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North End Fire Station

Solar Plus Storage Feasibility Study

405 Linwood Avenue SW

Tumwater, WA 98512

Parcel #09080004002

Prepared by Cascadia Renewables for the City of Tumwater

info@cascadiarenewables.com

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CASCADIA RENEWABLES

About Cascadia Renewables

Cascadia Renewables is a technical consultant based in Washington state, specializing in designing and deploying solar and storage assets. We leverage our combined decades of industry experience to support public and private entities as they pursue their clean energy goals. Our team has led regional clean energy policy initiatives focused on equality, transparency, and affordability.

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Acknowledgments

Community Stakeholders and Representatives:

- Brian Hurley – *Fire Chief* – Tumwater Fire Department
- Shawn Crimmins – *Assistant Fire Chief* – Tumwater Fire Department
- Mason Rolph – *Executive Director* – Olympia Community Solar
- Chris Graham – *Facilities Manager* – City of Tumwater
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Letter From the Field

Dear Brian Hurley,

We are pleased to present the City of Tumwater with this study, which examines the feasibility of constructing a solar plus storage system to enhance resiliency at the North End Fire Station.

The purpose of this study is to convey a clear, detailed, and accurate description of the design for a potential solar plus storage system to enhance community resilience, taking into account geographical, infrastructural, economic, environmental, and social context. This report is the culmination of an extensive design project, the goals of which include:

- Understanding community needs
- Assessing trends in energy usage and conditions of the site
- Determining the optimal system size and architecture
- Assessing the benefits, challenges, and risks of proceeding with the proposed system
- Identifying next steps

FUNDED BY WASHINGTON'S CLIMATE COMMITMENT ACT

This report is supported with funding from Washington's Climate Commitment Act. The CCA supports Washington's climate action efforts by putting cap-and-invest dollars to work reducing climate pollution, creating jobs, and improving public health. Information about the CCA is available at www.climate.wa.gov.

We intend this document to concicely convey the technical aspects of the design to those with experience reading such information. It is separated into three levels of detail:

1. A high-level summary of our findings and recommended design *(found on page 5)*
2. Detailed specifications of our design and design process *(pages 6–46)*
3. An appendix of calculations and ancillary documents for cross-referencing, as well as the findings and photos from our original site visit *(found in separate PDFs)*

To determine the feasibility of a solar plus storage system, it is necessary to specify equipment, equipment locations, system design, and hourly labor/services estimates. Though we provide this high level of fidelity, please note that this feasibility study is conceptual– it is not intended for construction purposes. It supports stakeholder decision-making, fundraising efforts, and future designs. To determine the final product specifications, equipment locations, system design, and hourly cost/estimates, Cascadia Renewables recommends a thorough 3+ bid RFP process.

Please direct yourself to any sections appropriate and relevant to your needs. If you have questions about this report, please contact us at info@cascadiarenewables.com.

Sincerely,

Cascadia Renewables

Design Abstract

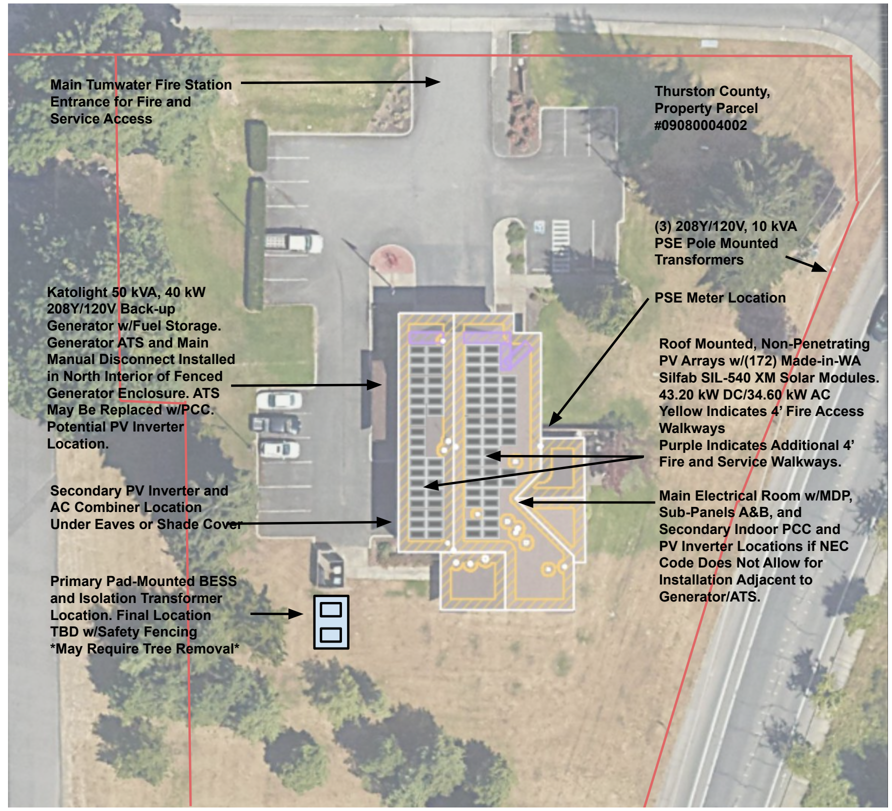
The conceptual solar plus storage system for the Tumwater Fire District North Station aims to improve the site's resilience by enabling the facility to function autonomously during power outages. This will allow it to serve as an Emergency Operations Center during extended outages or natural disasters. Financially, the system offers benefits by offsetting utility energy purchases with photovoltaic (PV) solar production as well as reducing monthly peak demand charges through the strategic use of the battery energy storage system (BESS) during high-demand periods.

With the installation of PV modules on the upper east and west-facing roof sections, the system is designed to maximize annual energy output while avoiding shading from nearby trees and rooftop structures. Excluding modules along the south edge accommodates future building expansions.

The primary purpose of the BESS is resilience, ensuring a continuous power supply during outages and reducing the runtime of the standby generator, which results in fuel conservation.

The project's feasibility is supported by its alignment with community goals, which includes serving 27,000 residents and supporting citywide emergency preparedness. The system is designed to offset 109.76% of annual energy consumption, contributing to ongoing sustainability efforts. The PV system's racking and roof mounting solutions ensure straightforward installation.

Given these considerations, the system is technically feasible and aligns with the project goals of enhancing the site's energy independence and resilience while also delivering economic benefits.



PV System Size	43.20 kW DC/34.60 kW AC
BESS Size	35 kW/143 kWh
Estimated Annual Electric Production	38,203 kWh
Estimated Percentage of Annual Consumption Offset	109.76%
First Year Bill Savings	$4,261.00
Period of Autonomy	**December:** 100% Demand - 39 hrs 150% Demand - 24 hrs 200% Demand - 17 hrs **July:** 100% Demand - Continuous 150% Demand - 37 hrs 200% Demand - 31 hrs

Design Specifications and Process

Introduction to the Site

Type of Building: The Fire Station is a modern stick-built wood construction, two-story building with garage bays for the fire apparatus, with internal offices and conference rooms that may be used as the primary alternate Emergency Operations Center.

Surrounding Conditions: The North End Station is one of only two fire stations in the city of Tumwater, with multiple access locations for easy access by the public and fire personnel during an extended emergency.

Typical Purpose of Site: Fire Station serving the north end of the City of Tumwater.

Emergency Function: The station serves as the regional fire station primarily for the City of Tumwater's north side and urban growth areas, and as the back-up Emergency Operations Center for large-scale emergency management, providing leadership and coordination during disasters. Additionally, it supports daily fire and emergency response activities critical to community safety.

Project Goals

In conversation with stakeholders, the community had the following goals:

- To continue providing emergency services for the City of Tumwater through increasingly challenging environmental conditions.
- To continue providing emergency fire services for the City of Tumwater throughout an ongoing emergency event where grid power may not be available and generator fuel supplies are limited or unavailable.

In service of those goals, the system was designed with the following priorities:

1. Provide backup power, enabling the building to remain operational during short, seasonal power outages.
2. Provide long-term back up power, enabling the building to remain operational during extended emergencies.
3. Increase redundancy of existing backup generator system, reducing generator runtime and fuel use.
4. Reduce the station's operational costs through the reduction or elimination of monthly electical bills, allowing internal funds to be reallocated.

Stakeholder Engagement

Key stakeholders included:

- Brian Hurley – *Fire Chief* – Tumwater Fire Department
- Shawn Crimmins – *Assistant Fire Chief* – Tumwater Fire Department
- Mason Rolph – *Executive Director* – Olympia Community Solar
- Chris Graham – *Facilities Manager* – City of Tumwater
- Alyssa Jones Wood – *Sustainability Manager* – City of Tumwater

Differing needs of stakeholders were voiced through the following interactions, summarized below.

Engagement Activities and Objectives:

December 23, 2024: Members of Cascadia Renewables conducted a comprehensive site assessment with personnel from the department.

February 24, 2024: A kickoff meeting was conducted between Cascadia Renewables and representatives of fire department, the City of Tumwater, and Olympia Community Solar. The goal of the meeting was to inform the stakeholders about the upcoming process, to make plans to aquire the necessary information to perfom a site analysis, and to get an impression of the goals of the stakeholders.

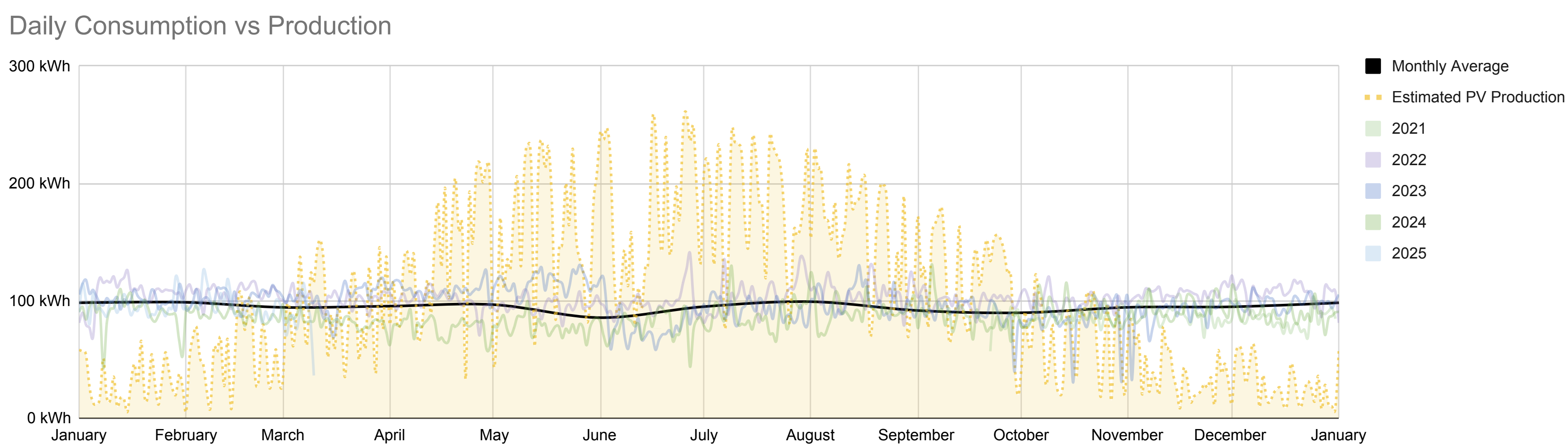
April 17, 2025: Cascadia Renewables held a design review meeting with members of the fire department, the City of Tumwater, and Olympia Community Solar to present the in-progress conceptual design. We received feedback on the design, responded to the concerns of the organizations, and made a plan to spread the word about the project's plans to the broader community.

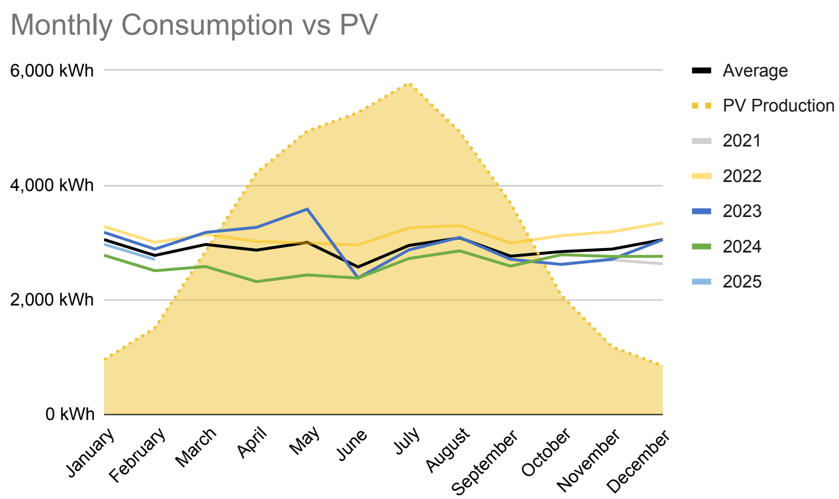
Preliminary Electrical Usage Analysis

The electrical usage analysis determines the optimal solar and battery system sizes for meeting the needs of the site. We consider this electrical analysis in tandem with information collected onsite to inform the conceptual design and verify the installability of the project if it is funded.

