General Services Administration
Public Buildings Service

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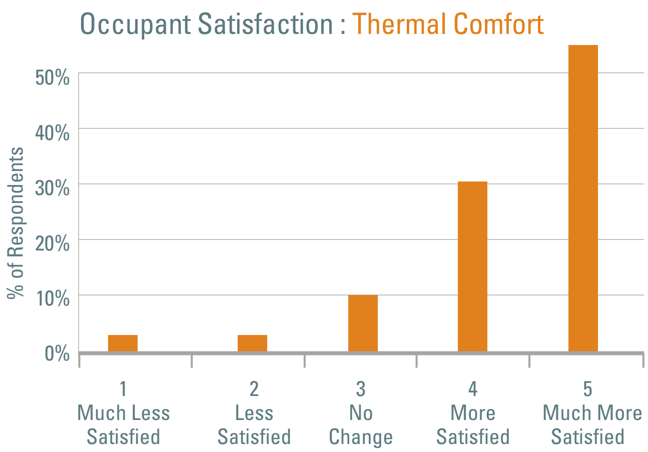
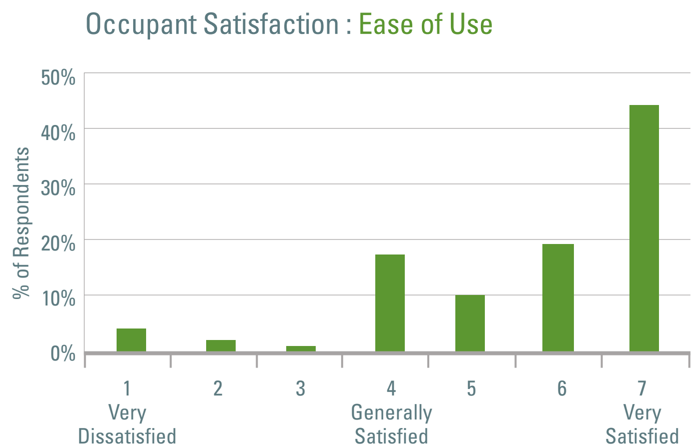
SOCIALLY DRIVEN HVAC FOR PERSONAL CONTROL

Smart Temperature Control Optimizes Comfort and Saves Energy

Traditionally, heating, ventilation, and air conditioning (HVAC) systems in commercial buildings are set to maintain indoor air temperature within a predetermined range, or "deadband." Relying on a fixed deadband, however, does not take into account individual thermal preferences and often leaves occupants feeling too hot or too cold. It can also waste energy by over-conditioning, particularly in spaces that are intermittently occupied or unoccupied altogether. Socially driven HVAC optimization addresses these problems by including direct input from occupants. From a web page or smartphone, occupants request temperature changes to their local environment; in response, the system immediately delivers a 10-minute stream of hot or cold air. Control software tracks user preferences over time, fine-tuning the deadband to provide occupant comfort and widening it to optimize for energy savings when there is no input. To put socially driven HVAC to the test, GSA's GPG program commissioned Oak Ridge National Laboratory (ORNL) to conduct measurement and verification (M&V) at the Federal Building and U.S. Courthouse in Phoenix, Arizona. Researchers found that 83% of occupants experienced an increase in thermal comfort. Modeling of large office buildings demonstrated average energy savings of 20% (cooling) and 47% (heating) over a typical GSA facility.

INTRODUCTION





"At first, I had to tell the system that I was too hot; then it learned what temperature I found comfortable, and I did not have to tell it again."

— Occupant Survey
Federal Building and U.S. Courthouse
Phoenix, Arizona
Pacific Rim Region
U.S. General Services Administration

TECHNOLOGY SPECIFICATIONS

Socially Driven HVAC Optimization

- Software-as-a-Service Solution (SaaS)
- Works with any BACnet enabled BMS
- Best suited to VAV with DDC; also compatible with pneumatically controlled systems that use wireless pneumatic thermostats[1]
- Can be activated for individual tenants or an entire building
- Occupant input via web-based or smartphone application
- System adjustments made via web-based management portal

What Is This Technology?

