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Energy Conservation Plan
For HVAC Systems

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Introduction:

At the core of any energy conservation plan is the need to perform outreach and education in order to build consensus for the benefits the plan seeks to achieve, while garnering support and acceptance for the changes that occur. Energy conservation plays an important part in the University's overall sustainability strategy.

By implementing these standards and strategies the University seeks to minimize resource consumption, environmental impact and cost. With the variety of facility types, activities and age, and the variety of heating and cooling systems and their associated controls that have been installed over time, it is important to have a plan that considers all these factors and differences in order to develop a comprehensive approach to energy conservation.

This plan is intended to establish, reasonable and comfortable occupied temperature ranges for students, faculty, and staff during regular business hours, standby temperature ranges when during normal business hours a space is unoccupied and more aggressive unoccupied temperature ranges for the remainder of times. The plan further identifies a variety of other control strategies that can provide additional incremental energy benefits. A key to all control strategies is having a high level of control functionality. To this end the plan recommends that all future facilities and renovations continue to implement full Direct Digital Control (DDC) systems, as has been the case since approximately 2001. In addition the plan recommends that occupancy sensors be included for each individual temperature controlled space. This will thus be the University's minimum design standard.

Goals:

To implement temperature limits and a variety of control strategies based on the available control system technologies currently in place in campus facilities, in order to reduce the consumption of energy. This plan shall include, but not be limited to temperature comfort ranges (limits), building schedule controls (occupied versus unoccupied), various control strategies and system upgrades and standardization of full DDC systems with occupancy sensors for all future facilities and renovations.

In recognition of the variety of facility control systems the degree to which temperature limits can be implemented is directly proportional to the level of available technology in a particular facility. Full DDC controlled facilities have the highest degree of control, while pneumatically controlled or locally controlled facilities offer lesser degrees of control. Hence a strongly communicated and supported program for education and outreach that explains the importance and benefits of controlling temperatures is vital in the absence of technology to control those facilities or spaces. Instead the plan must rely on users embracing the University's energy conservation goals.

Over time with campus expansion and system replacement in existing facilities, implementing enhanced technology can capture energy conservation with more certainty and repeatable results, thus providing a more comprehensive approach to the issue.

Systems:

Constant Volume Systems

Variable air volume systems are the design standard for Heating, Ventilating and Air Conditioning (HVAC) systems in all applications unless there is a compelling design requirement. Constant volume systems that exist should be converted to variable air volume systems in order to gain the efficiencies offered by the variable air volume system and the associated controls. Installation of full DDC control is also needed to maximize the new systems ability to conserve energy.

Controls:

Currently the University has a number of different control systems each with varying degrees of control capability. As stated previously the standard moving forward is to install full DDC facilities with occupancy sensors. To better understand the control systems the three classifications that follow provide a general understanding of the type of systems that currently exist.

Full DDC Facilities:

Those facilities where a DDC system has been fully implemented down to the room level of control are considered to be full DDC facilities. The full DDC system provides maximum data availability, and control at the room level. This system type also provides the ability to implement scheduling and enhanced control strategies on a room by room basis.

Since approximately 2002 the University has installed only full DDC systems in new capital projects. Only recently have occupancy sensors also been included.

Limited DDC Facilities:

Those facilities that do not have room level DDC controls, but that have DDC control of major HVAC equipment (fans and pumps) are considered Limited DDC facilities. Typically the room level control consists of pneumatic thermostats and VAV boxes. This approach allowed for increased control of major fan and pump systems, but did not allow for global point of use control.

From approximately 1990 to 2002 most capital projects used this design. Between 2001 and approximately 2006 the Utilities Department executed projects that converted what had been full pneumatic facilities to Limited DDC by converting the controls of major HVAC equipment.

Non-DDC Facilities

A group of older facilities that are most commonly steam heated and non-air conditioned are considered Non-DDC facilities. These facilities typically do not have major HVAC equipment and have their HVAC locally controlled using pneumatic or electric thermostats. These facilities typically predate 1990.

