Appendix E: Solar Facilities

Whatcom Transportation Authority
2017 Strategic Plan

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SOLAR POWER GENERATION AT FACILITIES AND SOLAR BUS STOP ILLUMINATION

Using renewable energy sources such as photovoltaic solar arrays (PV) can help reduce energy costs while also reducing carbon emissions. In recent years, the cost of solar arrays has fallen, making them a cost-efficient way to generate energy for decades to come. Many private and public organizations are now using solar as a way to produce energy locally in an effort to minimize both energy costs and reliance on fossil fuels.

Transit agencies are ideal candidates for solar installations because they require large amounts of electricity to operate and because they typically have large facilities with roofs or yards that can host solar arrays. Both large-scale solar arrays and small-scale solar installations can help reduce energy costs and improve operating efficiencies for transit agencies. This chapter will review best practices for solar installations at bus stops and transit agencies and will also provide a high-level feasibility analysis for solar installations at WTA's Maintenance, Operations, and Administration Base (MOAB); Bellingham Station; and Cordata Station.

SOLAR FACILITIES

Best Practices

While there are industry standards for solar panels and racking systems, much of the size, design, and expected kilowatt (kW) output of a PV system is dependent on context. Solar arrays can vary in size from less than ten kW to more than three megawatts (MW) of power. This order-of-magnitude difference in size makes it clear that the limiting factors on solar arrays are the availability of space suitable for solar panels, the ability of the electrical grid to handle backfeeding,[1] and the cost of purchasing and installing the system. Obviously, these factors are dependent on context; what might be appropriate in one context might not be appropriate in another. Thus, the best way to evaluate size and scale options for WTA's solar array is through case studies of solar arrays at other transit agencies.

The Capital District Transportation Authority (Albany, NY)

The Capital District Transportation Authority (CDTA) installed a 50 kW solar array at its headquarters in 2012 in an effort to reduce energy costs and uphold high standards of sustainability. The array has 220 solar panels that offset, but do not completely satisfy, the energy needs of the building.[2] The $4.5 million project included installing more efficient HVAC and lighting systems.[3] It was funded through a $3.2 million State of Good Repair grant[4] from FTA and $1.3 million from the New York State Energy and Research Development Authority. The project

[1] Backfeeding occurs when electricity is being given to the electrical grid rather than drawn from it. This can cause problems for the utility and may be a concern if the anticipated wattage of the solar array is greater than the electrical demand of the building.

[2] Source: http://www.cdta.org/news/too-big/7686

[3] Source: https://www.thestreet.com/story/10880362/1/cdta-to-put-45m-solar-project-out-to-bid.html

[4] This grant was specifically for roof restoration work, not for the solar installation itself. However, since solar installations should be built on new, well-maintained roofs, the grant was a necessary component of the solar installation for this particular project.

involved replacing 160,000 square feet of roofing and was completed in 2011. It is important to note that the cost of this system is reflective of the fact that it was completed five years ago. Prices for solar arrays have fallen in recent years, and tax breaks and grants can help defray costs further.

Indianapolis Public Transportation Corporation (Indianapolis, IN)

The Indianapolis Public Transportation Corporation (IndyGo) is a leader in installing solar arrays at transit facilities. IndyGo has installed and is using energy from its one MW solar array on the roof of its eight-acre operations and administrative facility. IndyGo's solar roof will improve operational efficiencies and significantly reduce energy costs. It is the second largest solar array installed by an American transit operator.[5] This investment in solar PV arrays produces enough power to offset the charging of 13 electric buses, lowering operational costs as well as saving energy and resources. The one MW solar system is the second-largest solar system at a transit agency.[6]

The rooftop array was completed in January of 2016 and cost a total of $2.2 million. Approximately 80% of the funding for the project came from a federal capital grant.[7]

Figure 1 IndyGo Solar Array

Metro Transit (Minneapolis and St. Paul, MN)

Metro Transit is beginning to use solar energy to power as many parts of its operation as possible. In recent years, it has installed 40 kW solar arrays at two of its facilities—a light-rail support facility in Minneapolis and a 1,000-space suburban park-and-ride that also includes LED lighting, electric-vehicle charging stations and a geothermal heating and cooling system.[8] It also uses solar

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[5] LA Metro has the largest system.

[6] Source: http://www.indygo.net/press-releases/indygo-leads-transit-industry-in-alternative-energy/

[7] Source: http://www.insideindianabusiness.com/story/31059268/indygo-solar-array-up-and-running

[8] Source: http://minnesota.cbslocal.com/2015/09/25/metro-transit-installs-solar-panels-on-bus-garages/

energy to power amenities at bus shelters.[9] The solar arrays include 150 panels and each cost $130,000. The agency selected the sites through a multi-criteria analysis of all of the facility assets in the agency's portfolio. The light rail support facility was selected because it was a source of high demand and the roof was flat and in good condition, while the park-and-ride facility was selected because it was a new construction project, so solar facilities could be included without requiring any building retrofit. These two projects, and others like them, will help Metro Transit reach its goal of installing 500 kilowatt-hours (kWh) of renewable energy systems by the end of 2020.[10]

Figure 2 Solar Array at Metro Transit Light Rail Facility

Valley Metro (Phoenix, AZ)

Valley Metro received a Transit Investments for Greenhouse Gas & Emissions Reduction (TIGGER) grant to construct a 780 kW solar array at its Rail Operations and Maintenance Center. The system has 2,800 solar panels and cost approximately $2,875,000. Valley Metro received $2.7 million in federal grants to fund capital construction. It received an additional $1.36 million in support from the local energy utility to fund long-term maintenance and operation of the system. The system was completed in 2014 and is mounted on ground level and on parking shade structures adjacent to the facility. The electricity created by the system will be used to power approximately 16% of the electrical demand of Rail Operations and Maintenance Center and should save $100,000 in electricity costs per year.[11]

[9] Solar bus shelters will be discussed in more detail in a later section.

