Reno NV, February 5, 2105

SUBJECT: **Los Angeles Rail Road System**.
Skanska Construction

Dear Skanska Construction Managers,

In accordance with your request, we have prepared a fully comprehensible report in reference to the sustainable railroad system in Los Angeles. This report summarizes the results of the analysis and presents our recommendation of the proposed project.

Thank you for opportunity to work on this project.

Best Regards,

Civil Engineering and Environmental Students

Executive Summary

Sustainability has become a global challenge in recent years. While no immediate solution can be found for such a complex problem, renowned construction companies such as Skanska Construction are working incessantly to build more sustainable structures and diminish the amount of pollution released in the environment each year.   Leadership in Energy and Environmental Design is a set of guidelines to help ensure a structure is built in more sustainable manner.

Modern building design is a field in which most decisions can have a dramatic effect on the community and environment around them. Decisions made over which materials, products, practices and innovations to be used could result in many different outcomes. In an attempt to help Skanska our team has come together to put an effective plan to make a transit station in Los Angeles that will take its citizens from Downtown Los Angeles to the heart of Santa Monica in 45 minutes. If followed, this project proposal should earn platinum certification under LEED V3.

By researching and reviewing both LEED 2009 and LEED v4 our team strongly agrees that LEED v4 will be the best, efficient way to get our structure LEED certified in gold or platinum. Our strategy is to meet the requirement for LEED neighbor develop location, which will generate 16/16 points under Location and Transportation. If the credits succeed for potential points under LEED neighborhood development location, then this topic could potential save the team time in the documentation process. The time savings will reduce costs for the owner and speed the building time. The team confidence in getting the maximum amount of points available, are reason is this category provides a second opportunity to receive points if our first attempt doesn't meet the requirements. LEED Neighbor Develop Location covers all the sections of Location and Transportation by creating alternative transportation by the light rail, long-term and short-term bicycle parking with extending racks, this would promote physical health. The alternative transportation will decrease the greenhouse gases by encouraging green vehicles, reduce the parking foot print, and reduce the island heat effect. The next goal for team is focusing on Sustainable Sites worth 10 points and more specific is maintain the integrity of the neighbors and ecosystem. To maintain the function and subsistence of our organic building will have a lot of open space by creating vaulted ceilings, multiplies of open windows facing east and west with a barrier to reduce radiant heat and place indoor plants to keep the organic feel. Rain water will be collected on all feasible improvises surface areas and channeled and stored into an underground cistern later be use for irrigation. Overall, the team will strive for a 9/10 points for sustainable site category. To ensure ultimate efficiency to collect the rain water, the rain water will be either diverted to the cistern or the plants bedding. Water Efficiency and very important topic, especially in Southern California. After, the rain water is collected the team plans to use the run off to water the plants during hot summers. In result, of all this collected water this will reduce the usage of potable water. The team plans to also use dual flush toilets, waterless urinals, meter control to regulate flow and motion sensor further reduce potable water. Our projections for water efficiency 9/ 11. In the largest category worth 33 point, energy and atmosphere the team is utilizing solar panels to stay off the grind…

Concrete and Carbon Footprint

In this part of the project we were given some data for the amount of concrete needed to build a station in on Colorado and 4th street .We were asked to calculate the amount of concrete needed to build this station. Looking at the takeoffs documents we were able to determine that the minimum amount of concrete needed to complete this design is 548 cubic yards.

Three batch plants were analyzed and compared for best prices. According to Skanska, a concrete with maximum strength of 4000 psi is to be used. Because of the complexity of the project we assumed that this concrete would be pumped rather than dumped. The prices for the concrete companies at questions are:

- City Park Concrete
    - $37812
- Slip Diamond Ready Mix
    - $43332
- White Castle Concrete
    - $38928

Unfortunately Concrete is a very polluting agent, but because of its properties if offers very desirable strength for complex structures such as this transit system. According to the website “greenrationbook.org.uk” one cubic yard is responsible for producing 400 lbs of CO2. The same amount of concrete will be asked to be supplied from the three different companies, so the amount of carbon footprint being released in the atmosphere by the amount of concrete needed is 219200 lbs. The difference in carbon footprint emitted in the atmosphere will come from the distances travelled by the concrete trucks to delivery the cement. According to a travelled distance analyses made, we came to a conclusion that the least travel distance for this trucks will be the least amount of carbon footprint emitted in the environment.

