SKANSKA

# Sustainable Building & LEED

BYU-IDAHO

## Problem Statement 1: LEED 2009 vs LEED v4 Assessment

Part 1: Overall Project Review

Utilizing the LEED 2009 and LEED v4 Rating System Reference Guides and provided LEED checklists, please provide a cursory assessment of LEED rating level achieved under each system based on available Project Documents.

By applying LEED 2009 Rating System Reference Guides we have determined this project achieves LEED Certified. We have calculated a total of 41 credits with the current building plan. Here is the credit break down:

- Sustainable Sites: 4 credits
- Water Efficiency: 4 credits
- Energy and Atmosphere: 18 credits
- Materials and Resources: 8 credits
- Indoor Environmental Quality: 6 credits
- Innovation: 1 credit

However, if Skanska choose to apply the LEED v4 Rating System Reference Guides we have determined this project will achieve LEED Gold Certified. We have calculated a total of 62 credits with the current building plan. Here is the credit break down for the Gold Certification:

- Location and Transportation: 11 credits
- Sustainable Sites: 5 credits
- Water Efficiency: 7 credits
- Energy and Atmosphere: 20 credits
- Materials and Resources: 10 credits
- Indoor Environmental Quality: 8 credits
- Innovation: 1 credit

Part 2: Materials Category

Please outline the major differences in documentation and compliance under the Materials category, based on review of overall changes in the rating systems. Provide pros and cons of each.

With the switch from LEED 2009 to LEED v4 there have been several changes. Serval credits have been moved or combined for v4. In addition to the restructuring of the credits from LEED 2009, three new credits have also been added.

1- *Building Product Disclosure and Optimization—Environmental Product Declarations*

- Addresses environmental life-cycle impacts and selecting products with improved life-cycles
- Rewards the use of products with Environmental Product Declarations

2- *Building Product Disclosure and Optimization—Sourcing of Raw Materials*
- Addresses raw material sourcing and selecting materials that have been appropriately sourced
- Rewards the use of products from manufacturers that provide information on land use practices, extraction locations, labor practices, etc.
- Replaces Recycled Content, Rapidly Renewable Materials, and Certified Wood

3- *Building Product Disclosure and Optimization—Material Ingredient Reporting*
- Addresses material ingredients and selecting products with optimized ingredients
- Rewards the use of products that have ingredient reporting in programs like Health Product Declaration, Cradle 2 Cradle, etc.

The introduction of these three credits and the combination of the previous ones lead to smarter comparisons, allowing optimized product assessments. These new credit do, however, raise an issue they contain requirements that are, at the moment, still untested and, in some cases, not clearly defined. In response to this USGBC has promised to be clearer in defining these requirements and to put applicable issues out to ballot as needed. All in all LEED v4 is an improvement over LEED 2009 as is leads to a more integrated, sustainable project that will result in reduced life-cycle impacts and energy savings.

Part 3: Recommendation of Rating System

Based on the above analysis, please provide a recommendation of which rating system the Project should register and comply with, and a proposed level of certification (Certified, Silver, Gold, or Platinum)? Please provide rational and documentation to support your decision in your conclusion.

Based our analysis, we recommend that Skanska use LEED v4 in place of LEED 2009. It will gain a greater LEED certification with the current plan. We also propose that Skanska just get the LEED Gold Certification provided. By our calculation sited above we have determined that project has already achieved 61 total credits under LEED v4. This is just barely above the minimum requirement for Gold. We believe that in order to achieve Platinum it would not be cost effective due to the amount and expense of credits required to achieve the additional 19 credit necessary for LEED Platinum.

# Problem Statement 2: Life Cycle Sustainability Analysis - Lighting

## Part 1: Annual Energy Use

What is the annual energy usage of each of the lighting options? (Provide in kWh)

The energy expended over the course of a year by the lighting fixtures varies by the type of fixture as well as the size. There are 3 sizes of fixtures in question on the 4th street station. The X-6A, X-6b and X-6C fluorescent bulbs consume more energy than their LED equivalent. The 30 watt bulb in the X-6A consumes 8409.6 KWH whereas the LED consumes only 4961.66, a 3447.94 KWH per year difference. Replacing the 40 watt fixtures will produce a savings of 14,913.72 KWH per year. With the fluorescent fixture consuming 36441.6 KWH per year and the LED consuming 21527.88 KWH. The 50 watt X-6C fixture consumes 15768 KWH while the LED equivalent only consumes 9303.12 KWH.

Calculating the savings for all of these, there is a total expenditure of 60619.2 KWH for the fluorescent fixtures. Converting to the LED fixtures will only consume 35792.66 KWH per year. A difference of 24826.54 KWH per year.

## Part 2: Life Cycle Analysis

Utilizing the provided subcontractor bids, complete a life-cycle analysis, over a 10 year cycle, of the two lighting options. Include material purchase, installation costs and maintenance costs in your analysis. Identify the criteria and or formula used to process.

Over the first ten years the building is operational the bulbs will need to be replaced 1 time, the bidding subcontractors have agreed to provide maintenance on these fixtures for a certain amount of time. They have also agreed on a price for installation and maintenance.

