

Degree of Comfort

A Thermal Comfort Study of 41 Cooper Square

Yudi Guo, ME '14

Daniel Moreno, ME '14

Advisor: Professor Melody Baglione
ME164 Capstone Senior ME Design



Problem

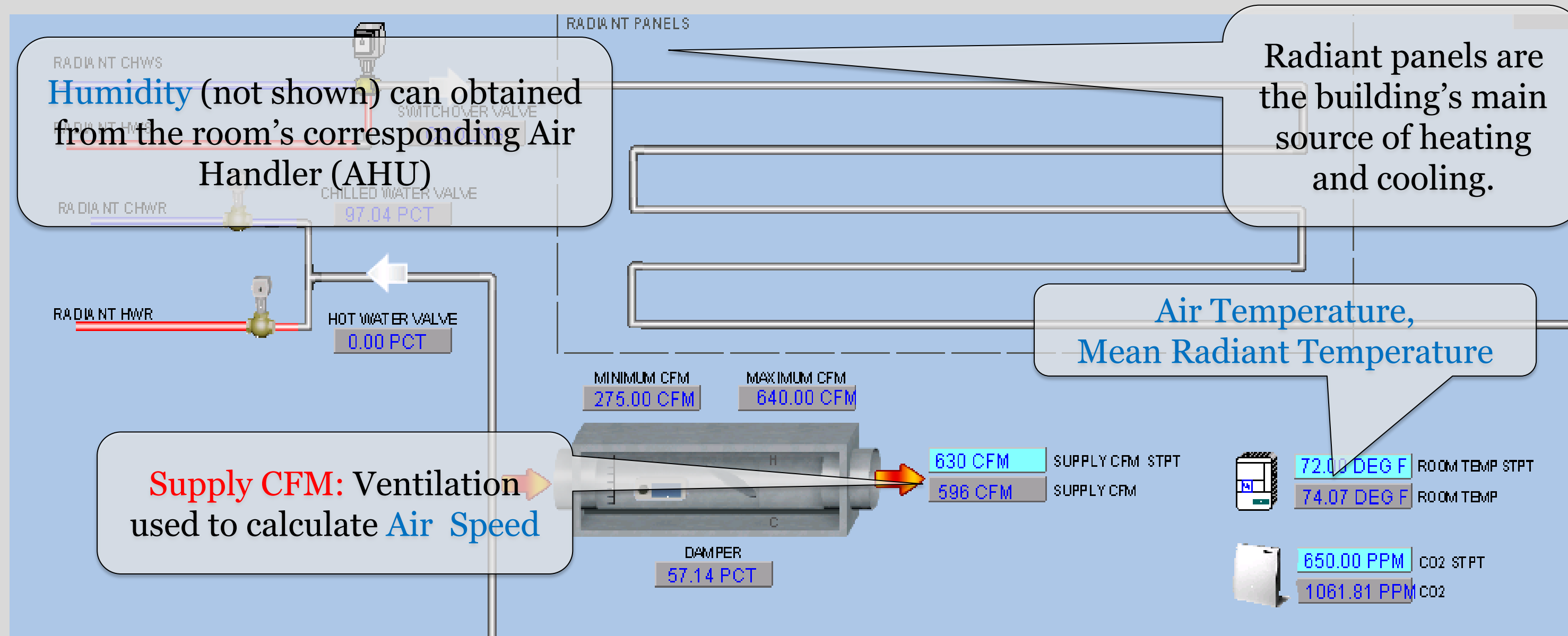
41 Cooper Square exhibits several energy-saving green features, but the thermal comfort of the building's occupants has not yet been assessed. Thermal discomfort is problematic as it can lead to decreased productivity and/or feelings of sickness.

Goals

1. Assess overall thermal satisfaction of building occupants.
2. Compare results from surveys to existing thermal comfort indices.
3. Evaluate extent to which building features maintain indoor comfort.

Building Management System

The building management system (BMS) of 41 Cooper Square, operated by Siemens, monitors building operation in real-time. Conditions for thermal comfort could be evaluated using data taken from the system.



A screenshot of the working systems in a room through the BMS' Insight program, powered by Siemens.

Survey Design

Two surveys were implemented in the study, each with different questions corresponding to different objectives:

Survey 1 (2/27/14 – 3/11/14)	Survey 2 (4/15/14 – 4/25/14)
ADDRESS GOAL #1	ADDRESS GOALS #2 & #3
<ul style="list-style-type: none"> ➤ Intended to be taken once ➤ Address general satisfaction of thermal comfort at 41CS ➤ Determine interest in future surveys among various groups 	<ul style="list-style-type: none"> ➤ Can be taken multiple times ➤ New questions to attain accurate comparison to comfort indices ➤ Connect with BMS data

The surveys were conducted using SurveyMonkey and announced to the Cooper Union community via e-mail.

PMV and PPD

The PMV/PPD scale is the most recognized thermal comfort index and is used by ASHRAE in building design.