[10] Source: http://www.metrotransit.org/sunshine-harnessed-for-electricity-at-lrt-facility

[11] Source: http://www.valleymetro.org/pressreleases/detail/solar_project_begins_at_light_rail_facility

Figure 3 Ground-Mounted Solar Array at Valley Metro

LA Metro (Los Angeles, CA)

LA Metro has been using solar energy to power its operations for several years and has built the largest solar array at a transit agency in the U.S. It has continuously invested in solar and now has solar arrays at four separate facilities. Collectively, the energy generated reduces energy costs by approximately $1 million and has lowered the agency's carbon footprint by about 16,500 metric tons annually.

The solar array at the Support Services Center is the largest the agency has built to date. It has 6,720 solar panels and produces 1.2 mW of electricity.[12] The project was a public/private partnership between LA Metro and Chevron Energy Solutions, a local energy utility. The $16.5 million project received $6.3 million in incentives from the Los Angeles Department of Water and Power (LADWP), Southern California Gas Co. (SoCalGas), and the South Coast Air Quality Management District. The project was financed by Bank of America.[13]

LA Metro has recognized that a large part of sustainability is demand management. To complement its shift to renewable energies, it has also taken steps to modernize heating and cooling systems, reduce overall building energy use, and educate employees on how they can contribute to the sustainability effort.[14]

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[12] Source: http://thesource.metro.net/2011/12/12/how-do-they-do-that-5/

[13] Source: http://uk.reuters.com/article/idUK256931+27-Apr-2009+MW20090427

[14] Ibid.

Figure 4 Solar Arrays at LA Metro Support Services Center

Lessons Learned for Solar Arrays at Transit Facilities

Solar arrays at transit facilities vary greatly in size, cost, and output. There is no one "right way" to achieve desired results; successful solar installations should be tailored to their surroundings. Before installing solar, it is important to think about:

- The structural capacity of the roof the installation will occupy.
- Funding opportunities for both capital costs and operational costs.
- The load capacity of the existing electrical grid and the current electrical building load of the facility.

While any solar capacity helps meet sustainability and cost-reduction goals, considering context-specific factors is key to ensuring that it achieves its maximum potential.

WTA Solar Facility Evaluation

This section seeks to identify anticipated generation capacities, costs, and potential concerns for solar installations at MOAB, Cordata Station, and Bellingham Station. While all three facilities could potentially host solar arrays, it is important to note that this is simply a preliminary feasibility study; to proceed further, WTA should contract a structural engineer to evaluate the structural constraints of each facility.

MOAB

MOAB has the largest roof of any facility owned by WTA. This makes it a strong candidate for a solar installation. At full buildout, the system could host 1,416 solar panels and produce approximately 395 kW, which would amount to approximately 425,613 kWh per year and $40,000 in annual energy savings.[15] However, the standing seam steel roof has multiple tiers and is pitched, meaning that the racking system for the solar arrays would need to withstand considerable force from wind. While a thorough structural evaluation is needed to move beyond schematic design, it is clear that roof penetrations[16] at minimum will be needed to secure the arrays to the roof.[17]

Also, the electrical meter and is located on the first floor, so it is likely that penetrations will be necessary to connect the array to the building's electricity system. It is possible that a weatherhead mount[18] will be sufficient to secure Supervisory Control and Data Acquisition (SCADA)[19] and energy connections. Once again, the veracity of these assertions should be evaluated by structural engineers. A preliminary schematic design can be found in Figure 6 and Figure 7.

Fuel and Wash Building

The Fuel and Wash Building is adjacent to MOAB and has a large roof made of prefabricated steel. It is a good candidate for a solar installation because it lacks the multi-tiered structure of MOAB's roof and is large enough to accommodate a 171.36 kW system at full buildout. If fully developed, the system would produce approximately 185,000 kWh of solar energy annually. This would result in an estimated $17,482 annual energy savings.

Installing an array on the Fuel and Wash Building roof would be less complicated than installing a solar array on MOAB because the Fuel and Wash Building only has one floor. This means that there would be less need for extended conduit and minimal need for in-wall penetrations.[20] However, the system will require penetrations of the roof to connect the solar system to the electrical control room in the northeastern corner of the facility. A walk-through with a structural

[15] Source: http://pvwatts.nrel.gov/pvwatts.php

[16] Roof penetrations are used to attach equipment to the roof. This is necessary both to ensure that high winds will not dislodge the solar array and to connect the array to the electrical room inside the building. While roof penetrations deserve caution, they can be done with no adverse impacts to the building.

[17] Industry standard is to have one penetration per 24 panel array.

[18] A weatherhead mount is a type of roof penetration that is suitable for small-scale installations. It is generally considered to be more weather-secure and cost-effective than other types of roof penetrations, but it also limits the amount of energy the system can generate. Industry standard is to require one 1.5 inch SCADA/electrical penetration per 20 kW of expected electrical generation.

[19] Supervisory control and data acquisition (SCADA) is a system for remote monitoring and control that operates with coded signals over communication channels (using typically one communication channel per remote station). It is a necessary part of performance monitoring, metering, and optimization.

[20] In other words, there likely will not be a need to run conduit through walls to reach the existing electrical panels.

engineer and an electrical engineer will be needed to verify that the existing electrical and structural components of the building can support a solar installation. A preliminary schematic design can be found in Figure 8.

Cordata Station

Cordata Station is also a good candidate for solar because it has two buildings and two canopy structures that could host solar panels. The canopy structures already have electrical elements, so the modifications needed to connect the solar arrays to the grid should be relatively minimal. The central canopy section of the station was left without solar panels because it is made of a translucent material and is intended to provide natural light to waiting passengers. Accordingly, this section of roof is unsuitable because solar panels limit light penetration.

At full buildout, Cordata Station could generate 55 kW, amounting to approximately 59,263 kW per year and $5,600 in annual energy savings. Figure 9 and Figure 10 display potential panel placement on both the canopy and building structures at Cordata Station.

