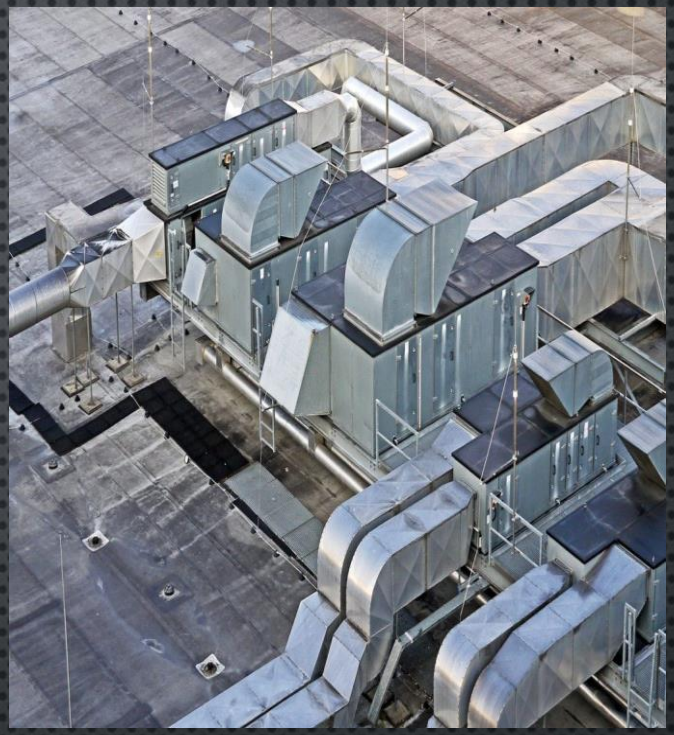
Seeing Green with UVC lights

The sticky truth of Biofilm

A biofilm is a group of microorganisms that can form on nearly any moist surface, including environments exposed to high levels of humidity. It's essentially a colony of microbes that latch on to each other and use their hair-like appendages to adhere to moisture-rich surfaces. Biofilm will grow and change in shape and size as more microbes attach and invade new surfaces.

Biofilm buildup in HVAC systems occurs in components that tend to be moist and warm, including evaporator coils, condensate pans and air ducts.

According to the Department of Energy, HVAC systems use about 35% of a building's energy on average.



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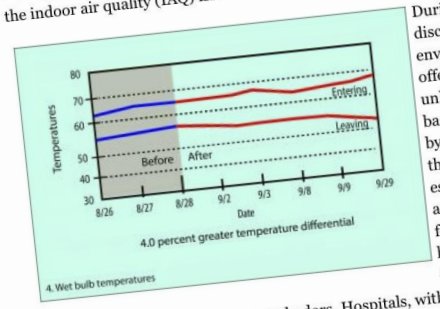
The Hidden Value of UV-C — A CB Exclusive

Contracting Business
by Forrest Fencl
Fri, 2013-08-09 09:18

Widely embraced in the 1990s as a cure for Sick Building Syndrome, Ultraviolet-C technology today provides an unmatched efficiency boost for HVAC systems.

While the use of Ultraviolet-C (UV-C) light in today's modern heating, ventilation and air conditioning (HVAC) equipment is now commonplace, it wasn't always that way. In fact, now known for delivering upwards of 25% energy savings, boosting airflow and extending HVAC equipment life, UV-C technology got its start by providing cleaner, healthier air.

During the mid-1990s, UV-C became popular in commercial air handling equipment to help mitigate the indoor air quality (IAQ) issues dominating the concerns at that time. [1,2,3]



