75F

7 WAYS Technology Will Transform Buildings in the Next Decade

EBOOK BY 75F CEO
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CHAPTER 1

EMS PLATFORMS WILL BE REPLACED BY PREDICTIVE SYSTEMS

Technology has the power to solve high-cost problems for engineers, owners, and facility managers in the built space. In years past, the Energy Management System was that technology – it introduced monitoring, controlling and measuring energy loads to the built space and those who manage it.

An EMS centrally controls devices, such as HVAC units and lighting systems across multiple locations, making them useful for those who oversee multiple spaces. Yet, considering the rapid technological advancements of this decade, the EMS now has considerable limitations. The future of efficiency now lies in predictive technologies.

THE EMS PROBLEM

1. The EMS has been around since the 1990s, and not much has changed.

The problem with the EMS is that the last big refresh was in about 2005, meaning it's been roughly 15 years since new technology has been applied. Within those years, technology has evolved significantly, most notably being the birth of cloud computing and the Internet of Things. EMS companies, however, have not leveraged this evolution in technology effectively because integration to the dizzying array of smart sensors and devices is so expensive and time consuming.

2. An EMS is a step up from manually correlating spreadsheets, but it does not intelligently process or act on the data it collects in a meaningful way.

An EMS was once a great tool for consolidating information and reviewing energy usage trends, while comparing them across multiple sites. What's still missing, however, is that most buildings and systems today have very little localization knowledge. An EMS knows the address of your building, but does not know its orientation, building usage pattern, or local weather. Orientation can make a huge difference in how much energy your buildings use. With an EMS, it's up to the user to determine what energy usage patterns are occurring in a building and then do the correlation across their building portfolio.

With advances in machine learning and AI that make building intelligence cheaper and more effective, these inefficiencies will disappear. This will happen first in less complex environments, and then across the hospitals and global companies with a range of equipment and systems.

3. While an EMS allows remote control and consolidation, it does so only within very simple parameters.

A quality EMS may allow you to turn your lights off or change the set point of a thermostat, but anything beyond that is outside the capabilities of almost all systems on the market today. Where there are critical mistakes, the EMS can help to identify those: For example, if your HVAC system is running 24/7, the EMS may alert you to that or help you program changes remotely.

If you are truly seeking energy efficiency beyond scheduling or alarms based on fixed parameters, a more intelligent system is required. Because of this, across the industry EMS systems are being supplanted by additional software layers and complexity to help understand the equipment installed in a space, how it is performing, and how it can be optimized.

4. The problem with EMS solutions today is that they are only as efficient as the equipment in place.
An EMS takes a very high-level overview of the system and does not consider the energy efficiency ratio (EER) of any particular unit. It is not smart enough to consider how the actual performance compares to the expected performance. Today, EMS systems are often installed in locations where intelligent building automation systems are not already in place or are not commissioned properly. As building automation systems become more powerful, easier to install, and deliver more value to customers in the coming decade, the days of old and limiting EMS systems operating as a lightweight building automation system will be numbered.

PREDICTIVE SYSTEMS ARE A SMART INVESTMENT

Technology exists today that allows us to build predictive and proactive systems that make buildings more energy efficient. Not only that, but these systems are intelligent enough to keep individuals in those buildings more comfortable and productive. Why use a glorified excel spreadsheet when you can access technology that drives real change? Monitor when you can manage and control? Cloud computing over much of the last two decades has been priced out of reach for most customers and most applications. Recently, the power of the cloud—combined with ubiquitous connectivity in buildings and the improved performance of edge devices—has made it more affordable than ever in building applications, with exponentially more data points to be collected, stored, and analyzed in any given timeframe, autonomously.

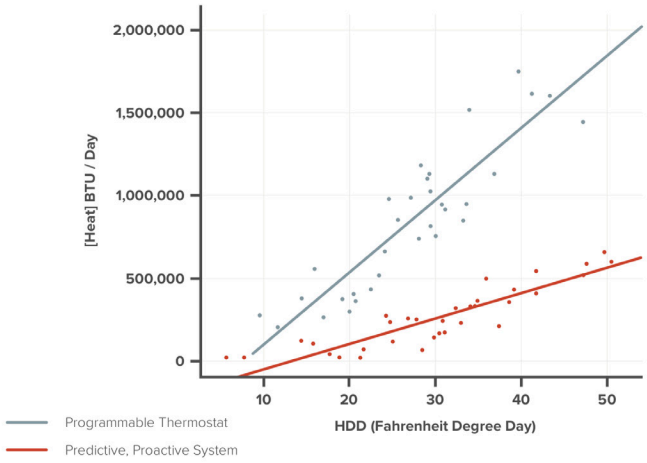
For reference, a typical EMS today may consider 15 to 20 control points, typically within a five- to 15-minute segment. On the generous side, that breaks down to tracking only two control points every 30 seconds. Furthermore, being able to trend those control points is considered a great victory.

In comparison, a predictive solution that leverages cloud-based algorithms can log hundreds of variables every minute. It's not just building automation, it's building intelligence. The result is a building solution that enables everything within the envelope to function more efficiently, save more energy, and even make people more comfortable.

Why are more and more buildings moving from an old EMS to a predictive building automation system or building intelligence system?

1. Predictive solutions have been proven to save more energy.

In 2015, a nationally recognized third-party verification lab began a multiyear comparative study to examine the performance of a programmable thermostat, which has been programmed for optimum efficiency within the given conditions. It compares those findings against a predictive, proactive system. The following graph depicts the data that was collected from Nov. 2015 – March 2016.



Let's break down this graph into its important components. The Y axis is the amount of energy in BTUs (British Thermal Units) that it took to reach the desired temperature. In this study, the desired temperature is a cozy 72 degrees Fahrenheit. The X axis is the heating degree day in Fahrenheit, or the number of degrees

that a day's average temperature is below 65 degrees Fahrenheit. For example, if it's a 45-degree day, that means it's a 20-heating-degree day. The gray line indicates how many BTUs a programmable thermostat is using to reach the desired temperature. Note that on a 30-heating-degree day it uses approximately 1 million BTUs to heat the building.

The orange line illustrates that a predictive system requires significantly less energy to heat the same building. In fact, the predictive and proactive system tested here uses less than 300,000 BTUs, indicating over 70% energy savings. Imagine how that would impact the energy bill of most buildings today.

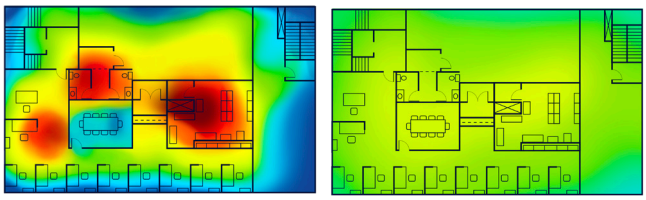
This further illustrates the above argument that an EMS is only as effective as the system already in place. For most light commercial buildings, that's a programmable thermostat, which may or may not be set up for optimal use.

2. Predictive solutions can benefit your bottom line.

Making up more than 40% of the energy usage within a commercial building, HVAC represents the largest opportunity to increase efficiency and your bottom line. A predictive solution that leverages cloud computing algorithms can deliver more than just energy savings.

With the ability to take in hundreds of data points, a predictive solution has the ability to consider factors such as weather forecast, building orientation, positioning of the sun, humidity, air quality, and mean radiant temperature to deliver comfort all while saving energy.

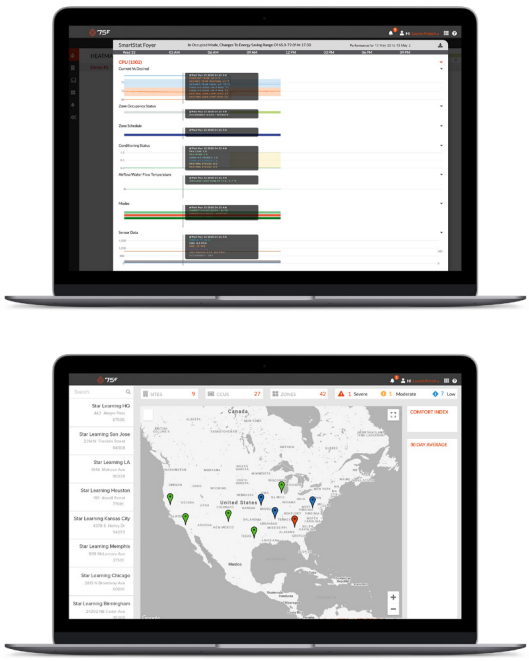
Imagine algorithms that can model the thermal envelope and air quality of your building before sending out the optimal strategy to achieve the perfect balance. That technology already exists today.



The heat map on the right shown above illustrates the common kinds of comfort and balance that come from a predictive system. This results in more productive employees, more frequent guest visits, and lower energy bills.

3. Predictive solutions can still provide all the valuable information that an EMS would, and then some.

Many building automation systems already deliver much more than just energy usage. Performance evaluation provides insight into equipment performance, which can help predict equipment failures and verify service actions. This drives even further efficiencies and helps to increase your bottom line. The coming decade will see predictive solutions that far outpace the capabilities of an EMS.



User-friendly interfaces allow for new ways of viewing energy usage, equipment performance and more.

CHAPTER 2

BUILDING HEALTH WILL BE MANAGED, NOT JUST MONITORED

Indoor air quality (IAQ) and occupant health will be a primary driver of building automation in the coming decade, but comfort and operational efficiency will remain close behind and extremely important. After COVID-19 forced commercial buildings in the U.S. to shut down for months in the spring of 2020, building owners and facility managers began searching for the right strategy to make indoor spaces more safe in the event of a pandemic while saving energy under such extreme conditions.

And, science and HVAC strategies recommended by experts to mitigate viral spread indoors can be extreme. The Centers for Disease Control and Prevention (CDC) and the American Society for Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) recommend opening outdoor air (OA) dampers as high as 100 percent, keeping systems running longer hours, and disabling demand-control ventilation (DCV). ASHRAE also recommends a two-hour purge of indoor air before and after occupancy.

Pandemics have the potential to be a recurring problem worldwide in years to come, and expert recommendations for indoor safety are likely to evolve as we learn more about COVID-19 and any pandemics that may follow. The BAS industry has invaluable potential to drive how we respond to these health emergencies in public indoor spaces.

The BAS of the future will have built-in pandemic algorithms that can be turned on or off as necessary; will tailor sequences to specific equipment types to avoid damage; and will be able to adapt to evolving safety recommendations instantaneously without any custom programming required on the user's end.

THE PROBLEM WITH HVAC COVID-19 MITIGATION RECOMMENDATIONS

Most system equipment is not designed for 100 percent OA loads all the time, so improper execution can cause damage and further rack up expenses. Following these recommendations without a building automation system can be time consuming and labor intensive, too. For example, a two million square-foot suite of buildings would require hundreds of rooftop units (RTUs). Without a building automation system, you'd need to climb onto the roof and manually open all those OA dampers to the extent possible. If there's an economizer, an HVAC technician would need to set the minimum position to 100 percent if possible.

Plus, utilizing increased OA will use more energy. Data from ASHRAE suggests higher OA ratios can double or even triple energy usage, as demonstrated in the below graphic.

Percent OA	EAT DB / WB	CHW GPM	Coil Pressure Drop (Ft H2O)	Total Capacity (MBH)	Sensible Capacity (MBH)
20	77.64 / 66.64	73.66	5.04	443.49	282.78
30	78.95 / 68.55	83.4	6.32	510.68	297.83
40	80.26 / 70.39	94.27	7.90	582.09	312.93
50	81.56 / 72.15	104.17	9.49	651.46	327.99
60	82.86 / 73.84	114.6	11.3	720.81	343.1
70	84.15 / 75.47	125.87	13.43	790.57	358.15
80	85.44 / 77.03	135.5	15.37	857.15	373.26
90	86.72 / 78.54	149.73	18.48	929.1	388.3

In this example, increasing ventilation from 20 percent OA to 90 percent doubles the required chilled water, triples the coil pressure drop, and requires just over twice the amount of cooling source from the chiller.

What's more, science and industry experts are still studying COVID-19, and their recommendations for keeping indoor spaces safer may evolve as we learn more about the virus. Manually adapting to new strategies as they evolve will be a burden on the facility manager. Despite the changing nature of HVAC best

practices and the financial and labor implications that go along with them, the smart facility manager will realize that building automation can make pandemic response dramatically easier.

