Student Competition - Sparks, NV
February 4 - 7, 2015

National Problem Statement:
Sustainable Building & LEED

The Colorado & 4th Street Transit Station, Santa Monica

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Problem Statement 1: LEED 2009 vs LEED v4 Assessment

Part 1 – Overall Project Review

To examine the LEED checklists created please reference Appendixes 1 and 2 attached to this submittal.

We have researched and summarized each section of the current LEED BDC v4 for new construction as well as its counterpart in the LEED v4. We have ensured that all of the most current sustainability practices have been considered while projecting the potential LEED certification this project can receive.

Part 2 – Materials Category

Being a contractor on a high-end sustainable transit center such as Phase 2 of the Exposition Line, materials and resources are a high regarded category. In order to receive LEED credits on this project, the types of materials being brought onto the job should be documented early on by specific individual and tracked throughout the entire job. The types of materials in a transit station need to be closely looked at as there are many unique conditions that need to be reviewed. In this section we will go through the different potential LEED credits in both LEED 2009 and LEED v4 and discuss the changes as well as some of the pros and cons of these changes.

Notable changes in the Material and Resources category from LEED 2009 to LEED v4 are:

- An additional prerequisite is added to v4 regarding construction and demolition waste management and planning.
- A compliance option has been added for total project waste reduction per gross floor area of the project.
- Multiple material streams must be diverted to earn the credit for waste diversion (Option 1).
- ADC has been specifically excluded from diversion calculations. In LEED 2009, it was allowed to count as diverted waste.
- Waste-to-energy may count as a diversion method if the facility meets European Union requirements for waste management and emissions into air, soil, surface water, and groundwater.

The first difference one is able to distinguish between the LEED 2009 and the new LEED v4 are the number of prerequisites. LEED 2009 consisted of one material and resource prerequisite, Storage and Collection of Recyclables, which reduces waste generated by building tenants and that is hauled and disposed in landfills. However, this still

incorporated into the new v4 standards along with the addition of two more. Version 4 also requires projects to satisfy conditions of reducing construction and demolition waste disposed of in landfills and incineration facilities by recovering, reusing, and recycling under Construction and Demolition Waste Management Planning. An additional qualification is directly applied to only the healthcare sector of construction which deals directly with reduction of mercury contained products and devices. The benefits of the new standards are a great step in the right direction for our industry. Construction waste is a significant portion of the waste produced in the world. Developing and implementing a plan to keep such materials out of landfills will prevent ground and water pollution while promoting recycling.

Another large difference between the LEED 2009 and LEED v4 is the removal of Building Reuse credits. These credits in the 2009 version awarded points based on the project retaining a percentage of the existing buildings elements such as walls, roofs, or other non-structural elements. These credits cannot apply to new construction projects and is therefore a disadvantage to those projects. These credits may have been removed but a new credit called Building Life-Cycle Impact Reduction has taken its place. This credit is similar to the Building Reuse credits. This credit and the LEED 2009 building reuse credits are good credits for major renovation projects but are not useful for new construction.

Part 3 – Recommendation of Rating System

Based on comparison of the benefits provided by each version, the Colorado and 4th Street Exposition Transit Project should register and comply with the 2009 LEED at a proposed level of Platinum certification. Upon credit assessment per version, we have determined the project is susceptible to higher achievement under the previous LEED version. Reviewing requirements, intent, and description, we value project success at the highest level. Currently, projects are still capable of complying under LEED 2009 regulations as long as it is registered prior to October 2016. The actual start date of construction can be up to one year following this deadline. In our checklists, appendixes 1 and 2, we have assumed the allotted credits will be attempted within project feasibility. Many credits outlined on the checklists will be reflected in the proceeding work of this document.

LEED 2009 for New Construction and Major Renovations

Project Checklist

Project Name: Colorado & 4th Streeet Transit Station

Date: 2/5/15

Sustainable Sites — Possible Points: 26

Y	?	N			
Y			Prereq 1	Construction Activity Pollution Prevention	
1			Credit 1	Site Selection	1
5			Credit 2	Development Density and Community Connectivity	5
		1	Credit 3	Brownfield Redevelopment	1
6			Credit 4.1	Alternative Transportation—Public Transportation Access	6
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
3			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
2			Credit 4.4	Alternative Transportation—Parking Capacity	2
1			Credit 5.1	Site Development—Protect or Restore Habitat	1
1			Credit 5.2	Site Development—Maximize Open Space	1
1			Credit 6.1	Stormwater Design—Quantity Control	1
1			Credit 6.2	Stormwater Design—Quality Control	1
	1		Credit 7.1	Heat Island Effect—Non-roof	1
	1		Credit 7.2	Heat Island Effect—Roof	1
		1	Credit 8	Light Pollution Reduction	1

Water Efficiency — Possible Points: 10

Y			Prereq 1	Water Use Reduction—20% Reduction	
4			Credit 1	Water Efficient Landscaping	2 to 4
		2	Credit 2	Innovative Wastewater Technologies	2
4			Credit 3	Water Use Reduction	2 to 4

Energy and Atmosphere — Possible Points: 35

Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
19			Credit 1	Optimize Energy Performance	1 to 19
5		2	Credit 2	On-Site Renewable Energy	1 to 7
		2	Credit 3	Enhanced Commissioning	2
2			Credit 4	Enhanced Refrigerant Management	2
		3	Credit 5	Measurement and Verification	3
		2	Credit 6	Green Power	2