Control Strategies:

To achieve the goals of this plan there are a number of control strategies that can be implemented to reduce the amount of energy used to heat and cool campus facilities. In particular these strategies include:

Zero Energy Dead Band Control & Global Limits for Full DDC Facilities

This strategy provides maximum energy conservation, but is applicable only to those facilities having full DDC systems. The strategy reduces the simultaneous heating and cooling by implementing "Zero Energy Dead Band" control and global temperature limits such that neither mechanical heating nor cooling energy is supplied when a space is within limits.

At a space level the VAV box controlling the space operates using whatever discharge air temperature is provided by the system and within its own capacity limitations in an effort to maintain occupied space temperatures within the temperature limit range.

At a system level all occupied spaces served are polled and averaged. This average space temperature is then used to adjust/optimize the system discharge temperature. As the average of all the occupied space temperatures moves away from the midpoint of the temperature limit range the system discharge temperature adjusts incrementally such that the average of the occupied space temperatures moves back toward midpoint.

This strategy may create situations where not all of the spaces in a given facility are at equal temperatures, but all occupied spaces will be between the limits. This strategy typically provides both the greatest occupant comfort and the lowest energy use while still meeting indoor air quality demands.

There are heating/cooling limits for up to three (3) occupancy modes. See the Temperature Limits section for the specific temperature limit values.

Occupied Mode

These limits are used in spaces that are occupied or scheduled to be occupied. The zero dead band creates a modest temperature range between which the space will be maintained. This range will be from the occupied heating limit to the occupied cooling limit. This feature is applicable to all full DDC facilities.

Standby Mode

These limits are used in those full DDC spaces that have occupancy sensors. The sensors can be used to signal the HVAC system that a space is unoccupied during normal business hours (not in unoccupied mode). In standby mode the limits will be broadened from the occupied mode to allow for greater energy conservation. A person walking into one of these spaces would cause the HVAC system to return to the occupied limits. In addition to turning on the lights if the space had drifted outside of the occupied temperature limits the space would be either heated or cooled back to the occupied limits. When the space becomes re-occupied, it will take approximately 90 seconds for the air damper to open, and at most 15 minutes for the limits to be attained.

Note that in certain cases were a full DDC systems does not include occupancy sensors this occupancy mode will not be available unless said sensors are retrofitted to the system.

Unoccupied Mode

These limits are used outside of regular business hours and are designed to increase energy conservation by allowing a much wider temperature fluctuation in a given space. The increased limits allow HVAC equipment to remain off for longer periods of time, as well as provide less energy when a space is neither occupied, nor expected to be occupied. HVAC equipment will start if these limits are exceeded to prevent freezing or excessive heating of a space. However, it will take a longer time to reach the occupied limits if the space has either cooled or heated to near the extremes of the range. This feature is applicable to all full DDC spaces.

Typically those spaces that have more extreme temperature conditions within a facility (either warm or cool) will have their temperatures maintained at the limits. All other spaces that are more representative of the system average temperature will be maintained at or near the midpoint of the operating range.

Temperature Control Ranges for Limited and Non DDC Facilities

The zero dead band control strategy is not a practical option for the Limited and Non DDC facilities as they are currently configured as neither technology supports the dead band control method. Therefore an alternate approach to achieve energy conservation is required for these facilities.

Typically speaking the Limited DDC facilities employ a single temperature set point control strategy that provides each space with independent control over temperature. Furthermore this control seeks to satisfy the set point at all times and therefore is almost always heating or cooling a space in order to maintain set point.

From a technical perspective the thermostats in these facilities can be modified to limit the range of user available temperature settings. These ranges could parallel the zero dead band limits, thus providing a sense of consistency. This would prohibit those individuals that would seek to lower temperatures during heating season from achieving increased conservation. Conversely in the cooling season if an individual raised their set point in an attempt to reduce cooling the reheat coil would add energy to heat the space, thus actually using more energy. Alternatively the temperature limits could be provided to users with the request that they abide by the plan limits.

Similarly in Non-DDC facilities there is not a good means of achieving control other than limiting (pinning thermostats) the range of control or seeking user compliance.

