WISCONSIN OFFICE OF ENERGY INNOVATION HEART OF THE VALLEY METRO SEWER DISTRICT 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 the Heart of the Valley (HOV) Metropolitan Sewerage District (MSD), Kaukauna Utilities, and WPPI Energy.

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 wastewater treatment plant that serves 52,000 customers in Outagamie County 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, Heart of the Valley Metropolitan Sewerage District, Kaukauna Utilities, and WPPI Energy.

The feasibility study methodology included the following primary tasks:

1. **Stakeholder Engagement** - SEPA convened a core project team of key stakeholders to discuss the feasibility of a microgrid project at Heart of the Valley Metro Sewer District
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 three (3) 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 Heart of the Valley Metropolitan Sewerage District Facility (MSD) in Kaukauna, WI, as seen in Figure 0.1. The MSD facility serves 52,000 customers which is necessary for the health and well-being of the surrounding communities. In addition to the continued service provided to the surrounding communities, a prolonged outage to the MSD facility has the potential to cause a spill into the Fox River, a vital waterway that leads into the Bay of Green Bay and Lake Michigan.[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 MSD facility to identify scenarios that provided resilience to the full operational load and a scenario that provided resilience to just the primary liquids-only processing load, as seen in Table 0.1 and Figure 0.2, while utilizing solar photovoltaic, battery storage, and natural gas generator

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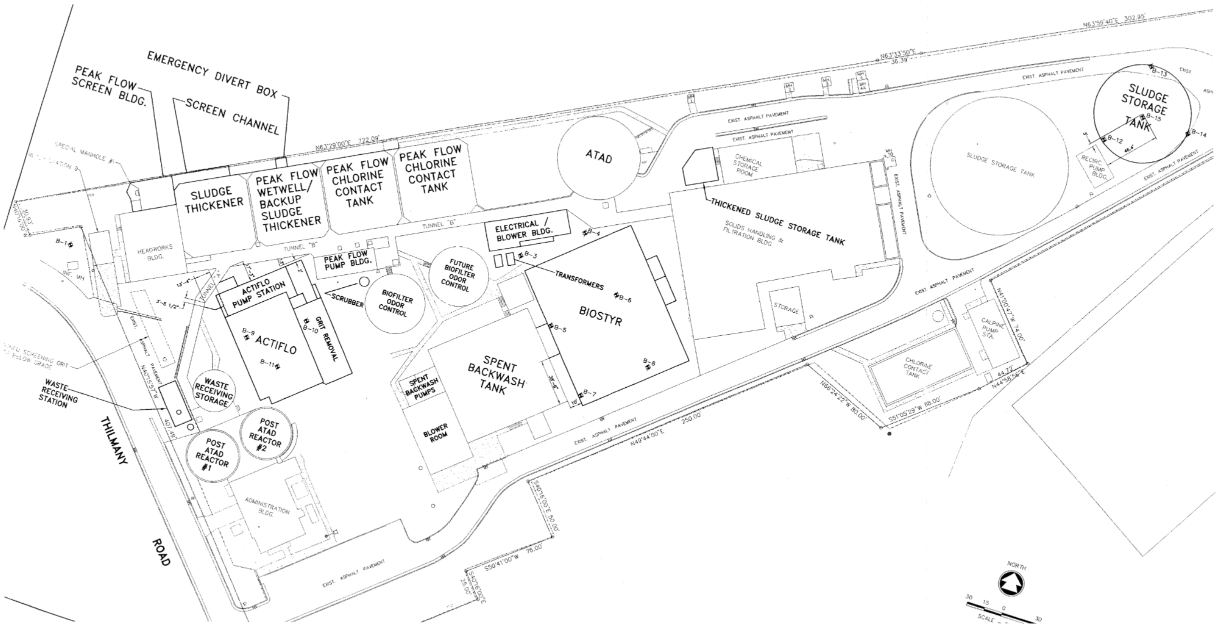
[1] https://apps.psc.wi.gov/ERF/ERFview/viewdoc.aspx?docid=420888

technologies. Based on input from the project team, this report also briefly addresses a “baseline” scenario, which offers a high-level comparative valuation for installing a 150 kW natural gas standby generator to support liquids-only processing during an outage. Though a full BCA was not completed for the “baseline” scenario, related costs are presented in the results.

Figure 0.1 – Heart of the Valley Metropolitan Sewerage District Facility Site Plan



Source: Heart of the Valley Metropolitan Sewerage District Facility, 2022

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

The microgrid components in this study include:

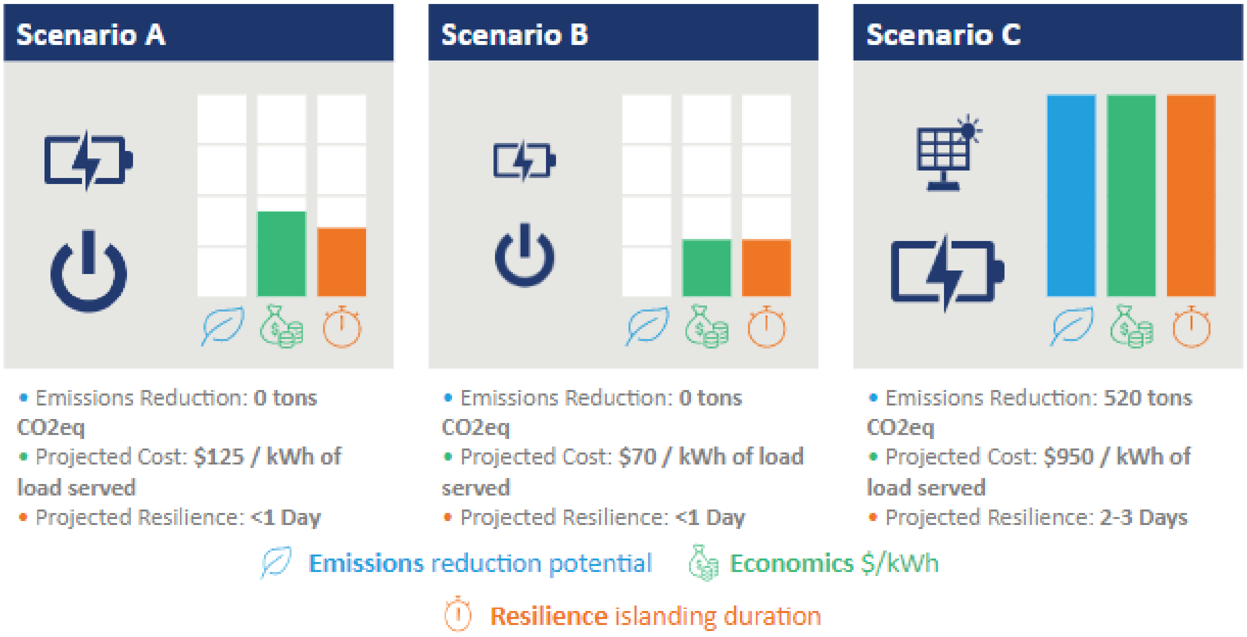
- Load: Heart of the Valley Metro Sewer District Facility
- Ground-Mounted Solar PV
- Battery Energy Storage System (BESS)
- Natural Gas Standby Generation
- Microgrid Controller
- Distribution System

Table 0.1 - Microgrid Scenario Summary

Scenario	Load	Solar	Solar kW-DC	Battery kW-DC	NG kW-DC
Scenario A	Full Operational Load	-	-	275	265
Scenario B	Primary Liquids-Only Load	-	-	150	150
Scenario C	Full Operational Load	Ground-Mounted Solar Only	35	2,850	45
“Baseline” Scenario	Primary Liquids-Only Load	--	--	--	150

Source: Smart Electric Power Alliance, 2022

Figure 0.2 – Overview of Proposed Microgrid Scenarios



Scenario A
- Emissions Reduction: **0 tons** CO2eq
- Projected Cost: **$125 / kWh** of load served
- Projected Resilience: **<1 Day**

Scenario B
- Emissions Reduction: **0 tons** CO2eq
- Projected Cost: **$70 / kWh** of load served
- Projected Resilience: **<1 Day**

Scenario C
- Emissions Reduction: **520 tons** CO2eq
- Projected Cost: **$950 / kWh** of load served
- Projected Resilience: **2-3 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 0.04 and 0.12, indicating that the NPV of costs outweigh the benefits in all scenarios. 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 three 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 the Heart of the Valley MSD, effectively reducing the BCR.

Table 0.2 - Summary of Costs and Benefits

Costs	Benefits*
● Generation (Solar Photovoltaic (PV) + Natural Gas Standby Generator (NG)) ● Battery Energy Storage System (BESS) ● Controller and Communications ● Distribution Upgrades ● 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 = 0.09	
Total NPV of Costs: $838,744	**Total NPV of Benefits:** $78,311
Scenario B: BCR = 0.12	
Total NPV of Costs: $359,574	**Total NPV of Benefits:** $42,715
Scenario C: BCR = 0.04	
Total NPV of Costs: $6,648,412	**Total NPV of Benefits:** $298,787

*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 Heart of the Valley Metropolitan Sewerage District, Kaukauna Utilities, WPPI Energy, and other local stakeholders to move to a more detailed benefit-cost analysis and ultimately to the implementation phase of microgrid development. The potential next steps include a determination of ownership and operation structures, further construction coordination, identification of financing and funding, and the development of a full engineering design and construction study. The continuation of strong engagement with community stakeholders through the implementation of the microgrid will facilitate the success of the project.

1.0 Introduction

A resilient energy system can absorb and recover in a timely manner from unavoidable external events, such as natural disasters. In recent years, the frequency and intensity of naturally occurring threats has substantially increased. Wisconsin suffered 32 billion-dollar disaster events costing over $166 billion in damages in the last 20 years. This is more than a 50% increase from eight such events costing $104 billion from 1980 to 2000.[2] Extreme weather events threaten the stability of the grid and cause power outages with attendant economic 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 Kaukauna, Wisconsin would bolster resilience for the facility's critical infrastructure function during emergency events, utilize renewable power sources, and provide energy savings and increase affordability for the facility.

1.1 Project Overview

Site and Customer Background

This report assesses the feasibility of utilizing a microgrid in building resilience for the Heart of the Valley MSD, a wastewater treatment facility in Kaukauna, WI.

Existing Infrastructure

The site consists of a 14.5 acre area containing a wastewater treatment facility, parking lot, and a service road that connects to all of the buildings. The site has an existing natural gas feed-in and hosts an interconnection point to Kaukauna's electric distribution grid.

Rationale for Microgrid

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

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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).

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.”[4]

Identification of Critical Infrastructure

As previously mentioned, the MSD facility serves 52,000 customers in the surrounding community. The site has two power sources from different substations but there are currently no back-up power solutions should both circuits fail. Should both circuits fail during a prolonged outage, tanks of raw influent water would start to overflow and contaminate the Fox River. The importance of sustained power at the MSD facility is vital to the health and wellbeing of communities along the Fox River, and further downstream to Bay of Green Bay, and Lake Michigan.

Key Partners and Stakeholders

Within this report, the core project team comprises stakeholders who supported the evaluation of preliminary microgrid scenarios to best support the Heart of the Valley MSD 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 the Heart of the Valley Metropolitan Sewerage District Facility.

SEPA, Heart of the Valley Metropolitan Sewerage District, Kaukauna Utilities, and WPPI Energy are the primary partners leading the project. Table 1.1 summarizes the role of each organization in carrying out the project.

Table 1.1 - Core Project Team and Responsibilities

Project Partners	Responsibility	Role
Heart of the Valley Metropolitan Sewerage District	Technical and strategic support	Microgrid customer and wastewater treatment facility
Kaukauna Utilities	Technical and strategic support	Local electricity distribution utility
Smart Electric Power Alliance (SEPA)	Stakeholder engagement and technical assistance	Microgrid feasibility study lead
WPPI	Technical and strategic support	Wholesale electricity supplier

Source: Smart Electric Power Alliance, 2022

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

Financial and Environmental Impact Analysis

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

1.2 Feasibility Study Methodology and Assumptions

Stakeholder Engagement

The core project team, composed of SEPA, Heart of the Valley Metropolitan Sewerage District, Kaukauna Utilities, and WPPI Energy discussed the resilience needs of the MSD site, and assessed feasibility in the development of a microgrid project. Each month, beginning in February 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. Heart of the Valley MSD provided historical facility load data in 15-minute intervals between November 1, 2020 and October 31, 2021. SEPA used this data in order to develop an hourly load profile for the load of the entire facility and the load from liquids-only processing. The estimated load data helped to quantify a load duration curve, which determines how much designed load the microgrid scenarios should serve.

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

System Sizing and Analysis

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

To determine solar PV site constraints, SEPA referenced a 2013 NREL study on land-use requirements for solar power plants which estimated the direct area capacity-weighted average land use of solar PV at 5.5 acres/MWac for a fixed-axis system. This value and the land available from the site assessment determined the maximum buildable solar capacity (kWac) on the site. To estimate the maximum buildable DC solar capacity, SEPA multiplied the maximum AC solar capacity by the conservative DC-to-AC ratio of 1.3 that was used in the study, instead of the ~1.18 value that was used in the NREL study.[5] As a result, estimates for maximum DC solar capacity might be slightly high.

