Solar Deck- Emphasis on hands-on experiments

Solar Thermal Collector Testing Setup on Solar Deck

Tracker
Test House
Collectors
PV Panels
Tubes
Cooker
Winter Solstice
Summer Solstice
Weather Station

LEGEND
Air Bleed Valve
Pressure Relief Valve
Expansion Tank
Collector 2
Flat Plate Collector 1
Serpentine Design
Water Heater 40 Gallons
Closed Inlets/outlets
The research vision was to develop a new adaptive learning methodology for sensor-actuator control systems for legacy buildings. It would be low cost and could be automated resulting in minimizing manual customizations and provide a much higher level of flexibility, additional features and evolution of needs.
Significance of the Research:

- an innovative approach to implement and dynamically control advanced building elements and systems
- investigation, demonstration and refinement of self-learning and adaptive control algorithm
- self-learning automatic adaptation when over time physical and operational changes are made to the building
- system is “generic”, expandable and not preprogrammed for a particular building
- can impact energy efficiency, ease the maintenance and customizations and handling of failures
Research Approach:
Research Methodology: *Test Cell- Daylighting Study*
Adaptive Intelligent Control (AIC)

About the Test Cell:
- **Size:** 8 ft X 8 ft X 8 ft
- **Location:** Solar deck of The Design School–North Building
- **Equipped with:** 9 sensor-motes, actuators, automated internal window blinds, dimmable lighting fixtures, air-conditioning systems and electronics.

Simulation Steps:
**Step 1:** Daylighting Simulation Results are performed for discrete days and times of year:
- June 21: 10 am, 12 pm and 2 pm
- September 23: 10 am, 12 pm and 2 pm
- December 23: 10 am, 12 pm and 2 pm
- Different blind angle openings: 0 (fully Open), 15, 30, 45, 50 (fully Closed)

**Step 2:** Application of MATLAB code to determine blind settings for discrete simulation cases:
Control objective was to get illumination levels at all 9 measurement points as uniform as possible. The applied MATLAB code is calculating CV values of each case. The following graphs show the best blind angles for the 3 simulated days. The following graph shows the steps to calculate the CV values:
- **SSE Calculation** (yi = 250 LUX for all combinations)
- **RMSE Calculation**
- **CV Value Calculation**

Simulation Results:

References:

nbi 2012
Nasim Karzi
Chair Professor
Agam Reddy
Herberger Institute for Design and the Arts
PhD Fall Exhibit 2012
Nasim Karzi
Chair Professor
Soffit Vents and Energy Savings

PROJECT ABSTRACT

GOAL: LOW COST STRATEGY FOR RESIDENTIAL ENERGY SAVINGS

The effects of soffit ventilation at attic temperatures and consequent heating and cooling loads was studied. Ideal soffit venting strategies include rafter vents and a ridge vent to create a superheated airflow through attics. However typical existing residential construction only includes gable vents on either ends of the building with two soffit vents, such as whirlwinds. The experiment studied the proposition that the simple addition of inexpensive soffit vents could result in energy savings with a simple payback period of less than a year or two.

THE EXPERIMENT

Two sets of measurements were taken on days of moderate cooling and moderate heating loads. Both sets of measurements showed reduced loads due to the addition of soffit vents. Prominent relative reductions in load would be expected if only the residential occupancy hours are considered. Furthermore the measurements were taken in October and November and therefore do not represent the peak loads. Higher temperature differences and thus greater savings would be expected during the peak summer and winter conditions. With further measurements testing the entire building during peak loads an accurate annual savings estimate is possible.

CALIBRATION AND TRIAL RUN

EFFECT OF SOLAR RADIATION ON TEMPERATURES WITHIN THE ATTIC
1. Increase in solar radiation results in rise of temperature in the attic during the daytime.
2. South side of the building results in more heating, hence higher temperatures.
3. Though SE eave temperature observed a rise, the temperature near the ridge for both vented and non vented remain almost the same.

WIND EFFECT ON TEMPERATURES WITHIN THE ATTIC
1. Not much winds speed observed during the setup for the soffit vented days.
2. The fluctuation in the wind flowing from the South can be observed in the temperature near South-East area for the November data.
3. Not much change observed in the center of the attic due to the air flow which is for a small period of time.

DESIGN OF EXPERIMENTAL SETUP

BUILDING DESCRIPTION
Single Family Residence
Location: Mesa, Phoenix
Area of the house: 2,000 sq ft approximately
Roof: Uninsulated Asphalt shingle roof

TEST CASES

1. No Venting
2. Soft with Gable & Whirlwind Venting

SETUP

1. Two sets (A and B), each having 6 thermocouple wires of varied lengths measured at various locations:
   - Distributed thermocouples
   - Attic: Below roof
   - Attic: Above Roof
   - Interior Ambient

2. 2. Set A: Toward the eave center, Set B: Toward the Gable

MEASUREMENTS

Cooling Load Days: 2 days in October (no vent and vented)
Heating Load Days: 2 days in November (no vent and vented)
Visual Image of the attic Interior

The data collected was compared with the weather conditions of the setup days.