FOY GROUP (FOY) has submitted a bid for the 2 options, fluorescent and LED lighting. The bid for fluorescent lighting is $290,000 and the bid for LED is $353,000. The cost of materials and installation is $36,592 for fluorescent lighting and $56,264 for LED lighting. For maintenance of the lighting types are $224,460 for LED and $193,500 for fluorescent.

McKinstrys' bid for the lighting is $200,000 and the bid for LED is $233,000. The cost of materials and installation is $31,750 for fluorescent lighting and $58,024 for LED lighting. For maintenance of the lighting types are $136,052 for both the fluorescent and LED.

Cochran's' bid for both lighting types are, for fluorescent is $189,600 and the bid for LED is $266,700. The cost of materials and installation is $34,453 for fluorescent

lighting and $61,966 for LED lighting. For maintenance of the lighting types are $147,920 for LED and $114,380 for fluorescent.

Part 3: Subcontractor Selection

What subcontractor would you select?

Judging by the prices the subcontractors have submitted and their scope of work submitted for the project we will select McKinstry to complete the project as our electrical subcontractor. We selected McKinstry because they have a lower price for the LED option and they are willing to work with our plans more than the other companies. McKinstry is planning to work normal business days and will maintain their work for the longest period of time under warranty. The difference between the fluorescent and LED pricing is $33,000

Part 4: Incentives & Rebates

Are there any available incentives or rebates to assist with the more efficient technology? According to the LA Department of Water and Power (LADWP) there is a rebate for switching fluorescent lighting with LED. The rebate amount for this is $.15 per KWH saved. Over the course of a year switching to LED lighting will save $24,826.54 KWH this will mean a total of $3,724 in rebates for the course of the year. With only these reimbursements and not the cost of the electricity saved it will take an estimated 9 years for this exchange to completely pay itself off.

Part 5: Incentives & Rebates

Based on the above analysis, what light fixtures does your team recommend? List supporting evidence in your conclusion.

Our team recommends exchanging the Fluorescent lights with their LED equivalents because doing that will gain points with the LEED counsel. Also switching to the LED lights will save money and even result in an increase of cash flow for the owner. This switch as well as others that will be implemented in this project will result in a more sustainable and green building for all to enjoy in the great city of Los Angeles.

## Problem Statement 3: Concrete Carbon Footprint

Part 1: Bid Comparison

1. How many cubic yards of concrete will be required for the 4th Street Station?

We calculated a total of 523 cubic yards form the quantity take off sheets.

| Cubic Yards of Concrete-4th Street Station | | |
|---|---|---|
| Item | Unit | Amount |
| Platform Footings East | CY | 92.92 |
| Platform Footings West | CY | 92.92 |
| Platform Walls East | CY | 70.78 |
| Platform Walls West | CY | 70.78 |
| Sidewalk Footings East | CY | 5.44 |
| Sidewalk Footings West | CY | 5.44 |
| Slab on Grade at Ramp East | CY | 10.71 |
| Slab on Grade at Ramp West | CY | 8.11 |
| Sidewalk Walls East | CY | 10.08 |
| Sidewalk Walls West | CY | 10.08 |
| Slab on Grade/MAT Footing East | CY | 3.58 |
| Slab on Grade/MAT Footing West | CY | 3.58 |
| TC& C Footings | CY | 20.15 |
| TC& C Walls | CY | 27 |
| TOS Footing | CY | 74 |
| TOS Building Walls | CY | 17.34 |
| | | |
| Total | CY | 522.91 |

2. What is the total price for each supplier? Which is the least expensive?

White Castle is the least expensive

| Total Price For Each Supplier | | | | | |
|---|---|---|---|---|---|
| Supplier | Description | Price | Units | Amount | Total |
| White Castle | 4000psi | $64.00 | CY | 529.91 | $33,914.24 |
| | 7% waste factor | | | | $2,374.00 |
| | Sales tax | | | | $189.92 |
| | Subtotal | | | | $36,478.16 |
| | | | | | |
| Slip Diamond Ready Mix | 4000psi | $73.50 | CY | 529.91 | $38,948.39 |
| | 7% waste factor | | | | $2,726.39 |
| | Sales Tax | | | | $3,115.87 |
| | Discount $1 per 10cy | | | | -$52.00 |
| | Sub total | | | | $44,738.64 |
| City Park Concrete | 4000psi | $63.00 | CY | 529.91 | $33,384.33 |
| | 7% waste factor | | | | $2,336.90 |
| | Sales Tax | | | | $2,670.75 |
| | Sub total | | | | $38,391.98 |

3. What is the carbon footprint of each supplier? Which supplier has the smallest footprint? Include transportation of the cement, aggregate and fly ash from the

source to the batch plant, and transportation of the ready mix concrete from the batch plant to the project. Ignore sourcing of water and admixtures.