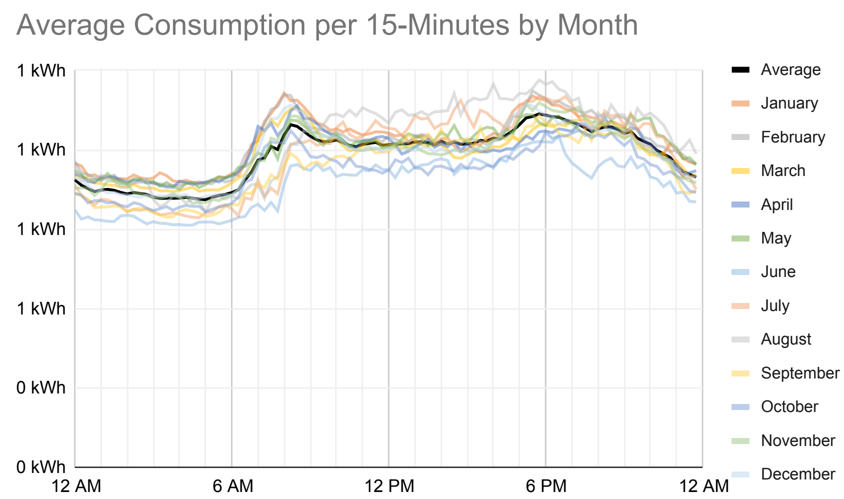
This analysis of the community's electricity consumption uses data from March 2024 to March 2025, providing a full year for accurate modeling. The data shows minor seasonal variations, with July seeing the highest demand due to increased air conditioning. Consumption is typically higher on weekdays due to typical business use. There are no expected changes to the electrical infrastructure that would affect current demand or consumption trends. This analysis offers insights to guide more efficient and sustainable energy management.

Estimated Annual Electric Consumption	34,805 kWh
Seasonal Fluctuation	19.75% fluctuation between minimum consumption in June and maximum consumption in August
Estimated Maximum Peak Demand	10 kW
98-Percentile of Consumption During a Single Day	122 kWh

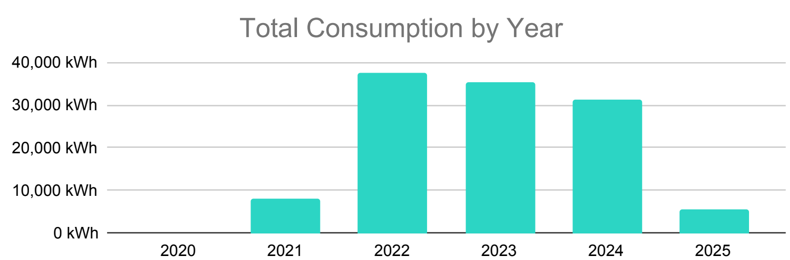




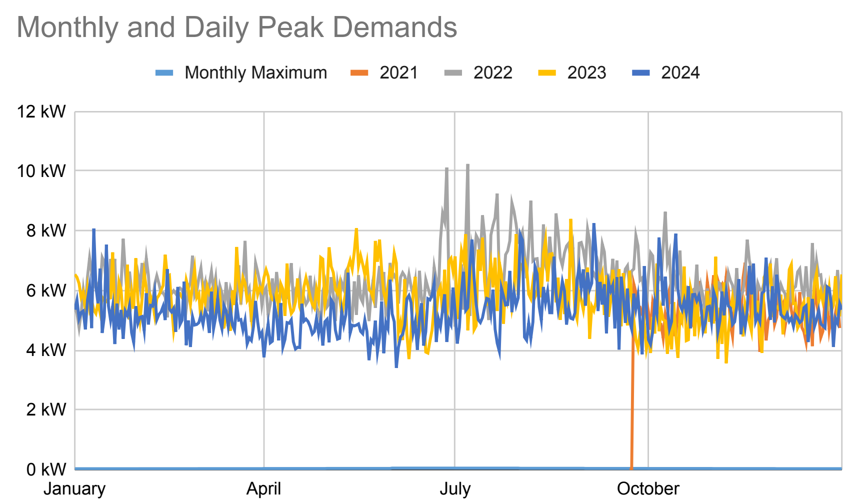
Monthly Consumption vs PV
6,000 kWh
4,000 kWh
2,000 kWh
0 kWh
January
February
March
April
May
June
July
August
September
October
November
December
Average
PV Production
2021
2022
2023
2024
2025



Average Consumption per 15-Minutes by Month
1 kWh
1 kWh
1 kWh
1 kWh
0 kWh
0 kWh
12 AM
6 AM
12 PM
6 PM
12 AM
Average
January
February
March
April
May
June
July
August
September
October
November
December



Total Consumption by Year
40,000 kWh
30,000 kWh
20,000 kWh
10,000 kWh
0 kWh
2020
2021
2022
2023
2024
2025

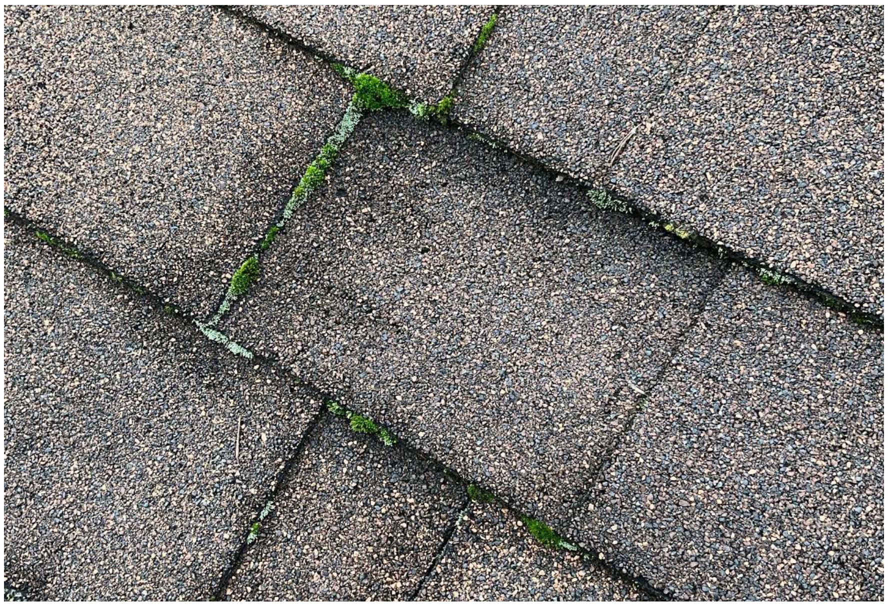


Monthly and Daily Peak Demands
Monthly Maximum
2021
2022
2023
2024
12 kW
10 kW
8 kW
6 kW
4 kW
2 kW
0 kW
January
April
July
October

Comprehensive Site Visit

Following the preliminary electrical analysis and an initial review of the available building plans and satellite imagery, members of the Cascadia Renewables' design team assessed the real-world conditions through a comprehensive site visit.

Roof:



Condition of the roof

Roof Quality	Fair condition with moss growth
Roof Type	Composition

Roof Angle	Roof 1: 22 degrees (5:12), Roof 2: 22 degrees (5:12)
Roof Age	Unknown - Less than 10 years of remaining useful life
Date After Which Roof Should Be Replaced	The composition shingle roof should be replaced prior to installing the PV system.

Structure:

Structure Type	The Fire Station is a modern stick-built wood construction, two-story building.
Assessment of Structure Quality	The structure appears to meet all building requirements to support a flush-mounted PV system on the plywood and composition shingle roofs.
Availability of Plans	Both structural and electrical plan sets were available onsite.
Soil Conditions	The Fire Station is surrounded by asphalt parking and driveways on the north and west side, with grass landscaping on the south and east sides.

Meter photo

MDP and Sub-Panels A & B

Electrical:

Service Utility	Puget Sound Energy (PSE)
Main Service Type	208Y/120V, 3-Phase
Electrical Topology	The Fire Station's electrical infrastructure is primarily located on the east wall in the main central interior living and workout area, with multiple access locations. The infrastructure includes a 225 A Main Distribution Panel, with two adjacent 225 A Sub-Panels.

Line Side Infrastructure	The Fire Station's 3-Phase 208 V power is fed to the externally mounted PSE meter from (3) pole-mounted 10 kVA PSE transformers located on the northeast edge of the property.
Electric Utility Hosting Capacity	Generation Hosting Capacity of 4.45 MWs
Location of Main Electrical Service	The main electrical service is located on the east wall in the main central interior living and work-out area of the Fire Station
Locations of Current Infrastructure	The PSE transformers are located on the northeast edge of the property, with the PSE Meter located centrally on the east exterior wall. The Generator and ATS are located centrally on the west exterior of the Fire Station. The Main Distribution Panel and Sub-Panel A &B are located on the east wall in the main central interior living and work-out area.
Main Transformer Rating, Voltage, and Phase	(3) Pole-Mounted 10 kVA, 208Y/120V, 3-Phase Transformers

Main Service Bus Capacity	225 A
Main Service Bus Voltage	208Y/120V, 3-Phase
Main OCPD Rating	225 A
Main Distribution Center Type	Panelboard
Amps Available for PV Interconnection Under 120% Rule	45 A

Generator:

Generator Brand	Katolight Power System Solutions
Generator Size	50 kVA, 40 kW, 208Y/120V, 3-Phase
Generator Fuel Type	Diesel - Could not verify fuel storage capacity during site visit

Generator Interconnection Method	The generator interconnects to the Fire Station through an Automatic Transfer Switch (ATS) that is located adjacent to the generator. The ATS feeds the main distribution panel allowing the generator to provide whole building backup power.
Generator Backup Configuration	Whole Building

Description of Shading: The primary east and west roofs are mostly shade-free, with limited shading along the lower northeast edge from adjacent trees, and small localized shading from rooftop vents and antennas.

Other:

Description of Accessibility: The Fire Station is located on the north edge of the City of Tumwater, halfway between the Tumwater Fire Headquarters and the City of Olympia, with easy access from multiple surrounding streets, including nearby I-5. The roofs are accessible from a single-story ladder on the southwest corner and lower east roofs, and a two-story ladder or man-lift onto the PV installation locations from the parking/driveways to the north and west.

Photovoltaic (PV) System Design

Overview:

The conceptual 43.20 kW DC PV array would be installed on the upper composition shingle roof. The system was designed using a max fit methodology, meaning it aims to fully offset the building's annual energy consumption by efficiently utilizing available roof space. The PV layout places the panels on the east and west-facing sections of the roof while avoiding areas that might experience shading from nearby trees or rooftop structures. This design ensures optimal energy production while facilitating easy installation and maintenance.

The PV system production was modeled using Aurora, a software that uses irradiance data, LIDAR data, and 3D models of buildings to determine PV output over the course of the day and the year.

In this report, specific products names are used. These recommendations are to be considered typical–comparable equipment may be substituted. When making substitutions, pay attention to all technical specifications, as some products that initially appear comparable may be different in key ways.

Solar irradiance visualized across the array

Specifications:

PV System Size	43.20 kW DC, 34.60 kW AC
PV Module	Silfab SIL-540 XM, 540 Watt Module
Number of Modules	80

Estimated Annual Electric Production	38,203 kWh
Estimated Percentage of Annual Consumption Offset	109.76%
Total Solar Efficiency	77.0% TSRF

Number and Models of Inverters	(2) SolarEdge SE 17.3K-US, 208V Commercial 3-Phase Inverters
Location of Inverters	The (2) PV inverters may be installed on the southwest wall of the Fire Station, but heat issues could arise if a shade cover is not included. CR recommends installing in fenced area adjacent to the generator and new PCC or indoors as space and code allows.

