Schatz Energy Research Center

Electrical Infrastructure and Green Port Conceptual Engineering Assessment Memorandum

Project:	Redwood Marine Multipurpose Terminal Replacement Project
Date of Report:	August 13, 2022
Recipient Organization:	Moffatt & Nichol
Technical Contact:	Shane Phillips, Moffatt & Nichol
Submitted by:	Schatz Energy Research Center

Introduction

This technical memorandum presents the results of the conceptual engineering assessment of the Electrical Infrastructure and Green Port Options for the Redwood Marine Multipurpose Terminal Replacement Project. The topic areas addressed in the assessment include a:

- description of the existing utility infrastructure,
- summary of the estimated energy use for all project phases,
- proposed electrical infrastructure for Phase 1 and 2,
- proposed electrical infrastructure for Phase 3 and 4,
- procurement and generation renewable energy options,
- backup power and grid reliability,
- proposed conceptual microgrid designs, and a
- summary of the proposed design concepts, key findings, and next steps.

For supporting documentation and detailed information refer to the following appendices:

A. *Integrated Capacity Analysis*
B. *RMT -Electrical Load Estimates*
C. *Conceptual Phasing Plan*
D. *Conceptual Master Plan*
E. *Overhead Line and Utility Re-routing Specifications*
F. *HelioScope Rooftop Annual Production Report*
G. *HelioScope Landfill Annual Production Report*

Electrical Infrastructure

A concept has been developed for the required infrastructure to serve the electrical loads for the various facilities presented in the May 7, 2022 Conceptual Master Plan. Site development will be conducted in phases. This approach was adhered to in developing the electrical infrastructure concepts.

Existing Utility Infrastructure on Samoa Peninsula

The Samoa peninsula is currently fed by two PG&E 60kV circuits, the Humboldt #1 and Essex Junction-Fairhaven circuits, both of which terminate in PG&E's Fairhaven Substation located approximately 1/2 mile south of the project site. As of the end of 2021, the 60kV Humboldt #1 and Essex Junction- Arcata- Fairhaven circuits feeding the Fairhaven substation had a capacity of 38MVA with a pre-project loading of < 90%[1].

An assessment of PG&E's Integrated Capacity Analysis (ICA) maps was conducted to evaluate the available capacity on the local utility distribution system to accept additional photovoltaic generation.[2] The total load hosting capacity on 12kV lines leaving the Fairhaven substation is 13.39 MW, 7.59 MW to the south and 5.80 MW to the north[3]. The property located directly south of the project site, the former Samoa pulp mill site, also owned by the Humboldt Harbor District, has a currently unused 20MW, 60kV substation located in the north-west corner of that site, which initially supplied power for pulp mill operations. This substation has a dedicated 12 kV feeder from the Fairhaven substation to the town of Samoa which is proposed for development for this project.

The project site is currently fed from PG&E 1103 circuit, a 12kV distribution line on wood poles, which currently transverses the project site from the Fairhaven substation 12kV switchyard in-route to feeding the town of Samoa. At this time, the load hosting capacity of the Fairhaven 1103 circuit is 5.8MW, which can reasonably be assumed to be available in part for Wind Port use; however, with the planned buildout of the Town of Samoa, a Large Load Application will be necessary to confirm that assumption and secure capacity. See the *Integrated Capacity Analysis* (Appendix A) for detailed information regarding existing electrical infrastructure.

Electrical Load Estimate

Estimates of the electrical loads for the onsite assembly and manufacturing facilities and operation of the major electrical equipment throughout the laydown areas and wharfs are presented in Table 1. Given that the project is in the early stages and the future facilities and their associated electrical loads are not known, a 50% contingency has been factored into the estimates. The combined Phase 1 and 2 estimate of 4 MW and 10.5 MW for Phase 3 and 4 will

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[1] CA North Coast OSW Study: Transmission Analysis, Quanta Technology, December 9, 2021

2 Customers are encouraged to use the Pre-Application process to get a general engineering review of a specific site without committing to a project application or queue. The ICA maps are designed to help contractors and developers find information on potential project sites for distributed energy resources. The maps show hosting capacity, grid needs, and other information about PG&E's electric distribution grid. The information on these maps is illustrative and is may not be representative of the current grid conditions.

[3] Integrated Capacity Analysis Map, PG&E, https://www.pge.com/en_US/for-our-business-partners/distribution-resource-planning/distribution-resource-planning-data-portal.page?ctx=large-business?ctx=business

be used for planning and preliminary design phase of the project. A breakdown of the equipment and facilities in operation for each phase and their estimated loads can be found in Appendix B.

Table 1: Electrical Load Estimates by Project Development Phases. Source: Moffatt & Nichol.

Phase	*Description*	*Estimated Load (MW)*	*Planning Load (MW) 50% Contingency*
1	Entry and Fabrication/Assembly Building	0.9	1.3
2	Wind Turbine Laydown Area and Wharf	1.8	2.7
3	Blade Manufacturing and Blade Laydown Area, Wharf	4.3	6.4
4	Tower Manufacturing and Tower Laydown Area	2.7	4.1

Proposed Electrical Infrastructure

The electrical infrastructure required to serve the future project loads is based on the project buildout as shown in the *Conceptual Phasing Plan* (Appendix C). The approach taken was to develop a conceptual design for the electrical infrastructure necessary to meet the combined electrical demand for the Phases 1 and 2 loads and a separate electrical infrastructure design to serve the future loads at the Phases 3 and 4 facilities. The location and routing of the proposed designs are shown in the *Conceptual Master Plan* (Appendix D). For line specification details, refer to the *Overhead Line and Utility Re-routing Specifications*[4][5][6] in Appendix E.

Proposed Electrical Infrastructure - Phase 1 and 2

The combined electrical load for Phase 1 and 2 of the project development is estimated to be between 2.7 and 4 MW. As part of the Nordic Aquafarms Samoa Peninsula Land-based Aquaculture Project, the Harbor District's 20 MW electric substation (here-in referred to as the District Substation) shall be increased by at least 5 megawatts to a total of 25 MW. The additional 5 MW of capacity is proposed to serve the combined estimated Phase 1 and Phase 2 electric loads via a new line from the upgraded switchyard to a new proposed 75' x 50', 12 kV switchyard to be located adjacent to the new Fabrication and Assembly building at the north end of the project site. Any remaining capacity of this line after the Phase 1 and 2 buildout is in operation may also be used for a portion of the Phase 3 and 4 electric loads. Revenue metering of this line will need to be installed during the upgrade of the existing pump mill switchyard.

This new line is proposed to be a new single circuit overhead 12kV distribution line routed on wood poles along the west-northwestern boundary of the project site and is to be located within the existing or expanded 50-foot wide Vance Ave. ingress/egress right of way and within the project boundary to the north end of the project site where it will eventually follow the north-boundary of the project to the proposed switchyard at the Fabrication and Assembly building. This new circuit will require approximately 18' of utility right-of-way or 30' of right of way where the relocation of the existing utilities currently traversing the site is likely.[7]

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[4] Specifications and Drawings for 12.47_7.2kV Line Construction, UEP_Bulletin_1728F-804, US Department of Agriculture Rural Utilities Service, 2018

[5] Overhead Electric Line Construction, GO-95, California Public Utilities Commission, 2015

[6] 2022-2023 Greenbook Manual, PG&E, https://www.pge.com/en_US/large-business/services/building-and-renovation/greenbook-manual-online/greenbook-manual-online.page

[7] Appendix E: Overhead Line and Utility Re-routing Specifications

Proposed Electrical Infrastructure - Phase 3 and 4

The combined electrical load for Phase 3 and 4 of the project development is estimated to be between 7 and 10.5 MW. The loads at the blade, tower, and wharf facilities are proposed to be fed from a new 75' x 50', 12 kV switchyard located at the south end of the project site. This switchyard is proposed to be fed via a new overhead line tap of the existing PG&E Fairhaven 1103 circuit at the southeast boundary of the project site and/or from a new overhead line from the existing District Substation. As of today, there is approximately 5.8MW of capacity on circuit 1103. With the remaining approximately 1-2.3 MW of capacity on the new circuit feeding Phases 1 and Phase 2, there would be 6.8-8.1 MW of capacity on the existing infrastructure at the time of construction of Phase 3 and Phase 4. Therefore, system upgrades will be required to feed the full Phase 3 and Phase 4 load. The customer is advised to apply for Large Load Service as early as possible. A large Load Service Application is anticipated to cost $30k and require a 90 days turnaround time.

New single-circuit overhead line(s) would be constructed from the tap(s) to the new switchyard along the improved southern site access roadway just south of the project site. This circuit(s) will require approximately 18' of utility right-of-way. PG&E circuit 1103, which currently traverses the Phase 3 and Phase 4 project site, is proposed to be rerouted around or underground as part of Phase 3 and 4 of the project.

Green Port - Renewable Energy

An important aspect for operating as a green port is the use of renewable energy to meet the demand of the all-electric terminal. The use of energy from onsite renewable energy generation and/or the procurement of carbon-free energy from electric service providers will eliminate harmful air emissions and greenhouse gases that would be emitted from traditional fossil-fuel electrical generation. This section presents the renewable energy procurement options, types renewable energy systems and their associated benefits, and an overview of backup power and grid reliability.

Renewable Energy Procurement

The electrical load for marine terminal operations is expected to be much greater than the amount of energy that could be generated on site from renewable resources for all phases of the project. In addition, the generation hosting capacity is limited without infrastructure upgrades or microgrids integration. Generation customers must submit an interconnection application to determine requirements and costs based on the project's location, size, and application date compared with other projects in the same area. The customer is advised to use the Pre-Application process to get a general engineering review of [the] site without committing to a project application or queue. Therefore, the majority of the energy may be purchased from either the local utility Pacific Gas & Electric (PG&E), the local Redwood Coast Energy Authority (RCEA) or through a power purchasing agreement with an offshore wind developer.

PG&E has two programs for customers to buy more renewable energy than is provided in their standard power mix, *Solar Choice* and *Regional Renewable Choice*. The *Solar Choice* program allows customers to purchase 50% or 100% of their energy use from solar energy projects. In the *Regional Renewable Choice* program customers can elect to purchase renewable energy from specific projects within PG&E's territory. At the time of this memorandum, both programs are closed to new enrollment.[8]

RCEA is a local joint powers agency that administers Humboldt County's Community Choice Energy program. Through this program, RCEA buys and provides a basic power mix higher in renewables to their customers at a lower cost than Pacific Gas & Electric (PG&E)[9]. Most customers in the region purchase electricity from RCEA, but, PG&E is responsible for delivering the electricity and maintaining the infrastructure. Currently, RCEA offers standard and premium electricity service options. The standard option, *REpower*, is lower in cost and higher in renewables than PG&E while the premium option, *REpower*$^+$, is 100% carbon free for $0.01 per kWh more than the standard option. RCEA energy rates replace PG&E rates and they also have a net metering (NEM) schedule for customers who use an eligible renewable electrical generation facility as defined in PG&E's Electrical Schedule NEM[10]. RCEA has procurement goals of 100% carbon-free electricity by 2025, and 100% local carbon-free electricity by 2030. Procurement of 100% carbon-free energy from RCEA for energy demands required beyond what may be produced from onsite renewable energy generators is the proposed approach for this project.