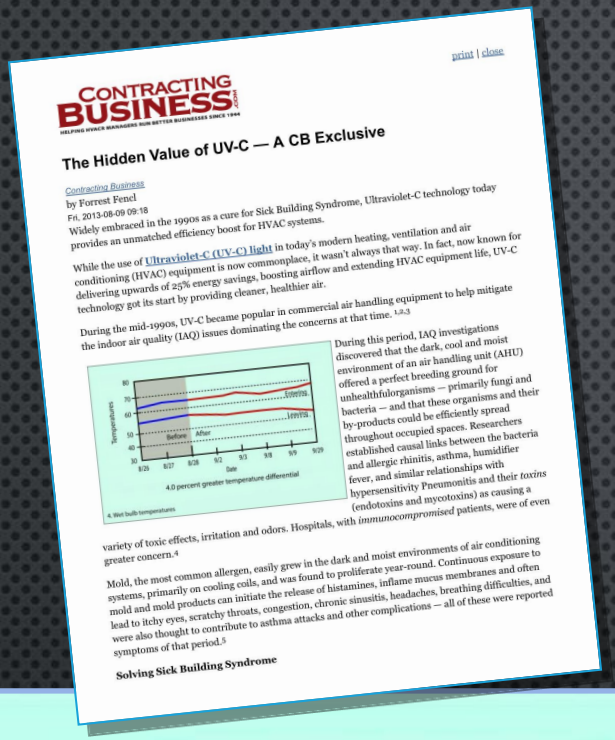
4. Wet bulb temperatures

During this period, IAQ investigations discovered that the dark, cool and moist environment of an air handling unit (AHU) offered a perfect breeding ground for unhealthfulorganisms — primarily fungi and bacteria — and that these organisms and their by-products could be efficiently spread throughout occupied spaces. Researchers established causal links between the bacteria and allergic rhinitis, asthma, humidifier fever, and similar relationships with hypersensitivity Pneumonitis and their *toxins* (endotoxins and mycotoxins) as causing a variety of toxic effects, irritation and odors. Hospitals, with *immunocompromised* patients, were of even greater concern.[4]

Mold, the most common allergen, easily grew in the dark and moist environments of air conditioning systems, primarily on cooling coils, and was found to proliferate year-round. Continuous exposure to mold and mold products can initiate the release of histamines, inflame mucus membranes and often lead to itchy eyes, scratchy throats, congestion, chronic sinusitis, headaches, breathing difficulties, and were also thought to contribute to asthma attacks and other complications — all of these were reported symptoms of that period.[5]

Solving Sick Building Syndrome

The hidden value of UV-C is its ability to **restore cooling capacity, reduce maintenance** and **increase energy savings**."