According to our problem statement the client will be charged based on amount of CO_2 emitted in the atmosphere. And based in our calculations and analyses we believe that the client should purchase the concrete from City Park Concrete. The concrete batch is about 3 miles of the construction site, and it also offers the best price available in the market too. Using the website "carbonify.com" we were able to calculate the amount of carbon foot print release that the companies would emit by delivering the requested amount of concrete. According to our calculations the amount of carbon footprint that we will emit by buying from City Park Concrete .007 tons per year. This is considerably less compared to the other companies. Please see attached calculations.

In terms of workers and the carbon footprint they emit in coming to work we came to the following conclusion:

If they were all to commute with their own car to work for one day a year they would emit altogether .464 tons of carbon per year.
If they were to commute only 15 miles from the construction site, they would emit .114 tons of carbon per year, therefore reducing the amount of carbon foot print emission by .35 tons per year.

If they were to carpool together for one day they would emit .194 tons of carbon per year. That would lessen our emission of carbon footprint by .27 tons per year.

Water Collection and Usage

Estimate of total irrigation demand by month for the 4th street station using the Landscape coefficient method.

Using the formula

Using the formula $ET_{l\,=}\,(K_l)(ET_0)$
Where

$ET_{l\,=}$ evapotranspiration of landscape
ET_0 = reference evapotranspiration
K_l = landscape coefficient
Where $K_l = (K_s)(K_d)(K_{mc})$
K_s= plant factor
K_d= density factor
K_{mc} = microclimate factor

Assumptions:

- use an average plant density of 1

-use a microclimate factor of 1.2

- use average evapotranspiration rates (by month) for the LA area

Table 1

	(L.A. Basin)(inches)	(inches)	Irrigation demands(gallons)
January	1.79	1.07	85755

February	2.12	1.27	100287
March	3.30	1.98	151881
April	4.49	2.69	211475
May	4.73	2.84	222373
June	5.03	3.02	235455
July	5.40	3.24	251440
August	5.38	3.23	250714
September	3.94	2.36	187493
October	3.40	2.04	164239
November	2.42	1.45	113363
December	2.22	1.33	104648

Part II

Assumptions:

- Rain water will be collected from rooftops, platform, track, and plaza, areas.
- Precipitation patterns will be similar to the 100 year averages.
- Cistern dimensions cannot exceed the footprint of bike module "C".
- All water that falls on impermeable collection areas will pool and be channeled into the cistern.

a. Given the average rainfall data for the Los Angeles area and the limited available impervious surface area (calculated to be 20,000 where rainwater collection is possible, the system will not be able to meet irrigation demands without supplemental water.

If wet season precipitation levels or the amount of impervious surface areas were great enough, the cistern would need to hold a minimum of 750,000 gallons in order to accommodate the demand during the driest three months where precipitation levels are virtually nonexistent.

Part III

Using the formula:

Area × depth = volume

Where:

Area = 825

Depth = 10 ft

Assumptions:

- The entire area underneath the north street bike module will be used.

- Cistern dimensions cannot exceed the footprint of bike module "C".

- Cistern will be rectangular in shape.

a. Interior dimensions of cistern will be 33'×'25'× 10' (l × w × h), giving a holding capacity of 8250 cf (61710 gal.)

b. Based on the total impervious surface area of the platform, track, and plaza areas, and average rainfall data, the cistern will not be full any month of the year. The supplemental water required for irrigation per month is listed in (table 3).