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] For a standby generator, SEPA used a Generac 24 kW unit as a reference, which has a footprint of 3kW/sqft.[7]

Financial and Environmental Impact Analysis

SEPA carried out a financial and environmental impact analysis for each of the three scenarios that compared the net present values of project costs and benefits, including emissions reduction benefits, over a presumed 20-year lifespan. This report shares the net present values of costs and benefits associated with each of the three 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

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[5] The NREL study used a weighted-average PV derate factor of 0.85 that was calculated by dividing the AC reported capacity by the DC reported capacity for each project that was included in the study. This value implies a DC-to-AC ratio of 1 / (0.085) = 1.176.

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

[7] https://www.generac.com/all-products/generators/home-backup-generators/guardian-series/24kw-7210-with-200amp-ser-transfer-switch

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

The Heart of the Valley MSD facility is located on a 4.5 acre lot. Solar will not be installed on the wastewater treatment buildings, but instead will be deployed on the surrounding property. The site assets and parcel outline are shown in an aerial image below.

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

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

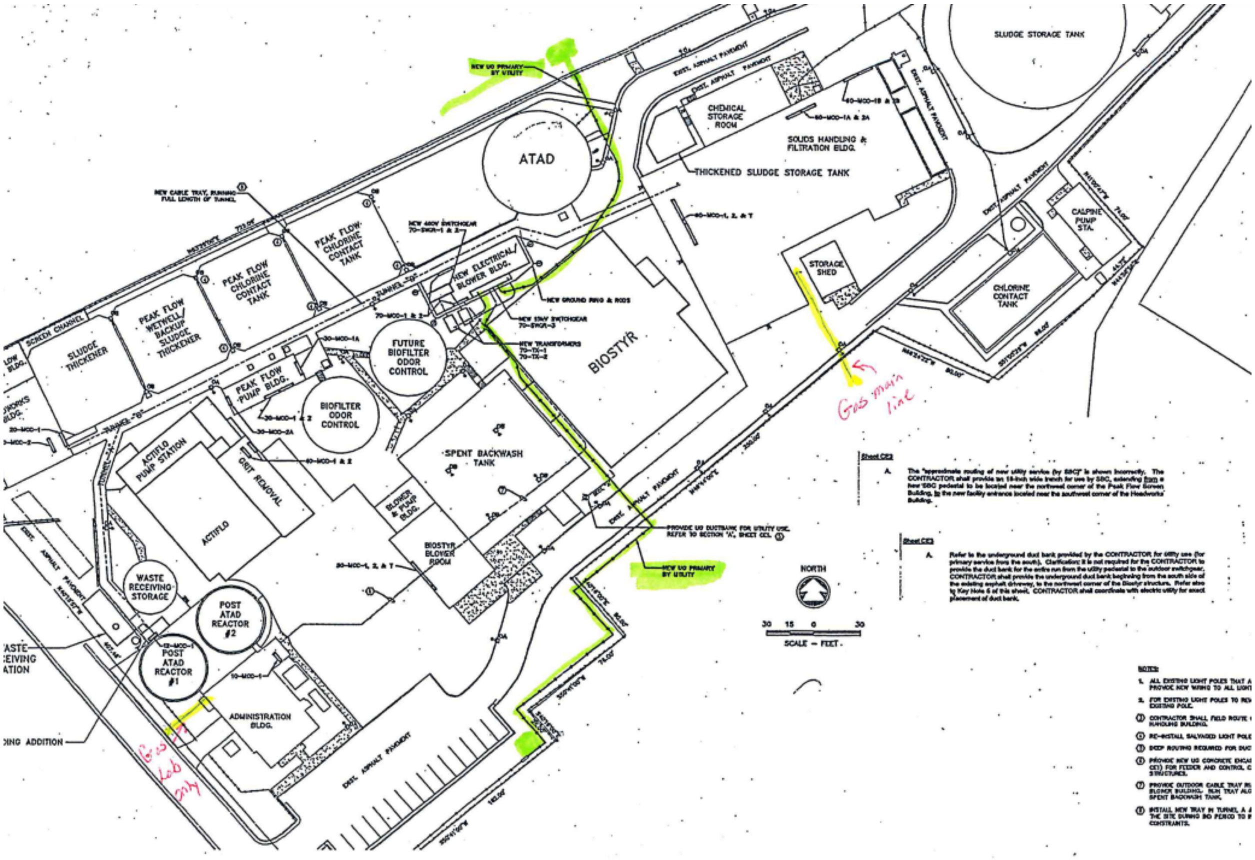
Available areas of the property are being considered for solar PV, battery energy storage, and natural gas standby back-up generation, along with microgrid controller functionality to allow for sustained islanding capabilities during a grid outage.

Detail infrastructure

The site has an existing natural gas feed-in and has two power sources from different substations. Despite the importance of ensuring a ride through during an extended outage, there are currently no back-up power solutions and no organizations have approached the MSD about a back-up power solution. Kaukauna Utilities along with the Heart of the Valley MSD is interested in pursuing a feasibility investigation to evaluate a microgrid system to serve the wastewater treatment facility.

Existing transformers, utility primary conductors, and natural gas lines are displayed on the map below.

*Figure 2.1.2 - **Site Infrastructure***



Sheet CE2

A. The "approximate routing of new utility service (by SBC)" is shown incorrectly. The CONTRACTOR shall provide an 18-inch wide trench for use by SBC, extending from a new SBC pedestal to be located near the northwest corner of the Peak Flow Screen Building, to the new facility entrance located near the southwest corner of the Headworks Building.

Sheet CE3

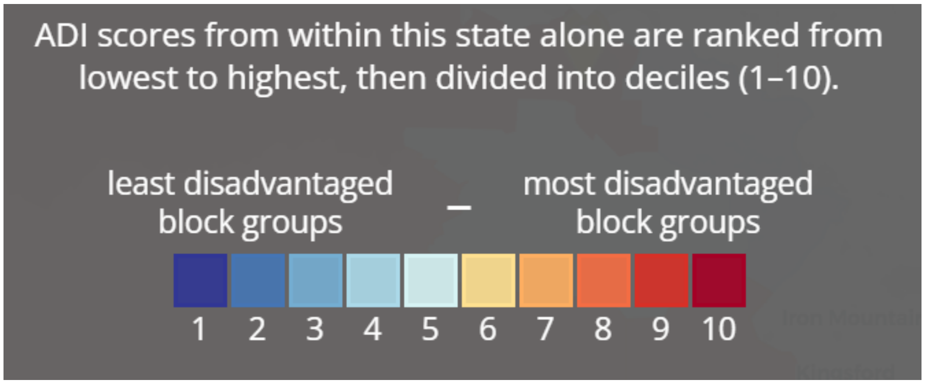
A. Refer to the underground duct bank provided by the CONTRACTOR for utility use (for primary service from the south). Clarification: it is not required for the CONTRACTOR to provide the duct bank for the entire run from the utility pedestal to the outdoor switchgear. CONTRACTOR shall provide the underground duct bank beginning from the south side of the existing asphalt driveway, to the northwest corner of the Biostyr structure. Refer also to Key Note 6 of this sheet. CONTRACTOR shall coordinate with electric utility for exact placement of duct bank.

Source: SEPA, 2022

Community vulnerability indicators

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

Figure 2.1.3 - ***State View: Area Deprivation Index Legend***



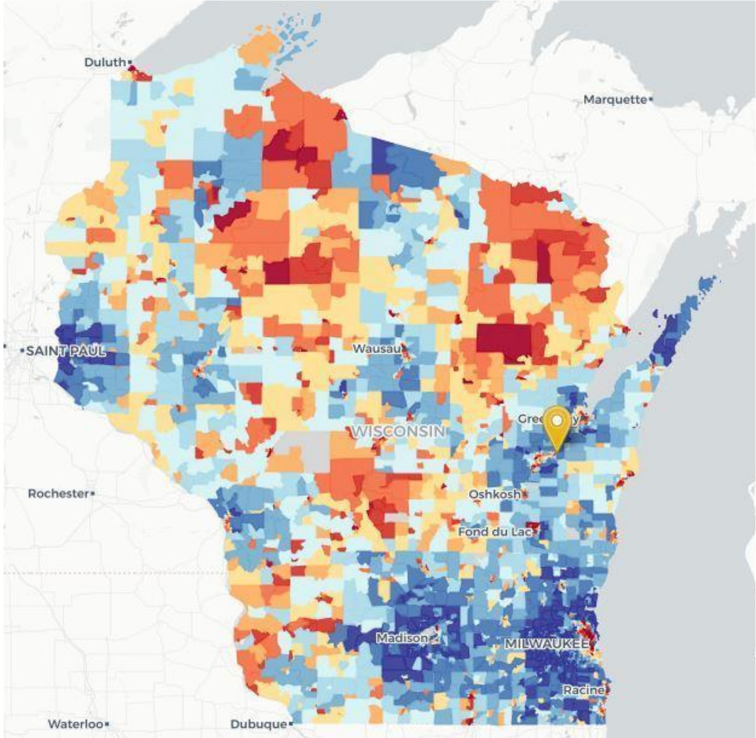
ADI scores from within this state alone are ranked from lowest to highest, then divided into deciles (1–10).

least disadvantaged block groups – most disadvantaged block groups

1	2	3	4	5	6	7	8	9	10

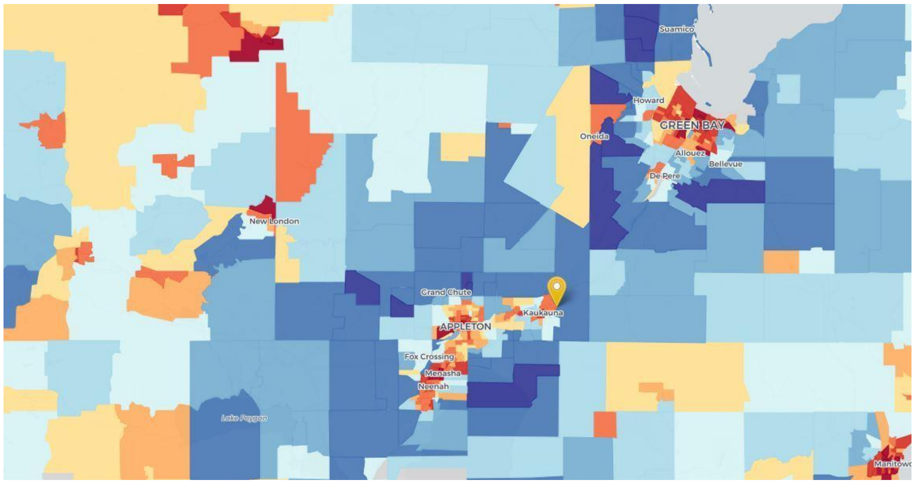
Source: University of Wisconsin-Madison, [Neighborhood Atlas Map](2021)

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



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

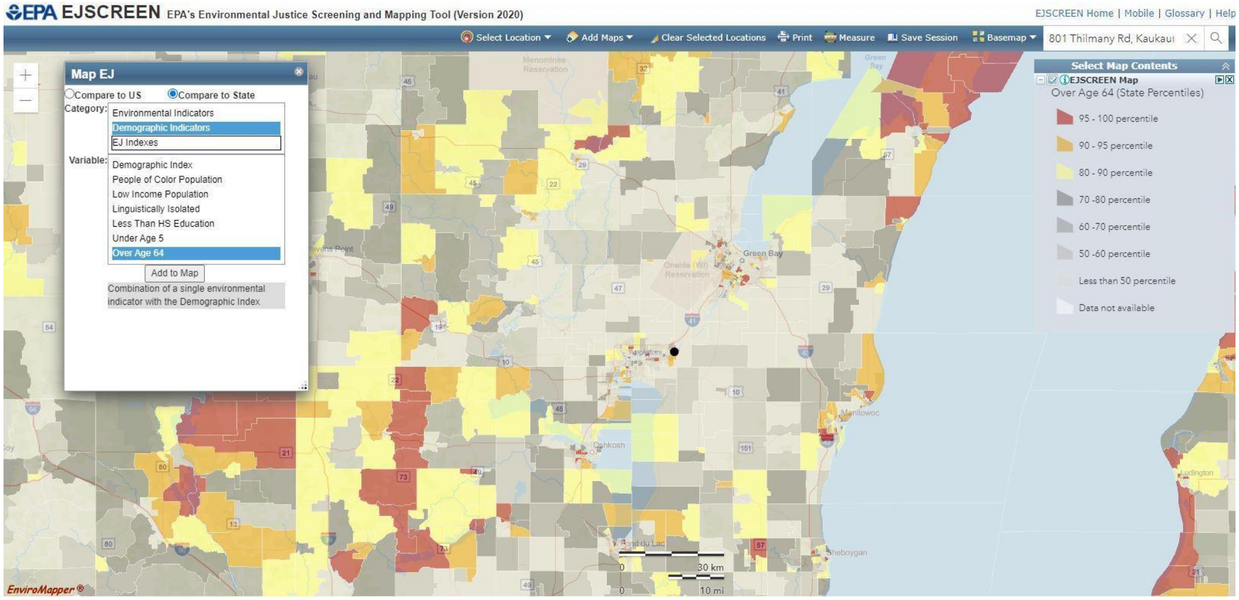
Figure 2.1.5 - ***Local View: Area Deprivation Index by Census Block Group***



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 site is located in an area where the percent of the population that is over the age of 64 is in the 90-95th percentile of the state.

