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THE PARTNERSHIP OF INDOOR AIR QUALITY AND ENERGY MANAGEMENT

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Energy management is often accused of being the cause of indoor air quality (IAQ) problems. Certainly overzealous energy saving routines can hurt space conditions. Fear of IAQ repercussions often discredit proper energy management activities.

However, it is bad energy management which has given rise to IAQ problems. A good energy management program will actually improve space conditions. Building systems must be carefully tuned in order to be energy efficient. Such tuning removes operating bugs which had caused comfort problems, nowadays termed 'IAQ' problems.

Owners of large buildings should not abandon energy management in favour of IAQ. Both IAQ and Energy Management programs have a common interest in good design, operation, and maintenance of building systems. The two activities are complementary parts of good building engineering. This paper summarizes the common elements of IAQ and Energy Management programs in existing buildings.

INTRODUCTION

As concern for Indoor Air Quality has grown, steps taken in the name of Energy Management have often been reversed. Intake air damper settings or HVAC system operating periods have been changed to reflect a new awareness of occupant needs. Energy use has gone up somewhat and energy management has taken a back seat to IAQ.

However it is the author's experience that good energy management programs actually improve space comfort conditions. This experience comes through implementing many energy management changes for large commercial and institutional building.

These two opposing perceptions must be reconciled as pressures grow for both healthy and efficient indoor spaces. Though pressure for energy efficiency is relatively low while oil prices

are down, the economic or environmental cost of energy waste will always be an important factor in building operations.

A fundamental step in reconciling the objectives of Energy and IAQ Management is to differentiate between Energy Management and Energy Conservation. The Conservation of energy is easy: turn it off, or turn it down, (and freeze in the dark). Energy Management on the other hand implicitly involves the optimizing of energy use to suit the needs of the space.

Prior to the 1973 Arab oil embargo energy had been so cheap that designers, builders, operators, and managers had not cared about it. They knew little of how to manage it properly. Nevertheless, in the last 17 years many building modifications have been made to save energy. Simple energy reductions performed without due care for maintenance of space conditions were destined to cause problems. The public now calls these problems 'sick buildings' or 'building related illnesses'.

As the building community has now had time to learn of the interaction between energy using systems and occupants, Energy Conservation is now giving way to proper Energy Management. To highlight the difference between Energy Management and Energy Conservation, an example is given below.

Example

A common energy saving opportunity found in existing buildings is to match air circulation rates to needs. Following a building's design it is often found that actual occupancy is less than design. For maximum efficiency the air handling system should be modified to suit the lower than design loads.

The proper Energy Management solution involves detailed measurement of the performance of the air system to verify that it is working properly in all its branches. Air requirements are then recalculated, fans adjusted, ducts rebalanced, and possibly diffusers modified. In the process, blockages which have accidentally arisen in air flow to individual rooms are eliminated and comfort problems eliminated.

The common Energy Conservation way of realizing the energy saving is to operate the fans for the fraction of each hour that reflects the fraction of original design air flow which is now required. An automatic timer is all that is needed to implement this Energy Conservation approach: a much lower cost than the Energy Management approach. However, the resultant operation is destined to aggravate latent problem zones. Accidental blockages in air flow to individual rooms have not been removed. When fans are off there is no air movement. Pollutants or annoying odours can accumulate to the perceptible level. Temperature control is lost. Furthermore, occupants hear fans going off so they realize services are being suspended.

Hypothesis

Incomplete engineering of valid energy savings ideas has frequently caused discomforts which could have been avoided.

These discomforts are frequently stated in the common terms of 'bad air', 'stuffiness', or 'sick building'. These modern terms are used to describe conditions ranging from too warm, to excessive levels of an offensive chemical or microorganism.

Experience has shown that most complaints, though now termed as Indoor Air Quality problems, have their roots in conventional HVAC system balance and control problems. Therefore the investigation of an IAQ problems must thoroughly review the performance of the HVAC systems. So must an Energy Management program.

Building owners stand to gain much if they appreciate the similarity of efforts in IAQ and Energy Management programs. Rather than throwing energy care to the wind, owners can simultaneously optimize energy and space conditions. They will avoid duplication of effort. They will also enjoy the harmony of single purpose, namely to serve the occupants needs with as little energy as necessary.

This paper reviews the common activities of IAQ and Energy Management programs for existing commercial and institutional buildings. It examines the four major phases of any building upgrading program. Though this analysis is presented from the point of view of upgrading an existing building, there are similar common activities in the design of new buildings.

PHASE I - ASSESSING OCCUPANT NEEDS

Activities Common to IAQ and Energy

Before implementing Energy or IAQ upgrades, the designer must know the occupancy profile. The number of people and their location in the space at each hour of the day defines the load pattern for the HVAC systems. With this information HVAC systems can be tuned for maximum energy efficiency for each hour of the day. The occupancy profile also defines the pattern of pollutant generation from humans and their activities. This information is needed so that ventilation rates can be tailored to control peak and average pollutant exposures.

The type of people and activity in the space must also be known along with the kind of clothing worn by occupants. Such information guides the selection of space temperature, humidity, air velocity, and ventilation rate. It also provides clues on the occupant tolerance to temperature float, or swings in space conditions from possible energy management strategies such as night setback or deadband temperature control. Though these thermal comfort matters primarily control an Energy program, they also play a role in what the public now calls IAQ. Many occupants will complain of stuffiness or bad air when there are temperature, humidity, or air movement problems. By maintaining good thermal comfort control there will be fewer 'IAQ' complaints.

