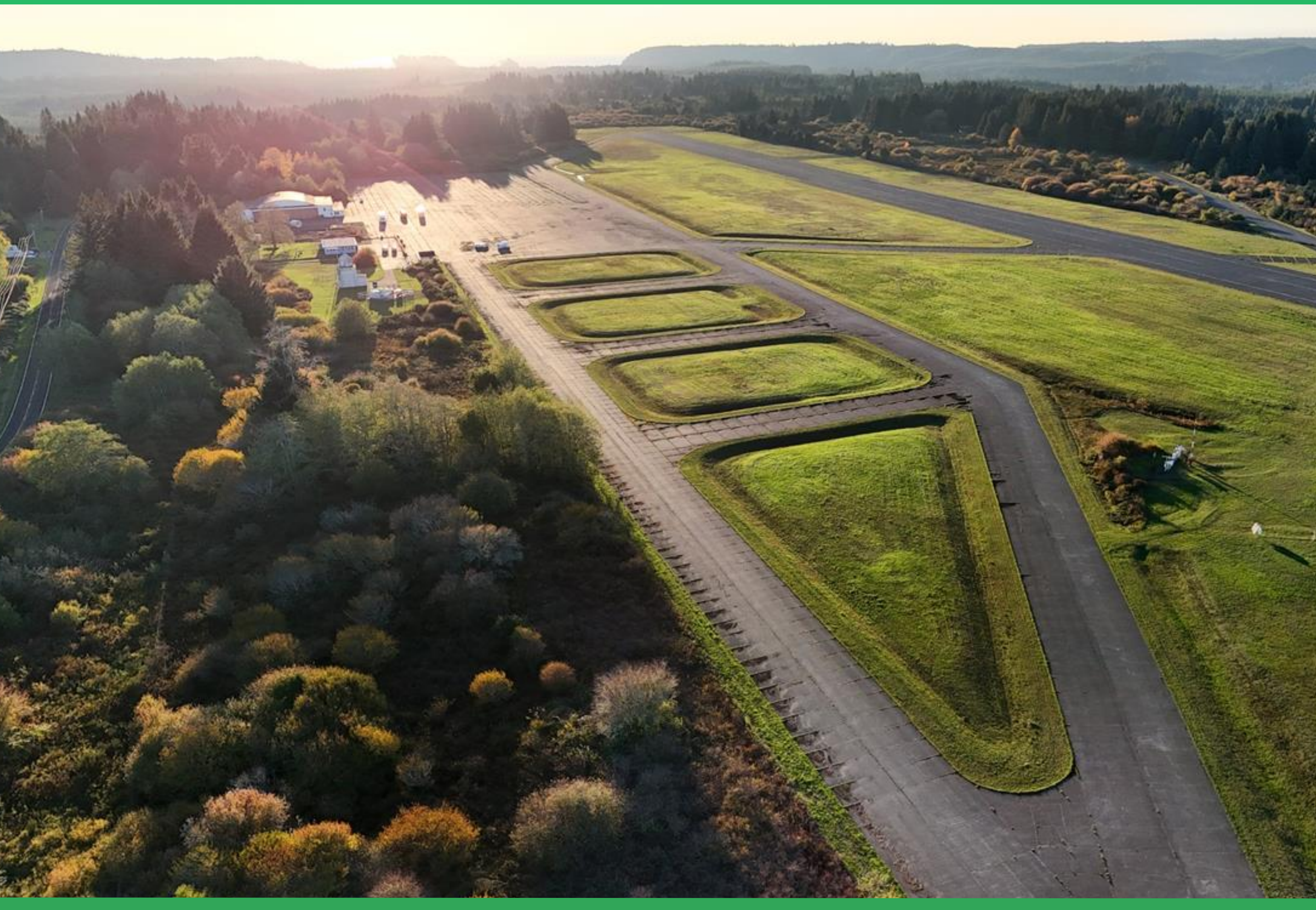
Quillayute Airport Microgrid Feasibility Report

Prepared for: Clallam County Fire District 6

March 8th, 2024



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Executive Summary

Geological studies estimate the likelihood of a Cascadia megaquake occurring within the next 50 years at something between 17% and 37%. It will cause widespread power outages, water failures, communication disruptions, and transportation blockages. The Quillayute Airport, in Clallam County, WA is ideally positioned, both physically and developmentally as an ideal opportunity to take the lead as an emergency response base of operations and all-hazard shelter facility for Clallam County Emergency Operational Area 2. As the only Tier 2 airbase on the outer coast of Washington and already designated as the assembly point for tsunami evacuation, ensuring reliable power for the emergency staging area is a critical next step in the airport's master planning and redevelopment process.

This study highlights the capabilities of the Airport to drastically increase emergency preparedness in the region and provides a comprehensive plan and design for a resilient, grid-tied, microgrid power system.

The design provided as part of this study includes a 60kW$_{dc}$ solar PV array coupled with a 61.4kWh$_{dc}$ battery energy storage system and a 60kW$_{ac}$ traditional generator for increased redundancy and resiliency. The PV system will produce 62.2MWh of energy annually and the microgrid will be capable of maintaining the designed load indefinitely.

As part of this project, basis of design drawings have been developed including site plans, equipment layouts, electrical single lines, additional communication infrastructure, structural foundational details and equipment specifications. With limited additional effort the drawing package could be taken to 100% construction documentation for permit and installation.

The recommended next steps should include the following:

1. Gaining approval from key stakeholders
2. Securing implementation funding
3. Development of a request for proposal (RFP) for an installation contractor
4. Contractor award, completion of engineering
5. Permitting and PUD interconnection
6. Equipment procurement, construction, commissioning
7. Operation and promotion of microgrid hub

This study and plan resulted in actionable steps for the Clallam County Fire District 6 to pursue. Once completed, the communities located in the Olympic Peninsula will be well prepared to deal with future adverse events, as well as collect the environmental and economic benefits associated with grid-tied solar PV.

The ProtoGen team wishes to extend a special thanks to key individuals for their assistance in development of this report:

- Chip Keen, Lead Commissioner, Clallam County Fire District 6
- Rod Fleck, City Attorney/Planner, City of Forks
- Colin Young, Supervisor, Clallam County PUD
- David Miller, AICP, Century West
- TJ Merrill, Sr. Solar & Storage Designer, A&R Solar

Contents

List of Figures

List of Tables

1 Introduction

This report was developed by ProtoGen, Inc. for Clallam County Fire District 6 (CCFD). The report assesses the feasibility of a microgrid system at the Quillayute Airport to support its role as the evacuation site for Northwest Washington. This microgrid will work in conjunction with the hangar revitalization project such that the hangar space can double as an emergency shelter.

The activities conducted included data collection, modeling and simulation, analysis, and recommendations development to serve as the basis of design for an RFP process to move the project towards construction. Numerous types of data were collected and/or developed to support modeling and simulation activities, including, but not limited to, conceptual designs, electric loads, microgrid equipment costing, seismic location design criteria, and information pertaining to energy markets and regulatory structures.

A site visit was conducted to meet with key personnel, field-verify existing conditions, and conduct surveys. These activities supported the development of equipment layout models and software-based modeling and simulations. A range of scenarios were then iteratively developed, refined, and analyzed to draw out critical insights and conclusions for development of the Quillayute Airport Microgrid. The most viable scenarios were then developed further to discuss more in-depth the economic, regulatory, and technical components of each.

The report concludes by providing actionable recommendations for the next steps by combining all the economic, technical, and regulatory findings. The report and drawings will enable the CCFD to confidently advance planning, utility negotiations, design, and grant submissions and can be used to develop a bid specification for engineering and construction of the envisioned microgrid project.

2 Background

The United States' electrical grid is increasingly at risk of cascading failures caused by sophisticated threat actors and severe weather events of increasing frequency and intensity. The greatest hazard identified for this project was the potential for a megaquake resulting from seismic activity at the Cascadia subduction zone. The primary emergency response needs for District 6, in which the Quillayute Airport is located are hydration, shelter, and communication. It is predicted that a massive seismic event here could cause total electrical grid failure, with an estimated restoration duration reaching a full year. Similarly, a total water systems failure would occur with water being restored with power, but 33% of resources needing to be rebuilt Communications will be out for extended durations with 67% likely needing to be replaced.

Ground transportation will become almost impassable with 80% of road surfaces having failures over three inches. The local road networks will be hindered by severe damage on all of the 11 bridges in the region, making air support the only viable means for significant support and evacuation of the region.

The Quillayute Airport is the only Tier 2 airbase on the outer coast of Washington with a main runway currently 4,210 feet long with an expansion planned to restore it to its original 5,000 feet length as shown in Figure 1[1]. This would make the airport the only location on the northwest coast of Washington capable of handling C17/C130 takeoffs and landings—allowing the airport to serve as a primary support and response location and command area for the Clallam County Emergency Management Plan operational areas 1 and 2 serving thousands of people trapped in the northwest corner of the Olympic Peninsula in an emergency event.

[1] Full resolution figures are available in the appendix.

Figure 1: Current conditions overlay on historical naval air station map

The CCFD recognized the need for energy resilience amid the potential impacts of the Cascadia Fault Line. The fault line, which spans from northern California up towards Vancouver Island, is predicted to be the cause of earthquakes that can reach a level of 9+ on the Ritcher scale. An earthquake of this level has the potential to cause serious damage to property and greatly impact the electrical capabilities of areas as well as infrastructure typically designed to save lives during catastrophes if adequate preparation for seismic activity was not intrinsic to the project at inception. In preparation for such events, the Quillayute Airport is intended to serve as an emergency shelter, command center, and evacuation point. The microgrid system basis of design was focused on allowing the airport to maintain power during major grid disruptions and allowing for continued life saving measures across the region including emergency communication, powering a community shelter, and providing an evacuation point and emergency planning and response base of operation in the region.

2.1 Quillayute Airport Master Plan

The airport's owner, City of Forks, recently developed its 20-year Airport Master Plan (AMP). The report was issued in January 2024, and was authored by the engineering consultant, Century West.[2] The AMP guides airport activities and capital improvements in the short and long term. The concept of a resilient energy system was not explored in the scope of the report. However, the renovation plans and priorities are applicable to this study and were used to guide the design ethos. The AMP noted that the airport does not currently contribute on-site resources in its role as a national guard response hub. A resilient power system at Quillayute would represent a departure from this status quo. As the document stated:

> *The operational side of these emergency response scenarios is comparable to a typical military or national guard response to a major event (earthquake, flood, etc.) in remote regions with limited facilities. Significant resources are rapidly mobilized as part of incident command systems, rather than maintained onsite in advance. Based on this "contingency" model, the master plan's alternatives evaluations are not driven by potential emergency response needs. The overall intent of the airport master plan is to address non-emergency facility needs for the current planning period while preserving emergency response capabilities to the extent feasible.*[3]

The AMP goes on to document the condition of the airport's two buildings—the hangar and the 'NOAA building'. Both structures are original to the site's WWII-era construction. The NOAA building is currently occupied and in working condition. An active weather station and balloon launch facility are located adjacent to the building. The hangar structure, on the other hand, has significantly degraded over time, with some renovations occurring in 2009 on the north side of the building. It is not currently occupied and will require significant restoration to facilitate occupancy and productive use.

Figure 2: Aerial view of hangar from NE

Figure 2 shows the partially renovated north wing and north exterior of the building. Visible here and in Figure 4 is the condition of the east hangar doors as can be compared to the doors on the west side of the building visible in Figure 5. The NOAA building is shown from the north in Figure 3.

[2] Quillayute Airport - Century West

[3] AMP, Page 5-1

Figure 3: Aerial view of NOAA building from north

The AMP affirms that the hangar assessment provided in the 2003 master plan is still accurate:

> *"The hangar/office is located on the central portion of the apron and consists of approximately 8,100 sq. ft. Due to a state of disrepair, rehabilitation to this building would include re-roofing, installation of new windows and doors, replacing and upgrading existing electrical, installation of a new septic tank, plumbing repairs, and heating of the building. Additional exterior work will need to be undertaken to replace rotting siding with new concrete-based siding that would match the original siding used on the building. Total estimated cost for pursuing such a project is estimated to be $190,000. The facility is currently occupied by WACO." (Dunkelberg, 2003)*[4]

Figure 4: Southeast view of hangar building

[4] AMP, Page 2-43, WACO was the tenant occupying the hangar at that point

Figure 5: Southwest view of hangar building

Both airport structures are eligible for listing on the National Register of Historic Places and there is no intention for either to be demolished.[5] Tenant revenue (for ground leases and rents) is a primary source of airport revenue to the City. The intent to rehabilitate the building and use it to accommodate non-aeronautical tenants was established during the partial renovation in 2009. There is also potential for additional hangar sites, as documented in the AMP.

In addition to revitalizing the hangar building, the AMP describes high priority improvements (specifically instrument control and runway lighting) that could increase airport utilization. Land use authority for these developments falls under Clallam County with the zoning classification of Western Region Rural Center (WRD).

2.2 Site Discovery

The microgrid site discovery process also engaged the airport’s rich history. The discovery process investigated the site’s topography, its buildings, and its main utility services: water and electrical. The intent was to develop a nuanced understanding of the place, its history, and not to jump to conclusions regarding microgrid options and configurations. These details form the basis for the development process engaged in the Technical Review section.

2.2.1 Water System

The water system for the airport also dates to the original WWII construction. The well receives a dedicated, single-phase electrical service, and includes a small underground space with an electrical panel and pressure tank. It is fully enclosed within the runway area at the northeast of the property and is adjacent to NOAA’s research equipment triangle, ASOS. According to the AMP, the construction of the water line is believed to be wood stave pipe. The 6” main line is understood to run down Quillayute road, around 2500’ feet, ending at the NOAA building and hangar. The buildings’ septic system also dates to WWII and its condition is unknown.

Steam vents and electrical pathways are believed to be still intact circulating around the site. Unfortunately, their location is not well documented and was not discovered in a site visit. Stakeholders expressed interest in exploring the re-use of these facilities, including the old power distribution house located between the hangar and the NOAA building. Due to the existing condition of the power house which can be seen in Figure 6, and the

[5] AMP, Page 2-23

lack of information for the conduit pathways, it is unlikely to be cost effective to attempt to reuse any of the existing infrastructure.

Figure 6: Old power distribution house exterior and interior [left, right, respectively]

2.2.2 NOAA Building and Research Equipment

The NOAA office provides a workspace for NOAA personnel and includes office space for another tenant. Adjacent to the building is an extensive collection of research equipment. The equipment at the ‘research triangle’, near the well, is served by a long electrical circuit from the building (facilitated by 240:600V, step-up/step-down transformers). The research equipment includes a balloon launch facility and a wide assortment of pole-mounted environmental sensors. Three, single-phase electrical services serve these NOAA facilities. One is for the NOAA building; one is for the tenant at the building; and one is dedicated to the balloon launch. The NOAA building service is backed up by a propane generator.

2.2.3 Airport Hangar

The airport hangar building also receives a separate Clallam PUD service. Unlike much of the building, the service equipment and main panelboard is of recent construction. This equipment would not require any upgrade as part of a larger building restoration. A 150kVA, 480V, 3-phase pad-mount transformer and 800A panelboard, located on the second floor, are shown in Figure 7.

Figure 7: Hangar main transformer [left] and main distribution panelboard [right]

A small number of lighting and plug load circuits are run throughout the building to serve very limited occupancy needs. As can be seen in Figure 8, the space is used for the annual 'Rain of Terror' Haunted Hangar event.

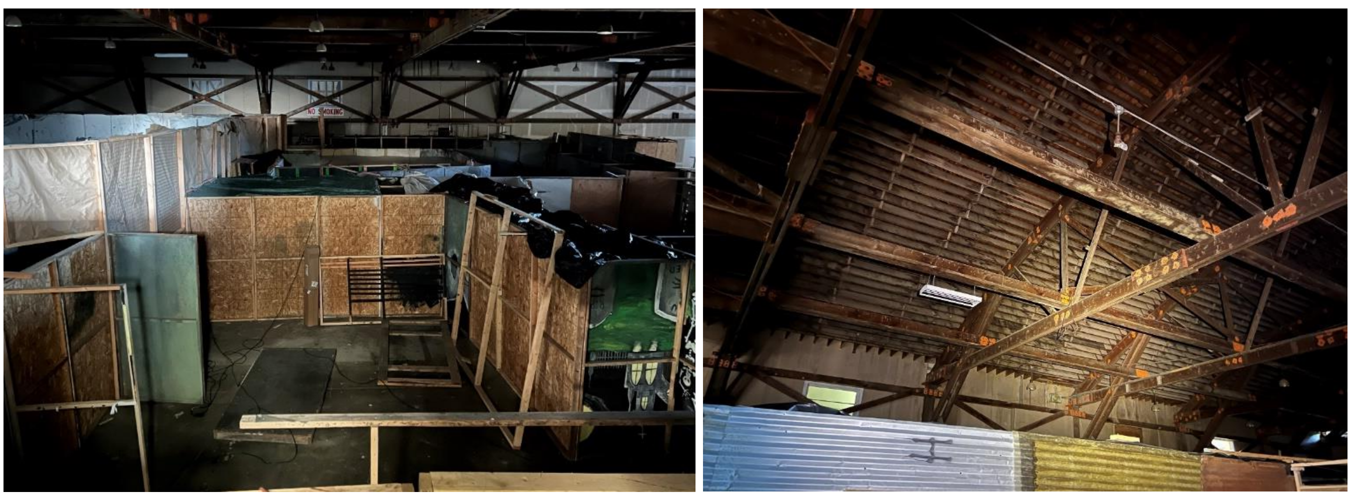

Figure 8: Hangar building main area interior photos

Much of the historical documentation and drawings for the airport is located at the Forks Township Municipal Building. Figure 9 is an overlay of the existing site conditions generated with aerial photogrammetry merged with original Naval planning drawings shows the existing conditions. Many of the original building foundations have not been excavated and their location is documented as far as possible.

Figure 9: transparent overlay of apron orthographic imagery with historic drawings

3 Technical Review

A technical review was conducted to help create a realistic and viable design concept. The intent was to view the site's existing conditions in the context of energy technologies and project opportunities. The recommendations balance technology costs and benefits and focus on the fulfilment of project goals. Subsequent modeling forms a 'basis of design' which is also communicated in drawing set format. See Appendix 9.1. It is recommended to become familiar with the drawing set prior to reading the remainder of this report.

The technical review summarizes important conclusions regarding the site's topography, existing electrical load and other features already discussed. These sections explain the rationale behind design decisions which can inform stakeholder review, construction drawings, bid specifications and final engineering.

Figure 10: Apron support structures ortho image

All of the structures and facilities shown in Figure 10 were considered as part of the project review, including the multiple electrical services across the airport site. Exploring a path to unify facilities into a single system was an important, initial consideration. The aggregate airport electrical load is relatively small (60MWh annually). The first consideration is the technical feasibility of a site-wide solution, which would unify the electrical services at a single point of isolation to create an island-able energy system. The second question is whether the functional outcomes of this system could be provided through alternate configurations.

On one hand, there is the geographic dispersion of the electrical services, and on the other hand, there are the differences in building appliance voltages (split phase 240V or three phase 208V or 480V). A unification of services would require heavy coordination with Clallam PUD, a new tariff arrangement, and very likely, hundreds of thousands of dollars in construction costs. The unification of services forces a redesign of building circuits, due to the incompatibility of split-phase 240V (at the NOAA building) and three-phase 480V (at the hangar).

In practice a centralized system would be derived either at the NOAA building's 240V service, or the hangar's 480V system. A system based at the NOAA building would have circuits extended to serve the well and hangar, or vice versa, for a system based at the hangar. When each of these threads are traced out, the design process starts to take on increased abstraction and project risk. Ultimately the complexities of electrical unification divert attention from the primary project goals.

The technical review established that the overarching emergency response goals *can* be served without costly electrical unification. The hangar is, overwhelming, the right electrical service to base an industrial, emergency response, system on. The findings and outcomes of this report should be incorporated into the restoration design for the hangar. This is primarily why the AMP recommendations were discussed above.

The reasons for not selecting the NOAA building are mainly due to its single-phase service voltage and size. The service will limit the sizing of a PV system (typically to around 10kW); it will preclude the inclusion of the 3-phase hangar as a response shelter; and will prevent 3-phase loads from being included in the emergency response. The NOAA building already has a back-up propane generator installed. Split-phase, back-up solutions are almost universally designed around the needs of the residential segment and do not suit this application.

The hangar transformer, on the other hand, permits a much larger PV system and will facilitate a larger emergency system. Because the building restoration has yet to be initiated, the power system could be designed in a ground up MEP process with minimal demolition. Such a system would be conceived as supporting the hangar as an emergency response shelter for the community but would also provision an industrial power source at the airfield apron, accessible to emergency responders.[6]

3.1 System Topology and Design Intent

A microgrid system provides electrical resilience in an emergency, when utility power is unavailable, while offsetting site load in normal grid-connected conditions. Any backup system requires local generation to maintain power during extended outages that exceed the capacity of any installed energy storage technologies. To provide resiliency via local generation, solar photovoltaic (PV) was selected as the primary generation technology for this site, coupled with a battery energy storage system (BESS), and a rotating machine generator for redundancy and situations where PV cannot fully cover the electrical demand. The configuration is reliable, effective, and is commercially available. Each technology plays a complimentary role in how the system operates and each technology requires unique design considerations that are explored in the sections that follow.

While grid-connected, the system would provide PV power to a renovated hangar under normal conditions. The battery would optimize the utility tariff where possible. In the case of an emergency, the system would transition to islanded mode, such that both the hangar and an out-of-doors emergency response area would be served backup power in parallel. The system would provide a continued power supply for an extended outage on the order of weeks or months.

The dual-purpose functionality requires assets to be co-optimized with consideration for both normal and emergency modes. The remainder of the section describes the existing and future loads, proposes new equipment locations and addresses various engineering considerations. The techno-economic review section discusses asset sizing, modeling and optimization.

3.2 Load Analysis and Development

A microgrid is defined as a group of interconnected loads and distributed energy resources that act as a single controllable entity with respect to the grid which can connect and disconnect from the grid to operate in parallel or independently in what is called “island mode”. To be able to operate for any defined or undefined duration independently from the grid, it is critical to understand the loads which must be served by the local generation resource from both a power (kW) and energy (kWh) perspective.

Load analysis, or in the case of this study load *development,* was performed to develop a thorough understanding of the systems which much be in place to deliver reliable and resilient energy for emergency

[6] Note that while some of the AMP’s renovations and improvements could be included in the context of a resilient system, the solar lighting anticipated for the runway would be separatee from this system. Runway lighting systems designed for that purpose are standalone.

operations. The stakeholder engagement process of this study included working with Clallam County PUD and all pertinent stakeholders to gain accurate information about the electrical loads on the airport site via historical meter data collection.

This section discusses the steps taken to understand the site loads, how they impacted system design, and the development of a theoretical load profile for the airport hangar building as the existing meter data was determined to be nonrepresentative of the anticipated future use of the facility.

3.2.1 Existing Electrical Load

Existing electric utility meter data supplied by Clallam County PUD was aggregated in Table 1**,** summing all meters at the airport for a total annual usage of 73.3 MWh.

Table 1: 2022 Existing Site Annual Usage

Meter #	Description	2022 Annual Usage [kWh]
65513	NOAA Blue Building	54,720
69683	Hangar Building	2,200
72145	Water Well	6,387
72150	NOAA Balloon Launch Building	2
72151	NOAA Blue Building Tenant Office	3,638
80466	NOAA Automated Balloon Launcher	6,348
All Meters	**Total**	**73,295**

A visual representation of the existing monthly usage is shown in Figure 11**,** indicating that the sum of existing loads peak in the winter months. Most of the existing load is due to the three meters connected to the NOAA buildings and a water well. However, since the maintenance hangar data was found to be unrepresentative of intended future use, the existing load data was effectively ignored, and a new load profile was fabricated to estimate annual consumption and peak demand more accurately for microgrid simulations.

This determination was made based on physical inspection of the hangar building and information gathered about the building's current occupancy patterns. As can be seen in Figure 4, Figure 5, and Figure 8, the hangar facility does not currently have fully functioning lighting or HVAC systems, and the occupancy schedule is primarily driven by only a single annual even during the Halloween season. This usage is shown by the approximately doubling of the hangar load in September and October in Figure 11.

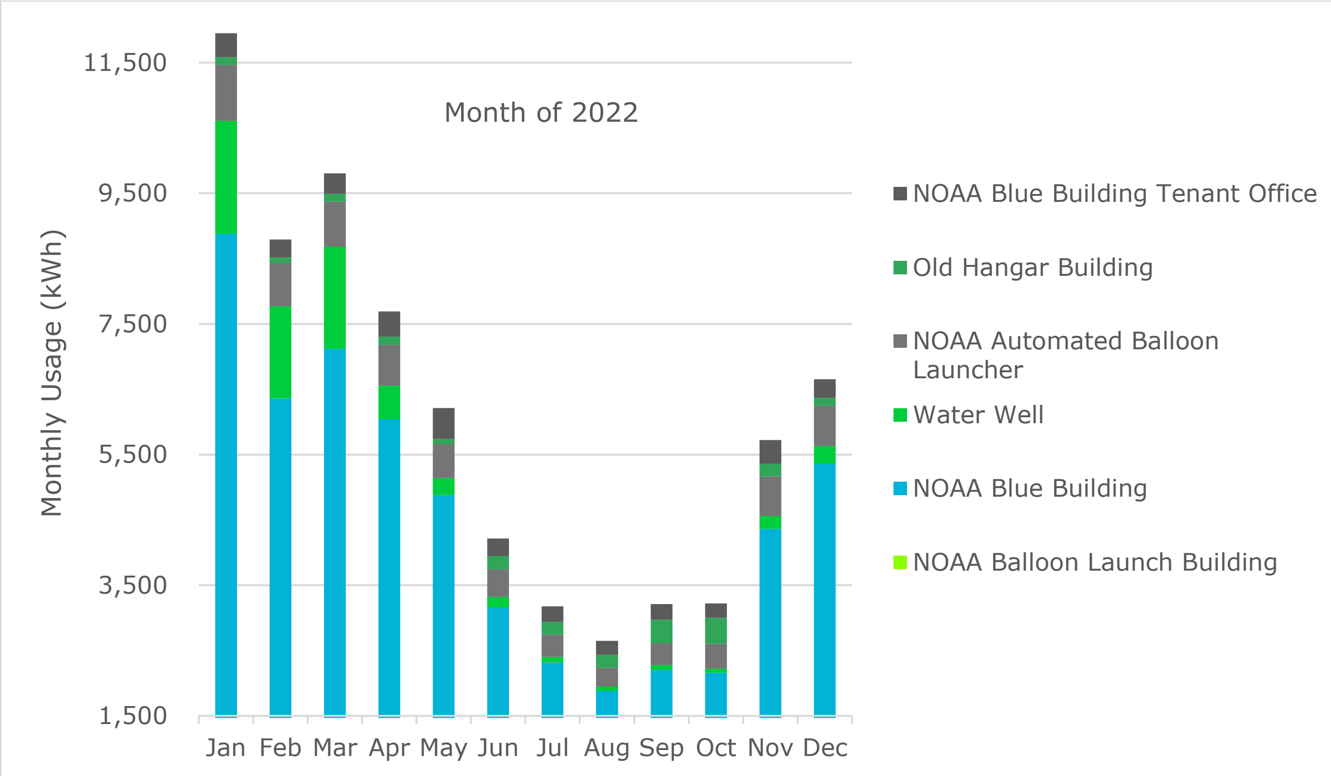

Figure 11: 2022 Monthly electricity usage summary by meter, Clallam PUD, all existing meters (2022)

3.2.2 Future Renovated Hangar Load

To estimate the energy consumption on an annual basis for the revitalized maintenance hangar, two national energy databases funded by the Department of Energy were used, NREL's Comstock Analysis Tool[7], and DOE's Building Performance Database[8] (BPD). NREL's Comstock platform was used to predict a normalized 15-minute interval load curve, classifying this facility as a typical warehouse in Washington with a maritime climate using the International Energy Conservation Code (IECC) standards[9].

Once the normalized curve was estimated, the Building Performance Database was used to determine the annual baseline electric usage for a typical warehouse by filtering the same building characteristics to find a median electric energy use intensity (EUI) of 12 kBtu/ft^2/year. According to the BPD, *electric* EUI refers to the electricity consumed on-site, normalized by gross floor area. This is not to be confused with *site* EUI which also includes non-electric energy consumed on-site such as fuel sources like natural gas, direct steam, and fuel oil. Nor should it be confused with *source* EUI, which is the equivalent primary energy (found in nature used as raw fuels) required to generate electricity and non-electric fuel used on-site. The filters applied to estimate the electric EUI for the maintenance hangar consider a warehouse in Washington given a floor area range of 0 to 25,000 ft^2 (see Figure 12).

[7] NREL's ComStock, Highly Granular Modeling of the U.S. Commercial Building Stock: https://comstock.nrel.gov/
[8] Building Performance Database: https://bpd.lbl.gov/explore
[9] IECC Climate Zone Map: https://basc.pnnl.gov/images/iecc-climate-zone-map

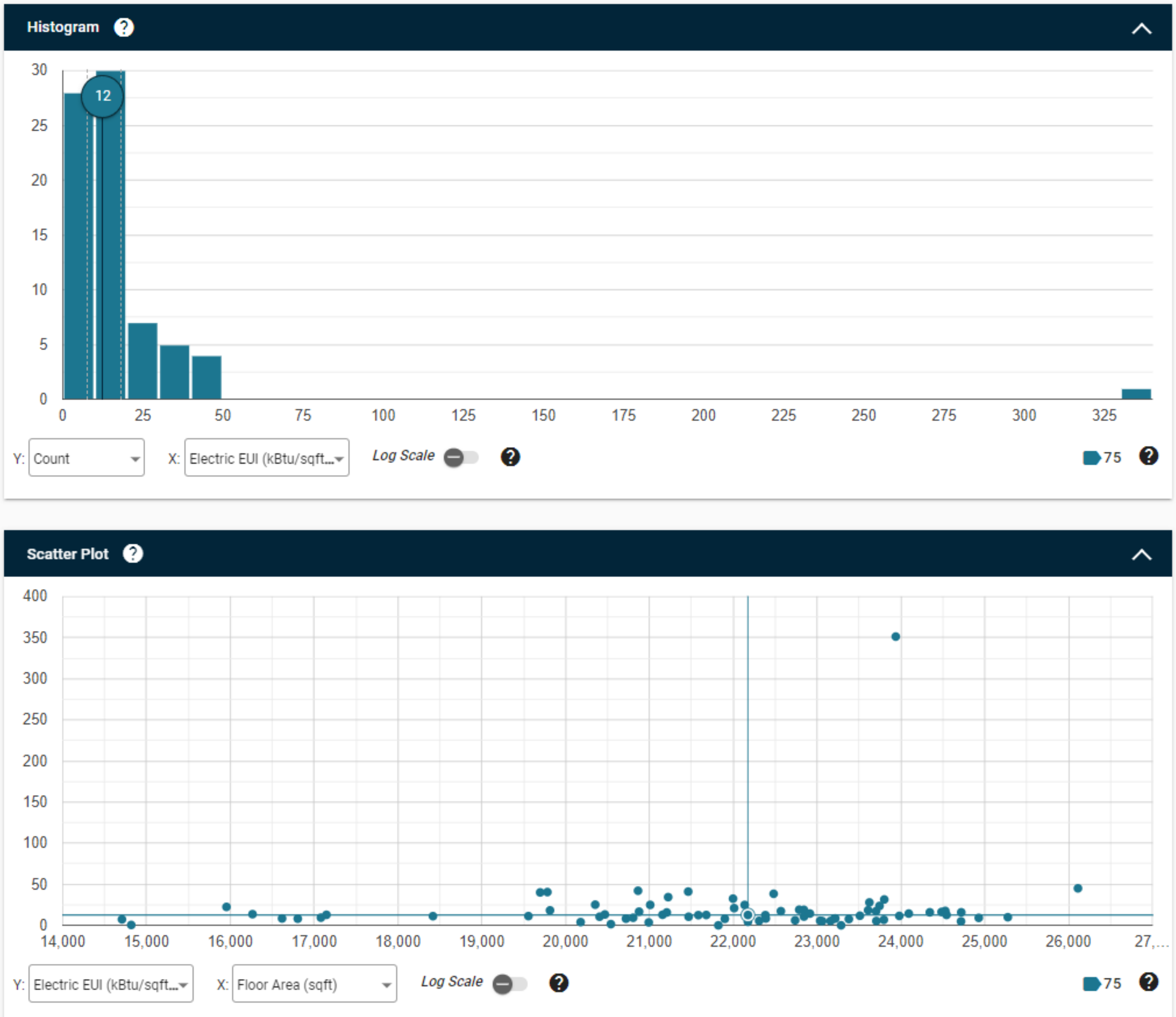

Figure 12: Building Performance Database, median electric EUI: (top) histogram and (bottom) scatter plot.