Materials and Resources — Possible Points: 14

Y			Prereq 1	Storage and Collection of Recyclables	
		3	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
		1	Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2
2			Credit 3	Materials Reuse	1 to 2

Materials and Resources, Continued

Y	?	N			
2			Credit 4	Recycled Content	1 to 2
2			Credit 5	Regional Materials	1 to 2
1			Credit 6	Rapidly Renewable Materials	1
1			Credit 7	Certified Wood	1

Indoor Environmental Quality — Possible Points: 15

Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
1			Credit 1	Outdoor Air Delivery Monitoring	1
1			Credit 2	Increased Ventilation	1
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1
1			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
1			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
1			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
1			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
1			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
1			Credit 5	Indoor Chemical and Pollutant Source Control	1
1			Credit 6.1	Controllability of Systems—Lighting	1
		1	Credit 6.2	Controllability of Systems—Thermal Comfort	1
		1	Credit 7.1	Thermal Comfort—Design	1
		1	Credit 7.2	Thermal Comfort—Verification	1
		1	Credit 8.1	Daylight and Views—Daylight	1
		1	Credit 8.2	Daylight and Views—Views	1

Innovation and Design Process — Possible Points: 6

1			Credit 1.1	Innovation in Design: Specific Title	1
1			Credit 1.2	Innovation in Design: Specific Title	1
1			Credit 1.3	Innovation in Design: Specific Title	1
1			Credit 1.4	Innovation in Design: Specific Title	1
1			Credit 1.5	Innovation in Design: Specific Title	1
1			Credit 2	LEED Accredited Professional	1

Regional Priority Credits — Possible Points: 4

1			Credit 1.1	Regional Priority: Specific Credit	1
1			Credit 1.2	Regional Priority: Specific Credit	1
1			Credit 1.3	Regional Priority: Specific Credit	1
1			Credit 1.4	Regional Priority: Specific Credit	1

Total — Possible Points: 110

86	2	22	

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

LEED v4 for BD+C: New Construction and Major Renovation

Project Checklist

Project Name: Colorado & 4th Street Transit Station
Date: 2/5/15

Y	?	N			
1			Credit	Integrative Process	1

13	1	2	**Location and Transportation**		16
x	x	x	Credit	LEED for Neighborhood Development Location	16
1			Credit	Sensitive Land Protection	1
		2	Credit	High Priority Site	2
4	1		Credit	Surrounding Density and Diverse Uses	5
5			Credit	Access to Quality Transit	5
1			Credit	Bicycle Facilities	1
1			Credit	Reduced Parking Footprint	1
1			Credit	Green Vehicles	1

7	0	3	**Sustainable Sites**		10
Y			Prereq	Construction Activity Pollution Prevention	Required
1			Credit	Site Assessment	1
2			Credit	Site Development - Protect or Restore Habitat	2
1			Credit	Open Space	1
3			Credit	Rainwater Management	3
		2	Credit	Heat Island Reduction	2
		1	Credit	Light Pollution Reduction	1

6	3	2	**Water Efficiency**		11
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
2			Credit	Outdoor Water Use Reduction	2
3	3		Credit	Indoor Water Use Reduction	6
		2	Credit	Cooling Tower Water Use	2
1			Credit	Water Metering	1

21	0	12	**Energy and Atmosphere**		33
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
		6	Credit	Enhanced Commissioning	6
18			Credit	Optimize Energy Performance	18
		1	Credit	Advanced Energy Metering	1
		2	Credit	Demand Response	2
2		1	Credit	Renewable Energy Production	3
1			Credit	Enhanced Refrigerant Management	1
		2	Credit	Green Power and Carbon Offsets	2

5	3	5	**Materials and Resources**		13
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
		5	Credit	Building Life-Cycle Impact Reduction	5
1	1		Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
1	1		Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
1	1		Credit	Building Product Disclosure and Optimization - Material Ingredients	2
2			Credit	Construction and Demolition Waste Management	2

7	2	7	**Indoor Environmental Quality**		16
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
1	1		Credit	Enhanced Indoor Air Quality Strategies	2
3			Credit	Low-Emitting Materials	3
1			Credit	Construction Indoor Air Quality Management Plan	1
1		1	Credit	Indoor Air Quality Assessment	2
		1	Credit	Thermal Comfort	1
1	1		Credit	Interior Lighting	2
		3	Credit	Daylight	3
		1	Credit	Quality Views	1
		1	Credit	Acoustic Performance	1

6	0	0	**Innovation**		6
5			Credit	Innovation	5
1			Credit	LEED Accredited Professional	1

4	0	0	**Regional Priority**		4
1			Credit	Regional Priority: Specific Credit	1
1			Credit	Regional Priority: Specific Credit	1
1			Credit	Regional Priority: Specific Credit	1
1			Credit	Regional Priority: Specific Credit	1

70	9	31	**TOTALS**	Possible Points:	**110**

Certified: 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

Problem Statement 2: Life Cycle Sustainability Analysis Lighting

Part 1 – Annual Energy Use

The fluorescent lighting options from Primus Lighting are T8 fixtures listed either at 25, 32 or 40 watts depending upon size of fixture. These are the original lights listed for the project. The smallest light, 3 foot 25 watts, has annual energy usage of 6570 kW/h. The middle light, 4 foot 32 watts, has an annual energy usage of 11,212 kW/h. The largest light, 5 foot 40 watts, has an annual energy usage of 17,520 kW/h. These numbers can be referenced in the chart under Annual Energy Use.

