IMPACT OF STUDENT INVOLVEMENT IN A SOLAR WALL STUDY FOR THE STATE OF MINNESOTA

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ACKNOWLEDGMENTS

BACKGROUND

- Unglazed transpired solar collectors (UTC)

- Experimental performance characterization

- Found to be acceptable for MN climate (74 MBtu/ft^2 annual savings and 40 F temperature increase)

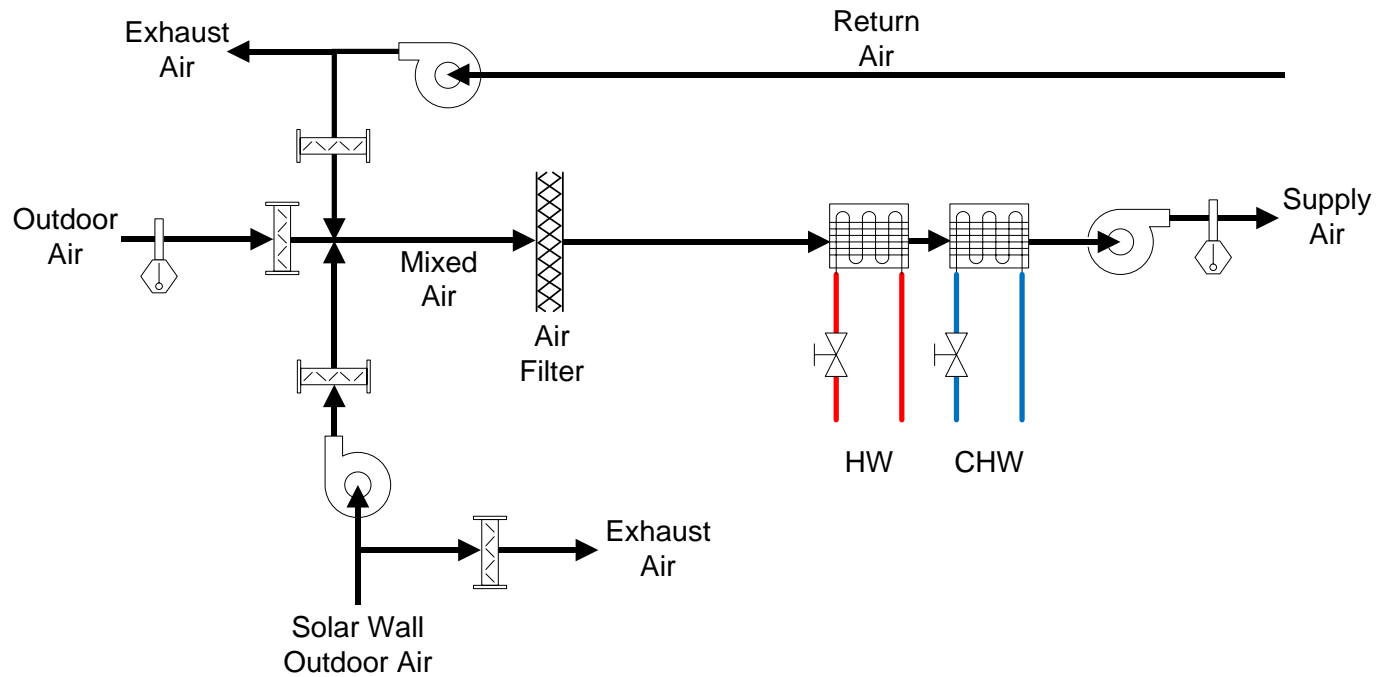- Student assistance has been a major component

WHAT EXACTLY IS A UTC?