Onsite Renewable Energy Systems

Solar photovoltaic (PV) systems are the main resource for generating on-site renewable energy. Grid-connected, net-metered PV systems provide cost savings by reducing the amount of energy purchased from the utility to meet the site's electrical needs. However, their use may be limited by the generation hosting capacity of the grid in this location. When coupled with battery energy storage, a PV- battery system can provide additional cost savings benefits through time of use savings and demand charge reductions. If the additional benefit of backup power (i.e. green resiliency) is desired, microgrid (MG) electrical switchgear can be installed that will allow for grid-islanding capability of the PV-battery system in the event of a utility grid outage and can also free up generation hosting capacity. For extended outages, a backup generator can be implemented to serve site loads beyond what the PV-battery system can provide. The benefits for each type of system are summarized in Table 2 below.

Table 2: Benefits of Various Types of Renewable Energy Systems

System Types	*Energy Use Savings*	*Time of Use Savings*	*Demand Charge Reduction*	*Short-term Backup Power*	*Extended Backup Power*
PV system	X				
PV-battery system	X	X	X		
PV-battery microgrid	X	X	X	X	
PV-battery-generator MG	X	X	X	X	X

8 https://www.pge.com/en_US/small-medium-business/energy-alternatives/private-solar/solar-choice-rates.page?

9 https://redwoodenergy.org/

10 https://www.cpuc.ca.gov/General.aspx?id=3800

Photovoltaic Systems

The installation of any one of the solar PV energy systems listed above to PG&E's Distribution System must follow Rule 21's net energy metering (NEM) interconnection process. Net energy metering allows customers who generate their own energy ("customer-generators") to serve their energy needs directly onsite and to receive a financial credit on their electric bills for any surplus energy fed back to their utility.[11]" A NEM schedule is applicable to customers who take service on an applicable time of use rate schedule[12]. This tariff describes the requirements for interconnection and metering of generation facilities connected to the distribution grid.

Battery Energy Storage Systems

Battery energy storage systems can provide several value streams to reduce the payback period of the investment. Table 3 lists the services that can be provided by commercial scale systems with the value stream providing an opportunity as an avoided cost (or avoided loss)[13]. The most common value stream for battery storage is lowering the cost of utility purchases by offsetting high demand charges or shifting electricity use from high- to low-cost periods (energy arbitrage).

Table 3: Value Streams for Storage: Opportunities To Avoid Costs and Losses

Service	*Description*
Demand charge reduction	Use stored energy to level load peaks to reduce demand charges
Energy arbitrage	Stores energy when grid prices are low then sells it when grid prices are high
Time-of-use bill reduction	Use storage to shift the time self-generated electricity is used onsite to reduce grid purchases when electricity costs are high

For demand charge reduction, the specified power rating of the battery energy storage system (i.e. battery inverter) must be high enough to address the peak demand at the facility and the energy storage capacity must be optimized to provide sufficient energy storage to be cost effective. Large battery systems can also provide grid services such as demand response, frequency regulation, and reserve markets (Table 4).

Table 4: Value Streams for Storage: Opportunities for Income

Service	*Description*
Demand response	Storage used to support participation in utility programs that pay customers to lower demand during system peaks
Frequency regulation	Stabilizes frequency on moment-to-moment basis
Reserve markets	Supply spinning, non-spinning reserves

11 Source: https://www.cpuc.ca.gov/General.aspx?id=3800

12 PG&E Electric NEM2 Schedule

13 https://www.nrel.gov/state-local-tribal/blog/posts/batteries-101-series-use-cases-and-value-streams-for-energy-storage.html

Microgrids

Microgrids are defined as local grids that can disconnect from the utility grid to operate autonomously. For example, a solar PV- battery microgrid with an optional backup generator, equipped with the appropriate islanding hardware and controls, can provide renewable power to a critical facility in the event of a grid outage and can eliminate constraints on renewable energy interconnection. A simplified single line diagram of a microgrid is shown in Figure 1.

During normal operations when utility grid power is available, both the generation and islanding breakers are closed (as shown in the schematic) and the solar array will generate solar energy to meet the electrical loads, charge the battery and/or export excess power to the grid. The battery system will dispatch energy as programmed to provide utility bill savings (e.g. operate in peak shaving mode to reduce demand charges).

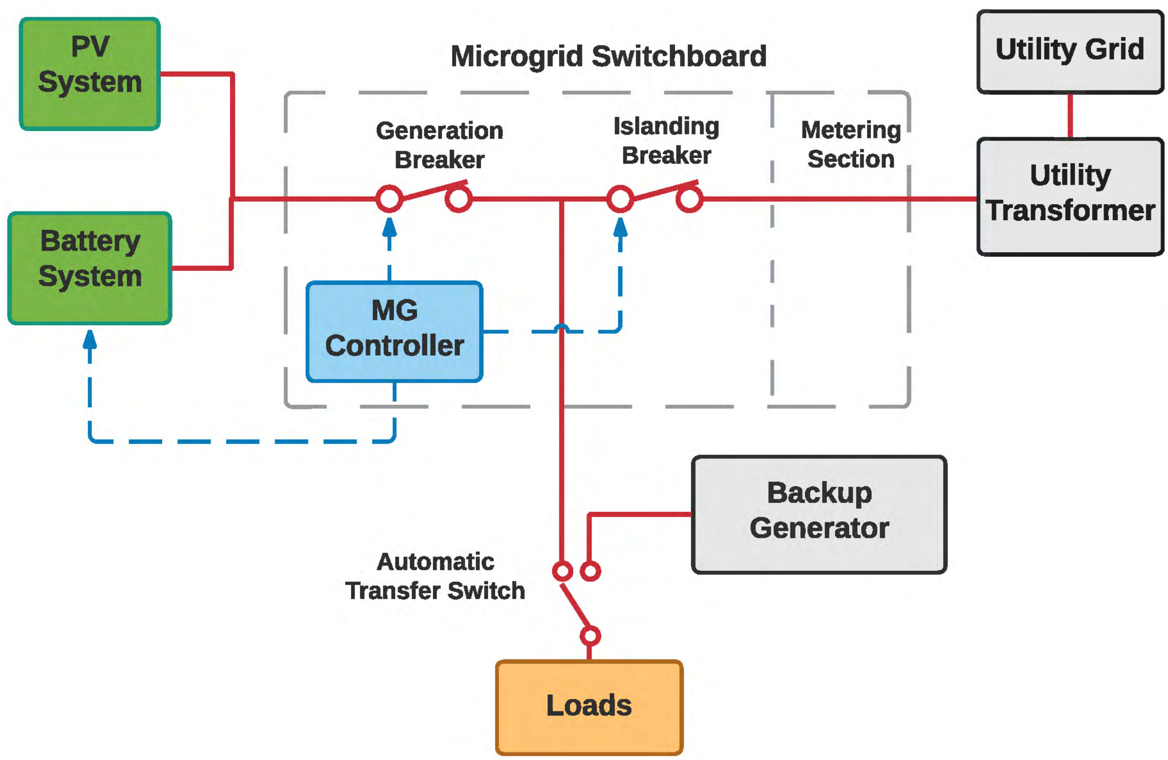

Figure 1: Simplified Single Line Diagram of a Microgrid

During a grid outage, the system enters island mode, and the islanding breaker opens and disconnects the facility from the utility grid. The facilities' loads are powered by energy from the solar array and battery. The microgrid can island and provide power for a period of time depending on the system design. The amount of time the PV-battery system can supply the load depends on the time of day the outage occurs and the state of charge of the battery system when the outage occurs. In the daytime, the PV system can directly supply the load whereas, if the outage occurred at night, the load would be supplied solely by the battery and the higher the state of charge, the longer the load can be met by the battery.

If the battery's state-of-charge drops to a specified low level and if there is either no PV generation or generation cannot keep up with demand, the microgrid controller opens the generation breaker and disconnects the facility from the solar array and battery system. The automatic transfer switch then detects the power outage and connects the facility to the backup generator.

During generator operation when the generation breaker is open, the battery system is allowed to recharge from the solar array until the state-of-charge is sufficient to resume islanding with the battery system and PV. At this point the microgrid controller closes the generation breaker, causing the automatic transfer switch to detect that power has been restored and reconnects the facility to the renewable generation and storage.

Backup Power and Grid Reliability

In the event of a utility grid outage, backup power is needed to serve critical loads. This emergency power must be available to ensure operations at the Fabrication & Assembly facility and that equipment handling activities are carried out in a safe manner wharf side during a power disruption.

PV-battery only microgrids have backup power capability and can serve the critical loads for short term grid outages. The battery system must be sized to meet design criteria to ensure the critical loads with specified energy requirements are met for a specified length of time. Critical loads can be an entire facility or a portion of a building's electrical load that affects the ability of a facility to operate and must continue to be powered during the entire grid outage or only long enough to put the terminal operations in a safe state. Preliminary critical loads include lighting, security, communication, and cranes. Major grid power disruptions such as winter storms or earthquakes that could result in prolonged power outages and would require a natural gas-powered generator to be integrated with a PV-battery microgrid to ensure critical functions are powered during extended grid outages.

In addition to identifying the critical loads, the reliability of the grid should be considered when evaluating backup power options. In October of 2019, there were two PG&E Public Safety Power Shutoff (PSPS) events due to potential fire conditions in other regions of the state that resulted in significant and unnecessary power outages within Humboldt County. In response to these events, engagement from Humboldt County leaders and customers prompted PG&E to reduce the undesirable local impact of PSPS events when severe weather is not forecasted locally.

In June 2020, PG&E announced that the Humboldt Bay Generating Station is capable of serving as a local power source during emergencies by reconfiguring the plant to island from the rest of the California grid. Figure 2 shows a map of the areas where power would be provided by the Humboldt Bay Generation Station during islanding conditions[14]. The Samoa Peninsula is included within the islanding portion of Humboldt County and should no longer experience power outages due to out of area PSPS events.

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[14] https://www.pgecurrents.com/2020/06/12/humboldt-bay-generating-station-ready-to-serve-as-a-direct-local-power-source-during-emergencies-reducing-impact-of-psps-events/

With the ability of the Humboldt Bay Generating Station to island during state-wide Public Safety Power Shutoff (PSPS) events, the number of long-term transmission-level outages due to these out of county safety issues are expected to be infrequent. Also, the likelihood of distribution-level outages is very low due to the limited overall length of the proposed distribution lines (less than 2 miles) and lack of nearby trees that could be a potential cause for local outages during winter storms.