| Carbon Footprint | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| | White Castle Concrete | | | | |
| Item | Company | Location | Distance | Vehicle Efficiency | CO2 Footprint |
| Transportation of Cement to Plant | Comex | Inglewood, CA | 12.46 | 6.5 mpg | 0.02 |
| Transportation of Aggregate to Plant | Polaris Material Corp | Britsh Colombia, Canada | 22 | 6.5 mpg | 0.58 |
| Transportation of Fly Ash to Plant | Headwaters Resources | South Jordan, UT | 690 | 6.5 mpg | 1.18 |
| Transportation of Ready Mix Conrete to Site | White Castle Concrete | Inglewood, CA | 10.5 | 6.5mpg | 0.02 |
| | | | | | |
| Total | | | | | 1.81 |
| | Slip Diamond Ready Mix | | | | |
| | Company | Location | Distance | Vehicle Efficiency | CO2 Footprint |
| Transportation of Cement to Plant | Standard Ready MIx | Santa Ana, CA | 35.4 | 6.5 mpg | 0.06 |
| Transportation of Aggregates to Plant | Saticoy Recycled | Oxnard, CA | 96.4 | 6.5 mpg | 0.17 |
| Transportation of Fly Ash to Plant | SRMG | Napa, CA | 11.7 | 6.5 mpg | 0.02 |
| Transportation of Ready Mix Conrete | Slip Diamond Ready Mix | Ontario, CA | 51.6 | 6.5mpg | 0.09 |

| | | | | | |
|---|---|---|---|---|---|
| to Site | | | | | |
| | | | | | |
| Total | | | | | 0.33 |
| | City Park Concrete | | | | |
| | Company | Location | Distance | Vehicle Efficiency | CO2 Footprint |
| Transportation of Cement to Plant | CalPortland Concrete Products | Ontario, CA | 35.5 | 6.5 mpg | 0.06 |
| Transportation of Aggregates to Plant | VULCAN | Irwindale, CA | 35 | 6.5 mpg | 0.07 |
| Transportation of Fly Ash to Plant | NO FLY ASH | | | | |
| Transportation of Ready Mix Conrete to Site | City Park Concrete | West LA, CA | 3.7 | 6.5mpg | 0.01 |
| | | | | | |
| Total | | | | | 0.13 |

4. Due to the sustainability goals of the client, each ton of CO2 produced has a cost to the project of $40/ton. Update the bid comparison from #2 with this information and recommend the best value supplier for the project.

| Total Price For Each Supplier | | | | | |
|---|---|---|---|---|---|
| Supplier | Description | Price | Units | Amount | Total |
| White Castle | 4000psi | $64.00 | CY | 529.91 | $33,914.24 |
| | CO2 Footprint | | | | $72.40 |

| | | | | | |
|---|---|---|---|---|---|
| | 7% waste factor | | | | $2,374.00 |
| | Sales tax | | | | $189.92 |
| | Subtotal | | | | $36,550.56 |
| | | | | | |
| Slip Diamond Ready Mix | 4000psi | $73.50 | CY | 529.91 | $38,948.39 |
| | CO2 Footprint | | | | $13.20 |
| | 7% waste factor | | | | $2,726.39 |
| | Sales Tax | | | | $3,115.87 |
| | Discount $1 per 10cy | | | | -$52.00 |
| | Sub total | | | | $44,751.84 |
| City Park Concrete | 4000psi | $63.00 | CY | 529.91 | $33,384.33 |
| | CO2 Footprint | | | | $5.20 |
| | 7% waste factor | | | | $2,336.90 |
| | Sales Tax | | | | $2,670.75 |
| | Sub total | | | | $38,397.18 |

Part 2: Local vs. Out of Town Labor

1. There are 11 concrete placements scheduled. On average, each lasts 1 day and is done by a crew of 4 laborers and 3 finishers. Of the 7 workers on the crew, 2 live in L.A.(16 MI), 3 live in Riverside (70 MI) and 2 live in Oceanside (93 MI). What is the carbon footprint of the crew for all placements?

The total carbon footprint is 4.56 tons.

2. By how many tons of CO2 could the carbon footprint be reduced if all laborers lived within 15 miles of the job?

3.44 tons of C02 could be saved.

3. By how many tons of CO2 could the carbon footprint be reduced if the out of town workers carpooled (i.e. one carpool from Oceanside and one carpool from Riverside)?

By carpooling C02 emissions could be reduced by 1.91 tons. We also included an alternative method to carpooling. The workers from Riverside could pick up the people in LA on their way to work if feasible.

| **Starting Point** | **Residents** | **Distence** | **mpg** | **Miles Traveled per Day** | **Total Miles Traveled** | **CO2 Emissions (Tons)** |
|---|---|---|---|---|---|---|
| **Part 1** | | | | | | |
| ***LA*** | **2** | **16** | **20** | **64** | **704** | **0.34** |
| ***Oceanside*** | **2** | **93** | **20** | **372** | **4092** | **1.98** |
| ***Riverside*** | **3** | **70** | **20** | **420** | **4620** | **2.24** |
| | | | | | **Total:** | **4.56** |
| **Part 2** | | | | | | |
| ***Within 15 Miles*** | **7** | **15** | **20** | **210** | **2310** | **1.12** |
| | | | | | **Difference:** | **3.44** |
| **Part 3** | | | | | | |
| ***LA*** | **1** | **16** | **20** | **32** | **352** | **0.17** |
| ***Oceanside*** | **1** | **93** | **20** | **186** | **2046** | **0.99** |
| ***Riverside*** | **1** | **70** | **20** | **140** | **1540** | **0.75** |
| | | | | | **Total:** | **1.91** |

| **Alternative Choice** | | | | | | |
|---|---|---|---|---|---|---|
| ***Oceanside*** | **1** | **93** | **20** | **186** | **2046** | **0.99** |
| ***Riverside*** | **1** | **70** | **20** | **140** | **1540** | **0.75** |
| | | | | | **Total:** | **1.74** |

## Problem Statement 4: Water Collection and Usage

Part 1: Irrigation Consumption

What is the estimated total water usage by month for the fourth street station based on the station landscaping?

