

THE INTERNET OF COMFORT



Deep Thoughts by Deepinder Singh: Part 3

A series on the future of cloud computing, big data and buildings

As we welcome the summer season, there is a lot to look forward to. Unfortunately, for facility managers, this is also what is known as thermostat war season.

As outdoor temperatures rise, the fundamental HVAC problems that ail most commercial buildings are exposed. Facility managers are busier than ever answering complaints from building occupants that are dissatisfied with their thermal environment. You don't have to go far to see what is happening. Front and center on the Life section of the *Wall Street Journal* is featured article "Let the Office Thermostat Wars Begin," detailing the familiar divisive issue that all offices face – what to set the office thermostat to. The article cites a 2009 survey of 452 facility managers by the International Facility Management Association in Houston, where more than 3 in 5 participants use personal fans, heaters, blankets or gloves to keep comfortable indoors.

While some look at these headlines and find the stories endearing, we see a far greater importance to ending the thermostat war. We see it as one of the most important factors to achieving a company's triple bottom line – economic, social and environment. Attacking the thermostat war head-on does more than just reduce occupant complaints. When employing the right solution, solving your building thermal problems increases profit (economic), increases employee productivity (social) and reduces energy usage (environmental). The HVAC industry has an important role to play and I am dedicating this paper to how the industry and its customers can achieve it.

THE CASE FOR COMFORT

In the words of Jerry McGuire, "Show me the money!" As a facility manager or sustainability officer, you are charged with the hard task of proving the ROI before implementing any type of solution – some of which are truly intangible. I want to arm you with studies that make what was once intangible into more tangible proof points. I believe that a focus on employee and

guest comfort is a crucial factor and directly impacts a company's bottom line. Merriam Webster dictionary defines comfort as "a state of physical ease and freedom from pain or constraint." At 75F, we take a broader view of comfort and say that it is "the variable driving employee productivity and guest satisfaction that most affects a company's bottom line."



In 2004, a Cornell University study linked warmer temperatures to fewer typing errors and higher productivity. Alan Hedge, professor of design and environmental analysis and director of Cornell's Human Factors and Ergonomics Laboratory, conducted a month long study where office workers were exposed to varying temperatures. Researchers recorded both the time spent typing and the time spent correcting errors. The study was exploring the link between changes in physical environment and employee productivity. This is what they found:

1. When the office temperature increased from 68°F to 77°F, typing errors fell by 44% and typing output jumped 150%.
2. Results also suggest raising the temperature to a more comfortable thermal zone saves employers about \$2 per worker, per hour.

This study suggests that the right temperature can increase productivity, but how important is the thermal environment within the employee's environment? A 2015 Leesman survey of nearly 136,000 respondents revealed that the top 3 features identified as the most important part of an effective

workspace are the desk, chair and temperature control. Not only that, but temperature control also had the highest number of dissatisfied people, meaning that technology is not keeping up with thermal comfort as a main priority for employees.

Results from the 2015 Harvard Center for Health and the Global Environment study show how green building affects health and cognitive function. A total of 24 participants spent 6 full work days in an environmentally-controlled office space at the TIEQ lab at the Syracuse Center of Excellence. They were exposed to conditions representative of conventional and green office buildings in the U.S., as well as green buildings with enhanced ventilation:

- Conventional: ~500 parts per million (ppm) as typical volatile organic compound (VOC) levels and 20 cubic feet per minute (cfm) of outdoor airflow per person
- Green: VOC levels reduced to approximately 50 ppm and 20 cfm outdoor air per person
- Green with enhanced ventilation: VOC levels reduced to approximately 50 ppm and 40 cfm outdoor air per person

At the end of each day, participants were administered a cognitive test. The results were staggering. On average, cognitive scores were 61% higher in green building conditions and 101% higher in enhanced green building conditions.

The green building movement is undergoing a fundamental shift. It's not just enough to reduce your carbon footprint. Definitive studies like the one published by Harvard not only help build the business case, but also refocus the industry on why we build buildings in the first place: to provide an environment in which occupants can thrive. These studies also highlight the importance that a proper HVAC strategy has on employee productivity and a company's bottom line.