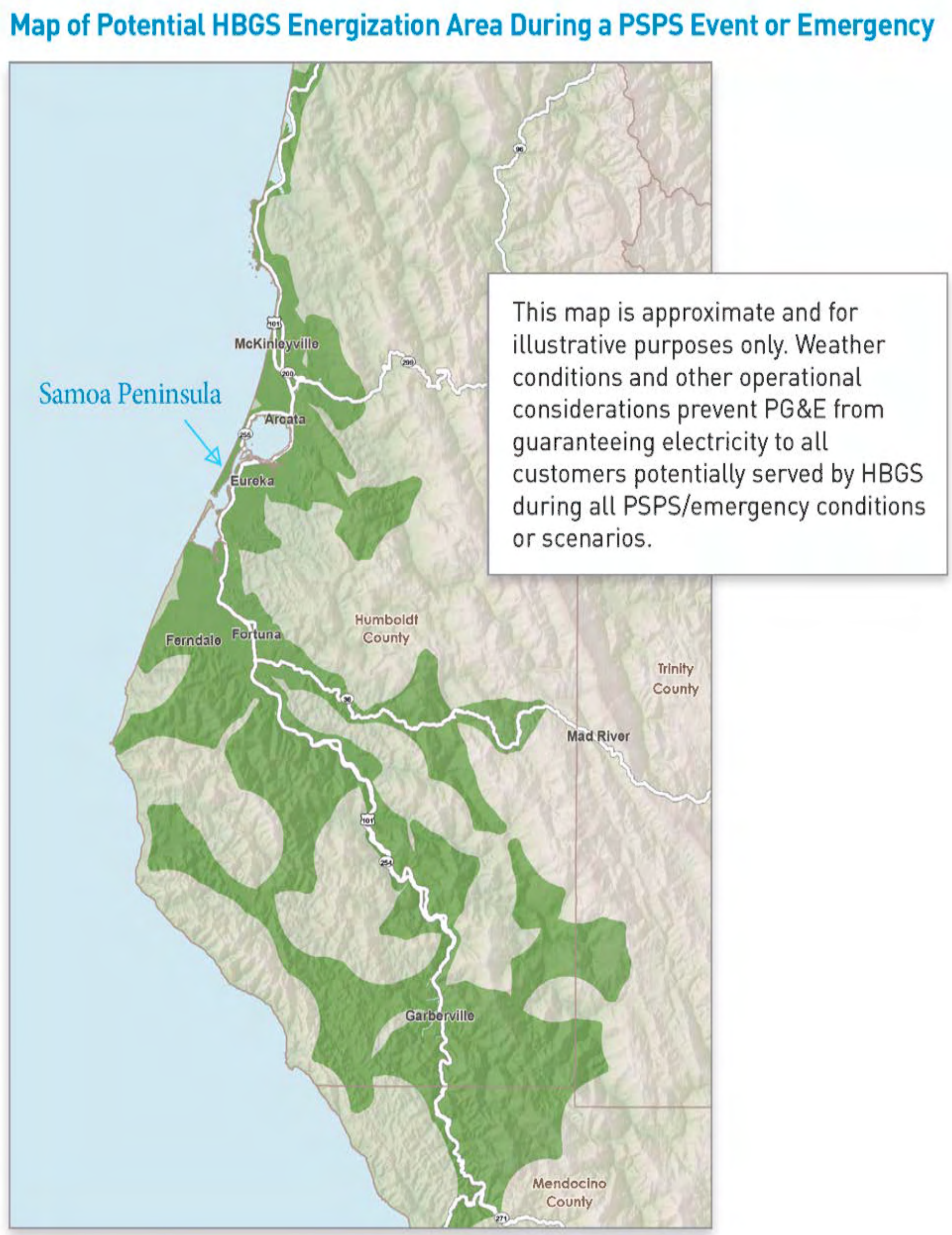


Figure 2 : Map of Areas (in green) served by PG&E during islanding conditions.

Proposed Energy Systems

Grid-connected microgrids are proposed to meet the electrical needs for the various phases of port development. Conceptualized PV-battery-generator microgrids will provide energy cost savings through onsite renewable energy generation from the photovoltaic system, short term backup power capability from the battery energy storage system and emergency power capability from a natural gas generator during extended outages. A Phase 1 and 2 12-kV microgrid electrical switchyard is proposed to be sited adjacent to the Fabrication & Assembly building and serve the facility and wharf operations associated with Phase 1 and 2. A Phase 3 and 4 microgrid switchyard is proposed to be located at the southern end of the property to serve the manufacturing facilities and southern wharf operations associated with Phase 3 and 4.

As shown in the *Integrated Capacity Analysis* map of the existing site electrical circuits (Appendix A), the existing Generation Hosting Capacity and the Generic PV Hosting Capacity of the 12kV infrastructure on the Samoa peninsula are limited. Therefore, microgrids are a way to utilize the solar generating capacity at the project site without additional infrastructure upgrades.

Phase 1 and 2 Switchyard Microgrid Conceptual Design

A 12kV switchyard is proposed for location on the north end of the project site on District-owned property for Phase 1 and 2 load service. The major equipment configuration of a 12kV switchyard microgrid is shown in Figure 3. The general concept of operation is as described in the Onsite Renewable Energy Systems section of this memo.

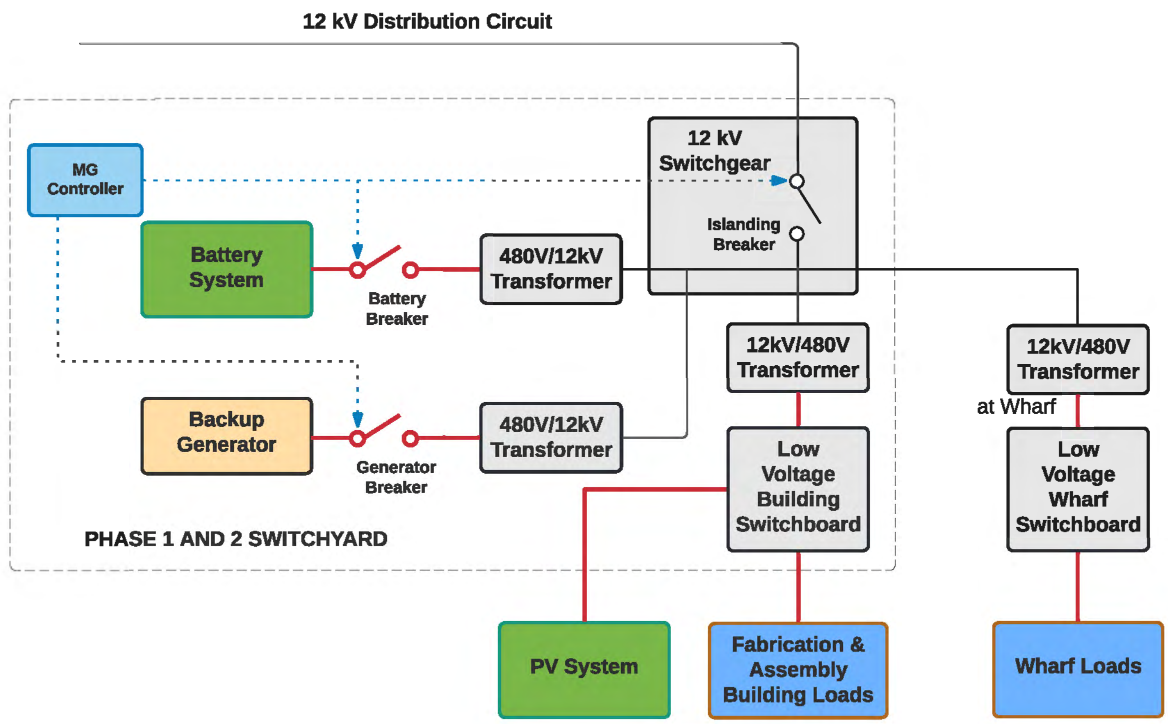


Figure 3 : Simplified Single Line Diagram of a 12kV Switchyard Microgrid

A typical arrangement of the major equipment and the estimated footprint of the substation is shown in Figure 4.

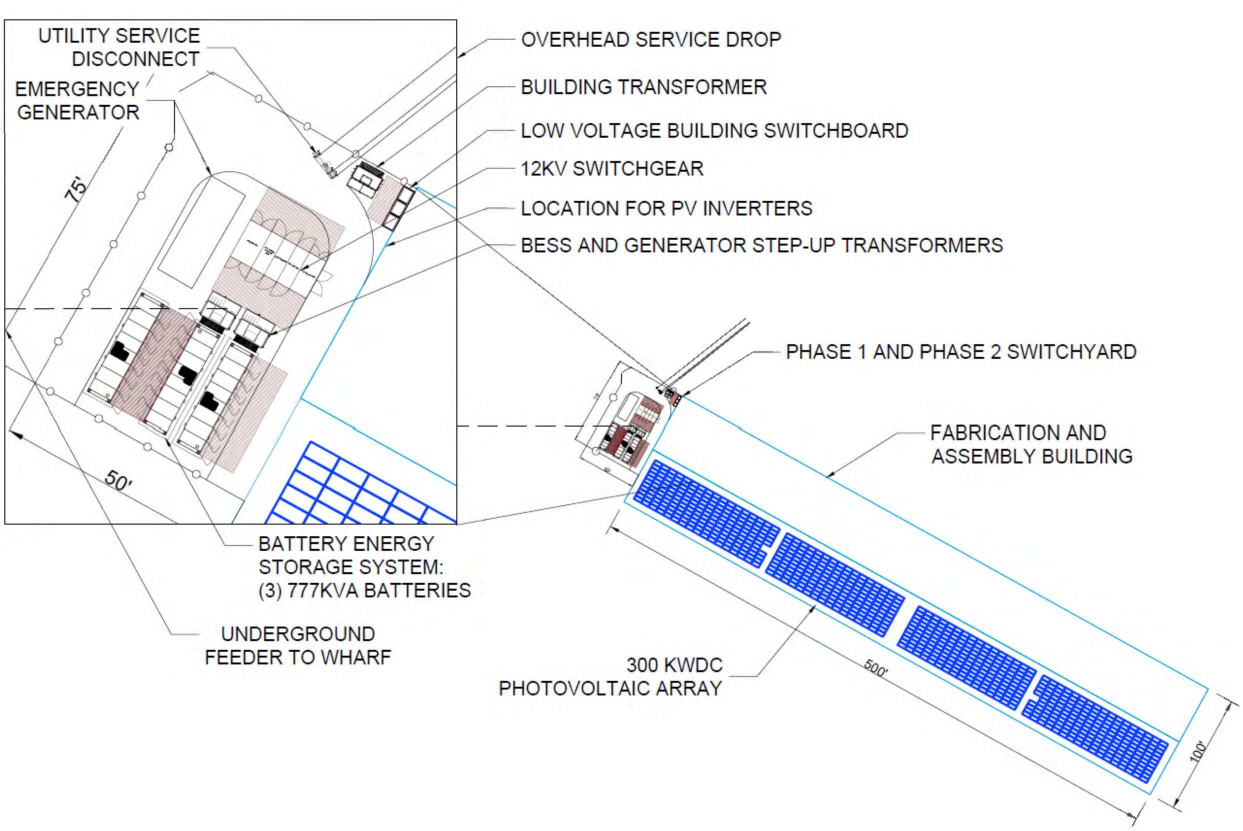


Figure 4 : Typical General Arrangement of the Phase 1 Switchyard Microgrid

Photovoltaic System

The conceptual PV system would be a roof-mounted photovoltaic (PV) array with an approximate system size of 300kWDC. The system was designed to utilize rows of 420W high efficiency, monocrystalline modules flush-mounted in rows in landscape orientation at a tilt of 14 degrees. The modules are designed for flush-mount attachment to a standing seam metal roof. IBC access pathways and smoke ventilation setbacks were included in the design.

