CASE STUDY

Keeping Employees Productive through Thermal Comfort

SMART BUILDINGS CENTER
A project of NEEC

Summary

Thermal comfort in the workplace can increase employee productivity. Thermal discomfort can also result in dissatisfied employees, an increase in maintenance time, and individual behaviors that compete with energy efficiency goals. Comfy is a "sofware-as-a-service" (SAAS) solution that is designed to provide building occupants an easy way to improve their thermal comfort immediately, improving employee comfort and satisfaction. The web and mobile-friendly user interfaces feed temperature requests directly to the building automation system (BAS), where the software calculates an instantaneous response of either warm or cool air or just remains at standby. Over time, the software identifies trends based on user feedback and dynamically adjusts temperature set points to tailor the individual spaces over the course of the day. The Vulcan headquarters building's 7th floor served as a pilot to evaluate Comfy for potential wider use in Vulcan's portfolio. Data was analyzed during April and May 2015 and was compared to industry research regarding potential energy savings by adjusting temperature set points.

Business Challenges: Battle of the Thermostat

The Value of Thermal Comfort in the Workplace

Most non-industrial workplaces spend far more on employee salary and benefits packages than any other costs. From a business perspective, it makes sense to prioritize efforts that maximize the productivity or output of this investment. Studies have shown that employee satisfaction with the thermal comfort of their workplace plays a significant role in both employee retention and productivity. One study even revealed that employees consider workplace comfort second only to compensation in terms of benefits (American Society of Interior Designers). Other studies estimate that productivity gains from making workplace thermal and lighting improvements can be quantified in the hundreds of billions of dollars (Fisk, W.J., ASHRAE Journal). Getting to universal thermal comfort is not an easy task, however, as individual thermal preferences vary widely. Furthermore, employee turnover or relocation within a workplace can add inconsistencies to these preferences. Installing the kind of systems capable of tailoring each workspace to the occupant's preferred temperature is generally not cost-effective in new buildings, and even more costly as a retrofit.

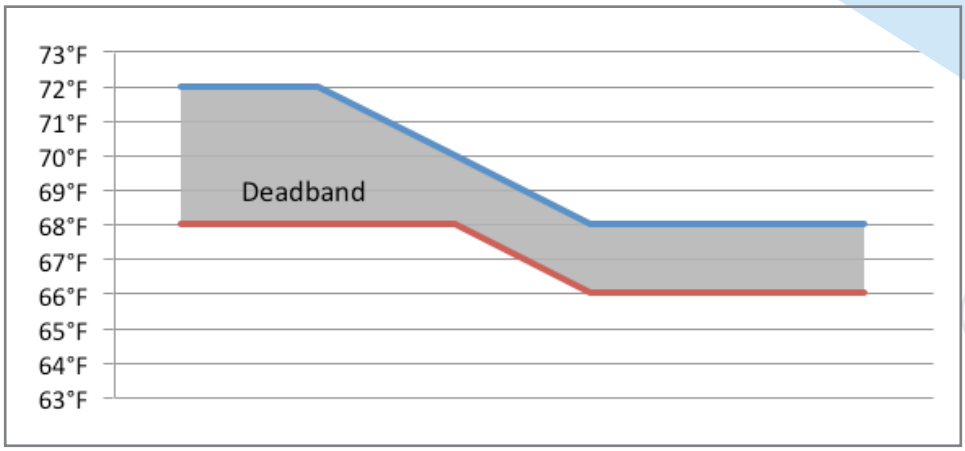
Current Approaches Can Create More Challenges

The typical new building approach is to establish a generally accepted temperature range, usually driven by energy code requirements and energy goals, and then program the heating, ventilation, and air conditioning (HVAC) system's set points accordingly. In many cases, different work zones have a thermostat allowing occupants to more finely tune their space temperature within an allowable range.

While this status quo approach builds in some flexibility to accommodate diverse and changing occupant preferences, building facilities staff still face the inevitable tide of heating and cooling complaints. The typical response is to narrow the range between the cooling and heating set points, also known as the

"deadband," in the Building Automation System (BAS). This ensures that the space temperature more frequently matches the desired temperature of the occupant. It should also be noted that the width of the deadband has a direct correlation to the system's energy use—in general, as the deadband range narrows, energy use increases.

The chart on the right shows a change in the deadband as set points are adjusted.



