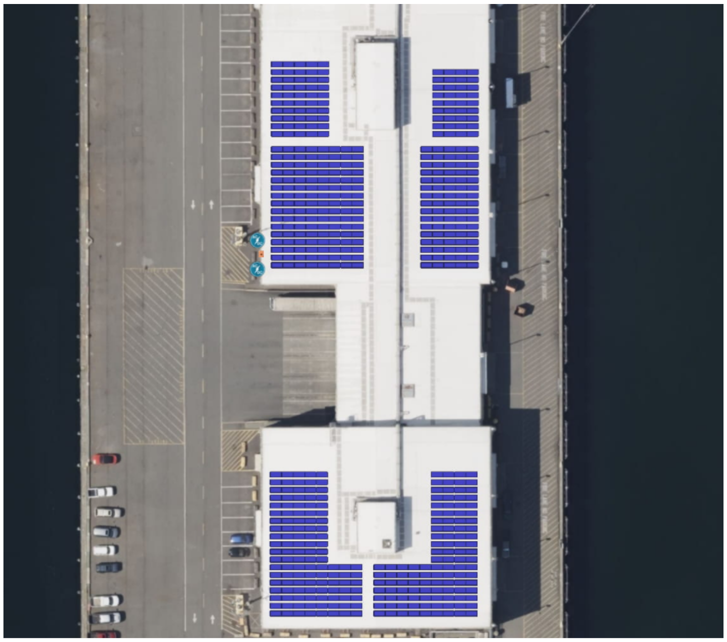

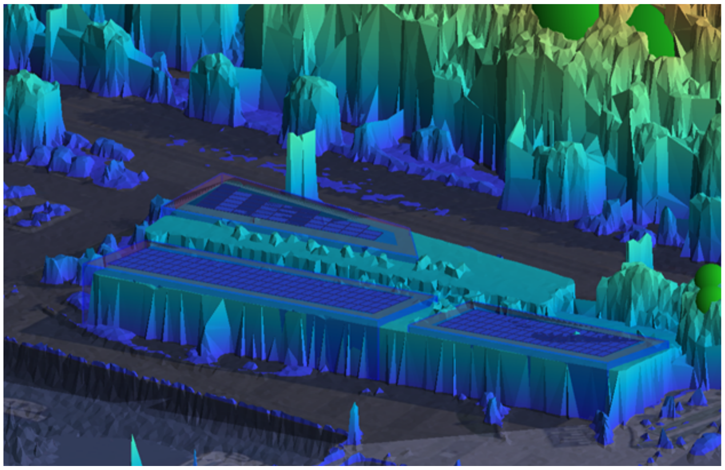

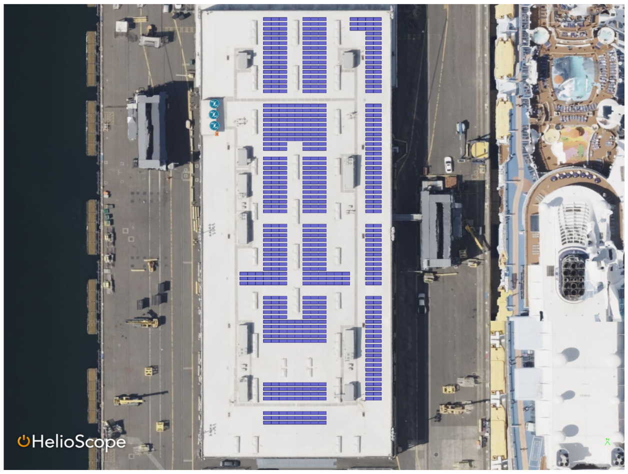

Port of Seattle
Env & Sustainability Audit Support Services

MARITIME SOLAR PHOTOVOLTAIC FEASIBILITY STUDY

FINAL REPORT | DECEMBER 2024

Acknowledgements

Säzän Group would like to acknowledge the following organizations and individuals for their contributions that supported the success of this solar feasibility study over so many sites in a compressed timeline:

Port of Seattle
Alex Adams, Senior Manager, Environmental Programs
Jacob Keith, Environmental Program Manager, Building Energy Diagnostician
Cam Walker, Energy Program Senior Environmental Management Specialist

TKDA Structural Engineers
Dan Munn, PE, SE
Craig Collins, PE

Project Context

This solar feasibility study for the Port of Seattle's maritime building portfolio is a critical component of the organization's broader sustainability and resiliency planning efforts, aligned with the Port's Century Agenda and Maritime Climate and Air Action Plan (MCAAP) goals. Rather than serving as a stand-alone report, this study should be considered complimentary to and in the context of the information, analyses and recommendations of previous work completed by the Port including the Sustainable Evaluation Framework and Seattle Waterfront Clean Energy Strategy. Similarly, implementation of the specific projects contained in this study will need to consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.

While three buildings were shortlisted as "prioritized sites" in the report, this does not exclude other assessed sites as infeasible for solar. The top 11 solar installation projects are all deemed feasible based on constructability, energy performance, cost-benefit, and Port-identified priorities. However, all 50 sites could potentially be feasible with further structural and electrical evaluation. The preliminary assessment of all 50 sites offers a strategic framework for the Port's clean energy project development.

Thorough coordination of these interconnected studies should be considered to achieve a holistic approach to meet the Port's ambitious goals for greenhouse gas reduction, energy efficiency, and operational resilience, while ensuring that infrastructure investments are forward-looking and aligned with a transition to a clean energy future. This integrated approach reflects the Port's commitment to thoughtful and holistic planning as it advances sustainability and climate leadership.

Table of Contents

I. Glossary

AC-Nameplate Capacity
The rated capacity of a solar inverter, which is used to dictate the Interconnection Standards for renewable energy systems that tie into the utility grid.

Alternating Current (AC)
A type of electrical current that is usable in buildings and for appliances.

Azimuth Angle
The angle between true south and the point on the horizon directly below the sun[1].

Battery Energy Storage System (BESS)
Technology and equipment used to store electricity for use at a later time.

British Thermal Unit (BTU)
Standard unit of measurement for energy defined as the amount of energy required to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

Curtailment
Forced reduction in solar PV production. Most commonly required to avoid export of solar PV power onto the grid to meet utility needs.

Direct Current (DC)
Electrical transmission and distribution that must be converted to Alternating Current for use in a building.

DC-Nameplate Capacity
The total combined rated capacity of solar panels within a photovoltaic array.

Energy Use Intensity (EUI)
A metric that quantifies a building's energy consumption per unit of its total floor area, typically expressed in kBTU per square foot per year.

Interconnection Standard
Utility requirements for how renewable energy systems connect to the grid.

Inverter Load Ratio (IRL)
The ratio of AC-Nameplate Capacity to DC-Nameplate Capacity in a solar array, a DC-to-AC ratio of 1.20 is typical, where the capacity of solar panels is greater than the inverter capacity.

Kilowatt Hour (kWh)
A measure of electricity defined as a unit of work or energy, measured as 1 Kilowatt (1,000 Watts) of power expended for 1 hour. One kWh is equivalent to 3,412 Btu.

Net Energy Metering
A solar incentive that allows utility customers to generate surplus solar energy that is sent back onto the grid for a billing credit at the retail utility rate**.**

Net Present Value (NPV)
Financial metric used to assess the profitability of an investment or project. The net difference between cash inflows and outflows over an extended period of time.

Photovoltaic (PV) Array
A renewable energy system that connects multiple solar PV modules and inverters to generate electricity.

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[1] https://www.energy.gov/eere/solar/solar-energy-glossary

Point of Interconnection (POI)
The location where a solar PV array connects to the utility grid.

Pounds per Square Foot (PSF)
Standard unit of measurement for pressure.

Solar Access (kWh/kW/Year)
A measurement of the available solar resource based on the annual electricity generation per kilowatt of installed solar capacity.

II. Executive Summary

The increasing demand for renewable energy sources and the strategic importance of reducing carbon emissions has driven the Port of Seattle (hereafter referred to as the "Port") to explore the feasibility of solar energy projects. Moreover, the Port's Century Agenda calls for all new energy needs to be met though energy conservation or renewable sources. Additionally, enhancing the resiliency of the Port's energy supply is a critical consideration, ensuring that maritime operations remain robust and secure in the face of potential disruptions.

The solar feasibility study conducted in this effort is a critical element in broader, ongoing building energy assessments aimed at enhancing overall energy efficiency, reducing operational costs, and promoting sustainable practices across the Port's maritime facilities. The results of this feasibility study will be integrated into the wider building energy assessment currently being performed and will support project teams in their evaluation of sustainability opportunities under the Sustainable Evaluation Framework Policy. By doing so, the Port aims to ensure that renewable energy opportunities are aligned with other energy-saving and sustainability initiatives, creating a cohesive strategy that optimizes the Port's building performance. In addition, typical eligibility requirements for solar photovoltaic (PV) installation grants include conducting a feasibility study to determine prioritized project development opportunities.

The study will provide a comprehensive analysis of the potential for solar power generation that will inform decision-making for future investments in solar energy installation, support the Port's sustainability goals, enhance energy security, and improve the overall resiliency of the Port of Seattle.

Säzän Group, working with the Port (hereafter referred to as the "Port"), completed a solar feasibility study that examined 50 of the Port's maritime facilities on seven different campuses around Seattle. Over all sites, this study modeled and evaluated the feasibility of more than 5.2 megawatts (MW) of rooftop solar photovoltaics (PV) on Port properties. All 50 sites were evaluated for feasible solar PV installations using Port directed criteria, and a variety of qualitative and quantitative measures such as:

- Financial viability[2]
- Energy production potential
- Alignment with the Port's strategic energy goals
- Capacity of existing site and building infrastructure
- Maintainability
- Visibility
- System complexity

The study process included a winnowing strategy to distill all sites down and identify ten sites for additional analysis to refine modeling and research additional constraints. Of those ten, three sites

[2] "Financial viability" in the context of this study is defined as a project that has a positive Net Present Value within the normal useful life of the PV system.

were prioritized for deeper analysis and pre-design development due to their relative advantages and Port stakeholder criteria. Detailed study methodology and prioritized site system details are presented in this report.

Property Name	Stoplight Assessment	Estimated Production Power (kWh)	Year 1 Energy Savings Estimate
Terminal 91 – Smith Cove Cruise Terminal		334,500	$ 36,493.95
Terminal 91 – C-175		281,100	$ 30,668.01
Shilshole Bay Marina – A-1 Admin		97,860	$ 10,676.53
Terminal 91 – C-173		493,700	$ 53,862.67
Terminal 91 – A-1 Warehouse		250,500	$ 27,329.55
Terminal 91 - Smith Cove Covered Walkways		192,000	$ 20,947.20
Pier 66 – Bell Harbor International Conference Center		35,290	$ 3,659.57
Pier 66 – Bell Harbor Marina Office		12,200	$ 1,265.14
Terminal 91 – C-155		402,900	$ 43,956.39
Fishermen's Terminal – N-9 Netshed		105,800	$ 9,701.86
Fishermen's Terminal – C-3 West Wall Office		32,350	$ 2,966.50

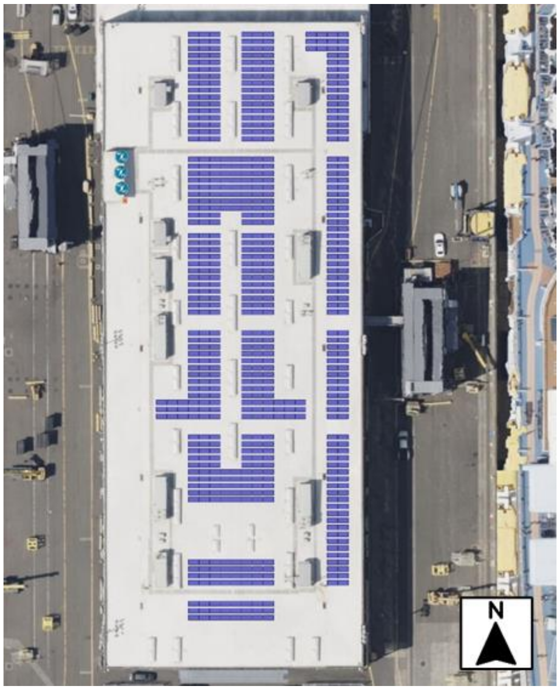
Figure 1: Site Screening Tool. Selection showing top 11 sites evaluated with respective modeled production and potential bill savings. In the Stoplight Assessment column, green indicates systems that performed well across evaluated metrics, red indicates systems that performed the least well, and yellow indicates systems with intermediate performance. In the Estimated Production column, values are color-coded to represent the modeled energy production of each system.

The top three sites identified through this study are Shilshole A-1, Terminal 91 C-175, and Terminal 91 Smith Cove Cruise Terminal. The top three sites are campus metered with high baseline energy demands; the power generated by each system is expected to be consumed onsite. As a result, none of the systems in this report are anticipated to export power from Port campuses to the grid. These prioritized solar project development opportunities were initially reviewed by Port staff for pre-design and, if chosen by the Port or its tenants to move ahead with a project in the future, are expected to provide cost effective, constructable, code-compliant, high performing installations that help lower energy costs while strengthening environmental stewardship at Terminal 91 and Shilshole Bay.

2.1 Key Findings & Recommendations

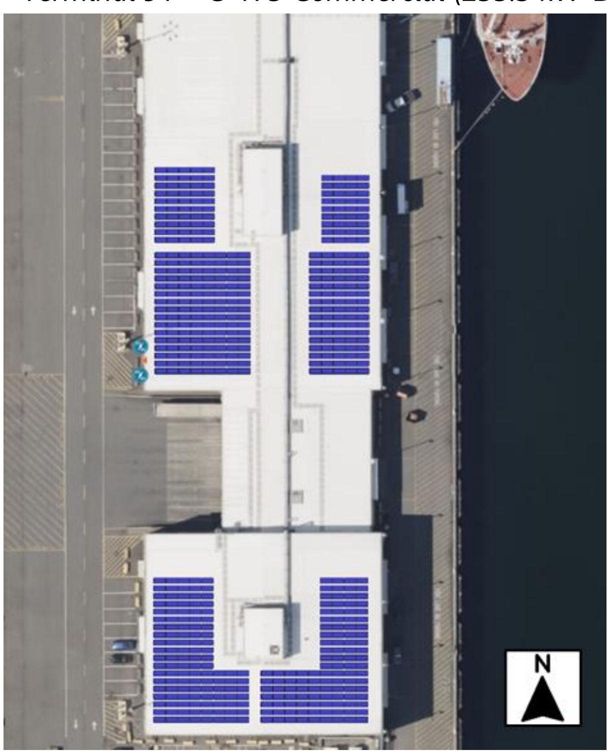
Of the 50 sites evaluated, the following solar PV arrays are the top three locations—hereafter referred to as priority locations—that are recommended for further consideration by the Port and development by project sponsors:

Terminal 91 – Smith Cove Cruise Terminal (303.8 kW-DC)



Payback year:	15
NPV (2024 USD):	$63,700
ROM cost of O&M (Year 1):	$3,000
ROM total installed cost estimate (with Port overhead premium):	$1,044,302
ROM decommissioning estimate (2050 USD):	$51,400
System Size (kW-DC):	303.8
Estimated cost per Watt (before Port overhead):	$2.75
Estimated cost per Watt (after Port overhead):	$3.44
Oct 2024 Utility Rate ($/kWh):	$0.1091

Terminal 91 – C-175 Commercial (255.3 kW-DC)



Payback year:	15
NPV (2024 USD):	$38,000
ROM cost of O&M (Year 1):	$2,600
ROM total installed cost estimate (with Port overhead premium):	$855,980
ROM decommissioning estimate (2050 USD):	$42,400
System Size (kW-DC):	255.3
Estimated cost per Watt (before Port overhead):	$2.70
Estimated cost per Watt (after Port overhead):	$3.38
Oct 2024 Utility Rate ($/kWh):	$0.1091

Shilshole Bay Marina – A-1 Administration Building (99.0 kW-DC)

Payback year:	15
NPV (2024 USD):	$16,500
ROM cost of O&M (Year 1):	$1,000
ROM total installed cost estimate (with Port overhead premium):	$290,106
ROM decommissioning estimate (2050 USD):	$16,600
System Size (kW-DC):	99.0
Estimated cost per Watt (before Port overhead):	$2.34
Estimated cost per Watt (after Port overhead):	$2.93
Oct 2024 Utility Rate ($/kWh):	$0.1091

Overall, this project identified numerous cost-effective and constructable solar PV array concepts on many Port facilities. The top 11 solar installation projects are all considered feasible in the context of constructability, energy performance, cost-benefit, and Port-identified priorities. However, all 50 sites may be feasible pending further structural and electrical evaluation. The preliminary evaluation conducted for all 50 sites provides a strategic framework for clean energy project development for the Port.

Key findings for the prioritized sites include the following considerations:

- All three system concepts are expected to achieve **payback in 17 years or less,** which is within the typical 25-year warranty period for solar PV modules.
- Combined energy savings of the prioritized sites are expected to be approximately **$77,800** in the year after construction, not including potential rebates, incentives, or grants.
- All three system concepts construction cost estimates fall within typical Washington Department of Commerce grant funding limits ($400,000-$3,000,000).
- Made-in-Washington solar modules from Silfab Solar are proposed as the basis of design. Washington-made modules will support efforts to receive the domestic content bonus from the IRS Investment Tax Credit (see section 5.1).

Outside of constructing the three priority system concepts from this report, additional recommendations include the following:

- Complete the roof replacement project at Smith Cove Cruise Terminal prior to any solar PV installation.

- Add building-level metering data to the site selection tool (Appendix A) for more granular evaluation of potential benefits of solar PV.
- Perform similar revenue grade evaluations for the remaining facilities within the Port's portfolio.
- When a selected project and timeline is established, identify specific grants and incentives to pursue that best align with that timeline and project scope.

2.2 Project Background and Purpose

This feasibility analysis represents an important and significant step towards the sustainability goals of the Port, the City of Seattle, King County, and Washington State. By targeting a wider, campus-level approach to building evaluations, the Port has created a more holistic image of renewable energy possibilities on your properties. This study aligns with the Strategic Objectives of the Port of Seattle Century Agenda[3], specifically Goal 4 "Be the greenest and most energy-efficient port in North America", the emission goals of being 50% below 2005 levels by 2030 and net zero or better by 2040 for scope 1&2 emissions, and carbon neutral or better by 2050 for scope 3 emissions[4]. The City of Seattle has also fostered a strong commitment to carbon footprint and emissions reductions. This project helps move the Port towards a lower Greenhouse Gas future which follows the goals within the Seattle Building Energy Performance Standard (BEPS)[6].

This project and the prioritized system concepts, if implemented, can advance the Maritime Climate and Air Action Plan (MCAAP)[7]. Although this project, and distributed renewables may not reduce Port local emissions from cargo handling or berthed vessels, it can provide the necessary infrastructure to reduce load on electrical distribution systems on Port terminals and properties that may otherwise face constraints in the future. This reduced load may then allow broader electrification of vehicles and shore power without requiring expensive and time-consuming upgrades of Port and SCL medium voltage feeders.

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[3] https://www.portseattle.org/page/century-agenda-strategic-objectives
[4] https://www.portseattle.org/page/measuring-greenhouse-gas-emissions-port-seattle#:~:text=The%20Port%20of%20Seattle%20cut,by%2050%20percent%20by%202030.
[6] https://www.seattle.gov/environment/climate-change/buildings-and-energy/building-emissions-performance-standard
[7] https://www.portseattle.org/page/charting-course-zero-port-seattles-maritime-climate-and-air-action-plan

III. Methodology

The solar feasibility study methodology details the procedures, assumptions, and considerations applied to each Maritime Port facility.

3.1 Remote Site Assessment

A remote site assessment for each location for all 50 Maritime Port facilities was conducted to evaluate solar feasibility for project development.

This remote assessment process involved reviewing the physical and environmental characteristics of each facility using available satellite imagery and Port-provided documentation. Preliminary solar models were developed for each site, assessing roof sizes, types, obstructions, orientations, and pitches based on the available information. This data informed the preliminary solar PV models produced in Helioscope modelling software.

The solar models produced using Helioscope modelling software, included the following design parameters:

1. Including walking paths for larger arrays to avoid the 150-foot array span limit (Seattle Fire Code 2021 section 1205.3.2) and provide easy maintenance access for rooftop equipment.
2. Microsoft Bing satellite imagery was typically used over other datasets for its improved alignment with the LIDAR data. LIDAR data was used for the shading analysis from adjacent structures and trees. Additionally, LIDAR was used to identify roof obstructions, pitch, and azimuth.

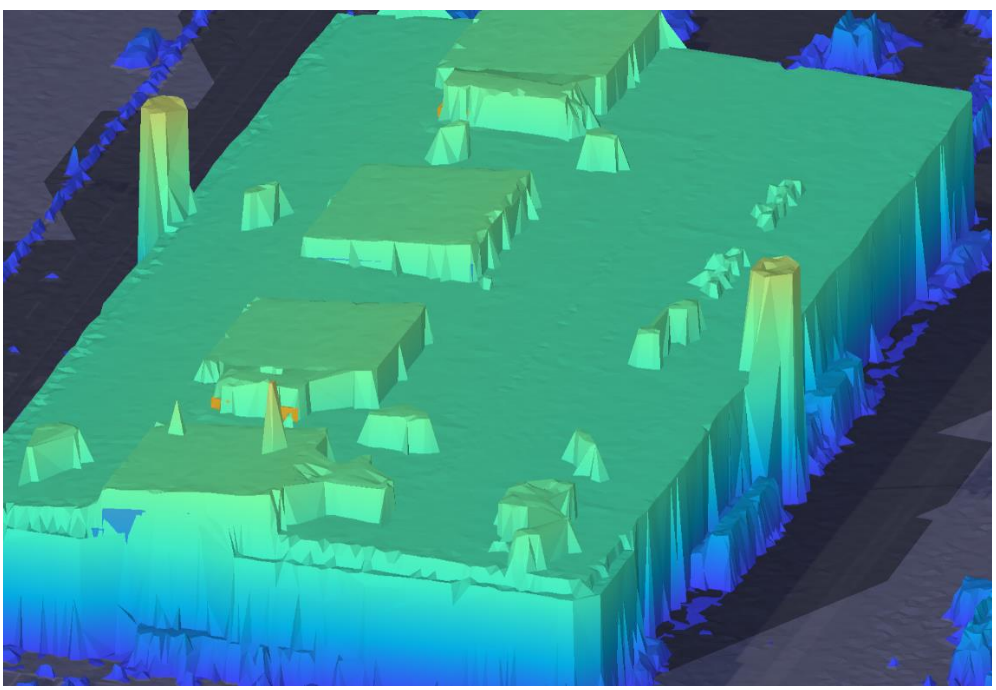

Figure 2: T91 A-1 Warehouse Building LIDAR showing roof slope, azimuth, and obstructions

3. Visible obstructions (parapet walls, skylights, and rooftop mechanical equipment) that were able to be identified from the available satellite imagery and street-view imagery were

modeled as "keepout" areas to ensure realistic solar install areas, accessibility, and shading impacts to the array.

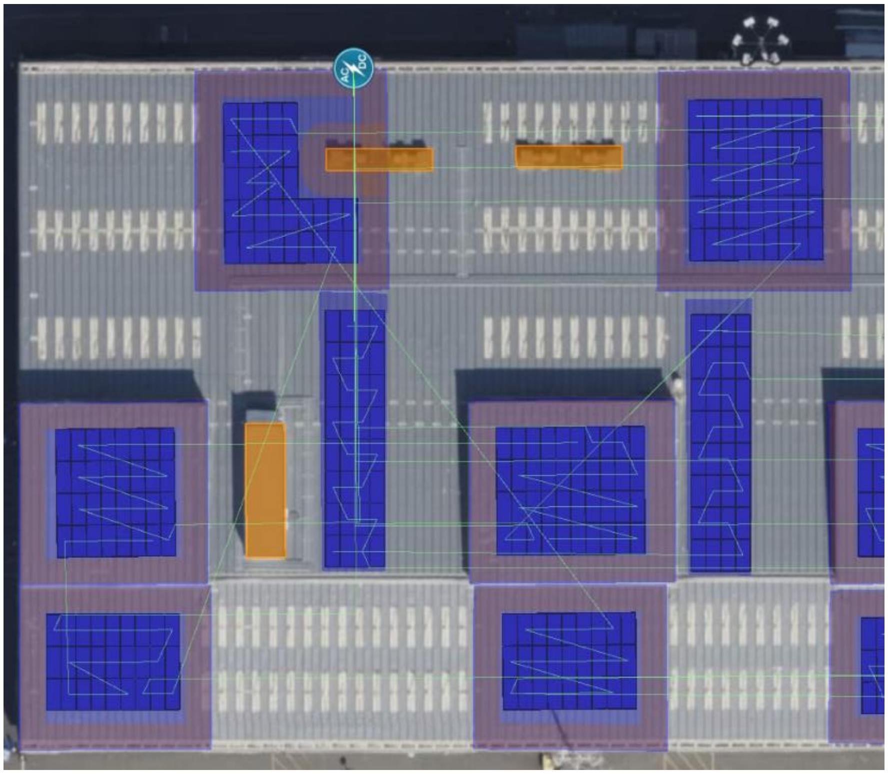

Figure 3: T91 A-1 Warehouse Building with "keepouts" in orange to provide more accurate shading in modeling. Heights and dimensions are then confirmed through site walks for shortlist facilities.

4. For the Terminal 91 Smith Cove and Pier 66 facilities, cruise ships were inserted into versions of the solar models to identify shading impacts. To account for the transient nature of these obstructions to the available solar resource, a weighted average can be used to estimate actual performance impacts through the year.

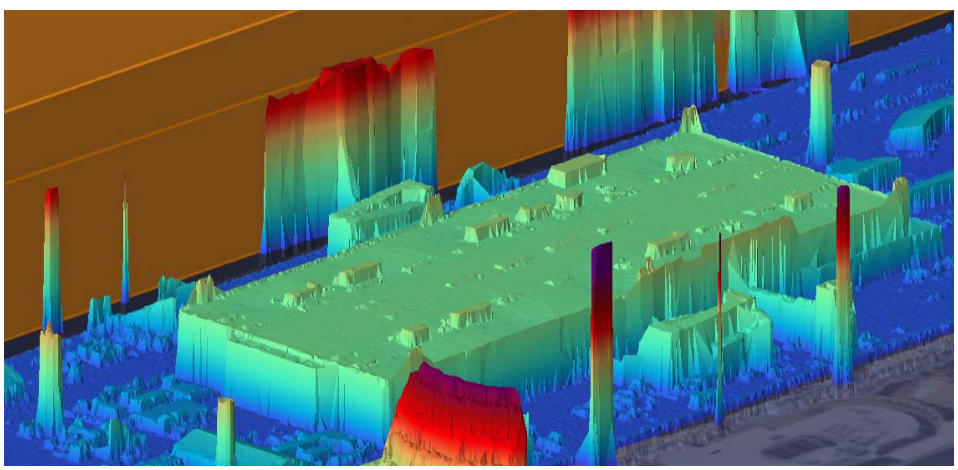

Figure 4: Smith Cove showing the large shading wall used to simulate a cruise ship. Limited LIDAR data was available (thin red features) and used to scale the "ship".

5. The default Helioscope value of 2% was used for the annual soiling level[8]. Constructed PV systems in the Pacific Northwest have not shown significant impacts from soiling due to regular rain washing. Washington State, located west of the Cascades is also expected to have negligible snow loss impacts[9].

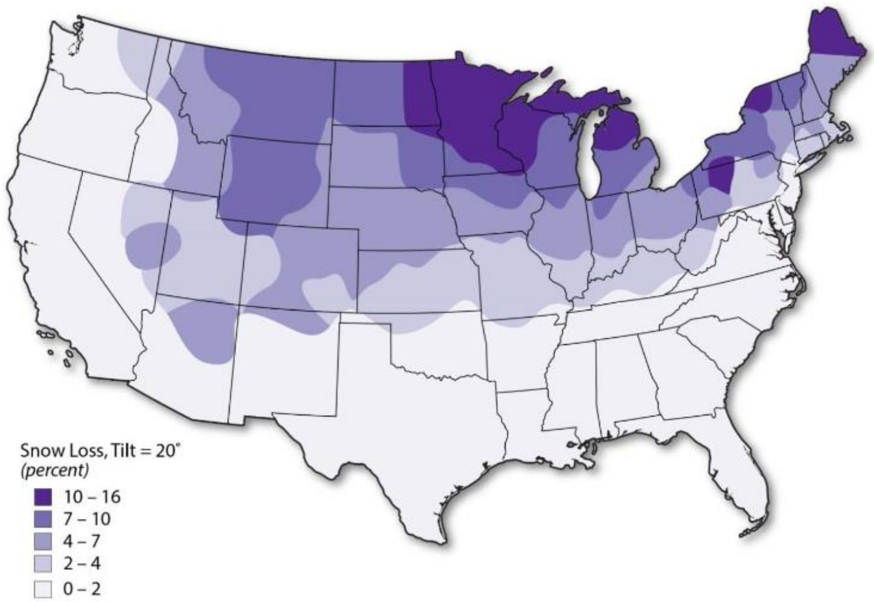

Figure 5: NREL Snow Loss Modeling; National figure from the referenced report. Map shows general trends in average snow losses as a percentage of annual energy production.

6. Default satellite-based ("prospector") weather data was used for modeling in this phase as a starting point for analysis.

The preliminary PV system models were developed for each facility using the parameters defined above. The preliminary models were then used to estimate annual solar energy production, overall performance, and shading impacts.

In preparation for the remote site assessment, the Port provided campus and utility feeder and transformer ratings and capacities from the Seattle Waterfront Clean Energy Strategy (SWCES) load forecast constraints analysis. This was in the form of a load forecasting report. These ratings were added to the screening tool to help identify any potential constraints on solar array sizing. Based on the available information at the time of the remote site assessment, no constraints on solar array size from medium voltage equipment were expected.

As a result of the evaluation described above, a ranked list of facilities was provided to the Port, including a shortlist of 10 properties that were recommended for further analysis. Facilities were organized by Port provided criteria into a color-coded "Traffic Light Assessment" matrix (see Figure 1 and Appendix A). Metrics considered in this assessment included but were not limited to:

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[8] In this study, "soiling level" refers to the accumulation of dirt, dust, pollen, or other debris. The soiling level value represents the percentage of potential energy output lost due to soiling on the solar panels.
[9] NREL Snow Loss Modeling; https://www.nrel.gov/docs/fy17osti/68705.pdf Note: This model has been validated through field testing

a. Roof condition, roof type, geometry, complexity, and age (as identified from satellite imagery)

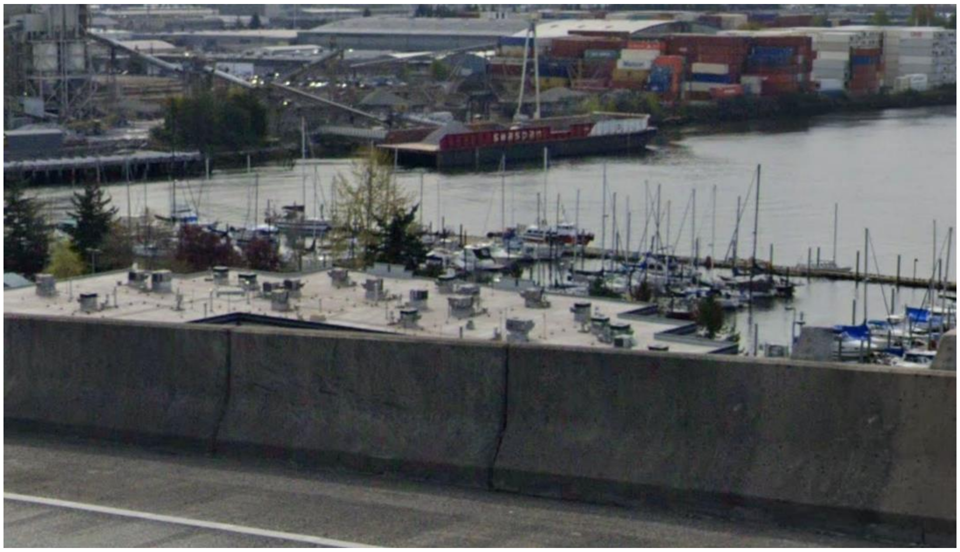


Figure 6: Overhead satellite imagery and Google Street View were both used to evaluate roof complexity and features. This image shows Terminal 102 Building A just above the highway parapet with a complex roof featuring a large number of scattered mechanical rooftop units.

b. Preliminary solar model performance including shading impacts.

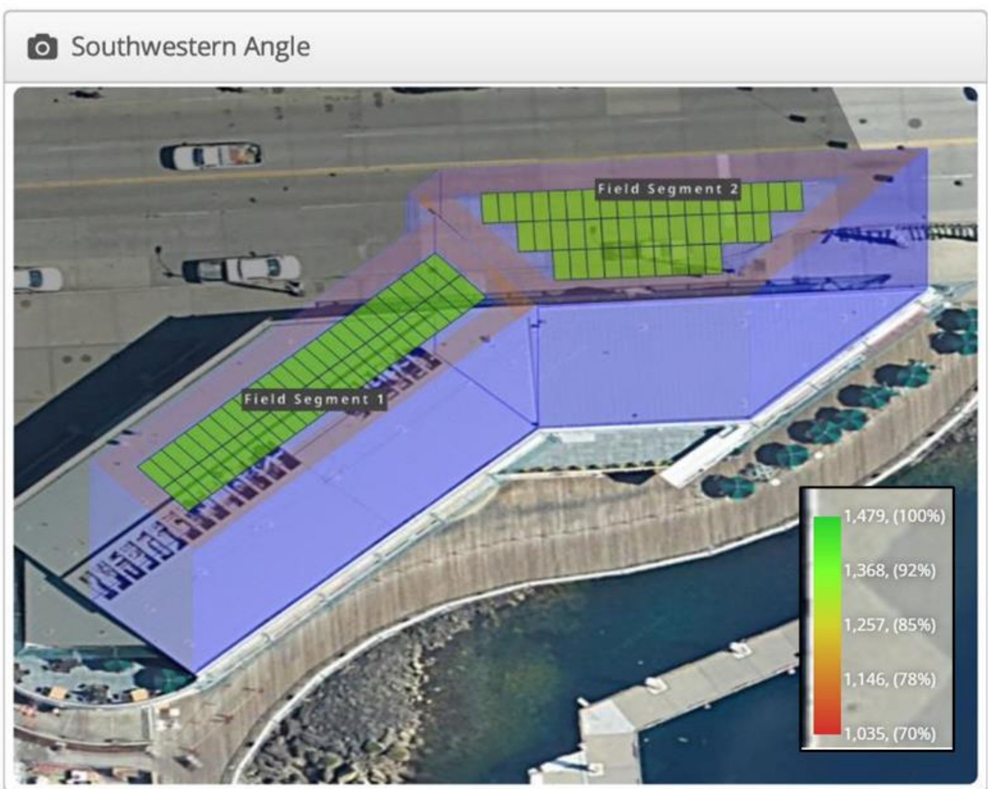


Figure 7: Shading render of Anthony's Restaurant on Pier 66. Light color green indicates no shading impacts.

c. Available roof area for solar modules with consideration for obstructions from rooftop equipment, maintenance access, and fire safety access,

d. Zoning/permitting restrictions

    i. Seattle City Light Customer Access Management (CAM) 420 review for height clearance of up to 4' above roof for solar

    ii. All sites are modeled in compliance with National Electrical Code (NEC) and National Fire Protection Association (NFPA) and first responder access requirements

e. Rough Order of Magnitude (ROM) costs and payback periods.

Additional screening criteria and site data to evaluate were provided by the Port throughout the feasibility study process and are captured in the screening tool spreadsheet (Appendix A) for future reference.

3.2 In-Person Site Assessment

After completion of the remote site assessment, the Port of Seattle selected the following 11 sites for in-person site assessments (ordered according to the "traffic light" score at that time):

1. Shilshole Bay Marina – A-1 Admin Building
2. Terminal 91 – C-175
3. Terminal 91 – A-1 Warehouse
4. Terminal 91 – C-173
5. Terminal 91 – Smith Cove Cruise Terminal
6. Terminal 91 – Smith Cove Cruise Terminal Covered Walkways[10]
7. Pier 66 – Bell Harbor Conference Center/Bell Street Cruise Terminal
8. Pier 66 – Bell Harbor Marina Office
9. Terminal 91 – C-155
10. Fishermen's Terminal – N-9 Netshed
11. Fishermen's Terminal – C-3 West Wall Office

During the walkthroughs at these facilities, the assessment team verified and clarified factors that affect solar feasibility to validate and update the model inputs and identify structural and other considerations for screening. Items assessed included:

i. Verification of roof type/conditions. This includes the physical properties of the roof, such as pitch/azimuth, material type, appearance, and obstructions.

[10] The Covered walkways are a part of the Smith Cove Cruise Terminal site but were tracked separately due to the expectation that any solar PV installation would be electrically independent from the Cruise Terminal due to having no preexisting electrical infrastructure.

Figure 8: Smith Cove Roof showing wear and discoloration with numerous patches.

ii. Generation of field photographs as documentation of existing conditions.

iii. Verification of relevant measurements such as parapet heights and standing seam profiles.

Figure 9: Shilshole A-1 Administrative Building standing seam roof profile. This allows designers to specify attachment hardware for more accurate construction bidding.

iv. Evaluation of accessibility for installation of a solar system and future maintenance.

v. Development of a qualitative structural assessment to evaluate structural feasibility of installing PV arrays on the subject roofs.

vi. Assessment of electrical infrastructure at each site in relation to potential solar array options, including needed upgrade requirements and associated upgrade costs, and identification of potential infrastructure deficiencies that would inhibit the installation of a PV system. These assessments will need to be verified by Port Engineering Services and Port Waterfront Project Management cost estimating team.

Figure 10: Fisherman's Terminal – Building C-3 Main panel which appears original construction from the 1950s. The age and residential voltage (240/120) of the building are some factors that made this building a lower priority.

vii. General opportunities and constraints the building poses on solar feasibility.

3.3 Solar Modeling, Energy Analysis, and Design

The preliminary array models that were developed in the remote site assessment were refined after the in-person site assessment based on information gathered from the in-person site assessments. Refinement efforts included more specific roof obstruction information, roof slopes, maintenance and other considerations from discussions with site operators. Due to significant issues identified on site, the following buildings were eliminated from further evaluation immediately by the Port:

- Terminal 91 – C-155 Warehouse
- Fishermen's Terminal – N-9 Netshed Storage
- Fishermen's Terminal – C-3 West Wall Office

The project team updated the screening tool spreadsheet with site assessment findings and associated updated solar model information and provided this to the Port with a review meeting. After reviewing the results, the Port selected 8 of the 11 sites assessed in person for further evaluation during the Solar Modeling, Energy Analysis, and Design phase:

1. Terminal 91 A-1 Warehouse
2. Terminal 91 Smith Cove Cruise Terminal
3. Terminal 91 Smith Cove Cruise Terminal – Covered Walkways
4. Terminal 91 C-175
5. Terminal 91 C-173
6. Shilshole Bay Marina A-1
7. Pier 66 Bell Harbor Conference Center
8. Pier 66 Bell Harbor Marina Office

Solar Feasibility Basis of Design

1. Solar PV Modelling Assumptions:
   a. Weather data was updated from satellite-based ("NREL prospector," see section 3.1 item 6) to the ground-based dataset from Boeing Field (TMY3) to better reflect local conditions.
   b. Racking type was updated based on site assessment observations: IronRidge family of products used for model details; BX family for ballasted arrays, and XR Rails for flush mount.
   c. SolarEdge brand inverter equipment was used throughout all designs for an available, high efficiency, manufacturer with excellent reputation. A variety of size ranges were used depending on the site array concept.

Figure 11: Example showing two SolarEdge inverters mounted to a building wall. This family of inverters was used as basis of design so any Port installations will be standardized across sites

   d. SolarEdge brand optimizers (DC-DC converters) were used throughout all designs to provide compatibility with the inverters and provide module-level control required by rapid shutdown requirements. The P1100 model selected allows the connection of two modules for one optimizer which is common industry practice for efficient installations.

e. Silfab Solar modules (490W) were used throughout all designs. This is a common, currently manufactured, commercial solar module with an American manufacturer with headquarters based in Washington State.

f. The designs for the selected buildings were completed in accordance with local code requirements regarding structural capacity, seismic safety, and fire safety for commercial and industrial applications.

g. The solar models were designed to preserve accessibility to be able to access key areas of the roofs for maintenance of the array and existing rooftop equipment.

Figure 12: Image shows a ballasted rooftop array like the ones proposed for Smith Cove and C-175. The array is designed around a vent pipe and two drains (top of image) with an access pathway between array sections.

h. When considering the impacts of marine environments on solar equipment, one important factor to take into account is salt corrosion. All equipment used as the basis of design is suitable for Port maritime facilities. Details about manufacturer certifications are provided in the Project Development section and in equipment datasheets. Equipment datasheets for each of the final 3 prioritized systems are located in Appendices C, D, and E.

i. A 4-foot buffer from fire vents, skylights, and other rooftop equipment (Seattle Fire Code 2021 section 1205.3.3).

j. A 6-foot buffer from the roof edge and parapets (Seattle Fire Code 2021 section 1205.3.1).

Figure 13: Smith Cove roof showing rooftop air handlers and skylights accommodated with access pathways and maintenance clearances to comply with Fire Code.

2. Estimated annual energy production of the modelled solar installation as kWh per year.
3. System losses were included in the model from the effects of annual soiling and shading impacts from transient features (i.e., cruise ships) and mechanical equipment.
4. Review of the historical energy data that was provided by the Port. Factors included electricity consumption patterns, peak demand times, and cost analysis.
5. Different panel technologies were evaluated during the study against considerations of site conditions, energy goals, and installation cost. Monocrystalline, mono-facial modules were used as basis of design for their much higher availability and cost performance as compared to other technologies.
6. The storage technologies were analyzed to identify potential benefits for the Port. However, as these sites are part of campuses, utility-scale battery systems would be required to provide the desired demand charge reduction with the utility. Therefore, battery equipment was not evaluated as part of this study.
7. Estimated EUI reduction from the installation of PV systems was not possible with the building-level data available during the study. Campus or building electricity consumption (in kWh) reduction was calculated and is provided in the screening tool.

After the analysis of the refined solar models was completed, Säzän prepared a Traffic Light Assessment Matrix which ranked the projects against the grid/building capacity, installation cost and complexity, energy production, and additional evaluation criteria guided by the Port.

3.4 Financial Analysis

Following the refinement of the solar modelling, energy analysis, and system design, a financial analysis was performed for the eight sites identified by the Port. The cost analysis includes initial equipment cost depending on the proposed configuration; life-cycle equipment maintenance, repair, and replacement costs and the utility billing credit for new solar PV at the 8 shortlisted sites.

Each site's modeling process included detailed parametric analysis of multiple system concepts to arrive at optimal value solutions. Typical methodology for each site includes the development of a maximum system option for all available roof areas, a minimum capacity option for solar readiness, and optimized or recommended option based on system performance. This methodology includes evaluating solar PV production, shading impacts, code compliance, and overall performance. Specific metrics are provided below:

- 25-year project life, 2% social discount rate[11]
- 2% inflation rate annually throughout project life.
- 4% annual utility escalation rate throughout project life.
- Assumes 30% Investment Tax Credit (ITC) direct payment occurs the year after construction (Year 1).
- PV inverter replacement is required approximately every 15 years. Replacement costs are projected based on their present-day value, adjusted for a 2% annual inflation rate compounded over the typical 15-year useful life.
- Decommissioning costs were estimated to be 3% of the installed cost, then adjusted for inflation over the expected life of the system. This was generated from the New York State Energy Research and Development Authority (NYSERDA) Decommissioning Solar report[12] and National Renewable Energy Laboratory (NREL) analysis of PV system unit costs for the same year[13] for the studied system size.
- $10/kW annual solar O&M costs, adjusted for inflation over the project lifespan.
- PV degradation rate set based on typical manufacturer datasheets, which is 0.5% per year.
- Generated electricity is valued at the utility billing rate for each site. To capture the value of the power generated by the Port's PV system, a production meter may be used to bill tenants for net energy consumption.
- Demand charge savings are evaluated as zero for all systems due to lack of certainty around coincident demand. Without large-scale battery installation at each site, it is unlikely that campus-level demand charges will be reduced by solar PV installations.
- Port overhead percentage of 25.1% for internal engineering support for design review, project management, construction management, testing & inspection, safety, contract administration, as well as environmental support and reviews. This rate will need to be

[11] https://www.whitehouse.gov/cea/written-materials/2024/02/27/valuing-the-future-revision-to-the-social-discount-rate-means-appropriately-assessing-benefits-and-costs/
[12] https://apa.ny.gov/Mailing/2021/05/LocalGov/NYSERDA-Decommissioning-Solar-Systems.pdf
[13] https://www.nrel.gov/news/program/2023/as-pv-market-evolved-in-the-last-year-prices-went-up-prices-went-down.html

reevaluated with the design of each project which may affect the overall cost/benefit of each project.
- **Note:** total cost of ownership in sections below shown as a positive value when project generates net revenue over the 25-year project life.

Specific product options were used during modeling and are included for consideration. Säzän is an independent, third-party consultant and only provides specific product options to support the feasibility of any given option – alternative product options may be available and identified through the final design and specifications process. Product cut sheets for the respective systems are provided in Appendices C, D, and E of this report.

Solar PV system components applied for engineer's estimate of total capital expenditure include:

- Modules - 490-Watt Silfab Solar Inc., SIL-490 HN as Basis of Design.
- Inverters – The Bell Harbor Marina office uses an Enphase 3-phase 208Y Inverter, the remaining systems utilize SolarEdge Commercial three-phase inverters as Basis of Design.
- Racking – Standing seam roofs evaluated with seam clamps (S5! Or equivalent) and IronRidge XR Family products. Ballasted mount racking used Iron Ridge BX Family products as basis of design.

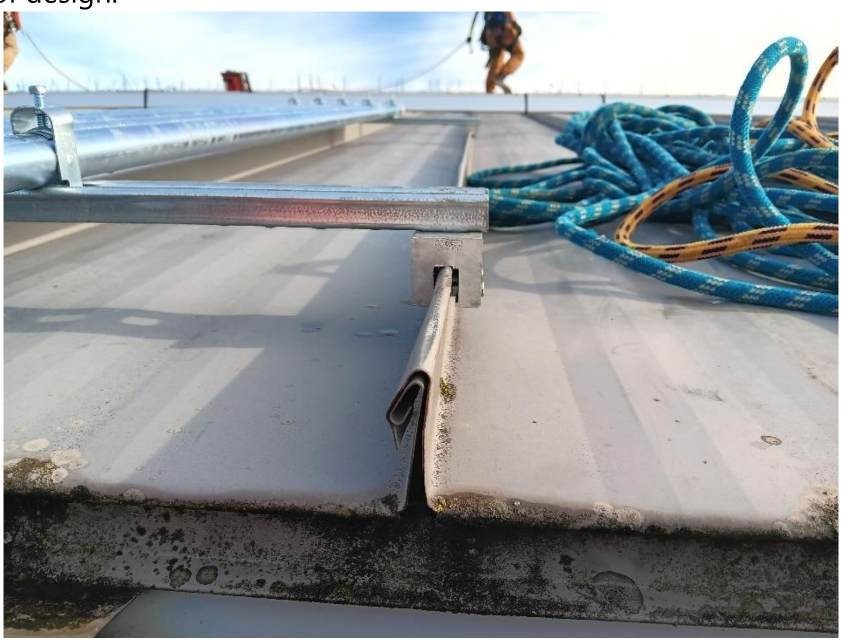


Figure 14: Image shows an example installation on standing seam metal roofing like that proposed for Shilshole A-1. Clamps on the metal roof allow the array to be attached without requiring penetrations to the roof, limiting the risk of voiding the roof warranty.

Net Present Value Calculation

The Net Present Value (NPV) is a useful metric for evaluating investments over long time horizons. It is based on the concept of the time value of money (i.e., social discounting), which recognizes that a dollar today is more valuable than a dollar in the future. In the context of this report, the NPV represents the value of a photovoltaic system today, accounting for costs (installation, operation, maintenance, decommissioning) and benefits (utility bill savings, net metering credits), while factoring in the effects of inflation, social discounting, and when the cash flows occur. The NPV can be calculated using the following summation formula:

$$NPV = \sum \frac{CF_n}{(1+r)^n}$$

Where:

- CF_t is the inflation-adjusted cash flow (cost and/or benefit) at time n. Detailed formulas for cash flow are provided in the Financial Formulas (Appendix F)
- r is the social discount rate
- n is the time period (year)

The sum above is evaluated for the life of the project. In the context of this feasibility study, the sum is evaluated from n=0 (installation) to n=25 (decommissioning). A positive NPV value reflects that the investment outperforms the effects of inflation and social discounting[14], while a negative value reflects that the effects of inflation and social discounting outperform the cash flows from utility savings and net metering. For systems with negative NPV value estimates, a positive value can be achieved either by performing preventative maintenance to extend the useful life of the system or applying a reduced social discount rate.

3.5 Project Development

After completing the Solar Modeling, Energy Analysis, and Financial Analysis phases, the Port sought input from internal teams, including Planning, Engineering, Real Estate, Facilities, and Environmental. This feedback was compiled into a decision matrix (Appendix B) to streamline data presentation, enabling staff to document insights, share specialized knowledge about the proposed buildings, and address any concerns. Following this internal review, the Port selected the following three sites for final project development:

1. Terminal 91 Smith Cove Cruise Terminal
2. Shilshole Bay Marina A-1 Admin Building
3. Terminal 91 C-175 Building

The final development of the system options at the top three sites included the following:

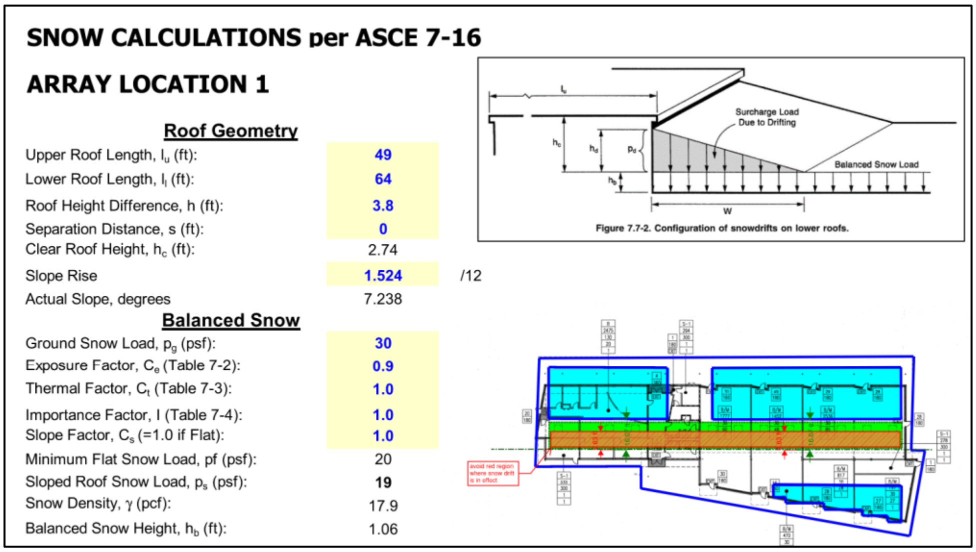
1. Three alternatives were produced through the study process with the final designs prioritizing the following:
    a. Cost Effectiveness, ROI, and simple payback. This included the provided Port overhead percentage added to installed cost estimates based on a $/Watt system unit cost. These values are provided in the screening tool spreadsheet with further financial analysis and graphs in Section V.

[14] https://www.whitehouse.gov/cea/written-materials/2024/02/27/valuing-the-future-revision-to-the-social-discount-rate-means-appropriately-assessing-benefits-and-costs/

b. Build America, Buy America (BABA) compliance and/or Made in Washington. Details on equipment specifications in this section and corresponding equipment datasheets are provided in Appendices C, D, and E for the evaluated systems.

c. Maximized energy production, sustainability, and resiliency.

2. A detailed structural analysis of the buildings, including a review of as-built structural drawings to verify the capacity of the structures to support the load of the PV systems. This analysis included considerations and verification of conditions from the on-site assessments.



SNOW CALCULATIONS per ASCE 7-16

ARRAY LOCATION 1

Roof Geometry		
Upper Roof Length, l_u (ft):	49	
Lower Roof Length, l_l (ft):	64	
Roof Height Difference, h (ft):	3.8	
Separation Distance, s (ft):	0	
Clear Roof Height, h_c (ft):	2.74	
Slope Rise	1.524	/12
Actual Slope, degrees	7.238	
Balanced Snow		
Ground Snow Load, p_g (psf):	30	
Exposure Factor, C_e (Table 7-2):	0.9	
Thermal Factor, C_t (Table 7-3):	1.0	
Importance Factor, I (Table 7-4):	1.0	
Slope Factor, C_s (=1.0 if Flat):	1.0	
Minimum Flat Snow Load, pf (psf):	20	
Sloped Roof Snow Load, p_s (psf):	19	
Snow Density, γ (pcf):	17.9	
Balanced Snow Height, h_b (ft):	1.06	

Figure 15: Excerpt from Shilshole A-1 Structural evaluation memo showing snow load calculation that includes analysis of areas subject to wind-driven drift build-up.

3. Assessment of the roof age warranty conditions for each site and how the installation of PV would affect the warranty conditions, including limitations or requirements set forth by the roof warranties.

   a. In all cases, the roof warranty holders and installers must be coordinated with prior to installing arrays to ensure warranty terms are met, and new equipment is acceptable. Respective details can be found in the Constructability Considerations subsections of each prioritized system.

4. Development of preliminary racking and mounting designs for the PV systems at the selected sites to verify compliance with local codes, seismic standards, and Port engineering standards.

   a. These preliminary racking designs accounted for design conditions of the building and local wind/snow conditions. The structural team was coordinated for the development of racking design to better understand code requirements at each site. Racking pre-design reports for the top three sites are provided in the appendices.

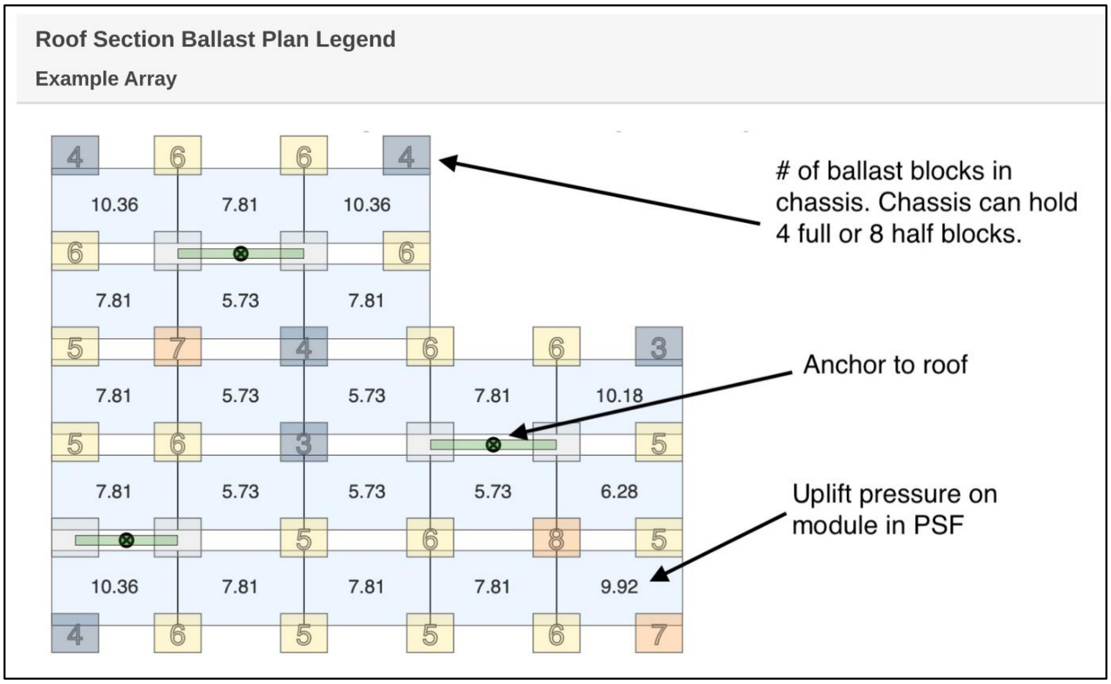


Figure 16: Example ballasted array plan from IronRidge designer software showing required ballasting, any required anchors, and uplift. Uplift pressure given in pounds per square foot (PSF).

5. Development of electrical drawings for the proposed solar PV systems at the selected sites to align with local electrical codes, fire safety regulations, and Port engineering standards. The drawings for any proposed solar array that moves forward as a project will need to be updated to account for the condition and capacity of on-site electrical infrastructure.
6. Specification of all major equipment and materials for the proposed PV systems:
    a. During this study, products that are Made in Washington or compliant with Build America, Buy America (BABA) requirements were prioritized. The IronRidge racking products are available from US manufacturing lines[15], and these product lines have been used throughout as the basis of design. Silfab no longer has an entirely US manufacturing line, but they are working towards opening a new facility in South Carolina[16] which in the future may meet BABA and IRA domestic content requirements.
    b. Products were selected that are marine grade rated. These are identified as meeting certain rigorous testing requirements for salt mist/spray resistance. The Silfab modules used as basis of design have passed IEC61701:2011 Level 5 Salt mist corrosion testing and are suitable for installation at port facilities[17]. Racking components are anodized or made of stainless steel for corrosion resistance.

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[15] https://files.ironridge.com/IronRidge_Domestic_Content_Brochure.pdf
[16] https://silfabsolar.com/domestically-produced-solar-energy-delivers-economic-benefits-for-the-us/
[17] SIL-HN Family install manual, Section 9.5; https://silfabsolar.com/wp-content/uploads/2024/05/SILFAB-MAN-SSI-07-20240422.pdf

   SolarEdge markets their products as "saline resistant" and allows installation near the shoreline with no direct salt splash.

   c. All designs included grid connectivity through grid-tied inverter systems. This is necessary for both electrical safety and to allow export of excess energy.

   d. Power monitoring system equipment was included in the cost estimate and is standard with modern commercial inverters. (e.g. SolarEdge Monitoring)

7. Development of a turnkey cost estimate for all three system options. This was calculated with an estimated $/Watt unit cost with escalations for expected site-specific considerations, and a 25.1% Port overhead added.

8. LIDAR analysis from modelling. This is provided in the appendices with the final solar model and shading reports.

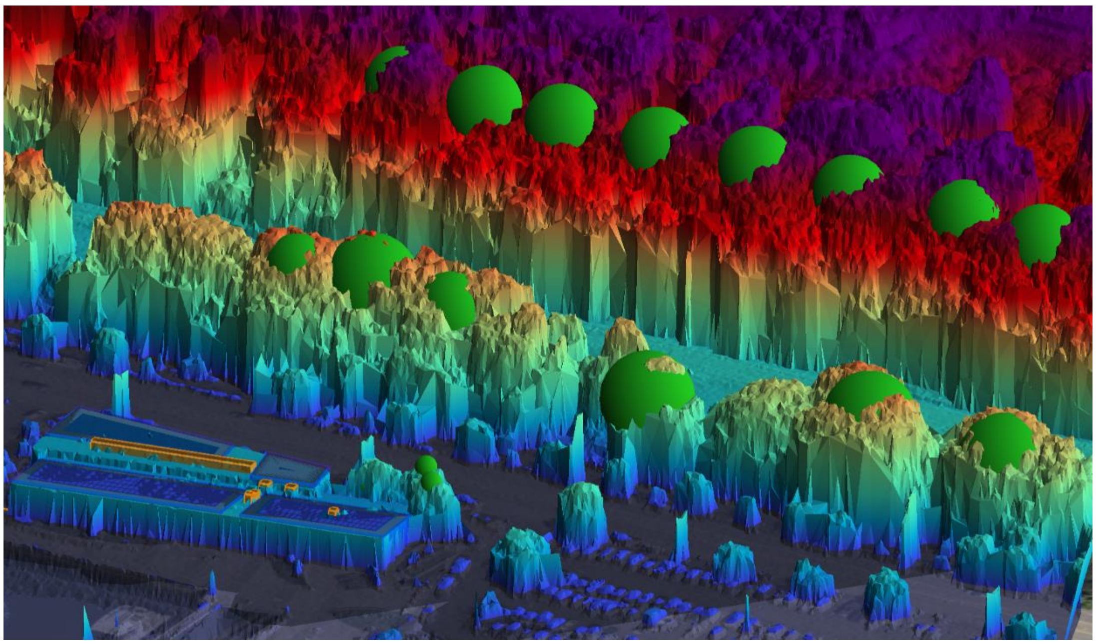


Figure 17: Helioscope LIDAR rendering showing Shilshole A-1 tree line to the east of the marina. The scale of the trees and slope is visible with LIDAR and simulated with the green tree "keepouts" to provide more accurate shading information.

9. Updated screening tool (Traffic Light Matrix, Appendix A)

Completion of the project development phase concluded with development and delivery of the structural roof capacity memos, roof age and warranty assessments, preliminary racking drawings, preliminary electrical drawings and one-line diagrams, and the cost estimate report for each of the three prioritized sites. This information is presented in Section V, Incentives and Financing Considerations.

IV. Prioritized Site System Details

The three prioritized sites selected for project development included in this analysis were evaluated based on input from the project team on system priorities. The solar modeling process included obtaining site information from public sources and project documents, then performing an iterative design process to determine cost effective concepts to fit the options desired. All three prioritized sites are outside of the Seattle City Light spot network boundary[18], which reduce constructability concerns for interconnection.

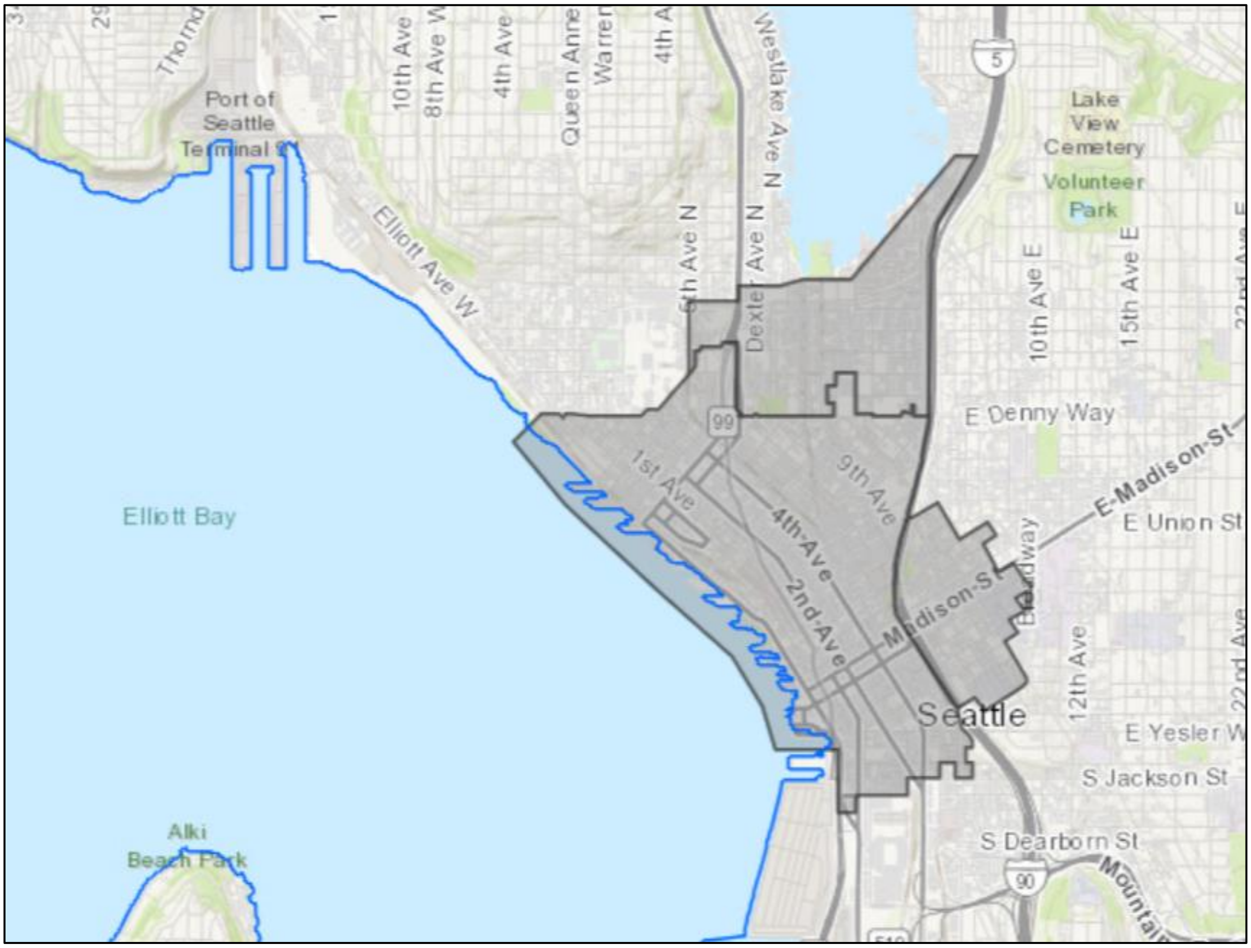


Figure 18: Seattle City Light spot network boundary indicated in grey.

18 https://experience.arcgis.com/experience/0fc12827b542465595570c7b9aa447bf/

4.1 Terminal 91 – Smith Cove Cruise Terminal (303.8 kW-DC)

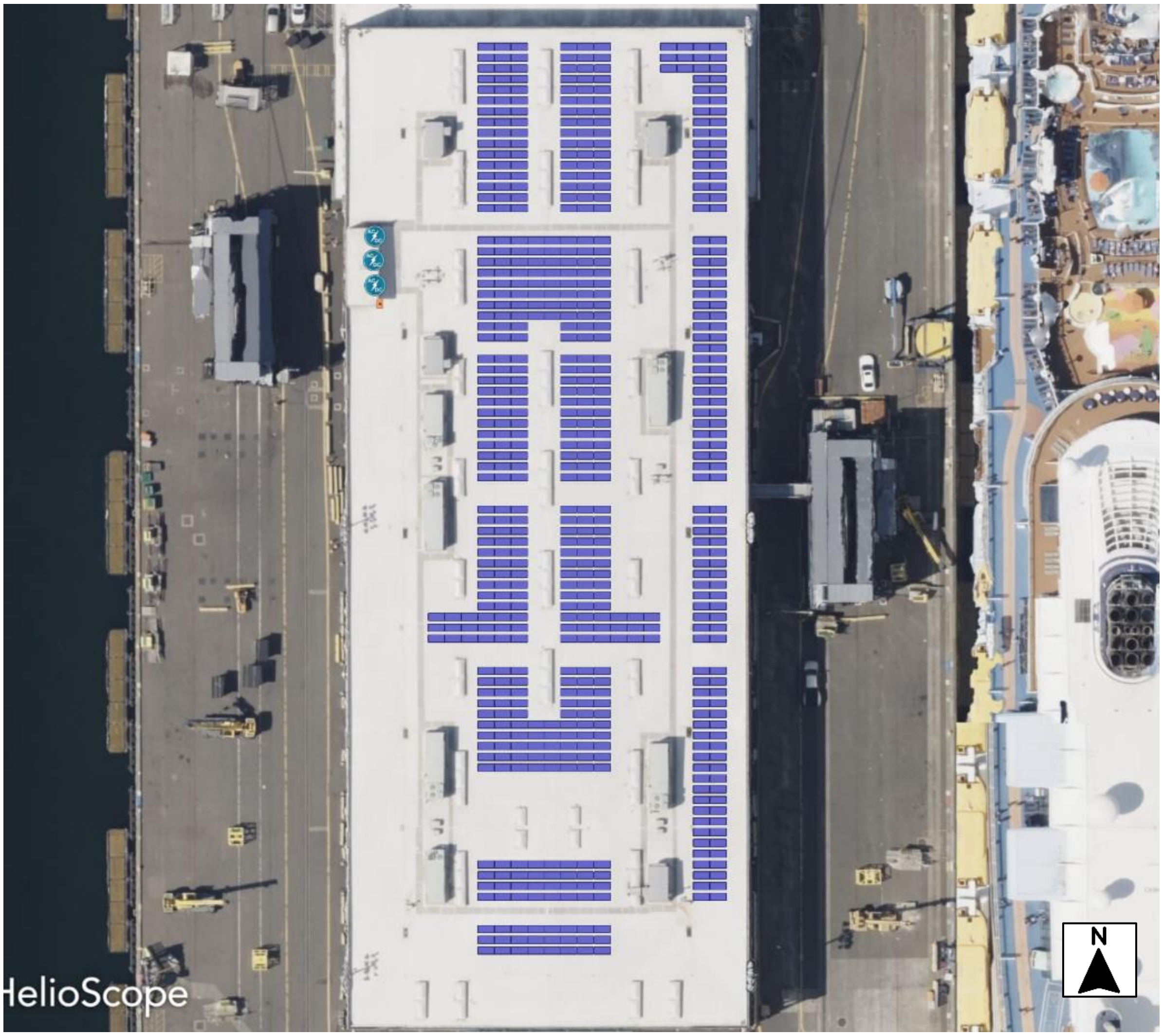


Figure 19: Smith Cove Cruise Terminal showing solar modules on roof of building as arranged in the pre-design concept.

System Summary

This project concept consists of a ballasted, grid-tied, rooftop solar array on the Cruise Terminal. This building is a cruise-ship terminal with extensive open areas inside for large crowds. Luggage processing and storage areas occupy many areas on the ground floor. The array concept occupies more than half of the roof area limited by the existing roof configuration (e.g. rooftop air handlers, skylights) and necessary access pathways and shade exclusions. The area array size is expected to be limited by the available breaker space within the main electrical panel.

This project is evaluated as feasible but should not be pursued until the existing roof system is replaced.

Structural Considerations

TKDA has performed a structural assessment of the Smith Cove Cruise Terminal located in Seattle, WA to determine its ability to support the proposed ballasted rooftop PV array system including modules, racking, and associated equipment. This assessment is based on the as- built structural and architectural drawings provided by the Port of Seattle. The original 2007 drawings are titled "Terminal 91 Cruise Ship Terminal" with KPFF as the Structural Engineer of Record (SEOR). The Smith Cove Cruise Terminal is a 2-story steel structure. The roof system is composed of a TPO membrane, gypsum, rigid insulation, and steel roof deck. Open web steel joists carry roof loads to W- shaped girders. The lateral system of the building utilizes vertical bracing.

The results of our analysis show that the existing framing is sufficient to carry proposed loading for the planned PV array as detailed in layout below. The preliminary racking design estimates an added weight of 4.55 pounds per square foot (psf) distributed dead load from the array which is within the 5psf limiting load in the field.

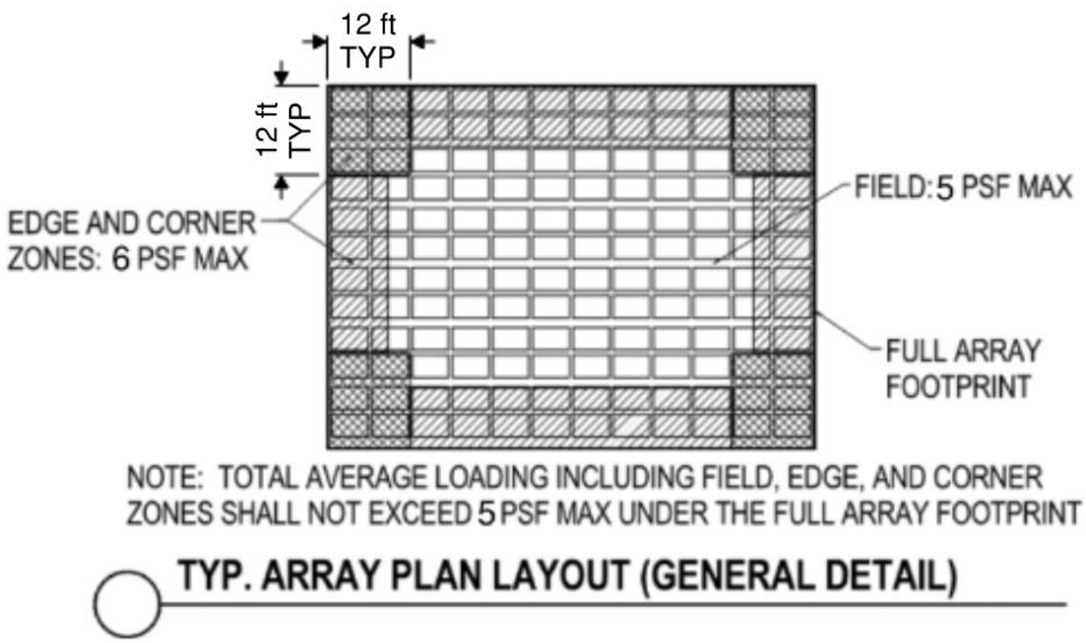


Figure 20: Structural Array Plan from engineering memo.

Electrical Considerations

The point of interconnection is recommended to be the main electrical panel located on the West side of the building on the ground floor. No size limitations are expected from the utility feed equipment as the building's two substations are fed directly from a 15kV substation switchboard. PV Array system size was limited to 265kW-AC during project development to enable use of a 400A-480/277V breaker. A spare slot this size appears to be present on the main distribution panel (SS-2) at the end for NEC Article 705 considerations. Another 400A spare is present on the other substation MDP (BS). Final design must confirm main panel bus constraints and arrangement is suitable for this size breaker.

Figure 21: Potential location for the expected 400A – 480/277V interconnection breaker in SS-2

Constructability Considerations

As mentioned in the summary, the existing roof condition is poor. The warranty expired January 15, 2024, and no solar PV installation is recommended prior to full replacement.

Figure 22: Smith Cove Roof showing wear and discoloration with numerous patches.

The size of the building provides flexibility in where to install array equipment. The storage room wall appears to have sufficient space for the expected equipment and is near the electrical room. Alternatively, the awning for roof access may provide sheltered areas for inverter equipment. Basis of design inverters (SolarEdge) are outdoor rated and designed to be suitable for areas near saltwater. The building is large with many open areas on both floors, but equipment locations should not interfere with existing operations.

Figure 23: Room 111 storage proposed for inverter installation.

Cruise ship season is well-defined with a regular off-season. This will allow installation of the rooftop array with little to no impact to operations or tenants. The large stairwell access to the roof, with clear paths around the building both provide safe and efficient construction access to the proposed array area.

The Port identified this building as requiring a glare impact study for any array. Cruise ships are tall enough that morning or evening sunlight might reflect off the south-facing array elements and impact passengers or crew.

The inverters and other electrical equipment are recommended for installation within the building. Installing new electrical equipment within the building is expected to provide a climate-controlled, secure, environment for the inverters, which reduces the risk of premature failure and extends the life of the equipment.

System Summary Table - Smith Cove Cruise Terminal

Payback year (With 30% ITC):	15
NPV (2024 USD):	$63,700
ROM cost of O&M (Year 1):	$3,000
Estimated total installed cost	$834,774
Estimated total installed cost (with Port overhead premium applied):	$1,044,302
ROM decommissioning estimate (2050 USD):	$51,400
System Size (kW-DC):	303.8
Estimated cost per Watt (before Port overhead):	$2.75
Estimated cost per Watt (after Port overhead):	$3.44
Oct 2024 Utility Rate ($/kWh):	$0.1091

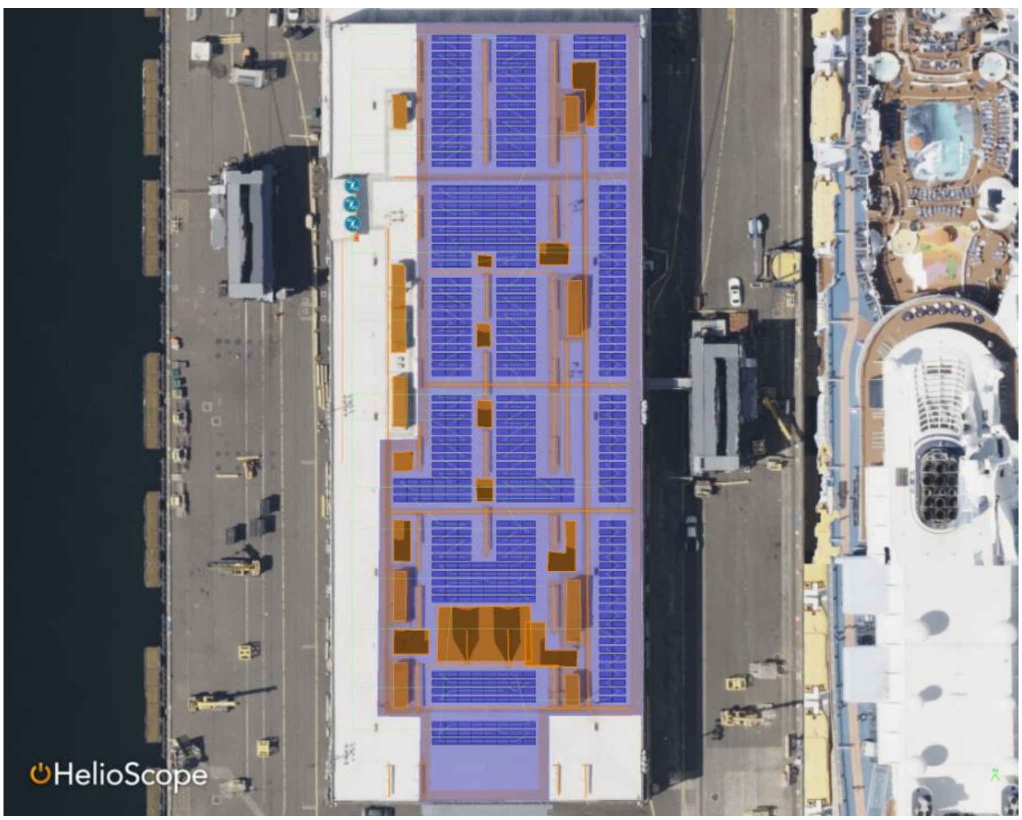


Figure 24: Final Helioscope Model for Smith Cove Cruise Terminal. Areas in orange are designated "keepout" areas, including mechanical equipment, access pathways, skylights, and roof drains.

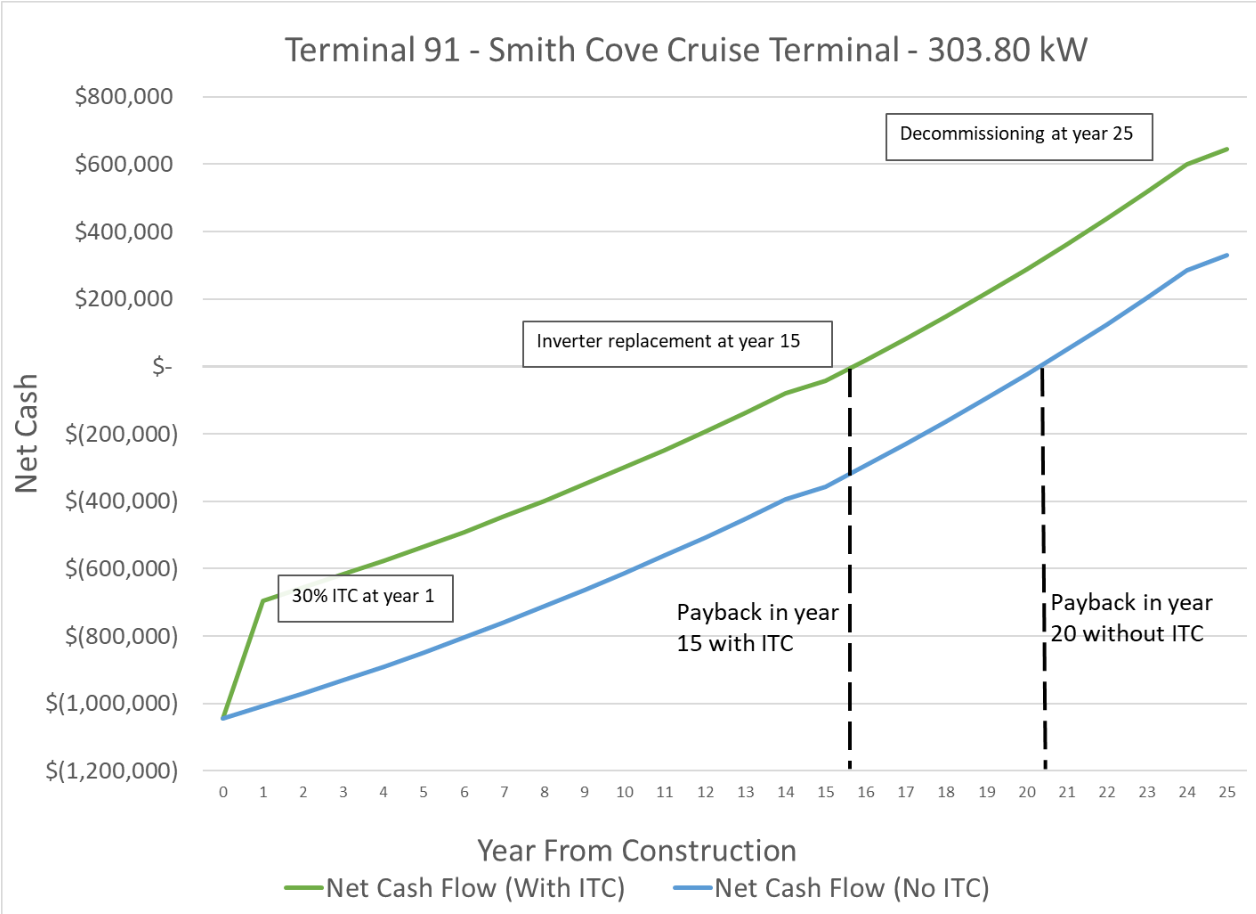


Figure 25: Smith Cove Cruise Terminal Financial Analysis Payback graph, indicating a payback in year 15 with the ITC, and year 20 without the ITC.

4.2 Terminal 91 - C-175 (255.3 kW-DC)

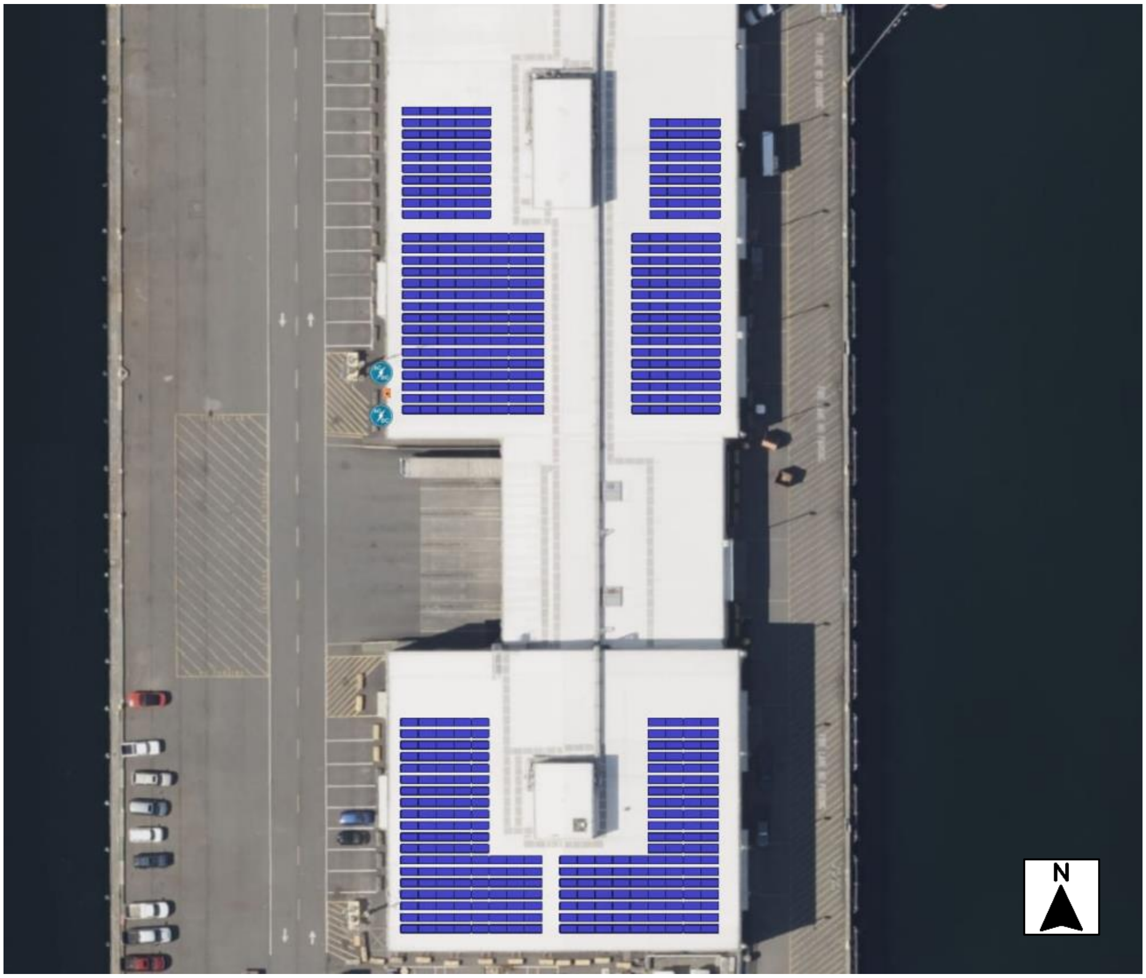


Figure 26: C-175 showing solar modules on roof of building as arranged in the pre-design concept.

System Summary

This system concept consists of a ballasted, grid-tied, rooftop solar array on the C-175 (Lineage) building. The building is an industrial cold-storage facility with ammonia refrigeration system throughout. There are limited offices within the building near the mechanical equipment spaces. The array concept was optimized to allow interconnection within the building's electrical system, or at the nearby substation. This system would also need to consider potential modifications to the lease agreement. It is necessary for the Port to review the lease language for prioritized projects to determine tenant and Owner constructability considerations See Constructability Considerations below.

This project is evaluated as feasible.