Also the annual energy use for the suggested LED upgrade lists the annual energy usage. Overall the usage for the LED's are smaller than that of the fluorescents. A cost per kW/h is provided from the Bureau of Labor at 22.3 cents for the Santa Monica area. Using this cost as a constant for the ten years, we are able to determine the life cycle cost for both the current fluorescents and proposed LEDs.

Annual Energy Use						Life Cycle Analysis		
	QTY	Watt	Total Watt	KW/h	kW/h 1yr.	cost/kW/h	Cost 1 yr	Cost 10 yr
X-6A	30	25	750	0.75	6570	0.223	1465.11	14651
X-6B	40	32	1280	1.28	11212.8	0.223	2500.4544	25005
X-6C	50	40	2000	2.00	17520	0.223	3906.96	39070
					35302.8		**7872.5244**	**78725**
X-6A alt.	30	17.7	531	0.53	4651.56	0.223	1037.2979	10373
X-6B alt.	40	23.63	945	0.95	8279.952	0.223	1846.4293	18464
X-6C alt.	50	29.5	1475	1.48	12921	0.223	2881.383	28814
					25852.512		**5765.1102**	**57651**

Part 2 – Life Cycle Analysis

Analyzing the bids provided from the subcontractors we took the cost for each fixture kW/h and multiplied it by total hours per year (8760 hr/yr) and then multiplied by 10 to get a projected cost after 10 years or energy usage. In order to figure our actual life cycle cost we then included the material and installation cost. The maintenance cost was not calculated into the annual costs. We did not include maintenance because this is for lights that need to be replaced. Given that we do not know when a light will fail we assume each light will last the full ten years. However we did include a 15% fee for FOY each year because this is a yearly check up on the system to make sure all lights are working correctly.

	Fixture:	X-6A	X-6B	X-6C	1 Yr Total	10 Yr Total	X-6A Alt	X-6B Alt	X-6C Alt	1 Yr Total	10 Yr Total
FOY	$ per fix	188	213	234			298	315	388		
	$ total fix	5640	6390	7020	19050		8940	9450	11640	30030	
	Maint. 15%				2858					4505	
	Life Cyle Analysis				**29780**	**115620**				**40300**	**81378**
	Fee 12%		(12% of $ total fix)		2286					3604	
	Design 6%		(6% of $ total fix)		1787					432	
	Total Subs $				**33853**	**119693**				**44336**	**85414**
McKinstry	$ per fix	194	220	241			307	325	400		
	$ total fix	7760	8800	9640	26200		12280	13000	16000	41280	
	Maint Incl.										
	Life Cyle Analysis				**34073**	**97053**				**47045**	**70106**
	Fee 15%		(15% of $ total fix)		5111					7057	
	Design 10%		(10% of $ total fix)		511					706	
	Total Subs $				**39694**	**102675**				**54808**	**77868**
Cochran	$ per fix	213	242	252			338	357.52	388		
	$ total fix	10650	12100	12600	35350		16900	17876	19400	54176	
	Maint.										
	Life Cyle Analysis				**43223**	**106203**				**59941**	**83002**
	Fee 13.5%		(13.5% of $ total fix)		4772					7314	
	Design $2500 LS				2500					2500	
	Total Subs $				**50495**	**113475**				**69755**	**92815**

Part 3 – Subcontractor Selection

After reviewing the cost analysis the current fluorescent lights are cheaper to install but, looking at the 10 year look ahead we found that the LED lights have a better return on investment. The initial cost of LEDs is about 20 thousand dollars more expensive to install but, after 10 years they will save about 30 thousand dollars. With the long term look ahead in mind we decided to install the LED alternative lighting. We will use McKinstry for installation.

Part 4 – Incentives and Rebates

Another reason to install the LED alternative lighting is for the incentives and rebates available. In the state of California, there are incentive programs to help implement energy efficiency into new construction and also remodels. Some of the incentives that we found for this project include:

1. **City of Santa Monica Building permit fee waiver-** The city of Santa Monica is advertising waiving project building permit fees for building implementing solar energy systems. The purpose of this incentive is to help standardize solar installation and inspection procedures while making sure all code requirements are met according to dsireusa.org.

2. **City of Santa Monica- Expedited Permitting for Green Buildings-** City of Santa Monica allows for priority plan check processing for buildings projects that are registered with the United States Building council for certification under the Leadership in Energy and Environmental Design (LEED) according to dsireusa.org. To receive the priority check, you must submit proof of LEED registration. At this time you can also specify materials, systems and strategies that you will implement/use in the plans submitted to the City for approval.

3. **Energy Efficiency Financing for Public Sector Projects-** The state or California is according to dsireusa.org, public sectors in the state of California can apply for low-interest loans from the California Energy Commission for energy efficiency project in their buildings and facilities. The loans are from 0 to 1 percent with no minimum loan amount. The maximum loan amount per applicant is three million dollars however. For a project to be considered, it must prove energy savings and meet the eligibility requirements of the loan program. Some examples that meet the criteria of the loan include: Lighting systems, Streetlights and LED traffic signals, Energy management systems and equipment controls, and Energy generation including renewable energy and combines heat and power projects.

Part 5 – Incentives and Rebates

Based on the information provided above and by our analysis of the alternative lighting system we would recommend installing LED lights on the Colorado/4th st project. The return on investment alone is a good reason to use LEDs but, the incentives can help speed up the permit process or schedule of the project and also save money on the cost of paying for the permits. Some incentives also will give a reduction in price charged per kW/h.