Perforated
Collector
Plate

Solar
Radiation

Exiting Air

Ambient
Air

Recaptured
Wall Loss

Wall
Loss to
Environment

Building
Wall
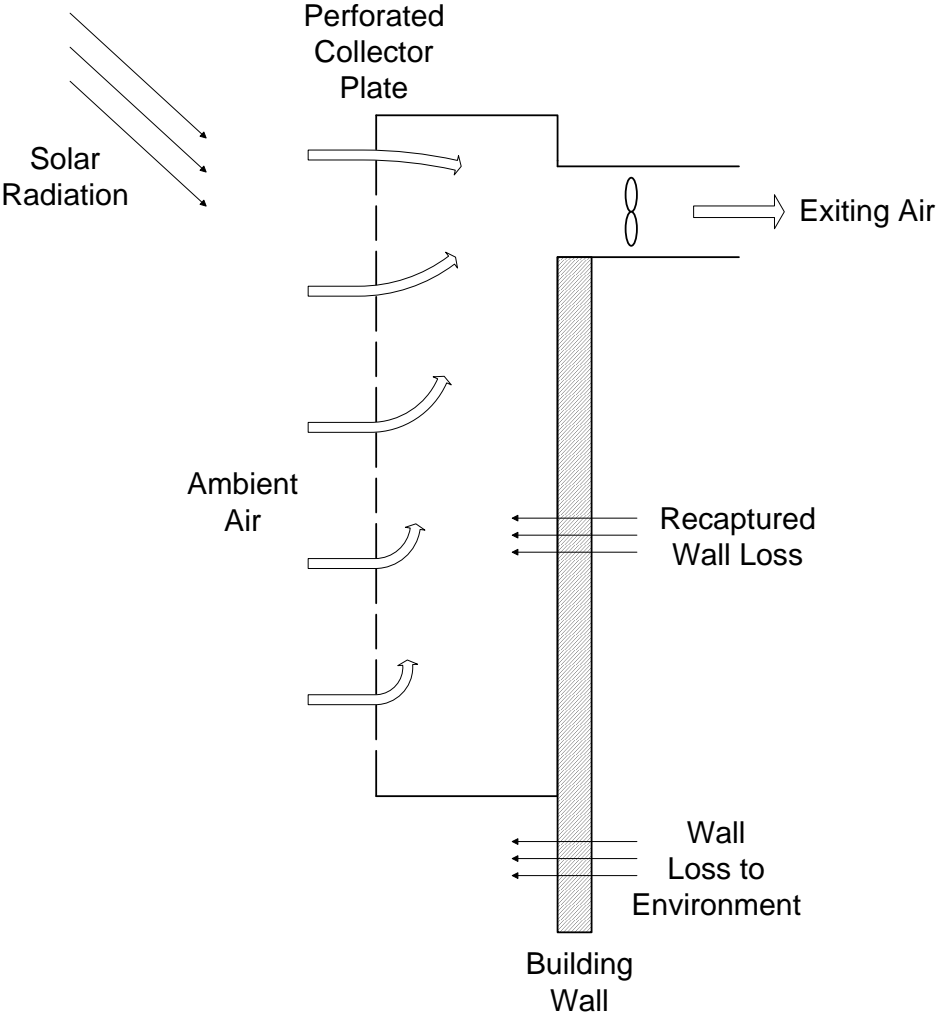
AVEDA UTC INSTALLATION

3RD PRECINCT HVAC SYSTEM

STUDENT SUPPORT

- Literature and background review
- Experimental planning and sensor selection
- Weather station installation
- Temperature sensor construction
- Data collection
- Data reduction and analysis

STUDENT ORGANIZATION

- Peer mentoring was used.
- New students were recruited as students graduated or left for other activities.
- Students worked with different faculty depending on tasks being addressed.
- Increasing levels of responsibility were given as experience grew.
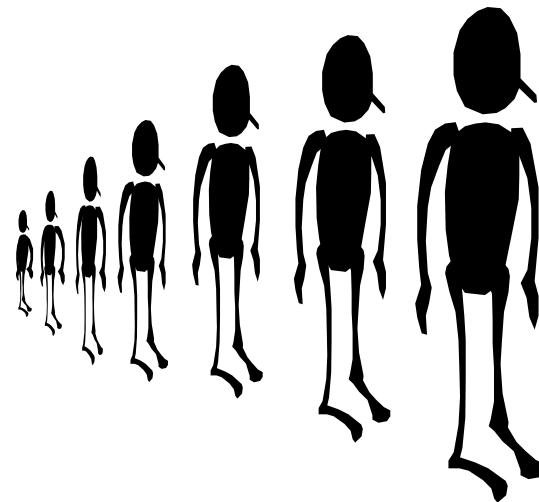
JANUARY IS COLD

- Weather stations for 3rd Precinct and AVEDA were installed in January (on the roofs of the buildings).