POSSIBLE EXPERIMENTS WITH SETUP

A HOME EFFECTIVE EXPERIMENT

This experiment only tested one quarter of the building with soft venting. Also the readings were taken at mid-times of the year. Ideally the entire building would be equipped with vents and measurements would be taken at peak times of the year. Furthermore the addition of rafter and ridge vents would lead to more complete remediation of the attic ventilation.

SERIES A. LOCATION CLOSER TO THE GABLE VENT

Series A, is a more accurate approximation of the vented configuration as the plane of thermocouples is located between the gables and whirlwind vents with soft vents on either side.

The heating load graph shows the addition of the soft vents would not increase the heating load in favor of lowering the cooling load during summer. Actually the heating load also showed a small reduction due to soft venting as well.

SERIES B. LOCATION CLOSER TO BUILDING CENTER

Soffit venting shows small reductions at peak loads but cools the attic much faster at night and keeps temperatures lower throughout the night.

The eave temperatures are very similar for both configurations with the SE being about overall higher temperatures due to eave exposure at the this time of year.

CONSTRUCTION AND INSTRUMENTATION

MATERIALS
1. Thermocouple Wire - Type T
2. Foam Insulation Board
3. Ruler
4. Screwdriver
5. Needles, Plier
6. Scissors

INSTRUMENTATION

Agilent Data Logger 34970A Plug in module: 26 channel Multiplexer

CONSTRUCTION

1. Soft Venting: Already present
3. Two sets of the thermocouples at the various mentioned points near rafters in the attic were fixed.
4. Data logger was used to measure the readings of thermocouples.

LESSONS LEARNED AND IMPROVEMENT AREAS

COOLING AND HEATING DEGREE MINUTES

An attempt to quantify the sun-day benefit of venting was done by calculating the degree minutes over a day. Both the cooling and heating days measured actually showed the building to stay in the comfort zone. By assuming the overall behavior would be the same the minimum and maximum temperatures for the cooling and heating conditions were used for calculation.

While this approximation shows a benefit due to the soft venting, the actual benefit would likely be much more if the data was acquired during peak loads.

ATE 562 Experimental Evaluation

Robert Murray, Evelyn Ochoa, Meha Sharma
Efficiency of Thermal Collector

**PROJECT ABSTRACT**
- The aim of this experiment is to find out the efficiency of a thermal collector in different conditions.
- Readings are recorded to find the effect of water flow on the efficiency of the collector.
- Study is also carried out to find the effect of insulation on the efficiency of the flat plate collector.
- Different sets of readings are taken with insulation of the pipe and without insulation of the pipe.

**INSTRUMENTATION**
1. Flat Plate Collector
   Make: Vaillant
   Model No.: VFK 135D

2. Data Logger
   Make: Agilent
   Model No.: 34970A

3. Pyranometer
   Make: LiCor 200SZ
   Model No.: PY 78969

4. Pipe Insulation
   Make: Frost King

5. Vibration Resistant Platinum RTD (PT100) Sensor
   with M12 Connector and Mounting Thread
   Make: Omega PP-21 RTD

**DATA ANALYSIS**

**Experimental Setup**

**CONCLUSION**
- Larger flow rates are having better thermal efficiency, as they have lower rise in temperature across panel and hence less convective heat loss from panel.
- Pipe outlet is showing a time lag due to lower flow rates.
- Temperature drop across piping reduced after adding insulation, which increases efficiency of the whole system.
- For a closed cycle, an optimum flow rate is advised focusing on minimizing heat loss from piping and storage tank.

**FUTURE SCOPE**
- Connecting more panels to increase efficiency and catering to larger demand.
- Studying the change in output by using different types of thermal collectors.
- Studying efficiency of the collector in different weather conditions.

Shriya Kulkarni, Anupam Raj
### Solar Panel Awning

**PROJECT OBJECTIVE**
- To study the performance of the awning at various orientations and tilted angles with a solar panel mounted on it.
- To measure how much power generated from the panel varies with the change in the tilt of the awning at a particular orientation of the window.
- To measure how much the height of the shaded region of the study area (here, window) varies with the change in the tilt of the awning at a particular orientation of the window.
- Find out whether the power generation and the shaded region values interact with each other independently of tilt and orientation.
- Find out the optimum angle which gives balanced output between power generation and shaded region of the window.