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?*

   The Colorado and 4th Station will require a place amount of 525 CY and a purchase amount of 562 CY to account for waste.

   - Place Amount = 525 CY
   - Purchase Amount = 562 CY

Take Off Summary			
Description	***CY Concrete***		
	East	*West*	*Total:*
Platform Footing	93	93	186
Platform Walls	71	71	142
Sidewalk Footing	6	6	12
Sidewalk Slab	10.71	8.11	18.8
Sidewalk Walls	10	10	20
Platform Slabs/Mat	4.3	3	7.3
Stair Footing	N/A	N/A	0
Stair Walls	N/A	N/A	0
Stairs	N/A	N/A	0
TC&C Footing	20		20
TC&C Walls	27		27
TOS	92		92
PLACE TOTAL:			**525.1**
PURCHASE TOTAL:		*%7 add*	**561.9**

2. *What is the total price for each supplier?*

White Castle	
$ 20.00	per load
$ 64.00	4000 PSI (1" rock)
$ 5,968.00	**Material Cost**
$ 1,124.00	**Delivery Cost****
$37,092.00	**TOTAL COST**

Slip Diamond	
$ 20.00	per load
$ 73.50	4000 PSI (1" rock)
41,307.00	**Material Cost**
$1,124.00	**Delivery Cost****
$42,431.00	**TOTAL COST**

City Park	
$ 25.00	per load
$ 63.00	4000 PSI (1" rock)
$35,406.00	**Material Cost**
$1,405.00	**Delivery Cost****
$36,811.00	**TOTAL COST**

**Assumed 10 CY trucks are used for all concrete suppliers
Assumed all concrete is ordered and placed in 2012.

3. *What is the Carbon footprint of each supplier? Which supplier has the smallest footprint?*

   The supplier with the lowest carbon footprint is City Park Concrete. A recap of each supplier is provided below.

White Castle - Carbon Footprint

From	To	Distance (miles)		Trips*	Avg MPG**	Gallons	CO2/Gal***	CO2 (kg)	CO2 Tons
		To	*From*						
Cement	Batch	0	0	0	0	0	0	0	0.00
Aggregate	Batch	1281	1281	1	10	256.2	14.3	3663.7	4.04
Flyash	Batch	47.8	47.8	1	10	9.56	14.3	136.7	0.15
Batch	Project	10.8	10.8	56	10	120.96	14.3	1729.7	1.91
Total:		**1340**	**1340**			**386.7**			**6.10**

Slip Diamond - Carbon Footprint

From	To	Distance (miles)		Trips*	Avg MPG**	Gallons	CO2/Gal***	CO2 (kg)	CO2 Tons
		To	*From*						
Cement	Batch	34.7	34.7	1	10	6.94	14.3	99.242	0.11
Aggregate	Batch	96.9	96.9	1	10	19.38	14.3	277.1	0.31
Flyash	Batch	355	355	1	10	71	14.3	1015.3	1.12
Batch	Project	51.3	51.3	56	10	574.56	14.3	8216.2	9.06
Total:		**538**	**538**			**671.9**			**10.59**

*Assumed delivery of cement, aggregate, and fly ash each took 1 trip and that concrete is delivered in 10CY trucks

**Assumed average MPG for all supplier's trucks is 10

***Assumed average carbon emissions for all supplier's trucks to be 14.3

All travel distances were collected from google maps

City Park - Carbon Footprint

From	To	Distance (miles)		Trips*	Avg MPG**	Gallons	CO2/Gal***	CO2 (kg)	CO2 Tons
		To	*From*						
Cement	Batch	48.4	48.4	1	10	9.68	14.3	138.4	0.15
Aggregate	Batch	23.2	23.2	1	10	4.64	14.3	66.4	0.07
Flyash	Batch	23.2	23.2	1	10	4.64	14.3	66.4	0.07
Batch (LA)	Project	3.7	3.7	56	10	41.44	14.3	592.6	0.65
Total:		99	99			60.4			**0.95**

*Assumed delivery of cement, aggregate, and fly ash each took 1 trip and that concrete is delivered in 10CY trucks
**Assumed average MPG for all supplier's trucks is 10
***Assumed average carbon emissions for all supplier's trucks to be 14.3
All travel distances were collected from google maps
City Park Travel distances are assumed based on 2nd tier supplier locations: CalPortland Concrete and San Grabel Valley Aggregates and the batch plant to be used is their west LA plant which is the closet plant.

4. CO2 Added Costs

White Castle	
$ 20.00	per load
$ 64.00	4000 PSI (1" rock)
$ 35,968.00	**Material Cost**
$ 1,124.00	**Delivery Cost****
$ 243.8	**CO2 Cost**
$ 37,335.84	**TOTAL COST**

Slip Diamond	
$ 20.00	per load
$ 73.50	4000 PSI (1" rock)
$ 41,307.00	**Material Cost**
$ 1,124.00	**Delivery Cost****
$ 423.63	**CO2 Cost**
$ 42,854.63	**TOTAL COST**

City Park	
$ 25.00	per load
$ 63.00	4000 PSI (1" rock)
$ 35,406.00	**Material Cost**
$ 1,405.00	**Delivery Cost****
$ 40.00	**CO2 Cost**
$ 36,851.00	**TOTAL COST**

**Assumed 10 CY trucks are used for all concrete suppliers
Assumed all concrete is ordered and placed in 2012.

Part 2 – Local vs. Out of Town Labor

1. *Out of Town Labor*

The overall footprint created by the work crew is 7.42 tons.

