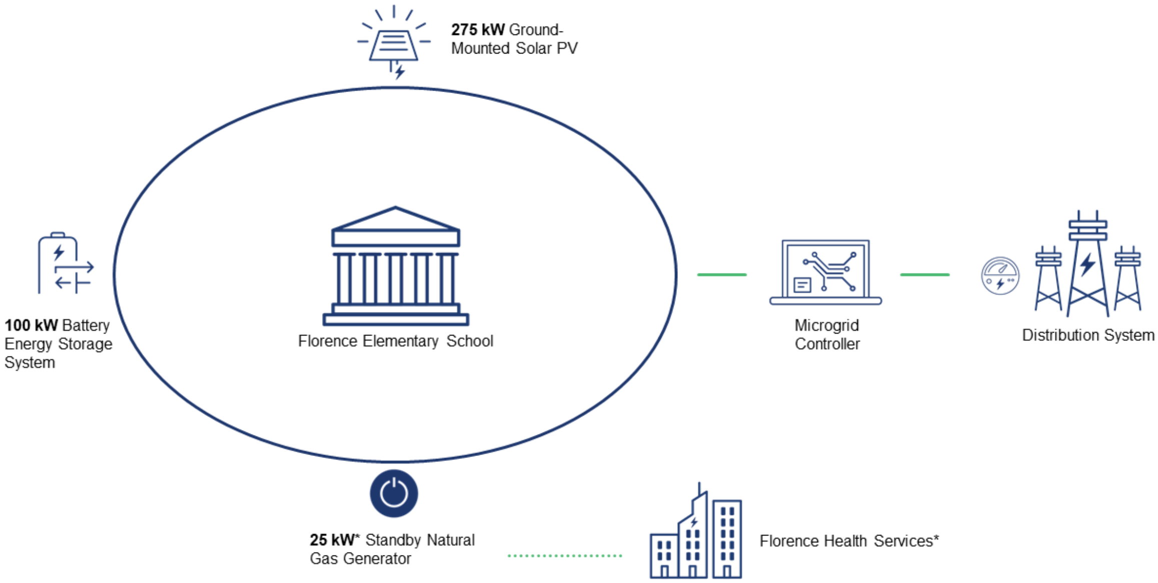



### Scenarios B and C




*When including Florence Health Services' load, the natural gas generator would be upsized to 170kW

Scenario D




*When including half of Florence Health Services' load, the natural gas generator would be upsized to 90kW

## Microgrid Operations

Florence Utilities will own and operate all medium voltage equipment, which includes disconnecting and reconnecting the microgrid from Florence Utilities' distribution system. The microgrid will have three modes described below. During each scenario, the microgrid controller will ensure proper voltage and frequency levels, manage loads and generation, and optimize battery charge/discharge schedule and charge levels.

### Operating Mode 1: Normal Operation/Blue Sky

During normal operation, the solar PV system will operate in parallel with Florence Utilities' distribution system. Where relevant, the natural gas generator will only operate for maintenance purposes. A schedule of maintenance operations will need to be provided to Florence Utilities Systems Operations. The microgrid controller will ensure that the battery storage system maintains a full charge.

During normal operation, the behind-the-meter battery storage system would also be used to reduce demand charges, or engage in energy arbitrage, bringing in revenue to offset project and O&M costs.

### Operating Mode 2: Microgrid Operation - Disconnecting from the Grid

During a scheduled or unplanned outage, Florence Utilities will initiate the microgrid isolation from the distribution grid. During a scheduled outage, this will be a seamless transition. During an unscheduled outage, the facility will be served by the BESS until the outage is repaired, or until the battery is drained and the natural gas generator comes online, if included in the scenario. The BESS and natural gas generator, where relevant, will operate to stabilize load and maintain voltage and frequency. Once voltage and frequency levels have stabilized, the solar will resume operation. During a long-term outage, battery storage will operate to manage transients and reduce peak load times. The scenario assumes that the battery will be fully charged when microgrid operation is initiated. Once the microgrid is in operation, the controller will manage the charge and discharge of the battery storage based on microgrid conditions and available solar output. The controller will act to maximize the usage of PV energy and minimize the use of the natural gas generator.

### Operating Mode 3: Microgrid Operation – Resuming Normal Operation

Once the distribution grid has been restored, the facility will be re-connected to the larger distribution grid. To do this, the microgrid will re-synchronize and operate in parallel with the distribution grid and the generator will power down. The battery storage system will discontinue operation except to re-charge or carry out economic functions. This will be designed to be a seamless transition.

## Interconnection

All resources will follow Florence Utilities' standard interconnection process for distributed generation.

### Microgrid

To house the microgrid controller, manage the electrical isolation of the facility from Florence Utilities' distribution system, and provide an interconnection point for the battery storage system and/or natural gas generator, an upright switchgear may need to be installed at the site. Since this is the isolation point for the microgrid from Florence Utilities' distribution system, it will need to be connected at the point where Florence Utilities' distribution enters the facility.

Typical dimensions for an upright 13 kV switchgear would be approximately 10' wide, 9' deep, and 9.5' tall.

### Solar, Natural Gas, and Battery Storage

The solar, BESS, and natural gas generation unit, if included, will interconnect to the microgrid isolation switchgear. The solar, BESS, and natural gas generator may require step-up transformers to convert to the distribution line voltage. For layout purposes, SEPA assumed that the battery storage system and the natural gas generator were close enough to each other to use a single step up transformer. The solar PV ground-mounted system may have a separately-metered interconnection and/or be served by a separate service transformer.

For layout purposes, SEPA assumed the footprint of the battery storage system in each scenario to be between 40 and 275 sq ft. based on battery sizes and available references.[10] In turn, the footprint of natural gas generators was assumed to be between 8 and 60 sq ft. based on generator capacity and available references.[11] Exact dimensions will depend on the equipment vendor selected.