Structural Considerations

TKDA has performed a structural assessment of the existing structure of Building C-175 from Terminal 91 in Seattle, WA to determine its ability to support a proposed ballasted rooftop PV array, including modules, racking, and associated equipment. This assessment is based on drawings provided by the Port of Seattle. The original 1992 drawings are titled "New Chill Building C-175" with DLR Group as Architect of Record (AOR) and Structural Engineer of Record (SEOR). Building C-175 is composed of HSS steel columns and W-shape steel girders with steel roof joists. The roof is a built-up roof composed of TPO membrane, insulation, and steel roof deck. In 2003, insulation was added to the underside of the roof deck. Notes on the additional insulation can be found in the 2003 as-built drawings with LMN as the AOR and Gary J Smoot as the SEOR.

The results of our analysis show that the existing framing is sufficient to carry proposed loading for the planned PV array as detailed in layout plan below. The preliminary racking design estimates an added weight of 4.55psf distributed dead load from the array which is within the 5psf limiting load in the field.

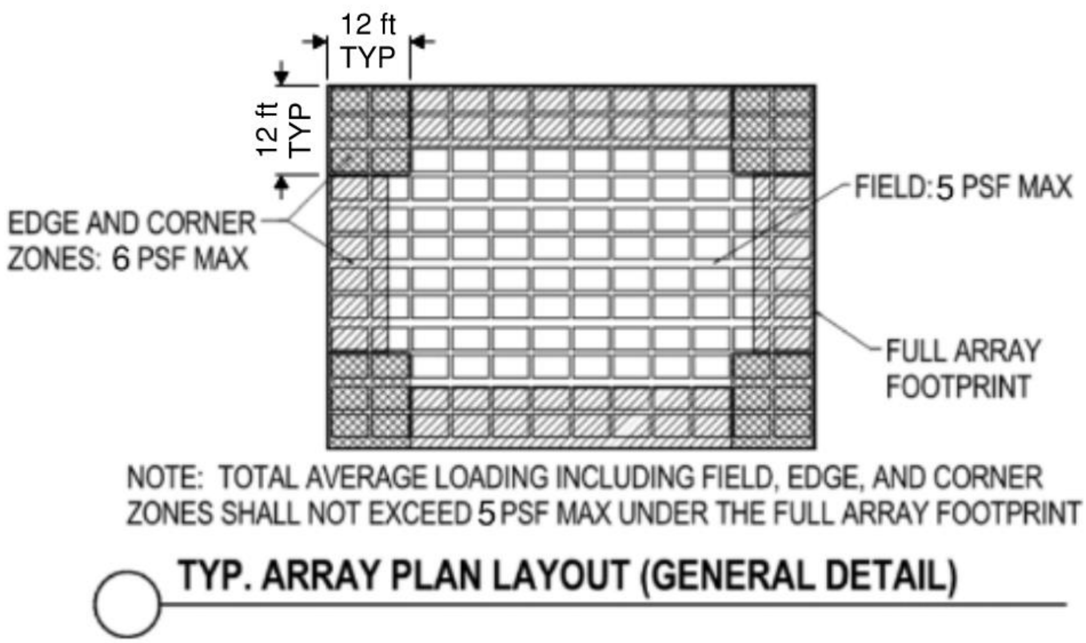


Figure 27: Structural Array Plan from engineering memo.

Limited attachments will be required to prevent array migration during earthquakes since the roof has no parapet. These will be engineered at the time of final design once final system configuration is determined.

Electrical Considerations

Two interconnection strategies were evaluated to provide flexibility and accommodate potential limitations with tenant agreements. The substation was evaluated as one potential interconnection location, but was deprioritized based on feedback from Port engineering. The recommended interconnection point is in the building's electric switchboard.

Figure 28: C-175 Main Distribution Panel (MDP). The three breakers expected to be decommissioned are red tagged in the right panel section at the top.

The building's 1600A-480/277V main distribution panel (MDP) is expected to have spare breaker locations that could be used for solar PV interconnection. The facility manager from Lineage described plans to retire and remove three large compressors in the coming years which will free up two 300A breaker slots and one 400A slot. Any of these might accommodate the proposed system size. Larger systems would require tap interconnections as the 1600A MDP can only accommodate a 200kW-AC solar PV system per NEC 705 "120% rule".

Constructability Considerations

Installation of solar on the building is expected to require evaluation and modification of the tenant agreement with Lineage. The described contract has the tenant responsible for all maintenance within the building, while the Port is responsible for the roof and exterior. Any electrical interconnections in the building's electrical system for a solar PV array would cross that boundary and require legal assessment. The facility manager for Lineage expressed excitement for a rooftop array, and mentioned that Lineage, company-wide, is actively pursuing ways to decarbonize with systems like the one suggested.

Construction will require careful scheduling around building operations as the facility operates year-round. There is space along the east and west sides of the building to crane modules onto the roof for construction. The west side of the building also has existing light poles and bollards that shelter areas of the wall that might be used to mount inverter equipment. New fencing and bollards might be necessary to meet Port access and protection requirements. The inverter equipment might also be attached to the rooftop penthouses, although this is a lower priority due to the expressed need for easy access by Port staff.

Figure 29: Showing the exterior wall area proposed for inverter mounting. The area is approximately midway up the west side of the building. New bollards to protect the inverters may be required.

The C-175 building has 10 years remaining on the roof warranty and may warrant replacement prior to any solar array installation as arrays continue to perform for at least 25 years. Based on visual evaluation during the site walk, the roof is in good condition with minor discoloration in places but no signs of damage.

If practical with current lease agreement terms between the Port and the tenant, the inverters and other electrical equipment are recommended for installation within the building. Installing new electrical equipment within the building is expected to provide a climate-controlled, secure, environment for the inverters, which reduces the risk of premature failure and extends the life of the equipment.

Figure 30: Showing existing roof condition with some minor discoloration, penthouses, and refrigerant lines. Half of the proposed array would be installed immediately south of the small penthouse.

System Summary Table - Terminal 91 C-175

Payback year (With 30% ITC):	15
NPV (2024 USD):	$38,000
ROM cost of O&M (Year 1):	$2,600
Estimated total installed cost	$684,236
Estimated total installed cost (with Port overhead premium applied):	$855,980
ROM decommissioning estimate (2050 USD):	$42,200
System Size (kW-DC):	255.3
Estimated cost per Watt (before Port overhead):	$2.68
Estimated cost per Watt (after Port overhead):	$3.35
Oct 2024 Utility Rate ($/kWh):	$0.1091

Figure 31: Helioscope Model for Terminal 91 C-175 showing keepouts (orange) and other model details. Keepout areas typically include mechanical equipment, access pathways, skylights, and roof drains.

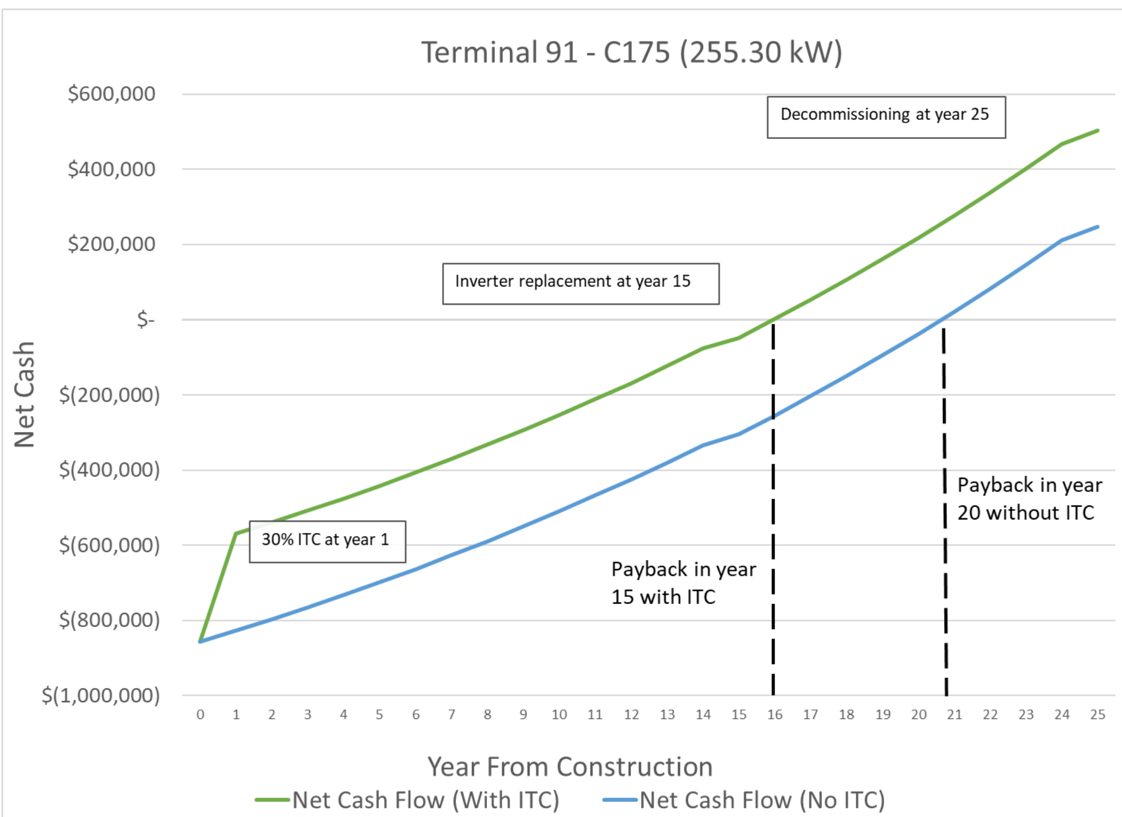


Figure 32: Terminal 91 C175 Building Financial Analysis Payback graph, indicating a payback in year 15 with the ITC, and year 20 without the ITC.

4.3 Shilshole Bay Marina - A-1 Admin Building (99.0 kW-DC)

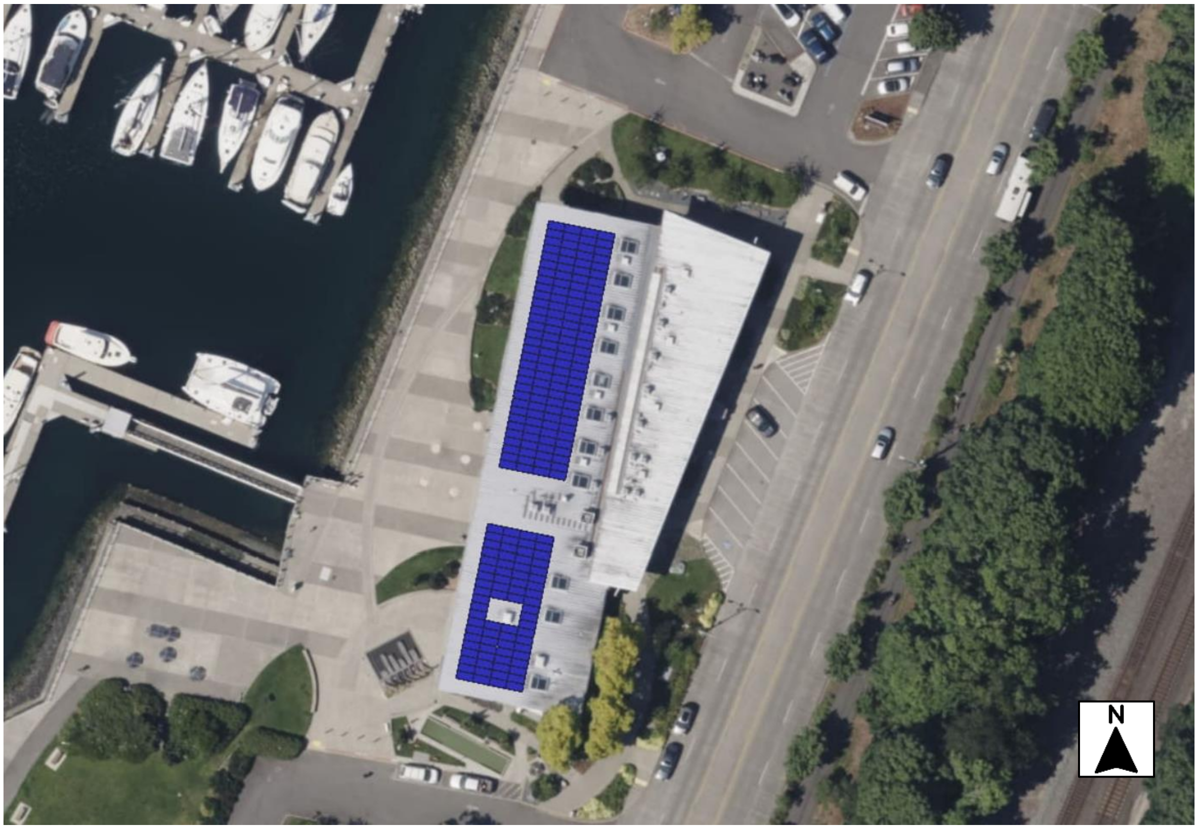


Figure 33: Shilshole A-1 Building showing solar modules on roof of building as arranged in the pre-design concept.

System Summary

This project concept consists of an attached, flush-mount, grid-tied, rooftop solar array on the west half of the building roof. The roof is standing seam metal which is expected to provide a cost-effective installation and operation. The array occupies all the available roof area on the west half of the building with clearances for existing rooftop equipment (e.g. maintenance access, shade impacts). A larger PV system was considered early in the study, but reduced to allow interconnection within the building's electrical system and avoid costly trenching for a larger system.

This project is evaluated as feasible.

Structural Considerations

TKDA performed a structural assessment of the Shilshole A-1 Building based on as-built structural and architectural drawings provided by the Port. The building is composed of steel columns with a mix of steel and wood roof framing. The results of the structural engineering assessment show that the existing framing is sufficient to carry the expected 3psf of additional load of the proposed solar array. 3psf is a conservative estimate for array weight based on the proposed flush-mount solar arrays installed on a standing seam metal roof.

Figure 34: Showing the west side of the building with key structural members exposed.

This additional load is less than 5% of the design loads (dead, live, and snow) which the 2021 State International Existing Building Code (IEBC) states does not require strengthening or modification of the affected building members[19]. If a future solar PV array is expected to exceed 3psf, this analysis will need to be revisited.

During the review of drawings, it was also noted that the design snow load in the drawings exceeds the code prescribed snow load.

Electrical Considerations

The 80kW-AC system is expected to provide the most efficient and lowest risk system with the existing electrical infrastructure. Interconnecting within the building, in the existing panels, will be a lower cost and less impactful pathway than that required for a larger array. If a larger array is desired in the future, intercepting the building's feeders from the substation to the north may be required.

[19] Washington State 2021 IEBC for new structures.

Figure 35: Panel 4MB proposed for interconnection using relocated spares

Panel 4MB is expected to have sufficient capacity for the 100A -480/277V breaker needed. During the site walk, three single-phase breaker slots were seen in this panel. Although these are not co-located, other loads may be moved to build a 3-phase breaker slot for the array.

Constructability Considerations

Standing seam metal roofing is excellent for solar PV installations. The seams allow for the use of seam clamps to attach the array which reduces or eliminates the need to penetrate the roof. A future contractor may opt to pass conduit through the roof, but paths around the roof edge or into the wall joining roof planes may be preferable.

Shilshole Bay A-1 Building roof workmanship warranty expired December 22, 2021, and the 30-year product warranty may be void as the building site is "less than one-half mile radius from a seacoast, saltwater, or other brackish water environment". It is recommend to confirm warranty terms with the roof manufacturer and installer.

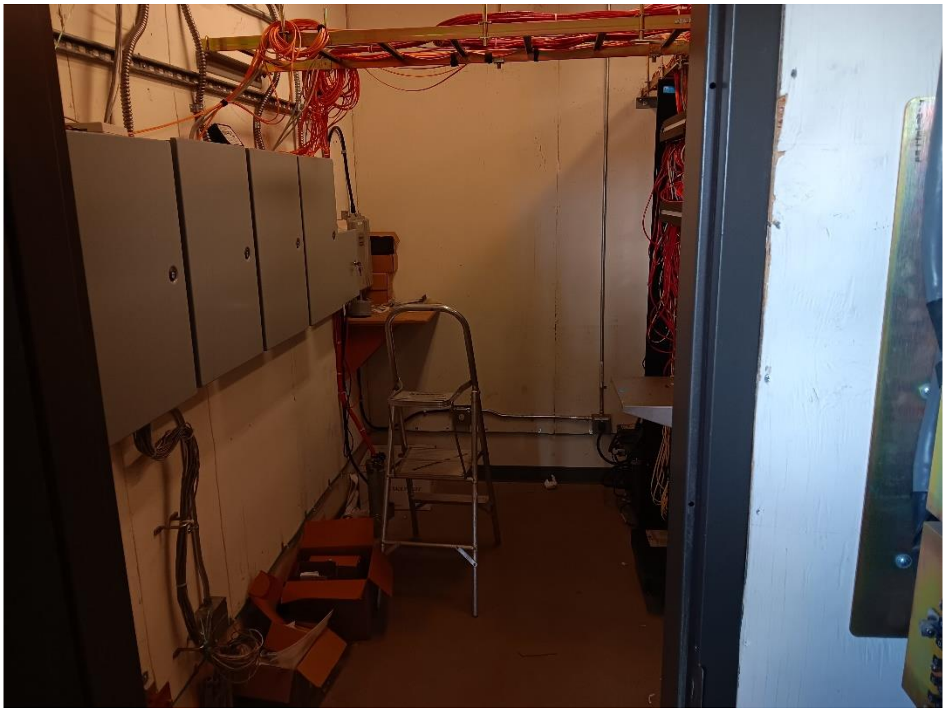


Figure 36: Proposed location for new solar PV equipment within the IDF room. This is expected to provide a secure and code-compliant location for installation while remaining near the electrical room.

The inverters and other electrical equipment are recommended to be installed inside the building. Installing new electrical equipment within the building is expected to provide a climate-controlled, secure, environment for the inverters which reduces the risk of premature failure and extends the life of the equipment.

System Summary Table - Shilshole Bay Marina A-1 Admin Building

Payback year (With 30% ITC):	15
NPV (2024 USD):	$16,500
ROM cost of O&M (Year 1):	$1,000
Estimated total installed cost	$231,900
Estimated total installed cost (with Port overhead premium applied):	$290,106
ROM decommissioning estimate (2050 USD):	$14,400
System Size (kW-DC):	99.0
Estimated cost per Watt (before Port overhead):	$2.34
Estimated cost per Watt (after Port overhead):	$2.93
Oct 2024 Utility Rate ($/kWh):	$0.1091

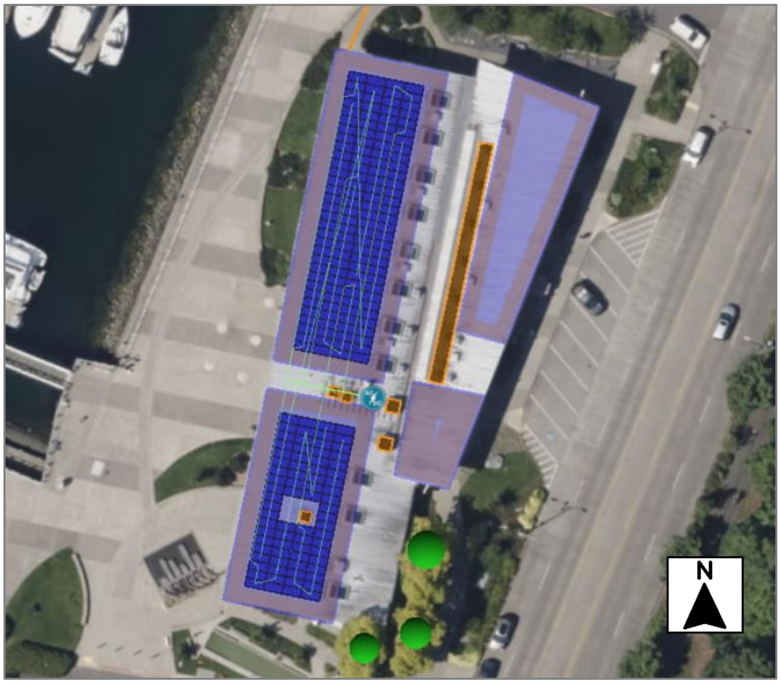


Figure 37: Final Helioscope Model for Shilshole Bay Marina A-1 Admin Building showing keepouts (orange) and other model details. Keepout areas typically include mechanical equipment, access pathways, skylights, and roof drains.

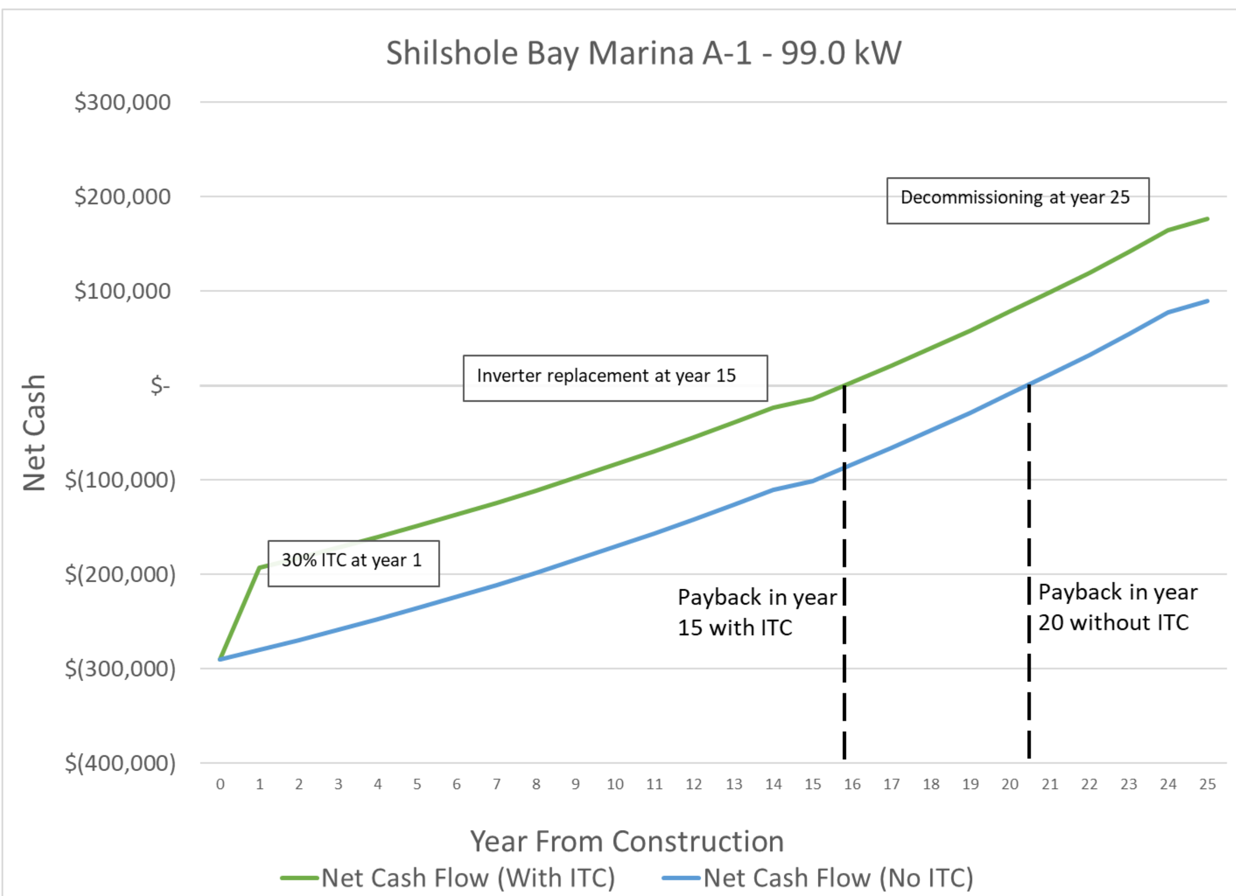


Figure 38: Shilshole Bay Marina A-1 Admin Building Financial Analysis Payback graph, indicating a payback in year 15with the ITC, and year 20 without the ITC.

V. Incentives and Financing Considerations

5.1 IRS Investment Tax Credit

Strategic use of incentives can help reduce capital expenditures across Port of Seattle facilities. The primary incentive for the development of solar projects at this scale is the Federal Investment Tax Credit (ITC) direct payment[20] under the Inflation Reduction Act of 2022. If the program qualifications are met, this program provides a cash reimbursement or base-credit of up to 30% of eligible project costs, with opportunities for bonus credits. Reimbursements are made the year after the system is placed in service. Further evaluation is needed to determine if the Port is eligible for this program, such as coordination with a tax attorney or Port legal representatives.

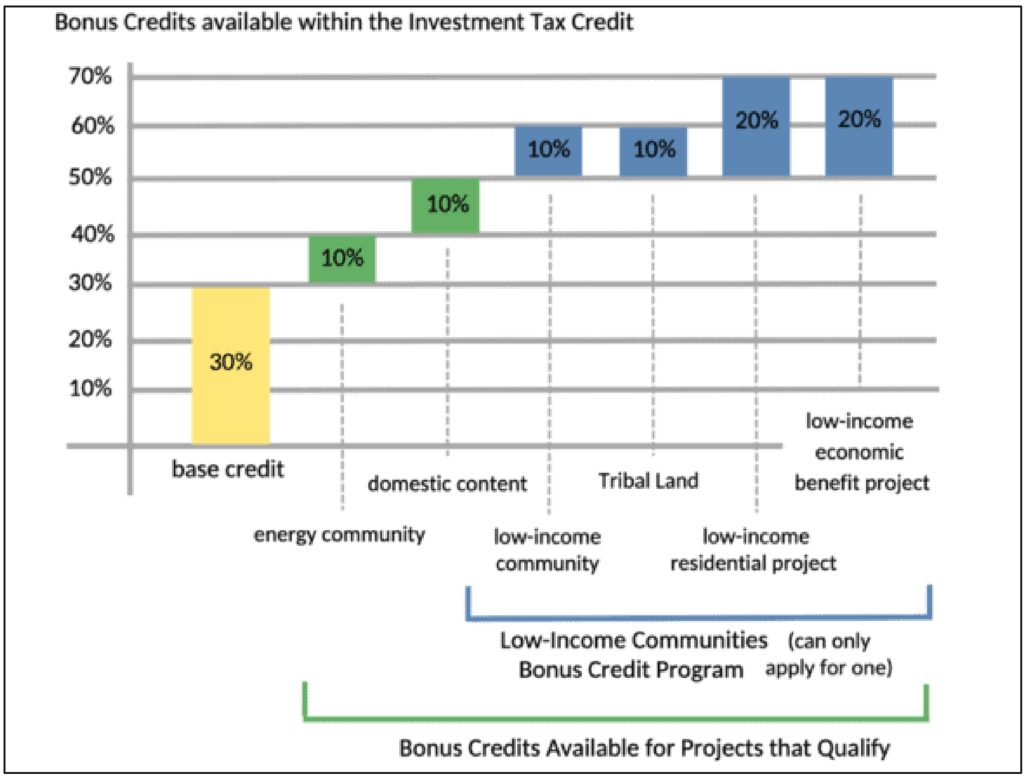


Figure 39: ITC Direct Payment Available from the Inflation Reduction Act. This program offers a base credit for 30% of Solar Project Costs for eligible entities. Further, the 10% domestic content bonus may be available to the Port of Seattle depending on installing qualifying equipment and eligibility.

While grants, rebates, and incentives like the ITC are subject to availability, eligibility, and adherence to filing timeline, other public agencies have been successful in applying the ITC for solar projects to receive a direct payment. UndauntedK12[21] is a non-profit organization that has supported public agencies throughout the direct payment process, including guidance on eligibility, process, and case study examples of successful reimbursement.

[20] https://www.whitehouse.gov/cleanenergy/directpay/
[21] https://www.undauntedk12.org/how-schools-get-reimbursed

5.2 Net metering and Distributed Generation

Additional considerations include net metering benefits provided under Washington State law RCW 80.60. This law allows renewable energy systems with a capacity of up to 100 kW-AC to participate in net metering, enabling excess energy produced by the system to be sent to the grid; the utility company then credits the customer at the retail utility rate for this energy. Due to high energy use at the campus level, which likely exceeds solar production throughout the year, surplus solar generation at the prioritized sites is expected to be distributed behind the campus meter, with no export to the utility grid. As a result, all solar production is anticipated to be used by Port facilities, although detailed energy use data, such as interval data, can inform coincident production and potential solar energy export quantity. Detailed energy use, such as interval data, is required to confirm and model power export potential.

There is some uncertainty around Net Metering and future utility programs regarding how they will value electricity produced from distributed generation like solar PV. The prioritized systems are all behind a campus meter with large loads. Because of this, the Port is expected to be insulated from energy export uncertainty as any energy generated and used within the campus loops will offset retail energy costs on a 1-for-1 basis. This is a key advantage to behind-the-meter solar generation. Systems can be designed to minimize electricity export through right-sizing solar PV to not exceed the minimum coincident demand or incorporating energy storage.

5.3 Grant Resources

Grant funding resources are a valuable consideration to reduce capital costs for PV systems. Washington State Department of Commerce Clean Energy Fund (CEF)[22] and the Energy Program in Communities (EPIC)[23] are both highly successful funding programs that offer a wide breadth of funding options. Specifically, the following programs have been identified as potential project funding sources for the Port of Seattle.

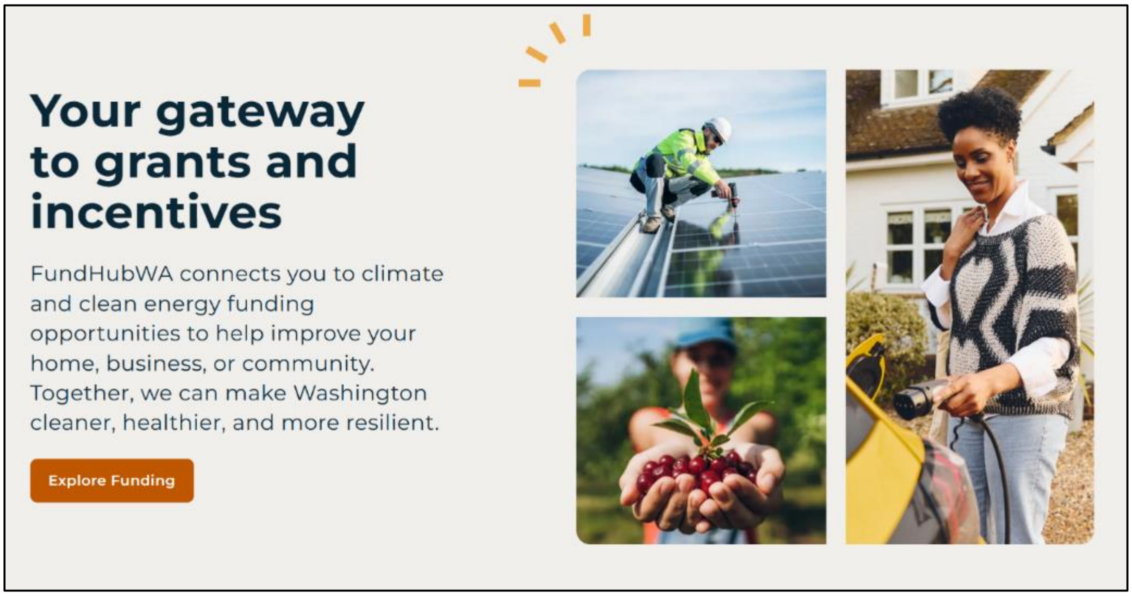
- CEF Grid Modernization Program
- EPIC Community Decarbonization Grant
- EPIC General Clean Energy Grant
- WA DOC Energy Efficiency and Retrofit Grant[24]

Based on historical trends, the Washington State Department of Commerce is expected to release funding opportunity announcements for many of these programs in spring 2025. Previous grant ceilings for these programs have ranged from $400,000 to $3 million. The projects identified in the shortlist are expected to fall within this funding range.

Two essential tools for identifying and targeting funding opportunities are the DSIRE[25] website and the recently launched FundHubWA[26] portal. Both platforms enable users to search for state and

22 https://www.commerce.wa.gov/epic/legacy-programs/cef/
23 https://www.commerce.wa.gov/epic/
24 https://www.commerce.wa.gov/energy-incentives/energy-efficiency-grant-program/
25 https://programs.dsireusa.org/system/program/wa
26 https://fundhub.wa.gov/funding-opportunities/

federal climate and clean energy grants and incentives, making them critical resources for securing future funding.



Credit: FundHubWA Portal

5.4 Operations and Maintenance (O&M) Reserves

One fiscal strategy is to hold energy savings from reduced grid purchases to fund O&M reserves. This strategy, in effect, redirects money that would have otherwise been spent on utility-provided energy towards the cost of operating and maintaining the system. Additionally, this strategy can be used to finance the decommissioning costs. O&M costs were included in financial analysis calculations for this study, so this strategy is not expected to negatively impact actual payback for the prioritized systems.

This strategy does not apply when the tenant pays bills directly to the utility. However, if the tenant pays utility expenses to the Port, a production meter should be installed to allow the Port to bill tenants for energy usage and recover its investment in the PV system through the savings from onsite generation.

VI. Conclusion

This feasibility study has successfully vetted 50 properties, defined the top 10 sites that are feasible and identified three constructable, cost-effective, solar PV array concepts that meet all the Port's selection and prioritization criteria. These projects align with the Port's Century Agenda Goal 4 and advance the MCAAP goals in the building and campus energy chapter, in addition to other local and regional sustainability goals. The following tasks are recommended to pursue design development of the prioritized sites:

- Roof replacement for the Smith Cove solar PV project.
- Plan and specifications review by Port Engineering Services of each project. Review should also identify additional building and/or site infrastructure upgrades needed for project feasibility as well as identifying how the power generation of each project would impact current electrical demand.
- Identify capital project process: have Port Engineering Services and/or Waterfront Project Management provide cost estimates for the plans revised by Port Engineering Services.
- Identify alternative funding source(s) (e.g., grant funding, private/public partnerships).
- Assemble a project team, such as a 'Port of Seattle Clean Energy Taskforce'.
- Obtain approval of each project by a project sponsor including any associated equipment (including battery storage), building and/or site improvements.

Säzän Group is excited to have been invited to support this Service Directive for the Port's sustainability initiatives and is happy to provide clarification or elaboration on any of our findings in this report. Säzän Group and TKDA Structural Engineers commend the Port on this initiative to evaluate and proactively consider opportunities for solar project development.

Appendices

Appendix A
Site Screening Tool

Data Table Columns	Data Source	Applicability	Definition
Property Name	Port	All Sites	
Property Address	Port	All Sites	
Port Campus	Port	All Sites	
Google Plus Code	Satellite Survey	All Sites	Google maps coordinate code. used for quickly locating the building site on Google Maps for buildings with limited public mapping.
Shortlist Y/N	Port	All Sites	
Stoplight Assessment	Satellite Survey	All Sites	Holistic qualitative scoring from 1-3 with 3 being best. Based on preliminary modeling and remote site survey only.
Site Owner	Port	All Sites	
Site Operator	Port	All Sites	
Building Square Footage	Port	All Sites	
Baseline Annual kWh Consumption	Port	All Sites	Electricity consumption per year. This can be used to determine fractional energy savings with solar.
Building Information - Satellite (Need to Confirm on site)	Satellite Survey	All Sites	Building construction and function description. This is useful for screening sites. (e.g. wooden pole barns are typically infeasble for solar structurally)
Building Type	Port	All Sites	Building type/function information
Roof Square Footage	Port	All Sites	
Roof Type -Satellite	Satellite Survey	All Sites	Apparent roof type from satellite imagery. Typical types are TPO, modified bitumen, corrugated and standing seam metal, and some others. Satellite roof type is only a visual estimate and will be confirmed for shortlisted sites.
Roof Condition (1-10) - Satellite	Satellite Survey	All Sites	Qualitative estimate of roof condition; 1 is very bad - 10 is excellent. Soiling, discoloration, water pooling, etc. are used for this qualitative evaluation. Solar arrays can last multiple decades, and roof replacement after an array is installed is much more expensive, so roof age and condition are important considerations for screening.
Roof Shape Complexity - Satellite (1-10)	Satellite Survey	All Sites	Qualitative estimate of roof complexity focused on shape: 10 is most complex. Mostly flat, square roofs of uniform height would be ranked 1. Roofs with multiple levels, various slopes, curved surfaces, small sections, or angled shapes are ranked with higher scores. This does not consider parapets, penetrations, mechanical equipment, etc.
Roof Obstruction Complexity (1-10) - Satellite	Satellite Survey	All Sites	Qualitative estimate of roof complexity focused on obstructions: 10 is most complex. no obstructions, parapets, or shading would be ranked 1. Roofs with many penetrations, skylights, or HVAC units would be ranked higher. Another aspect considered is the distribution of obstructions; a roof with many HVAC units on it all clustered together would be ranked lower than a roof with many scattered obstructions since the clustered layout may still allow a large array section that is efficient and easy to install.
Roof Aggregate Score (0-30)	Satellite Survey	All Sites	Single factor combining roof selection considerations for easy qualitative ranking (Roof Obstruction Complexity) + (Roof Shape Complexity) + (10-Roof Condition)
Roof Area Useable % Estimate- Satellite	Satellite Survey	All Sites	Qualitative estimate based on shape and obstructions. Visually estimated only.
Glare evaluation recommended? Y/N	Satellite Survey	All Sites	Are there adjacent buildings or locations that might be impacted by glare from a solar array? Visually estimated from satellite imagery and street view photos.
Array visibility estimated Y/N	Satellite Survey	All Sites	Can the rooftop and a future array be seen from areas away from the building? Visually estimated from satellite imagery and street view photos. This might include adjacent buildings, drivers on raised highways or roads, or from the street.
Roof Slope (Degrees)	Heliscope Modeling	All Sites	Roof Slope, 0 degrees being flat, all positive values.
Roof Azimuth (Degrees)	Heliscope Modeling	All Sites	Roof azimuth, 0 degrees being North, Positive values only clockwise from North. 180 being South. 270 west. Determined from LIDAR data in Helioscope.
Rooftop Height (ft)	Heliscope Modeling	All Sites	Roof Height in feet, determined from LIDAR. In relation to surrounding ground.
PV Application	Heliscope Modeling	All Sites	PV array information. E.g. Rooftop (Flat), Rooftop (Pitched), Fixed tilt
Shading%	Heliscope Modeling	All Sites	Percentage of the annual performance impacted by shading. This is modeled per module and can come from trees, structures, other parts of the array, and the horizon.
Module DC Nameplate (kW-DC)	Heliscope Modeling	All Sites	Size of the array in kilowatts based on the preliminary modeling. DC nameplate reflects the number of solar modules times the nameplate of those modules.
Module AC Nameplate (kW-AC)	Heliscope Modeling	All Sites	Size of the system inverters in kilowatts based on the preliminary modeling. AC nameplate comes from the conversion equipment size (inverters) and is typically slightly lower than the DC nameplate for a more cost effective and efficient system.
kWh/kWp	Heliscope Modeling	All Sites	unit performance of the preliminary modeling. kWh produced per year, per kW-DC nameplate
Estimated Production (kWH)	Heliscope Modeling	All Sites	Production estimate from preliminary Helioscope Model. Accounts for shading, and other factors.
Meter Type	Port	All Sites	Type of meter: Campus, or building-level
Total Electricity Use (2023 kWh)	Port	All Sites	Total building or campus electricity use for a year. Used to calculate the % offset of the site's solar array
Percent Offset of Campus Electricity (%)	Calculation	All Sites	(estimated production) / (total electricity use) * 100%
Total Solar Resource Fraction (TSRF)	Heliscope Modeling	All Sites	Percentage value related to the system productivity as compared to an ideal design for the site. Higher values indicate higher performance potential
>5kW Y/N	Calculation	All Sites	Is the DC nameplate > 5kW-DC?
Estimated Cost per Watt	Estimate	All Sites	Estimated unit ROM cost of the solar array. This is based on our experience on other installations and typical local costs. This is only based on the solar array preliminary concept and reflects our ROM estimate of potential bids from a commercial solar installer for the project. Does not include Port PM fees, bidding costs, RFP development, training, etc.
ROM Cost	Calculation	All Sites	(Cost per Watt) X (Module DC Nameplate)
SCL Rate Code	Port	All Sites	Utility rate code
SCL Rate Code Definition	Port	All Sites	Utility rate code
$/kWh (as of Oct 2024)	Port	All Sites	Unit cost of electricity by kWh from the utility provider for the specific site. This may be more than one number if billing is tiered.
Year 1 Energy Savings	Calculation	Shortlist	(Unit cost of electricity) X (estimated production in kWh)
Simple Payback (Years)	Calculation	Shortlist	(ROM Cost) / (Energy Savings). More detailed financial analysis provided for final site list.
Utility Hosting Capacity (kVA)	Port	Shortlist	Power capacity of the utility infrastructure serving the site or section of the campus. If the utility substation rating is known and is more limiting than the conductors, that number is used and annotated in the notes
Port Substation Capacity (kVA)	Port	Shortlist	Power capacity of the port infrastructure serving the site or section of the campus
Hosting Capacity Constraint Y/N	Port	All Sites	Is the hosting capacity limiting the size of the solar array at the site? E.g. is the rooftop sufficient for 100kW-Ac but the utility can only allow 15kW
Substation Feeding	Port	All Sites	Number or identifier for the Port's feeder/substation
Utility Feeder	Port	All Sites	Number or identifier for the Utility's feeder/substation
Downtown Spot Network Y/N?	Port	All Sites	Utility provided, is the site within the downtown spot network? This provides additional restrictions on solar installations

Port of Seattle Solar Screening Tool

Property Name	Property Address	Port Campus	Google Plus Code	Top 10 Y/N	Stoplight Assessment (Updated)	Site Owner -	Site Operator	Roof Square Footage
Shilshole Bay Marina – A-1 Admin Building	7001 Seaview Ave NW, Seattle, WA 98117	Shilshole Bay Marina	MHJW+74 Seattle, Washington	Y	3	Port of Seattle	Port of Seattle	12,160
Terminal 91 – C-175 Commercial	2001 W Garfield St #C175, Seattle, WA 98119	Terminal 91	JJG9+QXC Seattle, Washington	Y	3	Port of Seattle	Port of Seattle	88,000
Terminal 91 – Smith Cove Cruise Terminal	2001 W Garfield St #C100, Seattle, WA 98119	Terminal 91	JJG8+XR Seattle, Washington	Y	3	Port of Seattle	Port of Seattle	90,600
Fishermen's Terminal – I-3 Shipyard	1510 W Thurman St, Seattle, WA 98119	Fishermen's Terminal	MJ4F+55 Seattle, Washington	N	3	Port of Seattle	Tenant	12,370
Pier 66 – Anthony's Restaurant	2201 Alaskan Way, Seattle, WA 98121	Pier 66	JM62+8P Seattle, Washington	N	3	Port of Seattle	Port of Seattle	12,340
Pier 66 – World Trade Center West	2200 Alaskan Way, Seattle, WA 98121	Pier 66	JM62+FW Seattle, Washington	N	3	Port of Seattle	Property Manager	20,600
Pier 66 – Bell Harbor International ConferenceCe	2211 Alaskan Way, Seattle, WA 98121	Pier 66	JM62+F6 Seattle, Washington	Y	2	Port of Seattle	Port of Seattle	72,936
Pier 66 – Bell Harbor Marina Office	2203 Alaskan Way, Seattle, WA 98121	Pier 66	JM62+6J Seattle, Washington	Y	2	Port of Seattle	Port of Seattle	1,612
Terminal 91 – A-1 Warehouse	2001 W Garfield St, Seattle, WA 98119	Terminal 91	JJJ8+8R Seattle, Washington	Y	2	Port of Seattle	Port of Seattle	51,070
Terminal 91 – C-173 Commercial	2001 W Garfield St #C173, Seattle, WA 98119	Terminal 91	JJHC+V25 Seattle, Washington	Y	2	Port of Seattle	Port of Seattle	50,000
Terminal 91 - Smith Cove Covered Walkways	2001 W Garfield St #C100, Seattle, WA 98119	Terminal 91	JJH8+MRW Seattle, Washington	Y	2	Port of Seattle	Port of Seattle	Unknown
Fishermen's Terminal – C-2 Nordby	1711 W Nickerson St, Seattle, WA 98119	Fishermen's Terminal	MJ4C+273 Seattle, Washington	N	2	Port of Seattle	Port of Seattle	21,000
Fishermen's Terminal – N-3 Netshed Storage	1715 W Thurman St, Seattle, WA 98119	Fishermen's Terminal	MJ4C+4P Seattle, Washington	N	2	Port of Seattle	Port of Seattle	12,000
Fishermen's Terminal – N-4 Netshed Storage	1735 W Thurman St, Seattle, WA 98119	Fishermen's Terminal	MJ4C+5F Seattle, Washington	N	2	Port of Seattle	Port of Seattle	12,000
Fishermen's Terminal – N-6 Netshed Storage	602 Silky's Alley, Seattle, WA 98119	Fishermen's Terminal	MJ3C+V8 Seattle, Washington	N	2	Port of Seattle	Port of Seattle	11,400
Fishermen's Terminal – N-7 Netshed Storage	702 Silky's Alley, Seattle, WA 98119	Fishermen's Terminal	MJ3C+R5R Seattle, Washington	N	2	Port of Seattle	Port of Seattle	11,400
Fishermen's Terminal – N-8 Netshed Storage	812 18th Ave W, Seattle, WA 98119	Fishermen's Terminal	MJ3C+R2 Seattle, Washington	N	2	Port of Seattle	Port of Seattle	11,400
Maritime Industrial Center – A-1Warehouse/Sho	4600 27th Ave W, Seattle, WA 98199	Maritime Industrial Center	MJ75+66 Seattle, Washington	N	2	Port of Seattle	Port of Seattle	18,400
Maritime Industrial Center – A-2Warehouse/Sho	2700 W Commodore Way, Seattle, WA 98199	Maritime Industrial Center	MJ74+6W4 Seattle, Washington	N	2	Port of Seattle	Port of Seattle	4,590
Maritime Industrial Center – A-5Warehouse/Sho	2620 W Commodore Way, Seattle, WA 98199	Maritime Industrial Center	MJ75+5M6 Seattle, Washington	N	2	Port of Seattle	Port of Seattle	1,296
Shilshole Bay Marina – A-5 Office Building	6701 Seaview Ave NW, Seattle, WA 98117	Shilshole Bay Marina	MHGR+PRP Seattle, Washington	N	2	Port of Seattle	Port of Seattle	2,400
Shilshole Bay Marina – M-5 Restroom/ShowerFa	7001 Seaview Ave NW, Seattle, WA 98117	Shilshole Bay Marina	MHMW+6JV Seattle, Washington	N	2	Port of Seattle	Port of Seattle	480
Shilshole Bay Marina – M-6 Restroom/ShowerFa	7671 Seaview Ave NW, Seattle, WA 98117	Shilshole Bay Marina	MHMW+QJ Seattle, Washington	N	2	Port of Seattle	Port of Seattle	480
Terminal 102 – Building A	1001 SW Klickitat Way, Seattle, WA 98134	Terminal 102	HM92+WP5 Seattle, Washington	N	2	Port of Seattle	Port of Seattle	31,250
Terminal 102 – Building B	1001 SW Klickitat Way, Seattle, WA 98134	Terminal 102	HMC2+46P Seattle, Washington	N	2	Port of Seattle	Port of Seattle	29,687
Terminal 91 – M-86 Office	2001 W Garfield St #Bldg 86, Seattle, WA 98119	Terminal 91	JJM9+4V Seattle, Washington	N	2	Port of Seattle	Port of Seattle	2,286
Fishermen's Terminal – C-3 West Wall	4005 20th Ave W, Seattle, WA 98199	Fishermen's Terminal	MJ48+GW Seattle, Washington	Y	1	Port of Seattle	Port of Seattle	8,000
Fishermen's Terminal – N-9 Netshed Storage	909 16th Ave W, Seattle, WA 98119	Fishermen's Terminal	MJ3C+VJ Seattle, Washington	Y	1	Port of Seattle	Port of Seattle	9,360
Terminal 91 – C-155 Warehouse	2001 W Garfield St #C155, Seattle, WA 98119	Terminal 91	JJQ8+VW Seattle, Washington	Y	1	Port of Seattle	Port of Seattle	29,469
Fishermen's Terminal – C-10 Office	3918 15th Place W, Seattle, WA 98119	Fishermen's Terminal	MJ4F+62 Seattle, Washington	N	1	Port of Seattle	Port of Seattle	8,000
Fishermen's Terminal – I-2 Fire Department	1735 W Thurman St, Seattle, WA 98199	Fishermen's Terminal	MJ5C+7R7 Seattle, Washington	N	1	Port of Seattle	Port of Seattle	784
Fishermen's Terminal – I-8 Industrial	1561 W Nickerson St, Seattle, WA 98119	Fishermen's Terminal	MJ3F+X2 Seattle, Washington	N	1	Port of Seattle	Port of Seattle	9,500

Port of Seattle Solar Screening Tool

Port Provided or Assisted Data in Blue

1 is low, 10 is high — 1 is low, 10 is high

Property Name	Building Information	Building Type	Roof Type -From Site	Roof Age - Port	Roof Condition (1-10) - Satellite	Roof Shape Complexity - Satellite (1-10)	Roof Obstruction Complexity (1-10) - Satellite	Roof Sattelite Aggregate Score	Roof Area Useable % Estimate-Satellite	Glare evaluation recommended ? Y/N
Shilshole Bay Marina – A-1 Admin Building	Steel/Wood Framed, Mixed Use	Office/Retail	Standing Seam	Unknown	10	5	4	9	50%	N
Terminal 91 – C-175 Commercial	Steel Framed Warehouse	Refrigerated Warehouse/Offic	Membrane - TPO	9	9	5	5	11	50%	N
Terminal 91 – Smith Cove Cruise Terminal	Steel Framed	Transportation Terminal, stora	EPDM	15	5	1	7	13	50%	Y
Fishermen's Terminal – I-3 Shipyard	Tilt up Concrete	Shipyard	Torch Down - Mod-Bitumen	Unknown	7	1	2	6	70%	N
Pier 66 – Anthony's Restaurant	Steel Framed Restaurant	Restaurant	Standing Seam	Unknown	8	2	1	5	90%	N
Pier 66 – World Trade Center West	Concrete and Steel Office Buildi	Office	Built Up Roof	Unknown	9	1	3	5	80%	N
Pier 66 – Bell Harbor International ConferenceCe	Steel Framed Building	Transportation Terminal/Conv	Standing Seam, Membrane	Unknown	10	4	2	6	90%	N
Pier 66 – Bell Harbor Marina Office	Steel Framed Office	Office	Standing Seam	Unknown	10	3	3	6	60%	Y
Terminal 91 – A-1 Warehouse	Steel Framed Warehouse	Dry Warehouse	Standing Seam	Unknown	7	6	7	16	40%	N
Terminal 91 – C-173 Commercial	Steel Framed Warehouse	Dry Warehouse	Membrane - TPO	Unknown	9	2	1	4	100%	N
Terminal 91 - Smith Cove Covered Walkways	Steel framed awning	Steel framed awning	Corrugated Metal	Unknown	9	1	1	3	90%	Y
Fishermen's Terminal – C-2 Nordby	CMU - Commercial	Office	Torch Down - Mod-Bitumen	Unknown	8	1	8	11	25%	N
Fishermen's Terminal – N-3 Netshed Storage	Steel Framed Net Shed	Net Shed	Torch Down - Mod-Bitumen	Unknown	7	2	3	8	60%	N
Fishermen's Terminal – N-4 Netshed Storage	Steel Framed Net Shed	Net Shed	Torch Down - Mod-Bitumen	Unknown	7	2	3	8	60%	N
Fishermen's Terminal – N-6 Netshed Storage	Steel Framed Net Shed	Net Shed	Torch Down - Mod-Bitumen	Unknown	7	1	5	9	50%	N
Fishermen's Terminal – N-7 Netshed Storage	Steel Framed Net Shed	Net Shed	Torch Down - TPO	Unknown	5	1	5	11	50%	N
Fishermen's Terminal – N-8 Netshed Storage	Steel Framed Net Shed	Net Shed	Torch Down - TPO	Unknown	5	1	5	11	50%	N
Maritime Industrial Center – A-1Warehouse/Sho	CIP Concrete Structure	Warehouse/Shop	Torch Down - TPO	Unknown	5	1	4	10	50%	N
Maritime Industrial Center – A-2Warehouse/Sho	Wood Framed Industrial	Warehouse/Shop	Three-Tab - Torch Down Mod B	Unknown	7	5	1	9	100%	N
Maritime Industrial Center – A-5Warehouse/Sho	Steel Framed Warehouse	Warehouse/Shop	Corrugated Metal	Unknown	6	2	2	8	80%	N
Shilshole Bay Marina – A-5 Office Building	CMU Wall - Light Industrial	Office	Mod-Bitumen	Unknown	7	1	2	6	70%	N
Shilshole Bay Marina – M-5 Restroom/ShowerFa	CMU Wall - Restroom	Restrooms	Membrane	Unknown	9	1	3	5	70%	N
Shilshole Bay Marina – M-6 Restroom/ShowerFa	Steel Frame Bathroom	Restrooms	Standing Seam Metal	Unknown	10	1	1	2	90%	N
Terminal 102 – Building A	Typical Office Building	Office	Membrane	Unknown	5	2	7	14	30%	N
Terminal 102 – Building B	Typical Office Building	Office	Membrane	Unknown	5	2	8	15	20%	N
Terminal 91 – M-86 Office	Offices	Office	Corrugated Metal	Unknown	8	2	1	5	100%	N
Fishermen's Terminal – C-3 West Wall	Wood Framed Offices	Office	Torch Down - Mod-Bitumen	Unknown	5	1	2	8	80%	N
Fishermen's Terminal – N-9 Netshed Storage	Steel Framed Net Shed	Net Shed	Membrane - TPO	Unknown	9	1	1	3	100%	N
Terminal 91 – C-155 Warehouse	Steel Framed Warehouse	Warehouse	Corrugated Metal	Unknown	3	1	1	9	100%	N
Fishermen's Terminal – C-10 Office	Wood Framed - Offices	Industrial/Office	Torch Down - Composite	Unknown	7	1	5	9	50%	N
Fishermen's Terminal – I-2 Fire Department	Wood Framed - Shed	Fire Station	Corrugated Metal	Unknown	2	2	1	11	90%	N
Fishermen's Terminal – I-8 Industrial	Steel Frame Light Industrial	Industrial	Tar	Unknown	3	2	3	12	80%	N

Port of Seattle Solar Screening Tool

Property Name	Array visibility estimated Y/N	Rooftop Height (ft)	Roof Slope (Degrees)	Roof Azimuth (Degrees)	PV Application/Technology	Module DC Nameplate (kW-DC)	Module AC Nameplate (kW-AC)	kWh/kWp	Shading%	Estimated Production (kWH)	Meter Type
Shilshole Bay Marina – A-1 Admin Building	Y, some visibility from parking a	18	0	282	Flush Mount, seam clamps	100	80	989	2.40%	97,860	Campus Master
Terminal 91 – C-175 Commercial	Y, fishing vessels, Cruise ships f	17-35	0	90	Ballasted, flat roof	255	200	1,101	2.30%	281,100	Campus Master
Terminal 91 – Smith Cove Cruise Terminal	Y, cruise passengers on Cruise s	35	0	180	Ballasted, flat roof	304	240	1,101	2.80%	334,500	Campus Master
Fishermen's Terminal – I-3 Shipyard	Y, Highway	22.5	0	180	Fixed Tilt, Flat Roof	74	67	1,181	1.00%	87,690	Campus Master
Pier 66 – Anthony's Restaurant	Y, Water traffic	35	8.5	180	Flush Mount, Pitched Roof	46	33	1,118	0.00%	51,510	Building Meter
Pier 66 – World Trade Center West	N	50	0	221	Fixed Tilt, Flat Roof	87	66	1,154	2.10%	100,100	Building Meter
Pier 66 – Bell Harbor International ConferenceCe	Y, public, cruise passengers	37	12.5	270	Flush Mount, seam clamps	34	29	1,029	1.60%	35,290	Building Meters
Pier 66 – Bell Harbor Marina Office	Y, cruise passengers	12	17	90	Flush Mount, seam clamps	12	11	1,038	1.30%	12,200	Building Meter
Terminal 91 – A-1 Warehouse	Y, cruise passengers	29-42	Various	270	Flush Mount, seam clamps	241	200	1,039	1.50%	250,500	Campus Master
Terminal 91 – C-173 Commercial	Y, fishing vessels only	25	4.6	90	Flush mount, or ballasted depending	470	367	1,049	0.00%	493,700	Campus Master
Terminal 91 - Smith Cove Covered Walkways	Y, public, cruise passengers	11	15	270	Flush Mount, attached	183	133	1,048	0.30%	192,000	Campus Master
Fishermen's Terminal – C-2 Nordby	N	13.5	0	180	Flush Mount, Flat Roof	60	58	1,175	1.20%	70,270	Campus Master
Fishermen's Terminal – N-3 Netshed Storage	Y, Highway	27	3.7	90	Fixed Tilt, Flat Roof	76	67	1,146	2.90%	87,110	Campus Master
Fishermen's Terminal – N-4 Netshed Storage	Y, Highway	28	3.7	90	Fixed Tilt, Flat Roof	54	43	1,176	1.10%	67,410	Campus Master
Fishermen's Terminal – N-6 Netshed Storage	N	24	3.2	90	Fixed Tilt, Flat Roof	63	67	1,193	1.10%	74,870	Campus Master
Fishermen's Terminal – N-7 Netshed Storage	N	26	2.3	90	Fixed Tilt, Flat Roof	86	72	1,175	1.10%	100,700	Campus Master
Fishermen's Terminal – N-8 Netshed Storage	N	26	3.5	90	Fixed Tilt, Flat Roof	86	72	1,174	1.20%	100,700	Campus Master
Maritime Industrial Center – A-1Warehouse/Sho	N	29	0	180	Fixed Tilt, Flat Roof	120	100	1,186	1.50%	141,800	Campus Master
Maritime Industrial Center – A-2Warehouse/Sho	Y, Road traffic	10-23	Various	90	Fixed and Flush Mount	30	29	993	6.20%	30,190	Campus Master
Maritime Industrial Center – A-5Warehouse/Sho	Y, Road traffic	21	19	180	Flush Mount, Pitched Roof	14	14	1,026	0.00%	14,080	Campus Master
Shilshole Bay Marina – A-5 Office Building	N	12	0	180	Fixed Tilt, Flat Roof	13	10	1,156	0.80%	14,740	Campus Master
Shilshole Bay Marina – M-5 Restroom/ShowerFa	N	10	0	180	Flush Mount, Flat Roof	11	10	1,007	0.00%	10,850	Campus Master
Shilshole Bay Marina – M-6 Restroom/ShowerFa	Y, Marina traffic	12	6.6	184	Flush Mount, Pitched Roof	9	7	1,051	0.00%	9,276	Campus Master
Terminal 102 – Building A	Y, Highway	26	0	180	Fixed Tilt, Flat Roof	92	67	1,140	1.40%	105,100	Building Meters
Terminal 102 – Building B	Y, Highway	26	0	227	Fixed Tilt, Flat Roof	89	67	1,109	3.50%	98,960	Building Meters
Terminal 91 – M-86 Office	Y, Road traffic	20	4.4	90	Flush Mount, Pitched Roof	16	15	1,033	0.90%	16,710	Campus Master
Fishermen's Terminal – C-3 West Wall	N	22	0	180	Ballasted or Attached, none recomm	28	23	1,138	1.60%	32,350	Campus Master
Fishermen's Terminal – N-9 Netshed Storage	Y, Highway	26.5	4.7	90	Ballasted, flat roof	92	67	1,193	1.10%	105,800	Campus Master
Terminal 91 – C-155 Warehouse	N	19.7	4.8	90	Flush Mount, Attached	382	300	1,054	0.00%	402,900	Campus Master
Fishermen's Terminal – C-10 Office	N	17-21	0	180	Fixed Tilt, Flat Roof	14	14	1,023	0.70%	14,040	Campus Master
Fishermen's Terminal – I-2 Fire Department	Y, Boaters	12.5	0	180	Flush Mount, Flat Roof	6	6	1,057	0.00%	6,218	Campus Master
Fishermen's Terminal – I-8 Industrial	Y, Highway	10-14	0	180	Fixed Tilt, Flat Roof	56	58	1,172	1.60%	68,350	Campus Master

Port of Seattle Solar Screening Tool

Port Provided or Assisted Data in Blue

Property Name	Total Electricity Use (2023 kWh)	Percent Offset of Campus Electricity (%)	Total Solar Resource Fraction (TSRF)	>5kW Y/N	Estimated Cost per Watt (before overhead markup)	ROM Installed Cost (No Overhead Applied)	ROM Cost with 25.1% Port Overhead Applied	SCL Rate Code	SCL Rate Code Definition	$/kWh (as of Oct 2024)	Year 1 Energy Savings
Shilshole Bay Marina – A-1 Admin Building	6,493,434	1.507%	84.5%	Y	$ 2.70	$ 269,730	$ 337,432	ELGC	Large General Service,	$ 0.10910	$ 10,676.53
Terminal 91 – C-175 Commercial	11,367,730	2.473%	90.0%	Y	$ 2.70	$ 689,310	$ 862,327	ELGC	Large General Service,	$ 0.10910	$ 30,668.01
Terminal 91 – Smith Cove Cruise Terminal	11,367,730	2.943%	89.6%	Y	$ 2.70	$ 820,260	$ 1,026,145	ELGC	Large General Service,	$ 0.10910	$ 36,493.95
Fishermen's Terminal – I-3 Shipyard	8,301,100	1.056%	91.2%	Y	$ 3.20	$ 237,440	$ 297,037	EMDC	Medium General Servi	$ 0.09170	$ 8,041.17
Pier 66 – Anthony's Restaurant	782,760	6.581%	90.8%	Y	$ 3.10	$ 142,910	$ 178,780	EMDD	Medium General Servi	$ 0.10370	$ 5,341.59
Pier 66 – World Trade Center West	Unknown	Unknown	89.0%	Y	$ 3.20	$ 278,400	$ 348,278	EMDD	Medium General Servi	$ 0.10370	$ 10,380.37
Pier 66 – Bell Harbor International ConferenceCe	1,917,083	1.841%	84.1%	Y	$ 3.20	$ 109,760	$ 137,310	EMDD	Medium General Servi	$ 0.10370	$ 3,659.57
Pier 66 – Bell Harbor Marina Office	356,240	3.425%	83.0%	Y	$ 3.20	$ 37,760	$ 47,238	EMDD	Medium General Servi	$ 0.10370	$ 1,265.14
Terminal 91 – A-1 Warehouse	11,367,730	2.204%	84.2%	Y	$ 2.80	$ 675,080	$ 844,525	ELGC	Large General Service,	$ 0.10910	$ 27,329.55
Terminal 91 – C-173 Commercial	11,367,730	4.343%	85.4%	Y	$ 2.80	$ 1,317,120	$ 1,647,717	ELGC	Large General Service,	$ 0.10910	$ 53,862.67
Terminal 91 - Smith Cove Covered Walkways	11,367,730	1.689%	85.0%	Y	$ 2.80	$ 513,240	$ 642,063	ELGC	Large General Service,	$ 0.10910	$ 20,947.20
Fishermen's Terminal – C-2 Nordby	8,301,100	0.847%	91.0%	Y	$ 3.20	$ 191,360	$ 239,391	EMDC	Medium General Servi	$ 0.09170	$ 6,443.76
Fishermen's Terminal – N-3 Netshed Storage	8,301,100	1.049%	91.2%	Y	$ 3.00	$ 228,000	$ 285,228	EMDC	Medium General Servi	$ 0.09170	$ 7,987.99
Fishermen's Terminal – N-4 Netshed Storage	8,301,100	0.812%	91.2%	Y	$ 3.00	$ 161,700	$ 202,287	EMDC	Medium General Servi	$ 0.09170	$ 6,181.50
Fishermen's Terminal – N-6 Netshed Storage	8,301,100	0.902%	91.2%	Y	$ 3.00	$ 188,100	$ 235,313	EMDC	Medium General Servi	$ 0.09170	$ 6,865.58
Fishermen's Terminal – N-7 Netshed Storage	8,301,100	1.213%	91.1%	Y	$ 3.00	$ 257,400	$ 322,007	EMDC	Medium General Servi	$ 0.09170	$ 9,234.19
Fishermen's Terminal – N-8 Netshed Storage	8,301,100	1.213%	91.1%	Y	$ 3.00	$ 257,400	$ 322,007	EMDC	Medium General Servi	$ 0.09170	$ 9,234.19
Maritime Industrial Center – A-1Warehouse/Sho	853,600	16.612%	88.5%	Y	$ 3.00	$ 358,800	$ 448,859	EMDC	Medium General Servi	$ 0.09170	$ 13,003.06
Maritime Industrial Center – A-2Warehouse/Sho	853,600	3.537%	80.4%	Y	$ 3.20	$ 97,280	$ 121,697	EMDC	Medium General Servi	$ 0.09170	$ 2,768.42
Maritime Industrial Center – A-5Warehouse/Sho	853,600	1.649%	96.4%	Y	$ 3.50	$ 47,950	$ 59,985	EMDC	Medium General Servi	$ 0.09170	$ 1,291.14
Shilshole Bay Marina – A-5 Office Building	6,493,434	0.227%	91.9%	Y	$ 3.50	$ 44,450	$ 55,607	ELGC	Large General Service,	$ 0.10910	$ 1,608.13
Shilshole Bay Marina – M-5 Restroom/ShowerFa	6,493,434	0.167%	86.0%	Y	$ 3.50	$ 37,800	$ 47,288	ELGC	Large General Service,	$ 0.10910	$ 1,183.74
Shilshole Bay Marina – M-6 Restroom/ShowerFa	6,493,434	0.143%	90.7%	Y	$ 3.50	$ 30,800	$ 38,531	ELGC	Large General Service,	$ 0.10910	$ 1,012.01
Terminal 102 – Building A	230,045	45.687%	90.9%	Y	$ 3.00	$ 276,000	$ 345,276	ESMCM	Small General Service,	$ 0.11810	$ 12,412.31
Terminal 102 – Building B	351,118	28.184%	87.4%	Y	$ 3.00	$ 267,000	$ 334,017	ESMCM	Small General Service,	$ 0.11810	$ 11,687.18
Terminal 91 – M-86 Office	11,367,730	0.147%	84.6%	Y	$ 3.50	$ 56,700	$ 70,932	ELGC	Large General Service,	$ 0.10910	$ 1,823.06
Fishermen's Terminal – C-3 West Wall	8,301,100	0.390%	90.6%	Y	$ 3.30	$ 93,720	$ 117,244	EMDC	Medium General Servi	$ 0.09170	$ 2,966.50
Fishermen's Terminal – N-9 Netshed Storage	8,301,100	1.275%	91.1%	Y	$ 3.00	$ 276,300	$ 345,651	EMDC	Medium General Servi	$ 0.09170	$ 9,701.86
Terminal 91 – C-155 Warehouse	11,367,730	3.544%	85.3%	Y	$ 2.80	$ 1,070,160	$ 1,338,770	ELGC	Large General Service,	$ 0.10910	$ 43,956.39
Fishermen's Terminal – C-10 Office	8,301,100	0.169%	91.5%	Y	$ 3.50	$ 47,950	$ 59,985	EMDC	Medium General Servi	$ 0.09170	$ 1,287.47
Fishermen's Terminal – I-2 Fire Department	8,301,100	0.075%	91.2%	Y	$ 4.00	$ 23,600	$ 29,524	EMDC	Medium General Servi	$ 0.09170	$ 570.19
Fishermen's Terminal – I-8 Industrial	8,301,100	0.823%	91.2%	Y	$ 3.30	$ 186,120	$ 232,836	EMDC	Medium General Servi	$ 0.09170	$ 6,267.70

Port of Seattle Solar Screening Tool From SWCES Load Forecast Analysis Report

Property Name	Simple Payback (Years) (Includes Port Overhead)	Utility Hosting Capacity (kVA)	Port Substation Capacity (kVA)	Hosting Capacity Constraint Y/N	Substation Feeding	Utility Feeder	Downtown Spot Network Y/N?
Shilshole Bay Marina – A-1 Admin Building	31.6	7500	1000	N	6	substation feeder	N
Terminal 91 – C-175 Commercial	28.1	7500	1500	N	SS-1	MSS-1 South	N
Terminal 91 – Smith Cove Cruise Terminal	28.1	7500	3000	N	Cruise Building	MSS-1 South	N
Fishermen's Terminal – I-3 Shipyard	36.9	12800	2000	N	6	SCL - 2658	N
Pier 66 – Anthony's Restaurant	33.5	Unknown	Unknown	Unknown	Unknown	Unknown	Y
Pier 66 – World Trade Center West	33.6	Unknown	Unknown	Unknown	Unknown	Unknown	Y
Pier 66 – Bell Harbor International ConferenceCe	37.5	Unknown	Unknown	Unknown	Unknown	Unknown	Y
Pier 66 – Bell Harbor Marina Office	37.3	Unknown	Unknown	Unknown	Unknown	Unknown	Y
Terminal 91 – A-1 Warehouse	30.9	7500	3000	N	SS-8A	MSS-1 South	N
Terminal 91 – C-173 Commercial	30.6	7500	750	N	SS-2	MSS-1 South	N
Terminal 91 - Smith Cove Covered Walkways	30.7	7500	3000	N	Cruise Building	MSS-1 South	N
Fishermen's Terminal – C-2 Nordby	37.2	12800	1500	N	7	SCL - 2658	N
Fishermen's Terminal – N-3 Netshed Storage	35.7	12800	1500	N	7	SCL - 2658	N
Fishermen's Terminal – N-4 Netshed Storage	32.7	12800	1500	N	7	SCL - 2658	N
Fishermen's Terminal – N-6 Netshed Storage	34.3	12800	1500	N	7	SCL - 2658	N
Fishermen's Terminal – N-7 Netshed Storage	34.9	12800	1500	N	7	SCL - 2658	N
Fishermen's Terminal – N-8 Netshed Storage	34.9	12800	1500	N	7	SCL - 2658	N
Maritime Industrial Center – A-1Warehouse/Sho	34.5	Unknown	Unknown	Unknown	Unknown	Unknown	N
Maritime Industrial Center – A-2Warehouse/Sho	44.0	Unknown	Unknown	Unknown	Unknown	Unknown	N
Maritime Industrial Center – A-5Warehouse/Sho	46.5	Unknown	Unknown	Unknown	Unknown	Unknown	N
Shilshole Bay Marina – A-5 Office Building	34.6	7500	750	N	1	substation feeder	N
Shilshole Bay Marina – M-5 Restroom/ShowerFa	39.9	7500	500	N	8	substation feeder	N
Shilshole Bay Marina – M-6 Restroom/ShowerFa	38.1	7500	500	N	9	substation feeder	N
Terminal 102 – Building A	27.8	Unknown	Unknown	Unknown	Unknown	Unknown	N
Terminal 102 – Building B	28.6	Unknown	Unknown	Unknown	Unknown	Unknown	N
Terminal 91 – M-86 Office	38.9	7500	Unknown	N	Unknown	MSS-1 South	N
Fishermen's Terminal – C-3 West Wall	39.5	12800	1500	N	4	SCL - 2658	N
Fishermen's Terminal – N-9 Netshed Storage	35.6	12800	1500	N	7	SCL - 2658	N
Terminal 91 – C-155 Warehouse	30.5	7500	750	N	SS-13	MSS-1 South	N
Fishermen's Terminal – C-10 Office	46.6	12800	2000	N	6	SCL - 2658	N
Fishermen's Terminal – I-2 Fire Department	51.8	12800	2000	N	6	SCL - 2658	N
Fishermen's Terminal – I-8 Industrial	37.1	12800	1500	N	7	SCL - 2658	N

Port of Seattle Solar Screening Tool

Property Name	Notes
Shilshole Bay Marina – A-1 Admin Building	Resized to allow interconnection in building electrical and avoid trenching and feeder tap to substation, Production updated with Boeing Field TMY3, Detailed cost estimate at $2.34; $231,900 before Port Overhead
Terminal 91 – C-175 Commercial	Resized to accommodate either MDP (1600A) or Substation (2000A) interconnection, Production updated with Boeing Field TMY3, Detailed cost estimate at $2.68; $684,236 before Port Overhead
Terminal 91 – Smith Cove Cruise Terminal	Resized to accommodate MDP breaker frame limits (400A), Production updated with Boeing Field TMY3, Detailed cost estimate at $2.75; $834,774 before Port Overhead
Fishermen's Terminal – I-3 Shipyard	
Pier 66 – Anthony's Restaurant	
Pier 66 – World Trade Center West	
Pier 66 – Bell Harbor International ConferenceCe	Spot Network issues, interconnection complexity within building electrical system. Resized to possibly allow a 225A panel interconnection
Pier 66 – Bell Harbor Marina Office	Spot Network issues. Resized for Microinverter design, and roof anchors
Terminal 91 – A-1 Warehouse	Recommend deprioritizing due to complex roof geometry and sky lights likely increasing cost of installation.
Terminal 91 – C-173 Commercial	Note from Port Engineers indicates MDP is beyond useful life and interconnection not recommended.
Terminal 91 - Smith Cove Covered Walkways	Deprioritized due to unknown electrical infrastructure
Fishermen's Terminal – C-2 Nordby	
Fishermen's Terminal – N-3 Netshed Storage	Model updated for keepout height
Fishermen's Terminal – N-4 Netshed Storage	
Fishermen's Terminal – N-6 Netshed Storage	Model updated for keepout location
Fishermen's Terminal – N-7 Netshed Storage	
Fishermen's Terminal – N-8 Netshed Storage	Model updated for trees to the west
Maritime Industrial Center – A-1Warehouse/Sho	Model row alignment location adjusted
Maritime Industrial Center – A-2Warehouse/Sho	Model pitched roof line adjusted eliminating a row
Maritime Industrial Center – A-5Warehouse/Sho	
Shilshole Bay Marina – A-5 Office Building	
Shilshole Bay Marina – M-5 Restroom/ShowerFa	
Shilshole Bay Marina – M-6 Restroom/ShowerFa	Building is new on satellite. POS records may need update
Terminal 102 – Building A	Port Directed, will not be considered for solar
Terminal 102 – Building B	Port Directed, will not be considered for solar
Terminal 91 – M-86 Office	Substation 4 removed as part of berth project, new one will be installed
Fishermen's Terminal – C-3 West Wall	Deprioritized from Port
Fishermen's Terminal – N-9 Netshed Storage	Deprioritized from Port
Terminal 91 – C-155 Warehouse	Deprioritized by Port- Building may be demo'd as part of the Uploands Redevelopment. System size limited to 300kW-AC based on estimated transformer size (no markings visible) assuming line side tap or direct connect. Roughly 160kW-AC could be connected to MDP by 120% rule (1200A MDP, 1200A Main)
Fishermen's Terminal – C-10 Office	SCL Feeder 2658 is most limiting, but no information on what sites are served
Fishermen's Terminal – I-2 Fire Department	Building is on Dock 4
Fishermen's Terminal – I-8 Industrial	

Port of Seattle Solar Screening Tool

Property Name	Property Address	Port Campus	Google Plus Code	Top 10 Y/N	Stoplight Assessment (Updated)	Port Provided or Assisted Data in Blue Site Owner -	Site Operator	Roof Square Footage
Fishermen's Terminal – M-15 Restroom	12 20th Ave W, Seattle, WA 98199	Fishermen's Terminal	MJ58+6RX Seattle, Washington	N	1	Port of Seattle	Port of Seattle	650
Fishermen's Terminal – M-2 Restroom	2 15th Place W, Seattle, WA 98119	Fishermen's Terminal	MJ4F+73 Seattle, Washington	N	1	Port of Seattle	Port of Seattle	650
Fishermen's Terminal – M-4 Industrial	3919 18th Ave W, Seattle, WA 98119	Fishermen's Terminal	MJ4F+47F Seattle, Washington	N	1	Port of Seattle	Port of Seattle	2,275
Fishermen's Terminal – N-10 NetshedStorage	1015 16th Ave W, Seattle, WA 98119	Fishermen's Terminal	MJ3C+VRW Seattle, Washington	N	1	Port of Seattle	Port of Seattle	11,583
Fishermen's Terminal – N-11 NetshedStorage	1120 16th Ave W, Seattle, WA 98119	Fishermen's Terminal	MJ3C+RR Seattle, Washington	N	1	Port of Seattle	Port of Seattle	3,900
Maritime Industrial Center – A-3Warehouse/Sho	2620 W Commodore Way, Seattle, WA 98199	Maritime Industrial Center	MJ75+7RF Seattle, Washington	N	1	Port of Seattle	Port of Seattle	2,511
Maritime Industrial Center – A-4Warehouse/Sho	2620 W Commodore Way, Seattle, WA 98199	Maritime Industrial Center	MJ75+5Q Seattle, Washington	N	1	Port of Seattle	Port of Seattle	2,848
Shilshole Bay Marina – I-1 Little ConeyRestauran	8003 Seaview Ave NW, Seattle, WA 98117	Shilshole Bay Marina	MHPW+JP Seattle, Washington	N	1	Port of Seattle	Port of Seattle	1,200
Shilshole Bay Marina – M-1 Restroom/ShowerFa	6701 Seaview Ave NW, Seattle, WA 98117	Shilshole Bay Marina	MHGR+PWM Seattle, Washingtor	N	1	Port of Seattle	Port of Seattle	480
Shilshole Bay Marina – M-7 Restroom/ShowerFa	8003 Seaview Ave NW, Seattle, WA 98117	Shilshole Bay Marina	MHPW+JJR Seattle, Washington	N	1	Port of Seattle	Port of Seattle	2,400
Terminal 100 - Marine Maintenance Shop South	25 S Horton St, Seattle, WA 98134	Terminal 100	HMF6+PG Seattle, Washington	N	1	Port of Seattle	Port of Seattle	32,192
Terminal 91 – C-156 Warehouse	2001 W Garfield St #C156, Seattle, WA 98119	Terminal 91	JJQ9+H27 Seattle, Washington	N	1	Port of Seattle	Port of Seattle	8,000
Terminal 91 – W-390 Cold Storage	2001 W Garfield St #W390, Seattle, WA 98119	Terminal 91	JJP8+3W3 Seattle, Washington	N	1	Port of Seattle	Tenant Ground Lease	117,556
Terminal 91 – W-391 Cold Storage	2001 W Garfield St #W391, Seattle, WA 98119	Terminal 91	JJP8+CW4 Seattle, Washington	N	1	Port of Seattle	Tenant Ground Lease	105,900
Terminal 91 – W-392 Food Processing	2001 W Garfield St #W392, Seattle, WA 98119	Terminal 91	JJP9+Q2 Seattle, Washington	N	1	Port of Seattle	Tenant Ground Lease	150,100
Terminal 91 – W-40 Food Processing	2001 W Garfield St #W40, Seattle, WA 98119	Terminal 91	JJM8+PF Seattle, Washington	N	1	Port of Seattle	Port of Seattle	51,868

Port of Seattle Solar Screening Tool

Port Provided or Assisted Data in Blue

1 is low, 10 is high — 1 is low, 10 is high

Property Name	Building Information	Building Type	Roof Type -From Site	Roof Age - Port	Roof Condition (1-10) - Satellite	Roof Shape Complexity - Satellite (1-10)	Roof Obstruction Complexity (1-10) - Satellite	Roof Sattelite Aggregate Score	Roof Area Useable % Estimate-Satellite	Glare evaluation recommended? Y/N
Fishermen's Terminal – M-15 Restroom	Brick - Blockhouse	Restrooms	Membrane - TPO	Unknown	8	1	3	6	50%	N
Fishermen's Terminal – M-2 Restroom	Brick - Blockhouse	Restrooms	Membrane - PVC	Unknown	8	1	3	6	50%	N
Fishermen's Terminal – M-4 Industrial	Corrugated Steel, industrial	Industrial	Corrugated metal and FRP	Unknown	2	2	4	14	30%	N
Fishermen's Terminal – N-10 NetshedStorage	Wood Framed Net Shed	Net Shed	Standing Seam, Metal and FRP	Unknown	7	2	2	7	90%	N
Fishermen's Terminal – N-11 NetshedStorage	Wood Framed Net Shed	Net Shed	Standing Seam, Metal	Unknown	7	2	2	7	90%	N
Maritime Industrial Center – A-3Warehouse/Sho	Steel Framed Warehouse	Warehouse/Shop	Corrugated Metal	Unknown	6	2	2	8	45%	N
Maritime Industrial Center – A-4Warehouse/Sho	Steel Framed Warehouse	Warehouse/Shop	Standing Seam Metal	Unknown	7	2	2	7	45%	N
Shilshole Bay Marina – I-1 Little ConeyRestauran	Small Restaurant	Restaurant	Torch Down	Unknown	5	7	9	21	20%	N
Shilshole Bay Marina – M-1 Restroom/ShowerFa	CMU Wall - Restroom	Restrooms	Torch Down	Unknown	8	1	3	6	50%	N
Shilshole Bay Marina – M-7 Restroom/ShowerFa	Steel Frame Bathroom	Restrooms	Standing Seam	Unknown	7	1	9	13	20%	N
Terminal 100 - Marine Maintenance Shop South	CMU industrial, unknown fram	Office/Vehicle Maintenance	Torch Down - TPO	Unknown	7	6	7	16	30%	N
Terminal 91 – C-156 Warehouse	Steel Framed Warehouse	Office	Membrane - TPO	Unknown	6	4	6	14	50%	N
Terminal 91 – W-390 Cold Storage	CIP Concrete Structure	Refrigerated Warehouse/Food	Gravel over Liquid Applied	Unknown	6	1	3	8	70%	N
Terminal 91 – W-391 Cold Storage	CIP Concrete Structure	Refrigerated Warehouse/Food	Membrane - TPO	Unknown	7	1	1	5	90%	N
Terminal 91 – W-392 Food Processing	CIP Concrete Structure	Refrigerated Warehouse/Food	Membrane - TPO	Unknown	7	2	4	9	50%	N
Terminal 91 – W-40 Food Processing	CIP Concrete Structure	Food Processing/Office	Liquid Applied	Unknown	5	6	4	15	50%	N

Port of Seattle Solar Screening Tool

Property Name	Array visibility estimated Y/N	Rooftop Height (ft)	Roof Slope (Degrees)	Roof Azimuth (Degrees)	PV Application/Technology	Module DC Nameplate (kW-DC)	Module AC Nameplate (kW-AC)	kWh/kWp	Shading%	Estimated Production (kWH)	Meter Type
Fishermen's Terminal – M-15 Restroom	N	8.25	0	180	Flush Mount, Flat Roof	4	4	1,010	0.00%	4,456	Campus Master
Fishermen's Terminal – M-2 Restroom	N	10	0	180	Flush Mount, Flat Roof	8	7	667	28.50%	5,226	Campus Master
Fishermen's Terminal – M-4 Industrial	Y, Highway, some ground	18.5	27	115	Flush Mount, Pitched Roof	15	15	1,041	2.70%	15,310	Campus Master
Fishermen's Terminal – N-10 NetshedStorage	Y, Highway	21	4.4	180	Flush Mount, Pitched Roof	125	100	1,063	0.00%	132,900	Campus Master
Fishermen's Terminal – N-11 NetshedStorage	Y, Highway	20	5	180	Flush Mount, Pitched Roof	141	133	1,060	0.00%	149,100	Campus Master
Maritime Industrial Center – A-3Warehouse/Sho	Y, Road traffic	10	20	90	Flush Mount, Pitched Roof	8	6	944	0.00%	7,402	Campus Master
Maritime Industrial Center – A-4Warehouse/Sho	Y, Road traffic	9.4	34	180	Flush Mount, Pitched Roof	17	14	1,204	0.90%	20,070	Campus Master
Shilshole Bay Marina – I-1 Little ConeyRestauran	N	12.5	0	180	Flush Mount, Flat Roof	3	3	377	6.90%	2,872	Campus Master
Shilshole Bay Marina – M-1 Restroom/ShowerFa	N	9	0	180	Flush Mount, Flat Roof	8	7	917	0.90%	7,190	Campus Master
Shilshole Bay Marina – M-7 Restroom/ShowerFa	Y, Marina traffic	16	5	171	Flush Mount - Pitched Roof	9	7	1,039	0.00%	9,165	Campus Master
Terminal 100 - Marine Maintenance Shop South	Y, Highway	18	0	180	Fixed Tilt, Flat Roof	60	58	1,090	6.30%	65,720	Building Meter
Terminal 91 – C-156 Warehouse	N	13	0	180	Flush Mount - Flat Roof	89	67	1,054	0.00%	94,010	Campus Master
Terminal 91 – W-390 Cold Storage	Y, Road traffic	38.5	0	180	Fixed Tilt, Flat Roof	205	200	1,192	1.10%	245,300	Campus Master
Terminal 91 – W-391 Cold Storage	Y, Road traffic	42	0	180	Fixed Tilt, Flat Roof	558	500	1,190	1.10%	664,300	Campus Master
Terminal 91 – W-392 Food Processing	Y, Road traffic	25	0	90	Fixed Tilt, Flat Roof	443	400	1,191	1.20%	527,600	Campus Master
Terminal 91 – W-40 Food Processing	Y, Road traffic	22.5	0	180	Fixed Tilt, Flat Roof	357	300	1,177	1.00%	420,600	Campus Master

Port of Seattle Solar Screening Tool

Port Provided or Assisted Data in Blue

Property Name	Total Electricity Use (2023 kWh)	Percent Offset of Campus Electricity (%)	Total Solar Resource Fraction (TSRF)	>5kW Y/N	Estimated Cost per Watt (before overhead markup)	ROM Installed Cost (No Overhead Applied)	ROM Cost with 25.1% Port Overhead Applied	SCL Rate Code	SCL Rate Code Definition	$/kWh (as of Oct 2024)	Year 1 Energy Savings
Fishermen's Terminal – M-15 Restroom	8,301,100	0.054%	85.3%	N	$ 4.00	$ 17,600	$ 22,018	EMDC	Medium General Servi	$ 0.09170	$ 408.62
Fishermen's Terminal – M-2 Restroom	8,301,100	0.063%	61.0%	Y	$ 3.50	$ 27,440	$ 34,327	EMDC	Medium General Servi	$ 0.09170	$ 479.22
Fishermen's Terminal – M-4 Industrial	8,301,100	0.184%	85.6%	Y	$ 3.50	$ 51,450	$ 64,364	EMDC	Medium General Servi	$ 0.09170	$ 1,403.93
Fishermen's Terminal – N-10 NetshedStorage	8,301,100	1.601%	86.0%	Y	$ 3.00	$ 375,000	$ 469,125	EMDC	Medium General Servi	$ 0.09170	$ 12,186.93
Fishermen's Terminal – N-11 NetshedStorage	8,301,100	1.796%	85.6%	Y	$ 3.00	$ 423,000	$ 529,173	EMDC	Medium General Servi	$ 0.09170	$ 13,672.47
Maritime Industrial Center – A-3Warehouse/Sho	853,600	0.867%	83.6%	Y	$ 3.50	$ 27,440	$ 34,327	EMDC	Medium General Servi	$ 0.09170	$ 678.76
Maritime Industrial Center – A-4Warehouse/Sho	853,600	2.351%	98.3%	Y	$ 3.20	$ 53,440	$ 66,853	EMDC	Medium General Servi	$ 0.09170	$ 1,840.42
Shilshole Bay Marina – I-1 Little ConeyRestaurant	6,493,434	0.044%	81.2%	N	$ 4.00	$ 11,760	$ 14,712	ELGC	Large General Service,	$ 0.10910	$ 313.34
Shilshole Bay Marina – M-1 Restroom/ShowerFa	6,493,434	0.111%	85.3%	Y	$ 3.50	$ 27,440	$ 34,327	ELGC	Large General Service,	$ 0.10910	$ 784.43
Shilshole Bay Marina – M-7 Restroom/ShowerFa	6,493,434	0.141%	89.6%	Y	$ 3.50	$ 30,870	$ 38,618	ELGC	Large General Service,	$ 0.10910	$ 999.90
Terminal 100 - Marine Maintenance Shop South	370,066	17.759%	86.4%	Y	$ 3.25	$ 195,975	$ 245,165	ESMCM	Small General Service,	$ 0.11810	$ 7,761.53
Terminal 91 – C-156 Warehouse	11,367,730	0.827%	85.3%	Y	$ 3.10	$ 276,520	$ 345,927	ELGC	Large General Service,	$ 0.10910	$ 10,256.49
Terminal 91 – W-390 Cold Storage	11,367,730	2.158%	91.2%	Y	$ 2.80	$ 574,000	$ 718,074	ELGC	Large General Service,	$ 0.10910	$ 26,762.23
Terminal 91 – W-391 Cold Storage	11,367,730	5.844%	91.2%	Y	$ 2.80	$ 1,562,400	$ 1,954,562	ELGC	Large General Service,	$ 0.10910	$ 72,475.13
Terminal 91 – W-392 Food Processing	11,367,730	4.641%	91.1%	Y	$ 2.80	$ 1,240,400	$ 1,551,740	ELGC	Large General Service,	$ 0.10910	$ 57,561.16
Terminal 91 – W-40 Food Processing	11,367,730	3.700%	90.7%	Y	$ 2.90	$ 1,035,300	$ 1,295,160	ELGC	Large General Service,	$ 0.10910	$ 45,887.46

Port of Seattle Solar Screening Tool

From SWCES Load Forecast Analysis Report

Property Name	Simple Payback (Years) (Includes Port Overhead)	Utility Hosting Capacity (kVA)	Port Substation Capacity (kVA)	Hosting Capacity Constraint Y/N	Substation Feeding	Utility Feeder	Downtown Spot Network Y/N?
Fishermen's Terminal – M-15 Restroom	53.9	12800	1500	N	4	SCL - 2658	N
Fishermen's Terminal – M-2 Restroom	71.6	12800	2000	N	6	SCL - 2658	N
Fishermen's Terminal – M-4 Industrial	45.8	12800	2000	N	6	SCL - 2658	N
Fishermen's Terminal – N-10 NetshedStorage	38.5	12800	1500	N	7	SCL - 2658	N
Fishermen's Terminal – N-11 NetshedStorage	38.7	12800	1500	N	7	SCL - 2658	N
Maritime Industrial Center – A-3Warehouse/Sho	50.6	Unknown	Unknown	Unknown	Unknown	Unknown	N
Maritime Industrial Center – A-4Warehouse/Sho	36.3	Unknown	Unknown	Unknown	Unknown	Unknown	N
Shilshole Bay Marina – I-1 Little ConeyRestaurant	47.0	7500	225	N	10	substation feeder	N
Shilshole Bay Marina – M-1 Restroom/ShowerFa	43.8	7500	750	N	1	substation feeder	N
Shilshole Bay Marina – M-7 Restroom/ShowerFa	38.6	7500	225	N	10	substation feeder	N
Terminal 100 - Marine Maintenance Shop South	31.6	500	500	N	North Yard Service	North Yard Service	N
Terminal 91 – C-156 Warehouse	33.7	7500	750	N	SS-13	MSS-1 South	N
Terminal 91 – W-390 Cold Storage	26.8	7500	2500	N	SS-12	MSS-2 North	N
Terminal 91 – W-391 Cold Storage	27.0	7500	2500	N	SS-12	MSS-2 North	N
Terminal 91 – W-392 Food Processing	27.0	7500	2500	N	SS-12	MSS-2 North	N
Terminal 91 – W-40 Food Processing	28.2	7500	1500	N	SS-9	MSS-2 North	N

Port of Seattle Solar Screening Tool

Property Name	Notes
Fishermen’s Terminal – M-15 Restroom	
Fishermen’s Terminal – M-2 Restroom	
Fishermen’s Terminal – M-4 Industrial	
Fishermen’s Terminal – N-10 NetshedStorage	Roof structure appears visible through roofing which implies FRP or fiberglass. Strength concerns
Fishermen’s Terminal – N-11 NetshedStorage	Roof structure appears visible through roofing which implies FRP or fiberglass. Strength concerns
Maritime Industrial Center – A-3Warehouse/Sho	
Maritime Industrial Center – A-4Warehouse/Sho	
Shilshole Bay Marina – I-1 Little ConeyRestaurant	
Shilshole Bay Marina – M-1 Restroom/ShowerFa	
Shilshole Bay Marina – M-7 Restroom/ShowerFa	Model Updated- more conservative on roof penetration keepouts so array shrank.
Terminal 100 - Marine Maintenance Shop South	Older CMU building with large section of roof with curved barrel roof shape. Difficult install shape. Model updated, LIDAR misfit building height previously.
Terminal 91 – C-156 Warehouse	Modular buildings connected together based on the roof and AC unit spacing on the north wall
Terminal 91 – W-390 Cold Storage	
Terminal 91 – W-391 Cold Storage	
Terminal 91 – W-392 Food Processing	
Terminal 91 – W-40 Food Processing	

Appendix B

Port of Seattle Maritime Solar Feasibility Study Decision Matrix

Port of Seattle Maritime Solar Feasibility Study | Decision Matrix

Purpose: To narrow down feasible rooftops down to the top three (3) candidates for our solar consultant to develop fully (i.e. schematic drawings, detailed cost estimates, etc.). Please enter notes/input on the corresponding line for your team based on your experience with each building.