Table 2

	Average precip. (in)	Collected (gal.)	Required (gal.)
January	3.12	38900	46855
February	3.80	47370	52917
March	2.43	30300	121581
April	.91	11340	200135
May	.26	3240	219133
June	.09	1120	234335
July	.01	1500	249940
August	.04	2990	247724
September	.24	500	186993
October	.66	8220	156019
November	1.04	12970	100393

December	2.33	29050	75598

On- Site Renewable Energy

Part 1: Solar Panel Design_

Solar Panel Selection is based on mechanical advantages as well as the practicality of each respective design that is implemented into the construction of the Santa Monica transit Bay System. The three panels that will be analyzed are: Sunmodel Plus SW275 Mono model, SunPower X21-345 model, and the Grape Solar GS-Start-100W model. This section will discuss the overall advantages and disadvantages of each respect design and how it applies to the energy requirements of the Santa Monica Transit System. Making the following assumptions, this paper will propose to implement one of these three designs onto the new site.

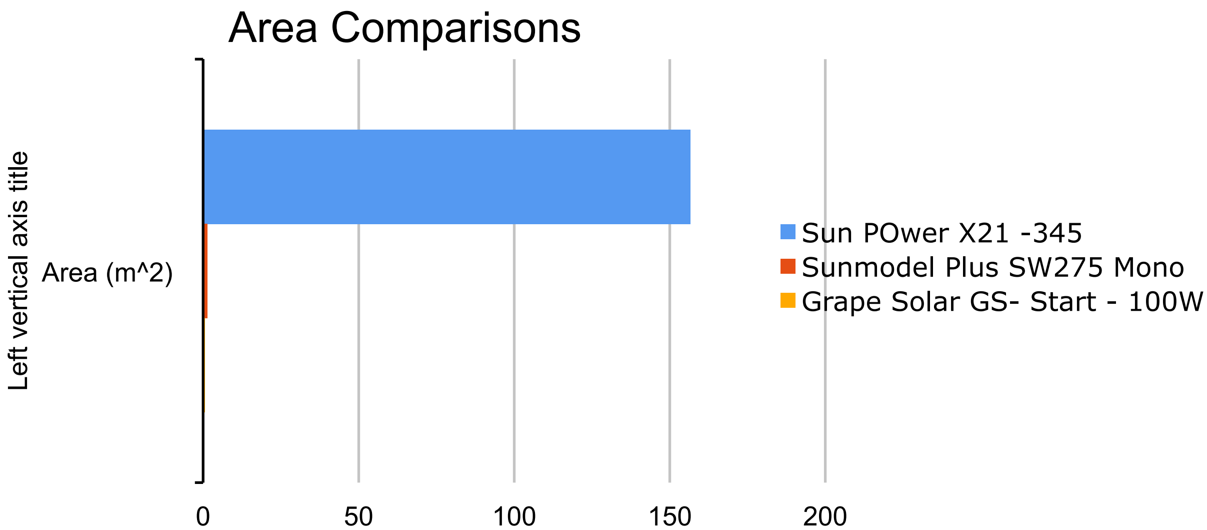
-Assume standard Test Conditions when evaluating output energy.
-Assume an annual average solar radiation of 6.1 kWh/m^2 -day
-Only available surfaces available for solar panels are the TOS boot roof and the C/S building Roof.
-Assume a default Performance Ratio of 0.75 (which factors in the shade provided by parapets)
-Assume proposed design energy demand of 240 kBtu/sqft-yr
-Pricing (Include Installation and material costs)