The landscaping area is 5,563 Sq. Ft, in which, 22, BTH Mexican fan palm, 200 shrubs 58 vine 18 CY of mulch will be planted. This area will need 30,452 gallons per year to sustain the trees and shrubs and ground cover. This was calculated by using the average of rain and evaporation rate per month close to Santa Monica, California. The percentage is obtained by subtracting from the rain fall which is in mm each month, the Evapotranspiration rate of that month and convert the difference to gallons per year.

Plant species were choose from the list in the sheet L-002, they can adapted to the environment in the transit station, require low maintenance and give a great and clean look to the landscaping.

- Trees: Mexican fan palms, life span 75 to 100 years,
- Shrubs: Catalina perfume
- Vines: Star Jasmine
- Ground cover: Lily Turf

One more element to the landscaping is discomposed granite.

Assuming that our plants will have a coefficient of .5, we need around 2550 gallons of water a month, especially during the months of May to October which is the dry season in California.

Part 2: Rain Water Collection

In order to reduce potable water usage, the owner would like to collect rain water from the 4th St. station site and reuse it for irrigating the landscaped areas. What size cistern (in gallons) would be necessary in order to not require supplemental water at any point during the year? The station will be opening on January 1st and the cistern will be completely empty.

By building the cistern under the bike module we will have plenty of space to store more than 30,500 gallons which will be used for the entire year without the need of supplementary water. The harvested water from the roof of the building will give around 1930 gallons, and we used 2538 gallons a month, to help in harvesting water we need to also collect some water from the landscape area during raining season and collect 600 gallons of water. By doing this the cistern will store the water to use for irrigation of the landscaping. (If the rain season keeps the same percentage as the last 4 years)

The amount of water harvested was calculated by measuring the area of the roof and multiplying this by the inches of rain (average by month) and multiplied by the factor of 0.623. The roof's area 996 sq. ft. X 3.1 inches of rain average in January X 0.623= +/- 930 gallons.

Part 3: Cistern

The only area available for cistern storage is under the area labeled bike module "C" at the north end of the station. The maximum excavation depth is 12 feet below the plaza precast pavers and the concrete tank would require 1 foot thick walls, and 1 foot thick horizontal slabs.

1. What is the capacity of the cistern?
   - The actual size of this cistern will be the measure of the Bike module C in Page A-S7-101
   - Excavation is 26' X 33' X 12', and the inside will be 1' less on all six sides.
   - Then the inside of the cistern is 24' X 31' X 9'10" this made a total of 7313.52 cubic feet.
   - To get the capacity of the cistern in gallons we used the formula 1 cubic foot = 7.48051 gallons.
   - The cistern under the bike module will have the capacity of store 54,708.93 gallons.
2. Based on this capacity, how much supplemental water would be required per month?
   - Every month we need around 2,537 gallons of water for the landscaping, if the cistern is installed in July we will need 2537 gallons of supplementary water during the dry season.
   - If the cistern is installed the 3th of January the extra water during the raining season will start filling the cistern and we can used it to irrigate during days of poor or no rain.
   - According to the average of rain in California found in http://www.holiday-weather.com/los_angeles/averages/,
   - We will have the necessary amount of water in the ground to store and use it, during the raining season. But during the dry season we will probably need to use 625 gallons of portable water per month.
   - There is a way to store or harvest enough water during a good winter if we used some underground piping to collect the excess of water during winter to accomplish the storage of 30,500 gallons during a year.

*To allow for partial credit, please clearly state any formulas used in solving this problem.

http://www.sandiego.gov/development-services/pdf/industry/apxewaterworksheets.pdf

http://www.endmemo.com/cconvert/galm2.php

## Problem Statement 5: On-Site Renewable Energy

Part 1: Solar Panel Design

Evaluate the three attached solar panel cut sheets to determine the best option to propose to the owner as a means of offsetting the energy output for the 4th St Station. The parameters are as follows:

1. The only available surfaces for the solar panels are the TOS booth roof and the C/S Building roof.

2. Assume standard test conditions when evaluating the output energy

3. Assume an annual average solar radiation of 6.1 kWh/m2-day.

4. Assume a default Performance Ratio of 0.75 (this factors in the shade provided by the parapets).

5. Utilize the proposed design energy demand summary provided in the drawings for the TOS booth. Assume a proposed design energy demand of 240 kBtu/sqft-yr for the C/S building.

6. Pricing (includes material and install costs)

   a. Sunpower X21-345 model – **$465/panel,**

   b. Sunmodule Plus SW275 Mono model - **$450/panel**

   c. Grape Solar GS-Start-100W model - **$150/panel**

Address the following:

1. Provide the quantity of panels required for each option to offset at least 8% of the

total output energy of the TOS booth and the C/S building, as well as marked-up

drawings showing your recommendation for the solar panel layouts (use the roof

layout details in the drawings).