Building Name	Est. Annual Production (kWh)	% of Building or Campus Electric Consumption	Payback Year	ROM Installed Cost ($)	Est. Annual Energy Savings ($)	Estimated Total Cost of Ownership ($)	Qualitative Structural Assessment (consultant)	Qualitative Electrical Assessment (consultant)	POS Team	Notes/Feedback
P66 Bell Harbor Marina Office	12,200	(12,200 kWh / 361,240 kWh * 100) = **3.37%**	17	$37,800	$1,265	$18,218	Good for solar, standing seam metal roof, minimal roof penetrations required	Panelboard has several spare locations for solar interconnection	Environmental (Jacob/Cam/Jessica)	[Jacob] Located in SCL's downtown spot network so sizing array and interconnection strategy must include backfeed prevention. Small rooftop compared to others. Solar would be visible by cruise ship passengers. [Jessica] Good location for public education/informative plaque. Low production, but if it's a high percentage of facility use than it may be more worthwhile for resilience and continuous operations. If this could be combined with the Bell Harbor conference center/cruise we may find efficiencies of scale if we need to do things like battery storage. Would reduce 5.3 metric tons CO_2e per year (EPA).
									Environmental (David/Lucian)	[Lucian] P66 doesn't have major capacity issues currently. Building electrification is a modest contributor to peak loads at this site, but as buildings electrify, they will ultimately be the largest contributor to overall electricity consumption at P66 in the longer-term. The takeaway is that solar may not contribute to peak load reduction at the site but appears to be valuable in the long-term considering the overall high consumption of energy by buildings here.
									Planning (Paul)	[Paul] General comments: Is there other electrical equipment in the building or on site that should be replaced due to age and/or condition?
									Real Estate (Susie)	[Susie] This roof is visible to Anthonys' upstairs diners and P66 rooftop visitors, so has very good public visibility. This roof was excluded from the P66 2022 roof capital project, and I'm not sure of the existing condition (i.e. when roof overlay/replacement would be needed).
									Facilities (Rob)	[Rob] I'll leave it up to the engineers to determine panel capacity but would caution on assuming there is space in the panels before talking to MM Electricians. We have temporarily added breakers to provide power to marina events in the past and there may be plans to add permanent power in the marina in the future.
									Structural Engineering (Perry)	[Perry] Unsure if original design/construction allowed for additional panel weight. Impacts could be gravity and lateral structural member modifications or design validation.
									Electrical Engineering (Kemeria)	Consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.

Building Name	Est. Annual Production (kWh)	% of Building or Campus Electric Consumption	Payback Year	ROM Installed Cost ($)	Est. Annual Energy Savings ($)	Estimated Total Cost of Ownership ($)	Qualitative Structural Assessment (consultant)	Qualitative Electrical Assessment (consultant)	POS Team	Notes/Feedback
P66 Bell Harbor Conf Center/Cruise	35,290	(35,290 kWh / 2,058,256 kWh * 100) = **1.71%**	16	$109,800	$3,659	$52,600	Good for solar, minimal roof penetrations required	No obvious interconnection location as building modifications over the years have filled panels	Environmental (Jacob/Cam/Jessica)	[Jacob] Energy intensive building could benefit from solar. Cruise/conference season is well defined so off-season construction can be done to avoid impacts to operations. Located in SCL's downtown spot network so sizing array and interconnection strategy must include backfeed prevention. South side of building may have safety/access control issues due to the public rooftop plaza nearby. Entire roof was just replaced in 2024. Building used by CTA (tenant) and Conference Center (tenant) who pays the electric bills and would likely need some sort of agreement. Solar would be visible by cruise ship passengers. Brand new roof replaced in 2024. Consultant recommends deprioritizing due to the downtown spot network grid restrictions and increased project cost due to grid restrictions. [Jessica] Would building this out expand our ability to provide EV charging (P66 apron) or other electrification efforts (if we need to add panel space, for example)? If installed, would be positive press for cruise. Low cost for pretty high number. Would reduce 15.4 metric tons CO2e per year (EPA). Need to understand building energy use to help with decision-making.
									Environmental (David/Lucian)	[Lucian] P66 doesn't have major capacity issues currently. Building electrification is a modest contributor to peak loads at this site, but as buildings electrify, they will ultimately be the largest contributor to overall electricity consumption at P66 in the longer-term. The takeaway is that solar may not contribute to peak load reduction at the site but appears to be valuable in the long-term considering the overall high consumption of energy by buildings here.
									Planning (Paul)	[Paul] Consultant noted that the impact from shading of cruise ships during the cruise season would not significantly diminish the feasibility of installing an array on this roof.
									Real Estate (Susie)	[Susie] Design should include seagull damage protection (P69 solar panels damaged by seagulls have required replacement), construction schedule will have to work around cruise and conference center schedules, is the distance to electrical room reasonable, please separately meter solar panels, plan for uninvited visitors, who typically explore the P66 roof via the public rooftop deck. The ROM pricing seems unreasonably low…please compare pricing to P69 solar project which I think was $500K-ish.
									Facilities (Rob)	No additional comment.
									Electrical Engineering (Kemeria)	Consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.
									Structural Engineering (Perry)	[Perry] Unsure if original design/construction allowed for additional panel weight. Impacts could be gravity and lateral structural member modifications or design validation.
									Cruise (Marie/Carma/Linda)	Need for metering so costs can be passed on to tenants.

Building Name	Est. Annual Production (kWh)	% of Building or Campus Electric Consumption	Payback Year	ROM Installed Cost ($)	Est. Annual Energy Savings ($)	Estimated Total Cost of Ownership ($)	Qualitative Structural Assessment (consultant)	Qualitative Electrical Assessment (consultant)	POS Team	Notes/Feedback
T91 C-173	493,700	(493,700 kWh / 178,614 kWh * 100) = **276%** This site would produce more than the building consumes and be able to feed excess back to the grid	14	$1,320,000	$53,855	$1,014,700	Okay for solar, limited information on design drawings, roof addition was overlay which reduces likelihood of ballasted system	Electrical room inaccessible due to construction, likely capacity due to abandoned cold storage equipment	Environmental (Jacob/Cam/Jessica)	[Jacob] Primarily warehouse space serving fleet with some light industrial repair work. Electrical loads primarily LED lighting. All electric building (no gas). Consultant recommends deprioritizing due to electrical equipment being at end-of-life. [Jessica] It's my understanding that we could use solar power at T91 as a microgrid, and this is a lot of power generation. This is a high energy user and could help grid resilience at T91 where we have limited capacity. Would reduce 216 metric tons CO2e per year (EPA). This is a priority location and use type.
									Environmental (David/Lucian)	[Lucian] No forecasted capacity constraints on the electrical infrastructure (Substation 2) serving this building currently.
									Planning (Paul)	[Paul] Defer to comments from Engineering on the appropriate location for power connection to building and feasibility of building's use of power generated by array. Consideration of microgrid development at T91 outside the scope of this project and would need to be considered in the context of an overall electrical concept plan for the site.
									Real Estate (Lily)	[Lily] Per Lease, Port is responsible for roof M&R. Good candidate for roof projects.
									Facilities (Mark/Windy)	No comment.
									Structural Engineering (Perry)	[Perry] Unsure if original design/construction allowed for additional panel weight. Impacts could be gravity and lateral structural member modifications or design validation.
									Electrical Engineering (Kemeria)	Consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.

Building Name	Est. Annual Production (kWh)	% of Building or Campus Electric Consumption	Payback Year	ROM Installed Cost ($)	Est. Annual Energy Savings ($)	Estimated Total Cost of Ownership ($)	Qualitative Structural Assessment (consultant)	Qualitative Electrical Assessment (consultant)	POS Team	Notes/Feedback
T91 C-175	293,200	(293,200 kWh / 2,011,500 kWh * 100) = **14.5%**	12	$689,300	$31,989	$681,600	Good for solar, seismic attachments needed required	Solar could be interconnected into the MDP directly or use compressor breakers after system modification	Environmental (Jacob/Cam/Jessica)	[Jacob] Refrigerant lines run across roof. Lineage responsible for interior building maintenance, so solar tied into the building electrical would require an agreement modification. Lineage is actively pursuing renewables in portfolio and are very interested in project potential. [Jessica] It's my understanding that we could use solar power at T91 as a microgrid, and this is a lot of power generation. This is a high energy user and could help grid resilience at T91 where we have limited capacity. Why does this location (larger SF) produce less kWh than the building above—it doesn't look like it's obstructed? Would reduce 128 metric tons CO2e per year (EPA). This is a priority location and use type.
									Environmental (David/Lucian)	[Lucian] No forecasted capacity constraints on the electrical infrastructure (Substation 1) serving this building.
									Planning (Paul)	[Paul] Defer to comments from Engineering on the appropriate location for power connection to building and feasibility of building's use of power generated by array. Consideration of microgrid development at T91 outside the scope of this project and would need to be considered in the context of an overall electrical concept plan for the site.
									Real Estate (Lily)	[Lily] Per lease, Port is responsible for roof M&R. Another reason for being a good candidate for solar roof.
									Facilities (Mark/Windy)	No comment.
									Structural Engineering (Perry)	[Perry] Unsure if original design/construction allowed for additional panel weight. Impacts could be gravity and lateral structural member modifications or design validation.
									Electrical Engineering (Kemeria)	Consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.

Building Name	Est. Annual Production (kWh)	% of Building or Campus Electric Consumption	Payback Year	ROM Installed Cost ($)	Est. Annual Energy Savings ($)	Estimated Total Cost of Ownership ($)	Qualitative Structural Assessment (consultant)	Qualitative Electrical Assessment (consultant)	POS Team	Notes/Feedback
T91 A-1 Warehouse	250,500	(250,500 kWh / 636,900 kWh * 100) = **39.3%**	15	$675,100	$27,328	$452,800	Good for solar, standing seam metal roof, minimal roof penetrations required	Significant spare capacity due to building no longer being used for manufacturing	Environmental (Jacob/Cam/Jessica)	[Jacob] Skylights in poor condition due to age. Should consider waiting until skylights are eliminated before doing solar as capacity could be increased. [Jessica] It's my understanding that we could use solar power at T91 as a microgrid, and this is a lot of power generation and could help grid resilience at T91 where we have limited capacity. Would reduce 109 metric tons CO2e per year (EPA). May support EVSE for tenant fleet/equipment electrification.
									Environmental (David/Lucian)	[Lucian] No identified capacity constraints on electrical infrastructure (SS-8A) serving this building. Substation is at approx. 20% utilization currently and projected to only increase to approx. 25% in 2050.
									Planning (Paul)	No comment.
									Real Estate (Lily)	[Lily] Per lease, TENANT/GF is responsible for maintaining roof membrane, Port for roof structure. This can have cost implications and complications for any roof projects. Note that North American Fish Co (Morenot) is a subtenant with no direct leasing relationship with Port.
									Facilities (Mark/Windy)	[Mark] Tenant is responsible for roofing, could present logistical problems for future maintenance, repair, replacement.
									Structural Engineering (Perry)	[Perry] Unsure if original design/construction allowed for additional panel weight. Impacts could be gravity and lateral structural member modifications or design validation.
									Electrical Engineering (Kemeria)	Consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.

Building Name	Est. Annual Production (kWh)	% of Building or Campus Electric Consumption	Payback Year	ROM Installed Cost ($)	Est. Annual Energy Savings ($)	Estimated Total Cost of Ownership ($)	Qualitative Structural Assessment (consultant)	Qualitative Electrical Assessment (consultant)	POS Team	Notes/Feedback
T91 Smith Cove Cruise Terminal	349,100	(349,100 kWh / 899,500 kWh * 100) = **38.8%**	12	$820,300	$38,073	$811,800	Good for solar, minimal roof penetrations required	Several spares on substation switchboard	Environmental (Jacob/Cam/Jessica)	[Jacob] Planned roof replacement soon and would need to be completed before solar installation. Skylights limit array layout. Cruise season is well defined so off-season construction can be done to avoid impacts to operations. Building used by CTA (tenant) who pays the electric bills and would likely need some sort of agreement. Looking to decarbonize/convert RTUs to heat pumps eventually which will increase electricity need. Solar would be visible by cruise ship passengers. [Jessica] It's my understanding that we could use solar power at T91 as a microgrid, and this is a lot of power generation and could help grid resilience at T91 where we have limited capacity. Would reduce 152 metric tons CO2e per year (EPA). May support ground transportation electrification. Visible to cruise passengers could be good for public perception and education opportunities. Would need to see building use to understand if battery storage may be beneficial.
									Environmental (David/Lucian)	[Lucian] No forecasted capacity constraints to the electrical infrastructure serving the cruise terminal building.
									Planning (Paul)	[Paul] Need to understand current condition of substation and any future loads identified for it. Consideration of microgrid development at T91 outside the scope of this project and would need to be considered in the context of an overall electrical concept plan for the site.
									Real Estate (Lily)	No comment.
									Facilities (Mark/Windy)	[Mark] There is a project submittal being generated from our Port Cruise team for a Large Cap project (full roof replacement). The roof is past its useful life and is failing in many areas. WPM has already had contractors provide findings and recommendations for the roof.
									Structural Engineering (Perry)	[Perry] Unsure if original design/construction allowed for additional panel weight. Impacts could be gravity and lateral structural member modifications or design validation.
									Electrical Engineering (Kemeria)	Consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.
									Cruise (Marie/Carma/Linda)	There is a reroofing project in planning – this may interfere.

Building Name	Est. Annual Production (kWh)	% of Building or Campus Electric Consumption	Payback Year	ROM Installed Cost ($)	Est. Annual Energy Savings ($)	Estimated Total Cost of Ownership ($)	Qualitative Structural Assessment (consultant)	Qualitative Electrical Assessment (consultant)	POS Team	Notes/Feedback
T91 Smith Cove Cruise Exterior Covered Walkways	192,000	(192,000 kWh / 899,500 kWh * 100) = **21.3%** This assumes offsetting the Cruise Terminal electric usage	14	$513,200	$20,940	$394,600	Good for solar, corrugated metal, minimal roof penetrations required	No electrical panels, substation would be least intrusive connection point	Environmental (Jacob/Cam/Jessica)	[Jacob] Cruise season is well defined so off-season construction can be done to avoid impacts to operations. No existing electrical infrastructure means having to trench to the building or substation. Focusing on the rooftop array should be the priority over the covered walkways. Solar would be visible by cruise ship passengers. Consultant recommends deprioritizing due to the increased project cost of interconnecting at the substation. [Jessica] It's my understanding that we could use solar power at T91 as a microgrid, this is a lot of power generation and could help grid resilience at T91 where we have limited capacity. Would reduce 83.9 metric tons CO2e per year (EPA). Visible to cruise passengers could be good for public perception and education opportunities.
									Environmental (David/Lucian)	[Lucian] No identified capacity constraints on electrical infrastructure (SS-8A) serving this building. Substation is at approx. 20% utilization currently and projected to only increase to approx. 25% in 2050.
									Planning (Paul)	[Paul] Need to understand current condition of substation and any future loads identified for it. Consideration of microgrid development at T91 outside the scope of this project and would need to be considered in the context of an overall electrical concept plan for the site.
									Real Estate (Lily)	No comment.
									Facilities (Mark/Windy)	[Mark] Infrastructure improvements would be needed but very interesting area to look at closer.
									Structural Engineering (Perry)	[Perry] Unsure if original design/construction allowed for additional panel weight. Impacts could be gravity and lateral structural member modifications or design validation.
									Electrical Engineering (Kemeria)	Consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.
									Cruise (Marie/Carma/Linda)	No comment.

Building Name	Est. Annual Production (kWh)	% of Building or Campus Electric Consumption	Payback Year	ROM Installed Cost ($)	Est. Annual Energy Savings ($)	Estimated Total Cost of Ownership ($)	Qualitative Structural Assessment (consultant)	Qualitative Electrical Assessment (consultant)	POS Team	Notes/Feedback
SBM A-1 Admin	99,300	(99,300 kWh / 114,292 kWh * 100) = **86.8%**	15	$269,700	$10,834	$198,200	Good for solar, minimal roof penetrations required	Appears to be space available in electrical room	Environmental (Jacob/Cam/Jessica)	[Jacob] Roof has not been replaced since building was constructed in 2005 (19 years old). [Jessica] Seems like a good candidate when the roof is replaced, if that will happen soon anyway, I would not include it as one of the top 3 priorities, but certainly as one to include in the CIP regardless. Need to know the building energy use- if this supports the whole building and other buildings on site, then would be more of a priority or could use battery storage element for resilience. 43.4 metric tons CO2e per year (EPA).
									Environmental (David/Lucian)	[Lucian] No forecasted constraint for the electrical infrastructure serving this building (Substation #6). Currently at ~28% utilization and even assuming the addition of 24 EV chargers by 2040 (as modeled in SWCES), that would bring the substation to ~82% utilization.
									Planning (Paul)	[Paul] Concur with other comments that this project should be done in conjunction with roofing replacement and any needed roof improvements the structural engineer identifies to support the additional dead load of the arrays.
									Real Estate (Trevor)	• I need to understand the expected remaining life of the existing roof surface – I will find that out if this project isn't already collecting that information. • There's relatively easy roof access with generous project laydown/staging area (with proper planning). • Given that SBM is on SCL's Large General Service rate schedule, I would be interested in any further justification a solar system could give to installing a battery bank/reserve system. The benefit would not just be cost savings from storing lower-cost overnight power but would enable better electrical independence from the urban grid, as well as the rest of the property, during events such as utility power outages or even a natural disaster. The facility, while not a high-critical-need asset, is fed like the rest of the Ballard shoreline from lines running along the north side of the Locks passageway, making it somewhat isolated and susceptible. • For bonus "example-setting" optics, an installation here would be highly visible to a constant stream of public visitors to the marina and road traffic along Seaview Ave to and from Golden Gardens.
									Facilities (Mark/Simon)	No additional comment.
									Structural Engineering (Perry)	[Perry] Unsure if original design/construction allowed for additional panel weight. Impacts could be gravity and lateral structural member modifications or design validation.
									Electrical Engineering (Kemeria)	Consider and evaluate the overall site-specific improvements for potential solar generation, associated layout, system sizing, battery storage device plans, and microgrid prospects. These efforts must also consider the capacity and lifespan of existing equipment.

Appendix C

Terminal 91 – Smith Cove Cruise Terminal Documents

Smith Cove Terminal Update Final POS Solar - Pier 91, Smith Cove park

Report

Project Name	POS Solar - Pier 91
Project Address	Smith Cove park
Prepared By	Sazan Group ses-marketing@sazan.com

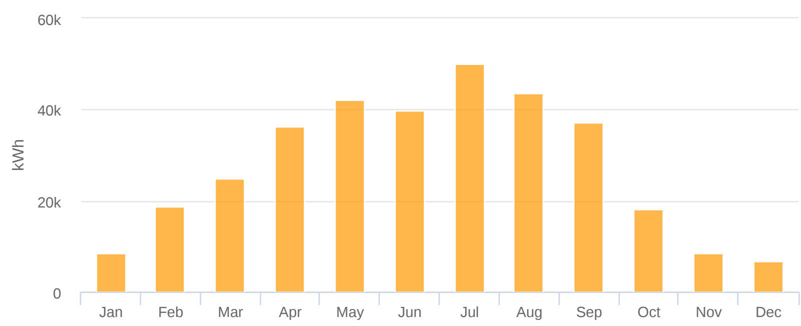
SÄZÄN GROUP

System Metrics

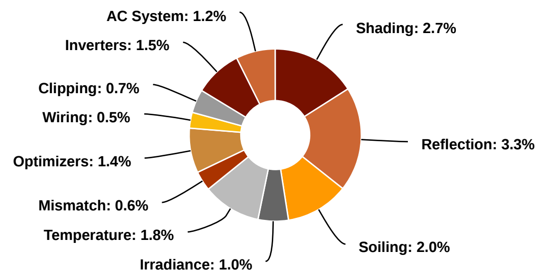
Design	Smith Cove Terminal Update Final
Module DC Nameplate	303.8 kW
Inverter AC Nameplate	240.0 kW Load Ratio: 1.27
Annual Production	334.5 MWh
Performance Ratio	84.3%
kWh/kWp	1,100.9
Weather Dataset	TMY, SEATTLE BOEING FIELD [ISIS], NSRDB (tmy3, II)
Simulator Version	7292ed3515-fa412b5027-77e944f598-0b5a9a1255

Project Location

Monthly Production



Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	1,212.3	
	POA Irradiance	1,305.7	7.7%
	Shaded Irradiance	1,270.5	-2.7%
	Irradiance after Reflection	1,228.4	-3.3%
	Irradiance after Soiling	1,203.8	-2.0%
	Total Collector Irradiance	**1,203.8**	**0.0%**
Energy (kWh)	Nameplate	365,584.7	
	Output at Irradiance Levels	362,066.8	-1.0%
	Output at Cell Temperature Derate	355,378.5	-1.8%
	Output After Mismatch	353,168.8	-0.6%
	Optimizer Output	348,167.8	-1.4%
	Optimal DC Output	346,430.3	-0.5%
	Constrained DC Output	343,855.1	-0.7%
	Inverter Output	338,668.5	-1.5%
	Energy to Grid	**334,450.5**	**-1.2%**

Temperature Metrics

Avg. Operating Ambient Temp	14.0 °C
Avg. Operating Cell Temp	21.1 °C

Simulation Metrics

Operating Hours	4265
Solved Hours	4265

Condition Set

Description	Condition Set 2 Ground
Weather Dataset	TMY, SEATTLE BOEING FIELD [ISIS], NSRDB (tmy3, II)
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
East-West	-3.56	-0.075	3°C
Carport	-3.56	-0.075	3°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
SIL-490 HN (2022) (Silfab Solar)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
P1100 (SolarEdge)	HelioScope	Mfg Spec Sheet
SE80KUS (2022) (SolarEdge)	HelioScope	Spec Sheet

Components

Component	Name	Count
Inverters	SE80KUS (2022) (SolarEdge)	3 (240.0 kW)
AC Panels	3 input AC Panel	1
AC Home Runs	6 AWG (Copper)	3 (261.1 ft)
AC Home Runs	3/0 AWG (Copper)	1 (552.5 ft)
Strings	10 AWG (Copper)	20 (8,770.6 ft)
Optimizers	P1100 (SolarEdge)	320 (352.0 kW)
Module	Silfab Solar, SIL-490 HN (2022) (490W)	620 (303.8 kW)

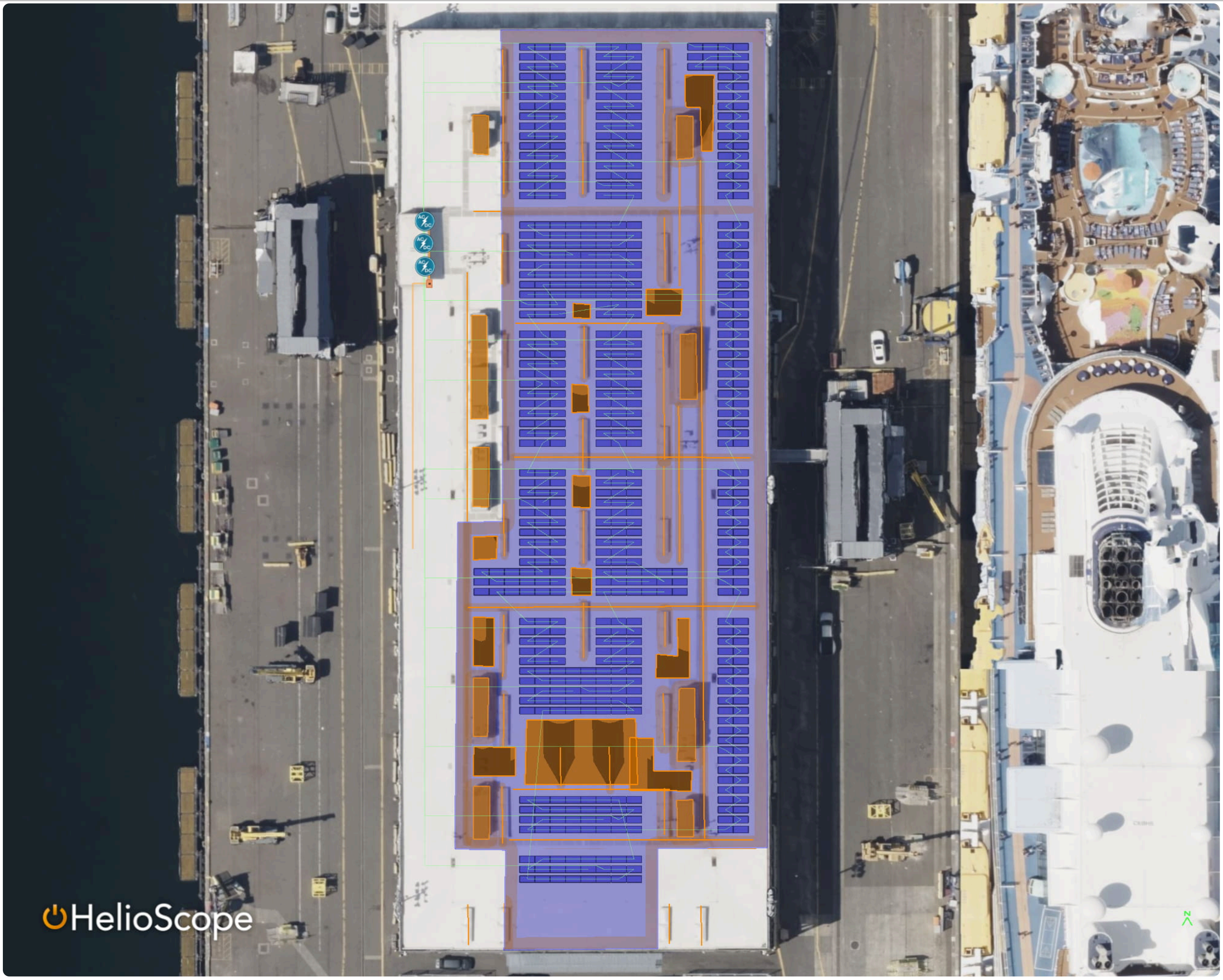
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	-	13-31	Along Racking

Field Segments

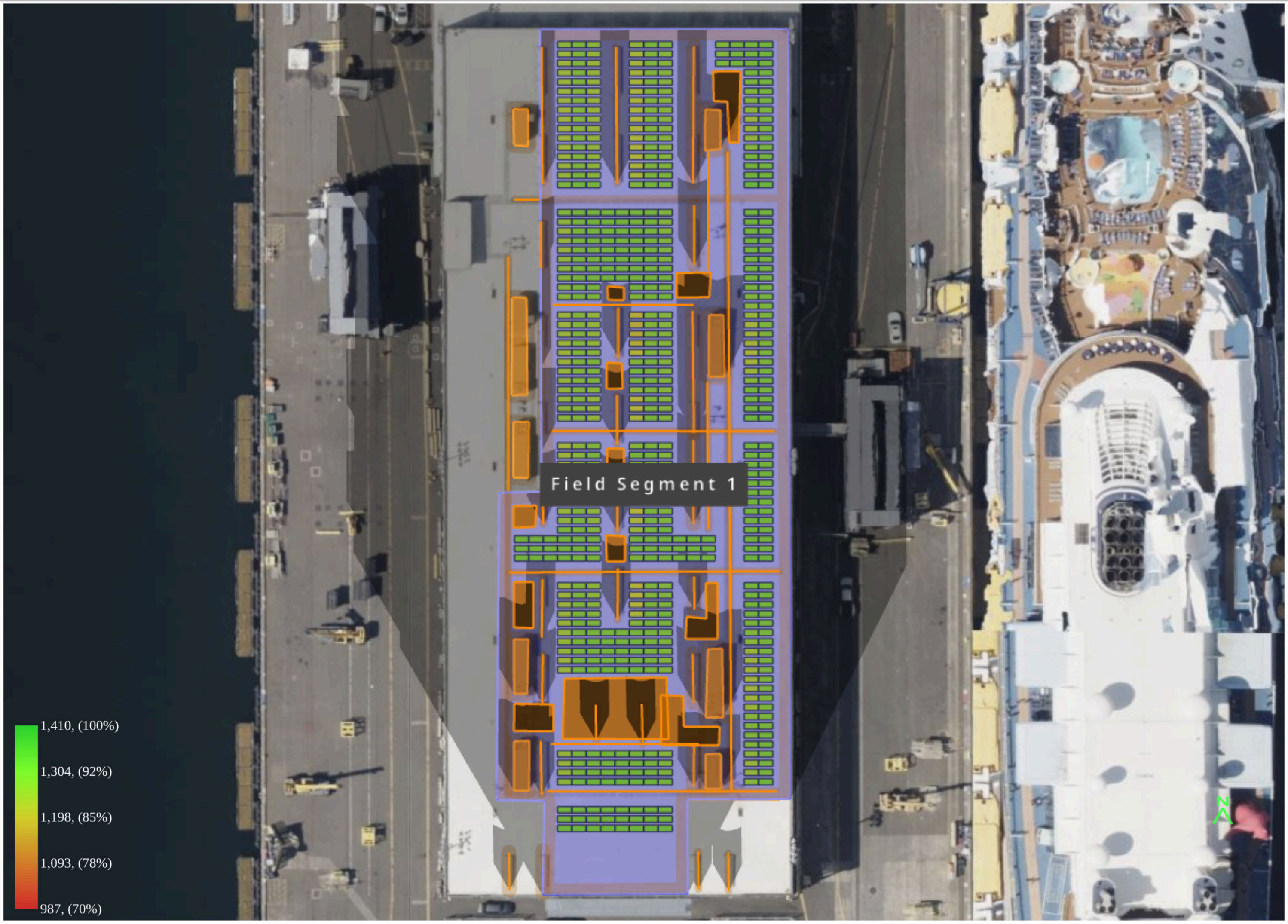
Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Fixed Tilt	Landscape (Horizontal)	Module: 10°	Module: 180°	1.5 ft	1x1	620	620	303.8 kW

Detailed Layout2



Smith Cove Terminal Update Final POS Solar - Pier 91, Smith Cove park

Shading Heatmap



Shading by Field Segment

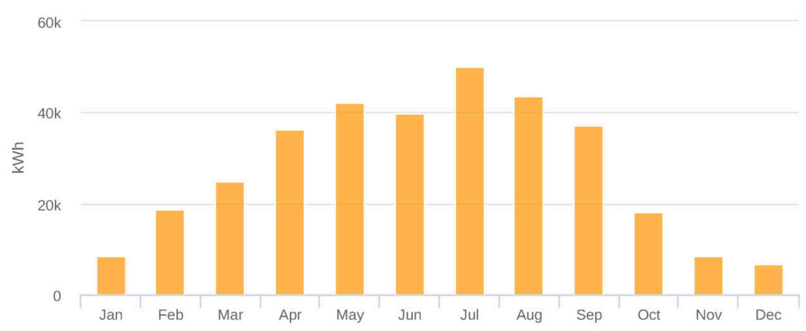
Description	Tilt	Azimuth	Modules	Nameplate	Shaded Irradiance	AC Energy	TOF[2]	Solar Access	Avg TSRF [2]
Field Segment 1	Module: 10.0°	Module: 180.0°	620	303.8 kWp	1,270.5kWh/m^2	334.5 MWh[1]	92.6%	97.3%	90.1%
Totals, weighted by kWp			**620**	**303.8 kWp**	**1,270.5kWh/m^2**	**334.5 MWh**	**92.6%**	**97.3%**	**90.1%**

[1] approximate, varies based on inverter performance
[2] based on location Optimal POA Irradiance of 1,409.9kWh/m^2 at 35.6° tilt and 186.5° azimuth

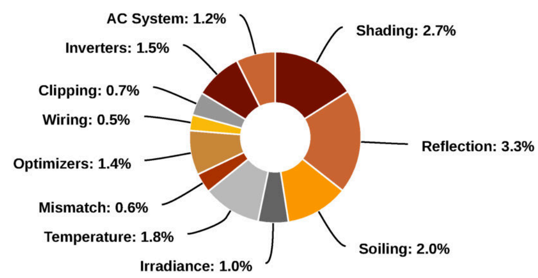
Solar Access by Month

Description	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Field Segment 1	94%	96%	98%	98%	98%	98%	98%	98%	97%	97%	94%	89%
Solar Access, weighted by kWp	**93.6%**	**95.7%**	**97.6%**	**97.8%**	**98.1%**	**98.1%**	**98.0%**	**97.9%**	**97.2%**	**96.8%**	**94.4%**	**89.4%**
AC Power (kWh)	**8,618.9**	**18,830.6**	**24,784.1**	**36,257.6**	**42,040.8**	**39,673.2**	**49,965.8**	**43,503.1**	**37,230.1**	**18,274.5**	**8,468.8**	**6,802.9**

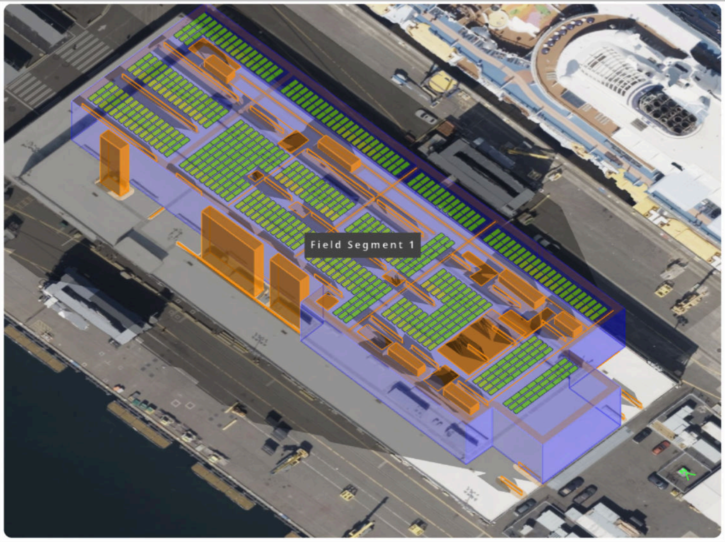
Monthly Production



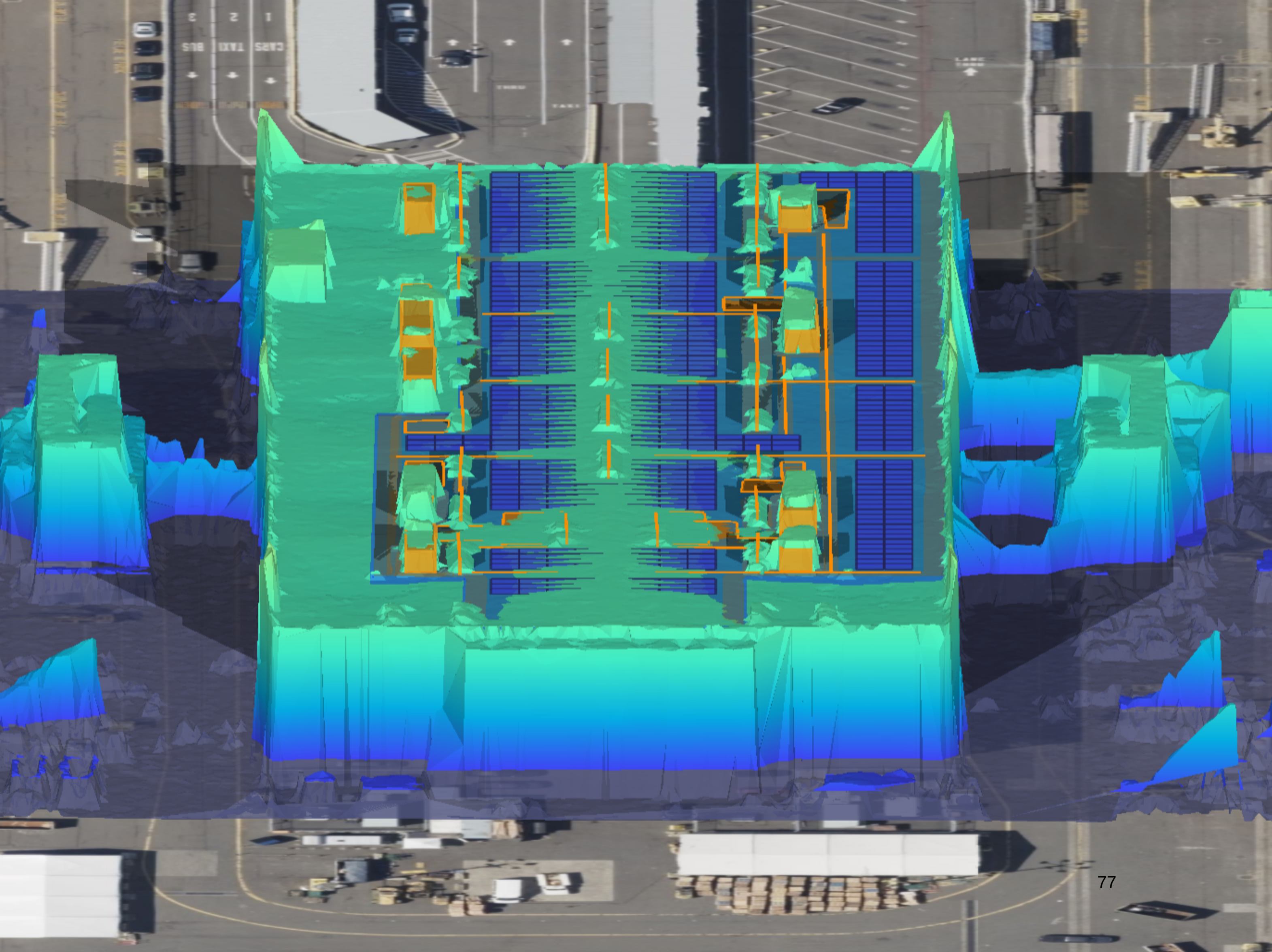
Sources of System Loss

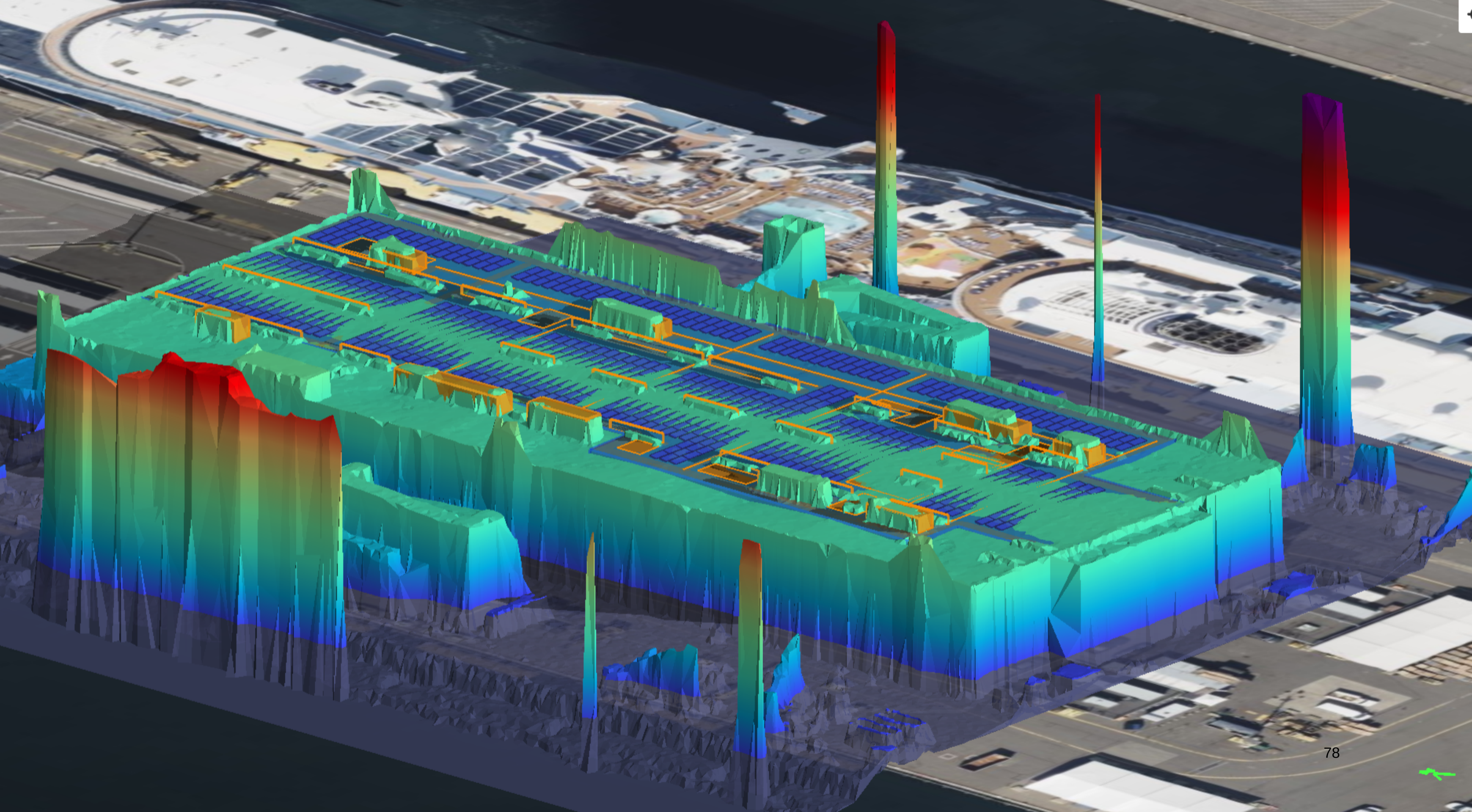


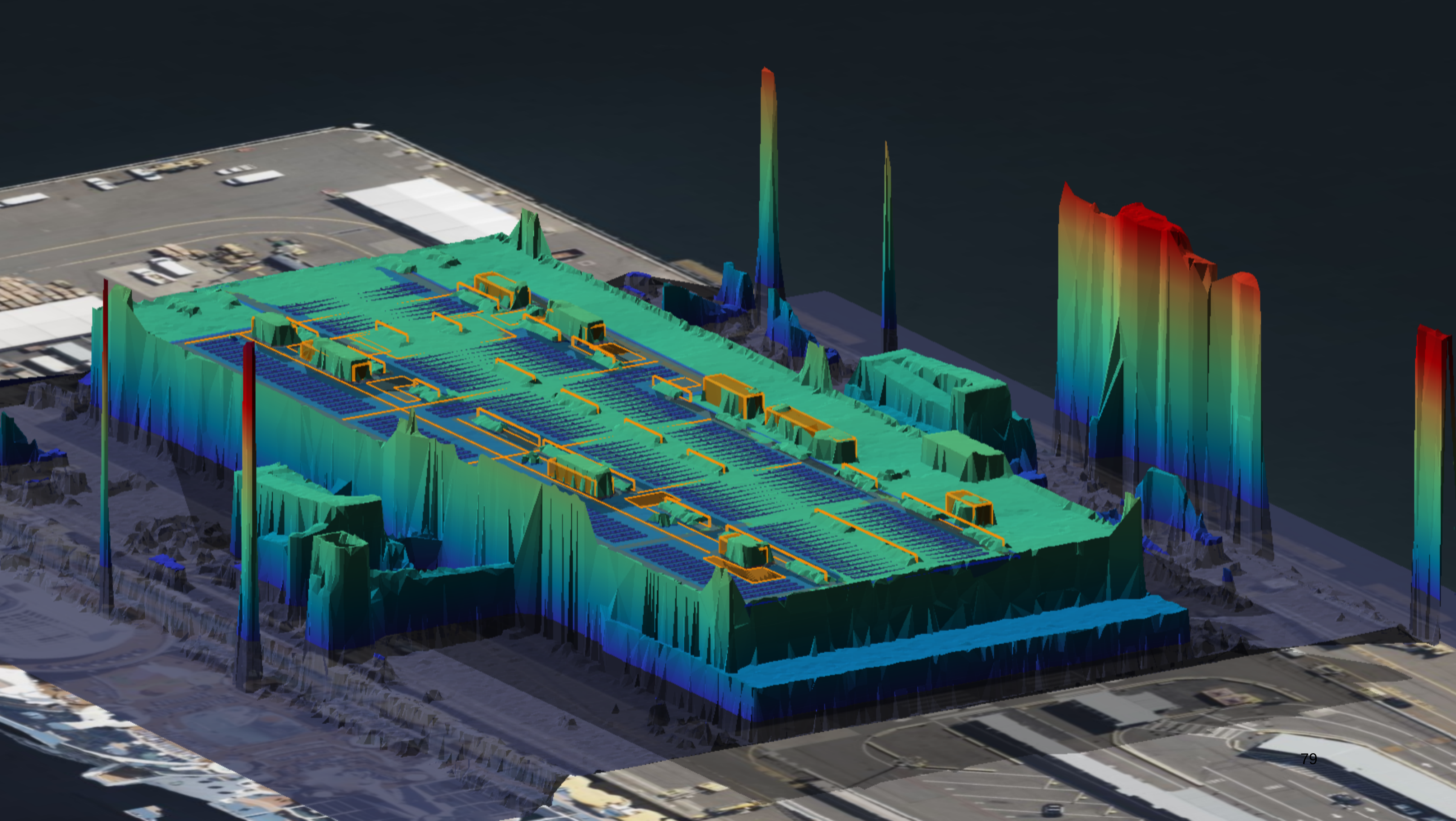
Southwestern Angle



Southeastern Angle







Port of Seattle
Solar Feasibility Assessment: Smith Cove Cruise Terminal

2001 W Garfield St, Seattle, WA 98119

TKDA Project No. 24026

December 20th, 2024

DANIEL A. MUNN
STATE OF WASHINGTON
38727
REGISTERED
PROFESSIONAL ENGINEER

80

12/20/2024

Structural Calculation Index

Calculation Section Page No.

December 20, 2024

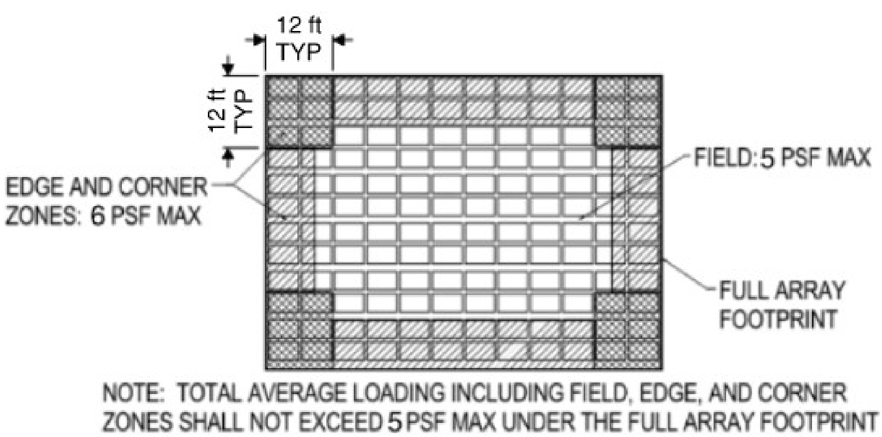
TKDA

Jack Newman
Säzän Consulting Services
600 Stewart Street, Suite 1400
Seattle, WA 98101

Re: Port of Seattle - Solar Feasibility Assessment
Smith Cove Cruise Terminal

TKDA has performed a structural assessment of the Smith Cove Cruise Terminal located in Seattle, WA to determine its ability to support the proposed ballasted rooftop PV array system including modules, racking, and associated equipment. This assessment is based on the as-built structural and architectural drawings provided by the Port of Seattle. The original 2007 drawings are titled “Terminal 91 Cruise Ship Terminal” with KPFF as the Structural Engineer of Record (SEOR). The Smith Cove Cruise Terminal is a 2-story steel structure. The roof system is composed of a TPO membrane, gypsum, rigid insulation, and steel roof deck. Open web steel joists carry roof loads to W- shaped girders. The lateral system of the building utilizes vertical bracing.

The results of our analysis show that the existing framing is sufficient to carry proposed loading for the planned PV array as detailed in layout below.



TYP. ARRAY PLAN LAYOUT (GENERAL DETAIL)

Section 503.3 of the 2021 Washington State IEBC states that any building alterations which cause an increase in design dead, live, or snow load of less than 5 percent do not require strengthening or modification of the affected members. The design snow load value shown on the general notes of the original building drawings is higher than the code prescribed snow load required at the roof. The results of our analysis show that the existing framing is sufficient to carry the increased loading due to the proposed ballasted rooftop PV array without additional strengthening. See calculations enclosed.

Per section 503.4 of the 2021 Washington State IEBC, building alterations resulting in a lateral load increase of less than 10 percent do not require strengthening or modification of the affected members. The total array weight is less than the maximum allowable array weight based on 10 percent of the original seismic weight tributary to the roof diagram thus no strengthening nor modifications are needed to the roof framing members. See calculations enclosed.

In summary, the existing building structure is adequate to support the proposed ballasted rooftop PV array given its average weight of 5 psf underneath the footprint of the array. Please contact TKDA with any further questions.

Sincerely,
TKDA Engineers

Daniel Munn, PE, SE
Vice President, Northwest Region

Project Name:	Port of Seattle Solar Feasibility Study
Project Location:	Seattle, WA
Building:	Smith Cruise Terminal
Date:	December 20th, 2024

Governing Building Codes: 2021 Washington State IEBC
ASCE 7-16

Vertical Gravity Weight Verification

Original Design Loads Per Design Drawings:

Load Case	Magnitude	Comments
Dead Load	20 psf	See Load Verification calculations
Snow Load	25 psf	WABO, UBC 97

IEBC § 503.3:
"Any existing gravity load-carrying structural element for which an alteration causes an increase in design dead, live or snow load, including snow drift effects, of more than 5 percent shall be replaced or altered as needed to carry the gravity loads required by the International Building Code for new structures. Any existing gravity load-carrying structural element whose gravity load-carrying capacity is decreased as part of the alteration shall be shown to have the capacity to resist the applicable design dead, live and snow loads including snow drift effects required by the International Building Code for new structures."

Actual Loads:

Load Case	Magnitude	Comments
Dead Load	20 psf	See Load Verification calculations
Snow Load	Varies d.t.drift considerations	ASCE 7-16, See calculations
Actual Array Weight =	5 psf	

Actual Snow Load + Actual Array Weight < Original Design Snow Load

Conclusions:
The design snow load value as shown on SB1.00 of the original building drawings is higher than the actual snow load present at the existing roof. The results of the analysis show that the existing framing is sufficient to carry the increased loading due to the proposed rooftop PV array without additional strengthening. See calculations enclosed.

Project Name: Port of Seattle Solar Feasibility
Project Location: Seattle, WA
Building: Smith Cruise Terminal
Date: December 20, 2024

Governing Building Codes: 2021 Washington State IEBC
ASCE 7-16

Seismic Weight Verification

Original Seismic Weight Calculation:

Item Description	Value	Comments
Roof Area =	88110 sf	Total roof area, determined from drawings
Roof DL =	20 psf	See Load Verification calculations
Weight Trib to Roof =	1762 kips	

IEBC § 503.4:
"Any existing lateral load-carrying structural element whose demand-capacity ratio with the alteration considered is not more than 10 percent greater than its demand-capacity ratio with the alteration ignored shall be permitted to remain unaltered."

Allowable Weight Increase Calculation:

Item Description	Value	Comments
10% Increase Per IEBC § 503.4 =	176.3 kips	Maximum array weight
Typ. Weight of Array =	5 psf	Under footprint
Actual Array Weight	103.9 kips	
Actual Array Area	20775 sf	Determined from layouts
Max Allowable Array Area =	35260 sf	

Conclusions:
The new solar array weight of 103.9 kips is less than the maximum allowable array weight of 176.3 kips based on a 10% increase per IEBC § 503.4. The results of the analysis shows that the existing framing is sufficient to carry the increased loading due to the proposed rooftop PV array without additional strengthening.

Building Geometry

Trib Area of Roof Girders $A_{trib} := 45\ ft \cdot 45\ ft = \left(2.03 \cdot 10^{3}\right)\ ft^{2}$

Joist spacing $s_{max} := 6\ ft$

Typical Roof Loads

Roof Dead see below

Roof Live Load per GSNs $RLL := 20\ psf$

Roof Snow Load per GSNs $SL := 20\ psf$

Confirmation of Roof Dead Loads

$DL_{deck} := 2.6\ psf$ 1 1/2", 18 GA Roof Deck

$DL_{insul} := (4\ in) \cdot 0.75\ \dfrac{psf}{in} = 3\ psf$ R-21 total required
R-4 for every 3/4"

$DL_{membrane} := 1\ psf$ TPO

$DL_{gyp} := 2.5\ psf$ 5/8" thick gyp underlay

$$DL_{joist} := \frac{\frac{13.4}{2}\ plf}{s_{max}} = 1.12\ psf$$ wt of 30K9, typical joist

$$DL_{stl} := \frac{130\ plf \cdot 45\ ft \cdot 2 + 31\ plf \cdot 45\ ft \cdot 2}{A_{trib}} = 7.16\ psf$$

$SDL := 2\ psf$ MEP

$$DL_{roof} := DL_{deck} + DL_{insul} + DL_{membrane} + DL_{gyp} + DL_{joist} + DL_{stl} = 17.37\ psf$$

Compare to values found in joist and deck tables $DL_{hand\_calc} := \text{Ceil}\left(DL_{roof} + SDL, 1\ psf\right) = 20\ psf$

SNOW CALCULATIONS per ASCE 7-16

SMITH TERMINAL, CASE 1

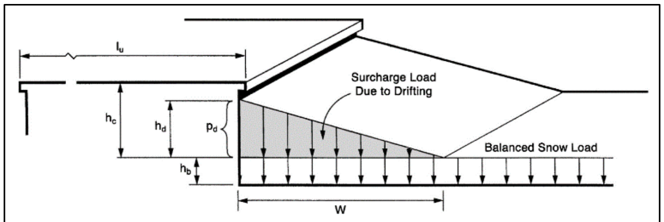


Figure 7.7-2. Configuration of snowdrifts on lower roofs.

Roof Geometry

Upper Roof Length, l_u (ft):	9	
Lower Roof Length, l_l (ft):	34.75	
Roof Height Difference, h (ft):	9	
Separation Distance, s (ft):	0	
Clear Roof Height, h_c (ft):	7.80	
Slope Rise	1	
Actual Slope, degrees	4.764	

Balanced Snow

Ground Snow Load, p_g (psf):	20	
Exposure Factor, C_e (Table 7-2):	0.9	
Thermal Factor, C_t (Table 7-3):	1.0	
Importance Factor, I (Table 7-4):	1.0	
Slope Factor, C_s (=1.0 if Flat):	1.0	
Minimum Flat Snow Load, pf (psf):	20	$= p_g$ *I or 20*I
Sloped Roof Snow Load, p_s (psf):	**20**	$= 0.7*C_e*C_t*I*C_s*p_g$ or $p_{f\,min}$
Snow Density, γ (pcf):	16.6	$= 0.13*p_g + 14 \le 30$
Balanced Snow Height, h_b (ft):	1.20	$= p_f / \gamma$
Adjacent Structure Factor, asf	1.00	= (20-s) / 20

Leeward Drift

$$h_d = \left(0.43 \cdot \sqrt[3]{l_u} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 0.59

Windward Drift

$$h_d = 0.75 \cdot \left(0.43 \cdot \sqrt[3]{l_l} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 1.34

Drift Size

Design Height, h_d (ft):	1.34	
But not greater than h_c (ft):	1.34	
Drift Width, w (ft):		
If $h_d \le h_c$, 4 * h_d	5.35	
If $h_d > h_c$, 4 * h_d^2 / h_c	0.92	
But not greater than 8*h_c:	62.36	
w (ft):	5.35	
Maximum Surcharge Load, p_d (psf):	22.21	$= h_d / \gamma$

Sloped Roof Results

Sloped Roof Snow Load, p_s (psf):	**20.0**	**psf**
Balanced Snow Height, h_b (ft):	**1.2**	**ft**

Drift Results - Does not apply

Drift Height, h_d	**1.34**	**ft**
Drift Width, w	**5.35**	**ft**
Maximum Surcharge Load, p_d	**22.21**	**psf**

Page 1 of 1

TKDA

PROJECT	SAZAN SMITH TERMINAL
TITLE	SMITH TERMINAL, CASE 1 SNOW CALCULATION

BY: CBC	SHEET:
CHKD: DM	PROJECT NO: 24026
DATE: 12/20/24	PAGE:

SNOW CALCULATIONS per ASCE 7-16

SMITH TERMINAL, CASE 2

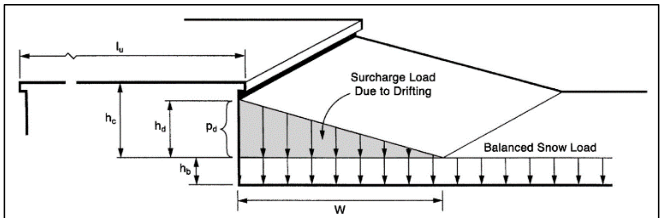


Figure 7.7-2. Configuration of snowdrifts on lower roofs.

Roof Geometry

Upper Roof Length, l_u (ft):	9	
Lower Roof Length, l_l (ft):	135.25	
Roof Height Difference, h (ft):	9	
Separation Distance, s (ft):	0	
Clear Roof Height, h_c (ft):	7.80	
Slope Rise	1	
Actual Slope, degrees	4.764	

Balanced Snow

Ground Snow Load, p_g (psf):	20	
Exposure Factor, C_e (Table 7-2):	0.9	
Thermal Factor, C_t (Table 7-3):	1.0	
Importance Factor, I (Table 7-4):	1.0	
Slope Factor, C_s (=1.0 if Flat):	1.0	
Minimum Flat Snow Load, pf (psf):	20	$= p_g * I$ or $20 * I$
Sloped Roof Snow Load, p_s (psf):	**20**	$= 0.7 * C_e * C_t * I * C_s * p_g$ or $p_{f\,min}$
Snow Density, γ (pcf):	16.6	$= 0.13 * p_g + 14 \le 30$
Balanced Snow Height, h_b (ft):	1.20	$= p_f / \gamma$
Adjacent Structure Factor, asf	1.00	$= (20-s) / 20$

Leeward Drift

$$h_d = \left(0.43 \cdot \sqrt[3]{l_u} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 0.59

Windward Drift

$$h_d = 0.75 \cdot \left(0.43 \cdot \sqrt[3]{l_l} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 2.75

Drift Size

Design Height, h_d (ft):	2.75	
But not greater than h_c (ft):	2.75	
Drift Width, w (ft):		
If $h_d \le h_c$, $4 * h_d$	11.00	
If $h_d > h_c$, $4 * h_d^2 / h_c$	3.88	
But not greater than $8 * h_c$:	62.36	
w (ft):	11.00	
Maximum Surcharge Load, p_d (psf):	45.64	$= h_d / \gamma$

Sloped Roof Results

Sloped Roof Snow Load, p_s (psf):	**20.0**	**psf**
Balanced Snow Height, h_b (ft):	**1.2**	**ft**

Drift Results - Does not apply

Drift Height, h_d	**2.75**	**ft**
Drift Width, w	**11.00**	**ft**
Maximum Surcharge Load, p_d	**45.64**	**psf**

Page 1 of 1

TKDA

PROJECT	SAZAN SMITH TERMINAL
TITLE	SMITH TERMINAL, CASE 2 SNOW CALCULATION

BY: CBC	SHEET:
CHKD: DM	PROJECT NO: 24026
DATE: 12/20/24	PAGE:

Solar Layout

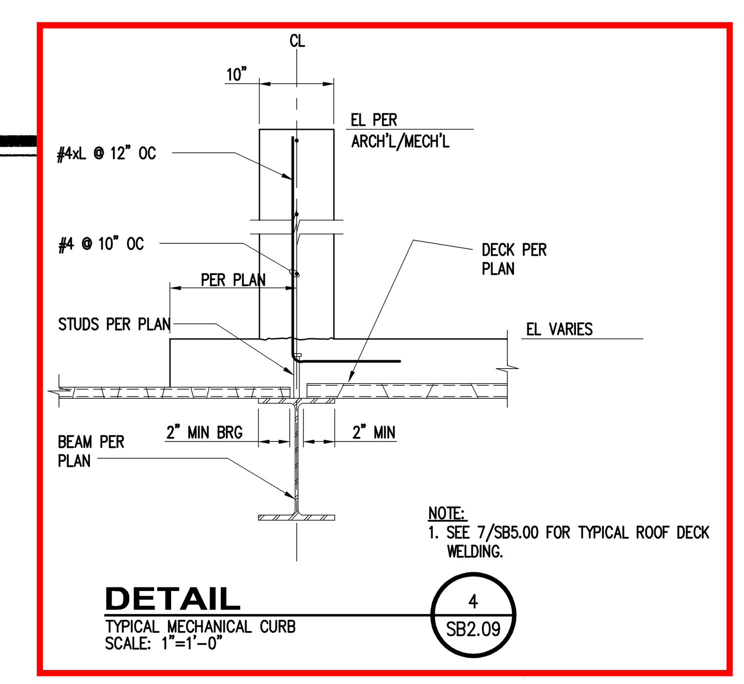
Conclusion - Solar arrays are outside of potential snow drift zones

Array Footprint
Avg wt under array equals 5 psf
Typical

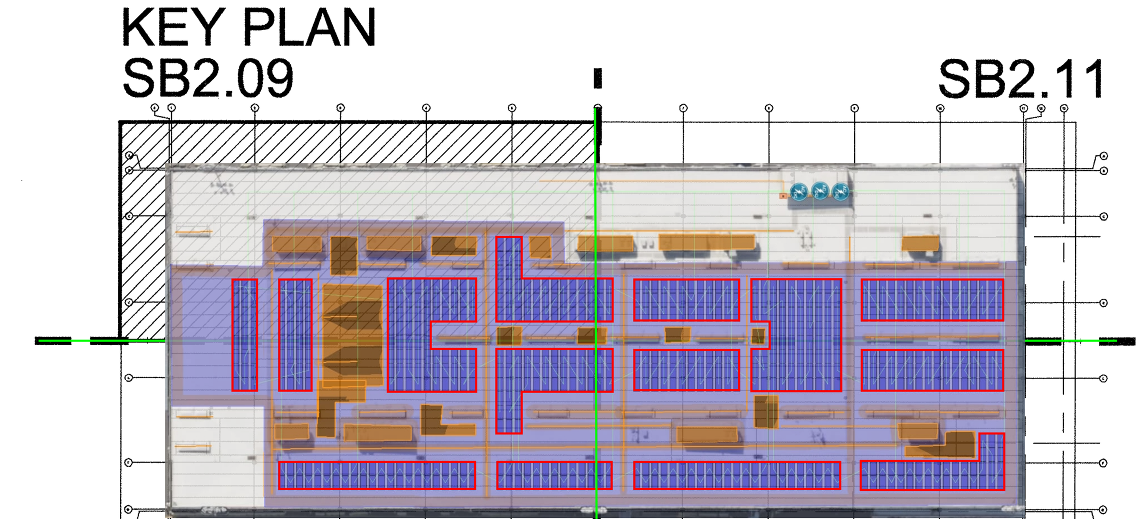
PLAN

PARTIAL ROOF FRAMING PLAN – SOUTH WEST
SCALE: 1/8"=1'-0"

1/8"=1'-0" Scale



KEY PLAN



NOTE:

1. SEE DRAWINGS SB1.X SERIES FOR STRUCTURAL NOTES, SYMBOLS, ABBREVIATION, AND DRAWING LIST.
2. REFERENCE DRAWINGS:
   - SB3.X SERIES – BRACED FRAME ELEVATIONS & DETAILS
   - SB4.X SERIES – CONCRETE DETAILS & SCHEDULES
   - SB5.X SERIES – STEEL DETAILS & STAIR PLANS
3. SEE ARCHITECHTURAL FOR ALL SLAB OPENING DIMENSION. CONTRACTOR SHALL COORDINATE WITH ENGINEER AND ARCHITECT PRIOR TO CONSTRUCTION.
4. CONTRACTOR SHALL COORDINATE ALL MECHANICAL / ELECTRICAL OPENING DIMENSIONS WITH ARCHITECTURAL AND MECHANICAL DRAWINGS PRIOR TO SUBMITTING SHOP DRAWINGS.
5. ROOF DECK AT THIS LEVEL SHALL BE 1 1/2"-18 GAUGE STEEL DECK, UNO. SEE NOTE 6 FOR EXCEPTION. SEE SHEET SB5.00 FOR ROOF DECK FASTENING DETAILS.
6. [hatch] INDICATES DECK AREA W/ 6" THK CONCRETE OVER 2" DEEP GA 18 METAL DECK, W/ #4 @ 18" IC @ MID-DEPTH.
7. MECHANICAL CURB PER DETAIL 4/SB5.03.
8. SEE SCHEDULE ON 10/SB5.12 FOR EQUIVALENT PLATE GIRDER BEAM SECTIONS.

kpff Consulting Engineers
101 Stewart Street, Suite 800
Seattle, Washington 98101
(206) 382-0600 Fax (206) 382-0500

PROJECT ENGR./ARCH.: MBG
DESIGNER: MBG
DRAWN BY: RMF
SCALE: AS SHOWN
DATE: 3/5/07
CHECKED BY: GLV
CHECKED/APPROVED BY: GLV

GREGORY L. VARNEY, STATE OF WASHINGTON, REGISTERED PROFESSIONAL ENGINEER, 25842, EXPIRES 1/25/08

REVISIONS

NO.	DATE	BY	DESCRIPTION
3	5/25/07	MBG	ADDENDUM #3
4	6/22/07	MBG	ADDENDUM #4

PROJECT MANAGER: CHU, CATHERINE
PROJECT ENGINEER:
DESIGN ENGINEER:
DRAFTER:
SCALE: AS NOTED
DATE:
CHECKED/APPROVED BY:

Port of Seattle
MARINE FACILITIES

PROJECT: TERMINAL 91
CRUISE SHIP TERMINAL

SHEET TITLE: PARTIAL ROOF FRAMING PLAN - SOUTH WEST

WORK ORDER NO. 103329
CONSULTANT'S NO. 106315
PORT OF SEATTLE NO. 91-0602 SB2.09

Solar Layout

Conclusion - Solar arrays are outside of potential snow drift zones

PLAN
PARTIAL ROOF FRAMING PLAN – SOUTH EAST
SCALE: 1/8"=1'-0"

1/8"=1'-0" Scale Feet

NOTE:
1. SEE SB2.09 FOR NOTES.

CALL 2 DAYS BEFORE YOU DIG 1-800-424-5555

PROJECT ENGR./ARCH:	MBG
DESIGNER:	MBG
DRAWN BY:	RMF
SCALE:	AS SHOWN
DATE:	3/5/07
CHECKED BY:	GLV
CHECKED/APPROVED BY:	GLV

REVISIONS

NO.	DATE	BY	DESCRIPTION	APP'D	NO.	DATE	BY	DESCRIPTION	APP'D

AS BUILT AND APPROVED
DATE: 09-30-09
AS CERTIFIED BY THE APPROVAL ON THE COVER SHEET FOR THIS SET, THIS DRAWING REPRESENTS A RECORD OF HOW THE PROJECT WAS CONSTRUCTED AND DOES NOT REPRESENT DESIGN OR CHANGE OF APPROVAL.

PROJECT MANAGER: C. CHU/J. JORDAN
PROJECT ENGINEER:
DESIGN ENGINEER:
DRAFTER:
SCALE: AS NOTED
DATE:
CHECKED/APPROVED BY:

Port of Seattle MARINE FACILITIES
PROJECT: TERMINAL 91 CRUISE SHIP TERMINAL
SHEET TITLE: PARTIAL ROOF FRAMING PLAN - SOUTH EAST

WORK PROJECT NO. 103329
CONSULTANT'S NO.
PORT OF SEATTLE NO. 91-0602 -SB2.10

Date : 11-13-2009 Time : 10:39
Dwg : I:\T91\2006\T-91 0602\As-Built\Vol2\Structural\910602SB2_10.DWG
Xref : X_TBLK, X_COLS, X_GRID, T91XPEN, X_ARCH

Solar Layout

Conclusion - Solar arrays are outside of potential snow drift zones

CALL 2 DAYS BEFORE YOU DIG 1-800-424-5555

PROJECT ENGR./ARCH:	MBG
DESIGNER:	MBG
DRAWN BY:	RMF
SCALE:	AS SHOWN
DATE:	3/5/07
CHECKED BY:	GLV
CHECKED/APPROVED BY:	GLV

REVISIONS

NO.	DATE	BY	DESCRIPTION	APP'D	NO.	DATE	BY	DESCRIPTION	APP'D

AS BUILT AND APPROVED
DATE: 09-30-09
AS CERTIFIED BY THE APPROVAL ON THE COVER SHEET FOR THIS SET, THIS DRAWING REPRESENTS A RECORD OF HOW THE PROJECT WAS CONSTRUCTED AND DOES NOT REPRESENT DESIGN OR CHANGE OF APPROVAL.

PROJECT MANAGER: C. CHU/J. JORDAN
PROJECT ENGINEER:
DESIGN ENGINEER:
DRAFTER:
SCALE: AS NOTED
DATE:
CHECKED/APPROVED BY:

Port of Seattle MARINE FACILITIES
PROJECT: TERMINAL 91 CRUISE SHIP TERMINAL
SHEET TITLE: PARTIAL ROOF FRAMING PLAN - NORTH WEST

WORK PROJECT NO. 103329
CONSULTANT'S NO.
PORT OF SEATTLE NO. 91-0602-SB2.11

Date : 11-13-2009 Time : 12:33
Dwg : I:\T91\2006\T-91 0602\As-Built\Vol2\Structural\910602SB2_11.DWG
Xref : X_TBLK, X_COLS, X_GRID, T91XPEN, X_ARCH

Solar Layout

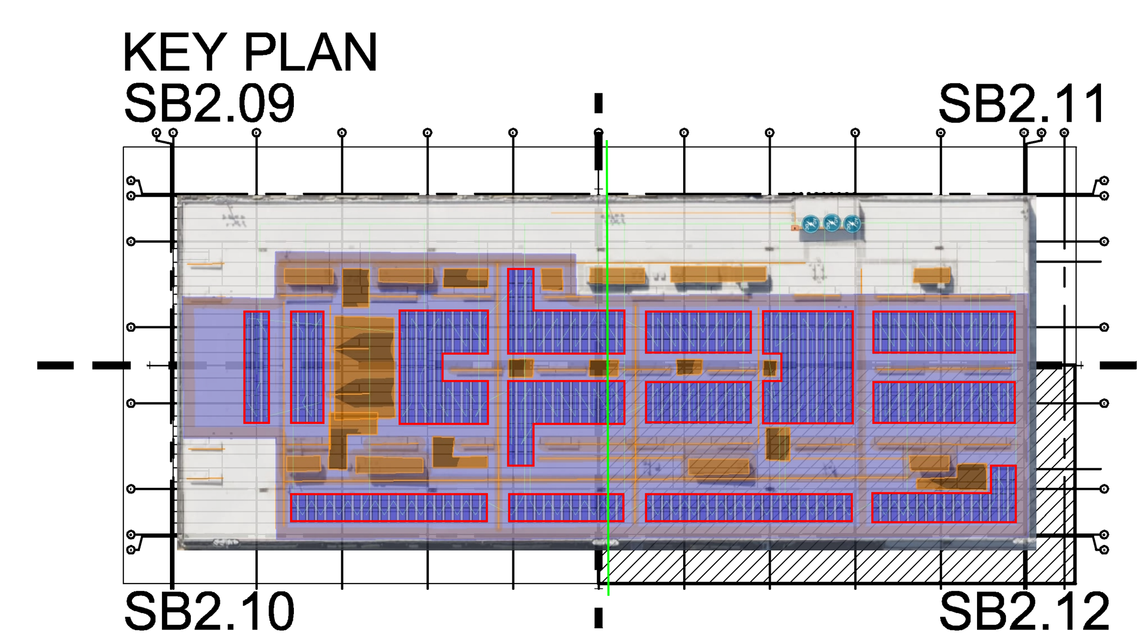
Conclusion - Solar arrays are outside of potential snow drift zones

PLAN

PARTIAL ROOF FRAMING PLAN – NORTH EAST

SCALE: 1/8"=1'-0"

1/8"=1'-0" Scale 5 0 5 10 15 20 Feet



NOTE:
1. SEE SB2.09 FOR NOTES.

CALL 2 DAYS BEFORE YOU DIG 1-800-424-5555

PROJECT ENGR./ARCH: MBG
DESIGNER: MBG
DRAWN BY: RMF
SCALE: AS SHOWN
DATE: 3/5/07
CHECKED BY: GLV
CHECKED/APPROVED BY: GLV

REVISIONS

NO.	DATE	BY	DESCRIPTION	APP'D	NO.	DATE	BY	DESCRIPTION	APP'D

AS BUILT AND APPROVED
DATE: 09-30-09
AS CERTIFIED BY THE APPROVAL ON THE COVER SHEET FOR THIS SET, THIS DRAWING REPRESENTS A RECORD OF HOW THE PROJECT WAS CONSTRUCTED AND DOES NOT REPRESENT DESIGN OR CHANGE OF APPROVAL.

PROJECT MANAGER: C. CHU/J. JORDAN
PROJECT ENGINEER:
DESIGN ENGINEER:
DRAFTER:
SCALE: AS NOTED
DATE:
CHECKED/APPROVED BY:

Port of Seattle MARINE FACILITIES

PROJECT: TERMINAL 91 CRUISE SHIP TERMINAL

SHEET TITLE: PARTIAL ROOF FRAMING PLAN - NORTH EAST

WORK PROJECT NO. 103329
CONSULTANT'S NO.
PORT OF SEATTLE NO. 91-0602 -SB2.12

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STANDARD ASD LOAD TABLE

OPEN WEB STEEL JOISTS, K-SERIES

Historical K series joist table

Based on a 50 ksi Maximum Yield Strength
Adopted by the Steel Joist Institute November 4, 1985
Revised to November 10, 2003 - Effective March 01, 2005

The black figures in the following table give the TOTAL safe uniformly distributed load-carrying capacities, in pounds per linear foot, of **ASD K-Series** Steel Joists. The weight of DEAD loads, including the joists, must be deducted to determine the LIVE load-carrying capacities of the joists. Sloped parallel-chord joists shall use span as defined by the length along the slope.

The figures shown in **RED** in this load table are the nominal LIVE loads per linear foot of joist which will produce an approximate deflection of 1/360 of the span. LIVE loads which will produce a deflection of 1/240 of the span may be obtained by multiplying the figures in **RED** by 1.5. In no case shall the TOTAL load capacity of the joists be exceeded.

The approximate joist weights per linear foot shown in these tables do not include accessories.

The approximate moment of inertia of the joist, in inches^4 is;

$I_j = 26.767(W_{LL})(L^3)(10^{-6})$, where W_{LL}= **RED** figure in the Load Table and L = (Span - 0.33) in feet.

For the proper handling of concentrated and/or varying loads, see Section 6.1 in the Code of Standard Practice for Steel Joists and Joist Girders.

Where the joist span exceeds the unshaded area of the Load Table, the row of bridging nearest the mid span shall be diagonal bridging with bolted connections at the chords and intersections.

