Renewable Energy Project: Solar Thermal Systems

Final Report

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1. Purpose

The purpose of this report is to evaluate solar thermal systems (STS) as a potential source of renewable energy by discussing its costs, benefits and impacts on Tulane's footprint goals.

2. Background and Opportunity

Tulane has signed on to the ACUPCC[1] and plans reaching carbon neutrality. To do so, Tulane is currently assessing renewable energy systems that can help reducing its carbon footprint. An alternative is the use of STS for heating up Reily Center's pool and potentially lowering down carbon emission coming from the current (traditional) energy sources. The implantation of such system depends on its cost, scale, feasibility, local and regional impact and amount of potential CO_2 reduction.

3. Critical factors

The following facts are critical for considering STS as an option:

- Configuration of current heating system
- Available (roof) surface
- Installation and Maintenance costs
- Financial Incentives
- Solar Energy available

[1] American College and University Presidents' Climate Commitment

4. Current Conditions

The following sections describe current status of heating system, pool and water specs, building conditions, and additional factors involved in the evaluation of STS.

4.1. Heating system

Current heating system uses natural gas boilers (two), and works as a 'closed loop system'. In this type of configuration, boilers' tubes and liquid (water or antifreeze) are heated up to 130 degrees warming up pool water as it passes over. So, pool water temperature depends on the opening and closing of valves that supply the boiler liquid. These boilers *also* provide warm water to 17 AHUs[2] of the HVAC[3] system at Reily Center.

This type of installation provides enough flexibility for adapting current heat exchanger to an additional source of power, but prevents determining an exact amount of energy (and costs consequently) used exclusively for the pool.

4.2. Pool

Reily's pool is 50 meters long (164 feet), 22.86 meters wide (75 feet), and 2.15 meters (on average) deep (7.05 feet), and is located indoors. Water temperature oscillates between 81 and 82 degrees with a volume of 650,000 gallons approximately.

4.3. Building

Reily Center has 19,000 square feet of roof surface available for potentially installing solar panels or solar collectors.

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[2] Air Heating Unit
[3] Heating, Ventilation, & Air Conditioning

4.4. Financial incentives

According to the Database of State Incentives for Renewables and Efficiency of the North Carolina Solar Center (1), in Louisiana there are financial incentives (such as Tax Credits) only for residential properties. So, Tulane could not be benefited from any state or national program.

4.5. Installation and Maintenance costs

Maintenance costs are minimal requiring only cleaning panel arrays once a year. However, New Orleans' natural conditions (exposure to high winds during hurricanes or tornados) may increase insurance costs.

4.6. The amount of solar energy available

The effectiveness of STS depends on the amount of sunshine they can get through the year. According to website *habitmagic* (2), New Orleans enjoys 2635 hours of sunshine a year, averaging 7.22 daily. During winter (January), sunshine is 5.1 hours per day while in summer (June) it rises to 9.0 hours.

5. Methodology

As pointed out previously, Reily Center's current heating system heats not only the pool but also other subunits inside the building making practically impossible to have specific energy-consumption data for our analysis. Lack of information led us to consider two alternatives:

- Find out comparable projects around the country, and use their figures (energy costs and consumption, system configuration, heat rate transfers, and so on) for our own model or
- Calculate potential energy savings scenarios *based on available roof space*.

Since technical and market data for the second option is available, we decided to build our model with the number of square feet for panels as the cornerstone of our analysis.

5.1. Model's outputs

According to our model each metric ton of CO_2 saved would cost **$41.99.** Our *base case*[4] considers the installation of **318 solar collectors** which would work as a supplement to the current system and whose total costs add up to **$234,872.61** with a net present value of **$(98,986.30).** Energy savings coming from this configuration would total **433,885 kw/h** or **1,480,545,813 BTU** representing savings of **$8,099 per year.** Finally, the amount of CO_2 saved would be **173,224 lb or 78.57 metric tons per year** approximately.

5.2. Extra Weight

As described, our base model consists of 318 collectors. Installing this number of structures will add significant weight to the existing building structure potentially requiring extra adjustments to prevent malfunctioning and/or major collapses and accidents. For the purpose of this report, the weight of 318 collectors is:

- Dry weight (in pounds): **4,554**
- Wet weight (in pounds): **11,178**

6. Evaluation

The installation of Solar Thermal Systems would represent a small decrease on Reily Center's energy demands, and consequently, a small improvement towards carbon neutrality. Even in the best case (where 19,000 square feet of roof space are used to locate solar collectors) the amount of CO_2 saved reaches only **149 MT** per year at a cost of **$446,257.** In comparison, according to Tulane's Greenhouse gas inventory (3), Reily Center's emissions total **1697 MT.** Therefore, even under the best case scenario, potential carbon dioxide reduction would amount to **less than**

[4] Base case refers to our estimation of the number of solar collectors that would be sufficient for Reily's pool.

9 percent of building's emissions. This number shrinks to **4.6 percent** if our base case (10,000 square feet) is used.

In addition to this fact, there are two other factors that limit the impact of STS. On the one hand, there are no economic incentives (such as tax credits) in the state of Louisiana or in the country from which Tulane may benefit to proceed with this investment. Consequently, any expense for this project would be subject to standard taxation regulations. On the other hand, placing solar collectors may require reinforcing Reily Center's structure to withstand new additional weight. Also, further modifications may be required to adapt STS to the current heating systems. Both circumstances may potentially escalate costs of installing STS[5].

[5] None of these factors has been included within our calculations.

