Green HVAC? Demystifying HVAC By Ron Prager

Not that long ago, almost all HVAC units were "Green." Painted green, that is. Unrelated to color, this was the equipment of the 70's. It was a time when the public was introduced to, and embraced "Energy Conservation," as a result of the oil issues of the time. Somewhere along the way, the color of new equipment faded from green to beige and khaki as the public interest in energy conservation faded strictly to measures that could pay for themselves within two years time. As history repeats itself, we are currently climbing on the "Green," bandwagon. This time it is not as a result of national pride and the cost of oil, but due to the fear of global warming and the realization that we have probably mortgaged our future by our past actions. But, when you get down to it, how different is today's greening from the energy conservation mantra of the 70's, and how different are the solutions we are able to deliver? How different is reducing your carbon footprint from reducing the quantity of oil consumed?

It's all about reducing energy usage and as long as this also results in cost reduction, people are going to embrace "Green." Yes, I am aware that alternate fuels and sustainability are a factor in the current situation, but the best way to reduce our carbon output, will always be to eliminate the need for the energy that caused the carbon to be discharged in the first place. So, how do we go green and reduce our carbon footprint in the HVAC world? We do it the same way we have always done it, but we do it in a more sophisticated way.

- We install control systems to shut down equipment when it is not required.
- We install other controls to use outdoor air for free cooling when possible.
- We limit the amount of outdoor air brought into a building because it takes lots of energy to condition that outdoor air.
- We design systems that are appropriately matched to our heating and cooling loads and we buy the most efficient equipment available.
- We reduce the heating and cooling loads in our interior spaces.
- We maintain equipment in such a fashion that it continues to operate at or close to its initial rated efficiency and we replace equipment when it becomes extremely wasteful of energy.

The other buzz word we hear at least four times a day is "Sustainability." In the HVAC world, the heating and cooling machines we own are primarily constructed of steel, copper, cast iron, and aluminum. When equipment is being replaced, you can rest assured that these raw materials from the old equipment are being recycled by someone. Visit a scrap metal dealer some day and watch what comes in the door. We have created a sustainable cycle by recycling the raw materials contained in our equipment. This cycle is so successful that over the past two years there has been an industry wide problem due to scrappers demolishing operating equipment on retailer's roofs just for the scrap value of the aluminum finned copper coils.

Speaking of recycling; HVAC contractors are required to recover any refrigerant contained within the systems when making repairs, as well as when disposing of equipment. What could be greener? As a result of the Montreal Protocol, the industry is phasing out refrigerants with the most potential to damage the ozone layer and to increase global warming, and has replaced them with less damaging refrigerants . Some municipalities have determined that the chemicals and even the waste water from coil cleaning posses a significant health hazard to our drinking water supply. Contractors must strain the water entering roof drains while cleaning coils in some cities. In others they are prohibited from using any chemicals to clean coils. The most stringent case we've heard

of; is a municipality that requires that contractors recover the waste water from coil cleaning and dispose of it in an “Approved manner.”

Facility managers at national retail chain stores are being challenged to “go green.” Of course, they are really being challenged to go green with a zero cost increase, or in a perfect world; while delivering a savings. While this is a very demanding challenge, those who succeed in meeting it will help improve their company’s public image and its bottom line. Hopefully they will also experience the feelings that come along with doing something in a small way to benefit our society and future generations.

I have put together some specific recommendations to get you started down a path to greener HVAC. The degree to which each item described below will increase efficiency, and longevity, will depend on many factors including geographic location, run time, usage profile and specific application.

Green Measures:

1. Turn it off!

Time clocks, energy management systems, thermostats, photocells, and occupancy sensors all serve the same purpose within a building. That purpose is to act as a good building janitor and turn off equipment and lighting during periods when they do not need to be operating. I challenge you to look at a set of prototypical electrical plans for your stores and make a spreadsheet listing of all of the different devices and pieces of equipment that use electrical power of natural gas. Then write down the current hours of operation for those items. Next to that, write down the hours those items really must be energized. Do your toilet exhaust fans really need to run 24/7? How about your hot water heaters?

Do the incandescent accent lights in your store need to be energized before the doors open to the public? Are you running pumps and cooling tower fans 24/7? Is there a way to cut your lighting levels down to 50% until the doors open to the public. During a recent four store EMS pilot program for a big box retailer we found one store where the lights were energized continuously 24/7 365 days a year. The manager had never seen the lights de-energized, but thought nothing of it because he or she knew they were operated automatically. When was the last time someone checked to see that there actually are trippers installed on the time clocks that control your store lights and your sign lighting? Any light or appliance that runs unnecessarily goes against green four ways. First, we have the energy wasted to power the device when it is not required. Second, every device has a specific number of usable hours built into it. Wasted run time equals wasted energy and materials required to manufacture and install a replacement. Third is the wasted energy required to power the HVAC system that has to remove the heat created by device that really should be turned off. Fourth, is the energy wasted because increased maintenance and service are required for the HVAC system due to the fact that it is running unnecessary additional hours.

