Measure Information Template **_Demand Response_**

California Building Energy Efficiency Standards Update for 2008

October 13, 2005 version 2 David Watson, LBNL/PIER

Purpose

This document is a report template to be used by researchers who are evaluating proposed changes to the **2008 California Building Energy Efficiency Standards**.

Overview

Description	**Title: "Global Temperature Adjustment (GTA) in Large Commercial Buildings"** **Applicable Domain:** Commercial buildings with new Energy Management and Control Systems (EMCS) for control of HVAC equipment and direct digital control of zones. **Description:** Global Temperature Adjustment (GTA) allows commercial building operators to adjust the space temperature setpoints for an entire facility with a simple set of actions from one location (e.g., from one screen on the human machine interface). GTA, as defined here, is a key step toward enabling effective and graceful sheds of electric loads in commercial buildings. GTA based DR strategies can be implemented either manually by building operators or automatically based on remote signals.
Type of Change	Mandatory Measure The change would add a mandatory measure.

Energy Benefits	GTA provides dispatchable short-term load reductions (< 6 hrs.), as opposed to traditional energy efficiency [1]. Because the measure enables commercial buildings to shed electric loads on an "as needed" basis, it would likely be used in the following circumstances: 1) During an electric grid contingency event. 2) During a period of high electric prices (e.g., 3-6pm on critical peak pricing days). 3) Whenever facility operators choose to monitor and limit peak demand to reduce peak demand charges. Each of the three aforementioned circumstances has a strong correlation with periods of high Time Dependent Valuation (TDV). For demand response with longer periods of advanced warning (e.g., day ahead programs), GTA can be used in pre-cooling strategies.
Non-Energy Benefits	Not applicable
Environmental Impact	No negative environmental impact. GTA is a software feature to be added to new Energy Management and Control Systems (EMCS). Inclusion of GTA feature does not require additional EMCS hardware. May have some positive environmental impact. Peak load reduction can reduce the need to operate the least efficient and most polluting peaker plants that are used during system wide peaks in load. Environmental analysis is not provided in this document.
Technology Measures	Global Temperature Adjustment (GTA) is a software feature that can be added to standard existing EMCS components by all known EMCS manufacturers. No additional hardware or revisions to existing hardware is required. The software code required to add this feature is small enough that no additional memory hardware should be required to add it to existing EMCS component designs. **Factory installed GTA**: (recommended method) GTA feature is added in the EMCS manufacturer's factory. The labor required to add GTA as a standard feature to new EMCS devices would be a one-time cost to the EMCS manufacturers of approximately \$20,000 to \$50,000 including changes to documentation and other overhead. Once the GTA feature is included in standard EMCS components, there would be no added cost to use this feature on all future field installations. **Field installed GTA:** (backup/transitional method) GTA feature is added by the field installation team on a project by project basis. When GTA functionality has not been factory installed, it can also be added in the field, either at the time of installation or at a later date. Some labor costs are incurred with field installation (see table 1). **Availability:** It appears that only two EMCS manufactures (not the largest players) currently offer GTA enabled control devices in their standard products. For these vendors, there is no extra charge for this feature, nor is it heavily promoted in their literature. The standard products containing this feature are sold nation-wide. GTA is not generally known or specified by design engineers. It generally appears in existing buildings only under the following circumstances: 1) products from the supporting vendors were selected (usually selected for other reasons). 2) an innovative facility operations staff directs a controls subcontractor to program the feature into their

[1] Energy efficiency and load shifting programs are already addressed in the TDV methodology included in the 2005 Title-24 building energy standards.

	building(s) after initial occupancy. **Persistence**: When provided as a standard product feature in this fashion, GTA software can lie "dormant" until needed to enable DR. When the GTA software is in place, DR strategies can easily be initiated at any time, even years after original installation. Similar types of dormant features are common in EMCS products (e.g., night setback mode). The flexibility to enable or disable the GTA feature (without removing it) makes it very persistent. Once the GTA software is installed (by either factory or field crews) there is no reason for on-site facility managers to remove it.
Performance Verification	Proper functionality of the GTA feature can be verified in commercial buildings through EMCS trend log analysis and test DR events with the main electric meter. Baseline load profiles can be compared to profiles when Global Temperature Adjustments have been made to reduce load.
Cost Effectiveness	See table 1 below.
Analysis Tools	Remote meter reading systems are already in place for most commercial sites over 200 kW (e.g., PG&E's InterAct system). These systems were used to gather and analyze data in field tests in 2003-2005. In addition, energy modeling using EnergyPlus corroborated field tests (and visa versa) in a wide variety of building and climate types.
Relationship to Other Measures	No substantially interdependencies with other measures.

Methodology

The recommendation of this measure is based on the outcome of research performed by the Demand Response Research Center (DRRC), managed by the Lawrence Berkeley National Laboratory (LBNL). The DRRC is substantially funded by the California Energy Commission PIER program. LBNL performed tests described below.

In the summers of 2003, 2004 and 2005 (in progress), 24 Commercial facilities throughout California participated in Demand Response research tests. The tests focused on technology, shed strategies and institutional/organizational issues surrounding DR.

Technology: A communications infrastructure was created that used the public Internet to communicate electric price signals to the participating sites throughout the state. When the prices went up several times each summer, electric loads at each site were shed in a pre-determined automated fashion.

Note: The measure described in this document (GTA) enables both manual and automated demand response. For simplicity, the scope of this proposal includes only manually initiated DR.