2. Which solar panel option provides the best value to the customer (please provide

supporting narrative justifying your decision with a cost analysis)

3. Determine the optimal orientation variables for the above identified panel array:

a. Direction for the solar panels to face at this location

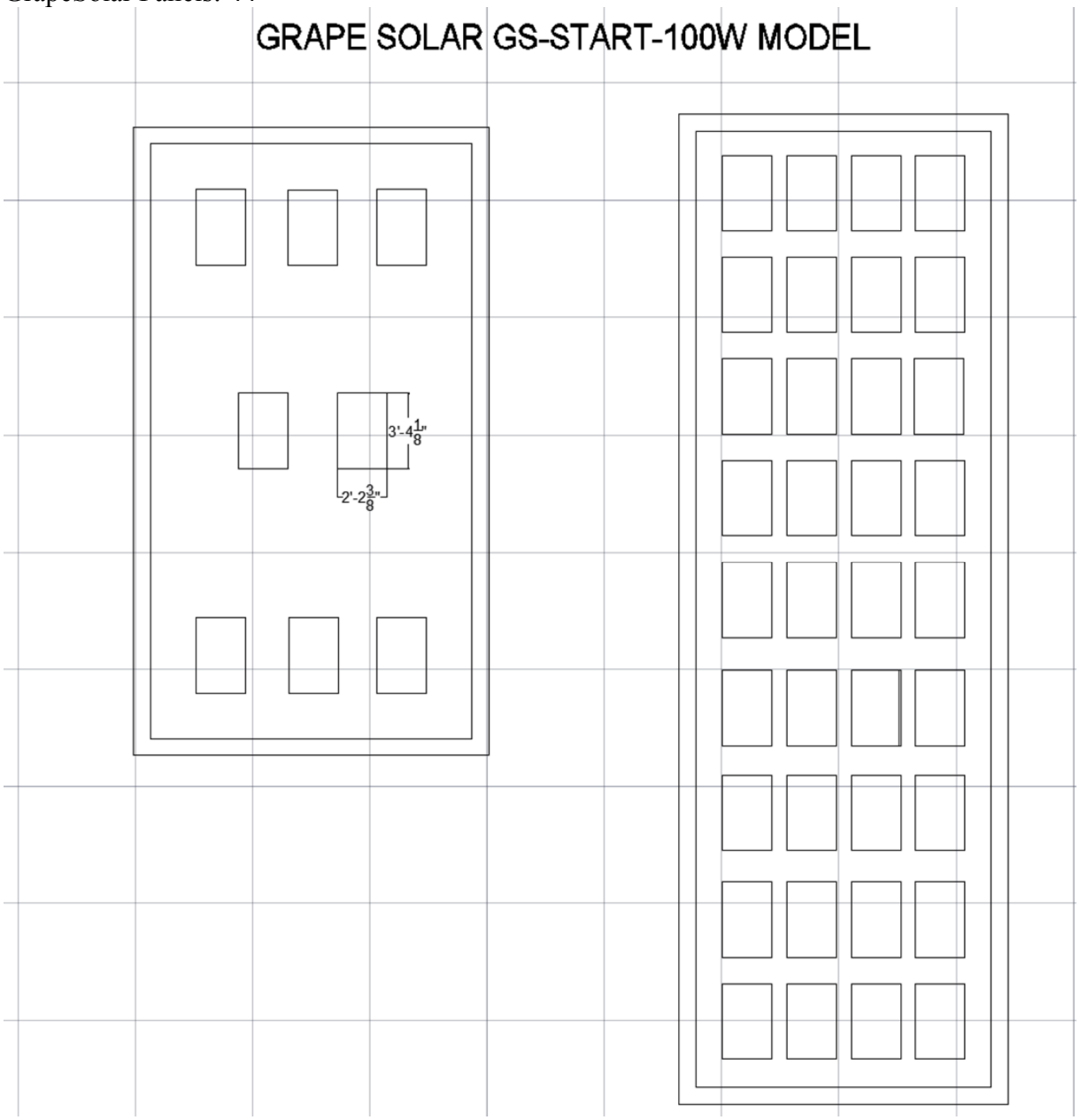
(North/South/East/West)

b. Using magnetic declination, determine the true angle the solar panels need to face to optimize the energy returns (using oE)