BUILDING AUTOMATION AND EPIDEMIC SEQUENCES

ASHRAE recommends building automation companies create an Epidemic Mode, a sequence of operations built specifically for indoor life during an ongoing pandemic. 75F already has such a sequence, and it's currently available to any customer free of any additional costs.

The sequence is based on the latest guidance from scientists, government organizations, and global industry leaders. As recommendations from these authorities evolve over time, 75F Epidemic Mode™ will update over the cloud to implement the most current strategies to minimize viral transmission, all while maximizing energy efficiency and IAQ.

Current recommendations for the commercial built environment include increasing outside air ventilation and flushing indoor air before and after occupancy hours. 75F Epidemic Mode™ achieves these directives through its specific application profiles, Smart Purge™ and Smart Enhanced Ventilation™. Both profiles are ready to use out of the box – no manual programming required.

Where implementing CDC and ASHRAE guidelines without help from a BAS may damage equipment, 75F's Epidemic Mode works to the extent possible for each individual piece of HVAC equipment based on its unique capacity and weather conditions. This way, building owners can rest easy knowing their HVAC system is working within proper health guidelines without risk of equipment damage from running a system outside parameters.

Once the pandemic is controlled and guidelines ease, 75F's technology allows building managers to remotely turn off Epidemic Mode™ and return to 75F's award-winning algorithms to improve comfort and energy savings.

While operating Epidemic Mode, there are still a few ways owners and facility managers can keep efficiency in mind. If it's the right approach for your building, consider using only one purge period before occupants arrive instead of both pre- and post-occupancy. This may be a consideration for buildings that will be truly unoccupied after set occupancy hours – meaning employees are not staying late, and no overnight cleaners are scheduled.

The 75F system will also keep building conditions in setback mode overnight and during purges so buildings will not need to work as hard to condition all the OA coming in for the purge. When a building is occupied and utilizing enhanced ventilation, buildings with some unoccupied zones – rarely used conference rooms, for example – may consider directing airflow to occupied spaces to save energy on empty spaces.

IAQ IS GOOD FOR MORE THAN OCCUPANT SAFETY

While enhanced ventilation and higher ratios of OA will cost more, research shows that superior IAQ and temperature control will directly affect a company's bottom line. This will remain an important business consideration both during a pandemic and in normal times when you're not using purges or opening OA dampers to 100 percent.

When employing the right solution, solving your building's thermal problems whether you're using pandemic sequences or not increases profit (economic), increases employee productivity (social), and reduces energy usage (environmental). The successful building owner will treat comfort and

health outside of a pandemic as the variable driving employee productivity and guest satisfaction that most affects a company's bottom line, and during a pandemic, as an essential element of occupancy.

It's first important to note that temperature control factors heavily into workplace satisfaction. A 2019 analysis of Leesman data with 557,959 respondents indicates that on a global scale, temperature control is important to 76.8 percent of workers. However, only 30.6 percent of survey takers were satisfied with their current employer's temperature control options, meaning that technology is not keeping up with thermal comfort as a main priority for employees.

If worker satisfaction alone isn't persuasive enough, results from a 2017 study facilitated through The Healthy Buildings Team at the Harvard T.H. Chan School of Public Health reveal compelling data about cognitive function in comfortable, green workplace environments.

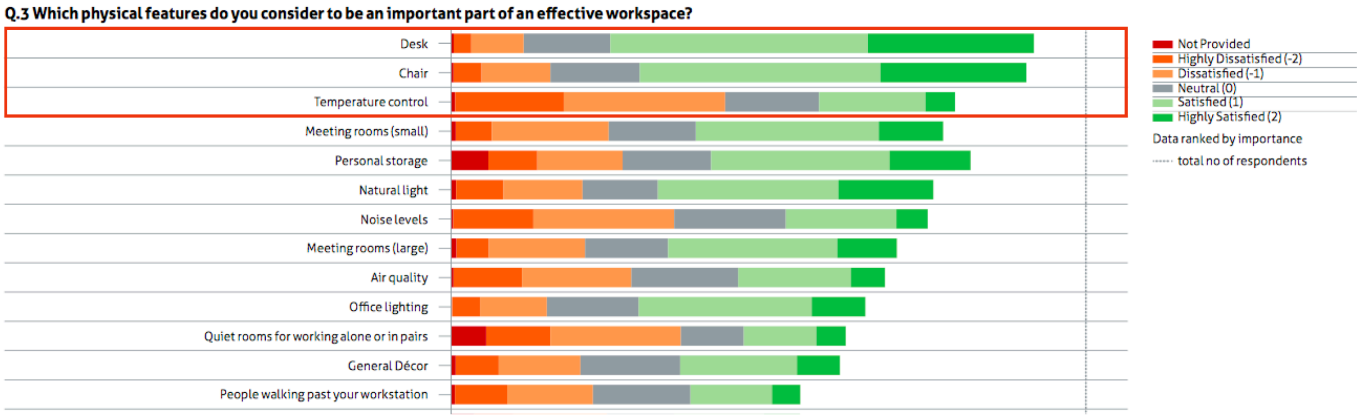
The study measured 109 participants from 10 high-performing buildings – meaning buildings surpassing the ASHRAE Standard 62.1-2010 ventilation requirement and with low total volatile organic compound concentrations.

Researchers administered a cognitive function test of higher order decision-making performance twice during the same week. Results showed that employees working in green-certified buildings scored 26.4 percent higher on those tests compared to those working in non-green-certified buildings. Additionally, these employees showed 30 percent fewer sick building symptoms, which include symptoms such as eye, nose, and throat irritation; mental fatigue; nausea; headaches; dizziness; and skin irritation. The study also indicates that thermal comfort is the workplace is associated with higher sleep quality.

Data linking healthier buildings to higher worker satisfaction and health is not a new phenomenon.

A Cornell University study links 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%.



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

2. Results also suggest raising the temperature to a more comfortable thermal zone saves employers about $2 per worker, per hour.

The green building movement is undergoing a fundamental shift. It's not just enough to reduce your carbon footprint. Definitive studies like the one Harvard published 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 that IAQ will be an ongoing concern for building owners of the future, and that 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-out strategic performance plan.

There is technology that can help – today, building automation is more customized and sophisticated than ever. The development of IoT and cloud computing has fundamentally shifted the way building owners can deliver comfort to occupants.

Look at the Edge, for example. Located in Amsterdam, the Edge is the most connected building on the planet. Fully realizing the potential for IoT with an unprecedented 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 everyone a desk, the space is set to their desired temperature and the lights dim or brighten based on saved preferences.

While not all buildings can 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 three 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 in its infancy 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.

Employees who used this had 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). Personal Comfort Systems is no longer an active company, and when it was, the chair cost 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.

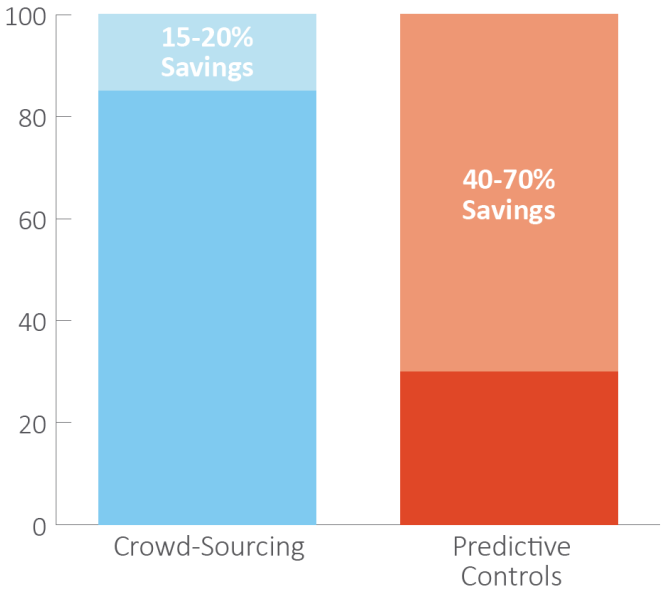
Crowd sourcing a building's thermostat settings has its advantages. It attacks occupant frustration with comfort head on. Whether or not individuals receive the temperature they want, there is certainly a placebo effect of feeling like you are being heard. Additionally, employee calls regarding discomfort decrease. The downside is that these systems do not regulate air quality, nor do they 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, such as 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. A typical HVAC system is set up for a static set of conditions. A 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, this is called Dynamic Airflow Balancing.

Now let's tackle the issue of air quality as it can be tricky and maybe even contradictory. 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 CO_2, NO_2 and CO levels, along with indoor enthalpy.



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

With a full understanding of building enthalpy and particulate levels, the system provides superior air quality while offering free cooling when conditions are appropriate. This solution is called Outside Air Optimization, or OAO. When bringing in outside air, humidity is also measured to ensure the indoor

A predictive solution that leverages cloud computing algorithms can deliver more than just comfort and energy savings.

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 to 70 percent in HVAC energy usage.

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 can 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 percent, eliminate breakdowns 70 to 75 percent of the time, minimize downtime, and increase production.

There are very few companies developing new and innovative solutions that tackle both efficiency and wellness simultaneously, yet the future of comfort and health is linked to efficiency and the savings that come with it. Business and property owners, facility managers, and sustainability officers must treat efficiency and building wellness as complementary and reflect this in how they maintain their buildings.

CHAPTER 3

PER SQUARE FOOT, COMMERCIAL ENERGY USE WILL FALL

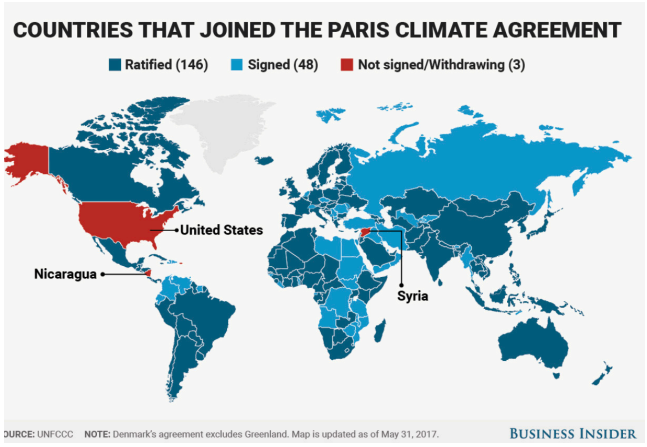
Given the power of predictive technology, there's great potential in reducing energy use across the commercial sector. More intelligent building systems will improve business processes and efficiency, tenant health and wellness, and overall resource management, for the mutual benefit of planet, profit and people.

THE SUSTAINABLE ENERGY TIMELINE

Sustainability is the ability to withstand change, accommodate inhabitants, maximize and preserve resources, and minimize waste. In December 2015, the Paris Climate Agreement was formed to combat planet earth's global warming, building on the 1992 United Nations Framework Convention on Climate Change (UNFCCC). The goal of the Paris Agreement is to prevent the global temperature from rising above pre-industrial levels by substantially cutting greenhouse gas emissions. The agreement encourages participating countries to significantly reduce their energy usage – with developed countries making a commitment to mobilize $100 billion a year in climate finance by 2020.

In June 2017, United States President Donald Trump made the controversial announcement that the U.S. would withdraw from the Paris Agreement. That withdrawal will take effect in November 2020. The U.S. makes up only 4.5% of the global population, yet consumes nearly 20% of the world's energy.

According to the U.S. Department of Energy, commercial buildings account for over 36% of the country's total energy consumption.



Source: UNFCCC, Business Insider

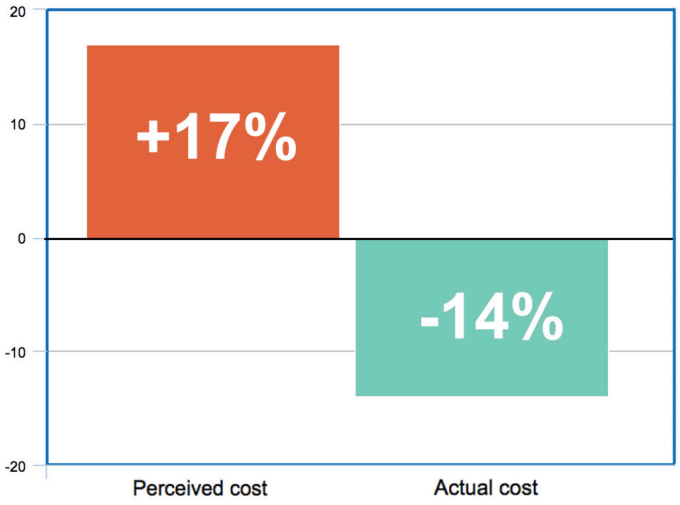
Despite the U.S. withdrawal from the Paris Agreement, business owners must take steps to mitigate energy usage. Thanks to tax incentives and recent advances in smart building technology for HVAC and lighting systems, the choice to be sustainable is more than a moral decision – it is a wise financial move, as well. Green buildings, whether built from the ground up or retrofitted, are now significantly less expensive than traditional models, and they bring many added benefits for both owners and occupants.