When the BAS adjustments fail to satisfy the initial request, however, occupants may take matters into their own hands, sometimes by blocking diffusers with tape and cardboard. This is initially satisfying to the occupant with the issue, but it causes broader problems. Just as blocking one outlet on a fountain causes the other outlets to spray water more intensely, blocking a diffuser causes other diffusers to output more air. Since the air distribution system is designed to deliver specific amounts of air, do-it-yourself modifications quickly become the problem of many in a zone as some spaces begin to be overcooled/overheated, diffusers begin to produce excessive noise, and the effects of the change in airflow begins to affect other equipment upstream from the diffusers. Some office tenants will then add individual space heaters or fans to compensate for this imbalance, standing at odds with an organization's energy goals.

Potential Solution: The Power of Call and Response

A new technology called Comfy, by Building Robotics, addresses these challenges with a low-effort technology solution that seeks to find the nexus of improved thermal comfort and increased energy efficiency.

Comfy's approach pairs a simple way for building occupants to make localized temperature change requests with an immediate automated heating or cooling response. The goal is to improve thermal comfort for a specific user in a specific space at a specific time, without adding workload to the facilities staff. An added goal of the product is to reduce HVAC energy consumption, as Comfy "learns" user preferences over time and adjusts temperature settings to match.

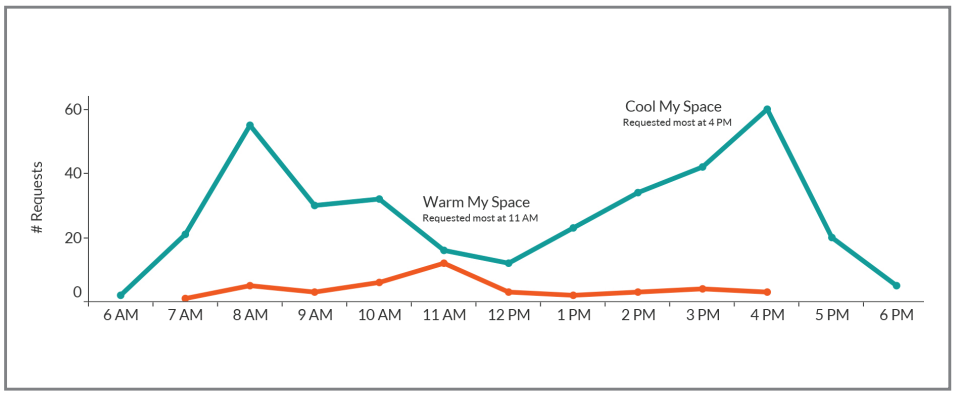
How Comfy Works

Primarily a software-as-a-service solution, with pricing on a per-square-foot basis, Comfy also includes installation of a small device that interfaces with the building's existing BAS though an open communication protocol (BACnet). This device then facilitates the connection between the BAS and Comfy's cloud-based services though a local internet connection. Then by monitoring the constant stream of BAS data, Comfy keeps track of many points of information including room temperature, airflow, and overall system operation. From any location in the building, occupants can access Comfy's user interface through a web or mobile browser and provide feedback on their thermal comfort in that space. A native mobile application is coming soon. Temperature feedback is streamlined to three simple choices:

When users select either "Warm My Space" or "Cool My Space," the request gets sent to and processed by Comfy's servers, delivered to Comfy's on-site device, and communicated to the HVAC control system, which then provides an instant stream of hot or cold air to the requestor's area for approximately 10 minutes.

Over time, the system learns what the occupants of each area prefer and when. Comfy then automatically applies this learning to the following days. For example, if the same area receives multiple cooling requests at 1:00pm every day, Comfy would signal to the BAS to reduce the maximum temperature at that time. Likewise, if Comfy receives multiple heating requests at 8:00am every day, the minimum temperature would be increased for the morning. This type of learning is illustrated in the graphic below, taken from an actual Comfy

When Comfy is first installed, the system adapts to users' input requests. The graph to the right shows that Vulcan occupants preferred to be cooled first thing in the morning and in the late-afternoon and a few users preferred warming during late-morning. Overall, the occupants wanted the space a bit warmer in the first half of the work day, compared to before Comfy was installed, thereby reducing the upper limit for cooling. In absence of user feedback or when users submit "I am Comfy" responses, Comfy signals the BAS to gradually widen the deadband range until users submit comfort requests again (as can be seen towards the end of the work day). An additional benefit of Comfy's service is that it includes ongoing customer support from Building Robotics, where users can contact the "Comfy Concierge" with both user interface and thermal comfort issues. Building Robotics either handles the requests directly or contacts facilities staff to troubleshoot local equipment. This type of direct notification provides an added benefit to facilities staff, because it can reduce time required to identify and resolve issues with the HVAC system.



