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November 25, 2009

VIA EMAIL (lvb.tpfa@shaw.ca)

File No.: i15126.01-F
Revised

Trinity Place Foundation
200, 602 – 1st Street SE
Calgary, AB T2G 5H8

Attention: Lawrence Braul

Dear Sir:

Subject: **KING TOWER SOLAR WALL INVESTIGATION
TRINITY PLACE/HIGH RISE APARTMENT TOWERS
CALGARY, AB**

INTRODUCTION

A. D. Williams Engineering Inc. (ADWE) has been contracted by the Trinity Place Foundation to complete an energy investigation into the solar wall that is currently in use at King Tower. The investigation provides a good estimate of the energy output of the solar wall system (2008-2009).

DESCRIPTION OF SYSTEM

The solar wall installed on the south facing wall of the building is connected by ducting across the rooftop to a recently installed Engineered Air make-up air (MUA) unit, located in the mechanical penthouse. The solar wall uses solar energy to pre-heat incoming air which is then distributed throughout the building.

In the cooler months, when the outside air temperature is less than 50^{o}F, the air is drawn up the chamber of the solar wall by the MUA unit. The incoming air is thus pre-heated and requires less energy input to heat the make-up air to the set-point temperature of approximately 55 ^{o}F.

In the warmer months, when the heating demand in the building is lower and the outside air temperature is higher than 50 ^{o}F, a damper is opened to allow fresh-air to enter the MUA unit directly and not through the solar wall

Photo 1: Ducting across roof to solar wall

A small fan located outside, which is attached to a take-off of the solar wall duct, is activated when the temperature at the head of the solar wall is above 95^{o}F. The heated air from the solar wall flows over two glycol heat exchangers. This heats up a closed loop glycol/water mixture, which is then pumped to a small heat exchanger which pre-heats the incoming domestic hot water. The pumps and fan are interlocked so that they operate only when the temperature at the head of the solar wall is 95^{o}F.

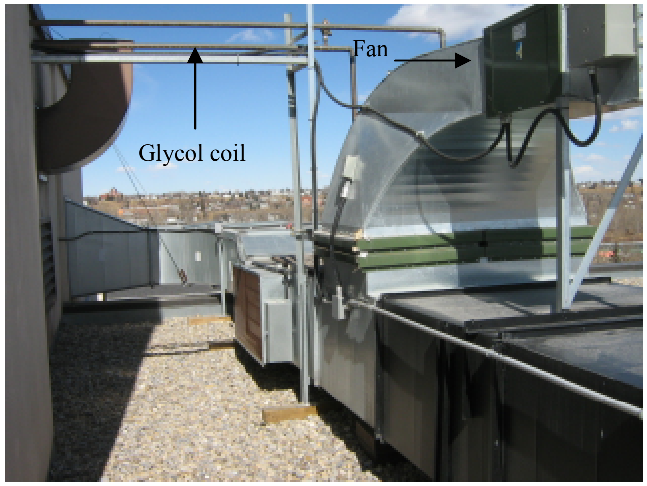


Photo 2: Domestic hot water fan and glycol coil

SYSTEM ANALYSIS

The first part of this investigation included verification of the system's air side specifications (airflow etc.) and the use of ACR TrendReader to analyze the temperature output during the cooler months when the solar wall is used to pre-heat incoming make-up air.

The second part of the investigation verified the energy savings on the domestic hot water pre-heat section of the solar wall. A BTU (British Thermal Unit) meter was installed on the water side of the system, which recorded the energy gained from the solar wall and the days in which the system was operating.

Photo 3: ISTEC BTU meter

MAINTENANCE AND AIR QUALITY

It is important to include the improvements noted by the maintenance staff due to the solar wall installation. It was reported that the indoor air quality has noticeably improved since the installation of the system. The solar wall acts as a filter when operating and the entire duct system (even when in summertime operation) allows almost zero moisture into the MUA unit. The filtration causes less dust and debris to collect on the heating coils in the MUA unit which means less cleaning is required by maintenance staff.

Less cleaning required by the staff should then result in fewer labour hours and thus fewer dollars spent maintaining the MUA system. The cleaner air entering the unit also means fewer filter changes each year and cleaner heat exchangers. This again translates into dollar savings. When the heat exchangers are cleaner, they are more effective at transferring heat energy to the air stream passing over them which in turn saves money over the year.