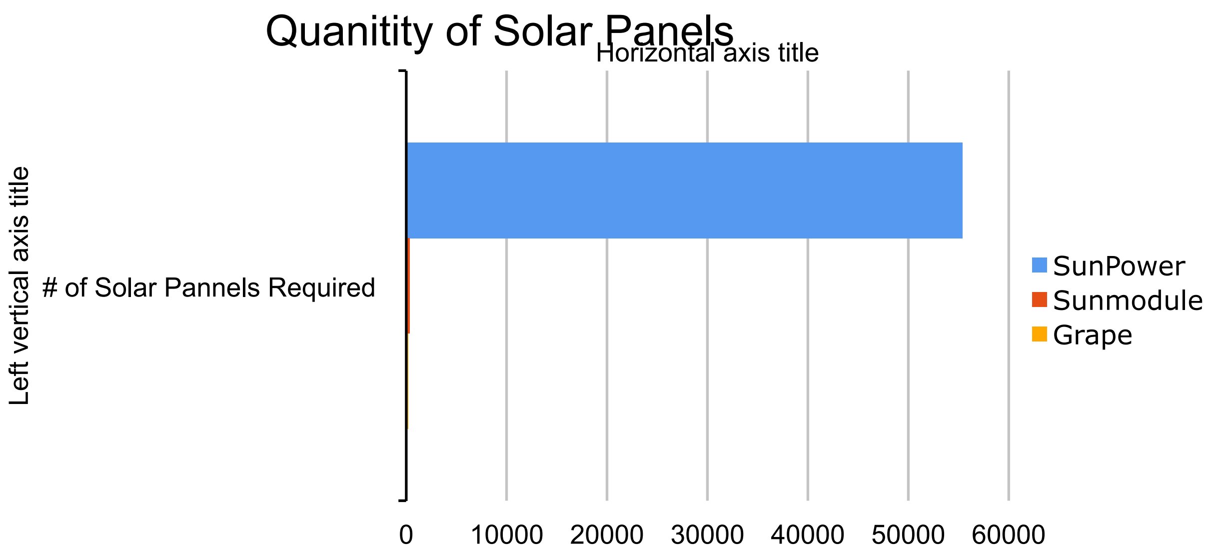
-SunPower X21-345 model - **$465/panel**
-Sunmodel Plus SW275 Mono model - **$450/panel**
-Grape Solar GS-Start - 100W model - **$150/panel**

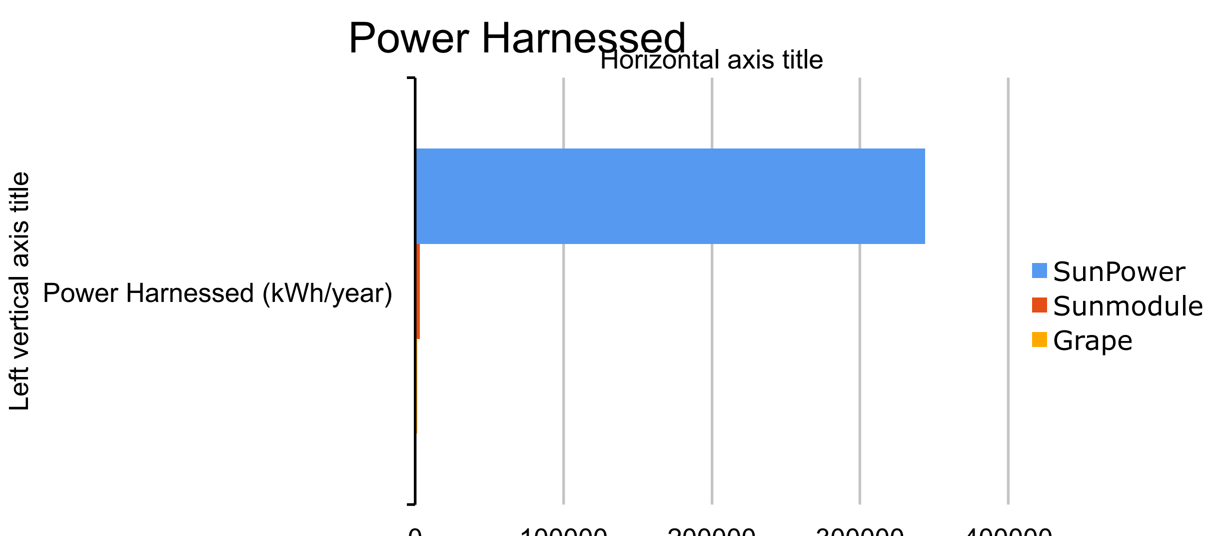
Some of the factors that will be taken into consideration are: the local climate, the feasibility of the design, and most importantly, the cost.