DECENTRALIZED HVAC CONTROL THAT ADAPTS TO OCCUPANT NEEDS

Socially driven HVAC is a software-as-a-service (SaaS) solution. It consists of a user interface, which enables occupants to respond to their thermal environment, and a controls package, which communicates with the building management system (BMS). The technology, currently offered by only one vendor, is best suited to buildings that use variable air volume (VAV) HVAC systems with direct digital control (DDC). The platform takes a decentralized approach to space conditioning, treating all zones independently. Occupants report if they are too hot or too cold, and in response the system immediately delivers a 10-minute stream of cool or warm air. If a zone has more than one occupant, the system uses advanced algorithms to reconcile opposing votes. Gradually, using trend analysis of all requests in a zone, the control application learns the temperature preferences of occupants and changes the deadband settings as needed. In some zones, this adaptive behavior decreases the deadband temperature range; in others, it expands the deadband, with the result that HVAC equipment cycles on and off less frequently. Because the system manages space conditioning automatically, it spares building maintenance staff the task of responding to individual hot/cold calls.

What We Did

MEASURED THE PERFORMANCE IN A MULTI-USE SETTING

The 289,000 ft^2 Phoenix Courthouse has 250 thermal zones spread over open and private offices, conference rooms, courtrooms, and ancillary spaces like hallways and elevators. Each zone is served by a VAV air handler that is controlled through a central BMS. The test period extended over three months in a warm season, so only cooling was measured. In 20 randomly selected zones, researchers verified that a stream of air issued from the air handlers when a temperature adjustment was requested. Using the site's BMS to collect temperature data before and after the retrofit, the team analyzed the results, extrapolated HVAC energy savings, and then modeled savings for three different building sizes across 16 climate zones. They also conducted interviews and surveyed occupants to assess changes in thermal comfort.

FINDINGS

SIGNIFICANT ENERGY SAVINGS In Phoenix, the technology raised the average cooling setpoint by 2°, from 75°F to 77°F. Researchers modeled energy savings assuming the deadband was widened by 2° in each direction, from 70°F-75°F to 68°F-77°F. They also modeled a 4° shift, assuming an initial deadband of 70°F-73°F, more typical of GSA facilities. Modeling of large office buildings based on a 2° shift predicts average energy savings of 11% (cooling) and 37% (heating). A 4° shift predicts savings of 20% (cooling) and 47% (heating).

PERSONAL CONTROL RESULTS IN HIGHER SATISFACTION 83% of occupants reported being more satisfied with their thermal environment. Also, there was wide user acceptance of the technology: the majority of occupants continue to use it more than a year after installation.

NOT NECESSARILY COST-EFFECTIVE BASED ON ENERGY SAVINGS ALONE Depending on installation size and duration of service, energy savings alone are not expected to cover annual subscription costs, which can be up to $0.60/$ft^2$/year. However, this calculation does not take into account possible operations and maintenance (O&M) savings, energy savings from reducing the use of personal fans and heaters, and gains in occupant productivity that may result from increased thermal comfort.

REDUCED HOT/COLD CALLS Calls to maintenance requesting temperature changes were reduced by 59% over the three-month test period.

PRIORITIZE WHERE THERMAL COMFORT IS AN ISSUE* Energy savings will be greatest in facilities that are only intermittently occupied and have high energy costs and narrow deadbands.

Modeling Demonstrates Energy Cost Savings per Square Foot§

Calculations do not include O&M savings, energy savings from reducing the use of personal fans and heaters, or gains in occupant productivity that may result from increased thermal comfort