ASD

STANDARD LOAD TABLE FOR OPEN WEB STEEL JOISTS, K-SERIES
Based on a 50 ksi Maximum Yield Strength - Loads Shown in Pounds per Linear Foot (plf)

Joist Designation	8K1	10K1	12K1	12K3	12K5	14K1	14K3	14K4	14K6	16K2	16K3	16K4	16K5	16K6	16K7	16K9
Depth (in.)	8	10	12	12	12	14	14	14	14	16	16	16	16	16	16	16
Approx. Wt (lbs./ft.)	5.1	5.0	5.0	5.7	7.1	5.2	6.0	6.7	7.7	5.5	6.3	7.0	7.5	8.1	8.6	10.0
Span (ft.) ↓																
8	550 550															
9	550 550															
10	550 480	550 550														
11	532 377	550 542														
12	444 288	550 455	550 550	550 550	550 550											
13	377 225	479 363	550 510	550 510	550 510											
14	324 179	412 289	500 425	550 463	550 463	550 550	550 550	550 550	550 550							
15	281 145	358 234	434 344	543 428	550 434	511 475	550 507	550 507	550 507							
16	246 119	313 192	380 282	476 351	550 396	448 390	550 467	550 467	550 467	550 550	550 550	550 550	550 550	550 550	550 550	550 550
17		277 159	336 234	420 291	550 366	395 324	495 404	550 443	550 443	512 488	550 526	550 526	550 526	550 526	550 526	550 526
18		246 134	299 197	374 245	507 317	352 272	441 339	530 397	550 408	456 409	508 456	550 490	550 490	550 490	550 490	550 490
19		221 113	268 167	335 207	454 269	315 230	395 287	475 336	550 383	408 347	455 386	547 452	550 455	550 455	550 455	550 455
20		199 97	241 142	302 177	409 230	284 197	356 246	428 287	525 347	368 297	410 330	493 386	550 426	550 426	550 426	550 426
21			218 123	273 153	370 198	257 170	322 212	388 248	475 299	333 255	371 285	447 333	503 373	548 405	550 406	550 406
22			199 106	249 132	337 172	234 147	293 184	353 215	432 259	303 222	337 247	406 289	458 323	498 351	550 385	550 385
23			181 93	227 116	308 150	214 128	268 160	322 188	395 226	277 194	308 216	371 252	418 282	455 307	507 339	550 363
24			166 81	208 101	282 132	196 113	245 141	295 165	362 199	254 170	283 189	340 221	384 248	418 269	465 298	550 346
25						180 100	226 124	272 145	334 175	234 150	260 167	313 195	353 219	384 238	428 263	514 311
26						166 88	209 110	251 129	308 156	216 133	240 148	289 173	326 194	355 211	395 233	474 276
27						154 79	193 98	233 115	285 139	200 119	223 132	268 155	302 173	329 188	366 208	439 246
28						143 70	180 88	216 103	265 124	186 106	207 118	249 138	281 155	306 168	340 186	408 220
29										173 95	193 106	232 124	261 139	285 151	317 167	380 198
30										161 86	180 96	216 112	244 126	266 137	296 151	355 178
31										151 78	168 87	203 101	228 114	249 124	277 137	332 161
32										142 71	158 79	190 92	214 103	233 112	259 124	311 147

ASD

STANDARD LOAD TABLE FOR OPEN WEB STEEL JOISTS, K-SERIES
Based on a 50 ksi Maximum Yield Strength - Loads Shown in Pounds per Linear Foot (plf)

Joist Designation	28K6	28K7	28K8	28K9	28K10	28K12	30K7	30K8	30K9	30K10	30K11	30K12
Depth (In.)	28	28	28	28	28	28	30	30	30	30	30	30
Approx. Wt. (lbs./ft.)	11.4	11.8	12.7	13.0	14.3	17.1	12.3	13.2	13.4	15.0	16.4	17.6
Span (ft.) ↓												
28	548 541	550 543	550 543	550 543	550 543	550 543						
29	511 486	550 522	550 522	550 522	550 522	550 522						
30	477 439	531 486	550 500	550 500	550 500	550 500	550 543	550 543	550 543	550 543	550 543	550 543
31	446 397	497 440	550 480	550 480	550 480	550 480	534 508	550 520	550 520	550 520	550 520	550 520
32	418 361	466 400	515 438	549 463	549 463	549 463	501 461	549 500	549 500	549 500	549 500	549 500
33	393 329	438 364	484 399	527 432	532 435	532 435	471 420	520 460	532 468	532 468	532 468	532 468
34	370 300	412 333	456 364	496 395	516 410	516 410	443 384	490 420	516 441	516 441	516 441	516 441
35	349 275	389 305	430 333	468 361	501 389	501 389	418 351	462 384	501 415	501 415	501 415	501 415
36	330 252	367 280	406 306	442 332	487 366	487 366	395 323	436 353	475 383	487 392	487 392	487 392
37	312 232	348 257	384 282	418 305	474 344	474 344	373 297	413 325	449 352	474 374	474 374	474 374
38	296 214	329 237	364 260	396 282	461 325	461 325	354 274	391 300	426 325	461 353	461 353	461 353
39	280 198	313 219	346 240	376 260	447 306	449 308	336 253	371 277	404 300	449 333	449 333	449 333
40	266 183	297 203	328 222	357 241	424 284	438 291	319 234	353 256	384 278	438 315	438 315	438 315
41	253 170	283 189	312 206	340 224	404 263	427 277	303 217	335 238	365 258	427 300	427 300	427 300
42	241 158	269 175	297 192	324 208	384 245	417 264	289 202	320 221	348 240	413 282	417 284	417 284
43	230 147	257 163	284 179	309 194	367 228	407 252	276 188	305 206	332 223	394 263	407 270	407 270
44	220 137	245 152	271 167	295 181	350 212	398 240	263 176	291 192	317 208	376 245	398 258	398 258
45	210 128	234 142	259 156	282 169	334 198	389 229	251 164	278 179	303 195	359 229	389 246	389 246
46	201 120	224 133	248 146	270 158	320 186	380 219	241 153	266 168	290 182	344 214	380 236	380 236
							230 144	255 157	277 171	329 201	372 226	372 226
							221 135	244 148	266 160	315 188	362 215	365 216
							212 127	234 139	255 150	303 177	347 202	357 207
							203 119	225 130	245 141	291 166	333 190	350 199
							195 112	216 123	235 133	279 157	320 179	343 192
							188 106	208 116	226 126	268 148	308 169	336 184
							181 100	200 109	218 119	258 140	296 159	330 177
							174 94	192 103	209 112	249 132	285 150	324 170
							168 89	185 98	202 106	240 125	275 142	312 161
							162 84	179 92	195 100	231 118	265 135	301 153
							156 80	173 88	188 95	223 112	256 128	290 145
							151 76	167 83	181 90	215 106	247 121	280 137
							146 72	161 79	175 86	208 101	239 115	271 130
							141 69	156 75	169 81	201 96	231 109	262 124

Typical 30K9 Joist Parameters:

DL = Unknown
Self wt = 13.4 plf
SL = 25 psf
joist spacing = 6'-0"
span = 45 ft

Determine Roof Dead Load:

w_{DL} = 303 plf - 25 psf * 6 ft = 153 plf

DL_{max} = 153 plf / 6ft = ~ 25 psf

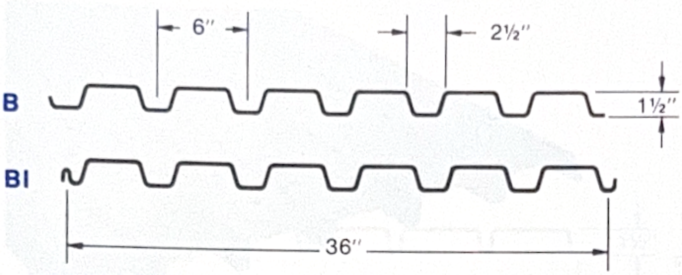
Summary - Based on the joist capacity, the maximum dead load equals 25 psf

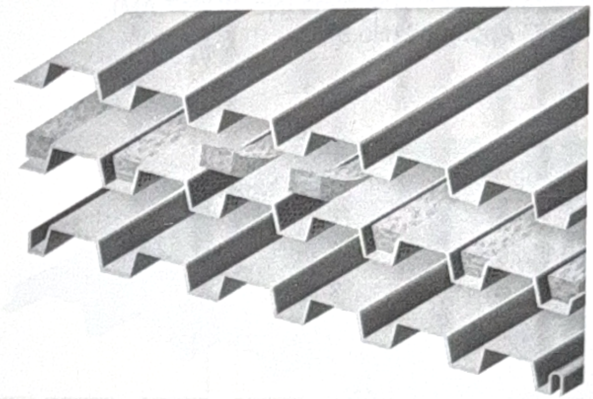
VULCRAFT

ROOF

1.5 B, BI, BA, BIA

Maximum Sheet Length 42'-0
Extra Charge for Lengths Under 6'-0
Factory Mutual Approved (No. 0C847.AM, 0G1A4.AM, and 3Y1A6.AM) **
ICBO Approved (No.3415)





SECTION PROPERTIES

Deck Type	Design Thick.	Weight (PSF) Ptd.	Weight (PSF) Galv.	I in⁴/ft	Sp in³/ft	Sn in³/ft	Fy KSI
B24	0.0239	1.36	1.46	0.121	0.120	0.131	60
B22	0.0295	1.68	1.78	0.169	0.186	0.192	33
B21	0.0329	1.87	1.97	0.192	0.213	0.221	33
B20	0.0358	2.04	2.14	0.212	0.234	0.247	33
B19	0.0418	2.39	2.49	0.253	0.277	0.289	33
B18	0.0474	2.72	2.82	0.292	0.318	0.327	33
B16	0.0598	3.44	3.54	0.373	0.408	0.411	33

ACOUSTICAL INFORMATION

Deck Type	Absorption Coefficient 125	250	500	1000	2000	4000	Noise Reduction Coefficient*
1.5BA, 1.5BIA	.11	.20	.63	1.04	.66	.36	.65

* Source: Riverbank Acoustical Laboratories — RAL™ A94–185.
Test was conducted with 1.5 inches of 1.65 pcf fiberglass insulation on 3 inch EPS Plaza deck for the SDI.

Parameters:

DL = Unknown
SL = 25 psf
Joist spacing = 6'-0" O.C

Deck Capacity = TL = 98 psf

DL = TL - SL = 98 psf - 25 psf = 73 psf

Summary - Deck could accommodate 73 psf dead load. Per Load verification calculations, if dead load equals 20 psf there would be 53 psf reserve capacity in the deck for solar.

Note, deck does not control the design.

VERTICAL LOADS FOR TYPE 1.5B

No. of Spans	Deck Type	Max. SDI Const. Span	Allowable Total (Dead + Live) Uniform Load (PSF) Span (ft.-in.) C. to C. of Support: 5'-0	5'-6	6'-0	6'-6	7'-0	7'-6	8'-0	8'-6	9'-0	9'-6	10'-0
1	B 24	4'-8	66	52	42	36	30	27	24	21	20		
	B 22	5'-7	91	71	57	47	40	34	30	27	24	22	20
	B 21	6'-0	104	81	64	53	44	38	33	29	26	24	22
	B 20	6'-5	115	89	71	58	48	41	36	31	28	25	23
	B 19	7'-1	139	107	86	69	57	48	41	36	32	29	26
	B 18	7'-8	162	124	98	79	65	55	47	41	36	32	29
	B 16	8'-8	206	157	123	99	81	68	58	50	44	39	34
2	B 24	5'-10	126	104	87	74	64	55	47	41	36	32	29
	B 22	6'-11	102	85	71	61	52	46	40	35	32	28	26
	B 21	7'-4	118	97	82	70	60	52	46	41	36	33	29
	B 20	7'-9	132	109	91	78	67	59	51	46	41	36	33
	B 19	8'-5	154	127	107	91	79	69	60	53	48	43	39
	B 18	9'-1	174	144	121	103	89	78	68	60	54	48	44
	B 16	10'-3	219	181	152	130	112	97	86	76	68	61	55
3	B 24	5'-10	130	100	79	65	54	45	39	34	31	27	25
	B 22	6'-11	128	106	89	76	65	57	50	44	39	34	31
	B 21	7'-4	147	122	102	87	75	65	56	49	42	38	34
	B 20	7'-9	165	136	114	97	84	72	61	53	46	41	36
	B 19	8'-5	193	159	134	114	98	84	71	61	53	47	41
	B 18	9'-1	218	180	151	129	111	96	81	69	60	52	46
	B 16	10'-3	274	226	190	162	140	119	100	85	73	64	56

Notes:
1. Load tables are calculated using sectional properties based on the steel design thickness shown in the Steel Deck Institute (SDI) Design Manual.
2. Loads shown in the shaded areas are governed by the live load deflection not in excess of 1/240 of the span. A dead load of 10 PSF has been included.
3. ** Acoustical Deck is not covered under Factory Mutual

303.8 kW ROOFTOP SOLAR PV ARRAY

SCALE: NTS

N

SÄZÄN
GROUP

600 Stewart St., Ste 1400
Seattle, Washington 98101

Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

BUILDING SMITH COVE
PORT OF SEATTLE

Port of Seattle

Project: B23-24007

Contents:

ROOFTOP SOLAR PV
MODULE LAYOUT

Drawn: JC

Checked: TC

Date: 12/19/24

Sheet Number:

E1.0

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Joseph Cauilan

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600 Stewart St., Ste 1400
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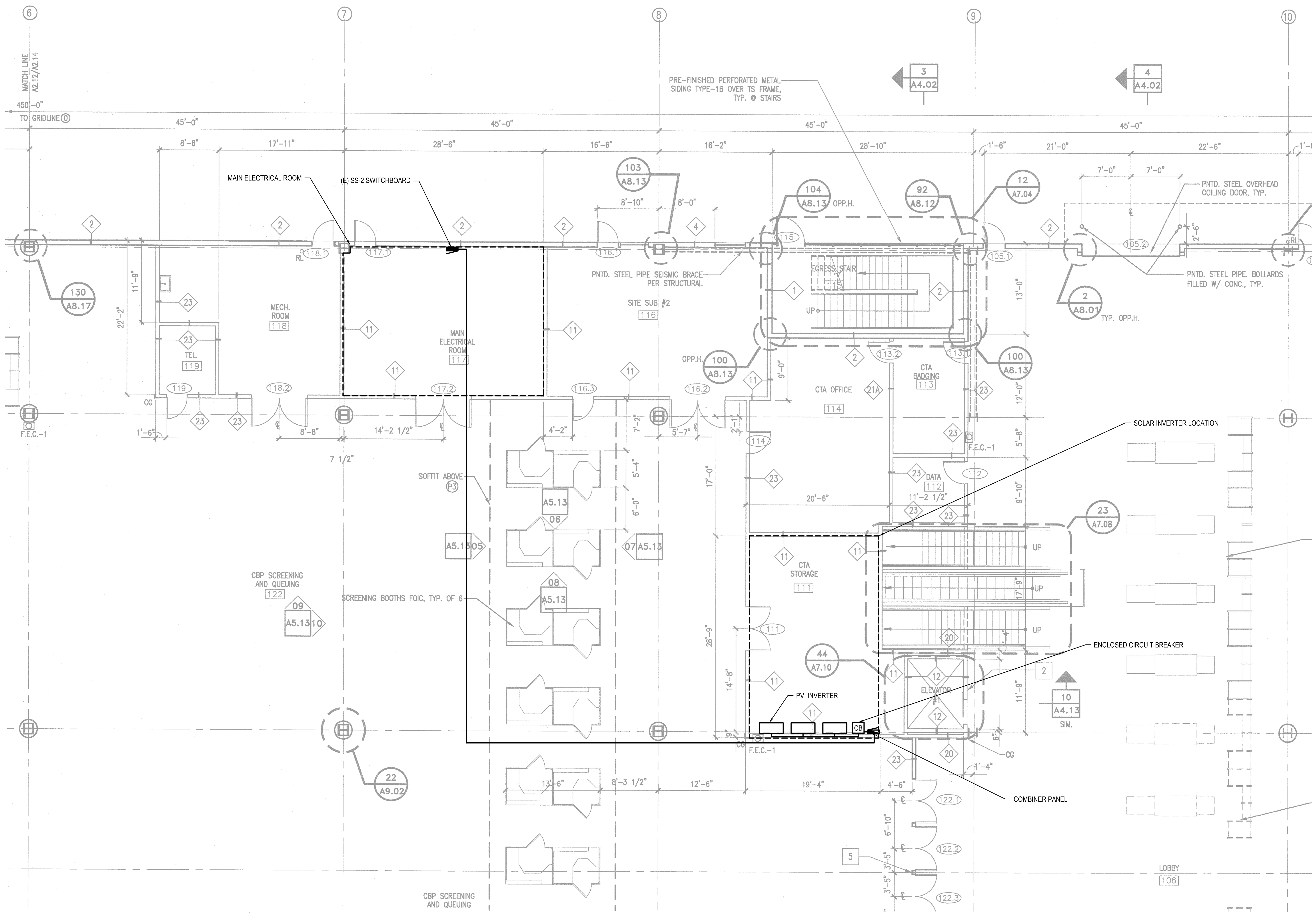
Fax 206.267.1701
SAZAN # XXX-XXXXX



SOLAR PV EQUIPMENT LAYOUT - FIRST FLOOR

1

SCALE: 1/8" = 1'0"

#	DESCRIPTION	DATE

BUILDING SMITH COVE
PORT OF SEATTLE

Port of Seattle

Project: B23-24007
Contents:

SOLAR PV
EQUIPMENT LAYOUT

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

E2.0

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600 Stewart St., Ste 1400
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Tel 206.267.1700
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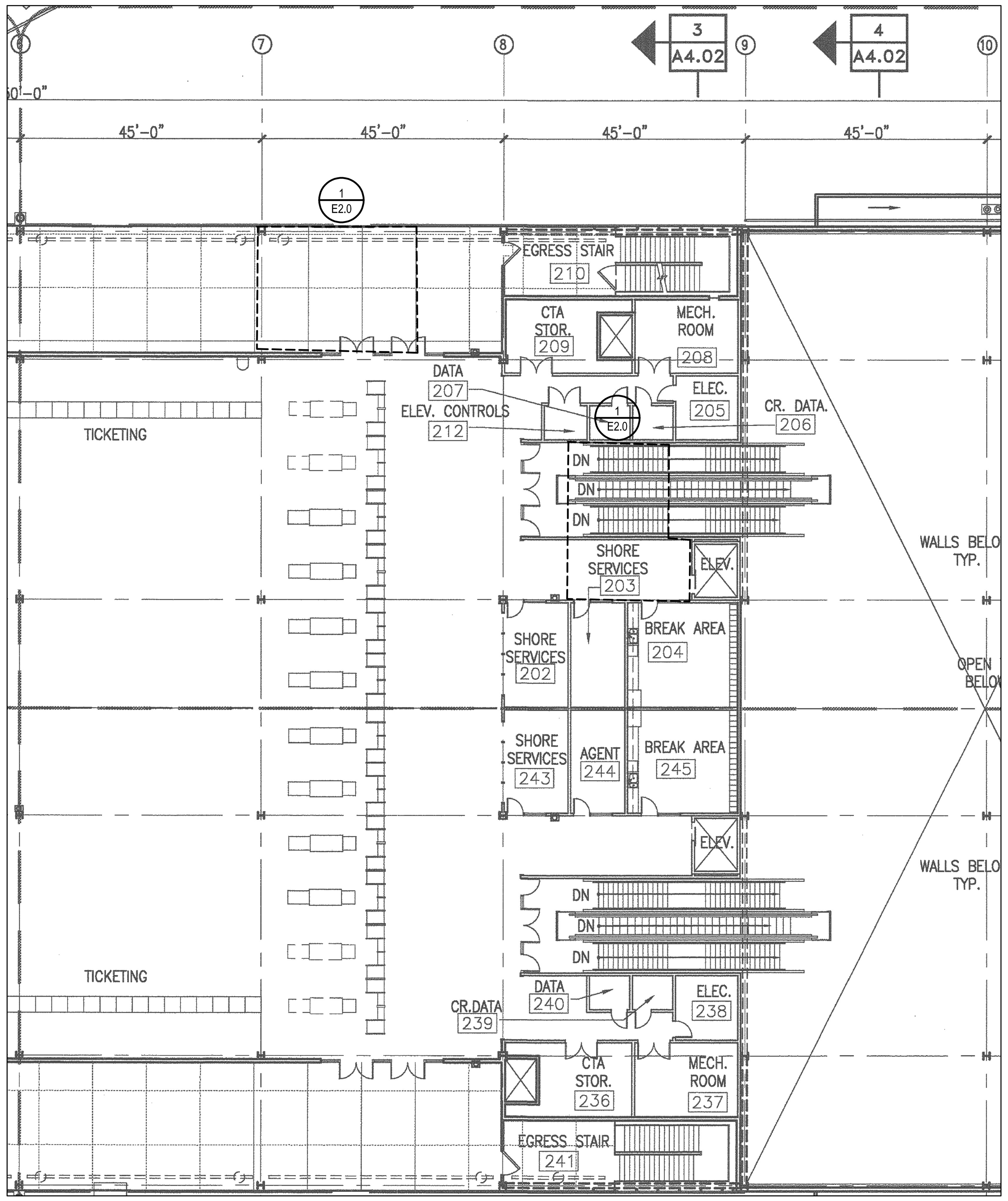
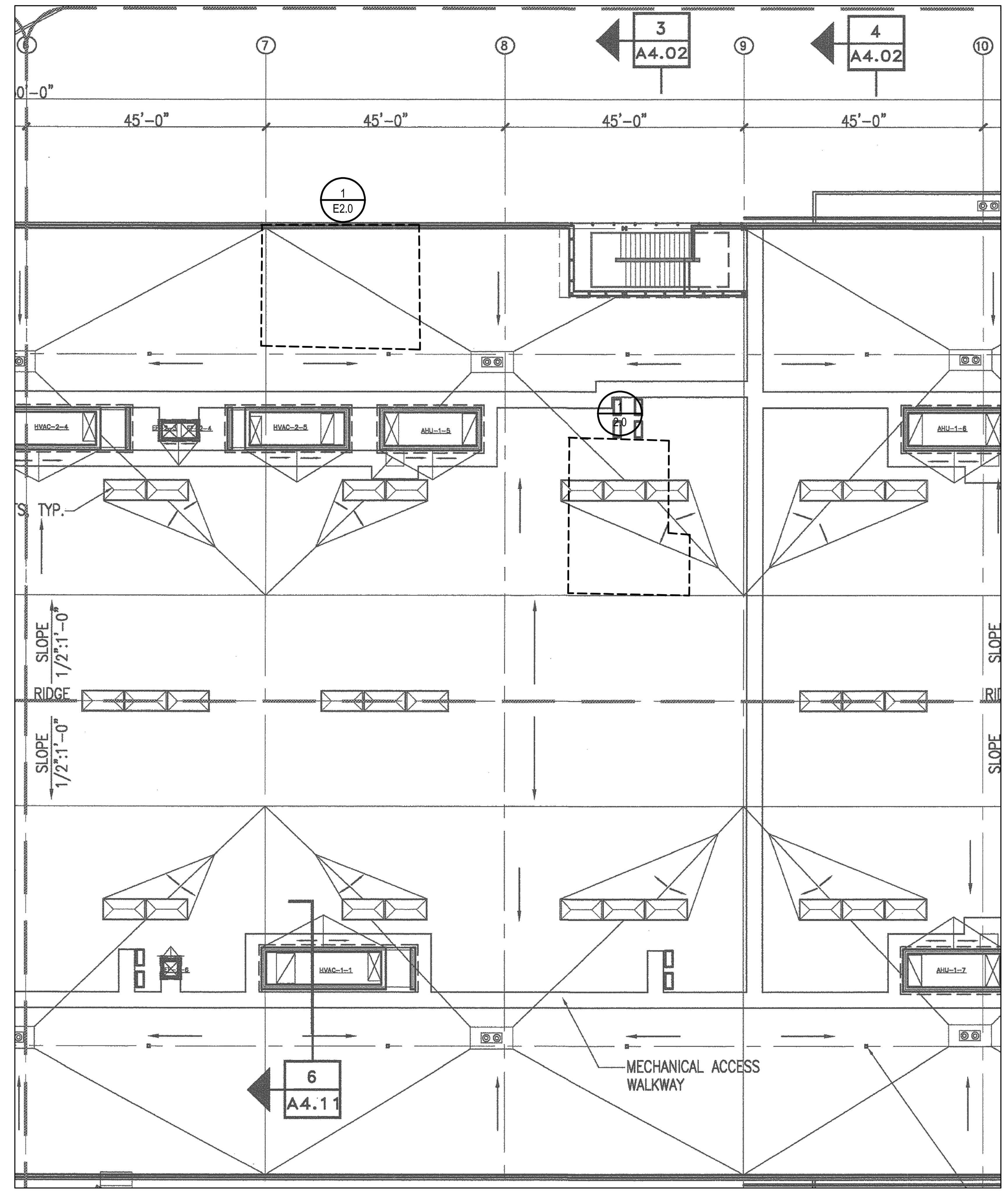
SAZAN # XXX-XXXXX



SOLAR PV EQUIPMENT LAYOUT - SECOND FLOOR (2)

SCALE: 1" = 20'0"



SOLAR PV EQUIPMENT LAYOUT - ROOF (3)

SCALE: 1" = 20'0"

#	DESCRIPTION	DATE

BUILDING SMITH COVE
PORT OF SEATTLE

Port of Seattle

Project: B23-24007

Contents:

SOLAR PV
EQUIPMENT LAYOUT

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

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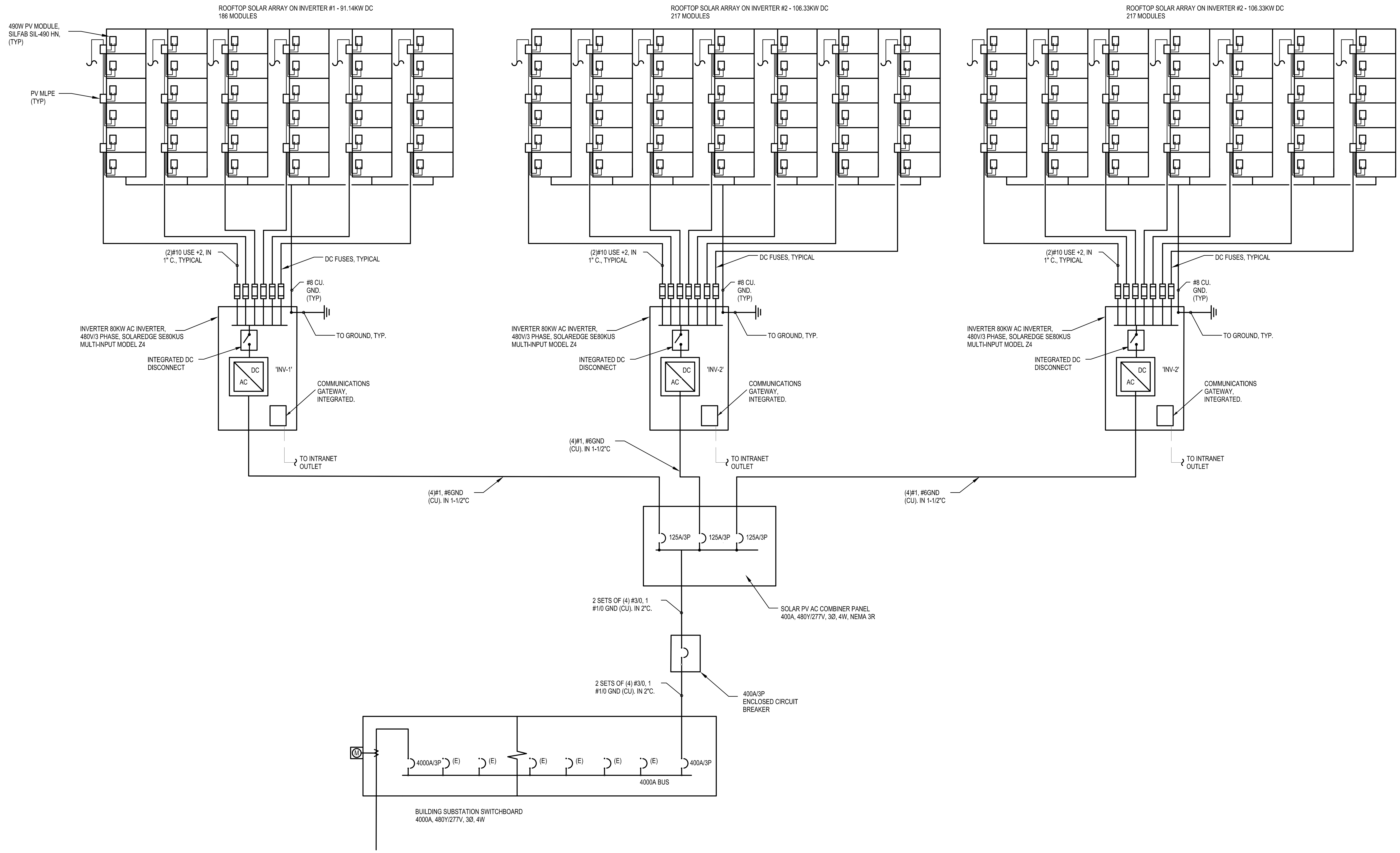

SOLAR PV SYSTEM - ONE LINE DIAGRAM

SCALE: NTS

1

SÄZÄN GROUP
600 Stewart St., Ste 1400
Seattle, Washington 98101
Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

BUILDING SMITH COVE
PORT OF SEATTLE

Port of Seattle

Project: B23-24007
Contents:

SOLAR PV SYSTEM - ONELINE DIAGRAM

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

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Joseph Cauilan

Project Details			
Name	Smith Cove North Segment	**Date**	12/04/2024
Location	2001 West Garfield Street, Seattle, WA 98119	**Total modules**	454
Module	Silfab: SIL-490 HN (35mm)	**Total watts**	222,460
Dimensions	Dimensions: 89.09" x 40.83" x 1.38" (2263.0mm x 1037.0mm x 35.0mm)	**ASCE code**	7-16

Load Conditions			
Risk category	II	**Ground snow load**	20 psf
Wind speed	97 mph	**Wind exposure**	C

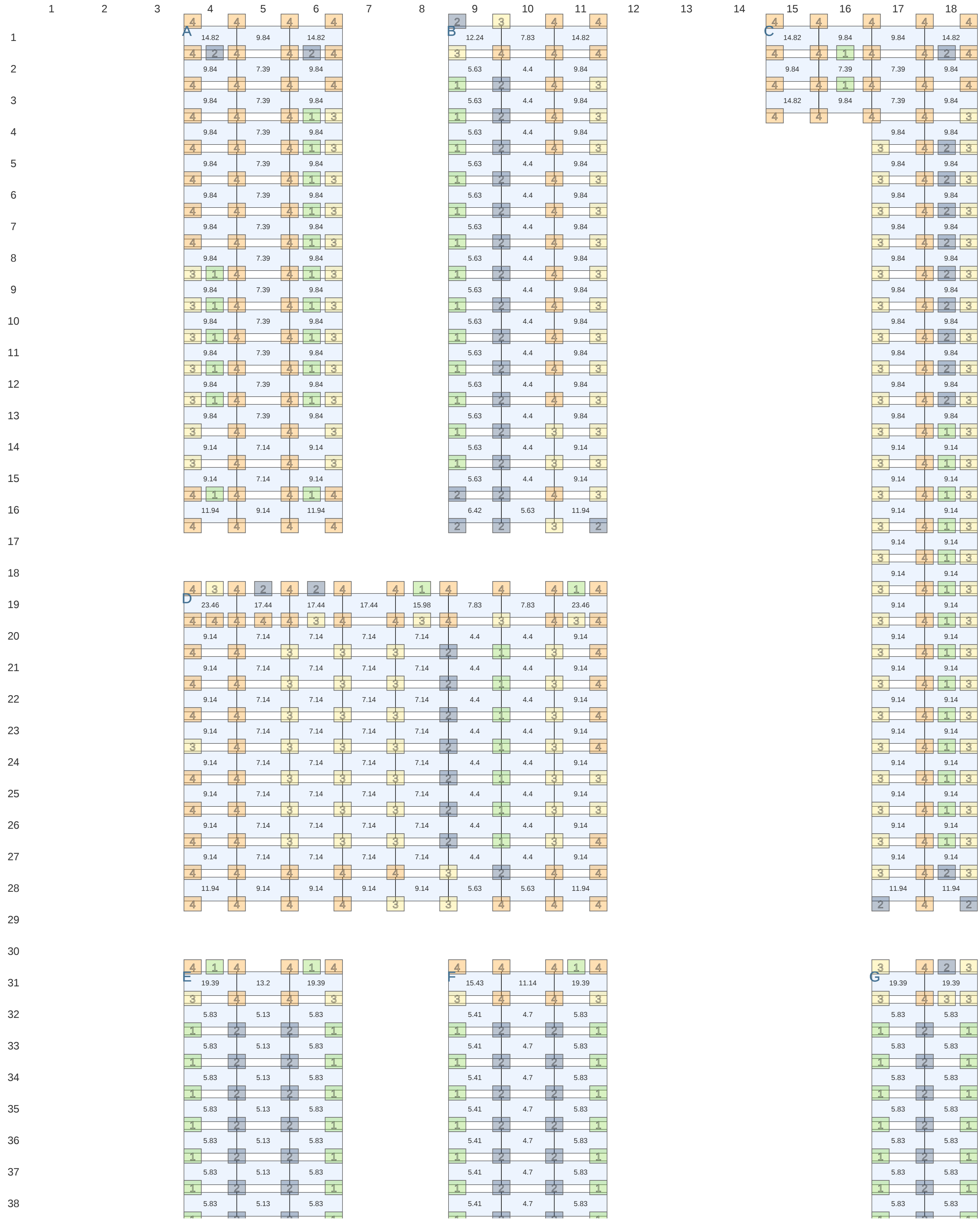
Building Information			
Height	35.0 ft	**Elevation**	15.0 ft
North-south	300.0 ft	**East-west**	150.0 ft
Roof slope	1 °	**Parapet height**	24.0 in
Fire setback	6.0 ft	**Parapet thickness**	8.0 in
Roof material	EPDM	**Roof manufacturer**	n/a
Color	n/a	**Thickness**	n/a

BX Parameters			
Tilt angle	10 °	**Seismic design**	Prescriptive Method
Block size	Full	**Block weight**	32.00 lbs
Spectral Acceleration (S_{DS})	1.113	**Seismic Design Category**	D
Calculations	Rectangular	**Setback**	6.7 ft
Ballast Relocation	Yes	**Supplemental Chasis**	Yes

Prescriptive Method Setbacks					
Between Arrays	1' 3.3"	**Array to Fixed Object**	2' 6.5"	**Array to Roof Edge**	2' 6.5"

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Panels: 454 Chassis: 722 Blocks: 1942 Anchors: 0



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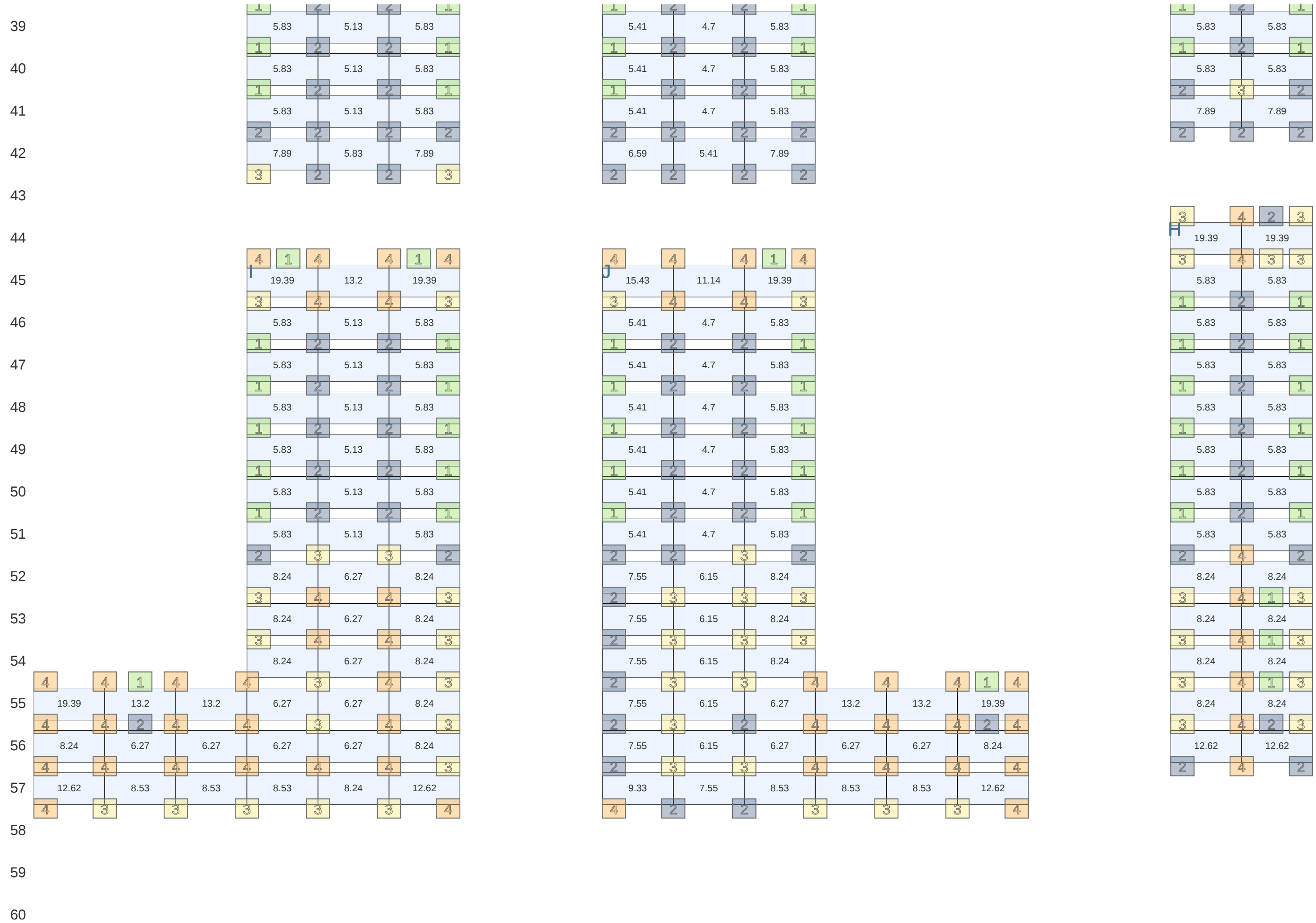
Last updated by Tom Bowen on 12/04/24 03:21 PM



** If any changes are made to panel placement or location relative to roof edges, the ballast plan must be recalculated.*

Sliding Group Information

Sliding group	Module count	Anchor count	Chassis count	Block count	Dead load	Area	PSF
A	48	0	87.00 (19 supplementals)	274.00	11,951.01	1,631.82	7.32
B	48	0	68.00	176.00	8,715.64	1,631.82	5.34
C	62	0	122.00 (27 supplementals)	365.00	15,841.68	2,108.65	7.51
D	80	0	109.00 (10 supplementals)	350.00	16,314.03	2,767.12	5.90
E	36	0	54.00 (2 supplementals)	104.00	5,655.30	1,235.12	4.58
F	36	0	53.00 (1 supplementals)	101.00	5,554.35	1,235.12	4.50
G	22	0	38.00 (2 supplementals)	70.00	3,688.14	756.76	4.87
H	26	0	48.00 (6 supplementals)	110.00	5,247.96	888.91	5.90
I	48	0	72.00 (4 supplementals)	205.00	9,661.90	1,677.31	5.76
J	48	0	71.00 (3 supplementals)	187.00	9,080.95	1,677.30	5.41

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Ballast and Anchors					
Module count	**454**	Chassis count	**722 (74 supplemental)**	Block count	**1,942**
Wind Anchors	**0**	Seismic Anchors	**n/a**	Anchors needed	**0**
Block weight	**62,144.00 lbs**	Components weight	**29,566.96 lbs**	Total weight	**91,710.96 lbs**
Area	**15,609.92 sq. ft**			Ground Coverage Ratio	**0.73**
Avg dist dead load	**5.88 psf**			Max chassis weight (Incl. 1 Module)	**190.11 lbs**

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Bill of Materials

Part	Spares	Qty
BX Components		
BX-10D-P1 BX Chassis 10 deg	0	722
BX-TCL-35MM-M1 BX Top Clamp, 35mm, Mill	0	2639
BX-BCL-M1 BX Bottom Clamp w/ Hardware	0	2639
BX-RB38-M1 38" Row Bonding Jumper	0	134
PV-LUG-02-A1 PV Module Grounding Lug	0	10
BX-MB8-M1 8" Module Bonding Jumper	0	310
QMAFBU-A-25 Accessory Frame Bracket, Universal, Mill	0	227

Assumptions

The results produced by IronRidge's Design Assistant are only valid if all the following conditions are met and the design parameters were entered accurately.

Design Parameters

- Design Assistant ballast calculations assume rectangular buildings.
- Building must be less than 60ft high, or building height must be less than the least horizontal dimension.
- Roof is a single level (e.g. no penthouse that extends above roof for part of the area).
- Roof has sharp eaves.
- Calculations assume a setback around each obstruction equal or larger than the height of the obstruction.
- Calculations assume that the array is aligned to the NW corner of the roof plus the setback. Panel edges must be parallel to the roof edges.
- Maximum rows and columns for the array will be calculated to ensure that setbacks on the east and south are at least as large as the setbacks on the north and west.
- Verify your minimum setback requirements with your local AHJ.
- If the building could hold an array larger than the maximum size array the Design Assistant can configure (60 rows x 60 columns), the setback will be expanded on the east and south sides of the array to extend all the way to the edge of the roof beyond the maximum sized array.
- Design Assistant does not account for any accelerated wind flow due to surrounding buildings.
- Defaulted at Soil Type D for seismic calculations.

Seismic Design

- Prescriptive setbacks are calculated using the approach from ASCE 7-16.
- Minimum $delta_{mpv}$ of 2 feet.
- Distance between a solar array and a roof edge without a qualifying parapet is 2.0 * I_e * $delta_{mpv}$.
- I_e, seismic importance factor, is from ASCE Section 1.5.1, Table 1.5-2.

Component/System Properties

- By default, anchor placements are made using the attachment's capacity of 525 uplift/392 lateral (lbs). It is the user's responsibility to verify reaction load capacity of the structural decking. If the structural decking cannot sustain these loads, the actual limits can be entered into Design Assistant (Anchor uplift strength/Anchor lateral strength).
- Concrete ballast block:
  - Manufactured per ASTM C 1491 (Standard specification for concrete pavers).
  - Manufactured to resist freeze-thaw as required per local conditions.
  - Design Assistant defaults block weights to 15.5 lbs (half block) and 32 lbs (full block). User is responsible for adjusting these weights to match actual blocks sourced.
- Chassis Weight: ~ 4.7 lbs
- E-W Module Gap: .375”
- Inter-Row Spacing:
  - 5 Degrees = 10”
  - 10 Degrees = 13”
- Chassis overhang:
  - 5 Degrees
    - North ~ 19" and South ~ 15.5"
  - 10 Degrees
    - North ~ 17" and South ~ 20.5"
- Coefficients of Static Friction under wet conditions for Tested Roof Types:
  - TPO = .69
  - KEE = .60
  - PVC = .60
  - Built Up = .50
  - Modified Bitumen = .50
  - EPDM = .73

Ratings/Certifications

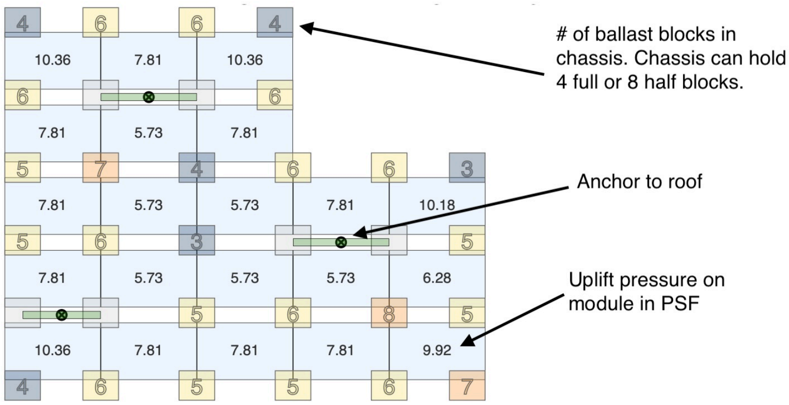
- UL 2703 Listed (See installation manual for more details)
- Class A System Fire Rating Per UL 1703
- Designed and Certified for Compliance with the International Building Code, ASCE/SEI-7, and SEAOC PV Guidelines
- Wind Tunnel Testing by I.F.I
- User to verify module manufacturer's clamping location and pressure limits.

Additional Notes

- Installer must clean roof of all debris before installing BX chassis and/or slip sheets. It is recommended to blow off debris or loose roofing material from Modified Bitumen or Built Up roofs.
- If array moves due to an earthquake, it shall be restored to its original position.
- If anchors are damaged due to an earthquake, they shall be replaced.
- Building engineer should evaluate the effect of snow loading and drifts on the roof prior to installation of the array.
- Site specific engineering is required if the system design exceeds the current capabilities of IronRidge's Design Assistant. Please contact technical support for additional assistance.
- IronRidge's technical support can be reached by the following:
  - Email: techsupport@ironridge.com
  - Phone: 800-227-9523 Ext. 1

Roof Section Ballast Plan Legend

Example Array



CHECKLIST

PRE-INSTALLATION

- ☐ Verify module compatibility. See Page 11 for info.

TOOLS REQUIRED

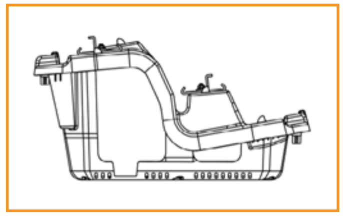
- ☐ Cordless Drill (optional)
- ☐ Torque Wrench (0-250 in-lbs)
- ☐ 9/16" Socket
- ☐ 7/16” Socket
- ☐ 1/2" Socket
- ☐ String Chalk Line

TORQUE VALUES

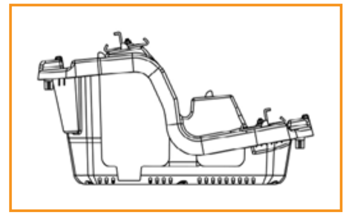
- ☐ Top Clamp Nuts (1/2” Socket): 120 in-lbs
- ☐ 5/16” MLPE Flange Bolts (1/2” Socket): 60 in-lbs
- ☐ 5/16” String Inverter Mount Bolts (1/2” Socket): 80 in-lbs
- ☐ 5/16” L-Foot to Chassis Nuts (1/2” Socket): 120 in-lbs
- ☐ 3/8” T-Bolt Bonding Hardware (7/16” Socket): 250 in-lbs
- ☐ 1/4” String Inverter Mount Hdw (7/16” Socket): 80 in-lbs
- ☐ Flat Roof Attach to L-Foot Hdw (9/16” Socket): 250 in-lbs
- ☐ Module Grounding Lug Nut (1/2” Socket): 60 in-lbs
  - ☐ Grounding Lug Terminal Screws (3/8” Socket): 20 in-lbs

➢ **Unless otherwise noted, all components have been evaluated for multiple use. They can be uninstalled and reinstalled in the same or new location.**

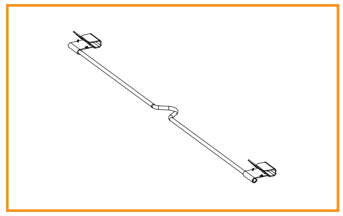
COMPONENTS



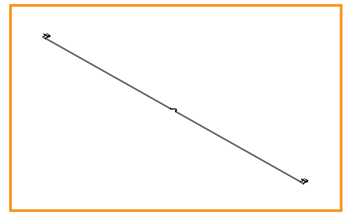
5° BX Chassis



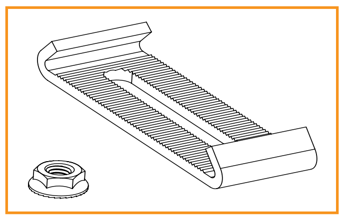
10° BX Chassis



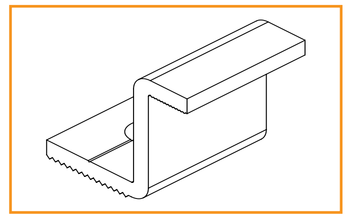
8" Module Bonding Jumper
Single Use Only



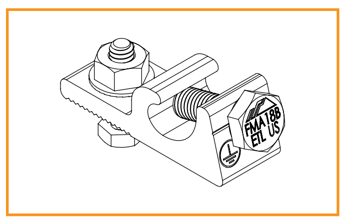
38" Row Bonding Jumper
Single Use Only



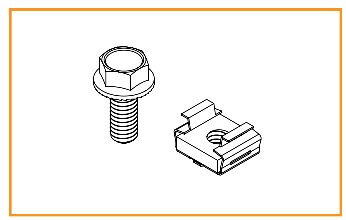
Bottom Clamp



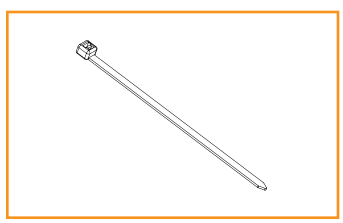
Top Clamp (Height Varies)



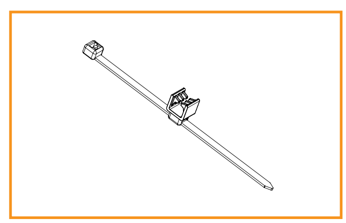
PV Module Grounding Lug



MLPE Mounting Hardware

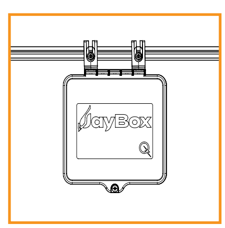


Cable Tie

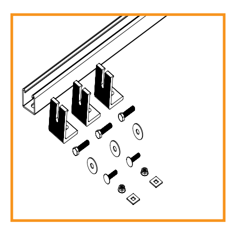


Edge Clip Cable Tie

String Inverter Mounting Kit



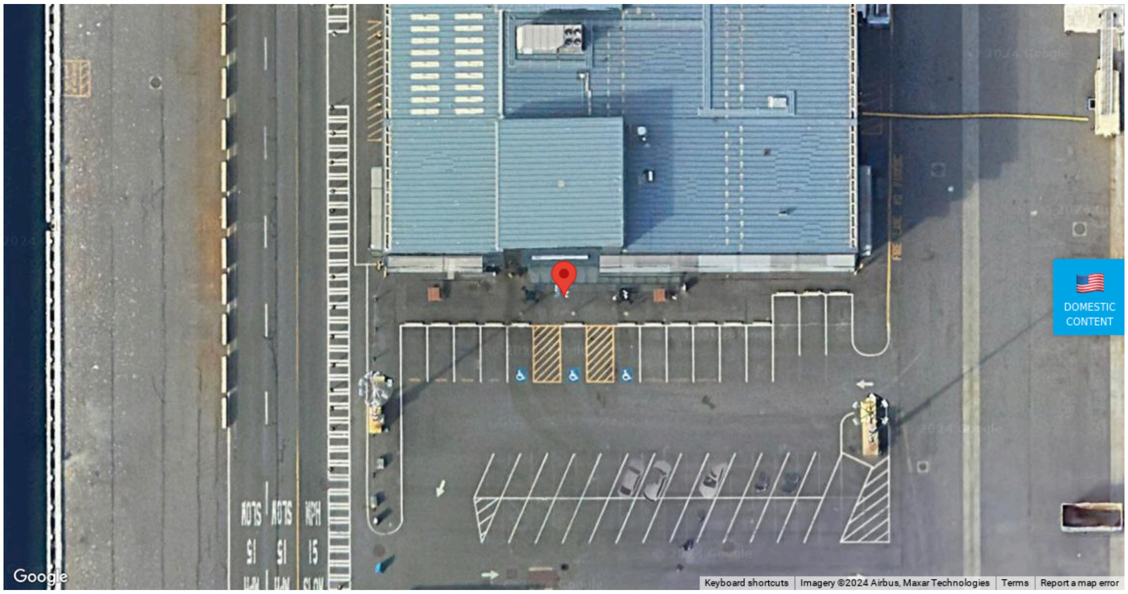
Jaybox



Flat Roof Attachment Kit

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Project Details			
Name	Smith Cover South Segment	**Date**	12/04/2024
Location	2001 West Garfield Street, Seattle, WA 98119	**Total modules**	172
Module	Silfab: SIL-490 HN (35mm)	**Total watts**	84,280
Dimensions	Dimensions: 89.09" x 40.83" x 1.38" (2263.0mm x 1037.0mm x 35.0mm)	**ASCE code**	7-16



Load Conditions			
Risk category	II	**Ground snow load**	20 psf
Wind speed	97 mph	**Wind exposure**	C

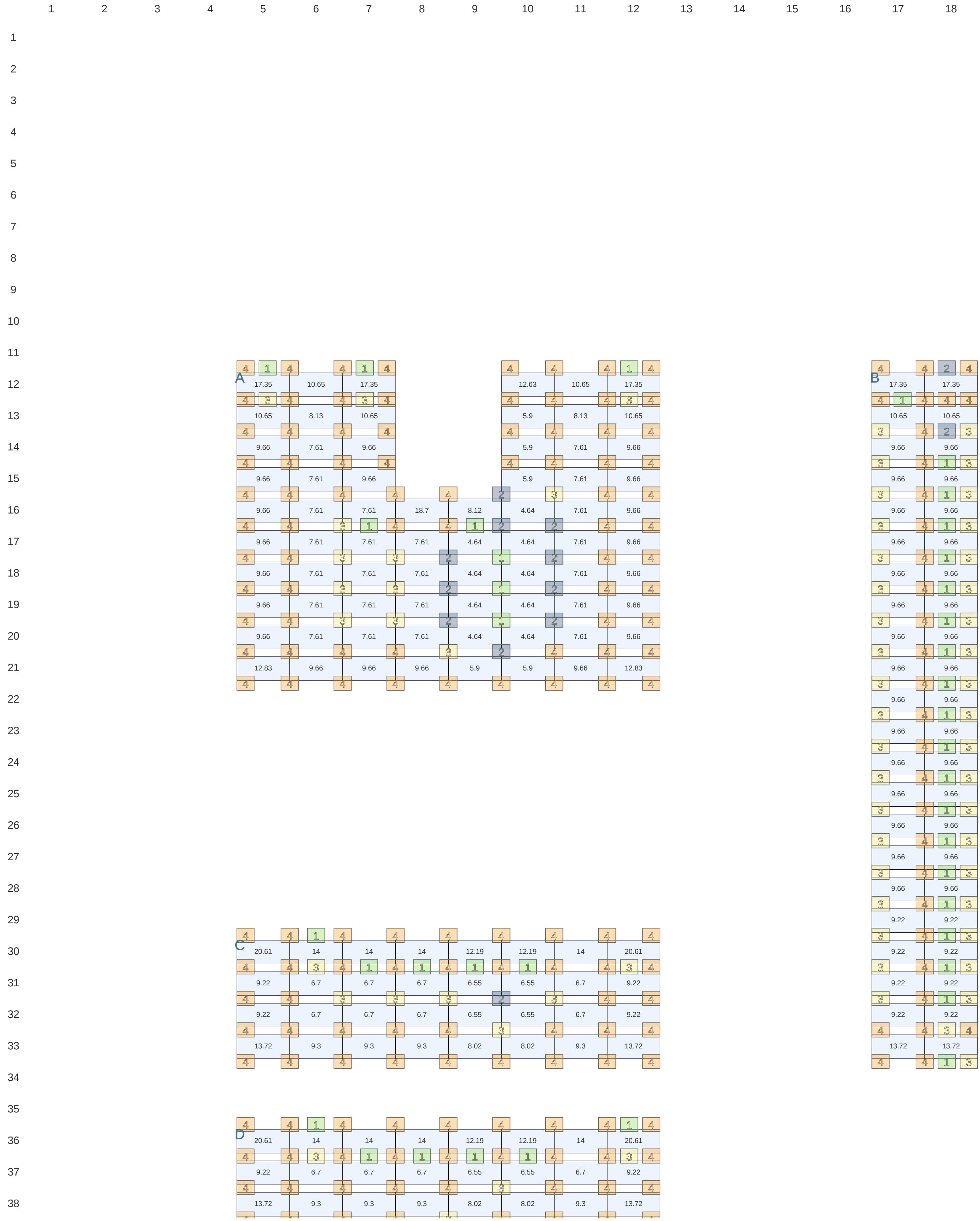
Building Information			
Height	40.0 ft	**Elevation**	11.0 ft
North-south	200.0 ft	**East-west**	150.0 ft
Roof slope	1 °	**Parapet height**	24.0 in
Fire setback	6.0 ft	**Parapet thickness**	8.0 in
Roof material	EPDM	**Roof manufacturer**	n/a
Color	n/a	**Thickness**	n/a

BX Parameters			
Tilt angle	10 °	**Seismic design**	Prescriptive Method
Block size	Full	**Block weight**	32.00 lbs
Spectral Acceleration (S_{DS})	1.109	**Seismic Design Category**	D
Calculations	Rectangular	**Setback**	6.7 ft
Ballast Relocation	Yes	**Supplemental Chasis**	Yes

Prescriptive Method Setbacks					
Between Arrays	1' 3.1"	**Array to Fixed Object**	2' 6.2"	**Array to Roof Edge**	2' 6.2"

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Panels: 172	Chassis: 292	Blocks: 962	Anchors: 0



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Last updated by Tom Bowen on 12/04/24 03:32 PM

39

40

41

** If any changes are made to panel placement or location relative to roof edges, the ballast plan must be recalculated.*

Sliding Group Information

Sliding group	Module count	Anchor count	Chassis count	Block count	Dead load	Area	PSF
A	72	0	103.00 (8 supplementals)	356.00	16,019.89	2,501.72	6.40
B	44	0	93.00 (24 supplementals)	268.00	11,562.87	1,483.55	7.79
C	32	0	52.00 (7 supplementals)	184.00	7,974.80	1,178.92	6.76
D	24	0	44.00 (8 supplementals)	154.00	6,517.64	914.22	7.13

Ballast and Anchors

Module count	**172**	Chassis count	**292 (47 supplemental)**	Block count	**962**
Wind Anchors	**0**	Seismic Anchors	**n/a**	Anchors needed	**0**
Block weight	**30,784.00 lbs**	Components weight	**11,291.20 lbs**	Total weight	**42,075.20 lbs**
Area	**6,078.41 sq. ft**			Ground Coverage Ratio	**0.71**
Avg dist dead load	**6.92 psf**			Max chassis weight (Incl. 1 Module)	**190.11 lbs**

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Bill of Materials

Part	Spares	Qty
BX Components		
BX-10D-P1 BX Chassis 10 deg	0	292
BX-TCL-35MM-M1 BX Top Clamp, 35mm, Mill	0	1004
BX-BCL-M1 BX Bottom Clamp w/ Hardware	0	1004
BX-RB38-M1 38" Row Bonding Jumper	0	39
PV-LUG-02-A1 PV Module Grounding Lug	0	4
BX-MB8-M1 8" Module Bonding Jumper	0	129
QMAFBU-A-25 Accessory Frame Bracket, Universal, Mill	0	86

Assumptions

The results produced by IronRidge's Design Assistant are only valid if all the following conditions are met and the design parameters were entered accurately.

Design Parameters

- Design Assistant ballast calculations assume rectangular buildings.
- Building must be less than 60ft high, or building height must be less than the least horizontal dimension.
- Roof is a single level (e.g. no penthouse that extends above roof for part of the area).
- Roof has sharp eaves.
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Component/System Properties

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    - Manufactured per ASTM C 1491 (Standard specification for concrete pavers).
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- E-W Module Gap: .375”
- Inter-Row Spacing:
    - 5 Degrees = 10”
    - 10 Degrees = 13”
- Chassis overhang:
    - 5 Degrees
        - North ~ 19" and South ~ 15.5"
    - 10 Degrees
        - North ~ 17" and South ~ 20.5"
- Coefficients of Static Friction under wet conditions for Tested Roof Types:
    - TPO = .69
    - KEE = .60
    - PVC = .60
    - Built Up = .50
    - Modified Bitumen = .50
    - EPDM = .73

Ratings/Certifications

- UL 2703 Listed (See installation manual for more details)
- Class A System Fire Rating Per UL 1703
- Designed and Certified for Compliance with the International Building Code, ASCE/SEI-7, and SEAOC PV Guidelines
- Wind Tunnel Testing by I.F.I
- User to verify module manufacturer's clamping location and pressure limits.

Additional Notes

- Installer must clean roof of all debris before installing BX chassis and/or slip sheets. It is recommended to blow off debris or loose roofing material from Modified Bitumen or Built Up roofs.
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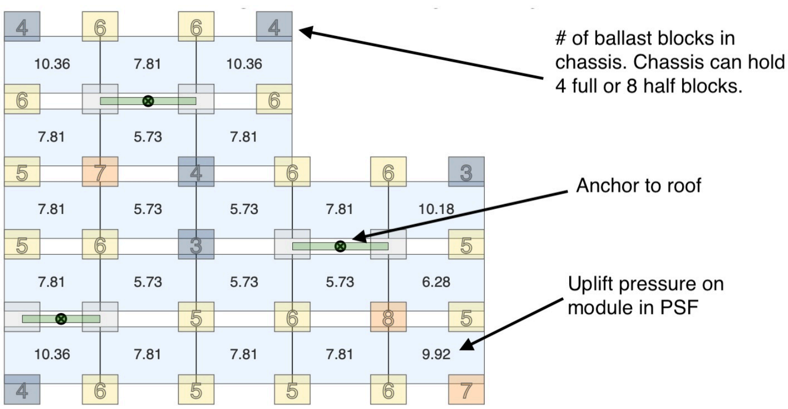
IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Roof Section Ballast Plan Legend

Example Array



CHECKLIST

PRE-INSTALLATION

- ☐ Verify module compatibility. See Page 11 for info.

TOOLS REQUIRED

- ☐ Cordless Drill (optional)
- ☐ Torque Wrench (0-250 in-lbs)
- ☐ 9/16" Socket
- ☐ 7/16” Socket
- ☐ 1/2" Socket
- ☐ String Chalk Line

TORQUE VALUES

- ☐ Top Clamp Nuts (1/2” Socket): 120 in-lbs
- ☐ 5/16” MLPE Flange Bolts (1/2” Socket): 60 in-lbs
- ☐ 5/16” String Inverter Mount Bolts (1/2” Socket): 80 in-lbs
- ☐ 5/16” L-Foot to Chassis Nuts (1/2” Socket): 120 in-lbs
- ☐ 3/8” T-Bolt Bonding Hardware (7/16” Socket): 250 in-lbs
- ☐ 1/4” String Inverter Mount Hdw (7/16” Socket): 80 in-lbs
- ☐ Flat Roof Attach to L-Foot Hdw (9/16” Socket): 250 in-lbs
- ☐ Module Grounding Lug Nut (1/2” Socket): 60 in-lbs
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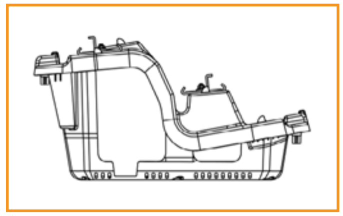
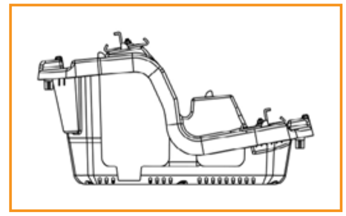
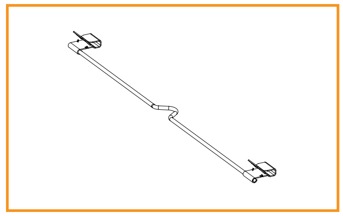
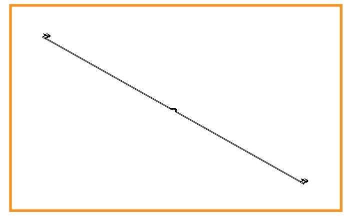
➢ **Unless otherwise noted, all components have been evaluated for multiple use. They can be uninstalled and reinstalled in the same or new location.**

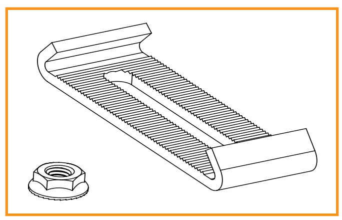
COMPONENTS

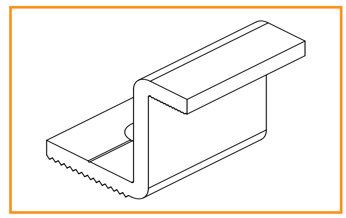

5° BX Chassis

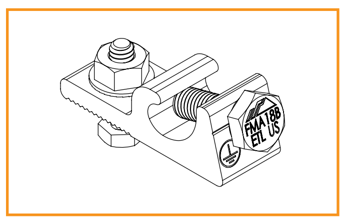

10° BX Chassis

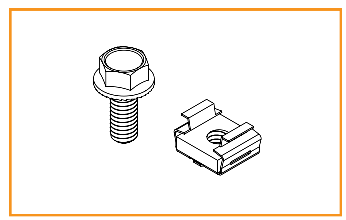

8" Module Bonding Jumper
Single Use Only

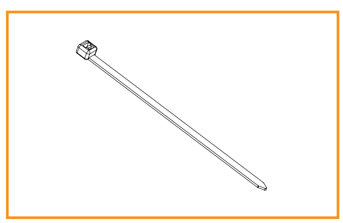

38" Row Bonding Jumper
Single Use Only

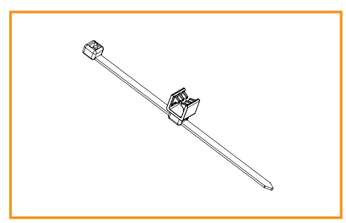

Bottom Clamp


Top Clamp (Height Varies)

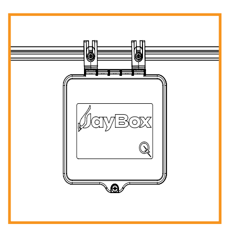

PV Module Grounding Lug


MLPE Mounting Hardware

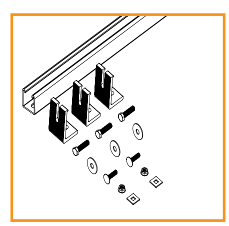

Cable Tie


Edge Clip Cable Tie


String Inverter Mounting Kit



Jaybox


Flat Roof Attachment Kit

SILFAB COMMERCIAL

SILFAB SOLAR®

SIL-490 HN

ENGINEERED FOR COMMERCIAL & UTILITY PROJECTS

Superior performance and proven reliability from a trusted source.

TOP PERFORMER 2023 PVEL PV MODULE RELIABILITY SCORECARD

SILFABSOLAR.COM

ELECTRICAL SPECIFICATIONS		490 HN	
Test Conditions		STC	NOCT
Module Power (Pmax)	Wp	490	362
Maximum power voltage (Vpmax)	V	45.23	41.61
Maximum power current (Ipmax)	A	10.83	8.69
Open circuit voltage (Voc)	V	53.96	49.64
Short circuit current (Isc)	A	11.36	9.12
Module efficiency	%	20.9%	19.3%
Maximum system voltage (VDC)	V	1500	
Series fuse rating	A	20	
Power Tolerance	Wp	0 to +10	

Measurement conditions: STC 1000 W/m² • AM 1.5 • Temperature 25 °C • NOCT 800 W/m² • AM 1.5 • Measurement uncertainty ≤ 3%
Sun simulator calibration reference modules from Fraunhofer Institute. Electrical characteristics may vary by ±5% and power by 0 to +10W.

MECHANICAL PROPERTIES / COMPONENTS	METRIC	IMPERIAL
Module weight	25.8kg ±0.2kg	56.9lbs ±0.4lbs
Dimensions (H x L x D)	2263 mm x 1037 mm x 35 mm	89 in x 40.8 in x 1.37 in
Maximum surface load (wind/snow)*	2400 Pa rear load / 5400 Pa front load	50.1 lb/ft² rear load / 112.8 lb/ft² front load
Hail impact resistance	ø 25 mm at 83 km/h	ø 1 in at 51.6 mph
Cells	156 Half cells - Si mono PERC 9 busbar - 83 x 166 mm	156 Half cells- Si mono PERC 9 busbar - 3.26 x 6.53 in
Glass	3.2 mm high transmittance, tempered, DSM antireflective coating	0.126 in high transmittance, tempered, DSM antireflective coating
Cables and connectors (refer to installation manual)	1350 mm, ø 5.7 mm, MC4 from Staubli	53.15 in, ø 0.22 in (12AWG), MC4 from Staubli
Backsheet	High durability, superior hydrolysis and UV resistance, multi-layer dielectric film, fluorine-free PV white backsheet	
Frame	Anodized Aluminum (Silver)	
Bypass diodes	3 diodes-30SQ045T (45V max DC blocking voltage, 30A max forward rectified current)	
Junction Box	UL 3730 Certified, IEC 62790 Certified, IP68 rated	

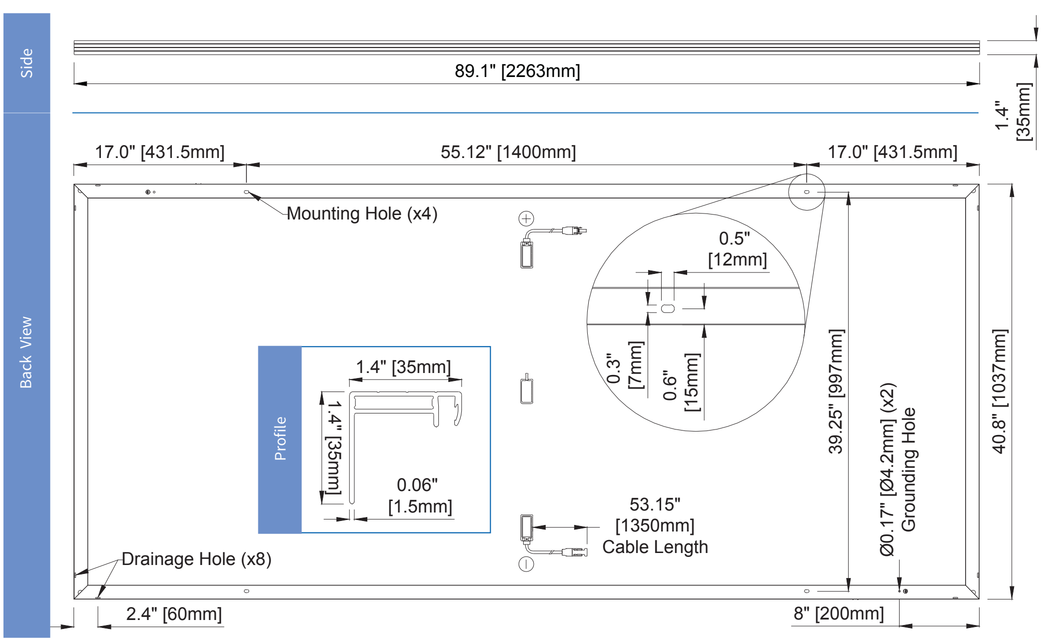
TEMPERATURE RATINGS	
Temperature Coefficient Isc	+0.064 %/°C
Temperature Coefficient Voc	-0.28 %/°C
Temperature Coefficient Pmax	-0.36 %/°C
NOCT (± 2°C)	45 °C
Operating temperature	-40/+85 °C

WARRANTIES	
Module product workmanship warranty	25 years**
Linear power performance guarantee	30 years
	≥ 97.1% end 1st yr ≥ 91.6% end 12th yr ≥ 85.1% end 25th yr ≥ 82.6% end 30th yr

CERTIFICATIONS	
Product	ULC ORD C1703, UL1703, CEC listed, UL 61215-1/-2, UL 61730-1/-2, IEC 61215-1/-2. IEC 61730-1/-2, CSA C22.2#61730-1/-2, IEC 62716 Ammonia Corrosion; IEC61701:2011 Salt Mist Corrosion Certifed, UL Fire Rating: Type 1
Factory	ISO9001:2015

SHIPPING SPECS	
Modules Per Pallet:	31
Pallets Per Truck	23
Modules Per Truck	713

* ⚠ Warning. Read the Safety and Installation Manual for mounting specifications and before handling, installing and operating modules.
** 12 year extendable to 25 years subject to registration and conditions outlined under "Warranty" at silfabsolar.com
PAN files generated from 3rd party performance data are available for download at: silfabsolar.com/downloads



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Silfab - SIL-490-HN+-20231221

INVERTER

Three Phase Inverter with Synergy Technology

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

Powered by unique pre-commissioning process for rapid system installation

- Pre-commissioning feature for automated validation of system components and wiring during the site installation process and prior to grid connection
- Easy 2-person installation with lightweight, modular design (each inverter consists of 2 or 3 Synergy units and 1 Synergy Manager)
- Independent operation of each Synergy unit enables higher uptime and easy serviceability
- Built-in thermal sensors detect faulty wiring, ensuring enhanced protection and safety
- Built-in arc fault protection and rapid shutdown
- Built-in PID mitigation for maximized system performance
- Monitored* and field-replaceable surge protection devices, to better withstand surges caused by lightning or other events
- Built-in module-level monitoring with Ethernet or cellular communication for full system visibility

*Applicable only for DC and AC SPDs

/ Three Phase Inverter with Synergy Technology

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

MODEL NUMBER	SE80KUS	SE100KUS	SE110KUS	SE120KUS	
APPLICABLE TO INVERTERS WITH PART NUMBER	SExxK-USx8Ixxxx				UNITS
OUTPUT					
Rated AC Active Output Power	80000	100000	110000	120000	W
Maximum AC Apparent Output Power	80000	100000	120000	120000	VA
AC Output Line Connections	3W + PE, 4W + PE				
Supported Grids	WYE: TN-C, TN-S, TN-C-S, TT, IT; Delta: IT				
AC Output Voltage Minimum-Nominal-Maximum(1) (L-N)	244 – 277 – 305				Vac
AC Output Voltage Minimum-Nominal-Maximum(1) (L-L)	422.5 – 480 – 529				Vac
AC Frequency Min-Nom-Max(1)	59.5 – 60 – 60.5				Hz
Maximum Continuous Output Current (per Phase, PF=1)	96.5	120	144.3		Aac
GFDI Threshold	1				A
Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds	Yes				
Total Harmonic Distortion	≤ 3				%
Power Factor Range	±0.85 to 1				
INPUT					
Maximum DC Power (Module STC) Inverter / Synergy Unit	140000 / 70000	175000 / 58300	210000 / 70000		W
Transformer-less, Ungrounded	Yes				
Maximum Input Voltage DC+ to DC-	1000				Vdc
Operating Voltage Range	850 – 1000				Vdc
Maximum Input Current	2 x 48.25	3 x 40	3 x 48.25		Adc
Reverse-Polarity Protection	Yes				
Ground-Fault Isolation Detection	167kΩ sensitivity per Synergy Unit(2)				
CEC Weighted Efficiency	98.5				%
Nighttime Power Consumption	< 8	< 12			W
ADDITIONAL FEATURES					
Supported Communication Interfaces(3)	2 x RS485, Ethernet, Wi-Fi (optional), Cellular (optional)				
Smart Energy Management	Export Limitation				
Inverter Commissioning	With the SetApp mobile application using built-in Wi-Fi access point for local connection				
Arc Fault Protection	Built-in, User Configurable (According to UL1699B)				
Photovoltaic Rapid Shutdown System	NEC 2014 – 2023, built-in				
PID Rectifier	Nighttime, built-in				
RS485 Surge Protection (ports 1+2)	Type II, field replaceable, integrated				
AC, DC Surge Protection	Type II, field replaceable, integrated				
DC Fuses (Single Pole)	25A, integrated				
DC SAFETY SWITCH					
DC Disconnect	Built-in				
STANDARD COMPLIANCE					
Safety	UL1699B, UL1741, UL1741 SA, UL1741 SB, UL1998, CSA C22.2#107.1, Canadian AFCI according to T.I.L. M-07				
Grid Connection Standards	IEEE 1547-2018, Rule 21, Rule 14 (HI)				
Emissions	FCC part 15 class A				

(1) For other regional settings please contact SolarEdge support.
(2) Where permitted by local regulations.
(3) For specifications of the optional communication options, visit the Communication product page or the Knowledge Center to download the relevant product datasheet.

Three Phase Inverter with Synergy Technology

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

MODEL NUMBER		SE80KUS	SE100KUS	SE110KUS	SE120KUS	UNITS
APPLICABLE TO INVERTERS WITH PART NUMBER		SExxK-USx8Ixxxx				
INSTALLATION SPECIFICATIONS						
Number of Synergy Units per Inverter		2	3			
Ac Max Conduit Size		2 ½"				in
Max AWG Line / PE		4/0 / 1/0				
DC Max Conduit Size		1 x 3"; 2 x 2"				in
DC Input Inverter/ Synergy Unit	Multi-input (SExxK-USxxxxxZ4)	8 / 4 pairs; 6-12 AWG	12 / 4 pairs; 6-12 AWG			
	Combined input (SExxK-USxxxxxW4)	2 pairs / 1 pair, Max 2 AWG; copper or aluminum	3 pairs / 1 pair, Max 2 AWG; copper or aluminum			
Dimensions (H x W x D)		Synergy Unit: 22 x 12.9 x 10.75 / 558 x 328 x 273 Synergy Manager: 14.17 x 22.4 x 11.6 / 360 x 560 x 295				in / mm
Weight		Synergy Unit: 70.4 / 32 Synergy Manager: 39.6 / 18				lb / kg
Operating Temperature Range		-40 to +140 / -40 to +60[4]				˚F / ˚C
Cooling		Fan (user replaceable)				
Noise		< 67				dBA
Protection Rating		NEMA 3R				
Mounting		Brackets provided				

(4) For power de-rating information refer to the Temperature Derating Technical Note for North America

SolarEdge is a global leader in smart energy technology. By leveraging world-class engineering capabilities and with a relentless focus on innovation, SolarEdge creates smart energy solutions that power our lives and drive future progress.

SolarEdge developed an intelligent inverter solution that changed the way power is harvested and managed in photovoltaic (PV) systems. The SolarEdge DC optimized inverter maximizes power generation while lowering the cost of energy produced by the PV system.

Continuing to advance smart energy, SolarEdge addresses a broad range of energy market segments through its PV, storage, EV charging, UPS, and grid services solutions.

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solaredge.com

Cautionary Note Regarding Market Data and Industry Forecasts: This brochure may contain market data and industry forecasts from certain third-party sources. This information is based on industry surveys and the preparer's expertise in the industry and there can be no assurance that any such market data is accurate or that any such industry forecasts will be achieved. Although we have not independently verified the accuracy of such market data and industry forecasts, we believe that the market data is reliable and that the industry forecasts are reasonable.

Power Optimizer

P605 / P650 / P701 / P730 / P800p / P801 / P850 / P950 / P1100

25 YEAR WARRANTY

POWER OPTIMIZER

PV power optimization at the module level

The most cost-effective solution for commercial and large field installations

- Specifically designed to work with SolarEdge inverters
- High efficiency with module-level MPPT, for maximized system energy production and revenue, and fast project ROI
- Superior efficiency (99.5%)
- Balance of System cost reduction; 50% less cables, fuses, and combiner boxes, and over 2x longer string lengths possible
- Fast installation with a single bolt
- Advanced maintenance with module level monitoring
- Module level voltage shutdown for installer and firefighter safety
- Use with two PV modules connected in series or in parallel

/ Power Optimizer

P605 / P650 / P701 / P730 / P801

Power Optimizer Module (Typical Module Compatibility)	P605 (for 1 x high power PV module)	P650 (for up to 2 x 60-cell PV modules)	P701 (for up to 2 x 60/120-cell PV modules)	P730 (for up to 2 x 72-cell PV modules)	P801 (for up to 2 x 72/144 cell PV modules)	
INPUT						
Rated Input DC Power(1)	605	650	700*	730**	800	W
Connection Method	Single input for series connected modules					
Absolute Maximum Input Voltage (Voc at lowest temperature)	65	96		125		Vdc
MPPT Operating Range	12.5 – 65	12.5 – 80		12.5 – 105		Vdc
Maximum Short Circuit Current per Input (Isc)	14.1	11	11.75	11**	12.5***	Adc
Maximum Efficiency	99.5					%
Weighted Efficiency	98.6					%
Overvoltage Capacity	II					
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER						
Maximum Output Current	15					Adc
Maximum Output Voltage	80					Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM SOLAREDGE INVERTER OR SOLAREDGE INVERTER OFF						
Safety Output Voltage per Power Optimizer	1 ± 0.1					Vdc
STANDARD COMPLIANCE						
EMC	FCC Part 15 Class B, IEC61000-6-2, IEC61000-6-3					
Safety	IEC62109-1 (class II safety)					
RoHS	Yes					
Fire Safety	VDE-AR-E2100-712:2013-05					
INSTALLATION SPECIFICATIONS						
Compatible SolarEdge Inverters	Three Phase Inverter SE16K & larger					
Maximum Allowed System Voltage	1000					Vdc
Dimensions (W x L x H)	129 x 153 x 52 / 5.1 x 6 x 2	129 x 153 x 42.5 / 5.1 x 6 x 1.7		129 x 153 x 49.5 / 5.1 x 6 x 1.9		mm / in
Weight	1064 / 2.3	834 / 1.8		933 / 2.1		gr / lb
Input Connector	MC4(2)					
Input Wire Length	0.16 / 0.52			0.16 / 0.52, 0.9 / 2.95(3)		m / ft
Output Connector	MC4					
Output Wire Length	Portrait Orientation: 1.4 / 4.5	Portrait Orientation: 1.2 / 3.9	-	Portrait Orientation: 1.2 / 3.9		m / ft
	-	Landscape Orientation: 1.8 / 5.9		Landscape Orientation: 2.2 / 7.2		
Operating Temperature Range(6)	-40 to +85 / -40 to +185					ºC / ºF
Protection Rating	IP68 / NEMA6P					
Relative Humidity	0 – 100					%

* For P701 models manufactured after work week 06/2020, the rated DC input is 740W.
** For P730 models manufactured after work week 06/2020, the rated DC input is 760W and the maximum Isc per input is 11.75A.
*** For P801 models manufactured in work week 40/2020 or earlier, the maximum Isc per input in 11.75A.
(1) The rated power of the module at STC will not exceed the Power Optimizer "Rated Input DC Power". Modules with up to +5% power tolerance are allowed.
(2) For other connector types, please contact SolarEdge.
(3) Longer input wire lengths are available for use with split junction box modules. For 0.9m/2.95ft order P730-xxxLxxx.
(4) For ambient temperatures above +70ºC / +158ºF, power de-rating is applied. Refer to Power Optimizers Temperature De-Rating Technical Note for more details.

PV System Design Using a SolarEdge Inverter(5)(6)(7)(8)		230/400V Grid SE16K, SE17 SE25K*, SE33.3K*		230/400V Grid SE27.6K*		230/400V Grid SE30K*		277/480V Grid SE33.3K*, SE40K*		
Compatible Power Optimizers		P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	
Minimum String Length	Power Optimizers	14	14	14	14	15	15	14	14	
	PV Modules	14	27	14	27	15	29	14	27	
Maximum String Length	Power Optimizers	30	30	30	30	30	30	30	30	
	PV Modules	30	60	30	60	30	60	30	60	
Maximum Continuous Power per String		11250		11625		12750		12750		W
Maximum Allowed Connected Power per String(8) (Permitted only when the difference in connected power between strings is 2,000W or less)		13500		13500		15000		15000		W
Parallel Strings of Different Lengths or Orientations		Yes								
Maximum Difference in Number of Power Optimizers Allowed Between the Shortest and Longest String Connected to the Same Inverter Unit		5 Power Optimizers								

* The same rules apply for Synergy units of equivalent power ratings that are part of the modular Synergy Technology Inverter.
(5) P650/P701/P730/P801 can be mixed in one string only with P650/P701/P730/P801. P605 cannot be mixed with any other Power Optimizer in the same string.
(6) For each string, a Power Optimizer may be connected to a single PV module if 1) each Power Optimizer is connected to a single PV module or 2) it is the only Power Optimizer connected to a single PV module in the string.
(7) For SE16K and above, the minimum STC DC connected power should be 11KW.
(8) To connect more STC power per string, design your project using SolarEdge Designer.

/ Power Optimizer

P800p / P850 / P950 / P1100

Power Optimizer Module (Typical Module Compatibility)	P800p (for up to 2 x 96-cell 5'' PV modules)	P850 (for up to 2 x high power or bi-facial modules)	P950 (for up to 2 x high power or bi-facial modules)	P1100 (for up to 2 x high power or bi-facial modules)	Unit
INPUT					
Rated Input DC Power(1)	800	850	950	1100	W
Connection Method	Dual input for independently connected	Single input for series connected modules			
Absolute Maximum Input Voltage (Voc at lowest temperature)	83	125			Vdc
MPPT Operating Range	12.5 – 83	12.5 – 105			Vdc
Maximum Short Circuit Current per Input (Isc)	7	14.1*		14.1	Adc
Maximum Efficiency	99.5				%
Weighted Efficiency	98.6				%
Overvoltage Capacity	II				
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER					
Maximum Output Current	18				Adc
Maximum Output Voltage	80				Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM SOLAREDGE INVERTER OR SOLAREDGE INVERTER OFF					
Safety Output Voltage per Power Optimizer	1 ± 0.1				Vdc
STANDARD COMPLIANCE					
EMC	FCC Part 15 Class B, IEC61000-6-2, IEC61000-6-3				
Safety	IEC62109-1 (class II safety)				
RoHS	Yes				
Fire Safety	VDE-AR-E2100-712:2013-05				
INSTALLATION SPECIFICATIONS					
Compatible SolarEdge Inverters	Three Phase Inverter SE16K & larger			Three Phase Inverter SE25K & larger	
Maximum Allowed System Voltage	1000				Vdc
Dimensions (W x L x H)	129 x 168 x 59 / 5.1 x 6.61 x 2.32	129 x 162 x 59 / 5.1 x 6.4 x 2.32			mm / in
Weight	1064 / 2.3				gr / lb
Input Connector	MC4(2)				
Input Wire Length	0.16 / 0.52	0.16 / 0.52, 0.9 / 2.95, 1.3 / 4.26, 1.6 / 5.24(3)	0.16 / 0.52, 1.3 / 4.26, 1.6 / 5.24(3)	0.16 / 0.52, 1.3 / 4.26(3)	m / ft
Output Connector	MC4				
Output Wire Length	Portrait Orientation: 1.2 / 3.9 Landscape Orientation: 1.8 / 5.9	Landscape Orientation: 2.2 / 7.2		2.4 / 7.8	m / ft
Operating Temperature Range(4)	-40 to +85 / -40 to +185				ºC / ºF
Protection Rating	IP68 / NEMA6P				
Relative Humidity	0 – 100				%

* For P850/P950 models manufactured in work week 06/2020 or earlier, the maximum Isc per input is 12.5A. The manufacture code is indicated in the Power Optimizer's serial number.
Example: S/N SJ0620A-xxxxxxxx (work week 06 in 2020)
(1) The rated power of the module at STC will not exceed the Power Optimizer "Rated Input DC Power". Modules with up to +5% power tolerance are allowed.
(2) For other connector types, please contact SolarEdge.
(3) Longer input wire lengths are available for use with split junction box modules.
For 0.9m/2.95ft order P801/P850-xxxLxxx. For 1.3m/2.95ft order P850/P950/P1100 -xxxXxxx. For 1.6m/5.24ft order P850/P950-xxxYxxx).
(4) For ambient temperatures above +70ºC / +158ºF, power de-rating is applied. Refer to Power Optimizers Temperature De-Rating Technical Note for more details.

PV System Design Using a SolarEdge Inverter(5)(6)(7)(8)		230/400V Grid SE16K, SE17K	230/400V Grid SE25K*	230/400V Grid SE27.6K*	230/400V Grid SE30K*	230/400V Grid SE33.3K	277/480V Grid SE33.3K*, SE40K*	
Compatible Power Optimizers		P800p, P850, P950	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	
Minimum String Length	Power Optimizers	14	14	14	15	14	14	
	PV Modules	27	27	27	29	27	27	
Maximum String Length	Power Optimizers	30	30	30	30	30	30	
	PV Modules	60	60	60	60	60	60	
Maximum Continuous Power per String		13500	13500	13950	15300	13500	15300	W
Maximum Allowed Connected Power per String(8) (Permitted only when the difference in connected power between strings is 2,000W or less)		1 string – 15750	1 string – 15750	1 string – 16200	1 string – 17550	2 strings or less – 15750	2 strings or less – 17550	W
		2 strings or more – 18500	2 strings or more – 18500	2 strings or more – 18950	2 strings or more – 20300	3 strings or more – 18500	3 strings or more – 20300	
Parallel Strings of Different Lengths or Orientations		Yes						
Maximum Difference in Number of Power Optimizers Allowed Between the Shortest and Longest String Connected to the Same Inverter Unit		5 Power Optimizers						

* The same rules apply for Synergy units of equivalent power ratings that are part of the modular Synergy Technology Inverter.
(5) P800p/P850/P950/P1100 can be mixed in one string only with P800p/P850/P950/P1100.
(6) For each string, a Power Optimizer may be connected to a single PV module if 1) each Power Optimizer is connected to a single PV module or 2) it is the only Power Optimizer connected to a single PV module in the string.
(7) For SE16K and above, the minimum STC DC connected power should be 11KW.
(8) To connect more STC power per string, design your project using SolarEdge Designer.

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CE

US Made

IRONRIDGE

Accelerate Solar with Domestic Content

IronRidge offers racking systems that use 100% domestically-produced components. Our products made in the United States include: XR10 Rails, XR100 Rails, HUG Roof Attachment, Comp Shingle Flashing, and the BX Ballasted System.

To meet the qualifying criteria for tax credit incentives, solar projects must use a combination of modules, MLPE and racking with a minimum aggregate threshold of 40% Domestic Content.

Pathway to 40+

NO NEED TO SETTLE

Pick reputable products that your crews like installing. Our offerings are listed to UL 2703 and UL 3741, tested rigorously, and manufactured to the highest quality standards.

DO YOUR HOMEWORK

Are you a financier or work with one? Understand terms and definitions. Obtain letters from the manufacturer documenting their position to share with your tax and legal counsel.

STACK MANUFACTURERS

Our partnerships with the leading inverter manufacturers allow multiple avenues for you to reach 40% in 2024 and 45% in 2025. See next page for the current list of domestic content.

Avoid the Pitfalls

READ THE FINE PRINT

Ensure you qualify. Only finance companies offering third-party-owned systems are eligible, not installation companies or homeowners. Consult a legal professional for guidance.

BE FULLY PREPARED

Audits by Financiers, Commercial Project Owners, and the IRS are serious business. Ensure that your manufacturing partners can help you navigate any potential oversight.