THE BUSINESS CASE FOR GOING GREEN

Misconceptions about cost prevent adoption of sustainable buildings. A 2007 opinion survey by the World Business Council for Sustainable Development found that green buildings were thought to cost 17% more than traditional buildings. But according to the World Green Building Trends 2018 Smart Market Report, new green buildings saw 14% decreased five-year operating costs, and green retrofitted buildings saw 13%. Additionally, on average new green buildings see a property value increase of 7% – with market demand for green buildings doubling every three years.

As Georg Kell and Bruno Berthon write in the UN Global Compact-Accenture CEO Study 2010, A New Era of

Perceived vs. Actual Cost of Green Buildings
(as compared to traditional buildings)



Based on data from the World Business Council for Sustainable Development and the World Green Building Trends 2016 Smart Market Report.

Sustainability – "Good performance on sustainability amounts to good business overall: the imperative to act has shifted from a moral to a business case".

SMART MEASURES FOR THE BUILDING OWNER

The United Nations Environment Program, or UNEP, is dedicated to combating climate change and developing sustainable practices. Because of these shared beliefs at the origin of our brand, 75F is a proud member of the International WELL Building Institute, as well as UNEP Sustainable Buildings and Climate Initiative, which is co-led by the U.S. Green Building Council (USGBC).

The USGBC is a non-profit organization that promotes sustainability in building design, construction and operation. They are best known for their development of the Leadership in Energy and Environmental Design (LEED). As the USGBC writes, "LEED is the most widely used green building rating system in the world. Available for virtually all building, community and home project types, LEED provides a framework to create healthy, highly efficient and cost-saving green buildings. LEED certification is a globally recognized symbol of sustainability achievement." Buildings receive a ranking based on a variety of factors, including indoor air quality performance, thermal comfort and enhanced commissioning.

PROGRAMS TO WATCH

Arc is a state-of-the-art platform designed to help collect, manage and benchmark your data to improve sustainability performance. With Arc, buildings can input their data to benchmark themselves and improve performance. Arc calculates a performance score out of 100, based on a global data set and action-oriented strategies across five categories: Energy, Water, Waste, Transportation and Human Experience. 75F is the first building automation solution to integrate Arc, enabling automatic score updates in 75F Facilisight software.

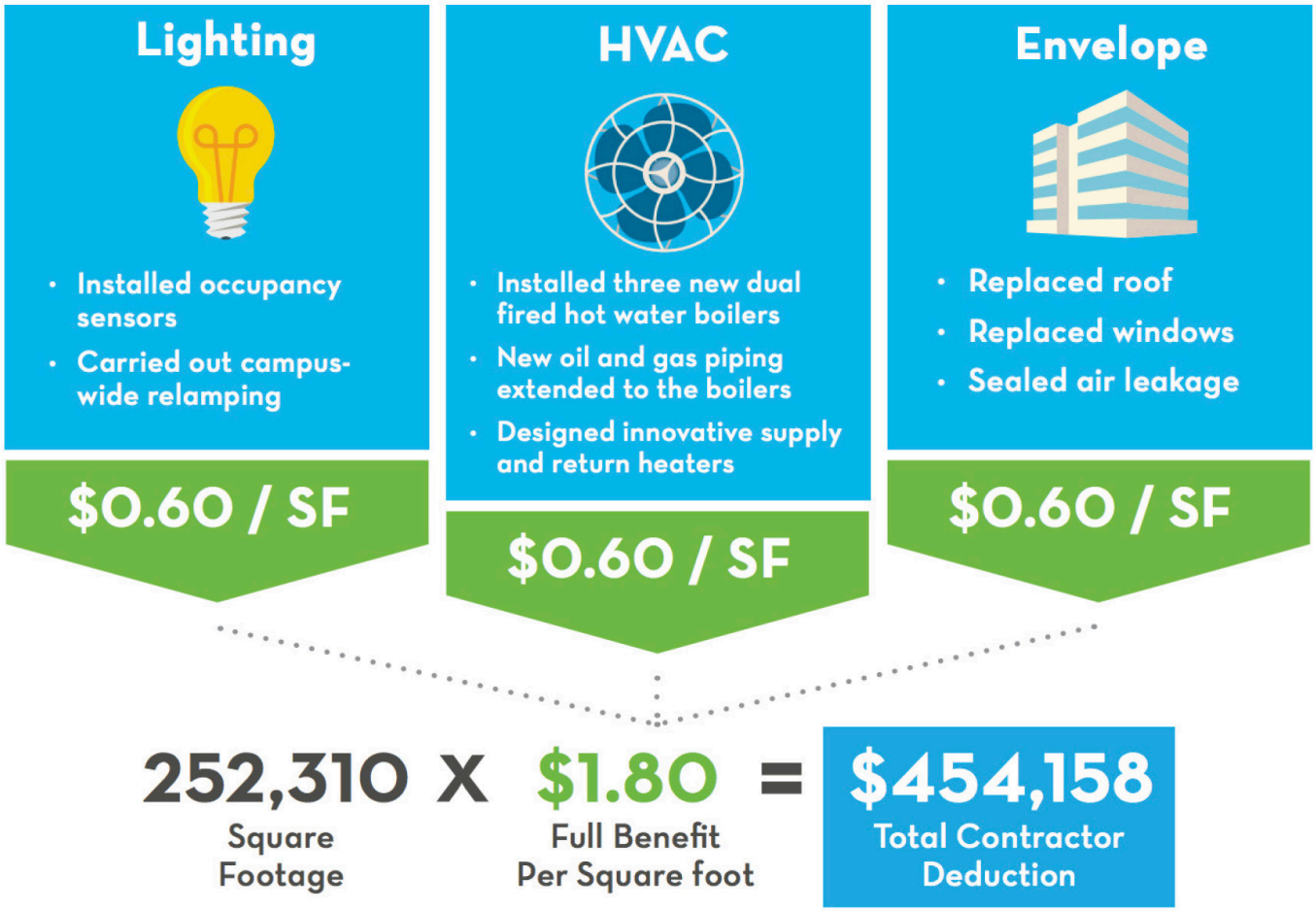
The International Well Building Institute has developed the WELL Building Standard, a flexible framework for improving health and human experience through design, advancing health and well-being in buildings globally. There is increasing importance in healthy building initiatives and 75F seeks to factor the WELL Building Standards into our solution development and is a longstanding WELL Building member.

The International Living Future Institute's Living Building Challenge seeks to develop regenerative buildings that connect occupants to light, air, food, nature, and community; self-sufficient and remain within the resource limits of their site; create a positive impact on the human and natural systems that interact with them.

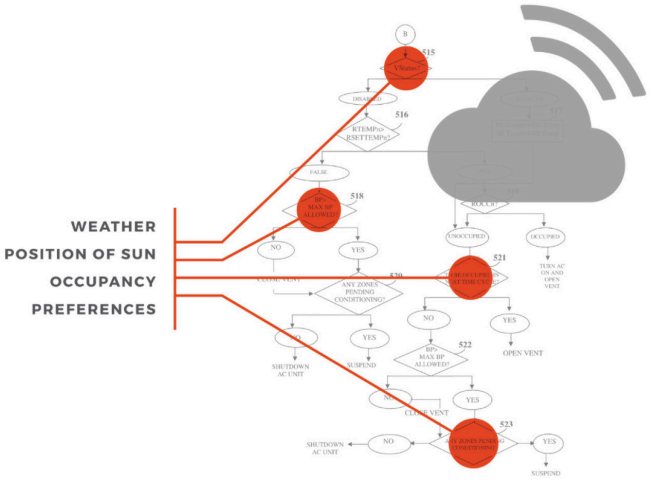
New Buildings Institute (NBI) is a nonprofit organization driving better energy performance in commercial buildings, promoting advanced design practices, innovative technologies, public policies and programs that improve energy efficiency, including the development of Zero Net Energy (ZNE) buildings: ultra-efficient new construction and deep energy retrofit projects that consume only as much energy as they produce from clean, renewable resources.

INCENTIVES TO BE SMART

To curb energy use, Congress offers incentives such as the Energy-Efficient Commercial Building Deduction (179D), which in 2006 through 2017 allowed qualifying building owners and businesses to receive a tax deduction of up to $1.80 per square foot for energy-efficient buildings – including retail, office, industrial and warehouse buildings. Energy-efficient improvements include HVAC and lighting systems, which ultimately cut energy costs and improve a



An example of potential savings from 179D after energy enhancements. Source: Alliantgroup



Smart HVAC systems can take into account everything from building orientation to local weather forecasts.

building's value. Low-interest financing packages further facilitate such efficiency enhancements.

New incentive packages continue to develop. Recently, 75F became the first company to partner with the **Center for Energy and Environment (CEE)** to take advantage of their new One-Stop Efficiency Shop® for HVAC upgrades. CEE designed and delivered the program for Xcel Energy Minnesota. A national leader, the CEE offering has earned the designation of "Exemplary Energy Efficiency Program" from the American Council for an Energy-Efficient Economy.

Efficiency isn't always top of mind when choosing a building, though smart building technologies offer great savings potential for commercial building owners and tenants alike. Common Area Maintenance (CAM) and Tenant Improvement (TI) funds can also be applied toward this end, improving property value while reducing operating expenses.

A wide range of HVAC system improvements qualify for tax incentives; examples include geothermal systems, thermal energy storage and Variable Refrigerant Flow (VRF) zoning. Though, the most comprehensive, efficient and often inexpensive way to create a qualifying energy efficient building is to implement a "smart" HVAC system. Web-based, smart HVAC systems can automatically adjust controls based on sensors and data sources, such as occupancy levels and weather, for optimum results and minimal energy use. Automated systems are markedly more efficient than manually controlled buildings, even surpassing newer standard HVAC systems.

A predictive, proactive HVAC system can save a building 30-70% more energy (Btu) during the winter months from November to March, according to a 2016 study conducted by the Gas Technology Institute (GTI), a nationally recognized third-party verification lab.
A second report from GTI conducted between November 2017 and November 2018 supported total HVAC energy savings up to 45% in a mild California climate.

Similar to HVAC upgrades, lighting systems improvements offer significant energy efficiency impact. The quickest and most common approach is relamping, replacing traditional lightbulbs with LEDs. Much like upgrades to HVAC systems, "smart"

Addressing the triple bottom line increases profits and employee productivity while reducing overall energy usage.
Source: RPM Retail

solutions can take lighting improvements further than wattage reduction by adding features such as timers, occupancy detectors and scheduling. When employed on a building-wide scale, these changes can amount to significant reductions in energy use.

A SHORTER ROI

Green buildings often experience very short ROIs which make smart HVAC and lighting systems appealing. In 2011, the UCLA Institute of Environment and Sustainability and CBRE produced a study on the trends and challenges of increasing building energy efficiency in retrofitting commercial real estate. Retrofit report analysis and surveys conducted by the researchers suggested decision makers expect a three- to five-year payback on any energy efficiency retrofit. Incentives and rebates can help shorten the payback period and start net savings returns.

A BETTER QUALITY OF WORK AND LIFE

Beyond a short ROI, plus ongoing energy savings, smart building infrastructure can also improve quality of life for both owners and tenants by enhanced monitoring, measurement and control capabilities of equipment and indoor environments. With building automation, facility managers can analyze and improve efficiency, pre-empt costly failure or service with pre-emptive monitoring, and maximize investment of time and money across equipment and staff, freeing up people's time to focus on higher-value priorities.

Perhaps the greatest value realized (and least measured) is that for people, in providing a welcoming, comfortable, healthy environment with temperatures, air quality and lighting to maximize occupant productivity and well-being. The true value of healthy buildings is just beginning to come to light with the advancing WELL Building standard and other human factor assessments. Consider that the cost of staffing represents about 100x that of energy costs, on an annual, per-square-foot basis. If the energy savings alone can justify smart building improvements in a matter of just 2-3 years, consider the exponential and immediate gains in providing a great place to work for happy, productive and healthy inhabitants in your building… and on this planet.