First and foremost, it is necessary to calculate the amount of energy that needs to be generated by the solar panels in order to account for the desired percentage of the building energy usage. As stated the the proposed design will meet the energy demand of **240 kBtu/sqft-yr** for the C/S building. The following computation will determine the amount of energy needed to meet the 8 percent goal.

240 kBtu/ ft^2 - yr * (400 ft^2) * (3.412kWh / 1 kBtu) = 327552 kWh/yr







Starting out with the energy demand, we convert to kWh and multiply the energy demand concentration by the general area that would be supplied with power.

573,216 kWh/yr is the total amount of energy that the solar panels must generate on a yearly basis. Having determined this value, the next step is to figure out the amount of power each type of solar panel can harness with the given solar radiation of 6.1 kWh/m^2 - day.

6.1 kWh / m^2 - day * (360 days / year) = 2196 kWh / m^2 -year

Next the surfaces areas of each solar panel are calculated which will determine the amount of Power **received** by the panel.

A1 (Area SunPower) = (1046 mm * 1559 mm) * 96 cells/module * (1 m / 1000m) ^2 =

156.549 m^2

A2 (Area Sunmodule) = (156 * 156) mm^2 / cell * 60 cells/module * (1 m / 1000m) ^2 =

1.460 m^2

A3 (Area GrapeSolar) = (156 * 104) mm^2 / cell * 36 cells/module * (1 m / 1000m) ^2 =

0.584 m^2

Followed by the Intensity of radiation, Power, that each solar panel receives:

P1 (Power received SunPower) = 2196 kWh / m^2 - year * 156.549 m^2 = 343782 kWh / year

P2 (Power received Sunmodel) = 2196 kWh / m^2 - year * 1.460 m^2 = 3206.16 kWh / year

P3 (Power received GrapeSolar) = 2196 kWh / m^2 - year * 0.584 m^2 = 1282.46 kWh /year

Next the efficiency and the performance ratios are taken into account to determine the amount of energy that is harnessed by each solar panel:

P1’ (Power harnessed by SunPower) = 343782 kWh / year * 0.75 * 0.215 = 55434.80 kWh/year

P2’ (Power harnessed by Sunmodel) = 3206.16 kWh / year * 0.75 * 0.1640 = 394.358 kWh/year

P3’ (Power harnessed by Grape Solar) = 1282.46 kWh /year * 0.1388 = 178.00 kWh/year

Finally, the total number of solar panels is calculated by dividing the total energy accumulation desired per year by the total power, P’ that each panel harness over the annual period.

#1 (Number of Panels of SunPower) = 327552 kWh/yr / 55434.80 kWh/year = 6 SunPower Solar Panels

#2 (Number of Panels of Sunmodel) = 327552 kWh/yr / 394.358 kWh/year = 831 SunModel Solar Panels

#3 (Number of Panels of Grape Solar) = 327552 kWh/yr / 178.00 kWh/year = 1840.18 Grape Solar Panels
These charts compare the there panels and it is quite clear that the Sun Power model is superior in most aspects to its other two counter parts. It is also more expensive, but because it meets the required 8 percent in quantity of solar panels which are feasible in the sense that there is enough roof space to install the required amount of panels.

The Grape Solar Panel is designed for high temperature, weak light environments, and a greater mechanical strength. The projects site, Santa Monica, receives 310 days of sunshine annually and the Grape Solar panel does not fit this niche.

The Sunmodel Plus solar panel is relatively efficient and cheap compared to the other two options. Its downfall is that it does not come close to the capacity that this project entails. The main reason behind the choice to go with the Sun Power Solar Panel was its capabilities to provided the desired amount of energy as well as come in a small quantity that can be mounted onto the available roof space.