EMS for Lighting and HVAC

Once you have developed a list of things that are consuming power unnecessarily, it’s time to think about controlling them. Today,

microprocessor based energy management systems are available that deliver amazingly fast paybacks. As a result of low first costs, two year pay backs are not uncommon assuming you can live without all the bells and whistles. These systems will generate emails when abnormal conditions exist and they allow Web access for viewing conditions and making adjustments. There is a cost associated with maintaining and monitoring these systems, but our experience has been that the costs are almost always justified. My personal feeling about EMS systems is that considering the fact that in retail we are usually dealing with a ten year lease, the best strategy is to go for the low hanging fruit because attempting to wring out every last percentage point of savings will make if far more difficult to justify the installation of a new system.

2. Space Temperature

We all know the value of raising cooling set points and lowering heating set points during unoccupied periods. Why waste energy heating and cooling unoccupied space? So, retailers install EMS systems and programmable thermostats to prevent this waste of energy. Then, unfortunately, they forget about them. EMS systems are not prone to tampering or a technician's whim the way thermostats are, but you still need to audit set points and schedules on a regular basis. With an EMS system, there might be the one time you had two out of six units down at a site, and someone lowered the set point on the four remaining units. Did that someone go back and adjust the settings after repairs were completed? After all, the incident occurred two years ago. If you are using thermostats, I'll bet that half the set points programmed into the thermostats were chosen by a technician who based the setting on not wanting to return on a nuisance call. In his mind, if 73°F is an acceptable cooling set point then 71°F will guarantee no complaints.

Another frequent abuse is people making scheduling allowances that are not necessary. They set the occupied start times for two hours prior to the time when someone actually enters the store. Almost all thermostats and all EMS systems today have an intelligent recovery feature. This causes the thermostat to learn how long it takes for the space to reach the set point temperature once the occupied period begins. The thermostat will determine how long prior to the programmed occupied start time it must begin heating or cooling so that the space reaches set point by the start of the occupied period. You don't have to build in a safety margin. The controls do it for you; so set up your controls with the actual occupied start time.

On the other hand, the unoccupied start time is something that you can actually tweak in many cases because most systems we have seen do not shut down systems prior to the start of the unoccupied period. If the store closes at 9:00PM and the manager leaves at 9:30, why not try setting the unoccupied start time for the sales area at 8:30PM and the unoccupied start time for the manager's office at 9:00 PM. You may be able to save 1 hour of run time for each site. Does it really matter that the space was 75°F rather than 73°F when the manager locked the door? The potential for savings is significant.

You also need to be aware of the relationship between space temperature and space relative humidity (RH). People feel comfortable at a range of temperatures and corresponding relative humidity. As relative humidity levels increase, we must lower the space temperature to obtain the same comfort levels. A person may feel comfortable in a 74°F store if the relative humidity is maintained at 50%. If the humidity exceeds 60%, you might have to lower the store temperature to 71°F for the same person to feel comfortable. Indoor RH is a function of outdoor temperature and humidity, the number of people in the space, the quantity of ventilation air being distributed, and the temperature of the air leaving your HVAC units. Some EMS systems actually have algorithms

that cause them to raise the cooling set point if the relative humidity in the space is low and lower the set point as the RH increases. This has the desired effect of reducing run time.

So how do we determine the appropriate temperature set points for a retail store? These numbers depend on so many factors that it is almost impossible to establish a norm. One retailer sells $3000.00 gowns and another sells plywood and 2X4's. A third sells chocolate that is extremely temperature sensitive. It's also about company culture and image. Another factor is the location of the temperature sensor in the space. If you use remote temperature sensors located five feet above the finished floor in one store and a remote sensor located behind a ceiling mounted return air grille in another store, don't expect to be able to use the same set points for both stores. The two sensors might be seeing temperatures that vary 5°F due to stratification. The best answer I have is, if you are serious about reducing energy consumption, squeeze till it hurts on a store by store basis, and let the manager know what you are doing. You can work as a team to reduce the energy usage (carbon footprint) of that store together.