Bellingham Transit Station

The steep angles and faceted construction of the building structure at Bellingham Transit Station make a solar installation on the building itself complicated. While technically feasible, installing solar on the building would be expensive and would result in a small system.

The canopy of Bellingham Transit Station is much better suited to a solar installation. At full buildout, the canopy could host 276 panels, generating 77.3 kW or 83,000 kW per year. This would generate approximately $7,800 in annual energy savings. However, it is important to note that the size of the system and the location of the electrical meter inside the station building impacts both the type of penetrations that are needed and the extent of new wire that will be needed to connect the solar panels to the building's electrical infrastructure. These two factors may make it necessary to rewire part of the electrical system for the station. Figure 11 displays the potential full-build scenario for Bellingham Transit Station.

Preliminary Costing Metrics

To provide an evaluation of return on investment, Figure 5 provides preliminary estimates of costs, savings, and the amount of energy reduction that could be obtained in the full build scenarios for each of the three properties. Each of the projects could potentially generate more than 40% of each facility's energy needs and would generate enough savings for a 30-year simple payback. Costs are reflective of the typical costs of installing solar systems in Washington State, which is currently between $3 and $4 per watt for all costs. It may be possible to achieve economies of scale and reduce system costs if the projects are developed in the same time period.

Figure 5 Preliminary Costing Metrics

Facility	Size (kW)	Annual Production (kWh)[21]	Cost[22]	Estimated Annual Cost Savings	Simple Payback[23]	% Current Consumption[24]
MOAB	396.5	425,613	$1.2 Million - $1.6 Million	$40,000	30 Years	40.4%
Bellingham Transit Station	77.3	83,000	$232,000 - $309,000	$7,800	30 Years	48.9%
Cordata Station	54.8	59,263	$164,000 - $219,000	$5,600	30 Years	70.6%
Fuel and Wash Building	171.4	184,815	$514,000 - $685,000	$17,482	30 Years	17.6%[25]

[21] Estimated using http://pvwatts.nrel.gov/

[22] Cost is generated by multiplying the total wattage of the project by a factor of 3 or 4. This range gives a ballpark estimate of hard costs including panels, meters, inverters, wiring, installation, and commissioning.

[23] Total project cost minus annual cost savings

[24] Based on 2015 electricity consumption data from WTA

[25] This figure was calculated using the total annual electricity consumption for MOAB because the Fuel and Wash building is on the same meter as MOAB. If this option is pursued, the planning team should ensure that the electricity produced at the Fuel and Wash building will not exceed the building's demand. This will ensure that the system is not backfeeding the grid.