The top plot in the figure is a histogram visualizing how the median value for electric EUI is determined, and the bottom plot is a scatter plot of electric EUI against floor area for each of the 75 buildings that contribute to this value. Because the filters applied do not include a distinction between different heating fuel types, it must include buildings heated by both electricity and non-electric heating fuel. This introduces a potential source of uncertainty in the estimate. For example, if the building is 100% electrically heated, the actual electric usage may be higher than our estimate, whereas if the building is 100% heated by propane, then the actual electric usage may be lower than our estimate. However, given a sample size of 75 buildings with the desired characteristics, the median value of 12 kBtu/ft^2/year provided a functional estimation.

Given the determined electric EUI value of 12 kBtu/ft^2/year, the annual consumption was then calculated by converting kBtu to kWh (1 kWh = 3.41214 kBtu) and scaling the load curve based on its floor area of 18,000 ft^2. This was determined from the imagery-based measurements of the hangar, estimating a floor space of 150′ x 125′. This calculation equates to a total of 63.3 MWh, as calculated in Equation 1.

$$Annual\ Consumption\ [kWh] = Energy\ Use\ Intensity\ \left[\frac{kBtu}{ft^2 * yr}\right] * \frac{1\ kWh}{3.41214\ kBtu} * Total\ Floor\ Area\ [ft^2]$$

$$= \ 12\ \frac{kBtu}{ft^2 * yr} * \frac{1\ kWh}{3.41214\ kBtu} * 18{,}000\ ft^2 = 63{,}303\ kWh$$

Equation 1: Estimated Annual Consumption using BPD's Electric EUI

Once the normalized curve was scaled to match the expected annual consumption of 63.3 MWh provided by the BPD, the load curve was complete and ready to be analyzed, as shown in Figure 13.

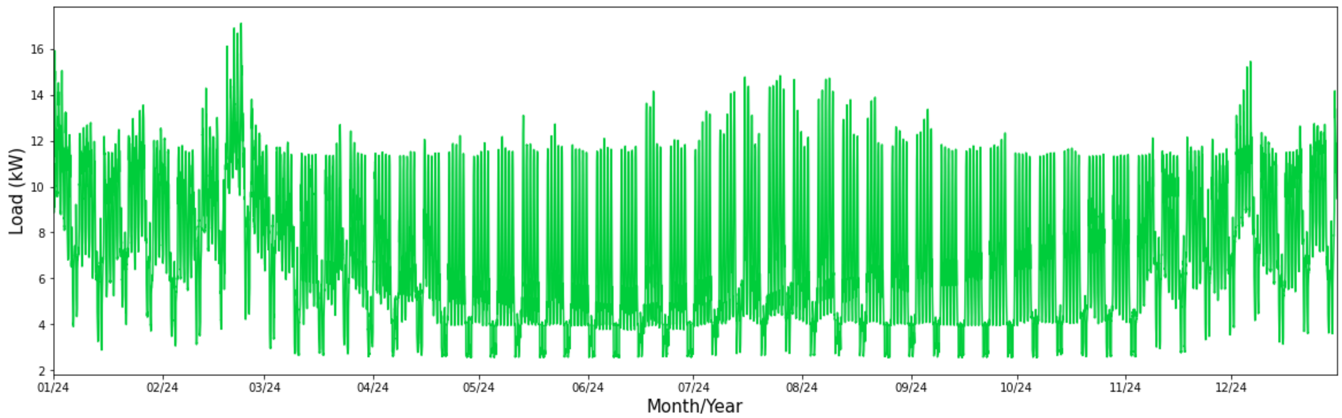

Figure 13: Maintenance hangar projected load curve, Comstock

Including the newly revitalized maintenance hangar, an updated estimated monthly usage is shown in Figure 14.

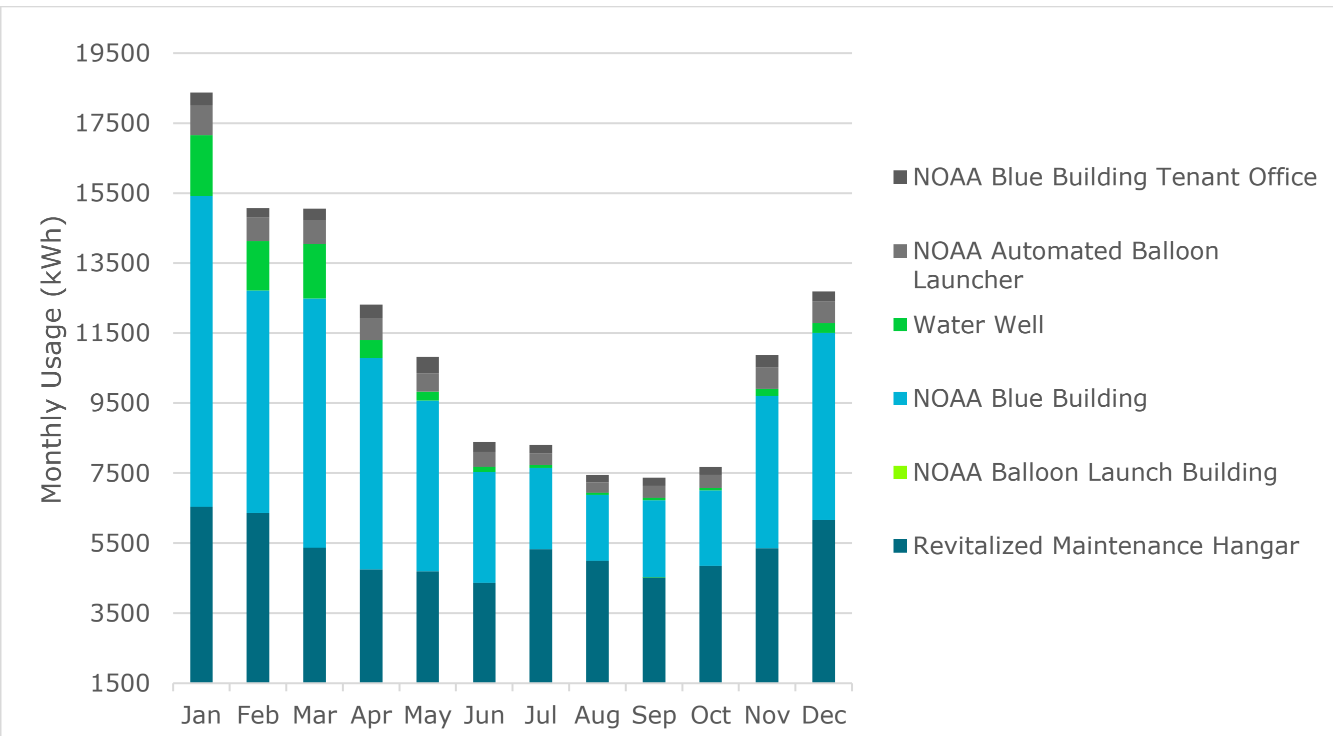

Figure 14: Estimated monthly usage by meter, including revitalized maintenance hangar

By analyzing the scaled 15-minute interval load curve, the 63.3 MWh annual consumption is paired with a peak demand of approximately 17 kW. Furthermore, Figure 15 shows aggregated average load per month over the course of a 24-hour period for a typical warehouse according to Comstock, indicating that the energy use fluctuates over the course of a year, with each month's peak energy consumption occurring during the daytime hours.

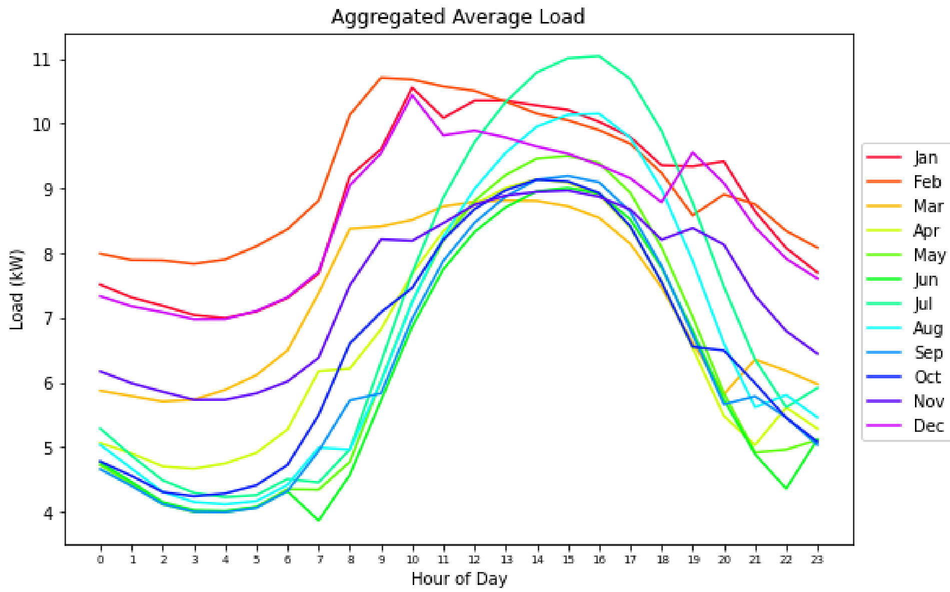

Figure 15: Aggregated Load Curves by Month

However, Figure 16 shows average load by weekday type and exhibits a clear distinction between weekdays and weekends with a much higher energy consumption during normal business hours (Monday-Friday, 9AM-5PM). In contrast, weekend loads are much lower overall compared to weekdays, with maximum usage during nighttime hours. This is to be expected due to lower worker occupancy during non-business hours.

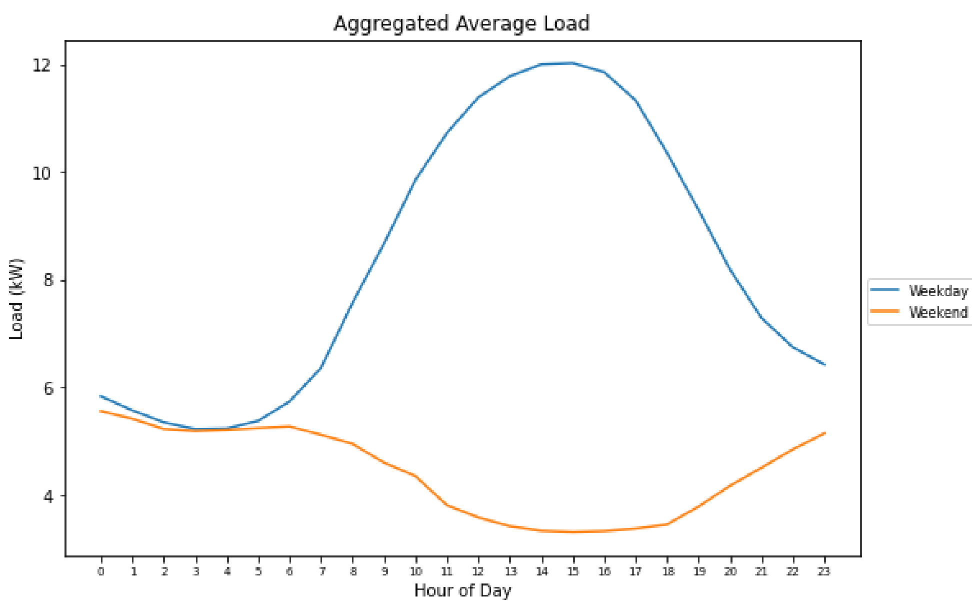

Figure 16: Aggregated Load Curve by Weekday Type

This occupancy schedule was determined to be a reasonable approximation for the hangar as the current plan for the hangar revitalization project incorporates taking on aviation industry tenants which would most likely have traditional business operating hours.

3.2.3 Load Schedule: Normal vs. Emergency Operations

To distinguish normal and emergency operating scenarios, a load schedule was created. The first step was to establish a breakdown of building loads unique to the maintenance hangar for both circumstances. This was accomplished by using the expected annual consumption from BPD for a typical warehouse in conjunction with the percentages of each load type from Comstock (see Table 2).

Table 2: Comstock load allocation

Load Type	% Load
Cooling	3.3%
Exterior Lighting	9.6%
Fans	7.5%
Interior Equipment	45.5%
Interior Lighting	22.0%
Electric Heating	12.1%

Loads unique to the maintenance hangar that were included to represent a multitude of possible tenant loads include the following: commercial electric range, plasma cutter, welding power source, plug loads, and refrigerated food storage. Plug loads can include electronic equipment such as computers, printers, communication devices, server room equipment, task lighting, security systems, phone chargers and break room appliances. Loads typical for any warehouse include lighting, fans, heating, and cooling. In Table 3, the load schedule is displayed which includes the expected loads for the revitalized maintenance hangar. In the same table, a similar load schedule was created for emergency conditions, in which the plasma cutter and welding power source load factors were reduced. Also, an emergency plug load was introduced for a designated outdoor response area, as well as several adjusted load factors to account for increased occupancy and daily hours of use. For example, the commercial electric range was increased from 3% to 6%, and the load factor for plug loads was increased from 50% to 75%.

Table 3: Normal and emergency load schedules

Description	Load Factor (normal operation)	Load Factor (emergency operation)	Max Capacity [kW]	Annual Usage (normal operation) [kWh]	Annual Usage (emergency operation) [kWh]
Commercial Electric Range	3%	6%	15.80	4,152	8,304
Plasma Cutter	1%	0.5%	9.90	867	434
Welding Power Source	2%	1%	5.80	1,016	508
Plug Loads	50%	75%	4.40	19,272	28,908
Emergency Plug Loads	0%	25%	2.00	-	4,380
Refrigerator	50%	50%	0.36	1,582	1,582
Freezer	75%	75%	0.30	1,980	1,980
Lighting	50%	50%	4.56	19,953	19,953
Fans	50%	50%	1.09	4,754	4,754
Cooling	6%	6%	3.95	2,079	2,079
Heating	9%	9%	9.74	7,683	7,683
Total Estimated Annual Usage (kWh)				**63,337**	**80,564**

As a part of the load schedule calculation, load factors for hangar-specific equipment were estimated based on expected time of use and duty cycle of operation. Additionally, maximum capacities were either estimated or referenced from data sheets for each appliance to approximate its contribution to annual usage for the facility. Data sheets for the commercial electric range, plasma cutter, welding power source, reach-in refrigerator and freezer are included in the Appendix 0.

Using the BPD's expected annual usage of 63.3 MWh as baseline, plug loads were adjusted such that the annual usage in normal operation matches the 63.3 MWh. By including emergency plug loads and adjusting the above-mentioned load factors in emergency operation, the annual consumption increases to 80.6 MWh, as shown in Table 3. As expected, the maintenance hangar has a 27% higher annual consumption if run solely with the emergency load schedule.

3.2.4 Load Analysis Assumptions

As stated earlier, Table 2 shows the breakdown by load type that contributes to a typical warehouse in Washington based on Comstock data. In this table, electric heating and cooling adds to roughly 15% of the annual consumption. A typical warehouse has enough heating and cooling for a small portion of the facility, such as a breakroom/kitchen, office space and bathrooms. However, for the maintenance hangar revitalization, there should be attention paid if the future design includes additional HVAC to maintain proper working conditions and storage. The final MEP (mechanical, electrical, plumbing) designed load estimations should be compared against those stated in this report to determine if the microgrid system as designed is adequate to provide the resiliency necessary as predicted. The load contribution from HVAC may vary compared to the estimate used in this study depending on several factors including how much of the floor area will require temperature control, how insulated the hangar will be after revitalization, and how frequently the hangar doors are opened. Additionally, the type of heating technology used matters. For example, utilizing forced-air unit heaters, gas-fired overhead infrared heaters and hydronic radiant in-slab heating have varying energy efficiencies and construction costs, which will impact the projected annual electric usage.

If propane were to be considered as another heating fuel source for the facility, the electric consumption due to electric heating would be reduced, which would effectively reduce the overall annual electric consumption of the facility. Referencing Table 3, 12% of the electric consumption is due to heating, so depending on how much non-electric heating is introduced when rehabilitating the hangar, the annual electric usage would reduce accordingly.

3.3 PV Array Design

Finding an appropriate PV location at the airport was a primary consideration. There is plenty of space to serve both the needs of the hangar load as estimated, as well an emergency response load. A capacity exercise revealed enough space for up to 180kW of ground-mounted PV adjacent to the hangar, and up to 260kW east of the entrance road as shown in Figure 17. Mounting PV on the hangar roof was not considered given the building could be jeopardized by an earthquake.

Figure 17: PV capacity placement study

With multiple options available, the grassy area south of the hangar was selected. The area is already inside the fenced perimeter and should not require significant new fencing, either for security or electrical code. The area east of the road requires significant excavation of old building foundations; several of which are shown in the design drawings, Figure 9, and Figure 10.

As long as the PV system is kept roughly 100' from the western tree line, there should be minimal shading impact. Permit stage diligence will need to confirm County-required setbacks from Quillayute Road, but it will likely not impact the array size. The arrays shown in the design drawings are oriented directly south, and the racking is recommended to provide a 25-degree tilt.

Note that a 15-degree system performs roughly 5% worse annually (978 kwh/year/kw versus 1,024 kwh/year/kw), while performing up to 25% worse in the winter, when power is most needed. A 35-degree system suffers from higher material cost and increased structural load and does not provide a meaningful production benefit.

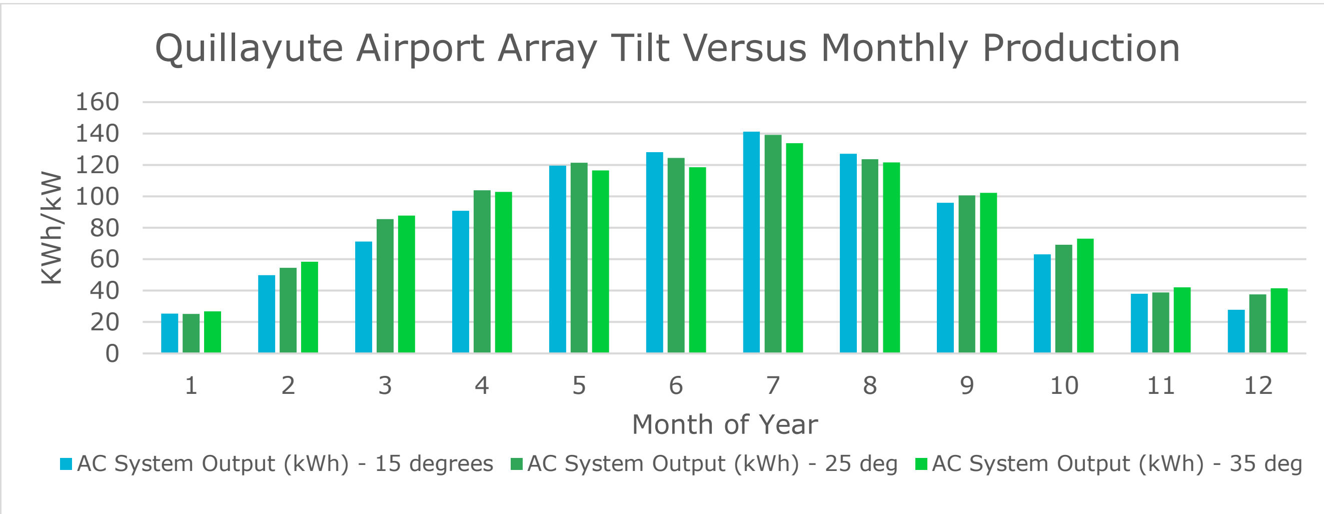

Figure 18: PV array tilt versus monthly output comparison

Figure 18 illustrates the seasonal variation of PV at the airport and demonstrates the influence of module tilt. Generation is plentiful in the summer and scarce in the winter. This will influence either grid-connected or islanded operation. In wintertime, the facility will be more reliant on the utility or the backup generator (in an outage). We do technoeconomic review because sizing systems necessitates this balance. Capturing more winter-time load will translate to a PV system overbuild in the summertime—which means curtailment, the loss of net metering, revenue and higher Capex costs.

3.4 Electrical Interconnection

A three-phase, 480V service now serves a minimal annual load at the unoccupied hangar. The Regulatory Review section touches on why the microgrid system is dependent on the build out of a larger hangar load. In context of net metering, the value of exported energy is effectively zero when it exceeds the annual building load.

An alternative design goal would be for the system to provide responsive grid-services often referred to as a grid-interactive system, in the absence of site load. The idea was explored directly with Clallam PUD, who provided their perspective on the proposed project. Colin Young—a supervisor at PUD—communicated that the utility *did* have interest to explore novel grid-support functionality, but on a timeframe well into the future as they do not currently have the means to utilize and control those services in place. He advised the airport to anticipate a standard review process typical of net metered customers in their territory.

The physical interconnection of a PV and storage system would be designed to cover the entire hangar facility. This interconnection location is referred to as the point of common coupling, PCC. The existing circuit between the building meter and main panelboard would be 'intercepted' which will avoid the partitioning of the hangar's electrical system into critical and non-critical loads. This design would be considered a whole building 'back-up' plan. There is ample PV generation available to support the full estimated hangar load, as well as a supplemental emergency response load.

Figure 19: Microgrid PCC location

The PCC location for the interconnection of the microgrid as shown in the single-line diagram of the drawing set is between the utility metering cabinet and the entrance to the building. This metering cabinet is shown between the building transformer and the building in Figure 19.

3.5 Electrical Design

The electrical design for this resilient microgrid project must first meet standard electrical codes, building codes and manufacturer requirements. The second design layer involves an implementation of 'N+1' resilience determinations. The N+1 frame of reference assumes each piece of equipment may fail in the course of a natural disaster. The system should have a layer of redundancy for each of its constituent parts.

If the battery cabinet was destroyed beyond repair, the generator would serve as a redundant power supply. If the restored hangar were to collapse in an earthquake, the power supply would remain available for exterior use. This N+1 redundancy may require responsive human action. The design should accommodate the isolation of failed components and anticipate and be ready for the required field repairs. Much of this flexibility is shown in the single line diagram and is described further in this section.

It is not unlikely that the *entire* PV system does not survive a major event. As the drawings show, each array block represents a single string of modules. In the case of a failure, each can simply be disconnected at the inverter and taken out of circuit to restore functionality at a reduced capacity without the damage section. Site personnel would have tools available to test PV circuits (via a handheld multi-meter, and/or an insulation resistance tester), pending on-site repairs.

Other N+1 recommendations include installing spare conduit and receptacles with quick connect plugs. If the most critical underground circuits were pulled apart, industrial extension cords would be stored on-site, and laid directly on the ground. The circuit between the battery inverter pad and the emergency response area is particularly critical and could be remedied using this method.

Another consideration is the outdoor emergency response panel. The expectation is that power is provisioned at relevant voltage levels for emergency response; specifically, 208V three-phase and 120V single-phase. Weather-tight NEMA receptacles and hard-wired circuits for communication devices would be provided. Emergency loads might evolve over time with input from new stakeholders, as response plans are developed. This design basis is expected to be a starting point to establish an emergency response load schedule. This power source would make power readily available at the airport apron, while not necessarily determining its final use.

3.6 Structural Design

The structural component of the project also concentrates on hardening the system against natural disaster. By using best practice structural engineering, the chances of the system surviving a disaster are increased. The focus should be on the PV racking, the concrete equipment pads and equipment attachment points.

How far this structural hardening can and should go is limited by common sense and the project budget. Designers should work within the context of commonly available materials or off-the-shelf products. Construction in seismic zones is well established with techniques, materials, and code requirements developed specifically for seismic ratings. The system should be constructed with appropriately designed, rated and listed components, by a PV contractor experienced in building to seismic regulations using standard PV products such as engineered racking, mounting clips, etc. The design basis provided in these drawings is a general representation of a ground mount system with high wind and snow loads. It may not meet Risk Category V design criteria exactly as shown, however the final design and materials proposed as the final integration design should have final engineering requirements specified and calculated by a structural engineer.

Humphrey Kariuki (principal of Equilux Engineering) consulted with ProtoGen on the design and provided the structural basis of design. Kariuki has deep experience performing calculations for the solar industry including in seismic zones. The system is not expected to avoid all impacts or failures, but to survive to such an extent that operation can continue. The following subsections outline the structural basis of design.

3.6.1 Structural Basis of Design Overview

The project shall be classified as a Risk Category V structure as defined by the Unified Facility Criteria (UFC) 3-301-02 (Design of Risk Category V Structures, National Strategic Military Assets). This risk category includes Emergency backup power-generating facilities required for primary power for Category V occupancy and Power-generating stations and other utility facilities required for primary power for Category V occupancy, if emergency backup power generating facilities are not available.

Risk category V is not defined in 2021 International Building Code or ASCE 7-16 building code as it typically applies to strategic military assets. For this risk category all structures, systems, and components (conduit, piping, cable trays, etc.) are designed to remain operational during the design basis earthquake (DBE).

3.6.2 Design Codes Criteria

The applicable codes and standards are as follows:

- 2021 International Building Code (IBC)
- ASCE 7-16 Minimum Design Loads and Associated Criteria for Buildings and Other Structures
- UFC 3-301-02 Design of Risk Category V Structures, National Strategic Military Assets
- ASCE/SEI 4-16 *Seismic Analysis of Safety-Related Nuclear Structures*, Standard
- ASCEE/SEI 43, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities
- Other industry consensus and peer reviewed standards that meet the requirements of Risk Category V structure are acceptable.

In instances where there is a conflict between the code, the more stringent requirements should be applied.

3.6.3 Seismic requirements

The PV structural system and attached electrical and mechanical components shall be designed based on an earthquake with a Moment Magnitude (Mw) greater than 9.0. It is anticipated that a seismic isolation system shall be used in the design of the structural system for Risk Category V non-structural elements. The anticipated seismic force resisting systems is expected to consist of structural steel braced or moment frames, although other structural systems may be proposed but shall they pass an independent structural design review.

3.6.4 Site specific seismic study and Geotechnical investigation

A site-specific seismic hazard study shall be completed for the subject project site based on ASCE 7-16, Chapter 21. The seismic study shall perform the evaluation of earthquake ground motions to characterize the project site to determine the appropriate ground motions, defined in terms of a design response spectra that has been developed from a probabilistic seismic hazard analysis (PSHA). The result should provide the design basis earthquake (DBE) to be used to evaluate the seismic demand of the PV system and its components.

Additionally, a response history analysis is required to determine the in-structure demand for the design and qualification of nonstructural equipment and distributed systems following the requirements in UFC 3-301-02. The ASCE/SEI 43-19, Section 2.4 Criteria for Developing Synthetic or Modified Recorded Acceleration Time Series shall be used to develop the seismic response histories for RC V facilities as required in UFC 3-301-02.

Per ASCE 43-05, the PV system shall be designed to meet the minimum requirements of Seismic Design Category 5 (SDC-5) and limit state D (SDB-5D) or to US Department of Energy (DOE) Target Performance Goal for SDC-5.

A design review of the proposed seismic force-resisting system and associated structural analysis (calculations) must be conducted by an independent licensed professional engineer as outlined in UFC 3-310-02 for Risk Category V structures including the entire structural system and all mechanical and electrical components that must remain operation after a design earthquake. The review shall also include all documents submitted including specifications, test data, shake table testing, etc.

3.6.5 Wind

The PV system framing, and components shall be designed using the wind speeds Risk Category V structures for extreme wind hazards including hurricanes and tornadoes. Since these wind parameters are not provided in the 2021 International Building Code or ASCE 7-16, the methods contained in the ANSI/ANS-2.3-2011 (R2016) Estimating Tornado, Hurricane, And Extreme Straight Line Wind Characteristics at Nuclear Facility Sites shall be used to determine the wind hazard design parameters. Alternatively, it is acceptable to perform a site-specific Probabilistic Wind Hazard Assessment (PWHA) to determine the design basis wind-related hazard parameters by following the procedures in Department of Energy Standard DOE-STD-1020-2012 (Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities).

3.6.6 Foundations

A geotechnical engineering investigation of the project site is required to evaluate the subsurface conditions of the project area including a seismic site classification of the soils.

A geotechnical investigation shall be conducted consistent with a structure assigned to Seismic Design Category SDC D per the requirements of ASCE 7 section 11.8.3 and Chapter 21, with the foundation system remaining elastic after the design earthquake. The investigation shall evaluate the site for the potential and the consequences of soil liquefaction and loss of soil strength and discuss mitigation measures such as the selection of the appropriate foundation type and depth and appropriate structural systems to accommodate anticipated seismic displacements and forces.

The geotechnical investigation shall also verify that the project is not located at a site with a known potential for an active fault.

3.7 Equipment Design Basis

As part of developing an equipment basis of design, A&R Solar (a Seattle-based PV contractor) shared Sol-Ark's commercial battery and inverter product. Sol-Ark is a national supplier of inverters that operate in grid-connected and islanded modes. Their 480V inverter and battery product constitutes a modular 'building block', starting with a 60kW inverter and 60kWh battery. The battery is a Lithium Iron Phosphate chemistry, comes with a 10-year warranty, has aerosol-based fire suppression and includes relevant UL9540a certifications. Given the projected future hangar load, a single Sol-Ark battery unit is ideal for the project design basis.

A key design feature of the product is that the transfer from grid-connected to island mode is managed internal to the inverter. This integration avoids customized controllers, contactors, relays and cumbersome interfaces between manufacturers or custom programming. The entire system is manufactured and supported by Sol-Ark. The company provided a design review on the single line diagram included in this package.

A&R also expressed interest in Ironridge components for the PV racking system. As a popular manufacturer of PV products, the Ironridge system includes module rails, clips and attachments. The structural framing relies on the procurement of standard 3" Schedule 40 steel pipe sections. Vertical pipe members are embedded in concrete foundations, which are shown in the drawings as a typical size for this racking structure but should be designed based on a geotechnical evaluation when the project moves forward.

4 Regulatory Review

The regulatory review examines the local, state, and federal regulatory and statutory concerns regarding the microgrid project. In typical project development situations, it can be challenging to understand jurisdictional boundaries on an issue-by-issue basis, as the regulatory landscape for these projects is a patchwork process involving many organizations, both private and governmental.

The Clallam County Public Utility District (CCPUD) is the local utility responsible for energy in Forks and at Quillayute Airport. Clallam PUD provides power to approximately 30,000 electric meters throughout a 2,000 square mile service territory consisting of Clallam County and small portions of Jefferson County. Clallam PUD operates a transmission and distribution system consisting of 145 miles of 69 KV and 115 KV transmission lines, 24 Distribution Substations, and 1778 miles of 12 KV and 25 KV distribution lines.[10] As a PUD, the utility is not subject to regulation by the Washington Utilities and Transportation Commission as it regulates the three large investor-owned utilities; Avista Corporation, PacifiCorp, and Puget Sound Energy.