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



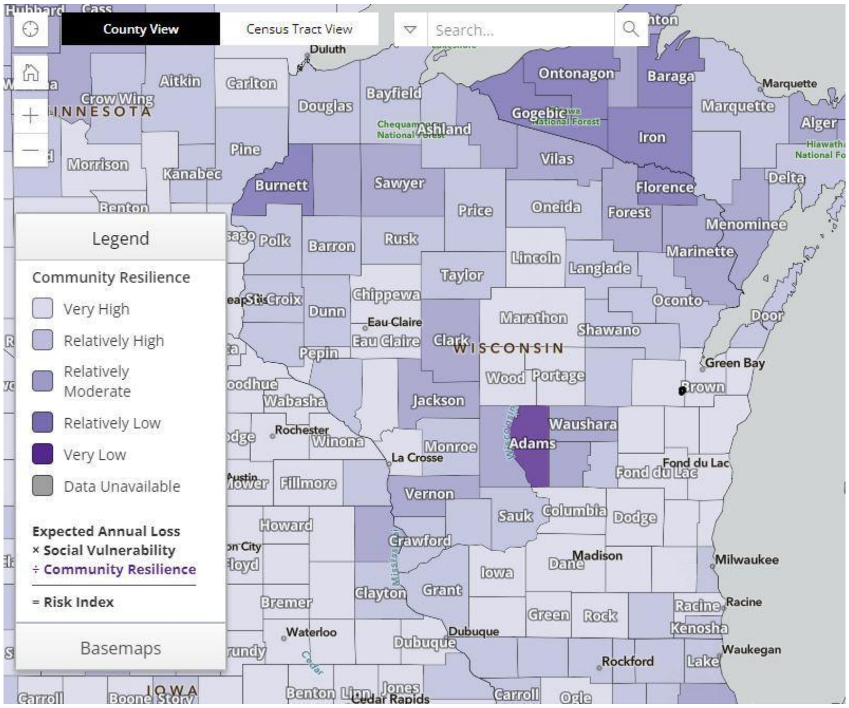
801 Thilmany Rd, Kaukau

○ Compare to US ● Compare to State
Category: Demographic Indicators
Variable: Over Age 64

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

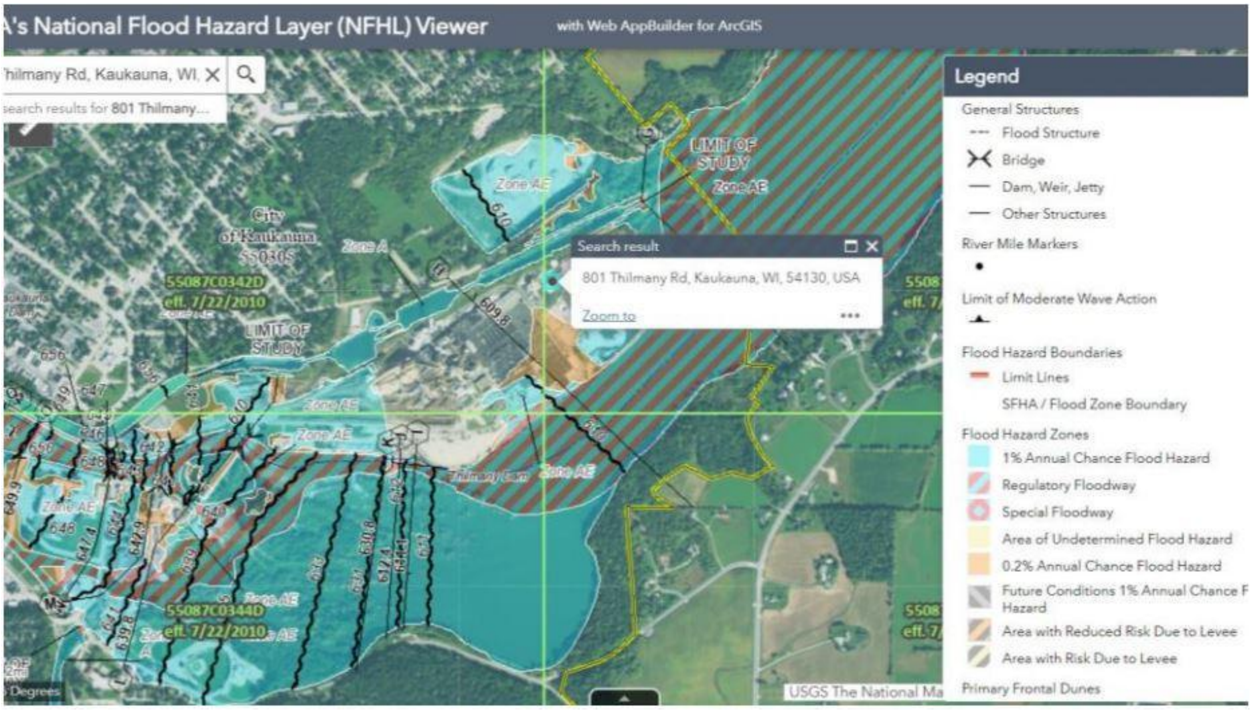
Figure 2.1.7 below indicates that the MSD facility site is located in an area that has very low to relatively low community resilience risk, and close proximity to flood zones.

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



Source: FEMA, [The National Risk Index](https://hazards.fema.gov/nri/)(2021)

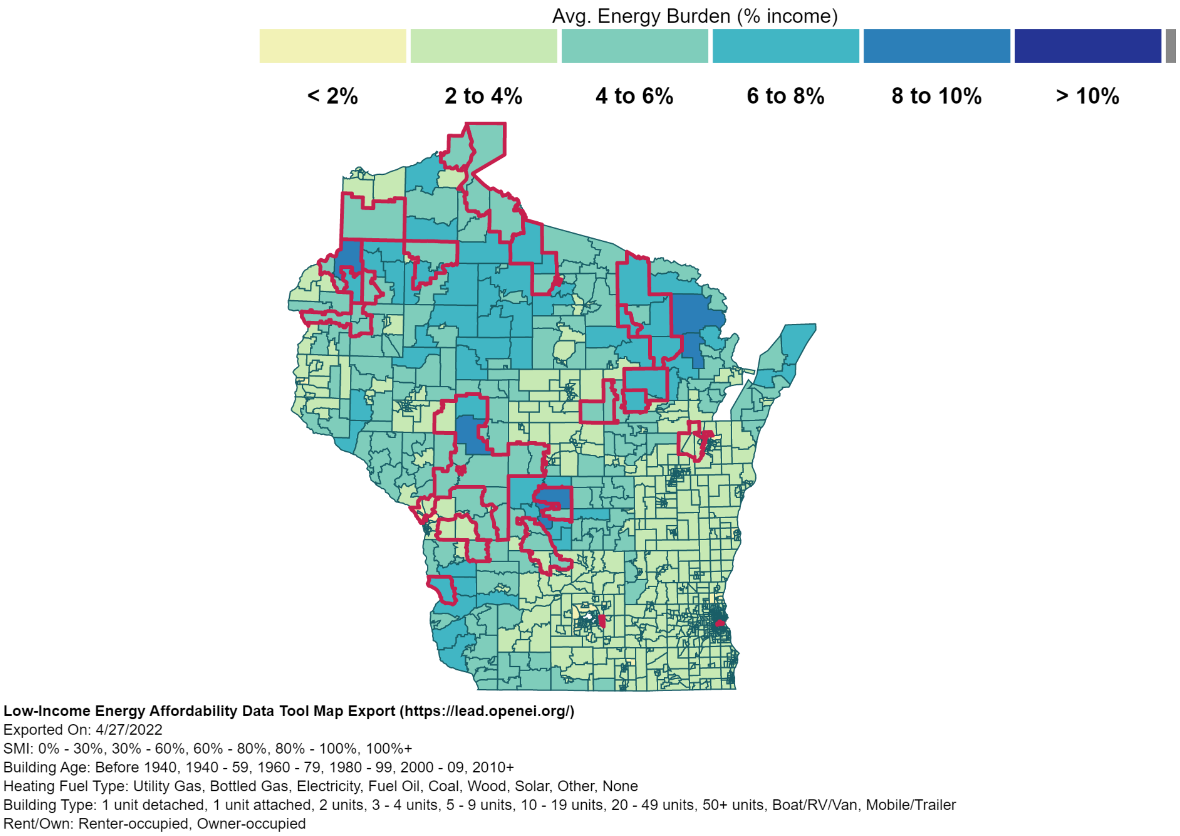
*Figure 2.1.8 - **Detailed Flood Hazards Near Proposed Site***



Source: FEMA, [National Flood Hazard Layer (NFHL) Viewer](https://hazards-fema.maps.arcgis.com/) (2021)

Below, Figure 2.1.9 indicates that the wastewater treatment facility is located in an area where the energy burden is lower (2%). The red outline on Figure 2.1.8 also delineates indigienous land, which is adjacent to the site.

*Figure 2.1.9 - **Average Energy Burden Near Proposed Site***



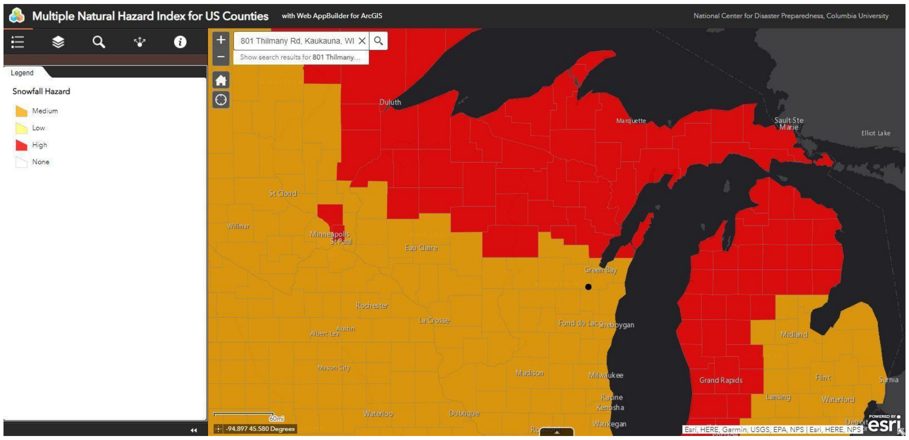
Low-Income Energy Affordability Data Tool Map Export (https://lead.openei.org/)
Exported On: 4/27/2022
SMI: 0% - 30%, 30% - 60%, 60% - 80%, 80% - 100%, 100%+
Building Age: Before 1940, 1940 - 59, 1960 - 79, 1980 - 99, 2000 - 09, 2010+
Heating Fuel Type: Utility Gas, Bottled Gas, Electricity, Fuel Oil,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

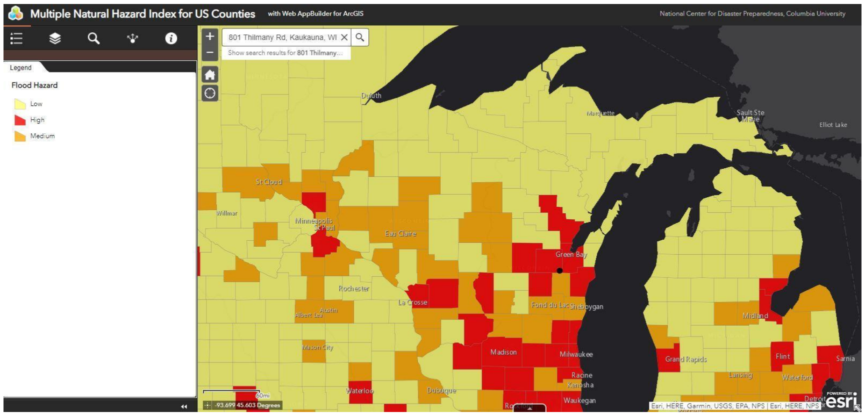
Figures 2.1.10 and 2.1.11 indicate the site has a moderate risk of snowfall hazards and high risk of flood hazards according to the National Center for Disaster Preparedness. A microgrid in this location may be ideal to support critical wastewater treatment services when other critical infrastructure is inundated. Figure 2.1.12 portrays the detailed flood hazards from FEMA.