3. Outdoor Air (Demand Controlled Ventilation):

A minimum quantity of outdoor air is introduced though HVAC systems to meet the ventilation requirements of occupied spaces. The alternative is having your customers turn blue as a result of oxygen deprivation. The required minimum amount of outdoor air introduced is determined by codes that are based to a large degree on the estimated maximum occupancy of the store. Most systems are set up so that the equipment delivers this quantity of outdoor air whenever the space is occupied. It doesn't matter if there are 3 occupants in a 10,000 square foot store or 300 occupants; the equipment is bringing in the same quantity of ventilation air. More importantly, the equipment is taking that outdoor air at whatever the ambient conditions are and heating or cooling and dehumidifying it so that it can be delivered to the conditioned space. The energy used to condition the outdoor air required for ventilating a retail store can be 25% of the total energy used to cool the store.

In the most retail stores, the only time store occupancy approaches design occupancy is during the Christmas shopping season. Due to the low outdoor ambient temperatures at this time of year in most geographic locations, it does not require huge quantities of energy to condition the outdoor air. However, in mid august, we are still bringing in quantities of outdoor air that are based upon Christmas shopping crowds and that air may be at 95°F and 80% relative humidity. Imagine if you staffed your stores for Christmas shopping volume year round. It would certainly reduce profitability, so why do we ventilate for Christmas shopping year round, when it has the same ultimate effect? The answer involves the way the ventilation codes were written and the fact that until relatively recently there was no way to vary ventilation rates based on the current number of occupants. For years, movie theatres were able to modulate their ventilation air based on the number of tickets purchased for each show, but very few retail stores have people counters tied into their HVAC systems. Today, there is a relatively inexpensive control strategy known as "demand controlled ventilation, "(DCV) that will perform this function reliably.

As you know, the respiration process involves absorbing oxygen contained in the air we breathe and expelling carbon dioxide. So if we put a lot of people into an enclosed space and we don't ventilate the space adequately, the oxygen levels drop and the carbon dioxide levels increase within the air in the space. Very sensitive carbon dioxide sensors have been developed within the past 15 years that allow us to measure the CO_2 in air. These same sensors are capable of sending a signal to the outdoor air damper actuators in HVAC units that determine the quantity of outdoor air being introduced. The dampers start at an almost closed position. As the number of

occupants increases, the CO_2 levels increase slightly and more outdoor air is introduced till the CO_2 levels drop. The set point of the CO_2 sensor is established at a point that insures that acceptable levels of carbon dioxide are maintained at all times. There is the potential for huge energy savings associated with demand controlled ventilation, however, prior to specifying DCV as a standard for your company, due diligence requires that you have a method to predict the energy savings. There are many software programs that are capable of giving you this information. A good starting point is a "Savings Calculator," that you can download free of charge from Honeywell's website. This tool will give you estimated energy savings for setback thermostats, different types of economizers, and demand controlled ventilation. All you need to do is to enter the city, hours of operation, application type, cost of installing the devices selected, and utility rates. It even calculates the savings in terms of CO_2 emissions.

Lennox DCV

(http://customer.honeywell.com/Business/Cultures/en-US/Products/Applications+and+Downloads/Economizer+Logic+Module+%28W7212%29+Simulator+and+Demand+Control+Ventilation+Savings-Estimator.htm) Demand controlled ventilation can be added to some existing systems, but the cost justification will be affected by the remaining usable life for the particular equipment. I strongly recommend that you look at DCV as an option when replacing equipment because the cost will almost always be justified. Like many of the recommendations presented herein, you should consult your design team when considering DCV.