Trial Application: One Floor at a Time

As a part of a Smart Buildings Center ATD program to deploy and evaluate new smart building technologies, Vulcan, one of Seattle's most prominent and forward-thinking real estate developers, installed Comfy on the 7th floor of their headquarters building near downtown Seattle. For years, the 7th floor has been notorious among Vulcan staff for having temperature issues, reportedly both too hot and too cold. Building operators noted that if Comfy could help alleviate the regular temperature complaints in this challenging space, the potential to alleviate similar issues throughout the entire Vulcan portfolio was promising. Through April 2015, the Vulcan facilities staff worked with Building Robotics to integrate Comfy with the existing BAS. In early May, the facilities staff introduced Comfy to the employees on that floor.

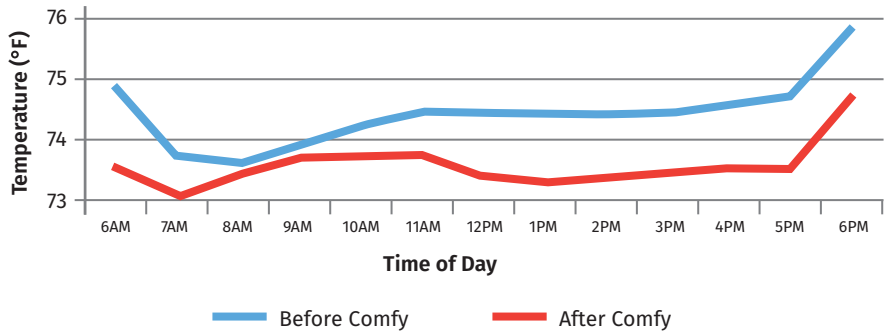
Initial Results: Greater Comfort, Less Burdened Staff

As of the writing of this report in late May 2015, Vulcan's Comfy system had been operating for 3 weeks and received 190 temperate requests. Reviews of Comfy's data indicated user input is already changing how (1) the building system preemptively responds to space heating and cooling throughout the day, (2) less frequently used spaces such as conference rooms are expanding their deadbands and therefore increase energy efficiency, and (3) some frequently used areas have settled at temperatures as high as 75ºF, a higher than expected set point that has been deemed by occupants collectively comfortable and that saves energy in the cooling season. Because of Comfy's learning behavior, the system will continue to better serve its users with more time and input.

One of the most immediate savings that Comfy proposes by increasing personal comfort is reducing the number of hot and cold calls to facilities staff. Since starting up the Comfy system, Vulcan's facility staff has reported a drop from an average 10 calls a month to 0 calls in the 3 weeks of the study. With an estimated cost of $25 per call charged by the property management company (based on hourly rates and time per call), this translates to an annual projected savings of $3,000.

In terms of energy savings, the average floor temperature has increased by about 1°F over the course of the day. Since the majority of HVAC activity was cooling during this time, an increase in the average floor temperature means that less cooling is being utilized, saving energy. A study performed by Lawrence Berkeley National Laboratory indicates that simply increasing a cooling set point by this amount may reduce energy use by 13% in the warmer months (Hoyt).

Vulcan Headquarters, 7th Floor – Average Temperature
April 22 – May 27, 2015
(chart from Building Robotics' Trendr tracking software)



Conclusion

Although the demonstration of Comfy at Vulcan headquarters was performed over a relatively short time period, occupants report that it has increased thermal comfort and offers a promising trajectory for reducing maintenance time and delivering energy savings. At the same time, the demonstration has provided the capability for occupants to tailor their working environment to their personal preferences as promised. Although the 7th floor staff is presently undergoing turnover as personnel are rearranged between floors, word about the Comfy program has spread throughout the building and Vulcan staff report enthusiasm about Comfy's capabilities. In fact, the building facilities staff is eager to roll Comfy out to all the Vulcan-occupied floors, as a tool for enhancing comfort and a means for reducing complaints about temperature. Should Comfy prove useful within Vulcan's headquarters, Vulcan staff also mentioned that it could be used at more properties in the Vulcan portfolio to provide value to tenants by allowing them to tailor their own environments and perhaps enhance Vulcan's leasing value.

References

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Hoyt, T., E. Arens, And H. Zhang. "Extending air temperature setponts: Simulated energy savings and design considerations for new and retrofit buildings." 2014. May 2015 https://escholarship.org/uc/item/13s1q2xc

About the Smart Buildings Center

The Smart Buildings Center (SBC) is a project of the Northwest Energy Efficiency Council (NEEC), which is a non-profit industry association of the energy efficiency industry. The SBC supports growth and innovation in the Pacific Northwest's energy efficiency industry, serving as a hub for industry activities and raising the visibility of energy efficiency companies and projects.

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