Report on Monitoring of a Solar Air Heating System in NWT

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Executive Summary

This report aims to provide a comprehensive description of setting up monitoring systems for a solar air heating system at the Weledeh Catholic School, Yellowknife.

A monitoring and implementation protocol was established: existing sensors logged by the building control system and new sensors installed are combined to calculate energy savings by the solar air heating system. Long-term plans include a two-year (one-year minimum) monitoring period and the production of energy saving reports. By quantifying the amount of energy production, the monitoring data intends to shed light upon the durability and suitability of such solar air heating systems in NWT.

Recent survey of existing solar air heating systems in the Northwest Territories suggested needs for continuous monitoring efforts and the knowledge gap of energy production from solar air heating systems. The report and appendices contain all the information needed to understand and to reproduce this monitoring project, including all sensor specifications, data acquisition set-up, energy saving calculations, lessons learnt and a list of useful contacts. To combat the general ‘build and forget’ mentality, it is recommended to make continuous monitoring plans mandatory for future renewable installations.

1. Brief Overview of Solar Air Heating Systems in NWT

A commercial building-integrated Solar Air Heating system, known as the **SolarWall** developed by Conserval Engineering (2009), has been widely implemented in the NWT. It is essentially a perforated dark metal cladding that captures solar thermal energy to heat incoming exterior air (Figure 1).

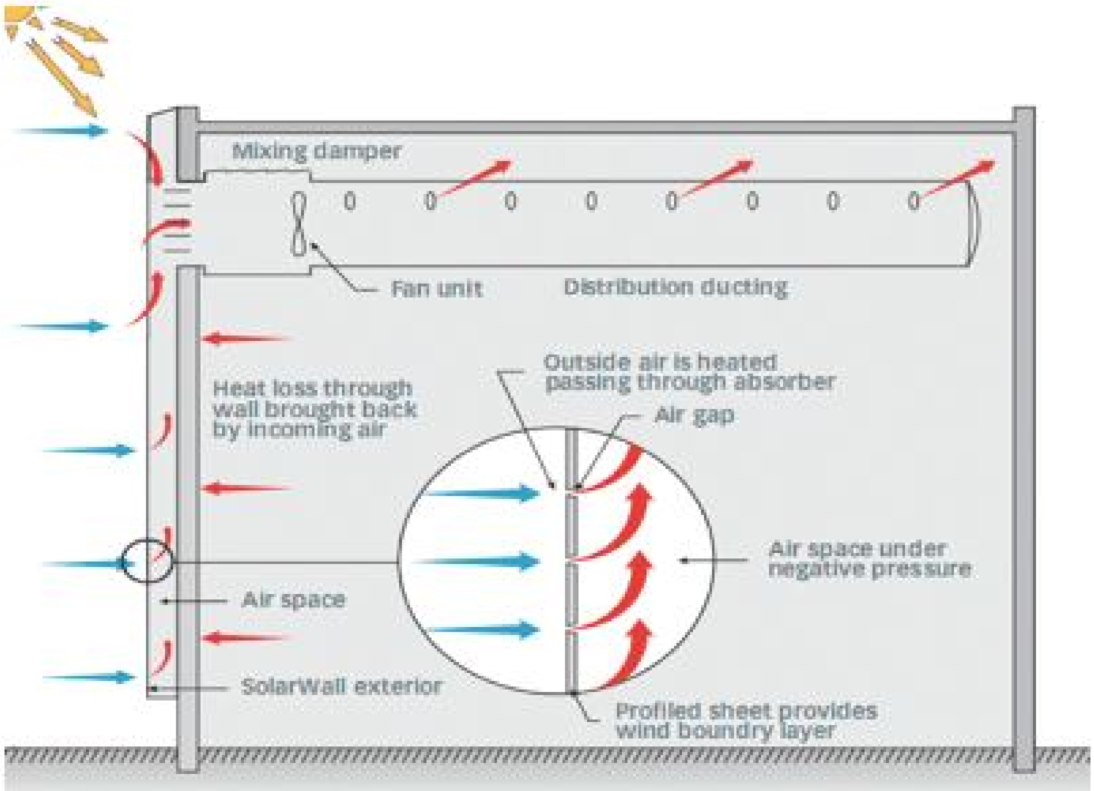

Figure 1. Schematic of a Typical SolarWall system (Conserval Engineering, 2009)

Also known as unglazed transpired solar air collectors, the SolarWall features small, well distributed pores comprising 2% of total area. An air cavity ranging from 15 to 30cm in depth is present behind the cladding (Figure 1). The heated exterior air is drawn by a fan through the tiny pores and ducted into the building to offset the ventilation heating loads.