Design Considerations:

Trenching, Cutting, and Wall Penetrations Trenching and pavement cutting will be required to connect the requested BESS location along the southwest edge of the property, across the asphalt driveway and concrete curbs, to the genarator/ATS location on the west side where the PCC will be installed. There may be a limited number of wall penetrations to allow for the integration of the PCC into the existing electrical infrastructure in the central living and work-out area.

Maintenance and Fire Access 4’ commercial fire setbacks will be provided on all roof locations to allow for easy maintenance and fire access.

Wire Run The externally mounted DC PV wire runs will vary from 30’ from the primary west-facing PV array location above the PV inverter location, to 80’ from the east-facing PV array.

Roof Shading The primary east and west roofs are mostly shade-free, with limited shading along the lower northeast edge from adjacent trees, and small localized shading from rooftop vents and antennas.

Required Upgrades Prior to PV Installation None

Interconnection Method for PV The (2) SolarEdge SE17.3K inverters will have their 208Y/120V output combined in a PV combiner panel, that will feed the PV input in the Point of Common Coupling (PCC) panel that will/may be installed in place of the existing generator ATS on the west exterior.

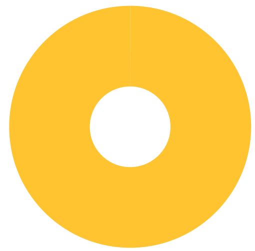
PV SYSTEM DETAILS

GENERAL INFORMATION
Facility: Meter #1
Address: 405 Linwood Ave SW Tumwater WA 98512

SOLAR PV SYSTEM RATING
Power Rating: 43,200 W-DC

SOLAR PV EQUIPMENT DESCRIPTION
Solar Panels: 43.2 kW-DC Standard Modules

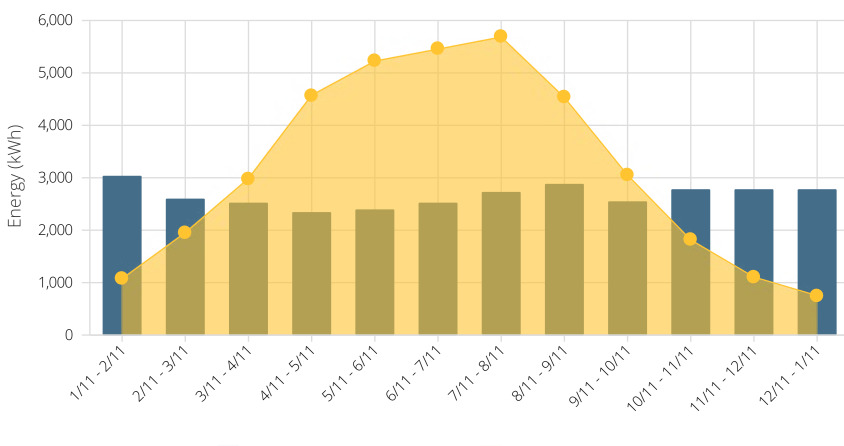
ENERGY CONSUMPTION MIX
Annual Energy Use: 31,814 kWh



SOLAR PV EQUIPMENT TYPICAL LIFESPAN
Solar Panels: Greater than 30 Years
Inverters: 15 Years

Solar PV System Cost and Incentives	
Solar PV System Cost	$185,900
Grant Amount	-$185,900
Net Solar PV System Cost	**$0**

MONTHLY ENERGY USE VS SOLAR GENERATION



Roof Loading and Mounting:

Mount Location	The PV modules will be installed on the upper east and west-facing roof sections.
PV Racking System	IronRidge Aire Rail System
PV Mounting System	Flush-mounted
Roof Penetrations	The system will be installed using IronRidge's FlashFoot 2 anodized aluminum flashing system for composition shingle roofs, with additional butyl tape to provide a weather-tight roof connection.
Roof Loading Capacity	25.0 psf
Additional Available Roof Loading	5.0 psf
Estimated PV System Roof Loading	2.5 psf
Assessment of Whether the Roof Will Support the System	Yes

Battery Energy Storage System (BESS) Design

Specifications:

BESS Size	35 kW/143 kWh
BESS Backup Configuration	The BESS is configured to backup the entire facility and serve as the primary backup power source, allowing the building to ride through season-al and medium duration outages without the need for the gen-erator. If, during island/off-grid operation, the BESS reaches a low state of charge, the micro-grid control system will turn on the standby generator which will power the building loads and recharge the BESS. Once the BESS reaches the desired state of charge, the generator will be turned off and the BESS will continue powering the building load with support from the PV system when available.
Peak Demand for Modeling Purposes	10 kW
Source of Peak Demand	Observed

PCC Location

Example of a Containerized BESS Unit

Overview:

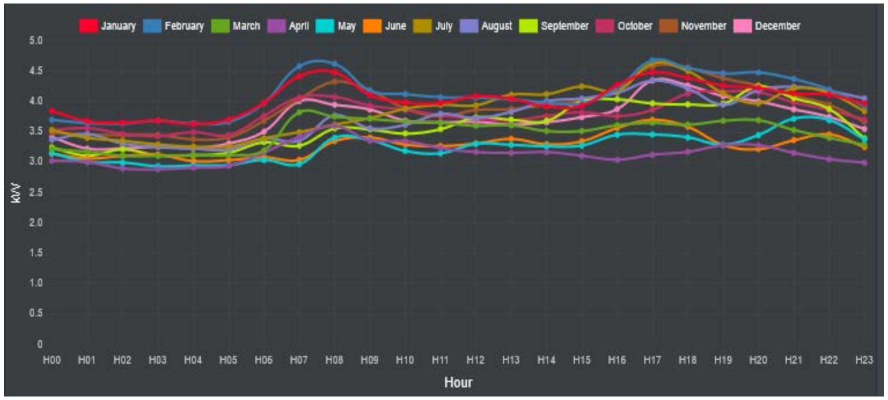
The conceptual 35kW/143 kWh BESS would be installed in the grassy area south of the parking lot, mounted on a concrete pad and enclosed by a security fence, to comply with local fire code requirements and limit its visibility from public areas. The system's design considers various scenarios, including 100%, 150%, and 200% of historical energy demand, and both full and zero PV resource availability. Such modeling assumptions ensure that the BESS effectively supports typical building operations and increased demand scenarios during emergencies and the eventual building expansion. The BESS integrates with an existing generator to offer robust backup power during extended outages, maintaining a steady power supply.

BESS dispatch performance is modeled in a program called Xendee, which considers many sources of data, including PV production, estimated site consumption, and grid energy pricing, to optimize a BESS for a variety of desired characteristics, including resiliency and financial benefit.

Demand Modeling:

For the BESS modeling, we utilized the interval data from March 9, 2024 to March 9, 2025 to create a daily building load profile in our system modeling software. This is representative of the actual historical daily load profile throughout the year and provides the most accurate basis for our system performance modeling.

Before constructing a system, we recommend conducting a month-long meter study, collecting 1-minute interval data to identify transient peaks in demand.



Load Profile based on 15-min Utility Interval Data

BESS Design Considerations:

Although utility data showed a building peak demand of 10 kW, we specified a 35 kW BESS inverter to ensure that the system can meet building demand and transient demand surges during an outage. When considering the increased building demand as a result of the planned building expansion, an additional 35kW BESS inverter may need to be added to the system to ensure the system can meet this increased demand. The BESS design features rack-mounted inverters that can easily be expanded for an estimated cost of $15,000 per 35kW inverter. We also designed the system to integrate with the existing backup generator to maximize system resilience and backup power supply redundancy.

The BESS will need to be installed on an concrete pad approximately 5' x 8' and, per discussions with fire and permitting officials, a security fence would be required around the BESS since it would be in a visible, high traffic area. This will increase the area required for the BESS to approximately 11' x 14’. The proposed BESS location in the grassy area on the south side of the propery is clear of nearby vegetation. A 10’ setback from exposures, including public ways and lots lines (WA Fire Code 1207.8.3) will need to be maintained when determining a final BESS location after the building expansion plans are finalized. Based on the site assessment, there appears to be sufficient space to accommodate the BESS while maintaining fire code clearances.

Generator Supplementation:

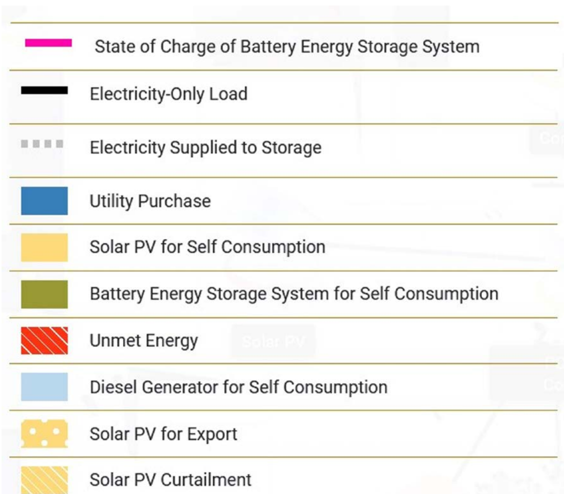
Though not part of a solar plus storage system, a standby generator can be a hugely beneficial complement to a BESS as it will allow a site to maintain extended autonomous operation in the winter. Additionally, a BESS complements a generator by allowing it to run less often and more efficiently than if the generator was installed alone.

Generator Recommendation	Keep Existing Generator
Proposed Generator Size	50 kVA, 40 kW, 208Y/120V, 3-Phase (Same as Existing)
Proposed Generator Fuel Type	Diesel - Could not verify Fuel Storage capacity during site visit. (Same as Existing)
Proposed Generator Interconnection Method	The generator interconnection would be moved from the existing ATS into a newly installed AC Aggregration Panel via a motorized breaker and SEL751 relay.
Proposed Generator Backup Configuration	Whole Building

Low-PV Outage Simulation:

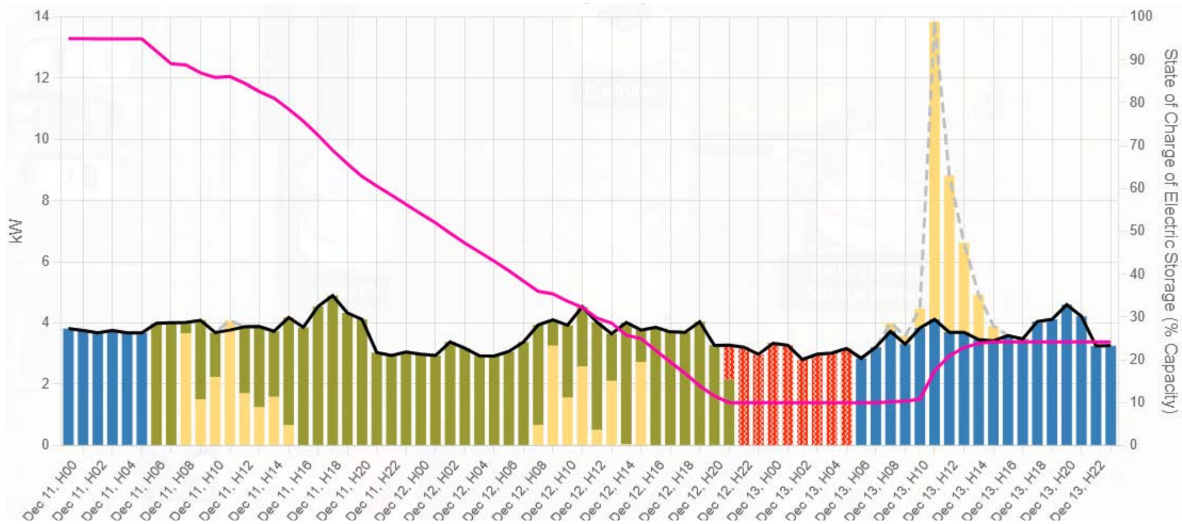
The BESS design was based on 100% of historical energy demand. Additional modeling was performed at 150% and 200% of historical energy demand in order to illustrate system performance in the event that building usage increases during an emergency. Modeling was also performed showing the generator dispatch to illustrate the reduction in generator runtime and how this redundant backup power source could be utilized during long duration outages.