All of these effects should add up to real savings to the building operator, but were not a part of this analysis. This should be considered when looking at the true payback of the system.

ANALYSIS

1.1 MAKE-UP AIR PRE-HEAT SYSTEM

.1 In order to determine the energy savings the solar wall provided for the make-up air pre-heating, the temperature difference between the outside air and the air at the MUA unit intake was determined. A temperature logger was installed in the intake chamber of the MUA unit and recorded the air temperature every hour. Hourly weather data was obtained from the Environment Canada website for Calgary, measured at the airport for the outside air temperature.

.2 It was necessary to adjust the Environment Canada outside temperatures for the downtown location of the King tower. When the solar wall is not operating toward the make-up air, the damper is open to the outside and the temperature in the intake chamber is essentially the outside air temperature. The average temperature difference between the Environment Canada temperatures and temperatures in the intake chamber when the wall was inactive was obtained and used to calculate a more accurate outside temperature for the downtown location.

.3 The next step in calculating the heat gain from the solar wall was finding the temperature difference between the air entering the MUA unit and the corrected outside temperature. The BTU output for each hour of recorded data was then calculated using the temperature change, air flow into the MUA unit (rated at 9,000 cfm), and a constant factor.

.4 The newly installed MUA unit consumes approximately 14% less natural gas per year, resulting in annual savings of approximately $2,323 in utilities (based on the Nexen Natural Gas billing provided by Trinity Foundation), and 75,923 ekWh (259,200,000 BTUs) of natural gas energy. This is based on an assumed 1,400 hours of annual operation. Electrically, the new unit is no more efficient compared to the older, Climate Master unit.

.5 The annual BTU output was determined from the assumed solar wall operation schedule. Because typical MUA units operate at approximately 55^{o}F, it was assumed the unit only gained from the solar wall when the outside temperature was below approximately 50^{o}F. If the outside temperature is above the set point in the MUA unit, then the system must consume energy to cool the incoming air. This analysis resulted in annual savings of approximately 35,642 ekWh (ekWh = equivalent kilowatt hour) and $1,091 in utilities, shown in the table below.

Table 1: Calculated Energy Savings for MUA System

Solar Wall Hours of Operation	MUA Unit Heat Gain from Solar Wall (ekWh)	CO_2 Emission Savings (tonnes)	Gas Price ($/ekWh)	Savings
Sunrise-Sunset (~8h/day)	35,642	6.369	$0.03060*	$1,090.66

*All utility pricing in this report was obtained from the Nexen billing statement provided by the Trinity Foundation.

DOMESTIC HOT WATER PRE-HEAT SYSTEM

The fan used to draw the heated air from the solar wall over the glycol coil automatically turns on when the temperature at the head of the solar wall is above 95^{o}F. It was reported that the pumps that supply domestic hot water (DHW) to and from the heat exchanger are interlocked with the fan and also operate when the head of the solar wall is above 95^{o}F.

In order to measure the DHW heat gain from the solar wall, a BTU meter was attached to the DHW side of the system. The BTU meter tracked the days of operation and total energy being produced by the system.

In order to calculate the total energy saved, the energy required to run the fan and pumps was subtracted from the heat added to the DHW from the solar wall. There was no temperature logger at the head of the solar wall to determine when the temperature was above 95^{o}F, so it was assumed that on the days of operation, tracked by the BTU meter, the fan and pumps run during the hours of daylight (approximately 8:00-17:00).

With these estimated operating schedules it was found that the annual energy savings were approximately 3,406 ekWh. This resulted in annual savings of approximately $10.47 as illustrated in the table below.