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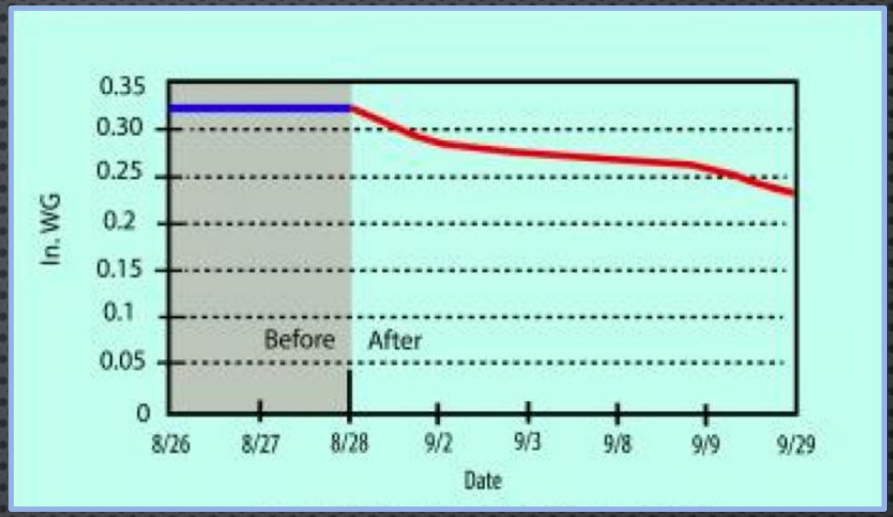
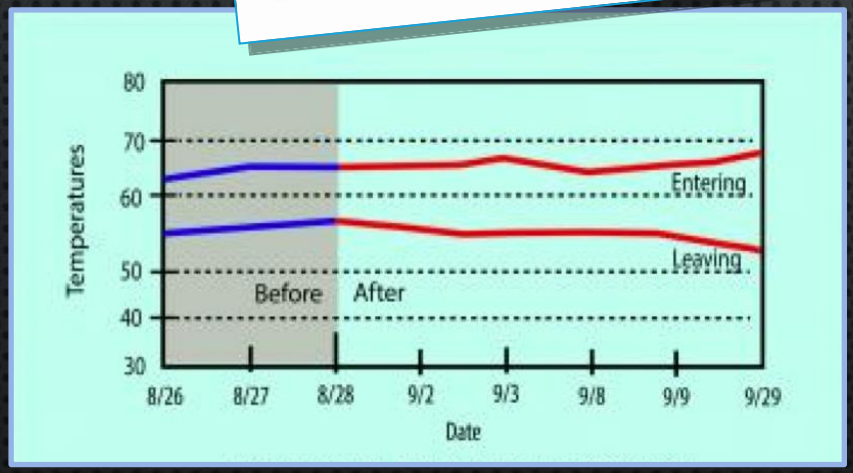
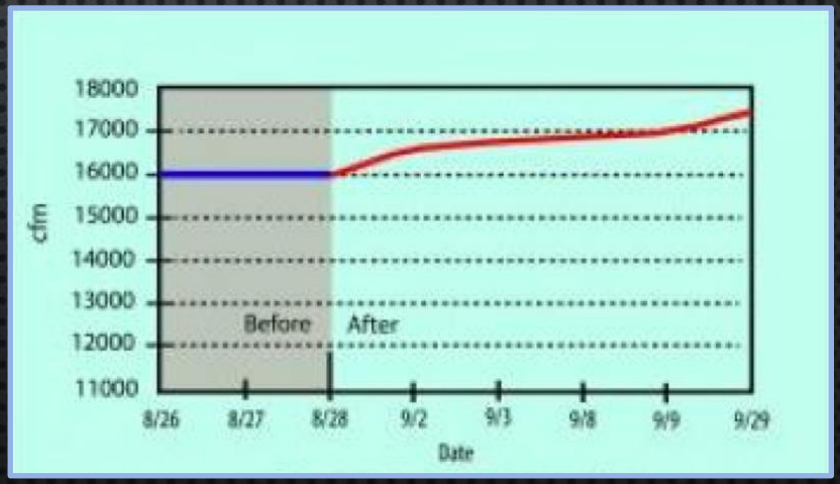
Solving Sick Building Syndrome



28% pressure drop across coil face



4.0% increase in temperature differential



8.6% increase in cfm

Field Study of Energy Use-Related Effects of Ultraviolet Germicidal Irradiation of a Cooling Coil

Joseph Firrantello, PE
Member ASHRAE

William Bahnfleth, PhD, PE
Fellow ASHRAE

Ross Montgomery, PE
Fellow ASHRAE

Paul Kremer

ABSTRACT

The energy use-related effects of ultraviolet germicidal irradiation (UVGI) to mitigate biological fouling (biofouling) of a chilled water cooling coil are investigated via [illegible] humid climate is monitored for 5 months [illegible]ure and humidity upstream and downstrea[illegible]ure drop. A UVGI coil irradiation syst[illegible]en passively monitored over a period of 14 months. The change in operation is estimated by comparing data from the baseline and post-irradiation periods. The 95% confidence intervals for average improvement of coil airside pressure drop and heat transfer coefficient are 11.07% to 11.13%, and 14.5% to 14.6%, respectively. Complexities of the physical phenomena involved, in particular, the combined effect of airflow and latent load on airside pressure drop, are taken into account.

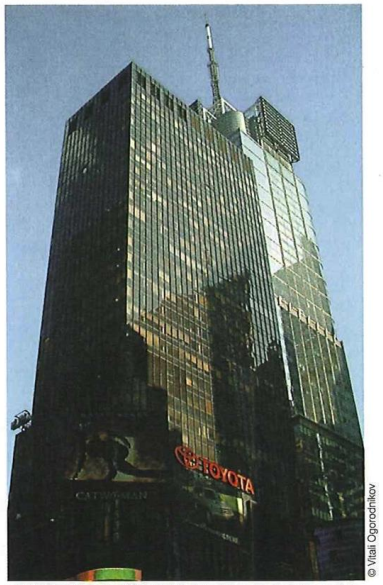
"Pressure drop improved 11%; Heat transfer coefficient improved 14%"

Results of ASHRAE coil cleaning study:

- 11% decrease in pressure drop, with corresponding 14% increase in airflow
- 100t cooling capacity increase building-wide
- Decrease in chiller plant load, resulting in correlated reductions in chemical costs, pump and cooling tower operation, maintenance and wear and tear.