This solar air heating system (SolarWall) is a simple, low-cost technology of relatively high efficiency. For new constructions, it also replaces the regular exterior cladding of a building, further lowering installation cost. Due to the large air volume required during operation, SolarWall is commonly used for commercial or institution buildings that have large ventilation requirements. Indoor air quality can be improved by ventilating larger than normal amount of solar pre-heated fresh air at low added cost. At night, the air plenum also recaptures heat loss from the building envelope and contributes to the overall energy savings. During the summer months when heating is not required, the solar heated air is dumped back outside via a bypass damper.

In a 1997 study (Enermodal Engineering, 1997), SolarWall were deemed economically feasible for use in remote communities in the Northwest Territories. Compared to implementations in populated southern locations with existing electric or natural gas grids, the effectiveness of SolarWall in northern remote locations is compensated by the longer heating period, clear and sunny weather, as well as additional solar gain from snow reflection. Furthermore, energy used in northern communities typically has higher cost and carbon footprint associated with transportation of fossil fuel. Hence, using solar air heating systems to displace of imported fuel in northern remote locations entails reasonable payback times and long-term environmental benefits.

2. Motivation

In a recent survey for all the existing SolarWall systems in the Northwest Territories, it is shown that only two out the six systems are proven to be functional as of December 2012 (Arctic Energy Alliance, 2013). Two others are not in working order, while the state of the other two systems is unknown. With the exception of a system in Fort Smith, which was monitored from April 2000 to March 2002 (Enermodal Engineering, 2001&2002), none of the six systems had any monitoring mandates.

The Northwest Territories has abundant amount of solar energy. For south-facing surfaces with latitude tilt, the annual average of mean daily global solar radiation of Yellowknife (Latitude 62.5°N, 14.4 MJ/m^2) and Fort Smith (Latitude 60°N, 14.8 MJ/m^2), are comparable to southern locations like Montreal (Latitude 45°N, 15.6 MJ/m^2) and Vancouver (49.2°N, 13.3 MJ/m^2) (Natural Resource Canada, 2007).

However, despite the overall sunny weather, the strong seasonal pattern of daily global radiation and its misalignment with heating loads near the Arctic (e.g. short daylight hours in the winter when heating is needed most) poses significant challenges on the solar air heating systems. Moreover, SolarWall systems are particularly prone to high wind conditions (common in NWT) and its efficiency drops quickly with increasing wind speed. Even with perfect sunny, low wind conditions, the solar heated air can only be used (e.g. for ventilation) if it is within a certain temperature range and hot air beyond room temperature is usually bypassed and unused. Therefore, it is imperative to benchmark the in-situ performance of solar air heating systems using monitoring data.

This report focuses on the full description of the monitoring set-up for the solar air heating system at the Weledeh Catholic School. It provides detailed information on the steps of monitoring set-up, sensors used and variables monitored, calculations performed to obtain the energy generation and collector efficiency, and description about the online display of monitoring data. A sample template of energy saving reports is also enclosed (Section 6.2 and Appendix D.5) to assist future decision-making and provide insights on the performance of solar air heating systems in NWT.

3. Project Description of the Solar Air Heating Monitoring at Weledeh Catholic School

The SolarWall system at the Weledeh Catholic School is currently the oldest (installed in 1998) and the largest (192 m^2) solar air heating system in the territory. Implemented near the building's completion, it can be considered as an original construction as part of the building. The wall is oriented at 15º west of south and partially shaded in shoulder seasons (Figure 2). Despite a worn-out fan belt in May 2012 that was quickly fixed, this solar air heating system at the Weledeh has been in operation since its installation in 1998 with minimal maintenance requirement, making it an ideal candidate for on-going monitoring.

Figure 2. SolarWall at Weledeh Catholic School, Yellowknife

With the support from the building facility manager and maintenance staff at the school, the *Arctic Energy Alliance* led this monitoring project in collaboration with *Concordia University* and the *NSERC Smart Net-zero Energy Buildings Strategic Research Network*.

