PG&E

CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

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July 3, 2006

July 13th, 2006 Workshop Report DDC to the Zone Level 2: Demand Shed Controls

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Overview

Description

This CASE report addresses one of five separate measures that extend the control requirements of the standard. All five of these requirements are possible at a very small cost if the installed control system is direct-digital control (DDC) to the zone level. This initiative does not seek to require installation of DDC to the zone level, rather it extends the current philosophy of the prescriptive requirements such as supply static pressure reset (Section 144(c)2D) that state a functional requirement of the control system if it is designed for DDC to the zone level.

The measures covered by this proposal are as follows:

1. Modification of the existing prescriptive measure 144(d) (Space-conditioning Zone Controls) to allow for "dual maximum" control of VAV boxes

2. A new mandatory measure for global demand shed controls that can automatically reset the temperature set-points of all non-critical zones by 1 to 4°F from a single central command in the building energy management and control system (EMCS).

3. Modification of the existing prescriptive measure 144(j)6 (Hydronic System Measures: Variable Speed Drives) to require demand based reset of the pressure setpoint for pumps serving variable flow systems based on valve demand. This measure is the hydronic analog of the existing prescriptive measure for supply air pressure reset in (Section 144(c)2D).

4. Modification of the existing mandatory demand controlled ventilation (DCV) requirements 121(c)3 (Required Demand Control Ventilation) to include high occupant density zones served by multiple zone systems.

5. Modification of the existing prescriptive measure 144(f) (Supply Air Temperature Reset Controls) for demand based supply air temperature reset for variable air volume (VAV) systems that operate when the system is on 100% free cooling from the air-side economizer.

As each of these measures is simply a matter of programming, the cost for implementing them is quite low. However, as described below each of these measures has a significant potential for energy and demand savings.

This specific report covers the global demand shed controls.

Energy Benefits

A number of recent studies have shown that between 1 to 2.4 w/sf of peak demand can be shed by simply globally resetting setpoints of thermostats in non critical zones in commercial buildings[i]. If implemented properly, the building's mass can float the impact of a 1°F to 4°F change in space temperature setpoint throughout the utility's on-peak period. Furthermore recent changes in ASHRAE Standard 55-2004 allow for this drift if the rate of change is controlled following rates set out in Table 5.2.5.2 (see Table 1).

Table 1 – Table 5.2.5.2 from ASHRAE Standard 55-2004

Time Period	1/4 h	1/2 h	1 h	2 h	4 h

Maximum Operative Temperature Change Allowed	2.0°F	3.0°F	4.0°F	5.0°F	6.0°F

Environmental Impact

This measure has no adverse environmental impacts as long as limits are placed on the amount of drift and the rate of change of the setpoints following guidelines in ASHRAE Standard 55..

Type of Change

This measure is proposed as a new mandatory requirement. It applies to new construction or retrofits of existing control systems with DDC systems to the zone level. The changes to the Title 24 documents are as follows:

Standards

- Add a new mandatory requirement 122(h)
- Modify the existing mandatory requirement for control system acceptance in 122(h) and renumber this paragraph to 122(i).

ACM

- Create a new acceptance test NJ 11 Global Demand Shed Control Acceptance.

Technology Measures

This measure only applies to systems with DDC to the zone level. As presented in our industry survey below, this represents between 90% to 95% of the new construction market.

Measure Availability and Cost

EMCS systems with DDC to the zone level are prevalent in the current building market. Our experience and surveys of the major EMCS vendors indicate that all of the major vendors are capable of meeting these proposed requirements. At least two of the major manufacturers (Alerton and ALC) currently offer this capability as a standard feature of their systems. For all of the manufacturers once programmed this capability can easily be incorporated into their precanned programs for distribution to their licensed contractors. Data on the major market players and the surveys are presented below.

Useful Life, Persistence and Maintenance

This measure will be tested through the Title 24 acceptance testing requirements. These proposed control sequences (like all controls) will need to be reviewed as part of the routine maintenance of the EMCS.

Performance Verification

As documented below a new acceptance requirement will be added to test this proposed requirement.

Analysis Tools

This measure can easily be evaluated using either eQuest or EnergyPro through the manipulation of the standard schedules. As a mandatory requirement no modeling is required for the Performance method.

Relationship to Other Measures

None of any significance.

Methodology

Demand Savings

The potential demand savings from this measure have been amply documented in the existing literature (see References). No additional research has been performed in support of this measure.