Study Verifies Coil Cleaning Saves Energy

By Ross D. Montgomery, P.E., Member ASHRAE; and
Robert Baker, Member ASHRAE



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1500 Broadway in NYC is the site of a coil cleaning study.

Although it's known theoretically that cleaning a coil can result in energy savings, little actual testing data and research exist to prove the point. As a result, building managers often ignore or reduce resources devoted to air-handler maintenance when faced with budget constraints. If proper maintenance is an important consideration in overall energy costs, conserving in that budget area can be self defeating.

Through our privately funded testing, monitoring and analysis, we believe we found a methodology and regimen that proves maintaining air-handler components in a clean condition can save energy dollars and improve other building parameter changes and efficiencies such as improved dehumidification and comfort, along with less mold and bacteria. Thus, we are encouraging IAQ environmental parameter improvements, better tenant satisfaction, and increased worker effectiveness.

It is difficult to find a building where such a study can be held. Fortunately, the owner and managers of a landmark 34-floor building on Times Square in New York City wanted to see what impact a dramatic change in coil cleaning nature and frequency might have. This building has only four large air handlers (SF-6, SF-7, SF-8, SF-9; 250 [880 kW], 123 [433 kW], 121 [425 kW] and 81 tons [285 kW], respectively) to service its 1.2 million ft^2 (111 500 m^2) of air-conditioned and heated space throughout the year.

The test project was performed at the building July through September 2005 to monitor and analyze the HVAC energy use before and after restoration of two air handlers, SF-8 (121 tons [425 kW]) and SF-9 (81 tons [285 kW]), which are similar in their constant volume operation to the other two air handlers in the building, and are located on the 34th floor mechanical room. This total of four air handlers interact by providing heating and cooling to the tenants of the 34 floors of the building. Periodic

About the Authors

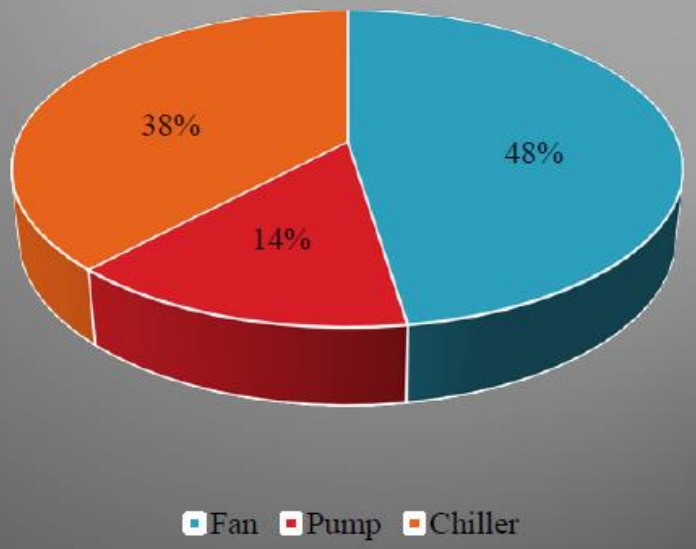
Ross D. Montgomery, P.E., is president of QST-Honeywell Controls in Palmetto, Fla. **Robert Baker** is founder and chairman of BBJ Environmental Solutions in Tampa, Fla.

(clean coils) represent a significant increase in latent heat transfer ability of the coil in the range of 10%.

…better building dehumidification by delivering sub-dew-point air temperature across the coil.