### Infrastructure Updates

#### Gas

For engineering purposes, the natural gas standby generator should be sited adjacent to the northwest edge of the facility, which will limit the length of gas extension required for service.

## 4.2 Financial and Environmental Impact

The financial and environmental impacts summarized in this section build on the technical analysis, and focus on developing a high-level inventory of potential benefits and costs for the proposed microgrid scenarios to assess the net benefits of each.

Understanding the balance between benefits and costs can clarify whether the proposed investment (and other costs) of the project are justified by the resulting benefits. Such assessments are especially important when the investment is being made “for public benefit,” or when externalized or non-economized benefits (such as cleaner air, reduced greenhouse gas (GHG) emissions, or improved public health) are realized.

The goal of this study is to develop a high-level inventory of potential benefits and costs for this specific microgrid project, and to establish a foundation for a more formal benefit-cost assessment once additional project details are finalized. The study focuses on quantifying utility and societal benefits in economic terms, and determining how these economic benefits compare to the costs of implementing, operating, and maintaining the project over its lifespan. This report was prepared by project participants and written in a relatively non-technical way to support engagement with stakeholders.

All benefits and costs included in the analysis are quantified, and the multi-year cash flow (over an assumed project life of 20 years) is translated into a Net Present Value (NPV). A simple benefit-cost ratio can then be computed based on the NPV of all benefits divided by the NPV of all costs. A benefit-cost ratio of 1.0 would indicate that benefits exactly match costs. A ratio of more than 1.0 indicates a net benefit in which benefits exceed costs, with higher ratios indicating a greater net benefit. A ratio of less than 1.0 indicates that costs exceed benefits, with lower ratios indicating a less favorable benefit-cost balance.

---

[10] SEPA used reference data from a publicly available SCE battery storage project which assumed a footprint of ~0.2 sq ft/kWh.
[11] SEPA used a Generac 24 kW unit as a reference, which has a footprint of 3kW/sqft.

All six proposed Florence Elementary microgrid scenarios would provide uninterrupted power to the facility for an extended period. The use of renewable generation assets will result in multiple benefits associated with clean on-site generation. These microgrid functions represent the basis for an inventory of both benefits and costs that can be used to quantify the net benefit of the project.

## Inventory of Benefits and Costs

Development of the benefit and cost inventory depends on detailed information about a proposed microgrid project, including possible microgrid configurations, microgrid asset sizing, necessary changes to the local distribution system serving the planned facility, islanding switchgear, and a specialized microgrid control system. Cost estimates include the initial capital costs of the microgrid assets and the expenses associated with operation and maintenance of the microgrid infrastructure over the long term.

The benefit-cost inventory assumes that the project will have a 20-year life-span and that, over that time, the solar production will decline by 0.4% annually, as is typical of photovoltaic systems. The solar system will supply renewable energy, and for the purpose of this analysis is assumed to be net-metered. The emissions reduction value associated with solar generation is the same regardless of interconnection method. No additional “grid services” are assumed for the microgrid components – such as dispatch of either the battery or natural gas generator.[12]

The load served by this project consists of Florence Elementary School or Florence Elementary and Florence Health Services in certain scenarios. For purposes of this analysis, all outages experienced by the facility are assumed to be the result of feeder-level failures – i.e., not the result of issues within the boundaries of the facility itself.

A formal benefit-cost analysis would make use of standardized tests. The protocols associated with those tests dictate what combination of benefits and costs are used in each case. Making those determinations depends upon knowing important details about ownership structure, which parties bear various real-world costs[13], benefits (often in the form of revenues) or avoided costs and to whom they accrue, and the role of the utility in the project. Many of those details are not known yet, as is typical for a feasibility study at this stage of development.

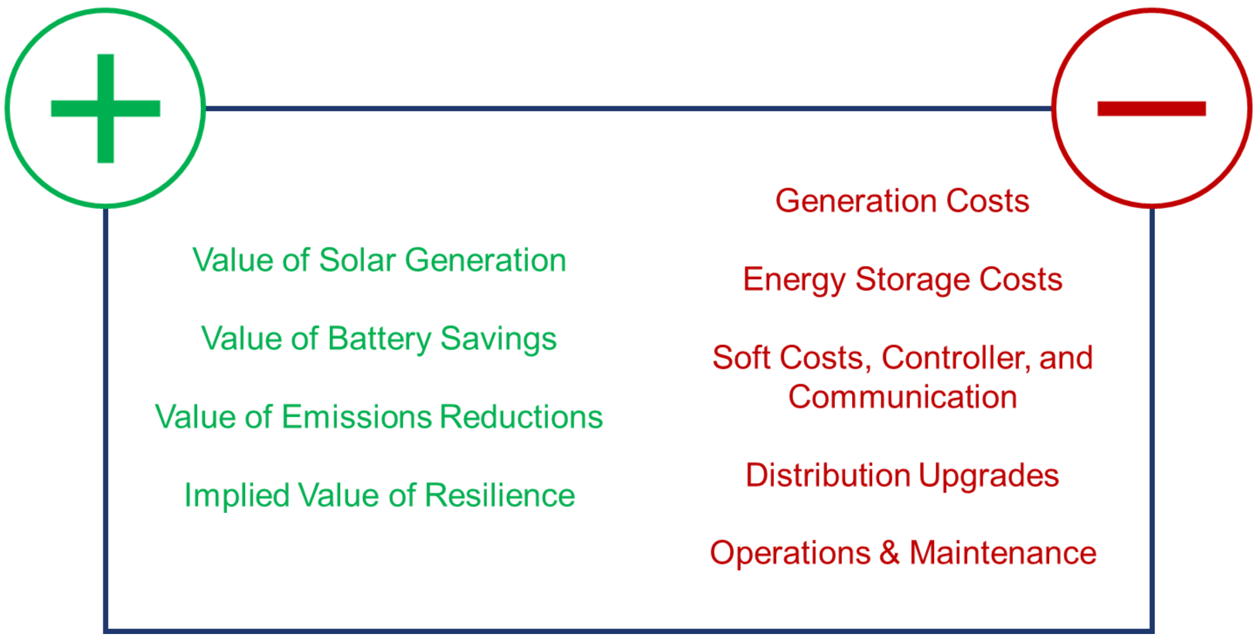
As a result, this study focused on developing an inventory of the benefits and costs that might be included in a formalized benefit-cost test. That inventory can provide early insight about the benefit-cost balance, and help establish the foundation for formalized benefit-cost assessment. It is important to note, however, that not all benefits or costs noted in the inventory below might be included in a particular test. Care is needed to ensure that a formalized test balances the