Worker	**Miles**			**MPG**	**Gallons**	**CO2/Gal***	**CO2 (kg)**	**Tons**
	To	***From***	***Total:***					
1	16	16	32	20	1.6	14.3	22.9	0.025
2	16	16	32	20	1.6	14.3	22.9	0.025
3	70	70	140	20	7	14.3	100.1	0.110
4	70	70	140	20	7	14.3	100.1	0.110
5	70	70	140	20	7	14.3	100.1	0.110
6	93	93	186	20	9.3	14.3	133.0	0.147
7	93	93	186	20	9.3	14.3	133.0	0.147
One Day Total:			856.0		42.8		612.0	0.7
All Placements Total:			**9416.0**		**470.8**		**6732.4**	**7.42**

2. *Local Labor*

The carbon footprint would be reduced by 5.6 tons if all crew members lived with in 15miles.

Worker	**Miles**			**MPG**	**Gallons**	**CO2/Gal***	**CO2 (kg)**	**Tons**
	To	*From*	*Total:*					
1	15	15	30	20	1.5	14.3	21.5	0.024
2	15	15	30	20	1.5	14.3	21.5	0.024
3	15	15	30	20	1.5	14.3	21.5	0.024
4	15	15	30	20	1.5	14.3	21.5	0.024
5	15	15	30	20	1.5	14.3	21.5	0.024
6	15	15	30	20	1.5	14.3	21.5	0.024
7	15	15	30	20	1.5	14.3	21.5	0.024
One Day Total:			210.0		10.5		150.2	0.2
All Placements Total:			**2310.0**		**115.5**		**1651.7**	**1.82**

3. Carpooling Labor

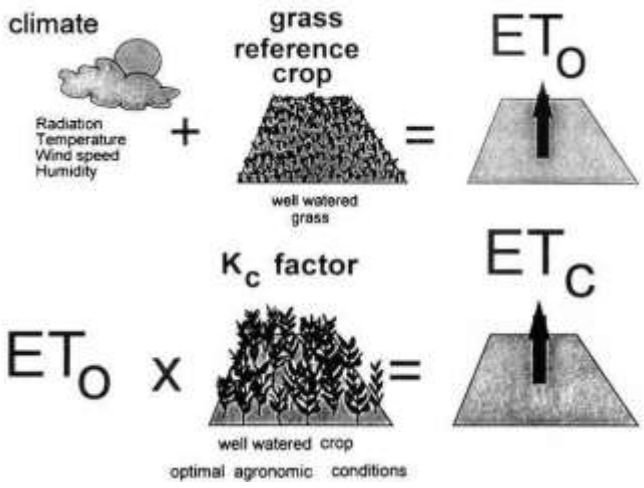
The carbon footprint would be reduced by 4.04 tons if the out of town workers carpooled.

Worker	**Miles**			**MPG**	**Gallons**	**CO2/Gal***	**CO2 (kg)**	**Tons**
	To	*From*	*Total:*					
1	16	16	32	20	1.6	14.3	22.9	0.025
2	16	16	32	20	1.6	14.3	22.9	0.025
3	70	70	140	20	7	14.3	100.1	0.110
4	*incl. above*	*incl. above*	0	20	0	14.3	0.0	0.000
5	*incl. above*	*incl. above*	0	20	0	14.3	0.0	0.000
6	93	93	186	20	9.3	14.3	133.0	0.147
7	*incl. above*	*incl. above*	0	20	0	14.3	0.0	0.000
One Day Total:			390.0		19.5		278.9	0.3
All Placements Total:			**4290.0**		**214.5**		**3067.4**	**3.38**

Problem Statement 4: Water Collection and Usage

Part 1: Irrigation Consumption

To calculate the total water usage on a monthly basis we first consulted the California Irrigation Management Information System (CIMIS) database. Using the equations in the diagram, we found values that considered both location and climate. The CIMIS database is composed of evapotranspiration values based on historical data derived from complex equations. Evapotranspiration defines the amount of water a crop uses in respect to the amount of water evaporated from its leaves and soil. With a plant coefficient of *0.5*, we needed an adequate ETo (real-time reference evapotranspiration) value to represent water use of standard pasture that satisfies both climate and location. From the database we used an ETo average from well-watered grass per zone one in the state of California. Using the equation below, we calculated the evapotranspiration (ETc) by multiplying by the plant coefficient and the reference measurement (ETo). The result, an ETc rate of *1.375 inches per month*. This allows one to infer that this specific zone and project does not require a great deal of water usage.



LEED Version 4 states non-vegetated surfaces, such as permeable or impermeable pavement, should be excluded from the landscape area calculations and requires outdoor water use reduction via two options. One representing no irrigation requirements, while the other incorporates reduced irrigation techniques. Utilizing the United States Environmental Protection (EPA) Interactive Water Budget Tool, the landscape will require *7,957 gallons per month*. The report from this test can be seen on the following page. Separating each planting condition (C and B) into its respective plant family, we performed quantity take offs at the appropriate locations. As you can see from the table in the following report, we estimated the area in which each landscape feature will cover. Reflecting upon vegetation type, its rooting system, native origin, and the above ETc value we assigned the relative water demand and the called out irrigation type. Using the water budget tool optimizes water use in landscape design.

Water Budget Tool Report

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Your landscape is 50% below the baseline for this site.