In operation, the period of autonomy of the BESS and estimated daily generator runtime will depend on numerous factors, including available solar resourc-

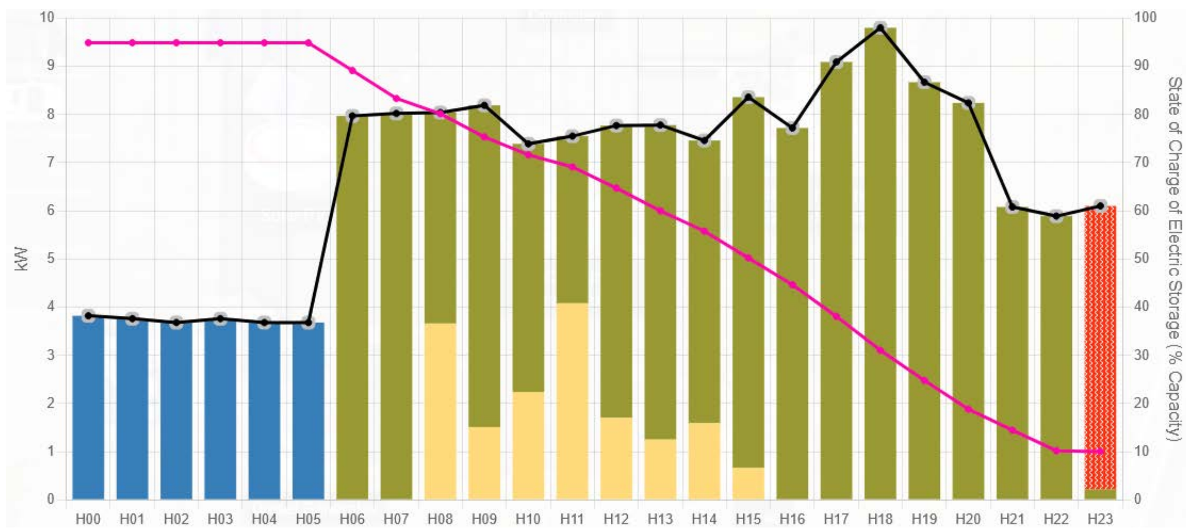


Dispatch Graph Key

December Outage Scenario Electricity Dispatch – 100% Demand



December Outage Scenario Electricity Dispatch – 200% Demand



es, BESS state of charge, and building loads during an outage. A change in any of these factors will impact these estimates.

December Period of Autonomy

100% Demand: 39 hrs

150% Demand: 24 hrs

200% Demand: 17 hrs

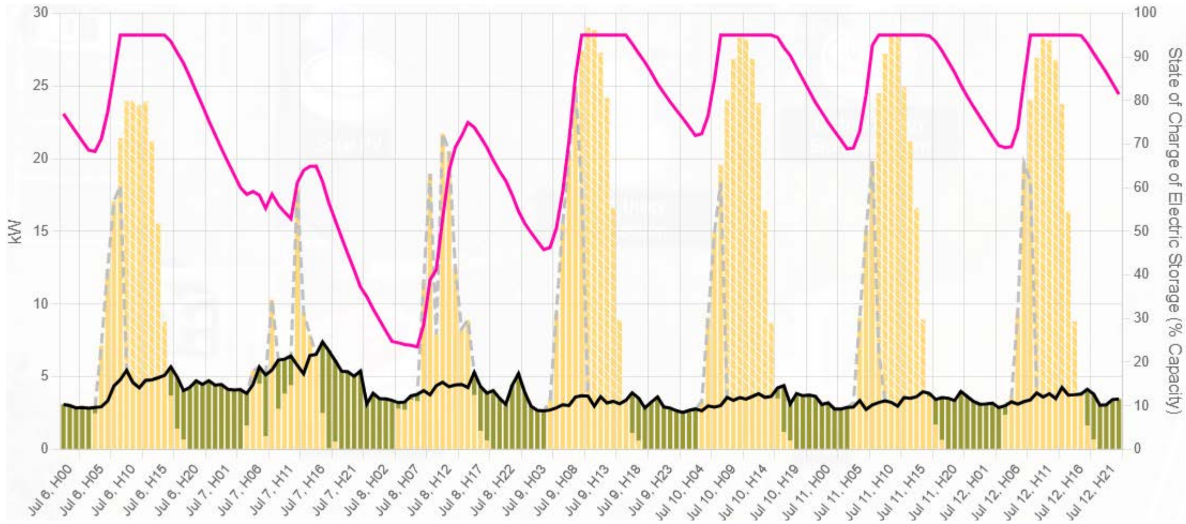
July Period of Autonomy

100% Demand: Continuous

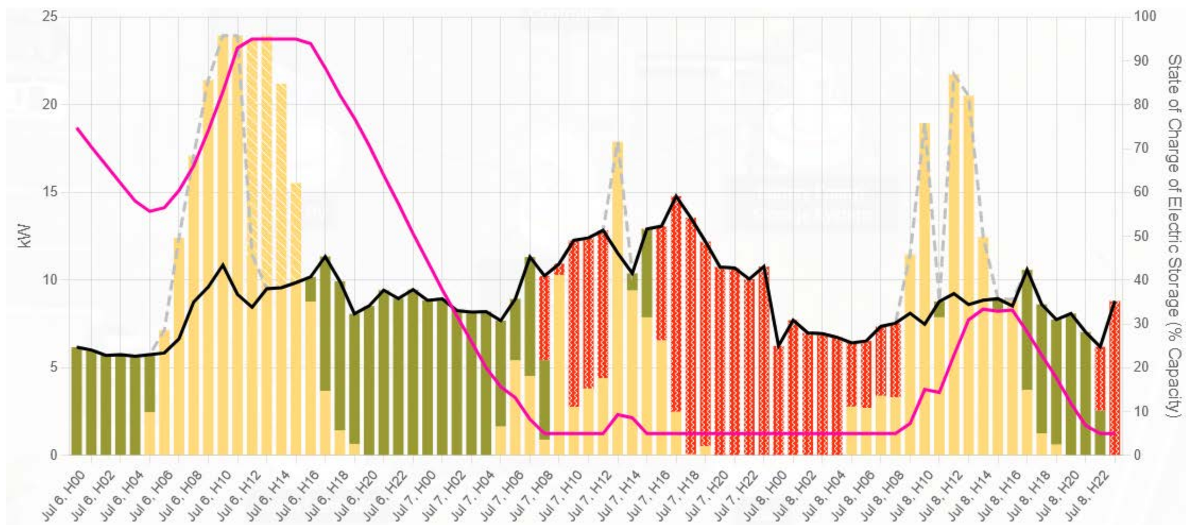
150% Demand: 37 hrs

200% Demand: 31 hrs

July Outage Scenario Electricity Dispatch – 100% Demand



July Outage Scenario Electricity Dispatch – 200% Demand



High-PV Outage Simulation:

Daily Generator Runtime Required for Continuous Site Uptime in December

100% Demand: 16 hrs/week

150% Demand: 30 hrs/week

200% Demand: 35 hrs/week

Daily Generator Runtime Required for Continuous Site Uptime in July

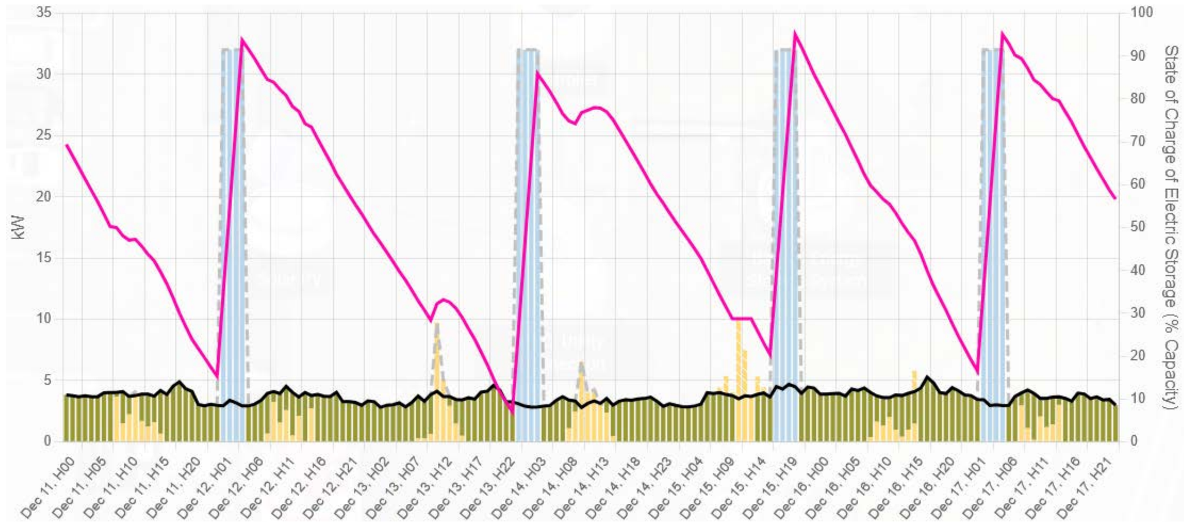
100% Demand: 0 hrs/week

150% Demand: 4 hrs/week

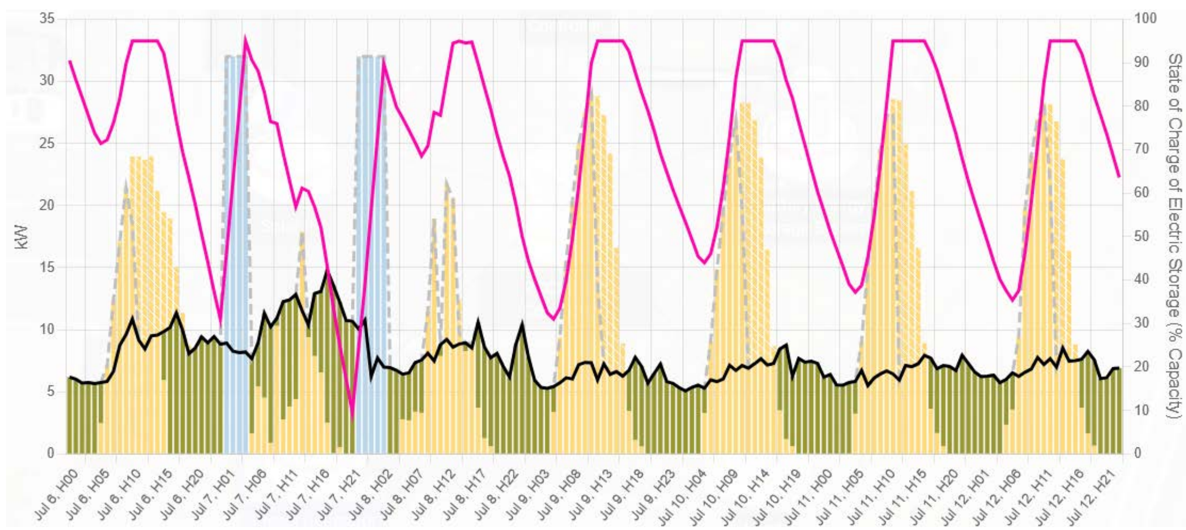
200% Demand: 9 hrs/week

In operation, the period of autonomy of the BESS and estimated daily generator runtime will depend on numerous factors, including available solar resources, BESS state of charge, and building loads during an outage. A change in any of these factors will impact these estimates.