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



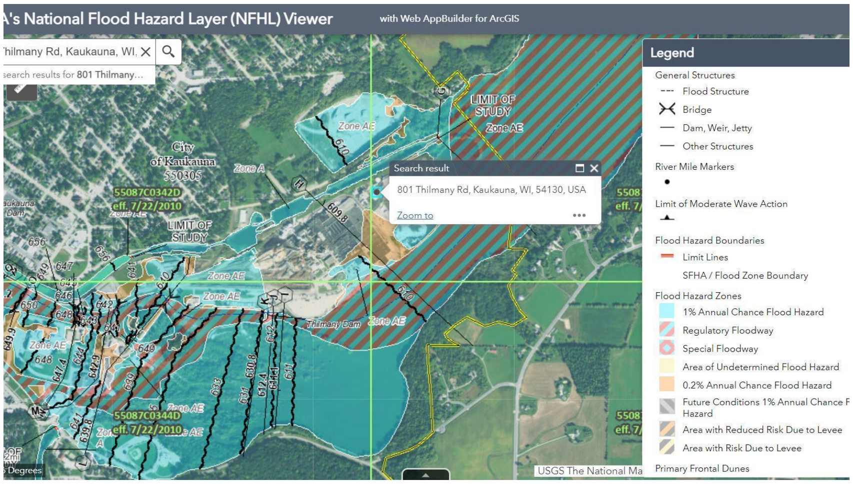
Source: Columbia University National Center for Disaster Preparedness, Multiple Natural Hazard Index for US Counties (2021)

Figure 2.1.11 - ***Flood Hazards Near Proposed Site***



Source: Columbia University National Center for Disaster Preparedness, Multiple Natural Hazard Index for US Counties (2021)

Figure 2.1.12 - ***Detailed Flood Hazards Near Proposed Site***



Source: FEMA, [National Flood Hazard Layer Viewer](https://msc.fema.gov/nfhl) (2021)

Site application and functionality

The Heart of the Valley MSD is interested in ensuring the operation of the facility in the event of a long duration power outage. The MSD facility serves the following communities with the associated population: Kaukauna (16,070), Kimberly (6,770), Little Chute (11,484), Darboy (14,114), and Combined Locks (3,577). The MSD facility has no existing generation or microgrid technologies but has an existing natural gas feed-in. Back-up power at the MSD facility is critically important to prevent a spill that would contaminate local waterways.

Critical services

The wastewater treatment facility will be utilized by the Heart of the Valley MSD and Kaukauna Utilities to ride-through during extended outages. Examples of critical services to be provided by the wastewater treatment facility are as follows:

- Liquids processing
- Solid handling
- Space heating
- Air conditioning
- Medical
- Refrigeration
- Charge critical tools
- Emergency response capabilities
- Oxygen
- WiFi
- Server storage

Customer information and historical outage information [pending update]

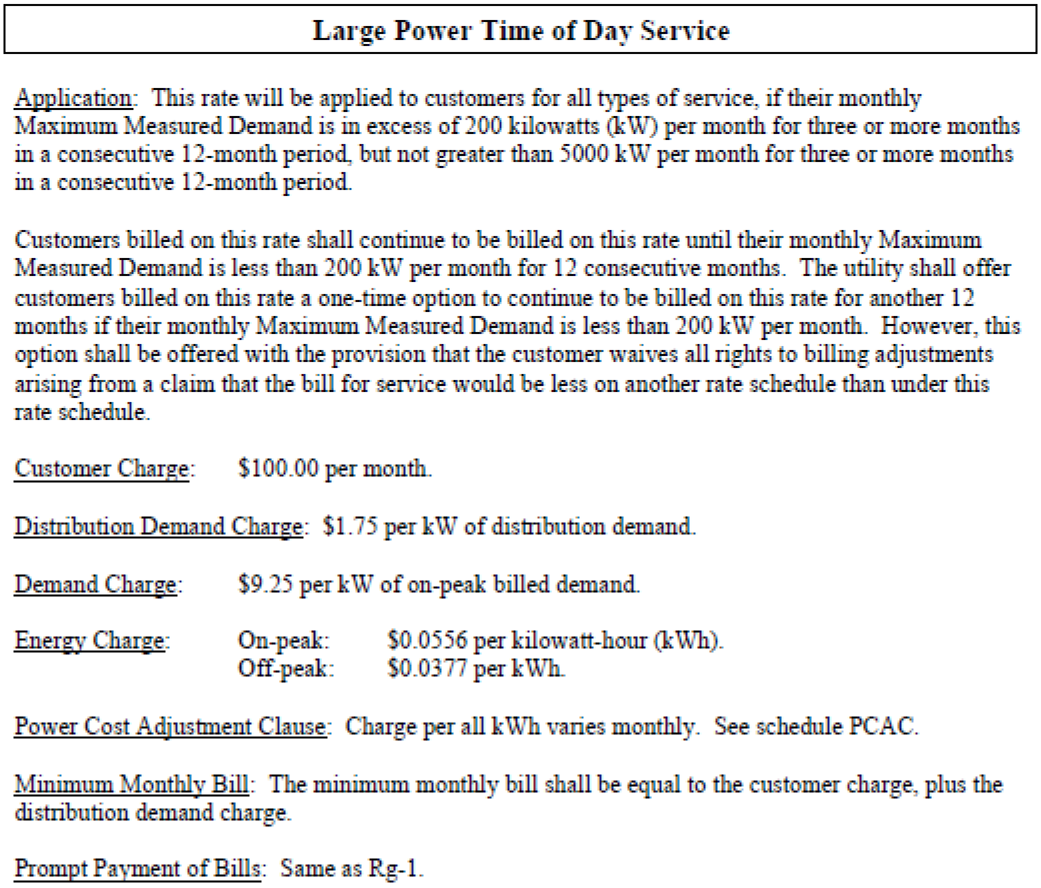
Kaukauna Utilities did not indicate that any significant outages have impacted the circuit to which the facility is connected, though this may not fully reflect the possibility of future outages. Since 2018, the circuit serving the wastewater treatment facility has experienced 5 outages, each lasting fewer than 45 minutes and impacting no more than 50 customers. Circuit reliability data can be found in

Due to its designation as critical infrastructure for Kaukauna, WI, it is imperative that the facility is able to operate during outage events.

Rate schedule

Kaukauna Utilities currently serves the wastewater treatment facility under the Large Power Time of Day Service – Cp-2 electric rate (Figure 2.1.13).

Figure 2.1.13 - Kaukauna Utilities Large Power Service (Cp-2) Rate Structure



Large Power Time of Day Service

Application: This rate will be applied to customers for all types of service, if their monthly Maximum Measured Demand is in excess of 200 kilowatts (kW) per month for three or more months in a consecutive 12-month period, but not greater than 5000 kW per month for three or more months in a consecutive 12-month period.

Customers billed on this rate shall continue to be billed on this rate until their monthly Maximum Measured Demand is less than 200 kW per month for 12 consecutive months. The utility shall offer customers billed on this rate a one-time option to continue to be billed on this rate for another 12 months if their monthly Maximum Measured Demand is less than 200 kW per month. However, this option shall be offered with the provision that the customer waives all rights to billing adjustments arising from a claim that the bill for service would be less on another rate schedule than under this rate schedule.

Customer Charge: $100.00 per month.

Distribution Demand Charge: $1.75 per kW of distribution demand.

Demand Charge: $9.25 per kW of on-peak billed demand.

Energy Charge: On-peak: $0.0556 per kilowatt-hour (kWh).
Off-peak: $0.0377 per kWh.

Power Cost Adjustment Clause: Charge per all kWh varies monthly. See schedule PCAC.

Minimum Monthly Bill: The minimum monthly bill shall be equal to the customer charge, plus the distribution demand charge.

Prompt Payment of Bills: Same as Rg-1.

Large Power Time of Day Service

Pricing Periods:

On-peak: 8:00 a.m. to 8:00 p.m., Monday through Friday, excluding holidays, specified below.

Off-peak: All times not specified as on-peak including all day Saturday and Sunday, and the following holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day, and Christmas Day, or the day nationally designated to be celebrated as such.

Discounts: The monthly bill for service will be subject to the following discounts applied in the sequence listed below.

Primary Metering Discount: Customers metered on the primary side of the transformer shall be given the following discounts on the monthly energy charge, distribution demand charge, and demand charge.

2,300 volts to 15,000 volts inclusive: 2.0 percent
Or:
Above 15,000 volts: 3.0 percent

The PCAC and the monthly customer charge will not be eligible for the primary metering discount.

Service Voltage Discount: Customers who own and maintain their own transformers or substations shall be given a credit of:

$0.20 per kW of distribution demand if receiving service from 2,300 volts to 15,000 volts, inclusive
Or
$0.40 per kW of distribution demand if receiving service above 15,000 volts

Customer-owned substation equipment shall be operated and maintained by the customer. Support and substation equipment is subject to utility inspection and approval.

Large Power Time of Day Service

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

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

Determination of On-peak Billed Demand: On-peak Billed Demand shall be the On-peak Maximum Demand.

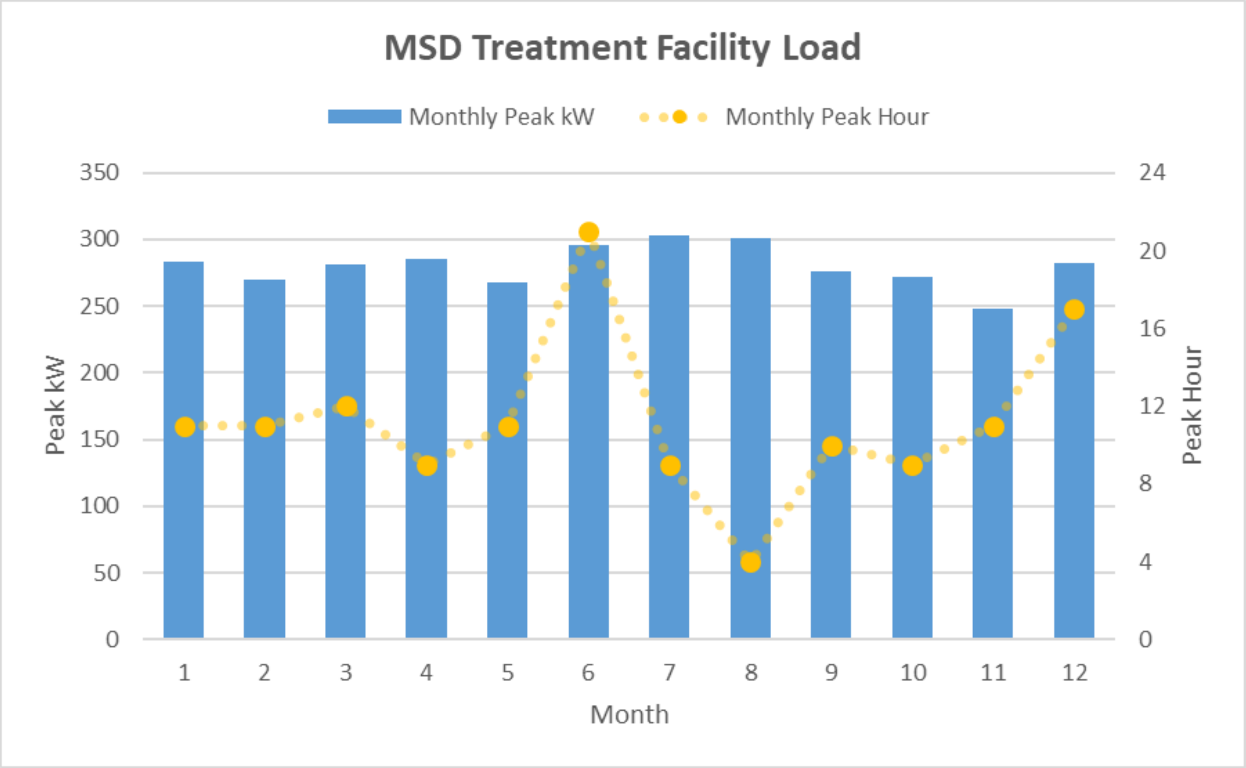
2.2 Initial Load and Solar Analysis

Load Analysis

Several different load and asset mix scenarios served as additional inputs in the microgrid sizing, siting, and financial analysis processes. For this study, SEPA considered three load scenarios. In the first scenario, the microgrid would serve the wastewater treatment facility's entire load. In the second and third scenarios, the microgrid would only serve the liquid processing load of the wastewater treatment facility.

The load depends on the time of year and time of day. The wastewater treatment facility's load peaks in the summer, but is generally consistent throughout the year as a result of the facility's 24/7 industrial-scale operations. Throughout the year, the load peaks in the mid-morning, though in June and December it peaks much later in the day and in August it peaks early in the morning. Figure 2.2.1 illustrates the variation of the facility's load throughout the year.