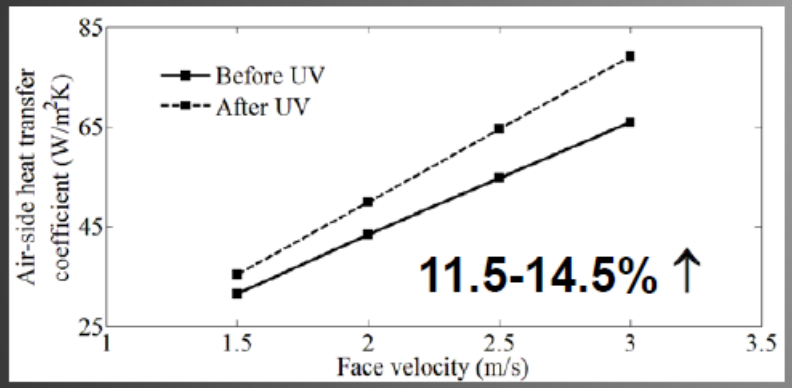
Yi, et al.—Annual Energy Impact

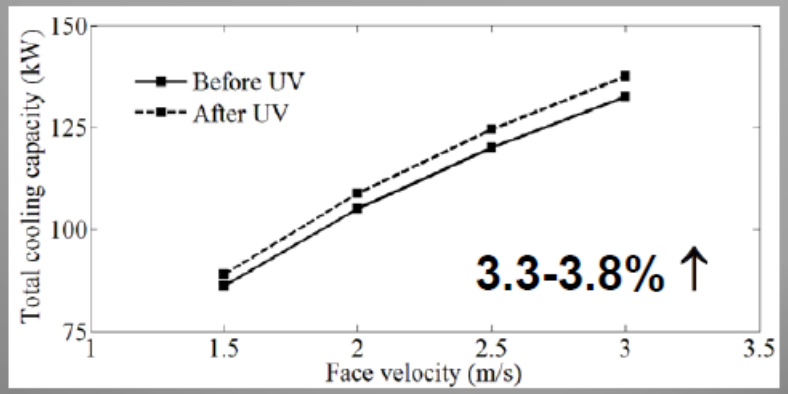
- Apply experimental results to EnergyPlus models
- Singapore:
  - Fan energy ↓ 9.1%
  - Pump energy ↓ 6.2%
  - Chiller energy ↓ 0.41 %
- Energy and economic impact vary with climate and occupancy