Figure 6 **MOAB North Roof Solar Plan**

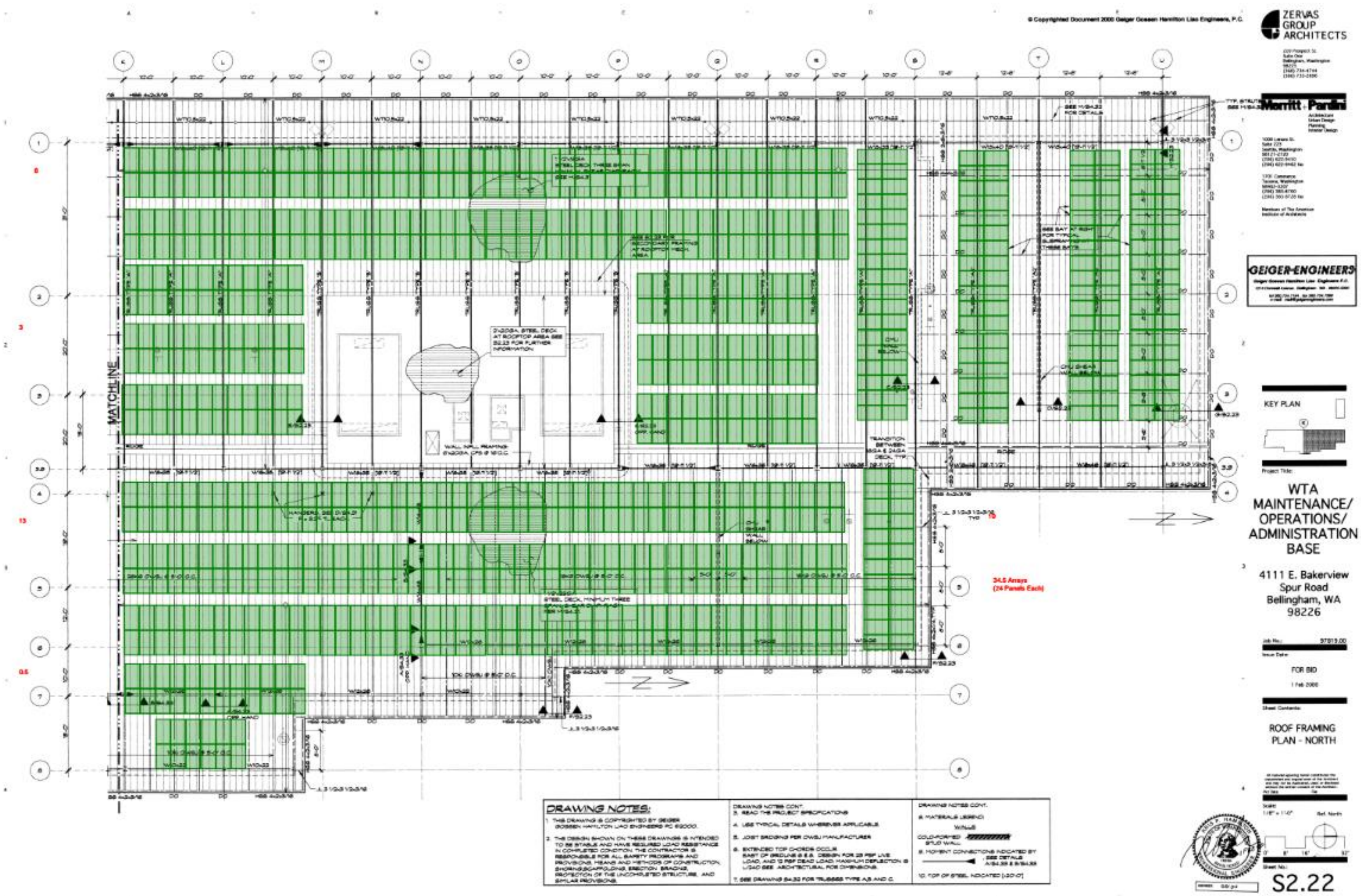


Figure 7 **MOAB South Roof Solar Plan**

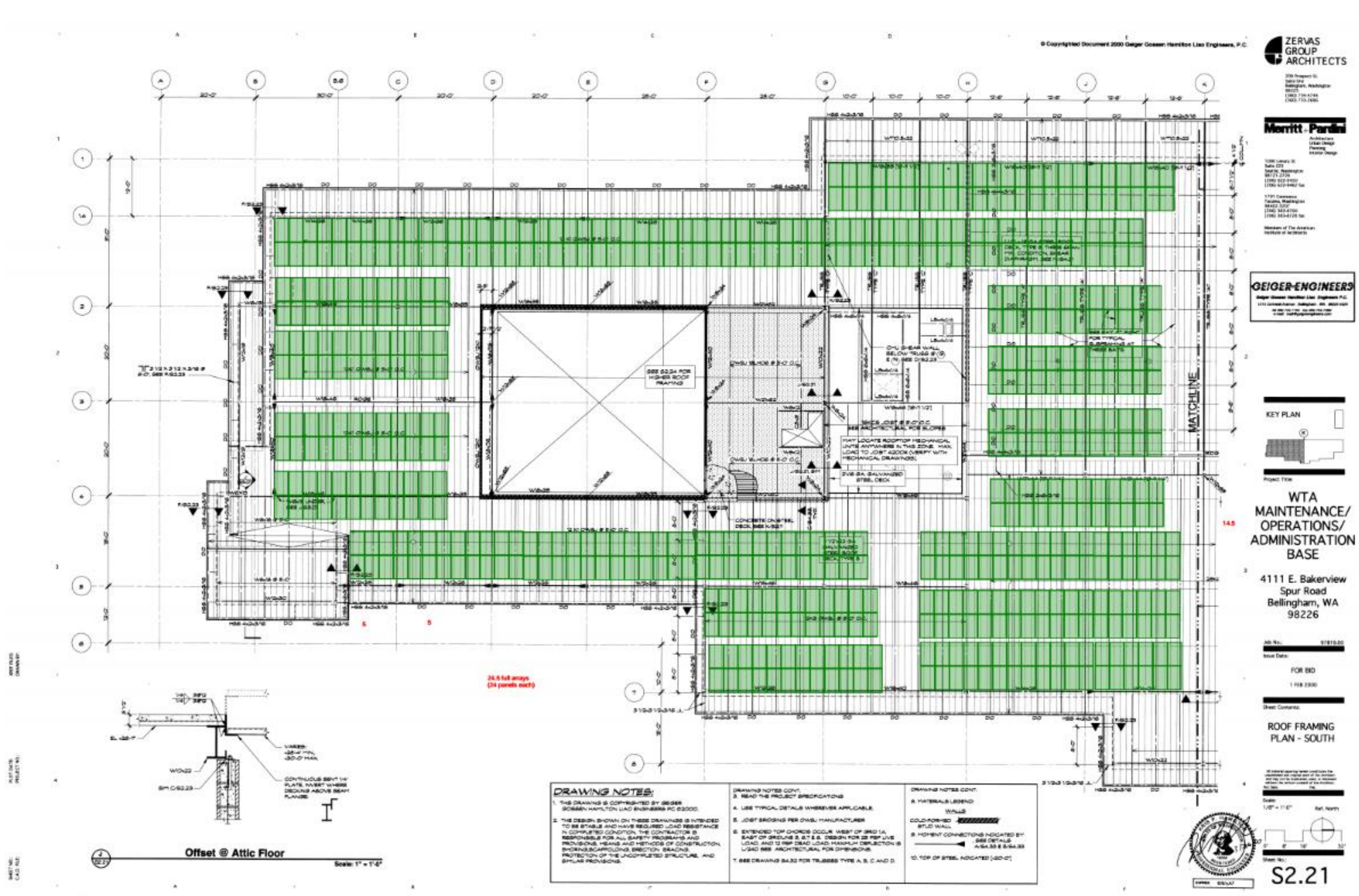


