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WISCONSIN OFFICE OF ENERGY INNOVATION HOLY WISDOM MONASTERY MICROGRID FEASIBILITY STUDY

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

June 2022

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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 Madison Gas & Electric, Holy Wisdom Monastery, and Hoffman Planning, Design, and Construction, Inc.

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 monastery, which serves as an emergency shelter for the local town, 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, Madison Gas & Electric, Holy Wisdom Monastery, and Hoffman Planning, Design, and Construction, Inc.

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 Holy Wisdom Monastery.
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 four (4) 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 the Holy Wisdom Monastery in Middleton, WI, as seen in Figure 0.1. During emergencies, the monastery is designated as an emergency shelter which would provide critical services for stranded airline travelers from Dane County Airport during an emergency. Monastery infrastructure also serves as an emergency location for Westport Township administrators during an extended electrical outage. The microgrid feasibility study proposal was motivated by a desire to replace the existing MGE owned diesel back-up generator with an expansion of the Monastery's on-site solar and the addition of storage and other potential clean energy solutions, and satisfy Holy Wisdom Monastery and MGE's clean energy and resilience goals.[1]

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 monastery and

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

retreat and developed four potential microgrid designs, as seen in Table 0.1 and Figure 0.2, to serve the load of the monastery and retreat, while utilizing solar photovoltaic and battery storage technologies.

Figure 0.1 – Holy Wisdom Monastery Site Plan

Source: Holy Wisdom Monastery , 2022

To ensure the microgrid designs would serve the needs of the monastery 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 four possible microgrid design scenarios that they determined would best suit the site and community.

The microgrid components in this study include:

- Load: Holy Wisdom Monastery and Retreat/Guest House
- Ground-Mounted Solar PV
- Battery Energy Storage System (BESS)
- Microgrid Controller
- Distribution System

Table 0.1 - Microgrid Scenario Summary

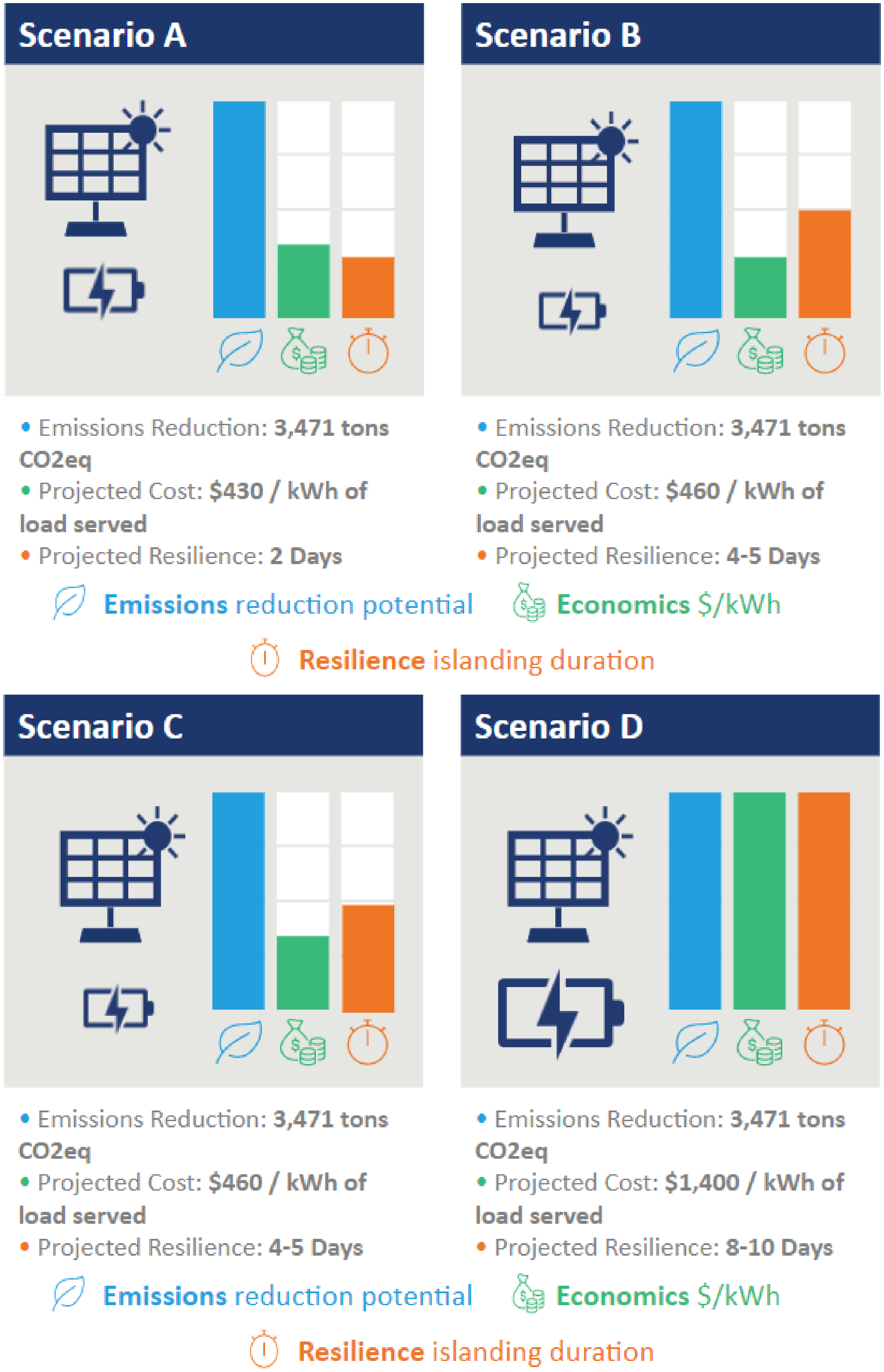
Scenario	Load	Solar	Solar kW-DC*	Battery Size kW (kWh)	Main Battery Function
Scenario A	Holy Wisdom Monastery	Ground Mounted Solar Only	270 (415.6 kW total)	175 (500)**	Short-Term Resilience Peak Shaving Energy Arbitrage
Scenario B	Holy Wisdom Monastery			150 (600)	Peak Shaving
Scenario C	Holy Wisdom Monastery			150 (600)	Energy Arbitrage
Scenario D	Holy Wisdom Monastery			1,000 (4,000)	Long-Term Resilience Economic Dispatch

*This table (and the BCA) only includes solar in addition to the 145.6 kWdc already installed at the site. Note that the islanding capacity is calculated with the assumption that a total of 415.6 kWdc is available to reduce load during the day and charge the battery during an outage

**This scenario actually proposes two separate batteries with a total capacity of 175kW/500kWh. The battery storage in this scenario has a shorter duration than the others that were modeled in this analysis with a 4-hour duration.

Source: Smart Electric Power Alliance, 2022

Figure 0.2 – Overview of Proposed Microgrid Scenarios



Scenario A

- Emissions Reduction: **3,471 tons CO2eq**
- Projected Cost: **$430 / kWh of load served**
- Projected Resilience: **2 Days**

Scenario B

- Emissions Reduction: **3,471 tons CO2eq**
- Projected Cost: **$460 / kWh of load served**
- Projected Resilience: **4-5 Days**

Scenario C

- Emissions Reduction: **3,471 tons CO2eq**
- Projected Cost: **$460 / kWh of load served**
- Projected Resilience: **4-5 Days**

Scenario D

- Emissions Reduction: **3,471 tons CO2eq**
- Projected Cost: **$1,400 / kWh of load served**
- Projected Resilience: **8-10 Days**

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 0.20 and 0.84, 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 outweigh the benefits in the four 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 Holy Wisdom Monastery, effectively reducing the BCR.

Table 0.2 - Summary of Costs and Benefits

Costs	Benefits*
● Generation (Solar Photovoltaic (PV) ● Battery Energy Storage System (BESS) ● Controller and Communications ● Distribution Upgrades (if applicable) ● MGE Resilience Service ● Operations & Maintenance	● Solar Generation (Demand savings, energy rate savings, and excess generation credits) ● BESS Economic Benefits (Energy arbitrage, demand savings) ● Emissions Reductions
Scenario A: BCR = 0.77	
Total NPV of Costs: $831,927	**Total NPV of Benefits:** $677,179
Scenario B: BCR = 0.67	
Total NPV of Costs: $889,535	**Total NPV of Benefits:** $629,406
Scenario C: BCR = 0.68	
Total NPV of Costs: $889,535	**Total NPV of Benefits:** $634,037
Scenario D: BCR = 0.22	
Total NPV of Costs: $2,848,195	**Total NPV of Benefits:** $634,037

*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 Holy Wisdom Monastery, Madison Gas & Electric, Hoffman Planning, Design, and Construction, Inc., 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 consequent economic 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. This microgrid project in Middleton, Wisconsin would bolster resilience for the monastery's shelter functions, 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 Holy Wisdom Monastery, which would provide critical services for stranded airline travelers during an emergency. Monastery infrastructure also serves as an emergency location for Westport Township administrators during an extended electrical outage.

Existing Infrastructure

The site has a 145.6 kilowatt (kW) customer-owned solar PV system and an existing 550 kilowatt (kW) diesel generator and consists of a 130 acre parcel containing a 30,000 square foot monastery, a retreat and guest house, parking lots, a lake, wooded nature trails, restored prairie, gardens and orchards that cuts through the green space.[4] The site hosts an interconnection point to Madison Gas & Electric's electric distribution grid.

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[2] NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022).
[3] SEPA, Commonwealth of Kentucky Regional Microgrids for Resilience Study, p. 7 (2021).
[4] https://holywisdommonastery.org/environment/environmental-history/

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. 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 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.”[5]

Identification of Critical Infrastructure

Holy Wisdom Monastery entered into agreements with the Dane County Airport to provide emergency shelter and critical services for stranded airline travelers during an emergency and for Town of Westport administrators during emergencies with extended electrical outage.

Key Partners and Stakeholders

Within this report, the core project team comprises stakeholders who supported the evaluation of preliminary microgrid scenarios to best support Holy Wisdom Monastery 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 Holy Wisdom Monastery.

SEPA, Holy Wisdom Monastery, Madison Gas & Electric, and Hoffman Planning, Design, and Construction, Inc. are the primary partners leading the project. Table 1.1 summarizes the role of each organization in carrying out the project.

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

Table 1.1 - Core Project Team and Responsibilities

Project Partners	Responsibility	Role
Smart Electric Power Alliance (SEPA)	Lead on community engagement and microgrid feasibility study development	Applicant and non-profit organization focused on advancing clean energy and resiliency goals
Madison Gas & Electric	Technical and strategic support	Local electric distribution utility
Holy Wisdom Monastery	Technical, strategic, and community engagement support	Microgrid customer and host of emergency shelter
Hoffman Planning, Design, and Construction, Inc.	Technical, strategic, and community engagement support	Holy Wisdom Board of Directors and Sustainability Team

Source: Smart Electric Power Alliance, 2022

Financial and Environmental Impact Analysis

This study includes a financial and environmental impact analysis of four proposed microgrid scenarios that serve the monastery through different asset mixes including solar PV, battery storage. 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, Holy Wisdom Monastery, Madison Gas & Electric, and Hoffman Planning, Design, and Construction, Inc., 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. Hoffman provided detailed load profile and solar profile data from the monastery, retreat/guest house, and existing solar PV at the site. The data provided figures for the average hourly (kW) load and generation at the site for 2019 and was used throughout the modeling and analysis process. Hoffman also provided an estimated annual generation profile for the proposed solar PV.