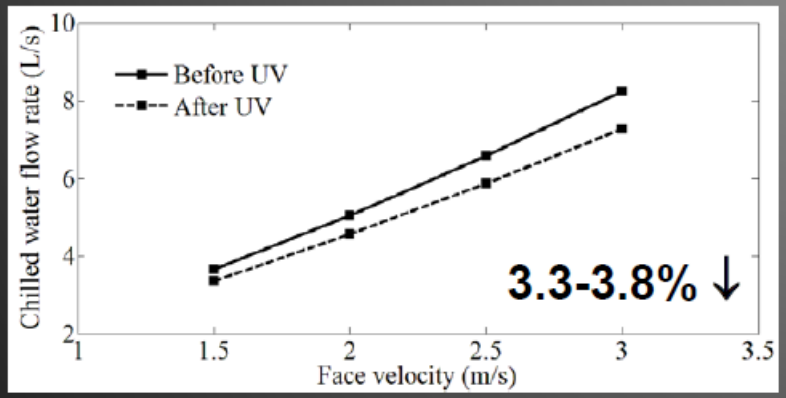


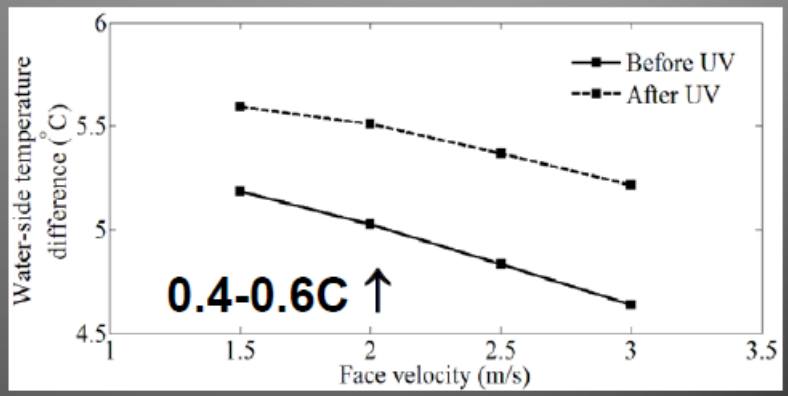
Yi, et al.—Heat Transfer Benefits

Singapore Laboratory









Coil Surface Treatment Economics

- Montgomery and Baker (*ASHRAE Journal,* November 2009)
  - ~10% – 15% HVAC efficiency improvement possible for clean vs. dirty coils
  - Not specific to UVGI
- Keikavousi (*Engineered Systems*, February 2004)
  - Badly fouled nominal 6000 cfm unit in Orlando FL,
  - ~$2000 installation cost, estimated $4900 annual savings
- Firrantello and Bahnfleth (ASHRAE RP-1738, 2017)
  - Simulation based on field measurements and Keikavousi's article
  - 0.5%–4.5% reduction in HVAC energy use—mostly fan energy
  - Significant collateral air quality benefit, reduce need for mechanical cleaning
  - Median benefit including IAQ benefit ~$0.15/sf NPV vs. $0.51/sf cost for conventional cleaning…depends on many parameters
- Yi, Sekhar, Bahnfleth, Cheong, Firrantello (2016, 2017)
  - Simulation based on measurements in Singapore laboratory
  - Energy savings and maintenance cost savings can result in net economic benefit

UVC fixtures are installed downstream and proximate to cooling coils:

<u>UVC eliminates surface pathogens on coils (biofilm) to!!</u>

- **reduce static pressure**
- **increase airflow**
- **restore thermal efficiency (heat exchange)**
- **reduce fan motor amps = energy savings.**
- **Reduce physical coil cleaning.**

Clean Coils vs Dirty Coils

The only difference……UVC Restores & Keeps HVAC units operating at original specifications….

Pressure drop improved 11%; Heat transfer coefficient improved 14%

UV-C lights eliminated coil-cleaning programs; yielding ongoing energy savings, a reduction in HVAC system maintenance, and the elimination of cleaning chemicals.

The facility also reports IAQ and infection control benefits as the regimen continues.

UVC: Florida Hospital Puts HVAC Maintenance Under A New Light

HVAC system downtime during coil cleaning can compromise humidity and temperature control, potentially leading to air quality or comfort problems. Florida Hospital has found that high-output ultraviolet-C lights installed in the AHUs reduce or eliminate coil-cleaning programs — yielding ongoing energy savings, a reduction in HVAC system maintenance, and the elimination of cleaning chemicals. The facility also reports IAQ and infection control benefits as the regimen continues.

Florida Hospital's (FH) experience with ultraviolet-C (UVC) began in 1998 after seeing a presentation on the technology at an ASHRAE conference. A new generation of UVC devices promised to offer an improvement over the UV lights that were long ago popular for upper air disinfection in hospitals and other health care environments. Unlike the upper air devices, the newer UVC lights were engineered specifically to provide peak output under HVAC conditions. Output of these devices was reportedly so much higher than conventional UV tubes in cold and moving air that they could be installed just downstream of a cooling coil to eradicate bacteria, viruses, and mold.

Upon learning about the benefits of the new UVC fixtures, FH staff felt that the potential for the health care system was enormous. FH is an acute-care health system with more than 2,800 beds throughout Florida. With a network of 17 hospitals and 12 walk-in urgent care centers, FH treats more than a million patient visits per year and is the second busiest system in the country.

To test the efficacy of the UVC devices, we decided to install the lights in AHU #107, a 27-year-old, 6,000 cfm unit located at the main Orlando campus. A UVC Emitter™ manufactured by Steril-Aire, Inc., was specified for this and for subsequent installa-

Within weeks after the UVC installation, static pressure over the coil decreased from 1.8 in.wg to just 0.7 in. wg. Air velocity over the coil more than doubled, from 230 fpm to 520 fpm. Both the coil and drain pan areas looked absolutely clean, with no more visible evidence of mold or organic buildup. The air exiting wetbulb temperature from the AHU also decreased significantly, from 57° F (before UVC) to 53° (with UVC).