[12] Additional grid services, if added to the operating profile of the microgrid, might introduce additional benefits that could be quantified.
[13] Whether these affect the benefit-cost analysis depends on which test you use. For instance the utility test versus the societal test. If the societal test was used, these would not change the overall results.

group of benefits and costs included, and that issues such as double-counting[14] and "transfer effects"[15] have been addressed.

The inventory summarized below has been developed with a focus on taking a "common sense" view of both benefits and costs, looking broadly at the "societal scale" of impact, and building upon the details about project implementation that are known at this time. The combination of these benefits and costs used in a specific formal test will depend on the test being performed, and additional project details being specified.

***Figure 4.2.1 - Overview of Benefits and Costs***




## Overview of Costs

The costs for the microgrid project relate primarily to the costs of construction, and long term operating and maintenance costs. These cost estimates were taken from a technical evaluation completed by the SEPA team, and are associated with each proposed scenario. The cost inventory includes:

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[14]Double-counting refers to a common error in aggregating benefits and costs which sees certain benefits or costs accounted for more than once in the same analysis. An example of this might be including both the value of emissions reductions based on a social cost of emissions and the avoided utility emission compliance costs embedded in energy prices. Since emission compliance costs (such as a cap & trade market for emissions like the regional greenhouse gas initiative) place a value on emissions in order to drive reduction, including both the avoided compliance costs and the societal emissions reduction value will overestimate the emissions reductions benefits from a project.

[15] Transfers exist within a benefit-cost test when both the benefits and costs flow to and from the same impacted population considered by a particular test, thereby canceling each other out. The nature of transfer considerations depends on the test being used.

1. **Generation (PV + NG):** Generation costs reflect the purchase and installation of a solar photovoltaic system and, in most scenarios, a dispatchable[16] natural gas standby generator. In each scenario, a photovoltaic system has been proposed for the microgrid to generate clean electricity, and (with the support of the natural gas generator and/or a BESS) allows the facility to operate independent of the grid. The PV system partially replaces traditional fuel use, providing significant emission reductions that are a key benefit of the overall project. The natural gas generator can be dispatched on demand, and can be used to firm the solar generation, as well as provide power in parallel with the solar system or when no sunlight is available. This is a one-time construction cost. The costs for the solar system do not include the Federal Investment Tax Credit (ITC). Further BCAs may need to reassess the value of the ITC, assuming that it would be available at the time of construction.
2. **Battery Energy Storage Systems (BESS):** This is a highly valuable component of a larger system that generates energy using intermittent sources of renewable energy such as solar, since it helps to balance the production and use of energy. The BESS is also important for a microgrid to handle transition events and to ensure power quality. For this study, initial BESS costs were captured in the first year as part of construction, but further BCAs may want to assume that the battery would need to be replaced partway through the life of the project, as the lifespan of a BESS is likely to fall short of the 20-year project life-span assumed in this study. Estimating the future costs of replacement must account for the net impact of inflation and expected reductions in battery costs over time, for example, a net cost reduction of 5% per year might be used to estimate replacement costs in a future year. Additionally, the costs for the BESS do not include the Federal Investment Tax Credit (ITC). Further BCAs may need to reassess the value of the ITC, assuming that it would be available at the time of construction and the system is eligible to receive the credit.
3. **Soft Costs, Controller, and Communications:** A specialized controller is used to manage the microgrid when in island mode, including direct interaction with the generation resources and the BESS. The costs of the controller, along with the costs of engineering, construction, commissioning, and regulatory affairs, are included as a one-time construction cost estimated at 16% of the component costs for each scenario.
4. **Distribution Upgrades:** In order to implement the microgrid, SEPA assumed that the existing distribution system at Florence Elementary will not require significant modifications. Construction costs for distribution upgrades **were not** included in this study, but may need to be incorporated into further BCAs.
5. **Operations & Maintenance[17]:** Unlike other cost components, operations and maintenance is an ongoing, recurring cost. These costs were taken from the NREL Annual Technology Baseline (ATB) 2021 for commercial solar PV and 4hr Lithium Ion BESS on an annual basis for the lifespan of the project.

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[16] “Dispatchable” means being able to stop and start the generator on demand.
[17] This BCA does not take into account O&M and fuel costs for the standby generator, assuming that it will only be used for emergency backup and the cost would be negligible.

## Overview of Benefits

Most of this study focused on identifying and quantifying the benefits from the microgrid project. All of these benefits are incremental to the baseline provision of service to the facility. As covered in more detail in Appendix 2: Detailed Benefits, the study modeled and estimated significant benefits associated with solar generation and improved resilience, including:

1. **Value of Solar Generation:** The value of solar generation was represented as the total annual value of:
    - **Energy Rate Savings:** Bill savings resulting from avoided energy purchases, as energy consumption at the facility is offset by on-site solar generation.
    - **Excess Generation Credit:** Bill credits resulting from solar generation in excess of the facility's load that is metered back to the grid at a predefined rate.
    - **Demand Savings:** Bill savings resulting from the reduction of facility load peaks that coincide with on-site solar generation.
2. **Value of Battery Savings:** The value of battery savings was represented as the total annual economic benefits provided by a BESS through:
    - **Energy Savings:** Bill savings resulting from shifting on-peak energy purchases to off-peak hours as noted in the TOU rate by charging the battery from excess solar or from the grid during off-peak hours and discharging it for use during on-peak hours.
    - **Demand Savings:** Bill savings resulting from the reduction of facility load peaks by strategically discharging the battery during hours of peak load.
3. **Value of Emissions Reductions[18]:** Solar PV generation reduces harmful emissions from burning fossil fuels that have local, regional, and global impact. Benefits include the total dollar value of reductions in mortality and morbidity from $PM_{2.5}$, $SO_2$, and $NO_x$[19], and the $CO_2$[20].
4. **Implied Value of Resilience:** The implied value of resilience focused on the ability of a microgrid to provide power to the facility when the public grid is inoperable. For Florence Elementary, resilience value should be based on its ability to provide emergency services to the community as a designated American Red Cross shelter during an extended outage or emergency. In this study, the implied value of resilience is the

[18] The emissions reductions calculated in each of the microgrid scenarios do not include emissions resulting from running the standby fossil fuel generators as they will only be used in long-term emergency situations (assuming that short-term resilience can be addressed through solar PV and energy storage) and the resulting emission reductions will be negligible.

[19] https://www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf

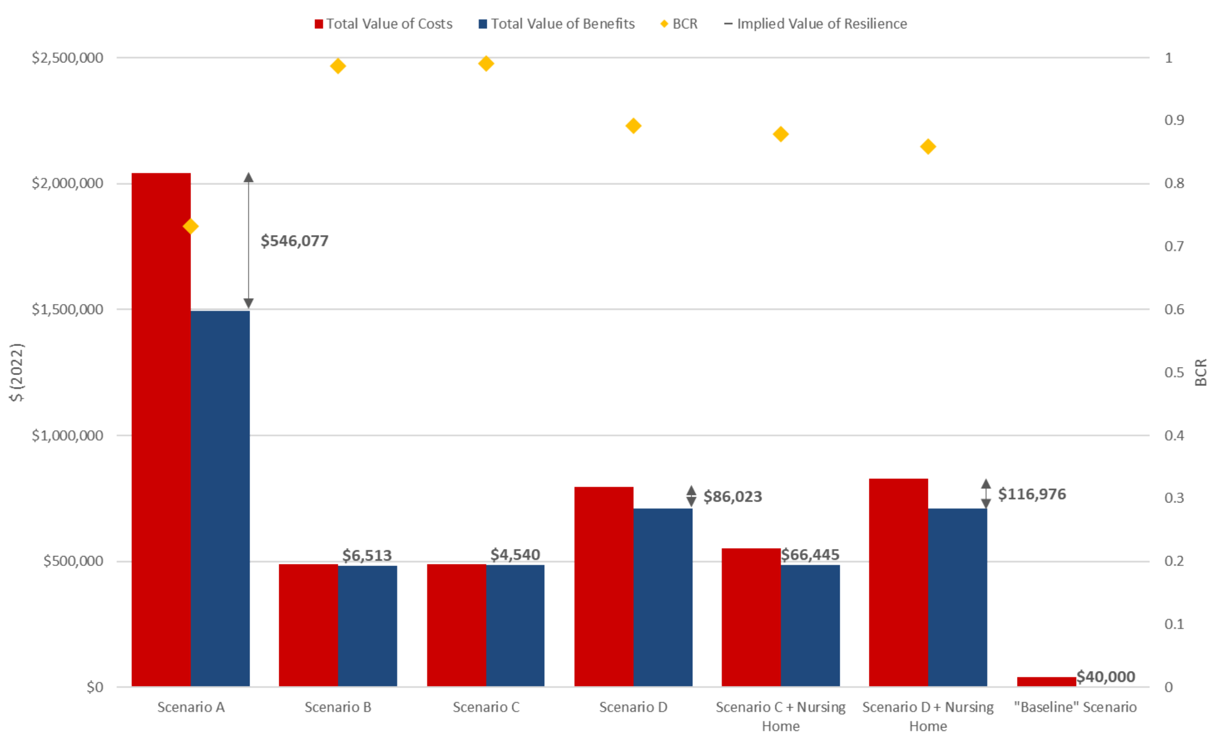
[20] https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf

remaining difference between the NPV of costs and benefits in each scenario when the costs outweigh the benefits. This value will not be included in the final BCRs for each scenario, but it can be used as a benchmark for stakeholders to consider when estimating the value of resilience at the site for future cost tests. In cases where the benefits exceed costs, this value will not be noted, as the project can be considered to be cost effective without the inclusion of this benefit.

## Summary of Results

The study quantified the economic valuation of both benefits and costs for the microgrid scenarios, including a nominal sum (i.e., the simple sum of annual costs), and a Net Present Value using a discount factor of 5%. That is, the weighted average cost of capital (WACC) is assumed to be 5%. A high-level summary of benefits and costs is displayed in Figure 4.2.2.

***Figure 4.2.2 - Summary of Benefits and Costs***




Source: SEPA, 2022

### Summary of Cost Results

The costs for each scenario are based on the initial construction costs and O&M costs each year over the 20-year period.

*Table 4.2.1 - Summary of Costs*

| Microgrid Costs | Low Cost Scenario | Mid Cost Scenario | High Cost Scenario |
|---|---|---|---|
| **Scenario A** | | | |
| **Generation (PV + NG)** | $945,567 | $971,422 | $1,039,506 |
| **BESS** | $449,273 | $550,876 | $618,563 |
| **Soft Costs/Controller/Comms** | $265,684 | $289,962 | $315,823 |
| **Operations & Maintenance** | $182,072 | $229,714 | $288,362 |
| **Total** | **$1,842,596** | **$2,041,973** | **$2,262,254** |
| **Scenario B** | | | |
| **Generation (PV + NG)** | $278,259 | $289,998 | $313,562 |
| **BESS** | $66,070 | $81,011 | $90,965 |
| **Soft Costs/Controller/Comms** | $65,586 | $70,668 | $77,053 |
| **Operations & Maintenance** | $39,022 | $47,349 | $59,187 |
| **Total** | **$448,936** | **$489,026** | **$540,767** |
| **Scenario C** | | | |
| **Generation (PV + NG)** | $278,259 | $289,998 | $313,562 |
| **BESS** | $66,070 | $81,011 | $90,965 |
| **Soft Costs/Controller/Comms** | $65,586 | $70,668 | $77,053 |
| **Operations & Maintenance** | $39,022 | $47,349 | $59,187 |
| **Total** | **$448,936** | **$489,026** | **$540,767** |
| **Scenario D** | | | |
| **Generation (PV + NG)** | $423,549 | $437,426 | $469,883 |
| **BESS** | $132,139 | $162,022 | $181,930 |
| **Soft Costs/Controller/Comms** | $105,845 | $114,181 | $124,155 |