AVEDA UTC INSTALLATION

12 . 18 . 2008
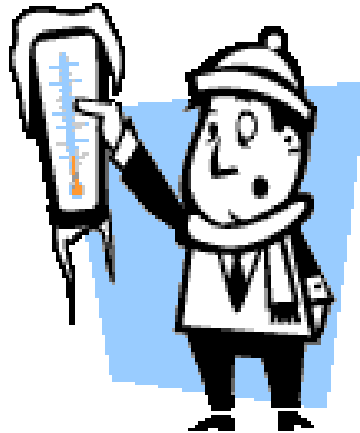
SO IS OCTOBER

"This experience has shown me that the best you can do in these situations is accept that things didn't go as planned and just keep moving forward."

BRECK SCHOOL INSTALLATION

STUDENT PERSPECTIVES

"I found it interesting to see how concepts which are given separate treatment during instruction are very interrelated in practice."

"Learning about the attention to detail required to write for a professional journal was truly eye opening. "

Equations:

Energy saved and used (all sites):

$$\dot{Q}_{save} = \dot{V} \cdot \rho \cdot c_p (T_{SWOA} - T_{OA})$$

$$\dot{Q}_{aux} = \dot{V} \cdot \rho \cdot c_p (T_{SA} - T_{MA})$$

Vertical Irradiance Given Horizontal Irradiance:

$$\cos \psi = \sin \theta \sin \theta_s + \cos \theta \cos \theta_s \cos(\alpha_s - \alpha)$$

$$G_\psi = G_H e^{-k_t(\psi^2 - \theta_s^2)}$$

Heat Transfer by Conduction/Convection:

$$\dot{Q}_c = U_c A (\bar{T}_c - T_{\infty,i})$$

$$\dot{Q} = UA(T_{\infty,o} - T_{\infty,i})$$

$$U_c = \frac{1}{\frac{1}{h_i A} + R_{bldg.wall} + \frac{1}{h_i A}}$$

$$U = \frac{1}{\frac{1}{h_o A} + R_{bldg.wall} + \frac{1}{h_i A}}$$

$$T_{OW,c} = \bar{T}_c + \frac{\dot{Q}_c}{h_i A}$$

$$T_{IW,c} = T_{\infty,i} - \frac{\dot{Q}_c}{h_i A}$$

$$T_{OW} = T_{\infty,o} + \frac{\dot{Q}}{h_o A}$$

$$T_{IW} = T_{\infty,i} - \frac{\dot{Q}}{h_i A}$$

Solar Wall Air Mass Flow Rate Fraction for Aveda:

$$\dot{m}_{SWOA} = \dot{m}_{SA} \frac{(T_{OA} - T_{MA})}{(T_{OA} - T_{SWOA})}$$

Moist Air Enthalpy:

$$\hbar = 0.240T + W_{OA}(1061 + 0.444T)$$

$$W_{OA} = 0.621945 \left(\frac{p_w}{p - p_w} \right)$$

$$p_w = \phi \cdot p_{ws}|_{t,p}$$

$$\ln p_{ws}|_{t,p} = \frac{C_8}{T} + C_9 + C_{10}T + C_{11}T^2 + C_{12}T^3 + C_{13} \ln T$$