STAY IN THE KNOW

New information is coming out regularly. We promise to keep our customers posted. Scan the QR code below to visit our page dedicated to Domestic Content details.

Scan the QR code to visit our page dedicated to Domestic Content: IronRidge.com/DC

IronRidge does not provides tax, legal or accounting advice. This material has been prepared for informational purposes only and is not intended to be relied upon in place of professional advice. You should consult your own advisors before engaging in any transaction.

Pathways to 40-45% Domestic Content

ENPHASE

MICROINVERTERS

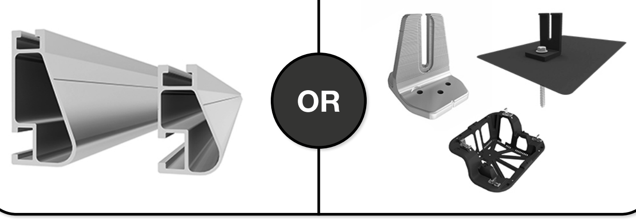
solaredge

INVERTERS & OPTIMIZERS

TESLA

POWERWALL & INVERTER

RAILS OR FASTENERS



RAILS AND FASTENERS

Not all domestic products shown.

Residential Products

Maker	Type	Part Number
Enphase	Inverters	**IQ8HC-72-M-DOM-US** **IQ8X-80-M-DOM-US** **IQ8HC-72-M-US**
SolarEdge	Inverters	**SE3800H-USMNUBL75** **SE5700H-USMNUBL75** **SE7600H-USMNUBL75** **SE10000H-USMNUBL75** **SE11400H-USMNUBL75** **USE3800H-USMNUBL75** **USE5700H-USMNUBL75** **USE7600H-USMNUBL75** **USE10000H-USMNUBL75** **USE11400H-USMNUBL75**
	Optimizers	**U650-1GM4MRMU**
Tesla	Inverters	**1538000-45-X**
IronRidge	Rails	**XR-10-168M-US** **XR-10-168B-US** **XR-100-168M-US** **XR-100-168B-US**
	Fasteners	**LFT-FLSH03-B1-US** **FLSH-01-B1-US** **QM-HUG-01-M1-US** **QM-HUG-01-B1-US**

Commercial Products

Maker	Type	Part Number
Enphase	Inverters	**IQ8P-3P-72-DOM-US**
SolarEdge	3-Phase Inverters	**USE-SIN-USR0IBNx6**
	Synergy Managers	**SE-DBL-US00IBNx6** **SE-TRI-US00IBNx6**
	Synergy Units	**USESUK-USR0INNN6**
	Optimizer	**C651U-1GMVMRRU** **C652U-1GMVMRRU**
IronRidge	Rails & Fasteners	**Same As Residential**
	BX Ballasted System	**BX-5D-P1** **BX-10D-P1** **BX-TCL-30MM-M1** **BX-TCL-32MM-M1** **BX-TCL-35MM-M1** **BX-TCL-38MM-M1** **BX-TCL-40MM-M1** **BX-TCL-40MM-M1** **BX-TCL-46MM-M1**

IRONRIDGE

BX System

Uniquely shaped for flat roofs.

IronRidge BX delivers superior power density and design flexibility to flat roof solar arrays. Made of a glass-reinforced composite, the BX Chassis is engineered for extreme structural loading, yet is also shaped to be roof-friendly and easy to install.

Certified BX plan sets can be obtained instantly through an online Design Assistant or by contacting IronRidge Commercial Services.

Glass-Reinforced Composite

Corrosion-free and engineered for long-term structural performance.

Commercial Services

Engineering support to optimize system design.

Class A Fire Rating

Certified to maintain the fire resistance rating of the existing roof.

Design Assistant

Online software makes it simple to create, share, and price projects.

UL 2703 & 3741 Listed

Entire system and components meet the latest UL safety standards.

25-Year Warranty

Products guaranteed to be free of impairing defects.

Chassis

5° Chassis

Ballasted mounting for 5 degree tilt angle.

- Max load spreading design
- Fully encloses ballast
- 360 degree drainage

10° Chassis

Ballasted mounting for 10 degree tilt angle.

- Max load spreading design
- Fully encloses ballast
- 360 degree drainage

Top Clamp

Combines with Bottom Clamp for top-bottom module grip.

- Secures above module
- One-tool attachment
- Mill aluminum 6000 series

Bottom Clamp

Combines with Top Clamp to up structural connection.

- Secures below module
- One-tool attachment
- Mill aluminum 6000 series

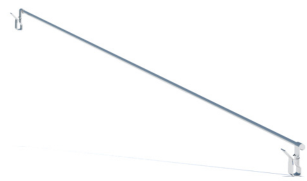
Grounding

8" Mod Bonding Jumper

Bond adjacent modules in the array.

- Press-on installation
- Tin-plate copper wire
- Factory crimped connection

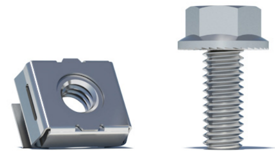
38" Row Bonding Jumper



Complete row-to-row bonding in the array.

- Press-on installation
- Tin-plate copper wire
- Factory crimped connection

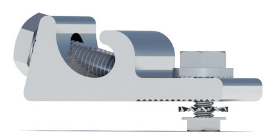
MLPE Mounting Hardware



Optional mounting hardware for MLPE devices.

- Cap screw and cage nut
- 5/16" socket install
- Stainless steel 300 series

PV Mod Grounding Lug



Connect arrays to equipment ground.

- Low profile
- Mounts to module frame
- One per continuous array

Accessories

Accessory Frame Bracket

Mount MLPE devices directly to module frame.

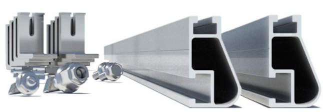
- Fits any module frame
- Mill aluminum finish
- UL 2703 listed

Cable & Edge Ties

Complete wire management with weatherproof ties.

- 12" length, bundles of 100
- UV stabilized polyamide
- Black finish

String Inverter Mount Kit



Create mounting platform for inverters.

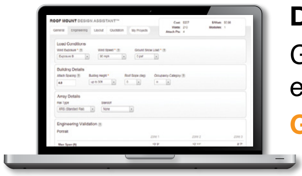
- Chassis, XR10 rail, hdw
- Up to 4' inverter base
- Raises inverter off deck

Flat Roof Attachment Kit

Add anchors to ballasted system.

- Includes hardware
- For ballast-attached hybrid
- Uses locally-sourced strut

Resources



Design Assistant

Go from rough layout to fully engineered system in minutes.

Go to IronRidge.com

Chassis Display #7 Recycle Label

Like most glass-filled nylons, it is 100% recyclable—usually living on in furniture.

Find more info at epa.gov/recycle

IRONRIDGE

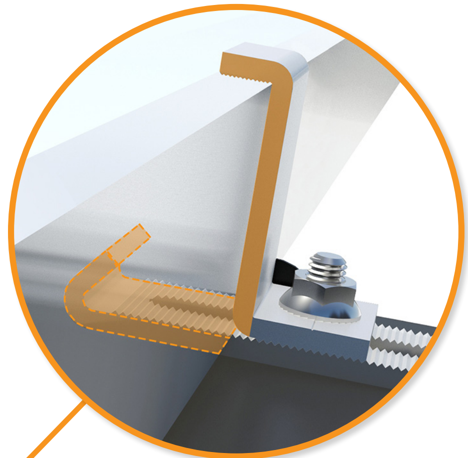
BX Chassis

Strong, Light, and Ready for Anything

The IronRidge BX System is designed to meet the needs of commercial solar—navigating complex roof layouts, while also handling the most extreme environmental conditions.

At the core of BX is the Chassis, a ballasted mount made of BASF Ultramid polyamides. They are exceptional for their high mechanical strength, rigidity and thermal stability (also being 100% recyclable).

Moreover, Ultramid polyamides afford good impact resistance even at low temperatures as well as UV protections for long life. Chassis come in 5° and 10° options and are backed by IronRidge's 25-year warranty.



Top & Bottom Clamp

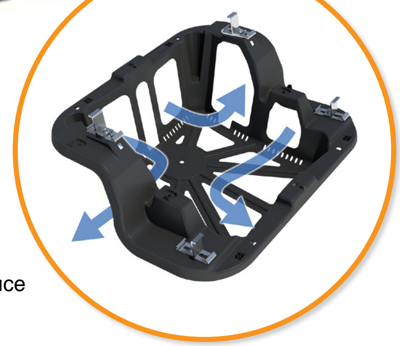
The multi-directional grip on the module from above and below ensures a strong connection regardless of force direction.

360° Reinforcement

A flange around the entire perimeter helps to reinforce and stiffen the Chassis in all directions—alongside wide bends to reduce point loading and braced corners to increase rigidity.

Roof-Friendly Design

Wide base spreads weight and reduces point pressure, while openings along the bottom and corners prevent pooling and reduce ballast weathering.



Inter-Row Spacing & Edge Clearances

5° Chassis

10° Chassis

With 10-13” inter-row spacing, BX provides an **8-10% increase** in power density compared with other ballasted systems—that’s a **capacity increase of 20%** in a typical 50kW system. The BX Chassis geometry also offers more than 5” of clearance in the 10-degree configuration and 8” in the 5-degree configuration, enabling the system to avoid drain domes, roof saddles, and conduit supports.

Flat Roof Attachment Anchors

BX Systems can be fully ballasted, fully anchored, or a hybrid optimized for the site.

Combine BX with an IronRidge Flat Roof Attachment Kit to eliminate hundreds of pounds of required ballast weight and achieve configurations as light as 3 PSF.

The placement and fastening method can be optimized for existing roof structures, and pre-approved membranes are offered to maintain membrane roof warranties.

Roof anchors not expected for Smith Cove

Testing & Certification

Design Assistant

Automated design software provides an accurate bill of materials, using a simple drag-and-draw interface to generate a complete system plan—also generate a ballast map showing the required ballast for each Chassis.

Permit Documentation

Design Assistant project reports are backed with a ASCE/PE stamp and Commercial Services are also available to assist with more complex projects. Visit our website or contact an IronRidge sales represenative.

UL 2703 & 3741 Listed

BX conforms to the latest UL safety standards for PV systems, including mechanical, bonding, hazard control, and Class A Fire Ratings (without wind deflectors). Ninety percent of solar modules are fully supported.

Cost Estimate - T91-Smith Cove Cruise Terminal (303.8 kW-DC)

Item	Unit Cost	Qty	Cost with Markup	$/Watt	Source
PV Modules (Sil-490 HN)	$ 404	620	$ 288,052	$ 0.95	Online price with 15% shipping and contractor markup
PV Racking (IronRidge 10degree BX Racking)	$ 111,532	1	$ 128,262	$ 0.42	MSRP with 15% shipping and contractor markup
SolarEdge P1100 Optimizers	$ 121	320	$ 44,528	$ 0.15	Online price with 15% shipping and contractor markup
SolarEdge SE80KUS Inverter (2x secondary units, 1x primary unit)	$ 4,531	3	$ 15,632	$ 0.05	Online price with 15% shipping and contractor markup
Sub-Total Material Costs			**$ 476,474**	**$ 1.57**	
Item	**Unit Cost**	**Qty**	**Cost**	**$/Watt**	
BOS (Conduit, cable, plumbing, etc.)	15%	-	$ 71,471	$ 0.24	Percentage of material costs based on project scope and complexity
Site Work (Trenching, pads, fence, sidewalk restoration, etc.)	$ 15,000	1	$ 15,000	$ 0.05	Allowance based on project scope
Total Direct Costs			**$ 562,945**	**$ 1.85**	
Contractor Design, Engineering, Permitting	8%	-	$ 38,118	$ 0.13	Typical as percentage of material costs
Contractor PM	10%	-	$ 47,647	$ 0.16	Typical as percentage of material costs
Contractor Labor	20%	-	$ 95,295	$ 0.31	Typical as percentage of material costs, prevailing wage for ITC credits
Sales Tax (Battery Equipment Only)	10.3%	-	$ -	$ -	City of Seattle Sales Tax Inclusive of state rate
Sub-Total			**$ 744,005**	**$ 2.45**	
Contingency	10%	-	$ 74,401		Typical as percentage of subtotal construction costs
Sub-Total			**818,406**	**$ 2.69**	
Escalation to midpoint of 2025	2.0%	-	**16,368**		
Total Construction Costs			**834,774**	**$ 2.75**	
Port of Seattle - Maritime Overhead Premium	25.1%	-	$ 209,528		Overhead rate provided by Port Staff
Total Project Costs			**$ 1,044,302**	**$ 3.44**	
System Size (W-DC)			**303,800**	**Watts**	

Appendix D
Shilshole A-1 Documents

A-1 Admin update final POS Solar - Shilshole Bay, shilshole marina

Report

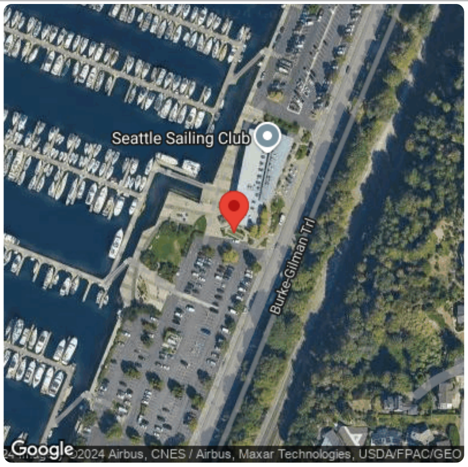
Project Name	POS Solar - Shilshole Bay
Project Address	shilshole marina
Prepared By	Sazan Group ses-marketing@sazan.com

SÄZÄN GROUP

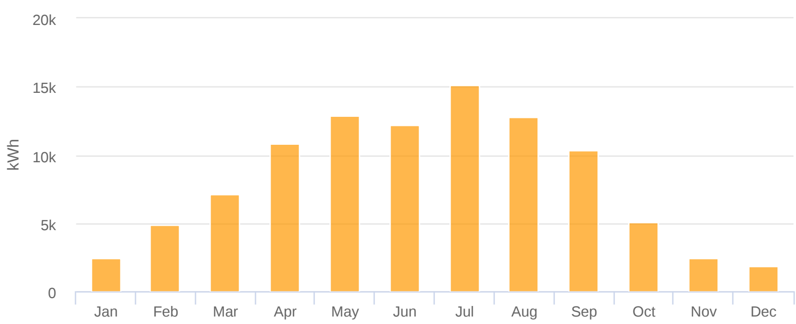
System Metrics

Design	A-1 Admin update final
Module DC Nameplate	99.0 kW
Inverter AC Nameplate	80.0 kW Load Ratio: 1.24
Annual Production	97.86 MWh
Performance Ratio	81.2%
kWh/kWp	988.7
Weather Dataset	TMY, SEATTLE BOEING FIELD [ISIS], NSRDB (tmy3, II)
Simulator Version	76d4770042-73948c4491-816dd164e2-89ee8d06e4

Project Location

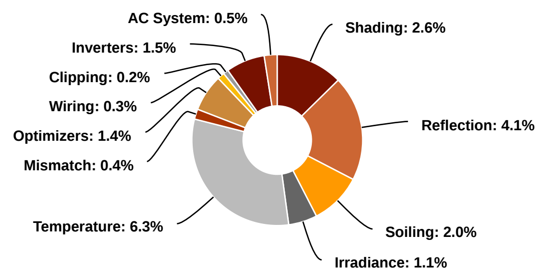


Monthly Production



Month	GHI (kWh/m^2)	POA (kWh/m^2)	Shaded (kWh/m^2)	Nameplate (kWh)	Grid (kWh)
January	29.3	30.0	28.2	2,582.7	2,444.9
February	60.0	61.9	57.7	5,259.5	4,867.1
March	84.9	86.2	83.7	7,756.3	7,135.8
April	130.0	131.5	128.8	12,012.9	10,843.2
May	157.6	156.8	154.3	14,427.1	12,841.7
June	151.5	150.5	148.2	13,871.0	12,187.1
July	193.8	191.5	189.3	17,734.3	15,124.0
August	160.9	160.4	157.9	14,757.1	12,766.3
September	130.4	132.0	127.5	11,823.6	10,362.1
October	61.8	63.2	60.0	5,520.1	5,027.4
November	29.1	29.9	28.2	2,584.8	2,399.1
December	23.0	23.3	22.0	1,981.4	1,862.8

Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	1,212.3	
	POA Irradiance	1,217.2	0.4%
	Shaded Irradiance	1,185.8	-2.6%
	Irradiance after Reflection	1,137.6	-4.1%
	Irradiance after Soiling	1,114.8	-2.0%
	Total Collector Irradiance	**1,114.8**	**0.0%**
Energy (kWh)	Nameplate	110,311.0	
	Output at Irradiance Levels	109,089.9	-1.1%
	Output at Cell Temperature Derate	102,173.4	-6.3%
	Output After Mismatch	101,774.2	-0.4%
	Optimizer Output	100,325.5	-1.4%
	Optimal DC Output	100,050.1	-0.3%
	Constrained DC Output	99,851.2	-0.2%
	Inverter Output	98,353.5	-1.5%
	Energy to Grid	**97,861.7**	**-0.5%**
Temperature Metrics			
	Avg. Operating Ambient Temp		14.0 °C
	Avg. Operating Cell Temp		27.6 °C
Simulation Metrics			
	Operating Hours		4265
	Solved Hours		4265

Condition Set

Description	Condition set 2 Ground (Boeing Field)
Weather Dataset	TMY, SEATTLE BOEING FIELD [ISIS], NSRDB (tmy3, II)
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
East-West	-3.56	-0.075	3°C
Carport	-3.56	-0.075	3°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
SIL-490 HN (2022) (Silfab Solar)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
P1100 (SolarEdge)	HelioScope	Mfg Spec Sheet
SE80KUS (2022) (SolarEdge)	HelioScope	Spec Sheet

Components

Component	Name	Count
Inverters	SE80KUS (2022) (SolarEdge)	1 (80.0 kW)
Strings	10 AWG (Copper)	7 (1,323.5 ft)
Optimizers	P1100 (SolarEdge)	104 (114.4 kW)
Module	Silfab Solar, SIL-490 HN (2022) (490W)	202 (99.0 kW)

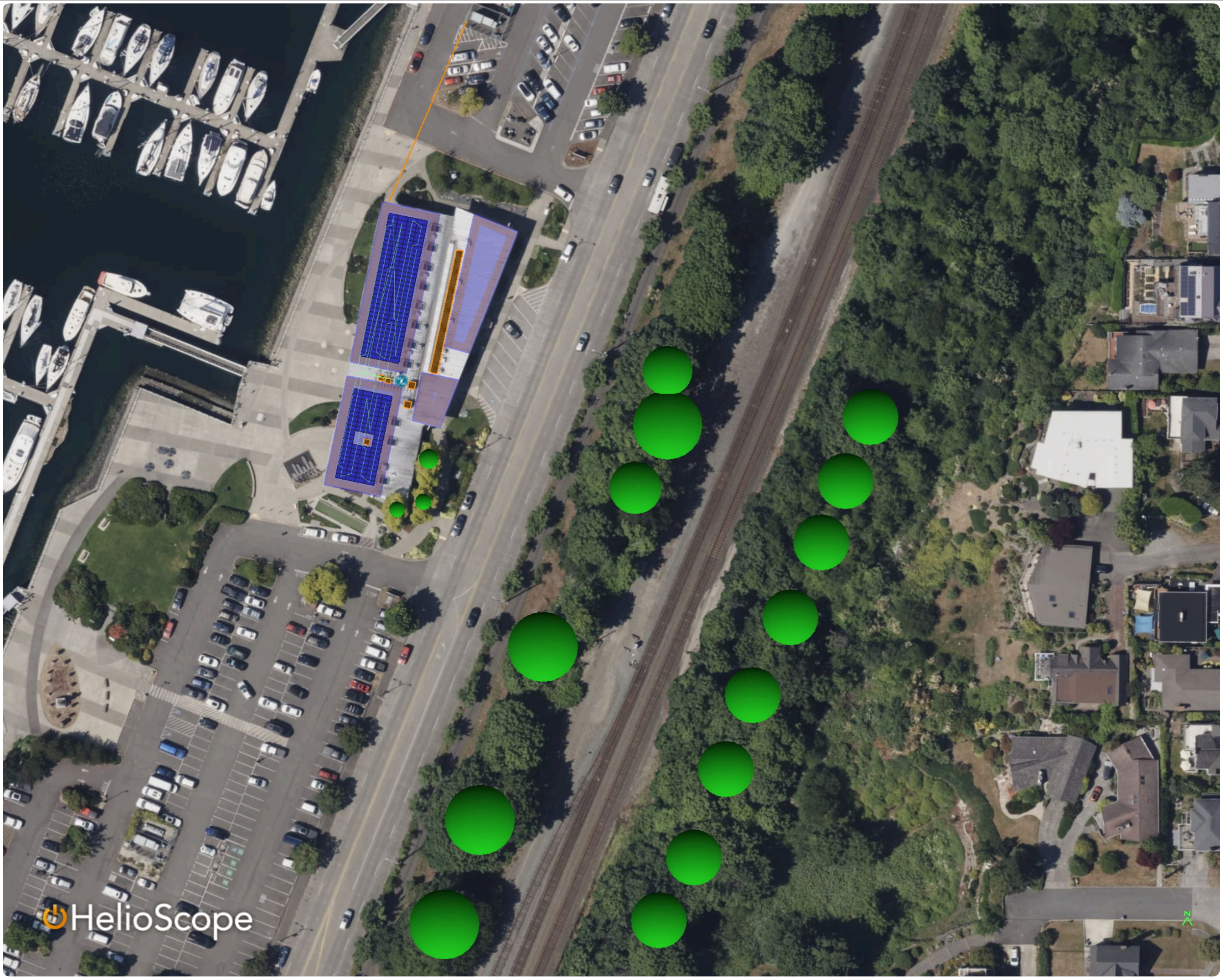
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	-	13-31	Along Racking

Field Segments

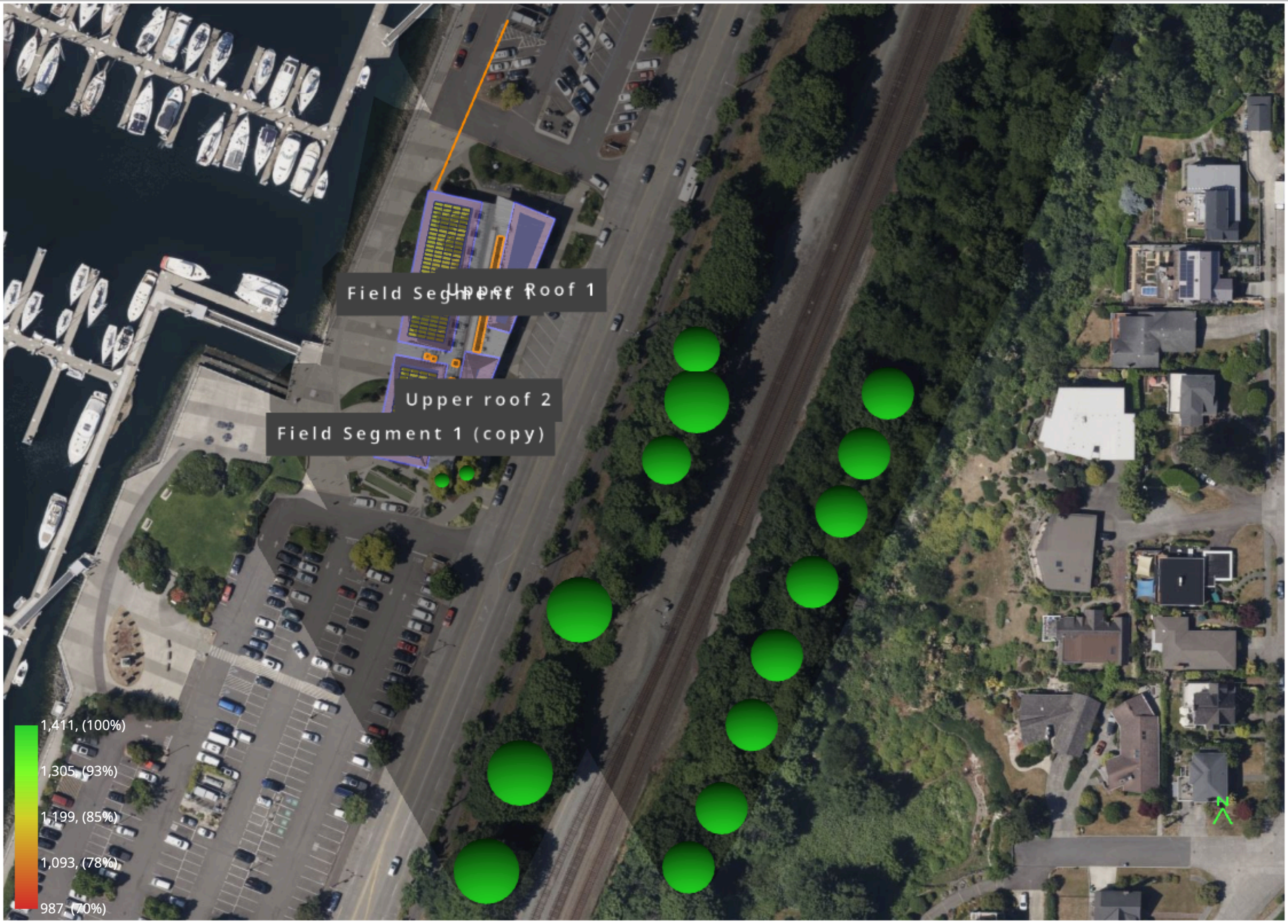
Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Field Segment 1	Flush Mount	Portrait (Vertical)	7.1780963°	101.41497°	0.0 ft	1x1	128	128	62.7 kW
Upper Roof 1	Flush Mount	Portrait (Vertical)	4.632786°	282.74875°	0.0 ft	1x1			0
Field Segment 1 (copy)	Flush Mount	Portrait (Vertical)	7.0554194°	101.73013°	0.0 ft	1x1	74	74	36.3 kW
Upper roof 2	Flush Mount	Portrait (Vertical)	4.632°	280.64062°	0.0 ft	1x1			0

Detailed Layout2



A-1 Admin update final POS Solar - Shilshole Bay, shilshole marina

Shading Heatmap



Shading by Field Segment

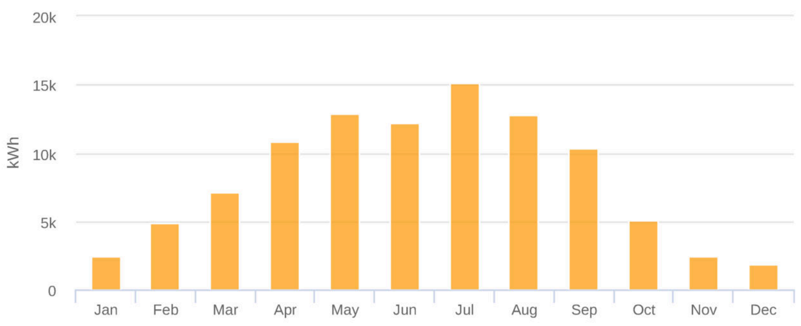
Description	Tilt	Azimuth	Modules	Nameplate	Shaded Irradiance	AC Energy	TOF[2]	Solar Access	Avg TSRF [2]
Field Segment 1	7.2°	101.4°	128	62.7 kWp	1,193.4kWh/m^2	62.4 MWh[1]	86.3%	98.1%	84.6%
Field Segment 1 (copy)	7.1°	101.7°	74	36.3 kWp	1,172.6kWh/m^2	35.5 MWh[1]	86.3%	96.3%	83.1%
Totals, weighted by kWp			**202**	**99.0 kWp**	**1,185.8kWh/m^2**	**97.9 MWh**	**86.3%**	**97.4%**	**84.1%**

[1] approximate, varies based on inverter performance
[2] based on location Optimal POA Irradiance of 1,410.7kWh/m^2 at 35.4° tilt and 187.1° azimuth

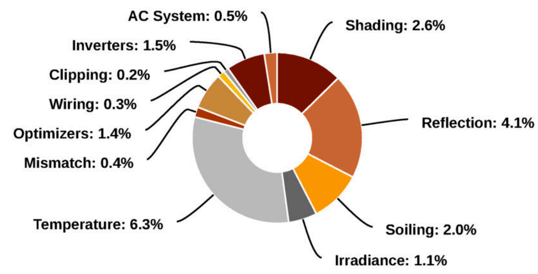
Solar Access by Month

Description	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Field Segment 1	95%	94%	98%	98%	99%	99%	99%	99%	97%	97%	95%	96%
Field Segment 1 (copy)	93%	91%	96%	97%	98%	98%	98%	97%	95%	92%	92%	93%
Solar Access, weighted by kWp	**94.0%**	**93.2%**	**97.0%**	**98.0%**	**98.4%**	**98.5%**	**98.9%**	**98.4%**	**96.6%**	**94.9%**	**94.3%**	**94.5%**
AC Power (kWh)	**2,444.9**	**4,867.1**	**7,135.8**	**10,843.2**	**12,841.7**	**12,187.1**	**15,124.0**	**12,766.3**	**10,362.1**	**5,027.4**	**2,399.1**	**1,862.8**

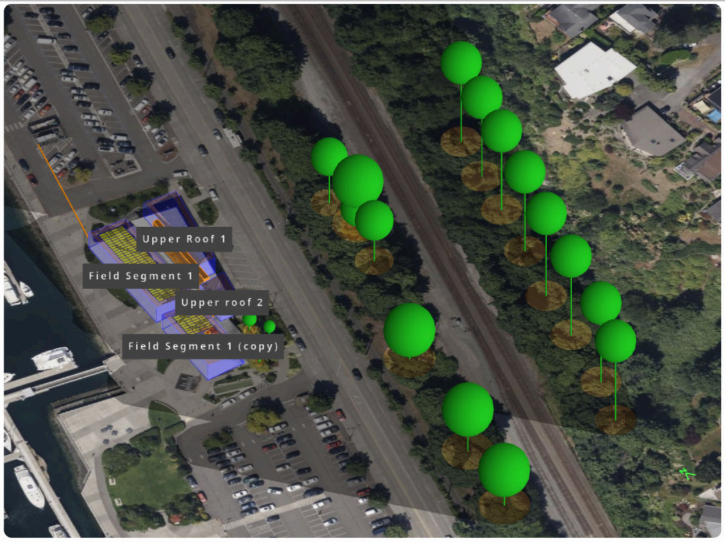
Monthly Production



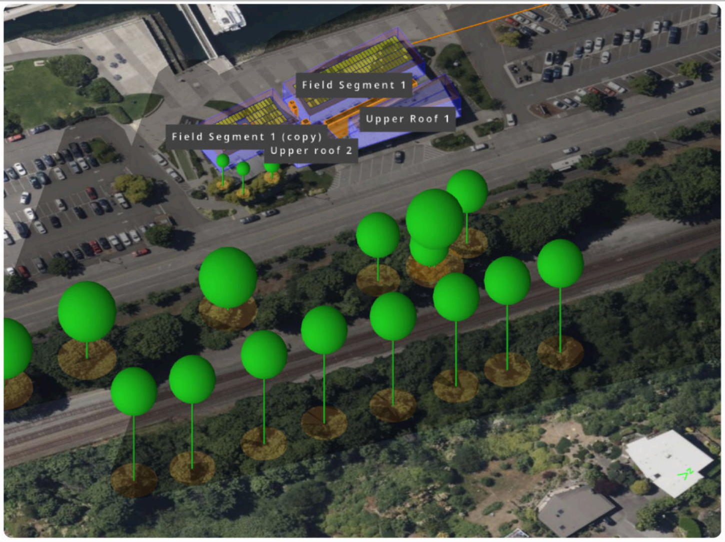
Sources of System Loss

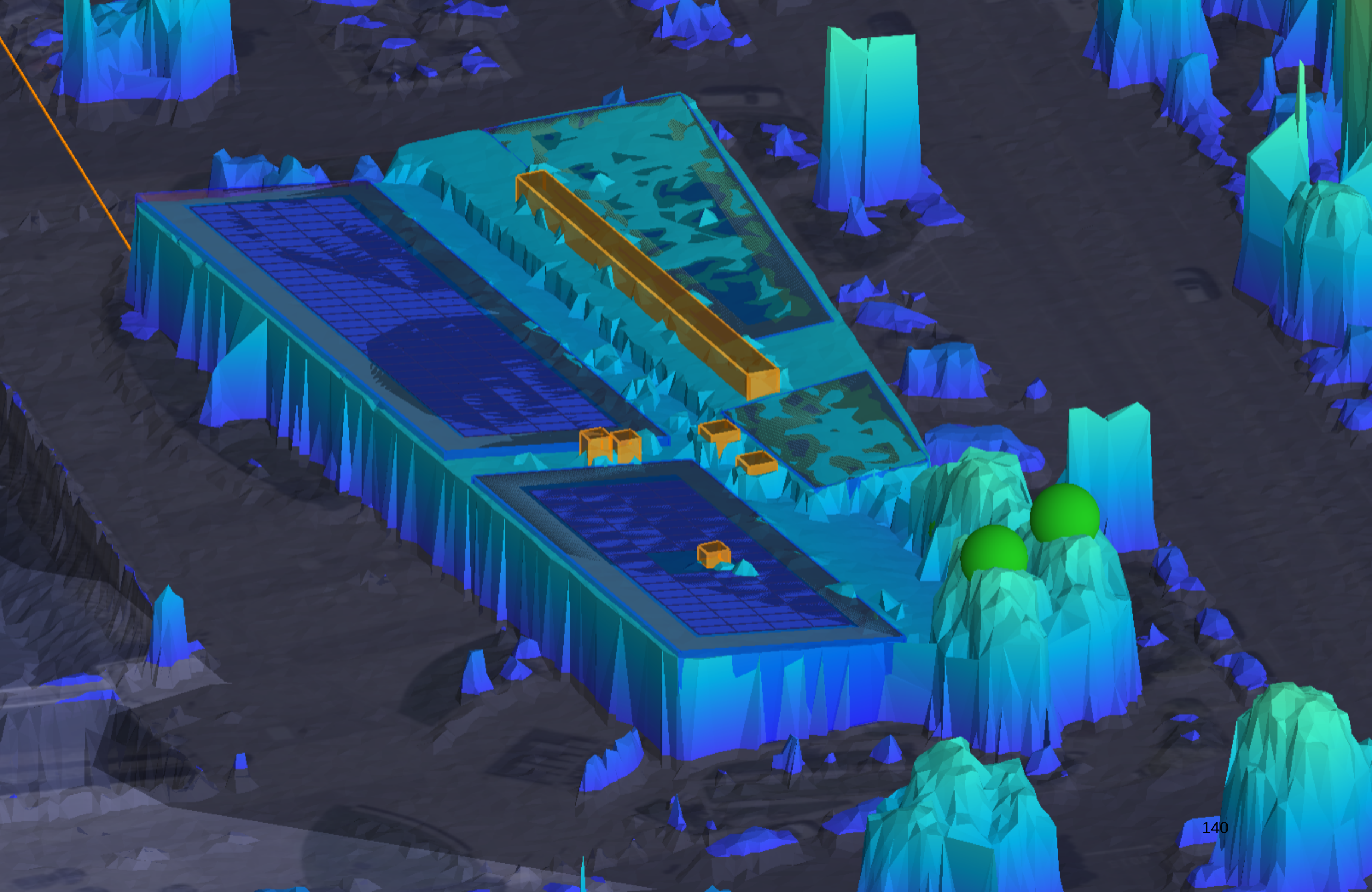


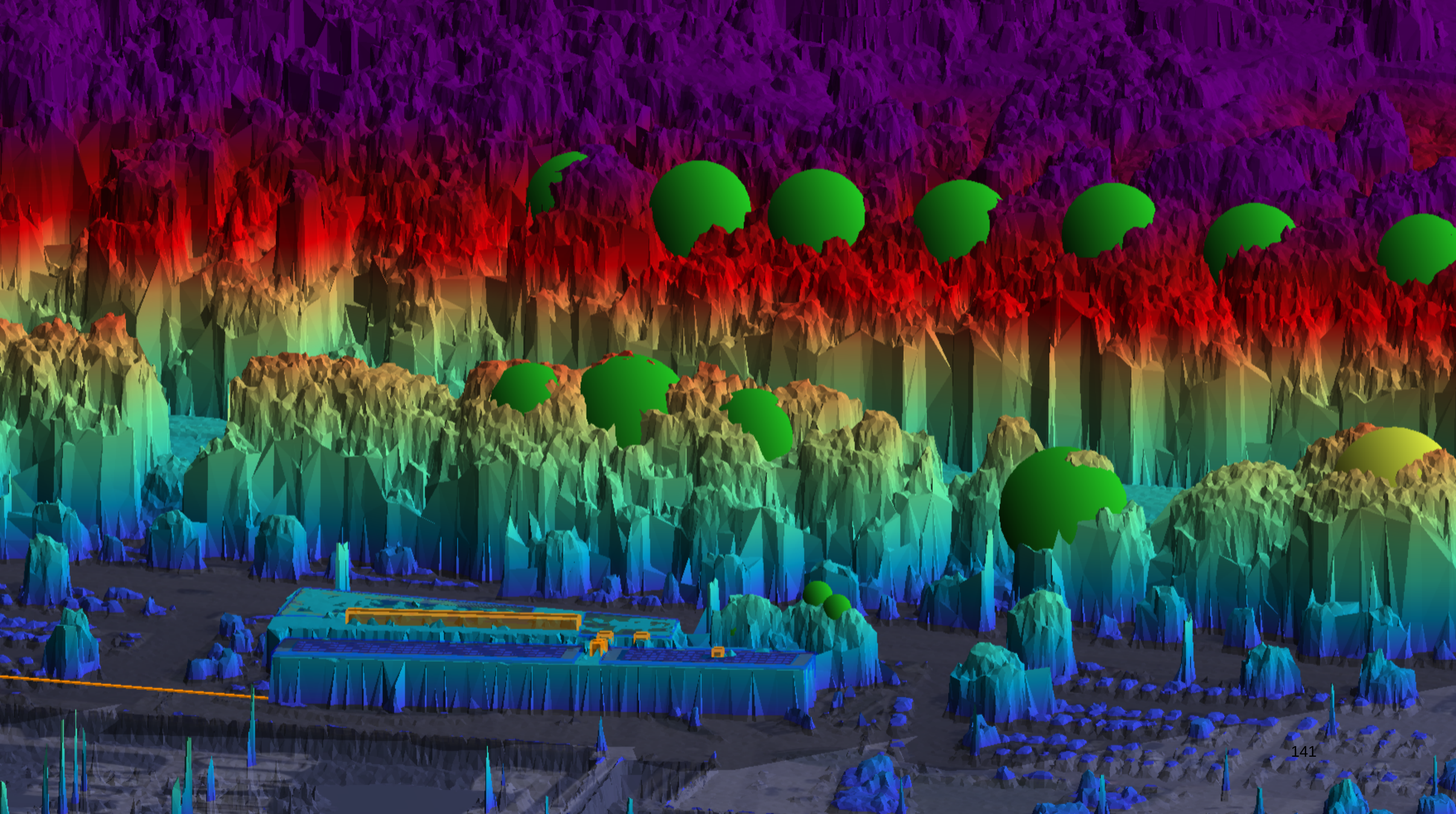
Southwestern Angle

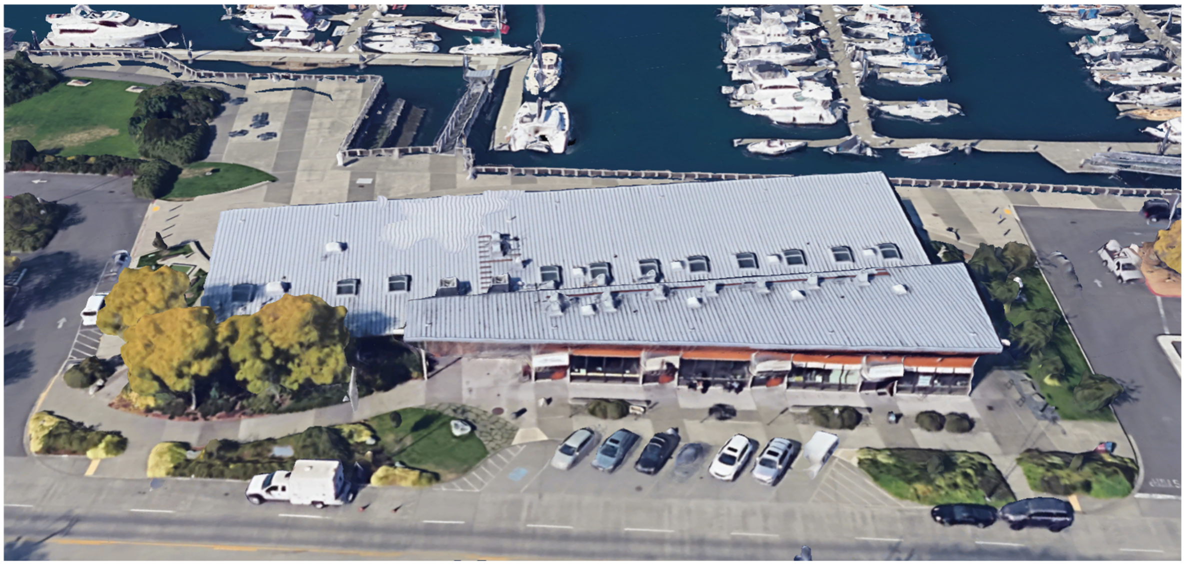


Southeastern Angle









Port of Seattle
Solar Feasibility Assessment:
Shilshole Bay Marina

7001 Seaview Ave NW #100, Seattle, WA 98117

TKDA Project No. 24026

December 20th, 2024

12/18/2024

Structural Calculation Index

Calculation Section **Page No.**

December 20th, 2024

Jack Newman
Säzän Consulting Services
600 Stewart Street, Suite 1400
Seattle, WA 98101

Re: Solar Feasibility Study
Rooftop Photovoltaic Array

TKDA has performed a structural assessment of the Shilshole Bay Marina existing building structure in Seattle, WA to determine its ability to support the proposed rooftop PV array, including modules, racking, and associated equipment. This assessment is based on the as-built structural and architectural drawings provided by the Port of Seattle. The Shilshole Bay Marina building is composed of steel columns with a mix of steel and wood roof framing.

The results of our analysis show that the existing framing is sufficient to carry 3 psf weight under the footprint of the array. Section 503.3 of the 2021 Washington State IEBC states that any building alterations which cause an increase in design dead, live, or snow load of less than 5 percent do not require strengthening or modification of the affected members. The design snow load value shown on the general notes of the original building drawings is higher than the code prescribed snow load required at the roof. The result of the analysis show that the existing framing is sufficient to carry the increased loading due to the proposed rooftop PV array without additional strengthening. See calculations enclosed.

Per section 503.4 of the 2021 Washington State IEBC, building alterations resulting in a lateral load increase of less than 10 percent do not require strengthening or modification of the affected members. The total array weight is less than the maximum allowable array weight based on 10 percent of the original seismic weight tributary to the roof diagram thus no strengthening nor modifications are needed to the roof framing members.

In summary, the existing building structure is adequate to support the proposed rooftop PV array given its average weight of 3 psf underneath the footprint of the array. Please contact TKDA with any further questions.

Sincerely,

Daniel Munn, PE, SE
Regional Vice President, Northwest Region
Professional Engineer: WA, AZ, MD, MI, TX

Project Name: Port of Seattle Solar Feasibility Studies
Project Location: Seattle, WA
Building: Shilshole Bay Marina
Date: December 20th, 2024

Governing Building Codes: 2021 Washington State IEBC
ASCE 7-16

Vertical Gravity Weight Verification

Original Design Loads Per Design Drawings:

Load Case	Magnitude	Comments
Dead Load	15 psf	Assumed
Snow Load	25 psf	WABO, UBC 97

IEBC § 503.3:
"Any existing gravity load-carrying structural element for which an alteration causes an increase in design, dead, live, or snow load, including snow drift effects, of more than 5 percent shall be replaced or altered as needed to carry the gravity loads required by the International Building Code for new structures. Any existing gravity load-carrying structural element whose gravity-load carrying capacity is decreased as part of the alteration shall be shown to have the capacity to resist the applicable design dead, live and snow loads including snow drift effects required by the International Building Code for new structures"

Actual Loads

Load Case	Magnitude	Comments
Dead Load	15 psf	Assumed
Snow Load	Varies d.t. drift considerations	ASCE 7-16, See calculations
Actual Array Weight =	3 psf	

Actual Snow Load + Actual Array Weight < Original Design Snow Load

Conclusions:
The new solar array weight of 3 psf kips is less than the maximum allowable array weight of 15 psf kips based on a 10% increase per IEBC § 503.4. The results of the analysis shows that the existing framing is sufficient to carry the increased loading due to the proposed rooftop PV array without additional strengthening.

Project Name:	Port of Seattle Solar Feasibility Studies
Project Location:	Seattle, WA
Building:	Shilshole Bay Marina
Date:	December 20th, 2024
Governing Building Codes:	2021 Washington State IEBC ASCE 7-16

Seismic Weight Verification

Original Seismic Weight Calculation:

Item Description	Value	Comments
Roof Area =	14974 sf	Total roof area, determined from drawings
Roof DL =	15 psf	See calculations
1/2 Wall Area =	7277 sf	1/2 height of wall area, Determined from design drawings
Wall DL =	8 psf	See calculations
Weight Trib to Roof =	285 kips	

IEBC § 503.4:

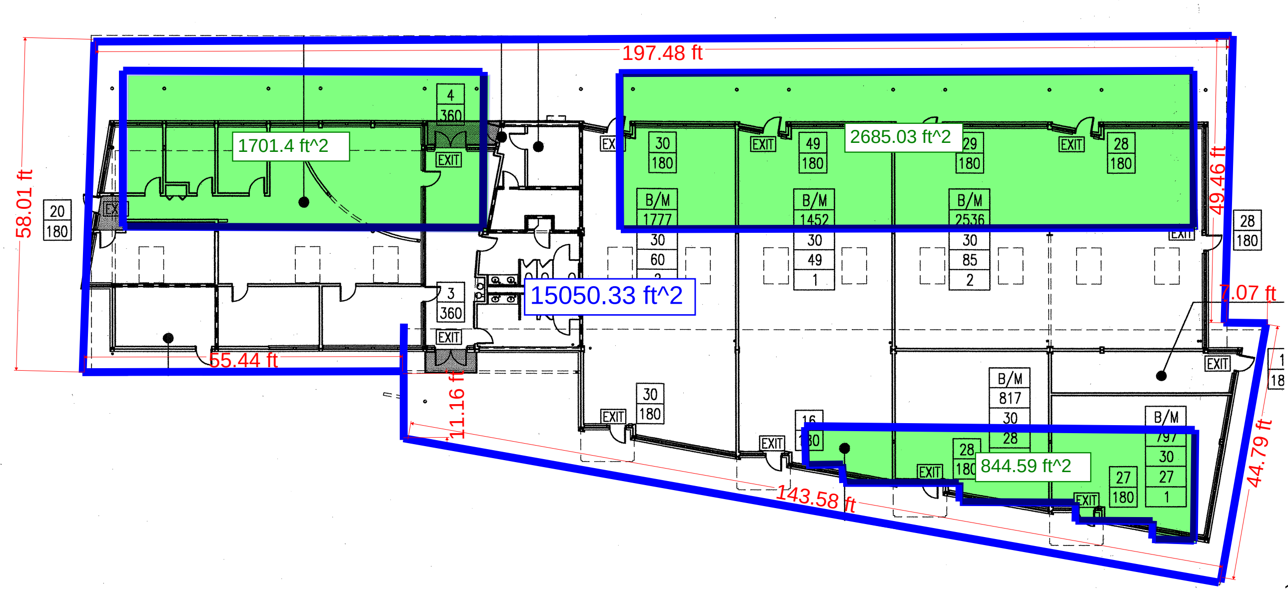
"Any existing lateral load-carrying structural element whose demand-capacity ratio with the alteration considered is not more than 10 percent greater than its demand-capacity ratio with the alteration ignored shall be permitted to remain unaltered."

Allowable Weight Increase Calculation:

Item Description	Value	Comments
10% Increase Per IEBC § 503.4 =	28.6 kips	Maximum array weight
Typ. Weight of Array =	3 psf	Under footprint
Actual Array Weight	15.7 kips	
Actual Array Area	5231 sf	Determined from layouts
Max Allowable Array Area =	9533 sf	

Conclusions:

The new solar array weight of 15.7 kips is less than the maximum allowable array weight of 28.6 kips based on a 10% increase per IEBC § 503.4. The results of the analysis shows that the existing framing is sufficient to carry the increased loading due to the proposed rooftop PV array without additional strengthening.



Design Load Verification

Dead Load - Roof

1) 3 1/8 x 16 GLB @ 48" O.C

$$q_{GLB} := 35\ pcf \cdot \frac{3.125}{12}\ ft \cdot \frac{16}{12}\ ft \cdot \frac{1}{4\ ft} = 3\ psf$$

2) W-shapes

$TribWidth_{avg} := 20\ ft$

$$linFT_{avg} := \frac{\left(26\ \frac{lbf}{ft} + 50\ \frac{lbf}{ft} + 68\ \frac{lbf}{ft} + 50\ \frac{lbf}{ft} + 40\ \frac{lbf}{ft} + 40\ \frac{lbf}{ft} + 40\ \frac{lbf}{ft}\right)}{7} = 45\ \frac{lbf}{ft}$$

$$q_W := linFT_{avg} \cdot \frac{1}{TribWidth_{avg}} = 2\ psf$$

3) 3/8" Plywood

$q_{ply} := 1.1\ psf$

4) 2" Tongue and Groove heavy timber decking

$$q_{T\&G} := 1.5\ \frac{lbf}{ft} \cdot \frac{1}{\frac{5}{12}\ ft} = 3.6\ psf$$

5) Metal decking

$q_M := 2\ psf$

6) MEP

$q_{MEP} := 3\ psf$

Total Dead Load - Roof

$q_{dead\_roof} := q_{GLB} + q_W + q_{ply} + q_{T\&G} + q_M + q_{MEP} = 15\ psf$

Total Dead Load - Wall

7) R19 Insulation, 5/8" Gypsum, 1x8 siding, 1/2" plywood, metal framing, etc.

$q_I := 0.6\ psf$ $q_G := 2.2\ psf$ $q_S := 2.06\ psf$ $q_{plyW} := 1.8\ psf$ $q_{MW} := 1.6\ psf$

$q_{dead\_wall} := q_I + q_G + q_S + q_{plyW} + q_{MW} = 8.26\ psf$

Roof Live Load

Per ASCE7, Table 4.3-1: $q_{live} := 20\ psf$

Sloped Roof Snow Load

Per ASCE 7, See snow calculations page

$q_{snow} := 20\ psf$

Array layouts are outside of potential drift zones

SNOW CALCULATIONS per ASCE 7-16

ARRAY LOCATION 1

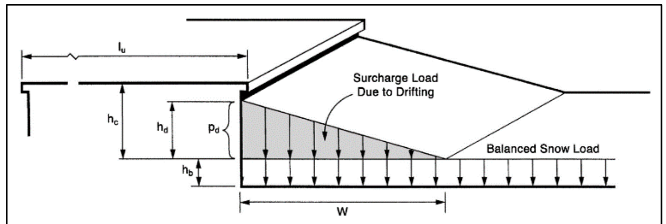


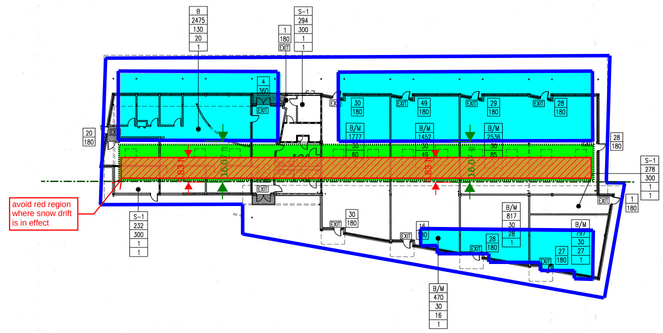
Figure 7.7-2. Configuration of snowdrifts on lower roofs.

Roof Geometry

Upper Roof Length, l_u (ft):	49	
Lower Roof Length, l_l (ft):	64	
Roof Height Difference, h (ft):	3.8	
Separation Distance, s (ft):	0	
Clear Roof Height, h_c (ft):	2.74	
Slope Rise	1.524	/12
Actual Slope, degrees	7.238	

Balanced Snow

Ground Snow Load, p_g (psf):	30
Exposure Factor, C_e (Table 7-2):	0.9
Thermal Factor, C_t (Table 7-3):	1.0
Importance Factor, I (Table 7-4):	1.0
Slope Factor, C_s (=1.0 if Flat):	1.0
Minimum Flat Snow Load, pf (psf):	20
Sloped Roof Snow Load, p_s (psf):	**19**
Snow Density, γ (pcf):	17.9
Balanced Snow Height, h_b (ft):	1.06
Adjacent Structure Factor, asf	1.00



Leeward Drift

$$h_d = \left(0.43 \cdot \sqrt[3]{l_u} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 2.46

Windward Drift

$$h_d = 0.75 \cdot \left(0.43 \cdot \sqrt[3]{l_l} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 2.12

Drift Size

Design Height, h_d (ft):	2.46	
But not greater than h_c (ft):	2.46	
Drift Width, w (ft):		
If $h_d \le h_c$, 4 * h_d	9.83	
If $h_d > h_c$, 4 * h_d^2 / h_c	8.82	
But not greater than 8*h_c:	21.91	
w (ft):	9.83	
Maximum Surcharge Load, p_d (psf):	43.98	$= h_d / \gamma$

Sloped Roof Results

Sloped Roof Snow Load, p_s (psf):	**19.0**	**psf**
Balanced Snow Height, h_b (ft):	**1.1**	**ft**

Drift Results - Does not apply

Drift Height, h_d	**2.46**	**ft**
Drift Width, w	**9.83**	**ft**
Maximum Surcharge Load, p_d	**43.98**	**psf**

Page 1 of 1

TKDA

PROJECT	SAZAN SHILLSHOLE	BY: WW	SHEET:
		CHKD: DM	PROJECT NO: 24026
TITLE	ARRAY LOCATION 1 SNOW CALCULATION	DATE: 12/11/24	PAGE:

Hazards by Location

Search Information

Address: 7001 Seaview Ave NW Ste 100, Seattle, WA 98117

Coordinates: 47.68068270000001, -122.4048252

Elevation: 15 ft

Timestamp: 2024-12-09T19:23:27.073Z

Hazard Type: Snow

ASCE 7-16

Ground Snow Load ⚠ 20 lb/sqft

The reported ground snow load applies at the query location of 15 feet up to a maximum elevation of 350 feet with a tolerance of 100 feet.

ASCE 7-10

Ground Snow Load ⚠ 15 lb/sqft

The reported ground snow load applies at the query location of 15 feet up to a maximum elevation of 400 feet.

ASCE 7-05

Ground Snow Load ⚠ 15 lb/sqft

The reported ground snow load applies at the query location of 15 feet up to a maximum elevation of 400 feet.

The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Please note that the ATC Hazards by Location website will not be updated to support ASCE 7-22. Find out why.

Disclaimer

Hazard loads are interpolated from data provided in ASCE 7 and rounded up to the nearest whole integer.

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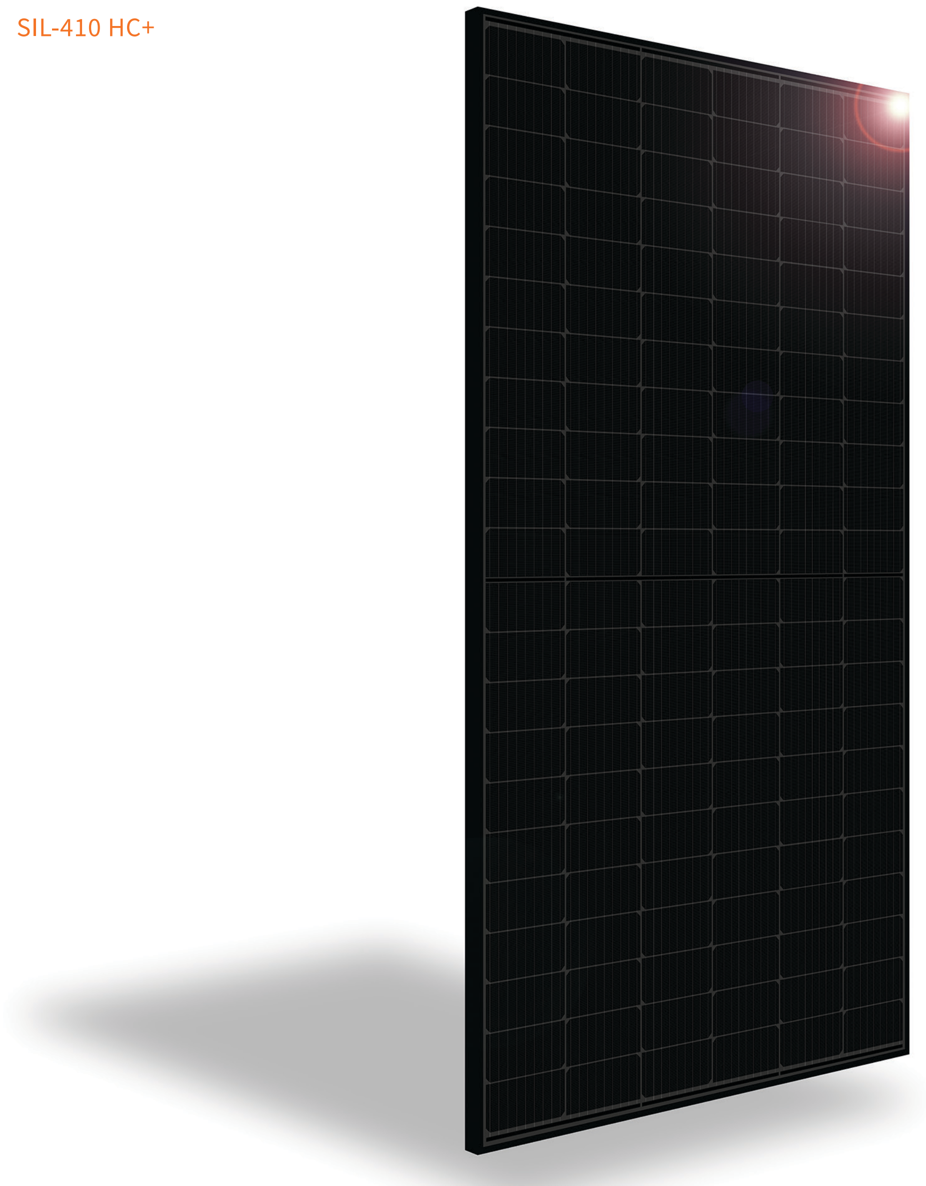
SILFAB PRIME

SILFAB SOLAR®

SIL-410 HC+



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DIRECT FROM THE SOURCE.

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Dependable, durable, high-performance solar panels engineered for North American homeowners.

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TOP PERFORMER 2023 PVEL kiwa PV MODULE RELIABILITY SCORECARD

PV MODULE INDEX REPORT 2023 HIGH ACHIEVEMENT IN PERFORMANCE RETC

PV Array Specifications

ELECTRICAL SPECIFICATIONS		410	
Test Conditions		STC	NOCT
Module Power (Pmax)	Wp	410	306
Maximum power voltage (Vpmax)	V	38.99	36.24
Maximum power current (Ipmax)	A	10.52	8.43
Open circuit voltage (Voc)	V	45.59	42.76
Short circuit current (Isc)	A	11.15	8.99
Module efficiency	%	20.7%	
Maximum system voltage (VDC)	V	1000	
Series fuse rating	A	20	
Power Tolerance	Wp	0 to +10	

Measurement conditions: STC 1000 W/m² • AM 1.5 • Temperature 25 °C • NOCT 800 W/m² • AM 1.5 • Measurement uncertainty ≤ 3%
Sun simulator calibration reference modules from Fraunhofer Institute. Electrical characteristics may vary by ±5% and power by 0 to +10W.

MECHANICAL PROPERTIES / COMPONENTS	METRIC	IMPERIAL
Module weight	21.3kg ±0.2kg	47lbs ±0.4lbs
Dimensions (H x L x D)	1914 mm x 1036 mm x 35 mm	75.3 in x 40.8 in x 1.37 in
Maximum surface load (wind/snow)*	5400 Pa rear load / 5400 Pa front load	112.8 lb/ft² rear load / 112.8 lb/ft² front load
Hail impact resistance	ø 25 mm at 83 km/h	ø 1 in at 51.6 mph
Cells	132 Half cells - Si mono PERC 9 busbar - 83 x 166 mm	132 Half cells- Si mono PERC 9 busbar - 3.26 x 6.53 in
Glass	3.2 mm high transmittance, tempered, anti-reflective coating	0.126 in high transmittance, tempered, anti-reflective coating
Cables and connectors (refer to installation manual)	1350 mm, ø 5.7 mm, MC4 from Staubli	53 in, ø 0.22 in (12AWG), MC4 from Staubli
Backsheet	High durability, superior hydrolysis and UV resistance, multi-layer dielectric film, fluorine-free PV backsheet	
Frame	Anodized Aluminum (Black)	
Bypass diodes	3 diodes-30SQ045T (45V max DC blocking voltage, 30A max forward rectified current)	
Junction Box	UL 3730 Certified, IEC 62790 Certified, IP68 rated	

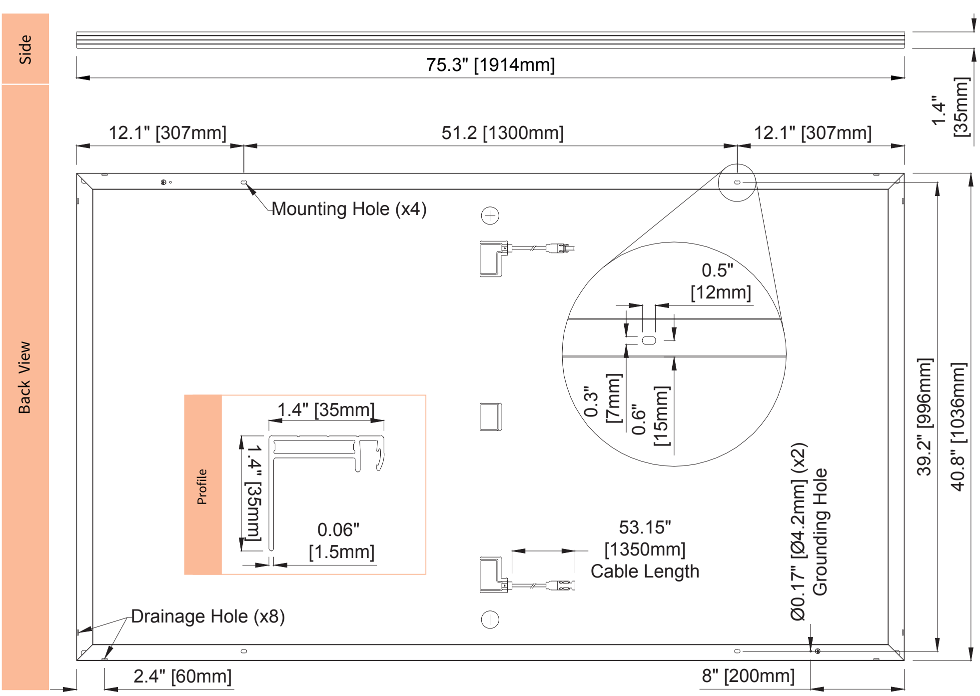
TEMPERATURE RATINGS	
Temperature Coefficient Isc	+0.064 %/°C
Temperature Coefficient Voc	-0.28 %/°C
Temperature Coefficient Pmax	-0.36 %/°C
NOCT (± 2°C)	45 °C
Operating temperature	-40/+85 °C

WARRANTIES	
Module product workmanship warranty	25 years**
Linear power performance guarantee	30 years
	≥ 97.1% end 1st yr ≥ 91.6% end 12th yr ≥ 85.1% end 25th yr ≥ 82.6% end 30th yr

CERTIFICATIONS	
Product	UL 61215-1:2017 Ed.1, UL 61215-2:2017 Ed.1, UL 61730-1:2017 Ed.1, UL 61730-2:2017 Ed.1 , CSA C22.2#61730-1:2019 Ed.2, CSA C22.2#61730-2:2019 Ed.2, IEC 61215-1:2016 Ed.1, IEC 61215-2:2016 Ed.1, IEC 61730-1:2016 Ed.2, IEC 61730-2:2016 Ed.2, IEC 61701:2020 (Salt Mist Corrosion), IEC 62716:2013 (Ammonia Corrosion), CEC Listing, UL Fire Rating: Type 2
Factory	ISO9001:2015

SHIPPING SPECS	
Modules Per Pallet:	26 or 26 (California)
Pallets Per Truck	32 or 30 (California)
Modules Per Truck	832 or 780 (California)

* ⚠ Warning. Read the Safety and Installation Manual for mounting specifications and before handling, installing and operating modules.
** 12 year extendable to 25 years subject to registration and conditions outlined under “Warranty” at silfabsolar.com.
PAN files generated from 3rd party performance data are available for download at: silfabsolar.com/downloads.



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Fort Mill SC 29715 USA
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240 Courtneypark Drive East
Mississauga ON L5T 2S5 Canada
T +1 905.255.2501
F +1 905.696.0267

ROOFTOP SOLAR PV
SEGMENT #2
74 MODULES (36.3 kW)

ROOFTOP SOLAR PV
SEGMENT 1
128 MODULES (62.7 kW)

99kW ROOFTOP SOLAR PV ARRAY

SCALE: NTS

N

SÄZÄN
GROUP
600 Stewart St., Ste 1400
Seattle, Washington 98101
Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

SHILSHOLE A-1
PORT OF SEATTLE

..\..\Port-of-Seattle-Logo-1.jpg

Project: B23-24007

Contents:

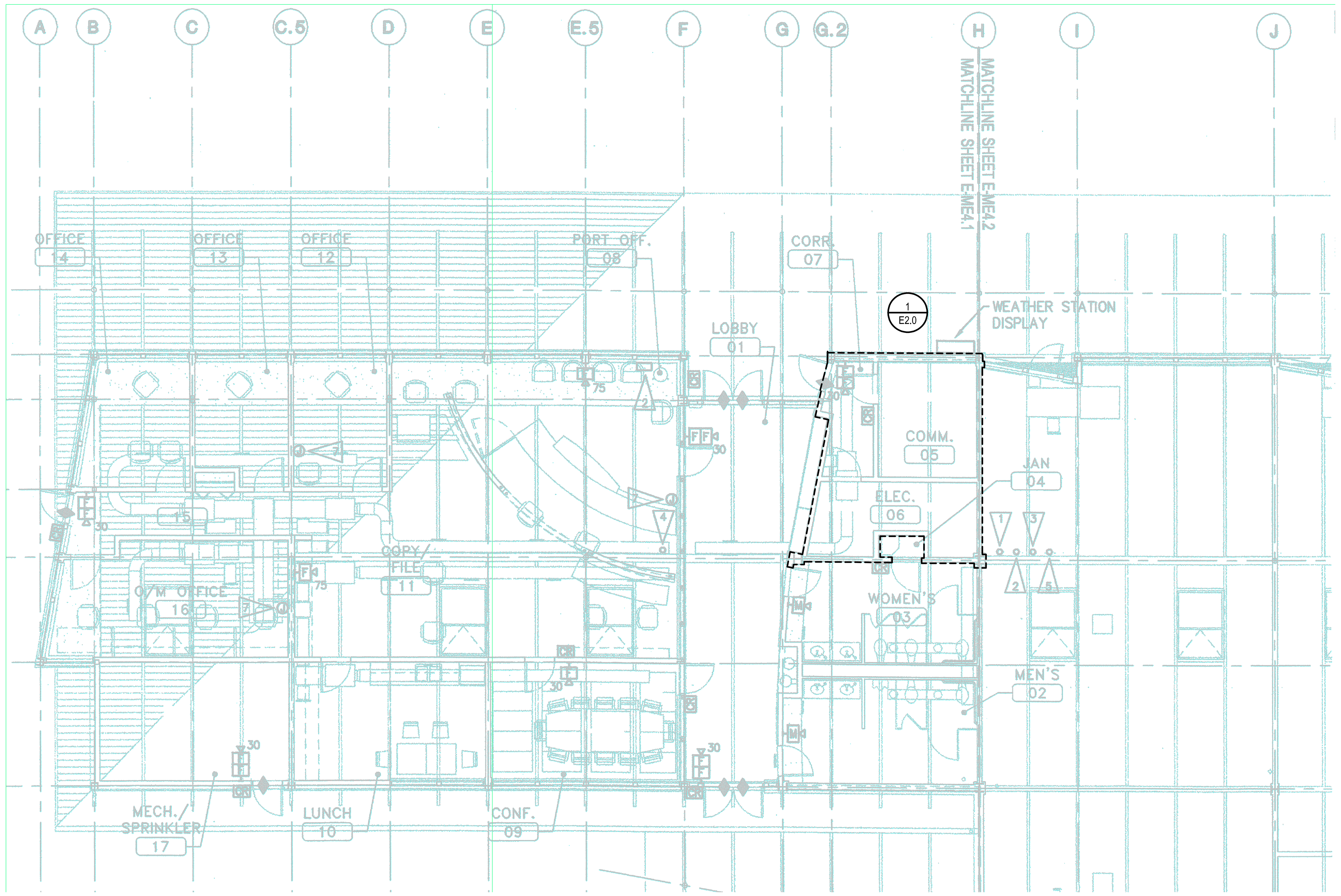
ROOFTOP SOLAR PV
MODULE LAYOUT

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

E1.0

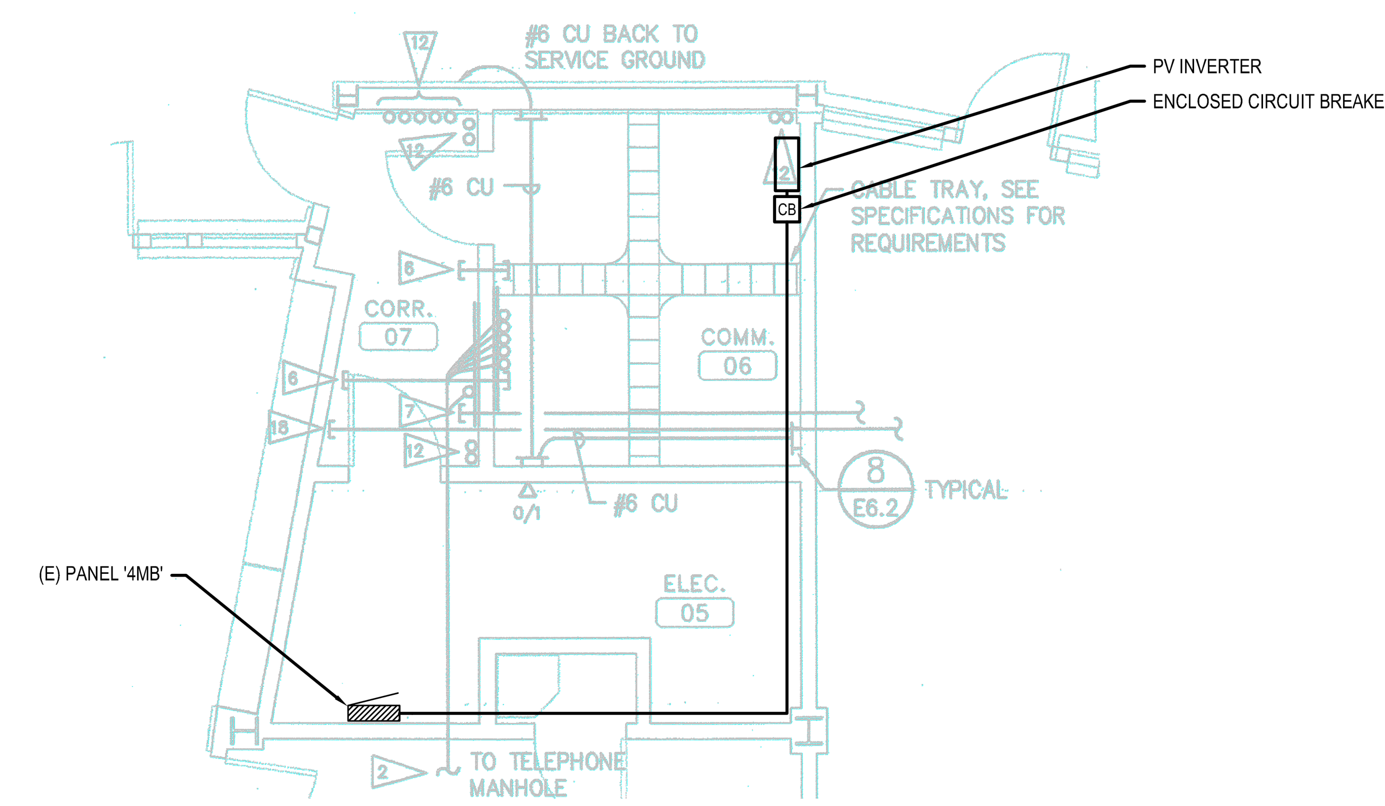
12/20/2024 8:33:16 AM S:\SES\Projects\B23 Port of Seattle\B23-24007 POS On-Call - Solar Feasibility\9. Project Documents\SHILSHOLE A-1\CAD\E1.0.dwg

Joseph Cauilan



SOLAR PV EQUIPMENT LAYOUT - FIRST FLOOR (2)

SCALE: 1/8" = 1'0"



ENLARGED SOLAR PV EQUIPMENT LAYOUT - FIRST FLOOR (1)

SCALE: 1/4" = 1'0"

SÄZÄN GROUP
600 Stewart St., Ste 1400
Seattle, Washington 98101
Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

SHILSHOLE A-1
PORT OF SEATTLE

..\..\Port-of-Seattle-Logo-1.jpg

Project: B23-24007

Contents:

SOLAR PV EQUIPMENT LAYOUT

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

E2.0

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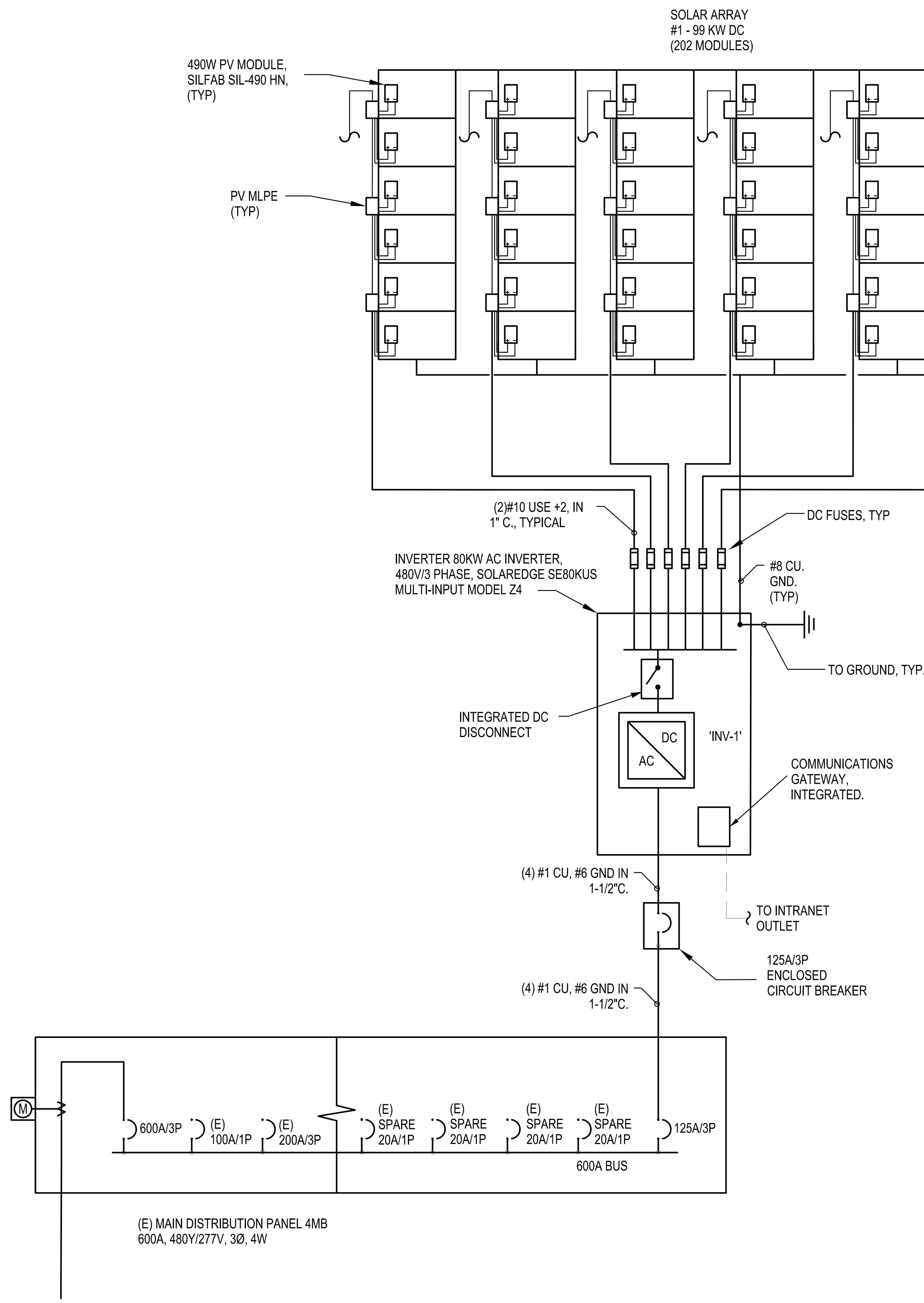
Joseph Cauilan



SOLAR PV SYSTEM - ONE LINE DIAGRAM

SCALE: NTS

1

SÄZÄN GROUP

600 Stewart St., Ste 1400
Seattle, Washington 98101

Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

SHILSHOLE A-1
PORT OF SEATTLE

..\..\Port-of-Seattle-Logo-1.jpg

Project: B23-24007

Contents:

SOLAR PV SYSTEM - ONELINE DIAGRAM

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

E3.0

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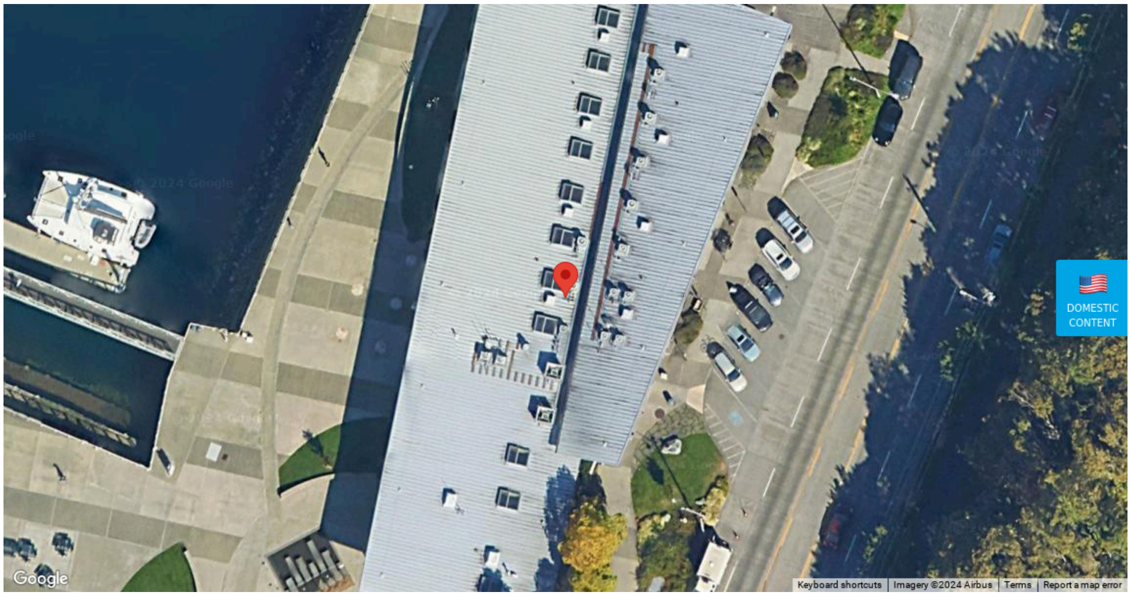
PLOTTED BY: Joseph Cauilan

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Project Details			
Name	Shilshole A-1	**Date**	12/06/2024
Location	7001 Seaview Avenue Northwest, Seattle, WA 98117	**Total modules**	202
Module	Silfab: SIL-490 HN (35mm)	**Total watts**	98,980
Dimensions	Dimensions: 89.09" x 40.83" x 1.38" (2263.0mm x 1037.0mm x 35.0mm)	**Attachments**	366
ASCE	7-16	**Rails per row**	2



System Weight	
Total system weight	12,798.3 lbs
Weight/attachment	35.0 lbs
Racking weight	1,308.5 lbs
Distributed weight	2.5 psf

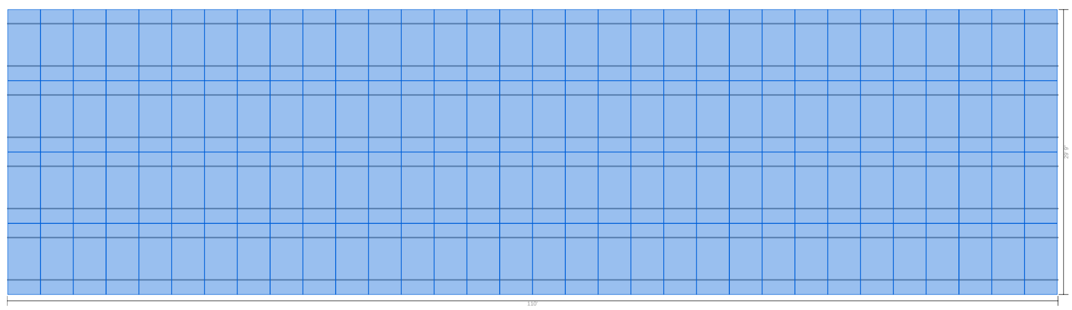
Load Assumptions	
Wind exposure	C
Wind speed	98 mph
Ground snow load	20 psf
Attachment spacing portrait	4.0'
Site Elevation	321.0 ft
S_{DS}	1.051

Roof Information			
Roof Material Family	Metal	**Roof material**	Standing Seam
Risk category	II	**Roof attachment**	Lynx with L-Foot
		Staggered attachments	Yes
Attachment hardware	T Bolt		
Roof shape	Gable		

Roof Plane A					
Height	30 ft	**Slope**	8 °	**Rafter spacing**	24 in

Roof Plane A: Roof Section 1		
Details		**Weights**
Panels: 128	Provided rail: 896' [64 x 168"]	Total weight: 8,103.5 lbs
Rail orientation: East-West	Attachments: 228	Weight/attachment: 35.5 lbs
Panel orientation: Portrait	Splices: 64	Total Area: 3,284.9 sq ft
Entry type: Graphical	Clamps: 240	Distributed weight: 2.5 psf

Diagram



Segments

Identifier	Columns	Row length	Rail length	Cantilever	Rail	Attachments	Splices	Clamps
A	32	110' 3"	110' 2"	1' 2"	224' [16 x 168"]	57	16	60
			Row segment totals (x 4) →		**896' [64 x 168"]**	**228**	**64**	**240**

Span Details XR100 - Portrait

Zone	Module Position	Max span	Max cantilever
Zone 1/2e	Normal	6' 10"	2' 9"
Zone 2n/2r/3e	Normal	6' 10"	2' 9"
Zone 3r	Normal	6' 10"	2' 9"

Reaction Forces XR100 - Portrait

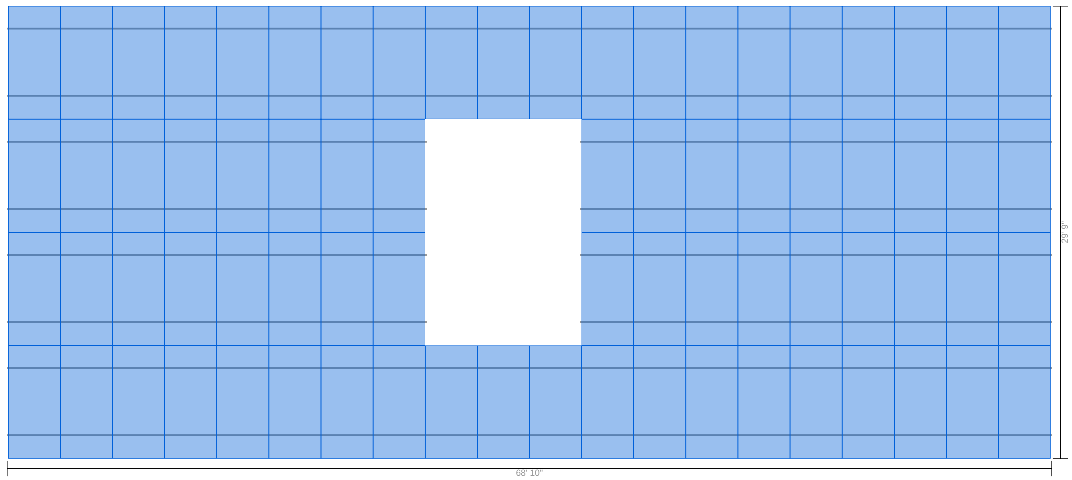
Zone	Module Position	Uplift (PSF)	Down (lbs)	Uplift (lbs)	Lateral Par (lbs)	Lateral Perp (lbs)
Zone 1/2e	Normal	14.3	359	244	55	26
Zone 2n/2r/3e	Normal	19.5	359	346	55	26
Zone 3r	Normal	23.1	359	419	55	26

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Roof Plane A: Roof Section 2

Details		Weights
Panels: 74	Provided rail: 532' [36 x 168", 4 x 84"]	Total weight: 4,694.8 lbs
Rail orientation: East-West	Attachments: 138	Weight/attachment: 34.0 lbs
Panel orientation: Portrait	Splices: 28	Total Area: 1,896.5 sq ft
Entry type: Graphical	Clamps: 136	Distributed weight: 2.5 psf

Diagram



Segments

Identifier	Columns	Row length	Rail length	Cantilever	Rail	Attachments	Splices	Clamps
A	20	68' 10"	68' 10"	5"	140' [10 x 168"]	37	8	38
			Row segment totals (x 2) →		**280' [20 x 168"]**	**74**	**16**	**76**
B	8	27' 7"	27' 7"	1' 10"	56' [4 x 168"]	15	2	14
			Row segment totals (x 2) →		**112' [8 x 168"]**	**30**	**4**	**28**
C	9	31'	31'	1' 6"	70' [2 x 84", 4 x 168"]	17	4	16
			Row segment totals (x 2) →		**140' [4 x 84", 8 x 168"]**	**34**	**8**	**32**

Span Details XR100 - Portrait

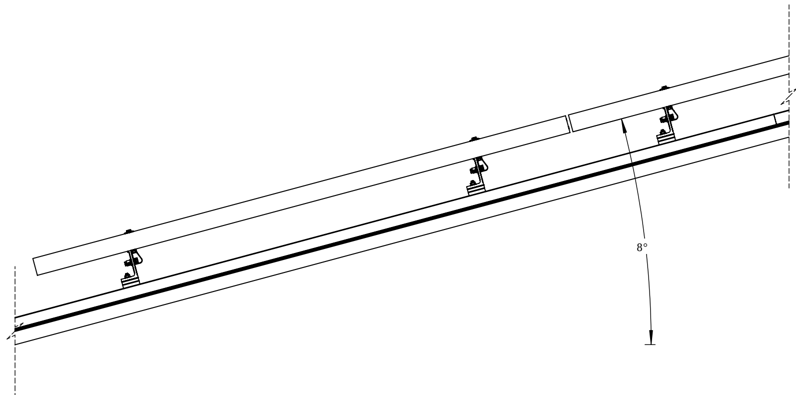
Zone	Module Position	Max span	Max cantilever
Zone 1/2e	Normal	6' 10"	2' 9"
Zone 2n/2r/3e	Normal	6' 10"	2' 9"
Zone 3r	Normal	6' 10"	2' 9"

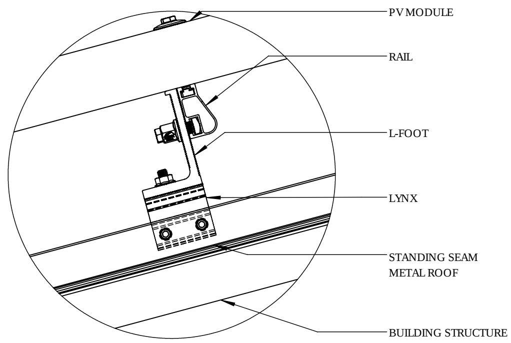
Reaction Forces XR100 - Portrait

Zone	Module Position	Uplift (PSF)	Down (lbs)	Uplift (lbs)	Lateral Par (lbs)	Lateral Perp (lbs)
Zone 1/2e	Normal	14.3	359	244	55	26
Zone 2n/2r/3e	Normal	19.5	359	346	55	26
Zone 3r	Normal	23.1	359	419	55	26

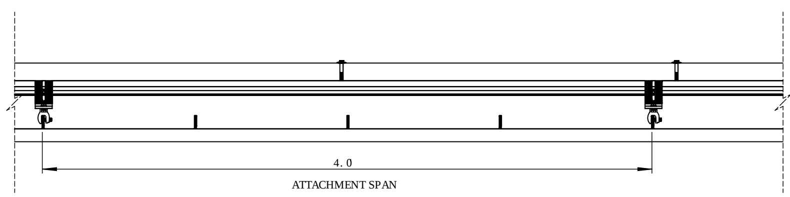
IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

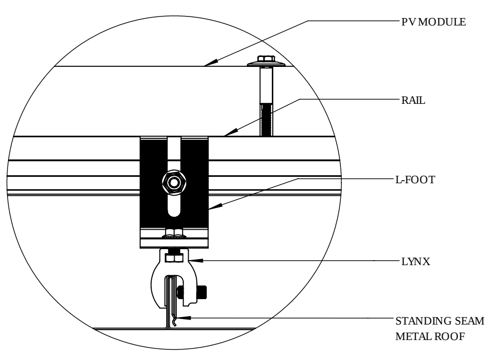
Side View (portrait)





Front View (portrait)

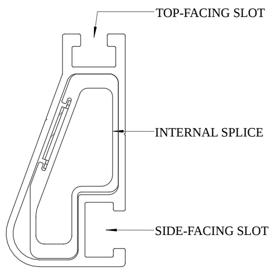




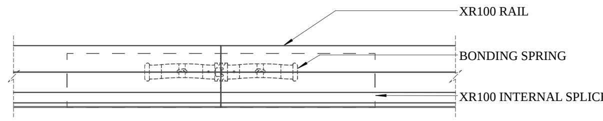
158

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Splice Details

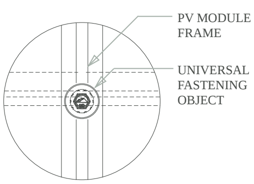


XR100

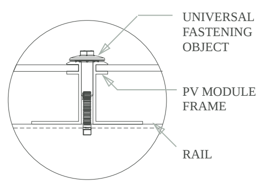


Splice Connection

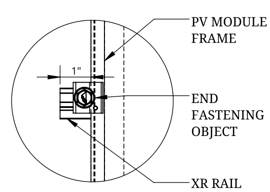
Clamp Detail



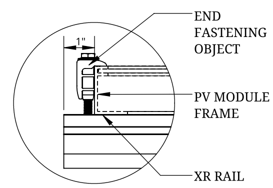
Mid Clamp, Plan



Mid Clamp, Front

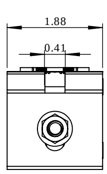


End Clamp, Plan

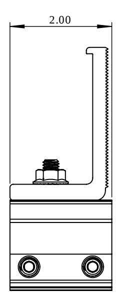


End Clamp, Front

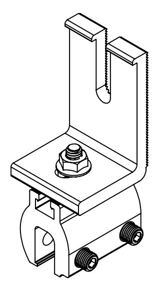
Lynx Standing Seam Metal Clamp



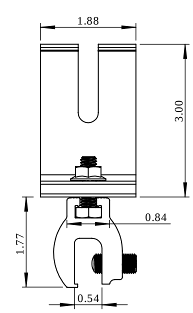
Plan View



Side View



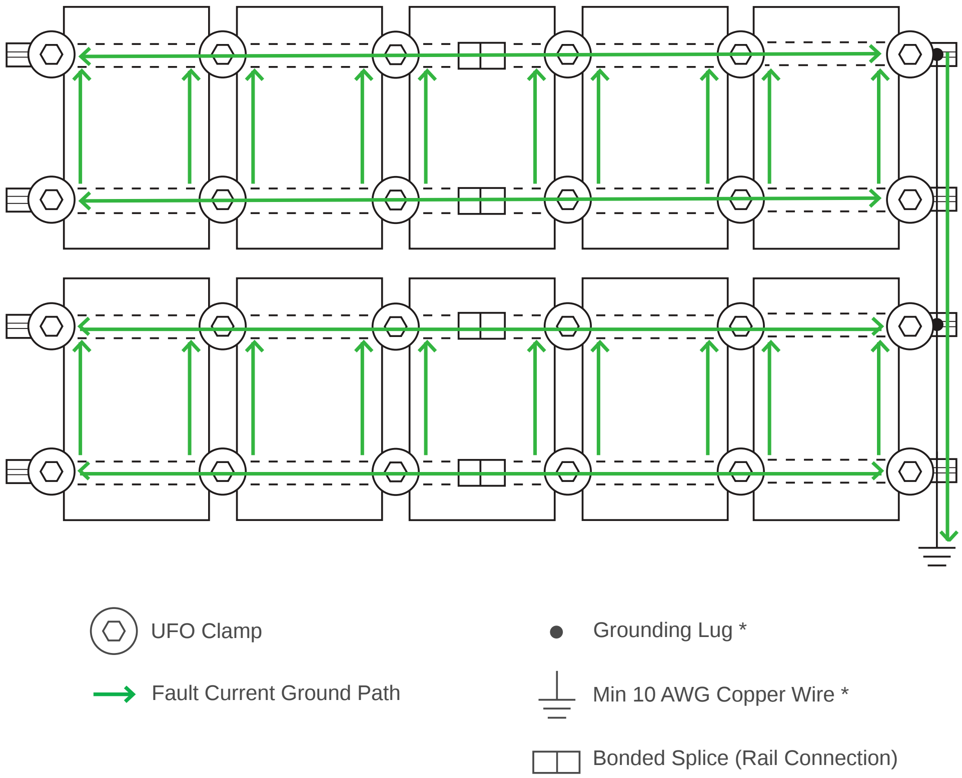
Perspective View



Front View

159

Grounding Diagram



* Grounding Lugs and Wire are not required in systems using Enphase microinverters.