Single Site or Development?
Single Site

Landscape Water Allowance
11140 gal/month

Landscape Area
3940.0 sq.ft

Landscape Water Requirement
7957 gal/month

Irrigation?
Yes

Potential Peak Watering Savings
3183 gal/month

Total Area of Turfgrass, Pools/Spas, and Water Features
0 sq. ft

Summary of Hydrozones

Zone	Area (sq. ft.)	Plant Type / Landscape Feature	Water Demand	Irrigation Type	Required Water (gal/month)
1	1185	Shrubs	Medium	Micro Spray	3419
2	1185	Groundcover	Low	Micro Spray	1367
3	785	Trees	Low	Micro Spray	906
4	785	Shrubs	Medium	Micro Spray	2265

Part 2: Rainwater Collection

Trees, shrubs, or other leafy plants help absorb, intercept and slow down rainfall, thereby reducing runoff. After a rainfall, large quantities of water are retained on the surface of leaves in the form of droplets. Subsequently, plants help control storm water runoff. Vegetation also absorbs carbon dioxide (a principle greenhouse gas), and they help cool the earth's surface; both functions help to reduce global warming (epa.gov/watersense). Plants use about one-third the amount of water in the winter as they do in summer. The proposed implementation of a cistern at the 4th-Colorado Exposition Transit Project is a 35,000 gallon underground reservoir tank. We came up with this size of tank by first finding the building footprint of the platform, track, and plaza, which was 17,712 square feet (scaled on Bluebeam). From there we multiplied the area by .6 (the amount of water, in gallons, retained for every inch of water per one square foot of surface area) by

seasonal averages based on historical data on a monthly basis. This calculation allowed us to call for a retainage of 10,000 gallons per month (on average) through the rainy season of January, February, March and April. Our findings show the cistern will need to provide during the dry summer months. From part one, the project will require about 8,000 gallons of irrigation water usage per month. Extending this number over the four month dry season, the cistern will need to provide 32,000 gallons starting in late May. With an empty installation beginning January 1, this cistern should be full nearing the end of April (based on retaining an average of 10,000 gallons per month during the rainy season).

Part 3 (A&B): Cistern

Given the parameters of the cisterns location, the maximum hole that can be excavated is 33 feet by 24 feet by 12 feet deep (maximum excavation depth). We obtained these dimensions by scaling the proposed area under the bike modules using Bluebeam. The controls of the cistern call for a concrete tank with one-foot thick walls and a one-foot concrete slab. Under these conditions the maximum height that the cistern can be is 9 feet tall. We are assuming that the cistern will be cylindrical shape. For this site, the most appropriate size cistern is to be 24 feet in diameter by 9 feet tall. This reservoir's maximum amount of water will be able to hold just over 30,000 gallons ($\pi r^2 h$). Based on the maximum capacity of our proposed cistern, our system will require approximately 3,000 gallons of supplemental water. This was found by subtracting the maximum water needed to satisfy the watering process at any given time subtracted from the 30,000 gallon capacity.

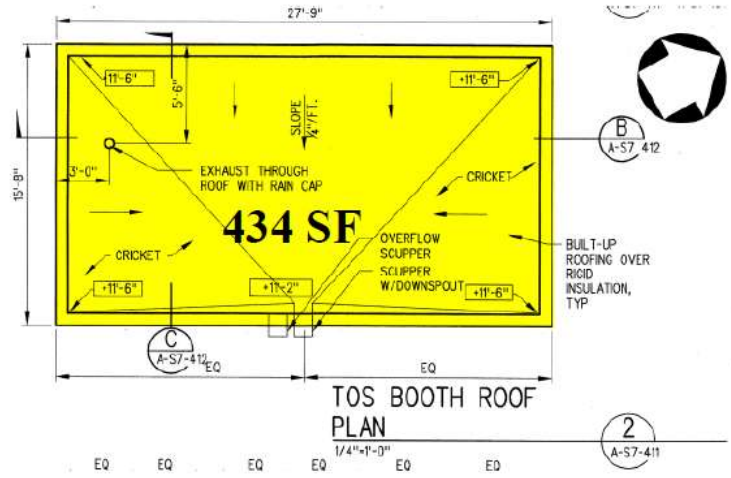
Problem Statement 5: On-site Renewable Energy

Part 1: Solar Panel Design

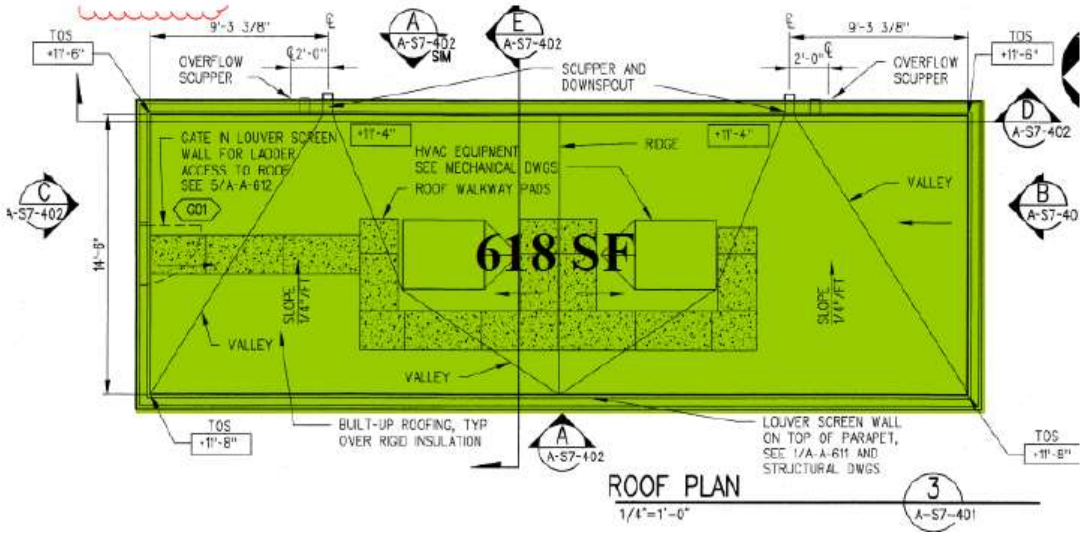
1. *Quantity of Panels to reach 8% energy building requirements.*