Power generated by the arrays was designed for AC conversion through three 100kW, 480V inverters adjacent to the building for 480V three phase interconnection into a building's low voltage switchboard. These inverters are UL 1741-SA listed and can be frequency-controlled by the battery energy storage system to ramp PV output to balance generation with the load. The DC/AC ratio is 1.01 for minimization of equipment variation on the overall site; however, inverter capacity could be downsized to a DC/AC ratio of up to 1.25 with minimal clipping with further inverter optimization. The inverters are connected to a building's low voltage switchboard through a solar subpanel and a visible, lockable disconnect to be located next to the inverters for ease of shutdown in the case of a fire.

Battery Energy Storage System

The conceptual microgrid includes a 2-MW battery energy storage system with a 1-hour duration of energy storage. This duration assumes the load during an outage will be 50% of the peak load (4 MW). Load shedding of non-critical loads during grid outages can be implemented to extend the hours of resiliency. The optimal battery system power rating and energy storage capacity will require further analysis as the electrical load assessment is further refined and critical loads are identified. The BESS output is rated for 480V, three phase interconnection, so a 2500KVA BESS transformer is included for step-up to 12kV for interconnection at the Main Switchgear.

Main Switchgear

The conceptual switchyard includes a new 3ph, 12kV, raintight Main Switchgear lineup containing a controllable main breaker to be supervised by a Schweitzer Engineering Laboratories 700GT+ Intertie and Generation Relay Islanding Controller, which interfaces with the integrated Site Controller to provide seamless transitions to an islanded battery-powered state and retransfers back to the local utility grid. The Main Switchgear contains all the metering, control, and UPS equipment required for interconnection with the utility grid and for PV, BESS, and load control and monitoring to ensure safe stable grid-connected and microgrid operation. The switchgear feeds loop-feed, pad-mount 12kV transformers for BESS and generator step-up and for step-down to feed the building and wharf loads.

Emergency Generator

A 2-MW natural gas generator is included for emergency back-up operations. The power rating assumes that the critical loads (i.e., lighting, security, communication, and cranes) will be a maximum of 50% of the combined 4 MW peak load from the Fabrication & Assembly building and Phase 2 wharf operations. The actual load during emergency operation will be based on the critical loads required during extended outages.

The expected runtime of the emergency generator is based on the reliability of the grid serving the project site. For short term grid outages, the microgrid battery system will provide backup power. With the ability of the Humboldt Bay Generating Station to island during state-wide Public Safety Power Shutoff (PSPS) events, the number of long-term transmission-level outages due to these out of county safety issues are expected to be infrequent. Generator runtime could range from 12 hours to 500 hours per year. Generator operation of 1 hour per month is required for maintenance purposes to ensure proper lubrication of the generator and verify system functionality and load transfer capability. Generator operation may be required during future electrical infrastructure work as the project phases are implemented. These planned utility grid outages could require up to 500 hours of operation during these construction activities.

Phase 3 and 4 Switchyard Microgrid Conceptual Design

A conceptual switchyard is proposed for location on the south end of the project site on District-owned property for Phase 3 and 4 load service. The basic design for the Phase 3 and 4 microgrid would be similar to the Phase 1 and 2 design. The Phase 3 and 4 site loads are estimated to be 10.5 MW and may require a larger battery system size as well as a larger emergency generator depending on critical load identification. Upsizing the equipment would increase the footprint; however, the medium voltage infrastructure has capacity as drawn to handle up to the remaining load hosting capacity of PG&E circuit 1103 (5.8 MW).

Photovoltaic System

For this concept, there are multiple options for installing PV systems, on the rooftops of the Phase 3 and 4 manufacturing buildings and an optional ground-mounted PV system(s) at the Harbor District landfill located on District-owned property across Vance Avenue from the existing former pulp mill site.

The roof-mounted PV designs for all phases were modeled using the same assumptions as in the Phase 1 and 2 microgrid concept. The aggregate nameplate DC capacity of conceptual rooftop PV systems on buildings for all phases is approximately 6.3 MW and has an estimated annual energy production of 7.1 GWh. See the Appendix F: *HelioScope Rooftop Annual Production Report* for additional details.

An optional ballasted PV system was designed for east-west facing landfill planes of the landfill utilizing generic PV modules and string inverters for siting and production estimating purposes. The optional landfill system was modeled for a conservative system size of approximately 2.5 MW and resulted in an annual solar energy production estimate of 2.9 GWh. See the Appendix G: *HelioScope Landfill Annual Production Report* for additional details.

The combined PV power rating from these sites is on the order of 8.8 MW of power with an estimated annual production of 10 GWh of solar energy. See the optional locations for solar included in the revised *Conceptual Master Plan* attachment for more information.

Emergency Generator

A 2-MW natural gas emergency generator is included for emergency back-up operations. The power rating assumes that the critical loads (i.e., lighting, security, communication, and cranes) will be similar to the Phase 1 and 2 emergency loads.

The expected runtime for the two Phase 3 and 4 emergency generators is similar to the Phase 1 and 2 generator and would range between 12 hours to 500 hours per year.

Summary of Proposed Design Concepts and Key Findings

Electrical Infrastructure

- The peak power demand for buildings and site operations is estimated to be:
    - Between 2.7 and 4 MW for Phase 1 and 2 and between 7 and 10.5 MW for Phase 3 and 4 for a total estimated power demand between 9.7 and 14.5 MW
    - 14.5 MW (50% reserve contingency) for all project phases is recommended for planning and preliminary design phase of the project
- 5 MW of capacity is to be built into the upgraded District substation and will be made available for the terminal redevelopment in Phases 1 and 2.
- The proposed Phase 1 and 2 electrical service is a new electrical distribution line from the District switchyard to a new Phase 1 and 2 12 kV switchyard located at the Fabrication and Assembly building
- There is 5.8 MW of load serving capacity remaining on the existing PG&E 1103 circuit at the time of this report
- The proposed Phase 3 and 4 electrical service design is for a tap of the existing PG&E circuit 1103 that will feed a new Phase 3 and 4 12 kV switchyard located at the southern end of the project site and will include optional line taps of the existing rerouted PG&E 1103 circuit for building-level service.
- The total load for all phases of the project is estimated between 9.7 and 14.5 MW while the total available capacity of the existing infrastructure is currently estimated at 10.8MW. The customer is advised to apply for Large Load Service as early as possible in order to plan for infrastructure upgrades. A large Load Service Application is anticipated to cost $30k and require a 90 days turnaround time.
- Approximately 30' of utility right-of-way is recommended for the new circuit feeding Phase 1 and Phase 2 and for relocation of existing utilities currently traversing the Phase 3 and Phase 4 project site contingent upon the results of utility engagement

Green Port

- Onsite renewable energy options include rooftop solar photovoltaic systems on all buildings and an optional ground-mounted PV system at the adjacent District landfill.
- PV Generation Hosting capacity is limited on PG&E circuit 1103 and unknown at the 60kV level. Generation customers must submit an interconnection application to determine requirements and costs based on the project's location, size, and application date compared with other projects in the same area. The customer is encouraged to use the pre-application process to get a general engineering review of [the] site without committing to a project application or queue.
- The aggregate nameplate DC capacity of conceptual rooftop PV systems on buildings for all phases is approximately 6.3 MW and has an estimated annual energy production of 7.1 GWh.
- The optional landfill system was modeled for a conservative system size of 2.5 MW and resulted in an annual solar energy production estimate of 2.9 GWh.

- The combined PV power rating from all systems is on the order of 8.8 MW of power with an estimated annual production of 10 GWh of solar energy.
- 100% renewable energy from the Redwood Coast Energy Authority can be procured to meet the energy demand required beyond what may be produced by onsite renewable energy systems.
- The goal of using 100% carbon-free energy to meet site electrical loads can be met through a combination of onsite solar photovoltaic energy production and the procurement of available renewable energy from the local electrical service provider. The procurement and use of low-cost wind energy should be investigated in subsequent stages of project development.

Proposed Energy Systems

- A Phase 1 and 2 Switchyard PV-battery-generator microgrid is proposed to supply energy and backup emergency power to the Phase 1 and 2 critical loads. Preliminary critical loads include lighting, security, communication, and cranes. Further design will be required as more electrical load information becomes available from a terminal operator. The microgrid includes a 2-MW natural gas generator that will provide emergency power to meet the estimated peak critical loads and has a maximum expected annual runtime of up to 500 hours.
- A Phase 3 and 4 Switchyard microgrid of similar design is proposed, but will include a larger battery system to handle short-term grid outages. The expected annual runtime of the 2-MW gas generator is 500 hours maximum.
- The proposed designs provide multiple levels of resiliency to meet the electrical needs of the terminal during normal and emergency operations. The levels of resiliency include: 1) Humboldt County has islanding capability during state outages, 2) microgrid battery systems will provide green un-interrupted resiliency during short outages, and 3) natural-gas generators will provide deep backup emergency power for extended outages.
- The backup generators have been sized to serve critical loads during an emergency. At this conceptual stage, these critical loads are assumed to be 50% of the planned estimate load for Phase 1 and 2 and 38% for the Phase 3 and 4.

Next Steps

1. Finalize entry and egress rights of way for comprehensive site plan development.
2. Finalize Green Port and backup power criteria to meet the resiliency and regulatory guidelines, facility operations, backup power resiliency, operational needs for the proposed development.
3. Apply for Large Load Service as early as possible in order to plan for utility system upgrades. A large Load Service Application is anticipated to cost $30k and require 90 days.
4. Submit a pre-application in order to get a general engineering review of the site in order to plan for utility system upgrades.