where,

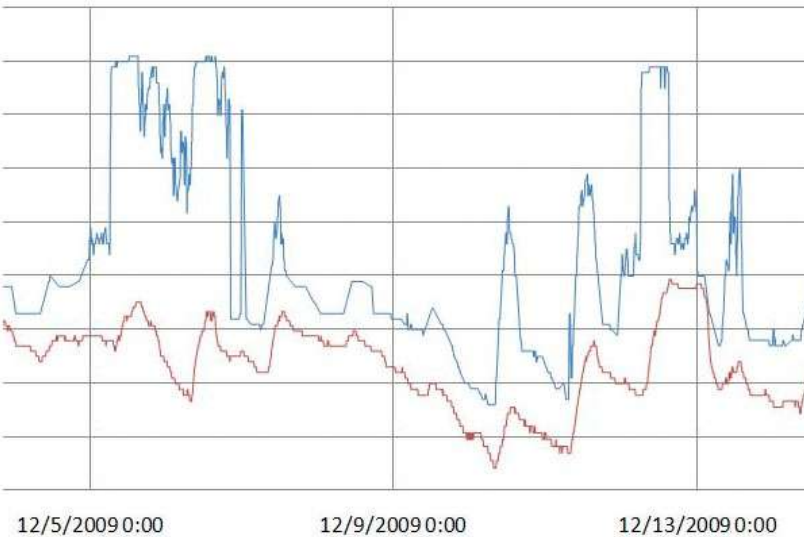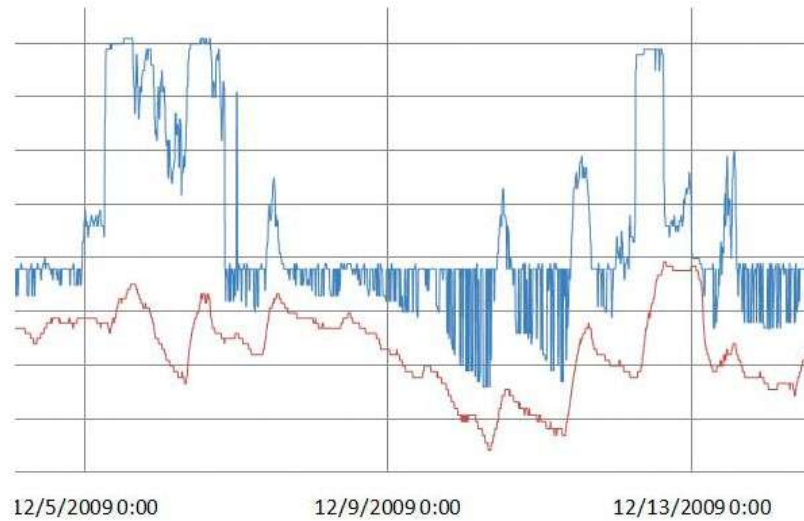$C_8 = -1.044\,039\,7 \times 10^4$