Making the choice to be sustainable is now easier than ever. Despite U.S. withdrawal from the Paris Agreement, U.S. business owners can still make significant reductions to their energy usage – creating a more sustainable world. The best part? The organizations who implement smart systems will save a great deal of money in the process and prove to be leading corporate citizens.

While sustainable buildings were once considered luxuries, they will be a must-have and widely beneficial choice for any building owner. The quick payback (further accelerated by incentives) and the ongoing energy savings potential from smart HVAC and lighting systems are significant. When combined with the quality of intelligent building and business management, and healthy, productive occupants, smart sustainable buildings are the clear choice of the future.

CHAPTER 4

HIGH TECH WILL BE INCREASINGLY IN DEMAND

The value of a high-tech building is going to grow faster than the valuation of a low-tech building. This inevitability is a win for property managers who have building automation systems installed in their facilities, and a loss for those who do not.

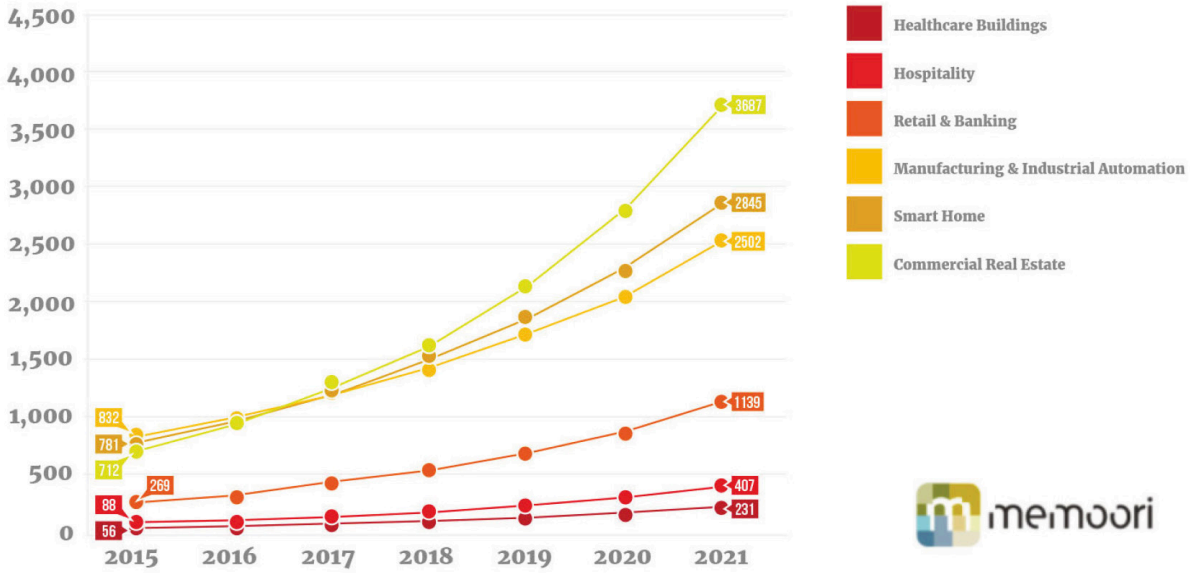
The commercial real estate (CRE) market is rich with opportunities for smart buildings to improve property management top- and bottom-line performance through expense reduction, increased property values, and better workplace experiences for tenants.

Amid the flurry of smart homes, self-driving cars, and smart wearable devices, only about 15% of commercial buildings in 2017 were "smart," with connected building automation systems in place[1]. But, that's about to change BIG TIME. The smart building research firm Memoori predicts IoT in commercial buildings will grow significantly between 2018 to 2022. According to the firm, the combined global market should rise from $34.8 billion from the end of 2017 to $84.2 billion by 2022.

Legacy building controls systems are overbuilt and expensive for most commercial building owners and operators. Those systems are being displaced by newborn digital solutions.

Fueled by the proliferation of affordable sensors and cloud computing, this new breed of building intelligence solutions is changing up the economics of the real estate investment world. Now, it's more affordable and easier than ever to realize net gains from the affordable, yet sophisticated, building automation systems (BAS) that combine the Internet of Things (IoT), wireless communications, big data, and cloud-based algorithms to make your buildings smarter, more efficient, and more attractive for both current and potential tenants.

GROWTH IN SMART BUILDING CONNECTED DEVICES OVER TIME (millions of devices)



The CRE market is projected to have the fastest and largest growth in connected devices between 2016 and 2021, surpassing even smart homes, according to the Smart Building Research firm Memoori[2]

SMART BUILDINGS OFFER NET GAINS

These new systems offer several ways to both reduce expenses and improve property values, netting positive for all real estate stakeholders: investors, owners, asset managers, brokers, property managers and, of course, tenants – the ultimate customers. When you factor utility incentives for energy-efficient systems, or just the annual operational savings, building automation systems are becoming a smarter choice for property CAM, TI, and upgrades on financial merits alone, before factoring the many workplace benefits.

Perhaps the greatest value in smart buildings is in the improved workplace experience, with comfortable, healthy, productive, and easily managed indoor environments for tenants. An intelligent building system can play a key role in attracting, retaining, and delighting tenants, offering lower energy bills, eco-friendly offices, and creating great places to work with healthy indoor air quality and unique occupant experiences (OX). 2. An EMS is a step up from manually correlating spreadsheets, but it does not intelligently process or act on the data it collects in a meaningful way.

An EMS was once a great tool for consolidating information and reviewing energy usage trends, while comparing them across multiple sites. What's still missing, however, is that most buildings and systems today have very little localization knowledge. An EMS knows the address of your building, but does not know its orientation, building usage pattern, or local weather. Orientation can make a huge difference in how much energy your buildings use. With an EMS, it's up to the user to determine what energy usage patterns are occurring in a building and then do the correlation across their building portfolio.

With advances in machine learning and AI that make building intelligence cheaper and more effective, these inefficiencies will disappear. This will happen first in less complex environments, and then across the hospitals and global companies with a range of equipment and systems.

SMART BUILDINGS' INFLUENCE ON OPEX

OpEx Reduction: Reduce operating expenses across building systems, including HVAC and lighting maintenance.

Energy Savings: A Smart Building system can save 30-50% of HVAC energy consumption, plus reduce LED and other lighting energy, conservatively $.20-.50 PSF.

Rebates: Utility-driven efficiency incentives can reduce total cost of acquisition and speed ROI timeframe.

Reduced HVAC Equipment: Higher efficiency means fewer or downsized equipment, or even eliminating traditional fixtures.

Extend Equipment Life: Retrofit controls to equipment; smart monitoring and predictive maintenance can add years to your equipment lifecycle

No IT Hardware Costs: No need to invest in workstations and software updates; cloud based software enhancements pushed wirelessly.

Lower Installation Costs: Get 5x faster installation of wireless system, eliminate temperature controls specialists and custom programming.

Remote Multi-site Management: Web and mobile monitoring and adjustments without site visits; reducing travel expenses and team disruption.

Optimization Through Insights: Further efficiencies can be driven by data insights, patterns understanding demand and supply / performance.

Higher Rates per Square: Smart building systems can lift property value by at least $.10/sf, increasing as much as 11.8%, adding to your topline.

Long term Hold Assets: 10+ year plans; internal rate of return.

Differentiation: Only 15% of commercial buildings are smart. Yet, progressive tenants seek and value the benefits and controls of smart, connected properties.

Staged for the Market: A smart automation system shows well. A quick retrofit to your current and vacant properties provide a fast enhancement. When showing, use a Google calendar feed or geofencing based pre-conditioning to make that first visit comfortable and inviting.

Attract + Retain Tenants: Smart systems, and applications that empower the users, are becoming a means to get interest from prospective tenants and to stay sticky with existing clients.

Creating the "Occupant Experience": Building automation provides a huge opportunity for landlords to give management remote insights, save energy, improve workplace IAQ and comfort, plus empower employees with control over their zones.

Higher Return TI Investment: Adding more-lasting and differentiated value than fresh paint and carpet.

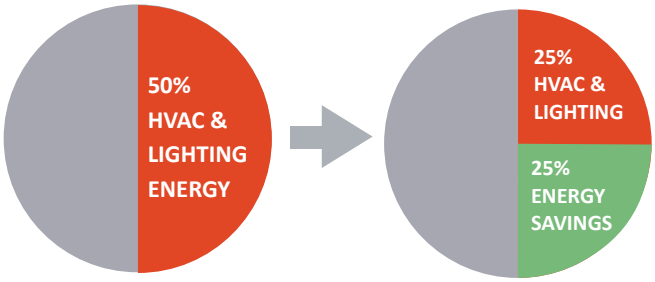
Higher Return CAM: Investments Can offer uncommon value for common areas and budget management.

Green Value in Sustainability: Green buildings have ever-increasing attention and value in the market, supporting corporate citizenship and triple-bottom line performance for profit, people and the planet too.

SMART SOLUTIONS CAN CUT ENERGY BY 25%

The U.S. Green Building Council cites that buildings consume 70% of U.S. electricity and account for 39% of U.S. CO_2 emissions. The U.S. Department of Energy (DOE) indicates that commercial buildings waste 30% of the energy they consume. This is a major opportunity for smart buildings' efficiency to save significant energy expenses and reduce environmental impact; yet, that's just the start of the savings.

One of the greatest and most immediate opportunities to reduce property operational costs is in energy reduction, particularly in more efficient management of heating, venting, air conditioning, and lighting.



Smart building controls can reduce HVAC and lighting energy consumption by up to 50%.

In the average commercial building, HVAC and lighting makes up about 50% of energy use[5]. So, the potential of 30-50% energy savings from smart HVAC could translate to 25% of total energy use. That alone is worth the investment, often with payback in less than three years, sometimes less than a year. Smart building technologies can reduce costs and add value to your TI packages, while boosting returns for owners and tenants alike.

Utility-driven rebates, low- or no-rate financing and tax incentives for energy efficient systems help cover costs and reduce payback timing, leading to net gains even sooner. A quick, no-cost site survey and estimated projection of energy savings can help to cost-justify the building automation system investment and define the payback timeframe, from only an energy savings perspective.

The US Green Building Council's LEED program recognizes Leadership in Energy and Environmental Design, with different levels of reward: LEED-certified buildings (40-49 credits), silver (50-59 credits), gold (60-79 credits) and platinum (80+ credits). LEED buildings have faster lease-up rates, may qualify for a host of incentives like tax rebates and zoning allowances, and retain higher property values[6].

LEED CREDITS INCREASE SAVINGS AND PROPERTY VALUE

For example, 75F intelligent building solutions can contribute to up to 38 different LEED v4.0 points, up to 11 credits. This provides even further capability for you to demonstrate sustainability and good corporate citizenship, in addition to eligibility for financial incentives, such as tax credits. And, new measurement tools such as USGB's Arc Score can help you assess your ongoing building performance benchmarked against others, whether you're a LEED building or not. The Arc score offers dynamic measures for Energy, Water, Waste, Transportation and Human Experience.

NEWER BAS ALTERNATIVES OFFER EQUIPMENT SAVINGS

The total cost of acquisition (TCA) can be significantly reduced with an energy efficient and easily installed IoT-based building automation solution. Building management systems are historically expensive and overbuilt, prohibiting adoption by the 85% of buildings that don't have them in place. Though, newer BAS alternatives with low-cost sensors, no specialized programming, and quick/easy setup can reduce the cost and time to implement.

Lower-cost Systems: Affordable sensors and wireless devices are making IoT-based BAS a cost-effective solution for commercial buildings of all sizes, at a fraction of traditional system costs.

Reduce Installation and Controls Costs: The speed and ease of installation for wireless and intuitive BAS systems can be 80% lower than traditional systems, making for quick retrofits with minimal occupant disruption.

Require Less HVAC Capacity and Equipment: A building automation system's overall efficiency can also reduce the number and size of HVAC equipment (such as RTUs) required to meet demands, reducing capital expenditures when new HVAC equipment is needed.

Extend the Life of Equipment: And a smart building automation system can add years to the lifecycle before needing to upgrade HVAC equipment, stretching your CapEx dollar even further.