Appendices

A. Integrated Capacity Analysis

B. RMT -Electrical Load Estimates

C. Conceptual Phasing Plan

D. Conceptual Master Plan

E. Overhead Line and Utility Re-routing Specifications

F. HelioScope Rooftop Annual Production Report

G. HelioScope Landfill Annual Production Report

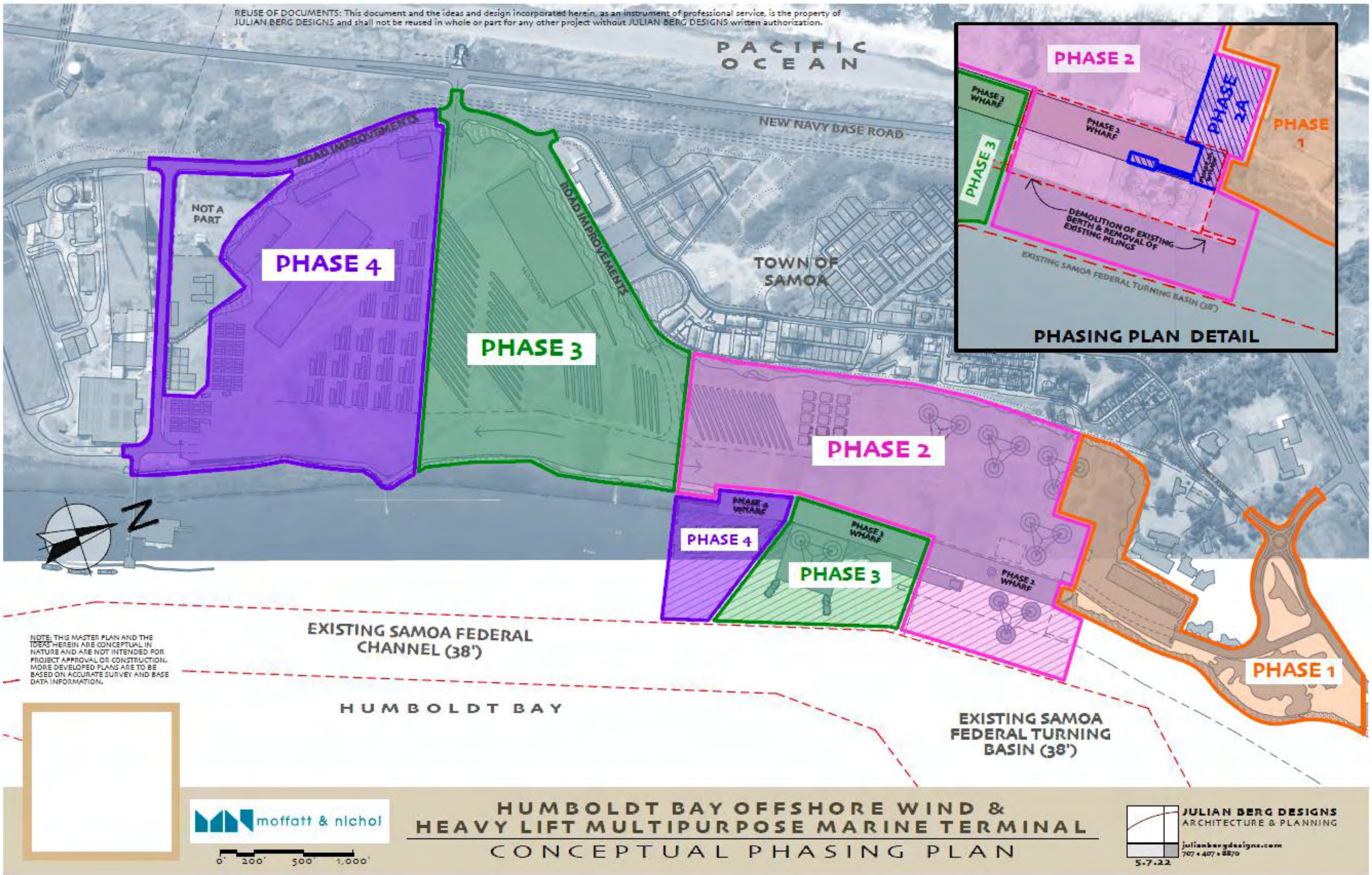
Appendix A: Integrated Capacity Analysis

Appendix B: RMT -Electrical Load Estimates

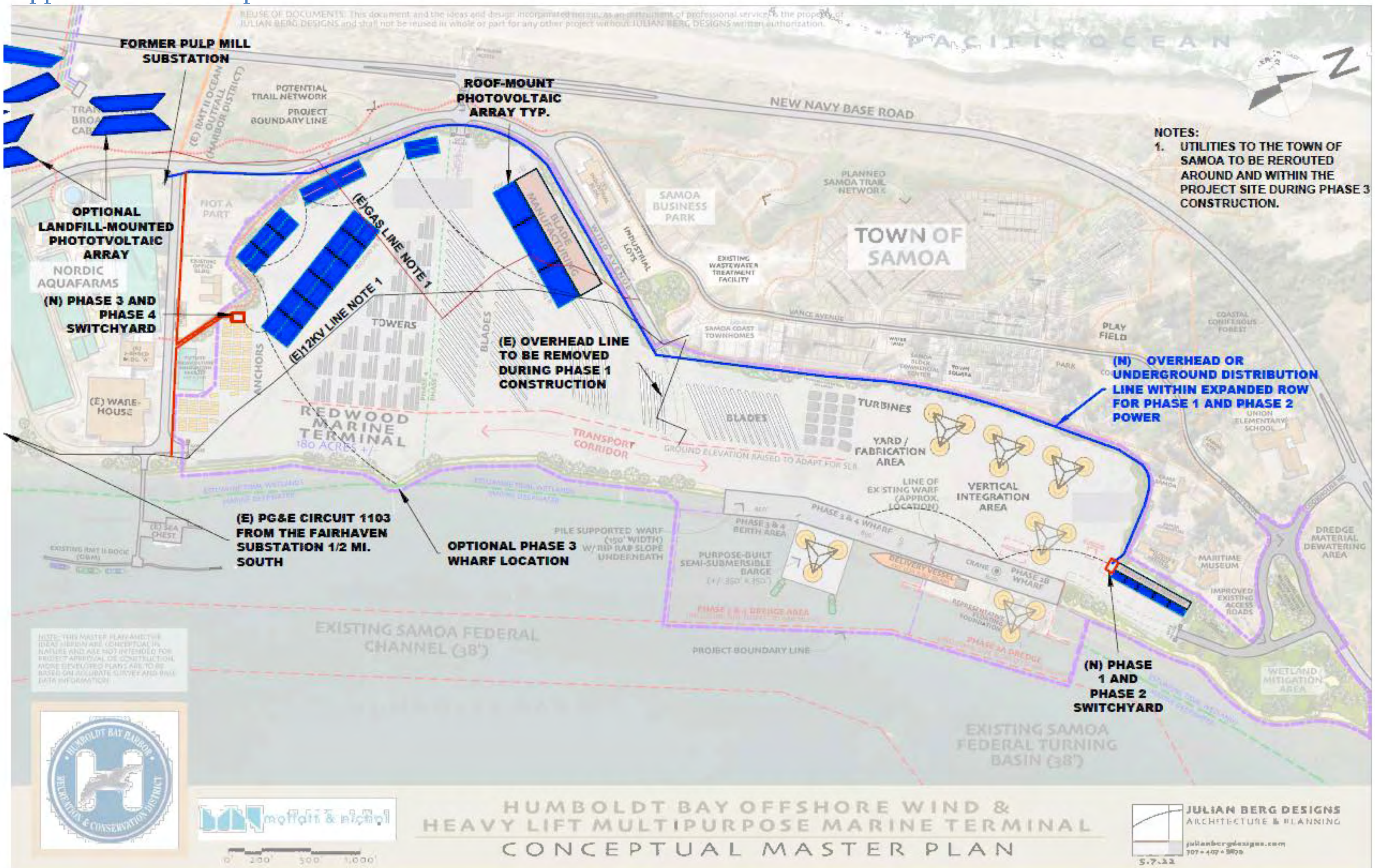
Electrical Load Estimate 2 Sept 2022

Phase	Description	Equipment	Quantity	Load KVA (each)	Connected Load (KVA)	Demand Factor	Total Load (kVA)	Notes
1	Entry and Fabrication/Assembly Building	High Mast Lighting Towers	3	9.60	28.8	1	28.8	
		Fabrication/Assembly Building (50,000 sqft)	50000	0.015	750	1	750	Phase 1
		Entry Gate / Miscellaneous	1	100.00	100	1	100	0.9 MVA
								1.3 MVA (50% Contingency)
2	Wind Turbine Laydown Area and Wharf	High Mast Lighting Towers	7	9.60	67.2	1	67.2	
		Wind Turbine Nacelle Heaters	10	10.00	100	1	100	
		Wharf Crane	1	600.00	600	0.8	480	
		Power Outlets (welding, tools, equipment)	8	15.00	120	0.5	60	
		Turbine Assembly Rack	1	200.00	200	1	200	
		Vessel Shore Power/Tug Charging	1	500.00	500	1	500	
		Battery Charging incl SPMTs	6	100.00	600	0.7	420	Phase 2
								1.8 MVA
								2.7 MVA (50% Contingency)
3	Blade Manufacturing and Blade Laydown Area, Wharf	High Mast Lighting Towers	7	9.60	67.2	1	67.2	
		Power Outlets (welding, tools, equipment)	7	15.00	105	0.5	52.5	
		Blade Manufacturing Facility (240,000 sqft)	240000	0.008	1920	1	1920	
		Turbine Assembly Rack	1	200.00	200	1	200	
		Vessel Shore Power/Tug Charging	1	500.00	500	1	500	
		Battery Charging incl SPMTs	16	100.00	1600	0.5	800	Phase 3
		Cranes	4	300.00	1200	0.6	720	4.3 MVA
								6.4 MVA (50% Contingency)
4	Tower Manufacturing and Tower Laydown Area	High Mast Lighting Towers	5	9.60	48	1	48	
		Wind Turbine Nacelle Heaters	10	10.00	100	1	100	
		Power Outlets (welding, tools, equipment)	5	15.00	75	0.5	37.5	
		Office Building (20,000 sqft)	20000	0.02	400	1	400	
		Manufacturing Building (40,000 sqft)	40000	0.01	400	0.75	300	
		Manufacturing Building (60,000 sqft)	60000	0.01	600	0.75	450	
		Tower Manufacturing Building (180,000 sqft)	180000	0.01	1440	0.75	1080	Phase 4
		Vessel Shore Power	1	300.00	300	1	300	2.7 MVA
								4.1 MVA (50% Contingency)
						Total MVA	9.7	
						Total MVA	**14.5**	50% Contingency