In order to achieve a level of consistency between the facilities with various temperature control capabilities the thermostats in the Limited and Non-DDC facilities could be pinned to restrict their operation to the same occupied ranges as the full DDC facilities. A strong and well supported education and communication plan with tacit oversight of compliance may also offer the best opportunity for conservation in these situations.

<u>Temperature Limits</u>

Based on the various temperature control strategies outlined above the Energy Conservation Plan for HVAC Systems suggests the following limits where applicable:

Unoccupied Mode: Heating Limit	60 degrees F
Standby Mode: Heating Limit	67 degrees F
Occupied Mode: Heating Limits	70 degrees F
Occupied Mode: Cooling Limits	75 degrees F
Standby Mode: Cooling Limit	78 degrees F
Unoccupied Mode: Cooling Limit	85 degrees F

Whether technologically enforced by a full DDC system or behaviorally adopted in Limited DDC and Non-DDC facilities the concepts of these limits in some form can be applied in whole or in part at all campus facilities.

Research by the American Society for Heating and Refrigeration Application Engineers (ASHRAE Standard 55 - Thermal Environmental Conditions for Human Occupancy) indicates that a temperature of 68^{o} F will be comfortable for most people (10% dissatisfaction rate) who are dressed appropriately for the heating season. Conversely temperatures in the 74-78^{o} F range should be comfortable for most people (10% dissatisfaction rate) who are dressed appropriately for the cooling season.

Building Scheduling

As a fundamental strategy it is important that facilities only be in occupied mode when sufficient occupants are present to warrant that the major systems and equipment be operational to heat or cool the facility. Times of limited use or times outside of normal business hours provide significant opportunities for energy conservation.

A renewed effort to optimize facility and/or system schedules to more closely match the necessary building occupancy hours can provide energy savings. Further by conveying to those occupants that are present outside of what are deemed to be reasonable normal business hours that the systems will be set to unoccupied mode eliminates the consumption of energy to heat either a significant portion or an entire facility for limited occupancy thus ensuring or providing savings.

Limited occupancy activities outside of normal business hours such as cleaning, maintenance or use by facility occupants for individual or small group activities may not warrant operation of large systems necessary to support such limited occupancy.

As occupancy sensor based controls for lighting and HVAC are implemented consideration of allowing these devices to return individual spaces to occupied mode unless globally overridden for the entire facility can be considered.

Average Space Temperature Based Discharge Air Reset

Campus facilities equipped with full DDC and variable air volume systems will use discharge air reset technology to reduce energy costs and optimize energy use. In these facilities the temperature in occupied spaces is allowed to freely float between the occupied heating/cooling limits. The discharge air temperature of the air handling unit is reset to maintain an average space temperature at the middle of the occupied mode range. The goal is to have the majority of zones in the facility operating at minimum air flow with no reheat. This may create situations where not all of the spaces in a given facility are at equal temperatures, but all occupied spaces will be between the limits. This strategy typically provides the greatest occupant comfort and the lowest energy use while still meeting indoor air quality demands.

Demand Controlled Ventilation based on CO2

This strategy utilizes full DDC systems with occupancy sensors and CO2 sensors to limit the quantity of outside air supplied by the system. Using sensed occupancy, CO2 levels and ASHRAE Standard 62 minimums outside air is minimized. Outside air will be measured using an air volume measuring station. By lowering outside air volume the energy used to heat, cool, humidify and/or dehumidify is decreased.

Static Pressure Reset

Full DDC control systems will monitor VAV box damper positions and if none of the VAV boxes are in the full open position the system static pressure is reduced, thus allowing the fan speed to reduce and subsequently allow VAV boxes to open further if necessary. By reducing the static pressure in the system supply ducts based on actual VAV performance fan horsepower can be reduced.

Exceptions and Special Applications

There may be challenges or special needs in certain facilities or applications. If appropriate and when verified, accommodations will be considered on a case-by-case basis. Modifications to the temperature limits will also be considered as the plan evolves. Where possible and as requested by constituent groups more stringent temperature limits will be considered in order to further increase energy conservation.