Figure 8 Fuel and Wash Building Solar Plan

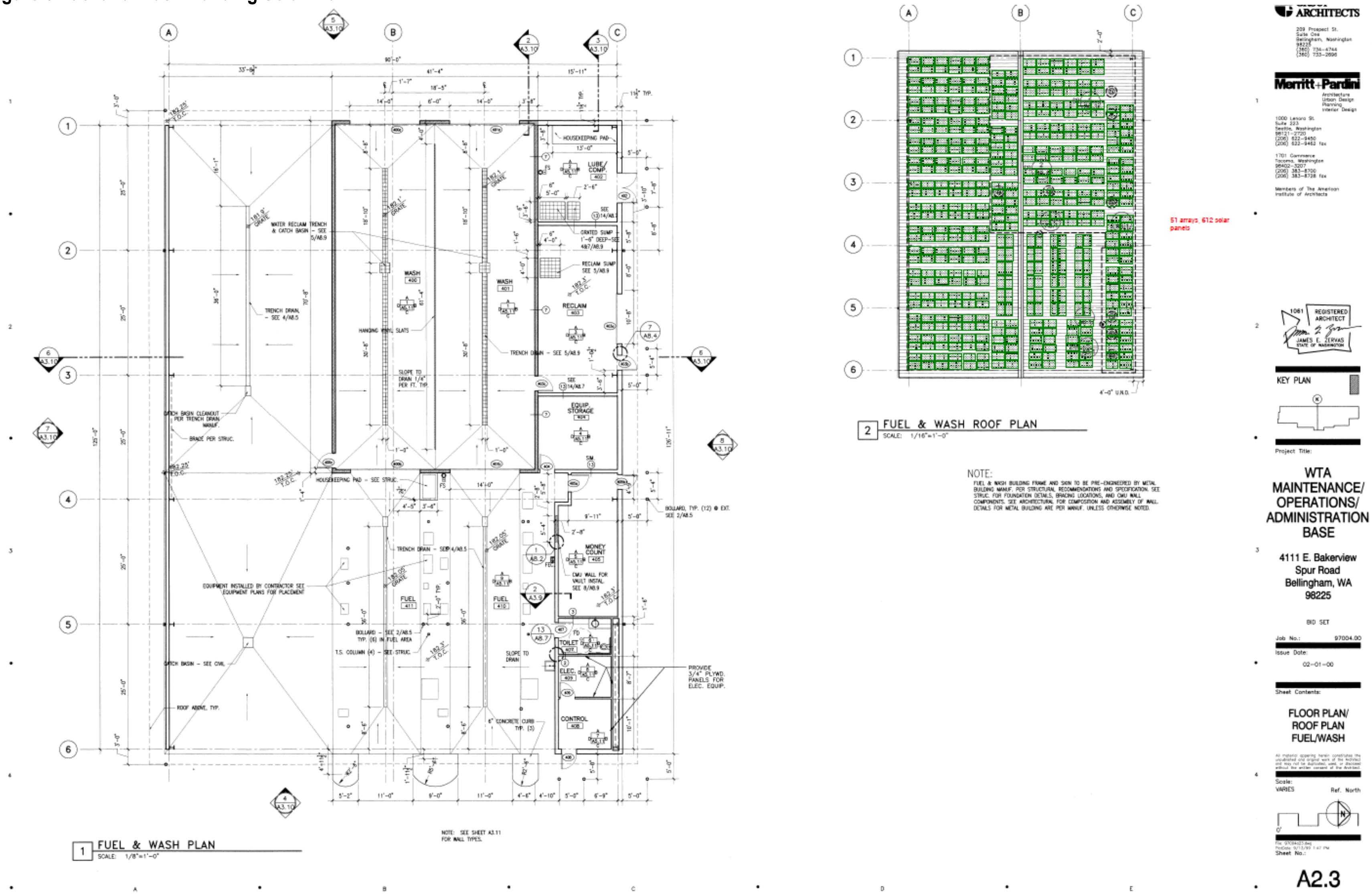


Figure 9 Cordata Station Canopy Plan