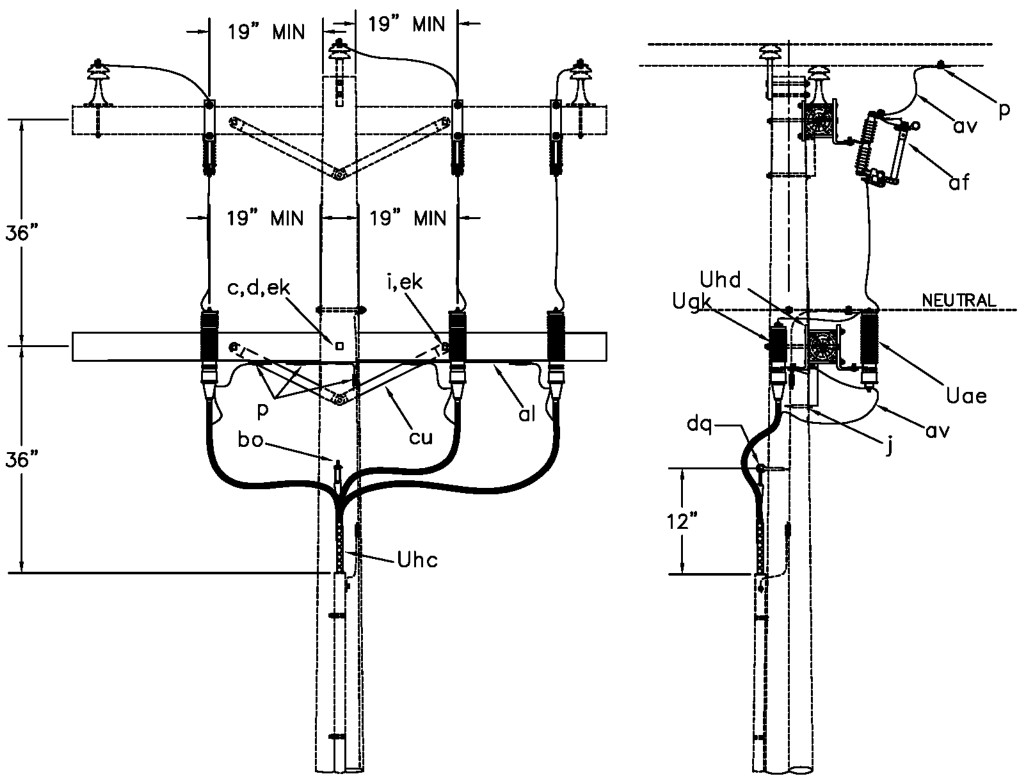
Appendix C: Conceptual Phasing Plan



Appendix D: Conceptual Master Plan



Appendix E: Overhead Line and Utility Re-routing Specifications



ITEM	QTY.	MATERIAL
c	1	Bolt, machine, 5/8” x required length.
d	2	Washer, square 2 1/4”.
g	1	Crossarm, 3 5/8” x 4 5/8” x 8’–0”
i	2	Bolt, carriage, 3/8” x 4 1/2”
j	1	Screw, lag 1/2” x 4” as required.
p		Connectors, as required.
af	3	Cutout
al		Staples, as required.
av		Jumpers, as required.
bo	1	Anchor, shackle.
cu	2	Brace, wood, 28”
dq	1	Eye screw, elliptical or drive hook.
ek	3	Locknuts, as required.
Uae	3*	Surge arrester
Ugk	3	Cable termination.
Uhc	3	Cable support.
Uhd	3	Crossarm mounting bracket.

NOTES:

1. TOTAL ARRESTER LEAD LENGTH MUST BE UNDER 3’.
2. NO BENDS PERMITTED WITHIN 6” OF CABLE TERMINAL BASE.
3. MINIMUM 4” BETWEEN BOLTS.

THREE PHASE CABLE TERMINAL POLE
WITH UPPER CROSSARM MOUNTING CUTOUTS
AND CROSSARM MOUNTING ARRESTERS

AUG 2016	3 – PHASE PRIMARY	
RUS		UC5

Crossing of Class H" Supply Line Over Major Railroad and Major Communication Lines

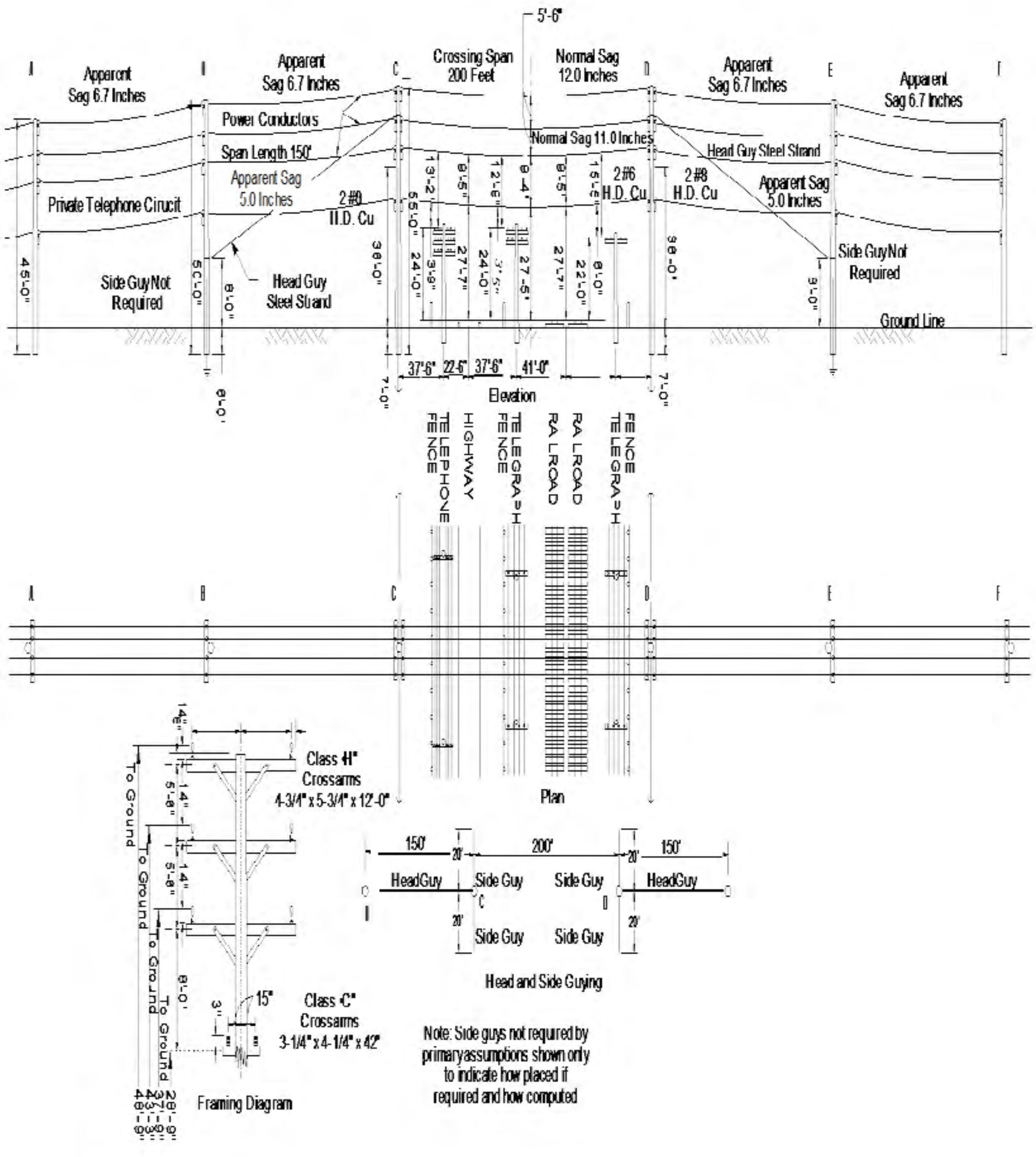


Table 1: Basic Minimum Allowable Vertical Clearance of Wires above Railroads, Thoroughfares, Ground or Water Surfaces; Also Clearances from Poles, Buildings, Structures or Other Objects (nn) (Letter References Denote Modifications of Minimum Clearances as Referred to in Notes Following This Table)

Case No.	Nature of Clearance	Wire or Conductor Concerned: A Span Wires (Other than Trolley Span Wires) Overhead Guys and Messengers	B Communication Conductors (Including Open Wire, Cables and Service Drops), Supply Service Drops of 0 - 750 Volts	C Trolley Contact, Feeder and Span Wires, 0 - 5,000 Volts	D Supply Conductors of 0 - 750 Volts and Supply Cables Treated as in Rule 57.8	E Supply Conductors and Supply Cables, 750 - 22,500 Volts	F Supply Conductors and Supply Cables, 22.5 - 300 kV	G Supply Conductors and Supply Cables, 300 - 550 kV (mm)
1	Crossing above tracks of railroads which transport or propose to transport freight cars (maximum height 15 feet, 6 inches) where not operated by overhead contact wires. (a) (b) (c) (d)	25 Feet	25 Feet	22.5 Feet	25 Feet	28 Feet	34 Feet	34 Feet (kk)
2	Crossing or paralleling above tracks of railroads operated by overhead trolleys. (b) (c) (d)	26 Feet (e)	26 Feet (e) (f) (g)	22.5 Feet (h) (i) (eee)	27 Feet (e) (g)	30 Feet (g)	34 Feet (g)	34 Feet (g) (kk)
3	Crossing or along thoroughfares in urban districts or crossing thoroughfares in rural districts. (c) (d)	18 Feet (j) (k) (ii)	18 Feet (j) (l) (m) (ii) (kkk)	19 Feet (hh) (eee)	20 Feet (ii)	25 Feet (o) (ii)	30 Feet (o) (ii)	30 Feet (o) (ii) (kk)
4	Above ground along thoroughfares in rural districts or across other areas capable of being traversed by vehicles or agricultural equipment.	15 Feet (k)	15 Feet (m) (n) (p)	19 Feet (eee)	19 Feet	25 Feet (o)	30 Feet (o) (p)	30 Feet (o) (kk)
5	Above ground in areas accessible to pedestrians only	8 Feet	10 Feet (m) (q)	19 Feet (eee)	12 Feet	17 Feet	25 Feet (o)	25 Feet (o) (kk)
6	Vertical clearance above walkable surfaces on buildings, (except generating plants or substations) bridges or other structures which do not ordinarily support conductors, whether attached or unattached.	8 Feet (r)	8 Feet (r)	8 Feet	8 Feet	12 Feet	12 Feet	20 Feet (ll)
6a	Vertical clearance above non-walkable surfaces on buildings, (except generating plants or substations) bridges or other structures, which do not ordinarily support conductors, whether attached or unattached	2 Feet	8 Feet (yy)	8 Feet	8 Feet (zz)	8 Feet	8 Feet	20 Feet
7	Horizontal clearance of conductor at rest from buildings (except generating plants and substations), bridges or other structures (upon which men may work) where such conductor is not attached thereto (s) (t)	-	3 Feet (u)	3 Feet	3 Feet (u) (v)	6 Feet (v)	6 Feet (v)	15 Feet (v)
8	Distance of conductor from center line of pole, whether attached or unattached (w) (x) (y)	-	15 inches (s) (aa)	15 inches (aa) (bb) (cc)	15 inches (o) (aa) (dd)	15 or 18 inches (o) (dd) (ee) (jj)	18 inches (dd) (ee)	Not Applicable
9	Distance of conductor from surface of pole, crossarm or other overhead line structure upon which it is supported, providing it complies with case 8 above (x)	-	3 inches (aa) (ff)	3 inches (aa) (cc) (gg)	3 inches (aa) (dd) (gg)	3 inches (dd) (gg) (jj)	1/4 Pin Spacing Shown in Table 2 Case 15 (dd)	1/2 Pin Spacing Shown in Table 2 Case 15 (dd)