December Outage Scenario Electricity Dispatch – 100% Demand, 40 kW Generator



July Outage Scenario Electricity Dispatch – 200% Demand, 40 kW Generator

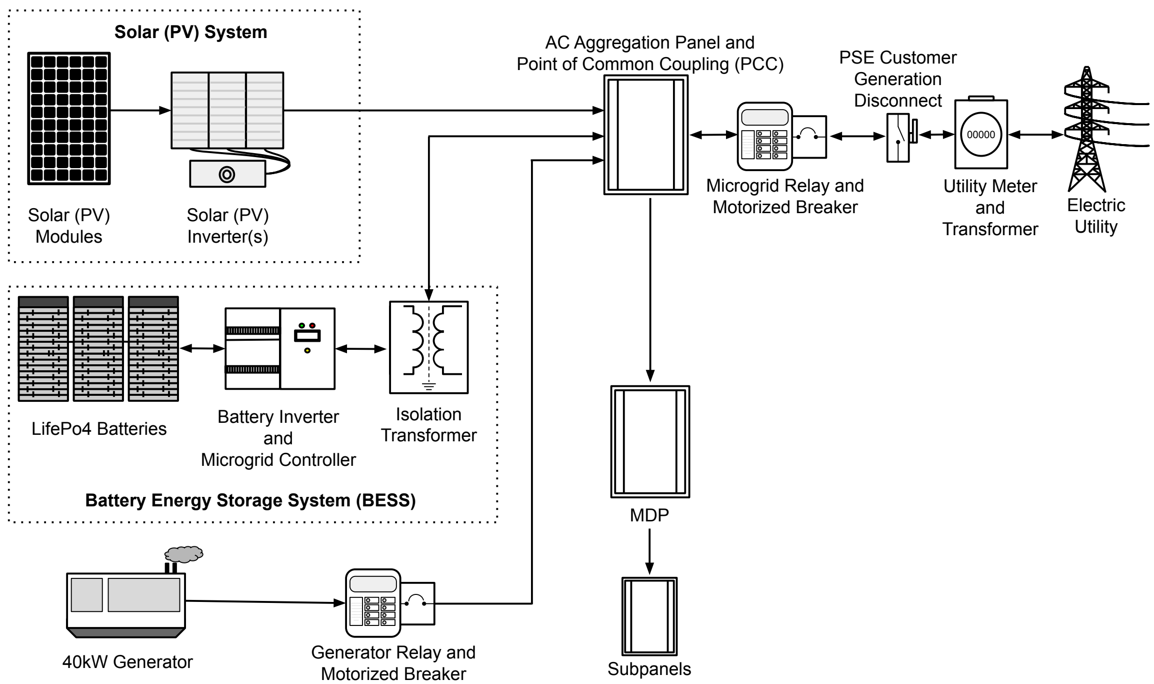


Interconnection

Topology:

The Tumwater Fire District North Station's power supply consists of a 225A, 208Y/120V incoming service from a 30kVA PSE pole-mounted transformer bank. The existing 225A-rated main distribution panel (MDP) is fed from an ATS that is connected to a 40kW standby generator. Our conceptual design replaces the existing ATS with a new 400A AC Aggregation Panel installed in the same location that would serve as the PCC. This Aggregation Panel/PCC combines the incoming utility feed, BESS, PV, Generator, and feeds the existing MDP in the electrical room. The PCC also includes a microgrid interconnect device (MID), which consists of a 225A rated motor controlled breaker and a SEL751 relay. The MID device automatically isolates the PCC from the utility during an outage, allowing the PV system, BESS, and generator to operate as a microgrid and supply power to the facility. The standby generator would be interconnected into the PCC via a motorized breaker controlled by the microgrid control system to provide grid isolation from the generator until the system moves into island mode during a utility outage and the generator is needed to recharge the BESS and power the facility. Replacing the existing 225A service disconnect would be a new lockable, knifeblade fused disconnect that functions as both a service disconnect and a PSE required distributed generation disconnect. This microgrid system utilizes an Energy Management System to ensure that the distributed energy resources are dispatched efficiently and that the capacity of the electrical equipment bussing is never exceeded.

This configuration meets the goal of powering the entire building during seasonal outages as well as increasing the period of autonomy to allow the facility to be used as an Emergency Operations Center during a long term outage or



Simplified single line diagram of the conceptual system showing the topology of its interconnection.

natural disaster. This system also helps to reduce the runtime of the existing standby generator, conserving fuel reserves and increasing the building resiliency. The interconnection is a crucial element that affects the project's feasibility, budget, and timeline. Cascadia Renewables recommends that an electrical engineer verify the final system design before implementation.

Locations of New Infrastructure:

The conceptual design envisions the following locations for the new electrical equipment associated with this system:

PV Inverters - In the fenced area adjacent to the generator

BESS - Pad mounted in grassy area south of the parking lot

AC Aggregation Panel/PCC - Replaces existing ATS unit in fenced generator area

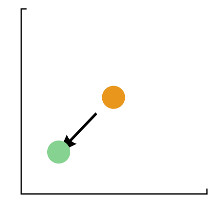
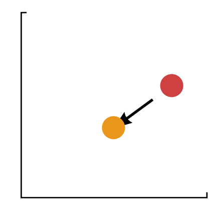
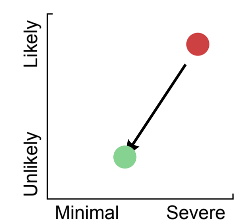
Utility Customer Generation Disconnect - Adjacent to PCC

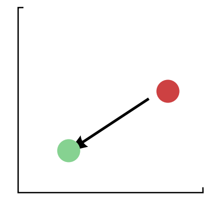
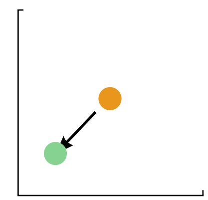
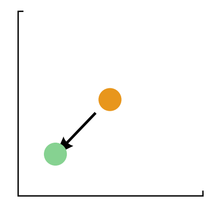
Microgrid Interconnect Device (SEL 751 Relay and Motorized Breaker) - Integrated into the new AC Aggregation Panel/PCC

PCC Location

Project Risks

Developing a solar plus storage system comes with uncertainties, from incomplete information and market fluctuation. This feasibility study aims to mitigate some risks while identifying how others might be addressed. Risks have varying levels of severity and likelihood, which can be reduced by varying degrees through the proposed mitigation strategies.

Risk	Impact	Mitigation	Risk Before and After Mitigation
Construction projects often encounter unforeseen challenges, including site-specific conditions, environmental constraints, and permitting issues.	Delays in project timelines, increased costs, potential legal disputes, and strained relationships with stakeholders.	Regular site assessments, proactive stakeholder engagement, and a robust project management approach can help identify and address potential hurdles early. Engage in thorough due diligence before finalizing a contractor to ensure they are sufficiently qualified and experienced to take on a complex solar plus storage project. Ensure that contracts have clear clauses regarding delays, with penalties or incentives for timely completion.	
Geopolitical events can impact supply chains, project financing, and overall project feasibility.	Disruption in material or equipment delivery, increased costs, potential project cancellation, or delays due to financing issues.	Diversifying supply chains, monitoring global events closely, and having contingency plans in place can help navigate these challenges. Consider insurance or hedging options that protect against geopolitical risks.	
The industry can experience shortages in critical equipment due to high demand or manufacturing constraints.	Project delays, the potential need for equipment substitutions leading to design modifications, and increased costs.	Seek contractors with established relationships with multiple suppliers, who maintain a strategic inventory and who monitor industry trends to anticipate shortages. Consider contracts allowing equipment substitution or alternative solutions in case of shortages.	

Risk	Impact	Mitigation	Risk Before and After Mitigation
The availability and cost of skilled labor can fluctuate based on market conditions.	Delays in project timelines, potential compromise in work quality, and increased labor costs.	Consider prioritizing contractors with a strong track record of workforce management and training or with established partnerships with local training institutions. Ensure contracts have provisions for labor continuity and quality assurance. Consider the timeline of construction and allowance for longer construction periods or delaying construction until more workforce development for the large-scale solar plus storage industry has occurred.	
Detailed engineering and site-specific surveys may reveal conditions or requirements that impact cost and timeline.	Potential redesign requirements, increased costs, and project delays.	Engage experienced engineering firms, conduct thorough preliminary surveys, and allocate resources for potential additional studies. Consider engaging independent third-party reviewers for critical project milestones. Allocate a portion of the budget for potential additional studies or modifications.	
Prices for materials, equipment, and services can be subject to market volatility.	Unpredictable project costs, potential financial strain, and challenges in budgeting and forecasting.	Negotiate fixed-price or capped-price contracts where possible. Maintain a contingency budget for unexpected price fluctuations and ensure transparency in cost adjustments.	

Logistical and Financial Analysis

Hurdles Presented by Existing Conditions

Below are construction challenges and setbacks that could arise while implementing this conceptual design and potential mitigation strategies for them. Overcoming certain hurdles may create additional expenses, while other hurdles necessitate further validation of the final design before incurring significant costs.

The roof should be replaced prior to the PV module installation

The roof sections designated for the PV installation appear aged to the point that they will not last the full length of the PV system's intended period of use or the PV module's warranted lifespan.

Mitigation Strategy 1: Consider the cost of re-roofing the designated roof section for the PV system before the PV module installation commences.

Mitigation Strategy 2: Prepare for the out-of-pocket costs to hire contractors to remove the PV system and mounting system, complete the re-roof, and reinstall the PV system after the initial installation. This process may cost more than the remaining value of the roof and is not covered by grant funding or tax credits.

The PV System layout and final BESS sizing and interconnection methods may change upon completion of the scheduled 2026 remodel/addition

No electrical or structural plans are available to determine the extent to which the scheduled 2026 remodel/addition will affect the current roof configuration or electrical usage/demand.

Mitigation Strategy 1: The PV roof layout should be verified with the architect to ensure that the current roofline is not affected. Additional new roofs may allow for a larger PV installation at the time of contracting/engineering.

Mitigation Strategy 2: The BESS storage capacity and peak output should be verified for compatibility with any changes to the electrical system and/or load profiles when the the scheduled 2026 remodel/addition is completed. These changes may result in the requirement for a larger BESS and PCC to accomodate additional loads that have not been accounted for at the time of this feasibility study.

BESS installation location will be in close proximity to areas that are accessible and/or visible

For safety reasons, the BESS system will need to be housed in a substantial outdoor metal enclosure at the location shown on the feasibility study's site plan. This is in a highly visible, high usage zone, and may impact the aesthetics or assesibility of this area.

Mitigation Strategy 1: An alternative location may be available and coordinated with the installing contractor at the time of final design. Additional costs may arise from this change.

Mitigation Strategy 2: Additional fencing may be installed to mitigate visibility and access to the BESS system. Electrical and property setbacks must be followed.

Fire Control Systems may activate during a power outage

Reviews of installed BESS systems show that some building Fire Control Systems may activate temporarily when the power goes out and the change from grid to battery power is occuring due to the millisecond delay.

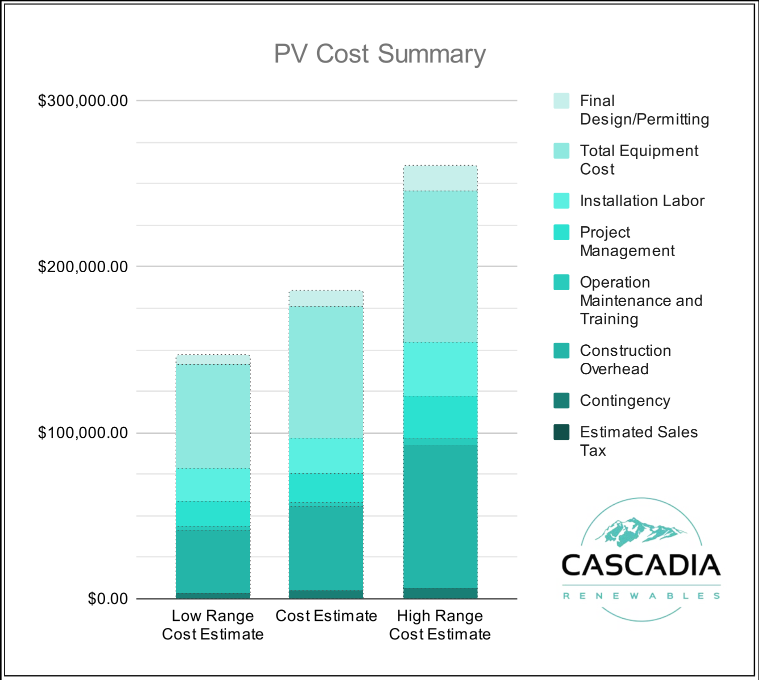
Mitigation Strategy: On-site personnel must be trained as to the proper operation and required steps for building and BESS operation during and extended emergency.