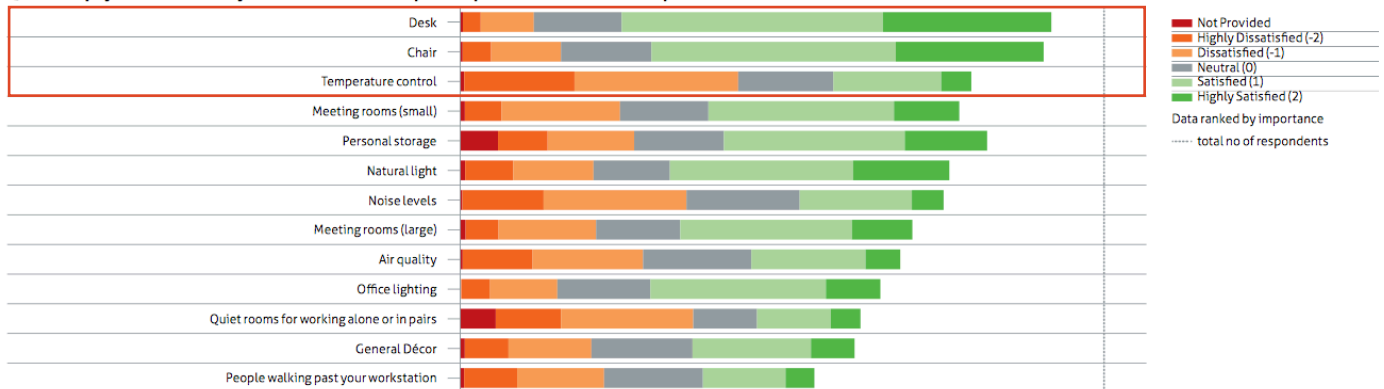
SO, NOW WHAT?

We now know air temperature and quality affect productivity and cognitive function. What does this mean for businesses? In today's world, longevity not only means having a strategic energy plan, it means having a robust and well thought through strategic performance plan.

Before you panic about how this will add to your "to-do" list, know that the good news is that we now have technology that can help. The development of the Internet of Things (IoT) and cloud computing has fundamentally shifted the way we can deliver comfort to employees. Today, we are more customized and sophisticated than ever.

Just take a look at the Edge. Located in Amsterdam, the Edge is the most connected building on the planet. Fully realizing the potential for IoT with an unprecedented

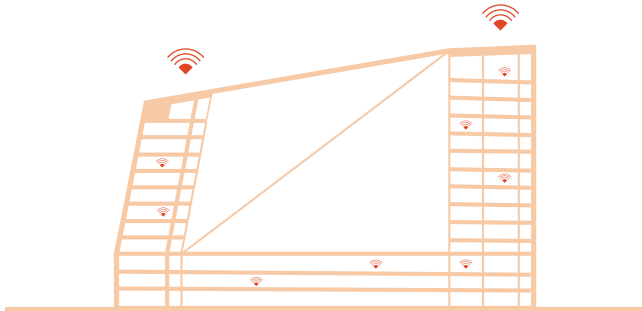
Q.3 Which physical features do you consider to be an important part of an effective workspace?



Source: <http://leesmanindex.com/wp-content/uploads/Leesman-Review-Issue-18.pdf>

network of over 40,000 sensors working together, the Edge maximizes comfort and minimizes energy usage. Efficiency, lighting and thermal comfort were so important that the building features over 28,000 light, heat and motion-detecting sensors. When employees arrive, the building assigns each individual a desk, the space is set to their desired temperature and the lights dim or brighten based on saved preferences.

While we can't all be the Edge, there is a way to harness



the power of IoT and cloud computing to optimize comfort for the masses.

To date, there have been 3 types of IoT approaches to the problem:

1. Hyper Individualization
2. Crowd-Sourcing
3. Predictive Control

The first approach, or what I call Hyper Individualization, is at its infancy stage and the technology is still quite expensive for the masses.

Personal Comfort Systems "Hyper Chair" is an example of this type of approach. A Hyper Chair has luxury car-like climate controls built in where employees can heat or cool their chair to any desired temperature. They can do so from an interface on the chair, or a smartphone. Now employees have a personal thermal environment that uses much less energy than current methods (maximum power of 15 watts compared to 1,500 watts for a space heater). Unfortunately, the chair costs about \$1,900.

The second approach, Crowd-Sourcing, places control in the hands of employees.

An example of this is *Comfy*. Created by Building Robotics, *Comfy* is a smartphone app that allows occupants to democratically regulate room temperatures. Based on a majority voting system, occupants can say they are comfortable, too hot, or too cold. Once votes are tallied, hot or cool air is pushed into the space accordingly. Crowd-sourcing a building's thermostat settings has its advantages. It attacks occupant frustration with comfort head-on. Whether or not individuals receive the temperature they want, there is certainly a placebo effect of feeling like you are being heard. Additionally, employee calls regarding discomfort decrease. The downside is that these systems do not air quality, nor do they actually solve the HVAC equipment issues that are creating discomfort in the first place.