The Quillayute Airport hangar is currently within the small general service schedule[11] for the CCPUD. This schedule is for entities where the demand is less than 50kW at all times. Hangar revitalization could potentially make the demand exceed 50kW and require a move to the medium general service schedule if future tenant's loads are significantly greater than those modeled. However, the modeled peak load anticipated is only 16.5 kW. The medium general service level is for entities where the demand is greater than 50kW at any time but is less than 300kW at least ten times per year. This move would include additional demand charges that are not a part of the airport's current small general service schedule but could also likely be mitigated or eliminated by utilizing the battery energy storage system to perform peak-shaving services.

4.1 Interconnection

CCPUD as a vertically integrated PUD can own and operate its own generation and distribution systems. To allow for new generation resources to use their infrastructure there are certain rules they prescribe to ensure safety and efficiency. These are known as interconnection rules. Based on the size of the potential PV system, the interconnection rules from tier 2 apply to this project. Tier 2 rules apply to projects with a nameplate capacity between 25-500kW. The first step is to submit application[12] to the utility. Then within two months of filing the application with the utility, they will either approve the interconnection, approve the interconnection with conditions, or deny the interconnection with a justification. If approved for interconnection, the applicant has one year from the date of approval to begin operation of the facility. There is also room for discussion directly with the utility during interconnection as the rules also state that even projects that do not meet the requirements of tier 2 can still be in this category if the utility determines that interconnection can be done safely with minor modifications.

4.2 Net Metering[13]

Under Washington law, every utility, both municipal utility and electric cooperatives, in the state must offer net metering services. These apply to systems with up to 100kW of capacity that generate electricity using fuel cells, solar, wind, water, or animal waste biogas as an energy source. All potential classes of customers, such as residential, commercial, industrial, and governmental, are all eligible to participate in the program. Access to the program is completed on a first-come-first serve basis until 2029.

Net metering uses a bidirectional meter that tracks that energy that flows both into and out of the system. If the energy generated by the customer exceeds the energy used from the grid, then the customer will receive energy credits that are banked and used towards the following month's bill. If the customer's generation does not exceed energy used from the grid, then the customer will be billed for that energy at their normal rate. This

[10] Electric | Clallam County PUD (clallampud.net)
[11] Electric Rate Information | Clallam County PUD (clallampud.net)
[12] http://clallampud.net/wp-content/uploads/2020/01/Interconnection-Application_20230228.pdf
[13] Chapter 80.60 RCW: NET METERING OF ELECTRICITY (wa.gov)

is done every month for a year and then every March the cycle restarts. Come this time, unused energy credits become the property of the CCPUD, and the customer's balance is set to zero[14].

5 Economic Review

An important function of this report is to provide an engineer's estimate for the basis of design system while the drawings create a reference for contractor estimation and bidding for the next phase of the project. PV plus Storage systems are significantly more costly than PV systems alone. This is due to the need for the battery, advanced controls, transfer switches and other balance of plant equipment. However, PV systems cannot provide energy resilience on their own. For the Quillayute project, two additional variables put upward pressure on the budget.

The remote location of Forks, relative to qualified installers, is significant, especially for a project requiring extended mobilization. Electricians and technicians from regional installers (likely from the Seattle-Tacoma-Olympia region) will be budgeted per diems and travel expenses.

The second key cost variable relates to the Risk Category V structural provisions. While these provisions help the system withstand an earthquake, most contractors have limited experience with such robust design standards. There may be confusion around what type of labor and material adders this requirement presents. It is the responsibility of the design/build installer to create and permit final engineering documentation.

A&R Solar supported ProtoGen in developing an engineering estimate for the project. They did not provide a proposal, and the numbers provided for system components, installation, and other balance of plant equipment were adjusted based on ProtoGen's experience and included the addition of several unique and additional resilience features described and shown in the drawings as well as discussed in subsequent sections of the report.

Additionally, several funding opportunities were identified as part of this study and are provided below, broken into state and federal funding opportunities.

5.1 State Funding Opportunities

5.1.1 WA State Department of Commerce's Clean Energy Grant Program[15]

Round 3 of the Clean Energy Grant Program, which is expected to open in the late spring 2024, may be a potential source of funding for this project. This upcoming round is a general round for many different project types. The potential PV at the Quillayute Airport could fit into a few of the eligible project categories, such as solar paired with battery storage for community facilities or electric grid modernization and innovation. They are expected to have approximately $84 million available for the planning, design, and construction of numerous projects.

5.1.2 Solar Plus Storage for Resilient Communities Grant[16]

The Solar Plus Storage for Resilient Communities Grant makes funds available for solar power and battery backups for community buildings that will provide critical services in the case of a power outage. There are two tracks available, one for planning and one for installation. A planning grant has already been awarded with this report as a product of that funding. This report can be used to pursue the second track, the installation track, to receive more funds for construction of the proposed system.

[14] RCW 80.60.030: Net energy measurement, charges for kilowatt-hour consumption, and credits for excess kilowatt-hour generation—Required calculation—Unused credit—Net metering system—Customer-generator meter aggregation.
[15] Clean Energy Grant Programs - Washington State Department of Commerce
[16] Solar plus Storage - Washington State Department of Commerce

5.1.3 Clean Energy Fund[17]

The Clean Energy Fund may also be another source of funding for this project. Within the Fund are numerous grant programs, including a Solar Deployment Grant Program[18] that makes funds available for solar projects in general and a Grid Modernization Program[19] that provides funding for energy resiliency projects that will support vulnerable populations. The Solar Program has not seen much movement with recent awards stemming from a 2021 cycle. Funds through the Grid Modernization Program were recently granted to Clallam County PUD for design of a microgrid at a substation under the 2023 cycle, totaling $128k. Both programs could see furthering funding in the coming months and may be a funding source.

5.2 Federal Funding Opportunities

5.2.1 FEMA BRIC Grant[20]

The Federal Emergency Management Agency's (FEMA) Building Resilient Infrastructure and Communities (BRIC) Grant provides funds for projects that are aimed at community resiliency for states, territories, and tribes. In the last round, a total of $112 million was available in state/territory allocations with a maximum of $2 million each. An estimated total of $701 million was available for a national competition, with a maximum federal share of $50 million per project. Local governments are considered sub-applicants and must submit applications to their state; they must also have a FEMA-approved state or tribal Hazard Mitigation Plan (HMP) in place by the application deadline. Currently, there is not an ongoing application period. However, there may be more opportunities for funding in the future.

5.2.2 FAA Airport Improvement Program[21]

This program provides funds to public agencies for planning and development of public-use airports that are included in the National Plan of Integrated Airport Systems (NPIAS). The Quillayute Airport is currently included in the NPIAS and eligible for grants. There are a variety of projects that can be covered by these grants including safety area improvements, planning studies, and environmental studies. Hangar projects are generally ineligible but may be eligible under certain circumstances and after discussions with the local Airport District or Regional Office.

5.2.3 Investment tax credits

Non-fossil fuel-based generating and storage resources are eligible under the Inflation Reduction Act (IRA) for a range of incentives. The most important of these is the Investment Tax Credit (ITC). The ITC can be claimed against PV systems, energy storage and even the costs of microgrid controllers and interconnection infrastructure. Historically, monetizing investment tax credits has required a project investor who has sufficient tax appetite, often resulting in the need for a project investor. This IRA changed this requirement with its "elective pay" (often called "direct pay") provision. Direct pay allows tax-exempt and governmental entities to receive a payment equal to the full value of tax credits for building qualifying clean energy projects[22].

The ITC for projects less than 1MW is structured with a base value of 30% of qualifying costs if the project meets the labor requirements. In addition to this, project-specific adders are available: domestic materials, energy community status, and income status, for a total incentive of up to 70%. This structure is shown in Table 4[23].

[17] Clean Energy Fund - Washington State Department of Commerce
[18] Clean Energy Fund Solar Program - Washington State Department of Commerce
[19] Energy Grid Modernization - Washington State Department of Commerce
[20] Before You Apply for Building Resilient Infrastructure and Communities (BRIC) Funds | FEMA.gov
[21] Overview: What is AIP & What is Eligible? | Federal Aviation Administration (faa.gov)
[22] https://www.whitehouse.gov/cleanenergy/directpay/
[23] Adapted from https://www.epa.gov/green-power-markets/summary-inflation-reduction-act-provisions-related-renewable-energy.

Table 4: ITC summary table (projects under 1MW)

<table>
<tr><th>Technology</th><th>Full rate
(if project meets labor requirements)</th><th>Domestic Content</th><th>Energy Community</th><th>Low Income</th><th>Range of Total Incentives Available</th></tr>
<tr><td>Solar Technology</td><td rowspan="4">30%</td><td rowspan="4">10% of material costs</td><td rowspan="4">10%</td><td rowspan="2">10% or 20%</td><td>6%-70%</td></tr>
<tr><td>Standalone Energy Storage Systems</td><td>6%-70%</td></tr>
<tr><td>Microgrid Controller</td><td rowspan="2">N/A</td><td>6%-50%</td></tr>
<tr><td>Interconnection Property</td><td>6%-50%</td></tr>
</table>

The modeling assumed that eligible property for this project would qualify for 30% ITC on all PV and BESS assets. The model utilizes the ITC credit to calculate economic returns and optimizations. However, the value of the ITC is not represented as a reduction to upfront overnight costs or project CapEx as it is an incentive received by the owner and not typically applied directly to project implementation expenses such as construction loans. Given the difficulty of sourcing and tracking the provenance of equipment, the Domestic Content adder was not included. The Quillayute Airport is not located in a statutorily defined Energy Community.[24] The airport does appear to be located at in a statutorily defined Low Income Census Tract. To simplify the modeling, the low-income adder was not modeled.

> *Clallam County, Washington meets the New Market Tax Credit Program's thresholds for low income, therefore meets the geographic eligibility requirement for Category 1 of the 48e Low Income Communities Bonus Credit Program. I.e., The census tract meets the thresholds detailed in Title 26 US Internal Revenue Code 45D(e).* [25]

It is important to note that IRS guidance is not finalized on all points, and that there is a potential for forthcoming updates that could change the current picture. For more information, visit the IRA page on the IRS's website.[26]

[24] https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d
[25] https://experience.arcgis.com/experience/12227d891a4d471497ac13f60fffd822
[26] https://www.irs.gov/inflation-reduction-act-of-2022

6 Technoeconomic Modeling Process

6.1 Overview

In the absence of accurate historical load data, the design of this system and the optimizations were centered around the estimated load developed and discussed in Section 3.2. When the hangar revitalization project is progressed the MEP engineer designing the hangar renovation should establish an annual load estimate. With energy modeling software, the engineer should confirm the load expectations included in this report against their design. It should also be noted that no amount of engineering will perfectly predict how the tenants will operate the building. This is true even where the connected loads are known.

Nonetheless, it is unlikely that the design basis will change dramatically after the renovation design is completed. It may be advisable to add or subtract one or two PV array blocks, depending on the hangar load schedule. The Sol-Ark building blocks are a function of the primary battery and inverter unit sizes—units that are relatively inflexible and should ideally be optimized around 60kW blocks.

6.2 Market and Product Summary

The small commercial/industrial (C&I) market segment (into which the hangar would fall from an equipment standpoint) has notably few entrants for battery and inverter products. Wedged between the residential segment (240/120V) and the C&I space (480V products that begin around 100-200kWh), there is limited product availability. Manufacturers have not seen a large enough demand to justify small, 3-phase products. Sol-Ark addresses the smaller end of the C&I market with their 60kW product and spans the range of needs given that their 60kW unit can be combined with up to six in a system.

Performing simulation around a singular 60kW Sol-Ark unit was easily justifiable given the ballpark magnitude of the hangar load, and the unit sizing of the inverter option. Instead of designing around a kWh target, design proceeds from the modular sizing of the product offering.

6.3 Technoeconomic Analysis

For this project and scale, the battery and inverter technology selection and availability take precedence in design requirements. For economic optimization, the PV sizing should meet 100% of the hangar's annual load but exceeding that should be avoided due to the net-metering rules with CCPUD outlined in Section 4.2. PV production more than this amount will not have economic value if gross exports exceed the annual energy need of the facility. The final consideration was to validate and confirm how this system sizing performs in the off-grid, resilient mode. Demonstrating system operation and creating an initial project budget and cashflow analysis is the primary purpose of the technoeconomic model.

6.3.1 Financial Assumptions and Model Inputs

This section discusses the inputs used in the technoeconomic optimization modeling. The financial methodology used was to model the system as an upfront cash purchase with a lump sum reinvestment strategy. This provides a model output for the full value of the project's upfront capital expenditure (CapEx). The lump sum reinvestment strategy assumes inverter and battery replacements in year ten of the project life cycle. This methodology allows for the clearest understanding of capital requirements for the purposes of securing grants or other financing vehicles, as well as comparing bid responses.

Operational expenses (OpEx) include any subscription fees for data or monitoring, as well as regular operations and maintenance expenses to ensure the system is functioning as designed as well as covering the regular periodic maintenance requirements of the equipment and components. The OpEx of this system is cost effective as the design intent was to utilize pre-established and compatible components with original equipment manufacturer (OEM) native controls and communications.

Table 5 provides a summary of the primary inputs used for the technoeconomic modeling of the designed system. The following subsections describe in greater detail the methodologies used for the pricing of individual technologies and components.

Table 5: Technoeconomic model inputs

Model Assumptions	
Outage Duration Modeled	2 weeks
Outage Load	125% of normal
Cash Flow Model	Cash
Reinvestment Strategy	Lump Sum
Incentives in Model	30% ITC on all
Utility Export Profile	Net Metered
Utility Tariff in Model	Small General
PV Size Limitation (kW)	60
Project Lifetime (Years)	20
Infrastructure	
Microgrid Controller	$8,000.00
Controller Fixed OPEX ($/year)	$1,140.00
Infrastructure (Resilient Extras, Comms, DAS)	$55,000.00
Technology	
PV (Ground Mount) Unit Cost ($/kWdc)	$5,300.00
PV Inverter Cost ($/kW)	$50.00
PV Inverter Lifetime (years)	10
PV Fixed OPEX ($/kWdc/Month)	$1.25
BESS Unit Cost ($/kWh)	$1,600.00
BESS Inverter Cost ($/KW)	$100.00
BESS Fixed OPEX ($/kWh/Month)	$0.42
BESS Lifetime (years)	10
BESS Charging Eff/Charging Rate	95%/0.5
BESS Discharging Eff/Discharging Rate	95%/0.5
Max SOC/Min SOC/Emer SOC	100%/10%/5%
Diesel Gen-set Unit Cost ($ lump sum)	$30,000.00
Diesel Gen-set Lifetime (years)	15
Diesel Gen-set OPEX ($/kW/year)	$4.00
Diesel Fuel Cost ($/gallon)	$5.00

6.3.1.1 Infrastructure

There were no significant infrastructure improvements included in the system design or model as the interconnection is a common and straightforward behind-the-meter, load-side connection. However, there is $63,000 included for additional monitoring and communication devices not included with the Sol-Ark platform in basic configuration. This money is to cover the CapEx for the equipment primarily related to the emergency connection pedestal. It includes considerations for multiple twist-lock receptacles to connect up to 480V/50A equipment, as well as the industrial extension cords to have on hand for field-expedient repairs or bypasses of system components in a worst-case scenario. Additionally, to satisfy the requirements of robust and resilient communications, additional equipment should be purchased in installed as describe in the drawing set to provide network access for native system components, as well as allowing emergency response personnel and equipment to access the hardwired, and cellular networks installed as part of the microgrid.

6.3.1.2 Photovoltaics (PV)

The pricing used for the PV systems in this study was based on input provided by local integrators received for similar systems in similar locations. Additionally, these prices included additional contingency for compliance with the structural requirements outlines in the structural basis of design.

6.3.1.3 Battery Energy Storage Systems (BESS)

The models utilized lithium chemistry technologies and industry pricing metrics developed through historical quotations and confirmed with a local system integrator. The systems were sized to utilize 100% of the battery's maximum state of charge (SOC) with a minimum SOC of 10% during normal operations and the ability to utilize down to 5% SOC in emergency conditions. The model assumes a full replacement of the BESS cells at year ten, so reserve capacity considerations are not built into the model. Integrators bidding on projects based on this report should assume energy usage profiles up to the full 100% energy rating, in kWh, of the BESS sizes. Considerations for cell degradation should be accounted for in quoted O&M agreements or performance contracts in line with the warranted service life of the system. A conservative charge and discharge rate (C-rate) for lithium chemistry was utilized in the models to mitigate cell degradation over the life of the modeled systems. The C-rate used in the models was 0.3C.

Operational expenses for the BESS were based on regular monitoring and testing intervals performed by an operations and maintenance contractor program. Cell replacement and the costs of maintaining energy capacity were not included in the pricing as the model implemented a full replacement value in year ten.

6.3.1.4 Diesel Generator Pricing

The models implemented diesel generators to support the primary PV-BESS microgrid. The generator was priced at $30,000 for a single 60kW generator which is inclusive of all material, labor, design, and installation. OpEx was set at $4/kW/year to cover typical maintenance and exercise operation. The fuel price used for diesel was $5/gallon.

6.3.2 Modeling Outcomes

The system designed for the hangar uses two types of generation, renewable energy from PV and traditional rotating machine generation from a diesel generator. To optimize the system the goal is to provide as much renewable energy as possible, while also optimizing for the economics of net metering as well as providing full energy resilience in all seasons despite the variability of the renewable resource; solar only works when the sun is shining. This results in a careful balance and optimization between the PV, the BESS, and the genset.

To account for variability and the uncertainty of when a grid outage or emergency event can occur, the system is optimized across all seasons. The following information is presented for two different scenarios utilizing the same optimized equipment mix: a two-week outage in the winter and a two-week outage in the summer. Using an outage duration of two weeks results in systems which generally perform fully for any extended duration as it is unlikely that minimal irradiance conditions would occur for longer and two weeks, at which point the solar energy resource is able to catch back up and recharge the energy storage system.

Table 6 shows the summary results of the designed system. This includes the size of the PV system along with average expected energy generated, the energy capacity of the battery system, the size of the diesel generator, capital and operating expense budgets, and the CO_2 emissions reduction for the estimated energy usage versus purchasing all of the energy from the grid.

Table 6: Microgrid system summary table

	PV		BESS	Genset	CapEx	OpEx	CO_2
Microgrid Description	**kW_{dc}**	**MWh_{ac}/yr**	**kWh**	**kW**	**$k**	**$k/yr**	**% red.**
Quillayute Hangar	60.0	62.2	61.4	60.0	517.0	2.5	91%

The charts in Figure 20 show the difference in energy usage if the system experiences a two-week outage in the summer versus in the winter. If the outage occurs in the winter the diesel generator must provide more energy to carry the load than if the outage occurs in the summer in which case the solar and batteries can more completely provide for the energy needs of the hangar.

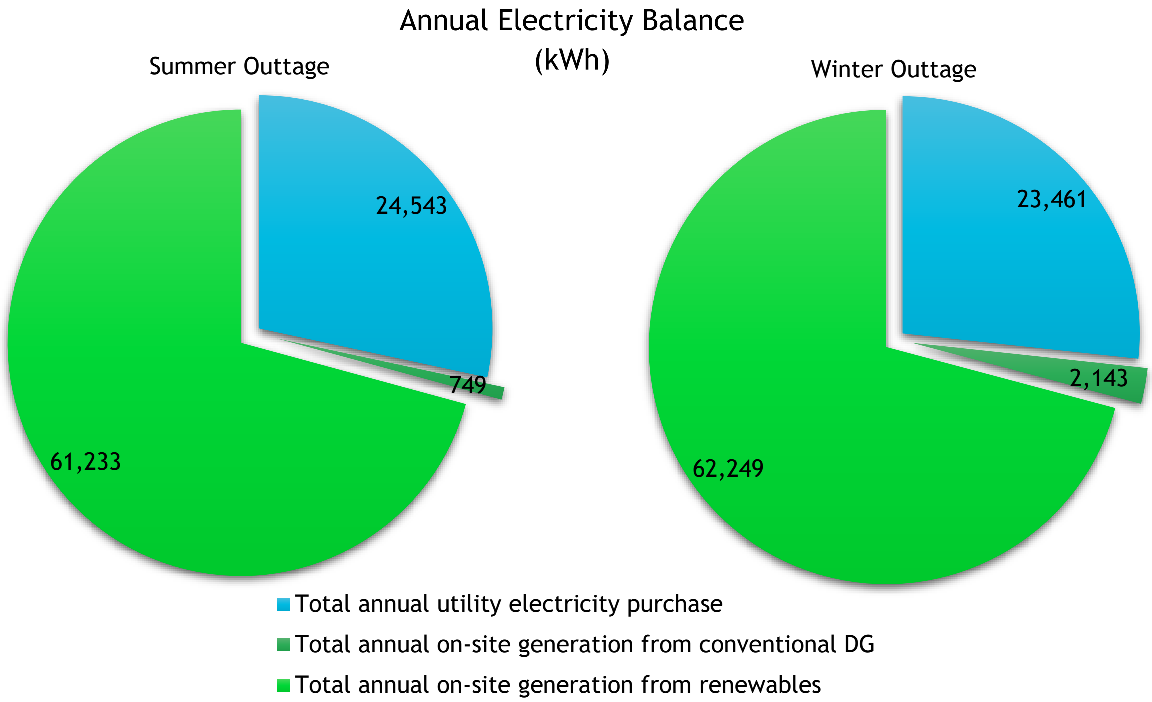

Figure 20: Annual electricity balance

Dispatch curves illustrate how all the systems work in tandem to cover the needs of the load, and also illustrate when the solar energy is being consumed on site, exported to the grid for net-metering, or curtailed in situations where the solar energy is more than the load requires and the BESS is already full.

Figure 21 illustrates how the designed system would operate for one week in the month of April under normal conditions. There is no demand charge on the utility tariff so the system does not show any demand reduction which would be a flattening of the black load line covered by the PV or BESS. The system is shown using energy storage in the mornings, as the PV then charges the batteries back up during the day (pink line showing state of charge) and exports energy back for net metering once the batteries are full. Energy is only purchased from the utility in the evenings or not at all if the solar resource is strong and the load for the day is minimal.

Figure 21: April normal operation dispatch curve

Figure 22 and Figure 23 show the system operation in a summer and winter outage, respectively. The key takeaway from these two figures is that in the summer outage, there is significantly more solar resource and some of the energy is curtailed (not used), and the diesel generator is only used for a few hours to cover the load on days when the load is greater than the solar can provide. In the winter outage, there is almost no PV curtailment as it is all needed to cover the load and recharge the batteries. The diesel generator is anticipated to need to run for significantly more hours in a winter outage condition to maintain the hangar’s energy needs.

Figure 22: August outage operation dispatch curve

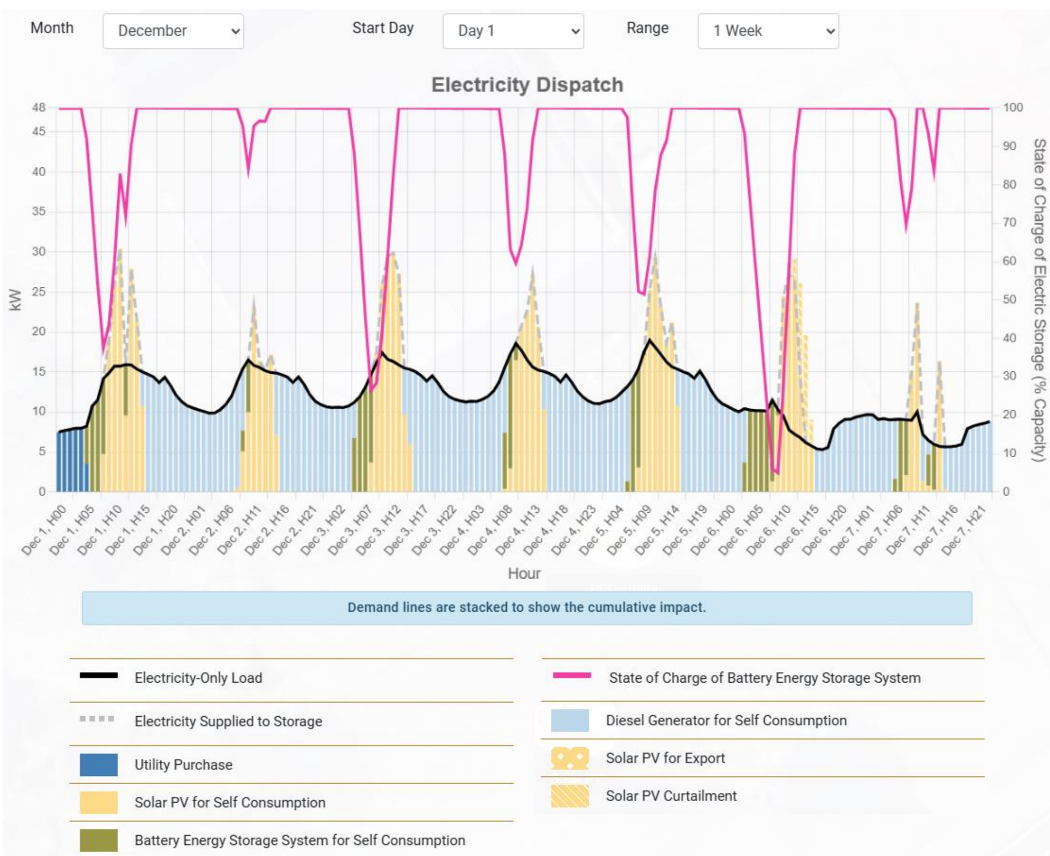

Figure 23: December outage operation dispatch curve

7 Key Findings

Several key findings and limitations were revealed during this study. Leveraging the airport and hangar as a resilience hub is a viable and beneficial plan. There are several key elements which should be given appropriate attention during future project development cycles.

The following list outlines the key considerations developed through the course of this study.

1. The hangar is an ideal location for a resilient microgrid due to the space available, the recently updated electrical service, and the versatility of the structure to shelter both people and equipment in case of an emergency.
2. Existing site infrastructure will likely not be cost effective to repurpose. The resilient electrical systems will be best served by installing all fresh infrastructure to support their integration.
3. There is adequate space to significantly increase the system size should the future load grow or the need to support more energy intensive loads in case of emergency become an even greater priority for the region.
4. Integration of other facilities on the site (such as the NOAA facilities) will be difficult due to separate electrical services, and the legal/regulatory challenges of providing utility services to a third party as a publicly owned facility.
5. The installation of the microgrid equipment needs to be highly considerate of the most likely hazards, primarily seismic. All final engineering and designs should have third party review and verification as outlined in Section 3.6.

7.1 Limitations

The study resulted in the identification of limitations and elements which will require future coordination.

1. The load developed and analyzed for the project not based on direct historical data for the hangar. The resilient energy system is sized to accommodate a typical fit-out of the existing space. However, it is critical that the energy usage profile generated by the hangar revitalization engineering team be coordinated against the basis of design for the energy system as provided in this study.
2. A basis of design for the structural elements of the energy system has been provided in this report. However, additional geotechnical studies should be completed as part of final system integration to confirm that the equipment meets the requirements of Risk Category V prior to installation for the specific area of installation.
3. The full extent of the spare equipment and field expedient repair solutions as part of the resiliency planning should be coordinated with the final design and selection of the equipment installed as well as any third-party equipment that would likely be supported in the case of emergency.

8 Conclusion

There is a strong need for a resilient microgrid system in the northwest region of the Olympic Peninsula. The Quillayute Airport is an ideal location for a resilience hub and base of operation in a disaster management and recovery situation. Clallam County Fire District 6 engaged ProtoGen to study the airport for the development of a microgrid plan. The study activities included interviews with key stakeholders, a site visit, data collection, and analysis of technical, regulatory, and economic factors. With consideration of these factors, an approximately 60kW, $517k microgrid was designed. Powered primarily with grid-interactive solar PV and battery energy storage, with a diesel generator in the rare event of extended dark sky conditions. Together these systems can accommodate long duration outages exceeding two weeks with confidence.

Basis of design drawings have been developed. The drawings include site plans, equipment layouts, single line electrical, structural foundational details and equipment specifications. With minimum effort the drawing package could be taken to 100% construction design for permit and installation.

The next steps should include approval from the key stakeholders, securing implementation funding, development of a request for proposal (RFP) for an installation contractor, contractor award, completion of engineering, permitting, PUD interconnection, equipment procurement, construction, commissioning, operation and microgrid hub promotion.

This study and plan resulted in actionable steps for the Clallam County Fire District 6 to pursue. Once completed, the communities located in the Olympic Peninsula will be well prepared to deal with future adverse events, as well as collect the environmental and economic benefits associated with grid-tied solar PV.

QUILLAYUTE AIRPORT MICROGRID

AN EMERGENCY RESPONSE RESILIENCE PROJECT

CITY OF FORKS

CLIENT

CLALLAM COUNTY FIRE DIST 6

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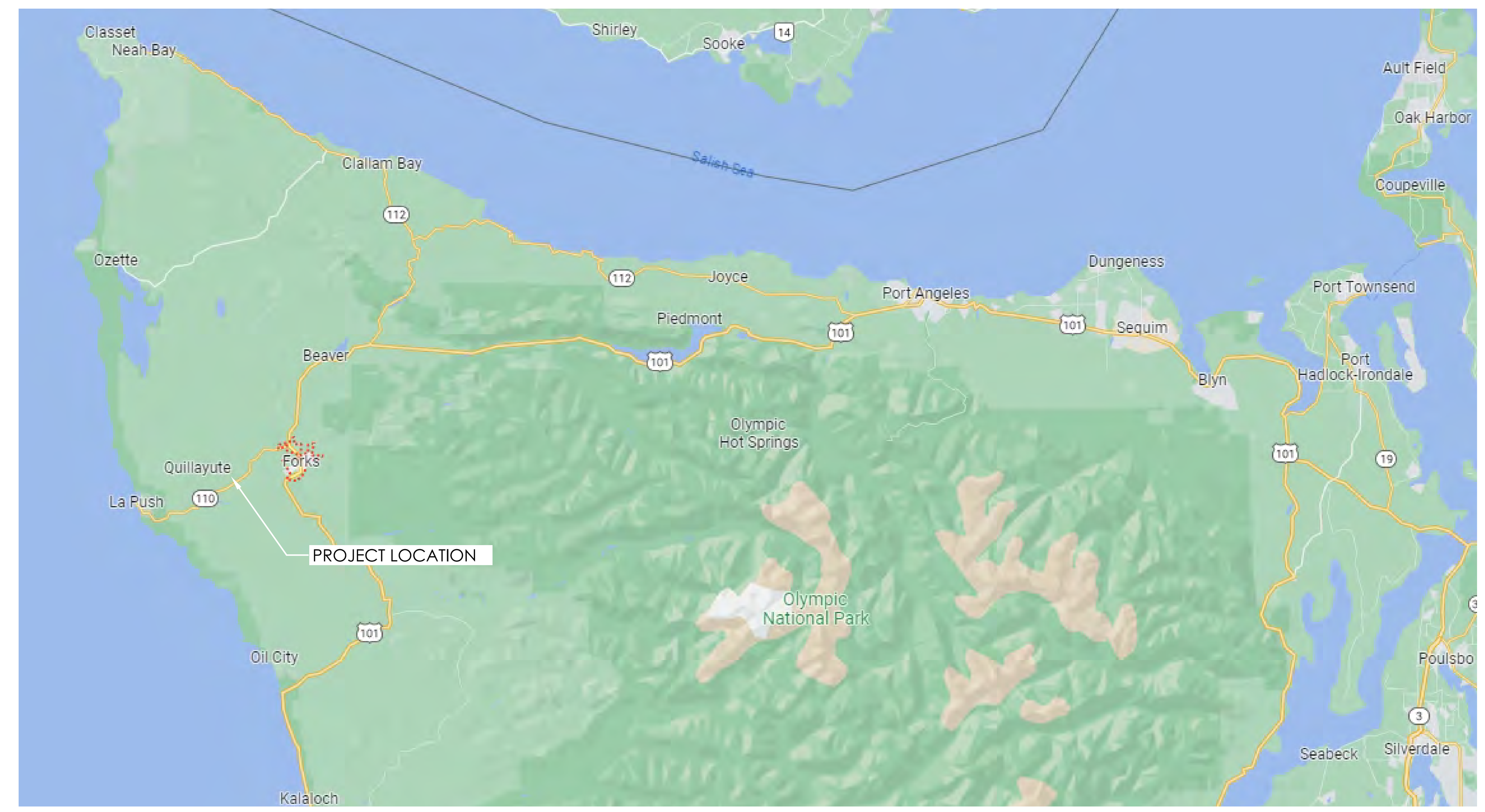
DRAWING INDEX

PROJECT DESCRIPTION

QUILLAYUTE AIRPORT IS A WWII HISTORIC SITE DESIGNATED AS A REGIONAL HUB FOR EMERGENCY RESPONSE ACTIVITIES. THE RESILIENT MICROGRID DESIGN IN THESE DRAWINGS PROVIDES A REGENERATIVE ELECTRICAL SUPPLY TO A WIDE VARIETY EMERGENCY RESPONSES, PLANNED AND UNPLANNED. THE DESIGN INCLUDES PV AS A PRIMARY SOURCE OF POWER AND A DIESEL OR PROPANE GENERATOR AS A BACKUP. THE STRUCTURAL DESIGN FOR THE SYSTEMS IS INTENDED TO BE AS ROBUST AS POSSIBLE IN PREPARATION FOR A CASCADIA SUBDUCTION EARTHQUAKE. IN NORMAL CONDITIONS, THE PV AND BATTERY SYSTEM OPERATES IN GRID-CONNECTED MODE TO OFFSET THE HANGAR'S ANNUAL ELECTRICAL LOAD IN ACCORDANCE WITH CLALLAM PUD'S NET METERING POLICY. THE SYSTEM ASSUMES A FORTHCOMING RENOVATION OF THE HISTORIC HANGAR. A PRELIMINARY ANNUAL LOAD WAS ASSIGNED BASED ON TYPICAL ENERGY USE INTENSITY FOR COMMERCIAL WAREHOUSE SPACE. THE LOAD OF THE 18,000SQFT HANGAR WAS SIMULATED WITH A 2-WEEK OUTAGE (WINTER AND SUMMER) BUT OTHERWISE FOR CONTINUOUS GRID CONNECTED OPERATION.