The sun rise in the east and sets in the west so the optimal direction for the solar panels to face is be inclined at a 15 degree angle facing the east. In order to optimize the light received by the solar panels with designated angles, the angle of incidence has to be changed to optimize the intensity of the solar radiation which will accumulate the the desired photovoltaic energy. The simple solution would be to install a photovoltaic sense which will trace the trajectory of the sun as it moves through the sky.

PART 2: Additional NetZero

The solar panel that we chose was the Grape Solar GS which costs $150/panel. The decision to choose this solar panel arose from the time limit of the

This panel will cost about $20,000 plus installation and the required structures that must be constructed. The reason that this costs so much is due to the time limit placed on the land that may be utilized in an attempt to create the NetZero project desired by the owner.

So the payback period is about 3 years, meaning after the the 3rd year there will be a net profit on the installation of these photovoltaic cells. The maintenance is very high, meaning that if there are any obscurities in the installation or mechanism of the panels, it would require a profession that is well versed in the field and familiar with these solar panels.

After the lease is over on the land given by the city, these panels can be reused in smaller projects and their efficiency makes them a reliable source of renewable energy. Any ancillary construction remaining on the parcel will excavated and maybe used on the 4th Street Station for landscape use or renovations.

On-Site Renewable Energy:

Alternative Renewable Energy Sources

In order to offset the maximum energy output on the 4th Street Station we need to look at alternative renewable energy sources besides photovoltaic panels onsite. In this section we analyzed four possible sources and provided feedback on whether it would be rational to implement or reject the source.

A.) Biofuel-based electrical systems

This system is an innovative way to use renewable supply of organic material to produce electricity. It also impacts the dependence on fossil fuels by reducing its use. Plant matter is one of many sources of biofuels which include energy crops, grassy and woody plants, residues from agriculture and forestry, organic components of municipal and industrial wastes are all forms of fuel for this system. This form of renewable energy would benefit the Santa Monica area greatly because sources of biofuels are readily available from food waste in restaurants which reduces the amount of waste that ends up in landfills. Converting waste into energy reduces the amount of greenhouse gases emitted into the atmosphere. Profits from implementing this form of energy source can be calculated from this basic formula: Profits = [Capital Costs - Incentives] / [Annual Cost Savings]

B.) Geothermal energy systems

Another form of a clean renewable source of energy which uses the Earth's heat can be applied to this transit station. Santa Monica sits on a hot spot known as the "Ring of Fire" because it is an area of high underground temperatures. In order to tap the geothermal energy, heat pumps would need to be installed underground in order to transport heat in or out of the transit station depending on the time of year. Prices for geothermal facilities are becoming economically competitive which makes it an attractive option compared to natural gas and conventional coal.

C.) Hydroelectric power systems

The limited availability of running water constricts this renewable energy source. Constructing a hydroelectric power system would involve a large area which would displace residential and commercial land and would require a reservoir. This would not be a rational source of energy for the local.

D.) Micro wind turbines

The location of the 4th Street Station makes this renewable energy source a viable alternative. The daily offshore wind currents combined with the Santa Ana winds will generate enough airflow to power the micro wind turbines. The fact that these wind turbines do not require much space is also a positive attribute to adopt this source of energy. Requires minimal installation and minimal noise is emitted from the turbine. Although the technology and cost may discourage some consumers, the reduction in greenhouse gases will provide a more sustainable transit station.

Problem Statement 2: Life Cycle Sustainability Analysis – Lighting

The purpose of this life cycle sustainability analysis is to assist the owner of the transit center in making a decision on whether to use fluorescent lighting fixtures (X-6A, X-6B, and X-6C) or LED lighting fixtures with the goal of reducing energy use and life-cycle costs.

Annual Energy Use

Based on the information given in the lighting bid proposals and the lighting cut sheets two lighting fixture systems were analyzed to calculate the annual energy usage of each of the lighting options. The X-6A, X-6B, and X-6C fluorescent lighting fixture proved to use more power than the alternative LED lighting fixtures over the course of a year.

