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Texas Facilities Commission
Energy and Energy Efficient Alternates Study

Department of Public Safety
New Area Office – Rio Grande City
Project # 08-014-0405

In conformance with Title 10-Chapter 2166, Section 2166.403, Texas Facilities Commission performs for each new construction project a review of alternate energy systems to determine the economic feasibility for each alternative. The report included here reviews and assesses alternates that are above the requirements of the latest energy codes for conservation of energy.

This project is for the design and construction of a new DPS area office on acquired land. The new area office will be a single story masonry building comprised of approximately 15,000 square feet.

Document posted for public viewing on the Texas Facilities Commission website starting May 7, 2012.

The report will be presented at the June 20, 2012 meeting of the Texas Facilities Commission.

DPS Rio Grande City – New Area Facility

Energy and Energy Efficient Alternates
Evaluation of Energy Conservation Alternates

This study has been preformed to comply with Alternate Energy and Energy-Efficient Architectural and Engineering Design in New Building Construction as required by Title 10-Chapter 2166, Section 2166.403

Alternative Energy Sources:

I. Solar

a. Photovoltaic

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material.

The idea of having renewable energy readily available makes photovoltaic systems a pretty attractive source of energy, especially since it gives the idea of having "free" energy and not having to purchase it from an electric utility company.

Given the zone location of the DPS Rio Grande City project makes this project an attractive candidate to implement the use of photovoltaic system.

However; the project budget, cost associated to photovoltaic system components, installation cost, and maintenance need to be taken into account to determine if this is a viable option for the project.

b. Solar water heating

Solar water heating is a form of renewable energy technology which harnesses the sun's energy to temper water for the needs of homes and businesses. Typically, sunlight is absorbed through a roof mounted flat plate collector panel. The fluid or water in the collector panel is heated and pumped into an insulated storage tank until it is needed. Solar water heating systems typically provide 40%-80% of a building's annual water heating needs. A thermostat within the system will indicate how much additional backup heat is required to supplement the solar heated water, which is usually the case. This backup heat would be provided by a conventional electric or gas water heating system.

The project budget, first cost associated with a solar water heating system, installation cost, additional maintenance, and payback time need to be taken into account to determine if this is a viable option for the project.

II. Biomass

a. Biomass power generation refers to the combustion of an organic material (biofuel) to power turbines which generate electricity. The most common biofuel is biodiesel. It is made by converting natural vegetable oils into fuels that can be used in many engines or combustion appliances without any major adjustments.

b. Some of the risks and limitations associated with biomass as an alternative energy source have been high capital costs, gas quality, readily available biomass, operational challenges, and finding a contractor able to install the system. Harmful constituents in the biomass that could have corrosive effects on pipeline infrastructure need to be removed and methane content needs to be increased to meet gas quality specifications. The processes required to accomplish this require a large available water source. Additionally, there is also a need for source testing which can be expensive. Prior to construction, systems require air quality impact analysis and permitting, environmental assessments and site surveys. These factors contributed to the conclusion of biomass as an alternative energy source not being viable for this project.

III. Geothermal

a. Geothermal energy utilizes the thermal reservoir of the earth's interior to derive energy. It is extremely dependent on location, as high temperatures are required for electric power generation to be effective.

b. In Texas, there are not any easily accessible fields that have the high temperatures required for electric power generation, therefore it was not considered for this project.
(Source: www.infinitepower.org – Texas State Energy Conservation Office)

IV. Wind

a. Wind Turbine

Wind energy is a way of using the wind flow projected to the blades of a wind turbine to spin a shaft. This shaft spins inside an electrical generator, generating electrical energy.

Other than wind speeds at a given height, additional considerations need to be taken into account for wind energy that would not need to be taken into account for photovoltaic systems.

Some of these considerations pertain to City regulations to allow erecting tall structures, to not exceed certain noise levels, and to install only natural habitat friendly systems.