Location		Large Office - 498,500 ft^2 Cost Savings ($/$ft^2$/yr)		Medium Office - 53,630 ft^2 Cost Savings ($/$ft^2$/yr)		Small Office - 5,500 ft^2 Cost Savings ($/$ft^2$/yr)	
CLIMATE ZONE	CITY	2° Shift[1]	4° Shift[2]	2° Shift[1]	4° Shift[2]	2° Shift[1]	4° Shift[2]
1A	Miami, FL	$0.06	$0.13	$0.14	$0.30	$0.23	$0.48
2A	Houston, TX	$0.06	$0.12	$0.10	$0.20	$0.16	$0.32
2B	Phoenix, AZ	$0.07	$0.13	$0.12	$0.24	$0.18	$0.38
3A	Atlanta, GA	$0.08	$0.15	$0.12	$0.23	$0.18	$0.35
3B-coast	Los Angeles, CA	$0.11	$0.15	$0.15	$0.27	$0.22	$0.50
3B	Las Vegas, NV	$0.06	$0.15	$0.09	$0.21	$0.16	$0.29
3C	San Francisco, CA	$0.09	$0.16	$0.11	$0.19	$0.17	$0.34
4A	Baltimore, MD	$0.09	$0.16	$0.12	$0.22	$0.15	$0.30
4B	Albuquerque, NM	$0.05	$0.10	$0.08	$0.15	$0.13	$0.27
4C	Seattle, WA	$0.09	$0.16	$0.10	$0.16	$0.12	$0.18
5A	Chicago, IL	$0.06	$0.10	$0.07	$0.12	$0.10	$0.19
5B	Boulder, CO	$0.06	$0.10	$0.07	$0.13	$0.11	$0.18
6A	Minneapolis, MN	$0.05	$0.09	$0.06	$0.11	$0.10	$0.18
6B	Helena, MT	$0.06	$0.10	$0.07	$0.11	$0.09	$0.15
7	Duluth, MN	$0.06	$0.10	$0.06	$0.10	$0.09	$0.15
8	Fairbanks, AK	$0.09	$0.12	$0.09	$0.14	$0.11	$0.19

§Current socially driven HVAC subscription fees up to $0.60/$ft^2$/yr, depending on installation size & service duration [1] 70°-75° to 68°-77° [2] 70°-73° to 68°-77°

CONCLUSIONS

These Findings are based on the report, "Socially Driven HVAC Optimization, Federal Building and U.S. Courthouse, Phoenix, Arizona," which is available from the GPG program website, www.gsa.gov/gpg

For more information, contact GSA's GPG program gpg@gsa.gov

What We Concluded

DYNAMIC THERMAL ENVIRONMENT THAT INCREASES COMFORT WHILE REDUCING ENERGY USE

In many commercial buildings, occupant thermal comfort and energy conservation are often at odds. Socially driven HVAC optimization reconciles this conflict. Researchers found that the technology improves on traditional thermostats by making occupants more comfortable while at the same time reducing energy consumption. In Phoenix, a well-run facility with an initial deadband of 70°F-75°F and occupied/unoccupied setback scheduling, the technology raised the average cooling setpoint by 2 degrees. And by providing occupants control over their local temperature, it enabled 83% of them to experience an increase in satisfaction with their thermal environment.

Socially driven HVAC is a low-risk technology that can be easily installed and removed without compromising or damaging other HVAC equipment. It has the potential to reduce energy use across the GSA portfolio, though because many GSA facilities are already well-run,[2] energy savings alone may not cover the annual subscription cost. Facilities that are only intermittently occupied and have high energy costs and narrow deadbands will realize the greatest savings.

BARRIERS TO ADOPTION

- **IT security:** This technology typically operates on the secure side of the facility's IT firewall and requires careful vetting by IT security.
- **Setpoint limitations:** Contractual obligations to keep temperatures within a narrow range may limit the ability of the technology to widen deadbands to more energy-saving settings. GSA's P-100 policy must also be considered for deployments within the agency's facilities.
- **Determining the value of non-energy benefits:** More research that provides a better understanding of the economic value of non-energy benefits may accelerate the technology's adoption. In a 2003 study, occupants ranked temperature as the most important aspect of their work environment.[3] In another, it was estimated that personal control of workplace temperature resulted in a 3% gain in productivity.[4]

Reference to any specific commercial product, process or service does not constitute or imply its endorsement, recommendation or favoring by the United States Government or any agency thereof.

Footnotes

[1] GSA's GPG program assessed wireless pneumatic thermostats in Findings GPG-020. www.gsa.gov/gpg

[2] GSA buildings are 44% more efficient than their commercial counterparts. EUI for Commercial Buildings is 92.9, according to CBECS, 2008. EUI for GSA is 52.4, according to EUAS October, 2015.

[3] International Facility Managers Association 2003 Corporate Facility Monitor Survey

[4] Loftness V. Hartkopf V. and Gurtekin B. (2003) "Linking Energy to Health and Productivity in the Built Environment: Evaluating the Cost-Benefits of High Performance Building and Community Design for Sustainability, Health and Productivity," USGBC Green Build Conference, 2003.

*Subject to evaluation and approval by GSA-IT and Security.

Technology for test-bed measurement and verification provided by Building Robotics.