The lighting needs of each area must be assessed for both energy and IAQ purposes. Excessive lighting and poor positioning of light sources can cause excess energy use and occupant headaches. Though not directly an IAQ problem, headaches contribute to a sense of discomfort which may be expressed in IAQ terms by occupants.

Special IAQ Concerns

In addition an IAQ program must assess pollutant sources within and beyond the building. Interior sources are typically of less concern for existing space than for new space, as off-gassing rates dwindle with building material age. However occupants may have introduced a new source of pollutants since building design.

The quality of the outdoor air must be assessed as part of an IAQ program. Though air cleaning is not usually a concern of energy management, the tradeoff between 'fresh' air and cleaning of recirculated air may have an energy impact. This is one of the few areas where energy and IAQ concerns become competitive. However Eto(1) and Cowan(2) have shown the energy costs of increased fresh air intake to be minor, for most commercial buildings.

PHASE II - ASSESSING CURRENT EQUIPMENT PERFORMANCE

Building systems rarely operate completely as designed for many years. The actual performance of systems must be established before the scope of Energy and IAQ upgrades can be finalized.

Activities Common to IAQ and Energy

Both Energy and IAQ programs must assess current air intake and distribution patterns. The Energy program uses this information to ensure that the right amount of cooling or heating is delivered to the space. An IAQ program uses it to ensure that outdoor air is distributed as needed.

Control equipment must accurately hold temperature and humidity in the space in order to use energy efficiently. The performance of controls must be monitored or spot checked. Where conditions are not well controlled, energy is wasted and there is a greater risk of occupant discomfort, often expressed in IAQ terms.

Special Energy Activities

Energy programs must address central plant efficiency, an area of no concern for IAQ. For example the boiler's efficiency or the temperature of a cooling water flow are important parameters for energy efficiency but have little bearing on IAQ.

Special IAQ Activities

An IAQ program may examine air currents within the space. The bypass of supply air to return air inlets without sweeping the occupied space must be understood before proposing any upgrades.

An IAQ program may also test the space to determine whether there are any special pollutants ranging from dust and chemicals to microorganisms. The performance of air cleaning equipment is important to an IAQ program but of little concern to an energy program.

PHASE III - RETROFIT DESIGN AND IMPLEMENTATION

The retrofit of existing space has hazards. The unknowns of exact field conditions and the difficulties of working around existing occupants plague both IAQ and Energy retrofits. To minimize disruption it therefore makes sense to conduct both retrofit programs simultaneously.

Both IAQ and Energy programs are likely to modify fans, dampers, ducts, and diffusers in order to improve the delivery of heating, cooling, and ventilation. The control equipment may also be upgraded to allow more reliable or sophisticated tailoring of operations to needs. Without reliable control, energy cannot be managed and space conditions cannot be certain.

Energy and IAQ each have their own special kinds of retrofits as well:

- Energy retrofits may focus on plant efficiency, improving boiler, chiller, or lighting efficiency.
- IAQ programs may retrofit air cleaning equipment and add special exhaust to remove contaminants at source.

PHASE IV - OPERATIONS & MAINTENANCE PROCEDURES

No Energy or IAQ program is complete without reviewing building operating and maintenance (O & M) methods. Such review should be done periodically to ensure peak IAQ and Energy performance.

Operations and maintenance procedures which must be reviewed for both IAQ and Energy reasons are:

- equipment operating periods compared to occupancy periods.
- setpoints on all controls in the central plant and heating/cooling distribution equipment.
- proper functioning of automatic valves, and dampers.
- proper setting of fixed dampers and valves.
- cleanliness of open circuit heat rejection systems such as cooling towers, or some humidifiers.
- cleanliness of the air side of heat exchanger surfaces such as coils and radiation.
- cleanliness of lamps and fixtures.
- filter pressure drop and cleanliness.

Some operational checks are unique to IAQ programs. They focus on identifying telltale signs of improper space cleaning or creeping contamination. They have no energy effect.

- carpet/floor cleanliness, dampness from basements, window condensation, drain pan failure or floods.
- cleanliness of condensate drain lines.
- cleanliness of duct interiors and acoustic lining.
- cleanliness of walls and ceilings.
- storage locations of volatile or hazardous chemicals.
- products and concentrations used for routine cleaning.
- procedures with ventilation systems on days when renovation activities generate dirt or fumes.

In addition, there may be some special IAQ test routines employed to satisfy everyone that the ventilation is proper. CO_2 testing is one such method.

CONCLUSIONS

Many of the activities of an Energy Management Program are identical to those needed to ensure good indoor environments. Both activities focus on accuracy of controls and air distribution. Without such fundamental HVAC system performance, there can be no control of space conditions or energy.

Having addressed the basic HVAC issues in the distribution system, Energy Management also address central plant efficiency matters. IAQ programs also address cleanliness of the space and housekeeping methods.

RECOMMENDATIONS

With many major common elements, IAQ and Energy Management programs should be conducted simultaneously. This way the building owner can minimize engineering and retrofit costs. He will also work out the minor cost tradeoffs between energy and IAQ in an environment where all objectives are seen and the results optimized.

Building owners are advised to regard Energy and IAQ Management as partners, rather than adversaries. They both belong to the family of good building engineering.

References

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