Light Fixture	Energy Usage (W)	Energy Usage in 1 year (kWh)
X-6A	25	219
X-6B	32	280.32
X-6C	40	350.4
X-6A LED Alternate	17.7	155.05
X-6B LED Alternate	24	210.24
X-6C LED Alternate	29.5	258.42

Table : the above table lists the individual light fixture's energy input and energy used over the course of one year in kWh.

Life Cycle Analysis

Utilizing the provided subcontractor bids a life cycle analysis of the two lighting fixture options was conducted over a 10-year period. The following information was included in the analysis: material purchase, installation costs, and maintenance costs. To find accurate values for the life cycle costs the initial costs of every bid plus the cost of electricity over a 10 year period was calculated separately and then averaged out to find and average value. For maintenance costs it was assumed that the light fixtures were replaced once in the 10-year period. Also, it was assumed that the cost of electricity in the Los Angeles California is 22.3 cents per kWh. The assumed amount per kWh is based off of the "Average Energy Prices, Los Angeles-Riverside-Orange County, December 2014" document on the Bureau of Labor Statistics website for the 2013-2014 year.

Light Fixture	kWh in 10 yr. period	22.3 cents /kWh over 10yrs
X-6A	2190	$488.37
X-6B	2803.2	$625.11
X-6C	3504	$781.40
X-6A LED Alternate	1550.5	$345.76
X-6B LED Alternate	2102.4	$468.84
X-6C LED Alternate	2584.2	$576.28

Table : The above table lists the energy use of the individual light fixtures over a 10 year period and the cost per kWh over a 10 year period for each individual light fixture.

Foy Group Bid

Light Fixture	Price /Fixture	Replacement Cost /Fixture	Life Cycle Analysis over 10 yrs
X-6A	$188	$125	
X-6B	$213	$125	
X-6C	$234	$125	
			Σ $3762.17
X-6A LED Alternate	$298	$145	
X-6B LED Alternate	$315	$145	
X-6CLED Alternate	$388	$145	
			Σ $4328.38

McKinstry Bid

Lighting Fixture	Price /Fixture	Replacement Cost /Fixture	
X-6A	$194	$113	
X-6B	$220	$113	
X-6C	$241	$113	
			Σ $2888.90
X-6A LED Alternate	$307	$113	
X-6B LED Alternate	$325	$113	
X-6CLED Alternate	$400	$113	Σ $2761.68

Cochran Bid

Light Fixture	Price /Fixture	Replacement Cost /Fixture	Life Cycle Analysis over 10 yrs
X-6A	$213	$133	
X-6B	$242	$133	
X-6C	$252	$133	
			Σ $3955.40
X-6A LED Alternate	$338	$172	
X-6B LED Alternate	$357.50	$172	
X-6CLED Alternate	$388	$172	
			Σ $4452.91

Average of Life Cycle Analysis based on the combined prices of the three bids submitted:

Lighting Fixture	Average Life Cycle Cost over 10 yr period
Fluorescent	$ 3555.50
LED	$3847.70

Subcontractor Assessment

The subcontractor with the most economically feasible costs is McKinstry Company because the costs over a 10-year period is lower than Foy group company and Cochran Company. McKinstry manages to offer the lowest price because the overhead percentage costs and the profit costs are included in the initial cost instead of an additional charge on a year-to-year basis like the competitors.

Incentives and Rebates

The state of California provides incentives non-residential buildings that make an effort to conserve electricity by means of using high efficiency lighting. The Database of State Incentives for Renewable and Efficiency (DSIRE) grants fifty-five cents per kWh saved in a year. Using the alternative LED lighting fixtures will qualify the Los Angeles Transit Center for a monetary incentive. By using the LED lighting fixtures the LA Transit Center will save 226.01 kWh per year. The savings of electricity will translate to $124.31 refund provided by the Utility Rebate Program offered by DSIRE.