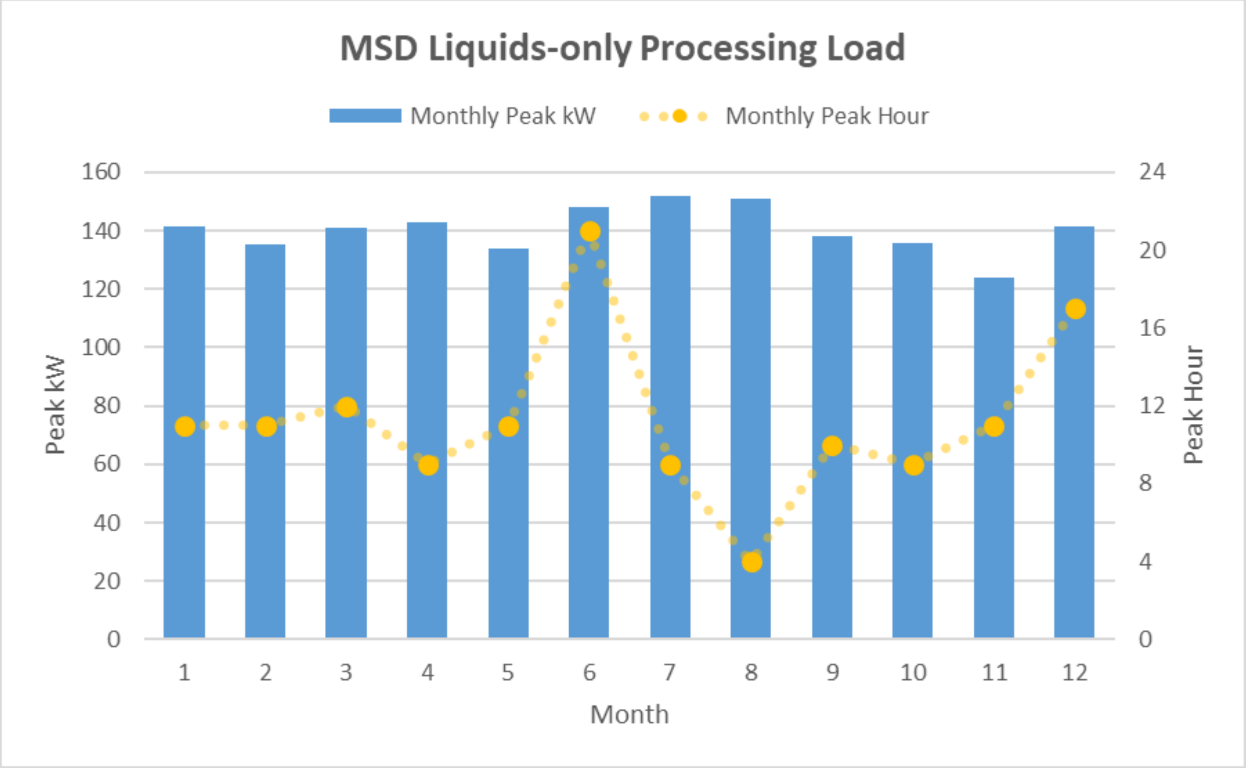
Figure 2.2.1 - Heart of the Valley MSD Load by Month



Source: Smart Electric Power Alliance, 2022

The liquids-only processing load, which accounts for about half of the facility's total load, has a similar profile to the full-capacity load, but with smaller peaks that can be met at a lower cost during an emergency or extended outage. The liquids-only processing load, as shown in Figure 2.2.2, peaks at the same time as the whole facility, but peaks at around 150 kW in July, rather than 300 kW at full capacity.

Figure 2.2.2 - Heart of the Valley MSD Liquids-only Processing Load



Source: Smart Electric Power Alliance, 2022

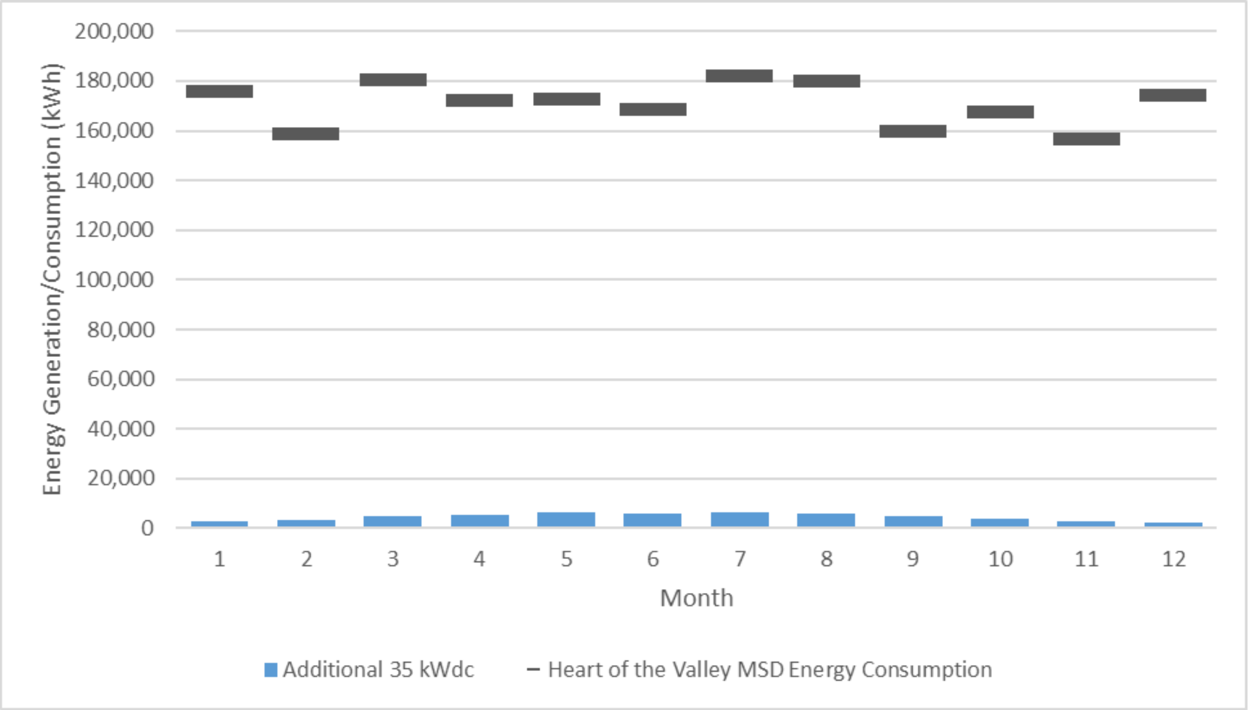
Solar Analysis

Within the asset mix scenarios, SEPA evaluated various combinations of solar PV, battery storage, natural gas standby generation, and islanding duration. Due to the limited available green space, solar was only considered for one scenario. In that scenario, the combined 6,516 square feet of space amounted to 35 kWDC of potential solar PV. To estimate hourly solar production at the site throughout the year, SEPA used NREL's PV Watts Calculator and the following inputs to build an annual baseline solar generation profile:

- **Solar Resource Data Site:** Lat, Lon: 44.29, -88.26
- **DC System Size:** 1000 kW
- **Array Type:** Fixed (open rack)
- **System Losses:** 14.08%
- **Tilt:** 20°
- **Azimuth (deg):** 180°

First, SEPA adjusted the baseline solar profile to match the proposed solar capacity. SEPA then modeled each of the asset mix scenarios in order to estimate financial and environmental benefits related to that solar generation. Figure 2.2.3 highlights the average monthly solar generation for each scenario alongside monthly energy consumption at the site.

Figure 2.2.3 - Proposed Solar Generation and Energy Consumption at Heart of the Valley MSD by Month



Source: Smart Electric Power Alliance, 2022

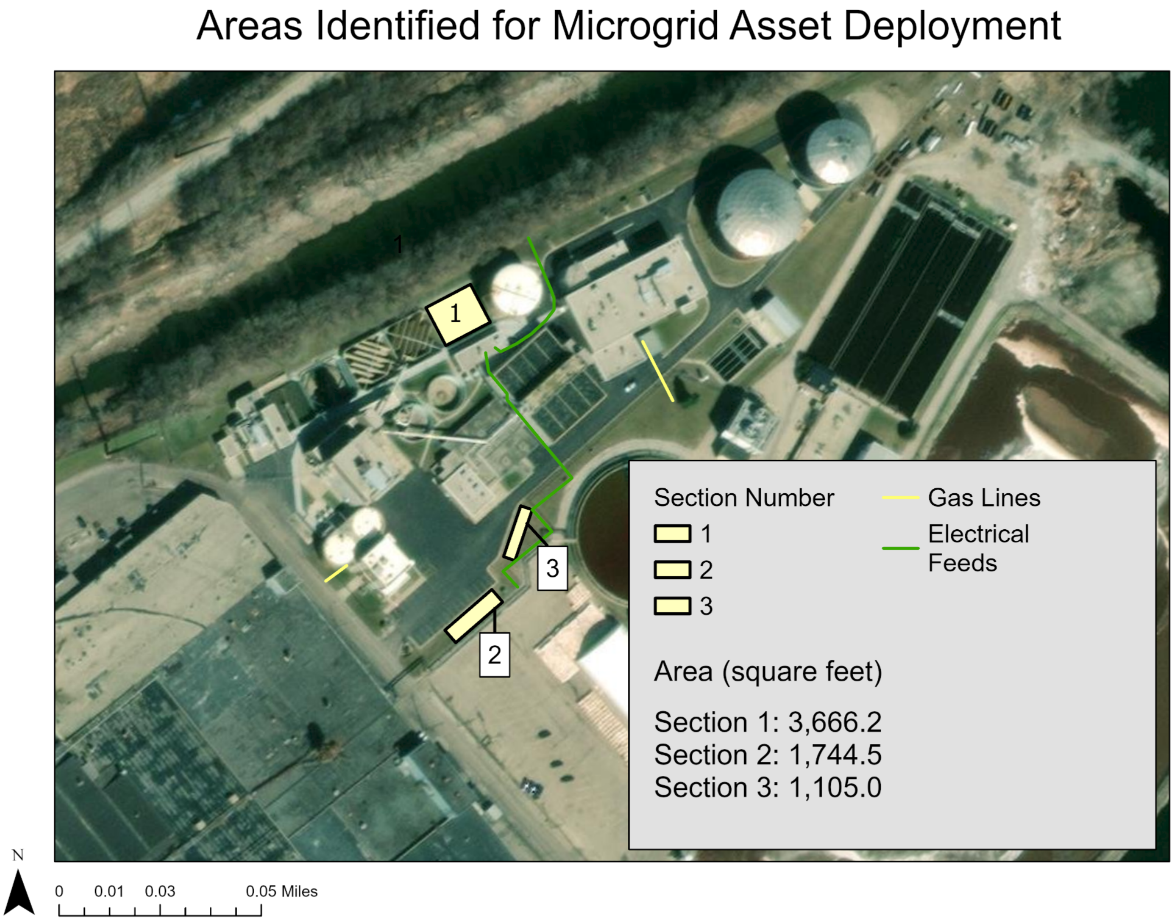
Following the initial solar and load analysis, SEPA sized different variations of battery energy storage to shape solar production and provide back-up emergency generation during outages. In cases where solar and battery storage scenarios were unable to serve the site's entire load, SEPA sized standby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

2.3 Site Availability

The team calculated the site availability of solar energy, battery energy storage, and natural gas standby generation with the support of the Heart of the Valley MSD. As illustrated in Figure 2.3.1, the MSD facility and Kaukauna Utilities provided SEPA with the site layout, electrical plans, and natural gas lines, which were used to identify three potential sections of the property that could host microgrid assets. The three sections for potential microgrid asset installation were identified in accordance with relevant building and fire codes. The site assessment ensured that solar areas adhered to the following wisconsin solar regulstions;

- The site was note located within 10 feet of a chimney or vent on the roof
- The site avoided areas demarcated by weland soil indicators
- The site did not extend beyond the roof
- And the ground-mount systems did not exceed half the building footprint of the principle structure

Figure 2.3.1 - Heart of the Valley MSD Site Map



Source: SEPA, 2022

Site Assessment for Solar PV

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

Table 2.3.1 - Heart of the Valley MSD Facility Map Key

Parcel	Usable Ground Area	Potential Solar PV (kW DC)
1	3,666 sq. ft	20
2	1,745 sq. ft	9
3	1,105 sq. ft	6
Total	**6,516 sq. ft**	**35**

Source: Smart Electric Power Alliance, 2022

Site Assessment for Microgrid Assets

Potential spacing for microgrid assets is available in the northwest and southwest corners of the site between the odor control and pump stations. The feasibility of these locations are subject to review by the Heart of the Valley MSD and other stakeholders. A required site review will also assess site civil limitations and clearances to safely operate the equipment. Additionally, the facility would likely choose to install screening planting around the electrical service equipment. Screening planting was not considered in the scope of this assessment.

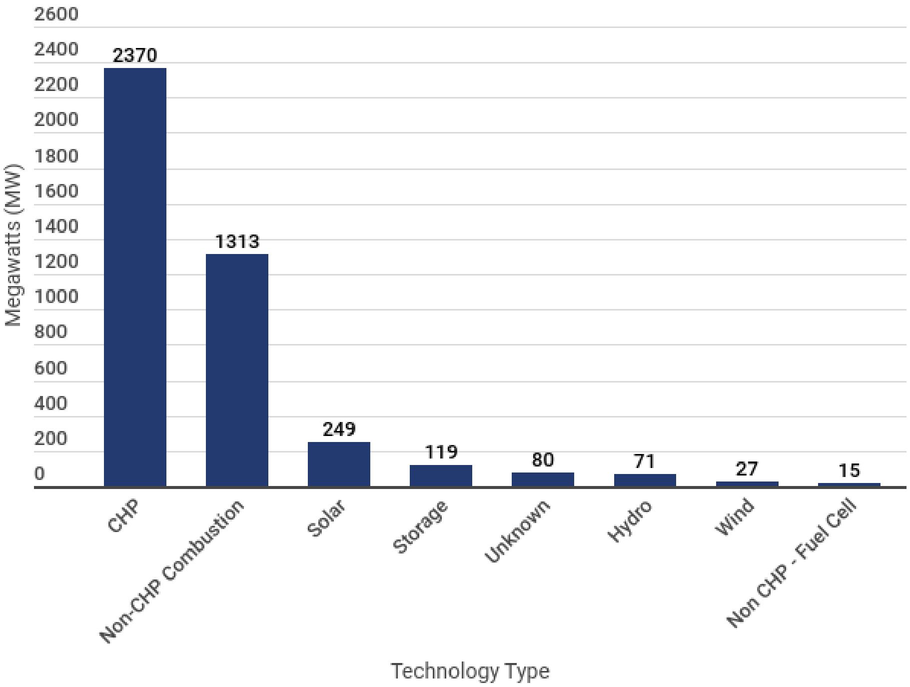
Existing Electric and Natural Gas Feed-In

Kaukauna Utilities identified the location of the existing natural gas main feeds and electric distribution feeder on the southwestern and western sides of the MSD facility to support the preliminary siting of the natural gas generator and battery storage system. These assets are tentatively sited near the northwest edge of the facility due to the proximity of both the electric distribution feeder and the natural gas line.