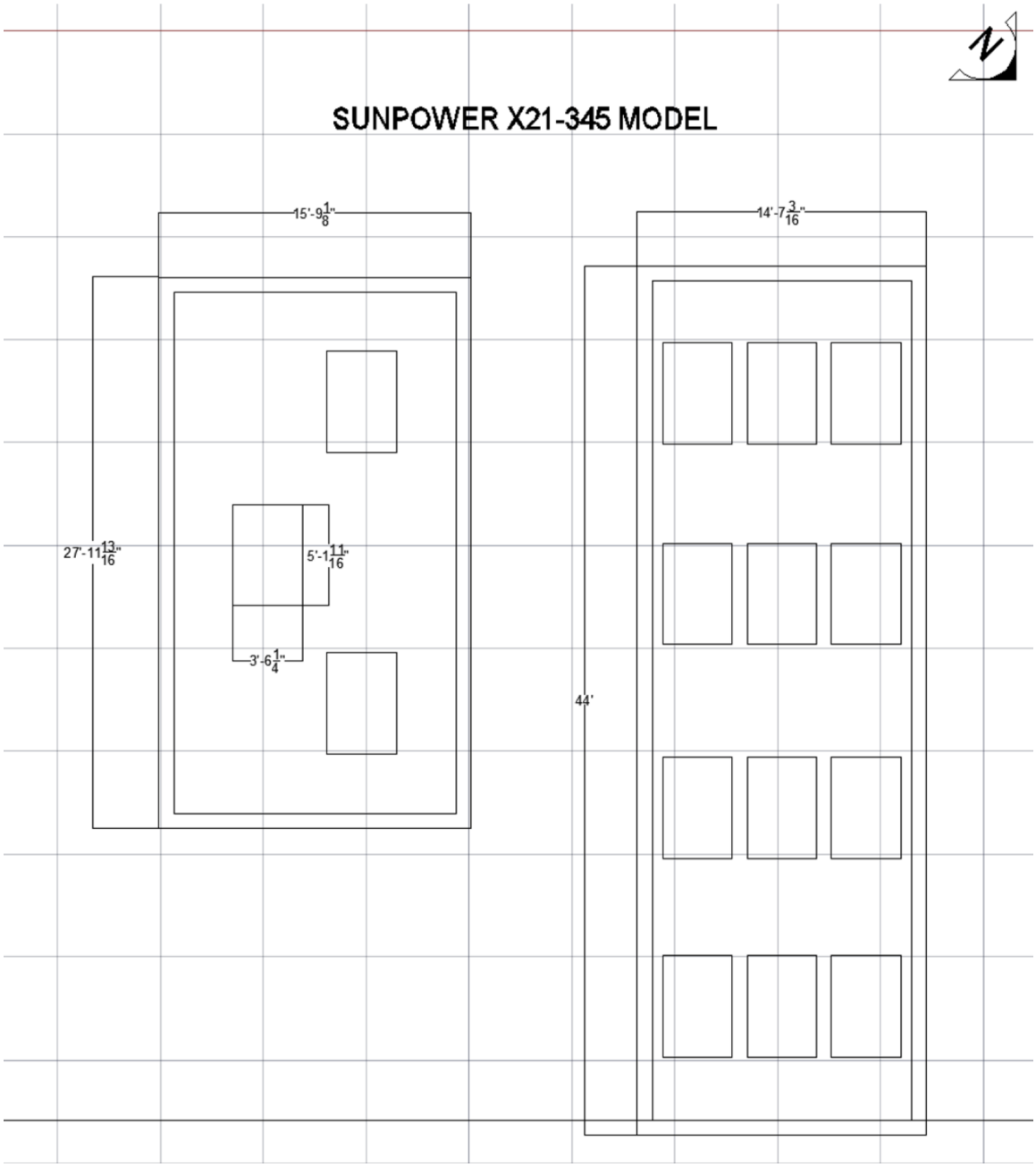
c. In order to maximize the amount of sunlight captured, the panels need to be tilted at least twice a year. Identify the two optimal adjustment dates for the location of the project as well as the optimum panel angle for each period.

To offset the total energy consumption (8327.984 kWh/yr) by 8%, the following number of panels per product is arranged as follows:

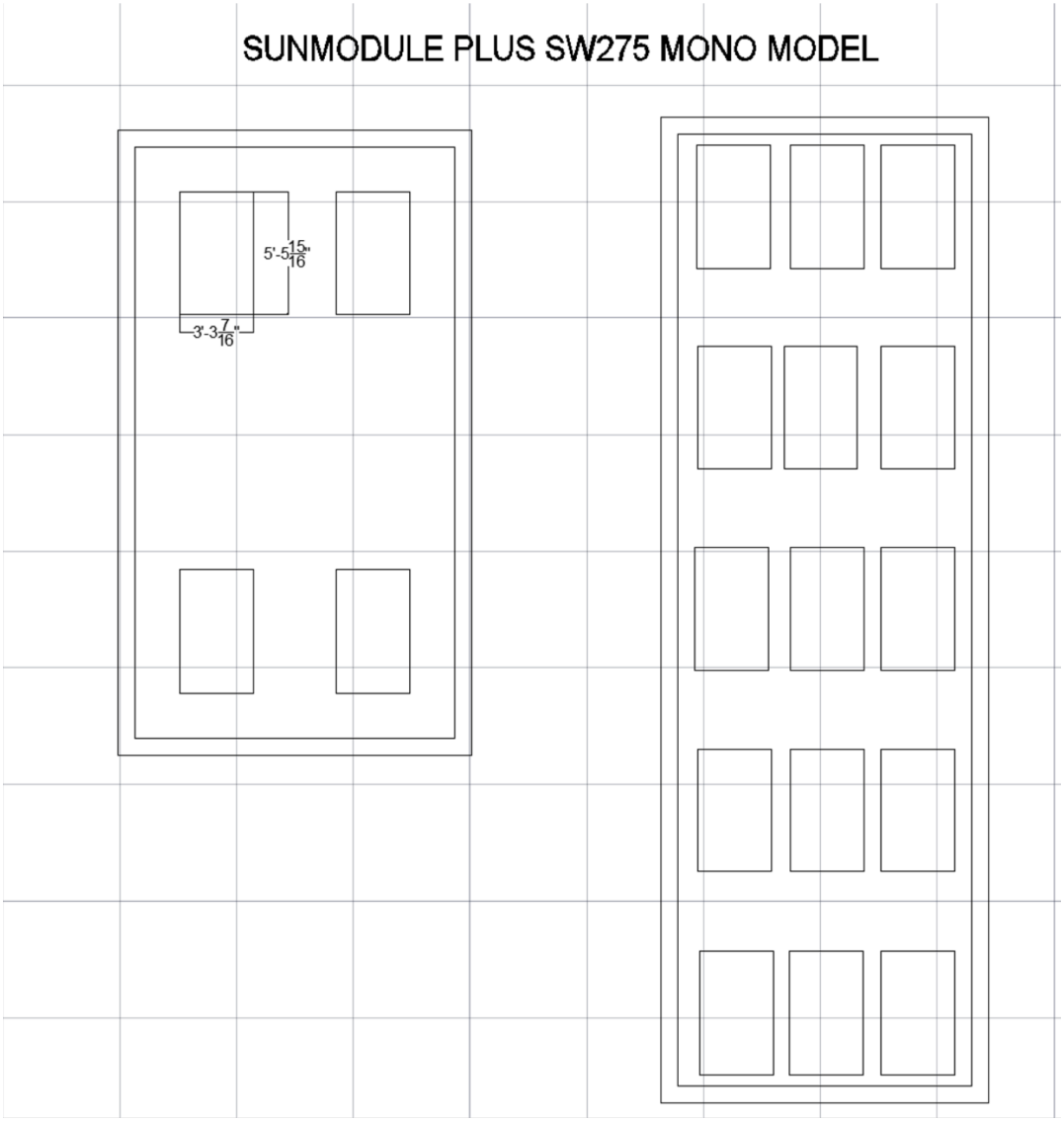
GrapeSolar Panels: 44



Sunpower Solar Panels: 15



Sunmodule Solar Panels: 19




To complete the 8% offset with the Grape Solar Panels, 44 would be needed. Although this is the highest amount needed they are smaller and they cost less overall, as shown below.

| | Cost per Panel | Panels Needed |
|---|---|---|
| GrapeSolar | $150.00 | 44 |
| Sunpower | $465.00 | 15 |
| Sunmodule | $450.00 | 19 |

A: Solar Panels to face the south.

B: The true angle to get maximum sunlight would be to follow the magnetic declination of the earth and the sun, approximately 0°-65°.

C: To reach maximum amount of sunlight rotate panels twice a year. On March 22nd rotate panels to 11.5°. On September 18th rotate panels to 58.5°.

Part 2: Additional Renewable Energy – Options to Net Zero

This client is requesting a design build proposal for achieving Net Zero Energy for this portion of the project, though they understand it is not feasible within current area limitations of the site. As an incentive toward a more energy efficient project, the City has offered the client a small parcel of land directly adjacent to this portion of the project at no cost. It is a small (~4 acre site) with no existing structures, ground coverage, or contamination issues. The owner is offering this parcel as a courtesy, on a 10 year no cost lease, as it is not viable for development at this time. The closest border of the parcel is 50 meters from the project site. Evaluate the project and adjoining parcel to provide a net zero energy option to the client using the adjacent parcel, using one of the 3 previously specified solar options (selected panel manufacturer may changes from Q1), provide the cost/savings of this option on a ten year cost analysis. For purposes of this analysis, cost of capital and depreciation shall be assumed to be zero (given this is a public owner).

Please detail the following:

- Product chosen, with quantity and cost of solar panels installed
- Cost estimate of panel supporting structure and any other ancillary construction scope; please itemize all scope items separately.
- Payback period for solar installation, including assumptions made in cost analysis.
- Projected maintenance cost of a system over its projected life (include any other maintenance

In order to achieve Net Zero Energy for the TOS Booth and the C/S Building, 550 GrapeSolar Panels would need to be installed on the 4 acres on the offsite piece of land. This would cost a total of $82, 500.00

| Material | Price | Amount | Cost |
|---|---|---|---|
| Rails/legs | $10.00 | $550.00 | $5,500.00 |
| Bolts | $2.18 | $28.00 | $61.04 |
| Espansion Joints | $2.95 | $275.00 | $811.25 |
| End Caps | $0.10 | $1,100.00 | $110.00 |
| Wiring (100 m) | $50.00 | $164.00 | $8,200.00 |
| | | Total Cost | $14,682.29 |

Assuming a 3 year loan of $9800.00, with monthly payments of $3900.00 at 2% the calculated payment plan is below.