PMV (Predicted Mean Vote):
Expected average value of thermal sensation for a given environment

PPD (Predicted Percentage Dissatisfied):
Expected number of occupants that will feel uncomfortable for a given PMV

Value	Sensation
+3	Hot
+2	Warm
+1	Slightly Warm
0	Neutral
-1	Slightly Cool
-2	Cool
-3	Cold

Professor Povl Ole Fanger's seven-point thermal sensation scale.

PMV is calculated from both environmental and personal factors.

Environmental Factors

Air Temperature
Mean Radiant Temperature
Humidity
Air Velocity

Obtained from building data

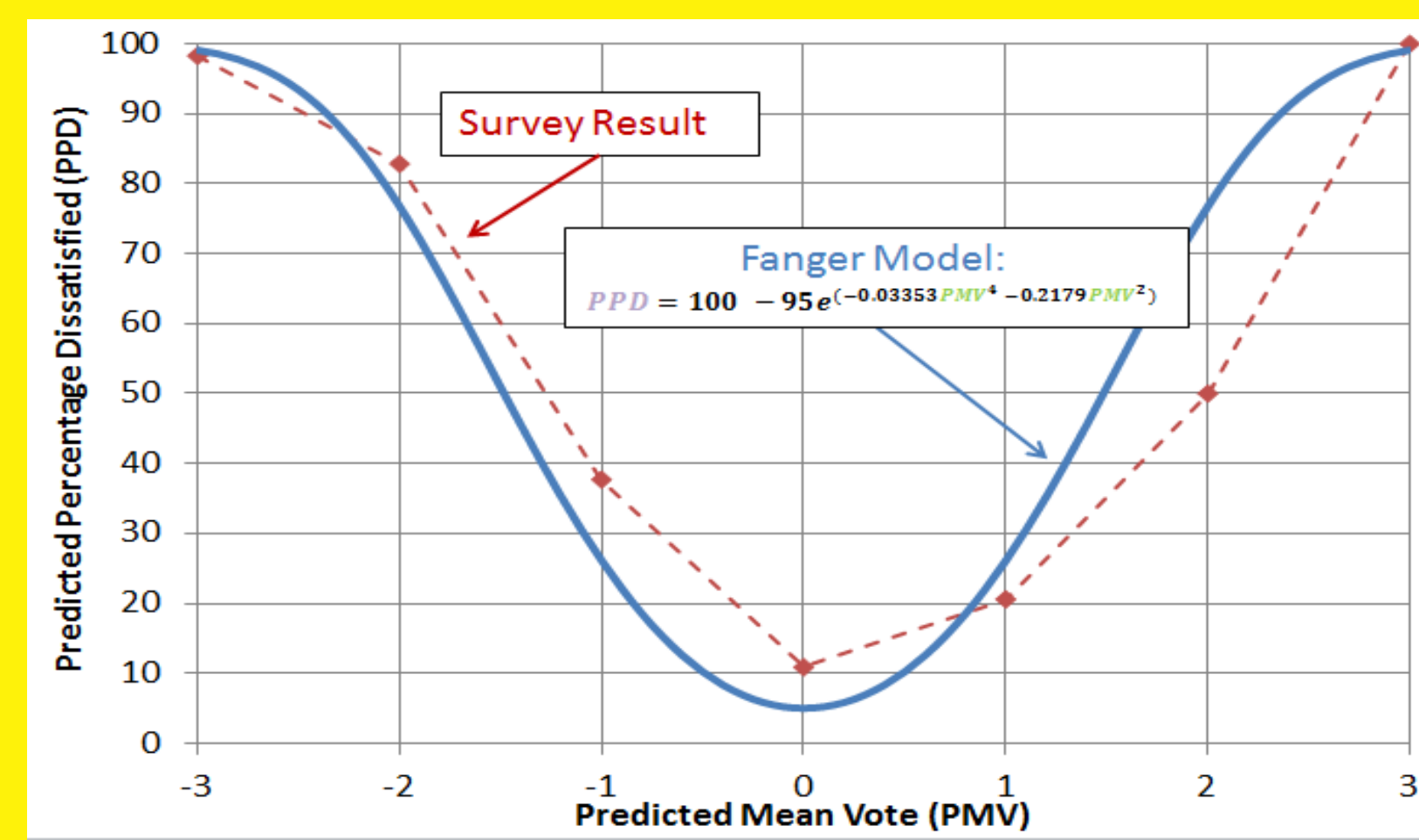
Personal Factors

Clothing

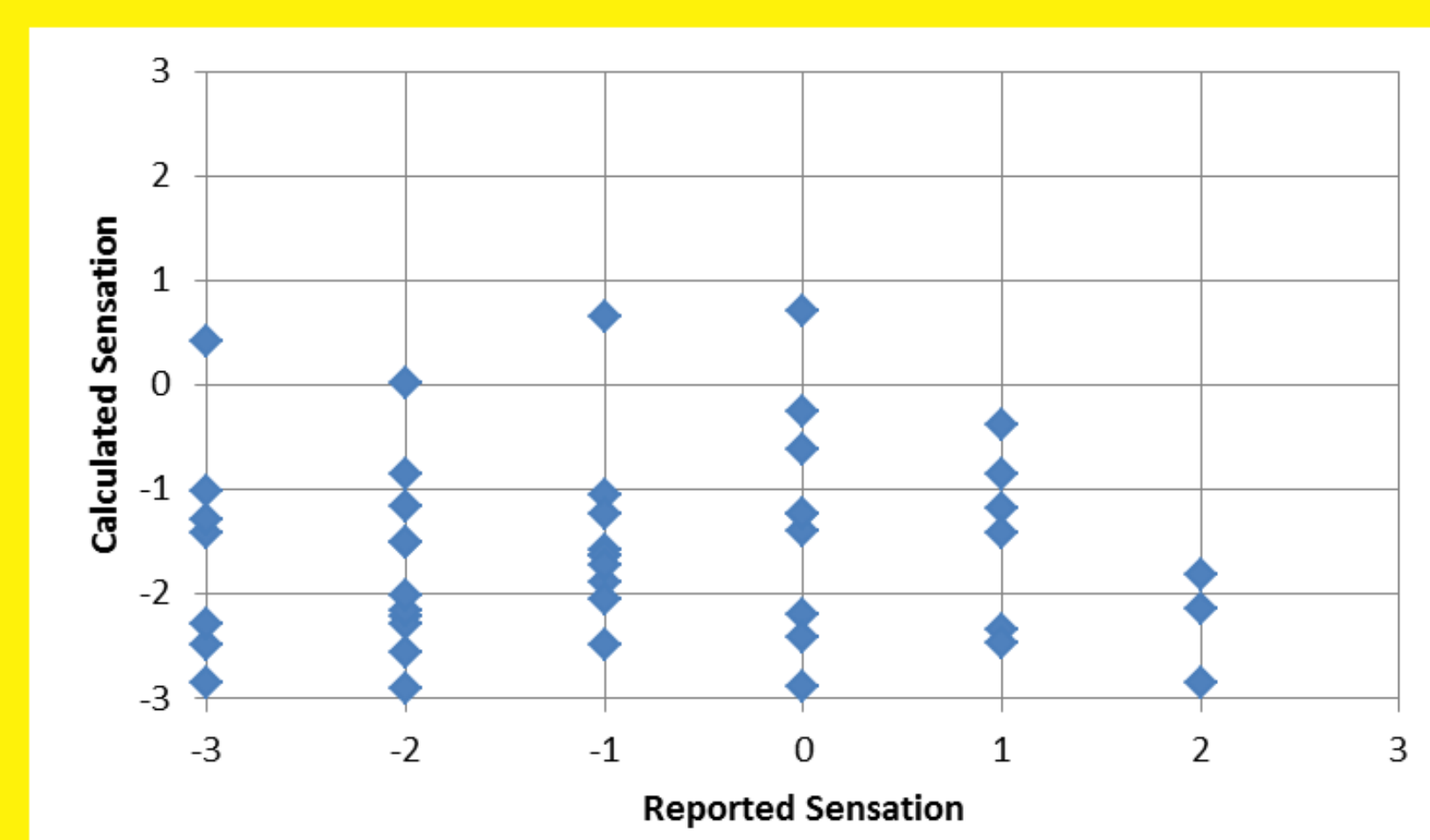
Activity

Obtained from survey data, or assumptions

Results



A total of **250** occupants filled out the first survey, with **52%** expressing dissatisfaction in their environment. **50%** occupants feel that the building is too cold. The comparison of the results with the PMV/PPD model suggests that colder environments at 41 Cooper Square are less tolerable than predicted.



Data from the second survey was combined with BMS data to calculate PMV (sensation) values using a MATLAB algorithm developed for this study. The trend does not show a linear correlation as one might expect, but the location of these points further suggest the building's perception of being cold.