Bill of Materials

Part	Spares	Qty
Rails & Splices		
XR-100-168A XR-100, 168" (14') Clear *** 2 x 168" rail to be cut on-site into 84" sections.**	0	102
XR100-BOSS-01-M1 Bonded Splice, XR100	0	92
Clamps & Grounding		
UFO-CL-01-A1 Universal Module Clamp, Clear	0	376
UFO-END-01-A1 End Fastening Object (End Clamp, 30-40mm), Mill	0	56
XR-LUG-03-A1 Grounding Lug, Low Profile	0	10
Attachments		
QM-LYNX-SS-M1 Lynx Standing Seam Metal Clamp (incl. h/w)	0	366
LFT-03-M1 Slotted L-Foot, Mill	0	366
BHW-TB-03-A1 T-Bolt, Bonding Hardware	0	366

ATTACHMENTS

PRE-INSTALLATION

- ☐ Verify module compatibility. See Page 21 for info.

TOOLS REQUIRED

- ☐ Cordless Drill (non-impact)
- ☐ Impact Driver (for lag bolts)
- ☐ Torque Wrench (0-250 in-lbs)
- ☐ 7/16" Socket
- ☐ 1/2" Socket
- ☐ 9/16" Socket
- ☐ 7/32" Drill Bit
- ☐ 3/8" Socket
- ☐ 1/8" Drill Bit
- ☐ 1/4" Drill Bit
- ☐ T30 Bit
- ☐ Channel Lock Pliers
- ☐ #3 Phillips Bit
- ☐ 3/16" Hex Bit

BONDING HARDWARE TORQUE VALUES

Please refer to each attachment's individual section for full details on all torque values and instructions.

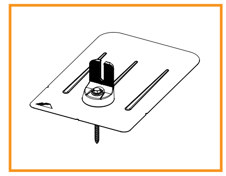
- ☐ 3/8" Bonding Hardware Nuts (7/16" Socket): 250 in-lbs
- ☐ All Tile Hook Carriage Bolts (7/16" Socket): 132 in-lbs
- ☐ Flat Roof Attachment Nuts (9/16" Socket): 250 in-lbs
- ☐ Lynx Set Screw (3/16" Hex Drive): 150 in-lbs
- ☐ Lynx Flange Nut (1/2" Socket): 150 in-lbs

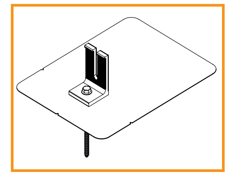
➢ **If using previous version of Integrated Grounding Mid Clamps, End Clamps, Expansion Joints and for a list of approved 3rd party components please refer to Alternate Components Addendum (Version 1.9)**

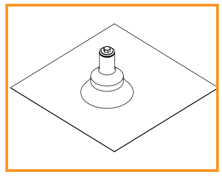
ATTACHMENTS

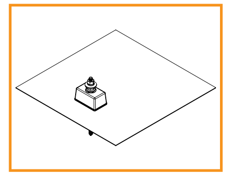
COMPOSITION SHINGLE

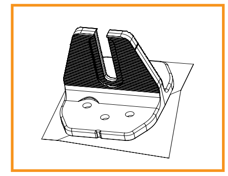

FlashFoot2


FlashVue

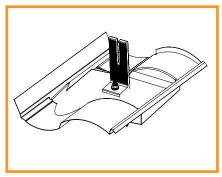

QM L-Mount

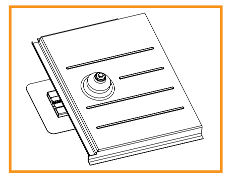

QM QBase

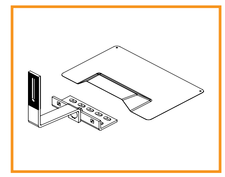

QM Classic Comp Mount

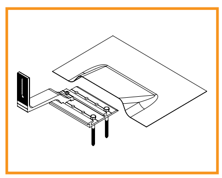

HUG (Halo UltraGrip)

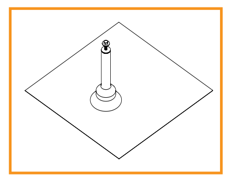
TILE

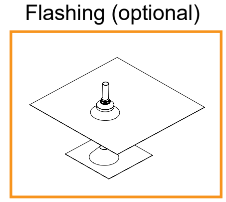

Knockout Tile


QM Tile Replacement

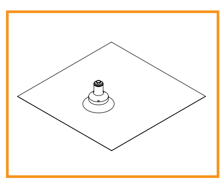

All Tile Hook and Flashing (optional)

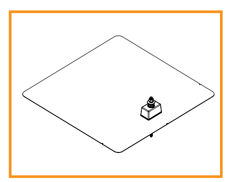

QM Quick Hook and Flashing (optional)

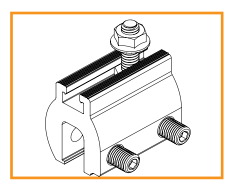

QM QBase Tile


QM Tile Conduit Penetration

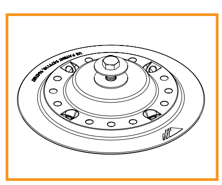
ADDITIONAL ROOF TYPES

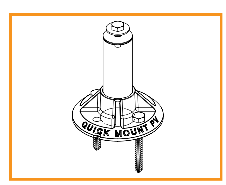

QM Qbase Shake - Slate - Metal Shingle


QM Classic Mount Shake


QM Lynx Metal Roof Attachment

LOW SLOPE ROOF


Flat Roof Attachment


QM QBase Mount

COMPONENTS

PRE-INSTALLATION

☐ Verify module compatibility. See Page 21 for info.

TOOLS REQUIRED

☐ Cordless Drill (non-impact)
☐ Impact Driver (for lag bolts)
☐ Torque Wrench (0-250 in-lbs)
☐ 7/16” Socket
☐ 1/2" Socket
☐ 9/16" Socket
☐ 7/32" Drill bit
☐ 1/8" Drill bit
☐ 1/4" Drill bit
☐ T30 Torx Bit
☐ Channel Lock Pliers
☐ #3 Phillips Bit
☐ Paddle Bit

BONDING HARDWARE TORQUE VALUES

Please refer to each attachment's individual section for full details on all torque values and instructions.

☐ Universal Fastening Object (7/16" Socket): 80 in-lbs

☐ Rail Grounding Lug Nut (7/16" Socket): 80 in-lbs

☐ Module Grounding Lug

  ☐ Grounding Nut (7/16" Socket): 60 in-lbs
  ☐ Grounding Lug Terminal Screws (7/16" Socket): 20 in-lbs

☐ Microinverter Kit Nuts (7/16" Socket): 80 in-lbs

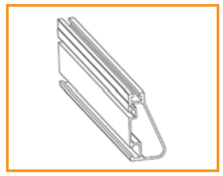
☐ Frameless Module Kit Nuts (7/16" Socket): 80 in-lbs

☐ 3/8" Bonding Hardware Nuts (7/16" Socket): 250 in-lbs

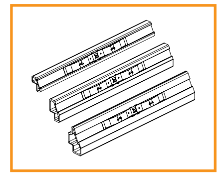
☐ Contour Clamp (T-30 Torx Bit): 80 in-lbs

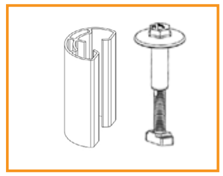
➢ **Unless otherwise noted, all components have been evaluated for multiple use. They can be uninstalled and reinstalled in the same or new location.**

COMPONENTS

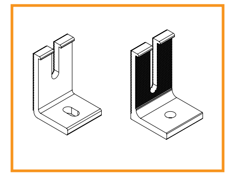

XR Rail


Wire Clip

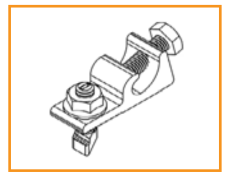

BOSS

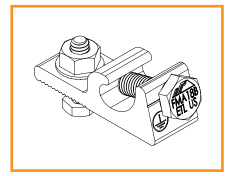

UFO and Stopper Sleeve (30-46MM)

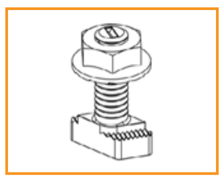

CAMO

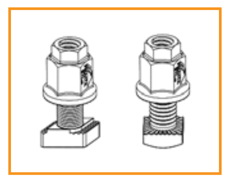

Ironridge L-Foot and QM L-Foot

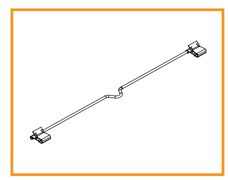
End Cap

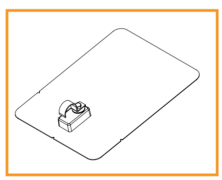

Rail Grounding Lug

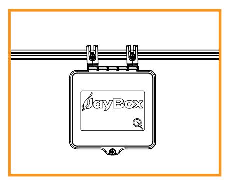

Module Grounding Lug


Microinverter Kit

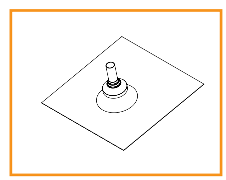

3/8" Bonding Hardware

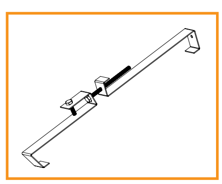

8" Bonding Jumper Single Use Only


QM Classic Conduit Comp Mount

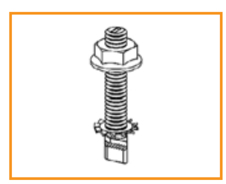


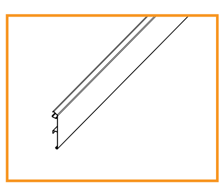
JAYBOX

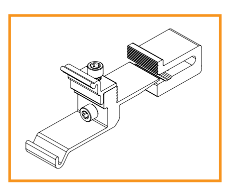

QM Composition Conduit Penetration


QM Tile Conduit Mount


Frameless End/Mid Clamp


Frameless Module Kit


Contour Trim


Contour Clamp

SILFAB COMMERCIAL

SILFAB SOLAR®

SIL-490 HN

ENGINEERED FOR COMMERCIAL & UTILITY PROJECTS

Superior performance and proven reliability from a trusted source.

TOP PERFORMER 2023 PVEL kiwa PV MODULE RELIABILITY SCORECARD

SILFABSOLAR.COM

Intertek

ELECTRICAL SPECIFICATIONS		490 HN	
Test Conditions		STC	NOCT
Module Power (Pmax)	Wp	490	362
Maximum power voltage (Vpmax)	V	45.23	41.61
Maximum power current (Ipmax)	A	10.83	8.69
Open circuit voltage (Voc)	V	53.96	49.64
Short circuit current (Isc)	A	11.36	9.12
Module efficiency	%	20.9%	19.3%
Maximum system voltage (VDC)	V	1500	
Series fuse rating	A	20	
Power Tolerance	Wp	0 to +10	

Measurement conditions: STC 1000 W/m² • AM 1.5 • Temperature 25 °C • NOCT 800 W/m² • AM 1.5 • Measurement uncertainty ≤ 3%
Sun simulator calibration reference modules from Fraunhofer Institute. Electrical characteristics may vary by ±5% and power by 0 to +10W.

MECHANICAL PROPERTIES / COMPONENTS	METRIC	IMPERIAL
Module weight	25.8kg ±0.2kg	56.9lbs ±0.4lbs
Dimensions (H x L x D)	2263 mm x 1037 mm x 35 mm	89 in x 40.8 in x 1.37 in
Maximum surface load (wind/snow)*	2400 Pa rear load / 5400 Pa front load	50.1 lb/ft² rear load / 112.8 lb/ft² front load
Hail impact resistance	ø 25 mm at 83 km/h	ø 1 in at 51.6 mph
Cells	156 Half cells - Si mono PERC 9 busbar - 83 x 166 mm	156 Half cells- Si mono PERC 9 busbar - 3.26 x 6.53 in
Glass	3.2 mm high transmittance, tempered, DSM antireflective coating	0.126 in high transmittance, tempered, DSM antireflective coating
Cables and connectors (refer to installation manual)	1350 mm, ø 5.7 mm, MC4 from Staubli	53.15 in, ø 0.22 in (12AWG), MC4 from Staubli
Backsheet	High durability, superior hydrolysis and UV resistance, multi-layer dielectric film, fluorine-free PV white backsheet	
Frame	Anodized Aluminum (Silver)	
Bypass diodes	3 diodes-30SQ045T (45V max DC blocking voltage, 30A max forward rectified current)	
Junction Box	UL 3730 Certified, IEC 62790 Certified, IP68 rated	

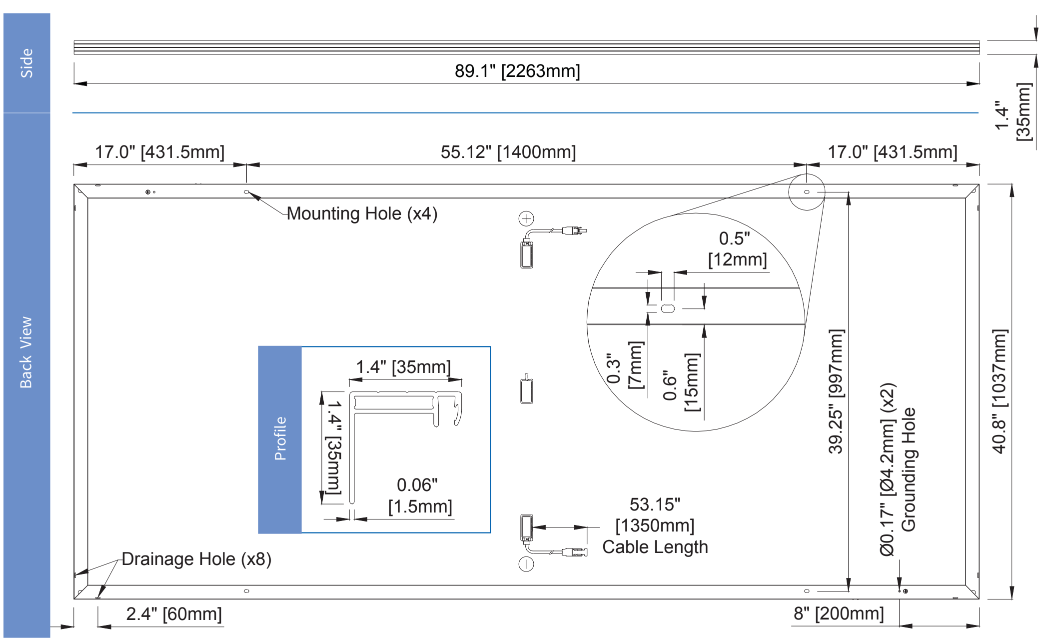
TEMPERATURE RATINGS	
Temperature Coefficient Isc	+0.064 %/°C
Temperature Coefficient Voc	-0.28 %/°C
Temperature Coefficient Pmax	-0.36 %/°C
NOCT (± 2°C)	45 °C
Operating temperature	-40/+85 °C

WARRANTIES	
Module product workmanship warranty	25 years**
Linear power performance guarantee	30 years
	≥ 97.1% end 1st yr ≥ 91.6% end 12th yr ≥ 85.1% end 25th yr ≥ 82.6% end 30th yr

CERTIFICATIONS	
Product	ULC ORD C1703, UL1703, CEC listed, UL 61215-1/-2, UL 61730-1/-2, IEC 61215-1/-2. IEC 61730-1/-2, CSA C22.2#61730-1/-2, IEC 62716 Ammonia Corrosion; IEC61701:2011 Salt Mist Corrosion Certifed, UL Fire Rating: Type 1
Factory	ISO9001:2015

SHIPPING SPECS	
Modules Per Pallet:	31
Pallets Per Truck	23
Modules Per Truck	713

* ⚠ Warning. Read the Safety and Installation Manual for mounting specifications and before handling, installing and operating modules.
** 12 year extendable to 25 years subject to registration and conditions outlined under "Warranty" at silfabsolar.com
PAN files generated from 3rd party performance data are available for download at: silfabsolar.com/downloads



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Silfab - SIL-490-HN+-20231221

Three Phase Inverter with Synergy Technology

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

INVERTER

Powered by unique pre-commissioning process for rapid system installation

- Pre-commissioning feature for automated validation of system components and wiring during the site installation process and prior to grid connection
- Easy 2-person installation with lightweight, modular design (each inverter consists of 2 or 3 Synergy units and 1 Synergy Manager)
- Independent operation of each Synergy unit enables higher uptime and easy serviceability
- Built-in thermal sensors detect faulty wiring, ensuring enhanced protection and safety
- Built-in arc fault protection and rapid shutdown
- Built-in PID mitigation for maximized system performance
- Monitored* and field-replaceable surge protection devices, to better withstand surges caused by lightning or other events
- Built-in module-level monitoring with Ethernet or cellular communication for full system visibility

*Applicable only for DC and AC SPDs

/ Three Phase Inverter with Synergy Technology

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

MODEL NUMBER	SE80KUS	SE100KUS	SE110KUS	SE120KUS	
APPLICABLE TO INVERTERS WITH PART NUMBER	SExxK-USx8Ixxxx				UNITS
OUTPUT					
Rated AC Active Output Power	80000	100000	110000	120000	W
Maximum AC Apparent Output Power	80000	100000	120000	120000	VA
AC Output Line Connections	3W + PE, 4W + PE				
Supported Grids	WYE: TN-C, TN-S, TN-C-S, TT, IT; Delta: IT				
AC Output Voltage Minimum-Nominal-Maximum[1] (L-N)	244 – 277 – 305				Vac
AC Output Voltage Minimum-Nominal-Maximum[1] (L-L)	422.5 – 480 – 529				Vac
AC Frequency Min-Nom-Max[1]	59.5 – 60 – 60.5				Hz
Maximum Continuous Output Current (per Phase, PF=1)	96.5	120	144.3		Aac
GFDI Threshold	1				A
Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds	Yes				
Total Harmonic Distortion	≤ 3				%
Power Factor Range	±0.85 to 1				
INPUT					
Maximum DC Power (Module STC) Inverter / Synergy Unit	140000 / 70000	175000 / 58300	210000 / 70000		W
Transformer-less, Ungrounded	Yes				
Maximum Input Voltage DC+ to DC-	1000				Vdc
Operating Voltage Range	850 – 1000				Vdc
Maximum Input Current	2 x 48.25	3 x 40	3 x 48.25		Adc
Reverse-Polarity Protection	Yes				
Ground-Fault Isolation Detection	167kΩ sensitivity per Synergy Unit[2]				
CEC Weighted Efficiency	98.5				%
Nighttime Power Consumption	< 8	< 12			W
ADDITIONAL FEATURES					
Supported Communication Interfaces[3]	2 x RS485, Ethernet, Wi-Fi (optional), Cellular (optional)				
Smart Energy Management	Export Limitation				
Inverter Commissioning	With the SetApp mobile application using built-in Wi-Fi access point for local connection				
Arc Fault Protection	Built-in, User Configurable (According to UL1699B)				
Photovoltaic Rapid Shutdown System	NEC 2014 – 2023, built-in				
PID Rectifier	Nighttime, built-in				
RS485 Surge Protection (ports 1+2)	Type II, field replaceable, integrated				
AC, DC Surge Protection	Type II, field replaceable, integrated				
DC Fuses (Single Pole)	25A, integrated				
DC SAFETY SWITCH					
DC Disconnect	Built-in				
STANDARD COMPLIANCE					
Safety	UL1699B, UL1741, UL1741 SA, UL1741 SB, UL1998, CSA C22.2#107.1, Canadian AFCI according to T.I.L. M-07				
Grid Connection Standards	IEEE 1547-2018, Rule 21, Rule 14 (HI)				
Emissions	FCC part 15 class A				

(1) For other regional settings please contact SolarEdge support.
(2) Where permitted by local regulations.
(3) For specifications of the optional communication options, visit the Communication product page or the Knowledge Center to download the relevant product datasheet.

/ Three Phase Inverter with Synergy Technology

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

MODEL NUMBER		SE80KUS	SE100KUS	SE110KUS	SE120KUS	UNITS
APPLICABLE TO INVERTERS WITH PART NUMBER		SExxK-USx8Ixxxx				
INSTALLATION SPECIFICATIONS						
Number of Synergy Units per Inverter		2	3			
Ac Max Conduit Size		2 ½”				in
Max AWG Line / PE		4/0 / 1/0				
DC Max Conduit Size		1 x 3"; 2 x 2"				in
DC Input Inverter/ Synergy Unit	Multi-input (SExxK-USxxxxxZ4)	8 / 4 pairs; 6-12 AWG	12 / 4 pairs; 6-12 AWG			
	Combined input (SExxK-USxxxxxW4)	2 pairs / 1 pair, Max 2 AWG; copper or aluminum	3 pairs / 1 pair, Max 2 AWG; copper or aluminum			
Dimensions (H x W x D)		Synergy Unit: 22 x 12.9 x 10.75 / 558 x 328 x 273 Synergy Manager: 14.17 x 22.4 x 11.6 / 360 x 560 x 295				in / mm
Weight		Synergy Unit: 70.4 / 32 Synergy Manager: 39.6 / 18				lb / kg
Operating Temperature Range		-40 to +140 / -40 to +60(4)				˚F / ˚C
Cooling		Fan (user replaceable)				
Noise		< 67				dBA
Protection Rating		NEMA 3R				
Mounting		Brackets provided				

(4) For power de-rating information refer to the Temperature Derating Technical Note for North America

SolarEdge is a global leader in smart energy technology. By leveraging world-class engineering capabilities and with a relentless focus on innovation, SolarEdge creates smart energy solutions that power our lives and drive future progress.

SolarEdge developed an intelligent inverter solution that changed the way power is harvested and managed in photovoltaic (PV) systems. The SolarEdge DC optimized inverter maximizes power generation while lowering the cost of energy produced by the PV system.

Continuing to advance smart energy, SolarEdge addresses a broad range of energy market segments through its PV, storage, EV charging, UPS, and grid services solutions.

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solaredge.com

Cautionary Note Regarding Market Data and Industry Forecasts: This brochure may contain market data and industry forecasts from certain third-party sources. This information is based on industry surveys and the preparer's expertise in the industry and there can be no assurance that any such market data is accurate or that any such industry forecasts will be achieved. Although we have not independently verified the accuracy of such market data and industry forecasts, we believe that the market data is reliable and that the industry forecasts are reasonable.

CE

Power Optimizer

P605 / P650 / P701 / P730 / P800p /
P801 / P850 / P950 / P1100

25
YEAR
WARRANTY

POWER OPTIMIZER

PV power optimization at the module level

The most cost-effective solution for commercial and large field installations

- Specifically designed to work with SolarEdge inverters
- High efficiency with module-level MPPT, for maximized system energy production and revenue, and fast project ROI
- Superior efficiency (99.5%)
- Balance of System cost reduction; 50% less cables, fuses, and combiner boxes, and over 2x longer string lengths possible
- Fast installation with a single bolt
- Advanced maintenance with module level monitoring
- Module level voltage shutdown for installer and firefighter safety
- Use with two PV modules connected in series or in parallel

/ Power Optimizer

P605 / P650 / P701 / P730 / P801

Power Optimizer Module (Typical Module Compatibility)	P605 (for 1 x high power PV module)	P650 (for up to 2 x 60-cell PV modules)	P701 (for up to 2 x 60/120-cell PV modules)	P730 (for up to 2 x 72-cell PV modules)	P801 (for up to 2 x 72/144 cell PV modules)	
INPUT						
Rated Input DC Power[1]	605	650	700*	730**	800	W
Connection Method	Single input for series connected modules					
Absolute Maximum Input Voltage (Voc at lowest temperature)	65	96		125		Vdc
MPPT Operating Range	12.5 – 65	12.5 – 80		12.5 – 105		Vdc
Maximum Short Circuit Current per Input (Isc)	14.1	11	11.75	11**	12.5***	Adc
Maximum Efficiency	99.5					%
Weighted Efficiency	98.6					%
Overvoltage Capacity	II					
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER						
Maximum Output Current	15					Adc
Maximum Output Voltage	80					Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM SOLAREDGE INVERTER OR SOLAREDGE INVERTER OFF						
Safety Output Voltage per Power Optimizer	1 ± 0.1					Vdc
STANDARD COMPLIANCE						
EMC	FCC Part 15 Class B, IEC61000-6-2, IEC61000-6-3					
Safety	IEC62109-1 (class II safety)					
RoHS	Yes					
Fire Safety	VDE-AR-E2100-712:2013-05					
INSTALLATION SPECIFICATIONS						
Compatible SolarEdge Inverters	Three Phase Inverter SE16K & larger					
Maximum Allowed System Voltage	1000					Vdc
Dimensions (W x L x H)	129 x 153 x 52 / 5.1 x 6 x 2	129 x 153 x 42.5 / 5.1 x 6 x 1.7		129 x 153 x 49.5 / 5.1 x 6 x 1.9		mm / in
Weight	1064 / 2.3	834 / 1.8		933 / 2.1		gr / lb
Input Connector	MC4[2]					
Input Wire Length	0.16 / 0.52			0.16 / 0.52, 0.9 / 2.95[3]		m / ft
Output Connector	MC4					
Output Wire Length	Portrait Orientation: 1.4 / 4.5	Portrait Orientation: 1.2 / 3.9	-	Portrait Orientation: 1.2 / 3.9		m / ft
	-	Landscape Orientation: 1.8 / 5.9		Landscape Orientation: 2.2 / 7.2		
Operating Temperature Range[6]	-40 to +85 / -40 to +185					ºC / ºF
Protection Rating	IP68 / NEMA6P					
Relative Humidity	0 – 100					%

* For P701 models manufactured after work week 06/2020, the rated DC input is 740W.
** For P730 models manufactured after work week 06/2020, the rated DC input is 760W and the maximum Isc per input is 11.75A.
*** For P801 models manufactured in work week 40/2020 or earlier, the maximum Isc per input in 11.75A.
(1) The rated power of the module at STC will not exceed the Power Optimizer "Rated Input DC Power". Modules with up to +5% power tolerance are allowed.
(2) For other connector types, please contact SolarEdge.
(3) Longer input wire lengths are available for use with split junction box modules. For 0.9m/2.95ft order P730-xxxLxxx.
(4) For ambient temperatures above +70ºC / +158ºF, power de-rating is applied. Refer to Power Optimizers Temperature De-Rating Technical Note for more details.

PV System Design Using a SolarEdge Inverter[5][6][7][8]		230/400V Grid SE16K, SE17 SE25K*, SE33.3K*		230/400V Grid SE27.6K*		230/400V Grid SE30K*		277/480V Grid SE33.3K*, SE40K*		
Compatible Power Optimizers		P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	
Minimum String Length	Power Optimizers	14	14	14	14	15	15	14	14	
	PV Modules	14	27	14	27	15	29	14	27	
Maximum String Length	Power Optimizers	30	30	30	30	30	30	30	30	
	PV Modules	30	60	30	60	30	60	30	60	
Maximum Continuous Power per String		11250		11625		12750		12750		W
Maximum Allowed Connected Power per String[8] (Permitted only when the difference in connected power between strings is 2,000W or less)		13500		13500		15000		15000		W
Parallel Strings of Different Lengths or Orientations		Yes								
Maximum Difference in Number of Power Optimizers Allowed Between the Shortest and Longest String Connected to the Same Inverter Unit		5 Power Optimizers								

* The same rules apply for Synergy units of equivalent power ratings that are part of the modular Synergy Technology Inverter.
(5) P650/P701/P730/P801 can be mixed in one string only with P650/P701/P730/P801. P605 cannot be mixed with any other Power Optimizer in the same string.
(6) For each string, a Power Optimizer may be connected to a single PV module if 1) each Power Optimizer is connected to a single PV module or 2) it is the only Power Optimizer connected to a single PV module in the string.
(7) For SE16K and above, the minimum STC DC connected power should be 11KW.
(8) To connect more STC power per string, design your project using SolarEdge Designer.

Power Optimizer

P800p / P850 / P950 / P1100

Power Optimizer Module (Typical Module Compatibility)	P800p (for up to 2 x 96-cell 5'' PV modules)	P850 (for up to 2 x high power or bi-facial modules)	P950 (for up to 2 x high power or bi-facial modules)	P1100 (for up to 2 x high power or bi-facial modules)	Unit
INPUT					
Rated Input DC Power[1]	800	850	950	1100	W
Connection Method	Dual input for independently connected	Single input for series connected modules			
Absolute Maximum Input Voltage (Voc at lowest temperature)	83	125			Vdc
MPPT Operating Range	12.5 – 83	12.5 – 105			Vdc
Maximum Short Circuit Current per Input (Isc)	7	14.1*		14.1	Adc
Maximum Efficiency	99.5				%
Weighted Efficiency	98.6				%
Overvoltage Capacity	II				
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER					
Maximum Output Current	18				Adc
Maximum Output Voltage	80				Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM SOLAREDGE INVERTER OR SOLAREDGE INVERTER OFF					
Safety Output Voltage per Power Optimizer	1 ± 0.1				Vdc
STANDARD COMPLIANCE					
EMC	FCC Part 15 Class B, IEC61000-6-2, IEC61000-6-3				
Safety	IEC62109-1 (class II safety)				
RoHS	Yes				
Fire Safety	VDE-AR-E2100-712:2013-05				
INSTALLATION SPECIFICATIONS					
Compatible SolarEdge Inverters	Three Phase Inverter SE16K & larger			Three Phase Inverter SE25K & larger	
Maximum Allowed System Voltage	1000				Vdc
Dimensions (W x L x H)	129 x 168 x 59 / 5.1 x 6.61 x 2.32	129 x 162 x 59 / 5.1 x 6.4 x 2.32			mm / in
Weight	1064 / 2.3				gr / lb
Input Connector	MC4[2]				
Input Wire Length	0.16 / 0.52	0.16 / 0.52, 0.9 / 2.95, 1.3 / 4.26, 1.6 / 5.24[3]	0.16 / 0.52, 1.3 / 4.26, 1.6 / 5.24[3]	0.16 / 0.52, 1.3 / 4.26[3]	m / ft
Output Connector	MC4				
Output Wire Length	Portrait Orientation: 1.2 / 3.9			2.4 / 7.8	m / ft
	Landscape Orientation: 1.8 / 5.9	Landscape Orientation: 2.2 / 7.2			
Operating Temperature Range[4]	-40 to +85 / -40 to +185				ºC / ºF
Protection Rating	IP68 / NEMA6P				
Relative Humidity	0 – 100				%

* For P850/P950 models manufactured in work week 06/2020 or earlier, the maximum Isc per input is 12.5A. The manufacture code is indicated in the Power Optimizer's serial number. Example: S/N SJ0620A-xxxxxxxx (work week 06 in 2020)

(1) The rated power of the module at STC will not exceed the Power Optimizer "Rated Input DC Power". Modules with up to +5% power tolerance are allowed.

(2) For other connector types, please contact SolarEdge.

(3) Longer input wire lengths are available for use with split junction box modules. For 0.9m/2.95ft order P801/P850-xxxLxxx. For 1.3m/2.95ft order P850/P950/P1100 -xxxXxxx. For 1.6m/5.24ft order P850/P950-xxxYxxx).

(4) For ambient temperatures above +70ºC / +158ºF, power de-rating is applied. Refer to Power Optimizers Temperature De-Rating Technical Note for more details.

PV System Design Using a SolarEdge Inverter[5][6][7][8]		230/400V Grid SE16K, SE17K	230/400V Grid SE25K*	230/400V Grid SE27.6K*	230/400V Grid SE30K*	230/400V Grid SE33.3K	277/480V Grid SE33.3K*, SE40K*	
Compatible Power Optimizers		P800p, P850, P950	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	
Minimum String Length	Power Optimizers	14	14	14	15	14	14	
	PV Modules	27	27	27	29	27	27	
Maximum String Length	Power Optimizers	30	30	30	30	30	30	
	PV Modules	60	60	60	60	60	60	
Maximum Continuous Power per String		13500	13500	13950	15300	13500	15300	W
Maximum Allowed Connected Power per String[8] (Permitted only when the difference in connected power between strings is 2,000W or less)		1 string – 15750	1 string – 15750	1 string – 16200	1 string – 17550	2 strings or less – 15750	2 strings or less – 17550	W
		2 strings or more – 18500	2 strings or more – 18500	2 strings or more – 18950	2 strings or more – 20300	3 strings or more – 18500	3 strings or more – 20300	
Parallel Strings of Different Lengths or Orientations		Yes						
Maximum Difference in Number of Power Optimizers Allowed Between the Shortest and Longest String Connected to the Same Inverter Unit		5 Power Optimizers						

* The same rules apply for Synergy units of equivalent power ratings that are part of the modular Synergy Technology Inverter.

(5) P800p/P850/P950/P1100 can be mixed in one string only with P800p/P850/P950/P1100.

(6) For each string, a Power Optimizer may be connected to a single PV module if 1) each Power Optimizer is connected to a single PV module or 2) it is the only Power Optimizer connected to a single PV module in the string.

(7) For SE16K and above, the minimum STC DC connected power should be 11KW.

(8) To connect more STC power per string, design your project using SolarEdge Designer.

SolarEdge is a global leader in smart energy technology. By leveraging world-class engineering capabilities and with a relentless focus on innovation, SolarEdge creates smart energy solutions that power our lives and drive future progress.

SolarEdge developed an intelligent inverter solution that changed the way power is harvested and managed in photovoltaic (PV) systems. The SolarEdge DC optimized inverter maximizes power generation while lowering the cost of energy produced by the PV system.

Continuing to advance smart energy, SolarEdge addresses a broad range of energy market segments through its PV, storage, EV charging, UPS, and grid services solutions.

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CE

US Made

IRONRIDGE

Accelerate Solar with Domestic Content

IronRidge offers racking systems that use 100% domestically-produced components. Our products made in the United States include: XR10 Rails, XR100 Rails, HUG Roof Attachment, Comp Shingle Flashing, and the BX Ballasted System.

To meet the qualifying criteria for tax credit incentives, solar projects must use a combination of modules, MLPE and racking with a minimum aggregate threshold of 40% Domestic Content.

Pathway to 40+

NO NEED TO SETTLE

Pick reputable products that your crews like installing. Our offerings are listed to UL 2703 and UL 3741, tested rigorously, and manufactured to the highest quality standards.

DO YOUR HOMEWORK

Are you a financier or work with one? Understand terms and definitions. Obtain letters from the manufacturer documenting their position to share with your tax and legal counsel.

STACK MANUFACTURERS

Our partnerships with the leading inverter manufacturers allow multiple avenues for you to reach 40% in 2024 and 45% in 2025. See next page for the current list of domestic content.

Avoid the Pitfalls

READ THE FINE PRINT

Ensure you qualify. Only finance companies offering third-party-owned systems are eligible, not installation companies or homeowners. Consult a legal professional for guidance.

BE FULLY PREPARED

Audits by Financiers, Commercial Project Owners, and the IRS are serious business. Ensure that your manufacturing partners can help you navigate any potential oversight.

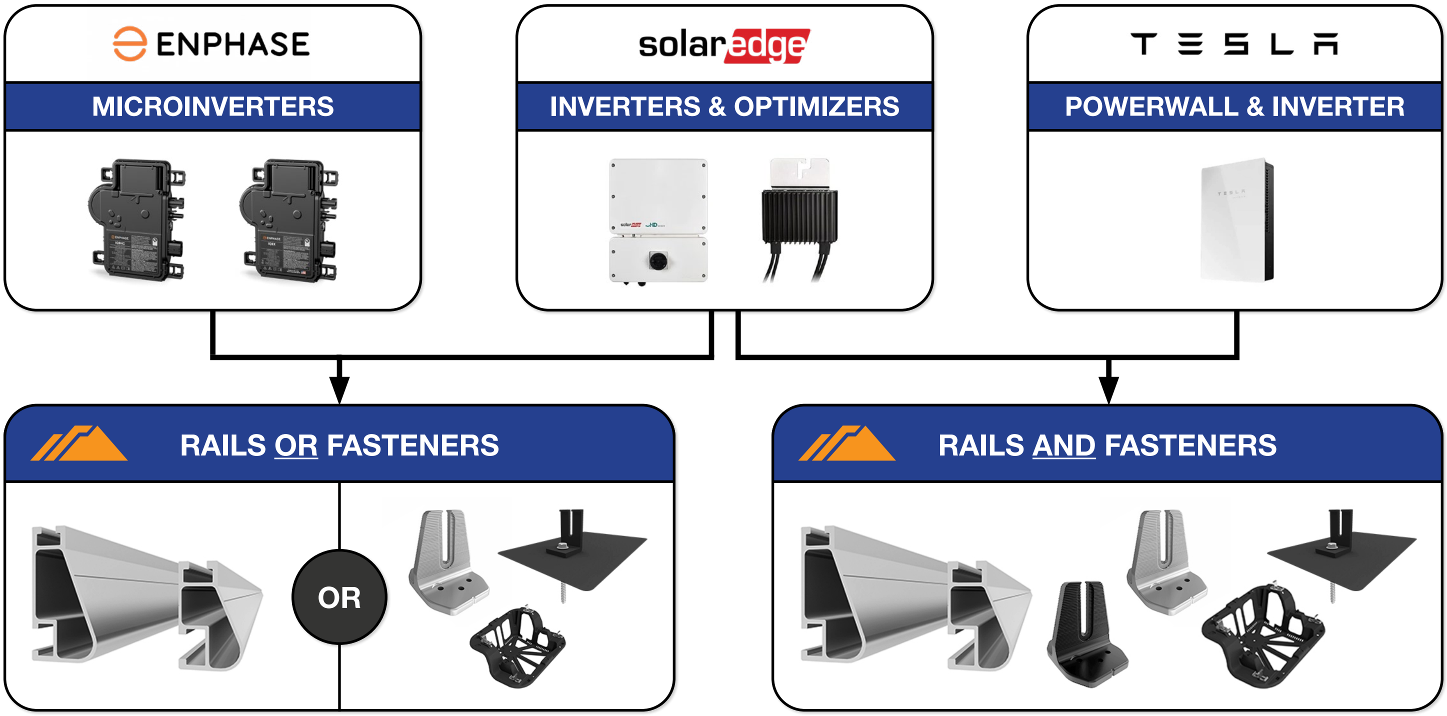
STAY IN THE KNOW

New information is coming out regularly. We promise to keep our customers posted. Scan the QR code below to visit our page dedicated to Domestic Content details.

Scan the QR code to visit our page dedicated to Domestic Content: IronRidge.com/DC

IronRidge does not provides tax, legal or accounting advice. This material has been prepared for informational purposes only and is not intended to be relied upon in place of professional advice. You should consult your own advisors before engaging in any transaction.

Pathways to 40-45% Domestic Content



Not all domestic products shown.

Residential Products

Maker	Type	Part Number
Enphase	Inverters	**IQ8HC-72-M-DOM-US IQ8X-80-M-DOM-US IQ8HC-72-M-US**
SolarEdge	Inverters	**SE3800H-USMNUBL75 SE5700H-USMNUBL75 SE7600H-USMNUBL75 SE10000H-USMNUBL75 SE11400H-USMNUBL75 USE3800H-USMNUBL75 USE5700H-USMNUBL75 USE7600H-USMNUBL75 USE10000H-USMNUBL75 USE11400H-USMNUBL75**
	Optimizers	**U650-1GM4MRMU**
Tesla	Inverters	**1538000-45-X**
IronRidge	Rails	**XR-10-168M-US XR-10-168B-US XR-100-168M-US XR-100-168B-US**
	Fasteners	**LFT-FLSH03-B1-US FLSH-01-B1-US QM-HUG-01-M1-US QM-HUG-01-B1-US**

Commercial Products

Maker	Type	Part Number
Enphase	Inverters	**IQ8P-3P-72-DOM-US**
SolarEdge	3-Phase Inverters	**USE-SIN-USR0IBNx6**
	Synergy Managers	**SE-DBL-US00IBNx6 SE-TRI-US00IBNx6**
	Synergy Units	**USESUK-USR0INNN6**
	Optimizer	**C651U-1GMVMRRU C652U-1GMVMRRU**
IronRidge	Rails & Fasteners	**Same As Residential**
	BX Ballasted System	**BX-5D-P1 BX-10D-P1 BX-TCL-30MM-M1 BX-TCL-32MM-M1 BX-TCL-35MM-M1 BX-TCL-38MM-M1 BX-TCL-40MM-M1 BX-TCL-40MM-M1 BX-TCL-46MM-M1**

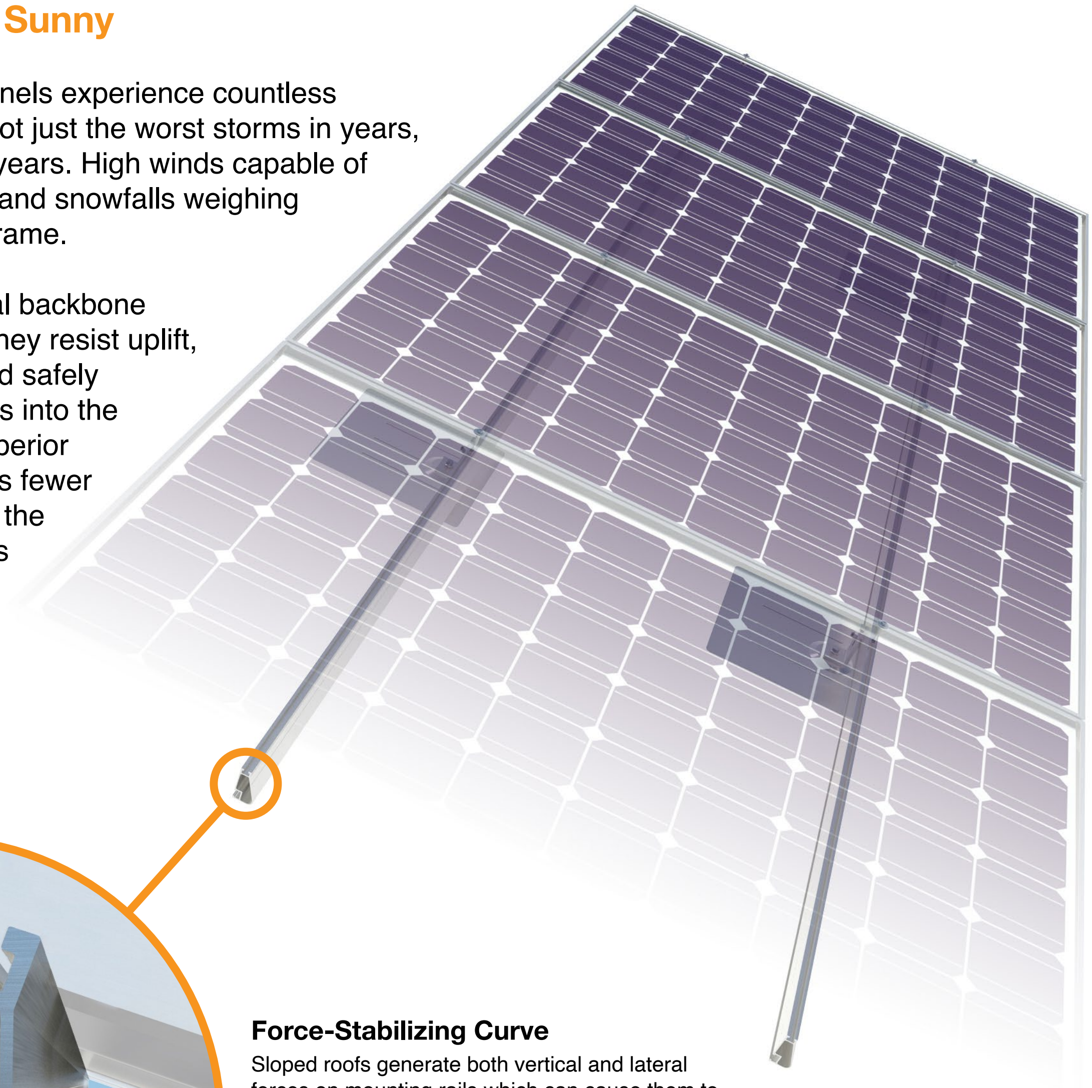
IRONRIDGE

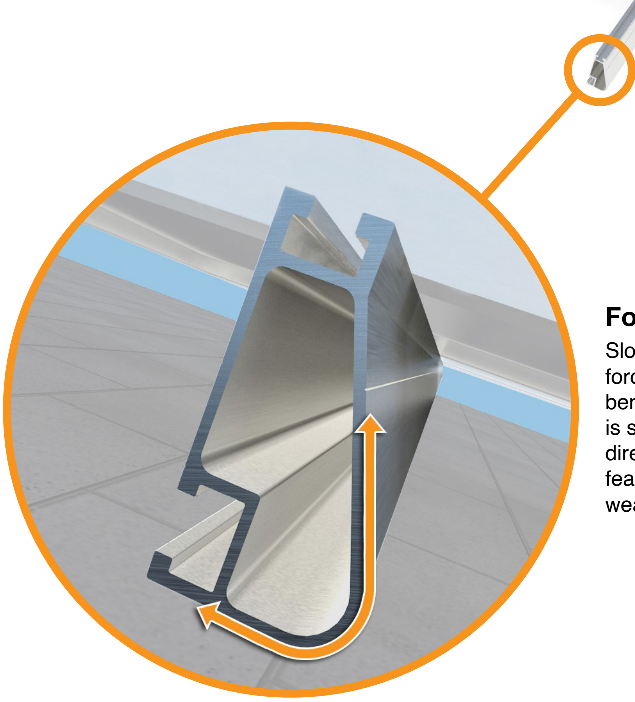
XR Rail® Family

Solar Is Not Always Sunny

Over their lifetime, solar panels experience countless extreme weather events. Not just the worst storms in years, but the worst storms in 40 years. High winds capable of ripping panels from a roof, and snowfalls weighing enough to buckle a panel frame.

XR Rails® are the structural backbone preventing these results. They resist uplift, protect against buckling and safely and efficiently transfer loads into the building structure. Their superior spanning capability requires fewer roof attachments, reducing the number of roof penetrations and the amount of installation time.





Force-Stabilizing Curve

Sloped roofs generate both vertical and lateral forces on mounting rails which can cause them to bend and twist. The curved shape of XR Rails® is specially designed to increase strength in both directions while resisting the twisting. This unique feature ensures greater security during extreme weather and a longer system lifetime.

Compatible with Flat & Pitched Roofs

XR Rails® are compatible with FlashFoot® and other pitched roof attachments.

IronRidge® offers a range of tilt leg options for flat roof mounting applications.

Corrosion-Resistant Materials

All XR Rails® are made of 6000-series aluminum alloy, then protected with an anodized finish. Anodizing prevents surface and structural corrosion, while also providing a more attractive appearance.

XR Rail® Family

The XR Rail® Family offers the strength of a curved rail in three targeted sizes. Each size supports specific design loads, while minimizing material costs. Depending on your location, there is an XR Rail® to match.

XR10

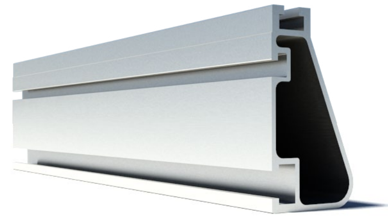
XR10 is a sleek, low-profile mounting rail, designed for regions with light or no snow. It achieves spans up to 6 feet, while remaining light and economical.

- 6' spanning capability
- Moderate load capability
- Clear & black anodized finish
- Internal splices available

XR100

XR100 is a residential and commercial mounting rail. It supports a range of wind and snow conditions, while also maximizing spans up to 10 feet.

- 10' spanning capability
- Heavy load capability
- Clear & black anodized finish
- Internal splices available



XR1000

XR1000 is a heavyweight among solar mounting rails. It's built to handle extreme climates and spans up to 12 feet for commercial applications.

- 12' spanning capability
- Extreme load capability
- Clear anodized finish
- Internal splices available

Rail Selection

The table below was prepared in compliance with applicable engineering codes and standards.* Values are based on the following criteria: ASCE 7-16, Gable Roof Flush Mount, Roof Zones 1 & 2e, Exposure B, Roof Slope of 8 to 20 degrees and Mean Building Height of 30 ft. Visit IronRidge.com for detailed certification letters.

Load		Rail Span					
Snow (PSF)	Wind (MPH)	4'	5' 4"	6'	8'	10'	12'
None	90						
	120						
	140	XR10		XR100		XR1000	
	160						
20	90						
	120						
	140						
	160						
30	90						
	160						
40	90						
	160						
80	160						
120	160						

ASCE Conditions
20PSF Snow, 98MPH Wind

*Table is meant to be a simplified span chart for conveying general rail capabilities. Use approved certification letters for actual design guidance.

S-5!®

The Right Way!®

S-5-Z and S-5-Z Mini

The right way to attach almost anything to metal roofs!

S-5-Z Clamp

The S-5-Z clamp is specially developed to fit profiles having a round "bulb" seam configuration. Its two-piece design allows it to be easily installed anywhere along the length of the rib. The S-5-Z is perfect for use with S-5!® ColorGard® snow retention system and other heavy-duty applications.

Installation is as simple as placing the clamp on the seam, positioning the insert piece, and tightening the patented round-point setscrews to the specified tension. Then, affix ancillary items using the bolt provided. Go to www.S-5.com/tools for information and tools available for properly attaching and tensioning S-5! clamps.

S-5-Z Mini Clamp

The S-5-Z Mini is a medium-duty, non-penetrating seam clamp and is a bit shorter than the S-5-Z and has one setscrew rather than two. The mini is the choice for attaching all kinds of rooftop accessories: signs, walkways, satellite dishes, antennas, rooftop lighting, lightning protection systems, solar arrays, exhaust stack bracing, conduit, condensate lines, mechanical equipment—just about anything!*

The S-5-Z clamp is specially developed to fit profiles having a round "bulb" seam configuration.

*S-5! mini clamps are not compatible with, and should not be used with, S-5! SnoRail™/SnoFence™ or ColorGard® snow retention systems.

888-825-3432 | www.S-5.com | MADE IN THE USA

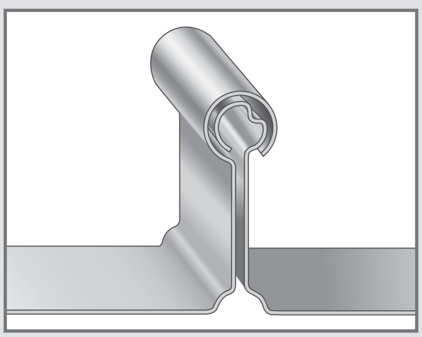
S-5! The Right Way!®

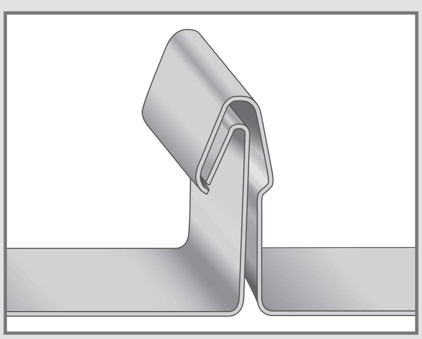
The strength of the S-5-Z clamp is in its simple design. The patented setscrews will slightly dimple the metal seam material but will not puncture it—leaving roof warranties intact.

The **S-5-Z and S-5-Z Mini clamps** are each furnished with the hardware shown to the right. Each box also includes a bit tip for tightening setscrews using an electric screw gun. A structural aluminum attachment clamp, the S-5-Z is compatible with most common metal roofing materials excluding copper. All included hardware is stainless steel. Please visit **www.S-5.com** for more information including CAD details, metallurgical compatibilities, and specifications.

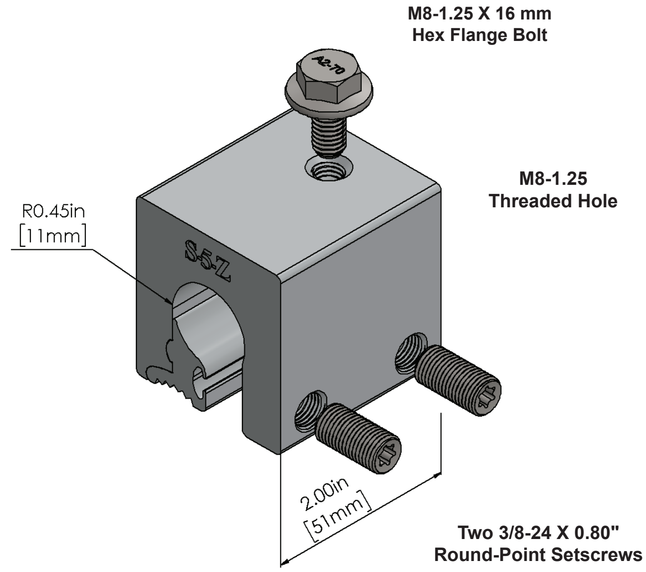
The S-5-Z clamp has been tested for load-to-failure results on a variety of bulb shaped standing seam roof profiles from leading manufacturers of panels. The independent lab test reports found on our website at www.S-5.com prove that S-5!® holding strength is unmatched in the industry.

Example Profiles

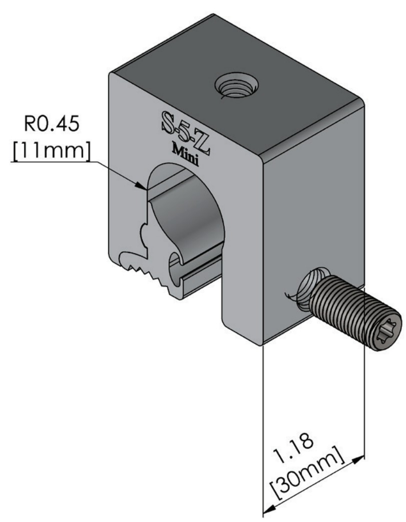




S-5-Z Clamp



S-5-Z Mini Clamp



Please note: All measurements are rounded to the second decimal place.

S-5!® Warning! Please use this product responsibly!

Products are protected by multiple U.S. and foreign patents. Visit the website at www.S-5.com for complete information on patents and trademarks. For maximum holding strength, setscrews should be tensioned and re-tensioned as the seam material compresses. Clamp setscrew tension should be verified using a calibrated torque wrench between 160 and 180 inch pounds when used on 22ga steel, and between 130 and 150 inch pounds for all other metals and thinner gauges of steel. Consult the S-5! website at www.S-5.com for published data regarding holding strength.

Distributed by

Cost Estimate - Shilshole Bay Marina - A-1 Admin Building (99.0 kW-DC)

Item	Unit Cost	Qty	Cost with Markup	$/Watt	Source
PV Modules (Sil-490 HN)	$ 404	202	$ 93,849	$ 0.95	Online price with 15% shipping and contractor markup
PV Racking (IronRidge Flush Mount XR)	$ 18,744	1	$ 21,556	$ 0.22	MSRP with 15% shipping and contractor markup
SolarEdge P1100 Optimizers	$ 121	104	$ 14,472	$ 0.15	Online price with 15% shipping and contractor markup
SolarEdge SE80KUS Inverter (2x secondary units, 1x primary unit)	$ 4,531	1	$ 5,211	$ 0.05	Online price with 15% shipping and contractor markup
Sub-Total Material Costs			**$ 135,088**	**$ 1.36**	

Item	Unit Cost	Qty	Cost	$/Watt	Source
BOS (Conduit, cable, plumbing, etc.)	15%	-	$ 20,263	$ 0.20	Percentage of material costs based on project scope and complexity
Site Work (Trenching, pads, fence, sidewalk restoration, etc.)	$ -	1	$ -	$ -	Allowance based on project scope
Total Direct Costs			**$ 155,351**	**$ 1.57**	
Contractor Design, Engineering, Permitting	8%	-	$ 10,807	$ 0.11	Typical as percentage of material costs
Contractor PM	10%	-	$ 13,509	$ 0.14	Typical as percentage of material costs
Contractor Labor	20%	-	$ 27,018	$ 0.27	Typical as percentage of material costs, prevailing wage for ITC credits
Sales Tax (Battery Equipment Only)	10.3%	-	$ -	$ -	City of Seattle Sales Tax Inclusive of state rate
Sub-Total			**$ 206,684**	**$ 2.09**	
Contingency	10%	-	$ 20,668		Typical as percentage of subtotal construction costs
Sub-Total			**227,353**	**$ 2.30**	
Escalation to midpoint of 2025	2.0%	-	**4,547**		
Total Construction Costs			**231,900**	**$ 2.34**	
Port of Seattle - Maritime Overhead Premium	25.1%	-	$ 58,207		Overhead rate provided by Port Staff
Total Project Costs			**$ 290,106**	**$ 2.93**	
System Size (W-DC)			**99,000**	**Wat**	

Appendix E

Terminal 91 – C-175 Documents

C-175 Commercial Update Final POS Solar - Pier 91, Smith Cove park

Report

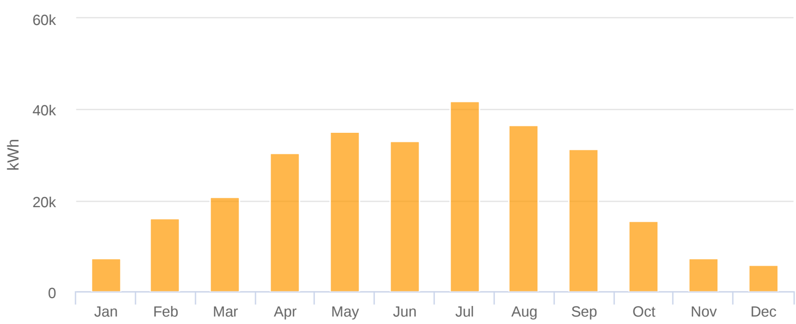
Project Name	POS Solar - Pier 91
Project Address	Smith Cove park
Prepared By	Sazan Group ses-marketing@sazan.com

System Metrics

Design	C-175 Commercial Update Final
Module DC Nameplate	255.3 kW
Inverter AC Nameplate	200.0 kW Load Ratio: 1.28
Annual Production	281.1 MWh
Performance Ratio	84.3%
kWh/kWp	1,101.2
Weather Dataset	TMY, SEATTLE BOEING FIELD [ISIS], NSRDB (tmy3, II)
Simulator Version	a941c5f9fb-ade56fb481-909d0b3577-e4292083fd

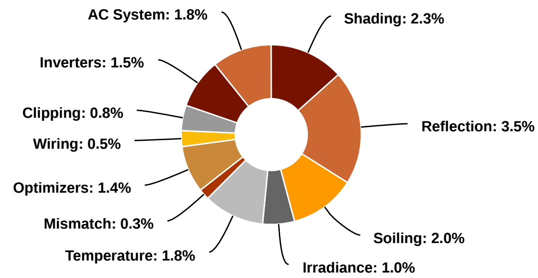
Project Location

Monthly Production



Month	GHI (kWh/m²)	POA (kWh/m²)	Shaded (kWh/m²)	Nameplate (kWh)	Grid (kWh)
January	29.3	33.5	31.7	7,545.4	7,295.7
February	60.0	72.6	70.6	16,833.0	16,115.9
March	84.9	93.7	91.8	22,089.3	20,823.2
April	130.0	138.4	135.8	32,818.1	30,356.0
May	157.6	162.9	160.0	38,756.5	35,153.8
June	151.5	154.7	151.9	36,814.2	33,164.6
July	193.8	199.6	196.3	47,673.2	41,813.8
August	160.9	171.3	168.4	40,841.0	36,498.1
September	130.4	146.8	143.7	34,666.0	31,426.2
October	61.8	70.7	69.0	16,534.8	15,490.7
November	29.1	33.2	31.6	7,543.0	7,177.7
December	23.0	28.1	25.4	6,037.3	5,812.5

Sources of System Loss



Annual Production

	Description	Output	% Delta
Irradiance (kWh/m^2)	Annual Global Horizontal Irradiance	1,212.3	
	POA Irradiance	1,305.7	7.7%
	Shaded Irradiance	1,276.3	-2.3%
	Irradiance after Reflection	1,232.1	-3.5%
	Irradiance after Soiling	1,207.5	-2.0%
	Total Collector Irradiance	**1,207.4**	**0.0%**
Energy (kWh)	Nameplate	308,151.9	
	Output at Irradiance Levels	305,193.2	-1.0%
	Output at Cell Temperature Derate	299,588.5	-1.8%
	Output After Mismatch	298,609.6	-0.3%
	Optimizer Output	294,358.5	-1.4%
	Optimal DC Output	292,951.0	-0.5%
	Constrained DC Output	290,691.1	-0.8%
	Inverter Output	286,302.4	-1.5%
	Energy to Grid	**281,128.3**	**-1.8%**
Temperature Metrics			
	Avg. Operating Ambient Temp		14.0 °C
	Avg. Operating Cell Temp		21.1 °C
Simulation Metrics			
	Operating Hours		4265
	Solved Hours		4265

Condition Set

Description	Condition Set 2 Ground
Weather Dataset	TMY, SEATTLE BOEING FIELD [ISIS], NSRDB (tmy3, II)
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
East-West	-3.56	-0.075	3°C
Carport	-3.56	-0.075	3°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
SIL-490 HN (2022) (Silfab Solar)	HelioScope	Spec Sheet Characterization, PAN

Component Characterizations

Device	Uploaded By	Characterization
SE100KUS (SolarEdge)	HelioScope	Spec Sheet
P1100 (SolarEdge)	HelioScope	Mfg Spec Sheet

Components

Component	Name	Count
Inverters	SE100KUS (SolarEdge)	2 (200.0 kW)
AC Panels	2 input AC Panel	1
AC Home Runs	1/0 AWG (Copper)	2 (91.9 ft)
AC Home Runs	350 MCM (Copper)	1 (2,314.1 ft)
Strings	10 AWG (Copper)	17 (5,610.3 ft)
Optimizers	P1100 (SolarEdge)	266 (292.6 kW)
Module	Silfab Solar, SIL-490 HN (2022) (490W)	521 (255.3 kW)

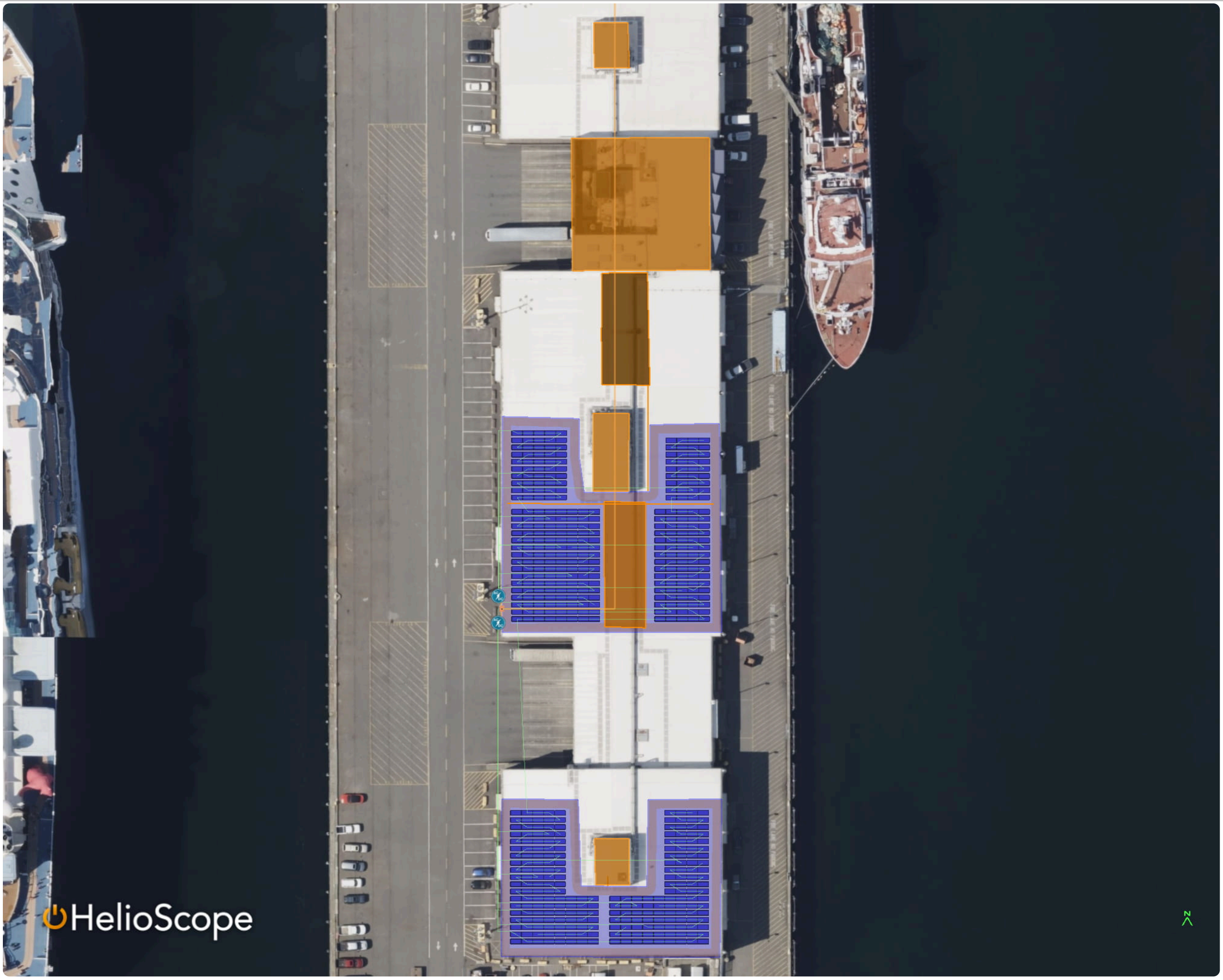
Wiring Zones

Description	Combiner Poles	String Size	Stringing Strategy
Wiring Zone	-	13-31	Along Racking

Field Segments

Description	Racking	Orientation	Tilt	Azimuth	Intrarow Spacing	Frame Size	Frames	Modules	Power
Middle 1	Fixed Tilt	Landscape (Horizontal)	Module: 10°	Module: 180°	1.5 ft	1x1	294	294	144.1 kW
Middle 2 (copy)	Fixed Tilt	Landscape (Horizontal)	Module: 10°	Module: 180°	1.5 ft	1x1	227	227	111.2 kW

Detailed Layout2



C-175 Commercial Update Final POS Solar - Pier 91, Smith Cove park

Shading Heatmap

Shading by Field Segment

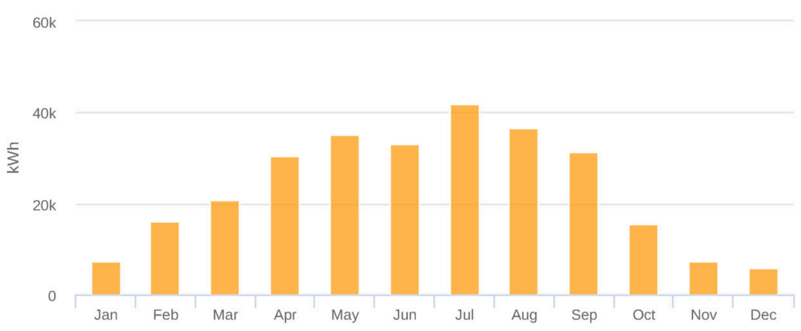
Description	Tilt	Azimuth	Modules	Nameplate	Shaded Irradiance	AC Energy	TOF[2]	Solar Access	Avg TSRF [2]
Middle 1	Module: 10.0°	Module: 180.0°	294	144.1 kWp	1,282.3kWh/m²	159.3 MWh[1]	92.6%	98.2%	90.9%
Middle 2 (copy)	Module: 10.0°	Module: 180.0°	227	111.2 kWp	1,268.5kWh/m²	121.9 MWh[1]	92.6%	97.2%	90.0%
Totals, weighted by kWp			**521**	**255.3 kWp**	**1,276.3kWh/m²**	**281.1 MWh**	**92.6%**	**97.7%**	**90.5%**

[1] approximate, varies based on inverter performance
[2] based on location Optimal POA Irradiance of 1,409.9kWh/m² at 35.6° tilt and 186.5° azimuth

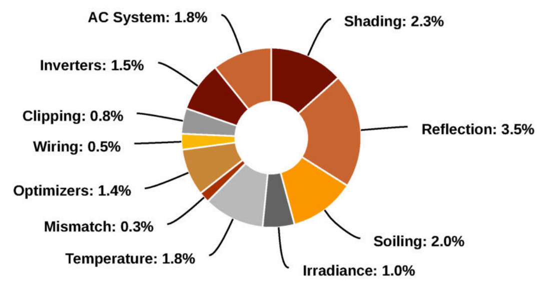
Solar Access by Month

Description	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Middle 1	95%	98%	98%	98%	99%	99%	99%	99%	99%	98%	96%	91%
Middle 2 (copy)	94%	96%	97%	98%	98%	98%	98%	98%	97%	97%	95%	90%
Solar Access, weighted by kWp	**94.4%**	**97.2%**	**98.0%**	**98.1%**	**98.2%**	**98.2%**	**98.3%**	**98.3%**	**97.9%**	**97.7%**	**95.3%**	**90.4%**
AC Power (kWh)	**7,295.7**	**16,115.9**	**20,823.2**	**30,356.0**	**35,153.8**	**33,164.6**	**41,813.8**	**36,498.1**	**31,426.2**	**15,490.7**	**7,177.7**	**5,812.5**

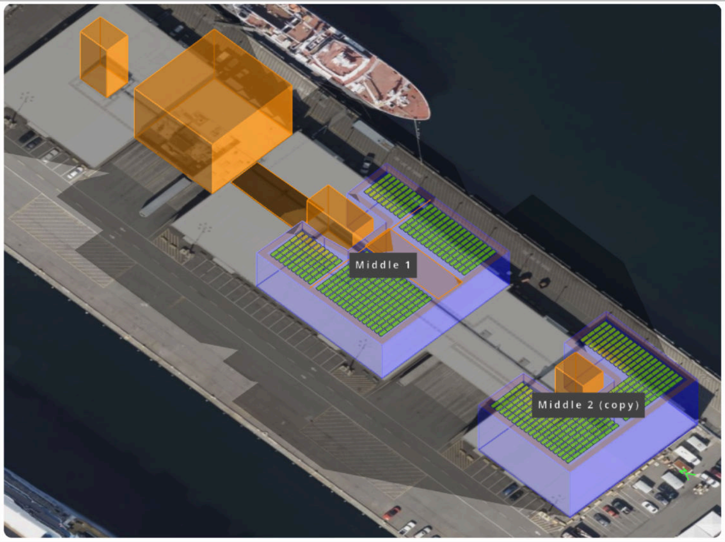
Monthly Production



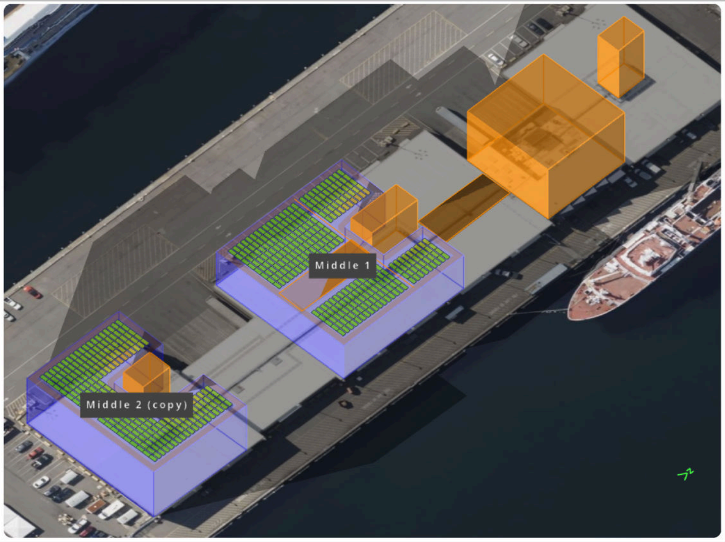
Sources of System Loss

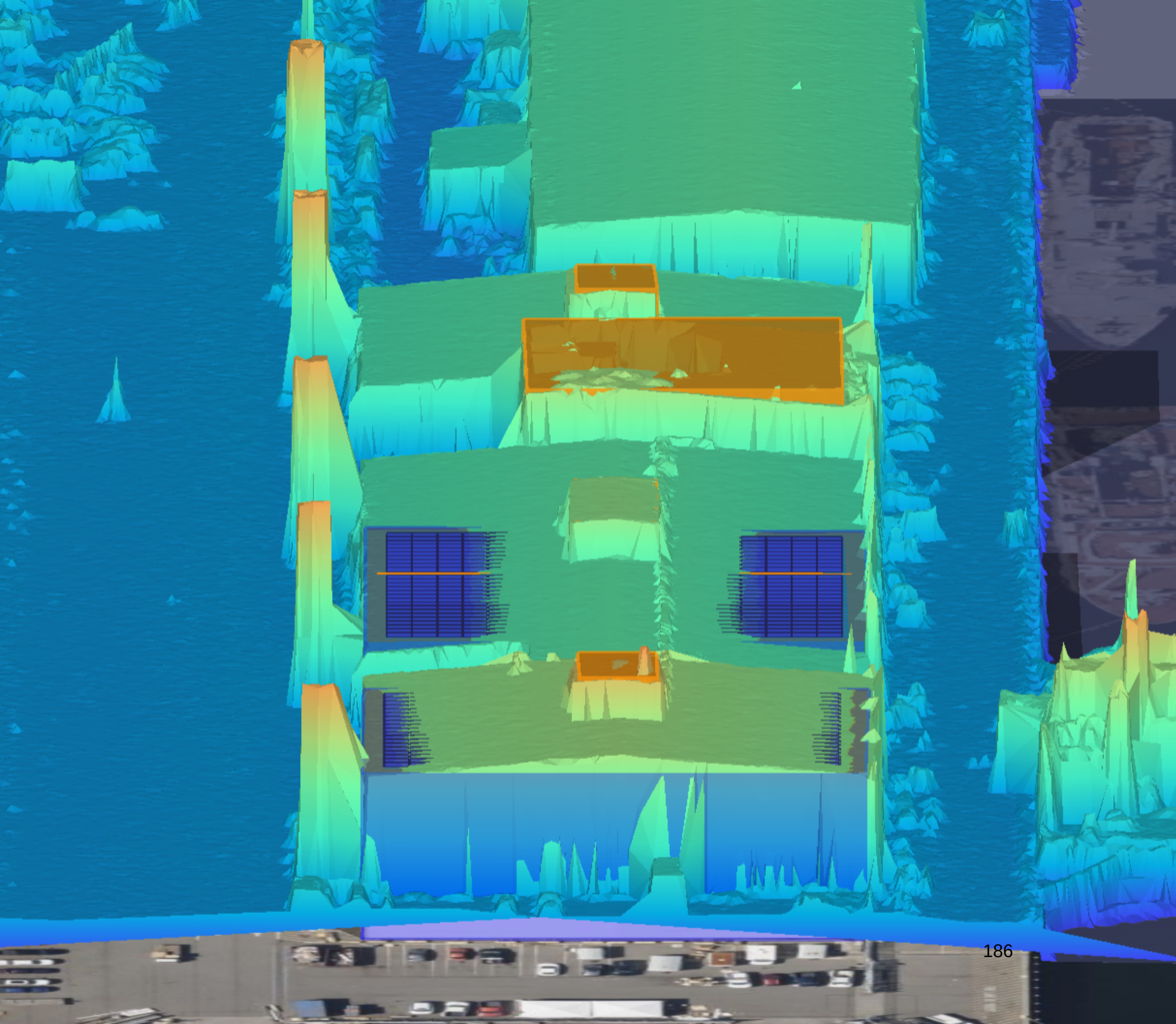


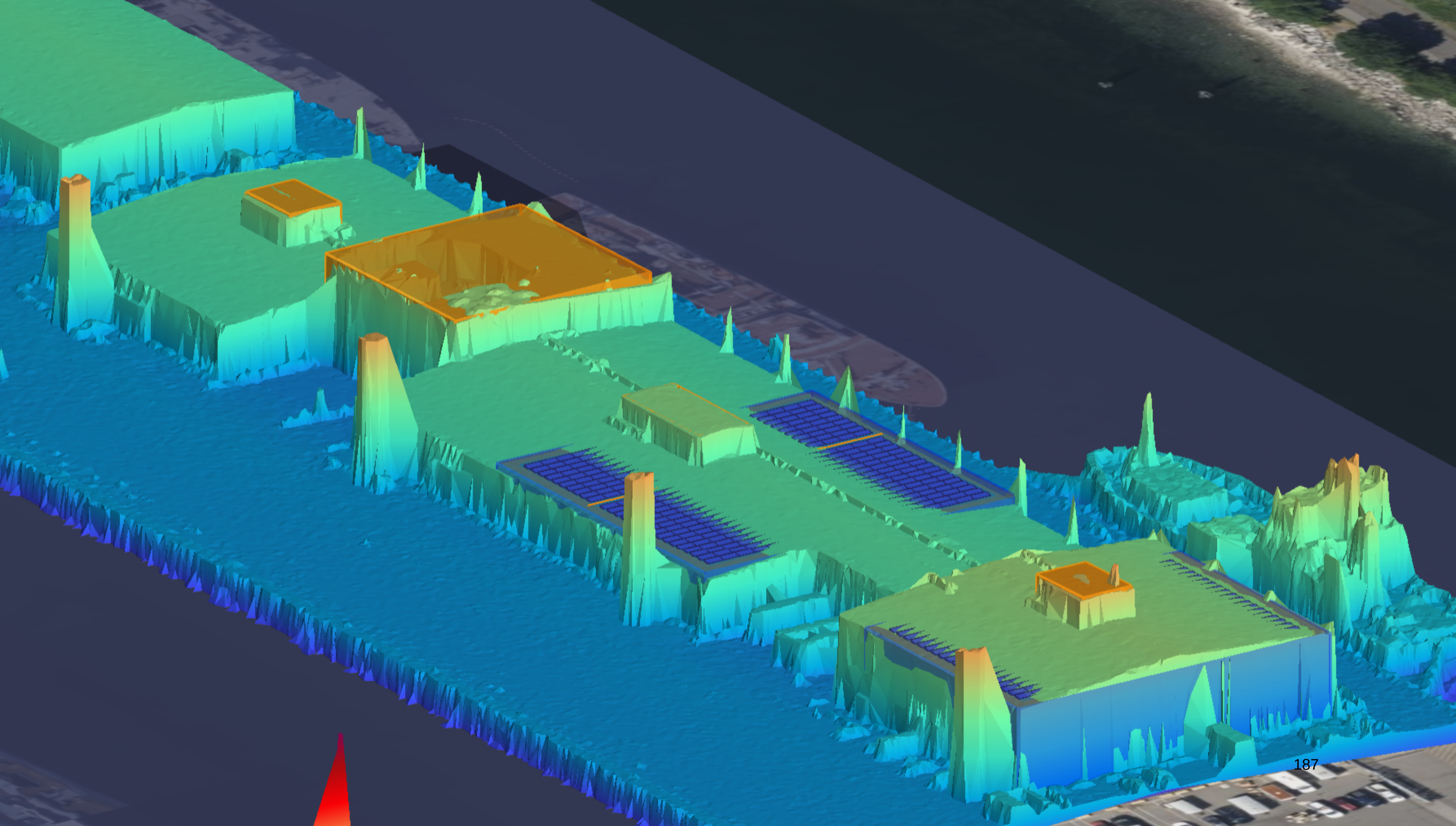
Southwestern Angle

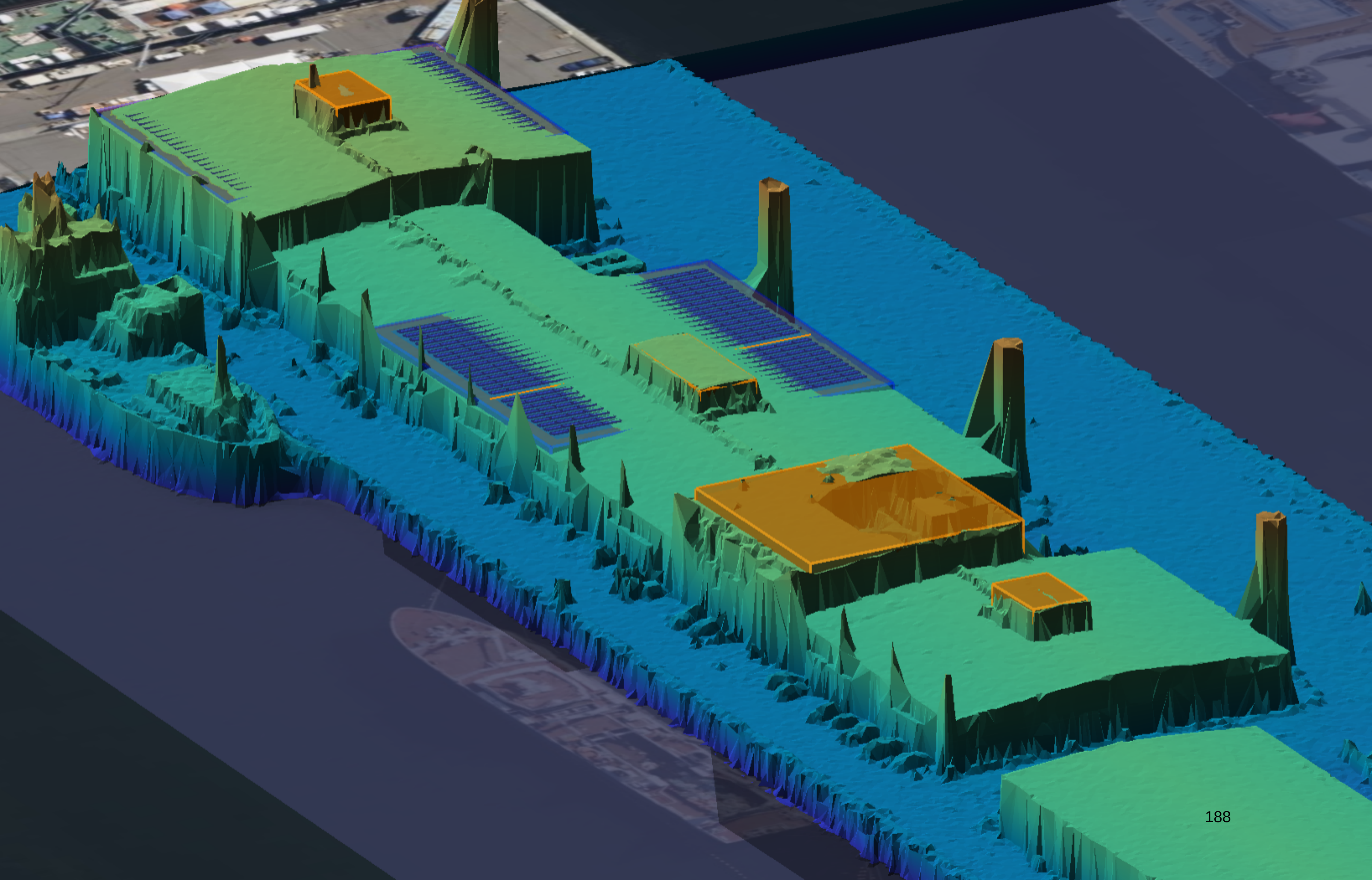


Southeastern Angle

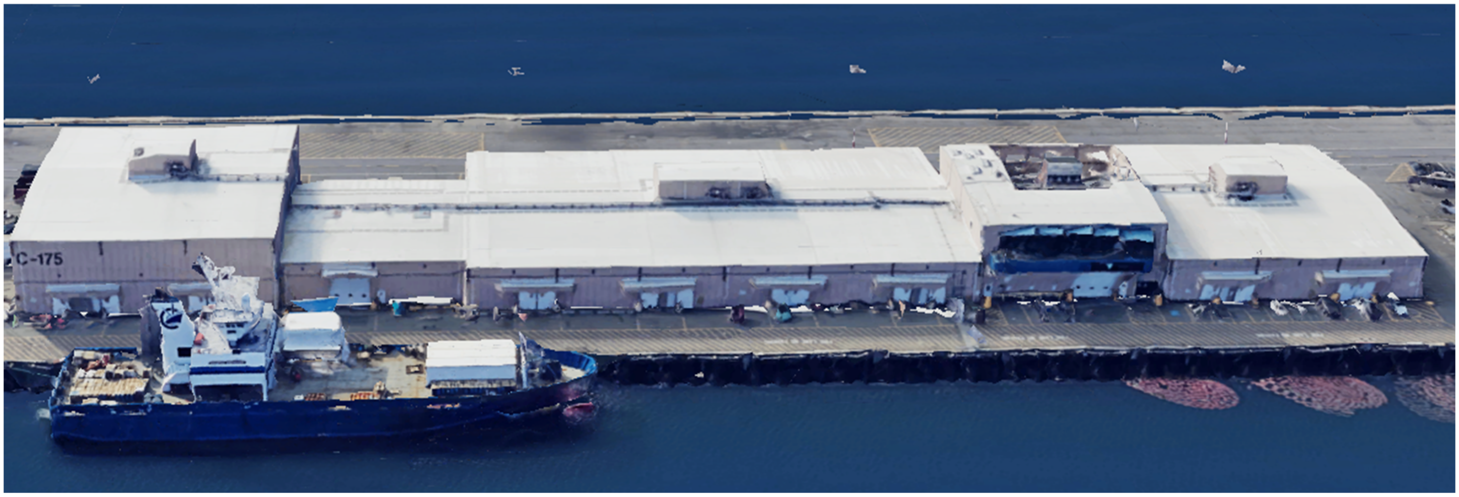








TKDA



Port of Seattle
Solar Feasibility Assessment:
Terminal 91 Building C-175

2001 W Garfield St, Seattle, WA 98119

TKDA Project No. 24026

December 20th, 2024

12/19/2024

Structural Calculation Index

Calculation Section **Page No.**

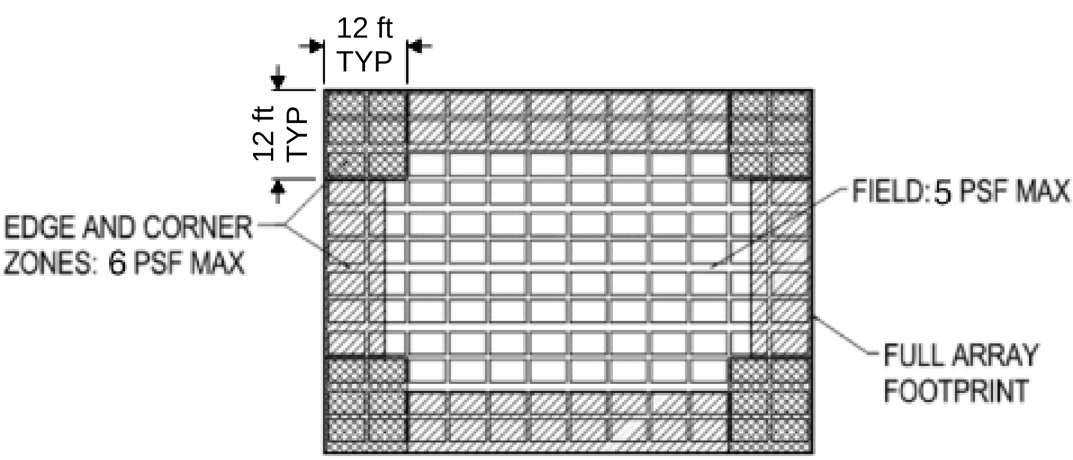
December 20, 2024

Jack Newman
Säzän Consulting Services
600 Stewart Street, Suite 1400
Seattle, WA 98101

Re: Port of Seattle - Solar Feasibility Assessment
T91, Bldg. C-175

TKDA has performed a structural assessment of the existing structure of Building C-175 from Terminal 91 in Seattle, WA to determine its ability to support a proposed ballasted rooftop PV array, including modules, racking, and associated equipment. This assessment is based on drawings provided by the Port of Seattle. The original 1992 drawings are titled "New Chill Building C-175" with DLR Group as Architect of Record (AOR) and Structural Engineer of Record (SEOR). Building C-175 is composed of HSS steel columns and W-shape steel girders with steel roof joists. The roof is a built-up roof composed of TPO membrane, insulation, and steel roof deck. In 2003, insulation was added to the underside of the roof deck. Notes on the additional insulation can be found in the 2003 as-built drawings with LMN as the AOR and Gary J Smoot as the SEOR.