4. *Outdoor Air (Economizers)*

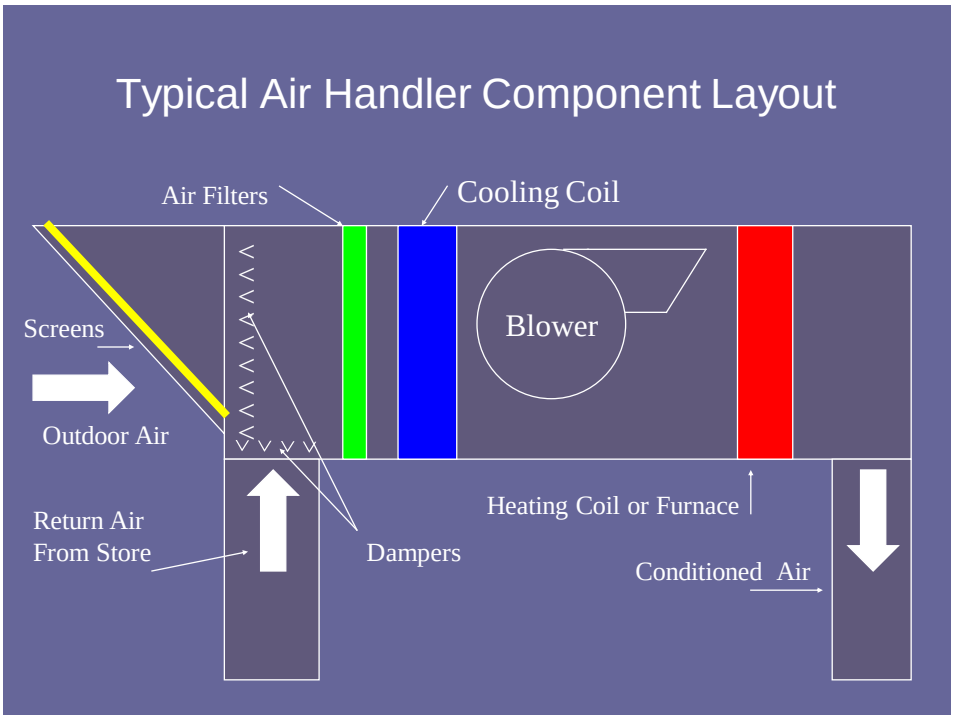
We just finished discussing how to avoid introducing large quantities of outdoor air for ventilation purposes in certain geographic locations due to the energy required to heat and cool this air. However, depending on the outdoor air temperature and relative humidity, and the space cooling requirements, there are times when it is extremely advantageous to introduce large quantities of outdoor air. Let's say it's a 45°F day in November at a store located in Connecticut. Chances are that due to internal loads such as people and lighting, that store will require cooling. The compressors in your HVAC units require large quantities of energy and they will be cycled on to provide mechanical cooling of the space. But, why use energy to create mechanical cooling which will cool the air to 50°F, when we have an unlimited supply of 45°F air surrounding the store? An outdoor air economizer cycle takes advantage of this source of "free cooling."

Whenever the HVAC system calls for cooling, a change-over control determines if the temperature (and sometimes the relative humidity) of the outdoor air is at a level that will allow it to be utilized to help cool the space. If the change-over control determines the outdoor air conditions are acceptable, the outdoor air dampers are opened fully so that up to 100% of the air delivered to the space by the HVAC unit is outdoor air. Occupants might feel uncomfortable if this air were introduced at a temperature below 50°F however, so a sensor in the discharge air stream modulates the outdoor air and return air dampers to maintain a discharge air temperature no lower than 50°F.

There is one piece to the economizer puzzle. If the equipment is delivering large quantities of outdoor air to a building, an equal quantity of air must be exhausted from the building. If you think of a building as a sealed box,

you realize that only so much air can be pumped into it without releasing an equal quantity of air. This is not usually an issue in mall stores that are open to a common area because the air is usually exhausted or relieved from the common area. However, in stand alone, or strip mall applications, the equipment must be fitted with a power exhaust fan and or relief dampers for the economizer to operate properly.

Depending on geographic location, there is significant energy savings to be had with the use of an outdoor air economizer cycle. Retrofitting existing equipment with economizers is not usually justified, but when replacing equipment, the cost of adding an economizer is almost always justified north of the Mason Dixon Line. More importantly, due to energy code requirements, most equipment with a capacity of more than 5 tons in locations north of the Mason Dixon Line is already equipped with economizers. The important question is, "Are they operational, and are they being maintained?" Economizers that don't work are not going to reduce your energy usage.



Layout of outdoor and return air dampers

5. *Equipment Replacement*

When evaluating proposals for major repair work to an HVAC system, most facility managers look at the replacement option as well, assuming the current equipment is more than 15 years old. When we add a "Green initiative," into the decision making process, the replacement option gains appeal. There are several reasons for this. The first is the fact that there are new units available today that are 25% more efficient than the units that were manufactured 15 years ago. The second, is that as an air conditioning unit ages, its efficiency decreases.

Compressors loose efficiency due to wear. Coils loose efficiency due to fouling and corrosion. Fans loose efficiency due to hardened dust deposits that are difficult to remove. Dampers loose efficiency due to leakage. Heat exchangers loose efficiency due to corrosion. The bottom line is that a new unit will be significantly more efficient than an existing unit.

The current phase out of refrigerant 22, and the fact that all new units will be charged with Refrigerant 410A also helps to make the decision to replace Green. The new refrigerant has far less negative effect with respect to damaging the ozone layer than the refrigerant used in existing equipment.