System Budget

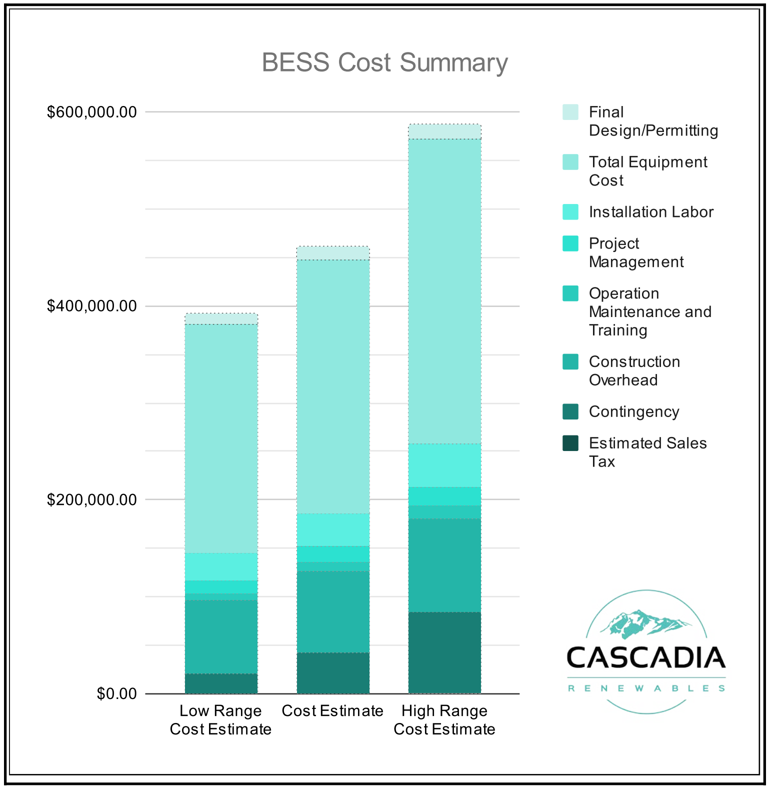
Cascadia Renewables included current Davis Bacon prevailing wage rates, contractor direct pricing, permitting, and consulting/engineering fees to determine the conceptual system pricing. The labor rates and equipment pricing used in the provided budgetary information are relevant to and compliant with local, regional, and federal grant programs to give the applicant access to an array of funding opportunities. The estimated installation cost excludes any required architectural or structural improvements, the internal organizational cost of procurement, and administration. This cost estimate also excludes future storytelling and community engagement efforts.

We advise applicants to consider these budget items separately and designate suitable resources for each. The cost estimate provided is based on market conditions, availability of labor, and equipment costs at the time of writing.

Since it is a well-established and competitive market, there is limited opportunity to reduce these costs further. The projected increase in the demand for BESS projects over the coming years may outpace the current supply. This may inflate equipment costs in the short term, which we reflect in our estimated budget. Final pricing may vary based on the chosen installation partner, final engineered solution, on-site soil, and geotech studies, which are not available within the scope of this feasibility study. We recommend establishing a comprehensive 3+ bid RFP process that encourages contractor participation, value engineering, and competitive pricing. We recommend periodic system price updates during the project development and construction.

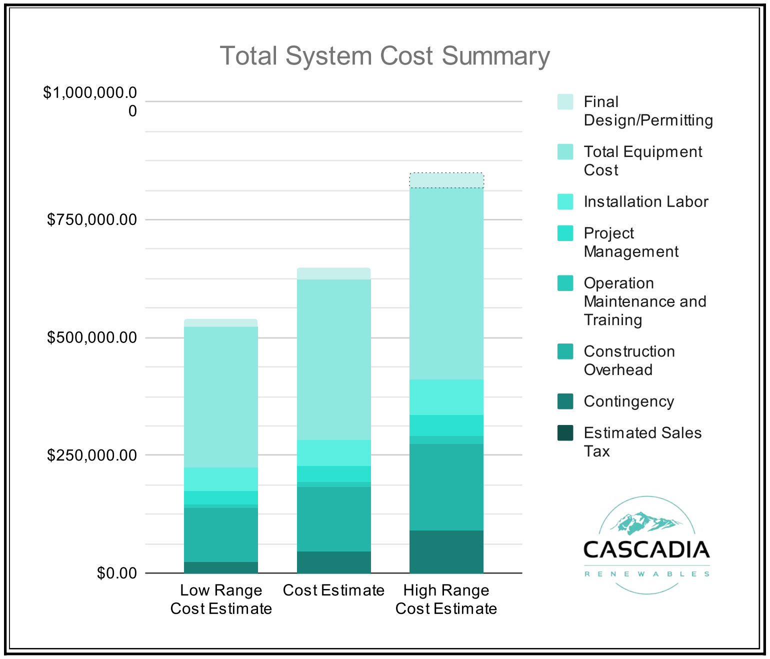


PV - COST SUMMARY			
Total Costs	**Low Range Cost Estimate**	**Cost Estimate**	**High Range Cost Estimate**
Final Design/Permitting	$5,000.00	**$10,000.00**	$15,000.00
Total Equipment Cost	$63,280.00	**$79,100.00**	$90,965.00
Installation Labor	$19,440.00	**$21,600.00**	$32,400.00
Project Management	$15,300.00	**$17,000.00**	$25,500.00
Community Outreach	TBD By Applicant	**TBD By Applicant**	TBD By Applicant
Operation Maintenance and Training	$2,125.00	**$2,500.00**	$3,500.00
Construction Overhead	$38,025.00	**$50,700.00**	$86,190.00
Contingency	$3,500.00	**$5,000.00**	$7,000.00
Estimated Sales Tax	$0.00	**$0.00**	$0.00
Total PV System Cost Estimate	**$146,670.00**	**$185,900.00**	**$260,555.00**
Cost/Watt ($/w)	**$3.40**	**$4.30**	**$6.03**



BESS - COST SUMMARY

Total Costs	Low Range Cost Estimate	Cost Estimate	High Range Cost Estimate
Final Design/Permitting	$11,475.00	**$13,500.00**	$15,525.00
Total Equipment Cost	$235,890.00	**$262,100.00**	$314,520.00
Installation Labor	$28,560.00	**$33,600.00**	$43,680.00
Project Management	$12,960.00	**$16,200.00**	$19,440.00
Community Outreach	**TBD by Applicant**	**TBD by Applicant**	**TBD by Applicant**
Operation Maintenance and Training	$7,000.00	**$10,000.00**	$14,000.00
Construction Overhead	$75,510.00	**$83,900.00**	$96,485.00
Contingency	$21,000.00	**$42,000.00**	$84,000.00
Estimated Sales Tax	$0.00	**$0.00**	$0.00
Total BESS System Cost Estimate	**$392,395.00**	**$461,300.00**	**$587,650.00**
Cost/Kilowatt Hour ($/kWh)	**$2,744.02**	**$3,225.87**	**$4,109.44**



Total System - COST SUMMARY

Total Costs	Low Range Cost Estimate	Cost Estimate	High Range Cost Estimate
Final Design/Permitting	$16,475.00	**$23,500.00**	$30,525.00
Total Equipment Cost	$299,170.00	**$341,200.00**	$405,485.00
Installation Labor	$48,000.00	**$55,200.00**	$76,080.00
Project Management	$28,260.00	**$33,200.00**	$44,940.00
Community Outreach	**TBD by Applicant**	**TBD by Applicant**	**TBD by Applicant**
Operation Maintenance and Training	$9,125.00	**$12,500.00**	$17,500.00
Construction Overhead	$113,535.00	**$134,600.00**	$182,675.00
Contingency	$24,500.00	**$47,000.00**	$91,000.00
Estimated Sales Tax	$0.00	**$0.00**	$0.00
Total System Cost Estimate	**$539,065.00**	**$647,200.00**	**$848,205.00**

Economic Benefit

This is a detailed breakdown of the cash flow of the system. Please note that this breakdown does not include the cost of operations and maintenance, as that cost is challenging to predict. Cascadia Renewables does not want to offset the confidence we otherwise have in these financial estimates by overshadowing our conclusions with less reliable data. To that effect, Cascadia Renewables recommends requesting an estimate for annual operations and maintenance as part of the contractor selection RFP.

Assumptions and Key Financial Metrics

Discount Rate	5.0%	Federal Tax Rate	0.0%	State Tax Rate	0.0%
Average Annual Utility Escalation	3.0%	PV Generation (kWh/kW-DC)	884 kWh/kW-DC	Average PV Degradation Rate	0.56%
Average ESS Degradation Rate	5.00%				

Years	Project Costs	Electric Bill Savings	Grant Amount	PV Generation (kWh)	Total Cash Flow	Cumulative Cash Flow
Upfront	-$647,200	-	-	-	-$647,200	-$647,200
1	-	$4,261	$647,200	38,204	$651,461	$4,261
2	-	$4,364	-	37,990	$4,364	$8,624
3	-	$4,469	-	37,776	$4,469	$13,094
4	-	$4,577	-	37,562	$4,577	$17,671
5	-	$4,688	-	37,348	$4,688	$22,359
6	-	$4,801	-	37,134	$4,801	$27,160
7	-	$4,916	-	36,920	$4,916	$32,076
8	-	$5,035	-	36,706	$5,035	$37,111
9	-	$5,155	-	36,492	$5,155	$42,266
10	-	$5,279	-	36,278	$5,279	$47,545
11	-	$5,405	-	36,064	$5,405	$52,951
12	-	$5,534	-	35,850	$5,534	$58,485
13	-	$5,666	-	35,636	$5,666	$64,151
14	-	$5,801	-	35,422	$5,801	$69,953
15	-	$5,939	-	35,208	$5,939	$75,892
16	-	$6,080	-	34,994	$6,080	$81,972
17	-	$6,224	-	34,780	$6,224	$88,196
18	-	$6,372	-	34,567	$6,372	$94,568
19	-	$6,522	-	34,353	$6,522	$101,090
20	-	$6,676	-	34,139	$6,676	$107,766
Totals:	-$647,200	$107,766	$647,200	723,422	$107,766	-

Maintenance Considerations

An operations and maintenance plan should be enacted by internal personell or an external contractor. When designing this plan, consider the following:

- The PV system will require regular annual or bi-annual PV module cleaning to remove any built-up debris in order to maintain the peak system performance and maximum BESS charging capabilities. The maintenance schedule will vary depending upon the site conditions, frequency of rain events, and build up of season debris such as fall leaves or needles.
- The BESS will require regular maintenance to maintain it's equipment warranty and ensure proper system functionality. The required maintenance steps and frequency will be defined by the equipment manufacturer but typically include servicing the BESS HVAC and fire protection systems, internal/external visual inspections, loose connections check, and a functional battery test on an annual basis.

Community Benefit

The North End Station plays a crucial role in serving the city of Tumwater. This facility operates as both a fire station and an emergency coordination hub. It supports daily fire department operations and serves as the primary Emergency Operations Center during major events or disasters. The site ensures that emergency services remain available during power outages, providing backup power to maintain operations and support the community's safety needs.

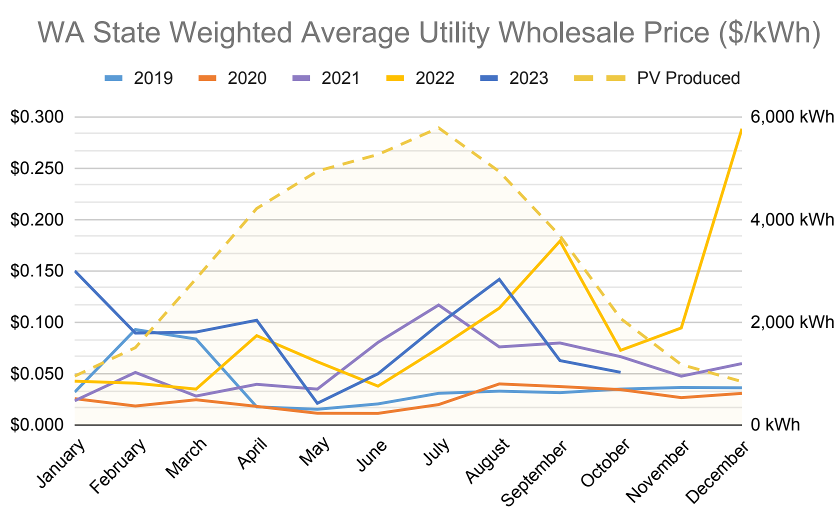
Approximately 27,000 people live in the range of the fire district. The City of Tumwater has only two fire stations: headquarters and North End station. If one or both of these stations were to become inoperable, the effect on the city's emergency response capacity would be immediate and severe.

By specifying local contractors and utilizing union labor and apprenticeship programs, the workforce local to the area can be trained. This increases the local capacity to develop future resiliency projects.