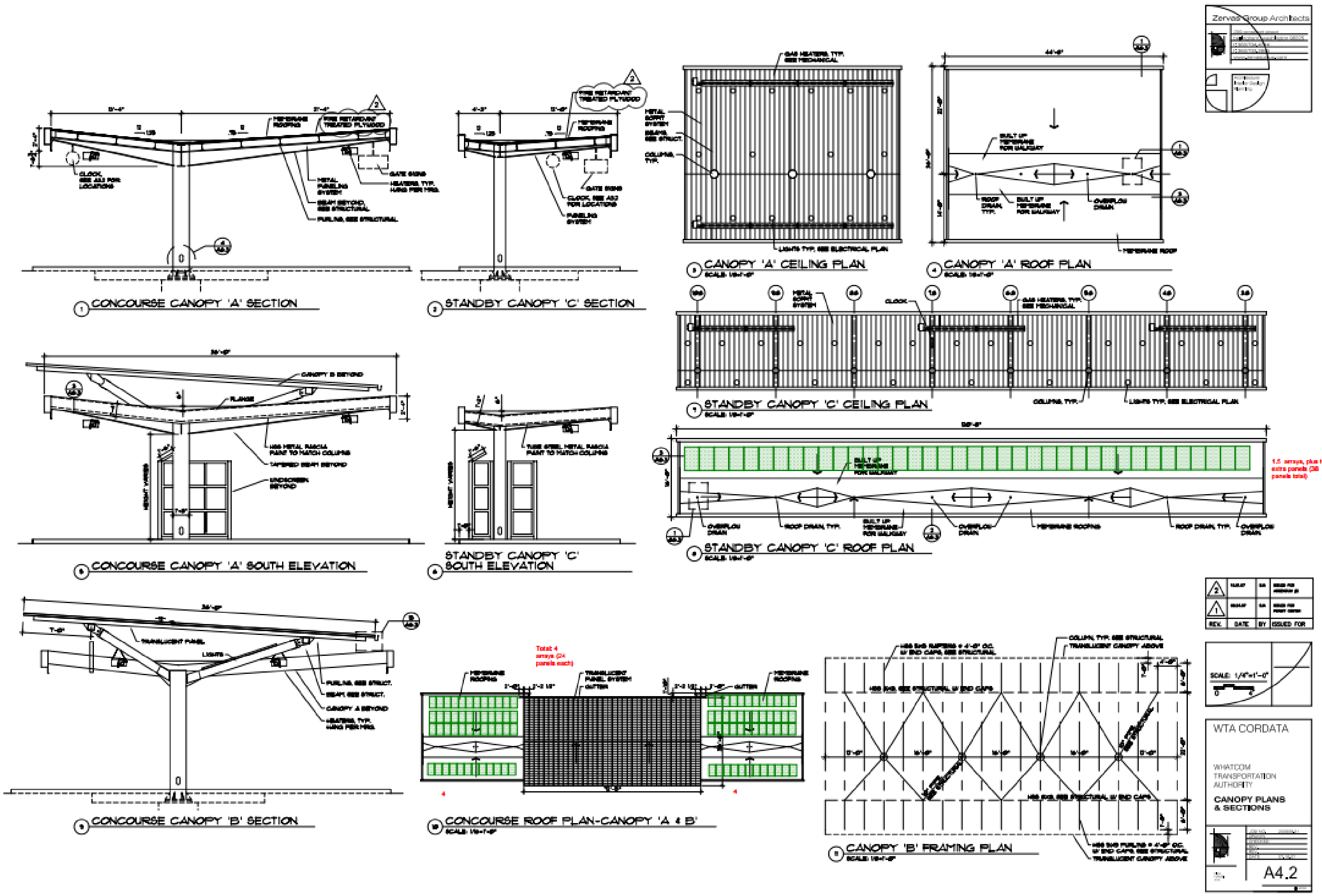


Figure 10 Cordata Station Building Plan

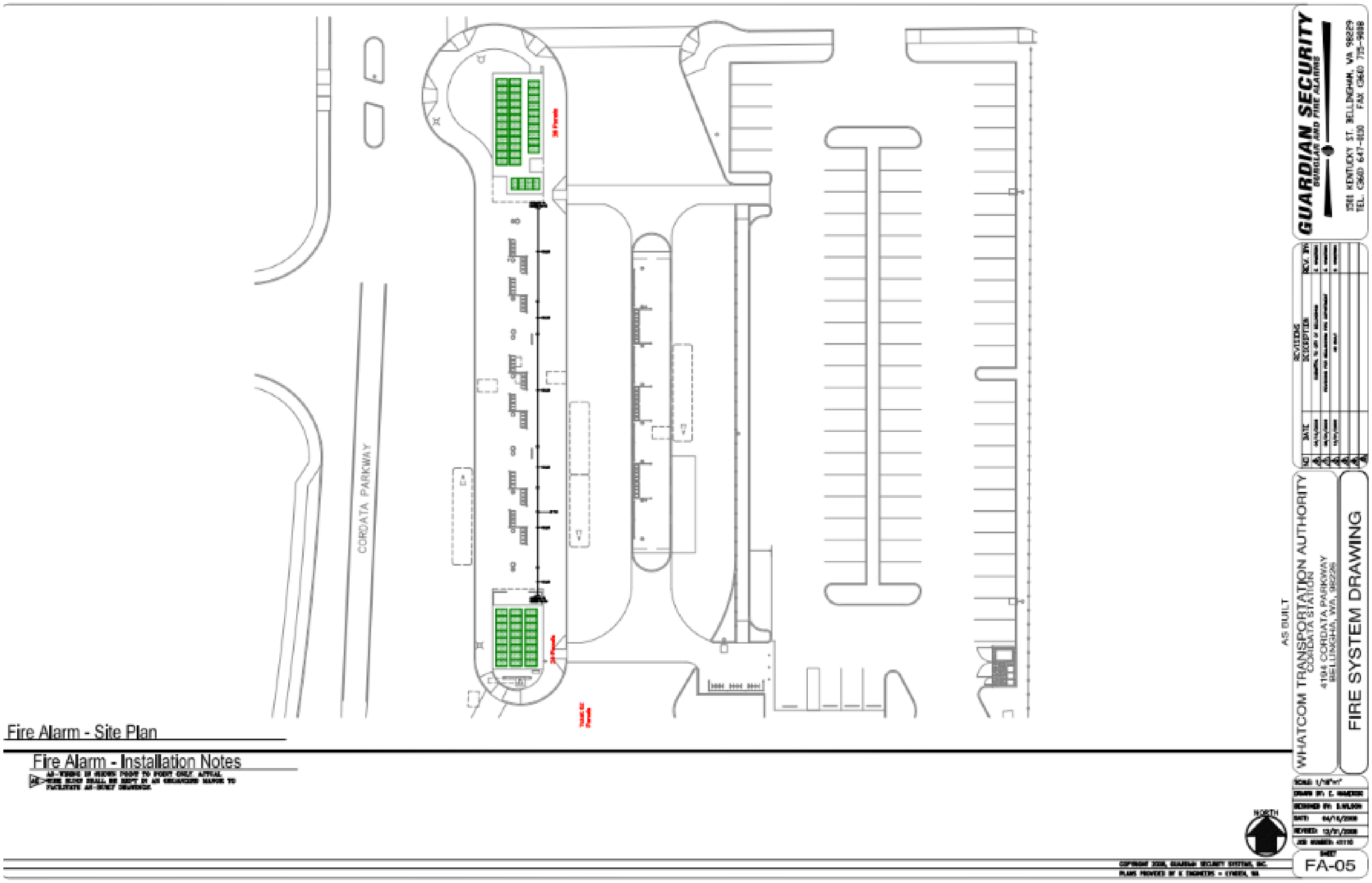
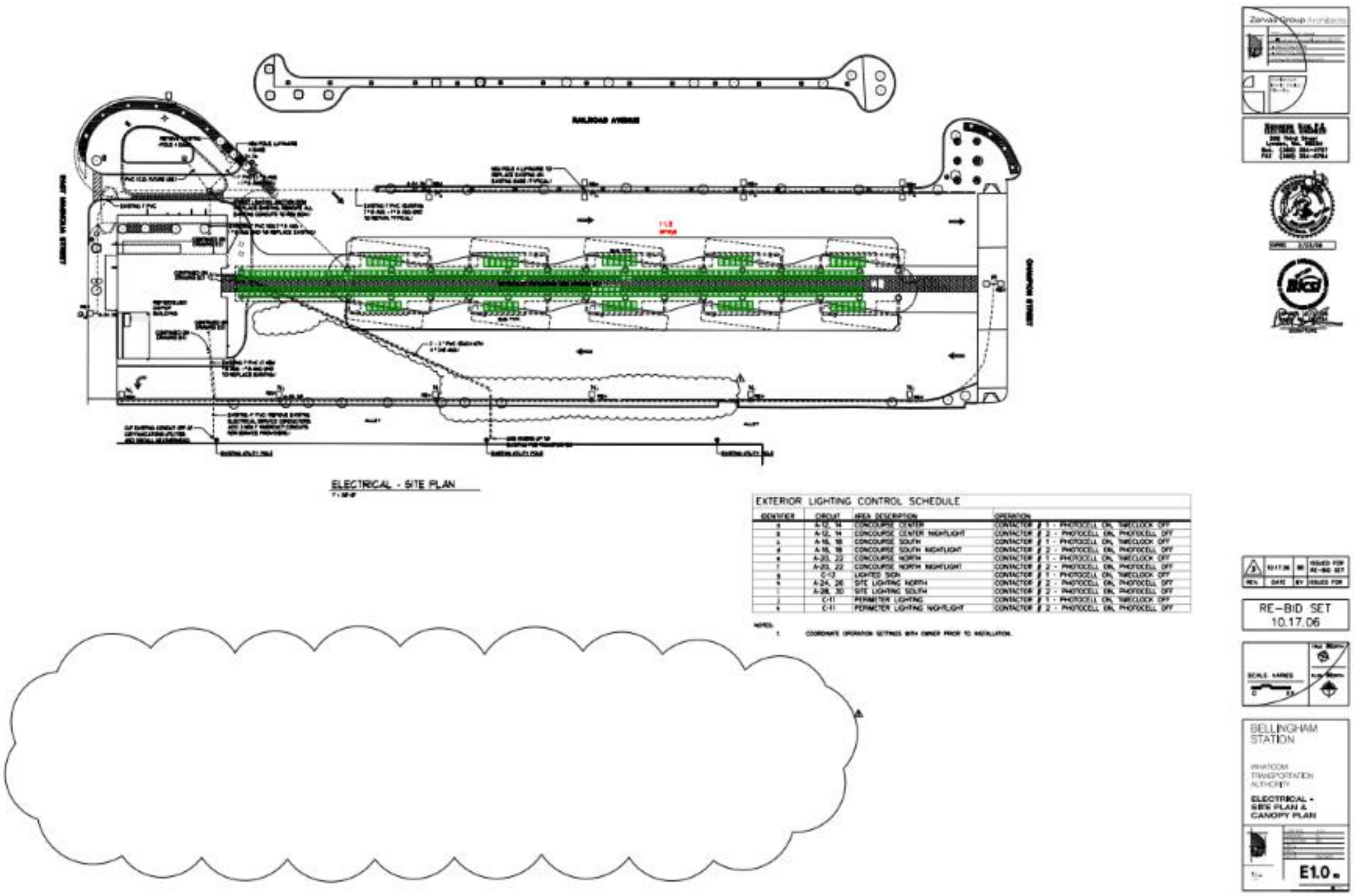