To plan where to construct the microgrid at the site, Holy Wisdom Monastery provided a site map and additional information regarding land availability for storage systems and solar PV. Madison Gas & Electric provided maps of existing 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 Holy Wisdom Monastery, 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 match an existing grant proposal, each microgrid scenario proposes an additional 270 kWdc solar PV in addition to the existing 145.6 kWdc solar PV at the site. The solar PV is sited at three different orientations (20% SE, SW and due south) and is positioned to protect prairie and avoid Indian Mounds. The proposed PV consists of bifacial PV modules mounted on tilt-adjustable racking that can be at steeper tilt angles and shed snow events easier. The solar profile data includes two adjustments a year in the spring and fall with average tilt of 45°.

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.[6]

Financial and Environmental Impact Analysis

SEPA carried out a financial and environmental impact analysis for each of the four 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

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[6] https://insideevs.com/news/323829/sce-unveils-americas-largest-battery-energy-storage-site/

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. 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

Holy Wisdom Monastery is located on a 130 acre lot. The site consists of a Monastery and retreat. The site facilities also include offices and meeting rooms, as well as several living quarters. In the event of a grid outage, the Monastery, Retreat, and Guest House need to be capable of supporting operation as an emergency shelter. Figure 2.1.1 below shows the layout of the site designating the location of the existing diesel generator and other utility owned equipment. Currently there are back-up services being provided to the Monastery and the retreat buildings. The site can also serve as an emergency shelter for the Town of Westport, which has a population of 3,586.
Solar will be deployed on a parcel of land adjacent to the retreat and guest house. The site assets and parcel outline are shown in the aerial images below.

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

Source: Statewide Parcel Map Initiative, V7 Statewide Parcel Data (2021)

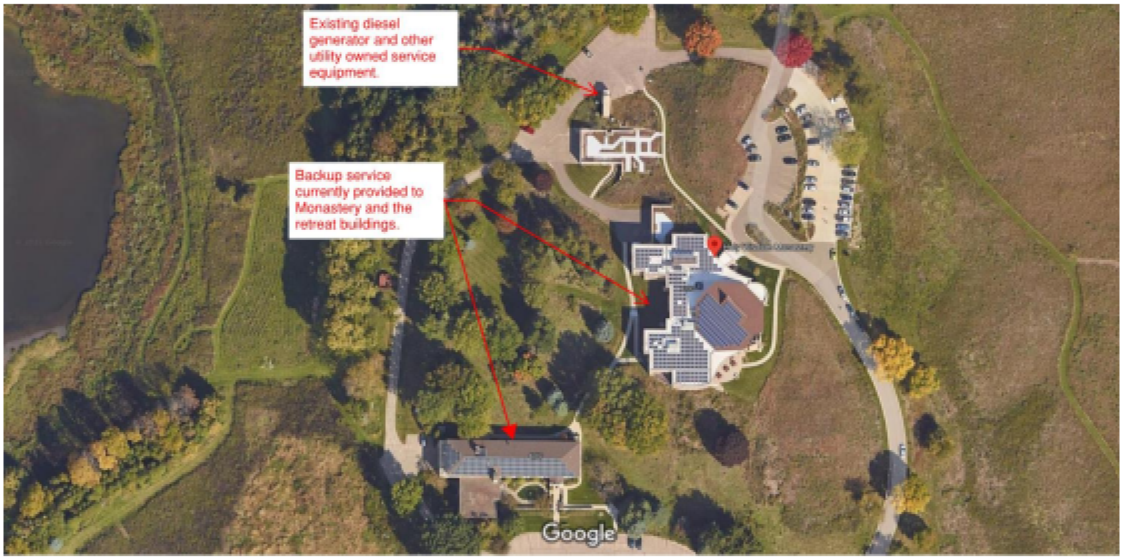
Available areas of the property are being considered for solar PV and battery energy storage, along with microgrid controller functionality to allow for sustained islanding capabilities during a grid outage.

Detail infrastructure

An existing 145.6 kW customer-owned solar system and a 550 kW utility-owned diesel back-up generator is installed at the monastery to provide emergency power generation and to serve the emergency shelter described above.

Existing solar, diesel generator, and buildings provided with backup service, are displayed on the map below.

Figure 2.1.2 - ***Site Infrastructure***

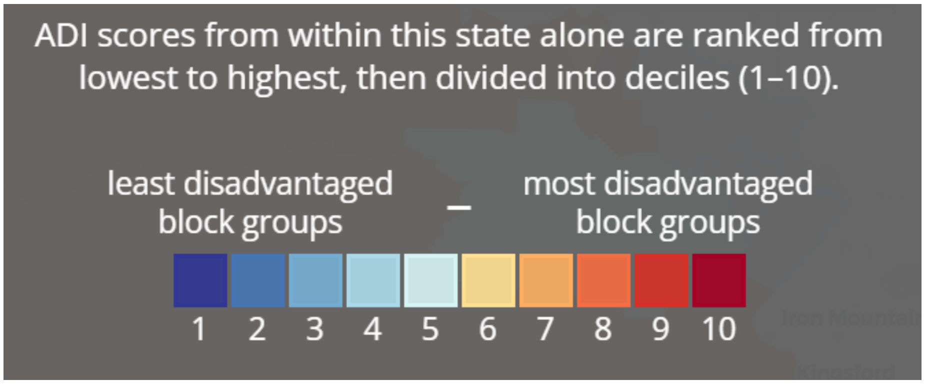


Source: MGE, 2021

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 least 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 - ***State View: Area Deprivation Index Legend***



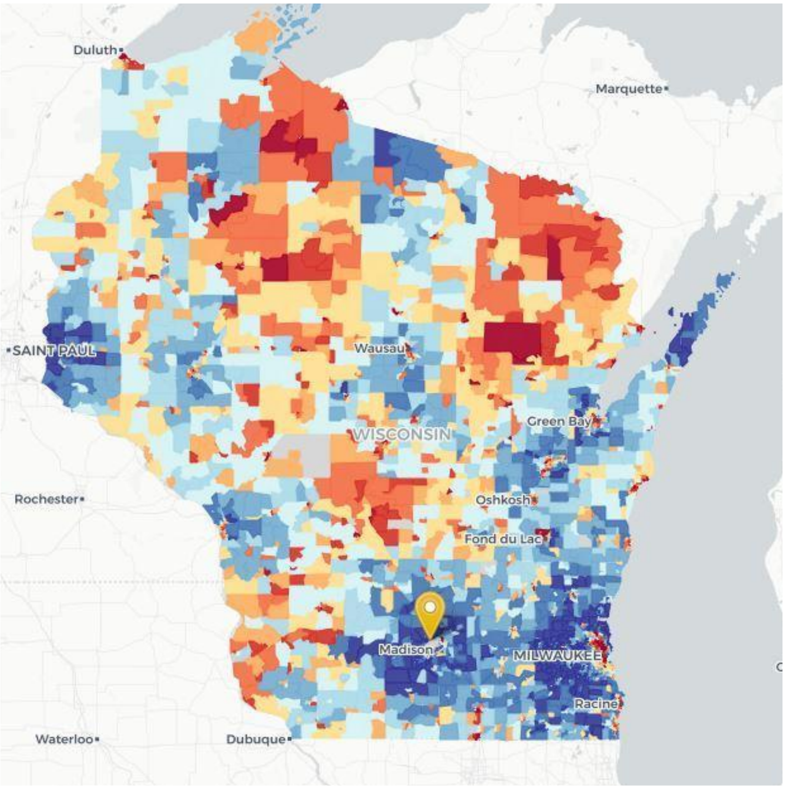
ADI scores from within this state alone are ranked from lowest to highest, then divided into deciles (1–10).

least disadvantaged block groups – most disadvantaged block groups

1 2 3 4 5 6 7 8 9 10

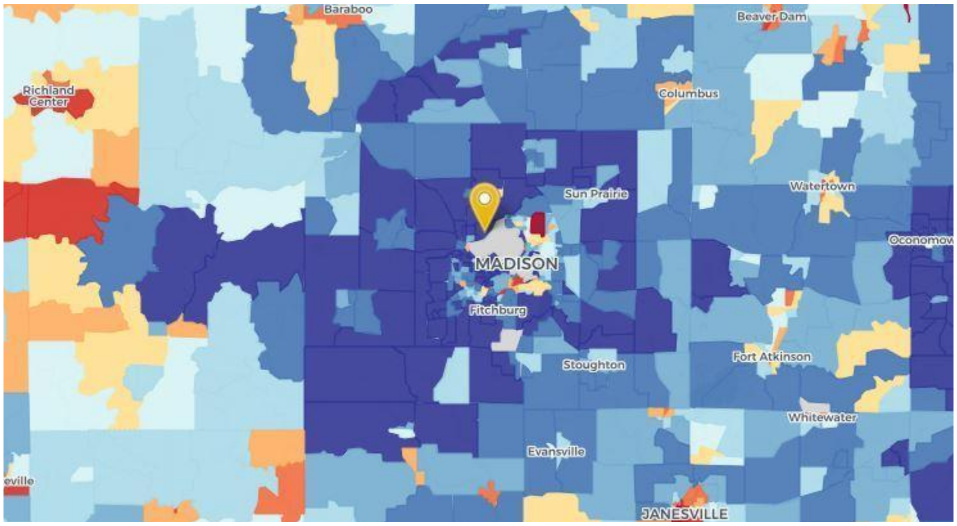
Source: University of Wisconsin-Madison, [Neighborhood Atlas Map](#)(2021)

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



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

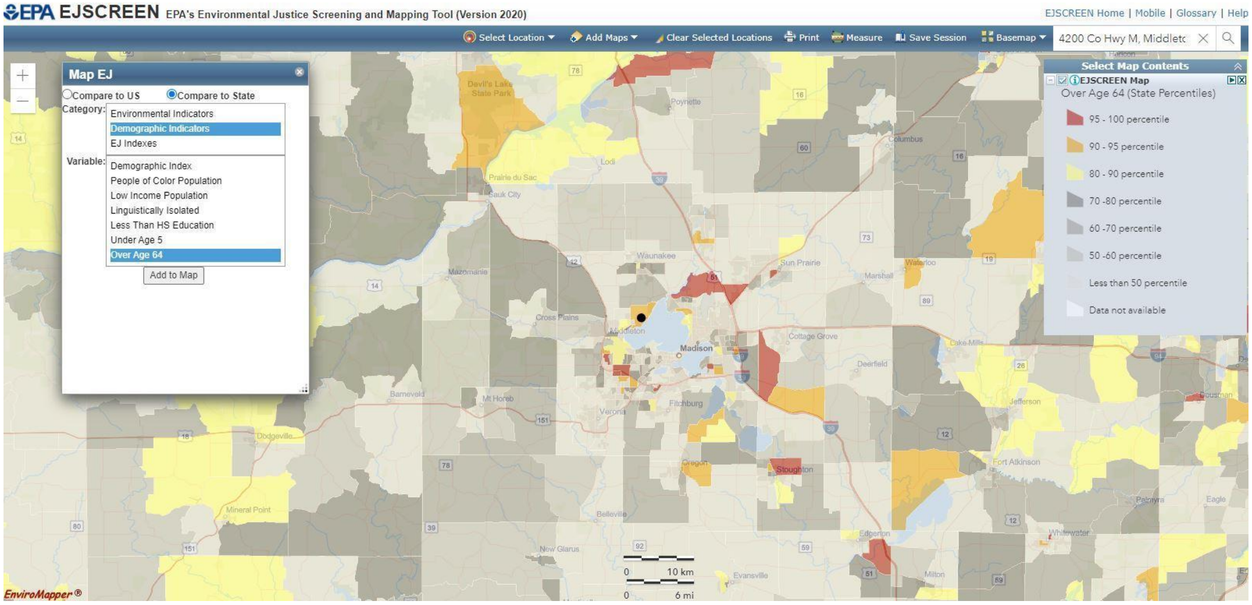
Figure 2.1.5 - ***Local View: Area Deprivation Index by Census Block Group***



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 80-90th percentile of the state.