It is known that wind turbines also represent a problem for birds. As bird attempt to fly between the blades of the wind turbines, the birds get hit by the blades. This is an environmental issue especially in areas of heavy bird migration such as in the lower portion of the Texas and Mexico border.

Maintenance associated cost is also a factor to take into account. This service is typically performed by qualified personnel. This translates into additional costs for service trips from the manufacturer representatives from a nearby large city to offer such support.

A typical wind turbine system cost is in around $10 per kW produced.

Using the photovoltaic simple payback analysis approach, it demonstrates that the simple payback for a $10 per kW wind turbine system would take longer than the photovoltaic's which is typically $8 per kW.

This initial payback makes the wind turbine a non viable alternate system for this project.

Additional Alternatives Considered for this project:

- Other alternatives considered

a. LED lighting for interior and exterior applications

The low energy consumption and long life expectancy of LED lighting when compared against other conventional lamps such as compact and linear fluorescents, metal halides, etc, make the LED lighting an alternative worth of consideration.

Given on the longer life expectancy of the LED, it provides an additional advantage which is the reduction in maintenance cost compared to standard fluorescent fixtures.

LED lighting initial cost is currently the biggest hurdle when making a decision to whether or not use such type of lighting instead of the more conventional type for either interior or exterior applications.

Methodology used in comparing systems and cost analysis.

TRACE 700 v6.2.6.5 software, an ASHRAE 90.1 accepted modeling tool, was used for the building energy consumption modeling of the DPS Rio Grande City project.

Preliminary projected energy consumptions are 1,761,363kBtu/yr for the baseline system and 1,313,983kBtu/yr for the proposed system.

The established energy rate used for this evaluation is $0.12 per kWh.

In order to establish a reference point for the minimum amount of renewable energy to determine if an alternate energy is considered a viable option, the LEED, Energy and Atmosphere, credit 2 requirement was used as reference point.

Per LEED, Energy and Atmosphere, credit 2; the renewable energy to implement must generate in energy at least 1% of the total building's annual energy cost.

The applicable LEED credits are established so that credits are earned as ASHRAE 90.1 standard's minimum requirements are exceeded.

Alternate Systems

<u>Photovoltaic Systems</u>

System Description

- A photovoltaic system converts solar energy via semiconductors into direct current to be utilized for different applications. One application is to generate power for typical building loads use where either a total or a portion of a building's loads are powered with energy derived from the solar type.

- The major components of the photovoltaic system are solar panels, inverters, a/c and d/c disconnects, mechanical supports, and its associated wiring.

- The averaged total output kilo-Watts-hours (kWhrs) a day from a solar panel array is proportional to the geographical location of the photovoltaic system. The Peak Sun Hours (PSH) is a measure of energy emitted from the sun at a given location. One (1) PSH equals 1kW of solar power reaching the surface over the duration of an hour (Source: solarpanelsathome.org).

- The Rio Grande City area has a PSH of 4.5 hours (Source: National Renewable Energy Laboratory).

Alternative cost comparison

- Using 1% as the minimum established requirement per LEED, Energy and Atmosphere, credit 2; the following table summarizes the calculations and simple payback for the building's anticipated loads, energy cost, and photovoltaic system size.

Non-Alternative Energy	Proposed Building	
	Energy Use (kWh/year)	Energy Cost ($/yr)
Entire Bldg	384,994	$ 46,199.28

Alternate Energy Photovoltaic	Proposed Building	
	Energy Use (kWh/year)	Energy Cost ($/yr)
(Savings indicated as negative numbers)	(3,850)	$ (461.99)

Alternate Energy Photovoltaic	Proposed Building	
	Energy Use (kWh/day)	Energy Cost ($/day)
(Savings indicated as negative numbers)	(11)	$ (1.27)

Minimum percentage of total energy cost as required by LEED EAc2	1%
Project Site Peak Sun Hours	4.5
Equivalent photovoltaic system size in kW	2.34
Typical photovoltaic cost per KW (Cost includes devices and installation)	$ 8.00
Typical initial cost of photovoltaic system	$ 18,752
Simple Payback Years *	**41**

Table 1

*Without any Federal or State incentives.