7. Appendix: Methodology details

7.1. Scenarios

Our model uses the following scenarios:

	SCENARIOS			
Available roof space (sq ft)	19,000	15000	10000	5000

For each of these configurations, we came up with total costs, potential savings (both in dollars and metric tons of CO_2), additional considerations, and discounted cost per reduction.

7.2. Solar Collector

The other centerpiece of our model is the panel collector's specs. For this model's purposes, a panel collector has the following characteristics (ECO Distributing (4)):

PANEL SPECS		
Dimensions	4'x8' (48 inches x 96 inches)	
Available area (sq ft)		32.00
Net Collector Area (sq ft)		31.40
% Useful area		98%
Price per Panel	$	236.00
Dry Weight		14.30
Wet Weight		35.10
Wet Weight Per sq. ft		1.12

7.3. Costs Model

We use the model presented by Mahjouri and Nunez (5) for calculating total costs:

COST ELEMENTS	
Item	Weight
Collector	32%
Monitoring and Control	2%
Installation	14%
Engineering	11%
Material	5%
Bond	4%
Transportation	2%
Training	1%
Warranty	7%
Feasibility Study	10%
Roofing Warranty	4%
Change Order	8%

7.4. Total Costs

Total costs are derived by calculating the number of panels (and costs) for each scenario and by applying each item from the cost model presented in last section.

	SCENARIOS			
Available roof space (sq ft)	19,000	15000	10000	5000
Number of Panels (4'x10')	605.10	477.71	318.47	159.24

Total Costs

Collector	$ 142,802.55	$ 112,738.85	$ 75,159.24	$ 37,579.62
Monitoring and Control	$ 8,925.16	$ 7,046.18	$ 4,697.45	$ 2,348.73
Installation	$ 62,476.11	$ 49,323.25	$ 32,882.17	$ 16,441.08
Engineering	$ 49,088.38	$ 38,753.98	$ 25,835.99	$ 12,917.99
Material	$ 22,312.90	$ 17,615.45	$ 11,743.63	$ 5,871.82
Bond	$ 17,850.32	$ 14,092.36	$ 9,394.90	$ 4,697.45
Transportation	$ 8,925.16	$ 7,046.18	$ 4,697.45	$ 2,348.73
Training	$ 4,462.58	$ 3,523.09	$ 2,348.73	$ 1,174.36
Warranty	$ 31,238.06	$ 24,661.62	$ 16,441.08	$ 8,220.54
Feasibility Study	$ 44,625.80	$ 35,230.89	$ 23,487.26	$ 11,743.63
Roofing Warranty	$ 17,850.32	$ 14,092.36	$ 9,394.90	$ 4,697.45
Change Order	$ 35,700.64	$ 28,184.71	$ 18,789.81	$ 9,394.90
Grand Total	$ 446,257.96	$ 352,308.92	$ 234,872.61	$ 117,436.31

7.5. Savings Model

To get potential savings figures of this project, we looked at the Solar Rating and Certification Corporation (6) and found manufacturers (in Lousiana) who offer similar systems to our basic configuration. We then gathered manufacturer panels' specs and their certified annual savings, and used them as a foundation for calculating savings.

SAVINGS MODEL		
Manufacturer	**Total Panel Area (sq/ft)**	**Annual savings (kw/hr)**
integrated solar llc	39.90	1,674.00
integrated solar llc	64.60	2,235.00
Sun Earth Inc	40.90	2,582.00
Sun Earth Inc	65.70	2,879.00
Sun Earth Inc	65.70	2,276.00
Heliodyne Inc	32.20	1,474.00
Sun Earth Inc	49.50	2,686.00
Sun Earth Inc	81.70	2,905.00

Potential savings are the result of dividing our scenarios by manufacturers' panels, and multiplying this number by annual savings. Our final goal is getting an average of annual savings by considering different manufacturers, products and efficiencies.

SAVINGS MODEL			SCENARIOS			
Manufacturer	**Total Panel Area (sq/ft)**	**Annual savings (kw/hr)**	19,000	15,000	10,000	5,000
integrated solar llc	39.90	1,674.00	797,143	629,323	419,549	209,774
integrated solar llc	64.60	2,235.00	657,353	518,963	345,975	172,988
Sun Earth Inc	40.90	2,582.00	1,199,462	946,944	631,296	315,648
Sun Earth Inc	65.70	2,879.00	832,588	657,306	438,204	219,102
Sun Earth Inc	65.70	2,276.00	658,204	519,635	346,423	173,212
Heliodyne Inc	32.20	1,474.00	869,752	686,646	457,764	228,882
Sun Earth Inc	49.50	2,686.00	1,030,990	813,939	542,626	271,313
Sun Earth Inc	81.70	2,905.00	675,581	533,354	355,569	177,785
Total ential energy savings if all roof area (per scenario) is used (on average, kw/h)			**840,134.03**	**663,263.71**	**442,175.80**	**221,087.90**

Using these outcomes, we finally come up with the following metrics:

- Energy savings in kw/h
- Energy savings in BTUs
- Savings in dollars
- Total pounds of CO_2 not used
- Total Metric tons of CO_2 not used

Since available area per panel is slightly less than 100% (98 percent to be exact), we have to reduce Potential Energy Savings to reflect this issue.

	SCENARIOS			
	19000	15000	10000	5000
Potential Energy Savings (kw/h)	840134	663264	442176	221088
Real energy Savings (kw/h) (98% of Potential)	824382	650828	433885	216943
Real energy Savings (BTU)	2813037044	2220818719	1480545813	740272906
Savings (in dollars)	15387	12148	8099	4049
Total Pounds of CO2 not used	329125.3	259835.8	173223.9	86611.9
Total Metric tons of CO2 not used	149.3	117.9	78.6	39.3

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