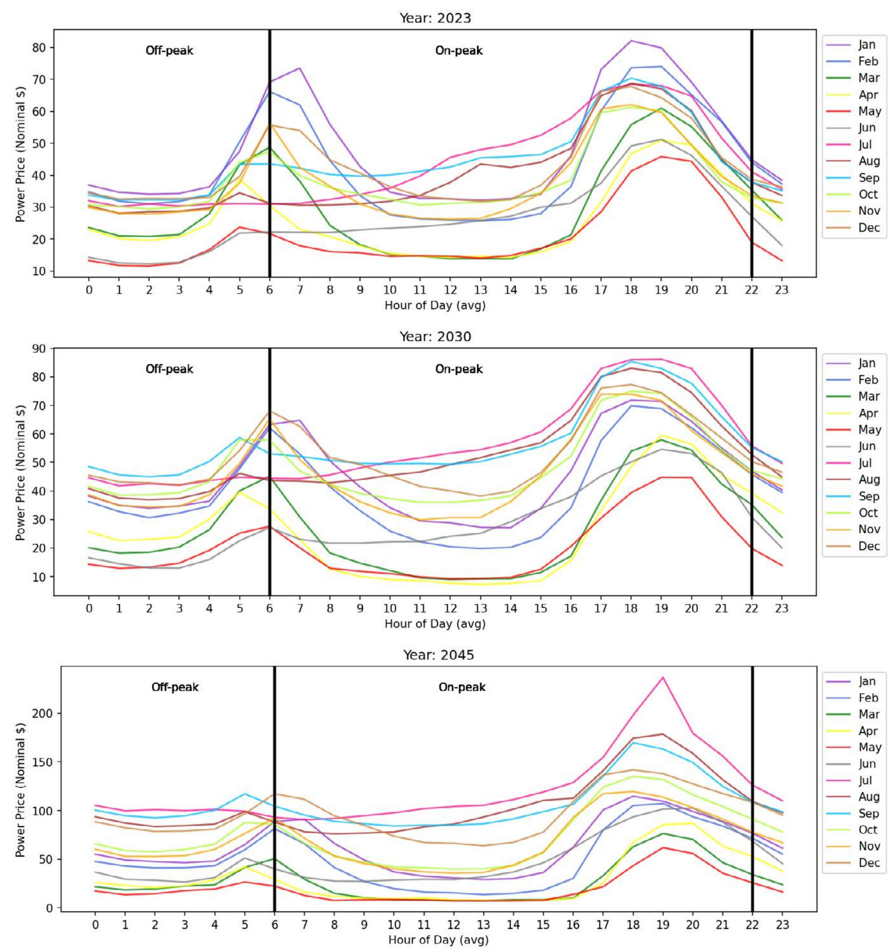
Over the warrantied lifetime of the PV array, the system will offset 599 tons of carbon, equivalent to planting 8,978 trees.

Grid Benefit

At a national level, the US electric grid is one of the world's largest and most complex machines, with aging infrastructure facing increased demand due to the electrification of transportation and buildings, population growth, and migration. Distributed Energy Resources (DERs) play a crucial role in strengthening existing grid infrastructure and moving toward a more equitable and sustainable electric grid. Washington State has historically relied on hydroelectric power to balance energy demand. However, climate change is reducing snowpack and our available hydro resources, making it necessary to explore alternative options. Regional electricity prices, represented in the middle Columbia WA State Weighted Average Wholesale Price graph below, have been increasingly volatile during late summer afternoons. The largest investor-owned utility (IOU) in WA, PSE, anticipates that this price volatility will increase in coming years (see graph below). In Washington State, solar generation can help address the energy shortfall during summers, and energy storage can provide balancing services and further reduce demand during peak periods.



Monthly production of the system vs average wholesale energy pricing. Coincidence of high production to high pricing is financially beneficial.



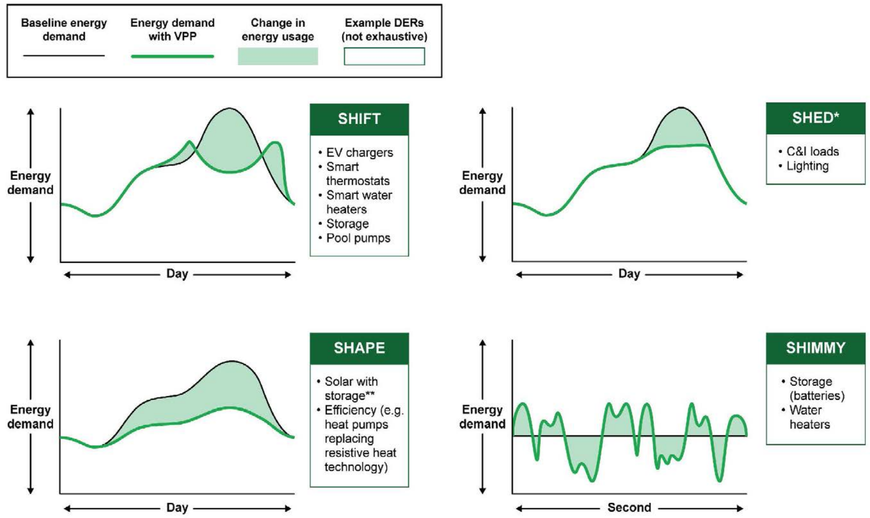
Daily price volatility by month for the years 2023, 2030, and 2045.

The US Department of Energy's September 2023 report titled "The Pathway To Commercial Liftoff: Virtual Power Plants" suggests integrating solar panels, battery storage, and micro-grid projects to optimize energy resource usage and manage grid stability. Virtual Power Plants (VPPs) and networked energy storage solutions are cost-effective alternatives to natural gas peaker plants, offering substantial benefits and low costs. The report highlights the importance of adopting innovative technologies to meet the growing energy demand sustainably and cost-effectively. Ultimately, strengthening the grid benefits the entire community. This project can play a part in improving regional energy infrastructure by reducing energy demand and providing grid-balancing services.

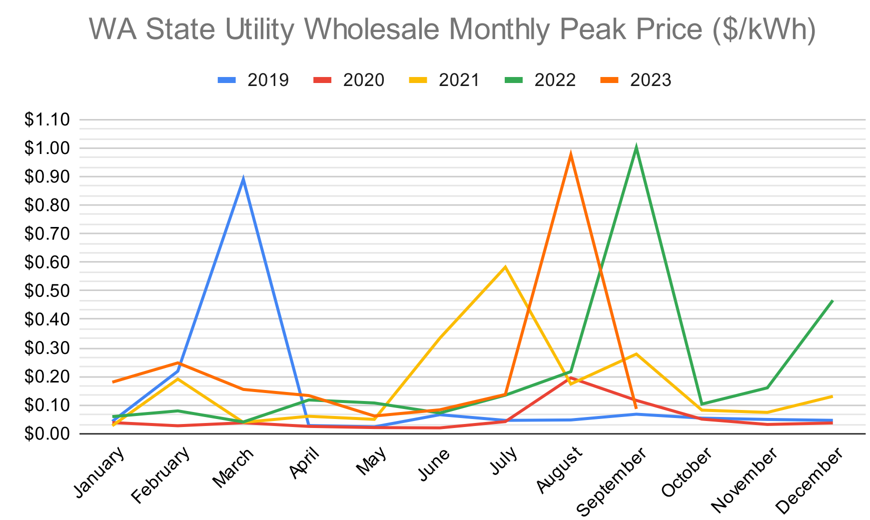
Energy pricing can serve as an effective method for utilities to encourage efficient energy dispatch from flexible resources such as solar and storage. A well-optimized system can use stored energy during high-demand periods, contributing to grid stability and economic efficiency. By implementing an appropriate demand response program, unused BESS capacity can be deployed to reduce peak demand across the service territory on a grid scale. This section aims to evaluate the potential benefits of the conceptual system in terms of reducing demand, exporting energy, and providing grid-balancing services.

PSE does not currently have a demand response program, so we have conducted optimizations to showcase the maximum demand reduction on-site while ensuring battery cell longevity.

To illustrate the effects that the conceptual system could have on the site's demand, we have simulated the conceptual system with a model of predicted consumption patterns. These charts depict the days on which the peak demand for July is predicted to occur, according to our simulation of the



Illustrations of the various ways DERs can influence demand. "Shape" (bottom left) is the most likely result of a solar plus storage system. Graphs by the US Department of Energy.

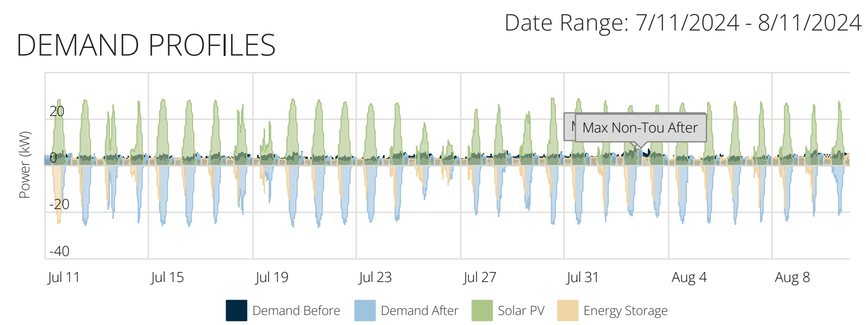


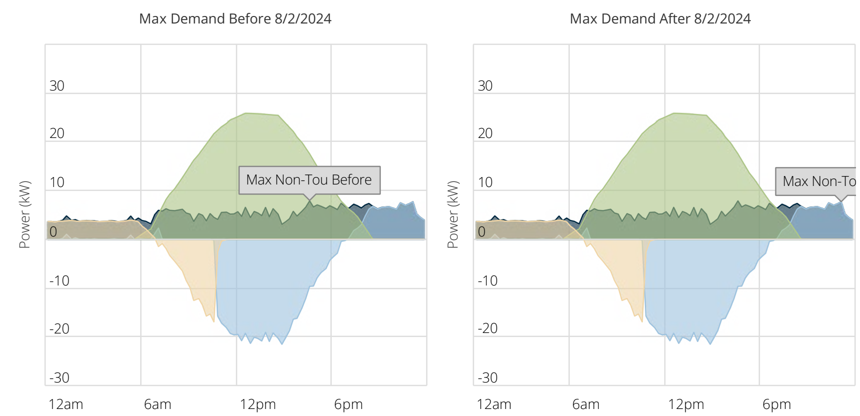
The highest wholesale costs can be mitigated by dispatching unused BESS capacity, given appropriate programs.

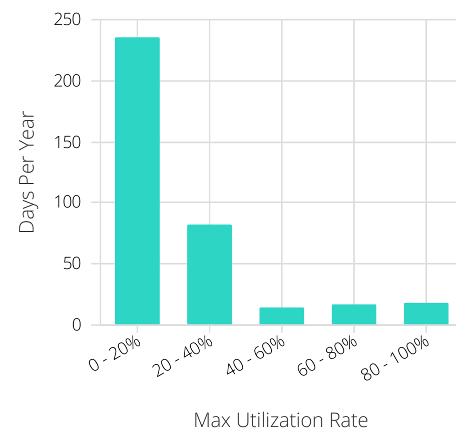
conceptual system. The demand of the site before accounting for the system is shown in dark blue, while the demand that would result from its implementation is shown in light blue. The difference between the demand before and the demand after is the sum of the PV generation (shown in green) and the BESS's flow (shown in yellow). The chart on the left displays the day of maximum historical demand, while the chart on the right displays the day of maximum simulated demand accounting for the effects of the conceptual system. The appendix provides the same series of charts relevant to each month throughout the year. Note that any smoothing or demand reduction on site represents a reduced burden on the local grid.

To promote system health and longetivity, the BESS should be configured to partially discharge each day. This discharge can be coordinated with times of peak building demand, which will reduce and flatten the demand profile of the building. Based on utility bills this facilitity is subject to monthly peak demand charges so the BESS could be strategically dispatched during times of peak building demand to lower monthly demand charges, providing additional economic benefits from the system.

The bar chart shows how many days each quintile of the BESS is used for on-site demand management throughout the year. It is worth noting that increased utilization of the BESS could result in a faster degradation rate.







Above: Dispatch graphs showing the effects of the conceptual solar plus storage system for August 2nd.

Left: Histogram of the distribution of BESS utilization over a year.

Permitting and Utility Agreements

If this project proceeds to installation, it will be the responsibility of the installer to verify the relevant authorities having jurisdiction (AHJs) and ensure all necessary permits and agreements are in place. As it pertains to this conceptual design, Cascadia Renewables has identified the following AHJs and has documented our interactions to date.

Labor & Industries - Electrical Permitting:

The conceptual PV system and BESS design will require electrical permitting and a possible plan review from the Washington Department of Labor & Industries to verify that they meet all current WAC and NEC code reviews. Code revisions may occur in the NEC and WAC and will need to be verified during the final system design.

Puget Sound Energy - Interconnection:

The conceptual PV system is designed to align with Puget Sound Energy's standard interconnection rules, with a capacity of 100kW AC or less per customer meter. This classification ensures the system adheres to the established approval procedures for Net Metering. To proceed, a Schedule 150 Application and Agreement for Interconnection, Net Metering, and Production must be submitted.