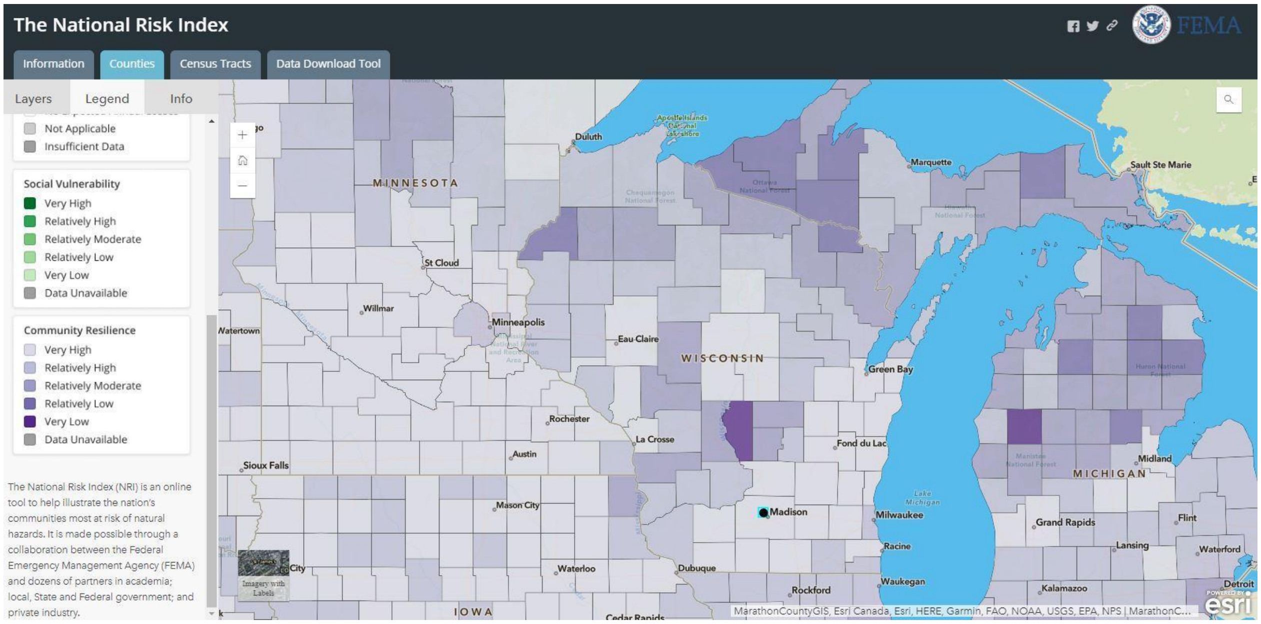
*Figure 2.1.6 - **Percentile of Population over 64 by Census Block***



Source: Environmental Protection Agency, EJSCREEN (2020)

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

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

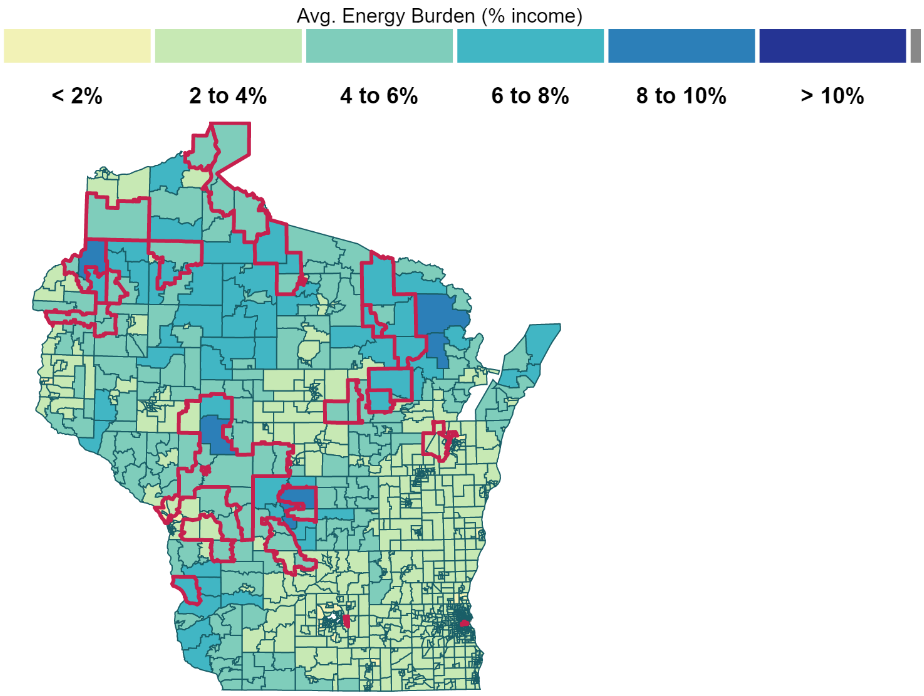


Source: FEMA, The National Risk Index (2021)

Below, Figure 2.1.8 indicates that the monastery site is located in an area where the energy burden is relatively low (2%). The red outline on Figure 2.1.8 delineates indigienous land.

The prevalence of vulnerable populations, such as elderly communities and low-moderate income customers, make it all the more important to improve energy resilience at the Holy Wisdom Monastery emergency shelter site. 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***



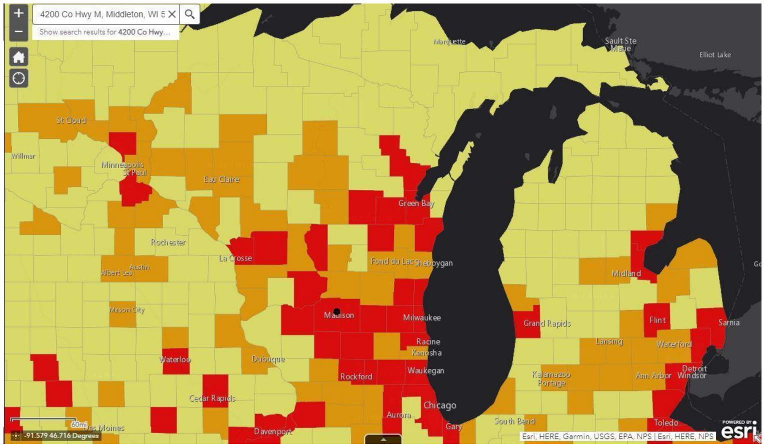
Low-Income Energy Affordability Data Tool Map Export (https://lead.openei.org/)
Exported On: 4/27/2022
SMI: 0% - 30%, 30% - 60%, 60% - 80%, 80% - 100%, 100%+
Building Age: Before 1940, 1940 - 59, 1960 - 79, 1980 - 99, 2000 - 09, 2010+
Heating Fuel Type: Utility Gas, Bottled Gas, Electricity, Fuel Oil, 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)

Flood hazards

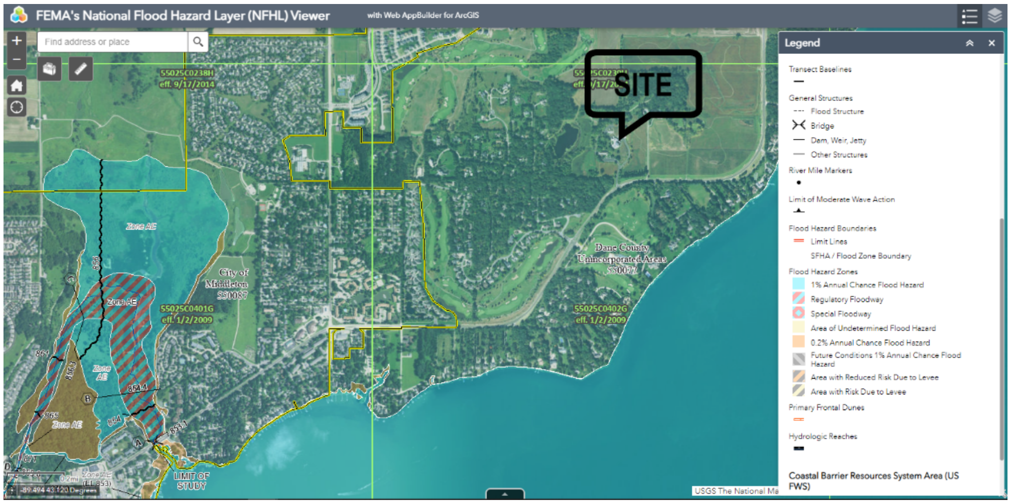
Below, Figure 2.1.9, indicates that the site is located in an area that has a high flood hazard index according to the National Center for Disaster Preparedness. A more detailed evaluation of the flood risk near the site is illustrated in Figure 2.1.10, sourced from FEMA's National Flood Hazard Layer Viewer.

*Figure 2.1.9 - **Flood Hazards Near Proposed Site***



Source: GeoData@Wisconsin (2018)

*Figure 2.1.10 - **Flood Hazards Near Proposed Site***



Source: FEMA, National Flood Hazard Layer Viewer (2021)

Site application and functionality

Holy Wisdom is interested in improving resilience for the designated emergency shelter at the site. Holy Wisdom Monastery has an agreement with the Dane County Airport to provide emergency shelter and critical services for stranded airline travelers during an emergency. Monastery infrastructure also serves as an emergency location for Westport Township administrators during an extended electrical outage.

Critical services

The monastery will be utilized by MGE 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

- Food preparation and storage
- Refrigeration
- Charge critical tools

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

Customer information and historical outage information

Holy Wisdom Monastery has not experienced any major outages since at least 2005. Most outages at the site have been brief, and resilience service was provided by the on-site backup generator provided by MGE. Historical outages at the site are outlined in Table 2.2.1.

Table 2.1.1 - Historical Outages, outage duration, and backup energy usage 2005 - 2021

Outage Duration (hr)	Frequency of Outages 2005 - 2021	Backup Energy Usage (kWh)
<1	4	78
1 - 2	3	156
2 - 3	1	234
>3	-	-

Source: Madison Gas and Electric, 2022

Generator Runs

The on-site diesel backup generator ran only once for 1 hour and 14 minutes between 2018 and 2021. All other generator operations during that time were for momentary outages and are negligible (<1 minute per run).