Figure 11 Bellingham Station Solar Plan



SOLAR BUS STOPS

Best Practices

Solar installations at bus stops are a low-cost way to provide power to difficult-to-reach locations. There are two types of bus stop solar facilities: on-grid systems and off-grid systems. The on-grid system is usually larger and can generate more power than the amenities at the bus stop would require. An on-grid system requires conduit to connect the location to the larger electrical grid. Depending on the location of the bus stop, running conduit to the shelter can be prohibitively expensive.

In situations where installing conduit would be prohibitively expensive, the best solution is to install an off-grid system, which uses a battery to store energy produced at the bus stop for later use. While batteries can be expensive, it is often less expensive to buy a battery than it is to install a connection to the electrical grid. The following case studies represent different approaches to using solar panels at bus stops.

The Capital District Transportation Authority (Albany, NY)

CDTA evaluated the feasibility of different types of solar-powered bus stop amenities in 2010. The pilot project involved installing four i-Shelter solar lighting systems on existing bus shelters, 25 i-Stop solar-powered bus stop signs at local stops, and 10 Bigbelly Cordless Compaction Systems. Collectively, purchasing and installing the infrastructure cost $20,500. The i-Stop is a fully integrated, solar-powered illuminated bus stop offering up to three unique LED-based features: (1) a security light, (2) an edge-lit illuminated schedule, and (3) a signal device for notifying bus operators when a stop is necessary. The i-Shelter is a solar-powered LED lighting system that operates off-grid and uses software to tailor output and charging performance to location. Both systems are made by Carmanah, a Canadian solar manufacturer.[26] The Bigbelly Cordless Compaction System is an off-grid high-capacity trash can that can help reduce the need for trash collection.

CDTA found that the i-Stop installations were very vulnerable to collisions and vandalism. The agency found that the solar shelters were much more resilient than the i-Stops and could provide more amenities because of their larger energy generation capacity. The i-Shelters were less vulnerable to vandalism and collision damage, and therefore had lower long-term maintenance costs.

CDTA found that the Bigbelly Solar Compactors were well used and helped keep transit stops clean without adding maintenance costs. The agency was careful to place the compactors away from building shadows or canopies to ensure that the compactors had access to light and would perform at their maximum efficiency. Although overall maintenance costs for the system was lower, it should be noted that the Bigbelly compactors require special trash bags, which was an unexpected upfront operating cost for the agency.[27]

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[26] Source: http://carmanah.com/company/news-and-updates/news-release/carmanah-provides-i-sheltertrade-solar-powered-led-lighting

[27] Source: https://www.dot.ny.gov/divisions/engineering/technical-services/trans-r-and-d-repository/C-08-04%20CDTA%20Solar%20Transit%20Stop%20Final%20Report_Feb%202011.pdf

Figure 12 i-Stop and i-Shelter Solar Installations

Figure 13 Big Belly Solar Trash Compactor in Seattle, WA

Metro Transit (Minneapolis and St. Paul, MN)

In early 2014, Metro Transit began installing solar panels at 25 bus shelters in Minneapolis. The solar panels power motion-sensing lights at the shelters. The solar arrays at the shelters include a battery pack that stores energy generated during the day and can supply up to 30 hours of light when fully charged. Each shelter system cost approximately $4,500 and was purchased with federal grants and local rebates. The agency is satisfied with the performance of the shelter but does not intend to expand solar operations to power real-time-information signs or amenities beyond lighting.[28]

Figure 14 Metro Transit Solar Powered Bus Stop

Lessons Learned for Solar Installations at Bus Stops

Solar installations at bus stops can help create safe, clean environments. Off-grid solar systems are particularly well-suited to remote areas because they do not require installation of new conduit but can still provide lighting or perhaps even power real-time information signs.