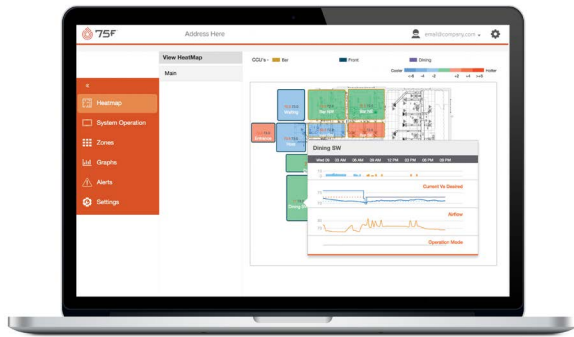
The third approach deploys Predictive Control systems that work to create individual thermal zones while improving indoor air quality.

First, let's look at how these predictive building automation systems solve thermal comfort issues. Ubiquitous sensors and cloud computing technology make collecting data easy. Collecting data on many thermal comfort points, like air temperature and humidity, allow predictive systems to deploy proactive strategies.

In fact, what was once considered a theory – continuous commissioning – is now a possibility.

Your typical HVAC system is set up for a static set of conditions. Your building, however, is a dynamic entity. In the morning the eastern part of a building experiences solar gain as the sun rises. As the sun shifts throughout the day, the western part of the building's temperature will rise. An intelligent solution can take temperature readings from different parts of the building and load them onto servers in the cloud. The power of cloud computing allows algorithms to crunch this historical data and create a thermal model of the building. The algorithms take the weather forecast and predict how the building will behave. The system then

determines an optimal control strategy and sends it back into the building before temperature imbalances occur. At 75F, we call this Dynamic Airflow Balancing.



Understanding how energy is used can be just as important as what you use to save it.

Now let's tackle the issue of air quality. Traditional demand control ventilation (DCV) and enthalpy economizer solutions have one major issue. Economizers offered in the market today get enthalpy data from a module installed on the rooftop unit (RTU). Should that module fail, the economizer fails. Leveraging IoT and cloud computing offers two advantages. First, it allows you to use live weather feeds to obtain outdoor enthalpy data rather than rely on inaccurate readings from an RTU module. Second, sensors throughout the building monitor CO₂, NO₂ and CO levels, and along with indoor enthalpy.

Energy usage for 2016-05-01 to 2016-05-14



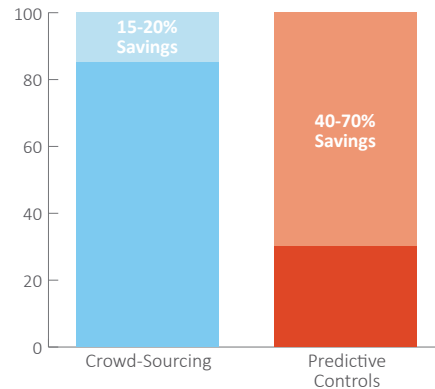
80.0% OAO energy savings
5,866,989 BTU saved

23.7% free cooling savings
92h 39m of free cooling
2,034 kWh saved

Real-time interfaces help visualize the impact systems like Outside Air Optimization have on energy usage and comfort.

With a full understanding of building enthalpy and particulate levels, the system provides superior air quality while offering free cooling when conditions are appropriate; a solution we call Outside Air Optimization

(OAO). When bringing in outside air, humidity is also measured to ensure the indoor environment doesn't become uncomfortable or cause mold to grow. Deploying strategies like this and Dynamic Airflow Balancing not only keep employees comfortable and productive, but data shows that these strategies can save anywhere between 40-70% in HVAC energy usage.



Building-wide systems that employ Predictive Control methodologies have drastically higher savings than those that utilize Crowd-Sourcing Technologies (data sourced from Comfy Case Study: Facility Manager's Perspective)

A predictive solution that leverages cloud computing algorithms can deliver more than just comfort and energy savings. With the ability to take in hundreds of data points, a predictive solution has the ability to provide insight into equipment performance, which can help predict equipment failures and verify service actions. Predictive maintenance is not a new term in the HVAC industry; it's been around for decades. According to the U.S. Department of Energy (DOE), past studies on predictive maintenance have shown it can reduce maintenance costs up to 30%, eliminate breakdowns 70-75% of the time, minimize downtime and increase production.

With all this technological advancement, it is shocking that there are very few companies developing new and innovative solutions that tackle both efficiency and wellness simultaneously. It is really up to business and property owners, facility managers and sustainability officers to demand more from their providers. Don't settle on the traditional way of doing business. Your employees and guests are far too important!



ABOUT THE AUTHOR

Deepinder Singh founded 75F in 2012 after he designed some of the world's fastest core networks for Tier 1 service providers like *AT&T*, *NTT* and *Verizon*. With almost 25 years experience in electronics and computing, he's brought a wealth of embedded products to the market. His key goal in every endeavor is to simplify operational complexity and make products intuitive.

That's why he created 75F, an intelligent building solution that utilizes the Internet of Things and the latest in cloud computing to create systems that predict, monitor and manage the needs of light commercial buildings.