| Month | Payment | Interest | Amount Left |
|---|---|---|---|
| 1 | $3,900.00 | $1,960.00 | $96,060.00 |
| 2 | $3,900.00 | $1,921.20 | $94,081.20 |
| 3 | $3,900.00 | $1,881.62 | $92,062.82 |
| 4 | $3,900.00 | $1,841.26 | $90,004.08 |
| 5 | $3,900.00 | $1,800.08 | $87,904.16 |
| 6 | $3,900.00 | $1,758.08 | $85,762.25 |
| 7 | $3,900.00 | $1,715.24 | $83,577.49 |
| 8 | $3,900.00 | $1,671.55 | $81,349.04 |
| 9 | $3,900.00 | $1,626.98 | $79,076.02 |
| 10 | $3,900.00 | $1,581.52 | $76,757.54 |
| 11 | $3,900.00 | $1,535.15 | $74,392.69 |
| 12 | $3,900.00 | $1,487.85 | $71,980.55 |
| 13 | $3,900.00 | $1,439.61 | $69,520.16 |
| 14 | $3,900.00 | $1,390.40 | $67,010.56 |
| 15 | $3,900.00 | $1,340.21 | $64,450.77 |
| 16 | $3,900.00 | $1,289.02 | $61,839.79 |
| 17 | $3,900.00 | $1,236.80 | $59,176.58 |
| 18 | $3,900.00 | $1,183.53 | $56,460.11 |
| 19 | $3,900.00 | $1,129.20 | $53,689.32 |
| 20 | $3,900.00 | $1,073.79 | $50,863.10 |
| 21 | $3,900.00 | $1,017.26 | $47,980.36 |
| 22 | $3,900.00 | $959.61 | $45,039.97 |
| 23 | $3,900.00 | $900.80 | $42,040.77 |
| 24 | $3,900.00 | $840.82 | $38,981.59 |
| 25 | $3,900.00 | $779.63 | $35,861.22 |
| 26 | $3,900.00 | $717.22 | $32,678.44 |
| 27 | $3,900.00 | $653.57 | $29,432.01 |
| 28 | $3,900.00 | $588.64 | $26,120.65 |
| 29 | $3,900.00 | $522.41 | $22,743.07 |
| 30 | $3,900.00 | $454.86 | $19,297.93 |
| 31 | $3,900.00 | $385.96 | $15,783.88 |
| 32 | $3,900.00 | $315.68 | $12,199.56 |
| 33 | $3,900.00 | $243.99 | $8,543.55 |
| 34 | $3,900.00 | $170.87 | $4,814.42 |
| 35 | $3,900.00 | $96.29 | $1,010.71 |
| 36 | $1,010.71 | $0.00 | $0.00 |

Solar Panels require minimum maintenance. In order to keep the panels running at their most efficient state, it's needed to be washed/sprayed off with water a few times a year. Roughly 3 gallons will clean one panel. There are 550 panels. 3 gallons x 550 gallons= 1650. The cost of a gallon of water in Los Angeles is .7 of a cent. The total cost of the amount of water needed to clean all the panels once is $11.55. Solar panels should be cleaned up to a few times a year. Assuming cleaning takes place at least four times over the course of the year the total cost would be $46.20.

Part 3: Alternative Renewable Energy Sources

Other than traditional photovoltaic panels, evaluate the following alternative renewable solutions for viability onsite. Please limit yourself to the listed considerations, and provide your rationale for selecting or rejecting the provided alternative.

a. Biofuel-based electrical systems

b. Geothermal energy systems

c. Hydroelectric power systems

d. Micro wind turbines

a. Biofuel-based electrical systems would not be a viable alternate renewable resource for this project. Biofuel is renewable but it emits large amounts of carbon dioxide. For this site it would take more energy to make the biofuel then it is worth.

b. Geothermal energy systems would also not be recommended for this site. Geothermal energy helps with water and air heat. Most of the buildings on site are open or smaller and a different smaller heating would work better.

c. Hydroelectric Power Systems would not be viable. The ocean is the closest water available for this but it is not close enough for on-site. There are also no rivers or other bodies of water nearby that could support this kind of power system.

d. Micro Wind Turbines could be a good resource to use on this project. Average wind speeds in this area are 7.5mph. The wind turbines could also be placed near enough to the train tracks to catch some of the wind from the trains as the go by.

## Addendum 1: Expo Daily Ridership

Part 1: Estimated Ridership of the Expo 1 & 2 project in 2030

What is the estimated ridership of the Expo 1 & 2 project in 2030 from Downtown LA to 4th Street Santa Monica Station?

> It is estimated that by 2030 the ridership of the Expo 1 & 2 from Downtown LA to 4th Street Santa Monica Station will be roughly 64,000.

Part 2: Gallons of Gasoline Saved

Assuming that all of these riders would have driven, calculate the number of gallons of gasoline saved? List all of your assumptions.

> Assuming that personal vehicles of the riders get an average of 20 miles per gallon of gasoline and that they live within 15 miles of their work places, they will have saved approximately 48000 gallons of gasoline. It will also reduce the carbon footprint by an estimated 46.55 tons.

Part 3: Ridership Incentives

List some innovative ways in which to increase ridership. Points awarded for creativity.

> In order to increase ridership on the Expo we recommend some sort of rewards system. Similar to “Frequent Flyer Miles” or a punch card give a bonus to those who regularly use the Expo.