When considering the replacement option, you should be evaluating the capacity of the existing equipment versus the actual load. Don't just replace like for like. The existing equipment may have been installed for a prior tenant with completely different loads and needs. You may have decreased the lighting load in the store by replacing fixtures. You may have tinted windows and reduced solar loads. The existing unit may have an oversized blower motor or heating section, because the original installer needed the equipment quickly and took what was available from stock.

Finally, if you are replacing equipment, you can now upgrade the system to include factory installed options such as economizers and demand controlled ventilation. We should also be evaluating the quality of the new equipment with respect to life expectancy. Life expectancy will affect the sustainability issue and will determine how much energy will be expended replacing systems over the life of the building. If we purchase new units with a ten year life expectancy, versus equipment with a 20 year life expectancy, we have doubled the energy required to produce air conditioning for this particular piece of real estate. In today's world, we must rethink our decision making process with respect to equipment replacement, from a Green standpoint.

6. *Maintenance and Repairs*

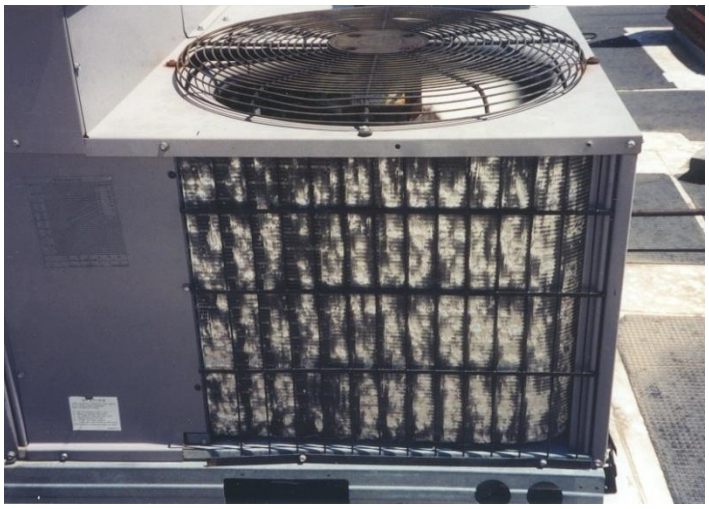
If you are serious about "Greening," with respect to your HVAC assets, you must maintain the equipment diligently. This cannot be stressed strongly enough. Any maintenance issue that caused increased runtime is causing wasted energy. Economizers that are not operating properly are not reducing your energy usage. Belts that are slipping are causing damage to other components in addition to wasting energy. Dirty condenser coils reduce equipment efficiency and cause premature compressor replacement. Systems that are either over charged or under charged with refrigerant are extremely inefficient and can cause premature compressor failure as well as damage to ceilings due to freeze ups.

Slipping Drive Belt

Dirty Condenser Coil Increases Energy Usage

Let's consider a simple situation where a condensate line was not cleaned during a PM visit, or filters were not replaced on a timely basis, and discuss the impact. We have the energy required to run the service call to clear the condensate line, including the fuel and maintenance of the service vehicle. We have the energy required at the contractor's office and at the retailer's office to process the paperwork including the lighting, heating and cooling of those spaces. We have the energy required to replace the damaged ceiling due to the condensate leak. This includes the fuel and maintenance for the ceiling contractor's vehicle, the portion of the ceiling contractor's overhead that is energy dependent, the cost of producing and shipping the materials required for the ceiling repair, and the energy dependent overhead for every process required to produce and ship the materials. While the quantities of wasted energy in this example may be miniscule, how many unnecessary condensate leaks occur in re tail space each year due to poor maintenance? It adds up.

There has always been a challenge to determining how much preventive maintenance is enough, and what repair work is really necessary. If the retail facilities manager is truly committed to a green initiative, he or she is going to have to reevaluate the decision making process with respect to HVAC maintenance and repair. We are also going to have to reevaluate the process from the standpoint of validating completion of preventive maintenance work. The only thing worse than not maintaining your equipment at high efficiency is to pay to have it maintained without the maintenance actually being performed.



Hail Damaged Inefficient Condenser Coils

Corroded Condenser Coils Decrease Efficiency

The purpose of this article is to present measures that have proven themselves over time in the past. I submit this as a realistic starting point for reducing the environmental impact of heating and cooling your stores. No snake oil and no magic bullets have been included. By the same token, there are many new strategies that are currently in the developmental or testing stages in my opinion that may have merit. Start thinking about the environmental impact of your HVAC systems and discuss your thoughts with your design professionals and your repair and maintenance professionals. You may be surprised at what you can accomplish in terms of energy savings, environmental impact, your company's image, and your own legacy for future generations.