- A more typical photovoltaic system size for this square footage of building would be a 10kW system.

- This typical 10kW solar panel system would costs around $80,000. These values are broken into $4 per Watt for the materials and $4 per Watt for labor of entire system typically.

- Such typical 10kW photovoltaic system would output an average of 45kW/hrs a day, which will equate to $5.4 a day of energy savings at a rate of $0.12kW/hr. This will equate to $1,971 a year approximately.

- Just as with the referenced 2.34kW system shown on the above table; the approximate payback for the 10kW photovoltaic system would be also around 40.5 years.

- The simple payback analysis of two other recent projects is listed below. The total budget cost for the PV Systems encompasses the PV system material, labor, commissioning, and training.

	Los Ebanos POE		Harlingen GSA	
Non-Alternative Energy Entire Building	Energy Use (kWh/year)	Energy Cost ($/yr)	Energy Use (kWh/year)	Energy Cost ($/yr)
	154,159	$ 18,499	206,567	$ 24,788
Project Site Peak Sun Hours	4.5		4.5	
PV System Size	kW		kW	
	15		8.4	
Alternate Energy (Savings indicated as negative numbers)	Energy Use (kWh/day)	Energy Cost ($/day)	Energy Use (kWh/day)	Energy Cost ($/day)
	(68)	(8.10)	(38)	(4.54)
Alternate Energy (Savings indicated as negative numbers)	Energy Use (kWh/year)	Energy Cost ($/yr)	Energy Use (kWh/year)	Energy Cost ($/yr)
	(24,637.50)	(2,957)	(13,797.00)	(1,656)
Sub Contractor's PV System Budget Cost	$ 107,000		$ 65,500	
Simple Payback System (Years)	36		40	

Table 2

- The payback would be significantly reduced if State and/or Federal Incentives are granted for the PV system. Table 3 shows approximate simple payback analysis if Federal and State incentives were granted.

	Los Ebanos POE		Harlingen GSA		RGC DPS	
Non-Alternative Energy Entire Building	Energy Use (kWh/year)	Energy Cost ($/yr)	Energy Use (kWh/year)	Energy Cost ($/yr)	Energy Use (kWh/year)	Energy Cost ($/yr)
	154,159	$ 18,499	206,567	$ 24,788	384,994	$ 46,199
Project site Peak Sun Hours	4.5		4.5		4.5	
PV System Size	kW		kW		kW	
	15		8.4		2.34	
Alternate Energy (Savings indicated as negative numbers)	Energy Use (kWh/day)	Energy Cost ($/day)	Energy Use (kWh/day)	Energy Cost ($/day)	Energy Use (kWh/day)	Energy Cost ($/day)
	(68)	(8.10)	(38)	(4.54)	(11)	(1.26)
Alternate Energy (Savings indicated as negative numbers)	Energy Use (kWh/year)	Energy Cost ($/yr)	Energy Use (kWh/year)	Energy Cost ($/yr)	Energy Use (kWh/year)	Energy Cost ($/yr)
	(24,637.50)	(2,957)	(13,797.00)	(1,656)	(3,843.45)	(461)
Sub Contractor's PV System Budget Cost	$ 107,000		$ 65,500		$ 18,752	
Incentives						
Typical AEP PV Rebate for Commercial (Approximate)	$ 22,500		$ 12,600		$ 3,510	
Federal PV Tax Credit for Commercial (Approximate)	$ 27,000		$ 14,400		$ 5,400	
Adjusted PV System Budget Cost with Incentives	$ 57,500		$ 38,500		$ 9,842	
Simple Payback System (Years)	19		23		21	

Table 3

- Budgets for these type of Federal and State incentives are limited and generally granted in a first come first serve basis. At the same time, as expected, by submitting an application for the incentives program does not guarantee that such funding will be provided.