We calculated the increase in capacity to be 95,245 Btuh or approximately 7.9 tons of air conditioning. If we use 1 kW/ton and multiply by 24 (hours/day) by 365 (days/year) by $0.07 (our electric rate), we arrive at a total of $4,867 in savings for this one unit. The total installed cost of the UVC Emitters was less than $2,000. Given the number of our facilities and the number of AHUs in these facilities, we estimate yearly energy savings well into the six figures. This estimate does not include additional savings for reduced maintenance.

Stated another way, we project that the hospital is conservatively saving 15% in HVAC system energy costs, and probably much more. These results are consistent with long-accepted industry studies documenting that just a one-micron buildup of dirt or debris on coil surfaces can lead to a 15% loss in operating efficiency.

Within weeks,

- **Static pressure decreased** from 1.8 in.wg to just 0.7 in. wg.
- **Air velocity more than doubled**, from 230 fpm to 520 fpm.
- The coil and drain pan had **no evidence of mold** or organic buildup.
- Air exiting wetbulb **temperature decreased significantly**, from 57°F to 53°F.

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By installing UVC into all AHUs, “We estimate yearly **energy savings over six figures, not including savings from reduced maintenance.**

Blue lights that equal Green

TODAY'S FACILITY MANAGER
TFM
The Source for Building Owners and Facility Executives

Friday, 7/2/04

Savings Come To Light:UVC Lights Improve IAQ And Provide Unexpected Efficiency Gains

UV achieved "…a 30% increase in cooling capacity and annual energy savings of more than 20%…"

heat.

And when City of Industry, CA-based Southern California Air Conditioning Distributors (SCACD), one of the world's largest Carrier distributors, installed UVC lights in its 30-year-old administrative facility, members of the building staff expected it would control mold and non-specific odors. What they didn't expect was that the lights would also rejuvenate coils and allow greater heat transfer, resulting in an impressive 30% increase in cooling capacity and annual energy savings of more than 20%.

ENERGY SAVINGS CALCULATOR

HVAC Information		
CFM	1200	CFM
Coil Pressure drop, Clean	0.75	w.g
Coil Pressure drop, Fouled	0.90	w.g
Leaving Air Temp, Clean	52	F
Leaving Air Temp, Fouled	65	F
Annual Hours of Cooling	4500	hours
Chiller Coeffient of Performance	4.10	
Cost per kWh	0.090	$
Annual Maintenance Cost	1000.00	$
Motor Effeciency	0.75	
Fan Effeciency	0.75	

UV information		
Total Number of UV Lamps	3	
Lamp Wattage	95	W
Annual Hours of Operation	8760	hours
Cost of Lamp Replacement	30.00	$
Months before Replacement	12	months
Installation Costs	1000.00	$
Cost of UV System	2000.00	$

Calculations		
Fan Energy, Clean	0.19	kW
Fan Energy Cost, Clean	76.95	$
Fan Energy, Fouled	0.22	kW
Fan Energy Cost, Fouled	89.10	$
Fan Energy Savings	12.15	$
Cooling Load, Clean	36,000.00	BTU-h
Cooling Load, Fouled	28,800.00	BTU-h
Thermal Loss	20.0%	
Coil Energy, Clean	2.57	kW
Coil Energy Cost, Clean	1,040.85	$
Coil Energy, Fouled	3.08	kW
Coil Energy Cost, Fouled	1,249.02	$
Coil Energy Savings	208.17	$
Total Lamp Watts	285	W
UV Costs, Operating	314.69	$ per year
UV Costs, Initial	3,000.00	$

Year To Year Savings	905.63	$
Payback	3.3	years

Year One	Year Two	Year Three	Year Four
-$2,094.37	-$1,188.74	-$283.11	$622.52

Year Five	Year Six	Year Seven	Year Eight
$1,528.15	$2,433.78	$3,339.41	$4,245.04