Table 2: Calculating Energy Savings for DHW System

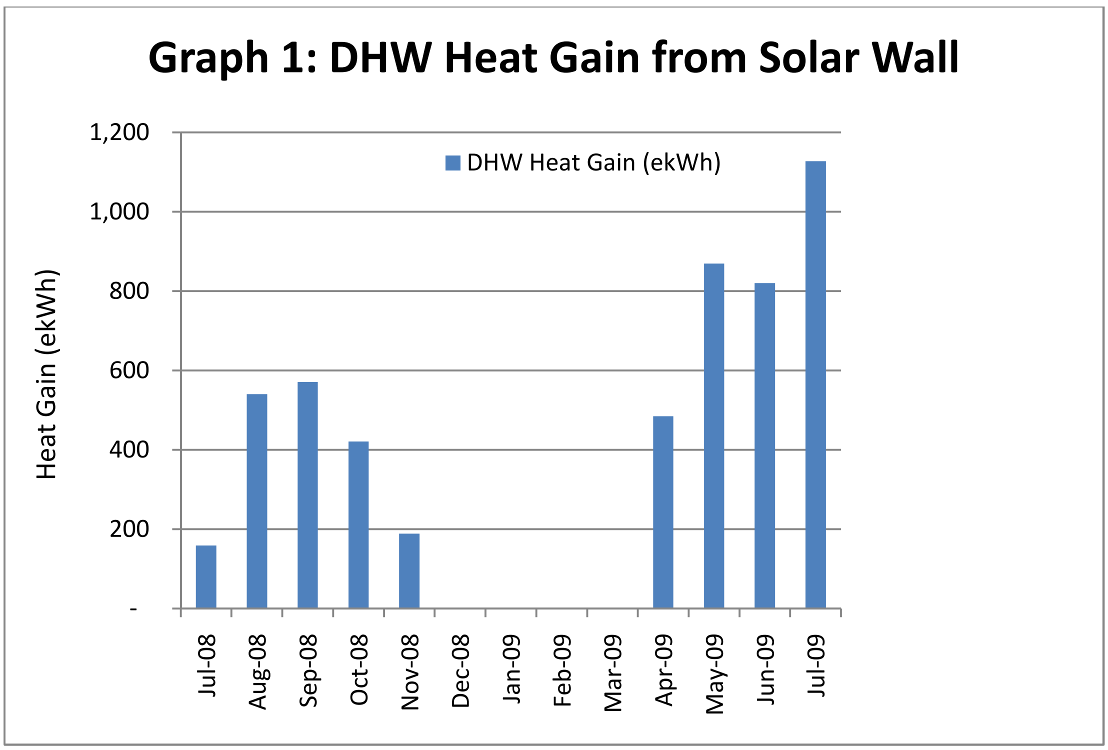
TOTAL DHW Energy Consumption	**Production/ (Consumption)**		**Utilities Price**		**Energy (Cost)/Savings**	**CO_2 Savings / (Increase) Tonnes**
Heat from Solar Wall	5,023	ekWh	0.03060	$/ekwh	$ 153.70	0.8976
Pumps	(544)	kWh	0.08858	$/kWh	$ (48.23)	(0.5374)
Fan	(1,073)	kWh	0.08858	$/kWh	$ (95.01)	(1.06)
TOTAL Savings:	**3,406**	**ekWh**	**-**	**-**	**$ 10.47***	**(0.700)****

*Overall the system is saving energy, but due to the much higher costs of electricity, there do not appear to be large cost savings based on our estimates of operating hours (which will be a bit high for the fan and pumps).