EMCS Market Share

The authors did a literature search and surveyed the major EMCS vendors to determine the market share of EMCS vendors in the HVAC controls market nationwide. The results follow:

1. Johnson 16%-25%
2. Siemens 15%-17%
3. Trane 6%-15%
4. Honeywell 7%-10%
5. Alerton 5%-10%
6. Automated Logics 7%-10%
7. Andover 7%-10%
8. Invensys 7%
9. All others 10%-20%

Graphical data from one of the market research sources is presented in Figure 1 below.

Figure 1 – EMCS Market by Company in 2001 (BCS 2002)

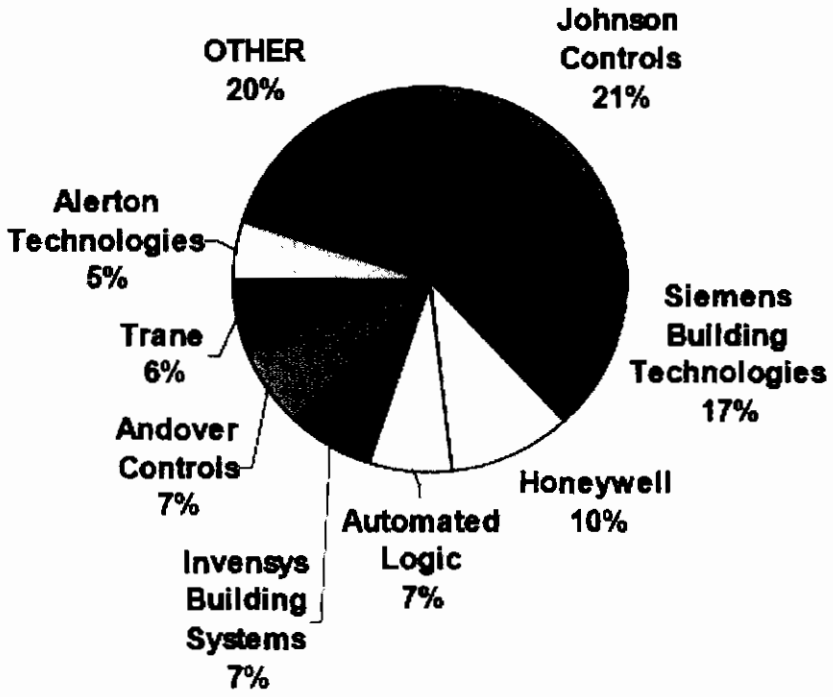
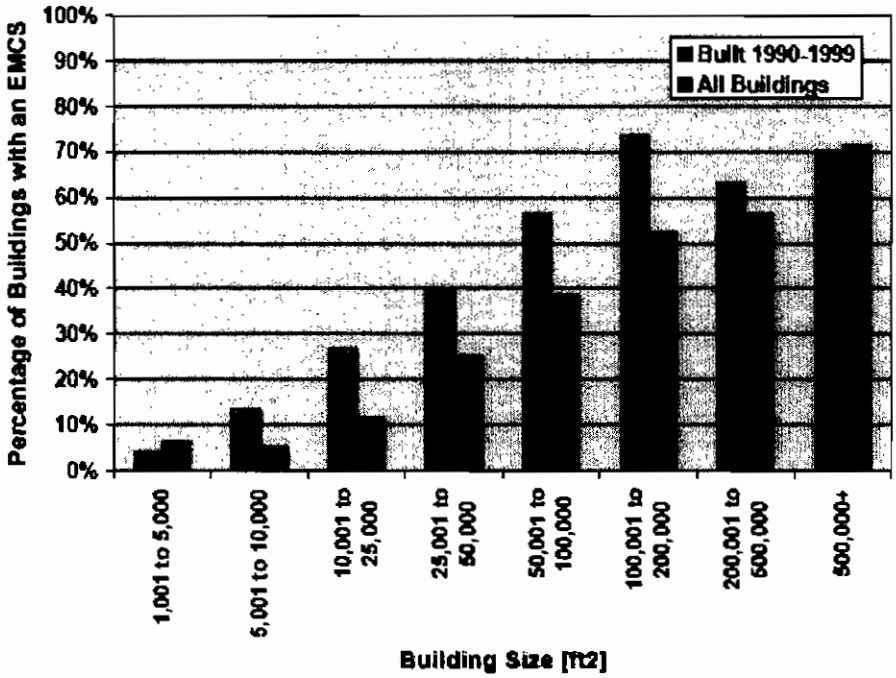


Figure 2 – Buildings with EMCS (EIA 1999)