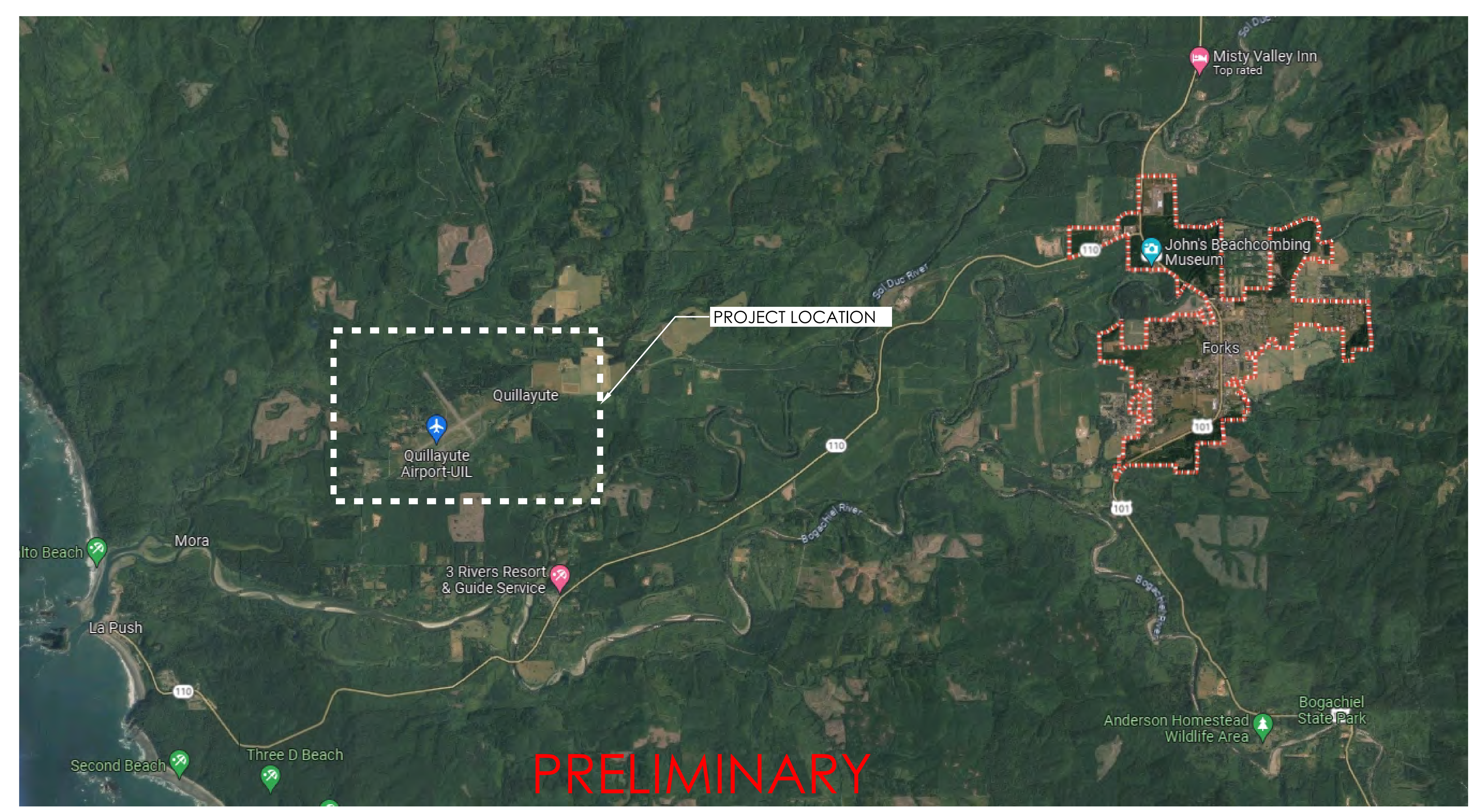
VICINITY MAP



MICROGRID SIMULATION SUMMARY

MICROGRID TOPOLOGY	ANNUAL LOAD SERVED (MWH)	PV SIZING (KWdc)	ANNUAL PV ENERGY MWH)	ENERGY STORAGE SIZING (KWH)	ROTATING MACHINE SIZING (KW)
PV + BATTERY + GENERATOR	63	60	61.2	61.4	60

AERIAL VIEW



HISTORIC QUILLAYUTE AIRPORT HANGAR

QUILLAYUTE AIRPORT MICROGRID

5144 QUILLAYUTE RD., QUILLAYUTE, WA 98331

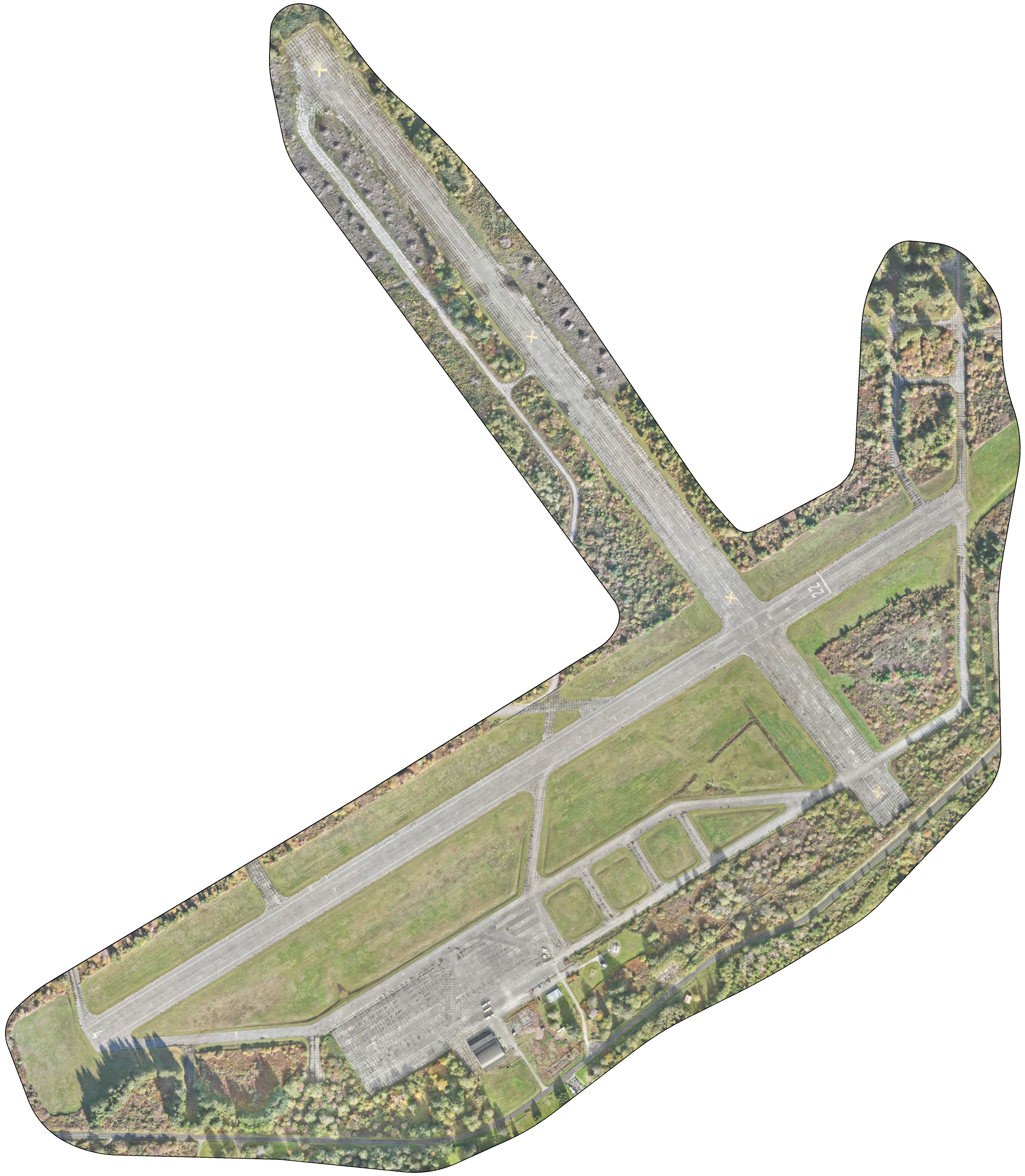
REVISION

PAPER SIZE: 24x36 ARCH D
SHEET: 1 OF 13 TOTAL

COVER PAGE

G000

PLOTTED: March 12, 2024



1 AIRPORT VIEW

1" = 200'

PLOTTED: March 12, 2024

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AIRPORT VIEW

A100

QUILLAYUTE AIRPORT ELECTRICAL CIRCUITS	
ITEM	SYMBOL
CLALLAM PUD AERIAL MEDIUM VOLTAGE	blue dashed line
CLALLAM PUD AERIAL LOW VOLTAGE	purple dashed line
CLALLAM PUD UNDERGROUND MEDIUM VOLTAGE	red dashed line
UNDERGROUND QUILLAYUTE CIRCUIT	dark blue dashed line

1 SITE PLAN
1" = 100'

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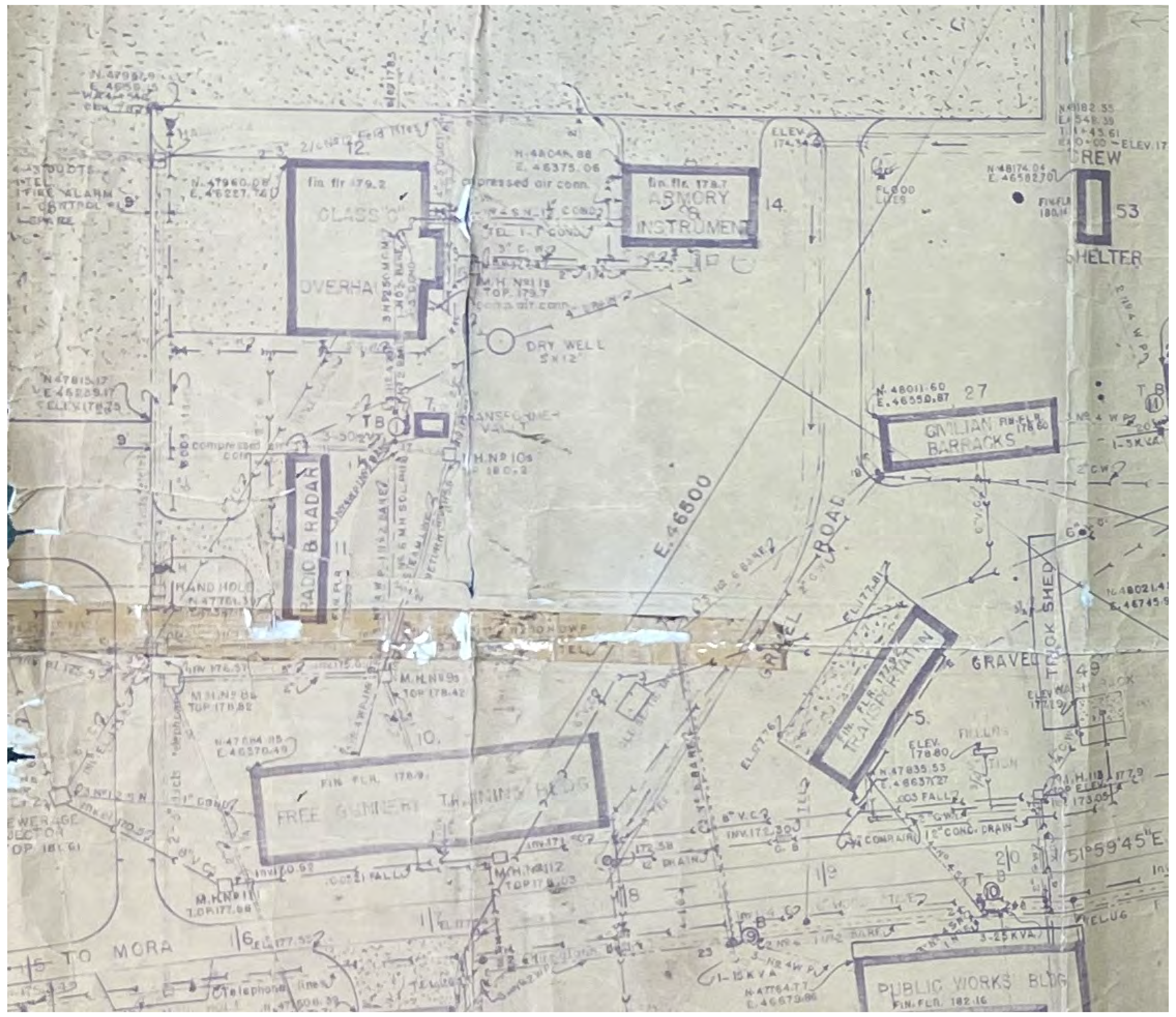
ELECTRICAL SITE PLAN

E100



2 ORIGINAL NAVY UTILITIES AS-BUILT

NTS

1 EXISTING CONDITIONS

1" = 30'

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EXISTING CONDITIONS

E101

1 ARRAY PLAN

1" = 30'

1
E104

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ARRAY PLAN

E102

1 CONDUIT PLAN

1" = 30'

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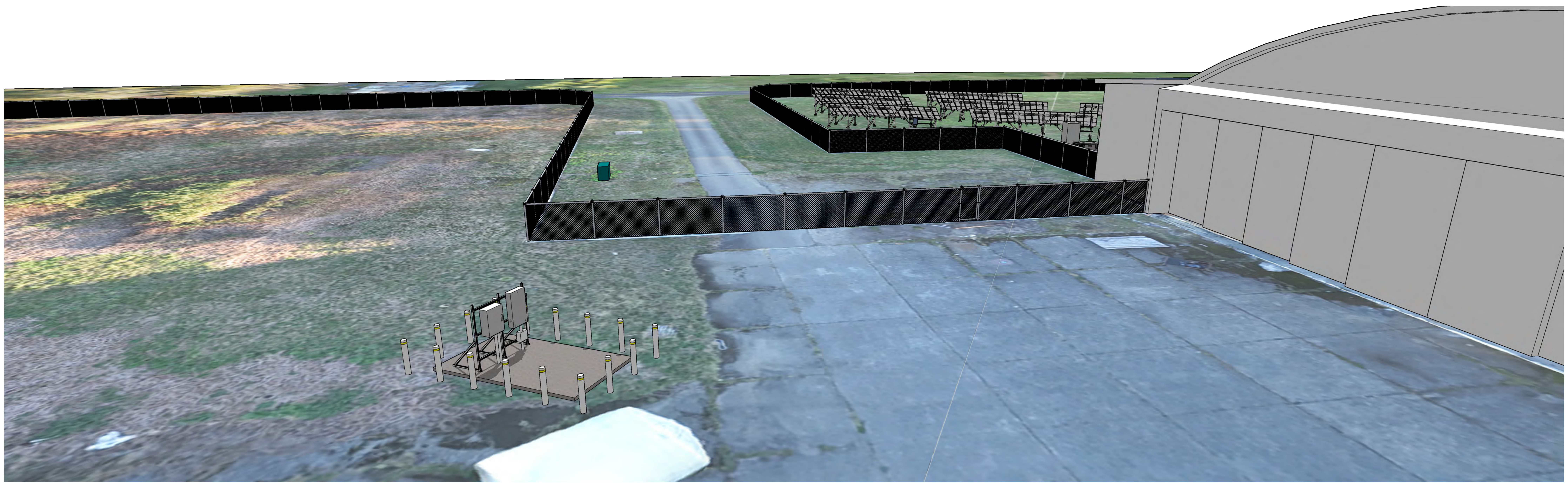
CONDUIT PLAN

E103

1 SW ISOMETRIC VIEW

NTS



2 NW ISOMETRIC VIEWS

NTS

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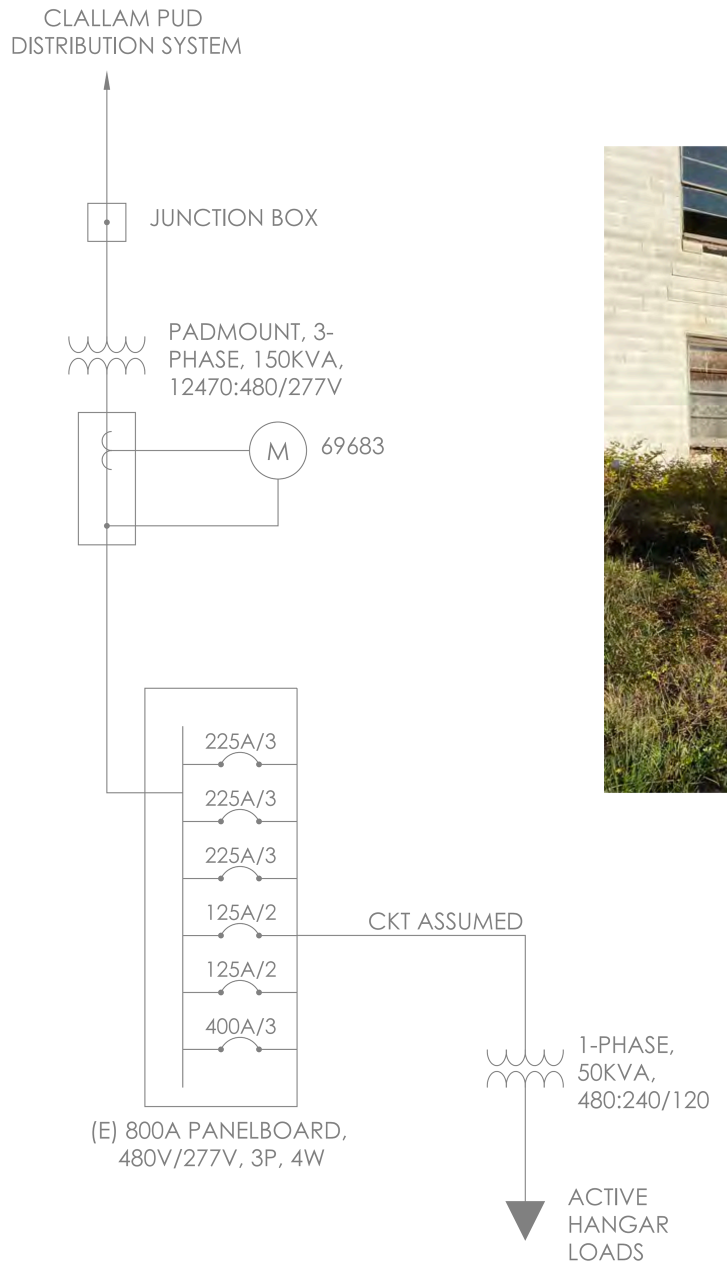
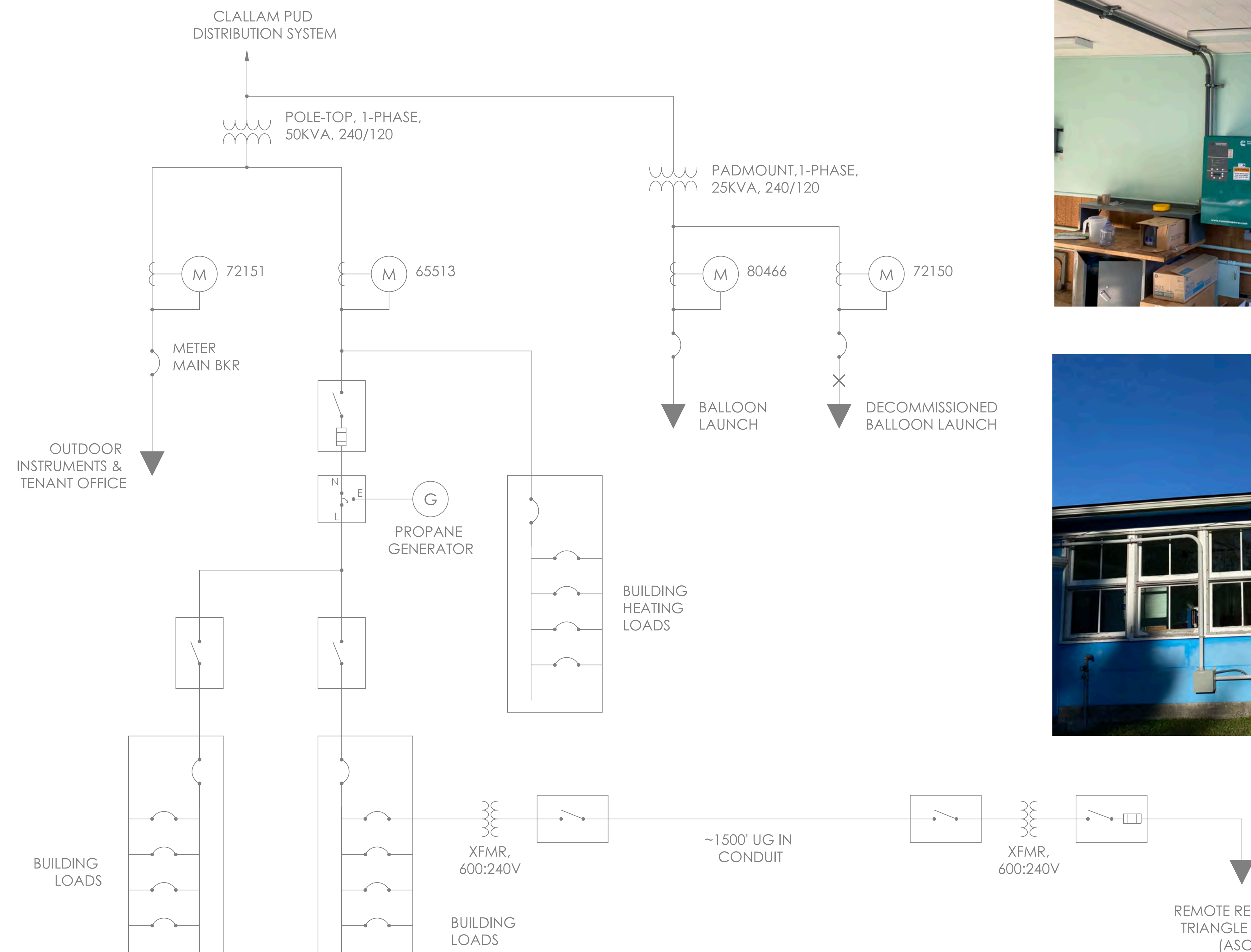
ARRAY ISOMETRIC VIEWS

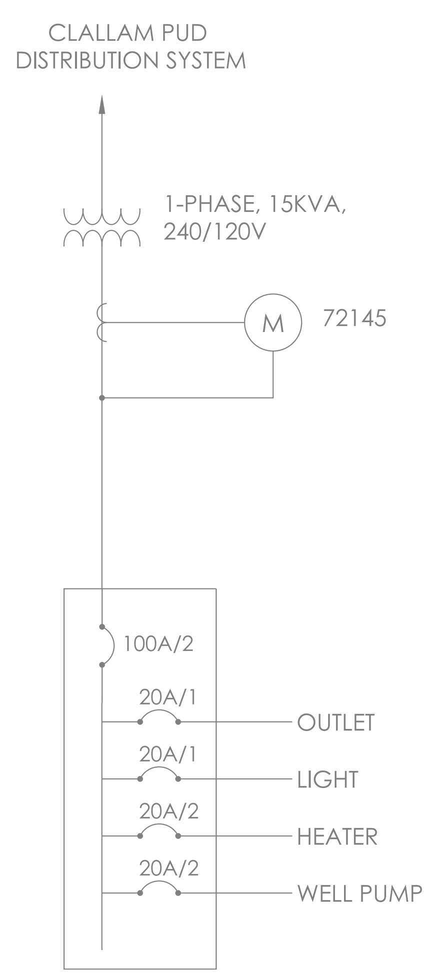
E104



1 SINGLE LINE DIAGRAM - HANGAR BUILDING
NTS



3 SINGLE LINE DIAGRAM - NOAA BUILDING, ASOS
NTS



2 SINGLE LINE DIAGRAM - WELL
NTS

METER NUMBER	SERVICE DESCRIPTION	ADDRESS	2022 ANNUAL LOAD (KWH)
65513	NOAA BLUE BUILDING	5092 QUILLAYUTE ROAD	54,720
69683	HANGAR BUILDING	5144 QUILLAYUTE ROAD	2,200
72145	WATER WELL	5142 QUILLAYUTE ROAD	6,387
72150	NOAA BALLOON LAUNCH BUILDING	5092 QUILLAYUTE ROAD	2
72151	NOAA BLUE BUILDING (TENANT OFFICE)	5092 QUILLAYUTE ROAD	3,638
80466	NOAA AUTOMATED BALLOON LAUNCHER	5092 QUILLAYUTE ROAD	6,348

4 METER LOADS
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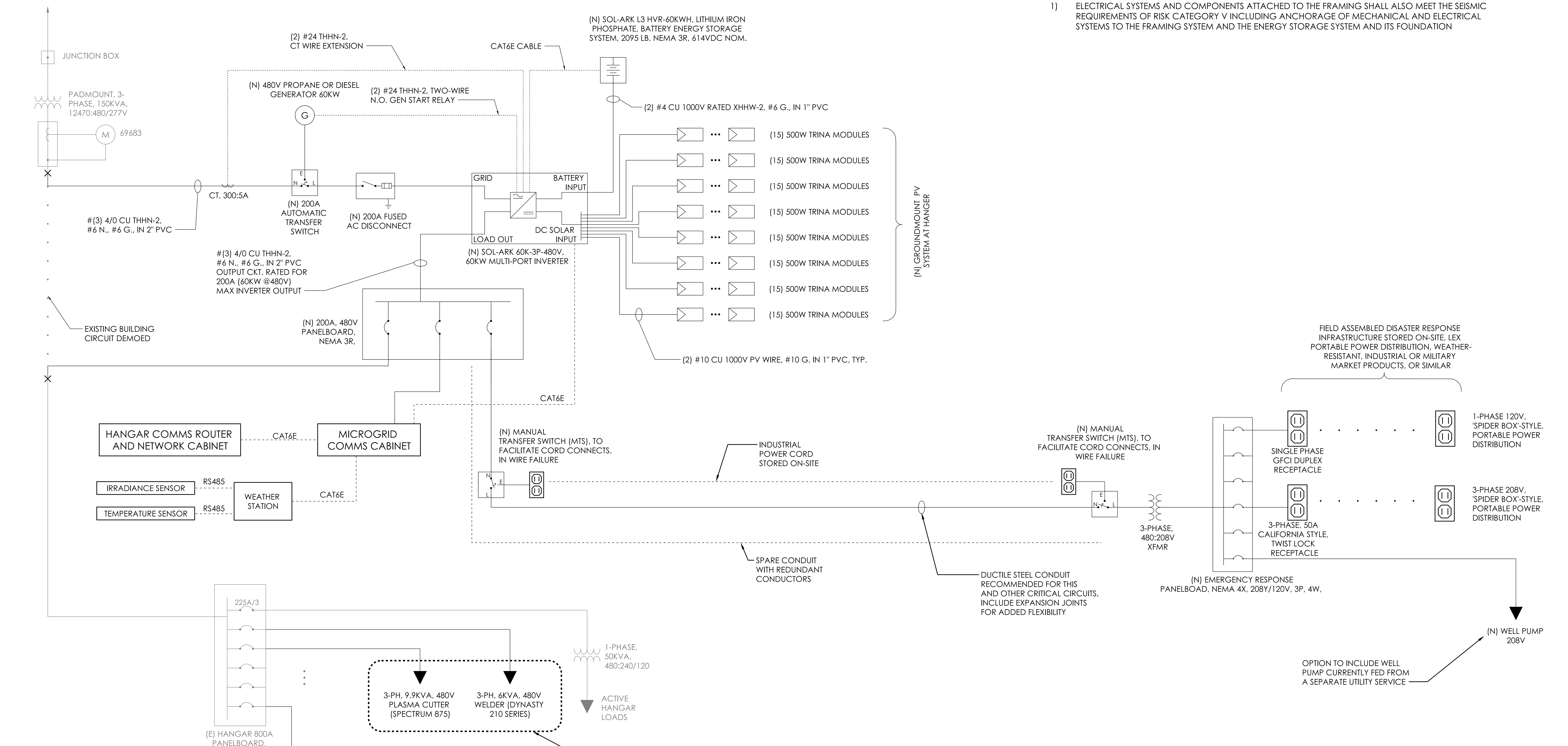
EXISTING SLD

E600

GENERAL ELECTRICAL NOTES

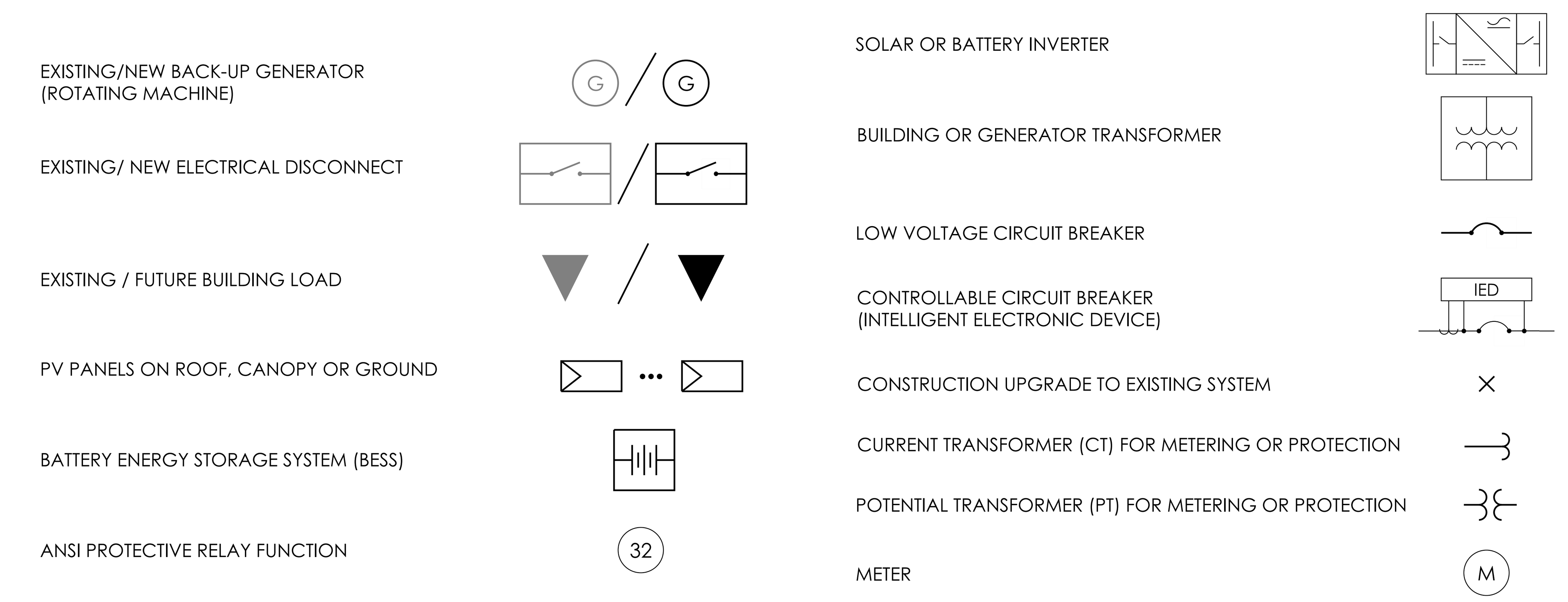
1) ELECTRICAL SYSTEMS AND COMPONENTS ATTACHED TO THE FRAMING SHALL ALSO MEET THE SEISMIC REQUIREMENTS OF RISK CATEGORY V INCLUDING ANCHORAGE OF MECHANICAL AND ELECTRICAL SYSTEMS TO THE FRAMING SYSTEM AND THE ENERGY STORAGE SYSTEM AND ITS FOUNDATION