Conclusion and Future Work

Both survey results and building data suggest that 41 Cooper Square is overall a cold environment. Furthermore, the study found that air ventilation in most rooms is relatively high, while humidity is kept low. Suggestions to improve occupant comfort level include lowering the ventilation rate in certain rooms, as well as increasing the set point temperature, particularly during the summer. The next step includes developing a more accurate prediction for mean radiant temperature, and air velocity profile and different locations in the room. Additionally, a more longitudinal survey can be administered to study the building thermal comfort performance.

References

- ASHRAE, ANSI. "Standard 55-2010: Thermal Environment Conditions for Human Occupancy. Atlanta, GA, American Society of Heating, Ventilating and Air-Conditioning Engineers." (2004).
- Fanger, Poul O. "Thermal comfort. Analysis and applications in environmental engineering." Thermal comfort. Analysis and applications in environmental engineering. (1970).
- "Melody Baglione." CU Faculty. N.p., n.d. Web. 29 April. 2014. <http://engfac.cooper.edu/melody>

Acknowledgements

Melody Baglione · Bob Hopkins (IT) · Pratik Raval (Transsolar) · Linda Lam (Transsolar) · Robert Topper (IRB) · Carmelo Pizzuto (B&G) · Julio Santillana (Engineer) · Ian (Siemens Tech)