Survey of EMCS Manufacturers on the Proposed Requirements

An email survey was sent to EMCS vendors to get their reaction to the proposed requirements. The survey was sent to Trane, Honeywell, Invensys, Alerton, Johnson, Automatic Logic Corporation and Siemens. At the time of this report, responses were received from Alerton, Automated Logic Corporation and Siemens. The survey that was sent follows:

Dear [Insert Name],

We are working on the development of the 2008 update of California's building energy code, Title 24. We are preparing for a workshop on July 13th and would appreciate your response by July 1st if possible. One of the issues we are researching relates to DDC controls. We are investigating a code change to specify control requirements on systems that have DDC to the zone level. In order to determine the feasibility of these ideas, we are surveying vendors and contractors for their opinions on the viability of these proposed measures and the make-up of the BMS market in California. To assist our deliberations, we would like you to answer the following questions:

1. *In your opinion, for new construction in commercial buildings what percentage of the controls marketplace (based on $ spent by owners) belongs to the following classes of control products:*

    a) *Fully DDC (including the zone controls)?*

    b) *Hybrid DDC and pneumatic systems?*

    c) *Fully pneumatic?*

    d) *Other (please elaborate)?*

    In considering your answer to this question exclude the single zone units that are controlled by programmable thermostats

2. *In your experience what are the most important (top 3 to 5) factors that drive a customer to purchase DDC controls? Consider the following list but feel free to list other major factors:*

    a) *First cost*

    b) *Energy savings*

    c) *Alarming*

    d) *Improved comfort and control*

    e) *Trending*

    f) *Tenant submetering*

    g) *Tenant after hours management*

    h) *Facility management*

    i) *Web based access*

    j) *Other factors (please list)*

3. *What are the relative installed costs of DDC and pneumatic systems for typical office and retail buildings?*

    a) *On a $/sf basis (or relative % cost basis) if you have the data*

    b) *Qualitatively, are they about the same or is one significantly more expensive?*

4. *Do you have any data on comparative maintenance costs for DDC and pneumatic systems?*

5. *Would you support a code change requiring DDC controls to the zone level for new control systems serving multiple zone systems and equipment?*

    a) *What are some questions or concerns you might have about such a code change?*

    b) *Are there systems or applications where this would not be appropriate?*

6. *The following are specific control requirements that we are considering. Please provide feedback (positive or negative about each). For each control requirement please address the following issues:*

    - *whether your existing systems (hardware and software) will be able to support these requirements*
    - *what exceptions should be included*
    - *the added effort to program and tune these control algorithms*

    Here are the proposed new control requirements

    a) *Hydronic pump pressure reset by demand (either directly by valve demand or through a " trim and respond " algorithm)*

    b) *Ability to globally reset cooling set points on zone thermostats on " non critical " zones by 1 to 4°F for central demand shed.*

    c) *Supply air temperature reset on VAV systems that is only enabled when the system is on 100% economizer cooling*

    d) *Demand controlled ventilation for multiple zone units serving one or more densely occupied zones. The control logic is likely to cascade with the first step controlling the zone box minimum and the second step controlling the minimum OSA damper position.*

Please contact us if you need any clarifications on the above questions. We thank you in advance for your time and we welcome your comments and feedback.

A summary of the survey results follow:

Question 1, EMCS market place: All three respondents indicated that DDC to the zone level was between 90% to 95% of the new construction market.

Question 2, Top Factors for DDC Purchases:

- Facility Management - 3 Votes
- Improved Comfort and Controls – 3 Votes

- Tenant After Hours Management – 2 Votes
- Alarming – 2 Votes
- Energy Savings – 2 Votes
- First Cost – 2 Votes
- Web Based Access – 1 Vote

Question 3, Relative First Cost of DDC and Pneumatic Controls: The consensus of the respondents is that pneumatic controls generally have a slightly smaller first cost. This cost depends on the number of points in the system as the pneumatic control system incurs a large first cost penalty for the compressor and associated equipment (like air dryers and filters). For small control systems DDC is actually less expensive. For medium and large control systems DDC is likely to be a slight cost premium.

Question 4, Relative Maintenance Cost of DDC and Pneumatic Controls: The consensus of the respondents is that pneumatic controls have a significantly higher maintenance cost (on the order of 20%-40%).

Question 5, Support for the Proposed Requirements: All respondents support the proposed requirements.

Results

As documented in the PCT PIER report, the present value per kW of demand shed is approximately $1,900. From the PIER/LBNL studies between 1 to 2.4 w/sf of peak demand can be shed in a typical building using global temperature reset. Using the value of 1 w/sf this yields $1.9 w/sf of present value savings for this measure. This far exceeds the few hours of programming time it would take to set up a system.