$C_9 = -1.129\,465\,0 \times 10^1$

$C_{10} = -2.702\,235\,5 \times 10^{-2}$

$C_{11} = 1.289\,036\,0 \times 10^{-5}$

$C_{12} = -2.478\,068\,1 \times 10^{-9}$

$C_{13} = 6.545\,967\,3 \times 10^0$

12/5/2009 0:00   12/9/2009 0:00   12/13/2009 0:00

12/5/2009 0:00   12/9/2009 0:00   12/13/2009 0:00

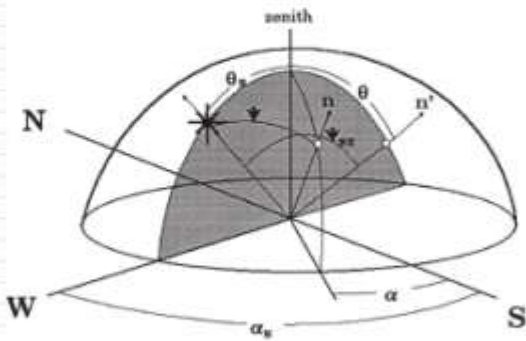| Date_Time	Solar Radiation _2246777 W/m^2	equation of time hours	local apparent time hours	hour angle radians	ω_t radians	declination at solar noon δ radians	earth-sun distance correction ε	$G_{0(t)}$	k_t
11/1/2009 0:04	0.625	-0.09097	0.198574	-3.08961	6.813535	0.20	1.17	0	0.00
11/1/2009 0:12	0.625	-0.09097	0.331908	-3.0547	6.813535	0.20	1.17	0	0.00
11/1/2009 0:20	0.625	-0.09097	0.465241	-3.01979	6.813535	0.20	1.17	0	
11/1/2009 0:28	0.625	-0.09097	0.598574	-2.98489	6.813535	0.20	1.17	0	
11/1/2009 0:36	0.625	-0.09097	0.731908	-2.94998	6.813535	0.20	1.17	0	
11/1/2009 0:44	0.625	-0.09097	0.865241	-2.91507	6.813535	0.20	1.17	0	
11/1/2009 0:52	0.625	-0.09097	0.998574	-2.88017	6.813535	0.20	1.17	0	
11/1/2009 1:00	0.625	-0.09097	1.131908	-2.84526	6.813535	0.20	1.17	0	
11/1/2009 1:08	0.625	-0.09097	1.265241	-2.81035	6.813535	0.20	1.17	0	
11/1/2009 1:16	0.625	-0.09097	1.398574	-2.77545	6.813535	0.20	1.17	0	
11/1/2009 1:24	0.625	-0.09097	1.531908	-2.74054	6.813535	0.20	1.17	0	
11/1/2009 1:32	0.625	-0.09097	1.665241	-2.70563	6.813535	0.20	1.17	0	
11/1/2009 1:40	0.625	-0.09097	1.798574	-2.67073	6.813535	0.20	1.17	0	
11/1/2009 1:48	0.625	-0.09097	1.931908	-2.63582	6.813535	0.20	1.17	0	
11/1/2009 1:56	0.625	-0.09097	2.065241	-2.60091	6.813535	0.20	1.17	0	
11/1/2009 2:04	0.625	-0.09097	2.198574	-2.56601	6.813535	0.20	1.17	0	
11/1/2009 2:12	0.625	-0.09097	2.331908	-2.5311	6.813535	0.20	1.17	0	
11/1/2009 2:20	0.625	-0.09097	2.465241	-2.49619	6.813535	0.20	1.17	0	
11/1/2009 2:28	0.625	-0.09097	2						
11/1/2009 2:36	0.625	-0.09097	2						
11/1/2009 2:44	0.625	-0.09097	2						
11/1/2009 2:52	0.625	-0.09097	2						
11/1/2009 3:00	0.625	-0.09097	3						
11/1/2009 3:08	0.625	-0.09097	3						
11/1/2009 3:16	0.625	-0.09097	3						
11/1/2009 3:24	0.625	-0.09097	3						
11/1/2009 3:32	0.625	-0.09097	3						
11/1/2009 3:40	0.625	-0.09097	3						

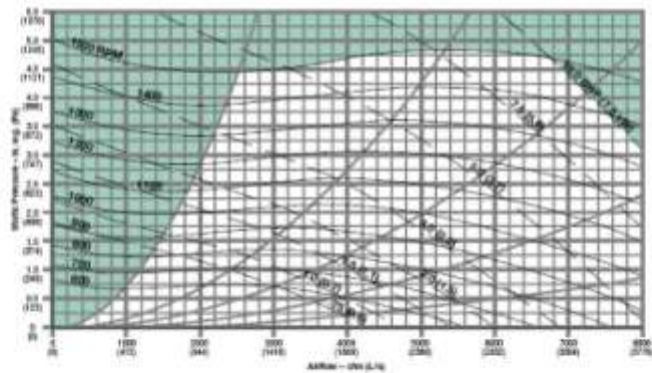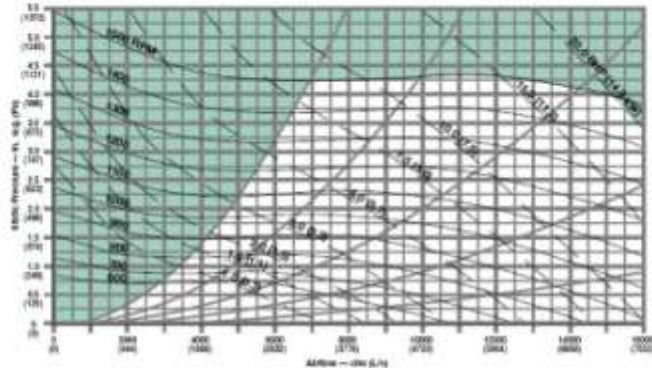Figure 34. RDS 800C supply fan, (2) 15" x 6" forward curved

Figure 35. RDS 800C supply fan, (2) 15" x 15" forward curved

CONCLUSIONS

Students have been integral to this project (it could not have been done without them).

The students have grown during this project.

The project experience touches on many, if not all, of the ABET outcomes a-k.