| | | | |
|---|---|---|---|
| **Operations & Maintenance** | $66,989 | $82,451 | $103,227 |
| **Total** | **$728,523** | **$796,079** | **$879,195** |
| **Scenario C (including Florence Health Services)** | | | |
| **Generation (PV + NG)** | $317,259 | $341,998 | $378,562 |
| **BESS** | $66,070 | $81,011 | $90,965 |
| **Soft Costs/Controller/Comms** | $73,015 | $80,573 | $89,434 |
| **Operations & Maintenance** | $39,022 | $47,349 | $59,187 |
| **Total** | **$495,365** | **$550,931** | **$618,148** |
| **Scenario D (including ½ Florence Health Services)** | | | |
| **Generation (PV + NG)** | $443,049 | $463,426 | $502,383 |
| **BESS** | $132,139 | $162,022 | $181,930 |
| **Soft Costs/Controller/Comms** | $109,560 | 119,133 | $130,345 |
| **Operations & Maintenance** | $66,989 | $82,451 | $103,227 |
| **Total** | **$751,737** | **$827,032** | **$917,886** |
| **"Baseline" Scenario** | | | |
| **Generation (PV + NG)** | $27,000 | $36,000 | $45,000 |
| **BESS** | -- | -- | -- |
| **Soft Costs/Controller/Comms** | $3,000 | $4,000 | $5,000 |
| **Operations & Maintenance** | -- | -- | -- |
| **Total** | **$30,000** | **$40,000** | **$50,000** |

Source: SEPA, 2022

### Summary of Benefits Results

The following chart summarizes the economic value of the benefits associated with the microgrid scenarios.

### *Table 4.2.2 - Summary of Benefits*

| Microgrid Benefits | NPV of Benefits ($2022) | First Year Benefits (Nominal $) |
|---|---|---|
| **Scenario A** | | |
| **Solar Generation** | $742,945 | $50,206 |
| **Battery Savings** | $27,886 | $1,823 |
| **Emissions Reductions** | $725,065 | $45,420 |
| **Implied Value of Resilience*** | $30,058 - $63,732 | - |
| **Total** | **$1,495,896** | **$97,488** |
| **Scenario B** | | |
| **Solar Generation** | $268,007 | $18,109 |
| **Battery Savings** | $11,488 | $751 |
| **Emissions Reductions** | $203,018 | $12,717 |
| **Implied Value of Resilience*** | $0 - $4,674 | - |
| **Total** | **$482,513** | **$31,577** |
| **Scenario C** | | |
| **Solar Generation** | $268,007 | $18,109 |
| **Battery Savings** | $13,461 | $880 |
| **Emissions Reductions** | $203,018 | $12,717 |
| **Implied Value of Resilience*** | $0 - $4,516 | - |
| **Total** | **$484,486** | **$31,706** |
| **Scenario D** | | |
| **Solar Generation** | $377,261 | $25,491 |

| | | |
|---|---|---|
| **Battery Savings** | $13,766 | $900 |
| **Emissions Reductions** | $319,028 | $19,985 |
| **Implied Value of Resilience*** | $1,482 - $13,572 | - |
| **Total** | **$710,056** | **$46,376** |
| **Scenario C (including Florence Health Services)** | | |
| **Solar Generation** | $268,007 | $18,109 |
| **Battery Savings** | $13,461 | $880 |
| **Emissions Reductions** | $203,018 | $12,717 |
| **Implied Value of Resilience*** | $873 - $10,725 | - |
| **Total** | **$484,486** | **$31,706** |
| **Scenario D (including ½ Florence Health Services)** | | |
| **Solar Generation** | $377,261 | $25,491 |
| **Battery Savings** | $13,766 | $900 |
| **Emissions Reductions** | $319,028 | $19,985 |
| **Implied Value of Resilience*** | $3,345 - $16,677 | - |
| **Total** | **$710,056** | **$46,376** |
| **"Baseline" Scenario** | | |
| **Solar Generation** | -- | -- |
| **Battery Savings** | -- | -- |
| **Emissions Reductions** | -- | -- |
| **Implied Value of Resilience*** | $2,407 - $4,012 | - |
| **Total** | **--** | **--** |

*The "Implied Value of Resilience" is an annual estimate, and displays a range of values for low, mid, and high-cost estimates. This value is not included in the "Total" benefits noted in the table, and does not impact the BCR values related to each scenario. A value of $0 suggests that the scenario is cost-effective without including resilience benefits in the BCA.
Source: SEPA, 2022

### Summary of the Benefit-Cost Ratio

A typical benefit-cost analysis greater than 1.0 indicates that benefits exceed costs, and the project is generally beneficial. In the simple case where all the benefits identified above can be included in the benefit portfolio[21], the net benefit results are as follows.