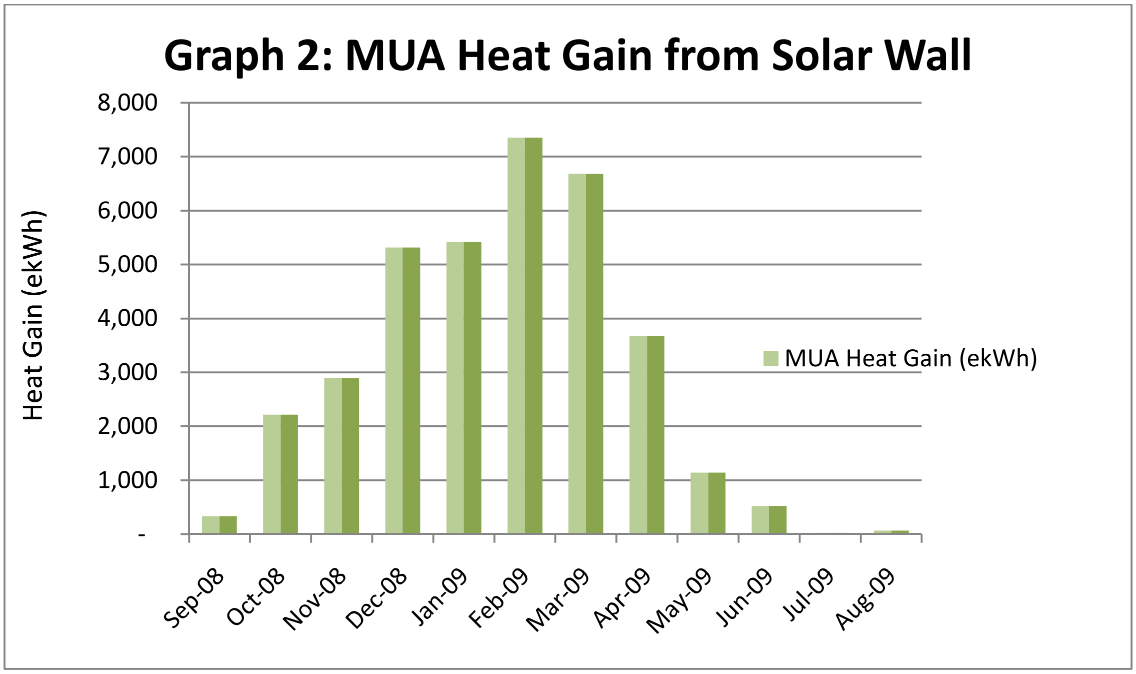
**This system is producing more CO_2 emissions due to the Alberta electricity being produced by coal fired power plants. The emission rate per ekWh is more than 10 times for electricity than natural gas in Alberta.

Solar Wall Heat Gains

The following graph shows the monthly heat gain from the solar wall by the domestic hot water system. These values were recorded by the BTU meter which began recording in July, 2008 and turned off on November 15, 2008. The system then recorded heat gains again beginning on April 9, 2009.



The graph below illustrates the heat gained from the solar wall by the MUA unit.



CONCLUSIONS

It was found that the combined annual savings from September, 2008 to August, 2009 for the solar wall installation were approximately **40,825 ekWh** and **$1,101** in utilities (based on the Nexen electrical and natural gas billing rates provided by the Trinity Place Foundation).

It was also found that the installation of the new Engineered Air MUA unit has annual natural gas savings on the order of **75,923 ekWh** (259,200,000 BTUs), a 14% improvement from the older Climate Master unit. This equates to annual savings of approximately **$2,323** (based on the Nexen electrical and natural gas billing rates provided by the Trinity Place Foundation).

Overall use of the solar wall all year around is a novel idea and is a great innovation of a technology that is most effectively used in Alberta during the winter months. Unfortunately due to the increased electrical use required to run the DHW loop, and the fact that Alberta's electricity costs are generally much higher than natural gas costs, it does not appear to have a great payback.

That being said, the innovation has been successful in saving total energy use in the building.

The overall CO_2 savings from the solar wall are approximately **5.67 tonnes** per year. The DHW portion of this wall is taking away from the total savings due to the higher emissions factor for electricity production in Alberta as compared with natural gas. The MUA pre-heat operation saves approximately 6.37 tonnes per year alone.

Additionally, the installation of the new MUA unit has overall CO_2 savings of approximately **13.6 tonnes** per year. These savings are due to the natural gas conserved annually by the Engineered Air MUA unit.

RECOMMENDATIONS

At the start of this project ADWE was informed that there were little funds available for implementation of this project (~$1,000). Our estimates and work shown in this report were done with approximately twice that budget; however, should funds become available and in order to achieve a more accurate representation of the actual energy savings from the solar wall the analysis procedure could be improved:

A second temperature sensor would need to be placed near the wall where the air is being drawn in. An airflow measuring station would also need to be installed on the MUA duct in order to provide a real-time flow reading at all times of the solar wall's operation.

Along with these instruments, a central processing system would need to store each sensor's signal in real-time. This central system would then need to calculate in real-time the BTU output of the solar wall and log all data. This would involve subtracting the temperature values and multiplying by a constant and the flow of the air at that time, as we did with our calculations.

To achieve higher accuracy in energy savings for the DHW system a current meter could be connected to the pumps and fan to measure the power consumed. This measurement would then need to be logged and stored in order to be subtracted from the BTU output of the DHW system.

Finally the system would then need to compute the overall BTU output of the system and log all data.