**EXPERIMENTAL SETUP**
- Orientation: 0°(S), 90°(W), -90°(E)
- Tilt: 0°, 60°, 45°
- Using the Sxnet solar tracker software set the panel in desired position.
- Measure the panel power input to the battery
- Duration: 9am - 5pm
- Interval: 10min
- Calculate the height of shaded region using solar angles for the given day

**ACTUAL SETUP**
- 170W PV module – bp solar
- SX170B-multicrystalline silicon cells
- Solar TRACKER- SxNET TOOL
- Battery input output data logger-Tristar
- MPPT- MSview

**ANALYST & RESULTS**

**CONCLUSION**
The mounted solar panel does perform as per the expectations. The tilted panel produces more power than the horizontal panel in South & West orientation. But for the east side this not the case.
The panel output and shading device does have interaction with each other.
The optimum tilt for the power generation and controlled shaded region for,
Window on South side – 30°% Power - (+)25%, Avg shaded region ht- 3.5ft
Window on West side – 30°% Power- (+)82%, Avg shaded region ht- 3.5 ft
Window on East side – 0°

**LESSONS LEARNT AND IMPROVEMENT SCOPE**
- More Number of tilt angels should be studied.
- Interactive model can be developed for decision making model for the optimum tilt angle for the particular orientation.
PROJECT ABSTRACT

Objective  
External louvers are increasingly used to provide solar protection for building glazed surfaces. This work is a comparative study of the effect of louver shading devices. The purpose of our experiment is to measure the effect of shading on southern building facades. The experiment was conducted on two buildings, South facade of Health services exam room and Design North Studio. The objective is to know how beneficial is shading to southern facades.

Method  
We performed data collection and analysis using a number of instruments such as thermocouples, pyranometer, photometer, Agilent Data logger, and Agilent data logger software.

Observation  
Shading resulted in lower thermal heat gain in comparison with unshaded facades. It balances daylight.

CALIBRATION AND TRIAL RUN

The experiment was performed on the course work of 3 experimental days which was affected by climate change.

Experiment schedule:  
Nov 27th: 9 am to 4 pm  
Nov 28th: 11 am to 1:30 pm  
Nov 29th: 2:45 pm to 4:30 pm

Below are the graphs of the experiment data:

The graph above shows few readings which have shot above the rest of the readings. The reason behind is that it was a bit cloudy on the day the readings were taken. And the jump is seen in the period when the sun is perpendicular to the Earth surface. Due to the uncertain activity in the weather, there is sudden jump in the graph.

DESIGN OF EXPERIMENTAL SET UP

Solar heat gain has been evaluated in two different places  
1. CDH South Window  
2. Health services

A number of thermocouples were installed at different places to record surface temperatures. A data logger was used to record data. The data sensors are used recording the light intensity, pyranometer, and temperature on the screen. The data logger was placed on an external wall to record the temperature.

Internally, Agilent data logger is used to record data. The thermocouple is placed on the wall to record the internal temperature of the wall. Both the pyranometer and the photo sensor are connected to the data logger to record the data.

Another Hobo data logger is also used to record the internal temperature of the room and the light intensity inside the space. The data is taken from 11:00 to 4:00 p.m. when the sun is around the south side.

Comparative analysis of the temperature, light intensity, solar radiation and temperature of the exterior and interior. Infrared images were taken from both sides to compare the heat transfer through the wall.

POSSIBLE EXPERIMENTS AND SETUP

Some of the experiments that could be done using this set up is:

Testing east and west side of the buildings in addition to the south. Comparing different glass types, and calculating the SHGC of the glasses that has been used. Comparing between different types of shading structures. We could use heat flux sensors to measure the heat transfer through the wall.

We could perform the experiment for longer period of time.

CONSTRUCTION AND INSTRUMENTATION

LESSONS LEARNT AND IMPROVEMENT AREAS

The image illustrates how the Trex screen is absorbing heat. The low E glass is not absorbing much. This shows how cool is the window frame behind the Trex screen. The photos are consistent with our prediction.

The building with tree shading device decreases the heat gain through the walls. The shaded vs. unshaded walls show a clear difference in temperature for both outside and inside.

The shaded window transmitting less heat than the unshaded room. The solar radiation has more influence on heat gain than the outdoor air temperature. The windows are very hard to isolate and analyse.

The ambient temperature influences the solar heat gain. The result is the solar radiation has more influence on heat gain than the outdoor air temperature.

ATE 562 Experimental Evaluation  
Sara Alavizadeh-Bhoomi Desai- Jaykumar Elumali
Real Time Energy Monitoring of College Avenue Commons

Wall & Roof Assemblage - **Thermal Resistance Monitoring**

South View

Side by side comparison of light louvers

**Lights, Plugs, HVAC, etc.**