HVAC Controls and Automation

What are HVAC Controls and Automation?

HVAC, the system that handles the heating, ventilation, and air conditioning for a given building, typically accounts for 40% of a commercial building’s energy use. From a whole building design perspective, there are many ways to reduce the energy usage (thus increasing energy efficiency) of an HVAC system, one of those ways being upgrading the existing control mechanisms. HVAC controls are what operate the system in a manner that can affect the thermal comfort of the building, as well as its cost effectiveness and the durability of the mechanical equipment. Maintaining occupant comfort is also a key objective for an HVAC system since air quality can have a profound effect upon the productivity and health of the occupants within.¹

How to Implement HVAC Controls and Automation

When considering upgrading HVAC controls, it is important to test the current system. Minimally, this involves a diagnostic visit by an engineer, but the preferred approach is to commission (or recommission) the building. As part of the commissioning process, HVAC systems can be tested under various conditions and operations in order to reveal any problems and inefficiencies the system is having. The commissioning process will also help the operations and maintenance staff to see if they are managing the HVAC system properly.² These steps can be completed by a qualified engineer who will inspect the system and make suggestions for fine tuning the HVAC system, whether they are with the management of the system or if the system needs a tune-up or complete re-design. For example, HVAC systems are often oversized (thus inefficient) and businesses can save upwards of 50% on their energy costs by correcting the operations of the HVAC system or by modifying the mechanical equipment. Another possible outcome of a commissioning process is to upgrade the controls system. More fully automated controls give operations & maintenance personnel the ability to monitor and adjust the HVAC system based upon real time changes in the outdoor environment and indoor occupancy levels. Since the mechanical equipment is being optimized by the control system, it becomes easier to establish a preventative maintenance and repair program for the HVAC system, which in turn typically improves its performance.³

The scope of the automated control system should be discussed and decided upon early in any renovation project. The nature of the initiative involves a whole building design approach since

these controls can work with the lighting, ventilation, and temperature, and many other features of a building. These controls include but are not limited to programmable thermostats to reduce heating and cooling loads (temperature), variable frequency drives (ventilation), occupancy sensors (lighting), and system integrated windows, all of which can have great impact upon the indoor environmental quality of a given space. Placement of these controls also has a great effect upon the type of energy savings that one can achieve. Optimizing these locations will ensure that higher efficiency is achieved and targeted energy savings are realized. Controls in general will last 10 to 15 years and can be easy to maintain as well as being cost effective.\(^4\)

**Examples**

**Control System with Exterior Sensors**

A new HVAC control system that is sensitive to the outside air temperature can be used to achieve significant gas usage savings during warmer months of the year by ensuring that excessive space heating is not occurring. If the HVAC system is responsive to outside conditions, the system will more easily and efficiently maintain interior conditions at set levels.

The calculations below are based on HVAC control system upgrades to a 25,000 square foot municipal building in NJ, undertaken in connection with the NJ BPU commercial audit program. The building is currently heated by a natural gas-fired hot water boiler system and has several heating zones. The building is cooled by a chilled water system. Water is heated by a natural gas-fired water heater. The heating, cooling, and water systems function with internal feedback loops, but are unaffected by external conditions. The control system upgrade modeled for the structure includes installation of sensors on the outside of the building to measure exterior temperatures.

- Total annual gas usage reductions: 5,674 therms\(^a\)
- Total annual cost savings: $7,376\(^b\)

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The chart below shows predicted gas usage reductions and cost savings for the building:

<table>
<thead>
<tr>
<th>Local Fiscal Impacts</th>
<th>HVAC Control System with Exterior Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lifetime of Measure (Years)</td>
<td>10 to 15 years</td>
</tr>
<tr>
<td>Annual Gas Usage Savings (therms)</td>
<td>5,674 therms</td>
</tr>
<tr>
<td>Annual Cost Savings ($)</td>
<td>$7,376</td>
</tr>
<tr>
<td>Estimated Upgrade Cost ($)</td>
<td>$300</td>
</tr>
<tr>
<td>Average Payback</td>
<td>0.1 years</td>
</tr>
</tbody>
</table>

See Notes section for further information on this chart.

Control System with Exterior Sensors

The calculations below are based on HVAC control system upgrades to a 7,000 square foot municipal building in NJ, undertaken in connection with the NJ BPU commercial audit program. The building is currently heated by a hot water system using a natural gas-fired boiler. The building is cooled by several window air conditioning units following the failure of the central air conditioning unit. Water is heated with an electric heater. The heating, cooling, and water systems are controlled based on user inputs and interior monitoring of conditions. The control system upgrade modeled for the building similarly includes installation of sensors on the outside of the building to measure exterior temperatures.

- Total annual gas usage reductions: 811 therms
- Total annual cost savings: $1,046

The chart below shows gas usage reductions and cost savings for the building:

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Miller Brewing Company – Trenton, OH
South Pointe Hospital – Cleveland, OH:
http://www.automatedlogic.com/case-study/south-pointe-hospital/

Benefits

- Improved indoor air quality
- Increased safety via smoke, fire, and light detectors integrated with automated controls
- Reduction in CO$_2$ emissions
- Increased occupancy comfort
- Increased energy savings through a reduction in energy usage

Costs

While prices will vary depending on the type of automated controls selected, if implementing a high performance HVAC system from a whole building design approach, annual energy savings can reach 30% with a payback period of 3 to 5 years, or 40% annually if the payback period is extended to 7 years.$^5$

Resources

Philadelphia High-Performance Building Renovation Guidelines

Enhanced Automation
http://www.energy.ca.gov/enhancedautomation/

The Whole Building Design Guide
http://www.wbdg.org/index.php

Flex Your Power – California Energy Efficiency and Conservation
http://www.fypower.org/com/

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Notes

Control System with Exterior Sensors example

a) Existing gas usage for the building during the summer months was compared to predicted gas usage determined by modeling the structure with the measured weather conditions in New Jersey. Predicted usage is subtracted from existing usage to determine gas usage reductions.


c) Estimated upgrade cost / Annual cost saving = $300 / $7,376 = 0.05

d) This payback period is noticeably shorter than one might expect because of the assumptions made about the cause of excessive summer natural gas usage – high usage was attributed to excessive space heating during the summer months when temperatures were not above 55 degrees in the evenings. This assumption is reasonable given that lows in May, June, and September in New Jersey routinely dip below 60 degrees based on NOAA climatic data. These temperatures increase demand for heating at night during those months and contribute to unnecessary natural gas usage. An HVAC system with modern controls is designed to avoid excess usage.

Control System with Exterior Sensors example

e) Existing gas usage for the building during the summer months was compared to predicted gas usage determined by modeling the structure with the weather conditions in New Jersey. Predicted usage is subtracted from existing usage.

f) As with the first example, $1.30/therm for utility (piped) gas seems reasonable.

g) Estimated upgrade cost / Annual cost saving = $300 / $1,046 = 0.29

h) This payback period may be shorter than one might expect because predicted cost reductions are dependent upon the assumptions made about the building. Nonetheless, these assumptions are based on measured performance of heating and cooling of the structure. It is speculated that this building is sometimes cooled below the thermostat set point by window air conditioners, thus leading to firing of the heating system to heat the building above the minimum heating limit. An immediate solution to such a problem would be turning off the heating system during the warmer months. Exterior controls would be similarly effective at remedying this problem and
adapting to exterior conditions other times of the year when temperatures are similarly mild or warm.