Lower IT Compute Costs: A cloud-based system eliminates the need to buy dedicated servers or workstations and the related maintenance of physical IT compute and forced upgrades over time.

Utility and repair/maintenance expenses remain the two largest operating expense categories for commercial buildings. An intelligent building automation system can start saving in ongoing operational expenses (OpEx) that make up the Total Cost of Ownership (TCO) for a building automation system.

The O&M Best Practices Guide[7] from the U.S. Department of Energy (DOE) outlines significant savings opportunities:

- Reduce maintenance costs up to 30%
- Replace parts only when actual performance degradation requires it, vs. a calendar schedule
- Eliminate 70-75% of equipment breakdowns
- Reduce equipment downtime 35-45%
- Remote monitoring also minimizes the need for expensive truck rolls to start diagnostics, which can run from hundreds to thousands of dollars, depending on facility and service provider.

Beyond energy savings, smart HVAC controls can reduce the number/capacity of new equipment, lower install costs, plus extend the life and reduce maintenance costs of existing equipment, retrofit across multiple brands and system types.

It is also useful to consider that, according to the DOE[8], operations and predictive maintenance can realize the same benefits (energy savings) as equipment retrofits costing approximately 20x more.

SMART BUILDINGS BENEFIT EVERYONE

Owners and investors can gain up to 25x increased property value for OpEx reductions, adding quick and affordable differentiated building amenities that attract and retain tenants and help stage for sale. Plus, their building feature performance-optimized equipment, with lower TCA and TCO.

A&E and developers, whether in new build or renovation, smart building systems offer opportunities for reduced equipment (due to efficiency), minimal wiring (wireless communications) greater environmental design control.

Asset managers managing physical property assets can get a lot smarter, with data visualization on lowered expenses and high value per square, across the portfolio.

Brokers benefit from attractive and differentiated smart properties which improve marketability, showing well, offering energy savings, engaging prospective tenants and facilitating speedy sales.

Property managers gain cross-portfolio monitoring and management (RMM) capabilities, down to the building, floor, zone and individual equipment performance level.

Facility managers get RMM, the ability to coordinate repairs, minimize emergency truck rolls, and deliver smarter service and maintenance based upon insights.

Mechanical services can deliver quicker installation and configuration, without programming or on involving controls specialists, staying competitive and in control.

Tenant executives & HR professionals offer great places to work, in addition to energy savings, comfortable workspace, reduced absences and turnover, healthy and productive employees, and a stronger employment brand.

Tenant occupants get comfortable, healthy environments catered to their preferences, plus smart tools to control temperature and lighting right from their mobile phone.

INCREASING VALUE IN YOUR PROPERTY ASSETS

Smart buildings attract and retain tenants. This helps to reduce vacancy and increase lease revenue. And, it can help you boost your lease cost per square foot. Together, these factors can start adding value to your property assets, in addition to the multiple capital and operational cost savings identified.

Vacancies are a double-edged sword, cutting into operating costs to maintain, while spending to market listings to prospective tenants – all without a revenue stream. A smart building can help attract and convert tenants to reduce vacancies.

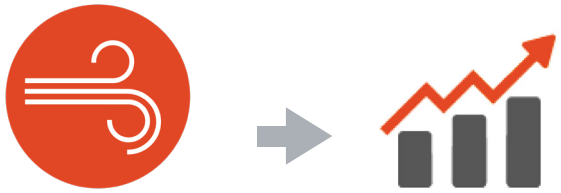
A smart building is a more attractive building. In addition to the energy savings and sustainability benefits, a connected building can **yield higher rates per square foot** – conservatively adding $.10/ per. Studies have indicated that high-performance buildings can increase the rental values as much as 11.8% for commercial buildings[9]. In addition to financial incentives, LEED buildings have faster lease-up rate and retain higher property values[10].

More businesses are recognizing that green business is good business, and their values and corporate citizenship efforts are integral to their brand. A smart and sustainable building adds value for management, while also delivering financial benefits.

CREATING THE IDEAL OCCUPANT EXPERIENCE

Employees increasingly seek workplace environments that cater to them. Deloitte's "The Edge" in Amsterdam, hailed as the most connected and greenest building, attracts and serves employees with mobile apps to guide to the best parking spots and building areas to support their working style, requirements and preferences. You can even empower occupants with mobile apps to control temperatures and lighting in their own zones. Advanced BAS solutions can capture occupant feedback and deliver employee controls, environments and experiences that significantly affect comfort, productivity, health and overall satisfaction.

Occupant health and wellness are paramount concerns for everyone involved in commercial environments. "Sick building syndrome" threatens the health of occupants and can cause absenteeism; it can result from a host of contributors, including building materials, high concentrations of chemicals or machinery, presence of asbestos or radon, old carpet, dirty air ducts, or a poorly designed or inefficient HVAC system. Smart buildings can sense and manage many of these factors to assure a healthy environment for all occupants.



Increased Indoor Air Quality

Increase in Productivity

Indoor Air Quality is likely to be 2-5x worse than outdoor air quality. Given that most of us spend 90% of our time indoors, your building's indoor air quality can significantly affect employee and customer health, comfort and productivity. Better air quality means employees take 30% fewer short-term leaves[11].

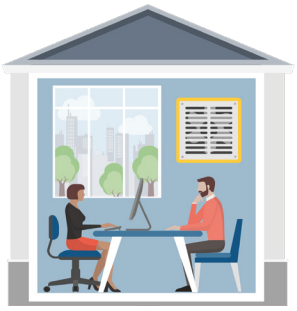
Improved indoor air quality can also **boost employee productivity** up to 8% in your facility, and can improve cognitive functioning. The Healthy Buildings program at the Harvard T.H. Chan School of Public Health has conducted the CogFx study, which has quantified and confirmed the negative effects of poor indoor air quality – namely high CO_2 and VOC levels – on human cognitive abilities.

Smart buildings can sense and proactively manage the environments for key factors in employee comfort and productivity:

- Thermal Comfort
- Air Quality
- Lighting
- Sound

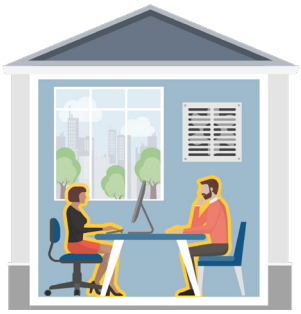
WHAT'S IN A SQUARE FOOT?

This 2/20/200 model presents a broad rule of thumb for relative investments in energy, rent and staffing. While a smart building system can pay for itself in less than three years on energy savings alone, the much larger values area in the enhanced value of the property for lease or sale purposes, and even greater value for the comfort, health and productivity of the tenants of the building.



$2 PSF/yr on Energy
Avg. annual energy expenditure. A smart building could reduce energy consumption 25% and pay for itself in under three years.

$20 PSF/yr on Building
Avg. annual building related costs. A smart building can help to reduce OpEx and increase lease value.



$200 PSF/yr on People
Annual investment in people. A smart building can help to boost comfort and productivity.

RETURN ON INVESTMENT

A 1-3 year energy payback is just the start. You can use the simple payback formula, as long as you have your current average utility payment per period and a quote for the estimated energy savings your building will achieve with the retrofit.

$$P = Vi / S$$

P = payback period
Vi = initial value of investment
S = estimated annual savings

These numbers can also help you calculate net present value (NPV), internal rate of return (IRR) and the impact on your net operating income (NOI). Energy savings free up additional investable dollars for other building improvement or tenant improvement projects.

OPEX reductions have a multiplier effect on asset value. Property investors can recognize asset valuation increases of up to 25x for operational expense reductions, assuming a 4% capital rate.

In recent years, **LED lighting retrofits** have been a popular approach to reduce energy demand at the fixture level. However, smart HVAC solutions can offer even higher efficiency and ROI compared to LED. Consider that the typical payback period on relamping is about six years, whereas the typical payback period on a smart HVAC system upgrade is about three years.

A **smart lighting controls solution** can take your LED lighting savings even further, with calendar scheduling combined sensors for light-level and occupancy to use lighting only when needed, and dimming capabilities. Smart building systems can seamlessly integrate controls of both HVAC and lighting, in a single-pane-of-glass user interface.

SMART BUILDING BUDGET OPTIONS

Smart buildings make for smart investments in cost savings and value enhancements, often with ROI in under 3 years. And, you may be surprised how affordable and easy a modern building automation solution can be.

An initial assessment of your existing property can quickly identify the equipment and installation costs, as well as determine eligibility for energy efficiency incentives and financing. Just starting with a review of utility bills by an energy consultant can go a long way toward identifying budget source for a BAS.

CAM Budgeting

A surplus of CAM funds gives property managers and asset managers options to attract new tenants and retain valuable tenants with building improvement activities. Consider that CAM can be used for capital expenditures. Building improvements are generally accepted if they reduce the property's operational costs, lead to reduced CAM charges and benefit all tenants. Whether your property is under a triple net (NNN) lease or a gross lease structure, upgrading your building's HVAC system falls into these parameters nicely, and it doesn't have to break the bank.

EXPENSE REDUCTIONS	ASSET VALUE INCREASE
Energy	Lease Value PSF
Maintenance & Repairs	Tenant Attraction / Lower Vacancy Rate
HVAC Equipment Acquisition + Installation	Tenant Retention / Satisfaction
Onsite IT Equipment	Data & Insights Across Properties
HR: Employee Turnover & Training	Sustainability
	TI + CAM value

TI Budgeting

Strategic capital planning and innovative TI packages are attractive to tenants seeking renovated office space in prime locations, going way beyond paint and carpet upgrades.

Tenants across industries see that they can get more value and customization opportunities in both CBD and suburban Class B buildings. Occupants benefit not only from reduced energy expenses, but also from the combination of comfort, improved indoor air quality and precise lighting controls – all factors that can boost employee productivity. And, 75F offers an occupant mobile app that empowers tenants to personalize zone-specific temperatures and lighting.

Combining all of these benefits increases net operating income (NOI), which can improve investor returns and create capital for investment in additional projects. According to JLL Research, tenant improvement packages range from $30 to $50 per square foot nationwide. At less than $5 per square foot, a smart BAS optimizes the use of IoT, cloud computing and machine learning.

A NEW APPROACH FOR A NEW BUILD

A smart building automation system can save up to 50% vs typical new controls acquisition and installation costs, due to modern, low-cost sensors, the speed of intuitive and wireless system setup, and cloud computing eliminating the need for onsite IT equipment. And, you can gain sensing and insights around your occupancy, indoor air quality, energy use

patterns, equipment performance and more.
Higher efficiency automation controls can reduce the required capacity of HVAC equipment in a new build design. One company was able to reduce the number and capacity of HVAC equipment, saving $150k for a new 115,000 sf office-warehouse property.

QUICK RETROFITS, FAST RETURNS

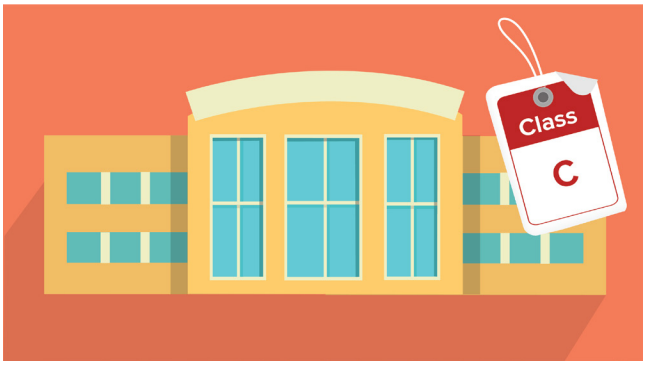
Aging Class A properties need to compete with the sprawling development of new premium Class A buildings, as well as the resulting rise in vacancy in the category.

You already have the premium location and fixtures. Though the HVAC and lighting systems may be nearing the end of their life, a smart automation system can help extend the life of this equipment and improve its efficiency. It can also provide preventative monitoring capabilities for more efficient property management and controls for tenants.

Some of the greatest values you can add are invisible: comfortable temperatures, high indoor air quality, a better occupant experience, and improved efficiency and management capabilities. With a building automation system, you can shift from reacting to issues to predicting and preemptively fixing them. This way, those issues never surface in the first place.

Aging Class B buildings, while typically well maintained, can benefit greatly from a building automation system. It can serve as an investment opportunity and an upgrade booster for stronger lease rates.