To provide a minimum of 8% of the total output energy of the TOS booth and the C/S building, 11 of the SunPower X21-345 panels, 14 of the SunModule Plus SW 275 MONO panels, or 38 of the GrapeSolar Star-100W Panels should be installed. See the attached Solar Panel Analysis spreadsheet for the basis of these quantities. Drawings for solar panel layouts are also attached.

TOS Booth Roof Plan:



C/S Building Roof Plan:



SUNPOWER

8% of Total Output Energy

TOS BOOTH

11 SOLAR PANELS

C/S

SUN MODULE

8% of Total Output Energy

TOS BOOTH

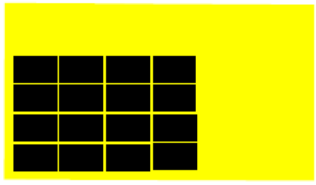
14 SOLAR PANELS

C/S

GRAPE

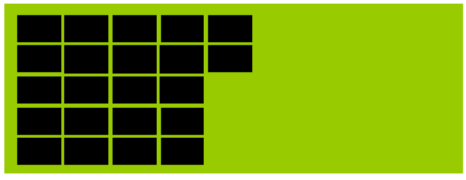
8% of Total Output Energy

TOS BOOTH



38 SOLAR PANELS

C/S



2. *Best Value of Solar Panel Options*

SunPower X21-345 Panels are the most appropriate option for this project in terms of best value. If the client wishes to pursue an 8% energy offset, 11 SunPower panels will only cost $5,115, as opposed to $6,300 for 12 SunModule panels, and $5700 for 38 Grape Solar panels, as is shown in the Solar Panel Analysis spreadsheet. The SunPower panels are also ranked in Class A+ for appearance and are designed for residential and commercial rooftops of low square footage, appropriate for this project.
But if the client wishes to utilize all of the square footage of the roof and maximize the quantity of solar panels and energy production, they can install 60 SunPower panels for $27,900, 67 SunModule panels for $30,150, or 142 Grape Solar Panels for $21,300. Although Grape Solar is the cheapest option, SunPower panels provide the most energy, about 34,560 kilowatt hours per year, which is 44% of the buildings total energy usage. This outweighs SunModule's 39% energy offset and Grape Solar's 30% energy offset for the quantities stated above.

3. *Optimal Orientation Variables for Panel Arrays.*

To optimize the energy production of the solar panel arrays at the Colorado and 4th Station, the arrays should be oriented to face southward, to gain as much solar energy as possible. The magnetic declination is positive 13 degrees and 46 minutes from geographical north, meaning the orientation of the solar panels should be angled 13 degrees, facing southwest. According to solarpaneltilt.com, the panels should be angled 11.6 degrees from the horizontal in the summer and 49.8 degrees in the winter, given a 35 degree latitude in Los Angles, where the project is located. The summer angle period should begin on March 30th and end on September 12th for the winter angle period.

SOLAR PANEL ANALYSIS	SUNPOWER	SUNMODULE	GRAPE
Price/Panel	$465	$450	$150
Efficiency %	21.5	16.4	16.8
Size/Panel (sm)	1.62	1.46	0.68
Size/Panel (sf)	17.5	15.7	7.36
Wind Load Capacity (psf)	50	113 to 170*	50
Ideal Applications	Com & Resi Roof	Heavy Snow-Loads	Multi-Purpose
Product Warranty (Years)	25	10	5
Performance Warranty (Years)	25	25	10 to 25**
Maximum Power (W)	345	275	100
kWH/Year/Panel***	576	459	166
Panel QTY****	60	67	142
Total Price for Panels	$27,900	$30,150	$21,300
kWH/Y Produced	34,560	30,753	23,572
8% Energy Demand Offset Check*****	34560/78475 = 44%	30753/78475 = 39%	23572/78475= 30%
Minimum Panel QTY for 8% Energy******	11	14	38
Minimum Panel Price	$5,115	$6,300	$5,700

Good	Bad

* Varies on 2-Rail and 3-Rail system respectively

**Varies on % Power Output

***See PV Energy output calculation spreadsheet for calculations

****Based on square footage of roof useable for solar panels: TOS: 434 sf, C/S = 618 sf, Total = 1052 sf

*****Energy Demand for the Building: C/S: 30,034 kWH/year and TOB power usage = 48441 kWH/year, Total = 78475

******8% Energy Demand = 78475*0.09 = 6278 kWH/Y, Minimum QTY = 6278 kWH/Y / kWH/Year/Panel

Calculation of the solar PV energy ouput of a photovoltaic system

Yelow cell = enter your own data
Green cell = result (do not change the value)
White cell = calculated value (do not change the value)

Global formula :

	Sol		
E = Energy (kWh)	576	459	166
A = Total solar panel Area (m²)	1.62	1.46	0.68
r = solar panel yield (%): ((max power/1000)/sm)	21.3%	18.8%	14.6%
H = Annual average irradiation on tilted panels (shadings not included)*	2226.5	2226.5	2226.5
PR = Performance ratio, coefficient for losses (range 0.9 and 0.5, default value = 0.75	0.75	0.75	0.75
Total power of the system	0.3	0.3	0.1

Part 2: Additional Renewable Energy – Options to Net Zero

For the Zero-Net Energy option, it would be in the best interest for the client to use the same panels as specified above, the SunPower X21-345. There will be 138 panels for a cost of $64,170. Installation cost associated with just the panels would be another $6,210, totaling $70,380.