*Table 4.2.3 - Summary of Benefits and Costs*

| | Low Cost Scenario | Mid Cost Scenario | High Cost Scenario |
|---|---|---|---|
| **Scenario A** | | | |
| Total Value of Costs (NPV) | $1,842,596 | $2,041,973 | $2,262,254 |
| Total Value of Benefits (NPV) | $1,495,896 | | |
| Net Impact (Benefits minus Costs) | ($346,700) | ($546,077) | ($766,358) |
| BCR | 0.81 | 0.73 | 0.66 |
| **Scenario B** | | | |
| Total Value of Costs (NPV) | $448,936 | $489,026 | $540,767 |
| Total Value of Benefits (NPV) | $482,513 | | |
| Net Impact (Benefits minus Costs) | $33,577 | ($6,513) | ($58,254) |
| BCR | 1.07 | 0.99 | 0.89 |
| **Scenario C** | | | |
| Total Value of Costs (NPV) | $448,936 | $489,026 | $540,767 |
| Total Value of Benefits (NPV) | $484,486 | | |
| Net Impact (Benefits minus Costs) | $33,550 | ($6,540) | ($56,281) |

[21] As noted in the introduction, a formal benefit-cost test would specify exactly which benefits and costs should be included for the benefit-cost calculation. Depending on the test, not all the benefits or costs identified in the inventory may be included in a particular test.

| | | | |
|---|---|---|---|
| BCR | 1.08 | 0.99 | 0.90 |
| **Scenario D** | | | |
| Total Value of Costs (NPV) | $728,523 | $796,079 | $879,195 |
| Total Value of Benefits (NPV) | $710,056 | | |
| Net Impact (Benefits minus Costs) | ($18,467) | ($86,023) | ($169,139) |
| BCR | 0.97 | 0.89 | 0.81 |
| **Scenario C (including Florence Health Services)** | | | |
| Total Value of Costs (NPV) | $495,365 | $550,931 | $618,148 |
| Total Value of Benefits (NPV) | $484,486 | | |
| Net Impact (Benefits minus Costs) | ($10,879) | ($66,445) | ($133,662) |
| BCR | 0.98 | 0.88 | 0.78 |
| **Scenario D (including ½ Florence Health Services)** | | | |
| Total Value of Costs (NPV) | $751,737 | $827,032 | $917,886 |
| Total Value of Benefits (NPV) | $710,056 | | |
| Net Impact (Benefits minus Costs) | ($41,681) | ($116,976) | ($207,830) |
| BCR | 0.94 | 0.86 | 0.77 |

Source: SEPA, 2022

## Interpretation

The proposed Florence Elementary scenarios provide substantial benefits mainly due to solar production, associated emissions and rate benefits, and the resilience service to allow the school to operate as an American Red Cross shelter during an outage. However, due to the small scale of this project, exclusion of the value of resilience, and the uncertainty associated with behind-the-meter solar and battery economic benefits, these benefits on their own do not balance the construction and operation/maintenance costs across nearly all scenarios whether considering low-, mid-, or high- costs. It is worth noting that the low-cost cases for both scenarios B and C prove to be cost effective even despite conservative estimates for solar and battery benefits and the exclusion of a resilience benefit. If the school district is able to internalize the emissions benefits related to solar generation, take advantage of the investment tax credit for solar and/or battery storage, and provide a site-specific value for energy resilience, these two scenarios, and possibly others with BCRs close to 1.0 are more likely to prove cost-effective in further analyses.

Although the benefit-cost ratios resulting from this high-level inventory of benefits and costs mostly fall below 1.0, other considerations provide additional context for this outcome:

1. Benefit-cost analysis is highly sensitive to scale, and smaller projects almost always result in lower benefit-cost ratios. This is especially true when there are relatively fixed costs, as are evident for this project. In this case, the benefit-cost ratio is primarily a result of the small project scale, not a meaningful representation of intrinsic microgrid technology value.
2. Actual economic (demand and rate savings) benefits related to solar and battery storage are very difficult to quantify accurately beyond those that would result from the most conservative generation and load scenarios (i.e. maximum historic load and minimum expected solar generation). For this reason, real-world benefits from these economic functions could surpass those estimated in this study, and increase cost-effectiveness.
3. Development of microgrid technology, and improved resilience for all utility customers, is a strategic goal that is not easy to quantify. The strategic value of the project, including workforce development, customer education, and benefits to the community who have access to the designated emergency shelter are not quantified in the benefits portfolio. These are qualitative factors that provide important context for the benefit-cost evaluation.

# 5.0 Conclusion

Despite providing significant measurable advantages, the net present value of benefits for the Florence Elementary property do not exceed the costs of the project under most scenarios before including resilience benefits in the analysis. That said, several scenarios present a situation in which a relatively small valuation for the benefit of resilience at the site would make a microgrid project cost-effective, as noted by the “Implied Cost of Resilience” values in the previous section.

This analysis establishes a framework for assessing the economic value of the microgrid project, including a preliminary quantification of the value of emission reductions and increased resilience. Further formalized benefit-costs tests can build upon this foundation once additional details about the project and other similar projects are finalized.

However, the benefit-cost outcomes are not the whole story. Small-scale programs frequently result in unfavorable benefit-cost ratios, especially when the fixed costs are large. Trialing new technologies, strategies and programs offer learning opportunities, and may advance strategic goals that intrinsically hold value themselves, but are often not quantified or included in a feasibility analysis. Externalities, such as the value of reducing emissions are likely undervalued in these scenarios, despite providing important societal benefits. Most importantly, the research and methodologies for quantifying the economic value of resilience is relatively new and likely incomplete. As such, they may not capture the strategic value of improved resilience, especially as more extreme weather (and other) events become more common.

From the perspective of technical feasibility, Florence Elementary is a workable site to construct and install a microgrid project. Project team members believe that this project would increase resiliency in Florence, WI by serving as a designated emergency shelter and providing critical services during prolonged outages.

Key learnings from this study include:

- Given the open space at the site, Florence Elementary is well suited to host solar PV for on-site generation.
- The solar and battery benefits are undervalued in the current benefit-cost framework and are dependent on real-world performance beyond the conservative estimates that were used for this study.
- Resilience benefits are likely to be significant given the facility's role as a designated American Red Cross emergency shelter.
- The deployment of carbon-free microgrid assets or a 100% renewable scenario, including solar PV and battery storage assets, would likely provide an additional benefit to the community through public awareness, and may interest the school board.