Rate schedule

This analysis assumes that Madison Gas & Electric currently serves Holy Wisdom Monastery under the Schedule Cg-4 electric rate which can be found in Appendix 3: Schedule Cg-4, Commercial and Industrial TOU Rate.

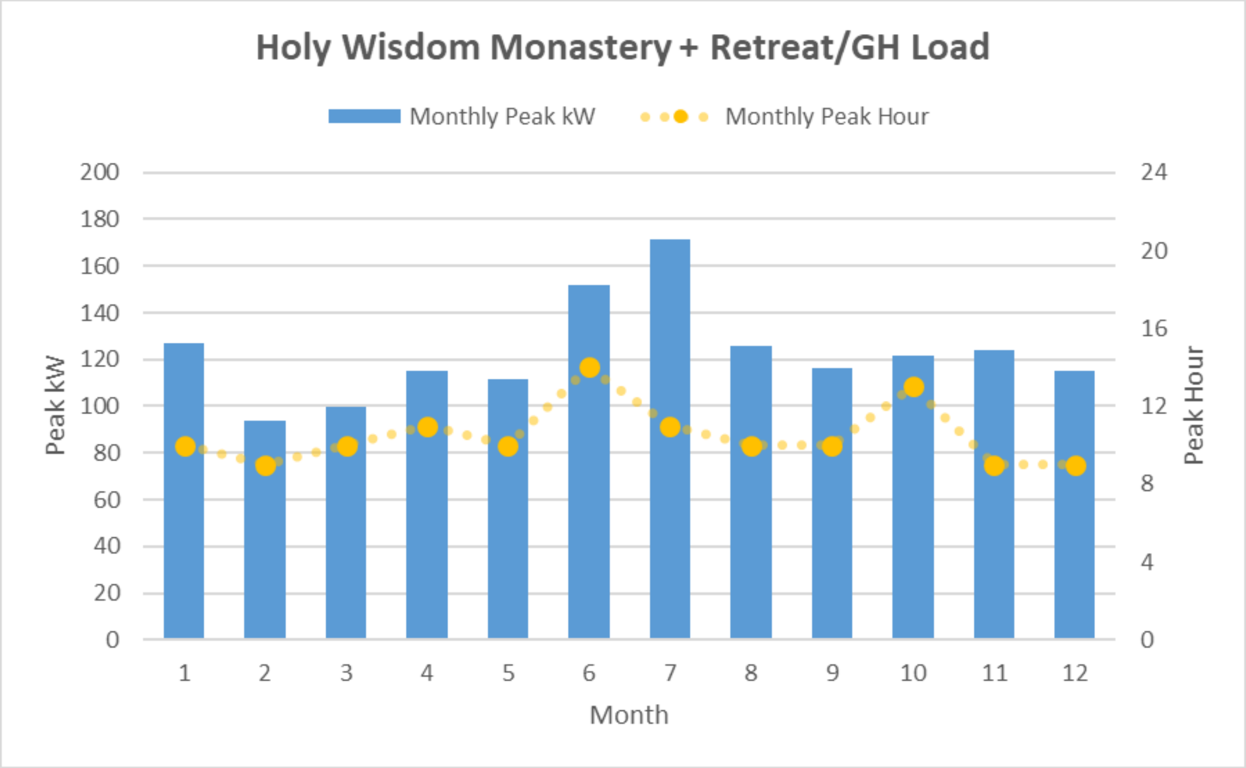
2.2 Initial Load and Solar Analysis

Load Analysis

Several different asset mix scenarios served as additional inputs in the microgrid sizing, siting, and financial analysis processes. For this study, SEPA considered just one load scenario, where the load of the monastery and retreat/guest house would be served by the microgrid.

The load depends on the time of year and time of day. The site's load clearly peaks in the summer. Throughout the year, the load peaks in the mid-morning, though in June and October, it peaks in the early afternoon. Figure 2.2.1 illustrates the variation of the site's load throughout the year.

Figure 2.2.1 - Holy Wisdom Monastery Load by Month



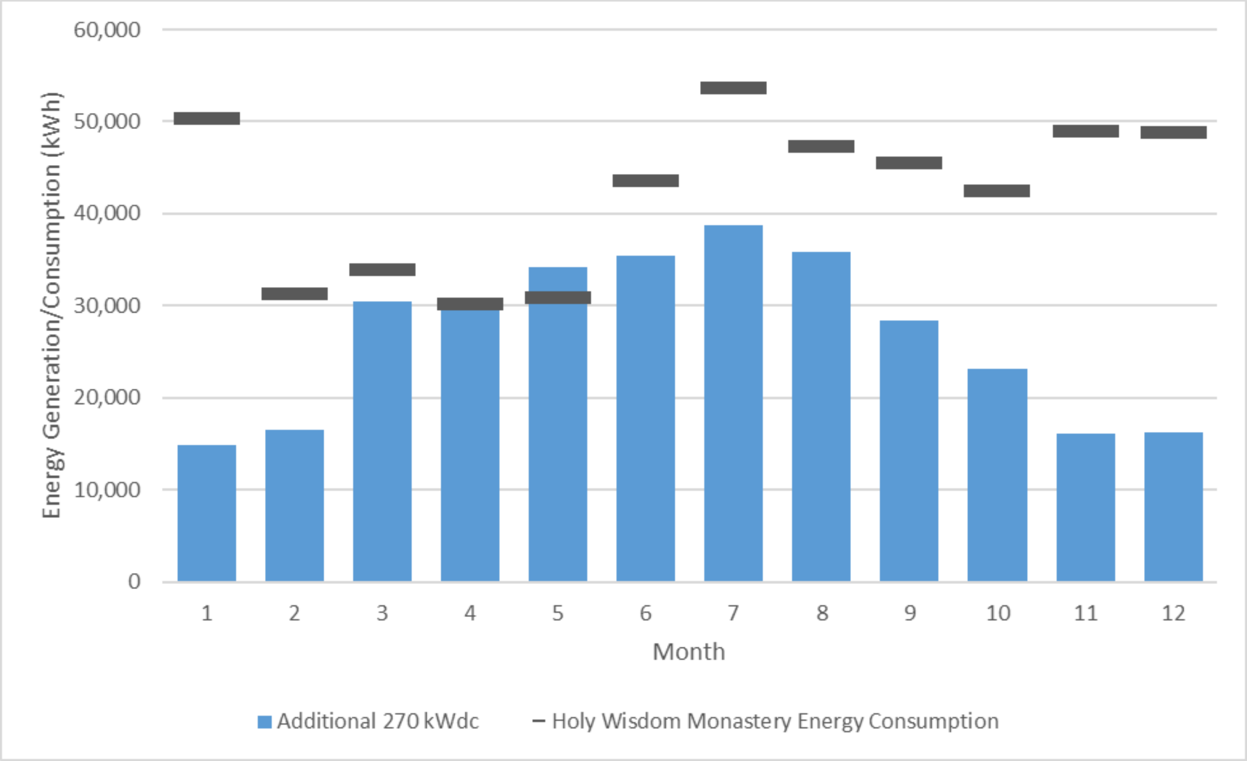
Source: Smart Electric Power Alliance, 2022

Solar Analysis

Within the asset mix scenarios, SEPA evaluated various combinations of battery storage and islanding duration. To match the proposed solar in an existing grant application, SEPA considered an additional 270 kWdc of solar PV in each scenario, as cited by Hoffman. Hoffman provided both historical generation data, an 8760 generation profile, from the existing 145.6 kW dc solar PV and an estimated generation profile for the proposed 270 kWdc.

SEPA modeled each of the asset mix scenarios in order to estimate financial and environmental benefits related to the additional solar generation. Figure 2.2.2 highlights the average monthly solar generation for additional 270kWdc alongside monthly energy consumption at the site.

Figure 2.2.2 - Proposed Solar Generation and Energy Consumption at Holy Wisdom Monastery by Month



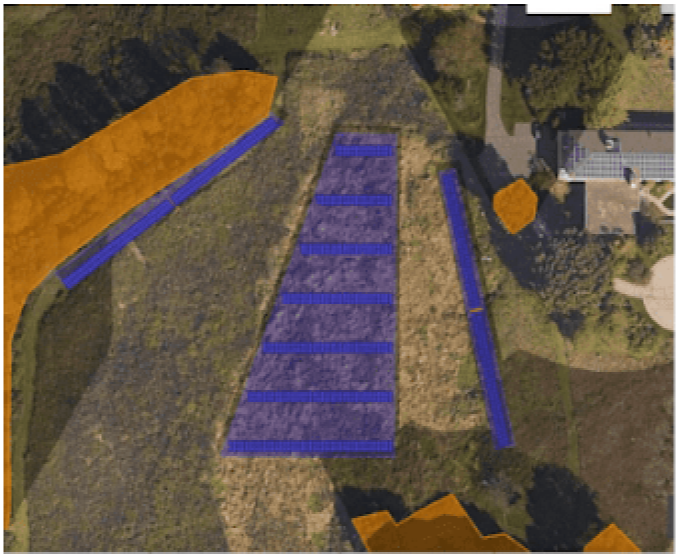
Source: Smart Electric Power Alliance, 2022

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 assumed that MGE would provide backup resilience services for $3,000/year. MGE resilience service fees were incorporated into the BCA assuming a 2.5% rate increase each year.

2.3 Site Availability

The team calculated the site availability of solar energy and battery energy storage with the support of Holy Wisdom Monastery and Hoffman. As illustrated in Figure 2.3.1, Holy Wisdom Monastery, MGE, and Hoffman provided SEPA with the site layout and electrical plans, which were used to identify sections of the property that could host microgrid assets. The proposed solar would be sited adjacent to the retreat as shown in Figure 2.3.1 below. Additionally, the site of the existing MGE-owned diesel generator could be used to site BESS of varying sizes as noted in the four scenarios.

Figure 2.3.1 -Holy Wisdom Monastery Proposed Solar PV Site

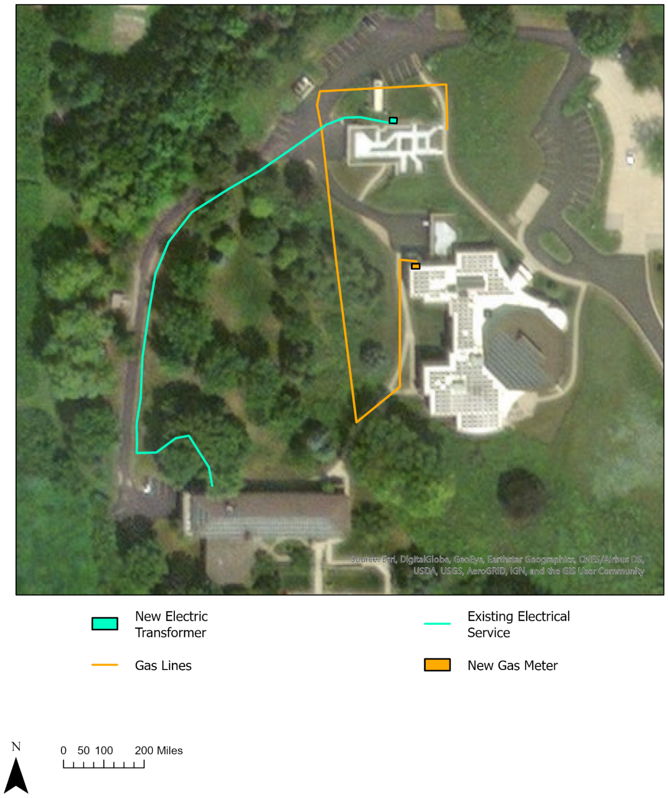


Source: Hoffman, 2021

Existing Electric and Natural Gas Feed-In

Hoffman supplied building drawings that detailed the location of utility assets including electric service lines, electric transformer, gas lines, and gas meter.