Whether equipped with aging rooftop units or boilers and heat pumps, retrofit building automation solutions can bring a new level of value to the property to attract or retain tenants with state-of-the-art sensing and controls, comfortable and healthy indoor air, and remote monitoring and maintenance efficiencies.



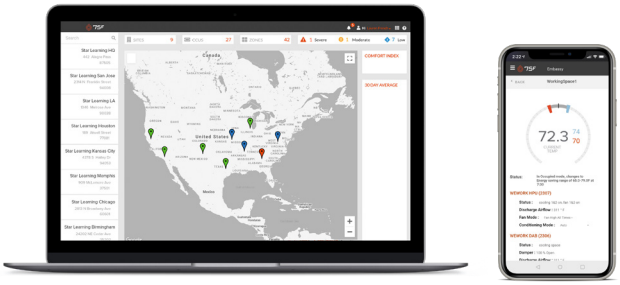
Aging Class C properties have a lot to gain from smart sensing and controls automation, which can quickly and easily be installed during renovation, including TI and CAM investments. Remote monitoring provides added insight across properties, including predictive analysis of equipment performance.

NO NEED TO BE ONSITE TO HAVE INSIGHT

Whether you manage a portfolio of 1000's of properties or a handful of select sites, the remote monitoring and management capabilities of smart building systems give you single-pane-of-glass visibility and control from your Web browser or mobile phone – down to the building, floor, zone and equipment levels.

Consider the hard costs and opportunity costs for travel to sites or ordering service truck rolls to manually assess facility performance and issues. With remote monitoring and control capabilities, you can sense and see early signals of issues in your facilities and even plan predictive maintenance, sending truck rolls only when needed….and equipped with knowledge and parts for an efficient visit.

Even a Frankenstein mix of properties and systems can be beautifully managed. Owners likely have a mix of building profiles in their portfolio. And within any one location, they may have a combination of HVAC systems installed, including different topologies, brands and models. Until now, they were forced to work within silos of these systems, or faced an expensive and resource-intensive investment to try to piece together these systems with custom programming and specialist involvement.



Today, it's possible to retrofit sensors and controllers within that Frankenstein mix of systems and get a beautifully integrated view of current status, energy use, zone and equipment drill-downs and more. What's more, you can add efficiencies and extend the lifespan of aging HVAC equipment, reducing OpEx and deferring capital equipment investments.

MARKET TIMING

When's the best time to install a smart building automation system? The short answer is now. Start with a quick assessment and a low-risk trial installation, which can be accomplished for less than a typical audit. And, start realizing immediate energy savings and benefits for your tenant and your efficient property management that can scale on your schedule. Timing in the fiscal year and the lease status can also create great opportunities for an intelligent building automation investment:

- TI
- CAM surplus
- Vacancy Opportunities
- And, new tax regulations may make an even stronger case.

Vacancy is an open window of opportunity. A vacant property presents a great time to install a building controls upgrade without tenant disruption, creating a welcoming and comfortable climate, adding remote visibility and timing for benchmarking energy use and performance.

A NEW ERA OF SMART BUILDINGS IS HERE

Commercial properties will become the smartest, most-connected buildings in the Internet of Things ecosystem over the next few years. Will your buildings offer the smarts and performance as high-value assets delivering strong returns, while creating ideal conditions to attract and delight your tenants? Smart buildings cut expenses in energy, maintenance and other areas, making for a straightforward payback timeframe. Though the improved experiences for owners, property manager and occupants alike will offer the greatest value and returns.

CHAPTER 5

SMART ROOFTOP ECONOMIZERS WILL BE INDUSTRY STANDARD

An economizer is a device designed to make a package rooftop unit (RTU) more energy efficient. The economizer controls the outside air damper of a rooftop unit (RTU) and brings in fresh outside air, which can provide free cooling when conditions are right. It also helps meet indoor air quality (IAQ) requirements. While few RTU economizers today are utilizing the Internet of Things (IoT), its inception enables intelligent companies to make smarter, more efficient decisions that increase savings and decrease our impact on the planet.

Based on the maximum occupancy of a building, IAQ standards require a certain amount of air exchanges every hour with fresh air from the RTU's outside air damper. There are two types of air exchanges. The first is when an RTU simply moves the air in a room by recirculating the air in the building and the second type freshens a room with outside air. When fresh air comes in, the same amount of air must also be exhausted out. Without smart controls, an outside air damper will typically be set to open a minimum of 20 to 30% to provide enough fresh air to meet the IAQ standards. The precise percentage opening of the damper is determined by factors such as how many Cubic Feet per Minute (CFM) is blowing, the size of the outside air damper relative to the ductwork and the size of the spaces being served.

Demand control ventilation (DCV) is a control strategy in which the outside air damper only opens when IAQ demands it based on CO_2 levels measured in the return air system. The outside air damper is kept nearly closed (well below the minimum of 20-30% outlined above) most of the time. Only if the CO_2 levels rise is the outside air damper opened to reduce them.

If CO_2 levels are low (say because the building is only partially occupied), DCV can save a lot of energy when it's freezing outside and outside air does not have to be heated up to 72°F. The same principle enables DCV to also save energy in hot, humid weather.

That same fresh outside air can provide free cooling when conditions are right. For example, if it were 72°F inside and 55°F outside, fresh air coming in at 55°F would help cool down the building. Free cooling through the economizer frequently works out nicely in the spring and fall and the outside air damper can be opened well past the minimum. It's just like opening a window on a spring day instead of turning on the A/C, which helps save energy.

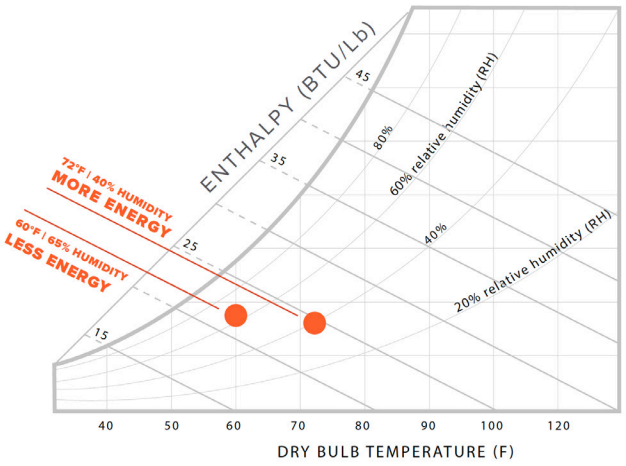
There are different strategies to determine when to bring in outside air and IoT is changing the game. One could just look at the outside air temperature alone and make the decision based on that, which is called "dry bulb." But the total amount of energy in the air (and therefore the amount of cooling power needed to remove it) is determined by both temperature and humidity. This is where it gets interesting and enthalpy comes into play. Typical economizer controls will have either a dry bulb or comparative enthalpy control. Comparative enthalpy controls will measure the outside air enthalpy based on the temperature and humidity and compares it with the indoor enthalpy to determine how much outside air to bring in.

HOW THE ENERGY OF AIR IS RELATED TO HUMIDITY

If you take water and let it evaporate, the water will convert into water vapor. During this time, the water left behind is cooled. If you've ever walked through a greenhouse that had water misters stationed within, you may have noticed you felt cooler inside. That's because mist will eventually evaporate, and as it does, it cools the air around it. The water vapor in the air stores a huge amount of energy.

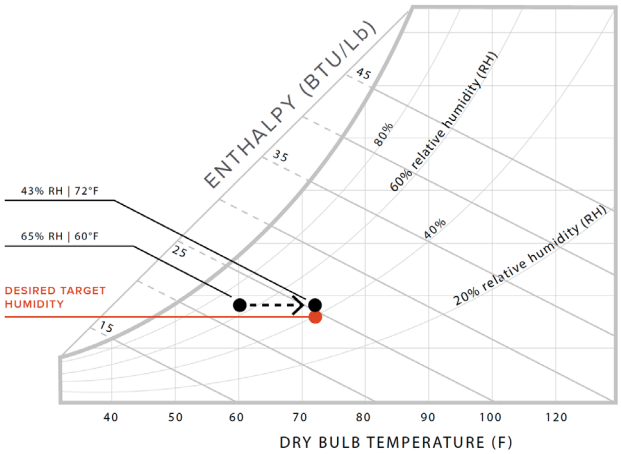
Enthalpy determines the total amount of energy in the air and is based on both humidity and temperature. While there is no simple math to determine enthalpy, we use a psychometric chart to discover how much energy the air has. This graphical representation calculates thermodynamic properties like dry bulb temperature, wet bulb temperature, humidity, enthalpy and air density.

Let's take an example of a building that has an inside temperature of 72°F with 40% humidity, while the air outside is cooler at 60°F with 65% humidity. In the chart below, the enthalpy slopes downward and diagonally from left to right. Note that 60°F with 65% humidity has less enthalpy than 72°F air with 40% humidity. So according to the graph, the outdoor enthalpy is less than the indoor enthalpy, so bringing in fresh air to cool the building (instead of mechanical cooling) makes sense.



This psychometric chart indicates that air which is 72°F with 40% humidity, has more energy than 60°F with 65% humidity.

However, enthalpy alone is not a good metric to determine when to use free cooling because it does not account for what bringing in the outside air would do to the indoor building's humidity. Even when the enthalpy is favorable, the humidity might still increase beyond what is comfortable for humans and good for the building. Mold growth due to high humidity is a big concern. Using the psychometric chart, note that 60°F air with 65% humidity will end up at 43% humidity when it heats up to 72°F.



This psychometric chart indicates that air which is at 60°F with 65% humidity, will end up with 43% humidity when heated to 72°F.

75F measures the indoor humidity and gets a desired target humidity for each building it automates. If that building's desired target humidity was 40%, the system can see that bringing in the outside air would make the building more humid, so it passes on getting that outside air even though it's tempting just looking at the enthalpy.

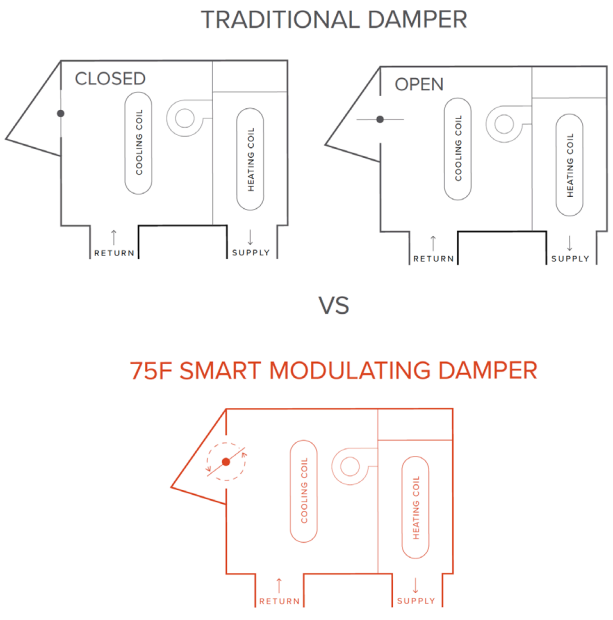
The comparative enthalpy method works most of the time, except when there are high humidity levels inside the building. Restaurants with steam cooking lines and high occupancy offices are notorious for this, and it causes the enthalpy comparison method to break down. 75F considers not just enthalpy, but also what bringing in the outside air will do to the building's indoor humidity.

RTUS IN A RESTAURANT SETTING

When it comes to restaurants, you have an RTU, a makeup air unit and exhaust hoods. The amount of air that gets pulled into the RTU through its outside air damper increases the air inside the restaurant. With outside air coming in and exhaust hoods expelling air out, the building pressure is dynamic and always

shifting. So as pressure within the restaurant grows, there's a hinged relief flap built into the RTU that enables excess air (positive pressure) to flow back outside. This exists to help balance the building's pressure and prevent doors from flying open. The problem with these flaps is they're not very accurate, they tend to stick, and generally don't work.

Economizers have no concept of what's going on in the building. They only turn on when the thermostat calls for cooling. Let's say the desired indoor temperature is 72°F and the actual temperature is 73°F. In a normal scenario, your thermostat requests cooling and that signal travels to the RTU, which holds the economizer. It would interpret the signal coming in from the thermostat as a request for cooling, even if the outside air is 60°F and ideal for free cooling.