The objectives of this monitoring project are to obtain the energy output and solar fraction (efficiency) of the SolarWall systems in the Yellowknife climate; to track operational issues, if any; and to shed light upon the durability and suitability of similar transpired solar air heating systems in Canada's North.

In order to evaluate the SolarWall performance, variables such as air mass flow rate, exterior temperature, air temperature and relative humidity at collector outlet, need to be monitored. Fortunately, as the SolarWall is directly linked to the building control system (Honeywell), some existing sensors are already implemented and logged by the building control interface to execute thermostatic control algorithms. Though past data were stored in temporary memory and cannot be recovered, the existing infrastructure is able to log future sensor data by asking the software to trend and store sensor values.

By using existing sensors, the cost of implementing monitoring systems can be reduced. With reasonable redundancy in sensor selections, this monitoring project aims to set an example and to build solar monitoring capacity in NWT in an efficient and cost-effective manner. The fieldwork and sensor implementations took place in two sessions (May and December 2012) in Yellowknife.

4. Design and Installation Guide for Monitoring Set Up

4.1 Monitoring Protocol

Compromising between data resolution and file size, the data retrieval interval is set to be every 15 minutes. Calculation of SolarWall power output (W/m^2) is carried out every hour (averaging 4 points). The results are integrated to generate the hourly and daily energy output (kWh or MJ) and solar fraction (%) of the collector.

Two CSV sheets are logged separately, both pertinent to the evaluation of SolarWall performance: one file is trending existing sensors via the Honeywell control interface, and the other file is generated by the new Agilent data acquisition system for all new sensors. At the current file growth rate of approximately 0.136kb per point value, the CSV file comprising all new sensors will be under 10MB per year. Both CSV files will be sent to a FTP server, which merges the data into a MS SQL database, calculates relevant energy savings, and enables online real-time display of SolarWall performance. The on-going monitoring plan aims for a minimum of 1-year data to fully characterize the system capacity.

Appendix C illustrates a step-by-step guide of viewing, reconfiguring, or rebooting the new monitoring laptop. It can be remotely accessed online and is currently sending data values to a online FTP server every 15minutes. The data files (CSV) are saved both on the local hard drive as well as on the server, which synchronizes with the local file path whenever there is internet connection. During occurrence of Internet interruption, the files are simply saved on the local hard drive until connexion to Internet is back on.

On the other hand, the current Honeywell software (Excel Building Supervisor) and host computer at the Weledeh school are too out-dated to trend and save data automatically. Instead, it is only capable of displaying data and output the values to files of obscure extensions with .c12 and .p12. For the moment, the Honeywell data are copied manually to a floppy disk (the only functional output path for the computer) and added to the other data file to conduct the calculations manually. Procedures to copy data from the current computer is elaborated in Appendix C.

The Weledeh school is scheduled to update its control software and host computers to the most recent versions in February 2013, It will then have the capacity to trend and output data to a local file path (.csv) automatically according to a pre-set schedule. The new control computer will also be linked to the internet and will be able to send the logged data to the server directly or via Dropbox.

Realistically, the online display of SolarWall energy output cannot be fully automated without updating the existing control computers and software at the Weledeh first. The critical timeline is therefore contingent upon the renewal of Honeywell control software and host computers.

4.2 Full Descriptions of Equipment and Set-Up

Variables logged from existing sensors via the Honeywell interface (control computer) include:

- Exterior temperature (OAT SF4DaTemp);
- SolarWall outlet air temperature (SF4WallTemp);
- Supply fan status (SF4SaFanStat);

- Supply dampers' status (SF4-AHU5OaDmpr, SF4-AHU6OaDmpr)
- Total ventilation volume supplied by SolarWall and directly from exterior (AHU5OAV, AHU6OAV)

The control sequence dictates that the SolarWall supply fan (SF4) will only turn on when the wall outlet temperature is greater than the exterior temperature by a significant amount. As shown in Figure 3, SolarWall servers as partial fresh air intake for air handling units AH5 and AH6, and building must also be in occupation for solar heated air to be useful (i.e. at least one of fresh air dampers of AH5 and AH6 must be open). Therefore, the SolarWall is characterized as "In Operation" when 'SF4SaFanStat'equals 1 AND either 'SF4-AHU5OaDmpr' or 'SF4-AHU6OaDmpr' equals 1.