Figure 2.3.2 -Holy Wisdom Monastery Utility Assets

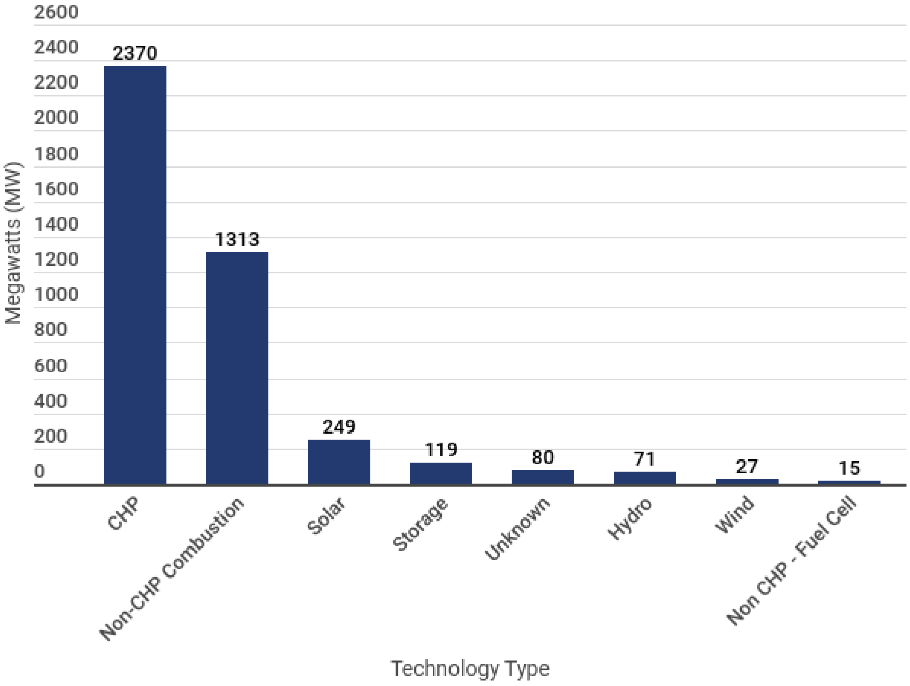


Source: SEPA, 2022

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: NREL, 2018.

3.1 Stakeholder Process and Findings

When determining potential asset mix scenarios for a Holy Wisdom Monastery 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 monastery, Hoffman, and MGE, 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 first check-in meetings, the team held discussions around microgrid resilience needs at the site 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 on-site diesel generator for which Holy Wisdom Monastery currently pays $3,000 per year.
2. The ample space at the site makes solar PV an ideal on-site generation resource for the Holy Wisdom Monastery.
3. Providing frequency regulation to MISO using an oversized battery would not provide a significant enough benefit to justify the costs of such a significant investment.
4. Incorporating a battery that is greater than 1 MW would require an engineering study, which would further drive up the costs of that scenario.
5. Holy Wisdom would need to actively manage and understand the services that are being provided from a backup services standpoint, understanding that part of the pack would be reserved for resiliency and the rest of the pack would be used to participate in the market.
6. 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 monastery.
7. Strategic load shedding could be used to reduce the facility's energy consumption during a long-term outage.

3.2 Microgrid Scenarios

Overview

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

Table 3.2.1 - Microgrid Scenario Components

Scenario	Load	Solar	Solar kW-DC*	Battery Size kW (kWh)	Island Days[7]
Scenario A	Holy Wisdom Monastery	Ground-Mounted Solar Only	270	175 (500)**	2***
Scenario B	Holy Wisdom Monastery			150 (600)	4-5***
Scenario C	Holy Wisdom Monastery			150 (600)	4-5***
Scenario D	Holy Wisdom Monastery			1000 (4000)	365

*This table (and the BCA) only includes solar in addition to the 145.6 kWdc already installed at the site. Note that the islanding capacity is calculated with the assumption that a total of 415.6 kWdc is available to reduce load during the day and charge the battery during an outage

**This scenario actually proposes two separate batteries with a total capacity of 175kW/500kWh. The battery storage in this scenario has a shorter duration than the others that were modeled in this analysis with a 4-hour duration.

***Battery Only - Islanding capacity only includes battery capacity, MGE resilience service ensures significant islanding capability, which is ultimately dependent on how much excess power HWM is able to generate during an outage.

Source: Smart Electric Power Alliance, 2022

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.

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[7] 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, July. 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 meet the facility’s load and charge the battery, the facility’s demand during an outage event, and the time of day and year that the outage occurs.

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)[8], and resilience capabilities for each microgrid scenario. The costs and islanding capabilities all vary in each of the four designs. The designs range from inexpensive to most expensive and short-term to long-term resilience, but all provide relatively similar emissions reductions given that the solar PV sizing is unchanged over the four scenarios.

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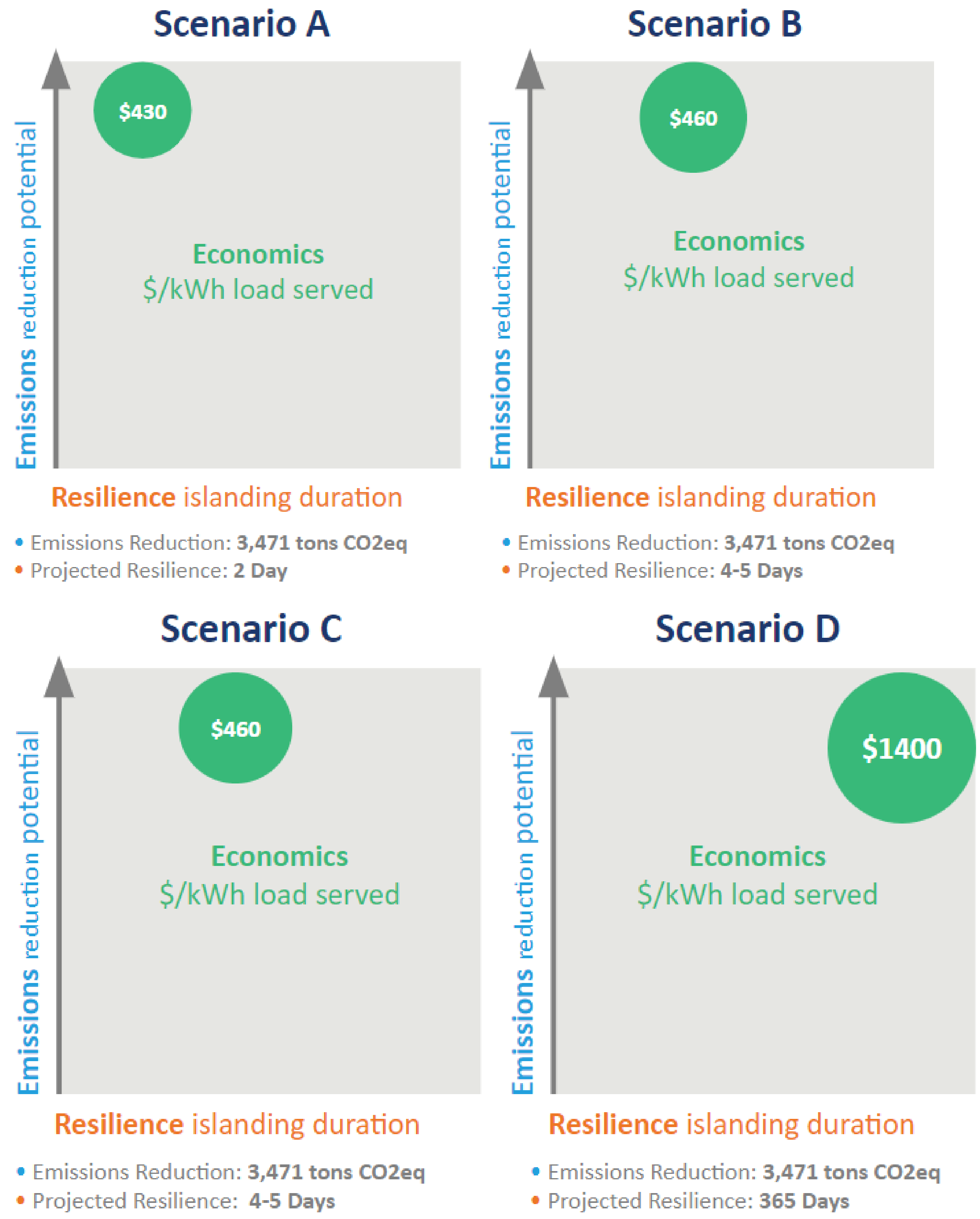
[8] This denominator refers to energy consumption (in kWh) at the monastery and guest house during a typical day in July, the month during which the highest 12-month demand peak occurs

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



Source: Smart Electric Power Alliance, 2022

Scenario Pros and Cons

The four microgrid design scenarios present their own benefits and drawbacks. Each of the scenarios features 270 kWdc solar PV that brings total annual on-site solar generation up to around 90% of on-site energy consumption year over year. For scenarios A-C, Holy Wisdom would continue to rely on Madison Gas & Electric to provide resilience service for disruptions longer than a day, for which Holy Wisdom currently pays $3,000 per year.

Scenario A, the scenario proposed by Hoffman in coordination with Holy Wisdom, consists of 270 kW solar PV and a 500 kWh BESS, which would be dispatched to provide economic benefits from both energy arbitrage and demand reduction. This scenario provides only short-term islanding capabilities, given that the battery is fully charged.

Scenarios B and C represent balanced 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 270 kW solar PV and a 150 kW 4-hour (600 kWh) BESS that would be used for either energy arbitrage or demand reduction–these two scenarios compare the benefits of using the battery for each of those purposes. These scenarios provide only short-term islanding capabilities, given that the battery is fully charged.

Scenario D, the most costly and only fully renewable microgrid design, serves the load of the entire site by deploying 270 kWdc solar PV and a 1MW 4-hour (4MWh) battery that would be managed and optimized by a third-party and could potentially operate in the MISO market to provide an additional economic benefit. This scenario takes advantage of a large BESS that would allow the site to island for a week or longer without a need for utility-provided resilience services.

After consulting with Convergence Energy, a third-party battery storage developer, it became clear that siting a 1 MW BESS at Holy Wisdom Monastery would not be economically feasible under current market conditions. Notably, given the solar development limits at the site, a developer would likely be unable to monetize the federal investment tax credit, and providing frequency regulation to MISO would not provide a significant enough benefit to justify the costs of such a significant investment, even under optimal conditions. Given the challenges associated with operating the battery in the MISO market, the BCA for Scenario D only includes the benefits of energy arbitrage from the BESS. SEPA suggests that HWM own/operate BTM assets at a size closer to Scenarios A-C. MGE has the ability to monetize more value streams for a large BESS, including grid benefits and resilience services for several customers, and are better suited to operate a large front-of-the-meter BESS.