The results of our analysis show that the existing framing is sufficient to carry proposed loading for the planned PV array as detailed in layout plan below.



NOTE: TOTAL AVERAGE LOADING INCLUDING FIELD, EDGE, AND CORNER ZONES SHALL NOT EXCEED 5 PSF MAX UNDER THE FULL ARRAY FOOTPRINT

TYP. ARRAY PLAN LAYOUT (GENERAL DETAIL)

Section 503.3 of the 2021 Washington State IEBC states that any building alterations which cause an increase in design dead, live, or snow load of less than 5 percent do not require strengthening or modification of the affected members. The result of the analysis shows that the existing framing is sufficient to carry the increased loading due to the proposed rooftop PV array without additional strengthening. See calculations enclosed.

Per section 503.4 of the 2021 Washington State IEBC, building alterations resulting in a lateral load increase of less than 10 percent do not require strengthening or modification of the affected members. The total array weight is less than the maximum allowable array weight based on 10 percent of the original seismic weight tributary to the roof diagram thus no strengthening nor modifications are needed to the roof framing members. See enclosed calculations.

In summary, the existing building structure is adequate to support the proposed ballasted rooftop PV array given its average weight of 5 psf underneath the footprint of the array. Please contact TKDA with any further questions.

Sincerely,
TKDA Engineers

Daniel Munn, PE, SE
Vice President, Northwest Region

Project Name:	Port of Seattle Solar Feasibility Studies
Project Location:	Seattle, WA
Building:	Terminal 91 Building C-175
Date:	December 20th, 2024
Governing Building Codes:	2021 Washington State IEBC ASCE 7-16

Vertical Gravity Weight Verification

Original Design Loads Per Design Drawings:

Load Case	Magnitude	Comments
Dead Load	17.1 psf	Per general notes + additional insulation from 2003 renovation
Snow Load	25 psf	WABO, UBC 97
Roof Live Load	20 psf	
Live Load (In roof penthouse)	50 psf	

IEBC § 503.3:

"Any existing gravity load-carrying structural element for which an alteration causes an increase in design, dead, live, or snow load, including snow drift effects, of more than 5 percent shall be replaced or altered as needed to carry the gravity loads required by the International Building Code for new structures. Any existing gravity load-carrying structural element whose gravity-load carrying capacity is decreased as part of the alteration shall be shown to have the capacity to resist the applicable design dead, live and snow loads including snow drift effects required by the International Building Code for new structures"

Actual Loads

Load Case	Magnitude	Comments
Dead Load	17.1 kips	Per general notes + additional insulation from 2003 renovation
Snow Load	25 psf	WABO UBC 97
Actual Array Weight =	5 psf	

Actual Snow Load + Actual Array Weight < Original Design Snow Load

Conclusions:

See RISA analysis. Per IEBC 503.3, the structural elements are sufficient to carry the increased 5 psf array weight due to the proposed ballasted rooftop PV array without additional strengthening. In addition, TKDA has also checked snow loading for ASCE7 values to confirm arrays are not within the snow drift limits.

TKDA

Project Name:	Port of Seattle Solar Feasibility Studies
Project Location:	Seattle, WA
Building:	Terminal 91 Building C-175
Date:	December 20th, 2024
Governing Building Codes:	2021 Washington State IEBC ASCE 7-16

Seismic Weight Verification

Original Seismic Weight Calculation:

Item Description	Value	Comments
Roof Area =	88851 sf	Total roof area, determined from drawings
Roof DL =	17 psf	See calculations
1/2 Wall Area =	51370 sf	1/2 Height of wall area, Determined from design drawings
Wall DL =	12 psf	See calculations
Weight Trib to Roof =	2149 kips	

IEBC § 503.4:
"Any existing lateral load-carrying structural element whose demand-capacity ratio with the alteration considered is not more than 10 percent greater than its demand-capacity ratio with the alteration ignored shall be permitted to remain unaltered."

Allowable Weight Increase Calculation:

Item Description	Value	Comments
10% Increase Per IEBC § 503.4 =	215.0 kips	Maximum array weight
Typ. Weight of Array =	5 psf	Under footprint
Actual Array Weight	26.2 kips	
Actual Array Area	5231 sf	Determined from layouts
Max Allowable Array Area =	43000 sf	

Conclusions:
The new solar array weight of 26.2 kips is less than the maximum allowable array weight of 215 kips based on a 10% increase per IEBC § 503.4. The results of the analysis shows that the existing framing is sufficient to carry the increased loading due to the proposed rooftop PV array without additional strengthening.

C-175 Design Load Verification

Building Geometry

Trib Area of Roof Girders $A_{trib} := \frac{41\ ft + 11\ in + 40.5\ ft}{2} = 41.21\ ft$

Penthouse Wall Height $H_{ph} := 12\ ft$

Penthouse Area Dimenions $B_{ph} := 30\ ft$ $L_{ph} := 23.5\ ft$ $A_{ph} := B_{ph} \cdot L_{ph} = 705\ ft^2$

Typical Roof Loads (not including Penthouse

Roof Dead Load per GSNs $DL := 15\ psf$ (See below, 2003 revamp added 3" of insulation to roof)

Roof Live Load per GSNs $RLL := 20\ psf$

Roof Snow Load per GSNs $SL := 25\ psf$

Confirmation of Roof Dead Loads

$DL_{deck} := 2.3\ psf$ HSB-36 roof deck, 20 GA (depth = 1.5 inches)

$DL_{insul\_1} := (6\ in - 1.5\ in) \cdot 0.75\ \frac{psf}{in} = 3.38\ psf$ Per A/6 of 1992 drawings- "6" Nominal Roof Deck & Insulation"

$DL_{insul\_2} := \frac{0.75\ psf}{in} \cdot 3\ in = 2.25\ psf$ Per TA-5 of 2003 drawings- 3" Board Insulation attached to underside of existing deck

$DL_{membrane} := 1\ psf$

$DL_{joist} := \frac{16\ plf}{8.2\ ft} = 1.95\ psf$

$DL_{stl} := \frac{108\ plf \cdot 0.83 + 62\ plf \cdot 0.17}{A_{trib}} = 2.43\ psf$

$DL_{roof} := DL_{deck} + DL_{insul\_1} + DL_{insul\_2} + DL_{membrane} + DL_{joist} + DL_{stl} = 13.31\ psf$

Use this value as new roof Dead Load $DL_{use} := DL + DL_{insul\_2} = 17.25\ psf$ $DL_{use} \cdot A_{trib} = 710.84\ plf$

C-175 Design Load Verification

Typical Penthouse Loads

Penthouse Floor $DL_{ph\_flr\_use} := DL_{use} = 17.25\ psf$

Penthouse Wall

$$DL_{ph\_walls} := \frac{H_{ph} \cdot (4\ in + 8\ in) \cdot \frac{0.75\ psf}{in} \cdot 2\ (B_{ph} + L_{ph})}{A_{trib} \cdot L_{ph}} = 11.93\ psf$$

Penthouse Roof $DL_{ph\_roof} := DL = 15\ psf$

Penthouse Live Load per GSNs $LL_{penthouse} := 50\ psf$

Penthouse Roof Live Load PH Roof live load = 20psf

Ballasted Solar Wt under array $solar := 5\ psf$

Member Loads (see RISA for additional information)

Case 1:

Outside W30 members

$DL_{om} := A_{trib} \cdot DL = 0.62\ klf$

Dead load used to account for self wt of girder inclusion in RISA

$RLL_{om} := A_{trib} \cdot RLL = 0.82\ klf$

$SL_{om} := A_{trib} \cdot SL = 1.03\ klf$

$DL_{solar\_om} := A_{trib} \cdot solar = 0.21\ klf$

Inside W24 members

$$DL_{im} := \frac{A_{trib}}{2} \cdot DL + \frac{A_{trib}}{2} \cdot (DL_{ph\_flr\_use} + DL_{ph\_walls} + DL_{ph\_roof}) = 1.22\ klf$$

$RLL_{im} := A_{trib} \cdot RLL = 0.82\ klf$

$SL_{im} := A_{trib} \cdot SL = 1.03\ klf$

C-175 Design Loads

$LL := \frac{A_{trib}}{2} \cdot LL_{penthouse} = 1.03\ klf$

$DL_{solar\_im} := \frac{A_{trib}}{2} \cdot solar = 0.1\ klf$

Case 2:

$A_{trib2} := 40.5\ ft$

Outside W30 members

$DL_{om} := A_{trib2} \cdot DL = 0.61\ klf$

Dead load used to account for self wt of girder inclusion in RISA

$RLL_{om} := A_{trib2} \cdot RLL = 0.81\ klf$

$SL_{om} := A_{trib2} \cdot SL = 1.01\ klf$

$DL_{solar\_om} := A_{trib2} \cdot solar = 0.2\ klf$

Inside W24 members

$DL_{im} := A_{trib2} \cdot \left(DL_{ph\_flr\_use} + DL_{ph\_walls} + DL_{ph\_roof}\right) = 1.79\ klf$

$RLL_{im} := A_{trib2} \cdot RLL = 0.81\ klf$

$SL_{im} := A_{trib2} \cdot SL = 1.01\ klf$

$LL := A_{trib2} \cdot LL_{penthouse} = 2.03\ klf$

Case 3:

Outside W30 members

$DL_{om} := A_{trib} \cdot DL = 0.62\ klf$

Dead load used to account for self wt of girder inclusion in RISA

$RLL_{om} := A_{trib} \cdot RLL = 0.82\ klf$

$SL_{om} := A_{trib} \cdot SL = 1.03\ klf$

$DL_{solar\_om} := A_{trib} \cdot solar = 0.21\ klf$

Inside W24 members

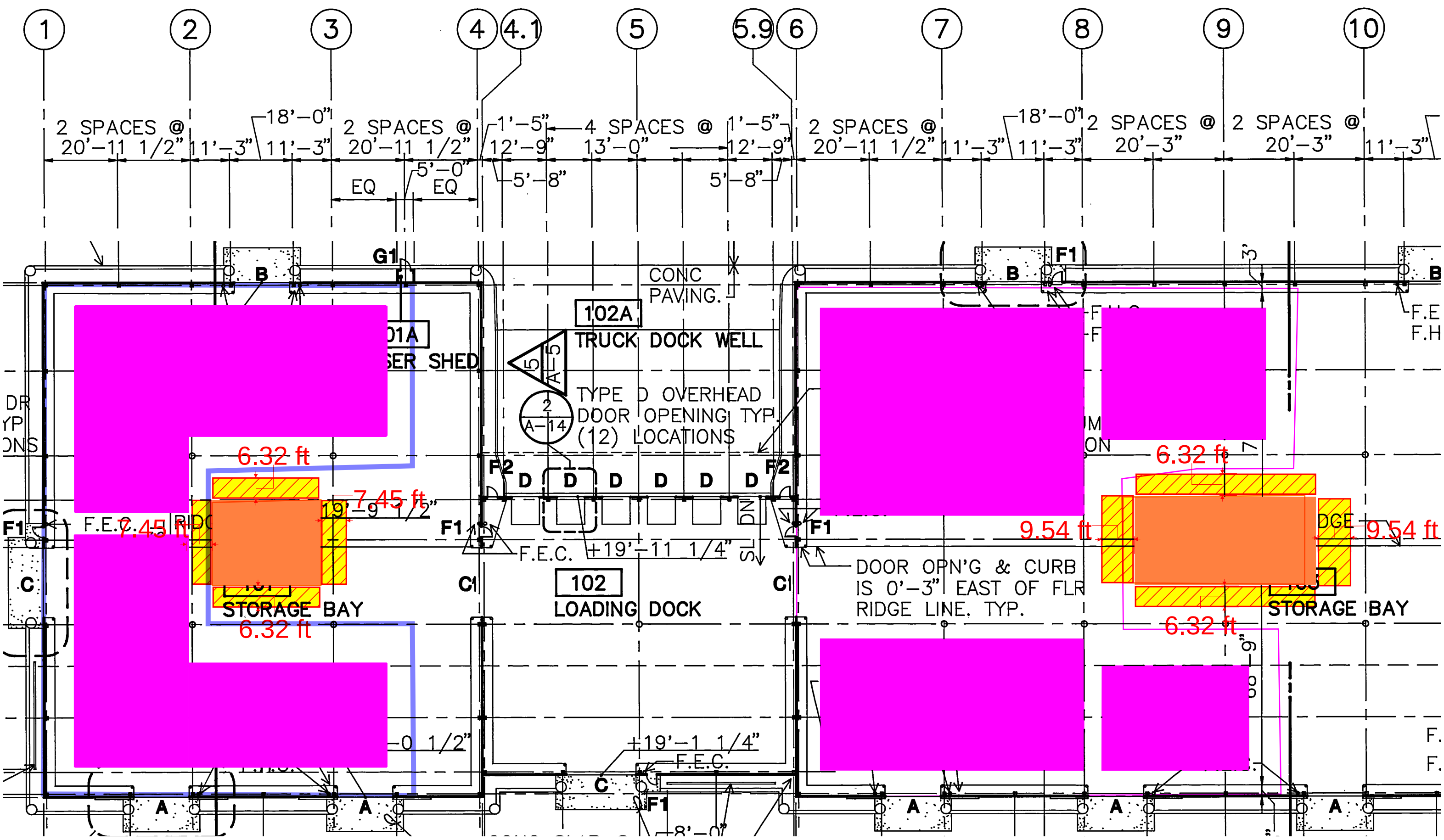
$DL_{im} := \frac{A_{trib}}{2} \cdot DL + \frac{A_{trib}}{2} \cdot \left(DL_{ph\_flr\_use} + DL_{ph\_walls} + DL_{ph\_roof}\right) = 1.22\ klf$

$RLL_{im} := A_{trib} \cdot RLL = 0.82\ klf$

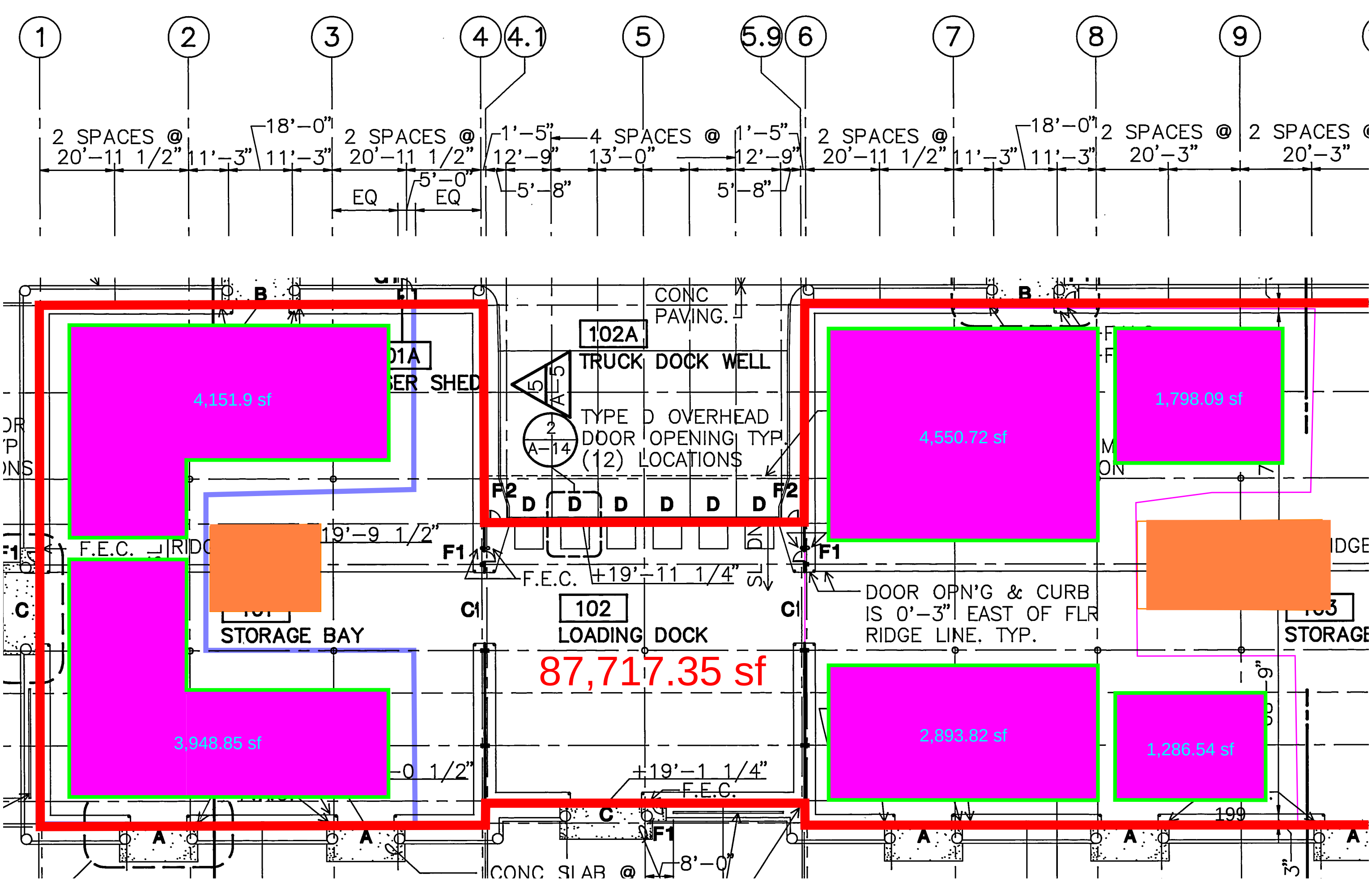
$SL_{im} := A_{trib} \cdot SL = 1.03\ klf$

$LL := \frac{A_{trib}}{2} \cdot LL_{penthouse} = 1.03\ klf$

Restrictive Regions by Snow Drift



Roof and Array Areas



SNOW CALCULATIONS per ASCE 7-16

GRID 1-4 NS

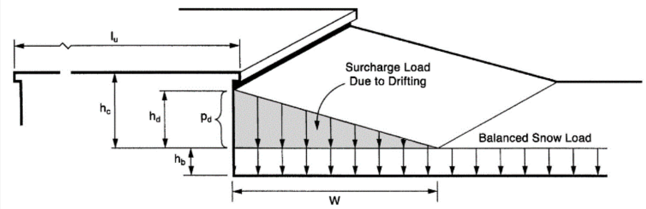


Figure 7.7-2. Configuration of snowdrifts on lower roofs.

Roof Geometry

Upper Roof Length, l_u (ft):	12.06	
Lower Roof Length, l_l (ft):	62	
Roof Height Difference, h (ft):	12.2	
Separation Distance, s (ft):	0	
Clear Roof Height, h_c (ft):	11.00	
Slope Rise	1	/12
Actual Slope, degrees	4.764	

Balanced Snow

Ground Snow Load, p_g (psf):	20	
Exposure Factor, C_e (Table 7-2):	0.9	
Thermal Factor, C_t (Table 7-3):	1.3	
Importance Factor, I (Table 7-4):	1.0	
Slope Factor, C_s (=1.0 if Flat):	1.0	
Minimum Flat Snow Load, pf (psf):	20	$= p_g * I$ or $20 * I$
Sloped Roof Snow Load, p_s (psf):	**20**	$= 0.7 * C_e * C_t * I * C_s * p_g$ or $p_{f\,min}$
Snow Density, γ (pcf):	16.6	$= 0.13 * p_g + 14 \leq 30$
Balanced Snow Height, h_b (ft):	1.20	$= p_f / \gamma$
Adjacent Structure Factor, asf	1.00	$= (20-s) / 20$

Leeward Drift

$$h_d = \left(0.43 \cdot \sqrt[3]{l_u} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 0.81

Windward Drift

$$h_d = 0.75 \cdot \left(0.43 \cdot \sqrt[3]{l_l} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 1.86

Drift Size

Design Height, h_d (ft):	1.86	
But not greater than h_c (ft):	1.86	
Drift Width, w (ft):		
If $h_d \leq h_c$, $4 * h_d$	7.45	
If $h_d > h_c$, $4 * h_d^2 / h_c$	1.26	
But not greater than $8 * h_c$:	87.96	
w (ft):	7.45	
Maximum Surcharge Load, p_d (psf):	30.91	$= h_d / \gamma$

Sloped Roof Results

Sloped Roof Snow Load, p_s (psf):	**20.0**	**psf**
Balanced Snow Height, h_b (ft):	**1.2**	**ft**

Drift Results - Does not apply

Drift Height, h_d	**1.86**	**ft**
Drift Width, w	**7.45**	**ft**
Maximum Surcharge Load, p_d	**30.91**	**psf**

TKDA

PROJECT	SAZAN TERMINAL C-175	BY: WW	SHEET:
		CHKD: DM	PROJECT NO: 24026
TITLE	GRID 1-4 NS SNOW CALCULATION	DATE: 12/16/24	PAGE:

SNOW CALCULATIONS per ASCE 7-16

GRID 1-4 EW

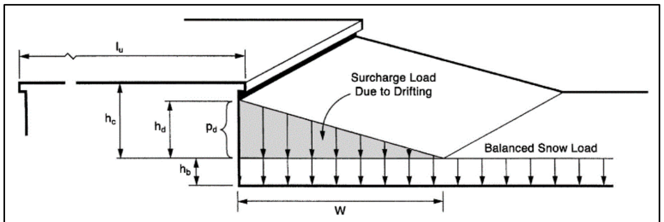


Figure 7.7-2. Configuration of snowdrifts on lower roofs.

Roof Geometry

Upper Roof Length, l_u (ft):	**17**	
Lower Roof Length, l_l (ft):	**46**	
Roof Height Difference, h (ft):	**12.2**	
Separation Distance, s (ft):	**0**	
Clear Roof Height, h_c (ft):	11.00	
Slope Rise	**1**	/12
Actual Slope, degrees	4.764	

Balanced Snow

Ground Snow Load, p_g (psf):	**20**	
Exposure Factor, C_e (Table 7-2):	**0.9**	
Thermal Factor, C_t (Table 7-3):	**1.3**	
Importance Factor, I (Table 7-4):	**1.0**	
Slope Factor, C_s (=1.0 if Flat):	**1.0**	
Minimum Flat Snow Load, pf (psf):	20	*= p_g*I or 20*I*
Sloped Roof Snow Load, p_s (psf):	**20**	*= 0.7*C_e*C_t*I*C_s*p_g or $p_{f\,min}$*
Snow Density, γ (pcf):	16.6	*= 0.13*p_g +14 ≤ 30*
Balanced Snow Height, h_b (ft):	1.20	*= p_f / γ*
Adjacent Structure Factor, asf	1.00	*= (20-s) / 20*

Leeward Drift

$$h_d = \left(0.43 \cdot \sqrt[3]{l_u} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 1.09

Windward Drift

$$h_d = 0.75 \cdot \left(0.43 \cdot \sqrt[3]{l_l} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 1.58

Drift Size

Design Height, h_d (ft):	1.58	
But not greater than h_c (ft):	1.58	
Drift Width, w (ft):		
If $h_d \le h_c$, 4 * h_d	6.32	
If $h_d > h_c$, 4 * h_d^2 / h_c	0.91	
But not greater than 8*h_c:	87.96	
w (ft):	6.32	
Maximum Surcharge Load, p_d (psf):	26.22	*= h_d / γ*

Sloped Roof Results

Sloped Roof Snow Load, p_s (psf):	**20.0**	**psf**
Balanced Snow Height, h_b (ft):	**1.2**	**ft**

Drift Results - Does not apply

Drift Height, h_d	**1.58**	**ft**
Drift Width, w	**6.32**	**ft**
Maximum Surcharge Load, p_d	**26.22**	**psf**

Page 1 of 1

TKDA

PROJECT: SAZAN TERMINAL C-175	BY: WW	SHEET:	
TITLE: GRID 1-4 EW SNOW CALCULATION	CHKD: DM	PROJECT NO: 24026	
	DATE: 12/16/24	PAGE:	

SNOW CALCULATIONS per ASCE 7-16

GRID 6-12 NS

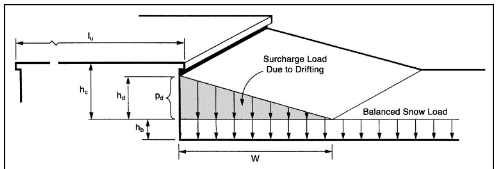


Figure 7.7-2. Configuration of snowdrifts on lower roofs.

Roof Geometry

Upper Roof Length, l_u (ft):	26.41	
Lower Roof Length, l_l (ft):	100.55	
Roof Height Difference, h (ft):	12.2	
Separation Distance, s (ft):	0	
Clear Roof Height, h_c (ft):	11.00	
Slope Rise	1	/12
Actual Slope, degrees	4.764	

Balanced Snow

Ground Snow Load, p_g (psf):	20	
Exposure Factor, C_e (Table 7-2):	0.9	
Thermal Factor, C_t (Table 7-3):	1.3	
Importance Factor, I (Table 7-4):	1.0	
Slope Factor, C_s (=1.0 if Flat):	1.0	
Minimum Flat Snow Load, pf (psf):	20	$= p_g*I$ or $20*I$
Sloped Roof Snow Load, p_s (psf):	**20**	$= 0.7*C_e*C_t*I*C_s*p_g$ or $p_{f\,min}$
Snow Density, γ (pcf):	16.6	$= 0.13*p_g + 14 \le 30$
Balanced Snow Height, h_b (ft):	1.20	$= p_f / \gamma$
Adjacent Structure Factor, asf	1.00	$= (20-s) / 20$

Leeward Drift

$$h_d = \left(0.43 \cdot \sqrt[3]{l_u} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 1.50

Windward Drift

$$h_d = 0.75 \cdot \left(0.43 \cdot \sqrt[3]{l_l} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 2.38

Drift Size

Design Height, h_d (ft):	2.38	
But not greater than h_c (ft):	2.38	
Drift Width, w (ft):		
If $h_d \le h_c$, $4 * h_d$	9.54	
If $h_d > h_c$, $4 * h_d^2 / h_c$	2.07	
But not greater than $8*h_c$:	87.96	
w (ft):	9.54	
Maximum Surcharge Load, p_d (psf):	39.59	$= h_d / \gamma$

Sloped Roof Results

Sloped Roof Snow Load, p_s (psf):	**20.0**	**psf**
Balanced Snow Height, h_b (ft):	**1.2**	**ft**

Drift Results - Does not apply

Drift Height, h_d	**2.38**	**ft**
Drift Width, w	**9.54**	**ft**
Maximum Surcharge Load, p_d	**39.59**	**psf**

Page 1 of 1

TKDA

PROJECT	SAZAN TERMINAL C-175
TITLE	GRID 6-12 NS SNOW CALCULATION
BY:	WW
SHEET:	
CHKD:	DM
PROJECT NO:	24026
DATE:	12/16/24
PAGE:	

SNOW CALCULATIONS per ASCE 7-16

GRID 6-12 EW

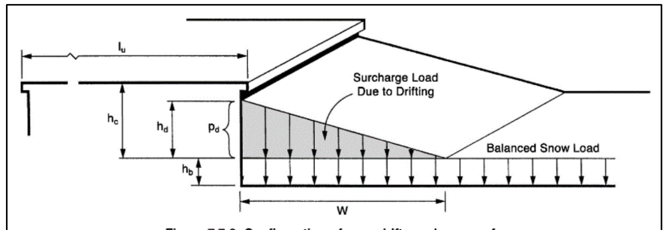


Figure 7.7-2. Configuration of snowdrifts on lower roofs.

Roof Geometry

Upper Roof Length, l_u (ft):	17	
Lower Roof Length, l_l (ft):	46	
Roof Height Difference, h (ft):	12.2	
Separation Distance, s (ft):	0	
Clear Roof Height, h_c (ft):	11.00	
Slope Rise	1	/12
Actual Slope, degrees	4.764	

Balanced Snow

Ground Snow Load, p_g (psf):	20	
Exposure Factor, C_e (Table 7-2):	0.9	
Thermal Factor, C_t (Table 7-3):	1.3	
Importance Factor, I (Table 7-4):	1.0	
Slope Factor, C_s (=1.0 if Flat):	1.0	
Minimum Flat Snow Load, pf (psf):	20	$= p_g*I$ or $20*I$
Sloped Roof Snow Load, p_s (psf):	20	$= 0.7*C_e*C_t*I*C_s*p_g$ or $p_{f\,min}$
Snow Density, γ (pcf):	16.6	$= 0.13*p_g + 14 \le 30$
Balanced Snow Height, h_b (ft):	1.20	$= p_f / \gamma$
Adjacent Structure Factor, asf	1.00	= (20-s) / 20

Leeward Drift

$$h_d = \left(0.43 \cdot \sqrt[3]{l_u} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 1.09

Windward Drift

$$h_d = 0.75 \cdot \left(0.43 \cdot \sqrt[3]{l_l} \cdot \sqrt[4]{p_g + 10} - 1.5\right) \cdot \sqrt{I_s} \cdot asf$$

Drift Height, h_d (ft): 1.58

Drift Size

Design Height, h_d (ft):	1.58	
But not greater than h_c (ft):	1.58	
Drift Width, w (ft):		
If $h_d \le h_c$, $4 * h_d$	6.32	
If $h_d > h_c$, $4 * h_d^2 / h_c$	0.91	
But not greater than $8*h_c$:	87.96	
w (ft):	6.32	
Maximum Surcharge Load, p_d (psf):	26.22	$= h_d / \gamma$

Sloped Roof Results

Sloped Roof Snow Load, p_s (psf):	**20.0**	**psf**
Balanced Snow Height, h_b (ft):	**1.2**	**ft**

Drift Results - Does not apply

Drift Height, h_d	**1.58**	**ft**
Drift Width, w	**6.32**	**ft**
Maximum Surcharge Load, p_d	**26.22**	**psf**

Page 1 of 1

TKDA

PROJECT	SAZAN TERMINAL C-175
TITLE	GRID 6-12 EW SNOW CALCULATION

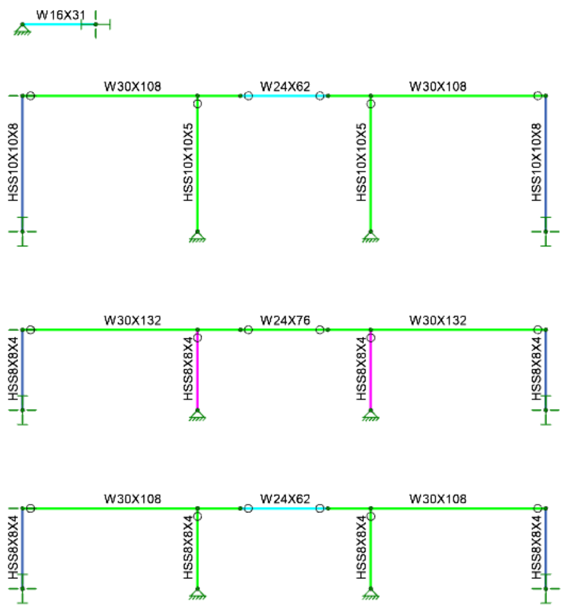
BY: WW	SHEET:
CHKD: DM	PROJECT NO: 24026
DATE: 12/16/24	PAGE:

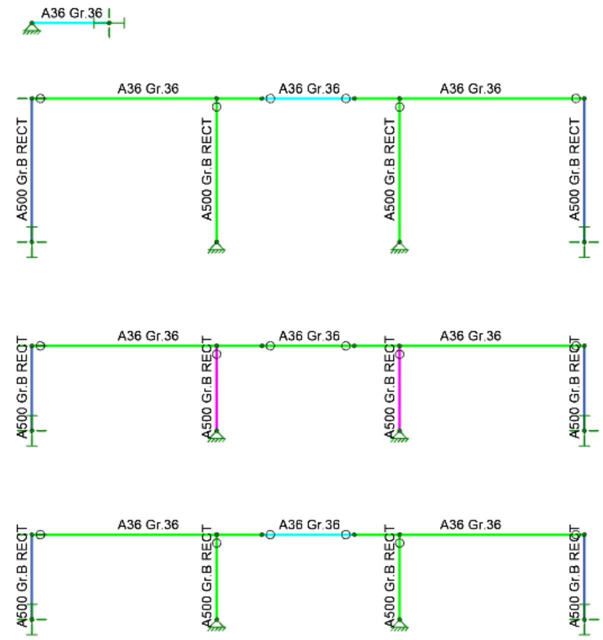
Edge Beam:

Case 1:

Case 2:

Case 3:





Member Profiles

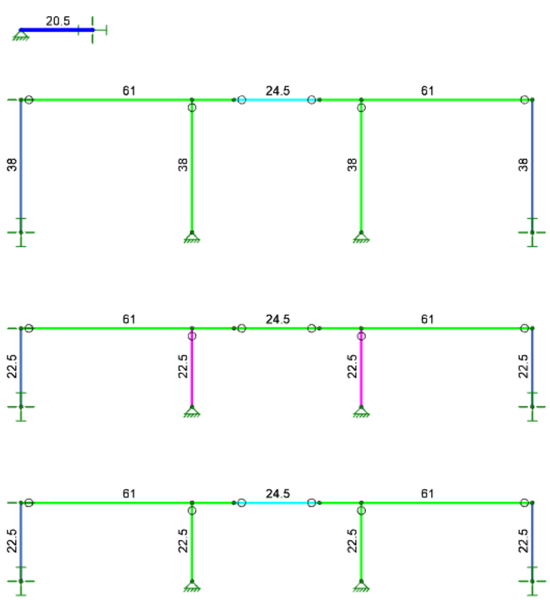
Material

Edge Beam:

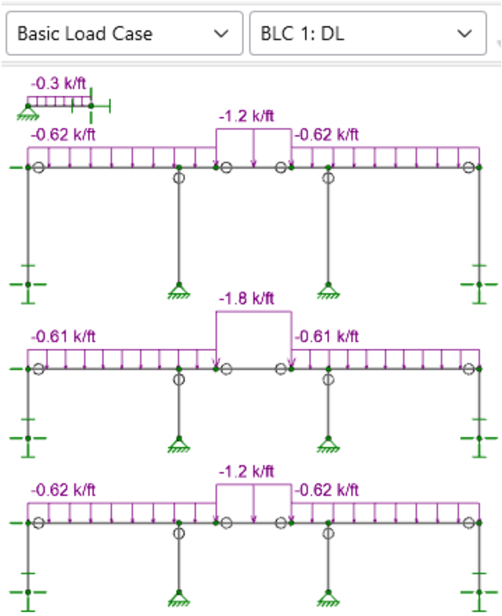
Case 1:

Case 2:

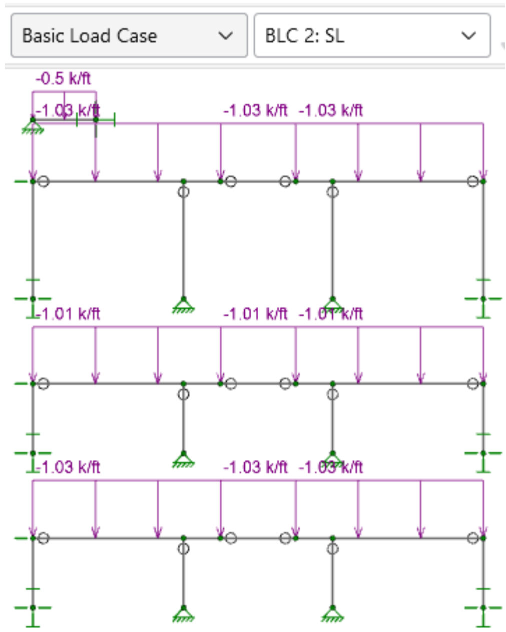
Case 3:



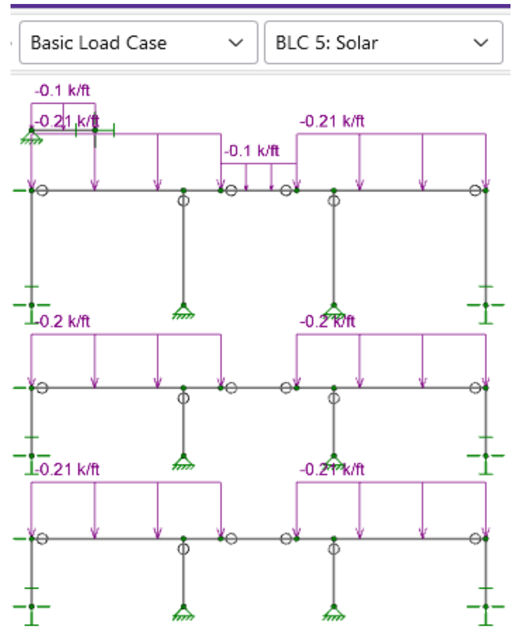
Member Lengths (ft)



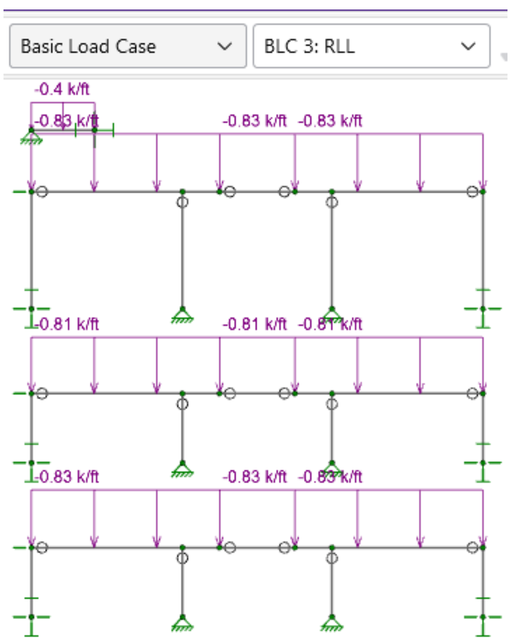
Dead Loading



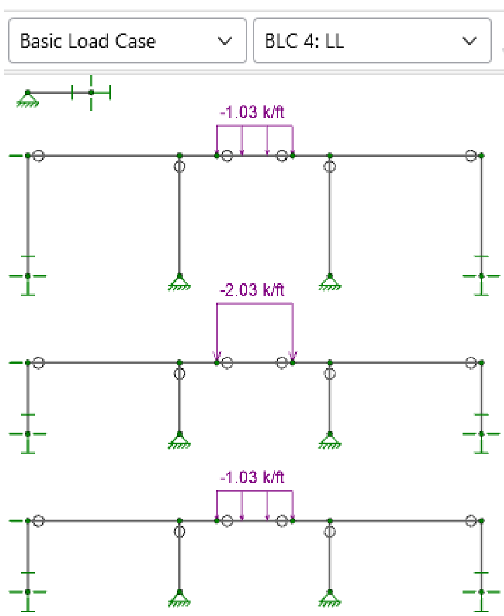
Snow Loading



Solar Contribution



Roof Live Loading



Live Loading

Basic Load Cases

	BLC Description	Category	X Gravity	Y Gravity	Z Gravity	Nodal	Point	Distributed
1	DL	DL		-1				10
2	SL	SL						10
3	RLL	RLL						10
4	LL	LL						3
5	Solar	DL						8

Load Combinations

	Description	Solve	P-Delta	SRSS	BLC	Factor	BLC	Factor	BLC	Factor	BLC	Factor
1	DL	✓	Y		DL	1						
2	LL	✓	Y		LL	1						
3	DL+LL	✓	Y		DL	1	LL	1				
4	IBC 21/ASCE Strength 1	✓	Y		DL	1.4						
5	IBC 21/ASCE Strength 2 (a)	✓	Y		DL	1.2	LL	1.6			RLL	0.5
6	IBC 21/ASCE Strength 2 (b)	✓	Y		DL	1.2	LL	1.6			SL	0.5
7	IBC 21/ASCE Strength 2 (c)	✓	Y		DL	1.2	LL	1.6				
8	IBC 21/ASCE Strength 3 (a)	✓	Y		DL	1.2	RLL	1.6	LL	0.5		
9	IBC 21/ASCE Strength 3 (c)	✓	Y		DL	1.2	SL	1.6			LL	0.5

Code Check

Hot Rolled Steel | Cold Formed Steel | Wood | Concrete Beams | Concrete Columns | Aluminum | Stainless

	Member	Shape	Code Check	Loc[ft]	LC	Shear Check	Loc[ft]	Dir	LC	phi*Pnc [k]	phi*Pnt [k]	phi*Mn y-y [k-ft]	phi*Mn z-z [k-ft]	Cb	Eqn
1	M1	W30X108	0.805	12.073	9	0.237	12.073	y	9	391.162	1027.08	118.53	934.2	1	H1-1b
2	M2	W30X108	0.805	48.927	9	0.237	48.927	y	9	391.162	1027.08	118.53	934.2	1	H1-1b
3	M3	W24X62	0.752	12.25	9	0.211	24.5	y	6	294.409	589.68	42.341	378.993	1	H1-1b
4	M4	W30X132	0.844	12.073	6	0.229	11.438	y	6	632.616	1257.12	157.68	1179.9	1	H1-1b
5	M5	W30X132	0.844	48.927	6	0.229	49.563	y	6	632.616	1257.12	157.68	1179.9	1	H1-1b
6	M6	W24X76	0.838	12.25	6	0.324	24.5	y	6	443.103	725.76	77.22	537.678	1	H1-1b
7	M7	HSS10X10...	0.199	0	9	0	38	y	9	278.22	712.08	209.415	209.415	1	H1-1b*
8	M8	HSS10X10...	0.199	0	9	0	38	y	9	278.22	712.08	209.415	209.415	1	H1-1b*
9	M9	HSS8X8X4	0.274	0	9	0	22.5	y	9	179.632	293.94	66.288	66.288	1	H1-1a*
10	M10	HSS8X8X4	0.274	0	9	0	22.5	y	9	179.632	293.94	66.288	66.288	1	H1-1a*
11	M11	HSS10X10...	0.886	0	9	0	38	y	9	186.336	459.54	129.31	129.31	1	H1-1a*
12	M12	HSS10X10...	0.886	0	9	0	38	y	9	186.336	459.54	129.31	129.31	1	H1-1a*
13	M13	HSS8X8X4	0.999	0	9	0	22.5	y	9	179.632	293.94	66.288	66.288	1	H1-1a*
14	M14	HSS8X8X4	0.999	0	9	0	22.5	y	9	179.632	293.94	66.288	66.288	1	H1-1a*
15	M15	W30X108	0.786	12.073	9	0.236	12.073	y	9	391.162	1027.08	118.53	934.2	1	H1-1b
16	M16	W30X108	0.786	48.927	9	0.236	48.927	y	9	391.162	1027.08	118.53	934.2	1	H1-1b
17	M17	W24X62	0.728	12.25	9	0.205	24.5	y	6	294.409	589.68	42.341	378.993	1	H1-1b
18	M18	HSS8X8X4	0.298	0	9	0	22.5	y	9	179.632	293.94	66.288	66.288	1	H1-1a*
19	M19	HSS8X8X4	0.298	0	9	0	22.5	y	9	179.632	293.94	66.288	66.288	1	H1-1a*
20	M20	HSS8X8X4	0.902	0	9	0	22.5	y	9	179.632	293.94	66.288	66.288	1	H1-1a*
21	M21	HSS8X8X4	0.902	0	9	0	22.5	y	9	179.632	293.94	66.288	66.288	1	206 H1-1a*
22	M22	W16X31	0.547	10.25	9	0.143	20.5	y	9	150.49	295.812	18.981	126.41	1	H1-1b

< 1.0, ok   < 1.0, ok

STANDARD LOAD TABLE

LONGSPAN STEEL JOISTS, LH- SERIES

Based on a Maximum Allowable Tensile Stress of 30,000 psi

Historical LH joist table

Adopted by the Steel Joist Institute May 25, 1983
Revised to November 15, 1989

The black figures in the following table give the TOTAL safe uniformly-distributed load-carrying capacities, in pounds per linear foot, of LH-Series joists. The weight of DEAD loads, including the joists, must in all cases be deducted to determine the LIVE load-carrying capacities of the joists. The approximate DEAD load of the joists may be determined from the weights per linear foot shown in the tables.

The red figures in this load table are the LIVE loads per linear foot of joist which will produce an approximate deflection of 1/360 of the span. LIVE loads which will produce a deflection of 1/240 of the span may be obtained by multiplying the red figures by 1.5. In no case shall the TOTAL load capacity of the joists be exceeded.

This load table applies to joists with either parallel chords or standard pitched top chords. When top chords are pitched, the carrying capacities are determined by the nominal depth of the joists at center of the span. Standard top chord pitch is ⅛ inch per foot. If pitch exceeds this standard, the load table **does not** apply. This load table may be used for parallel chord joists installed to a maximum slope of ½ inch per foot.

When holes are required in top or bottom chords, the carrying capacities must be reduced in proportion to reduction of chord areas.

The top chords are considered as being stayed laterally by floor slab or roof deck.

The approximate joist weights per linear foot shown in these tables do not include accessories.

Joist Designation	Approx. Wt. in Lbs. per Linear Ft. (Joists Only)	Depth in inches	SAFE LOAD* in Lbs. Between	CLEAR SPAN IN FEET															
			21–24	25	26	27	28	29	30	31	32	33	34	35	36				
18LH02	10	18	12000	468	442	418	391	367	345	324	306	289	273	259	245				
(red)				313	284	259	234	212	193	175	160	147	135	124	114				
18LH03	11	18	13300	521	493	467	438	409	382	359	337	317	299	283	267				
(red)				348	317	289	262	236	213	194	177	161	148	136	124				
18LH04	12	18	15500	604	571	535	500	469	440	413	388	365	344	325	308				
(red)				403	367	329	296	266	242	219	200	182	167	153	141				
18LH05	15	18	17500	684	648	614	581	543	508	476	448	421	397	375	355				
(red)				454	414	378	345	311	282	256	233	212	195	179	164				
18LH06	15	18	20700	809	749	696	648	605	566	531	499	470	443	418	396				
(red)				526	469	419	377	340	307	280	254	232	212	195	180				
18LH07	17	18	21500	840	809	780	726	678	635	595	559	526	496	469	444				
(red)				553	513	476	428	386	349	317	288	264	241	222	204				
18LH08	19	18	22400	876	843	812	784	758	717	680	641	604	571	540	512				
(red)				577	534	496	462	427	387	351	320	292	267	246	226				
18LH09	21	18	24000	936	901	868	838	810	783	759	713	671	633	598	566				
(red)				616	571	527	491	458	418	380	346	316	289	266	245				
			22–24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
20LH02	10	20	11300	442	437	431	410	388	365	344	325	307	291	275	262	249	237	225	215
(red)				306	303	298	274	250	228	208	190	174	160	147	136	126	117	108	101
20LH03	11	20	12000	469	463	458	452	434	414	395	372	352	333	316	299	283	269	255	243
(red)				337	333	317	302	280	258	238	218	200	184	169	156	143	133	123	114
20LH04	12	20	14700	574	566	558	528	496	467	440	416	393	372	353	335	318	303	289	275
(red)				428	406	386	352	320	291	265	243	223	205	189	174	161	149	139	129
20LH05	14	20	15800	616	609	602	595	571	544	513	484	458	434	411	390	371	353	336	321
(red)				459	437	416	395	366	337	308	281	258	238	219	202	187	173	161	150
20LH06	15	20	21100	822	791	763	723	679	635	596	560	527	497	469	444	421	399	379	361
(red)				606	561	521	477	427	386	351	320	292	267	246	226	209	192	178	165
20LH07	17	20	22500	878	845	814	786	760	711	667	627	590	556	526	497	471	447	425	404
(red)				647	599	556	518	484	438	398	362	331	303	278	256	236	218	202	187
20LH08	19	20	23200	908	873	842	813	785	760	722	687	654	621	588	558	530	503	479	457
(red)				669	619	575	536	500	468	428	395	365	336	309	285	262	242	225	209
20LH09	21	20	25400	990	953	918	886	856	828	802	778	755	712	673	636	603	572	544	517
(red)				729	675	626	581	542	507	475	437	399	366	336	309	285	264	244	227
20LH10	23	20	27400	1068	1028	991	956	924	894	865	839	814	791	748	707	670	636	604	575
(red)				786	724	673	626	585	545	510	479	448	411	377	346	320	296	274	254

STEEL JOIST INSTITUTE STANDARD SJI

STANDARD LOAD TABLE / LONGSPAN STEEL JOISTS, LH- SERIES

Based on a Maximum Alllowable Tensile Stress of 30,000 psi

Joist Designation	Approx. Wt. in Lbs. per Linear Ft. (Joists Only)	Depth in Inches	SAFE LOAD* in Lbs. Between 28–32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
24LH03	11	24	11500	342 235	339 226	336 218	323 204	307 188	293 175	279 162	267 152	255 141	244 132	234 124	224 116	215 109	207 102	199 96	191 90
24LH04	12	24	14100	419 288	398 265	379 246	360 227	343 210	327 195	312 182	298 169	285 158	273 148	262 138	251 130	241 122	231 114	222 107	214 101
24LH05	13	24	15100	449 308	446 297	440 285	419 264	399 244	380 226	363 210	347 196	331 182	317 171	304 160	291 150	280 141	269 132	258 124	248 117
24LH06	16	24	20300	604 411	579 382	555 356	530 331	504 306	480 284	457 263	437 245	417 228	399 211	381 197	364 184	348 172	334 161	320 152	307 142
24LH07	17	24	22300	665 452	638 421	613 393	588 367	565 343	541 320	516 297	491 276	468 257	446 239	426 223	407 208	389 195	373 182	357 171	343 161
24LH08	18	24	23800	707 480	677 447	649 416	622 388	597 362	572 338	545 314	520 292	497 272	475 254	455 238	435 222	417 208	400 196	384 184	369 173
24LH09	21	24	28000	832 562	808 530	785 501	764 460	731 424	696 393	663 363	632 337	602 313	574 292	548 272	524 254	501 238	480 223	460 209	441 196
								788 474	768 439	737 406	702 378	668 351	637 326	608 304	582 285	556 266	533 249	511 234	490 220
								[illegible] 498	807 472	787 449	768 418	734 388	701 361	671 337	642 315	616 294	590 276	567 259	544 243

Parameters:

DL = 15 psf
Self wt = 16 plf
SL = 25 psf
joist spacing = 8'-2"
span = 42 ft

Available Capacity = (40psf + x)*8.167ft + 16 plf = 399 plf

x = 6.9 psf

Summary - Joists could accommodate 6.9 psf additional loading

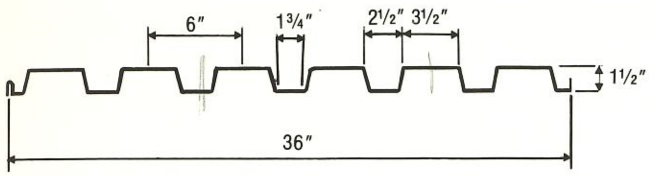
								45	46	47	48	49	50	51	52	53	54	55	56
								286 [illegible]	275 159	265 150	255 142	245 133	237 126	228 119	220 113	213 107	206 102	199 97	193 92
								[illegible] [illegible]	364 209	350 197	337 186	324 175	313 166	301 156	291 148	281 140	271 133	262 126	253 120
								427 [illegible]	410 236	394 222	379 209	365 197	352 186	339 176	327 166	316 158	305 150	295 142	285 135
								456 [illegible]	438 252	420 236	403 222	387 209	371 196	357 185	344 175	331 165	319 156	308 148	297 140
								563 [illegible]	540 309	519 291	499 274	481 258	463 243	446 228	430 216	415 204	401 193	387 183	374 173
								625 [illegible]	600 342	576 322	554 303	533 285	513 269	495 255	477 241	460 228	444 215	429 204	415 193
								682 [illegible]	655 373	629 351	605 331	582 312	561 294	540 278	521 263	502 249	485 236	468 223	453 212
								782 [illegible]	766 435	737 408	709 383	682 361	656 340	632 321	609 303	587 285	566 270	546 256	527 243
								816 [illegible]	799 452	782 433	766 415	751 396	722 373	694 352	668 332	643 314	620 297	598 281	577 266

Joist Designation	Approx. Wt.	Depth	Safe Load					53	54	55	56	57	58	59	60	61	62	63	64
32LH06	14	32	16700	338 211	326 199	315 189	304 179	294 169	284 161	275 153	266 145	257 138	249 131	242 125	234 119	227 114	220 108	214 104	208 99
32LH07	16	32	18800	379 235	366 223	353 211	341 200	329 189	318 179	308 170	298 162	288 154	279 146	271 140	262 133	254 127	247 121	240 116	233 111
32LH08	17	32	20400	411 255	397 242	383 229	369 216	357 205	345 194	333 184	322 175	312 167	302 159	293 151	284 144	275 137	267 131	259 125	252 120
32LH09	21	32	25600	516 319	498 302	480 285	463 270	447 256	432 243	418 230	404 219	391 208	379 198	367 189	356 180	345 172	335 164	325 157	315 149
32LH10	21	32	28300	571 352	550 332	531 315	512 297	495 282	478 267	462 254	445 240	430 228	416 217	402 206	389 196	376 186	364 178	353 169	342 162
32LH11	24	32	31000	625 385	602 363	580 343	560 325	541 308	522 292	505 277	488 263	473 251	458 239	443 227	429 216	416 206	403 196	390 187	378 179
32LH12	27	32	36400	734 450	712 428	688 406	664 384	641 364	619 345	598 327	578 311	559 295	541 281	524 267	508 255	492 243	477 232	463 221	449 211
32LH13	30	32	40600	817 500	801 480	785 461	771 444	742 420	715 397	690 376	666 354	643 336	621 319	600 304	581 288	562 275	544 262	527 249	511 238
32LH14	33	32	41800	843 515	826 495	810 476	795 458	780 440	766 417	738 395	713 374	688 355	665 337	643 321	622 304	602 290	583 276	564 264	547 251
32LH15	35	32	43200	870 532	853 511	837 492	821 473	805 454	791 438	776 422	763 407	750 393	725 374	701 355	678 338	656 322	635 306	616 292	597 279

Joist Designation	Approx. Wt.	Depth	Safe Load 42–56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
36LH07	16	36	16800	292 177	283 168	274 160	266 153	258 146	251 140	244 134	237 128	230 122	224 117	218 112	212 107	207 103	201 99	196 95	191 91
36LH08	18	36	18500	321 194	311 185	302 176	293 168	284 160	276 153	268 146	260 140	253 134	246 128	239 123	233 118	227 113	221 109	215 104	209 100
36LH09	21	36	23700	411 247	398 235	386 224	374 214	363 204	352 195	342 186	333 179	323 171	314 163	306 157	297 150	289 144	282 138	275 133	267 127
36LH10	21	36	26100	454 273	440 260	426 248	413 236	401 225	389 215	378 206	367 197	357 188	347 180	338 173	328 165	320 159	311 152	303 146	295 140
36LH11	23	36	28500	495 297	480 283	465 269	451 257	438 246	425 234	412 224	401 214	389 205	378 196	368 188	358 180	348 173	339 166	330 159	322 153
36LH12	25	36	34100	593 354	575 338	557 322	540 307	523 292	508 279	493 267	478 255	464 243	450 232	437 222	424 213	412 204	400 195	389 187	378 179
36LH13	30	36	40100	697 415	675 395	654 376	634 359	615 342	596 327	579 312	562 298	546 285	531 273	516 262	502 251	488 240	475 231	463 222	451 213
36LH14	36	36	44200	768 456	755 434	729 412	706 392	683 373	661 356	641 339	621 323	602 309	584 295	567 283	551 270	535 259	520 247	505 237	492 228
36LH15	36	36	46600	809 480	795 464	781 448	769 434	744 413	721 394	698 375	677 358	656 342	637 327	618 312	600 299	583 286	567 274	551 263	536 252

Type HSB-36

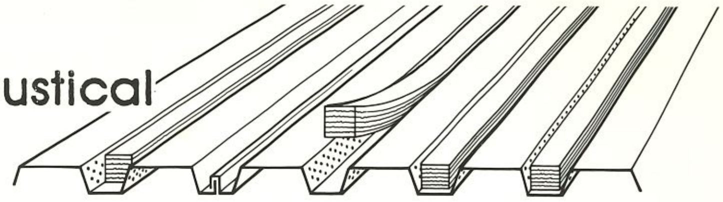
High Shear B Deck-36″ Wide
Verco's New Standard B Deck
Higher lateral load capacity



Standard button punch side lap

Overlapping side lap available 24″ or 30″ wide — special order

Acoustical



Vertical Webs Perforated With 5/32″ Diameter Holes Staggered 7/16″ C/C
Insulation Strips in Low Flutes Field Installed

Absorption Coefficients						Noise Reduction Coefficient
125	250	500	1000	2000	4000	
.60	.99	.92	.79	.43	.23	.80

NRC Determined By Tests In Accordance With ASTM Designation C423 Conducted By Riverbank Acoustical Laboratories.

Perforations do not significantly affect Properties or Shear Values.

Gage	Weight (Lbs./Sq. Ft.) Prime Painted	Weight (Lbs./Sq. Ft.) Galvanized	I (In⁴)	+S (In³)	−S (In³)
22	1.8	1.9	.175	.187	.198
20	2.2	2.3	.216	.235	.248
18	2.8	2.9	.302	.322	.335
16	3.4	3.5	.377	.411	.417

FACTORY MUTUAL APPROVED: STEEL ROOF DECKS, Class I Fire and I-60 or I-90 Windstorm Rated (Minimum)

Factory Mutual Approved Spans for HSB Roof Deck

Gage	22	20	18
Span*	6′-1″	6′-7″	7′-9″

*Factory Mutual will allow these calculated spans to be extended by a maximum of 6 inches (152 mm), but only to satisfy valid column spacing requirements that could not otherwise be met. Whenever this extension is allowed, side lap fastening must occur at a maximum of 18 inch (457 mm) intervals instead of the normally required 3 feet (0.9 m).

- SIDE SEAMS SCREWED FOR F-M

VERTICAL LOADS (Lbs./Sq. Ft.) HSB-36 and HSB-36 WITH SHEARTRANZ® **PRIME PAINTED OR GALVANIZED**

	Gage		5′-0″	5′-6″	6′-0″	6′-6″	7′-0″	7′-6″	8′-0″	8′-6″	9′-0″	9′-6″	10′-0″
Simple Span	22	s	114	94	79	67	58	51	44	39			
		Δ	92	69	53	42	34	27	22	19			
	20	s	143	118	99	85	73	64	56	49	44		
		Δ	113	85	66	52	41	34	28	23	19		
	18	s	196	162	136	116	100	87	76	68	60	54	49
		Δ	159	119	92	72	58	47	39	32	27	23	20
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	111	98	86	77	69	62
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	59	48	40	34	29	25
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54	47	42	37		
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—		
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67	59	52	47	42	38
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	47	40	34
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	91	80	70	63	56	51
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	56	48
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	113	99	88	78	70	63
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	—	—	70	60
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67	59	52	46		
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51	42	35	30		
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	84	74	65	58	52	47
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	63	52	44	37	31	27
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	113	99	88	79	71	64
			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	89	73	61	51	44	37
	16	s	317	262	220	188	162	141	124	110	98	88	79
		Δ	—	—	216	170	136	111	91	76	64	54	47

Parameters:

DL = 15 psf
SL = 25 psf
joist spacing = 8′-2″ oc

Deck Capacity = 54 psf

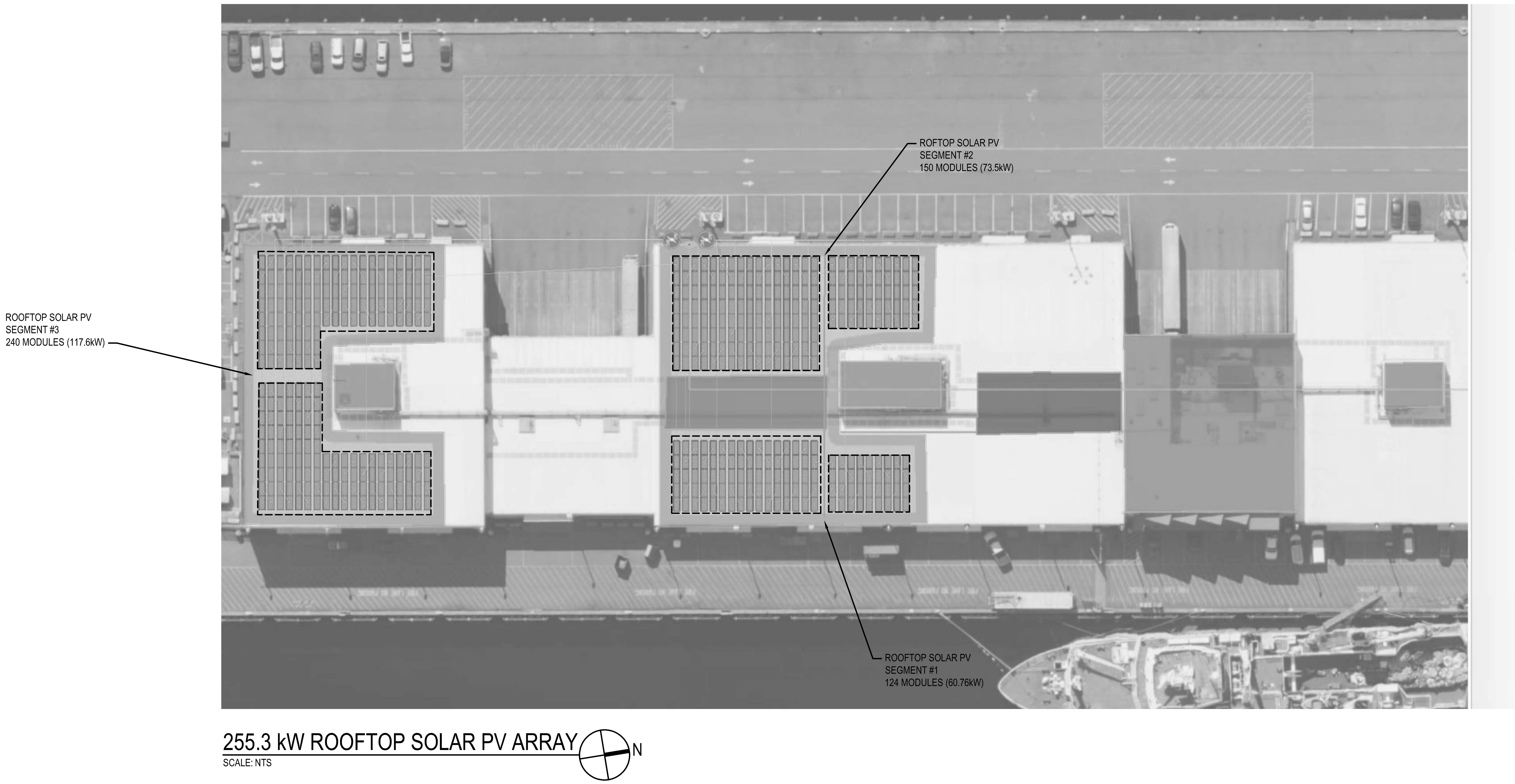
Controlling Limit State = DL + SL = 40 psf

Summary - Deck could accommodate 14 psf additional dead loading d.t. solar.

Note, deck does not control the design.

See page 14, item 1 on how to use this table.

VERCO MANUFACTURING CO.



255.3 kW ROOFTOP SOLAR PV ARRAY
SCALE: NTS

SÄZÄN GROUP
600 Stewart St., Ste 1400
Seattle, Washington 98101
Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

BUILDING C-175
PORT OF SEATTLE

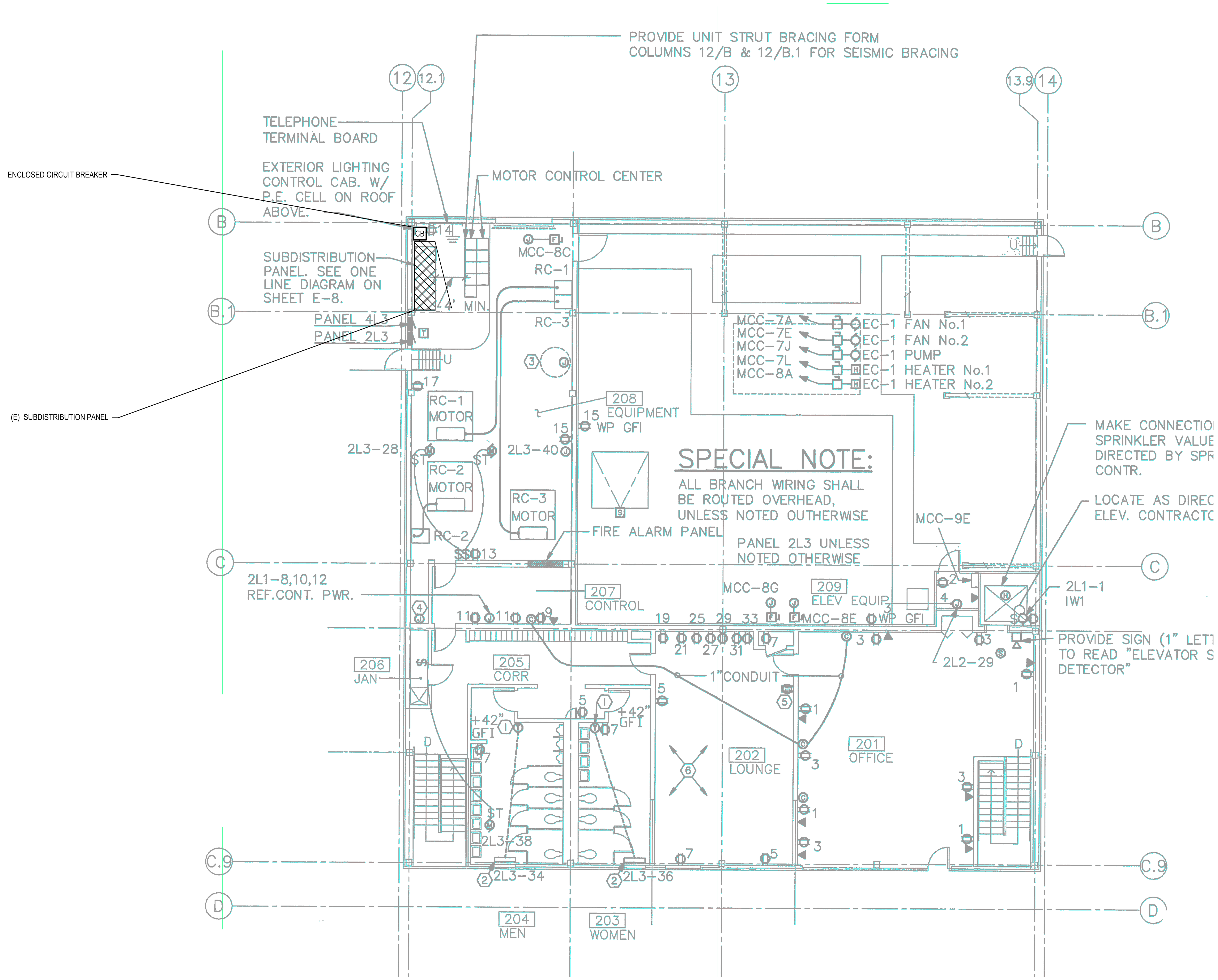
Port of Seattle

Project: B23-24007
Contents:

ROOFTOP SOLAR PV
MODULE LAYOUT

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

E1.0



ENLARGED PV EQUIPMENT LAYOUT - FIRST FLOOR

SCALE: 1" = 10'0"

1

SÄZÄN GROUP
600 Stewart St., Ste 1400
Seattle, Washington 98101
Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

BUILDING C-175
PORT OF SEATTLE

Port of Seattle

Project: B23-24007
Contents:

SOLAR PV
EQUIPMENT LAYOUT

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

E2.0

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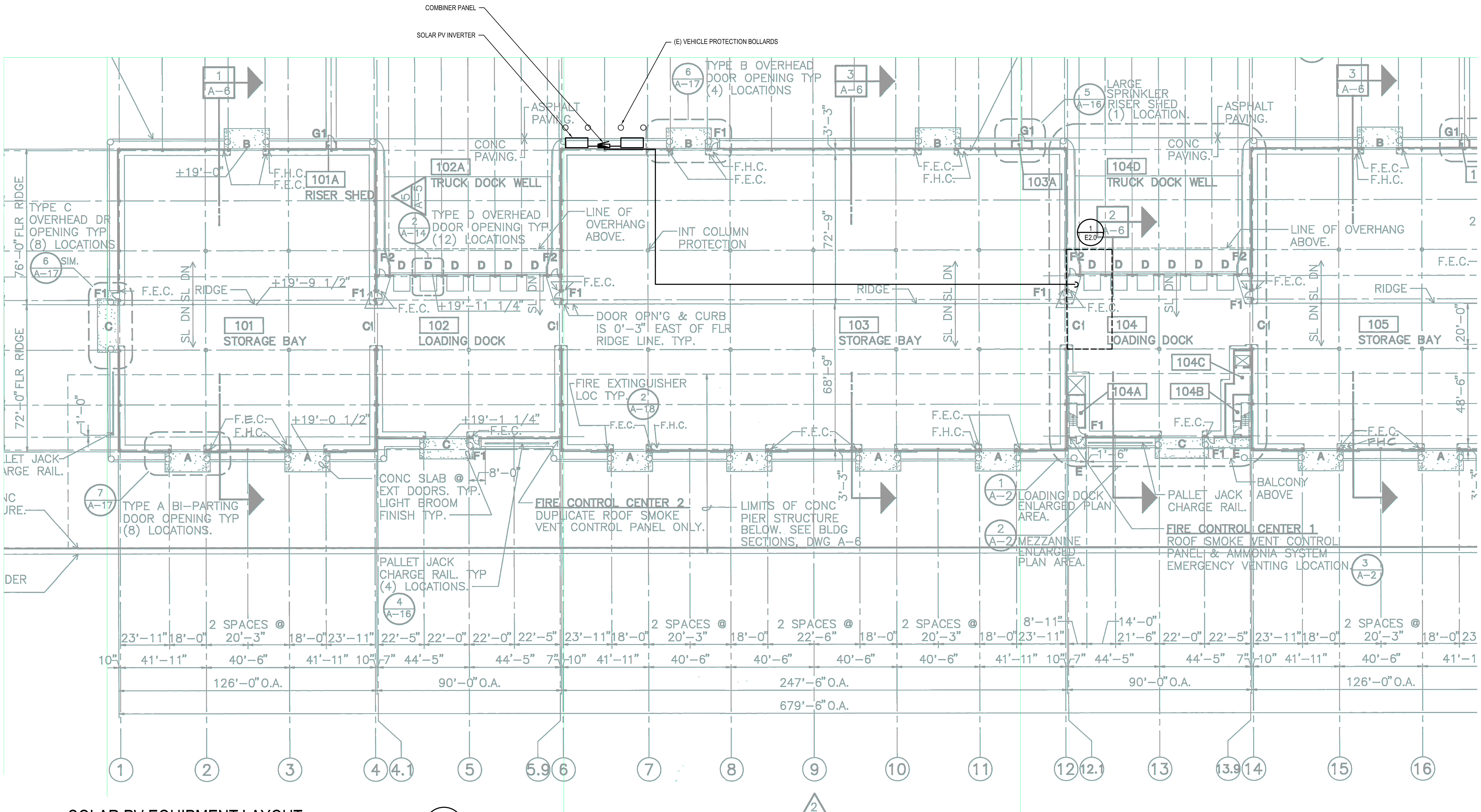
Joseph Cauilan



SOLAR PV EQUIPMENT LAYOUT

SCALE: 1" = 30'0"

1

SÄZÄN GROUP
600 Stewart St., Ste 1400
Seattle, Washington 98101
Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

BUILDING C-175
PORT OF SEATTLE

Port of Seattle

Project: B23-24007

Contents:

SOLAR PV EQUIPMENT LAYOUT

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

E2.1

212

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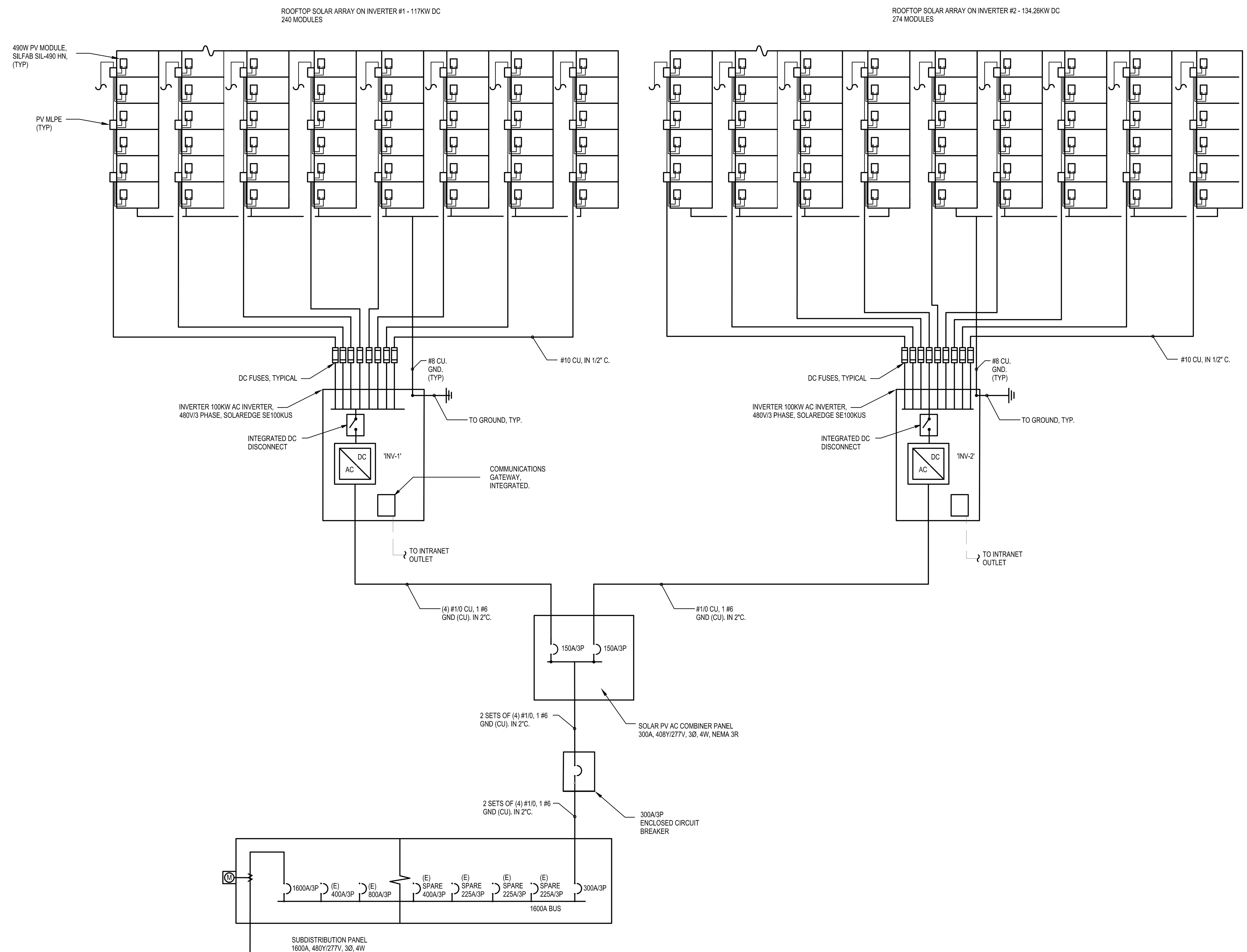
Joseph Cauilan



SOLAR PV SYSTEM - ONE LINE DIAGRAM

SCALE: NTS

1

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Joseph Cauilan

SÄZÄN GROUP
600 Stewart St., Ste 1400
Seattle, Washington 98101
Tel 206.267.1700
Fax 206.267.1701
SAZAN # XXX-XXXXX

#	DESCRIPTION	DATE

BUILDING C-175
PORT OF SEATTLE

Port of Seattle

Project: B23-24007

Contents:

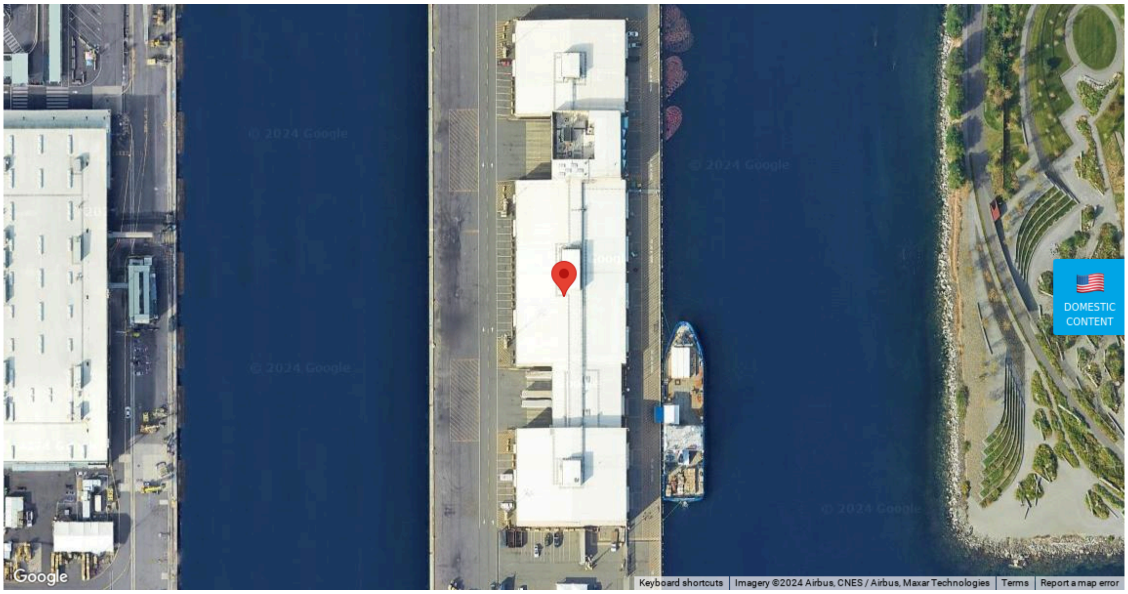
SOLAR PV SYSTEM - ONELINE DIAGRAM

Drawn: JC
Checked: TC
Date: 12/19/24
Sheet Number:

E3.0

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Project Details			
Name	C-175	**Date**	12/06/2024
Location	2001 West Garfield Street, Seattle, WA 98119	**Total modules**	521
Module	Silfab: SIL-490 HN (35mm)	**Total watts**	255,290
Dimensions	Dimensions: 89.09" x 40.83" x 1.38" (2263.0mm x 1037.0mm x 35.0mm)	**ASCE code**	7-16



Load Conditions			
Risk category	I	**Ground snow load**	20 psf
Wind speed	92 mph	**Wind exposure**	C

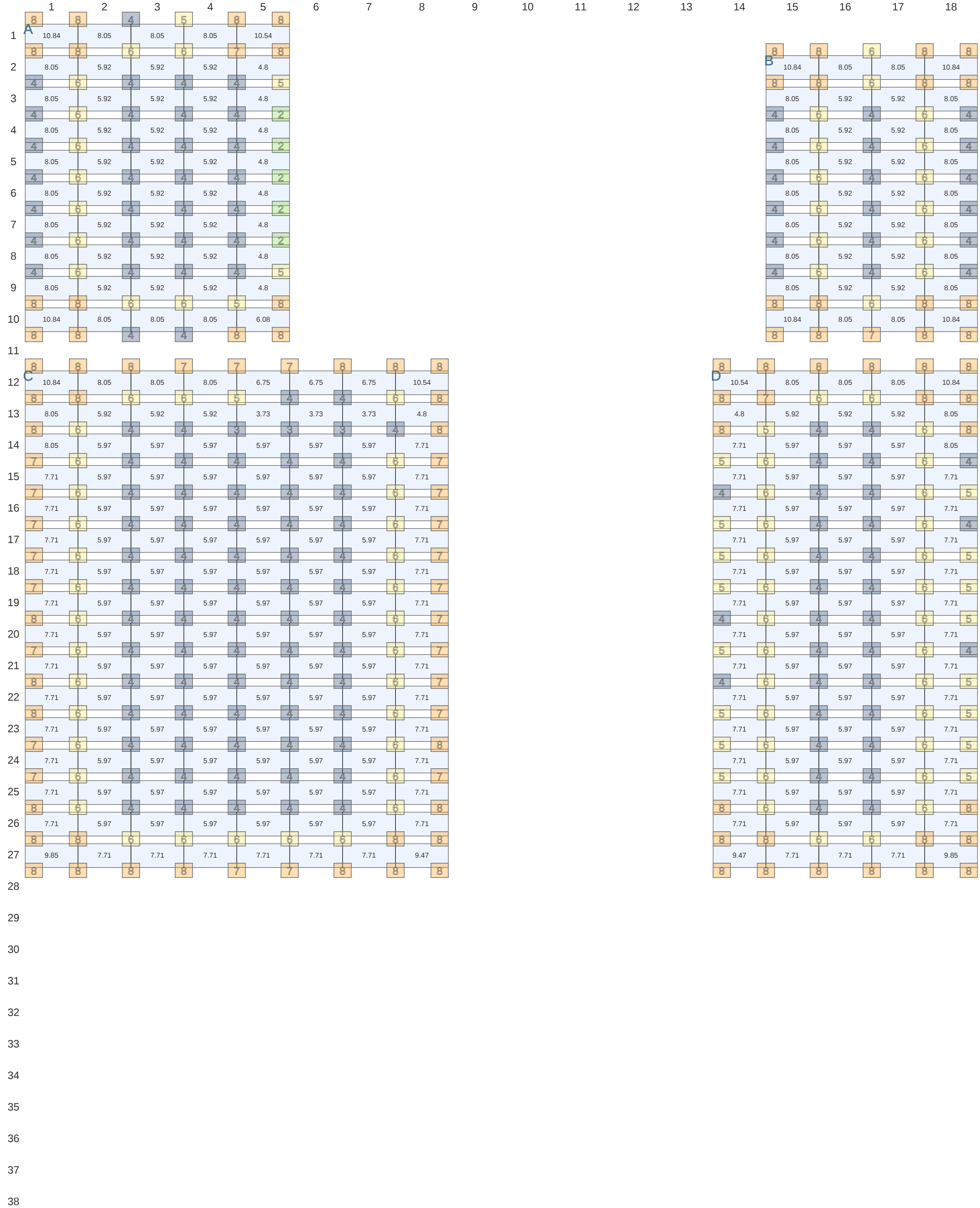
Building Information			
Height	30.0 ft	**Elevation**	15.0 ft
North-south	350.0 ft	**East-west**	150.0 ft
Roof slope	1 °	**Parapet height**	0.0 in
Fire setback	6.0 ft	**Parapet thickness**	N/A
Roof material	EPDM	**Roof manufacturer**	n/a
Color	n/a	**Thickness**	n/a

BX Parameters			
Tilt angle	10 °	**Seismic design**	Prescriptive Method
Block size	Half	**Block weight**	15.50 lbs
Spectral Acceleration (S_{DS})	1.112	**Seismic Design Category**	D
Calculations	Rectangular	**Setback**	6.0 ft
Ballast Relocation	Yes	**Supplemental Chasis**	Yes

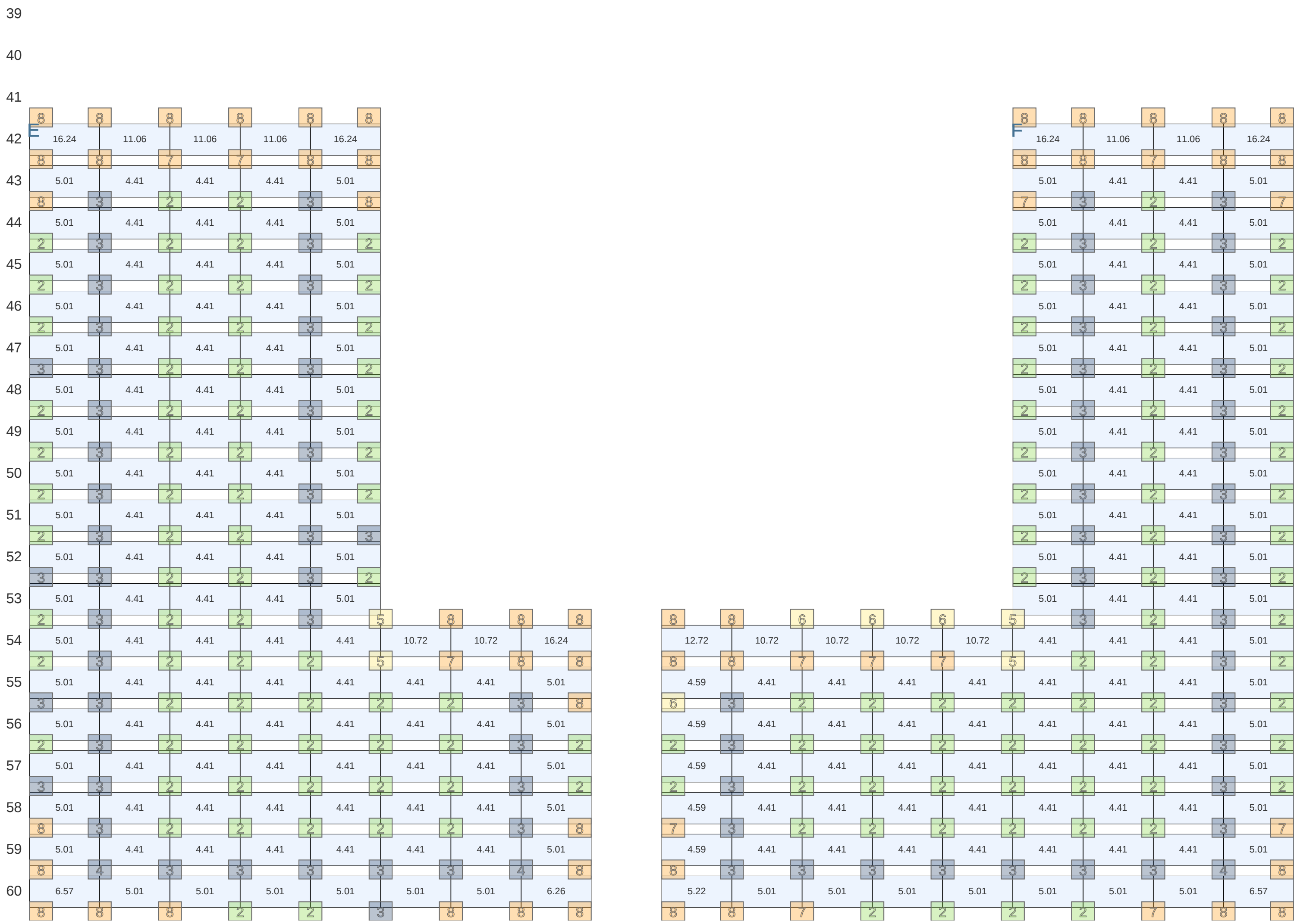
Prescriptive Method Setbacks					
Between Arrays	1' 3.2"	**Array to Fixed Object**	2' 6.4"	**Array to Roof Edge**	5' 0.8"

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Panels: 521 Chassis: 655 Blocks: 3100 Anchors: 0



216



** If any changes are made to panel placement or location relative to roof edges, the ballast plan must be recalculated.*

Sliding Group Information

Sliding group	Module count	Anchor count	Chassis count	Block count	Dead load	Area	PSF
A	50	0	66.00	339.00	8,440.32	1,728.91	4.88
B	36	0	50.00	297.00	6,909.88	1,250.56	5.53
C	128	0	153.00	857.00	21,359.29	4,355.33	4.90
D	80	0	102.00	578.00	14,039.50	2,721.22	5.16
E	116	0	144.00	523.00	15,452.52	3,957.64	3.90
F	111	0	140.00	506.00	14,883.14	3,807.15	3.91

Ballast and Anchors

Module count	**521**	Chassis count	**655**	Block count	**3,100**
Wind Anchors	**0**	Seismic Anchors	**n/a**	Anchors needed	**0**
Block weight	**48,050.00 lbs**	Components weight	**33,034.65 lbs**	Total weight	**81,084.65 lbs**
Area	**17,820.81 sq. ft**			Ground Coverage Ratio	**0.74**
Avg dist dead load	**4.55 psf**			Max chassis weight (Incl. 1 Module)	**186.11 lbs**

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Bill of Materials

Part	Spares	Qty
BX Components		
BX-10D-P1 BX Chassis 10 deg	0	655
BX-TCL-35MM-M1 BX Top Clamp, 35mm, Mill	0	2438
BX-BCL-M1 BX Bottom Clamp w/ Hardware	0	2438
BX-RB38-M1 38" Row Bonding Jumper	0	83
PV-LUG-02-A1 PV Module Grounding Lug	0	6
BX-MB8-M1 8" Module Bonding Jumper	0	432
QMAFBU-A-25 Accessory Frame Bracket, Universal, Mill	0	261

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Assumptions

The results produced by IronRidge's Design Assistant are only valid if all the following conditions are met and the design parameters were entered accurately.