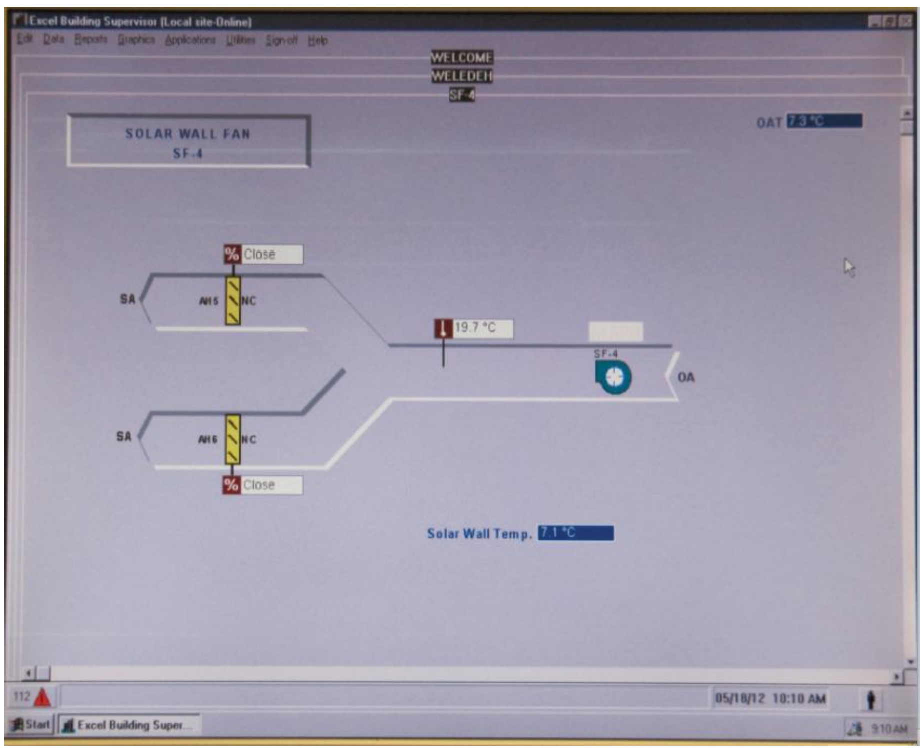

Figure 3. Honeywell Building Control Interface showing the sensors related to SolarWall controls

The SolarWall supply fan (SF4) is a constant speed vane axial fan of 5150 L/s volume flow rate. The specification of the fan is summarized in Table 1 below. Unfortunately, no monitoring equipment is available at the fan section to measure the actual air flow rate. The calculations of SolarWall Energy output is based on constant air volume when the fan is turned on.

Table 1. SolarWall Supply Fan Specifications

Vane Axial Fan QFAN-1, Model number QFNA30 Size 30" (750mm), Arrangement 9, Class 1, Horizontal Discharge	
Tags	Performance
Static pressure water gage (Pa)	125
Fan std air volume (L/s)	5150
Fan speed (rpm)	1155
Fan break horsepower (kW)	2.1

Variables logged from new sensors using the Agilent data acquisition unit are:

- Exterior temperature;
- Solar irradiance;
- SolarWall outlet temperature before fan;
- Air temperature and humidity after fan;

The new sensors and data acquisition system were purchased or donated by the Arctic Energy Alliance and the NSERC Smart Net-zero Energy Buildings Strategic Research Network. Table 2 summarizes all the new equipment installed and in operation at the time of the report.

Table 2. List of New Equipment Installed

Equipment	**Description**	**Supplied by**
Data acquisition Switch unit and Channel	Agilent 34970A Data acquisition Switch Unit, 34901A Multiplexer Module 2/4 wire.	Network
Laptop	Windows XP, DAQ software installed: Agilent Benchlink Data Logger 3, Agilent IO Library Suite.	AEA
Relative Humidity Sensor	Omega HX 71 MA Series RH Probe	AEA