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 and the distribution system. The components of a microgrid include facility load, generation (solar PV), battery energy storage, a microgrid controller, and interconnection to an existing distribution line.

For the purposes of this analysis, it is assumed that MGE will own and operate the medium voltage distribution infrastructure and provide resilience service in scenarios A-C, while the other infrastructure including solar facilities and battery storage would be owned by Holy Wisdom Monastery. In general, the scope of the necessary fieldwork is largely agnostic to the ownership model.

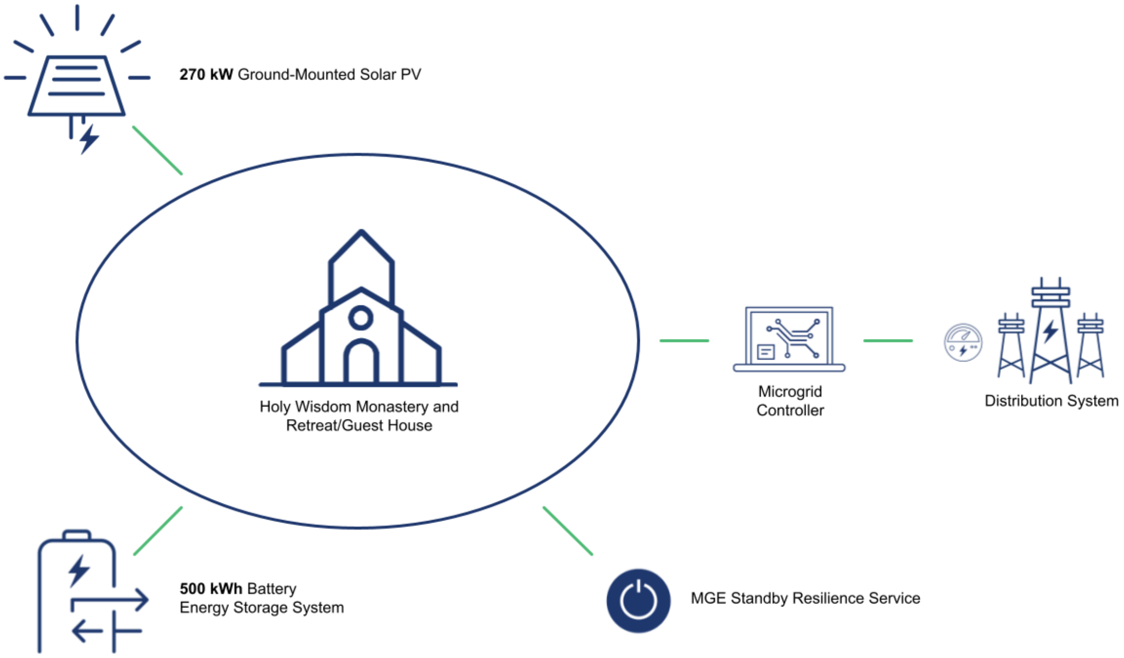
SEPA designed scenarios A-D to serve Holy Wisdom Monastery through a mix of ground-mounted solar and battery storage. The preliminary sizing estimates for each scenario enable the microgrid to rely partially on generation from solar PV during the summer, and utilize battery storage or MGE resilience services for islanding during periods of low solar output.

Note that SEPA completed the sizing analysis using historic load profile data that included projected load changes due to planned energy efficiency measures (i.e. geothermal HVAC and lighting retrofits). Therefore, the site's load could change in future years depending on how those measures actually impact the load and lead to different results for the load analysis.

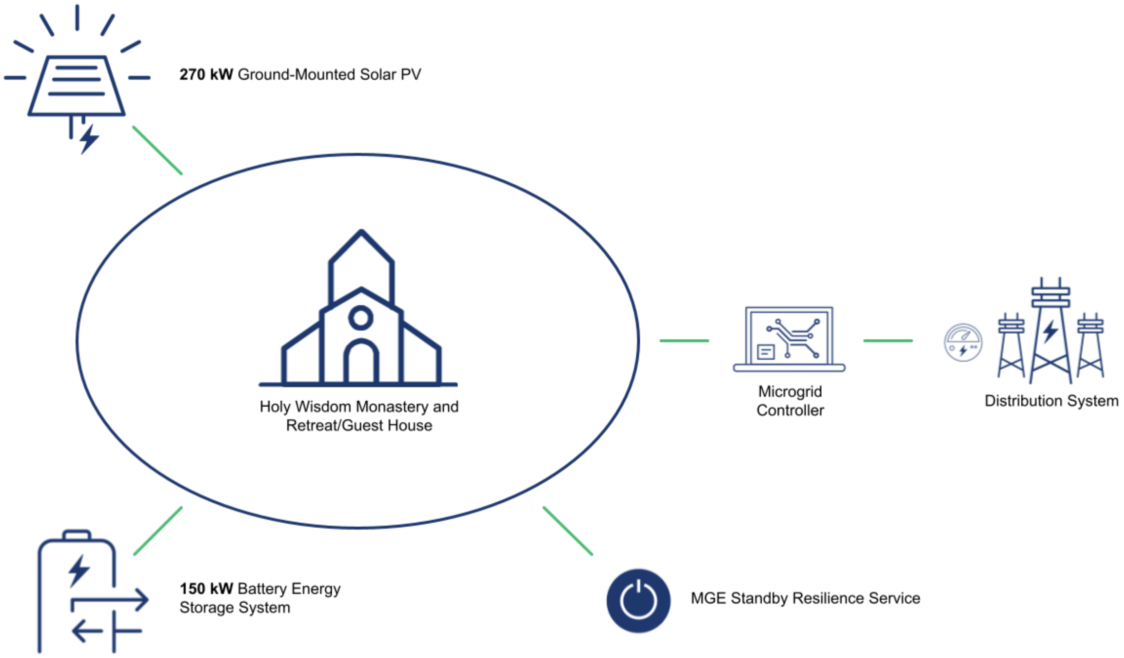
Site Layout

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.

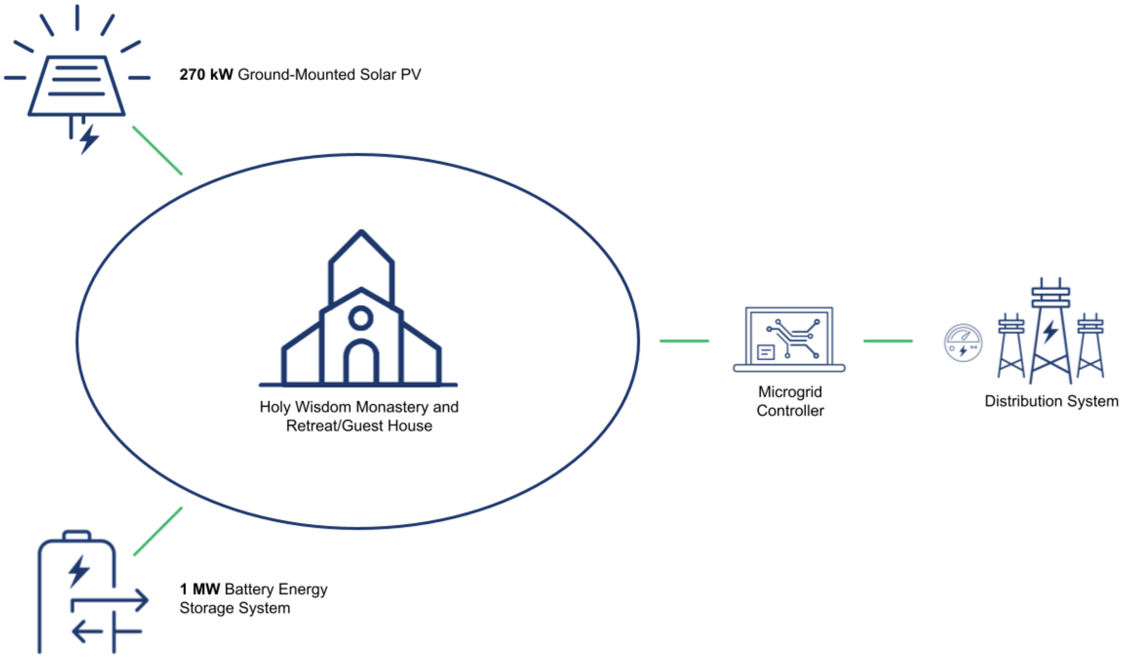
Scenario A



Scenarios B and C



Scenario D



Microgrid Operations

MGE will own and operate all medium voltage equipment, which includes disconnecting and reconnecting the microgrid from MGE's 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 microgrid system will operate in parallel with MGE's distribution system. The MGE owned energy storage will be used as a MISO market resource to realize the value from energy arbitrage and ancillary services market participation. The HWM on site generation and energy storage will operate in a manner in line with the proposed scenarios A-C to maximize the value of those assets.

Operating Mode 2: Microgrid Operation - Disconnecting from the Grid

During a scheduled or unplanned outage, MGE 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 HWM-owned battery is drained and MGE begins to provide resilience service, if included in the scenario. The BESS 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 MGE resilience service.

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 MGE's standard interconnection process for distributed generation.

Microgrid

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

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

Solar and Battery Storage

The solar and BESS will interconnect to the microgrid isolation switchgear. The solar and BESS may require step-up transformers to convert to the distribution line voltage. 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 100-800 sq ft. based on battery sizes and available references.[9] Exact dimensions will depend on the equipment vendor selected.

Infrastructure Updates

Electrical

Given the level of PV and BESS being proposed in each of the scenarios, it is likely that some level of study will need to be performed. MGE was not able to provide the exact costs to do this, and they were not included in the benefit-cost analysis. MGE also noted that it is unlikely that there would be a need to do any physical work such as reconductoring or transformer

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[9] SEPA used reference data from a publicly available SCE battery storage project which assumed a footprint of ~0.2 sq ft/kWh.

replacements. Minor work such as fuse replacements may be necessary, but that cost would be minimal.

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.

All four proposed Holy Wisdom Monastery microgrid scenarios would provide uninterrupted power to the facility for at least a day, after which they would need resilience service from MGE. In scenario D, the microgrid would provide sufficient resilience capability that would avoid the need to employ MGE to render resilience services. 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 the battery.[10]

The load served by this project consists of Holy Wisdom Monastery and the retreat/guest house located on the site. 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[11], 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 group of benefits and costs included, and that issues such as double-counting and "transfer effects"[12] 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.