Conclusion

Based on the initial investment to implement a PV system; the limited budget for the project, and given that no federal or state incentives are taken into account for this project, a PV system is not recommended.

Solar Water Heating

- Alternate costs

- According to the U.S. Department of Energy, costs of a solar water heating system can range from $27.50 to $115 per square foot, depending on the size and type of system selected (Source: www.eere.energy.gov – US Department of Energy). Solar collector sizes were estimated and system information was input into a solar water heating calculator (Source: www.infinitepower.org – Texas State Energy Conservation Office). Assuming 70% water heating from solar power, the first time costs and payback for each system are as follows:

Area Served	Base System Energy Source (current design)	Estimated Solar Water Heating System First Cost	Payback Time for Solar Water Heating System
Driver's License	Electricity	$3,700	28 Years
DPS Offices	Electricity	$10,500	20 Years

Table 4

These estimated payback times do not include any installation, maintenance, or utility costs that would be required.

- Conclusion

Based on the initial investment to implement a solar water heating system, and the limited budget for this project; a solar water heating system is not recommended for this project.

Other Alternate systems considered:

LED Exterior lighting

System Description

- LED lighting is the latest trend for exterior lighting. Their life expectancy and their input wattage are pretty attractive when compared against Metal Halide (MH) and High Pressure Sodium (HPS) type fixtures. The LED type fixtures most noticeable drawback is the initial cost.

- For this project a comparison of LED and MH was performed. The preliminary count of fixtures was of 26 for MH and 30 for the LED type. This difference in count provides a comparable foot-candle level performance and max-to-min lighting levels between both fixture types.

Alternate Costs

- The life expectancy of LED is 4 times longer than the MH with a total of 13.7 years of life expectancy. The estimated initial and maintenance cost for the MH for the 13.7 years is of approximately $18,000 and for the LED $30,000.

- The energy cost saving with LED fixtures is about $4,029/ year:

EXTERIOR LIGHTING		
	METAL HALIDE	LED
APPROX. BUDGET COST PER FIXTURE	$ 450.00	$ 970.00
APPROX. COUNT REQUIRED	26	30
ESTIMATED LAMP LIFE EXPECTANCY(HRS)	15,000	60,000
ESTIMATED LAMP LIFE EXPECTANCY(YRS)	3.4	13.7
INITIAL APPROXIMATE BUDGET COST	$ 11,700.00	$29,100.00
APPROX METAL HALIDE (400W) BUDGET COST INLCUDING LABOR. (SOURCE RSMEANS)	$ 60.00	---
REPLACEMENT OF METAL HALIDE BULBS COMPARED TO LED REPLACEMENT (YEARS)	4	---
APPROXIMATE BUDGET COST OF REPLACEMENT OF EACH METAL HALIDE FIXTURES 4 TIMES	$ 6,240.00	---
INITIAL COST + BULBS REPLACEMENTS	**$ 17,940.00**	**$29,100.00**
DIFFERENCE	**$ 11,160.00**	

LIGHT FIXTURE ONLY. DOES NOT INCLUDE POLE.

	METAL HALIDE	LED
INPUT WATTS	461	144
TOTAL KW	12.0	4.32
TOTAL KW PER NIGHT	143.83	51.84
KWH RATE	$ 0.12	$ 0.12
TOTAL OPERATIONAL COST PER NIGHT	$ 17.26	$ 6.22
COST DIFFERENCE (MH vs. LED)	$ 11.04	
APPROX SAVINGS WITH LED PER YEAR	$ 4,029.25	

ASSUMING 12 HOURS OF OPERATION PER NIGHT

METAL HALIDE	LED	YEAR	DIFFERENCE
Energy Cost	Energy Cost		Energy Cost
$ 6,299.84	$ 2,270.59	1	$ 4,029.25
$ 12,599.68	$ 4,541.18	2	$ 8,058.50
$ 18,899.52	$ 6,811.78	3	$ 12,087.75
$ 25,199.37	$ 9,082.37	4	$ 16,117.00

Approximately break-even for the $11,160 initial cost is 3 years.