(Duct Insertion style)	Transmitter, (4-20mA), Extra cable, power supply;	
Pyranometer (to measure Solar Radiation)	Li-Cor 200 SA 50, PY 80200, transmitter at 107.3 ohm, Extra cable, mounting base, 10mV per 1000 W/m^2	Network and AEA
Thermocouple (to measure Outdoor Temperature)	T type, no accessory;	Network
Batter Back up, UPS	Cyber Power, CP1350AVRLCD, tested and in operation	AEA
Mobile Internet Stick	Bell MC 679 Turbo Stick, tested and in operation	AEA

As shown in Figure 4 and 5, one relative humidity probe and two thermocouples are positioned in-duct before and after the SolarWall fan. At the building exterior, a pyranometer is mounted on the SolarWall to measure solar irradiance (W/m^2) and a shielded thermocouple is installed at a nearby shaded location to measure the outside temperature.

Note that exterior temperature measurement by the new sensor is a redundant parameter, as it is already logged by an exterior temperature sensor (RTD) located on the other side of the building. Monitoring results indicates that these two sensors have similar values within 1.5°C difference, reasonable considering their difference in locations.

Relative Humidity Sensor Insertion In-duct
HX71-MA

Pyranometer (Solar Radiation) Outdoor Wall mount
LI-200SA-50

Figure 4. Three New Sensors needed to complete SolarWall energy monitoring

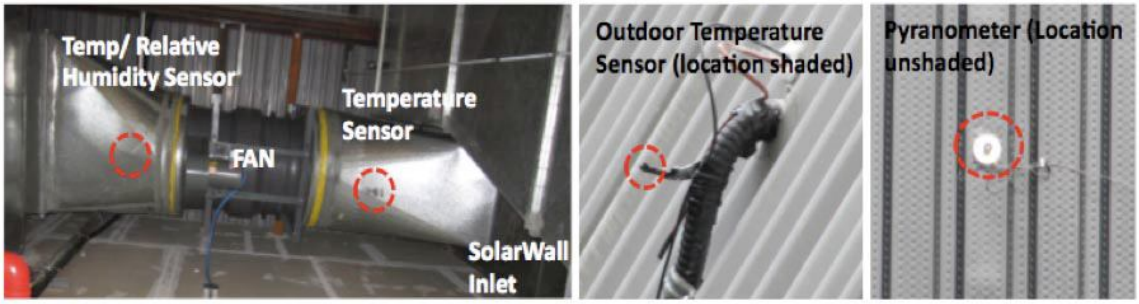

Figure 5. Locations of New Sensors implemented for the Weledeh SolarWall system

The in-duct temperature measured right before the fan is not the same parameter as the SolarWall outlet temperature. The original sensor is positioned directly behind the SolarWall, very close to the wall air inlet. The same location is no longer accessible and the temperature reading near the fan is simply to qualitatively assure that the SolarWall outlet temperature logged by the control system makes sense.

Most sensors are configured with analog output in the mV range. Nevertheless, the relative humidity sensor is configured in the mA range (with an external power supply) to eliminate the static noise caused by long wiring extensions. All the new sensors are wired to feed values into the Agilent data acquisition and processed by the monitoring laptop (Figure 6).

Figure 6. The Monitoring Laptop and Agilent Data Acquisition system for all new sensors

A mobile Internet Stick enables Internet connection on the monitoring laptop. Remote desktop connection is set up to access the monitoring laptop remotely if any changes are required (Details see Appendix C). The data files are saved locally and are automatically synchronized online. To account for the frequent power outage in the city, a UPS battery (Uninterruptable Power Supply) is connected to provide continuous power supply of 3 to 7 hours. In the unlikely case that the UPS is drained before the power comes back on, Appendix C also explains how to reboot the systems locally.

5. Energy Output Calculation

5.1 Density of humid air

Each hour, the density of the solar heated air is calculated from air properties measured immediately after the fan (Figure 5). The T-type thermocouple readings are directly converted to °C by the Agilent data acquisition software, whereas the relative humidity (RH) reading in mA needs to be converted using the following equation:

$$\phi = RH \text{ (in \%)} = \frac{\text{reading [in mA] - 4}}{0.16}$$

The density of the humid air ($\rho_{\text{humid air}}$) is calculated by:

$$\rho_{\text{humid air}} = \frac{p_d}{R_d T} + \frac{p_v}{R_v T} = \frac{p_d M_d + p_v M_v}{RT}$$

where

$\rho_{\text{humid air}}$ = Density of the humid air (kg/m³)
p_d = Partial pressure of dry air (Pa)
R_d = Specific gas constant for dry air, 287.058 J/(kg·K)
T = Temperature (K)
p_v = Pressure of water vapor (Pa)
R_v = Specific gas constant for water vapor, 461.495 J/(kg·K)