Based on the enthalpy, the system would calculate that it would be less expensive to bring in free cooling, so the damper opens 100%. It would open a full 100% because typical economizers have no concept of how much cooling is required, they are simply fully open or fully closed if the mixed air temperature is above a minimum (typically 55°F). The economizer is now fully open and there's a whole lot of outside air flowing in. Let's hope that hinged flap functions properly, or you'll be left with excess positive pressure, forcing your doors to swing open.

Even when the flap does operate, there's always going to be a fair amount of excess pressure built in, which is the same amount of pressure it takes to open that flap. As soon as the indoor temperature goes back to 72°F, the economizer will turn off. As described, typical economizers are 100% open, then 100% closed, all the time. This causes a huge amount of pressure in the building and then a sudden drop. This is how they work, especially with mixed air temperatures of 55°F and above. If the mixed air temperature is below 55°F, some of them will modulate so that the air slowly comes to be 55°F. This would typically happen only when the outside air is around 35°F. However, if the outside temperature drops below 35°F, there's a good chance you don't need the free cooling anyway. Buildings mostly use free cooling when the outside air is 55-70°F.

75F understands the building loads and mixes the indoor and outdoor air together to exactly satisfy the load, resulting in a space that is more consistent and comfortable. Instead of saying let's fully open the damper and then fully close it, 75F takes the overall average open percentage and simply opens the damper that percentage. For example, if an economizer is needed to be on for 10 minutes and then off for 15 minutes, that would mean it would be in use 40% of the time. So 75F opens the damper 40% for the full 25 minutes, alleviating the yoyo pressure scenario. Now, a lot of outside air isn't rushing in all at once. This leaves you with a system that is more stable.

Restaurants must be mindful of pressure as their exhaust hoods expel a lot of gas, requiring new air to come in. That air has traditionally been replaced by a makeup air unit, which is a dedicated outdoor air system (DOAS). The problem is that these units are

quite expensive, the installation is rather costly, and they run 24/7. You've now got an RTU running for regular operations and a makeup air unit that runs solely to tie back to the exhaust hoods. Finally, people said why not use an RTU as a makeup air unit and just keep its outside air damper open about 50% to compensate for the exhausted air?

There is a problem with this theory, however. Having the hood on constantly is not economical because first thing in the morning, it's turned on at one fixed speed and then it expels a set amount of CFM all the time. The fryers are not yet turned on, cooling is unnecessary as there are no guests, and now you're wasting a lot of energy. So, restaurant owners started installing temperature sensors and infrared smoke sensors in exhaust hoods.

These sensors assess the exhausted air temperature to determine the size of the actual cooking load. As the cooking load increases, the exhaust speed ramps up to increase the amount of air being pushed out. The unfortunate part is that the RTU is never informed. So as this cooking load increases, the RTU has a fixed percentage opening and you end up going back to the same scenario of having negative pressure.

CORRECTING RESTAURANT PRESSURE IMBALANCES

To correct this issue of excess pressure, 75F monitors indoor and outdoor pressure before opening the outside air damper the perfect percentage. This ensures pressure is forever maintained and allows the hood to run independently. Even more importantly, the facility manager no longer needs to arbitrarily set the outside air damper to minimum value based on expected exhaust loads. When it comes to the cool air brought in by the 75F economizer, it can be limited based on pressure if needed. However, limiting free cooling would be extremely rare since the outside damper generally doesn't need to be opened fully (see previous note on our modulation). This prevents positive pressure, which would result in the doors blowing open. In a restaurant, the pressurization piece is used both for positive and negative pressure.

IoT for verification. One of the most difficult things with standard economizers is verifying the operation of the units. Economizers are notorious for not being maintained and having dampers that stick, sensors that go bad or actuator motors that fail. 75F uses sensors to verify that economizing action is happening. This can be done by looking at the outside air temperature, the indoor air temperature and the mixed air temperature (the temperature of the inside air once it has been mixed with the cool air from outside). Not only does this make sure the economizer is working, you can calculate just how much energy is saved in real time.

Lastly, enthalpy sensors go bad quite frequently. This most often occurs when they are exposed to outside air (especially hot, humid air), which they need to be to function. 75F uses live weather feeds from reliable sources such as meteorological stations and airports instead. This IoT innovation eliminates one of the most common points of failure to the traditional economizers operation and allows the 75F solution to perform more reliably, delivering essential energy savings and superior IAQ.

For an economizer to be effective, it must factor in a building's temperature, humidity, pressure, air quality, thermal envelope, and forecasted weather. IoT and cloud computing track these factors and use them for making proactive, smart decisions that heighten comfort and productivity. All the while, this smart solution lowers energy consumption and carbon footprint.

CHAPTER 6

SMART SENSORS AND IOT WILL BECOME UBIQUITOUS

If there is a reason IoT devices are both higher rated and enjoy higher adoption in home automation or consumer applications than in commercial buildings, it is the sheer complexity and demands of most buildings today.

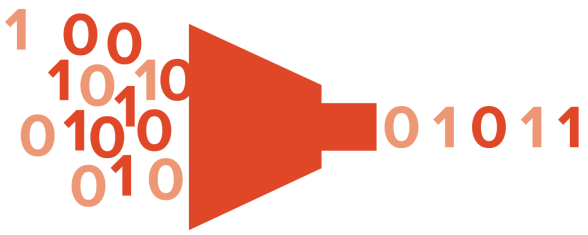
Survey after survey suggest several main barriers to broader IoT adoption by commercial building owners, engineers, and managers. Let's explore 9 common pitfalls of the past to see why smart sensors and devices will be ubiquitous in most commercial buildings in 10 years or less. Not the majority of large buildings, the majority of all buildings.

1. Early IoT systems were often deployed without a clear understanding of the problem they were meant to solve.

Technology for technologies' sake is real, and more data than useful information generates as a result. When considering IoT as a business tool, ask yourself whether it will provide a value to your building or occupants, or will help you reach a specific goal. Most of all, it's important to have a plan that, if deployed, is capable of scaling.

IoT is sometimes confused with an early adoption stage where progress is more important than ROI. For example, a consumer might use platforms such as Arduino or Particle.io (previously Spark.io) and find they can turn on a simple tie rack remotely using a phone app. That's great, but if they were to market this idea, they would be doing a disservice to their end consumer by increasing the complexity in that customer's life. A problem and measure of value is required.

While it's exciting to pull out your phone and be able to automate something, it's crucial to ask if there is value in employing IoT to solve a specific problem. Becoming enamored with IoT for the sake of IoT is something of which to be cognizant, and it's an oft-cited failure of a building automation or IoT deployment.



2. Smart devices must generate meaningful information, not noise.

Self-driving cars are just a natural extension of sensor proliferation that has been going on for decades across the auto industry. Even with engine computers, this sensor focus has until recently only generated noise -- sometimes even actionable noise -- and not information of measurable value.

For example, a common issue in any car is the continuously flashing check engine light. Should that data prove actionable at any point, you might call a service tech and hear something along the lines of, "As long as it runs, if it was my car, I would ignore it." While honest, this response defeats the purpose of the sensor in the first place, much less the hundreds on your average car.

Similarly, when a car alarm goes off it rarely elicits a response from passerby. A car owner might even turn off an alarm without even checking on the problem. The rate of false positives from smart devices or sensors are simply so high that as the number of alarms grows, so too does our capacity to ignore the warnings, which then become more of a nuisance than a value.
The solution to this problem is basic system intelligence. Self-driving cars today have increasingly powerful and affordable systems with both built-in reliability

Source: ironpaper.com/webintel/articles/internet-things-market-statistics-2015

and the ability to instantly sanitize real-world data. Automation in cars means creating software from the ground up capable of understanding the history and behavior of the system and thus excluding outliers.

Buildings are no different. However, this means two things: Having a perfect knowledge of the data via flawless integration and creating software from the ground up capable of understanding massive data sets and scale. With these attributes, smart devices and sensors can combine with smart software to filter out the noise and drive value.

Critical to the success of this integration and software is the aforementioned requirement to understand the problem you are solving, because only if you have that knowledge can a system make sense of the inputs -- the typical range of values a CO_2 sensor would see, for example. Modern software is designed to constrain and sanitize sensor data coming in automatically, so the noise is filtered out and unnecessary alarms are prevented from deploying in the first place.

Just like cars and airlines and finance, the coming years will see buildings move from the era of noise to the era of information as software unlocks new and untapped value from sensor and device networks.

3. Until recently, IoT offered more complexity than redundancy.

Most experienced building engineers will agree that the more instrumentation you install, the less reliable a system becomes. This is due to a well-understood concept called mean time between failures (MTBF). Much like it sounds, MTBF is the average time from one failure to the next. The MTBF of all the individual components of a system create the MTBF of the overall system.

Take a simple sensor with a failure rate of 100,000 hours, meaning that after 100,000 hours it is expected to fail. Now let's say you have ten of those same sensors in a given floor or zone. By increasing the data generated, you have also reduced your failure rate by a factor of 10 to one in 10,000, because any one of those sensors fail can cause the entire system to fail. Multiplied across a building with many zones and you have a system that is made to handle complexity and not redundancy.

Essentially, you've decreased the reliability of the system ten-fold by installing all that instrumentation. It's imperative that if you're considering deploying thousands or even millions of IoT devices to solve a problem in your building, that the MTBF of each IoT device is incredibly high. Only by doing this can the overall system MTBF remain acceptable.

In essence, this means moving from failure in 100,000 hours, to failure in one million hours or more. It means lowering the cost of the hardware and building self-healing networks and software to adapt in the event a device fails. It also means making each failure gentle enough that hardware can be identified and replaced in minutes and not hours or days.

This is a hard problem, but again, a solvable one. Manufacturing advances in hardware and improvements in software mean designing for redundancy is the new focus across the IoT industry. Instead of over-engineering systems, companies around the world are racing to build more reliable ones, and IoT solutions are being deployed in increasingly critical environments.

4. IoT cannot advance faster than user experience or interface.

The more devices you have, the less of a user interface (UI) you want to provide. Too many interfaces can confuse the operator. Instead of adding more components into simple devices, low-cost and high-density LED screens offer richer and more intuitive UI at minimal additional cost. The future of IoT will

involve these and other tech advancements that improve the user experience faster than they improve device performance. As the number of IoT networks and applications grows, manufacturers and building automation companies are getting more sophisticated about where complexity is introduced into their product. Where users or installers interface with a handful of gateway devices vs. where they interface with thousands of small devices.

You can also have a combination of interface levels for when complexity vs. simplicity is needed.

The industry has also made progress in understanding interface optimization. Where too little of an interface is provided, users can end up overloading functions. Let's take pairing a Bluetooth speaker, for example. For cost reasons, most offer just one small LED light and a few buttons. Every time you have to re-pair a speaker, users are required to open the manual to figure out which button does what. If it's blinking too fast, does that mean the device is pairing or has it lost pairing? Does a red blink and a blue blink mean the battery is low or is the device out of range? Most readers are familiar with this maddening experience—not unlike setting a VCR over 30 years ago despite the incredible advancement in technology since then.

Moore's Law dictates that like computers and smartphones, the power of IoT systems and automation will continue to grow even as the cost falls. Nevertheless, such progress requires investment in software and engineering. Without both, many systems oversimplify interfaces to cut costs or still use wired laptops as temporary portable interfaces in lieu of web based applications. User experience in many IoT systems is sacrificed for expediency and margin.

What has already changed the industry and promises to transform it even further is market expectations about what an interface should be, and the benchmark is Apple smartphones or bluetooth pairing of headsets or mobile calling. Just as interface friction is gradually falling across modern devices on the market today, the next decade will see incredible transformation in user experience and interfaces within commercial buildings—from installation through daily use.

5. IoT device management will be standard.

On its own, the term IoT is broad. It includes any device that can connect to the internet. In today's world, you can have billions of IoT devices, but that also means that practically there are billions of components with the potential to go wrong. In the future it will be not just important but critical that IoT solutions are packaged with device management out of the box and already existing frameworks and standards make that easier than ever before.

Today this device management can range from monitoring the power status or network signal strength, to pushing firmware updates or new device profiles remotely. Remote push is a critical piece because they allow systems to be patched as security vulnerabilities or other bugs in the network are found, or as new ways to optimize the network are discovered. It would be a bit too utopian to say that an IoT system will never have bugs – hackers over a long history of computing devices have proven otherwise. Still, limits to the growth of IoT networks based on a lack of comprehensive device management will no longer exist.