Table 1 (Continued)

Case No.	Nature of Clearance	Wire or Conductor Concerned: A Span Wires (Other than Trolley Span Wires) Overhead Guys and Messengers	B Communication Conductors (Including Open Wire, Cables and Service Drops), Supply Service Drops of 0 - 750 Volts	C Trolley Contact, Feeder and Span Wires, 0 - 5,000 Volts	D Supply Conductors of 0 - 750 Volts and Supply Cables Treated as in Rule 57.8	E Supply Conductors and Supply Cables, 750 - 22,500 Volts	F Supply Conductors and Supply Cables, 22.5 - 300 kV	G Supply Conductors and Supply Cables, 300 - 550 kV (mm)
10	Radial centerline clearance of conductor or cable (unattached) from non-climbable street lighting or traffic signal poles or standards, including mastarms, brackets and lighting fixtures, and from antennas that are not part of the overhead line system.	-	1 Foot (u) (rr) (ss)	15 inches (bb) (cc)	3 Feet (oo)	6 Feet (pp)	10 Feet (qq)	10 Feet (ll)
11	Water areas not suitable for sailboating (tt) (uu) (ww) (xx)	15 Feet	15 Feet	-	15 Feet	17 Feet	25 Feet	25 Feet (kk)
12	Water areas suitable for sailboating, surface area of: (tt) (vv) (ww) (xx)							
	(A) Less than 20 acres	18 Feet	18 Feet	-	18 Feet	20 Feet	27 Feet	27 Feet (kk)
	(B) 20 to 200 acres	26 Feet	26 Feet	-	26 Feet	28 Feet	35 Feet	35 Feet (kk)
	(C) Over 200 to 2,000 acres	32 Feet	32 Feet	-	32 Feet	34 Feet	41 Feet	41 Feet (kk)
	(D) Over 2,000 acres	38 Feet	38 Feet		38 Feet	40 Feet	47 Feet	47 Feet (kk)
13	Radial clearance of bare line conductors from tree branches or foliage (aaa) (ddd)	-	-	18 inches (bbb)	-	18 inches (bbb)	1/4 pin spacing shown in table 2, Case 15 (bbb) (ccc)	1/2 pin spacing shown in table 2, Case 15
14	Radial clearance of bare line conductors from vegetation in Extreme and VeryHigh Fire Threat Zones in Southern California (aaa) (ddd) (hhh)(jjj)			18 inches (bbb)		48 inches (bbb) (iii)	48 inches (fff)	120 inches (ggg)

References to Rules Modifying Minimum Clearances in Table 1	Rule
(a) Shall not be reduced more than 5% because of temperature or loading	37
1 Supply lines	54.4-B1
2 Communication lines	84.4-B1
(b) Shall be increased for supply conductors on suspension insulators, under certain conditions	37
(c) Special clearances are provided for traffic signal equipment	58.4-C
(d) Special clearances are provided for street lighting equipment	58.5-B
(e) Based on trolley pole throw of 26 feet. may be reduced where suitably protected	56.4-B2
1 Supply guys	56.4-B2
2 Supply cables and messengers	57.4-B2
3 Communication guys	86.4-B2
4 Communication cables and messengers	87.4-B2
(f) May be reduced depending on height of trolley contact conductors	
1 Supply service drops	54.8-C5
2 Communication service drops	84.8-D5
(g) May be reduced and shall be increased depending on trolley throw	
1 Supply conductors (except service drops)	54.4-B2
2 Communication conductors (except service drops)	84.4-B2
(h) May be decreased where freight cars are not transported.	
1. Trolley contact and feeder conductors.	74.4-B1
2. Trolley span wires	77.4-A
(i) May be reduced for trolley contact and span wires in subways, tunnels, under bridges and in fenced areas	
1 Trolley contact conductors	74.4-E
2 Trolley span wires	77.4-B
(j) May be reduced at crossings over private thoroughfares and entrances to private property and over private property	
1 Supply service drops	54.8-B2
2 Supply guys	56.4-A
3 Communication service drops	84.8-C2
4 Communication guys	86.4-A
(k) May be reduced along thoroughfares where not normally accessible to vehicles	
1 Supply guys	56.4-A1
2 Communication guys	86.4-A1
(l) May be reduced where within 12 feet of curb line of public thoroughfares	
1 Supply service drops	54.8-B1
2 Communication service drops	84.8-C1
(m) May be reduced for railway signal cables under special conditions	84.4-A4

Table 2: Basic Minimum Allowable Clearance of Wires from Other Wires at Crossings, in Midspans and at Supports (Letter References Denote Modifications of Minimum Clearances as Referred to in Notes Following This Table) All Clearances are in Inches

Case No.	Nature of Clearance and Class and Voltage of Wire, Cable or Conductor Concerned	Other Wire, Cable or Conductor Concerned			Supply Conductors (Including Supply Cables)							
		A Span Wires, Guys and Messengers	B Trolley Contact Conductors 0 – 750 Volts	C Communication Conductors (Including Open Wire, Cables and Service Drops)	D 0 – 750 Volts (Including Service Drops) and Trolley Feeders (a)	E 750 - 7,500 Volts	F 7,500 - 20,000 Volts	G 20,000 - 35,000 Volts	H 35,000 - 75,000 Volts	I 75,000 - 150,000 Volts	J 150,000 - 300,000 Volts	K (kk) 300,000 - 550,000 Volts
	Clearance between wires, cables and conductors not supported on the same poles, vertically at crossings in spans and radially where colinear or approaching crossings											
1	Span wires, guys and messengers (b)	18 (c)	48 (d, e)	24 (e)	24 (e)	36 (f)	36	72	72	78	78 (gg)	138 (hh)
2	Trolley contact conductors, 0 - 750 volts	48 (d, e)	-	48 (d)	48 (d, h)	48	72	96	96	96	96 (gg)	156 (hh)
3	Communication conductors	24 (e)	48 (d)	24	48 (i)	48 (dd)	72	96	96	96	96 (gg)	156 (hh)
4	Supply conductors, service drops and trolley feeders, 0 - 750 volts (qq)	24 (e)	48 (d, h)	48 (i)	24	48	48	96 (oo)	96	96	96(gg)	156 (hh)
5	Supply conductors, 750 - 7,500 volts (qq)	36 (f)	48	48 (dd)	48	48 (h)	72	96 (oo)	96	96	96(gg)	156 (hh)
6	Supply conductors, 7,500 - 20,000 volts (qq)	36	72	72	48	72	72	96 (oo)	96	96	96 (gg)	156 (hh)
7	Supply conductors, more than 20,000 volts (qq)	72 (g)	96 (g)	96 (g)	96 (g, oo)	96 (g, oo)	96 (g, oo)	96 (g, oo)	96 (g)	96	96 (gg)	156 (hh)
	Vertical separation between conductors and/or cables, on separate crossarms or other supports at different levels (excepting on related line and buck arms) on the same pole and in adjoining midspans											
8	Communication Conductors and Service Drops	-	-	12 (j, rr)	48 (k, l, m, n, pp)	48 (k)	72 (m n)	72 (m)	72	78	87 (gg)	147 (hh)
9	Supply Conductors Service Drops and Trolley Feeders, 0 - 750 Volts	-	-	48 (k, l, m, n, pp)	24 (h, k, m, o)	48 (k, m, p)	48 (k, m, p)	72 (m, nn)	72	78	87 (gg)	147 (hh)

2.3.4. (continued)

Table 2-1 Minimum Separation and Clearance Requirements for Trenches[1]

		G	Duct T	DB T	C	S	P	SL
				(In Inches)				
G	Gas[2]	–	12	12	12	6	12	6
T	Telephone (Duct)	12	–	1	1	12	12	12
T	Telephone (Direct Bury)	12	1	–	1	12	12	12
C	CATV	12	1	1	–	12	12	12
S	Electric Secondary	6	12	12	12	1.5	3	1.5
P	Electric Primary	12	12	12	12	3	3	3
SL	Streetlight[3]	6	12	12	12	1.5	3	1.5
NE	Foreign Electric Sources, Non-PG&E[4]	12	12	12	12	12	12	12

1 All separation clearance distances are in inches.
2 For more information about this table, see Company Bulletin TD-5453B-002, "Updated Separation Requirements For Conduit in Joint Trench." located in Appendix B.
3 Streetlight circuits ***not owned*** by PG&E must be installed to meet the requirements in PG&E's *Joint Trench Configurations & Occupancy Guide*. Specifically, applicants must review the requirements for working with a second utility company.
4 Considered a "utility" as defined in Utility Standard S5453, "Joint Trench."

PG&E does ***not*** differentiate between the clearances for casing/conduit and pipe. The clearances and installation requirements are the same for both.

For more information on backfill-sand requirements, see Engineering Material Specification EMS-4123, "Backfill Sand," located in Appendix B.

For more information on the minimum separation and clearance requirements for service trenches, see the *Joint Trench Configurations & Occupancy Guide*.

When different service facilities (e.g., gas, electric, telecommunications) are installed in close proximity (e.g., in a joint trench), applicants must ensure that the facilities maintain a minimum horizontal separation of 36 inches from the gas riser where they transition from below ground to above ground.

Clearances between other facilities can be reduced ***only*** when the parties supplying those services or facilities reach a mutual agreement.

Note: Applicants must ensure that sufficient space is provided between facilities at all times to allow for safe maintenance and operation.

A. Applicants must ***not*** install any electrical devices or equipment including wires, cables, metering and telecommunication enclosures, bond wires, clamps, or ground rods within 36 inches of the gas service riser.