And p_v, vapor pressure of water, is given by:

$$p_v = \phi p_{\text{sat}}$$

where ϕ is the relative humidity, and p_{sat} is the saturation pressure given by:

$$p_{\mathrm{sat}} = 6.1078 \times 10^{\frac{7.5T}{T+237.3}}$$

T is the air temperature in °C, p_{sat} is in hPa (100Pa).

While p_d is calculated as:

$$p_d = p - p_v$$

Where p simply denotes the absolute pressure of the system (101325 Pa).

5.2 Incident Solar Radiation

The Pyranometer is installed with matching end transmitter, already calibrated by the manufacturer to give irradiance results varying linearly according to the mV output (10mV per 1000 W/m^2). Therefore, the conversion from reading is given as:

Irradiance (in W/m^2) = Reading (in mV) *100

The sensor itself has a temperature dependence of ±0.15% per °C maximum from 25°C, and absolute error under natural daylight conditions is ±5% maximum, typically ±3%. Note that the pyranometer only reads a Irradiance level at a single location, it does not necessarily represent the average amount of incoming solar irradiance over the entire SolarWall surface (192m^2).

The sensor is deliberately positioned to be outside the shaded area in Spring, in the middle of the collector lengthwise, and at about the top one-third height-wise. However, significant errors can still stem from the point representation of solar irradiation level. In comparison, errors associated with the limitations of the pyranometer are negligible. For future references, placing more pyranometers at discrete, representative locations on the SolarWall could increase the accuracy of solar radiation measurement.

5.3 Instantaneous Collector Output

The instantaneous power of the SolarWall can be calculated by:

$$P_{sw} = VFR \cdot \rho \cdot c_p \cdot (T_{sw} - T_{ext}) \cdot F_{sw}$$

When P_{sw} is in W/m^2; VFR is the volume flow rate of air drawn (m^3/s); ρ is the density of humid air calculated from Section 3.4.1; c_p is the specific heat capacity of air, assumed to be 1.005 kJ/kg°C as it varies very little within temperature range of -50°C and +50°C; (T_{sw}-T_{ext}) is the air temperature rise due to heating by the SolarWall;

F_{sw} is a virtual factor that signifies whether the SolarWall is in operation. If the supply fan is on (=1) and at least one of the air dampers is open (=1), F_{sw} is set to 1; If the supply fan is off (=0) or both fresh air dampers are closed (=0), F_{sw} is set to 0, nullifying the power output of SolarWall at the moment (not in operation) even if the temperature rise is greater than zero.

The exterior temperature used for this calculation is taken from the new sensor installed at a shaded location on the adjacent façade of the SolarWall. For evaluation of SolarWall performance, there are, in fact, two known benchmarks with disparaging results depending where the exterior temperature measurement is taken:

Close to the vertical air film near the SolarWall façade, the exterior temperature is commonly much higher than exterior temperature measured away from the dark façade (Athienitis et al., 2011). Therefore, using exterior temperature at the Wall's immediate inlets would result in a lower energy yield. For the scope of this monitoring project, the exterior temperature is take away from the SolarWall façade, as we are only interested in the overall system performance and energy offset as compared to directly using exterior air for ventilation.

5.4 SolarWall Energy Output and Solar Fraction

The useful energy captured by the SolarWall, Q_{sw}, is calculated by integrating the power at discrete time intervals (Δt=15min):

$$Q_{sw} = \sum (P_{sw} \cdot A_{sw})\Delta t = \sum (VFR \cdot \rho \cdot c_p \cdot (T_{sw} - T_{ext}) \cdot F_{sw} \cdot A_{sw}) \cdot \Delta t$$

where A_{sw} is total area of the SolarWall (192 m^2). This calculation is performed for the four data points within the hour to generate one value of Q_{sw} every hour. Similarly, the solar gain (G) on the entire façade is also integrated for each Δt=15min over the entire area:

$$G = \sum (\text{Irradiance} \cdot A_{sw}) \cdot \Delta t$$

With some unit conversions, the values of Q_{sw} and G can be expressed in MJ or kWh.