If the project partners decide to move forward, next steps include:

- Determine ownership and operation structures between Florence Utilities, Florence Elementary, and a developer in order to have the appropriate information needed for the final BCA
- Identify potential funding sources to facilitate a public-private partnership (e.g., third-party finance, customer finance, utility investment and recovery in rates)
- Conduct a full engineering design and construction study
- Explore additional state and federal funding and grant programs (e.g., IIJA and FEMA BRIC)

# 6.0 Appendices

## Appendix 1: Project Team Check-In Summaries

This appendix includes summaries of each monthly project team check-in.

### January 2022

During the initial kick-off meeting with the project team, SEPA focused heavily on getting the group acquainted with each other. SEPA provided a background on the microgrid feasibility study and the grant, including information regarding project tasks, goals, and timeline. Project team members began to discuss the site, its role as both an educational institution and an emergency shelter, and its resilience needs. SEPA started a discussion around data collection expectations and needs in order to begin the site analysis and develop preliminary microgrid scenarios. Additionally, SEPA gathered initial information about the site including existing infrastructure, facility load, and microgrid fuel preferences. Following this meeting, SEPA began to gather relevant data and began an initial site assessment.

### February 2022

The second project team check-in meeting included an initial discussion around siting microgrid components, especially solar PV. SEPA shared some initial results from its site assessment and worked with the team to address outstanding questions and concerns. Following this meeting, SEPA began to develop preliminary microgrid scenarios and finalized the site assessment.

### March 2022

The third project team check-in meeting focused on validating the final site assessment and discussion of the proposed preliminary microgrid scenarios. SEPA shared its initial site assessment with the project team, and noted a few adjustments that needed to be made to the proposed solar sites. SEPA also shared an outline of four initial microgrid scenarios in order to discuss the pros and cons of each with the project team. The project team also discussed the possibility of including an additional scenario that includes the load of a nearby nursing home. Following this meeting, SEPA finalized the microgrid scenarios and shared them with the project team.

### April 2022

The fourth project team check-in meeting was used to confirm the final microgrid scenarios that would be included in the study and have a final discussion around the pros and cons of each. During the meeting, SEPA shared some initial economic analysis highlights for each scenario, such as expected capital costs, emissions reductions, and solar benefits associated with each. Following this meeting, SEPA finalized the BCAs for each microgrid scenario in preparation for writing the final report.

## Appendix 2: Detailed Benefits

This appendix includes the quantification of significant benefits associated with solar generation, battery storage, and improved resilience for the facility.

### Value of Solar Generation

The Value of Solar Generation was determined on an hourly basis, then aggregated for annual values. This represents the total annual value of:

- **Energy Rate Savings:** Bill savings resulting from avoided energy purchases, as energy consumption at the facility is offset by on-site solar generation.

- **Excess Generation Credit:** Bill credits resulting from solar generation in excess of the facility's load that is metered back to the grid at a predefined rate.
- **Demand Savings:** Bill savings resulting from the reduction of facility load peaks that coincide with on-site solar generation

PV Watts, developed by the National Renewable Energy Laboratory (NREL) was used to provide an estimate of solar generation on an hourly basis for the first year. This tool is widely accepted in the industry, and accounts for the location of the solar installation, local weather patterns, the size of the system, characteristics of the array, system losses, tilt, azimuth, and other parameters. The tool is commonly used to estimate the energy production and performance of potential photovoltaic energy systems. SEPA provided a PV Watts production profile for the site, which was the basis for estimating solar generation value for each scenario.

Energy rate savings were estimated by calculating the average site load that would be met by on-site solar for each hour of the year and multiplying that value by the energy rate during that time to determine the rate savings (or avoided costs) associated with purchasing that energy from the grid to meet the site's load. When estimating this benefit, SEPA assumed an annual solar degradation rate of 0.4% and an annual rate increase of 2.5%.

Excess generation credits were estimated by calculating the average on-site solar generation in excess of the facility's load for each hour of the year and multiplying that value by the buyback rate to determine the benefit associated with delivering energy back to the grid after meeting the site's load. Again, SEPA assumed an annual solar degradation rate of 0.4% and an annual rate increase of 2.5%.

Demand savings were estimated by examining the new load peaks for each month after considering the load peak reductions that would result from on-site solar generation. In order to avoid over-valuing this benefit, SEPA only considered demand reductions that would occur from the least favorable circumstances, that is days in which load is at its highest and solar generation is at its lowest. In order to achieve this, SEPA created sample hourly profiles for each month that represented the lowest observed solar generation for each hour during that month (from the PV Watts profile), and the highest observed site load for each hour during that month. SEPA subtracted the hourly minimum solar generation figures from the corresponding hourly maximum load figures for each month to generate a net hourly site load profile for each month under the least favorable circumstances. SEPA compared the new monthly and annual load peaks to those in the original load profile to estimate a conservative, but plausible estimate for demand savings.

## Value of Emissions Reduction

Electricity generation that results from the burning of fossil fuels results in harmful emissions that have local, regional, and global impact. Over recent decades, renewable energy, like solar power, has emerged as a key strategy in reducing these emissions to improve air quality (especially key criteria pollutants like $NO_X$, $SO_2$, and $PM_{2.5}$) and avoid the release of greenhouse gasses that contribute to climate change.

The avoided emissions are quantified by determining the emission output that would have been produced on a "pounds per MWh" basis had that energy been generated at a traditional fossil fuel plant. The Emissions and Generation Resource Integrated Database (eGRID) provided region-specific emissions factors as "Pounds per MWh" values which were used to determine the environmental or emissions reduction impact of the avoided fossil fuel plant generation.[22] This process was repeated for four criteria pollutants which all have their own unique environmental impacts and behave differently in the atmosphere: carbon dioxide ($CO_2$), nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), and particulate matter ($PM_{2.5}$). The economic impact of emissions was quantified using parameters from the Federal Interagency Working Group on the Social Cost of Carbon (for $CO_2$), and a separate study from the U.S. Environmental Protection Agency for impact factors on $NO_x$, $SO_2$, and $PM_{2.5}$.[23] These conversion factors translate the emissions reductions (in tons) to an economic benefit (in dollars) to society at large.