1 SINGLE LINE DIAGRAM - HANGER BUILDING

NTS

LEGEND



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PROPOSED SLD

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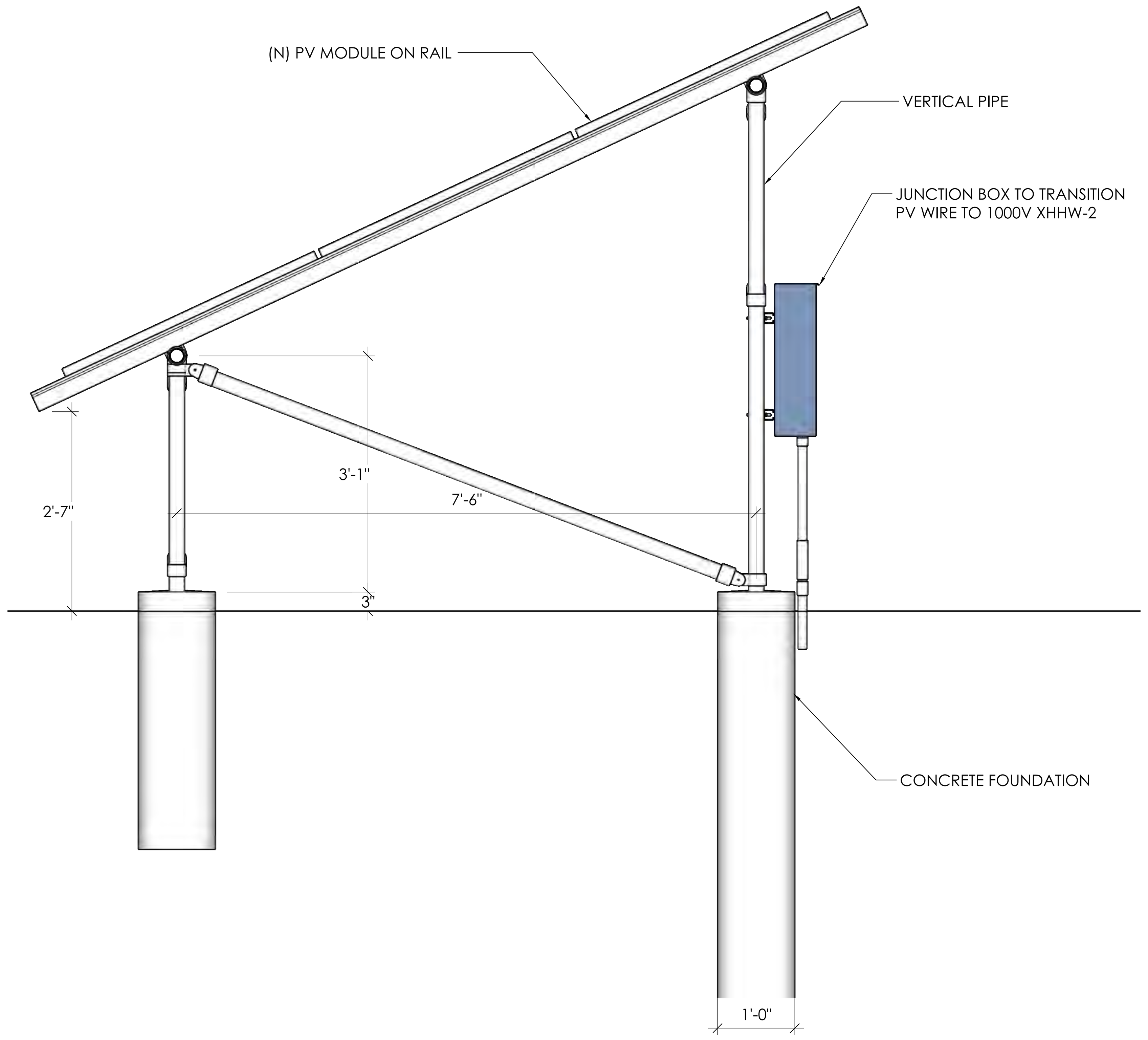
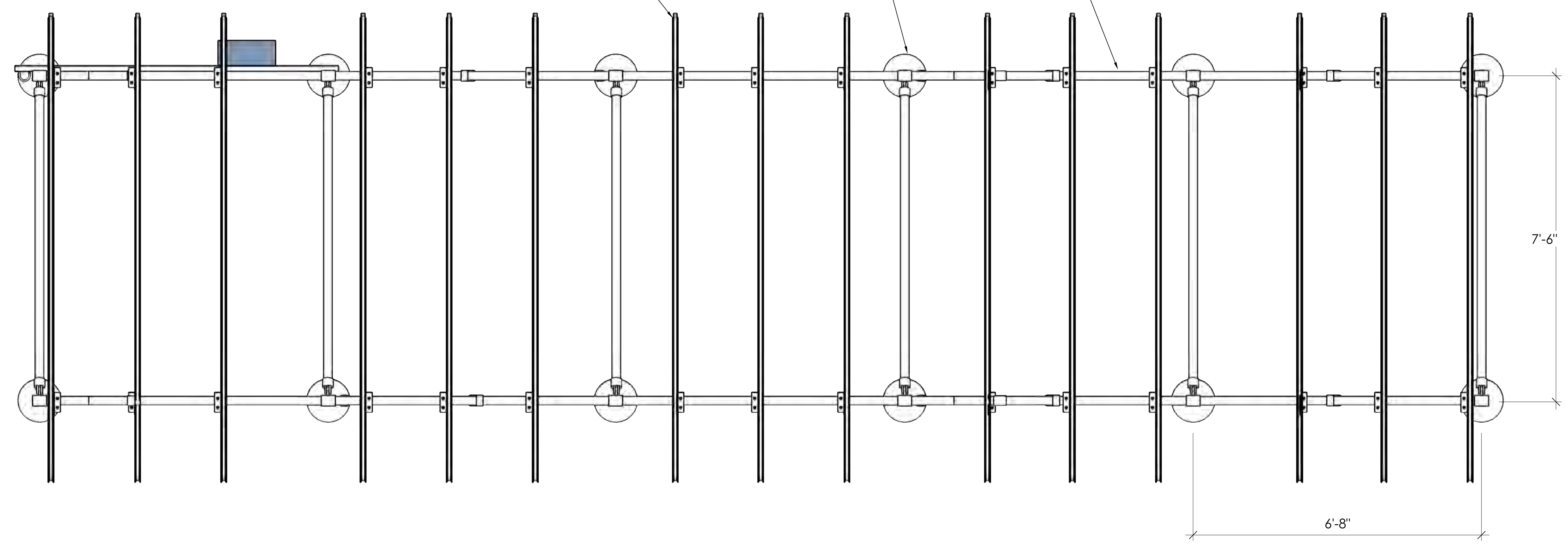


1 RACKING PROFILE
3/4" = 1'



2 RACKING PLAN (MODULES REMOVED)
1/2" = 1'

GENERAL STRUCTURAL FRAMING NOTES

1) THE FRAMING SYSTEM SHOWN HERE, INCLUDING THE FOUNDATION SYSTEM, IS A GENERAL REPRESENTATION OF A TYPICAL GROUND MOUNTED PV SYSTEM AND DOES NOT PRECLUDE OTHER GROUND MOUNTED PV FRAMING THAT MEET THE DESIGN REQUIREMENTS
2) THE FRAMING SYSTEM SHALL MEET THE REQUIREMENTS OF A RISK CATEGORY V STRUCTURE AS DEFINED IN THE UNIFIED FACILITY CRITERIA (UFC) 3-301-01 - DESIGN OF RISK CATEGORY V STRUCTURES, NATIONAL STRATEGIC MILITARY ASSETS
3) DESIGN SHALL CONFORM TO ASCE 7-16 AND IBC 2021 AS WELL AS THE UFC 3-301-01 AND IN AREAS OF CONFLICT BETWEEN THE CODES, THE MOST STRINGENT REQUIREMENTS SHALL APPLY
4) FRAMING AND FOUNDATION SYSTEM SHALL MEET THE SEISMIC REQUIREMENTS OF A DESIGN EARTHQUAKE WITH A MINIMUM MOMENT MAGNITUDE (Mw) = 9.0
5) OTHER SYSTEMS AND COMPONENTS ATTACHED TO THE FRAMING SHALL ALSO MEET THE SEISMIC REQUIREMENTS OF RISK CATEGORY V INCLUDING ANCHORAGE OF MECHANICAL AND ELECTRICAL SYSTEMS TO THE FRAMING SYSTEM AND THE ENERGY STORAGE SYSTEM AND ITS FOUNDATION

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RACKING DETAILS

S100

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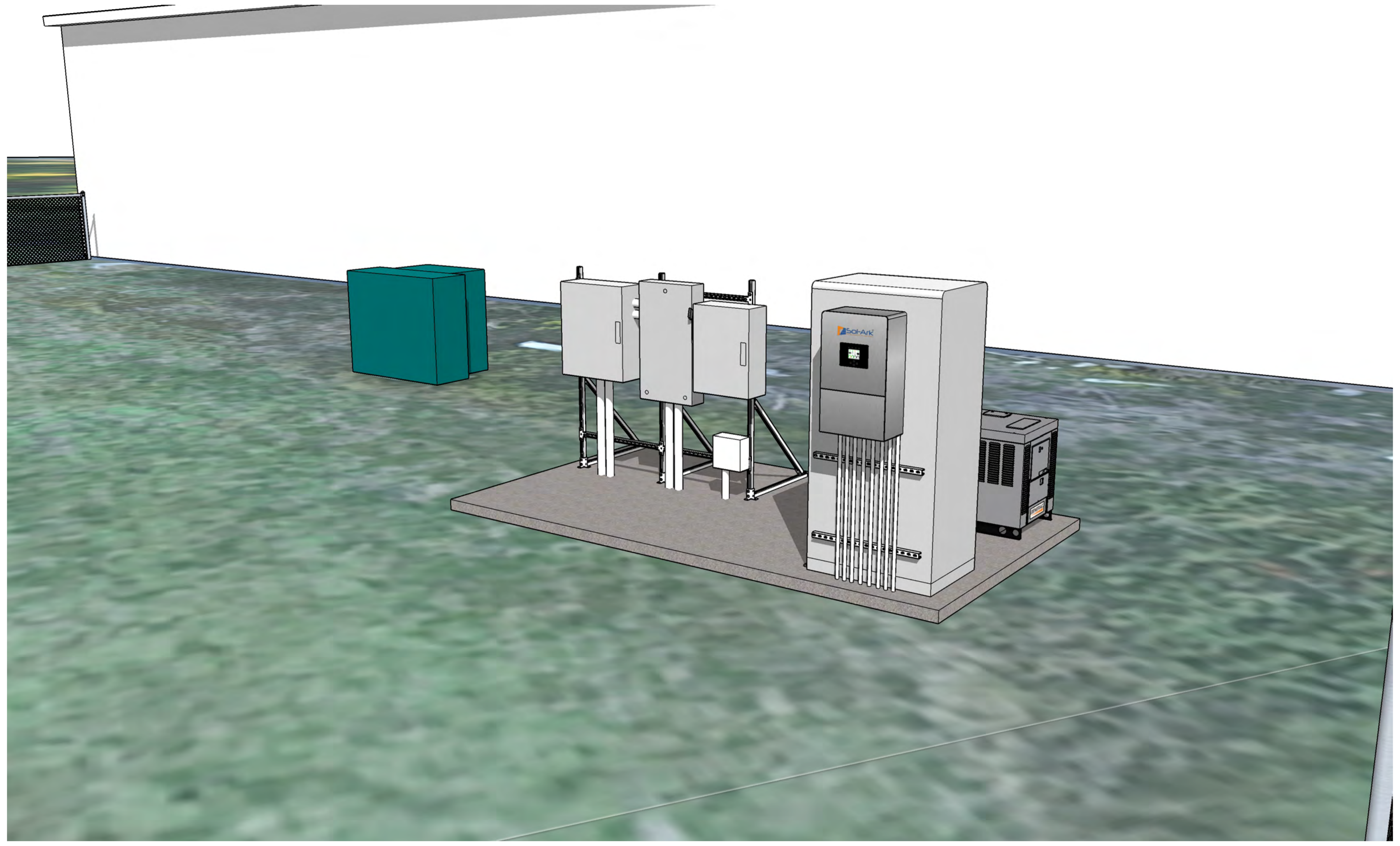
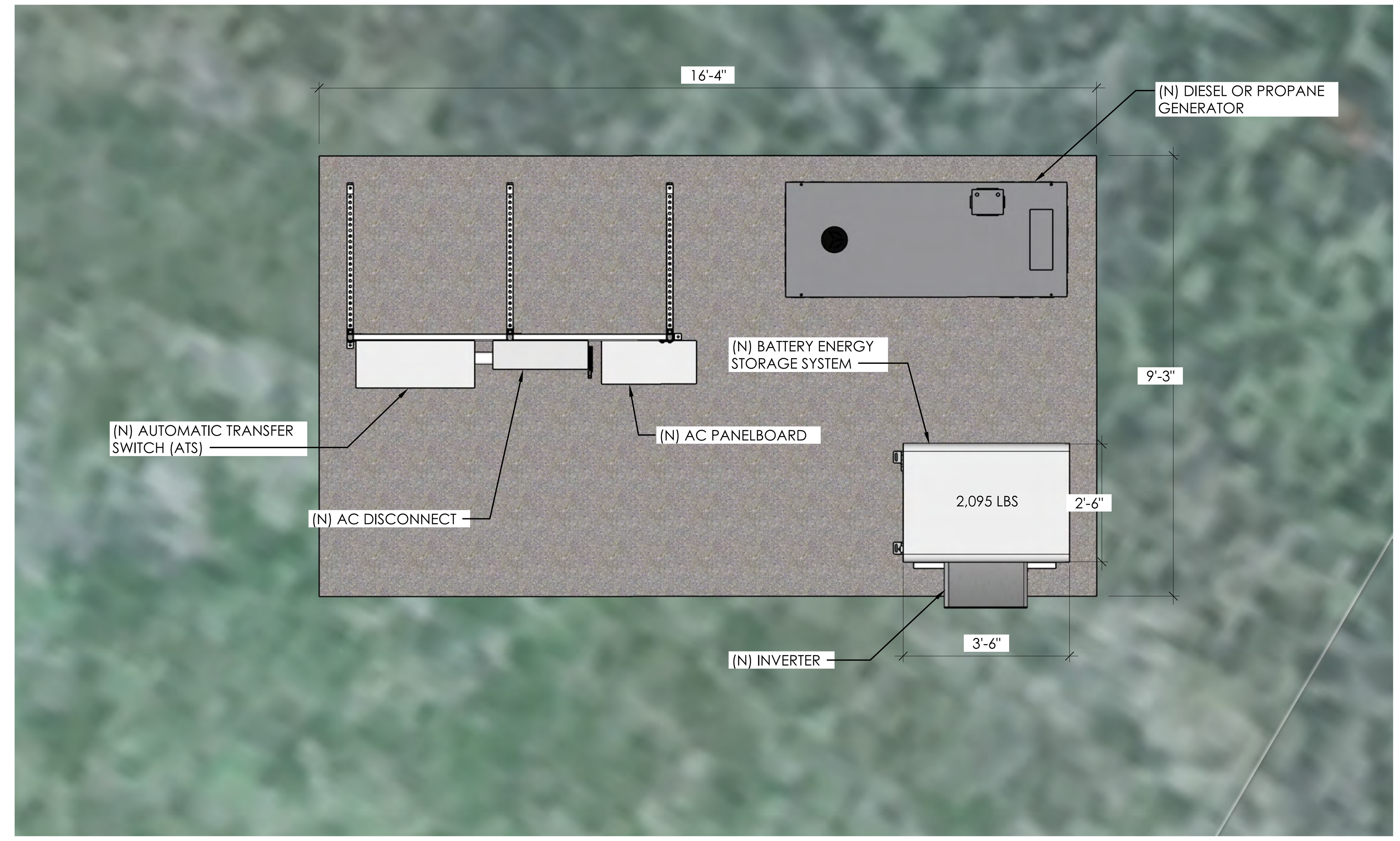


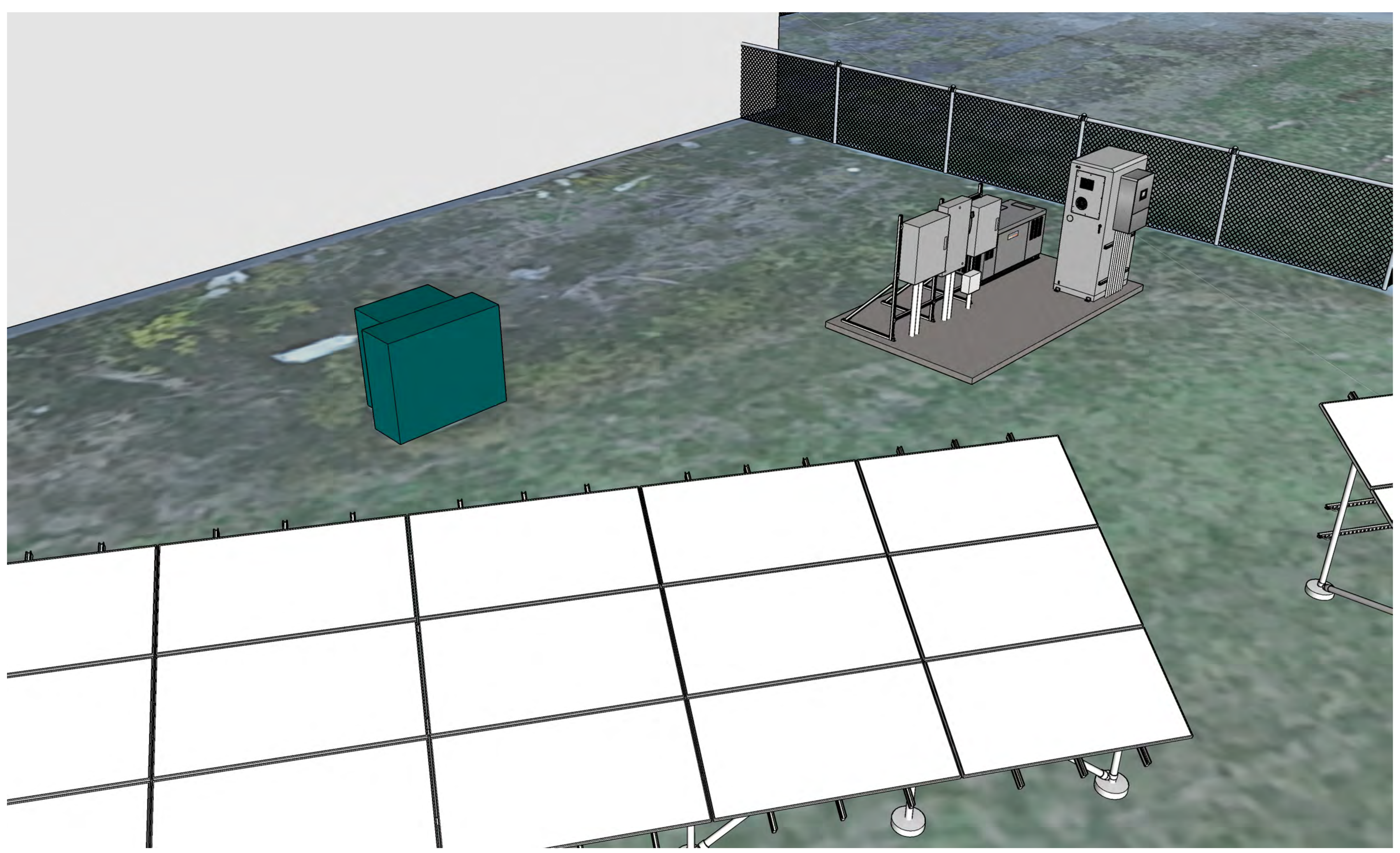
1 MICROGRID PAD ISOMETRIC

NTS



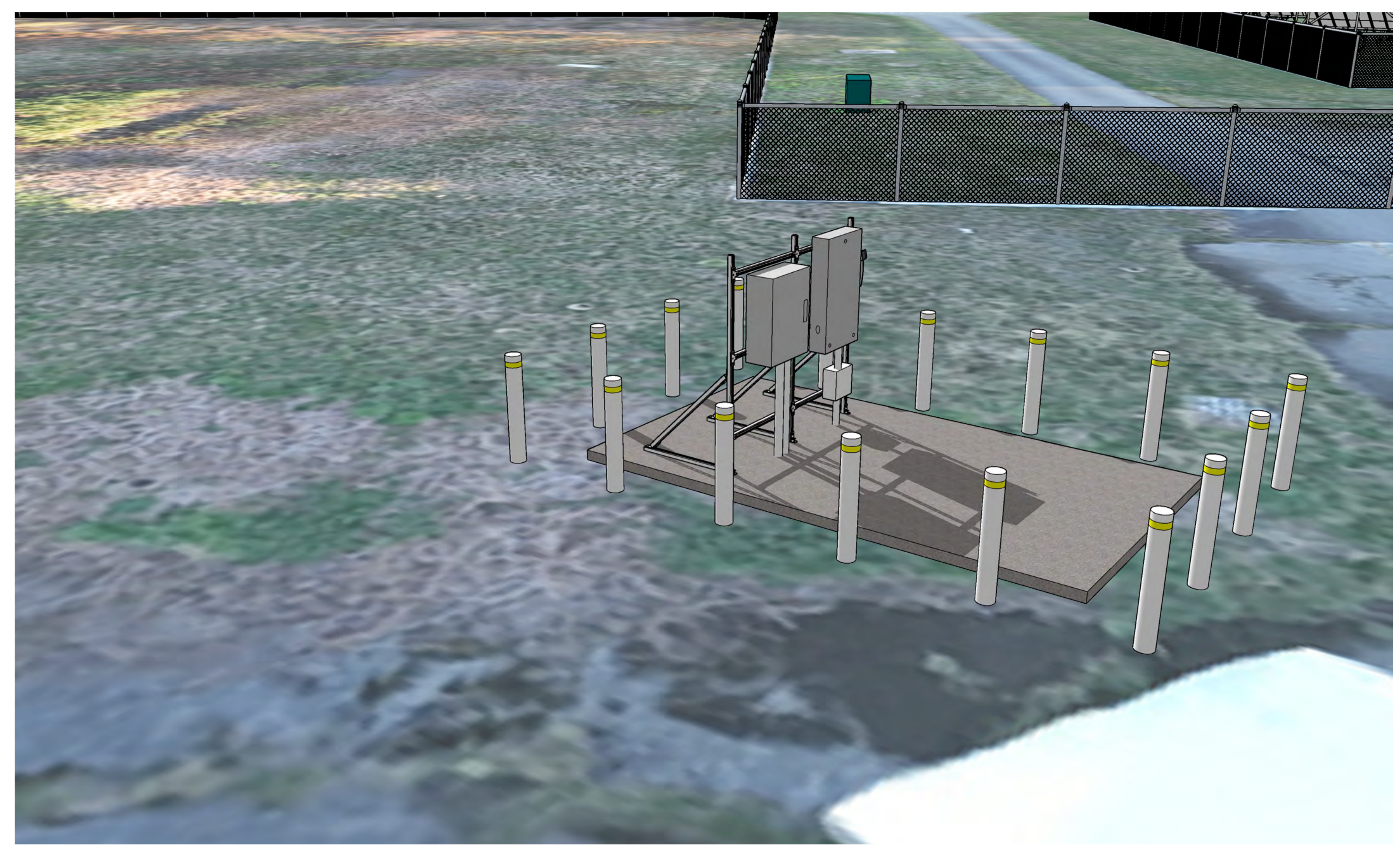
2 MICROGRID PAD PLAN

1/2" = 1'



3 MICROGRID PAD ISOMETRIC

NTS



4 RESPONSE PAD ISOMETRIC

NTS

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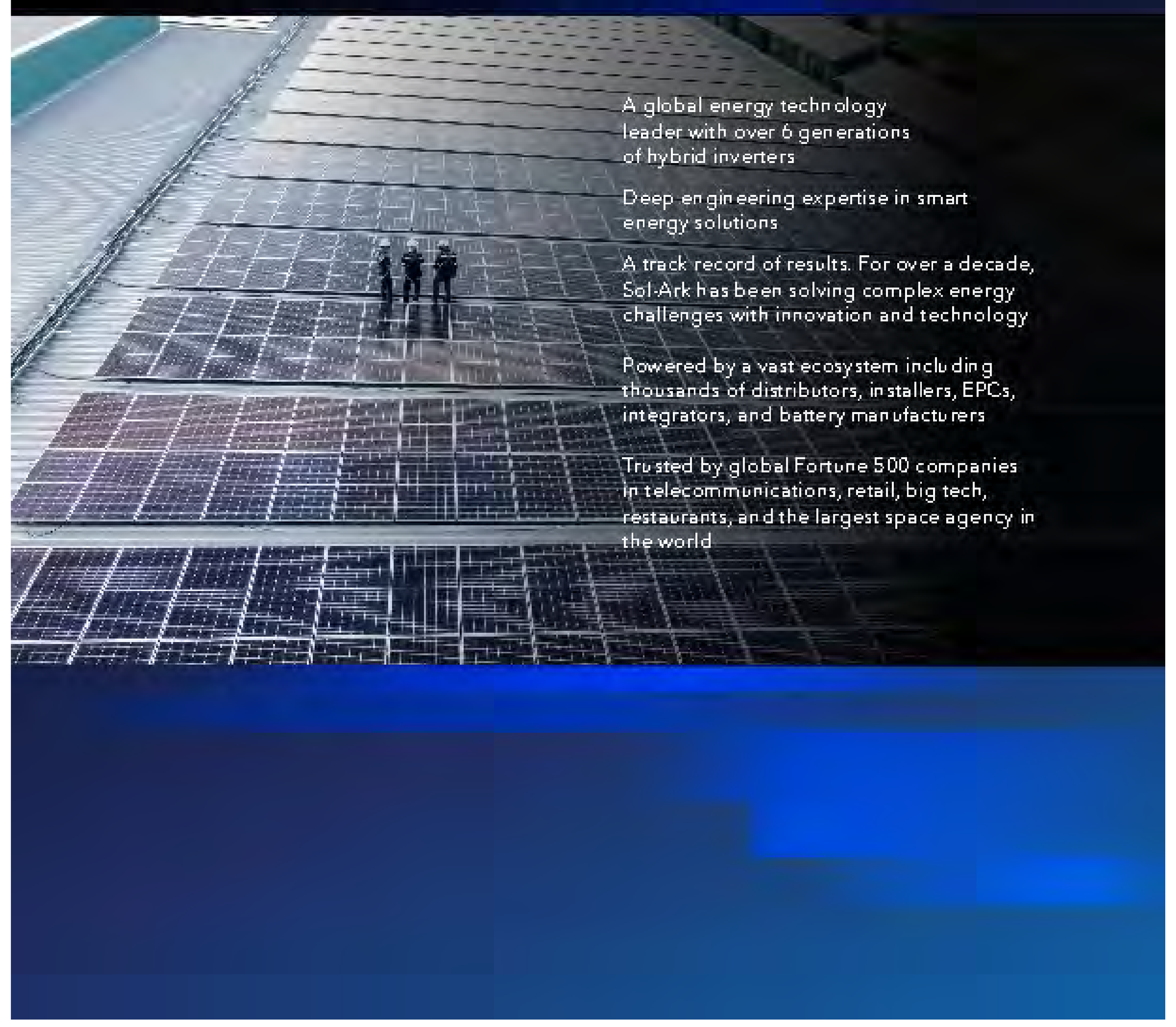
PAD DETAILS

S101

Sol-Ark

Sol-Ark Commercial Energy Solutions



DATASHEET

60K-3P-480V

C&I Hybrid Inverter

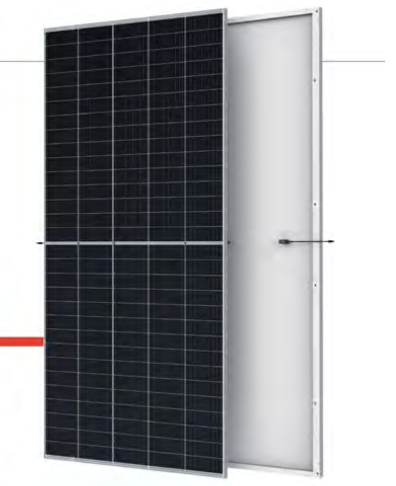
Input Data (PV)	
Max. Allowed PV Power (STC)	78,000W
Nominal Voltage Range	150-850V
Startup Voltage	150V
Max. Input Voltage [1]	1,000V
Max. operating input current per MPPT	36A
Max. short circuit current per MPPT	55A
No. of MPP Trackers	4
No. of PV Strings per MPPT	2
Max. AC Coupled Input	120,000W
Output Data (AC)	
Nominal AC Voltage (3Φ)	277/480V
Grid Frequency	50 / 60Hz
Real Power, max continuous (3Φ)	60,000W
Max. Output Current	72.3A
Peak Apparent Power (7s, off-grid, 3Φ)	120,000VA @ 144A
Max. Grid Passthrough Current	200A
Power Factor Output Range	+/- 0.8 adjustable
Backup Transfer Time	5ms (adjustable)
CEC Efficiency	96.5%
Max Efficiency	97.5%
Design (DC to AC)	Transformerless DC
Stackable	Up to 12 in parallel
Battery Input Data (DC)	
Battery Chemistry	Lithium iron phosphate
No. of Battery Inputs	2
Battery Input Terminal Rating	50A
Nominal DC Voltage	> 600V
Operating Voltage Range	160 - 800V
Battery Capacity Range	50 – 9900Ah
Max. Battery Charge / Discharge Current	100A (50A per input)
Charge Controller Type	3-Stage with Equalization
Grid to Battery Charging Efficiency	96.0%
Automatic Generator Start (AGS)	2 Wire Start - Integrated
BMS Communication [2]	CANBus & RS485
General Data	
Dimensions (H x W x D)	894 x 528 x 295 mm (35.2 x 20.8 x 11.6 in)
Weight	79.4 kg (172 lb)
Enclosure	IP65 / NEMA 3R
Ambient Temperature	-40~60°C, > 45°C Derating
Noise	< 30 dB @ 25°C (77°F)
Idle Consumption - No Load	60W
Communication and Monitoring	Wi-Fi & LAN Hardware Included
Warranty	10 Years (15 Years [4)])
Category	
Certifications and Listings (Grid Support Interactive Inverter)	UL 1741-2021 (incl UL1741SB), CSA C22.2 No 107.1-16, IEEE 1547-2018 & 1547a-2020 & 1547.1-2020 (SRD V2.0), UL1699B, CEC[3], SGIP[3]
PV DC Disconnect Switch – NEC 240.15	Integrated
Ground Fault Detection – NEC 690.5	Integrated
PV Rapid Shutdown Control – NEC 690.12	Integrated
PV Arc Fault Detection – NEC 690.11	Integrated
PV Input Lightning Protection	Integrated
PV String Input Reverse Polarity Protection	Integrated
Surge Protection	DC Type II / AC Type III

1. See Installation Guide for more details on sizing array strings, the highest input voltage is based on the voltage open-circuit of the array at the minimum design temperature.
2. Active BMS communication is required for all lithium batteries. A list of compatible batteries can be found on our website.
3. Currently pending listing.
4. 5-year extension is available for purchase by registered Gold level installers only.