Lastly, the solar fraction (f), or collector efficiency, is defined as the amount of solar thermal energy captured by the SolarWall and used for preheating ventilation:

$$f_{sw} = Q_{sw} / \text{G}$$

The same calculation of f_{sw}, Q_{sw} and G can be carried out for summation of each hour, each day, or each month.

5.5 Building Heat Loss Recapture at Night

In addition to the active energy capture, the other added benefit of solar air heating system is its ability to recapture the building heat loss at night. To better understand the concept heat recapture, the term 'at night', should be referred to as 'periods when SolarWall is not in operation' instead. When the outdoor temperature is lower than building interior, the air cavity behind the metal cladding adds insulation value to the original building envelope, as long as there is no active drawing of air through the façade pores.

However, it is not easy to quantify exactly how much heat is captured due to the existence of SolarWall cavity. In calculating the thermal resistance of a multi-layered installation, the R-values of the individual layers are added. The difference in envelope heat loss ($\Delta Q_{heat\ loss}$) between a normal wall (wall 1), and the same wall with SolarWall addition (wall 2) can be expressed as:

$$\Delta Q_{\text{heat loss}} = \Delta T \cdot (U_1 - U_2) \cdot A$$

where U1 and U2 are overall thermal conductivity of the two wall assemblies:

$$\frac{1}{U_1 A} = \frac{1}{h_{O\_1} A} + R \quad , \quad \frac{1}{U_2 A} = \frac{1}{h_{O\_2} A} + R + R_{aircavity}$$

ΔT (K) is the temperature difference between the exterior and the building interior; A (m^2) is the area of interest; R is the thermal resistance (m^2K/W) comprising all the same wall layers and interior air film; $R_{\text{air cavity}}$ is the resistance of the SolarWall air cavity (15cm to 30cm); h_{O_1} and h_{O_2} are the outside air film coefficients of the two wall assemblies, respectively.

A common simplification is to assume h_{O_1} and h_{O_2} are the same value when SolarWall are not in operation. The heat recapture due to SolarWall cavity can be simplified as:

$$\Delta Q_{\text{heat loss}} = \Delta T \cdot A \cdot \left(\frac{1}{R} - \frac{1}{R + R_{aircavity}}\right)$$

In reality, the corrugated and perforated surface profile of SolarWall will exhibit a very different air film coefficient than a normal flat wall surface. In other words, the values of h_{O_1} and h_{O_2} will never be the same. The value of h_O also changes with surface wind conditions (speed and direction). Computerized Fluid Dynamics (CFD) analysis is necessary to determine the h_O values with more confidence. However, with no local wind data available on a commercial scale system, one can only assume that the effect of h_O is negligible.

The effective thermal resistance of the enclosed air cavity ($R_{\text{aircavity}}$) is strongly influenced by radiative heat transfer and distance between the two surfaces. For high emissivity surfaces, the value of $R_{\text{aircavity}}$ doesn't vary much beyond 10 cm in cavity depth (McQuiston, 2005). For the calculation in this monitoring project, the heat loss recapture employes a constant $R_{\text{aircavity}}$ value of 0.2 m^2K/W and uses the simplified equation for heat recapture ($\Delta Q_{\text{heat loss}}$).

6. Long-Term Monitoring Plans

6.1 Description of the Online Data Display

As one of the project objectives, the monitoring data and energy saving calculations will be made available online. Using an automated file transfer tool (Fling FTP), the two CSV files are uploaded automatically to a secure FTP site hosted by the AEA (details see Appendix C.1). The data from the two files will then be imported and merge in a unified database in MS SQL server. Calculations are performed at the database level and the end results are ready for display at different time intervals (hourly, daily, monthly).

Samples data files from the Honeywell trending and the Agilent acquisition are shown in Appendix D. Sample calculations for energy savings and other variables of interests are shown in Excel format. Collaborating with *SOS New Media*, those variables of interest will be calculated automatically to display online via a web interface.

A dashboard interface can be used to visualize the data accessible for the general public. The main interface could consist of plots and graphics only, with the option to view values in a tabular form if desired.