## Value of Battery Savings

The value of battery savings was represented as the total annual economic benefits provided by a BESS through:

- **Energy Arbitrage:** Bill savings resulting from shifting on-peak energy purchases to off-peak hours as noted in the TOU rate by charging the battery from excess solar or from the grid during off-peak hours and discharging it for use during on-peak hours

**OR**

- **Demand Savings:** Bill savings resulting from the reduction of facility load peaks by strategically discharging the battery during hours of peak load

Note that each scenario assumed that the battery was being used for either one of the economic functions, but not for both. Energy arbitrage benefits were estimated by calculating the minimum value of either:

- The annual net energy consumption during peak hours as defined in the TOU rate schedule (i.e. the annual total (kWh) of energy consumption after estimated solar generation for all hours between 8:00 AM and 8:00 PM) multiplied by the difference between the on-peak and off-peak rates. This demonstrates the maximum annual savings that could result from charging the battery during off-peak hours and discharging it during on-peak hours to meet the facility's load, given that the battery has sufficient capacity to do so.

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[22] United States Environmental Protection Agency (EPA), Emissions & Generation Resource Integrated Database (eGRID).
[23] The Interagency Working Group on the Social Cost of Greenhouse Gases, Technical Support Document:- Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866 (2016).

**OR**

- The sum of the capacity of the battery (kWh) or the capacity of the battery designated for energy arbitrage multiplied by the difference between the on-peak and off-peak rates for each day of the year. This demonstrates the annual capacity-limited maximum given that the battery does not have sufficient capacity to mitigate all on-peak energy purchases and deliver maximum annual savings from energy arbitrage. Each day, the battery would be fully charged during off-peak hours and fully-discharged during on-peak hours.

It is worth noting that this value does not take into account additional benefits that would result from on-site solar generation charging the battery and further reducing off-peak energy purchases.

Demand savings benefits were estimated by assuming that the battery would be discharged strategically to reduce site demand by avoiding going above a certain set demand peak for each month. SEPA calculated the value of that demand peak for each month by maximizing the annual savings that could be achieved given the limits defined by the capacity of the BESS, the extent to which on-site solar generation is able to charge the battery under unfavorable conditions, and the costs associated with charging the battery from the grid in order to reduce demand peaks.

When estimating this benefit, SEPA assumed an annual rate increase of 2.5% for both energy and demand rates.

## Implied Value of Resilience

A primary focus of this project was to quantify the value that a microgrid could bring to the facility in terms of resilience (i.e., the ability to provide power when the utility grid is inoperable). In order to quantify resilience value as part of the benefit portfolio, it must be expressed in economic terms. Valuation of resilience is relatively new and the study team found that there is little research and few precedents upon which to base the analysis. For that reason, SEPA presented an “Implied Value of Resilience” that is equivalent to the annualized benefit required to make each microgrid scenario cost-effective.

The implied value of resilience should be compared to the project team’s own valuation of the ability of a microgrid to provide power to the facility when the public grid is inoperable. For Florence Elementary, this real-world resilience value should be based on its ability to provide emergency services to the community during an extended outage or emergency. In this study, the implied value of resilience was noted as the remaining difference between the NPV of costs and benefits in each scenario, annualized over the 20-year project lifecycle. In cases where the benefits exceed costs, this value was not noted, as the project can be considered cost-effective without the inclusion of this benefit. This value was not included in the final BCRs for each scenario, but it can be used as a benchmark for stakeholders to consider when estimating the value of resilience at the site for future cost tests. That is to say, if stakeholders perceive the actual value of resilience at the site to be greater than the implied value of resilience noted here, then it is more likely that the project would be cost-effective in further BCAs.

# Appendix 3: American Red Cross Memorandum of Understanding

Memorandum of Understanding between the School District of Florence County and The American Red Cross

If the Florence Elementary School is to be used as a shelter for The American Red Cross, the following memorandum has been agreed upon.

1. The Gymnasium (room 650) will be used as the Florence County shelter whether school is in or out of session. (If school is in session Physical Education instruction will be modified for the time of the facility is used)
2. The Florence County Sheriff's Office will provide at least 1 deputy for security (depending on availability) of the facility for the duration of the shelter operation.
3. Entrance E (West side of Building) will be used as the entrance into and departure from the facility. People utilizing the shelter will check in at entrance E before entering the shelter.
4. Entrance E (West side of Building) will be used by visitors to enter the facility. Visitors will check in at Entrance E and receive a visitor pass. Visitation hours will be from 8:00 am - 8:00 pm.
5. Room 644 will be used as the Command Center. (If school is in session Music classes will be modified for the time the facility is used.
6. Room 643 can be used for materials that need to be in a locked closet.
7. Room 641 will be available for the needs of the shelter (If school is in session Art classes will be modified for the duration of time the facility is used)
8. Room 642 can be used for materials that need to be in a locked closet.
9. If school is not in session Room 640 can be used for the needs of the shelter.
10. Rooms 645 and 646 will be used as private restroom/bathing facilities
11. Room 651 will be used as an office space.
12. If school programming is not in session The American Red Cross will have access to the Kitchen facility with approval from a District Administrator (Elementary Principal, High School Principal, Superintendent).
13. A break room for The American Red Cross Volunteers will be provided
14. Public WiFi will be provided by the school.

______________________________ ________________
Representative of The American Red Cross — Date

______________________________ ________________
Representative of the School District of Florence County — Date

______________________________ ________________
Representative of Florence County Sheriff's Office — Date

**Updated: 3/5/2021**