While many agencies have successfully implemented solar installations at bus stops, several agencies had difficulties with vandalism, equipment failure, or vendor unreliability. These issues deterred some agencies from widely implementing solar bus stop facilities.

Based on review of case studies, it seems like the grant money used to fund solar arrays at transit facilities is either not sought or not awarded for smaller bus-stop level solar installations. This may indicate that funding solar installations at bus stops will actually be more difficult than funding larger solar installations at transit facilities. If solar bus stops are considered, it will be important to carefully balance the provision of new amenities with upfront and hidden costs of implementing these systems.

[28]Source: http://www.metrotransit.org/solar-power-lighting-metro-transit-buildings-shelters

Evaluation of Solar-Powered Bus Stops for WTA

WTA has several different types of stops and shelters. Some of these stops could be well-suited for solar amenities. This is particularly true for stops that are removed from other light sources or do not have easy tie-ins to the existing electrical grid. Solar amenities at bus stops can be used to power lights, signs, and trash cans. The off-grid systems require a dedicated battery to store electricity. Solar bus stop kits are available that provide all the equipment necessary to retrofit existing bus stops with solar capacities.

As with most infrastructure systems, bulk purchasing results in economies of scale. If purchased in bulk, a bus stop retrofit kit costs in the range of $1,500. The precise cost of the kit relies on many factors, like the ease of attaching solar to the roof of the shelter, the after-dark run time for the corridor[29], and the amenities to be powered at the stop. It is possible that each stop will have different needs; further work should be done to evaluate each of WTA's stops for solar feasibility.

[29] Longer after-dark run times require larger, more expensive batteries.

FUNDING OPPORTUNITIES

Solar installations at public agencies are usually funded through a combination of federal grants, local match, and rebates from the local utility. All of these options are available to WTA, but as the specific grants and rebate programs vary by location, this section will seek to identify sources of funding for WTA's solar installations.

Puget Sound Energy

Whatcom County is a leader in solar energy generation. Puget Sound Energy (PSE), the electric utility for the region, partners with businesses and citizens to provide support for solar installations. PSE supports renewable electricity generation through the Renewable Energy Advantage Program (REAP), which provides a way for solar producers to sell excess energy back to PSE. The rate at which energy is purchased depends on whether or not the solar panels and inverters used in the system were manufactured in Washington State.[30] For example, if both panels and inverters are produced in Washington, PSE will buy energy back at 0.468¢ per kWh[31], but if the equipment was manufactured elsewhere, energy will be bought back at 0.13¢ per kWh. This program assumes that the system will generate excess power. Due to the high level of demand from WTA's facilities, it is unlikely that the agency would be able to regularly sell energy back to PSE.

Washington State Department of Commerce

The Washington State Department of Commerce (DoC) operates a grant program specifically to help local government agencies improve energy efficiency through projects like solar retrofits. The grant requirements are complex; reviewing the entirety of the program is outside of the scope of this feasibility study. However, it should be noted that the DoC requires a funding match, demonstration that the simple payback of the system will take no more than 100 years, a Measurement and Verification plan, and a stamped structural engineering letter confirming the integrity of roofs selected for solar installations. The DoC grants can only be used to purchase capital assets; they cannot be used to fund installation or maintenance.

The grant program also funds street lighting projects, so both bus stop solar installations and solar arrays at transit facilities could be eligible for funding. Grants are awarded through a competitive selection process, and WTA's solar facility plans could be submitted for consideration in 2017.[32]

Leasing

There is also potential for WTA to contract with an energy service company to lease its facilities for use in solar projects. For example, leasing roof space for solar should be a consideration as WTA constructs new facilities and expands existing ones.

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[30] Source: http://pse.com/savingsandenergycenter/Renewables/Pages/REAP-Incentive-Structure.aspx

[31] This price is not guaranteed

[32] Source: http://www.commerce.wa.gov/Documents/2015-17%20Energy%20Efficiency%20and%20Solar%20Grant%20Guidelines%20final%2011.4.15.pdf

SOLAR RECOMMENDATIONS FOR WTA

In conclusion, WTA should incorporate building design elements to facilitate the installation of solar panels, as well as incorporating solar bus stops into the system.

WTA is a good candidate for solar installations at both the facility level and at the bus stop level. Large roofs at MOAB, the Fuel and Wash building, and Cordata Station could easily host solar installations capable of generating 40%, 17.62%,[33] and 70.6% of facility power needs respectively. New development expansion at Bellingham Transit Station could also be made to be PV ready, meaning that the roof would have the structural capacity and electrical tie-ins for solar incorporated into the design of the building. This would reduce the overall need for retrofit expenses and would help reduce installation costs.

Solar at bus stops is also a good option for WTA because it is a low-cost way to increase safety and passenger comfort, as well as promoting awareness of WTA's sustainability initiatives. There is much to be gained from implementing solar at bus stops, especially in more rural locations. While case study research revealed that i-Stops—solar powered lights on bus stops without shelters—are more vulnerable to vandalism and damage, retrofitting bus shelters with solar capacity can be a more secure way to provide amenities at transit facilities.

While the numbers in this report are generalized based on past experience and industry standards and the capacity analysis assumes that facility roofs can be dedicated to solar installations, it is clear that there is a strong business case for solar for the WTA. These projects can help WTA move toward a more sustainable future.

[33] This figure was calculated based on MOAB's total energy consumption because the Fuel and Wash building and MOAB share a meter.