Design Parameters

- Design Assistant ballast calculations assume rectangular buildings.
- Building must be less than 60ft high, or building height must be less than the least horizontal dimension.
- Roof is a single level (e.g. no penthouse that extends above roof for part of the area).
- Roof has sharp eaves.
- Calculations assume a setback around each obstruction equal or larger than the height of the obstruction.
- Calculations assume that the array is aligned to the NW corner of the roof plus the setback. Panel edges must be parallel to the roof edges.
- Maximum rows and columns for the array will be calculated to ensure that setbacks on the east and south are at least as large as the setbacks on the north and west.
- Verify your minimum setback requirements with your local AHJ.
- If the building could hold an array larger than the maximum size array the Design Assistant can configure (60 rows x 60 columns), the setback will be expanded on the east and south sides of the array to extend all the way to the edge of the roof beyond the maximum sized array.
- Design Assistant does not account for any accelerated wind flow due to surrounding buildings.
- Defaulted at Soil Type D for seismic calculations.

Seismic Design

- Prescriptive setbacks are calculated using the approach from ASCE 7-16.
- Minimum $delta_{mpv}$ of 2 feet.
- Distance between a solar array and a roof edge without a qualifying parapet is 2.0 * I_e * $delta_{mpv}$.
- I_e, seismic importance factor, is from ASCE Section 1.5.1, Table 1.5-2.

Component/System Properties

- By default, anchor placements are made using the attachment's capacity of 525 uplift/392 lateral (lbs). It is the user's responsibility to verify reaction load capacity of the structural decking. If the structural decking cannot sustain these loads, the actual limits can be entered into Design Assistant (Anchor uplift strength/Anchor lateral strength).
- Concrete ballast block:
  - Manufactured per ASTM C 1491 (Standard specification for concrete pavers).
  - Manufactured to resist freeze-thaw as required per local conditions.
  - Design Assistant defaults block weights to 15.5 lbs (half block) and 32 lbs (full block). User is responsible for adjusting these weights to match actual blocks sourced.
- Chassis Weight: ~ 4.7 lbs
- E-W Module Gap: .375”
- Inter-Row Spacing:
  - 5 Degrees = 10”
  - 10 Degrees = 13”
- Chassis overhang:
  - 5 Degrees
    - North ~ 19" and South ~ 15.5"
  - 10 Degrees
    - North ~ 17" and South ~ 20.5"
- Coefficients of Static Friction under wet conditions for Tested Roof Types:
  - TPO = .69
  - KEE = .60
  - PVC = .60
  - Built Up = .50
  - Modified Bitumen = .50
  - EPDM = .73

Ratings/Certifications

- UL 2703 Listed (See installation manual for more details)
- Class A System Fire Rating Per UL 1703
- Designed and Certified for Compliance with the International Building Code, ASCE/SEI-7, and SEAOC PV Guidelines
- Wind Tunnel Testing by I.F.I
- User to verify module manufacturer's clamping location and pressure limits.

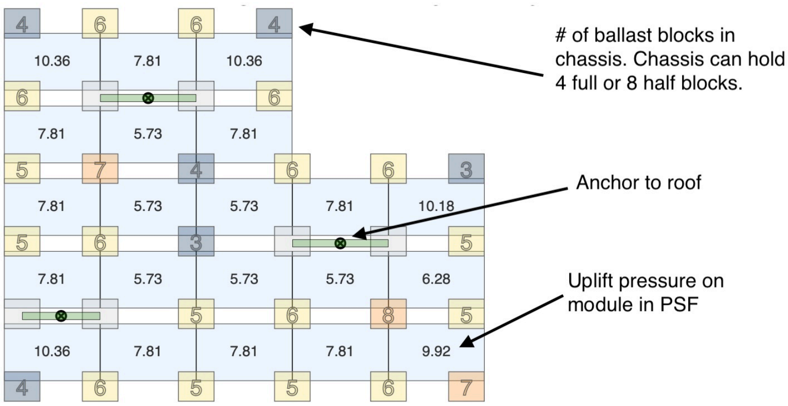
Additional Notes

- Installer must clean roof of all debris before installing BX chassis and/or slip sheets. It is recommended to blow off debris or loose roofing material from Modified Bitumen or Built Up roofs.
- If array moves due to an earthquake, it shall be restored to its original position.
- If anchors are damaged due to an earthquake, they shall be replaced.
- Building engineer should evaluate the effect of snow loading and drifts on the roof prior to installation of the array.
- Site specific engineering is required if the system design exceeds the current capabilities of IronRidge's Design Assistant. Please contact technical support for additional assistance.
- IronRidge's technical support can be reached by the following:
  - Email: techsupport@ironridge.com
  - Phone: 800-227-9523 Ext. 1

IRONRIDGE
28357 INDUSTRIAL BLVD., HAYWARD, CA 94545

Roof Section Ballast Plan Legend

Example Array



PRE-INSTALLATION

- ☐ Verify module compatibility. See Page 11 for info.

TOOLS REQUIRED

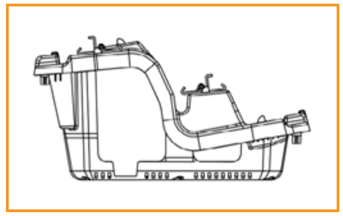
- ☐ Cordless Drill (optional)
- ☐ Torque Wrench (0-250 in-lbs)
- ☐ 9/16" Socket
- ☐ 7/16" Socket
- ☐ 1/2" Socket
- ☐ String Chalk Line

TORQUE VALUES

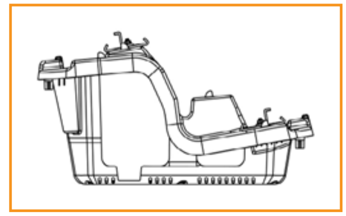
- ☐ Top Clamp Nuts (1/2" Socket): 120 in-lbs
- ☐ 5/16" MLPE Flange Bolts (1/2" Socket): 60 in-lbs
- ☐ 5/16" String Inverter Mount Bolts (1/2" Socket): 80 in-lbs
- ☐ 5/16" L-Foot to Chassis Nuts (1/2" Socket): 120 in-lbs
- ☐ 3/8" T-Bolt Bonding Hardware (7/16" Socket): 250 in-lbs
- ☐ 1/4" String Inverter Mount Hdw (7/16" Socket): 80 in-lbs
- ☐ Flat Roof Attach to L-Foot Hdw (9/16" Socket): 250 in-lbs
- ☐ Module Grounding Lug Nut (1/2" Socket): 60 in-lbs
    - ☐ Grounding Lug Terminal Screws (3/8" Socket): 20 in-lbs

➤ **Unless otherwise noted, all components have been evaluated for multiple use. They can be uninstalled and reinstalled in the same or new location.**

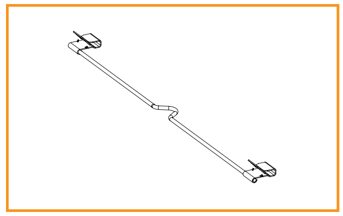
COMPONENTS



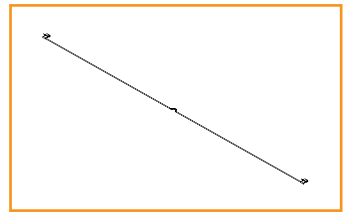
5° BX Chassis



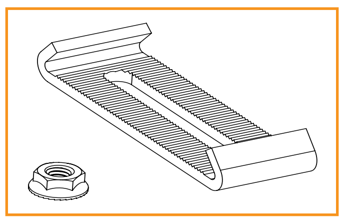
10° BX Chassis



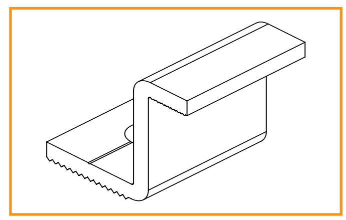
8" Module Bonding Jumper
Single Use Only



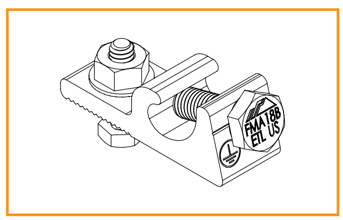
38" Row Bonding Jumper
Single Use Only



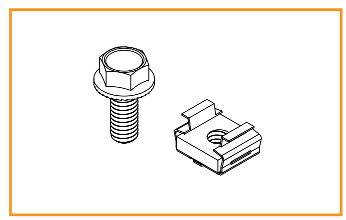
Bottom Clamp



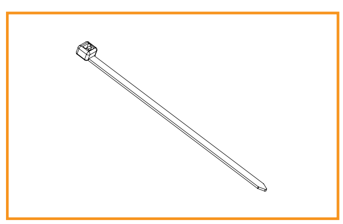
Top Clamp (Height Varies)



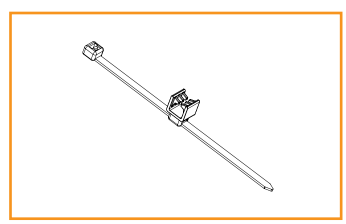
PV Module Grounding Lug



MLPE Mounting Hardware

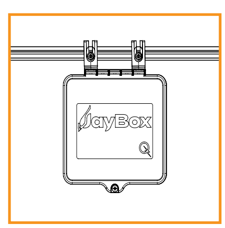


Cable Tie

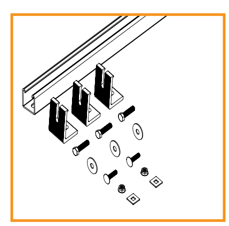


Edge Clip Cable Tie

String Inverter Mounting Kit



Jaybox



Flat Roof Attachment Kit

SILFAB COMMERCIAL

SILFAB SOLAR®

SIL-490 HN

ENGINEERED FOR COMMERCIAL & UTILITY PROJECTS

Superior performance and proven reliability from a trusted source.

TOP PERFORMER 2023 PVEL kiwa PV MODULE RELIABILITY SCORECARD

SILFABSOLAR.COM

CE Intertek IEC

ELECTRICAL SPECIFICATIONS		490 HN	
Test Conditions		STC	NOCT
Module Power (Pmax)	Wp	490	362
Maximum power voltage (Vpmax)	V	45.23	41.61
Maximum power current (Ipmax)	A	10.83	8.69
Open circuit voltage (Voc)	V	53.96	49.64
Short circuit current (Isc)	A	11.36	9.12
Module efficiency	%	20.9%	19.3%
Maximum system voltage (VDC)	V	1500	
Series fuse rating	A	20	
Power Tolerance	Wp	0 to +10	

Measurement conditions: STC 1000 W/m² • AM 1.5 • Temperature 25 °C • NOCT 800 W/m² • AM 1.5 • Measurement uncertainty ≤ 3%
Sun simulator calibration reference modules from Fraunhofer Institute. Electrical characteristics may vary by ±5% and power by 0 to +10W.

MECHANICAL PROPERTIES / COMPONENTS	METRIC	IMPERIAL
Module weight	25.8kg ±0.2kg	56.9lbs ±0.4lbs
Dimensions (H x L x D)	2263 mm x 1037 mm x 35 mm	89 in x 40.8 in x 1.37 in
Maximum surface load (wind/snow)*	2400 Pa rear load / 5400 Pa front load	50.1 lb/ft² rear load / 112.8 lb/ft² front load
Hail impact resistance	ø 25 mm at 83 km/h	ø 1 in at 51.6 mph
Cells	156 Half cells - Si mono PERC 9 busbar - 83 x 166 mm	156 Half cells- Si mono PERC 9 busbar - 3.26 x 6.53 in
Glass	3.2 mm high transmittance, tempered, DSM antireflective coating	0.126 in high transmittance, tempered, DSM antireflective coating
Cables and connectors (refer to installation manual)	1350 mm, ø 5.7 mm, MC4 from Staubli	53.15 in, ø 0.22 in (12AWG), MC4 from Staubli
Backsheet	High durability, superior hydrolysis and UV resistance, multi-layer dielectric film, fluorine-free PV white backsheet	
Frame	Anodized Aluminum (Silver)	
Bypass diodes	3 diodes-30SQ045T (45V max DC blocking voltage, 30A max forward rectified current)	
Junction Box	UL 3730 Certified, IEC 62790 Certified, IP68 rated	

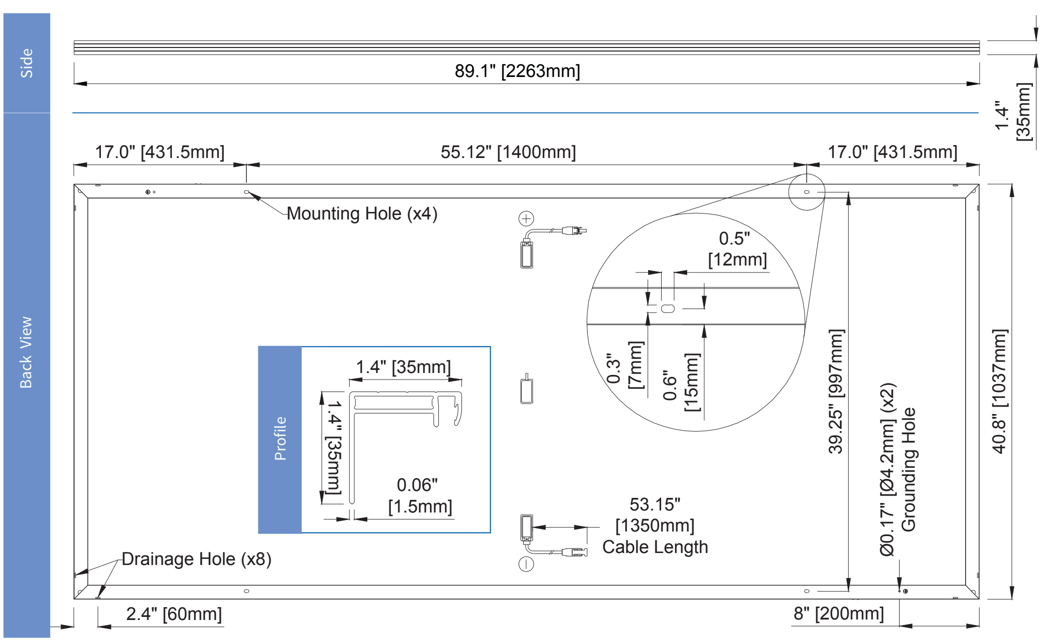
TEMPERATURE RATINGS	
Temperature Coefficient Isc	+0.064 %/°C
Temperature Coefficient Voc	-0.28 %/°C
Temperature Coefficient Pmax	-0.36 %/°C
NOCT (± 2°C)	45 °C
Operating temperature	-40/+85 °C

WARRANTIES	
Module product workmanship warranty	25 years**
Linear power performance guarantee	30 years
	≥ 97.1% end 1st yr ≥ 91.6% end 12th yr ≥ 85.1% end 25th yr ≥ 82.6% end 30th yr

CERTIFICATIONS	
Product	ULC ORD C1703, UL1703, CEC listed, UL 61215-1/-2, UL 61730-1/-2, IEC 61215-1/-2. IEC 61730-1/-2, CSA C22.2#61730-1/-2, IEC 62716 Ammonia Corrosion; IEC61701:2011 Salt Mist Corrosion Certifed, UL Fire Rating: Type 1
Factory	ISO9001:2015

SHIPPING SPECS	
Modules Per Pallet:	31
Pallets Per Truck	23
Modules Per Truck	713

* ⚠ Warning. Read the Safety and Installation Manual for mounting specifications and before handling, installing and operating modules.
** 12 year extendable to 25 years subject to registration and conditions outlined under “Warranty” at silfabsolar.com
PAN files generated from 3rd party performance data are available for download at: silfabsolar.com/downloads



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Silfab - SIL-490-HN+-20231221

Three Phase Inverter with Synergy Technology

INVERTER

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

Powered by unique pre-commissioning process for rapid system installation

- Pre-commissioning feature for automated validation of system components and wiring during the site installation process and prior to grid connection
- Easy 2-person installation with lightweight, modular design (each inverter consists of 2 or 3 Synergy units and 1 Synergy Manager)
- Independent operation of each Synergy unit enables higher uptime and easy serviceability
- Built-in thermal sensors detect faulty wiring, ensuring enhanced protection and safety
- Built-in arc fault protection and rapid shutdown
- Built-in PID mitigation for maximized system performance
- Monitored* and field-replaceable surge protection devices, to better withstand surges caused by lightning or other events
- Built-in module-level monitoring with Ethernet or cellular communication for full system visibility

*Applicable only for DC and AC SPDs

/ Three Phase Inverter with Synergy Technology

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

MODEL NUMBER	SE80KUS	SE100KUS	SE110KUS	SE120KUS	
APPLICABLE TO INVERTERS WITH PART NUMBER	SExxK-USx8Ixxxx				UNITS
OUTPUT					
Rated AC Active Output Power	80000	100000	110000	120000	W
Maximum AC Apparent Output Power	80000	100000	120000	120000	VA
AC Output Line Connections	3W + PE, 4W + PE				
Supported Grids	WYE: TN-C, TN-S, TN-C-S, TT, IT; Delta: IT				
AC Output Voltage Minimum-Nominal-Maximum(1) (L-N)	244 – 277 – 305				Vac
AC Output Voltage Minimum-Nominal-Maximum(1) (L-L)	422.5 – 480 – 529				Vac
AC Frequency Min-Nom-Max(1)	59.5 – 60 – 60.5				Hz
Maximum Continuous Output Current (per Phase, PF=1)	96.5	120	144.3		Aac
GFDI Threshold	1				A
Utility Monitoring, Islanding Protection, Configurable Power Factor, Country Configurable Thresholds	Yes				
Total Harmonic Distortion	≤ 3				%
Power Factor Range	±0.85 to 1				
INPUT					
Maximum DC Power (Module STC) Inverter / Synergy Unit	140000 / 70000	175000 / 58300	210000 / 70000		W
Transformer-less, Ungrounded	Yes				
Maximum Input Voltage DC+ to DC-	1000				Vdc
Operating Voltage Range	850 – 1000				Vdc
Maximum Input Current	2 x 48.25	3 x 40	3 x 48.25		Adc
Reverse-Polarity Protection	Yes				
Ground-Fault Isolation Detection	167kΩ sensitivity per Synergy Unit(2)				
CEC Weighted Efficiency	98.5				%
Nighttime Power Consumption	< 8	< 12			W
ADDITIONAL FEATURES					
Supported Communication Interfaces(3)	2 x RS485, Ethernet, Wi-Fi (optional), Cellular (optional)				
Smart Energy Management	Export Limitation				
Inverter Commissioning	With the SetApp mobile application using built-in Wi-Fi access point for local connection				
Arc Fault Protection	Built-in, User Configurable (According to UL1699B)				
Photovoltaic Rapid Shutdown System	NEC 2014 – 2023, built-in				
PID Rectifier	Nighttime, built-in				
RS485 Surge Protection (ports 1+2)	Type II, field replaceable, integrated				
AC, DC Surge Protection	Type II, field replaceable, integrated				
DC Fuses (Single Pole)	25A, integrated				
DC SAFETY SWITCH					
DC Disconnect	Built-in				
STANDARD COMPLIANCE					
Safety	UL1699B, UL1741, UL1741 SA, UL1741 SB, UL1998, CSA C22.2#107.1, Canadian AFCI according to T.I.L. M-07				
Grid Connection Standards	IEEE 1547-2018, Rule 21, Rule 14 (HI)				
Emissions	FCC part 15 class A				

(1) For other regional settings please contact SolarEdge support.
(2) Where permitted by local regulations.
(3) For specifications of the optional communication options, visit the Communication product page or the Knowledge Center to download the relevant product datasheet.

/ Three Phase Inverter with Synergy Technology

For the 277/480V Grid for North America

SE80KUS / SE100KUS / SE110KUS / SE120KUS

MODEL NUMBER		SE80KUS	SE100KUS	SE110KUS	SE120KUS	UNITS
APPLICABLE TO INVERTERS WITH PART NUMBER		SExxK-USx8Ixxxx				
INSTALLATION SPECIFICATIONS						
Number of Synergy Units per Inverter		2	3			
Ac Max Conduit Size		2 ½"				in
Max AWG Line / PE		4/0 / 1/0				
DC Max Conduit Size		1 x 3"; 2 x 2"				in
DC Input Inverter/ Synergy Unit	Multi-input (SExxK-USxxxxxZ4)	8 / 4 pairs; 6-12 AWG	12 / 4 pairs; 6-12 AWG			
	Combined input (SExxK-USxxxxxW4)	2 pairs / 1 pair, Max 2 AWG; copper or aluminum	3 pairs / 1 pair, Max 2 AWG; copper or aluminum			
Dimensions (H x W x D)		Synergy Unit: 22 x 12.9 x 10.75 / 558 x 328 x 273 Synergy Manager: 14.17 x 22.4 x 11.6 / 360 x 560 x 295				in / mm
Weight		Synergy Unit: 70.4 / 32 Synergy Manager: 39.6 / 18				lb / kg
Operating Temperature Range		-40 to +140 / -40 to +60(4)				˚F / ˚C
Cooling		Fan (user replaceable)				
Noise		< 67				dBA
Protection Rating		NEMA 3R				
Mounting		Brackets provided				

(4) For power de-rating information refer to the Temperature Derating Technical Note for North America.

SolarEdge is a global leader in smart energy technology. By leveraging world-class engineering capabilities and with a relentless focus on innovation, SolarEdge creates smart energy solutions that power our lives and drive future progress.

SolarEdge developed an intelligent inverter solution that changed the way power is harvested and managed in photovoltaic (PV) systems. The SolarEdge DC optimized inverter maximizes power generation while lowering the cost of energy produced by the PV system.

Continuing to advance smart energy, SolarEdge addresses a broad range of energy market segments through its PV, storage, EV charging, UPS, and grid services solutions.

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CE

Power Optimizer

P605 / P650 / P701 / P730 / P800p /
P801 / P850 / P950 / P1100

25
YEAR
WARRANTY

POWER OPTIMIZER

PV power optimization at the module level

The most cost-effective solution for commercial and large field installations

- Specifically designed to work with SolarEdge inverters
- High efficiency with module-level MPPT, for maximized system energy production and revenue, and fast project ROI
- Superior efficiency (99.5%)
- Balance of System cost reduction; 50% less cables, fuses, and combiner boxes, and over 2x longer string lengths possible
- Fast installation with a single bolt
- Advanced maintenance with module level monitoring
- Module level voltage shutdown for installer and firefighter safety
- Use with two PV modules connected in series or in parallel

/ Power Optimizer

P605 / P650 / P701 / P730 / P801

Power Optimizer Module (Typical Module Compatibility)	P605 (for 1 x high power PV module)	P650 (for up to 2 x 60-cell PV modules)	P701 (for up to 2 x 60/120-cell PV modules)	P730 (for up to 2 x 72-cell PV modules)	P801 (for up to 2 x 72/144 cell PV modules)	
INPUT						
Rated Input DC Power(1)	605	650	700*	730**	800	W
Connection Method	Single input for series connected modules					
Absolute Maximum Input Voltage (Voc at lowest temperature)	65	96		125		Vdc
MPPT Operating Range	12.5 – 65	12.5 – 80		12.5 – 105		Vdc
Maximum Short Circuit Current per Input (Isc)	14.1	11	11.75	11**	12.5***	Adc
Maximum Efficiency	99.5					%
Weighted Efficiency	98.6					%
Overvoltage Capacity	II					
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER						
Maximum Output Current	15					Adc
Maximum Output Voltage	80					Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM SOLAREDGE INVERTER OR SOLAREDGE INVERTER OFF						
Safety Output Voltage per Power Optimizer	1 ± 0.1					Vdc
STANDARD COMPLIANCE						
EMC	FCC Part 15 Class B, IEC61000-6-2, IEC61000-6-3					
Safety	IEC62109-1 (class II safety)					
RoHS	Yes					
Fire Safety	VDE-AR-E2100-712:2013-05					
INSTALLATION SPECIFICATIONS						
Compatible SolarEdge Inverters	Three Phase Inverter SE16K & larger					
Maximum Allowed System Voltage	1000					Vdc
Dimensions (W x L x H)	129 x 153 x 52 / 5.1 x 6 x 2	129 x 153 x 42.5 / 5.1 x 6 x 1.7		129 x 153 x 49.5 / 5.1 x 6 x 1.9		mm / in
Weight	1064 / 2.3	834 / 1.8		933 / 2.1		gr / lb
Input Connector	MC4(2)					
Input Wire Length	0.16 / 0.52			0.16 / 0.52, 0.9 / 2.95(3)		m / ft
Output Connector	MC4					
Output Wire Length	Portrait Orientation: 1.4 / 4.5	Portrait Orientation: 1.2 / 3.9	-	Portrait Orientation: 1.2 / 3.9		m / ft
	-	Landscape Orientation: 1.8 / 5.9		Landscape Orientation: 2.2 / 7.2		
Operating Temperature Range(6)	-40 to +85 / -40 to +185					ºC / ºF
Protection Rating	IP68 / NEMA6P					
Relative Humidity	0 – 100					%

* For P701 models manufactured after work week 06/2020, the rated DC input is 740W.
** For P730 models manufactured after work week 06/2020, the rated DC input is 760W and the maximum Isc per input is 11.75A.
*** For P801 models manufactured in work week 40/2020 or earlier, the maximum Isc per input in 11.75A.
(1) The rated power of the module at STC will not exceed the Power Optimizer "Rated Input DC Power". Modules with up to +5% power tolerance are allowed.
(2) For other connector types, please contact SolarEdge.
(3) Longer input wire lengths are available for use with split junction box modules. For 0.9m/2.95ft order P730-xxxLxxx.
(4) For ambient temperatures above +70ºC / +158ºF, power de-rating is applied. Refer to Power Optimizers Temperature De-Rating Technical Note for more details.

PV System Design Using a SolarEdge Inverter(5)(6)(7)(8)		230/400V Grid SE16K, SE17 SE25K*, SE33.3K*		230/400V Grid SE27.6K*		230/400V Grid SE30K*		277/480V Grid SE33.3K*, SE40K*		
Compatible Power Optimizers		P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	P605	P650, P701, P730, P801	
Minimum String Length	Power Optimizers	14	14	14	14	15	15	14	14	
	PV Modules	14	27	14	27	15	29	14	27	
Maximum String Length	Power Optimizers	30	30	30	30	30	30	30	30	
	PV Modules	30	60	30	60	30	60	30	60	
Maximum Continuous Power per String		11250		11625		12750		12750		W
Maximum Allowed Connected Power per String(8) (Permitted only when the difference in connected power between strings is 2,000W or less)		13500		13500		15000		15000		W
Parallel Strings of Different Lengths or Orientations		Yes								
Maximum Difference in Number of Power Optimizers Allowed Between the Shortest and Longest String Connected to the Same Inverter Unit		5 Power Optimizers								

* The same rules apply for Synergy units of equivalent power ratings that are part of the modular Synergy Technology Inverter.
(5) P650/P701/P730/P801 can be mixed in one string only with P650/P701/P730/P801. P605 cannot be mixed with any other Power Optimizer in the same string.
(6) For each string, a Power Optimizer may be connected to a single PV module if 1) each Power Optimizer is connected to a single PV module or 2) it is the only Power Optimizer connected to a single PV module in the string.
(7) For SE16K and above, the minimum STC DC connected power should be 11KW.
(8) To connect more STC power per string, design your project using SolarEdge Designer.

/ Power Optimizer

P800p / P850 / P950 / P1100

Power Optimizer Module (Typical Module Compatibility)	P800p (for up to 2 x 96-cell 5'' PV modules)	P850 (for up to 2 x high power or bi-facial modules)	P950 (for up to 2 x high power or bi-facial modules)	P1100 (for up to 2 x high power or bi-facial modules)	Unit
INPUT					
Rated Input DC Power[1]	800	850	950	1100	W
Connection Method	Dual input for independently connected	Single input for series connected modules			
Absolute Maximum Input Voltage (Voc at lowest temperature)	83	125			Vdc
MPPT Operating Range	12.5 – 83	12.5 – 105			Vdc
Maximum Short Circuit Current per Input (Isc)	7	14.1*		14.1	Adc
Maximum Efficiency	99.5				%
Weighted Efficiency	98.6				%
Overvoltage Capacity	II				
OUTPUT DURING OPERATION (POWER OPTIMIZER CONNECTED TO OPERATING SOLAREDGE INVERTER					
Maximum Output Current	18				Adc
Maximum Output Voltage	80				Vdc
OUTPUT DURING STANDBY (POWER OPTIMIZER DISCONNECTED FROM SOLAREDGE INVERTER OR SOLAREDGE INVERTER OFF					
Safety Output Voltage per Power Optimizer	1 ± 0.1				Vdc
STANDARD COMPLIANCE					
EMC	FCC Part 15 Class B, IEC61000-6-2, IEC61000-6-3				
Safety	IEC62109-1 (class II safety)				
RoHS	Yes				
Fire Safety	VDE-AR-E2100-712:2013-05				
INSTALLATION SPECIFICATIONS					
Compatible SolarEdge Inverters	Three Phase Inverter SE16K & larger			Three Phase Inverter SE25K & larger	
Maximum Allowed System Voltage	1000				Vdc
Dimensions (W x L x H)	129 x 168 x 59 / 5.1 x 6.61 x 2.32	129 x 162 x 59 / 5.1 x 6.4 x 2.32			mm / in
Weight	1064 / 2.3				gr / lb
Input Connector	MC4[2]				
Input Wire Length	0.16 / 0.52	0.16 / 0.52, 0.9 / 2.95, 1.3 / 4.26, 1.6 / 5.24[3]	0.16 / 0.52, 1.3 / 4.26, 1.6 / 5.24[3]	0.16 / 0.52, 1.3 / 4.26[3]	m / ft
Output Connector	MC4				
Output Wire Length	Portrait Orientation: 1.2 / 3.9 Landscape Orientation: 1.8 / 5.9	Portrait Orientation: 1.2 / 3.9 Landscape Orientation: 2.2 / 7.2		2.4 / 7.8	m / ft
Operating Temperature Range[4]	-40 to +85 / -40 to +185				°C / °F
Protection Rating	IP68 / NEMA6P				
Relative Humidity	0 – 100				%

* For P850/P950 models manufactured in work week 06/2020 or earlier, the maximum Isc per input is 12.5A. The manufacture code is indicated in the Power Optimizer's serial number.
Example: S/N SJ0620A-xxxxxxxx (work week 06 in 2020)
(1) The rated power of the module at STC will not exceed the Power Optimizer "Rated Input DC Power". Modules with up to +5% power tolerance are allowed.
(2) For other connector types, please contact SolarEdge.
(3) Longer input wire lengths are available for use with split junction box modules.
For 0.9m/2.95ft order P801/P850-xxxLxxx. For 1.3m/2.95ft order P850/P950/P1100 -xxxXxxx. For 1.6m/5.24ft order P850/P950-xxxYxxx).
(4) For ambient temperatures above +70ºC / +158ºF, power de-rating is applied. Refer to Power Optimizers Temperature De-Rating Technical Note for more details.

PV System Design Using a SolarEdge Inverter[5][6][7][8]		230/400V Grid SE16K, SE17K	230/400V Grid SE25K*	230/400V Grid SE27.6K*	230/400V Grid SE30K*	230/400V Grid SE33.3K	277/480V Grid SE33.3K*, SE40K*	
Compatible Power Optimizers		P800p, P850, P950	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	P800p, P850, P950, P1100	
Minimum String Length	Power Optimizers	14	14	14	15	14	14	
	PV Modules	27	27	27	29	27	27	
Maximum String Length	Power Optimizers	30	30	30	30	30	30	
	PV Modules	60	60	60	60	60	60	
Maximum Continuous Power per String		13500	13500	13950	15300	13500	15300	W
Maximum Allowed Connected Power per String[8] (Permitted only when the difference in connected power between strings is 2,000W or less)		1 string – 15750	1 string – 15750	1 string – 16200	1 string – 17550	2 strings or less – 15750	2 strings or less – 17550	W
		2 strings or more – 18500	2 strings or more – 18500	2 strings or more – 18950	2 strings or more – 20300	3 strings or more – 18500	3 strings or more – 20300	
Parallel Strings of Different Lengths or Orientations		Yes						
Maximum Difference in Number of Power Optimizers Allowed Between the Shortest and Longest String Connected to the Same Inverter Unit		5 Power Optimizers						

* The same rules apply for Synergy units of equivalent power ratings that are part of the modular Synergy Technology Inverter.
(5) P800p/P850/P950/P1100 can be mixed in one string only with P800p/P850/P950/P1100.
(6) For each string, a Power Optimizer may be connected to a single PV module if 1) each Power Optimizer is connected to a single PV module or 2) it is the only Power Optimizer connected to a single PV module in the string.
(7) For SE16K and above, the minimum STC DC connected power should be 11KW.
(8) To connect more STC power per string, design your project using SolarEdge Designer.

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CE

US Made

IRONRIDGE

Accelerate Solar with Domestic Content

IronRidge offers racking systems that use 100% domestically-produced components. Our products made in the United States include: XR10 Rails, XR100 Rails, HUG Roof Attachment, Comp Shingle Flashing, and the BX Ballasted System.

To meet the qualifying criteria for tax credit incentives, solar projects must use a combination of modules, MLPE and racking with a minimum aggregate threshold of 40% Domestic Content.

Pathway to 40+

NO NEED TO SETTLE

Pick reputable products that your crews like installing. Our offerings are listed to UL 2703 and UL 3741, tested rigorously, and manufactured to the highest quality standards.

DO YOUR HOMEWORK

Are you a financier or work with one? Understand terms and definitions. Obtain letters from the manufacturer documenting their position to share with your tax and legal counsel.

STACK MANUFACTURERS

Our partnerships with the leading inverter manufacturers allow multiple avenues for you to reach 40% in 2024 and 45% in 2025. See next page for the current list of domestic content.

Avoid the Pitfalls

READ THE FINE PRINT

Ensure you qualify. Only finance companies offering third-party-owned systems are eligible, not installation companies or homeowners. Consult a legal professional for guidance.

BE FULLY PREPARED

Audits by Financiers, Commercial Project Owners, and the IRS are serious business. Ensure that your manufacturing partners can help you navigate any potential oversight.

STAY IN THE KNOW

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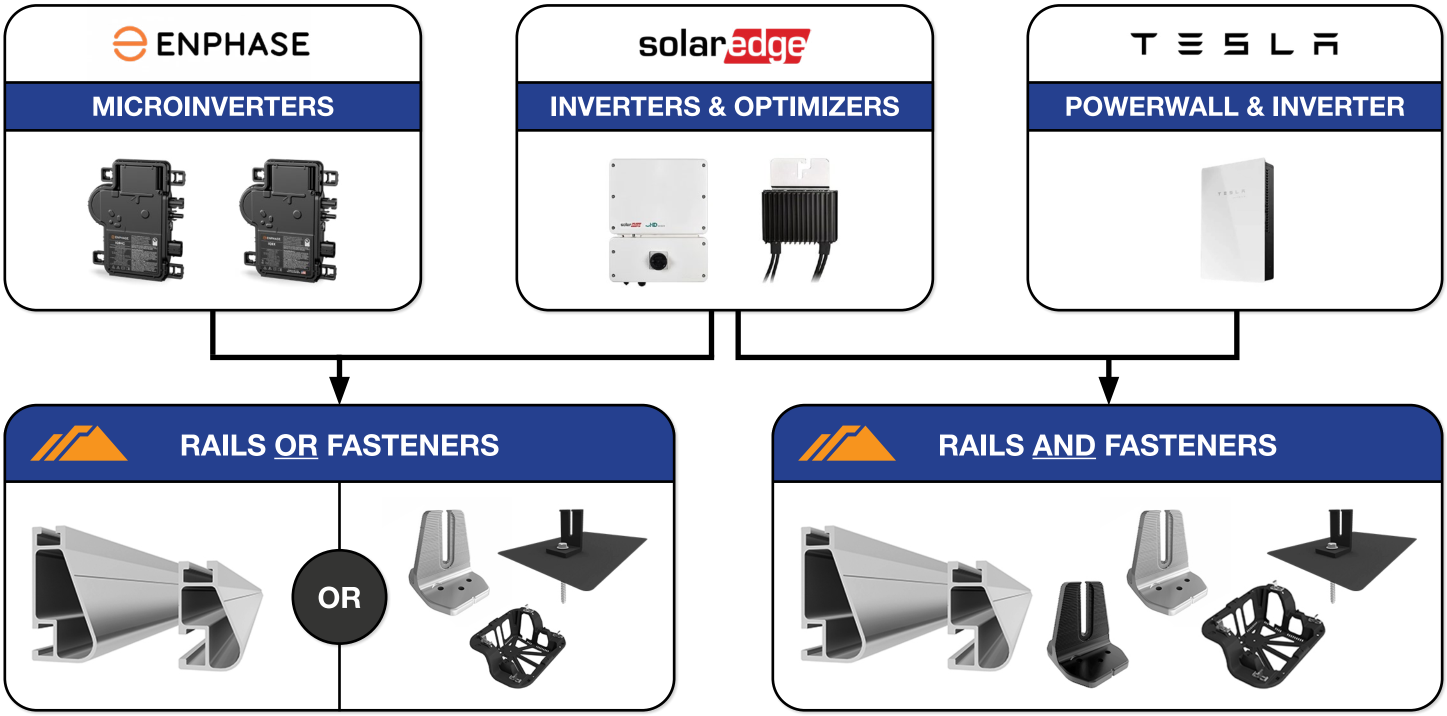
IronRidge does not provides tax, legal or accounting advice. This material has been prepared for informational purposes only and is not intended to be relied upon in place of professional advice. You should consult your own advisors before engaging in any transaction.

Pathways to 40-45% Domestic Content



Not all domestic products shown.

Residential Products

Maker	Type	Part Number
Enphase	Inverters	**IQ8HC-72-M-DOM-US** **IQ8X-80-M-DOM-US** **IQ8HC-72-M-US**
SolarEdge	Inverters	**SE3800H-USMNUBL75** **SE5700H-USMNUBL75** **SE7600H-USMNUBL75** **SE10000H-USMNUBL75** **SE11400H-USMNUBL75** **USE3800H-USMNUBL75** **USE5700H-USMNUBL75** **USE7600H-USMNUBL75** **USE10000H-USMNUBL75** **USE11400H-USMNUBL75**
	Optimizers	**U650-1GM4MRMU**
Tesla	Inverters	**1538000-45-X**
IronRidge	Rails	**XR-10-168M-US** **XR-10-168B-US** **XR-100-168M-US** **XR-100-168B-US**
	Fasteners	**LFT-FLSH03-B1-US** **FLSH-01-B1-US** **QM-HUG-01-M1-US** **QM-HUG-01-B1-US**

Commercial Products

Maker	Type	Part Number
Enphase	Inverters	**IQ8P-3P-72-DOM-US**
SolarEdge	3-Phase Inverters	**USE-SIN-USR0IBNx6**
	Synergy Managers	**SE-DBL-US00IBNx6** **SE-TRI-US00IBNx6**
	Synergy Units	**USESUK-USR0INNN6**
	Optimizer	**C651U-1GMVMRRU** **C652U-1GMVMRRU**
IronRidge	Rails & Fasteners	**Same As Residential**
	BX Ballasted System	**BX-5D-P1** **BX-10D-P1** **BX-TCL-30MM-M1** **BX-TCL-32MM-M1** **BX-TCL-35MM-M1** **BX-TCL-38MM-M1** **BX-TCL-40MM-M1** **BX-TCL-40MM-M1** **BX-TCL-46MM-M1**

IRONRIDGE

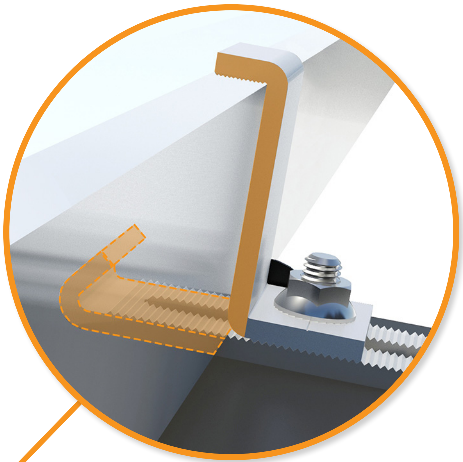
BX Chassis

Strong, Light, and Ready for Anything

The IronRidge BX System is designed to meet the needs of commercial solar—navigating complex roof layouts, while also handling the most extreme environmental conditions.

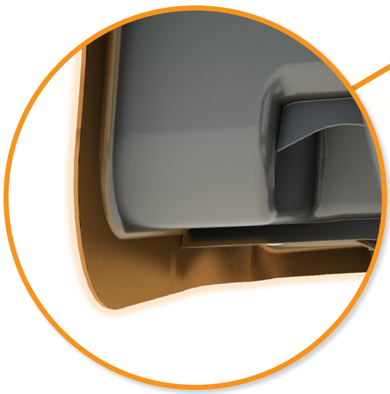
At the core of BX is the Chassis, a ballasted mount made of BASF Ultramid polyamides. They are exceptional for their high mechanical strength, rigidity and thermal stability (also being 100% recyclable).

Moreover, Ultramid polyamides afford good impact resistance even at low temperatures as well as UV protections for long life. Chassis come in 5° and 10° options and are backed by IronRidge's 25-year warranty.



Top & Bottom Clamp

The multi-directional grip on the module from above and below ensures a strong connection regardless of force direction.



360° Reinforcement

A flange around the entire perimeter helps to reinforce and stiffen the Chassis in all directions—alongside wide bends to reduce point loading and braced corners to increase rigidity.

Roof-Friendly Design

Wide base spreads weight and reduces point pressure, while openings along the bottom and corners prevent pooling and reduce ballast weathering.

Inter-Row Spacing & Edge Clearances

5° Chassis

10° Chassis

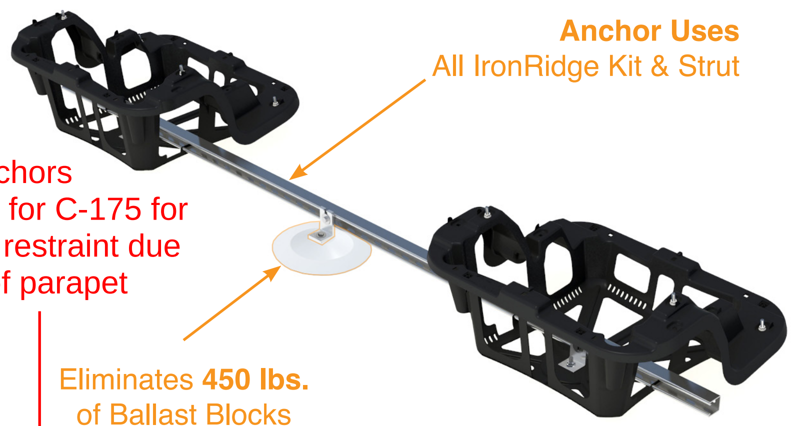
With 10-13” inter-row spacing, BX provides an **8-10% increase** in power density compared with other ballasted systems—that’s a **capacity increase of 20%** in a typical 50kW system. The BX Chassis geometry also offers more than 5” of clearance in the 10-degree configuration and 8” in the 5-degree configuration, enabling the system to avoid drain domes, roof saddles, and conduit supports.

Flat Roof Attachment Anchors

BX Systems can be fully ballasted, fully anchored, or a hybrid optimized for the site.

Combine BX with an IronRidge Flat Roof Attachment Kit to eliminate hundreds of pounds of required ballast weight and achieve configurations as light as 3 PSF.

The placement and fastening method can be optimized for existing roof structures, and pre-approved membranes are offered to maintain membrane roof warranties.



Roof anchors required for C-175 for Seismic restraint due to lack of parapet

Testing & Certification

Design Assistant

Automated design software provides an accurate bill of materials, using a simple drag-and-draw interface to generate a complete system plan—also generate a ballast map showing the required ballast for each Chassis.

Permit Documentation

Design Assistant project reports are backed with a ASCE/PE stamp and Commercial Services are also available to assist with more complex projects. Visit our website or contact an IronRidge sales represenative.

UL 2703 & 3741 Listed

BX conforms to the latest UL safety standards for PV systems, including mechanical, bonding, hazard control, and Class A Fire Ratings (without wind deflectors). Ninety percent of solar modules are fully supported.

IRONRIDGE

BX System

Uniquely shaped for flat roofs.

IronRidge BX delivers superior power density and design flexibility to flat roof solar arrays. Made of a glass-reinforced composite, the BX Chassis is engineered for extreme structural loading, yet is also shaped to be roof-friendly and easy to install.

Certified BX plan sets can be obtained instantly through an online Design Assistant or by contacting IronRidge Commercial Services.

Glass-Reinforced Composite

Corrosion-free and engineered for long-term structural performance.

Commercial Services

Engineering support to optimize system design.

Class A Fire Rating

Certified to maintain the fire resistance rating of the existing roof.

Design Assistant

Online software makes it simple to create, share, and price projects.

UL 2703 & 3741 Listed

Entire system and components meet the latest UL safety standards.

25-Year Warranty

Products guaranteed to be free of impairing defects.

Datasheet

Chassis

5° Chassis

Ballasted mounting for 5 degree tilt angle.

- Max load spreading design
- Fully encloses ballast
- 360 degree drainage

10° Chassis

Ballasted mounting for 10 degree tilt angle.

- Max load spreading design
- Fully encloses ballast
- 360 degree drainage

Top Clamp

Combines with Bottom Clamp for top-bottom module grip.

- Secures above module
- One-tool attachment
- Mill aluminum 6000 series

Bottom Clamp

Combines with Top Clamp to up structural connection.

- Secures below module
- One-tool attachment
- Mill aluminum 6000 series

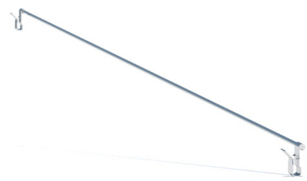
Grounding

8" Mod Bonding Jumper

Bond adjacent modules in the array.

- Press-on installation
- Tin-plate copper wire
- Factory crimped connection

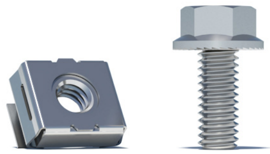
38" Row Bonding Jumper



Complete row-to-row bonding in the array.

- Press-on installation
- Tin-plate copper wire
- Factory crimped connection

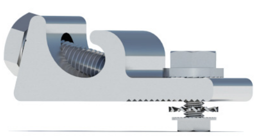
MLPE Mounting Hardware



Optional mounting hardware for MLPE devices.

- Cap screw and cage nut
- 5/16" socket install
- Stainless steel 300 series

PV Mod Grounding Lug



Connect arrays to equipment ground.

- Low profile
- Mounts to module frame
- One per continuous array

Accessories

Accessory Frame Bracket

Mount MLPE devices directly to module frame.

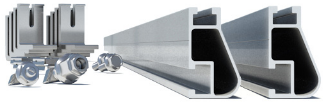
- Fits any module frame
- Mill aluminum finish
- UL 2703 listed

Cable & Edge Ties

Complete wire management with weatherproof ties.

- 12" length, bundles of 100
- UV stabilized polyamide
- Black finish

String Inverter Mount Kit



Create mounting platform for inverters.

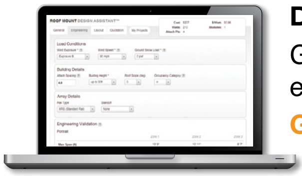
- Chassis, XR10 rail, hdw
- Up to 4' inverter base
- Raises inverter off deck

Flat Roof Attachment Kit

Add anchors to ballasted system.

- Includes hardware
- For ballast-attached hybrid
- Uses locally-sourced strut

Resources



Design Assistant

Go from rough layout to fully engineered system in minutes.

Go to IronRidge.com

Chassis Display #7 Recycle Label

Like most glass-filled nylons, it is 100% recyclable—usually living on in furniture.

Find more info at epa.gov/recycle

Cost Estimate - T91 - C-175 (255.3 kW-DC)

Item	Unit Cost	Qty	Cost with Markup	$/Watt	Source
PV Modules (Sil-490 HN)	$ 404	521	$ 242,057	$ 0.95	Online price with 15% shipping and contractor markup
PV Racking (IronRidge 10degree BX Racking)	$ 73,540	1	$ 84,571	$ 0.33	MSRP with 15% shipping and contractor markup
SolarEdge P1100 Optimizers	$ 121	266	$ 37,014	$ 0.14	Online price with 15% shipping and contractor markup
SolarEdge SE100KUS Inverter (3x secondary units, 1x primary unit)	$ 6,785	2	$ 15,605	$ 0.06	Online price with 15% shipping and contractor markup
Sub-Total Material Costs			**$ 379,246**	**$ 1.49**	

Item	Unit Cost	Qty	Cost	$/Watt	Source
BOS (Conduit, cable, plumbing, etc.)	15%	-	$ 56,887	$ 0.22	Percentage of material costs based on project scope and complexity
Site Work (Trenching, pads, fence, sidewalk restoration, etc.)	$ 15,000	1	$ 15,000	$ 0.06	Allowance based on project scope
Total Direct Costs			**$ 451,133**	**$ 1.77**	
Contractor Design, Engineering, Permitting	8%	-	$ 30,340	$ 0.12	Typical as percentage of material costs
Contractor PM	10%	-	$ 37,925	$ 0.15	Typical as percentage of material costs
Contractor Labor	20%	-	$ 75,849	$ 0.30	Typical as percentage of material costs, prevailing wage for ITC credits
Sales Tax (Battery Equipment Only)	10.35%	-	$ -	$ -	City of Seattle Sales Tax Inclusive of state rate
Sub-Total			**$ 595,247**	**$ 2.33**	
Contingency	10%	-	$ 59,525		Typical as percentage of subtotal construction costs
Sub-Total			**654,772**	**$ 2.56**	
Escalation to midpoint of 2025	4.5%	-	**29,465**		
Total Construction Costs			**684,236**	**$ 2.68**	
Port of Seattle - Maritime Overhead Premium	25.1%	-	$ 171,743		Overhead rate provided by Port Staff
Total Project Costs			**$ 855,980**	**$ 3.35**	
System Size (W-DC)			**255,300**	**Watts**	

Appendix F

Port of Seattle Maritime Solar Feasibility Study Formulas

Maritime Solar Photovoltaic Feasibility Study Formulas

The following formulas were used to perform financial analysis for the project. The calculations are performed for each year of the model period. 25-years was selected for this period based on typical solar module performance warranty period. Formulas start at the base-level inputs and roll up into the final calculations. Throughout the calculations, construction is assumed to occur within a single year ($Year_0$), and *n* is used as the time variable for number of years since construction (e.g. *n=0* in the construction year)

Annual Inflation Adjustment ($USD)

This is a generic formula for all inflation adjusted values.

$$(Year_0\ Value) * \left(1 + (Inflation\ Rate)\right)^{Year\ after\ Construction} = Year_n\ Value$$

O&M costs and Inverter Replacement costs are both inflation adjusted. Electricity rates are separately regulated through the utility commission and are escalated at a different rate.

Annual O&M Expenses ($USD)

O&M expense estimates start in year 1 at $10 per kW-DC of system size and are inflation adjusted annually.

$$Inflation\ Adjusted\ O\&M\ Expenses = Year_n\ O\&M\ Expenses$$

Annual Module Production (kWh)

Module performance starts at 100% in year 1 and is degraded at a constant 0.5% annually. This adjusted percent is then applied to the year 1 production estimate from Helioscope Modeling.

$$(Year\ 1\ modeled\ production\ in\ kWh) * \left(100\% - (0.5\%) * (Year\ after\ Construction)\right) = Year_n\ Production\ in\ kWh$$

Annual Electricity Cost ($/kWh)

The electricity rates provided for each site by the Port were escalated at a fixed utility escalation rate of 4% which is the historical average for our area.

$$(Year\ 1\ Electricity\ Cost\ in\ \$/kWh) * \left(1 + (Utility\ Escalation\ Rate)\right)^{Year\ after\ Construction} = Year_n\ Electricity\ Cost$$

Annual Electricity Value ($USD)

Annual module production estimate in kWh is multiplied by that year's estimated electricity value $/kWh

$$Year_n\ Electricity\ Cost\ in\ \$/kWh * Year_n\ Production\ in\ kWh = Year_n\ Production\ Value$$

Equipment Replacement Costs ($USD)

This value encompasses periodic replacement costs expected. For the 25-year period modeled, this is limited to inverter replacement at year 15. Module replacement at year 25 is evaluated as occurring just after the model period is completed so it is not included in this analysis.

Inverter replacement costs are inflation adjusted after a year 1 value of $70/kW-AC

$$Year_n\ Inverter\ Replacement = \ Year_n\ Equipment\ Replacement = \$0\ for\ all\ years\ but\ year\ 15$$

Decommissioning Costs

System decommissioning is evaluated as occurring 25 years after construction. Costs are taken as 3% of initial installation costs and inflation adjusted. These costs are included in NPV calculation.

$$System\ Installation\ Cost * (3\%) = Year_0\ Decommissioning\ Costs$$

Investment Tax Credit (ITC) ($USD)

This tax credit is taken as 30% of the system installation costs including any soft costs associated with construction. The Port may receive this credit under the Direct Pay Provision of the Inflation Reduction Act 2021. Financial performance with and without the ITC are provided in the report, and eligibility requirements are discussed in detail there.

$$System\ Installation\ Cost * (30\%) = ITC\ Value\ in\ \$USD$$

System Installation Cost and Cost per Watt ($USD/Watt)

Cost per Watt is a convenient unit cost for solar PV systems used widely by the industry for easy comparison between systems of varying size.

$$Cost\ Per\ Watt\ \$/Watt = \frac{System\ Installation\ Cost}{System\ Size\ in\ Watts - DC}$$

In the report body we provide two Cost Per Watt values, with and without the 25.1% Port overhead applied.

Annual Cash Flow ($USD)

Cash flow each year is the sum of costs and benefits of the system.

$$Year_n\ Production\ Value - \ Year_n\ Equipment\ Replacement - \ Year_n\ O\&M\ Expenses = Year_n\ Cash\ Flow$$

The *ITC Value in $USD* is applied as a positive value to the cash flow in year 1. Payback graphs also show cash flow without the ITC.

Inflation adjusted decommissioning costs are included in cash flow at year 25.

Net Cash Flow ($USD)

Net cash flow is the sum of each year's cash flow added to the initial investment during construction (Year 0).

$$Year_n\ Net\ Cash\ Flow = System\ Installation\ Cost - \sum^{n} Year_n\ Cash\ Flow$$

Payback Year

The payback year is the year where Net Cashflow crosses the zero threshold.

$$Payback\ Year = n \text{ where } Year_n\ Net\ Cash\ Flow \geq \$0$$

Net Present Value

Net Present Value (NPV) is calculated with the inflation adjusted cash flow and discount rate. A more detailed discussion of NPV is provided in the report body.

$$NPV = \sum^{n} \frac{Year_n\ Cash\ Flow}{(1+r)^n}$$

- r is the discount rate
- n is the time period (year)

Appendix G

Port Provided Documents List

Maritime Solar Feasibility Study -Port Provided Documentation

- Port of Seattle Campus Map
- Seattle Waterfront Clean Energy Strategy (SWCES) Load Forecasting Analysis – Site Level Results
- Campus Level Electricity Data Table – for 2023 only
- Building Level Electricity Data Table
    - Shilshole Bay Marina – A-1 Admin Building
    - Terminal 91 – C-175
    - Terminal 91 – A-1 Warehouse
    - Terminal 91 – C-173
    - Terminal 91 – Smith Cove Cruise Terminal
    - Pier 66 – Bell Harbor Conference Center/Bell Street Cruise Terminal
    - Pier 66 – Bell Harbor Marina Office
- Facility Roof Information Table
- Screening Tool Inputs:
    - Site Owner
    - Site Operator
    - Meter type
    - Building Type
    - $/kWh (October 2024)
    - SCL Rate Code
    - SCL Rate Code Definition
- As-built drawings for in-person site assessments
    - Shilshole Bay Marina – A-1 Admin Building
    - Terminal 91 – C-175
    - Terminal 91 – A-1 Warehouse
    - Terminal 91 – C-173
    - Terminal 91 – Smith Cove Cruise Terminal
    - Pier 66 – Bell Harbor Conference Center/Bell Street Cruise Terminal
    - Pier 66 – Bell Harbor Marina Office
    - Terminal 91 – C-155
    - Fishermen's Terminal – N-9 Netshed
    - Fishermen's Terminal – C-3 West Wall Office
- Pier 66 Annual Energy Use by meter and month.
- Site Electrical Distribution Diagrams:
    - Fishermen's Terminal – N-9 Netshed
    - Fishermen's Terminal – C-3 West Wall Office
    - Pier 66 – Bell Harbor Conference Center/Bell Street Cruise Terminal
    - Shilshole Bay Marina – A-1 Admin Building
    - Terminal 91 – C-175
    - Terminal 91 – C-173

- Roof Warranty Letters
    - Terminal 91 – C-175
    - Terminal 91 – Smith Cove Cruise Terminal
    - Shilshole Bay Marina – A-1 Admin Building

Appendix H
Project Team and Key Resumes

Project Team and Roles

Säzän Group was able to complete this project successfully due to our stellar team of engineers and renewable energy specialists. Resumes are provided for the primary contributors to the project.

Säzän Group Inc.

Tom Marseille, PE, Hon AIA, LEED Fellow, Managing Principal

Principal in Charge of the project providing oversight and management of the On-Call Contract.

Jack Newman, REP, VMA, Director Clean Energy Solutions

Project Manager and primary point of contact for the project. Lead facilitator of the study responsible for collaboratively developing evaluation and screening criteria, QC of technical work, and report development.

Tom Bowen, EIT, REP, Technical Lead

Solar and Battery storage specialist leading the project technical analysis. Performing remote and in-person site assessments, solar modeling, battery analysis, equipment selection, and racking design.

Tyler Beam, PE, Associate Principal, Electrical

Professional Engineering support for QC of the prioritized site electrical pre-designs and regular consultation during concept development.

Thomas Childs, Associate Principal, Electrical

Electrical Engineer leading the pre-design team and providing interconnections strategy considerations.

Grant Williams, Project Coordinator

Provided meeting and project coordination support. Research, narrative, and workbook development for financial analysis on project.

Saez Consulting Engineers (A TKDA Company)

Dan Munn, PE, SE, Regional Vice President

Project manager providing engineering QC and final review of structural memos.

Craig Collin, PE

Lead structural engineering support for the project providing field inspections, site evaluations, structural analysis, and constructability considerations.

SÄZÄN GROUP

Jack Newman, REP, VMA

Clean Energy Funding Specialist/Director of Clean Energy Solutions

Jack is the Director of Clean Energy Solutions at Säzän Group. He is a Certified Renewable Energy Professional with more than 10 years in the clean energy industry. Six of those years has been spent working with renewable energy feasibility studies, microgrid project development, solar modeling and analysis, and grant funding assistance. His experience includes energy benchmarking, feasibility studies, utility program management, construction cost estimating, and project management.

Licensure

Certified Renewable Energy Professional, Association of Energy Engineers

Value Methodology Associate, SAVE International

Education

BS, Construction Management, University of Washington

NABCEP Solar PV Mastery Training Completion

Kaplan Clean Technology Academy

Association of Energy Service Practitioners Leadership Program

RELEVANT PROJECTS

Washington State Department of Commerce, Solar Plus Storage for Resilient Communities, Technical Assistance, Statewide, WA
Technical assistance for municipal, tribal, and remote communities on solar + storage feasibility study development, modeling, cost estimates, report development, and grant application assistance. Our role as statewide technical assistant to Commerce offered feasibility study support in compliance with Track 1 grant requirements at no cost to the communities we serve. Projects included microgrid feasibility studies for Whatcom County, Quileute Tribe, and Port Gamble S'Klallam Tribe.

Kitsap County, Department of Emergency Management, Microgrid Study, Bremerton, WA
Project Manager for providing a microgrid feasibility study for their renovated facility, including solar PV and battery energy storage integration for the Emergency Operations Center, and grant application assistance for project development.

Port of Seattle, Solar Feasibility Study, Seattle, WA
Project Manager in assessing the viability of installing solar energy systems on 50 locations for the Port of Seattle. This involves site visits for storage facilities, warehouses, terminal buildings, an administration building, and conference centers for a total of 1,221,552 SF of roofs. Project final deliverable is a solar feasibility study to determine three locations for solar PV and battery storage development.

City of Issaquah, Solar Plus Storage Resiliency & Grant Overlay Consulting, Issaquah, WA
Project Manager in support of solar plus storage feasibility assessments on potential sites in Issaquah. These studies include full analysis and pre-design for solar and battery storage integration on six sites in the City. Säzän Group worked with project partners and stakeholders to gather information; facilitate a stakeholder engagement process; and provide energy analyses, cost estimates, microgrid modeling, constructability review, payback analyses, equipment specifications, and an overview of funding resources.

Port of Bellingham, Indefinite Duration Indefinite Quantity Solar Feasibility Studies, and Owner's Representation, Bellingham, WA
Project Manager supporting the Port’s IDIQ contract. Under the IDIQ Säzän Group performed solar PV feasibility studies for 12 buildings. Säzän Group worked with project partners and stakeholders to gather information, identify legal, structural, electrical, and regulatory hurdles for development, and develop budget planning estimates for the Port’s board. Of the 12 sites, the BLI Airport was selected for prioritization and construction. Säzän Group supported the Port with Owner’s Representation services, RFP development, and construction management for the array and ribbon cutting is expected early December 2024.

Licensure
Certified Renewable Energy Professional, Association of Energy Engineers

Engineer in Training

Education
BS, Mechanical Engineering, Washington State University

Tom Bowen, EIT, REP

Project Manager/Technical Lead

Tom has been serving Säzän Group for the past four years and has become indispensable for his ability and skill in conducting technical analysis and feasibility studies. Before coming to Säzän Group, Tom spent nearly 20 years with the Department of Defense where he operated and maintained naval submarine nuclear power plant systems. He has 10 years of experience in quality assurance certification and program administration. Tom's ability to understand critical electrical and mechanical systems and his keen eye for detail makes him ideal at leading studies and writing successful grants for the solar and clean energy field.

RELEVANT PROJECTS

Washington State Department of Commerce, Solar Plus Storage for Resilient Communities, Technical Assistance, Statewide, WA
Technical assistance for municipal, tribal, and remote communities on solar + storage feasibility study development, modeling, cost estimates, report development, and grant application assistance. Our role as statewide technical assistant to Commerce offered feasibility study support at no cost to the selected communities. We then used those studies to complete Commerce Track 2 grant applications for those communities. Projects included community engagement and microgrid feasibility studies for Whatcom County, Quileute Tribe, and Port Gamble S'Klallam Tribe.

Kitsap County, Department of Emergency Management, Microgrid Study, Bremerton, WA
Technical Lead for providing a microgrid feasibility study for their renovated facility, including solar PV and battery energy storage integration for the Emergency Operations Center, and grant application assistance to support project development.

Port of Seattle, Solar Feasibility Study, Seattle, WA
Technical lead in assessing the viability of installing solar energy systems on 50 locations for the Port of Seattle. This involves site visits for storage facilities, warehouses, terminal buildings, an administration building, and conference centers for a total of 1,221,552 SF of roofs. Project final deliverable is a solar feasibility study to determine three locations for solar PV and battery storage development.

City of Issaquah, Solar Plus Storage Resiliency & Grant Overlay Consulting, Issaquah, WA
Technical lead in support of solar plus storage feasibility assessments on potential sites in Issaquah. These studies include full analysis and pre-design for solar and battery storage integration on six sites in the City. Säzän Group worked with project partners and stakeholders to gather information; facilitate a stakeholder engagement process; and provide energy analyses, cost estimates, microgrid modeling, constructability review, payback analyses, equipment specifications, and an overview of funding resources.

Confederated Tribes of the Coos, Lower Umpqua, and Siuslaw Indians, Solar Plus Battery Storage feasibility Study, Coos Bay, OR
Project Manager and technical lead for two solar and battery storage feasibility studies for the Tribe's Administration building and Emergency Services Building. This included solar PV modeling, site assessment, battery modeling, community engagement surveys, single line diagrams, and site plans. We assisted in applying for and obtaining a $1M construction grant from the Oregon Department of Energy.

J. Tyler Beam, PE

Electrical Engineer

With more than 20 years of experience providing electrical design, consulting, and engineering services, Tyler Beam's experience includes project management and design for a variety of projects ranging from healthcare, multifamily, municipal, industrial, hospitality, commercial facilities. He has a wide variety of experience in both new and renovation projects for power, lighting, fire alarm, communications, security, and access control systems. Tyler's approach allows him to plan and organize the coordination and design process to successfully deliver projects.

Licensure
Professional Engineer,
Electrical: WA #52711
OR #078010PE
CA #E-21545
UT #11571699-2202
NV #31795
CO #PE.0056793
NC #057187

Education
BS, Electrical Engineering,
Henry Cogswell College,
Everett, WA

Relevant Project Experience

City of Seattle, City Hall Water Heaters, *Seattle, WA*
Electrical Engineer

City of Renton, City Hall Elevators, *Renton, WA*
Electrical Engineer

City of Renton, City Hall Emergency Generators, *Renton, WA*
Electrical Engineer

City of Seattle, Municipal Tower Floors 28/30/34/35/36 TI, *Seattle, WA*
Electrical Engineer

City of Seattle, South Precinct HVAC Replacement, *Seattle, WA*
Electrical Engineer

Pierce County, Medical Examiner Building Upgrades, *Tacoma, WA*
Electrical Engineer

US Department of Veterans Affairs, 2nd Floor Renovation, *Spokane, WA*
Electrical Engineer

Evergreen Health, Coral Tower Telecomm Rooms Upgrade, *Kirkland, WA*
Electrical Engineer

Mason Health, Mason General Hospital Upgrades, *Shelton, WA*
Electrical Engineer

Mason Health, Mason General Hospital Campus Master Plan Phase I, *Shelton, WA*
Electrical Engineer

MultiCare Health Systems, Tacoma General Hospital TI, *Tacoma, WA*
Electrical Engineer

Viriginia Mason Franciscan Health, West Seattle Clinic 2nd Floor, *Seattle, WA*
Electrical Engineer

SÄZÄN GROUP

THOMAS CHILDS

Lead Electrical Designer

PROPORTION OF WORK HOURS

Design: 25%
Construction: 10%

WORK HISTORY

20+ years in in MEP engineering
10 years with Säzän Group

EDUCATION

BA Psychology,
Cal State Northridge

REFERENCES

Marc Everson,
ABBOTT Construction,
Project Executive
(206) 467-8500 x 110,
meverson@
abbottconstruction.com

Brad Velasco,
VECA Electric,
Director of Preconstruction
(206) 436-5271,
brad.velasco@veca.com

Thomas has more than 20 years of electrical engineering design, lighting and lighting controls design, and project management experience over a wide variety projects. His expertise includes power distribution, fire alarm systems, nurse call systems, lighting controls for commercial and theatrical applications, lighting design for interior, exterior, and sports arenas, construction coordination, and feasibility studies.

SELECTED PROJECT EXPERIENCE

- **University Village Retail Center, Seattle, WA** - Thomas's role as Electrical Project Manager served the project in consulting services for facility master plan electrical design, engineering services, Seattle City Light coordination, new construction projects, and Owner's representation for engineering oversight for consistency with University Village standards, tenant coordination, and service design and load calculations.
- **University Village Shopping Center South Building and West Garage, Seattle, WA** - Thomas's role as Electrical Designer included the design for 314,000 SF new construction with five levels of parking (700+ stalls) above two levels of shell retail space. Design services included extensive utility coordination and site utility relocations to accommodate the new building and complete electrical design.
- **University of Washington, Interdisciplinary Engineering Building, Seattle, WA** - Thomas's role as Electrical Designer included design for the new construction of a 63,000 SF undergraduate engineering building. The design includes relocating the UW medium voltage distribution system that was running through the project site and modifications to tunnel node NE2, complete building electrical design, lighting, lighting controls systems, telecommunications infrastructure, classroom services equipment integration, and fire alarm.
- **The Boeing Company Renton Plant Building 10-109, Building 04-074, and IMPACC/MMCO Breaker Rebuild and Controls Replacement Upgrade, Renton, WA** - Thomas was the Electrical Designer for this electrical infrastructure improvement. Project included upgrades and replacing the main plant's Substations #1 and #2 Medium Voltage Switchgear MMCO relay controls and infrastructure wiring.

Dann Munn, PE, SE

TKDA | Structural Engineering Support

Certifications
Professional Engineer, Structural, WA #38727

LEED AP

Education
BS, Civil Engineering, Arizona State University

Dan engages professional partners regionally in the planning and implementation of engineering design projects and renewable energy installations. He works directly with Design-Build contractors as a design expert for solar + BESS installations and works directly with owners and Construction Managers as a structural and Civil expert in renewable energy installations. Dan is experienced in assisting solar RFPs for design-build solicitation, performing design peer reviews, and for manufacturer and installer engagement. He has led the design of over 100 solar plants from traditional rooftops to some of the most unique facade applications for iconic structures. Recent designs include multi-site solar and renewable energy systems throughout seven rooftops for Seattle Public Schools, a custom 6-MW tiled roof and facade system at a confidential corporate client's headquarters, and a 6.4-MW rooftop solar system for the Mandalay Bay Resort and Conference Center in Las Vegas, which was the largest rooftop solar plant in the US at the time.

RELEVANT PROJECTS

Hunt Energy Network, Battery Energy Storage Facilities, Various Locations, TX
Dan conducted the civil design layout, site planning, grading plans, road layouts, section views, SWPPP, erosion control plans, culverts, and drainage/retention requirements for over 25 and counting 10 MWh BESS Peaker plants as a part of the ERCOT program for energy resiliency and carbon reduction program.

Confidential Client, Solar Campus-wide PV + BESS Roll-out, Mountainview, CA
Dan was selected to work as the Owner's Engineer for the client's district energy team responsible for PV and BESS roll-out over seven campuses and 30 buildings as a part of the Solar Fund projects. Dan's role was to team with their performance modeling experts and electrical engineering firm peers to help master plan PV and battery installations that maximize carbon and financial paybacks for the clean energy investment dollars. Dan's role on the team was to review existing building structures, peer review roof systems' age and condition, and existing site utility infrastructure.

CSU Dominguez Hills, Solar Project, Dominguez Hills, CA
The project involved the completion of building surveys and rooftop evaluations including 3D laser roof scans for solar array installations at two California locations. Using a combination of a Faro Scene and Leica BLK360, we produced 3D models of the rooftops to be used in solar array layouts to ensure minimal conflict between existing roof features and solar installation. Seven large rooftops have been completed to date including the 300,000 SF Kroger Bakery in La Habra and multiple buildings at California State University Dominguez Hill.

Port of Bellingham, Solar Assessments, Bellingham, WA
Owner's engineer services for multi-site as a sub to Säzän Group. Dan performed full structural engineering calculations for 12 existing buildings which informed the Port's selection of BLI Airport for prioritization and construction of a 100kW-AC rooftop array. Ribbon cutting on this project is expected early December 2024.

Seattle Public Schools, Solar Addition, Seattle, WA*
Dan led the engineering team for the design and installation of solar rooftop PV on six school sites for the Seattle Public School District. The projects were awarded over $750,000 in grant awards from Seattle City Light and the Washington Department of Commerce.

**Prior to TKDA*

CRAIG COLLINS, PE

STRUCTURAL ENGINEER

Licensed professional engineer with a primary focus in steel design. Experienced in the design of buildings and other miscellaneous structures. With a construction and detailing background, he provides well thought-out solutions that can enhance a project at all stages.

Previous Experience

Project Engineer, ***General Motors Plant Modernization*** | *Various Locations.* Project engineer for massive overhaul of facilities in Ft Wayne, IN, Arlington, TX, and Flint, MI. Responsibilities included the design of a building link between stamping plant and assembly plant, modification of existing buildings, trestles, conveyor lines, and truss analysis/reinforcing. Frequent site visits were performed at all locations to verify existing conditions or modify construction conflicts.

Lead Structural Engineer, ***Computer Design Research and Learning Center,*** *University of Illinois, Chicago, IL.* Lead structural engineer for new 168,000 sq. ft, 6-story $85MM educational building. Engineering responsibilities included basement design, Design o three new laboratory spaces. Responsibilities included analysis of existing conditions, design of select steel framing, façade support, coordination with architect, overseeing drawing production, and shop drawing review during CA.

Project Lead, ***Damen Green Line Station****, Chicago, IL.* Project lead for a new $60 million new CTA station. DZSE's scope included connection design for HSS framed pedestrian bridge, HSS framed stair tower, station house, and modifications to existing elevated track support framing.

Project Lead, ***Kennedy Space Center Launch Complex,*** *Titusville, IL.* Project lead to modify an existing Launch Tower (LC39A). Scope included replacement or reinforcement of existing tower members, erection sequencing, & connection design.

Project Lead, ***William Eckhardt Research Center Laboratory****, Chicago, IL.* Project Lead to design three new laboratory spaces. Responsibilities included analysis of existing conditions, design of mezzanine, stair, and various support structures for sensitive equipment.

Project Lead, ***Sauganash Elementary Annex II,*** *Chicago, IL.* Project lead for new 37,000 sq. ft., 3-story $26MM addition to an existing Chicago Public School, including a partial basement. Engineering responsibilities included basement design, steel framing design of gravity and lateral systems, façade support, overseeing drawing production, coordination with architect and owner (CPS), and shop drawing review during CA.

PREVIOUS EMPLOYERS

Senior Project Engineer, ***DWA (Formerly DZSE),*** *Aug 2016 – May 2024*

Staff Engineer II, ***Ruby + Associates****, May 2012 – Aug 2016*

Date of Hire
June/2024

Years With Previous Firms
12

Education
M.Eng. – Structural Engineering,
University of Michigan, Ann Arbor, 2015

B.S. - Civil Engineering, Purdue University, West Lafayette, 2012

Registrations
Professional Engineer – MI #6201063798

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