Mono Multi Solutions

THE Vertex

BACKSHEET MONOCRYSTALLINE MODULE



500W+ MAXIMUM POWER OUTPUT

21.1% MAXIMUM EFFICIENCY

0~+5W POSITIVE POWER TOLERANCE

PRODUCTS TSM-DE18M(II) | POWER RANGE 480-505W

High customer value
- Lower LCOE (Levelized Cost Of Energy), reduced BOS (Balance Of System) cost, shorter payback time
- Lower guaranteed first year and annual degradation
- Designed for compatibility with existing mainstream system components
- Higher return on Investment

High power up to 505W
- Large area cells based on 210mm silicon wafers and 1/3-cut cell technology
- Up to 21.1% module efficiency with high density interconnect technology
- Multi-busbar technology for better light trapping effect, lower series resistance and improved current collection

High reliability
- Minimized micro-cracks with innovative non-destructive cutting technology
- Ensured PID resistance through cell process and module material control
- Resistant to harsh environments such as salt, ammonia, sand, high temperature and high humidity areas
- Mechanical performance up to 5400 Pa positive load and 2400 Pa negative load

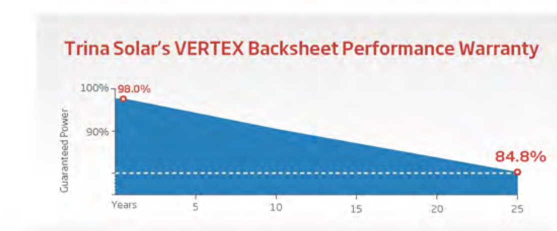
High energy yield
- Excellent IAM (Incident Angle Modifier) and low irradiation performance, validated by 3rd party certifications
- The unique design provides optimized energy production under inter-row shading conditions
- Lower temperature coefficient (-0.36%) and operating temperature

Founded in 1997, Trina Solar is the world's leading total solution provider for solar energy. With local presence around the globe, Trina Solar is able to provide exceptional service to each customer in each market and deliver our innovative, reliable products with the backing of Trina as a strong, bankable brand. Trina Solar now distributes its PV products to over 100 countries all over the world. We are committed to building strategic, mutually beneficial collaborations with installers, developers, distributors and other partners in driving smart energy together.

Comprehensive Products and System Certificates
IEC61215/IEC61730/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

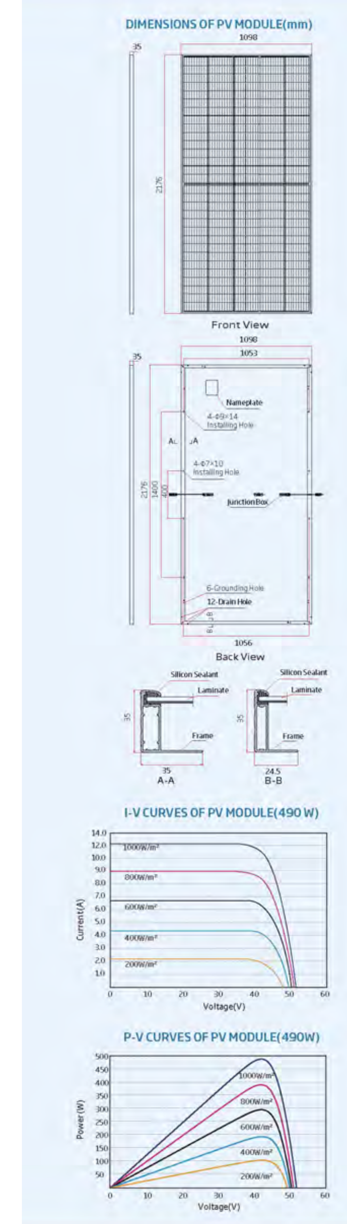
Trinasolar

Trina Solar's VERTEX Backsheet Performance Warranty



Vertex

BACKSHEET MONOCRYSTALLINE MODULE



ELECTRICAL DATA (STC)						
Peak Power Watts-P_{MAX} (Wp)*	480	485	490	495	500	505
Power Tolerance-P_{MAX} (W)	0 ~ +5					
Maximum Power Voltage-V_{MPP} (V)	42.0	42.2	42.4	42.6	42.8	43.0
Maximum Power Current-I_{MPP} (A)	11.42	11.49	11.56	11.63	11.69	11.75
Open Circuit Voltage-V_{OC} (V)	50.8	51.1	51.3	51.5	51.7	51.9
Short Circuit Current-I_{SC} (A)	11.99	12.07	12.14	12.21	12.28	12.35
Module Efficiency η_m (%)	20.1	20.3	20.5	20.7	20.9	21.1

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measuring tolerance: ±3%.

ELECTRICAL DATA (NMOT)						
Maximum Power-P_{MAX} (Wp)	363	367	371	375	379	382
Maximum Power Voltage-V_{MPP} (V)	39.6	39.8	40.0	40.2	40.4	40.6
Maximum Power Current-I_{MPP} (A)	9.15	9.20	9.26	9.32	9.37	9.43
Open Circuit Voltage-V_{OC} (V)	48.0	48.2	48.4	48.6	48.8	49.0
Short Circuit Current-I_{SC} (A)	9.65	9.72	9.77	9.83	9.89	9.94

NMOT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA	
Solar Cells	Monocrystalline
Cell Orientation	150 cells
Module Dimensions	2176 ×1098× 35 mm (85.67 × 43.23 × 1.38 inches)
Weight	26.3 kg (58.0 lb)
Glass	3.2 mm (0.13 inches), High Transmission, AR Coated Heat Strengthened Glass
Encapsulant Material	EVA
Backsheet	White
Frame	35 mm (1.38 inches) Anodized Aluminium Alloy
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²), Portrait: N 280mm/P 280mm(11.02/11.02inches) Landscape: N 1400 mm /P 1400 mm (55.12/55.12 inches)
Connector	MC4 EVO2 / TS4*

*Please refer to regional datasheet for specified connector.

TEMPERATURE RATINGS	
NMOT (Nominal Module Operating Temperature)	41°C (±3°C)
Temperature Coefficient of P_{MAX}	- 0.36%/°C
Temperature Coefficient of V_{OC}	- 0.26%/°C
Temperature Coefficient of I_{SC}	0.04%/°C

MAXIMUMRATINGS	
Operational Temperature	-40~+85°C
Maximum System Voltage	1500V DC (IEC)
Max Series Fuse Rating	20A

(Do not connect Fuse in Combiner Box with two or more strings in parallel connection)

WARRANTY
12 year Product Workmanship Warranty
25 year Power Warranty
2% first year degradation
0.55% Annual Power Attenuation

(Please refer to product warranty for details)

PACKAGING CONFIGUREATION
Modules per box: 30 pieces
Modules per 40' container: 600 pieces

Trinasolar

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

Version number: TSM_EN_2020_A www.trinasolar.com

Sol-Ark | L3 Series Limitless Lithium™ Battery Energy Storage System

480V Outdoor and Indoor

Battery Energy Storage System

Battery Model:	L3 HVR-60	L3 HV-60
SKU:	L3-HVR-60KWH	L3-HV-60KWH
System Data		
Compatible Inverter	Sol-Ark 60K-3P-480V-N	
Environmental Rating	Outdoor	Indoor
Cell Chemistry	Lithium Iron Phosphate	
Battery Cabinet Capacity	61.44 kWh	
System Usable Energy [1]	55.30 kWh	
Built-In DC Disconnect Rating	200A	
Internal Fuse Rating	160A	
Real Power (backup) Per Inverter	60 kWac	
Max DC-Coupled Solar Per Inverter	78 kWac	
Max AC-Coupled Solar Per Inverter	125 kWac	
Max Battery Cabinets Per Inverter	6	16
Maximum Inverters Per System	6 [2]	10
Recommend Depth of Discharge	90%	
System Nominal Voltage	614.4V	
System Operating Voltage	588V-672V	
Charge/Discharge Current [3]		
• Recommend	50A	
• Nominal/Continuous	100A	
• Peak Discharge (2 min @ 25°C)	125A	
System Roundtrip Efficiency	90% (25C, 0.5C)	
Product Dimensions (WxDxH)	76x107x226 cm (30x42x89 in)	58x58x218 cm (23x23x86 in)
Net Weight	950 kg (2,095 lbs)	773 kg (1,705lbs)
Mounting Type	Outdoor Enclosure	Freestanding Rack Mount
Operating Temperature [4]	-10°C – 50°C (14°F – 122°F)	4°C – 43°C (40°F – 110°F)
Humidity	5%–85% RH	
Operating Altitude [5]	3000m (9,843 ft)	
Storage Conditions [6]	-4°F – 95°F Up to 85% RH (non-condensing) State of Charge (SOC) 30%	
Ingress Rating	IP55 (NEMA 3R)	IP20 (NEMA 1)
Noise Level @ 1m	75 dBA at 30°C (86°F)	< 40 dBA at 30°C (86°F)
Seismic Zone	4	
Communication Ports	CAN2.0/RS485	
Battery Module Specifications		
Battery Module Configuration	12s1p	12s1p
Battery Module Energy	5.12kWh	
Battery Module Nominal Voltage	51.2V	
Battery Module Nominal Capacity	100Ah	
Warranty and Certification		
Performance Warranty [7]	10 years or 196MWh Throughput	
Product Warranty	10 Years	
Certifications	UL1973, UL9540, UL9540a, UN38.3, FCC, Prop 65	

1. DC usable energy, test conditions: 90% DOD, 0.3C charge and discharge at 25°C. System usable energy may vary due to system configuration parameters.
2. For larger outdoor installations use the Sol-Ark Mega Ark.
3. Output current is affected by battery temperature and SOC.
4. Temperature is based on the average cell temperature as measured by the BMS. Battery charging is disabled below 0°C (32°F). Derating occurs above 45°C (113°F). For HVR model, operating temperature range only applies if using included climate controls. See Sol-Ark technical sales for planning outdoor sites.
5. Battery will operate at a maximum of 1C charge/discharge up to 2000m, above 2000m maximum output is derated to 0.8C, contact Sol-Ark for details.
6. Storage temperature of the battery with no charge or discharge
7. EOL (End of Life) 70% retained capacity. See L3 Series warranty document for details.

Datasheet

IRONRIDGE

Ground Mount System

All-Terrain Mounting

The IronRidge® Ground Mount System combines our XR100® or XR1000® rails with locally-sourced steel pipes or mechanical tubing, to create a cost-effective structure capable of handling any site or terrain challenge.

Installation is simple with only a few structural components and no drilling, welding, or heavy machinery required. In addition, the system works with a variety of foundation options—including concrete piers, ground screws, helical or driven piles, and above-ground ballast blocks.

Rugged Construction
Engineered steel and aluminum components ensure durability.

PE Certified
Pre-stamped engineering letters available in most states.

UL 2703 Listed System
Meets newest effective UL 2703 standard.

Design Software
Online tool generates engineering values and bill of materials.

Flexible Architecture
Multiple foundation and array configuration options.

25-Year Warranty
Products guaranteed to be free of impairing defects.

Datasheet

360° Product Tour
Visit ironridge.com

Substructure

Top Caps
Connect vertical piers with cross pipes or tubing.

Bonded Rail Connectors
Attach and bond XR Rails® to cross pipes or tubing.

Diagonal Braces
Optional brace provides additional support.

Cross Pipe & Piers
Steel pipes or mechanical tubing for substructure.

Rail Assembly

XR100® & XR1000® Rails
Curved XR Rails® increase spanning capabilities.

UFO®
Universal Fastening Objects bond modules to rails.

Stopper Sleeves
Snap onto the UFO® to turn into a bonded end clamp.

CAMO
Bond modules to rails while staying completely hidden.

Resources

Design Assistant
Go from rough layout to fully engineered system. For free.
Go to ironridge.com/design

NABCEP Certified Training
Earn free continuing education credits, while learning more about our systems.
Go to ironridge.com/training

1 CUTSHEETS

NTS

PRELIMINARY

CITY OF FORKS

CLIENT

ProtoGen ENERGY ALIGNED
WWW.PROTOGENENERGY.COM
888.365.GRID (4743)

ENGINEER'S STAMP

PRELIMINARY NOT FOR CONSTRUCTION

QUILLAYUTE AIRPORT MICROGRID

5144 QUILLAYUTE RD., QUILLAYUTE, WA 98331

REVISION

PAPER SIZE: 24x36 ARCH D
SHEET: 12 OF 13 TOTAL

CUTSHEETS

G100

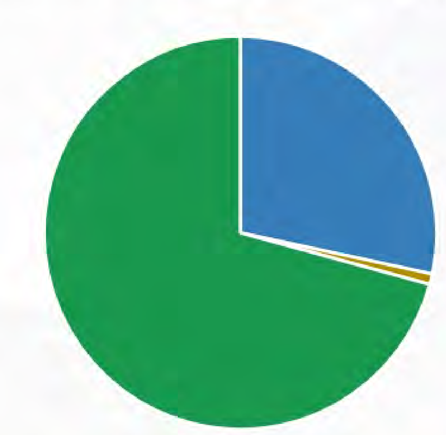
PLOTTED: March 12, 2024

2-WEEK OUTAGE: SUMMER

GRID-CONNECTED OPERATION: MAY

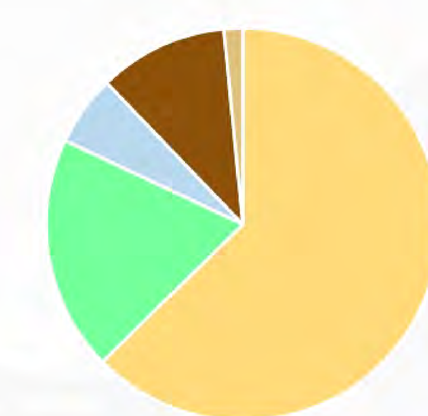
2-WEEK OUTAGE: WINTER

Annual Electricity Balance (kWh)



Total annual electricity purchase (kWh)	24,543
Total annual on-site generation from conventional DG (kWh)	749
Total annual on-site generation from renewables (kWh)	61,233
Total	86,524

Investments

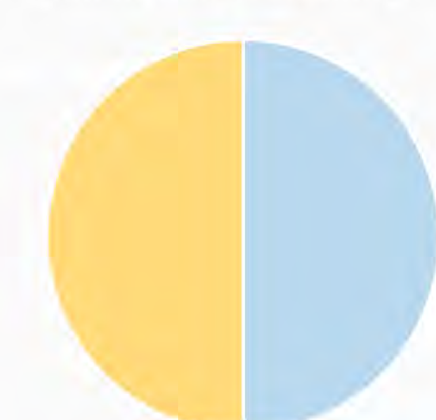


New Solar PV	$324,000
New Battery Energy Storage System	$100,082
New Diesel Generator	$30,000
New Utility Connection	$55,000
New Controller	$8,000
Total	$517,082

Annual PV Electricity Balance (kWh)

Electricity Consumed On-site	40,084
Electricity Exported	21,148
Electricity Curtailed	1,077
Total	62,310

Generation Technologies



New Diesel Generator (kW) (1 units)	60
New Solar PV (kWdc)	60
Total	120

PRELIMINARY

1 XENDEE SIMULATION

NTS

PLOTTED: March 12, 2024

CITY OF FORKS

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ProtoGen ENERGY ALIGNED
WWW.PROTOGENENERGY.COM
888.365.GRID (4743)

ENGINEER'S STAMP

PRELIMINARY NOT FOR CONSTRUCTION

QUILLAYUTE AIRPORT MICROGRID

5144 QUILLAYUTE RD., QUILLAYUTE, WA 98331

REVISION

PAPER SIZE: 24x36 ARCH D
SHEET: 13 OF 13 TOTAL

XENDEE SIMULATION

XEN-1


TAXIWAY NO. 2
WARM-UP APRON
APRON
TAXIWAY NO. 1
HANGAR
LINE CREW SHELTERS
ADMINISTRATION
100,000 GAL. GASOLINE TANKS
WOODED
SCALE 1"=50'
LEGEND
WATER LINES
SEWER LINES
STEAM LINES
THE AUSTIN COMPANY
ENGINEERS AND BUILDERS
NAVAL AIR CENTER
SEATTLE, WASH.
AUXILIARY AIR STATION
QUILLAYUTE, WASH.
SCALE 1"=50'
LEGEND
TRANSFORMER BANK
WATER LINES
SEWER LINES
STEAM LINES & RETURN
TELEPHONE LINES
POWER LINES & POLES
FIRE ALARM SYSTEM
FIRE HYDRANT
GATE VALVE
CATCH BASIN & DRAIN
CONSTRUCTION CAMP BLDGS.
Drawn by
Submited by
Approved
C.O.
SHEET 2 OF
U.S. NAVAL
AUXILIARY AIR STATION
QUILLAYUTE, WASH.
UTILITY
LAYOUT PLAN

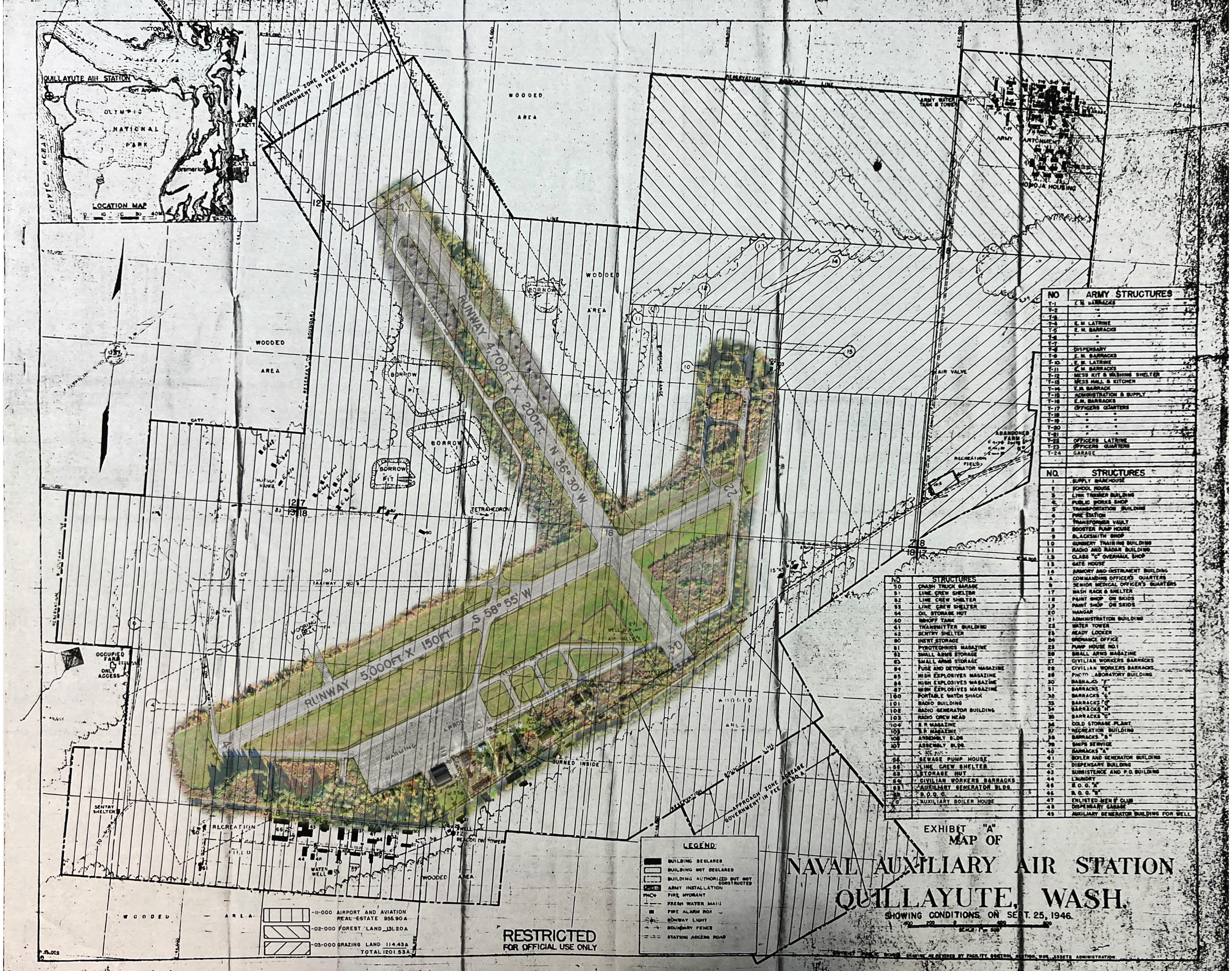
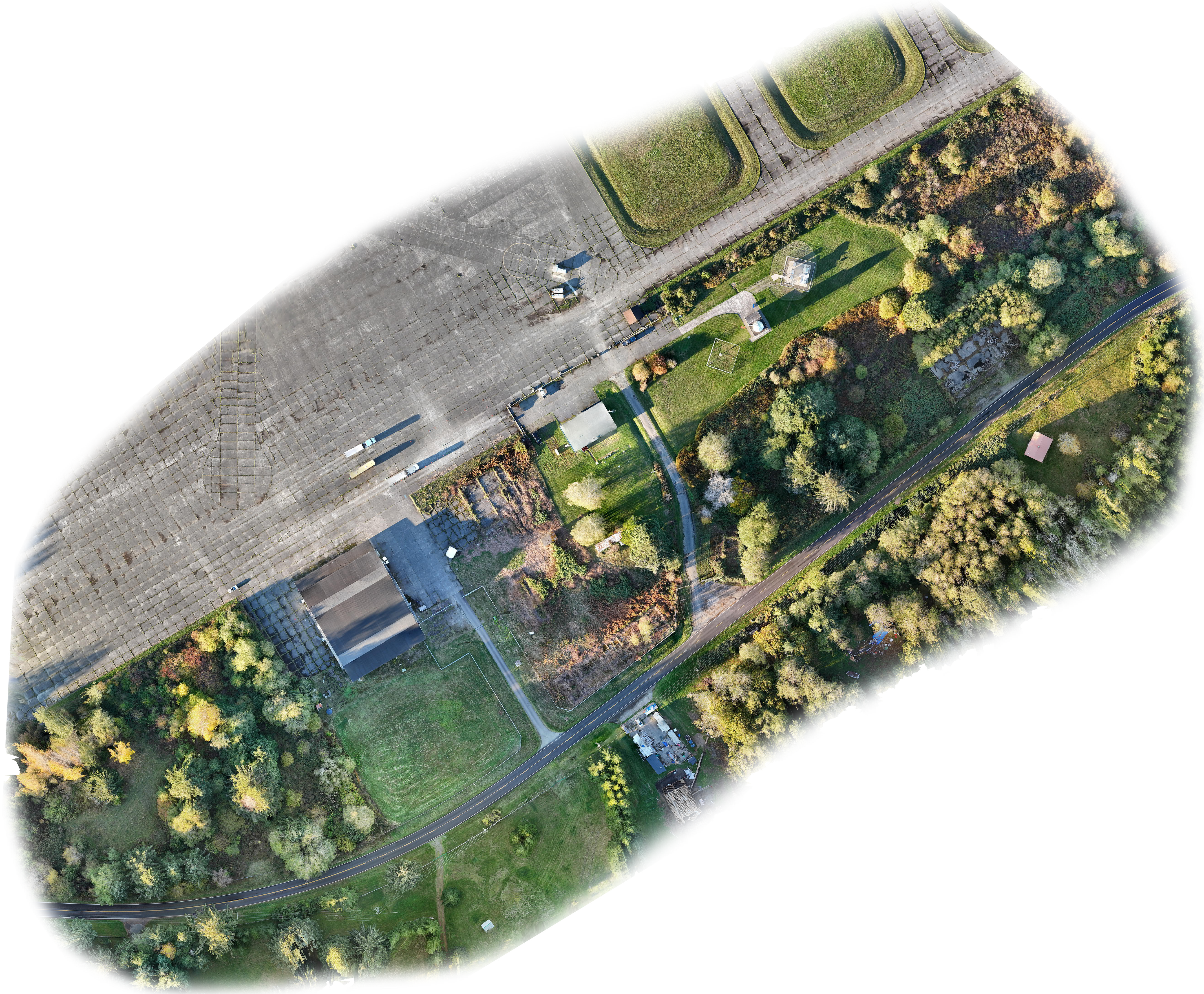
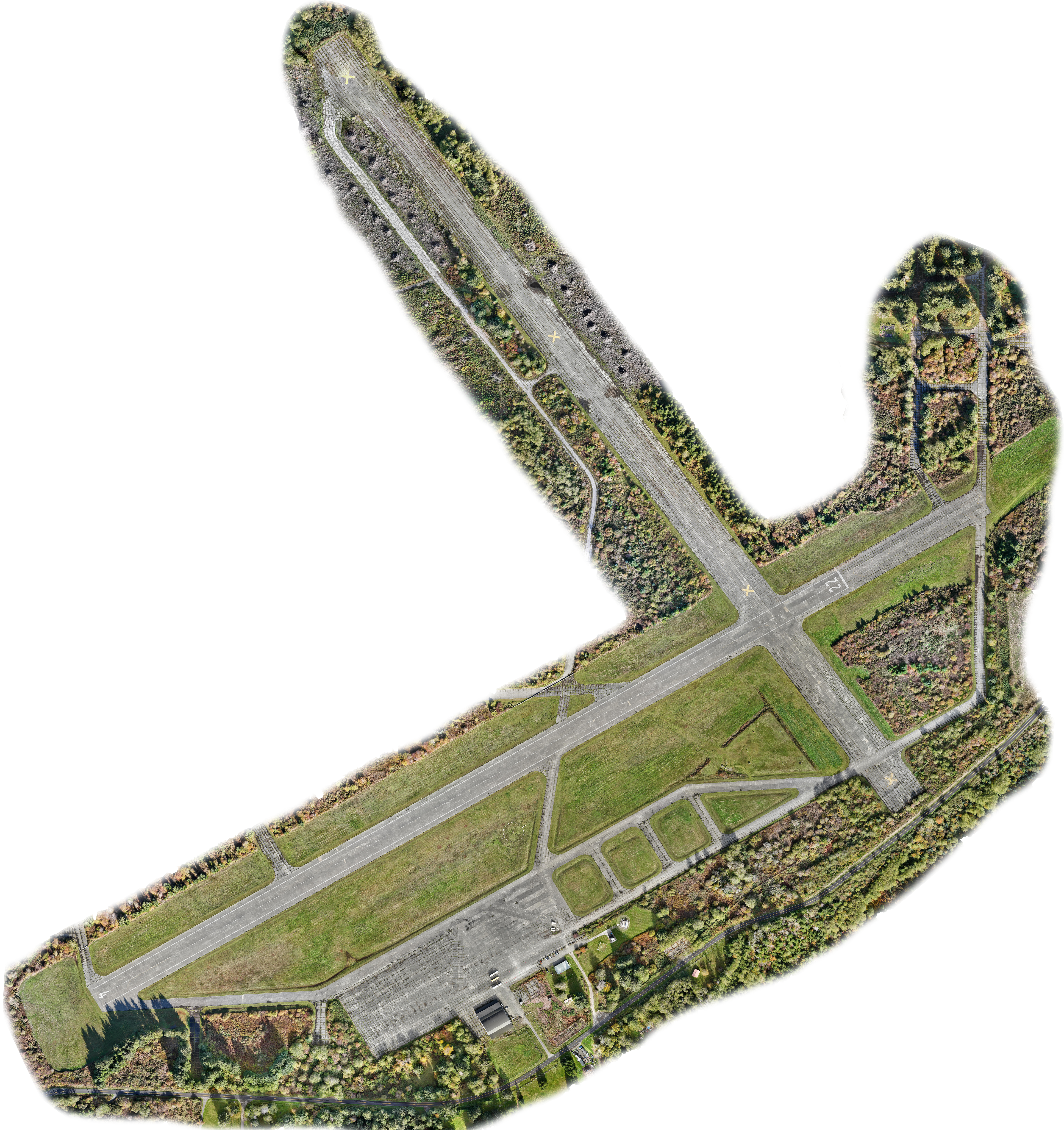