Recommended Daily Display for the **Daily SolarWall Performance Web Interface** (Data Resolution: Hourly) involve bar chart for the following variables:

- Average Hourly Exterior Temperature (°C)
- Average Hourly Solar Irradiance (W/m2)
- Average Hourly Instantaneous output from SolarWall (W/m2)
- Number of SolarWall operational hours in the day
- Total Daily Solar Radiation (MJ/m2)
- Total daytime energy output from SolarWall (MJ/m2)
- Daily Mean Solar Fraction (Yield) of SolarWall output (%)
- Daily heat recapture at night (MJ/m2)

Similar display can also be applied for monthly averages. Monthly bar charts of the variables above such as daytime solar air heating energy (MJ), night heat recapture output (MJ) and operating hours in a month can be displayed on the web as data accumulates throughout the year.

6.2 Set Up of Annual Energy Saving Report

One of the main objectives from the monitoring efforts is to determine the annual energy savings as a result of the solar air heating system at the Weledeh School. The first year's monitoring data will be used to produce an Annual Energy Saving Report that quantifies the energy benefits due to the SolarWall system. The results will be used as a baseline to compare with the second year's monitoring data if available, and possibly to project the past and future energy savings of solar air heating at the Weledeh school.

Monthly bar charts involving the following variables should be included in Annual Energy Saving Report:

Weather related variables:

- Average Monthly Exterior Temperature (°C), from the closest weather station and measured on-site
- Average Monthly Exterior Wind Speed (m/s), from the closest weather station
- Total Monthly Solar Radiation (MJ/m2), from the closest weather station and measured on-site

Total energy output:

- Monthly daytime energy output from Solar Air Heating (MJ/m2)
- Monthly Mean Solar Fraction (Efficiency) of SolarWall daytime output (%)
- Total Monthly Heat recapture at night (MJ/m2)
- Total Monthly energy output of SolarWall (air heating and heat recapture) (MJ)

Transient performance:

- Days of SolarWall operation in a month
- Total hours of SolarWall operation in a month
- Peak Instantaneous output from SolarWall (W/m2)

Environmental Benefits:

- Displacement of heating oil (litre)
- Associated Greenhouse Gas (GHG) displacement (kg)

The displacement of fossil fuel and its associated GHG footprint is calculated according to multipliers given by RETScreen-NRCan:

- Diesel Fuel/ #2 Heating Oil – 38.7 MJ per litre
- Heating Oil/Diesel (per litre)   2.87 kg's of CO2 produced

For example, for a theoretical annual energy savings by SolarWall of 38700MJ, the displacement of diesel fuel is 1000 liter, equivalent of 2870 kg of CO2 avoided.

The energy saving report will lay the foundation for future durability and suitability investigation of Solar Air Heating systems in the NWT. Using the indicators listed above, the daytime energy output of solar air heating (MJ/m^2) in relation to weather conditions such as solar radiation, exterior temperature and wind speed can be evaluated.

In addition, the hourly data (averaged from data every 15min) during peak months (shoulder seasons) will provide insight to the temporal patterns of SolarWall operation during a typical day. As solar air heating functions best with low outdoor temperature, long sun-lit hours, and high ventilation demands/long operation hours, ameliorations for operation strategies can be recommended accordingly.

Ideally, a minimum of two-year monitoring data should be collected. The first-year results of energy saving can be used as a baseline, and energy savings for the following year can be projected. The projected result is then validated by the second-year monitoring data.

Some financial analyses to calculate the economical feasibility of solar air heating systems can also be carried out assuming the annual energy savings in the past is similar to the monitored period of 2013-2014. More details of the energy saving report can be found in Appendix D.5 and the excel file.

7. Conclusions

This monitoring project aims to achieve the following objectives:

- To provide a comprehensive case study that can be reproduced for other monitoring projects
- To track the energy output of the 14-year old SolarWall system
- To determine the durability and suitability of solar air heating systems in NWT based on monitoring data
- To make the information accessible to the public via a real-time, graphic web interface
- To learn from existing installations and to help develop a long-term design and installation guideline for future solar air heating systems in NWT.

The solar air heating system at the Weledeh School is currently being monitored, though it is still necessary to manually extract the data from the building control system at the moment. Once the control software and computer are updated to enable automated trending, the monitoring data and energy saving results will be fully accessible online. An annual energy savings report is expected after one-year of continuous monitoring.

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