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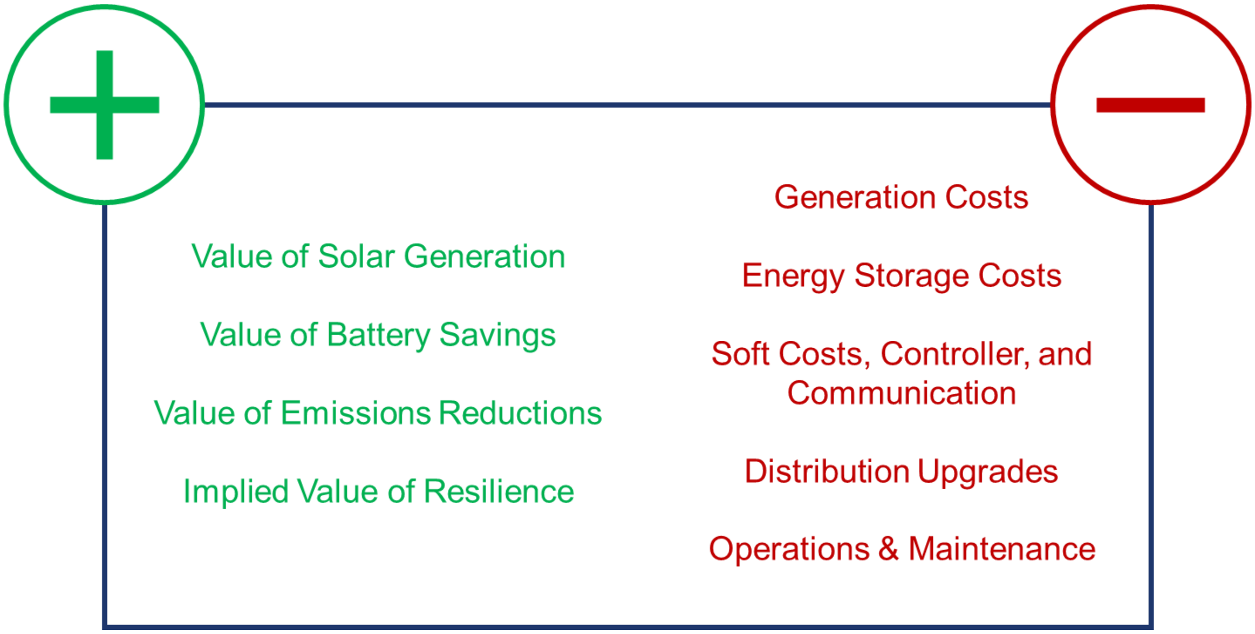
[10] Additional grid services, if added to the operating profile of the microgrid, might introduce additional benefits that could be quantified.

[11] 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.

[12] 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.

Figure 4.2.1 - Overview of Benefits and Costs



Source: SEPA, 2022

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:

1. **Generation (PV):** Generation costs reflect the purchase and installation of a solar photovoltaic system. In each scenario, a photovoltaic system has been proposed for the microgrid to generate clean electricity, and (with the support of 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. This is a one-time construction cost. The costs for the solar system include a long-term warranty for the inverters to ensure their continued operation over the assumed lifespan of the project. Solar PV costs were taken from the NREL Annual Technology Baseline (ATB) 2021 for commercial solar PV. 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. BESS costs were taken from the NREL Annual Technology Baseline (ATB) 2021 for 4hr Lithium Ion BESS. 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 Holy Wisdom Monastery 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. **MGE Resilience Service:** The MGE resilience service 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. The cost of resilience service was assumed to be $3,000/year based on discussions with MGE.
6. **Operations & Maintenance:** 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.

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:** 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 PM2.5, SO2, and NOx[13], and the CO2[14].
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 Holy Wisdom Monastery, resilience value should be based on its ability to provide services to onsite guests and emergency shelter and critical services for the Town of Westport and Dane County Airport. In this study, the implied value of resilience is the 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.

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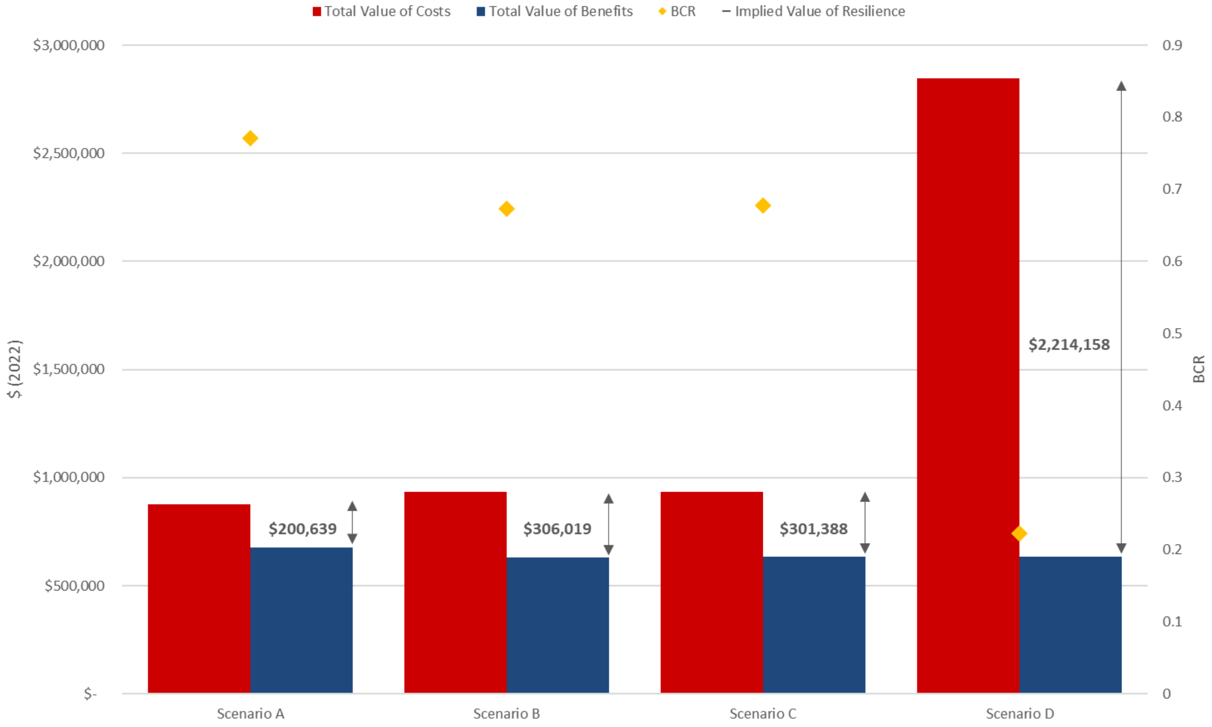
[13] https://www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf

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

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)	$408,645	$419,819	$449,242
BESS	$165,174	$202,528	$227,413
Soft Costs/Controller/Comms	$109,299	$118,542	$128,887
MGE Resilience Service	$45,891		
Operations & Maintenance	$72,882	$91,038	$114,160
Total	**$801,890**	**$877,818**	**$965,593**

Scenario B			
Generation (PV)	$408,645	$419,819	$449,242
BESS	$198,209	$243,033	$272,895
Soft Costs/Controller/Comms	$115,591	$126,258	$137,550
MGE Resilience Service	$45,891		
Operations & Maintenance	$79,496	$100,425	$126,082
Total	**$847,831**	**$935,425**	**$1,031,660**
Scenario C			
Generation (PV)	$408,645	$419,819	$449,242
BESS	$198,209	$243,033	$272,895
Soft Costs/Controller/Comms	$115,591	$126,258	$137,550
MGE Resilience Service	$45,891		
Operations & Maintenance	$79,496	$100,425	$126,082
Total	**$847,831**	**$935,425**	**$1,031,660**
Scenario D			
Generation (PV)	$408,645	$419,819	$449,242
BESS	$1,321,392	$1,620,223	$1,819,303
Soft Costs/Controller/Comms	$329,531	$388,579	$432,104
Operations & Maintenance	$304,382	$419,574	$531,414
Total	**$2,363,949**	**$2,848,195**	**$3,232,064**

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	$326,170	$22,035
Battery Savings**	$66,575	$4,352
Emissions Reductions	$284,434	$17,818
Implied Value of Resilience*	$10,007 - $23,143	-
Total	**$677,179**	**$44,205**
Scenario B		
Solar Generation	$326,170	$22,035
Battery Savings	$18,802	$1,229
Emissions Reductions	$284,434	$17,818
Implied Value of Resilience*	$13,845 - $28,596	-
Total	**$629,406**	**$41,082**
Scenario C		
Solar Generation	$326,170	$22,035
Battery Savings	$23,432	$1,532
Emissions Reductions	$284,434	$17,818
Implied Value of Resilience*	$13,473 - $28,224	-
Total	**$634,037**	**$41,385**
Scenario D		
Solar Generation	$326,170	$22,035

Battery Savings	$23,432	$1,532
Emissions Reductions	$284,434	$17,818
Implied Value of Resilience*	$138,813 - $208,472	-
Total	**$634,037**	**$41,385**

*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.
**The battery savings value for Scenario A was calculated by Hoffman Planning, Design & Construction, Inc. and includes an estimate of benefits resulting from the optimization of the 500 kWh BESS for both energy arbitrage and demand reduction. The value was estimated using NREL’s price signals dispatch algorithm.[15]
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[16], 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)	**$801,890**	**$877,818**	**$965,593**
Total Value of Benefits (NPV)	**$677,179**		
Net Impact (Benefits - Costs)	**($124,711)**	**($200,639)**	**($288,414)**
BCR	**0.84**	**0.77**	**0.70**
Scenario B			
Total Value of Costs (NPV)	**$847,831**	**$935,425**	**$1,031,660**
Total Value of Benefits (NPV)	**$629,406**		

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[15] https://www.nrel.gov/docs/fy21osti/79575.pdf

[16] 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.

Net Impact (Benefits - Costs)	**($218,426)**	**($306,019)**	**($402,254)**
BCR	**0.74**	**0.67**	**0.61**
Scenario C			
Total Value of Costs (NPV)	**$847,831**	**$935,425**	**$1,031,660**
Total Value of Benefits (NPV)	**$634,037**		
Net Impact (Benefits - Costs)	**($213,795)**	**($301,389)**	**($397,624)**
BCR	**0.75**	**0.68**	**0.61**
Scenario D			
Total Value of Costs (NPV)	**$2,363,949**	**$2,848,195**	**$3,232,064**
Total Value of Benefits (NPV)	**$634,037**		
Net Impact (Benefits - Costs)	**($1,729,912)**	**($2,214,158)**	**($2,598,027)**
BCR	**0.27**	**0.22**	**0.20**

Source: SEPA, 2022

Interpretation

The proposed Holy Wisdom Monastery scenarios provide substantial benefits mainly due to solar production, associated emissions and rate benefits, and the BESS resilience which allows the facility to ride out an outage for at least a day before relying on utility-provided services. However, due to the small scale of this project and the uncertainty associated with behind-the-meter solar and battery economic benefits, these benefits on their own are unable to balance the construction and operation/maintenance costs across all scenarios whether considering low-, mid-, or high- costs. If Holy Wisdom is able to internalize the emissions benefits related to solar generation and take advantage of the investment tax credit for solar and/or battery storage, some scenarios with higher BCRs may prove cost-effective in further analyses.

Although the benefit-cost ratios resulting from this high-level inventory of benefits and costs all 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 Holy Wisdom Monastery site do not exceed the costs of the project in any scenario 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, Holy Wisdom Monastery is a workable site to construct and install a microgrid project. Project team members believe that this project would increase resiliency in the community by serving as an emergency shelter for stranded travelers and providing critical services during prolonged outages.

Key learnings from this study include:

- Given the open space at the site, Holy Wisdom Monastery is well suited to host solar PV for on-site generation.

- The solar and battery benefits are likely 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 an 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 potential investors.

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

- Determine ownership and operation structures between Holy Wisdom Monastery, MGE, 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.