Statewide Energy Savings

[To be developed later]

Recommendations

Proposed Standards Language

New Mandatory Control Requirement 122(h)

122(h). Automatic Demand Shed Controls. HVAC systems with DDC to the zone level shall be programmed to allow centralized demand shed for non-critical zones as follows:

1. All current zone cooling temperature setpoints in non-critical zones shall be capable of being reset upwards by up to four degrees from a single central DDC signal.
2. The system shall be capable of restoring the original cooling temperature setpoints from a single central DDC signal.
3. The system shall be programmed to provide an adjustable rate of change limiter on the zone reset signals.

~~(h)~~(i) Space Conditioning Controls Acceptance. Before an occupancy permit is granted for a newly constructed building or space, or a new space-conditioning or ventilating system serving a building or space is operated for normal use, all spaceconditioning controls serving the building or space, which is the subject of the building permit, shall be certified as meeting the Acceptance Requirements for Code Compliance. A Certificate of Acceptance shall be submitted to the building department that:

1. Certifies plans, specifications, installation certificates, and operating and maintenance information meet the requirements of Part 6.

2. Certifies that the space-conditioning system meets the requirements of Sections 121 (c) 1 and 121 (c) 2.

3. Certifies that space-conditioning controls meet the requirements of Section 122 (a) through Section 122 (~~g~~h).

Alternate Calculation Manual

New Acceptance Test NJ 11 Global Demand Shed Control Acceptance

NJ 11 Global Demand Shed Control Acceptance

NJ.11.1 Construction Verification

Prior to Acceptance Testing, verify and document the following:

- That the EMCS interface provides a central demand shed interface.

NJ.11.2 Equipment Testing

Step 1: Engage the global demand shed system. Verify and document the following:

- That the cooling setpoint in non-critical spaces increases by the proper amount.
- That the cooling setpoint in critical spaces remains unchanged.

Step 2: Disengage the global demand shed system. Verify and document the following:

- That the cooling setpoint in non-critical spaces returns to their original values.
- That the cooling setpoint in critical spaces remains unchanged.

Bibliography and Other Research

Part I: Measure Analysis and Life Cycle Cost for the 2005 California Building Energy Efficiency Standards. April 11thth, 2002. California Energy Commission. P400-02-011.

Part II: Measure Analysis and Life Cycle Cost for the 2005 California Building Energy Efficiency Standards. May 16thth, 2002. California Energy Commission. P400-02-012.

Part 1V: Measure Analysis and Life Cycle Cost for the 2005 California Building Energy Efficiency Standards. August 13th, 2002. California Energy Commission. P400-02-014.

Eley Associates, March 11, 2002. *Life Cycle Cost Methodology, 2005 California Building Energy Efficiency Standards*, California Energy Commission Contract Number 400-00-061. Available at http://www.energy.ca.gov/2005_standards/documents/index.html

EIA, 1999, "Commereial Buildings Energy Consumption Survey (CBECS)", US DOE EIA. Available from http://www.eia.doe.gov/emeu/cbecs/contents.html

BCS Partners, 2002, "The Building Control Systems Market (2001-2006)", Report by BCS Partners, July.

Energy Impact of Commereial Building Controls and Performance Diagnostics: Market Characterization, Energy Impact of Building Faults and Energy Savings Potential. TIAX LLC for US DOE. November 2005.

Demand Responsive Control of Air-Conditional via Programmable Communicating Thermostats (PCTs). SCE Case Initiative. February 14th, 2006

Proposal for 2008 Title 24 Global Temperature Adjustment (GTA). David Watson, Lawrence Berkeley National Lab. February 23rd, 2006. http://www.energy.ca.gov/title24/2008standards/documents/2006-02-22+23_workshop/presentations/2006-02-23_GLOBAL_TEMP_ADJUST.PDF.

PIER Demand Response Research Center website, http://drrc.lbl.gov/autodr2/autodr2.html

Peak Demand Reduction from Pre-Cooling with Zone Temperature Reset in an Office Building. Xu, P., P. Haves, and M.A. Piette, (Lawrence Berkeley National Laboratory) and J.E. Braun, (Purdue University). Proceedings,ACEEE 2004 Summer Study on Energy Efficiency in Buildings: Breaking out of the Box, August 22-27, 2004, Asilomar, Pacific Grove, CA. Washington, D.C.: American Council for an Energy-Efficient Economy. LBNL-55800. August 2004

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Appendices

None.

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[i] See for instance the papers posted on the website, http://drrc.lbl.gov/drrc-pubs3abs.html#58815. Also the presentation in the Feburary 2006 Title 24 2008 workshop by David Watson (see link under references).