EXHIBIT "A"
MAP OF
NAVAL AUXILIARY AIR STATION
QUILLAYUTE, WASH.
SHOWING CONDITIONS ON SEPT. 25, 1946.
QUILLAYUTE AIR STATION
OLYMPIC NATIONAL PARK
PACIFIC OCEAN
LOCATION MAP
APPROACH ZONE ACREAGE GOVERNMENT IN FEE
WOODED AREA
RUNWAY 4,700FT. X 200FT. N 36° 30' W
RUNWAY 5,000FT. X 150FT. S 58° 55' W
BORROW PIT
TETRAHEDRON
OCCUPIED FARM
ARMY ATTACHMENT
ABANDONED FARM
RECREATION FIELD
AIR VALVE
RESERVATION BOUNDARY LINE
SENTRY SHELTER
RECREATION
WATER WELL
BURNED INSIDE
LEGEND
BUILDING DECLARED
BUILDING NOT DECLARED
BUILDING AUTHORIZED BUT NOT CONSTRUCTED
ARMY INSTALLATION
FIRE HYDRANT
FRESH WATER MAIN
FIRE ALARM BOX
RUNWAY LIGHT
BOUNDARY FENCE
STATION ACCESS ROAD
-11-000 AIRPORT AND AVIATION REAL ESTATE 955.90A
-02-000 FOREST LAND 131.20A
-03-000 GRAZING LAND 114.43A
TOTAL 1201.53A
RESTRICTED
FOR OFFICIAL USE ONLY
NO ARMY STRUCTURES
T-1 E.M. BARRACKS
T-4 E.M. LATRINE
T-5 E.M. BARRACKS
T-8 DISPENSARY
T-9 E.M. BARRACKS
T-10 E.M. LATRINE
T-11 E.M. BARRACKS
T-12 MESS KIT & WASHING SHELTER
T-13 MESS HALL & KITCHEN
T-14 E.M. BARRACK
T-15 ADMINISTRATION & SUPPLY
T-16 E.M. BARRACKS
T-17 OFFICERS QUARTERS
T-22 OFFICERS LATRINE
T-23 OFFICERS QUARTERS
T-24 GARAGE
NO. STRUCTURES
1 SUPPLY WAREHOUSE
2 SCHOOL HOUSE
3 LINK TRAINER BUILDING
4 PUBLIC WORKS SHOP
5 TRANSPORTATION BUILDING
6 FIRE STATION
7 TRANSFORMER VAULT
8 BOOSTER PUMP HOUSE
9 BLACKSMITH SHOP
10 GUNNERY TRAINING BUILDING
11 RADIO AND RADAR BUILDING
12 CLASS "C" OVERHAUL SHOP
13 GATE HOUSE
14 ARMORY AND INSTRUMENT BUILDING
A COMMANDING OFFICER'S QUARTERS
B SENIOR MEDICAL OFFICER'S QUARTERS
17 WASH RACK & SHELTER
18 PAINT SHOP ON SKIDS
19 PAINT SHOP ON SKIDS
20 HANGAR
21 ADMINISTRATION BUILDING
22 WATER TOWER
23 READY LOCKER
24 ORDNANCE OFFICE
25 PUMP HOUSE NO.1
26 SMALL ARMS MAGAZINE
27 CIVILIAN WORKERS BARRACKS
28 CIVILIAN WORKERS BARRACKS
29 PHOTO LABORATORY BUILDING
30 BARRACKS "F"
31 BARRACKS "E"
32 BARRACKS "C"
33 BARRACKS "G"
34 BARRACKS "H"
35 BARRACKS "C"
36 COLD STORAGE PLANT
37 RECREATION BUILDING
38 BARRACKS "B"
39 SHIPS SERVICE
40 BARRACKS "A"
41 BOILER AND GENERATOR BUILDING
42 DISPENSARY BUILDING
43 SUBSISTENCE AND P.O. BUILDING
44 LAUNDRY
45 B.O.Q. "A"
46 B.O.Q. "B"
47 ENLISTED MEN'S CLUB
48 DISPENSARY GARAGE
49 AUXILIARY GENERATOR BUILDING FOR WELL
NO STRUCTURES
50 CRASH TRUCK GARAGE
51 LINE CREW SHELTER
52 LINE CREW SHELTER
53 LINE CREW SHELTER
54 OIL STORAGE HUT
60 IMHOFF TANK
61 TRANSMITTER BUILDING
62 SENTRY SHELTER
80 INERT STORAGE
81 PYROTECHNICS MAGAZINE
82 SMALL ARMS STORAGE
83 SMALL ARMS STORAGE
84 FUSE AND DETONATOR MAGAZINE
85 HIGH EXPLOSIVES MAGAZINE
86 HIGH EXPLOSIVES MAGAZINE
87 HIGH EXPLOSIVES MAGAZINE
100 PORTABLE WATCH SHACK
101 RADIO BUILDING
102 RADIO GENERATOR BUILDING
103 RADIO CREW HEAD
104 S.P. MAGAZINE
105 S.P. MAGAZINE
106 ASSEMBLY BLDG
107 ASSEMBLY BLDG.
SEWAGE PUMP HOUSE
LINE CREW SHELTER
STORAGE HUT
CIVILIAN WORKERS BARRACKS
AUXILIARY GENERATOR BLDG.
B.O.Q. C.
AUXILIARY BOILER HOUSE
DRAWING AS REVISED BY FACILITY CONTROL SECTION, WAR ASSETS ADMINISTRATION




22

Project ____________________

AIA # ______________ SIS # ______________

Item # ______________ Quantity ________ C.S.I. Section 114000

60" ELECTRIC RESTAURANT RANGE

6 French Plates / 24" Griddle

Model EV60SS-6FP24G208
Shown with adjustable legs

MODELS

- ❑ **EV60SS-6FP24G208** 6 French Plates / 24" Griddle / 1 Standard Oversized Oven / 1 Standard Oven / 208V
- ❑ **EV60SS-6FP24G240** 6 French Plates / 24" Griddle / 1 Standard Oversized Oven / 1 Standard Oven / 240V

STANDARD FEATURES

- Fully MIG welded aluminized steel frame for added durability
- Stainless steel front, sides, back riser, shelf and legs
- Six 9½" round, 2 KW French plates with infinite heat control switches
- 24" wide, ⅞" thick griddle plate, one thermostat provided for every 12" griddle width
- Full width pull out stainless steel crumb tray
- 5 KW oven with top browning control
- One standard oversized oven, interior measures 26½"w x 26⅜"d x 14"h and one standard oven, interior measures 20"w x 26½"d x 14"h
- Thermostat adjusts from 200°F to 500°F
- Cool to the touch control knobs and oven handles
- Each oven has one oven rack and three rack positions
- 18" x 26" sheet pans fit side to side and front to back in standard oversized oven; 18" x 26" sheet pans fit front to back in standard oven
- Requires 208 volt or 240 volt, 1 or 3 phase power supply (ranges shipped in 3 phase and are field convertible to single phase)
- One year limited parts and labor warranty

SPECIFIER STATEMENT

60" wide electric restaurant range, Vulcan Model No. EV60SS-6FP24G208. Fully MIG welded aluminized steel frame for added durability. Stainless steel front, sides, back riser, plate shelf and 6" adjustable legs. Six 9½" round French plates, 2 KW input per plate. Full width pull out stainless steel crumb tray located beneath the cooking top. 24" wide, ⅞" thick griddle plate, one thermostat provided for every 12" griddle width. Comes with one standard oversized oven and one standard oven. Oversized oven interior measures 26½"w x 26⅜"d x 14"h. Standard oven interior measures 20"w x 26½"d x 14"h. Each oven comes with one oven rack and three rack positions. Oven doors are heavy duty with integrated door hinge spring mechanisms, requiring no adjustments. 5 KW input. Top browning heat control. Thermostat adjusts from 200°F to 500°F. Oven controls are protected from heat in an insulated side compartment. Requires 208 or 240 volt, 1 or 3 phase power supply. All ranges are shipped in 3 phase and are field convertible to single phase.

Exterior Dimensions:
34⅔"d x 60"w x 58"h on 6" adjustable legs

ACCESSORIES (PACKAGED AND SOLD SEPARATELY)

- ❑ Extra oven rack with two rack guides
- ❑ Set of four casters (two locking)
- ❑ 10" stainless steel stub back
- ❑ ESB36 salamander broiler
- ❑ Reinforced high shelf for ESB36 salamander broiler
- ❑ Towel bar
- ❑ Cutting board
- ❑ Condiment rail
- ❑ Fryer shield

Approved by ______________ Date ________ Approved by ______________ Date ________

60" ELECTRIC RESTAURANT RANGE

6 French Plates / 24" Griddle

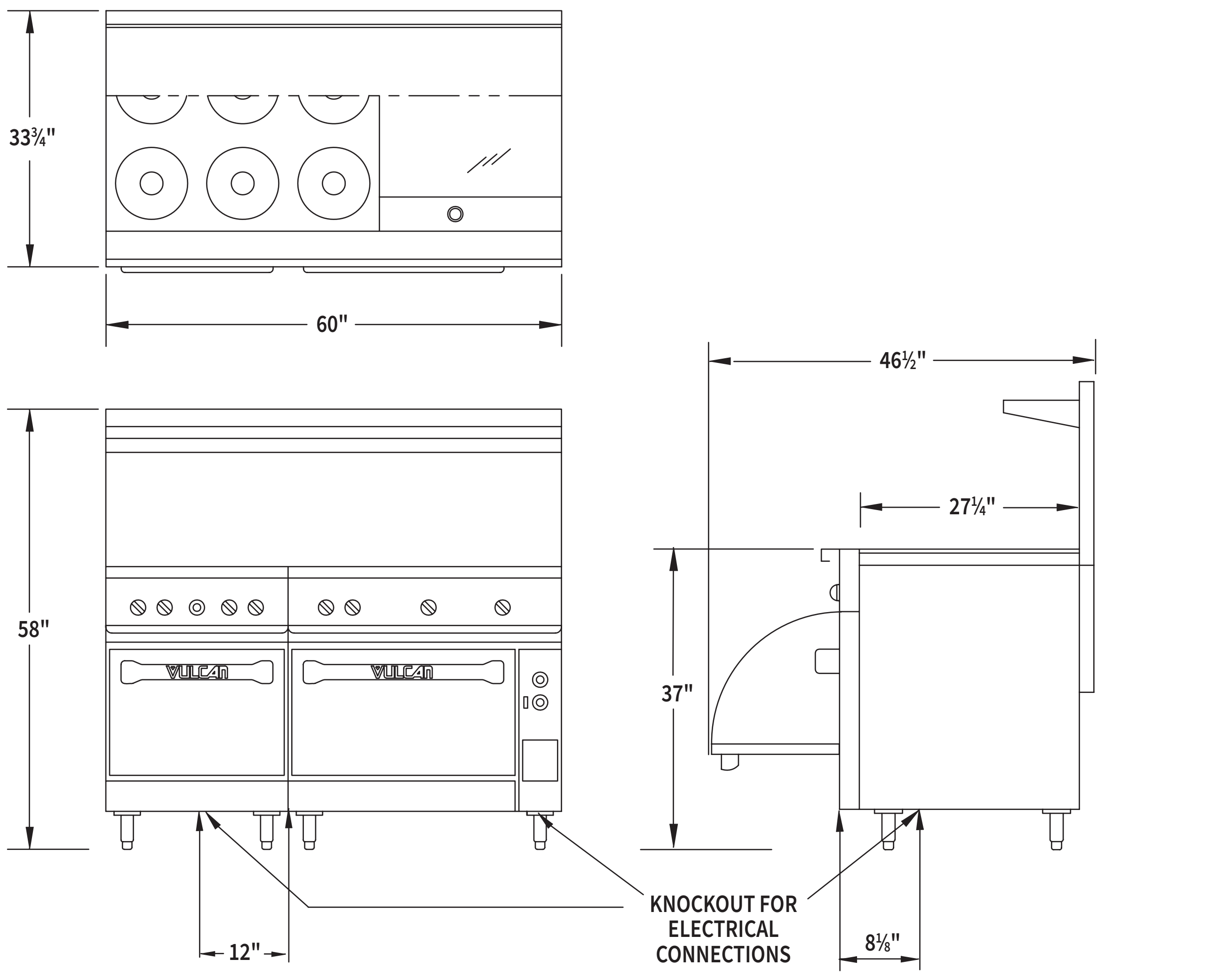
INSTALLATION INSTRUCTIONS

INSTALLATION MANUAL

Clearances from Combustible Construction	Rear	Sides
Range with French Plates	0"	3"
Range with Griddle Tops	0"	3"
Range with Hot Tops	0"	6"

Ranges with an ESB Salamander Broiler mounted above: Refer to the ESB Salamander Broiler spec sheet for clearance specifications.

This appliance is manufactured for commercial use only and is not intended for home use.



The EV60 ranges require two separate electrical hook-ups.

CAD and/or Revit Files Available

Available Voltages - 208 or 240 Volt - 1 or 3 Phase																								
3 Phase Loading									Nominal Amps per Line Wire															
Model Number	kW		kW per Phase						3 Phase LT						3 Phase RT						1 Phase			
			LT 3 PH			RT 3 PH			208 Volt			240 Volt			208 Volt			240 Volt			LT		RT	
	LT	RT	X-Y	Y-Z	X-Z	X-Y	Y-Z	X-Z	X	Y	Z	X	Y	Z	X	Y	Z	X	Y	Z	208	240	208	240
EV60SS-6FP24G208	13.0	15.8	5.0	4.0	4.0	3.4	7.4	5.0	37.5	37.5	33.3	--	--	--	35.0	45.0	51.6	--	--	--	62.5	--	76.0	--
EV60SS-6FP24G240	13.0	15.8	5.0	4.0	4.0	3.4	7.4	5.0	--	--	--	32.5	32.5	28.9	--	--	--	30.3	39.0	44.7	--	58.3	--	65.8

Note: To calculate 480 volt amps, take 240 volt amp ratings shown and divide by two.

As continued product improvement is a policy of Vulcan, specifications are subject to change without notice.

Spectrum® 875/875 Auto-Line™

Air Plasma Cutting and Gouging

Quick Specs

Industrial Applications
Construction
Maintenance/repair
Fabrication

Process
Air plasma cutting and gouging

Rated Input
875: 208 or 230 V, 1-phase
875 Auto-Line: 208–575 V, 1- or 3-phase

Rated Output at 104°F (40°C)
875/875 Auto-Line: 1-phase: 60 A at 140 VDC, 208 V: 40% duty cycle, 230 V: 40% duty cycle
875 Auto-Line: 3-phase: 60 A at 140 VDC,
208 V: 40% duty cycle
230–380 V: 50% duty cycle
380–575 V: 60% duty cycle

See page 2 for 100% duty cycle ratings

Cutting Capability
Rated: 7/8 in. (22.2 mm)
Sever: 1-1/4 in. (32 mm)

System Weight
875: with 20 ft. torch: 49 lb. (22.2 kg)
with 50 ft. torch: 58 lb. (26.3 kg)
875 Auto-Line with hand-held torch:
with 20 ft. torch: 54 lb. (24.5 kg)
with 50 ft. torch: 63 lb. (28.6 kg)
875 Auto-Line with machine torch:
with 25 ft. torch: 56 lb. (25.4 kg)
with 50 ft. torch: 63 lb. (28.6 kg)

Required Input Pressure / Flow
6.75 cfm (191 L/min.) at 90 psi minimum (621 kPa), 120 psi maximum (828 kPa)

875 Auto-Line™ unit automatically connects to any primary input voltage from 208–575 volts single- or three-phase, 50 or 60 Hz.

LVC™ line voltage compensation provides peak performance power under variable conditions (power fluctuations up to ±15 percent) for steady cuts and cleaner ending cuts.

Consumables storage compartment provides convenient access to consumables and parts.

Heavy-duty work clamp with flexible cable and quick connect.

Wind Tunnel Technology™ prevents abrasive dust and particles from damaging internal components.

Fan-On-Demand™ cooling system operates only when needed. In dirty or dusty environments, this feature reduces the amount of airborne dust/dirt pulled through the unit.

Auto postflow calculates the length of postflow time based on the amount of cutting time to optimize consumable life and eliminate excessive air usage.

Can be powered by Miller engine drives with generator power. See page 2 for engine drive compatibility and recommended settings.

Ultra-Quick Connect™ XT60 torch with an ergonomic handle to help prevent operator fatigue and a flexible cable that makes maneuvering easier (see page 4 for more detail).

XT60M long body or short body machine torches are available. See page 4 for more information.

Comes complete with:
- XT60 hand-held torch with 20 ft. (6 m) or 50 ft. (15.2 m) cable; **or** XT60M long body or short body machine torch with 25 ft. (7.6 m) or 50 ft. (15.2 m) cable —torches include a complete set of 60 A consumables
- Heavy-duty work clamp and flexible cable with quick connect
- 10 ft. (3 m) power cord
- Extra consumables
- Machine torch packages include corresponding automation kit

Auto-Refire™ technology provides ultimate customer convenience by automatically controlling the pilot arc when cutting expanded metal or multiple pieces of metal. The pilot arc will switch in and out as fast as needed when cutting expanded metal and provides maximum power for cutting thicker metal—all automatically! No need for manual re-triggering which reduces user hand fatigue.

Starts without high-frequency so it will not interfere with or damage controls or computers.

Automatic air regulation. For end user convenience, the unit has no pressure gauge or manual regulator knob. The unit automatically adjusts the air pressure to the torch for optimum cutting and gouging. No adjustments necessary.

Automation kits and accessories are available. See page 3 for more information.

TRUE BLUE® 3YR. WARRANTY

Power source is warranted for three years, parts and labor.
XT torch is warranted for one year, parts only.

Miller Electric Mfg. Co.
An ITW Welding Company
1635 West Spencer Street
P.O. Box 1079
Appleton, WI 54912-1079 USA

Equipment Sales US and Canada
Phone: 866-931-9730
FAX: 800-637-2315
International Phone: 920-735-4554
International FAX: 920-735-4125

MillerWelds.com

ISO 9001 REGISTERED QUALITY SYSTEM

Specifications (Subject to change without notice.)

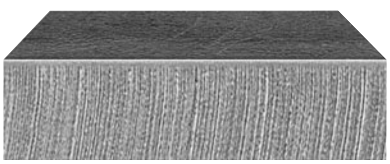
Non-Auto-Line model is 1-phase only.

Model	Rated Output at 104°F (40°C)*	Amps Input at Rated Output, 50/60 Hz		Max. Open-Circuit Voltage	Plasma Gas	Dimensions	Net Weight
875	1-phase: 60 A at 140 VDC, 208 V: 40% duty cycle 230 V: 50% duty cycle	208 V: 47 230 V: 42	KVA: 9.9 KW: 9.8	400 VDC	Air or nitrogen only	H: 13.5 in (343 mm) W: 8.75 in (222 mm) D: 18.5 in (470 mm)	**With hand-held torch*** 20 ft. (6.1 m): 49 lb. (22.2 kg) 50 ft. (15.2 m): 58 lb. (26.3 kg)
875 Auto-Line™	1-phase: 60 A at 140 VDC, 208 V: 40% duty cycle 230 V: 40% duty cycle 230 V: 100% duty cycle at 50 A	208 V: 47.4 230 V: 42.2	KVA: 9.9 KW: 9.7	400 VDC	Air or nitrogen only		**With hand-held torch*** 20 ft. (6.1 m): 54 lb. (24.5 kg) 50 ft. (15.2 m): 63 lb. (28.6 kg) **With machine torch**** 25 ft. (7.6 m): 56 lb. (25.4 kg) 50 ft. (15.2 m): 63 lb. (28.6 kg)
	3-phase: 60 A at 140 VDC, 208 V: 40% duty cycle 230–380 V: 50% duty cycle 380–575 V: 60% duty cycle 380–575 V: 100% duty cycle at 50 A	208 V: 27.5 230 V: 25 380 V: 15 460 V: 12.4 575 V: 9.8	KVA: 9.9 KW: 9.4				

**Add 8.5 lb. (3.9 kg) for shipping weight.*
***Add 11.5 lb. (5.2 kg) for shipping weight.*

Certified by Canadian Standards Association to both the Canadian and U.S. Standards.

Mild Steel Cutting Capability (Thickness to scale.)



1/2 in. (12.7 mm) at 34 ipm

7/8 in. (22.2 mm) at 15 ipm

Note: Recommended maximum piercing capacity for hand-held and automated applications is 7/16 inch (11 mm).
Maximum sever cut of 1-1/4 inches (32 mm) at 3 ipm.
For aluminum and other metals with high thermal conductivity, cutting capabilities will be derated as much as 30%.

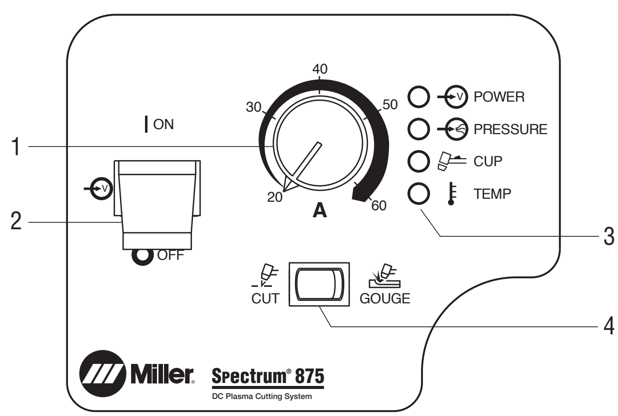
Mild Steel Recommended Cut Speed

Thickness	Approximate Travel Speeds*
1/4 in. (6.4 mm)	105 ipm (2667 mm/min.)
3/8 in. (9.5 mm)	54 ipm (1372 mm/min.)
1/2 in. (12.7 mm)	34 ipm (864 mm/min.)
5/8 in. (15.9 mm)	27 ipm (686 mm/min.)
3/4 in. (19.0 mm)	18 ipm (457 mm/min.)
7/8 in. (22.2 mm)	15 ipm (381 mm/min.)
1 in. (25.4 mm)	10 ipm (254 mm/min.)

** Travel speeds are approximately 80% of maximum.*

Rated cut capacity is based on traveling approximately 15 inches per minute to achieve a steady, precise cut. This is the key rating that should meet or exceed your typical cutting thickness requirements.

Control Panel



1. Output Control
2. Power Switch
3. Status and Troubleshooting Lights
4. Process Control

Engine Drive Compatibility

Equipment	Continuous Generator Power	Mild Steel Cut Capacity (Approximate)	Spectrum Output Amp Setting
Bobcat™ 225 and 250	9.5 kW	1/2 in.	45 A, 240 V, full KVA plug
Bobcat™ 250 with EFI, Trailblazer®	10.5 kW	1/2 in.	45 A, 240 V, full KVA plug
Big Blue® 400 Pro	10 kW	1/2 in.	45 A, 240 V, full KVA plug
Big Blue® 600 Pro, 800 Series	1-ph: 12 kW, 3-ph: 20 kW	7/8 in.	50 A, 240 V, full KVA plug

Note: LP powered machines need to be derated by 15%.

Genuine Miller® Accessories

Protective Cover
300388
Mildew-resistant, odor-free, waterproof cover protects your machine's finish. Cable management pouches provide storage for 20-foot (6.1 m) torch and work cables.

Full KVA Adapter Cord 300517 Field NEMA 14-50P to NEMA 6-50R. Adapts engine drive 120/240 V plug to Spectrum® 240 V plug.

RTI Filter and Bracket 300491
Dryer will remove water, dirt and oil as small as one micron with 99.9 percent efficiency. Can be mounted on plasma cutter or on wall. Install as close as possible to point of air consumption.

Miller Service Parts Accessories

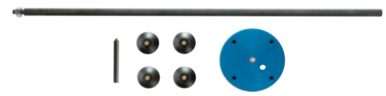
The following accessories must be ordered from Miller Service Parts.

RTI Replacement Filter Element 212771
For RTI filter 300491.

XT60 Consumable Kit 256033
Consumable kit includes 3 standard electrodes, 3 standard tips, 1 drag shield, 1 deflector, 1 o-ring, 1 swirl ring, 1 retaining cup, 1 gouge tip, 1 gouge shield and silicone grease.

Plasma Standoff Roller Guide 253054
Helps maintain recommended standoff distance to maximize cutting performance and improve tip life.

Plasma Circle-Cutting Guide 253055
Cut straight lines or circles up to 12-inch diameter with ease.



Suction/Magnetic Pivot Base 195979
Add this to your cutting guide for convenient attachment to all flat surfaces. The extended arm accommodates holes up to 30-inch diameter.

In-Line Air Filter Kit 228926
Mounts to the back of the Spectrum® 375 X-TREME™, 375, 625 X-TREME™, 875 and 875 Auto-Line™. Includes male and female 1/4-inch NPT quick-disconnect fittings and hose for easy on/off connection. The replaceable filter element filters to .85 microns for removal of 99.9 percent of water, dirt and oil.

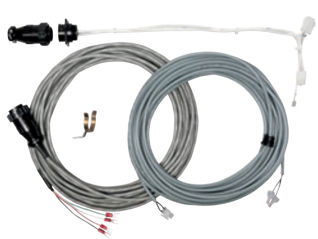
In-Line Air Filter Replacement Element 228928
For in-line filter 228926.

Torch Cable Cover Kits
239642 20 ft. (6.1 m)
231867 25 ft. (7.6 m)
231868 50 ft. (15.2 m)

Flexible Work Cable
234838 20 ft. (6.1 m)
234930 50 ft. (15.2 m)
Work cable with quick connect and heavy-duty clamp.

Automation Accessories

For Spectrum 875 (single-phase)



Automation Kit 301156
Now available for single-phase Spectrum 875, kit works with both XT60M long and short body machine torches to provide automation capabilities. Consists of the following components which can also be ordered separately:

- **Jumper Plug 256574**
  For changing back to hand-held torch after kit has been installed.
- **Internal Remote Harness 265527**
  For remote start only.
- **CNC Signal Cable 220240**
  For arc initiation and cutting sequence.
- **Voltage Sensing Signal Wire Assembly 300872**
  For torch height control.
- **Shield Sense Tab 263310**

External Reed Switch 190602
Provides dry contact closure for ok-to-move signal. (Not included with Automation Kit 301156.)

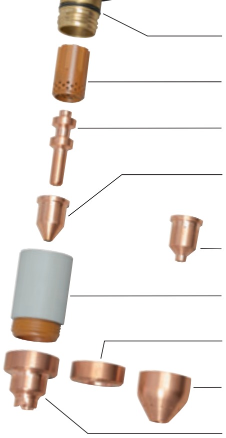
For Spectrum 875 Auto-Line

Automation Kit 301157
Kit for Spectrum 875 Auto-Line works with both XT60M long and short body machine torches to provide automation capabilities. Consists of the following components which can also be ordered separately:

- **Internal Remote Harness 265528**
  For remote start and ok-to-move signal.
- **CNC Signal Cable 220240**
  For arc initiation and cutting sequence.
- **Voltage Sensing Signal Wire Assembly 246285**
  For torch height control.
- **Remote Pendant Control 195513**
  For remote manual momentary on/off.
- **Shield Sense Tab 263310**

Note: Automation Kits are for upgrading hand-held torch packages to add machine torch capabilities. Machine torches are not included in Automation Kits and must be ordered separately. See back page to order machine torches.

XT60 and XT60M Replacement Torches and Consumables



O-ring	263834
Swirl Ring	256028
Electrode	256026
Tip	249929 (60 A) 262643 (40 A)
Gouge Tip	249935
Retaining Cup	256029
Deflector	256030
Gouge Shield	256031
Drag Shield	256027

Note: Replacing drag shield with deflector offers improved arc visibility while maintaining 1/16-inch standoff. For gouging, replace the tip and drag shield with gouge tip and gouge shield. The rest of the XT60 consumables are common.

XT60 Hand-Held Torch
249953 20 ft. (6.1 m)
249954 50 ft. (15.2 m)

No-slip grip for easy control and torch dexterity.

Ergonomic design with unique thumb guide and finger grip contours.

Trigger guard protects against inadvertent arc initiation.

80-degree handle provides natural arm and elbow positioning while cutting.

Robust tip front end design optimizes arc performance and tip life.

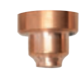
Laser-etched tip for easy identification.

New retaining cup design provides increased cutting visibility and quick turn for easy consumable change.

Strain relief is durable and corrosion resistant, and **more flexible cable** has improved bend radius.

XT60M Machine Torch
249955 25 ft. (7.6 m), long body
249956 50 ft. (15.2 m), long body
257464 25 ft. (7.6 m), short body
263952 50 ft. (15.2 m), short body

Shield Sense Tab 263310
Included in Automation Kits, not included with torches.



Machine Shield 265226

Note: The XT60M consumables are the same as the XT60 consumables, except for the machine shield.

Ordering Information

Power Source	Stock No.	Description	Qty.	Price
Spectrum® 875 208/230 V, 1-phase	**907583** **907583001** **907583002** **907583003**	With 20 ft. (6.1 m) XT60 hand-held torch With 50 ft. (15.2 m) XT60 hand-held torch With 25 ft. (7.6 m) XT60M long body machine torch With 25 ft. (7.6 m) XT60M short body machine torch		
Spectrum® 875 Auto-Line™ 208–575 V, 1- or 3-phase	**907584** **907584001** **907584002** **907584003** **907584004** **907584005**	With 20 ft. (6.1 m) XT60 hand-held torch With 50 ft. (15.2 m) XT60 hand-held torch With 25 ft. (7.6 m) XT60M long body machine torch With 25 ft. (7.6 m) XT60M short body machine torch With 50 ft. (15.2 m) XT60M long body machine torch With 50 ft. (15.2 m) XT60M short body machine torch		
Replacement Torches and Consumables	**(See above)**	*Order from Miller Service Parts*		
Accessories				
Automation Accessories	**(See page 3)**			
Protective Cover	**300388**			
Full KVA Adapter Cord	**300517**	Adapts engine drive 120/240 V plug to Spectrum® 240 V plug		
RTI Filter and Bracket	**300491**			
RTI Filter Replacement Element	**212771**	For RTI filter 300491. *Order from Miller Service Parts*		
XT60 Consumable Kit	**256033**	*Order from Miller Service Parts*		
Plasma Standoff Roller Guide	**253054**	*Order from Miller Service Parts*		
Plasma Circle-Cutting Guide	**253055**	*Order from Miller Service Parts*		
Suction/Magnetic Pivot Base	**195979**	*Order from Miller Service Parts*		
In-Line Air Filter Kit	**228926**	*Order from Miller Service Parts*		
In-Line Air Filter Replacement Element	**228928**	For in-line filter 228926. *Order from Miller Service Parts*		
Torch Cable Cover Kits		See page 3. *Order from Miller Service Parts*		
Flexible Work Cable w/Heavy-Duty Clamp	**234838** **234930**	20 ft. (6.1 m) cable with quick connect. *Order from Miller Service Parts* 50 ft. (15.2 m) cable with quick connect.		

Date: **Total Quoted Price:**

Distributed by:

Miller
The Power of Blue®

Issued March 2022 • Index No. AD/4.81

Dynasty® 210 Series

TIG/Stick Welding Power Source

Quick Specs

Industrial Applications
Aerospace
Heavy fabrication
Precision fabrication
Aluminum ship repair
Pipe and tube fabrication
Anodized aluminum fabrication

Processes
AC/DC TIG (GTAW)
Pulsed TIG (GTAW-P)
Stick (SMAW)

Input Power 120–480 V, 3-phase or 1-phase power

Amperage Range 1–210 A (DC)
2–210 A (AC)

Rated Output 210 A at 18.4 V, 60% duty cycle

Net Weight 47 lb. (21.3 kg)

Reimagined for Your Pursuit of Perfection.

Experience unfailing precision arc performance paired with a state-of-the-art, user-friendly interface that puts advanced capabilities at your fingertips. Dynasty TIG power sources help minimize error and achieve high-precision welds every time, making the best welders even better.

Easy-to-understand interface with 4.5-inch LCD display.
- Ensures proper machine setup and parameter selection
- Informative on-screen explanations and dynamic images enhance the parameter selection process

Dynasty 210
Machine only

Dynasty 210
Wireless Complete

Program memory allows easy naming, saving and recalling of favorite weld settings.
- Deliver more productivity by eliminating the need to manually set the parameters
- Deliver consistent quality by welders of all skills

Pro-Set™ eliminates the guesswork when setting weld parameters.

Locks and limits. Provides control of weld parameter ranges minimizing deviation from the welding procedure specification (WPS).

AUTO-LINE™ TECHNOLOGY
Allows for any input voltage hookup (120–480 V) with no manual linking, providing convenience in any job setting. Ideal solution for dirty or unreliable power.

Blue Lightning™ provides more consistent high-frequency (HF) arc starts and greater reliability compared to traditional arc starters.

USB. Front panel port provides the ability to easily update software, back-up settings and transfer saved weld programs from one unit to the next.

Visit MillerWelds.com/TIGSoftware for the latest software updates and expansions.

Cooler Power Supply (CPS) is an integrated 120-volt dedicated-use receptacle for the Coolmate™ 1.3. Available on select models.

Cooler-On-Demand™ feature operates the auxiliary cooling system only when needed, reducing noise, energy use, and airborne contaminants pulled through the cooler. Available on CPS models only.

TRUE BLUE® 3 YR. WARRANTY

Power source is warrantied for three years, parts and labor.

Miller Electric Mfg. LLC
An ITW Welding Company
1635 West Spencer Street
P.O. Box 1079
Appleton, WI 54912-1079 USA

Equipment Sales US and Canada
Phone: 866-931-9730
FAX: 800-637-2315
International Phone: 920-735-4554
International FAX: 920-735-4125

MillerWelds.com

Certified System ISO 9001 Quality

Weld Process Features

AC TIG

Balance control provides adjustable oxide removal which is essential for creating the highest quality aluminum welds.