December 2021

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. WI OEI and Hoffman noted that they were applying for an OEI grant that could provide funding for a geothermal HVAC system, a BESS, and solar PV. Project team members began to discuss the site, its role as 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.

January 2022

During the second project team check-in, Holy Wisdom and Hoffman followed up with the details of the grant request they submitted, and the components included in the request. Holy Wisdom noted that they were planning for 500kWh total BESS and 270kW solar PV to be added to the site in addition to a geothermal system and energy efficiency measures. SEPA shared its initial site assessment with the project team, and the team landed on the possibility of including the additional 270 kWdc solar PV across all four scenarios. The meeting included an initial discussion around sizing a BESS for resilience and a discussion about MGE providing long-term resilience service to the facility to replace the backup generation. Following this meeting, SEPA began to develop strawman microgrid scenarios to share with the team.

February 2022

The third project team check-in meeting focused on discussing and validating the initial strawman microgrid scenarios. The team decided to create a scenario that mirrors what HWM and Hoffman proposed for the grant request, two scenarios that compare battery operation for energy arbitrage and demand reduction, and a 100% renewable scenario that avoids the need for MGE resilience service. The project team discussed the pros and cons of each scenario and discussed next steps to determine high-level values for MGE resilience service and the value of using a BESS to be compensated for grid services in the MISO market. Following this meeting, SEPA began to flesh out preliminary microgrid scenarios and worked to finalize the site assessment.

March 2022

The fourth project team check-in meeting focused on validating the final microgrid scenarios. 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. SEPA shared updates from the initial strawman scenarios and discussed options to evaluate the potential benefits of operating a battery in the BESS market through a third party (Convergence Energy). Following this meeting, SEPA finalized the microgrid scenarios, shared them with the project team, and began to work through the economic analysis.

April 2022

The fifth project team check-in meeting was brief and included a discussion about how SEPA implies the value of resilience from the analysis and what Hoffman should include in their analysis for scenario A. 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

Hoffman provided SEPA with a solar production profile for the site, which included existing and planned solar, and 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.[17] 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 $PM_{2.5}$.[18] 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.

OR

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[17] United States Environmental Protection Agency (EPA), Emissions & Generation Resource Integrated Database (eGRID).

[18] 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).

- 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.

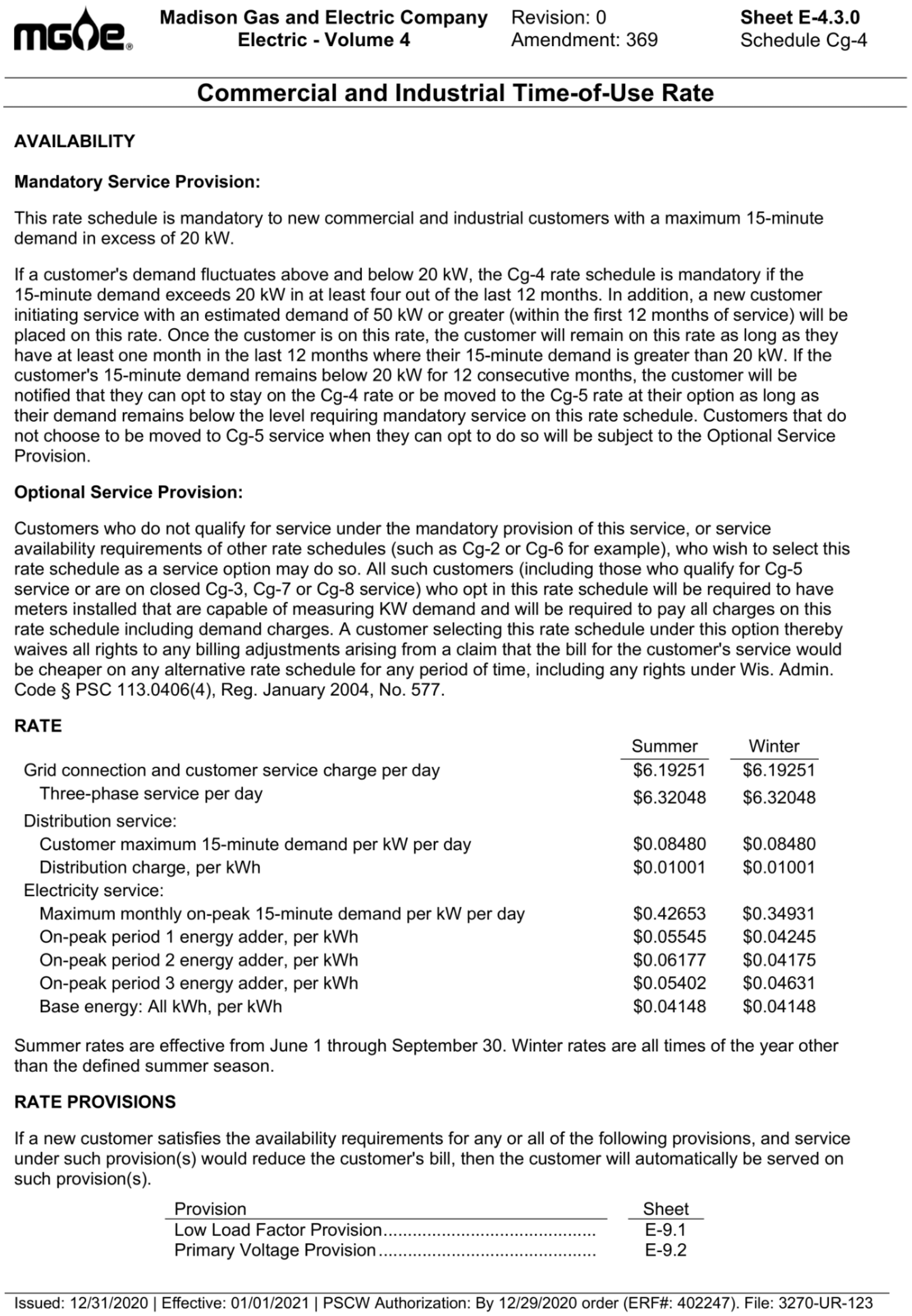
When estimating this benefit, SEPA assumed an annual rate increase of 2.5% for both energy and demand rates.

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 Holy Wisdom Monastery, this real-world resilience value should be based on its ability to provide emergency services to its onsite guests and 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: Schedule Cg-4, Commercial and Industrial TOU Rate



Madison Gas and Electric Company Electric - Volume 4	Revision: 0 Amendment: 369	**Sheet E-4.3.0** Schedule Cg-4

Commercial and Industrial Time-of-Use Rate

AVAILABILITY

Mandatory Service Provision:

This rate schedule is mandatory to new commercial and industrial customers with a maximum 15-minute demand in excess of 20 kW.

If a customer's demand fluctuates above and below 20 kW, the Cg-4 rate schedule is mandatory if the 15-minute demand exceeds 20 kW in at least four out of the last 12 months. In addition, a new customer initiating service with an estimated demand of 50 kW or greater (within the first 12 months of service) will be placed on this rate. Once the customer is on this rate, the customer will remain on this rate as long as they have at least one month in the last 12 months where their 15-minute demand is greater than 20 kW. If the customer's 15-minute demand remains below 20 kW for 12 consecutive months, the customer will be notified that they can opt to stay on the Cg-4 rate or be moved to the Cg-5 rate at their option as long as their demand remains below the level requiring mandatory service on this rate schedule. Customers that do not choose to be moved to Cg-5 service when they can opt to do so will be subject to the Optional Service Provision.

Optional Service Provision:

Customers who do not qualify for service under the mandatory provision of this service, or service availability requirements of other rate schedules (such as Cg-2 or Cg-6 for example), who wish to select this rate schedule as a service option may do so. All such customers (including those who qualify for Cg-5 service or are on closed Cg-3, Cg-7 or Cg-8 service) who opt in this rate schedule will be required to have meters installed that are capable of measuring KW demand and will be required to pay all charges on this rate schedule including demand charges. A customer selecting this rate schedule under this option thereby waives all rights to any billing adjustments arising from a claim that the bill for the customer's service would be cheaper on any alternative rate schedule for any period of time, including any rights under Wis. Admin. Code § PSC 113.0406(4), Reg. January 2004, No. 577.

RATE

	Summer	Winter
Grid connection and customer service charge per day	$6.19251	$6.19251
Three-phase service per day	$6.32048	$6.32048
Distribution service:		
Customer maximum 15-minute demand per kW per day	$0.08480	$0.08480
Distribution charge, per kWh	$0.01001	$0.01001
Electricity service:		
Maximum monthly on-peak 15-minute demand per kW per day	$0.42653	$0.34931
On-peak period 1 energy adder, per kWh	$0.05545	$0.04245
On-peak period 2 energy adder, per kWh	$0.06177	$0.04175
On-peak period 3 energy adder, per kWh	$0.05402	$0.04631
Base energy: All kWh, per kWh	$0.04148	$0.04148

Summer rates are effective from June 1 through September 30. Winter rates are all times of the year other than the defined summer season.

RATE PROVISIONS

If a new customer satisfies the availability requirements for any or all of the following provisions, and service under such provision(s) would reduce the customer's bill, then the customer will automatically be served on such provision(s).

Provision	Sheet
Low Load Factor Provision	E-9.1
Primary Voltage Provision	E-9.2

Issued: 12/31/2020 | Effective: 01/01/2021 | PSCW Authorization: By 12/29/2020 order (ERF#: 402247). File: 3270-UR-123

Commercial and Industrial Time-of-Use Rate

MINIMUM MONTHLY CHARGE

The minimum monthly charge will be the grid connection and customer service charge plus the demand charge for the customer maximum 15-minute demand multiplied by the number of days in the billing period.

PAYMENT

Payment is due not later than the due date shown on the bill. Any Company billing charges unpaid after the due date will be subject to a late payment charge as described in the Company's electric service rules under Late Payment Charge.

PRICING PERIOD DEFINITIONS

On-Peak Period 1	10 a.m. through 1 p.m.: Monday through Friday, excluding holidays.
On-Peak Period 2	1 p.m. through 6 p.m.: Monday through Friday, excluding holidays.
On-Peak Period 3	6 p.m. through 9 p.m.: Monday through Friday, excluding holidays.
Base Energy Period	Includes all hours of all days.
Holidays	New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas.

DETERMINATION OF DEMAND

1. All monthly demand and energy usage will be measured by meters installed and maintained by the Company. Estimates made by the Company, based on historic records plus known load characteristics, will be used for billing purposes if meter failure occurs.

2. The customer maximum 15-minute demand will be the greatest rate at which electrical energy has been used during any period of 15 consecutive minutes in the current or preceding 11 months.

3. The maximum on-peak 15-minute demand will be the greatest rate at which electrical energy has been used in 15 consecutive minutes during on-peak periods of the billing month.

CHARACTER OF SERVICE

For lighting and power service, 60-cycle, alternating current is provided at the voltage levels specified in the Company's electric service rules and regulations.

SPECIAL TERMS AND PROVISIONS

1. This rate schedule will remain in effect for a minimum of one year from the date consumption is initiated.

2. The meter must be located outside or in a location that is readily accessible by Company personnel during normal working hours.

3. Customers who have their meters turned off and back on within a 12-month period will pay the minimum monthly charges, applicable to the customer, for the months while service was not being used.