Annual cost for our electric bill without renewable energy would be $17,500, according to the Bureau of Labor Statistics rate of $.223/kWh. Over the course of ten years, assuming no deflation or cost of capital, the building would save $175,000 over its lifetime with a net-zero energy system.

The construction cost of the system, excluding panel costs stated above, is $49,079, as can be seen on the cost estimate spreadsheet.

Maintenance cost of this system over its ten-year lifespan will be low; the panels have a 25 year product and performance warranty, so material replacement costs will be free for the entire life cycle. In the event of a panel replacement, the cost would be about $30 to replace a panel, assuming a $40 wage rate and a forty-five minute replacement time. The client can budget 25 panels needing replacement over the next ten years, so the replacement cost would sum to $750. For additional maintenance, assuming a $40 wage rate and a bi-weekly, four-hour system analysis, monthly maintenance would be $320 and therefore $38,400 over the lifetime of the system. Adding $750 panel replacement, the budgeted maintenance cost will become $39,150, which then can be rounded to $40,000.

Therefore, we will save $175,000 – $40,000 maintenance cost – $70,380 panel cost - $45,599 other construction costs, which equals $19,021 total savings over a ten year period. In conclusion, it will take eight years and eleven months to pay off all costs associated with implementing a net zero option via solar panels.

Part 2 Calculations:

Description	No	Dimensions		SF
		L	W	
Solar Panel System				
Sunpower X21-345	138	5.13	3.417	2416
DPW 2-Tier Roof-Ground Mount 8 Type G Module	23	15	7	2416
Low Voltage 6 Gauge Copper Wire	1	150		

General Conditions				
Indirect Labor				
Description	Hours		Cost Rate	Cost Extension
Project Manager		1	$75.00	$75.00
Superintendent		8	$55.00	$440.00
Indirect Labor Subtotal				$515.00
General Expenses				
Description	Hours	Quantity	Cost Rate	Cost Extension
Storage Container	8	1	$50.00	$400.00
Recycling & Garbage	4	1	$38.00	$152.00
General Expenses Subtotal				$552.00
General Conditions TOTAL				**$1,067.00**

			Labor					Material/Sub		
Description	Qty	Unit	UMH	Man Hours	Wage Rate	Unit L Cost	Labor Cost	Unit M Cost	Material Cost	Total Cost
-										
Solar Panels										
Sunpower X21-345	138	EA	0.75	104	60	45.00	6,210	465	64,170	70,380
DPW 2-Tier Roof-Ground Mount 8 Type G Module	23	EA	0.5	12	60	30.00	690	949	21,827	22,517
Low Voltage 6 gauge copper wire	170	LF	0.105	123	43.55	65.50	11,135	64	10,880	22,015
Total Solar Panel System										**114,912**

Part 3: Alternative Renewable Energy Sources

Assuming that the four acre parcel is available to the project, other renewable energy sources outside of photovoltaic panels are available to the jobsite. Biofuel-based electrical systems, for example, are a feasible option, so long as there is a renewable biomass available to use for electrical system. There will be a material cost associated with purchasing biofuel and a maintenance cost to refuel the system that needs to be taken into account. The biofuel-based system can be placed on the roof or on the four acre parcel.

Geothermal energy systems are not feasible because electricity generation would require steam-powered turbines, the cost of which would be too high to produce. Geothermal energy could be easily used, however, for heating of the building.

Hydroelectric power does not make sense for this building because there is no water supply big enough in the area to generate enough power for the building.

Finally, micro-wind turbines are a feasible option. There are four acres to place several thousand turbines, one of which can produce roughly five and a half watts. Under that assumption, the building would need roughly 1650 to 2000 micro-wind turbines to meet the energy demands of the building, which all can fit on four acres.

Addendum #1

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

   By 2030, both phases of the Expo project will be complete and there will be an estimated 64,000 riders a day. That is more than double the current rider count; 27,000. The Expo 2 phase is expected to open early 2016.

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

   According to the California Department of Transportation Los Angeles residents average drive to work is 23 miles. Assuming that cars get an average of 23 miles per gallon in 2030, it would take two gallons of gas per car to get to and from work. Two gallons of gas times 64,000 riders equals 128,000 gallons of gas being saved a year. With an average of $3.50 a gallon this is $448,000 than could be put into the Expo train line.

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

   Some of the innovated ways to increase ridership include:

   - Selling monthly passes at a discounted price.
   - Discounted ticket prices for public bus rider members.
   - Free ride Fridays (free rides from 4 to close on all Fridays).
   - Promote Bike Activity with the Light Rail system by
     - Including more bike racks at the transit stations.
     - Creating room for bikes either inside or outside (similar to buses) of train cars to catch the eye of the busy bike community and allow for bikers to bike to the train and also bike away once they reach their destination.