6. Self-configuring IoT devices will be the rule, rather than the exception.

One of the most common methodologies for IoT is to have the end device connect directly to Wi-Fi. That is, however, by far the most expensive solution because

it requires each end device to have a full Wi-Fi stack onboard. On the other side of the spectrum, many manufacturers end up employing small aggregation networks like Bluetooth BLE 4.0 or ZigBee. These networks require a gateway that communicates data out to the internet. In each of these cases, the devices are not self-configuring, so you have to provide a simple way of reconfiguring them in an intuitive manner.

For example, consider the Amazon Dash button that connects to your Wi-Fi and allows you to order laundry detergent, paper towels, or other pre-set products via Amazon Prime at the push of a button. This is a good example of an interface that doesn't normally need to be repaired or set up. Or, closer to home, a wireless thermostat from Honeywell or some other manufacturer that will go through a pairing process once when it is powered up out of the box. In both cases, if you change your Wi-Fi password (a similar issue exists if the gateway device for a Zigbee or other aggregation network needs to be replaced) or you change to a new Wi-Fi router with another security protocol, then you're likely headed for a lot of consternation.

Until recently, reconfiguring devices was not just frustrating and inefficient, it did not scale. Any single change would take down a multitude of devices, and sometimes the entire building or network.

The solution is a new generation of self-configuring IoT devices that automatically connect to a gateway out of the box. The gateway serves two important purposes: It can provide a rich interface (as through a touchscreen) and it allows easy changes to system parameters such as the Wi-Fi connection that can automatically be applied across an entire network.

7. IoT will move from third-party platforms to native architectures that can scale.

Across many technologies and industries, third-party platforms are used to accelerate adoption in the early stages of market development. At some point, companies in the market begin to introduce their own operating systems or hardware to take advantage of the greater efficiencies and scale that are possible from in-house development. This is something that will occur both across the tech industry and in IoT today.

Just as Facebook was created using off-the-shelf scripting languages and had to completely rebuild the backend software stack several different times as the network scaled, IoT companies are moving to native architectures capable of greater performance and scale.

8. Edge advancements mean IoT can move from cloud control to local intelligence.

Cloud computing enables storing and accessing data via the internet. Despite the many advantages inherent in cloud computing, IoT companies are beginning to take advantage of the increasing power within devices to create more robust and powerful automation systems. This is a shift that will accelerate in the coming decade and which will contribute to more bulletproof IoT implementations.

A known limitation of cloud computing is that where every decision must be made on the cloud and then sent back to each device, a lot can go wrong. This

is like trying to drive a rover on mars from mission control vs telling the rover where to go and watching it navigate on it's own to the destination. In the first scenario, the entire data chain must be perfect before you can accomplish even the most trivial of tasks. In the second, the hardware is compact enough and cheap enough that it can make localized decisions and computations. This means modern IoT devices or building automation systems will continue to function when wireless connectivity goes down. It also means that while leveraging cloud computing, the future of IoT deployments will involve an always-on backup plan for local intelligence.

Surprisingly, many older automation companies or products on the market today have no backup plan, meaning they rely solely on getting instruction back from the cloud. On the consumer side, this looks something like automating a garage door when the owner comes home. A simple solution when all systems are functioning optimally, but one which still requires:

- The use of the correct smartphone with a GPS triangulation enabled
- Connection to the internet and cellular data
- Internet availability of a web server such as IFTTT for the programmed logic.
- A garage widget that is powered and connected to the home Wi-Fi router
- A router connection to the Internet Service Provider (ISP).

Without a backup plan, something as simple as opening a door requires a home ISP service working, the garage widget companies' servers working, and the IFTTT servers working. At minimum! Advancements in edge devices mean that the hardware on the garage door can be designed to notify the owner where there is a failure and can manually open the door as required.

Systems that allow IoT networks to fail or degrade gracefully are critical to more widespread adoption. This local intelligence will soon be common thanks to the new computing capabilities available at the edge in sensors and devices. What was once too bulky or expensive to be practical is now too impressive to ignore.

9. IoT will finally deliver the end-to-end solution customers expect.

Many IoT offerings in the market today provide data-gathering capability but efficiently analyzing this data or extracting value is rare. Software as a service companies have stepped in to fill the gap with interfaces and additional software layers specific to building needs, even as equipment manufacturers have worked to add high-end sensor packages at the opposite end of the market. In this fragmented landscape, true end-to-end solutions are valuable, and in the coming decade companies are going to move beyond legacy systems and start to think about how to best leverage this tool to increase efficiencies and improve solutions.

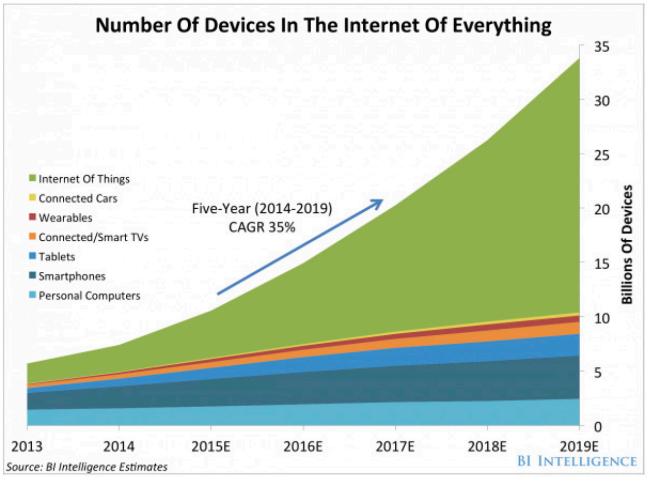
This is where cloud computing is already starting to accelerate industry-wide IoT adoption. Paired with cloud computing, something truly beautiful happens: building owners, engineers, and facilities managers benefit from massive amounts of aggregated data, without having to manage or maintain servers. IoT hardware and cloud computing software are not separate entities, but really belong together in a holistic and end-to-end solution. This includes overseeing the hardware and encryption, software, management tools, and all analytics on the backend in a single system.

The acceleration in IoT over the next decade will be driven by full-stack, end-to-end solutions via acquisition or native development and not narrow sensor deployments that deliver more frustration than value.

CHAPTER 7

NETWORK SECURITY WILL BE MORE IMPORTANT THAN EVER

IoT is the next revolution in the explosion of devices everywhere. The number of endpoints in the IoT world has been growing rapidly, and it won't slow down in the coming decade. Without proper precautions, these endpoints will be vulnerable to hackers looking to attack IoT devices in order to grow their botnet armies. Computers aren't the only device at risk – hackers can target a multitude of devices ranging from baby monitors and self-driving cars to smart thermostats. In this era of growing botnets, zombies and security breaches, IoT systems will need to emphasize safety more than ever.



Source: ironpaper.com/webintel/articles/internet-things-market-statistics-2015

Gartner, Inc. estimates there will be 5.8 billion endpoints in the IoT market in 2020. Gartner further predicts that utilities will be the highest user of IoT endpoints; in 2019, 1.17 billion endpoints fell under the utility category. In 2020, Gartner predicts that will rise to 1.37 billion. Finally, Gartner says building automation will be the segment with the largest growth rate in 2020. The sheer number of devices in existence makes fertile ground for skillful hackers.

A bot – short for robot – is a script or software application that performs tasks on command. Evil bots complete malicious tasks and install intrusive software including computer viruses, trojan horses, spyware, adware, and other malevolent programs. This invasive software allows attackers to take remote control over any infected computer that's connected to the internet. Known also as web robots, bots are usually part of a network of infected machines, known as a botnet. Botnets are often created from victim machines that stretch across the globe, unbeknownst to the owners and can be used to spread spam and perpetuate scams. The infected machines are also referred to as zombies.

IoT devices are vulnerable to IoT viruses because most don't have a UI (user interface). This means that to configure an IoT device requires some sort of access over the network via a web interface or app using TCP/UDP sockets. The issue is that access methodology needs to be common across each device. So even if the device is protected with a password, it is the same default across all devices. Most consumers don't like having to remember their regular passwords, from banking to online grocery shopping. Therefore, it's easy to leave the password set to the default, meaning that simple brute force for well-known default passwords gives an attacker easy access.

The very fact that IoT devices don't have a UI means users don't regularly interact with them, making it easy to ignore their presence. Once set up, users tend to forget that these devices are connected to the internet, leaving them vulnerable to attack.

By design, IoT devices have limited computational capabilities and no concept of firewalls or diagnostic tools. The cumbersome access methods, like using a web browser or app to specifically log into each device makes it unlikely that anyone will use them. When was the last time somebody logged into their light bulbs to

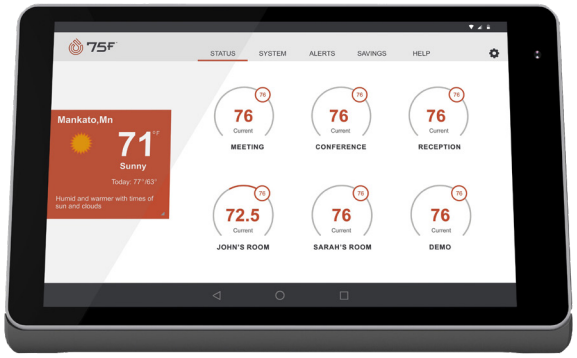
do a tcpdump to check if there were rogue packets?

One key mistake manufacturers are making is they're pushing their devices to connect directly to the internet over Wi-Fi. The right thing to do would be to use a simpler protocol like ZigBee within the premise and then have an aggregated feed through a secure gateway. The gateway could have more compute resources and hence a greater chance of running tools that would secure it. For that to happen however, the IoT model must mature. Equally as importantly, the industry needs to unite around standards. Right now, every manufacturer from Amazon and Wink to Nest think they hold the golden key to gateway standards and yet no one truly does.

The other issue lies in accepting automatic remote updates to devices over the air. At the heart of this, manufacturers want to ship out product before it's fully featured and thoroughly tested. This is partially because consumers welcome upgrades because of the exciting new features. From a hacker's perspective, however, this quick-to-market product ignites a wealth of opportunity because the underlying framework to push malicious updates comes built in with each device. The cross checks to prevent this (if any), are rudimentary and easily overcome for these simple devices.

PREVENTING IOT BOTNETS

Dealing with the rising threat of IoT botnets is not only important, but doable. As Smokey the bear says, "Care will prevent 9 out of 10 fires." If you're connecting a device to the internet, change the default password! Even if you must write it down and stick it to the device itself, don't overlook this crucial step. Now if people are coming into your house to steal your refrigerator's password for ordering groceries, you have other things to worry about. Get behind a good firewalling router and turn the firewall function on. Unsurprisingly, the firewall works much better when it's enabled.



Touch screen interface allows for direct access to our devices, removing the need for risky open TCP ports.

75F specifically adheres to the model of having a secure gateway that protects all on premises devices. Ours is based on a hardened version of android. From a software standpoint, there is a strong distinction between having a kernel that is not remotely upgradeable and an application that is limited to only the permissions it needs to function. 75F chose to provide an actual user experience (UX) on our devices for configuration (touch screen on our gateway and buttons/LCD on room modules), so there are no open TCP ports. 75F also enforces the creation of a distinct account password as part of our setup process for all remote access.

End devices (wireless room modules and smart dampers) communicate back to the gateway over a hardware encrypted mesh network. These devices are thoroughly field tested, and for production deployments, firmware does not update over the internet. Having spent the time to understand client requirements upfront and having them well sorted out in the beginning, there are no device features necessitating firmware updates. Furthermore, any unidentified packets are reported back to our cloud-hosted servers. There, a central alarming infrastructure will analyze them and promote identification.

The key to killing off IoT botnets lies in the very things that make them vulnerable. Their limited compute power may make it difficult to put tools to firewall. But it also means that an attacker with a compromised

device has fewer resources to mount a Distributed Denial of Service (DDOS) attack. So IoT botnets are really only useful if there are literally thousands of compromised devices as part of a coordinated attack. To make it worth their while, attackers must get more compute or network leverage from the IoT device than the effort of hacking it. Doing simple things like changing the default password might make it unappealing enough to a potential hacker.

The IoT industry is not slowing down. Do your due diligence: Take the time to change default passwords, invest in a strong firewalling router and ensure the firewall function is enabled. Until the Internet of Things industry unites to create uniform standards, it will ultimately be up to the consumer to ensure their devices are safe and secure.

ABOUT THE AUTHOR

Deepinder Singh founded 75F after designing 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.