3.0 Microgrid Scenarios Development

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

Figure 3.1 - Current Microgrid Installations by Technology



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

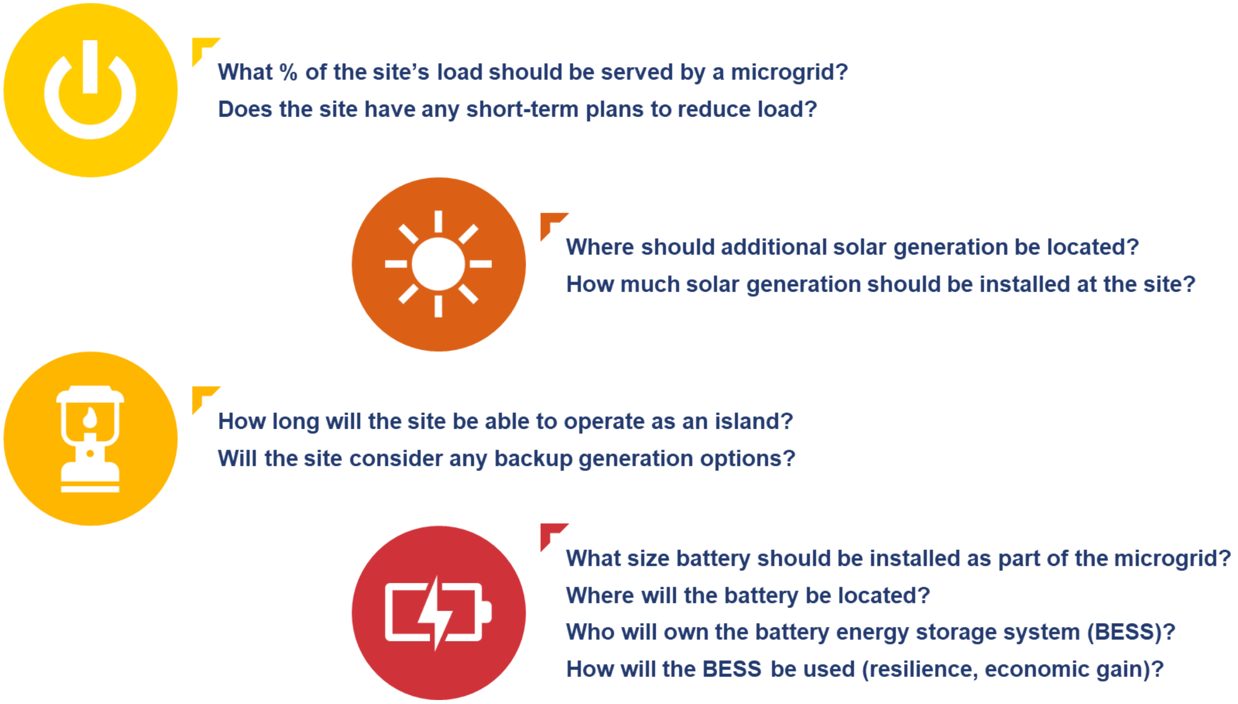
3.1 Stakeholder Process and Findings

When determining potential asset mix and load scenarios for the Heart of the Valley MSD facility 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 Heart of the Valley MSD and local utility, provided input regarding project requirements to meet resilience, sustainability, and environmental goals. SEPA met with the full project team on a monthly basis to discuss scenario development considerations and study progress. During the February March check-in meetings, the team held discussions around microgrid resilience needs at the wastewater treatment plant 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 3.2.

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. Covering just the liquids processing at the facility could be a more cost-effective way to effectively ride-through an outage.that is less 24 hours, at which point the solids would need to be processed.
2. Solar PV is an impractical resource to serve the entire load of the wastewater treatment plant during an extended outage based on the limited space on-site..
3. The limited solar availability also lessens the benefits that a larger battery could provide given the limited generation that the battery could use to charge.
4. Natural gas infrastructure already exists at the Heart of the Valley MSD facility and microgrid scenarios could potentially utilize natural gas standby generation to provide long-term cost-effective resilience for outages.
5. A percentage of the battery capacity will be charged and reserved for short-term resiliency benefits. During normal grid operations, the remaining percentage of the battery capacity will be utilized for economic dispatch - either peak shaving or energy arbitrage.

3.2 Microgrid Scenarios

Overview

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

Table 3.2.1 - Microgrid Scenario Components

Scenario	Load	Solar	Solar kW-DC	Battery kW-DC	NG kW-DC	Island Days[8]
Scenario A	Full Operational Load	-	-	275	265	<1*
Scenario B	Primary Liquids-Only Load	-	-	150	150	<1*
Scenario C	Full Operational Load	Ground Mounted Solar Only	35	2,850	45	2 Days
"Baseline" Scenario	Primary Liquids-Only Load	-	-	-	150	365**

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

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. 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.

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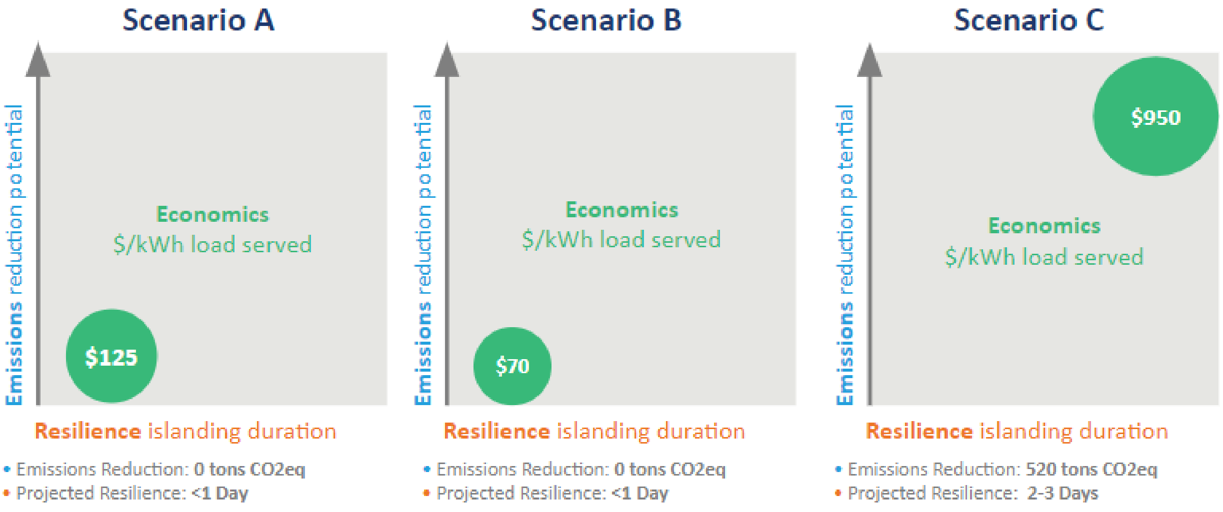
[8] This value is an estimate of the duration of islanding capability that the microgrid can provide on a typical day during the peak load month, July. Estimates may be given as a range to account for fluctuations in islanding capability based on instantaneous weather and grid conditions. Islanding duration 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.

Figure 3.2.1 summarizes relative emissions reductions, projected costs (per kWh load served), and resilience capabilities for each microgrid scenario. The costs, carbon emissions, load coverage and grid support all vary in each of the three designs. The designs range from inexpensive to most expensive, carbon free to significant natural gas generation.

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



Source: Smart Electric Power Alliance, 2022

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

Scenario Pros and Cons

The three microgrid design scenarios present their own benefits and drawbacks. A key finding is that the limited space at the wastewater treatment facility makes it impractical to deploy solar as a microgrid asset. Additionally, the solar constraints and significant load at the site make battery storage an impractical long-term resilience measure given that it would need to be charged primarily from the grid.

Scenario A considers the benefit of a relatively modest BESS to provide short-term resilience and some economic benefit through energy arbitrage, and an appropriately sized standby natural gas generator to meet 100% of the facility's load during a long-term outage. This scenario does not include any solar PV, and would rely on the continuity of the natural gas distribution system to provide backup power to the facility during an outage.

Scenario B mirrors scenario A in that it considers the benefit of a relatively modest BESS to provide short-term resilience and some economic benefit through energy arbitrage, and an appropriately sized standby natural gas generator. In contrast, scenario B provides a cheaper alternative to scenario A, by only considering the load of liquids-only processing and proposing a smaller battery and natural gas backup generator to meet those needs. As with Scenario A, the facility would rely on the continuity of the natural gas distribution system to provide backup power to the facility during an outage. Given the more limited microgrid components, scenario B would not permit the facility to operate at full capacity in the event of a long-term outage.

Scenario C, the most costly and only 100% renewable design, serves the load of the entire site for multiple days without the need for backup fossil generation. The scenario proposes a small amount of on-site solar PV, though this additional generation would mostly serve to provide an economic benefit through energy savings and demand reduction during the day. The space constraints at the site make it impossible to build a sufficient amount of solar PV to provide a notable resilience benefit during an extended outage through daytime generation and battery charging. Given the limited solar PV capacity, the oversized battery in this scenario would only be able to provide about 2 days of resilience at full processing capacity.

A “baseline” scenario, which proposes a 150 kW natural gas standby generator in lieu of a microgrid is also presented for comparison.

Microgrid scenarios that propose a more renewable or 100% carbon-free microgrid, such as scenario C, require a significant amount of solar PV and battery storage, which can substantially increase the cost of a project. While the supplementation of a microgrid with natural gas prevents the project from being powered entirely by renewable energy, its inclusion in the form of back-up generation is often necessary to serve the load of the entire site while reducing project cost and increasing resilience. Though it is not the most renewable option, SEPA recommends that MSD focus microgrid planning around the compact and cost-effective resilience provided by natural gas standby generation, given the constraints of the site. To reduce the emissions associated with this standby generation, MSD may want to research technologies such as co-generation or wastewater biogas in future analyses.

4.0 Microgrid Feasibility

4.1 Preliminary Engineering Considerations

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

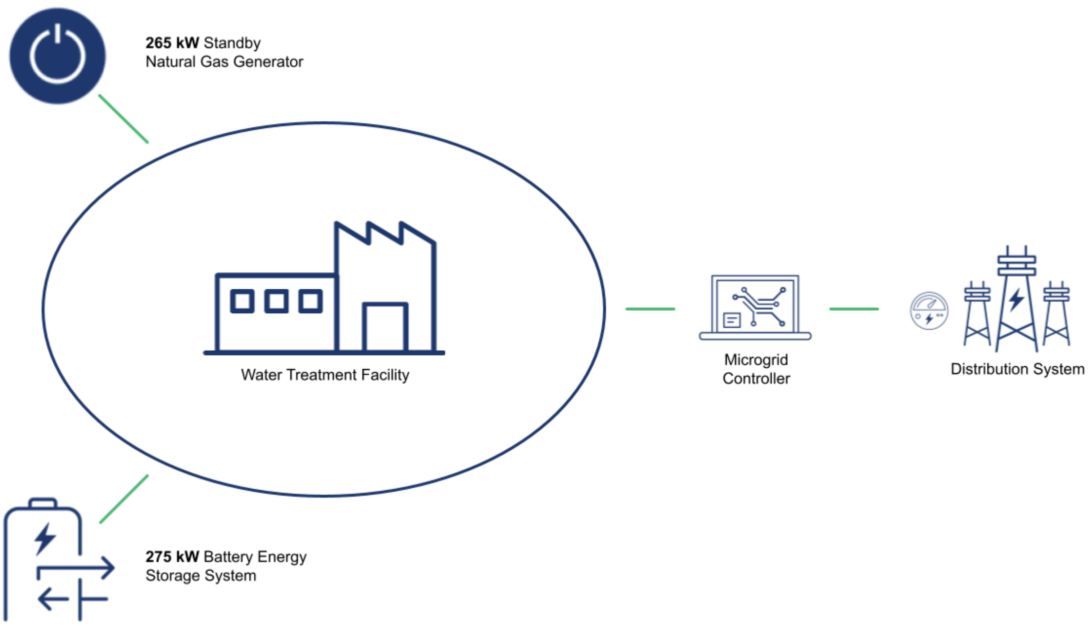
For the purposes of this analysis, it is assumed that Kaukauna Utilities will own and operate the medium voltage distribution infrastructure. For Scenario C, Kaukauna utilities or a third-party would likely operate the large battery storage system in partnership with HoVMSD for energy arbitrage, peak shaving, MISO operations, and resiliency benefits. Typically these arrangements include a revenue share between all entities. Potential microgrid operating modes may include black start services, and other emergency and grid-connected services. In general, the scope of the necessary fieldwork is largely agnostic to the ownership model.

SEPA designed scenarios A-C to serve the Heart of the Valley MSD facility, with one of those scenarios, scenario B, focused on serving primary liquids-only load, through a mix of ground-mounted solar, battery storage, and natural gas generation. Solar was only incorporated into scenario C due to limited space availability at the site.