Table 5

- The approximate break-even for the selection of LED exterior fixtures compared to MH type is approximately 3 years.

Conclusion

- LED type fixtures for site lighting represent a viable alternative when considering maintenance and energy consumption.

<u>LED Interior lighting</u>

System Description

- Just as with exterior lighting; LED lighting for interior applications is known for energy savings and long life expectancy.

- The typical life expectancy of linear fluorescent and compact fluorescent could be anywhere between 7,500 to 24,000 hours. For the purpose of this analysis; a life expectancy of 15,750 hours was used.

Alternate Costs

- Based on the conventional interior fixture types used and their equivalent in LED type, the LED type fixtures cost approximately 1.8 times as much as the interior types. Depending on the LED fixture grade, some LED type fixtures cost as much as 3 times as the fluorescent type.

- It shall be understood that a direct fixture to fixture comparison from a fluorescent to a LED type layout does not result in the most optimum and efficient lighting system from the stand point of foot-candle average, foot-candle max to min ratio, and overall building's energy consumption.

- The LED cost and foot-candle performance used for the purpose of this comparison was from ActiveLED, a lighting vendor in the Austin/San Antonio, Texas area. ActiveLED provided the LED layout, foot-candle values from simulation tool results, cost of fixtures, and total input wattages.

- A significant difference between interior and exterior lighting layouts when comparing conventional non-LED with LED type fixtures, is the space constraints in the interior application as well as the reflection of the lighting due to the ceiling and walls.

- This is often overlooked when considering LED without differentiating the application, interior or exterior type. In an exterior application the average and max to min foot-candle levels are easier to target due to not being constrained by walls and mounting heights.

- The conventional and the LED type fixtures for an interior application was not significant enough to obtain a break even point as attractive as with the exterior lighting application.

INTERIOR LIGHTING		
	STANDARD	**LED**
APPROX. INITIAL BUDGET COST FOR ALL INTERIOR LTS	$ 43,080.00	$ 76,400.00
ESTIMATED LAMP LIFE EXPECTANCY(HRS)	15,750	60,000
ESTIMATED LAMP LIFE EXPECTANCY(YRS)	7.5	28.7
ESTIMATED BALLAST LIFE EXPECTANCY(HRS)	35,000	---
ESTIMATED BALLAST LIFE EXPECTANCY(YRS)	16.8	---
APPROX REPLACEMENT LABOR COST BALLAST/LAMP.	$ 50.00	---
NUMBER OF BALLAST REPLACEMENTS PER LED FIXTURE LIFETIME	1.7	---
NUMBER OF STD FIXTURE REPLACEMENTS PER LED FIXTURE LIFETIME	3.8	---
TOTAL APPROXIMATE NUMBER OF BALLASTS	18.0	---
TOTAL APPROXIMATE BALLASTS COST	$ 409.00	---
LABOR COST TO REPLACE THE BALLAST (FOR 1 LED LIFETIME)	$ 1,542.86	---
TOTAL LABOR + BALLATS (FOR 1 LED LIFETIME)	$ 2,244.00	---
TOTAL APPROXIMATE QTY OF STD FLUORESCENTS	33.0	---
TOTAL APPROXIMATE STD LAMP COST	$ 68.00	---
LABOR COST TO REPLACE STD FIXTURES (LED LIFETIME)	$ 6,285.71	---
TOTAL LABOR + LAMPS (LED LIFETIME)	$ 6,544.76	---
APPROXIMATE BUDGET COST OF REPLACING FLUORESCENT FOR 1-LED LIFE TIME.	$ 8,788.76	---
INITIAL COST + BULBS REPLACEMENTS	**$ 51,868.76**	**$ 76,400.00**
DIFFERENCE	---	**$ 24,531.24**