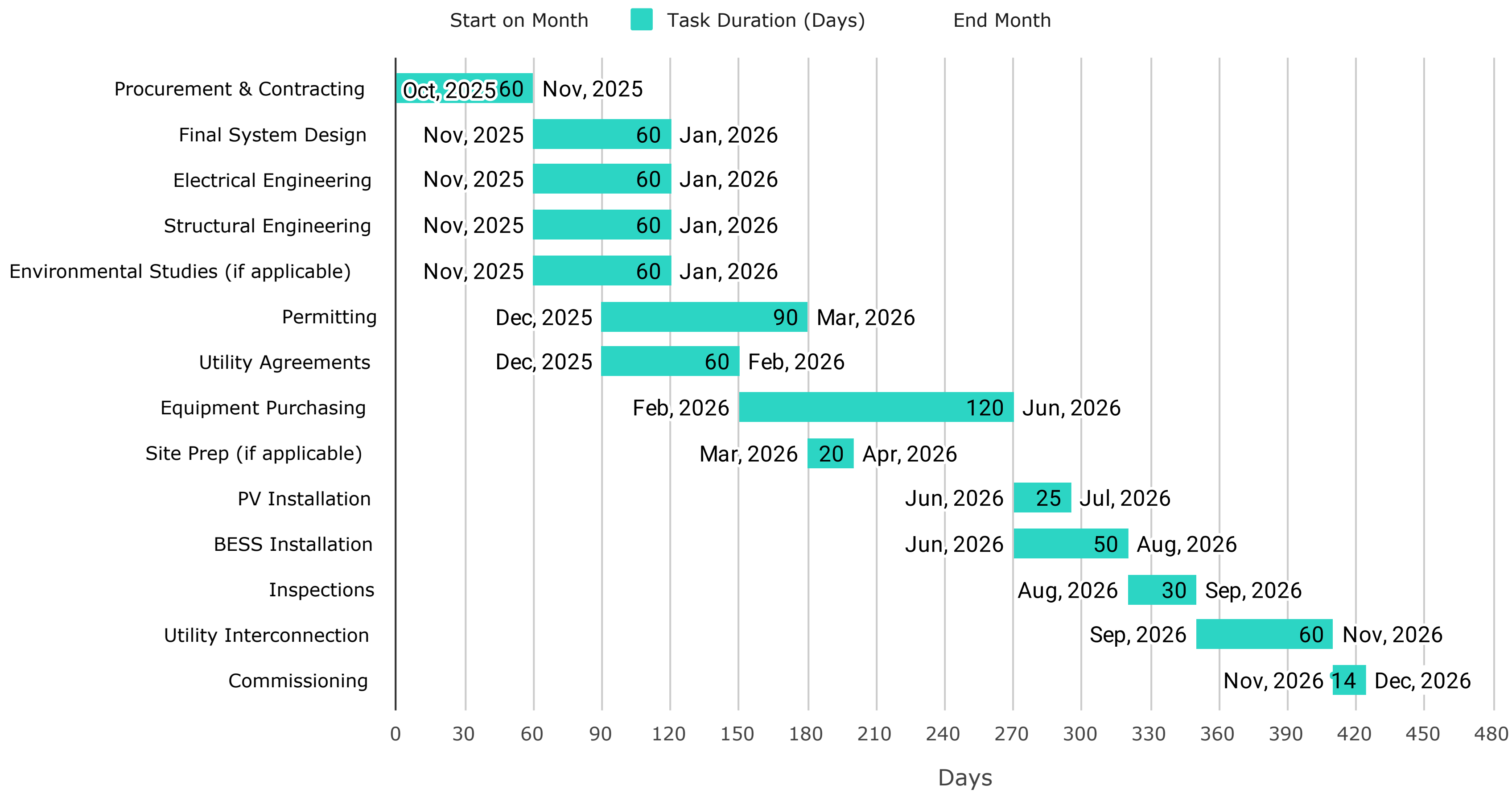
Department of Archeology and Historic Preservation:

This permit is required any time there is soil disturbance. DAHP does not charge a fee to process or issue a permit; however, there are penalties for failing to obtain or comply with a permit.

Solar, BESS, Building, and Fire Review/Permitting:

The City of Tumwater Community Development Department will provide single point review and permitting for the rooftop solar arrays, the BESS installation location, BESS pad and fire code compliance. Al Christensen, the Building and Fire Safety Official at the Department provided an initial review of the project on 3/25/2025 to determine permitting requirements. The rooftop solar array will require a standard Building Permit Application that includes a site plan, rooftop array layout drawing, stamped engineering letter or plans showing compliance to snow/wind loading requirements, and equipment specification sheets. The BESS installation can be included in this single permit application, with additional documentation showing compliance to NFPA/NEC required setbacks and fire safety requirements. Planning will require that the BESS be shielded from public view by a solid wall or fence and that a Foundation Plan be submitted. Chainlink fences are not acceptable as shielding. The initial review indicated that no land use, or additional special use permits will be required. All fire reviews for the BESS and PV system will be included in the Building Permit review, with no additional permit applications required. Please note that the Department indicated that the "rules may change by the time of installation. The Department is currently reviewing other ongoing installations in the County and may be updating permitting requirements or BESS installation policies."

Schedule


Start on Month
Task Duration (Days)
End Month
Procurement & Contracting
Oct, 2025
60
Nov, 2025
Final System Design
Nov, 2025
60
Jan, 2026
Electrical Engineering
Nov, 2025
60
Jan, 2026
Structural Engineering
Nov, 2025
60
Jan, 2026
Environmental Studies (if applicable)
Nov, 2025
60
Jan, 2026
Permitting
Dec, 2025
90
Mar, 2026
Utility Agreements
Dec, 2025
60
Feb, 2026
Equipment Purchasing
Feb, 2026
120
Jun, 2026
Site Prep (if applicable)
Mar, 2026
20
Apr, 2026
PV Installation
Jun, 2026
25
Jul, 2026
BESS Installation
Jun, 2026
50
Aug, 2026
Inspections
Aug, 2026
30
Sep, 2026
Utility Interconnection
Sep, 2026
60
Nov, 2026
Commissioning
Nov, 2026
14
Dec, 2026
0 30 60 90 120 150 180 210 240 270 300 330 360 390 420 450 480
Days

Summary of Feasibility and Next Steps

Installing a solar plus storage system, incorporating Battery Energy Storage Systems (BESS), offers a practical solution for enhancing power reliability, especially during outages. This system design ensures continuous power supply, adapting to both typical and emergency energy needs. During outages, the BESS can back up the entire facility and significantly reduce reliance on grid power. For extended periods without solar resource availability, such as in winter, a generator can be utilized to provide long-term autonomy.

In this setup, the existing 40kW standby generator will be integrated to recharge the BESS. This integration effectively extends the duration of autonomous power, providing additional resilience during prolonged grid failures. This system configuration offers a significant improvement in site energy resilience, providing numerous benefits and increased support to the community, even during disasters and long-term outages.

Next Steps:

- Once building expansion plans are finalized, evaluate the available space and proposed location for the pad-mounted BESS.
- Determine the anticipated increase in building demand after the expansion and evaluate if an additional 35kW BESS inverter will be needed.
- Consider funding pathways and potential grant writing efforts
- If successful in grant requests and negotiations, construct project.

Additional Reference Information

General Site Information

Managing Organization	City of Tumwater
Site Address	405 Linwood Avenue SW Tumwater, WA 98512
Parcel Number	09080004002
Organization Contact	Brian Hurley, Fire Chief
Organization Contact Phone Number	(360) 754-4170
Organization Contact Email	BHurley@ci.tumwater.wa.us

Utility Information

Service Electric Utility	Puget Sound Energy (PSE)
Electric Utility Meter Number	P158621671
Electric Utility Tariff Structure	Commercial 24
Electric Utility Hosting Capacity	Generation Hosting Capacity of 4.45 MWs

Minimum Equipment Recommendations

The conceptual system has been designed assuming specific named products. These choices are based on the current market, and the named equipment may not be the best choice for the project or may not be available at the time of hypothetical construction. When evaluating bids, we recommend considering the following criteria to be the acceptable minimums.

PV Modules:

Warranty: Minimum of 12 years for the product, extending to 25 years, covering parts and labor.

Performance Guarantee: A linear performance warranty that guarantees at least 86% of nominal power rating after 25 years.

Manufacturing Standards: Modules should be Tier 1 qualified, preferably assembled in the USA.

Cell Type: Monocrystalline cells.

Frame and Weight: Anodized aluminum frame with an average system weight not exceeding 2.6 pounds per square foot (psf).

Certifications: Compliance with UL 1703/UL 61730; PID Resistance (IEC 62804); Salt Mist (IEC 61730) when PV system is within 2 kilometers of shoreline; and Fire Classification matching that of the existing roof.

PV Inverters:

Efficiency and Warranty: Minimum efficiency of 96%, with a 10-year limited warranty, extendable up to 5-15 years.

Compliance and Compatibility: Must comply with IEEE 1547/ UL1741SB standards; suitable for output voltages of 120/240V Single-Phase, 120/208V 3-Phase, or 277/480V 3-Phase as dictated by the BESS design and existing electrical infrastructure; FCC Part 15 Class A; SunSpec Modbus Compliant.

Safety Features: UL1699B; NEC 2020 Rapid Shutdown Compliant; Ground Fault Detection and Interruption, AC and DC Surge Protection

PV Monitoring:

Monitoring Level: Module-level monitoring

Connectivity: Connection options should include hard-wired Ethernet, Wi-Fi, or a cellular connection.

User Interface: A web-based portal accessible to customers, displaying real-time and historical data on PV power, energy production, system alerts, and module status.

Mounting System:

Warranty and Design: A minimum of a 25-year manufacturer warranty. The mounting system design should be suitable for the specific roof type and capable of withstanding local wind, seismic, and snow loading requirements.

Compatibility with Roof Materials: For composition shingles, fully flashed mounting feet are recommended, including the usage of butyl tape and/or polyurethane caulking. The mounting system must comply with UL2703 and local building codes, as well as maintain the roof's warranty and fire classification.

Examples of Mounting Systems for Composition Roofs.

BESS Specifications:

Warranty: Minimum 5-year manufacturer's warranty with 5-10-year warranty extension options.

Standards Compliance: Must comply with UL 9540 and UL 9540A for safety. Must adhere to NFPA 855 standards for installation and safety.

Battery Chemistry: Lithium Iron Phosphate (LFP/LiFePO4) is preferred for its stability, safety, and longevity.

Compatibility: Should be compatible with a range of third-party inverters and microgrid control systems. Should include generator compatibility and black start capability.

Enclosure Rating: A minimum NEMA 3R rating is required for outdoor installations to ensure protection against weather elements. If the system is to be installed near salt water, the enclosure must be suitable for the environment, and warranties must not be voided.

Fire Suppression: Active chemical fire suppression and exterior ventilation is recommended for all indoor and outdoor installations.

Battery Heating/Cooling Equipment: Integrated HVAC or alternate active temperature control system to maintain ideal battery operating conditions and temperature.

Country of Origin: Must meet any specific country of origin requirements as per the funding source's guidelines.

Energy Capacity and Power Output: Specified based on the project's energy storage needs, considering peak demand shaving, load leveling, and backup power requirements.

Multimodal BESS Inverter: Should have the following listings and certifications, including but not limited to: UL 1741SB, IEEE 1547, IEEE 519, NEMA 3R Enclosure, Minimum efficiency of 95% with a minimum 10-year limited warranty, extendable up to 5-15 years

Efficiency and Performance: High round-trip efficiency and low degradation rate over the system's operational life.

Safety Features: Advanced Battery Management System (BMS) for monitoring cell voltage, temperature, state of charge, and overall system health. Overcharge, deep discharge, overcurrent, and short-circuit protection.

Scalability: Ability to scale up the system with additional energy storage modules or integrate with existing renewable energy systems.

Installation Flexibility: Suitable for various installation environments, including ground mount, rooftop, or integrated within existing infrastructure.

Maintenance: Low maintenance requirements, with remote monitoring and diagnostics capabilities.

Microgrid Controller:

Functionality: Highly recommended to include a microgrid controller for advanced management capabilities.

Integration: Should offer interoperability with third-party Virtual Power Plant (VPP) providers.

Features: Capable of real-time monitoring, demand response, load management, and predictive analytics.

User Interface: Intuitive, user-friendly interface for system management and data visualization.

Grid Support: Ability to monitor grid voltage and frequency to initiate power quality correction measures using distributed energy assets when needed.