Overall estimated implementation costs for this type of monitoring of the system would be $16,000-17,000 and may be outside the scope of a private investigation.

CLOSURE

This report has been prepared based upon the information referenced herein. It has been prepared in a manner consistent with good engineering judgement. Should new information come to light, A. D. Williams Engineering Inc. requests the opportunity to review this information and our conclusions contained in this report. This report has been prepared for the exclusive use of Trinity Place Foundation, and there are no representations made by A. D. Williams Engineering Inc. to any other party. Any use that a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties.

Yours truly,

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PERMIT TO PRACTICE
A. D. WILLIAMS ENGINEERING INC.

Signature

Date 25 Nov 09

PERMIT NUMBER: P6394

The Association of Professional Engineers, Geologists and Geophysicists of Alberta

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APPENDIX A

MUA - SOLAR WALL HEAT GAIN

The hourly heat gain by the MUA unit was calculated from the following equation:

$$Q = cfm*0.98* \Delta T*t$$

Where Q represents the heat gain in Btu, cfm represents the flow into the MUA unit (9000 cfm), ΔT is the temperature difference between the outside air and air entering the unit from the solar wall, and finally t is the time, which in all of our calculations was equal to one, because measurements were taken every hour.

From this equation the hourly heat gain from the solar wall was found and the monthly heat gain was calculated by taking the sum of the heat gains during the daylight hours shown in the tables below.

Table 1A: Daylight hours

Avg Sun Set/Rise Hours		
Month	**Rise**	**Set**
Sep-08	7:00	20:00
Oct-08	8:00	19:00
Nov-08	8:00	17:00
Dec-08	8:00	17:00
Jan-09	8:00	17:00
Feb-09	8:00	18:00
Mar-09	8:00	19:00
Apr-09	7:00	20:00
May-09	6:00	21:00
Jun-09	5:30	22:00
Jul-09	6:00	21:30
Aug-09	6:30	21:00

Source: www.timeanddate.com

Table 2A: Summary of MUA Unit Heat Gain from Solar Wall

	Sep-08 (Start Sep 9/08)	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09
Monthly Heat gain (Btu)	1,138,130	7,566,823	9,896,194	18,146,287	18,486,876	25,105,112
(ekWh)	333	2,216	2,899	5,315	5,415	7,354

	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09 (End Aug 25/09)	Total
Monthly Heat gain (Btu)	22,820,738	12,550,388	3,886,623	1,780,630	88,665	216,739	121,683,205
(ekWh)	6,684	3,676	1,138	522	26	63	35,642

APPENDIX B

DOMESTIC HOT WATER SYSTEM - SOLAR WALL HEAT GAIN

The following table shows the information generated by the BTU meter. It also has rows inserted that calculate the hours of operation for both the pump and fan.

Table 3A: BTU Meter on DHW System

7/2009	6/2009	5/2009	4/2009	3/2009	2/2009	1/2009	12/2008	11/2008	10/2008	9/2008	8/2008	7/2008		*Month*
17,683	13,836	11,037	8,069	6,416	6,416	6,416	6,416	6,416	5,773	4,337	2,388	544	**17,139**	*Totalizator btu * 1000*
31	27	30	22	0	0	0	0	15	30	27	31	17	**230**	*Number active days*
279	243	270	198	0	0	0	0	135	270	243	279	153	**2070**	*Pump &Fan Schedule (9h/day)*
77	123.8	78.8	77	77	73.4	73.4	77	77	102.2	104	78.8	78.8	**123.8**	*Maximum temperature °F*
4	3	2	2	0	0	0	0	2	5	2	2	0	**5**	*Maximum flow gal/min*

APPENDIX C

ENGINEERED AIR MUA UNIT NATURAL GAS SAVINGS

Table 4A: Annual Natural Gas Savings for Engineered Air MUA Unit

Equipment	Operating Info				Hours of Operation/ year	Nat. Gas Cons/year	
	INPUT (MBTU/hr)					BTU	ekWh
MUA (EngAir)	1080	1085 rpm	208V	7.5 HP	1440	1,555,200,000	455,536.03
Old MUA (Climate-Master)	1260	830 rpm	208 V	5 HP	1440	1,814,400,000	531,458.70

Savings from new MUA per year	
ekWh	$
75,922.67	2,323.23