Frequency controls the width of the arc cone and can improve directional control of the arc.

AC Waveforms

- **Advanced square** provides a fast freezing puddle, deep penetration and fast travel speeds.
- **Soft square** for a soft buttery arc with maximum puddle control and good wetting action.
- **Sine** for customers that like a traditional arc. Quiet with good wetting.
- **Triangular** reduces the heat input and is good on thin aluminum. Fast travel speeds.

DC TIG

Exceptionally smooth and precise arc for welding exotic materials.

Pulse Waveforms

- **Square** provides a fast freezing puddle for ultimate arc control.
- **Sine** produces a reduced audible sound and provides a more fluid puddle that is good for overlaying applications.
- **Triangular** provides a quick-forming puddle while futher reducing heat for thin materials.

AC/DC Stick

DIG control allows the arc characteristics to be changed for specific applications and electrodes. Lower the DIG setting for smooth running electrodes like E7018 and increase the DIG setting for stiffer, more penetrating electrodes like E6010.

Hot Start™ adaptive control provides positive arc starts without sticking.

AC frequency control adds stability for smoother welds when AC stick welding.

Stick-Stuck™ detects if the electrode is stuck to the part and turns the welding output off to safely and easily remove the electrode. Menu selectable.

Specifications (Subject to change without notice.)

Welding Mode	Input Power	Welding Amperage Range	Rated Output at 60% Duty Cycle	Phase	Amps Input at Rated Load Output, 50/60 Hz 120 V	208 V	240 V	400 V	480 V	KVA	KW	Max. Open-Circuit Voltage	Dimensions	Net Weight
TIG (GTAW)	208–480 V	2–210 A (AC) 1–210 A (DC)	210 A at 18.4 V	3-phase	—	16	14	8	7	5.7	5.2	80 VDC (30 VDC*)	H: 13.88 in. (352 mm) W: 8.5 in. (216 mm) D: 21.88 in. (555 mm)	47 lb. (21.3 kg) 50 lb. (22.7 kg) with CPS
				1-phase	—	28	23	14	12	5.8	5.6			
	120 V	2–150 A (AC) 1–150 A (DC)	125 A at 15 V	1-phase	26	—	—	—	—	2.8	2.7			
Stick (SMAW)	208–480 V	5–210 A	160 A at 26.4 V	3-phase	—	16	14	9	8	6.0	5.8			
				1-phase	—	28	24	14	12	6.4	5.5			
	120 V	5–100 A	90 A at 23.6 V	1-phase	27	—	—	—	—	2.9	2.8			

**Sense voltage for low OCV stick and Lift-Arc™ TIG.*

IP23 rating *— This equipment is designed for outdoor use. It may be stored, but is not intended to be used outside during precipitation unless sheltered. Operating temperature range is 14 to 104°F (-10 to 40°C). Storage temperature range is -22 to 149°F (-30 to 65°C). Portions of the preceding text are contained in EN 60974-1: "Welding power sources for arc welding equipment."*

Certified by Canadian Standards Association to both the Canadian and U.S. Standards. CE *All CE models conform to the applicable parts of the IEC 60974 series of standards.*

Performance Data

Input Power	TIG (GTAW) Duty Cycle	Stick (SMAW) Duty Cycle	AC TIG Material Thickness Range	DC TIG Material Thickness Range	Stick Electrode Maximum Diameter	Generator Requirement
208–480 V	210 A, 60% 175 A, 100%	210 A, 30% 160 A, 60% 125 A, 100%	0.012–1/4 in. (0.3–6.4 mm)	0.002–1/4 in. (0.05–6.4 mm)	6010: 3/16 in. (4.8 mm) 7018: 5/32 in. (4.0 mm) 7024: 5/32 in. (4.0 mm)	9 kW
120 V	150 A, 40% 125 A, 60% 100 A, 100%	100 A, 40% 90 A, 60% 75 A, 100%				

Coolmate™ 1.3 Cooler

- Dynasty® 210 models with CPS turn Coolmate 1.3 on and off
- Power indicator light
- Fluid level sight window
- Rustproof polyethylene-molded coolant tank and filler spout
- 1/4 hp motor is thermally protected to guard against overheating
- Efficient fin and tube heat exchanger
- Factory-set pressure relief valve (55 psi) maintains consistent pressure during operation
- Filter and coolant filling spout are conveniently located
- Brass-body, positive displacement rotary vane pump provides consistent coolant flow and pressure rating with long pump-life expectancy

Input Power	Maximum Current Draw	Maximum Cooling Capacity	Rated Cooling Capacity	Tank Capacity	Dimensions	Net Weight
115 V, 50/60 Hz	5.9 A (50 Hz) 4.7 A (60 Hz)	3,400 W (11,600 Btu/hr.) 3.8 qt./min. (3.6 L/min.)	1,330 W (4,540 Btu/hr.) 1.1 qt./min. (1 L/min.)	1.3 gal. (4.9 L)	H: 11.38 in. (289 mm) W: 10.38 in. (264 mm) D: 24.25 in. (616 mm)	46 lb. (21 kg)

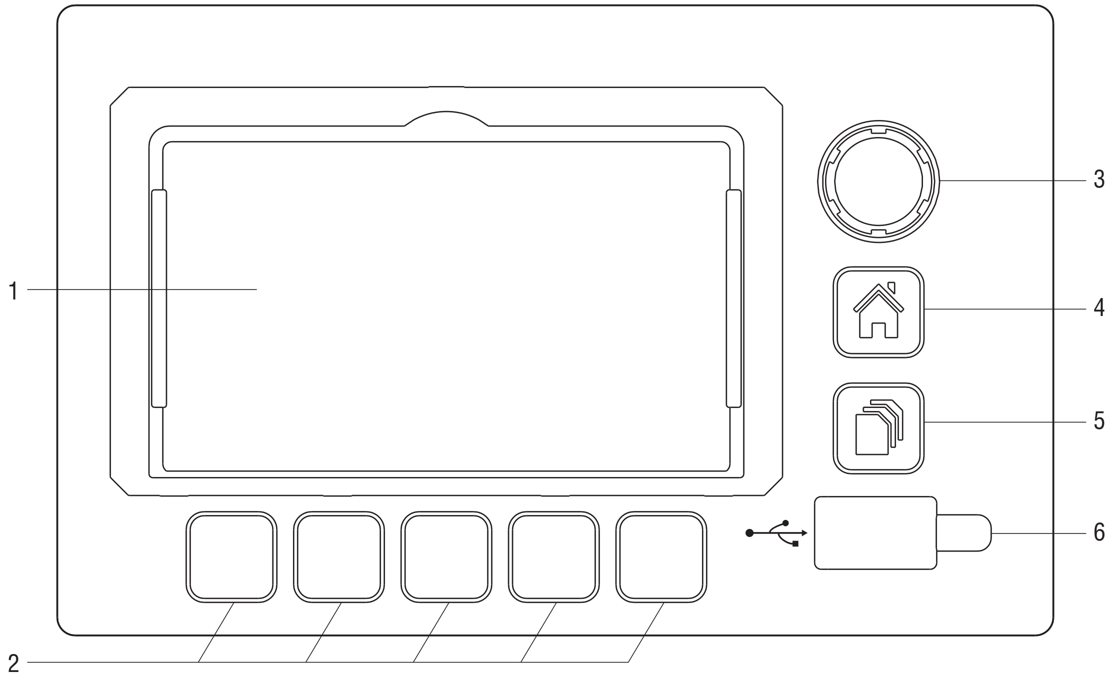
Weldcraft™ W-250 (WP-20) TIG Torch

- Efficient around-the-head cooling design extends torch life and minimizes downtime due to overheating
- Lightweight, compact body design for increased comfort and control

Cooling Method	AC Rating	DC Rating	Consumables	Electrode Range
Water-cooled	180 A, 100% duty cycle	250 A, 100% duty cycle	13N	.020–1/8 in. (0.5–3.2 mm)

Dynasty® 210 Control Panel

1. Color LCD Display
2. Soft Keys *(Multiple functions depending on screen displayed.)*
3. Control Knob *(Adjusts amperage or parameter values depending on mode.)*
4. Home Button
5. Program Button
6. USB Port



Amperage	
TIG AC	2–210 A**
TIG DC	1–210 A**
Stick	5–210 A
Process	AC TIG HF, DC TIG HF, AC TIG Lift-Arc™, DC TIG Lift-Arc™, AC Stick, DC Stick
Tungsten (inch)	.020, .040, 1/16, 3/32, 1/8 inch, General (.05, 1.0, 1.6, 2.4, 3.2 mm)
Trigger	Remote Standard: Foot, Finger, Pushbutton Sequencer: Pushbutton Hold (2T), 3T 4T, 4TE, 4TL, 4TM
Pulse	
Pulses per Second*	DC: 0.1–500 pps AC: 0.1–500 pps
Peak Time*	5–95%
Background Amps*	5–95%
DC Pulse Waveshape:	Square, Sine, Triangular
AC Waveshape	
Balance*	Ball: 30–99% EN
Frequency*	20–400 Hz
Waveshape	Advanced Square, Soft Square, Sine, Triangular
Independent	EN Amperage: 2–210 A** EP Amperage: 2–210 A** EN Waveshape: Advanced Square, Soft Square, Sine, Triangular EP Waveshape: Advanced Square, Soft Square, Sine, Triangular
Commutation	Low, High

Sequencer Control	
Initial Amps	AC: 2–210 A** DC: 1–210 A**
Initial Time	0.0–25.0 seconds
Initial Slope	0.0–50.0 seconds
Weld Time	0.0–999 seconds
Final Slope	0.0–50.0 seconds
Final Amps	AC: 2–210 A** DC: 1–210 A**
Final Time	0.0–25.0 seconds
Preflow	0.0–25.0 seconds
Postflow	Auto/Off–50 seconds
DIG*	Off–100%
Hot Start™	On, Off
Stick-Stuck™	On, Off
OCV	Normal, Low
Programs	1–99 (user defined program names)
Locks and Limits	Individual Parameters
Languages	English, Spanish, French, German, Italian, Dutch, Swedish, Polish

**Pro-Set parameter selectable. **Amperage range is tungsten size dependent.*

Dynasty® 210 Models/Packages

Build an Air-Cooled Package

Select desired stock number for each step.

907816
Dynasty shown.

301311
kit shown.

Step 1 • Select Dynasty

Dynasty 210	**907816**
Dynasty 210 (CPS)	**907816001**
Dynasty 210 (CPS), CE	**907816003**

Note: For models without the Cooler Power Supply (CPS), the Coolmate 1.3 must be powered through an external 120-volt facility power.

Dynasty comes with:
- Adjustable shoulder strap and center carry handle
- 8 ft. power cord (no plug)
- Two 50 mm Dinse-style connectors

Step 2 • Select Contractor Kit

A-150 TIG Torch and RFCS-14 HD Foot Control	**301309**
A-150 TIG Torch with RCCS-14 Fingertip Control	**301311**
A-200 TIG Torch with RFCS-14 HD Foot Control	**301549**
A-200 TIG Torch with RCCS-14 Fingertip Control	**301550**

See page 6 for kit contents.

Build a Water-Cooled Package

Select desired stock number for each step.

907816002 Dynasty 210 TIGRunner® shown with four bottles of 043810 Low-Conductivity Coolant.

301580 remote shown.

300185 kit shown.

Step 1 • Select Dynasty TIGRunner® and Coolant

Dynasty 210 (CPS) TIGRunner	**907816002**
Dynasty 210 (CPS) TIGRunner, CE	**907816004**
&	
Low-Conductivity Coolant (must be ordered in quantities of four)	**043810**

Dynasty TIGRunner comes with:
- Adjustable shoulder strap and center carry handle
- 8 ft. power cord (no plug)
- Coolmate™ 1.3 (with quick connects on the CE TIGRunner)
- Small Runner™ cart

Step 2 • Select Remote Control

Wireless Foot (recommended)	**301580**
RFCS-14 HD Foot	**194744**
RCC-14 E/W Fingertip	**151086**
RCCS-14 N/S Fingertip	**043688**
RMS-14 Pushbutton	**187208**
RMLS-14 Momentary/Maintained	**129337**
RHC-14 Hand	**242211020**
Wireless Hand	**301582**

See page 7 for remote descriptions.

Step 3 • Select Torch Kit

W-250 Kit (recommended for 210 model)	**300185**
W-280 Kit	**300990**

See page 6 for kit contents.

*Note: If ordering torch or torch kit for the CE TIGRunner, the **QRW** water hose quick connect is required.*

Water-Cooled Packages

Use a single stock number to order a complete preconfigured system.

Water-Cooled Complete Package

Dynasty 210 (CPS) Complete with Wireless Foot Control	**951936**

Water-cooled complete package comes with:
- Dynasty 210 (907816)
- Coolmate™ 1.3
- Coolant (4 one-gallon bottles)
- Small Runner™ cart
- Wireless foot control
- W-250 torch kit (see page 6 for contents)

2-Wheel Trolley Cart
300971
For Dynasty® 210/300 and Maxstar® 210/280 with or without Coolmate 1.3 cooler. Easy-to-maneuver two-wheel cart features single-cylinder rack, chain for cylinder, cable holders, torch holder, storage area, and filler rod storage area.

Small Runner™ Cart
301615
For Dynasty® 210/300 and Maxstar® 210/280 with Coolmate 1.3 cooler. Cart features single-cylinder rack, foot pedal holder, two cable/torch holders, and two TIG filler rod holders.

Coolmate™ 1.3
301616 CE
301617 CE, with quick connects
120 V, 50/60 Hz
1.3-gallon cooler designed to cool torches up to 280 amps.

Low-Conductivity Coolant 043810
Sold in cases of four one-gallon recyclable plastic bottles. Miller coolants contain a base of ethylene glycol and deionized water to protect against freezing to -37 degrees Fahrenheit (-38˚C) or boiling to 227 degrees Fahrenheit (108˚C). Also contains a compound that resists algae growth.

Protective Cover
301382
Fits Dynasty® 210/300 and Maxstar® 280.

Performance TIG Gloves
263346 Small
263347 Medium
263348 Large
263349 X-Large
Completely unlined, goat grain leather with triple-padded palm.

TIG Torches, Kits and Connectors

*Contractor kit **301311** shown.*

Contractor Kits
301309 A-150 with RFCS-14 HD
301311 A-150 with RCCS-14
301549 A-200 with RFCS-14 HD
301550 A-200 with RCCS-14
All-in-one TIG/stick welding kit comes with either a Weldcraft™ A-150 **OR** A-200 TIG torch, RFCS-14 HD foot control **OR** RCCS-14 fingertip control, 200-amp stick electrode holder and 300-amp work clamp with 15-foot (4.6 m) cables, flow gauge regulator with 12-foot (3.7 m) gas hose, gas hose coupler, AK2C torch accessory kit and TIG torch connector.

Weldcraft™ A-150 (WP-17) TIG Torch
WP-17-12-R (12 ft.)
WP-17-25-R (25 ft.)
150-amp air-cooled torch. Torch body gas valve models are available.

*Note: A-150 (WP-17) torches require **195378** connector.*

Weldcraft™ A-200 (WP-26) TIG Torch
WP-26-12-R (12 ft.)
WP-26-25-R (25 ft.)
200-amp air-cooled torch. Torch body gas valve models also available.

*Note: A-200 (WP-26) torches require **195379** connector.*

Air-Cooled TIG Torch Connectors
195378* All air-cooled torches (except A-200)
195379 A-200 (WP-26)
50 mm Dinse-style for one-piece air-cooled torch.
A-80 (WP-24) torches require* ***24-5* *connector.*

*Torch kit **300185** shown.*

Water-Cooled Torch Kits
300185 W-250 (recommended)
300990 W-280
Kit comes with Weldcraft™ 25-foot (7.6 m) TIG torch with Dinse-style connector, torch cable cover, work clamp with 15-foot (4.6 m) cable, flowmeter regulator with gas hose and AK4GL gas lens torch accessory kit.

Weldcraft™ W-225 Modular (WP-225) TIG Torch
WP-225-12-R (12 ft.)
WP-225-25-R (25 ft.)
225-amp water-cooled torch. Includes 1726 and 9-70 torch heads.

*Note: W-225 Modular (WP-225) torch requires **195377** connector.*

Water-Cooled TIG Torch Connector 195377
50 mm Dinse-style with water return line. For use with all Weldcraft™ water-cooled torches.

Weldcraft™ Gas Hose Quick Connect QRG
Allows for quick connection and removal of torch shielding gas hoses.

Weldcraft™ Water Hose Quick Connect QRW
Allows for quick connection and removal of torch coolant hoses.

Genuine Miller® Accessories

Remote Controls and Switches

Wireless Remote Foot Control 301580
For remote current and contactor control. Receiver plugs directly into the 14-pin receptacle of Miller machine. 90-foot (27.4 m) operating range.

RFCS-14 HD Foot Control 194744
Maximum flexibility is accomplished with a reconfigurable cord that can exit the front, back or either side of the pedal. Foot pedal provides remote current and contactor control. Includes 20-foot (6 m) cord and 14-pin plug.

RCC-14 Remote Contactor and Current Control 151086
East/west rotary-motion fingertip control attaches to TIG torch using two hook-and-loop fasteners. Includes 26.5-foot (8 m) cord and 14-pin plug.

RCCS-14 Remote Contactor and Current Control 043688
North/south rotary-motion fingertip control attaches to TIG torch using two hook-and-loop fasteners. Includes 26.5-foot (8 m) cord and 14-pin plug.

RMS-14 On/Off Control 187208
Momentary-contact switch for contactor control. Rubber-covered pushbutton dome switch ideal for repetitive on-off applications. Includes 26.5-foot (8 m) cord and 14-pin plug.

RMLS-14 Switch 129337
Momentary- and maintained-contact rocker switch for contactor control. Push forward for maintained contact and backward for momentary contact. Includes 26.5-foot (8 m) cord and 14-pin plug.

RHC-14 Hand Control 242211020
Miniature hand control for remote current and contactor control. Dimensions: 4 x 4 x 3.25 inches (102 x 102 x 83 mm). Includes 20-foot (6 m) cord and 14-pin plug.

Wireless Remote Hand Control 301582
For remote current and contactor control. Receiver plugs directly into the 14-pin receptacle of Miller machine. 300-foot (91.4 m) operating range.

Tungsten

Tungsten	Amp Range	2% Ceriated (AC/DC)	2% Lanthanated (AC/DC)
1/16 in. (1.6 mm)	70–150 A	**WC116X7**	**WL2116X7**
3/32 in. (2.4 mm)	140–250 A	**WC332X7**	**WL2332X7**
1/8 in. (3.2 mm)	225–400 A	**WC018X7**	**WL2018X7**
5/32 in. (4.0 mm)	300–500 A	**WC532X7**	**WL2532X7**

Ordering Information

Equipment and Options	Stock No.	Description	Qty.	Price
Dynasty® 210	**907816**	Auto-Line™ 120–480 V, 50/60 Hz. 8 ft. power cord		
Dynasty® 210 (CPS)	**907816001** **907816003**	Auto-Line™ 120–480 V, 50/60 Hz. 8 ft. power cord Auto-Line™ 120–480 V, 50/60 Hz, **CE.** 8 ft. power cord		
Water-Cooled Packages				
Dynasty® 210 (CPS) TIGRunner®	**907816002** **907816004**	Auto-Line™ 120–480 V, 50/60 Hz. 8 ft. power cord (Torch kit, accessories and coolant sold separately) Auto-Line™ 120–480 V, 50/60 Hz, **CE.** 8 ft. power cord (Torch kit, accessories and coolant sold separately)		
Dynasty® 210 (CPS) Complete with Wireless Foot Control	**951936**	Auto-Line™ 120–480 V, 50/60 Hz. 8 ft. power cord		
Accessories				
2-Wheel Trolley Cart	**300971**	For Dynasty 210/300 and Maxstar® 210/280 with or without Coolmate 1.3		
Small Runner™ Cart	**301615**	For Dynasty 210/300 and Maxstar® 210/280 with Coolmate 1.3		
Coolmate™ 1.3	**301616** **301617**	120 V, 50/60 Hz, **CE.** *Requires coolant* 120 V, 50/60 Hz, **CE.** With quick connect. *Requires coolant*		
TIG Coolant (must be ordered in quantities of four)	**043810**	1-gallon plastic bottle. Protects against freezing to -37° Fahrenheit (-38°C) or boiling to 227° Fahrenheit (108°C)		
Protective Cover	**301382**	For Dynasty 210/300 and Maxstar 280		
TIG Gloves		See page 6		
TIG Torches, Kits and Connectors				
Air-Cooled Contractor Kits		See page 6		
Weldcraft™ A-150 (WP-17) TIG Torch	**WP-17-12-R** **WP-17-25-R**	12 ft. (3.7 m) cable. Requires **195378** connector 25 ft. (7.6 m) cable. Requires **195378** connector		
Weldcraft™ A-200 (WP-26) TIG Torch	**WP-26-12-R** **WP-26-25-R**	12 ft. (3.7 m) cable. Requires **195379** connector 25 ft. (7.6 m) cable. Requires **195379** connector		
Air-Cooled TIG Torch Connectors	**195378** **195379**	Connects all air-cooled Weldcraft™ torches (except A-200) to Dinse-style connector. A-80 (WP-24) torches require **24-5** connector Connects Weldcraft™ A-200 (WP-26) torch to Dinse-style connector		
Water-Cooled Torch Kits		See page 6		
Weldcraft™ W-225 Modular (WP-225) TIG Torch	**WP-225-12-R** **WP-225-25-R**	12 ft. (3.7 m) cable. Requires **195377** connector 25 ft. (7.6 m) cable. Requires **195377** connector		
Water-Cooled TIG Torch Connector	**195377**	Connects Weldcraft™ water-cooled torches to Dinse-style connector		
Weldcraft™ Quick Connects (sold each)	**QRG** **QRW**	For gas hoses For water hoses		
Tungsten		See page 7		
Remote Controls		See page 7		

Date: **Total Quoted Price:**

Distributed by:

Miller
The Power of Blue®

Item #: 178A49RHC Project: ____________________

Qty: __________ Date: __________ Approval: __________

Avantco Refrigeration

Avantco A-49R-HC 54" Solid Door Reach-In Refrigerator

Item #178A49RHC

Technical Data

Width	54 Inches
Depth	32 3/16 Inches
Height	82 1/2 Inches
Power Cord Length	96 Inches
Interior Width	49 3/8 Inches
Left Door Opening Width	22 9/16 Inches
Right Door Opening Width	22 9/16 Inches
Shelf Width	23 1/4 Inches
Interior Depth	27 1/8 Inches
Shelf Depth	23 5/8 Inches

Features

- Corrosion-resistant stainless steel exterior and aluminum interior with 304 stainless steel floor
- Features 2 self-closing and stay-open locking doors
- Includes 6 epoxy coated shelves with 88 lb. capacity each
- Digital temperature controller with automatic defrost function
- R-290 refrigerant; 115V; 1/2 hp; 3.14 Amps

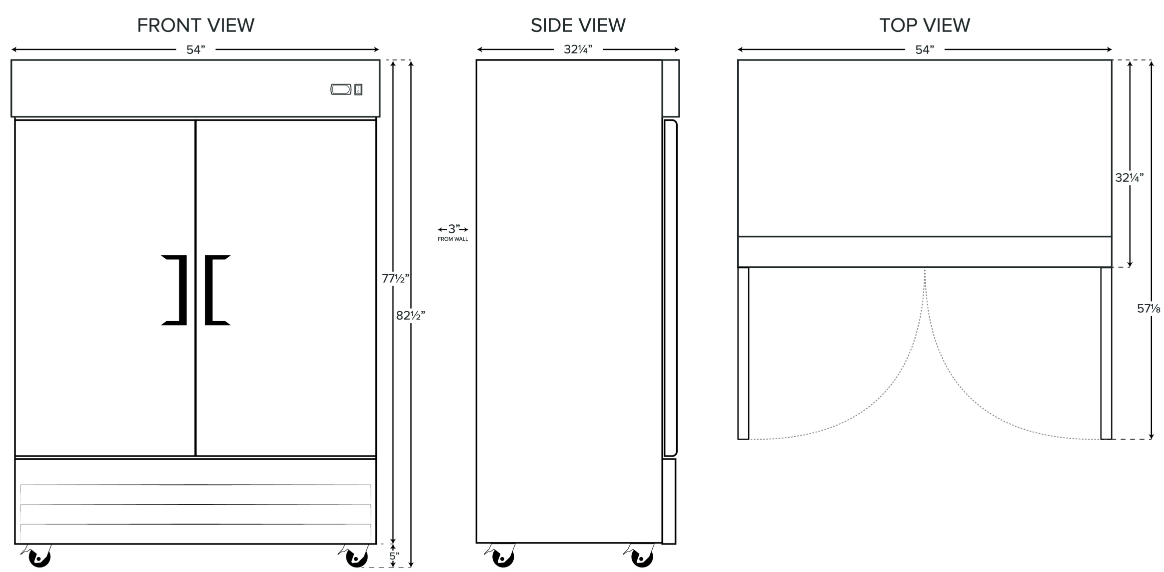
Certifications

5-15P **ETL Sanitation** **ETL, US & Canada**

Technical Data

Interior Height	53 1/2 Inches
Amps	3.14 Amps
Hertz	60 Hertz
Phase	1 Phase
Voltage	115 Volts
Access Type	Doors
BTU (LBP)	1264 BTU
Capacity	46.65 cu. ft.
Casters	With Casters
Color	Silver
Compressor Location	Bottom Mounted
Construction	Stainless Steel and Aluminum
Door Style	Swing
Door Type	Solid
Dutch Half Doors	Without Dutch Half Doors
Features	Removable Magnetic Door Gaskets Self-Closing Doors
Handle Material	Plastic
Hinge Location	Left/Right
Horsepower	1/2 HP
Individual Shelf Capacity	88 lb.
Installation Type	Freestanding
Number of Doors	2 Doors
Number of Shelves	6 Shelves
Plug Type	NEMA 5-15P
Refrigerant Capacity	4.6 oz.
Refrigerant Type	R-290
Sections	2 Sections
Temperature Range	33 - 40 Degrees F
Type	Refrigerators

Plan View



Avantco Refrigeration

Notes & Details

Your establishment relies on refrigeration for proper food safety, and with this Avantco A-49R-HC 54" solid door refrigerator, you receive performance you can depend on! A painted aluminum interior with a 304 stainless steel floor gives you increased durability, while a 430 stainless steel door and exterior sides give it a sleek appearance. For convenience, 6 epoxy coated shelves feature shelf clips for customization when desired.

Designed to maintain temperatures from 33-40 degrees Fahrenheit, this refrigerator boasts a bottom-mounted 1/2 hp compressor that Uses R-290 refrigerant. This specialized refrigerant has an ozone depletion potential (ODP) of 0 and a global warming potential (GWP) of 3. In addition, the bottom-mounted design makes it easy for employees to load and unload products due to the raised bottom shelf. For optimal temperature retention, the entire cabinet is foamed-in place using polyurethane insulation. Other helpful features include stay open doors with locks, automatic defrosting, and a digital temperature control with digital display. This item requires a 115V electrical connection for operation. <

⚠ **WARNING:** This product can expose you to chemicals including lead, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information, go to www.p65warnings.ca.gov.

Avantco Refrigeration

Item #: 178A19FHC Project: ____

Qty: ____ Date: ____ Approval: ____

Avantco A-19F-HC 29" Solid Door Reach-In Freezer

Item #178A19FHC

Technical Data

Width	29 Inches
Depth	25 1/2 Inches
Height	82 1/2 Inches
Power Cord Length	96 Inches
Interior Width	24 3/8 Inches
Right Door Opening Width	24 5/16 Inches
Shelf Width	23 3/8 Inches
Interior Depth	20 3/8 Inches
Shelf Depth	19 5/16 Inches
Interior Height	53 1/2 Inches

Features

- Corrosion-resistant stainless steel exterior and aluminum interior with 304 stainless steel floor
- Features a self-closing and stay-open locking door
- Includes 3 epoxy coated shelves with 88 lb. capacity each
- Digital temperature controller with automatic defrost function
- R-290 refrigerant; 115V; 2/3 hp; 2.62 Amps

Certifications

5-15P **ETL, US** **ETL Sanitation**

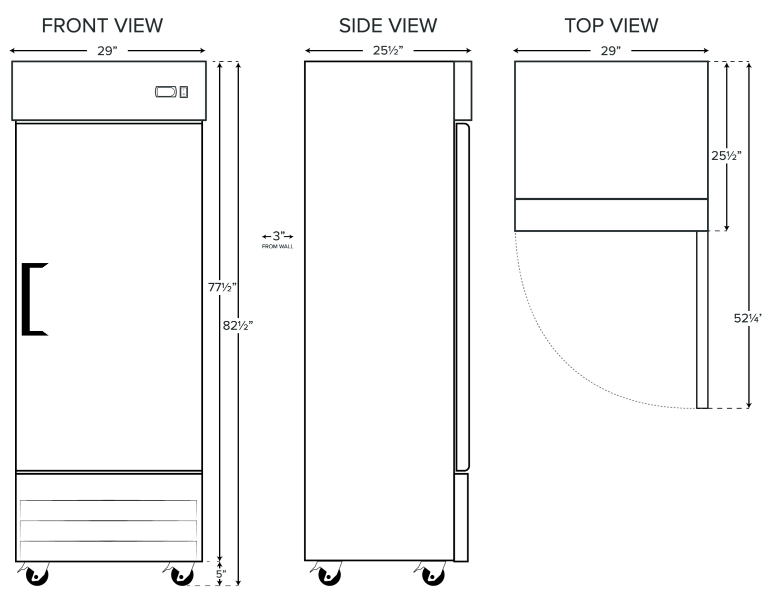
AVANTCO REFRIGERATION

Avantco Refrigeration

Technical Data

Amps	2.62 Amps
Hertz	60 Hertz
Phase	1 Phase
Voltage	115 Volts
Access Type	Doors
BTU (LBP)	2080 BTU
Capacity	17.3 cu. ft.
Casters	With Casters
Color	Silver
Compressor Location	Bottom Mounted
Construction	Stainless Steel and Aluminum
Door Style	Swing
Door Type	Solid
Dutch Half Doors	Without Dutch Half Doors
Features	Removable Magnetic Door Gaskets
Handle Material	Plastic
Hinge Location	Right
Horsepower	2/3 HP
Individual Shelf Capacity	88 lb.
Installation Type	Freestanding
Number of Doors	1 Doors
Number of Shelves	3 Shelves
Plug Type	NEMA 5-15P
Refrigerant Capacity	4.1 oz.
Refrigerant Type	R-290
Sections	1 Section
Temperature Range	-8 - -1 Degrees F
Type	Freezers

Plan View



Avantco Refrigeration

Notes & Details

Your establishment relies on refrigeration for proper food safety, and with this Avantco A-19F-HC 29" solid door freezer, you receive performance you can depend on! A painted aluminum interior with a 304 stainless steel floor gives you increased durability, while a 430 stainless steel door and exterior sides give it a sleek appearance. For convenience, 3 epoxy coated shelves feature shelf clips for customization when desired.

Designed to maintain temperatures from -8 to -1 degree Fahrenheit, this freezer boasts a bottom-mounted 2/3 hp compressor that Uses R-290 refrigerant. This specialized refrigerant has an ozone depletion potential (ODP) of 0 and a global warming potential (GWP) of 3. In addition, the bottom-mounted design makes it easy for employees to load and unload products due to the raised bottom shelf. For optimal temperature retention, the entire cabinet is foamed-in place using polyurethane insulation. Other helpful features include the stay open locking door mechanism, automatic defrosting, and a digital temperature control with digital display. This item requires a 115V electrical connection for operation.

⚠ **WARNING:** This product can expose you to chemicals including lead, which are known to the State of California to cause cancer, birth defects, or other reproductive harm. For more information, go to www.p65warnings.ca.gov.