ENERGY RATE $/KWh	$ 0.12
HOURS PER DAY	8
WORKING DAYS PER YEAR	261

LAMP COST	$ 4
NON-EMERGENCY BALLAST	$ 30
EMERGENCY BALLAST	$ 45

STANDARD TYPE TOTAL (kVA)	12.173
LED TYPE TOTAL (kVA)	7

	NON-LED TYPE (INTERIOR)	LED TYPE (INTERIOR)
ENERGY COST/ DAY	$ 11.69	$ 6.72
ENERGY COST / YEAR	$ 3,050.07	$ 1,753.92
DIFFERENCE/YEAR	$ 1,296.15	

STANDARD TYPE Energy Cost	LED Energy Cost	YEAR	Difference in Energy Cost by Year
$ 3,050	$ 1,754	1	$ 1,296
$ 6,100	$ 3,508	2	$ 2,592
$ 9,150	$ 5,262	3	$ 3,888
$ 12,200	$ 7,016	4	$ 5,185
$ 15,250	$ 8,770	5	$ 6,481
$ 18,300	$ 10,524	6	$ 7,777
$ 21,350	$ 12,277	7	$ 9,073
$ 30,501	$ 17,539	10	$ 12,961
$ 33,551	$ 19,293	11	$ 14,258
$ 36,601	$ 21,047	12	$ 15,554
$ 39,651	$ 22,801	13	$ 16,850
$ 42,701	$ 24,555	14	$ 18,146
$ 45,751	$ 26,309	15	$ 19,442
$ 48,801	$ 28,063	16	$ 20,738
$ 51,851	$ 29,817	17	$ 22,034
$ 54,901	$ 31,571	18	$ 23,331
$ 57,951	**$ 33,324**	**19**	**$ 24,627**
$ 61,001	$ 35,078	20	$ 25,923
$ 64,051	$ 36,832	21	$ 27,219
$ 67,101	$ 38,586	22	$ 28,515

Table 6

- The break-even point is of 19 years approximately.

- AEP Texas Central Company, electric utility company to provide service to the DPS facility in Rio Grande City, offers incentives for new construction buildings that demonstrate demand and energy savings for the implementation of energy efficient light fixtures such as LEDs.

- For such incentive program, the fixture's brand and model need to be part of a pre-approved selection of light fixtures published and updated by AEP Central Company.

- For this DPS project, such incentive will be in the ball park of $1,500.

- This incentive amount is obtained from built-in equations in a Lighting Equipment Survey form downloaded from AEP's website. After selecting the fixtures and specifying the counts, the total energy savings is calculated. This total savings is translated into the incentive amount, which is capped up to a given kWh value.

- Having this incentive, will not significantly reduce the break-even point, since it will reduce it down to around 17 years.

- Considering LED type lighting for interior application is not recommended for this project given on the expected break-even point. This conclusion correlates well with a report prepared by Pacific Northwest National Laboratory for the U.S. Department Of Energy (DOE). The report is titled "Laboratory Evaluation of Light-Emitting Diode (LED) T8 Replacement Lamp Products". Source:
 (http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/gateway_t8-replacement.pdf).

- The application of LED fixtures has increased in recent years. Packaging of the LED lamps and heat sinks into new and more efficient fixtures provide more advanced products. As the demand and volume of production a various manufacturers increase, the cost will likely be reduced.

Energy Calculations

The project will comply with the Energy Conservation Design Standard for New State Buildings.

Conclusion

From the above discussed energy conservation alternates; the most viable option will be the LED for the exterior application given on its break even point of being only 3 years compared to other alternates such as the photovoltaic which is 40 years of paybacks.

Government incentives and environmental awareness have increased the volume of products available for energy savings. As manufacture production increases worldwide, the cost of LED and renewable energy systems will continue to reduce the product cost. The combination of reduced product cost and increased energy cost will improve the viability over time.