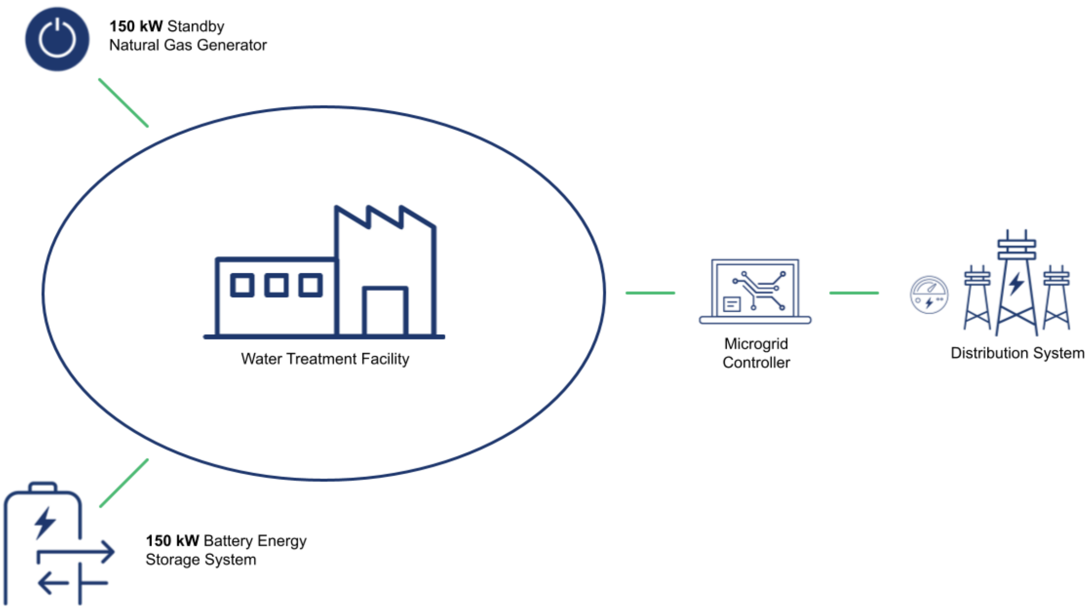
Site Layout

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.

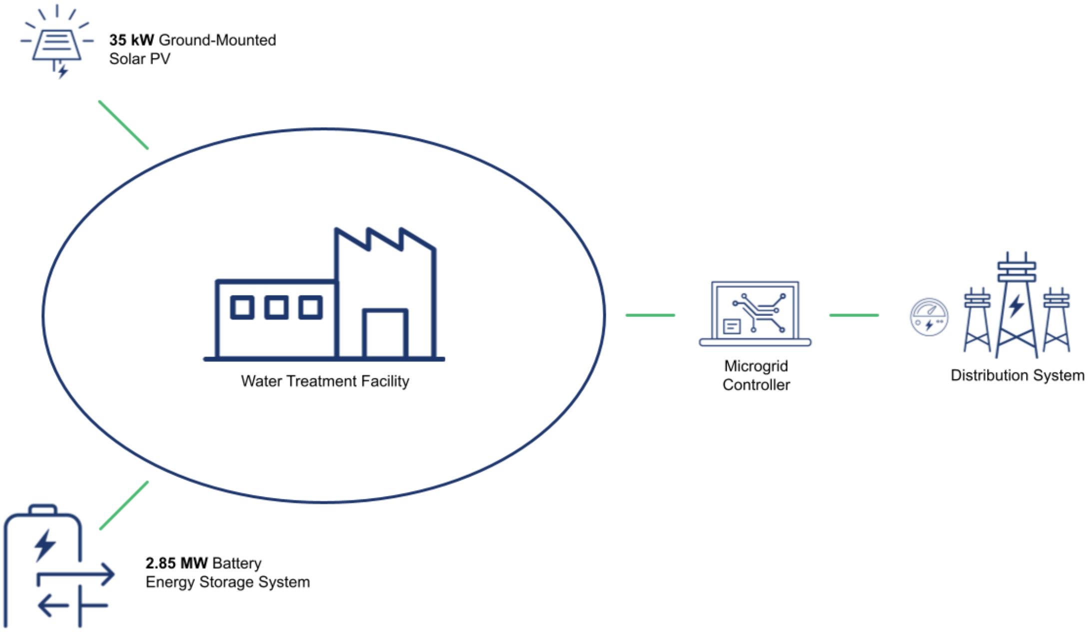
Scenario A: Full Operational Load



Scenario B: Primary Liquids-Only Processing



Scenario C: No Fossil



Microgrid Operations

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

Operating Mode 1: Normal Operation/Blue Sky

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

The battery storage system would also be used to reduce demand charges, or engage in energy arbitrage, bringing in revenue to offset costs.

Operating Mode 2: Microgrid Operation - Disconnecting from the Grid

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

Operating Mode 3: Microgrid Operation – Resuming Normal Operation

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

Interconnection

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

Microgrid

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

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

Solar, Natural Gas, and Battery Storage

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

For layout purposes, SEPA assumed the footprint of the battery storage system in each scenario to be between 125 and 2,250 sq ft. based on battery sizes and available references.[9]

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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.

In turn, the footprint of natural gas generators was assumed to be between 50 and 88 sq ft. based on generator capacity and available references.[10] Exact dimensions will depend on the equipment vendor selected.

Infrastructure Updates

Gas

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

4.2 Financial and Environmental Impact

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

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

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

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

All three proposed Heart of the Valley MSD facility microgrid scenarios would provide uninterrupted power to the facility for an extended period. The use of renewable generation assets in Scenario C will result in multiple benefits associated with clean on-site generation.

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[10] SEPA used a Generac 24 kW unit as a reference, which has a footprint of 3kW/sqft.

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 and excess energy will be reimbursed at the avoided cost rate. The emissions reduction value associated with solar generation is the same regardless of interconnection method. No additional “grid services” are assumed for the microgrid components – such as dispatch of either the battery or natural gas generator.[11]

This project focused on the full operational load of the Heart of the Valley MSD facility as well as the liquids-only processing load from the facility. 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[12], 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

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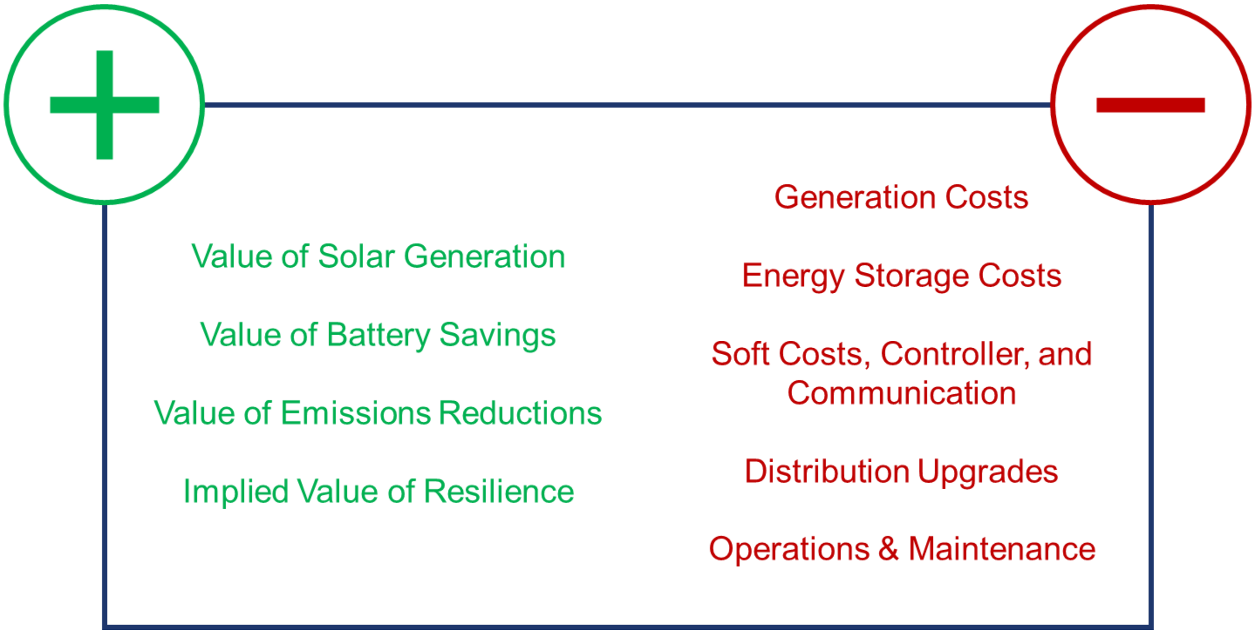
[11] Additional grid services, if added to the operating profile of the microgrid, might introduce additional benefits that could be quantified.

[12] Whether these affect the benefit-cost analysis depends on which test you use. For instance the utility test versus the societal test. If the societal test was used, these would not change the overall results.

group of benefits and costs included, and that issues such as double-counting and “transfer effects”[13] have been addressed.

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

Figure 4.2.1 - Overview of Benefits and Costs



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 + NG):** Generation costs reflect the purchase and installation of a solar photovoltaic system and, in most scenarios, a dispatchable[14] natural gas standby generator. In each scenario, a photovoltaic system has been proposed for the microgrid to generate clean electricity, and (with the support of the natural gas generator and/or a

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[13] 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.

[14] “Dispatchable” means being able to stop and start the generator on demand.

BESS) allows the facility to operate independent of the grid. The PV system partially replaces traditional fuel use, providing significant emission reductions that are a key benefit of the overall project. The natural gas generator can be dispatched on demand, and can be used to firm the solar generation, as well as provide power in parallel with the solar system or when no sunlight is available. This is a one-time construction cost. The costs for the solar system include a long-term warranty for the inverters to ensure their continued operation over the assumed lifespan of the project. The costs for the solar system do not include the Federal Investment Tax Credit (ITC). Further BCAs may need to reassess the value of the ITC, assuming that it would be available at the time of construction.

2. **Battery Energy Storage Systems (BESS):** This is a highly valuable component of a larger system that generates energy using intermittent sources of renewable energy such as solar, since it helps to balance the production and use of energy. The BESS is also important for a microgrid to handle transition events and to ensure power quality. For this study, initial BESS costs were captured in the first year as part of construction, but further BCAs may want to assume that the battery would need to be replaced partway through the life of the project, as the lifespan of a BESS is likely to fall short of the 20-year project life-span assumed in this study. Estimating the future costs of replacement must account for the net impact of inflation and expected reductions in battery costs over time, for example, a net cost reduction of 5% per year might be used to estimate replacement costs in a future year. Additionally, the costs for the BESS do not include the Federal Investment Tax Credit (ITC). Further BCAs may need to reassess the value of the ITC, assuming that it would be available at the time of construction and the system is eligible to receive the credit.
3. **Soft Costs, Controller, and Communications:** A specialized controller is used to manage the microgrid when in island mode, including direct interaction with the generation resources and the BESS. The costs of the controller, along with the costs of engineering, construction, commissioning, and regulatory affairs, are included as a one-time construction cost estimated at 16% of the component costs for each scenario.
4. **Distribution Upgrades:** In order to implement the microgrid, SEPA assumed that the existing distribution system at Heart of the Valley MSD will not require significant modifications. Construction costs for distribution upgrades **were not** included in this study, but may need to be incorporated into further BCAs.
5. **Operations & Maintenance**[15]**:** Unlike other cost components, operations and maintenance is an ongoing, recurring cost. These costs were taken from the NREL Annual Technology Baseline (ATB) 2021 for commercial solar PV and 4hr Lithium Ion BESS on an annual basis for the lifespan of the project.

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[15] This BCA does not take into account O&M and fuel costs for the standby generator, assuming that it will be used only in the event of a long-term energy emergency and costs will be highly variable and negligible over the 20-year project lifecycle.