This distance can be reduced to 18 inches for electrical devices or equipment certified for National Electric Code (NEC) Class I, Division 2 locations. See Figure 2-19, "Electric and Gas Meter Set Separation Dimensions and Clearances," on Page 2-32, and Figure 2-21, "Gas Regulator Set Clearance Requirement from Sources of Ignition," on Page 2-35.

Appendix F: HelioScope Rooftop Annual Production Report

HelioScope | Annual Production Report produced by Steve Richards

Design 1 OSW Wind Port, 936 Vance Ave, Samoa, CA 95564

Report

Project Name	OSW Wind Port
Project Address	936 Vance Ave, Samoa, CA 95564
Prepared By	Steve Richards steven.c.richards@humboldt.edu

Schatz Energy Research Center

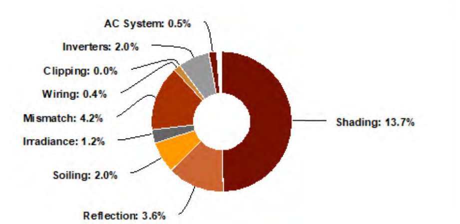
System Metrics

Design	Design 1
Module DC Nameplate	6.35 MW
Inverter AC Nameplate	5.10 MW Load Ratio: 1.25
Annual Production	7.097 GWh
Performance Ratio	75.2%
kWh/kWp	1,117.0
Weather Dataset	TMY, 10km Grid (40.85,-124.15), NREL (prospector)
Simulator Version	ada662d322-df0e856433-c90e500374-981fef9d56

Project Location

Monthly Production

Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,450.6	
	POA Irradiance	1,485.6	2.4%
	Shaded Irradiance	1,281.6	-13.7%
	Irradiance after Reflection	1,234.9	-3.6%
	Irradiance after Soiling	1,210.2	-2.0%
	Total Collector Irradiance	1,210.2	0.0%
Energy (kWh)	Nameplate	7,693,915.2	
	Output at Irradiance Levels	7,602,838.9	-1.2%
	Output at Cell Temperature Derate	7,627,499.1	0.3%
	Output After Mismatch	7,310,069.3	-4.2%
	Optimal DC Output	7,278,645.6	-0.4%
	Constrained DC Output	7,277,946.9	0.0%
	Inverter Output	7,132,380.7	-2.0%
	Energy to Grid	7,096,719.0	-0.5%
Temperature Metrics			
	Avg. Operating Ambient Temp		12.0 °C
	Avg. Operating Cell Temp		18.6 °C
Simulation Metrics			
		Operating Hours	4654
		Solved Hours	4654

Condition Set

Description	Condition Set 1												
Weather Dataset	TMY, 10km Grid (40.85,-124.15), NREL (prospector)												
Solar Angle Location	Meteo Lat/Lng												
Transposition Model	Perez Model												
Temperature Model	Sandia Model												
Temperature Model Parameters	Rack Type	a	b	Temperature Delta									
	Fixed Tilt	-3.56	-0.075	3°C									
	Flush Mount	-2.81	-0.0455	0°C									
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D	
	2	2	2	2	2	2	2	2	2	2	2	2	
Irradiation Variance	5%												
Cell Temperature Spread	4° C												
Module Binning Range	-2.5% to 2.5%												
AC System Derate	0.50%												
Module Characterizations	Module	Uploaded By	Characterization										
	CS3W-420P (1000V) (Canadian Solar)	HelioScope	Spec Sheet Characterization, PAN										
Component Characterizations	Device	Uploaded By	Characterization										
	CPS SCH100KTL-DO/US-480 (Chint Power Systems)	HelioScope	Spec Sheet										

Components

Component	Name	Count
Inverters	CPS SCH100KTL-DO/US-480 (Chint Power Systems)	51 (5.10 MW)
Strings	10 AWG (Copper)	561 (305,313.6 ft)
Module	Canadian Solar, CS3W-420P (1000V) (420W)	15,127 (6.35 MW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	-	20-29	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 11	Fixed Tilt	Landscape (Horizontal)	14°	319°	0.0 ft	1x1	0	0	0
Field Segment 3	Fixed Tilt	Landscape (Horizontal)	14°	349°	0.0 ft	1x1	0	0	0
Field Segment 4	Fixed Tilt	Landscape (Horizontal)	14°	169°	0.0 ft	1x1	4,551	4,551	1.91 MW
Field Segment 5	Fixed Tilt	Landscape (Horizontal)	14°	289.5°	0.0 ft	1x1	286	286	120.1 kW
Field Segment 6	Fixed Tilt	Landscape (Horizontal)	14°	109.5°	0.0 ft	1x1	286	286	120.1 kW
Field Segment 7	Fixed Tilt	Landscape (Horizontal)	14°	267.4°	0.0 ft	1x1	583	579	243.2 kW
Field Segment 8	Fixed Tilt	Landscape (Horizontal)	14°	87.3°	0.0 ft	1x1	583	579	243.2 kW
Field Segment 9	Fixed Tilt	Landscape (Horizontal)	14°	247°	0.0 ft	1x1	954	950	399.0 kW
Field Segment 10	Fixed Tilt	Landscape (Horizontal)	14°	67°	0.0 ft	1x1	954	950	399.0 kW
Field Segment 11	Fixed Tilt	Landscape (Horizontal)	14°	247.9°	0.0 ft	1x1	3,172	3,152	1.32 MW
Field Segment 12	Fixed Tilt	Landscape (Horizontal)	14°	67.8°	0.0 ft	1x1	3,172	3,152	1.32 MW
Field Segment 12	Fixed Tilt	Landscape (Horizontal)	14°	138.7°	0.0 ft	1x1	650	642	269.6 kW

Detailed Layout

Appendix G: HelioScope Landfill Annual Production Report

HelioScope | Annual Production Report produced by Steve Richards

Design 2 Landfill, 936 Vance Ave, Samoa, CA 95564

Report

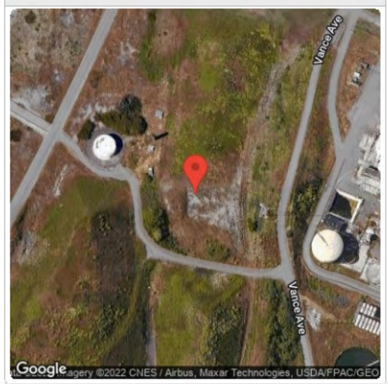
Project Name	Landfill
Project Address	936 Vance Ave, Samoa, CA 95564
Prepared By	Steve Richards steven.c.richards@humboldt.edu

Schatz Energy Research Center

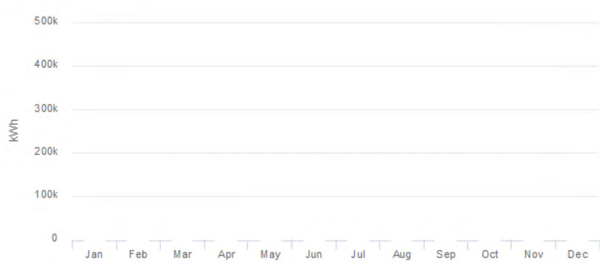
System Metrics

Design	Design 2
Module DC Nameplate	2.51 MW
Inverter AC Nameplate	2.02 MW Load Ratio: 1.24
Annual Production	2.920 GWh
Performance Ratio	82.0%
kWh/kWp	1,163.0
Weather Dataset	TMY, 10km Grid (40.85,-124.15), NREL (prospector)
Simulator Version	6d631a840a-5f7ded908c-38381c2dbb-6ef8d412e1

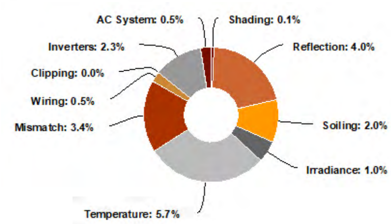
Project Location



Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,450.6	
	POA Irradiance	1,418.2	-2.2%
	Shaded Irradiance	1,416.3	-0.1%
	Irradiance after Reflection	1,359.0	-4.0%
	Irradiance after Soiling	1,331.8	-2.0%
	Total Collector Irradiance	**1,331.8**	**0.0%**
Energy (kWh)	Nameplate	3,346,545.0	
	Output at Irradiance Levels	3,312,837.1	-1.0%
	Output at Cell Temperature Derate	3,123,624.1	-5.7%
	Output After Mismatch	3,018,390.3	-3.4%
	Optimal DC Output	3,003,880.4	-0.5%
	Constrained DC Output	3,003,871.6	0.0%
	Inverter Output	2,935,135.7	-2.3%
	Energy to Grid	**2,920,460.0**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		12.0 °C
	Avg. Operating Cell Temp		26.9 °C
Simulation Metrics			
	Operating Hours		4654
	Solved Hours		4654

Condition Set

Description	Condition Set 1
Weather Dataset	TMY, 10km Grid (40.85,-124.15), NREL (prospector)
Solar Angle Location	Meteo Lat/Lng
Transposition Model	Perez Model
Temperature Model	Sandia Model
Irradiation Variance	5%
Cell Temperature Spread	4° C
Module Binning Range	-2.5% to 2.5%
AC System Derate	0.50%

Temperature Model Parameters

Rack Type	a	b	Temperature Delta
Fixed Tilt	-3.56	-0.075	3°C
Flush Mount	-2.81	-0.0455	0°C

Soiling (%)

J	F	M	A	M	J	J	A	S	O	N	D
2	2	2	2	2	2	2	2	2	2	2	2

Module Characterizations

Module	Uploaded By	Characterization
CS3W-420P (1500V) (Canadian Solar)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
Sunny Tripower 24000TL-US (SMA)	HelioScope	Modified CEC

 1/3 August 10, 2022

Components

Component	Name	Count
Inverters	Sunny Tripower 24000TL-US (SMA)	84 (2.02 MW)
Strings	10 AWG (Copper)	405 (90,480.2 ft)
Module	Canadian Solar, CS3W-420P (1500V) (420W)	5,979 (2.51 MW)

Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	-	4-19	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Landscape (Horizontal)	15°	270°	2.0 ft	1x1	882	882	370.4 kW
Field Segment 2	Flush Mount	Landscape (Horizontal)	15°	98.5°	2.0 ft	1x1	832	832	349.4 kW
Field Segment 3	Flush Mount	Landscape (Horizontal)	15°	298°	2.0 ft	1x1	1,181	1,181	496.0 kW
Field Segment 4	Flush Mount	Landscape (Horizontal)	15°	85°	2.0 ft	1x1	863	863	362.5 kW
Field Segment 5	Flush Mount	Landscape (Horizontal)	15°	91°	2.0 ft	1x1	323	323	135.7 kW
Field Segment 6	Flush Mount	Landscape (Horizontal)	15°	104°	2.0 ft	1x1	1,037	1,037	435.5 kW
Field Segment 7	Flush Mount	Landscape (Horizontal)	15°	285°	2.0 ft	1x1	861	861	361.6 kW

Detailed Layout