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[16]:** 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[17], and the CO2[18].
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 Heart of the Valley MSD, resilience value should be based on its ability to ensure operation during an extended outage or emergency to prevent a spill into the Fox River. In this study, the implied value of resilience is the remaining difference between the NPV of

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

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

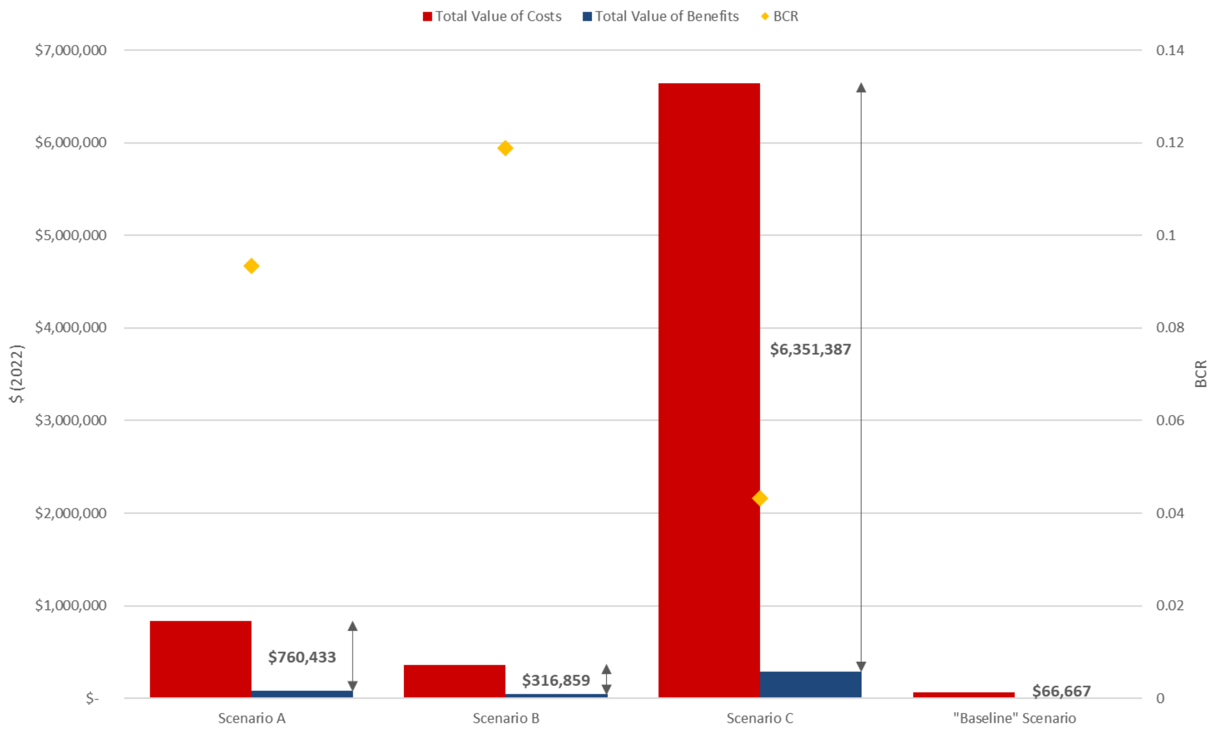
[18] https://19january2017snapshot.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf

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

Summary of Results

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

Figure 4.2.2 - Summary of Benefits and Costs



Source: SEPA, 2022

Summary of Cost Results

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

Table 4.2.1 - Summary of Costs

Microgrid Costs	Low Cost Scenario	Mid Cost Scenario	High Cost Scenario
Scenario A			
Generation (PV + NG)	$132,500	$172,250	$212,000
BESS	$363,383	$445,561	$500,308
Soft Costs/Controller/Comms	$94,454	$117,678	$135,678
Operations & Maintenance	$72,757	$103,254	$131,137
Total	**$663,094**	**$838,744**	**$979,123**
Scenario B			
Generation (PV + NG)	$9,000	$11,700	$14,400
BESS	$198,209	$243,033	$272,895
Soft Costs/Controller/Comms	$39,468	$48,521	$54,723
Operations & Maintenance	$39,686	$56,320	$71,529
Total	**$286,363**	**$359,574**	**$413,548**
Scenario C			
Generation (PV + NG)	$53,038	$54,488	$58,307
BESS	$3,765,966	$4,617,634	$5,185,014
Soft Costs/Controller/Comms	$727,429	$889,928	$998,728
Operations & Maintenance	$759,196	$1,075,813	$1,366,136
Total	**$5,305,837**	**$6,637,864**	**$7,608,185**
“Baseline” Scenario			
Generation (PV + NG)	$45,000	$60,000	$75,000
BESS	--	--	--
Soft Costs/Controller/Comms	$5,000	$6,667	$8,333

Operations & Maintenance	--	--	--
Total	**$50,000**	**$66,667**	**$83,333**

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	$0	$0
Battery Savings	$78,311	$5,119
Emissions Reductions	$0	$0
Implied Value of Resilience*	$46,924 - $72,283	--
Total	**$78,311**	**$5,119**
Scenario B		
Solar Generation	$0	$0
Battery Savings	$42,715	$2,792
Emissions Reductions	$0	$0
Implied Value of Resilience*	$19,551 - $29,757	--
Total	**$42,715**	**$2,792**
Scenario C		
Solar Generation	$40,940	$2,764
Battery Savings	$202,897	$13,264

Emissions Reductions	$42,639	$2,671
Implied Value of Resilience*	$402,750 - $587,513	--
Total	**$286,477**	**$18,699**
“Baseline” Scenario		
Solar Generation	--	--
Battery Savings	--	--
Emissions Reductions	--	--
Implied Value of Resilience*	$4,012 - $6,687	--
Total	**--**	**--**

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

Summary of the Benefit-Cost Ratio

A typical benefit-cost analysis greater than 1.0 indicates that benefits exceed costs, and the project is generally beneficial. In the simple case where all the benefits identified above can be included in the benefit portfolio[19], 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)	**$663,094**	**$838,744**	**$979,123**
Total Value of Benefits (NPV)	**$78,311**		
Net Impact (Benefits minus Costs)	**($584,783)**	**($760,433)**	**($900,812)**

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

BCR	**0.12**	**0.09**	**0.08**
Scenario B			
Total Value of Costs (NPV)	**$286,363**	**$359,574**	**$413,548**
Total Value of Benefits (NPV)	**$42,715**		
Net Impact (Benefits minus Costs)	**($243,648)**	**($316,859)**	**($370,833)**
BCR	**0.15**	**0.12**	**0.10**
Scenario C			
Total Value of Costs (NPV)	**$5,305,837**	**$6,637,864**	**$7,608,185**
Total Value of Benefits (NPV)	**$286,477**		
Net Impact (Benefits minus Costs)	**($5,019,360)**	**($6,351,387)**	**($7,321,708)**
BCR	**0.05**	**0.04**	**0.04**

Source: SEPA, 2022

Interpretation

The proposed Heart of the Valley MSD facility scenarios provide limited benefits beyond resilience mainly due to the lack of space to include on-site solar generation. Solar-related benefits including emissions reductions, rate benefits, and increased economic and resilience benefits from battery storage due to battery charging capabilities cannot be captured at the site. Due to the solar limitations, the small scale of this project, and the uncertainty associated with behind-the-meter solar and battery economic benefits, benefits do not balance the construction and operation/maintenance costs across all scenarios whether considering low-, mid-, or high-costs.

Although the benefit-cost ratios resulting from this high-level inventory of benefits and costs 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.
4. Qualifying for and monetizing the investment tax credit for solar and/or battery storage can improve the BCR for a microgrid. Future BCAs should consider incorporating this benefit should the scenario prove eligible.

5.0 Conclusion

Despite providing significant measurable advantages, the net present value of benefits for the Heart of the Valley MSD facility do not exceed the costs of the project under all scenarios before including resilience benefits in the analysis. In order to justify the development of one of the proposed scenarios, Heart of the Valley MSD would have to value resilience at the same levels suggested by the “Implied Cost of Resilience” values in the previous section. For Scenarios A and B, our implied valuation may prove to be a relatively modest over the 20-year presumed lifecycle of a microgrid project, but this value would have to be validated through further analysis and discussion with Heart of the Valley MSD.

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, the Heart of the Valley MSD facility is a workable site to construct and install a microgrid project. Project team members believe that this project would increase resiliency in Kaukauna, WI by serving as a wastewater treatment facility whose operation is critical to preventing a wastewater spill into the Fox River during an extended outage.

Key learnings from this study include:

- Given the limited space at the site, Heart of the Valley MSD is not well suited to host solar PV for on-site generation.
- Solar PV sizing limits also limit the ability of a BESS to provide economic and resilience benefits, as they rely primarily on the distribution grid for day-to-day charging
- Using the natural gas infrastructure that already exists at the Heart of the Valley MSD facility could potentially provide long-term, cost-effective resilience for outages
- Resilience benefits are likely to be significant given the facility's role as a community lifeline and critical infrastructure facility, as defined by the Cybersecurity and Infrastructure Security Agency[20]

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

- Determine ownership and operation structures between Kaukauna Utilities, Heart of the Valley MSD, 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.

February 2022

During the initial kick-off meeting with the project team, SEPA focused heavily on getting the group acquainted with each other. SEPA provided a background on the microgrid feasibility study and the grant, including information regarding project tasks, goals, and timeline. Project team members began to discuss the site, its critical infrastructure role, 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, critical loads, and microgrid fuel preferences. Following this meeting, SEPA began to gather relevant data, perform an initial site assessment, and develop preliminary microgrid scenarios.

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[20] https://www.cisa.gov/critical-infrastructure-sectors

March 2022

The second project team check-in meeting included an initial discussion around siting microgrid components and gathering initial reactions to preliminary draft scenarios. SEPA shared some initial results from its site assessment and worked with the team to address outstanding questions and concerns. SEPA also shared an outline of three initial microgrid scenarios in order to discuss the pros and cons of each with the project team. During the meeting, the Heart of the Valley team made it clear that liquids handling is mission critical, but that solids-handling could be down for up to 24 hours. This information prompted the SEPA team to create a scenario that covered just the load of the liquids processing, which amounted to approximately 50% of the total load. Following the meeting, SEPA finalized the site assessment and began the economic analysis.

April 2022

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

Appendix 2: Detailed Benefits

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

Value of Solar Generation

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

- **Energy Rate Savings:** Bill savings resulting from avoided energy purchases, as energy consumption at the facility is offset by on-site solar generation.
- **Excess Generation Credit:** Bill credits resulting from solar generation in excess of the facility’s load that is metered back to the grid at a predefined rate.
- **Demand Savings:** Bill savings resulting from the reduction of facility load peaks that coincide with on-site solar generation

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

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

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

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

Value of Emissions Reduction

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

The avoided emissions are quantified by determining the emission output that would have been produced on a "pounds per MWh" basis had that energy been generated at a traditional fossil fuel plant. The Emissions and Generation Resource Integrated Database (eGRID) provided region-specific emissions factors as "Pounds per MWh" values which were used to determine the environmental or emissions reduction impact of the avoided fossil fuel plant generation.[21] This process was repeated for four criteria pollutants which all have their own unique

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

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 $PM_{2.5}$.[22] 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

- 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.

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[22] 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).

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.

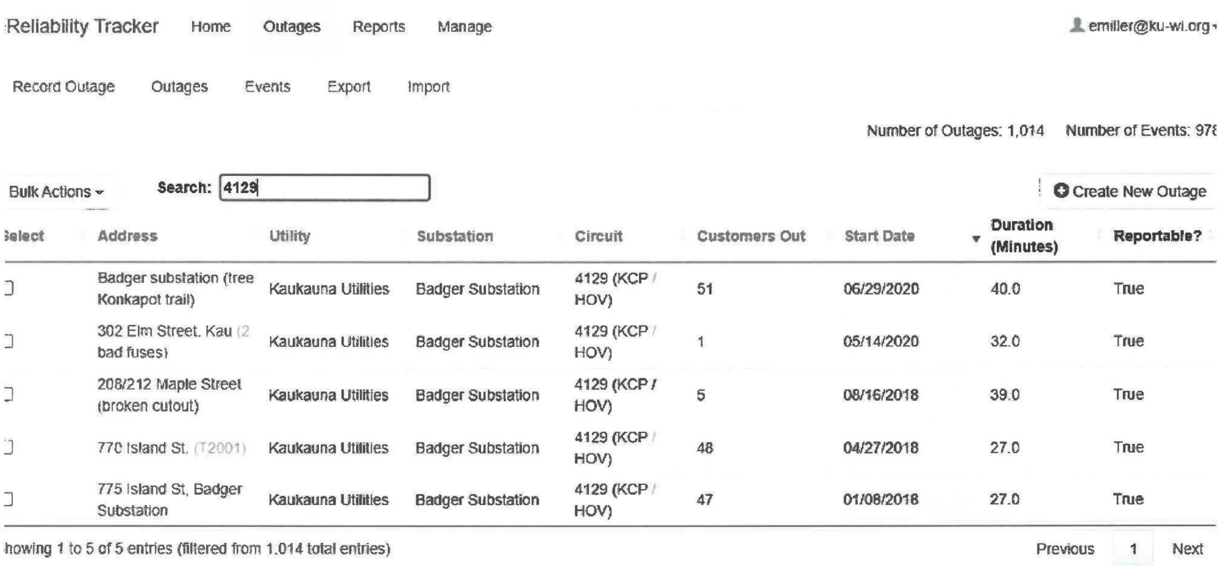
When estimating this benefit, SEPA assumed an annual rate increase of 2.5% for both energy and demand rates.

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

Appendix 3: Historic Outage Data



Number of Outages: 1,014 Number of Events: 97

Search: 4129

elect	Address	Utility	Substation	Circuit	Customers Out	Start Date	Duration (Minutes)	Reportable?
☐	Badger substation (tree Konkapot trail)	Kaukauna Utilities	Badger Substation	4129 (KCP / HOV)	51	06/29/2020	40.0	True
☐	302 Elm Street, Kau (2 bad fuses)	Kaukauna Utilities	Badger Substation	4129 (KCP / HOV)	1	05/14/2020	32.0	True
☐	208/212 Maple Street (broken cutout)	Kaukauna Utilities	Badger Substation	4129 (KCP / HOV)	5	08/16/2018	39.0	True
☐	770 Island St. (T2001)	Kaukauna Utilities	Badger Substation	4129 (KCP / HOV)	48	04/27/2018	27.0	True
☐	775 Island St, Badger Substation	Kaukauna Utilities	Badger Substation	4129 (KCP / HOV)	47	01/08/2018	27.0	True

howing 1 to 5 of 5 entries (filtered from 1,014 total entries)

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Source: Kaukauna Utilities, 2022