Shed strategies: Various shed strategies were used at each of the participating sites. Although some assistance was provided with the communications technology, the selection and implementation of the shed strategies was performed by the facility staff and/or their controls subcontractors. Of the 24 sites, seven of them successfully used the GTA shed strategy.

Institutional/Organizational issues: Institutional and organizational issues can act as impediments to demand response. In many cases, senior managers had a desire for their site(s) to participate, but methods to do so were undefined. In most cases, facilities staff and their control sub-contractors figured out shed strategies and implementation methods "on-the-fly". Coordination between many groups was required adding time, complexity and cost to the effort. Factory installed GTA was shown to reduce the effort required to implement DR in commercial buildings.

Cost Effectiveness:

Costs: In commercial facilities that have factory installed GTA included in their EMCSs (recommended method), there is no added cost to a given building. Since the GTA feature resides in the software embedded in the standard control devices there is no added cost for hardware or software labor during installation. When the GTA feature is programmed in the field (backup/transitional method), field studies indicate a cost of approximately $2,400 per 100,000 ft.^{2}

Benefits: The benefit of the GTA feature is dependant on the value of DR. Table 1 shows benefits based on the commonly used value for shed capacity of $85/kW. Table 1 uses 1.0 W/ft.^{2} for the shed amount. This value is based on field studies shown in table 2. Simple calculations indicate payback periods of between zero and 1/3 year. While the annual benefits of DR would continue to accrue, there is no cost to maintain the GTA feature, once it is installed.

Installation Scenarios	Cost	Cost/kW	Annual Benefit	Simple Payback (yrs)
Factory GTA (recommended method)	$0	$0	$8,500	Instant
Field GTA (backup method)	$2,400	$24	$8,500	0.3

Table 1 - Costs and benefits for a typical $100,000 ft.^{2} office building.

Notes:

1) Sheds amounts and durations vary based on weather, building type and other factors. See table 2 for more detail.

2) Factory GTA – GTA feature is added in the EMCS manufacturer's factory. The above calculations do not include one-time costs of programming. The labor required to add the GTA feature to the standard product would likely be a one-time cost of approximately $10,000 to $50,000.

3) Field GTA – GTA feature is added by the field installation team on a project by project basis.

Analysis and Results

Global Temperature Adjustment shed strategy was used in about one-third of the 24 commercial facilities that participated in demand response and pre-cooling tests in California in 2003 and 2004. In these field tests, GTA was shown to be the most effective and least objectionable strategy out of the five HVAC shed strategies tested. Sites that used other HVAC shed strategies usually did so because the Global Temperature Adjustment feature was not available at their site.

Reasons that GTA was not available include:
1) Space temperature not controlled by EMCS (e.g., use of pneumatic zone controls).
2) EMCS space temperature controllers did not include the GTA feature.

The sites that provided some of the largest sheds and required the least amount of set-up labor were sites that already had the GTA feature prior to our research tests. Some of these sites programmed this feature themselves and some had it as part of their standard EMCS package. If it did not already exist in their EMCS, most sites deemed it to be too time-consuming and costly to program the GTA feature just for a research project.

It appears that only two EMCS manufactures (not the largest players) currently offer GTA enabled control devices in their standard products. GTA does not cost extra in these products. Like most DR related sequences and associated features, GTA is not generally known or specified by design engineers.

In contrast to global temperature adjustment, shed strategies that target central HVAC systems (e.g., chiller limiting, fan limiting etc.) were also researched. Since these centralized strategies do not ensure closed-loop control at the zone level, occupants may be exposed to extreme deviations from normal temperature and ventilation ranges. These centralized strategies are often less effective as well. For example, by limiting chiller capacity, VAV fans work harder to make up the difference. From a whole-building perspective, this can use similar or more energy than normal operation.

Recommendations

Global Temperature Adjustment (GTA) should be added as a mandatory requirement for new commercial buildings with the following attributes: Commercial buildings with new Energy Management and Control Systems (EMCS) for control of HVAC equipment and direct digital control of zones.

The following text should be added to the 2008 CA Code of Regulations, Title 24:

Proposed Nonresidential Standards Language

SUBCHAPTER 3 NONRESIDENTIAL, HIGH-RISE RESIDENTIAL, AND HOTEL/MOTEL OCCUPANCIES—MANDATORY REQUIREMENTS FOR SPACE-CONDITIONING AND SERVICE WATER-HEATING SYSTEMS AND EQUIPMENT

SECTION 122 – REQUIRED CONTROLS FOR SPACE-CONDITIONING SYSTEMS

Applicable for: Nonresidential (i.e., Commercial) buildings with new Energy Management and Control Systems (EMCS) for control of HVAC equipment and direct digital control of zones.

Requirement: The Global Temperature Adjustment (GTA) feature of the Energy Management and Control Systems (EMCS) shall provide the operator the ability to adjust the space temperature setpoints for the entire facility (e.g., all VAV boxes) with one command from one location.

EMCSs may also have the option to adjust space temperature setpoints at each individual final space temperature control device (e.g., each individual VAV box controller), but this option alone does not comply with this measure.

Exceptions: Global Temperature Adjustment (GTA) is not required for floor space that is used for health care, process controls, or unoccupied data processing.

Verification: EMCS products that offer GTA as a standard feature from the factory are not required to undergo additional field verification. EMCS products for which GTA is added in the field must undergo a functional verification process by an authorized agent.

The following text should be added to the 2008 CA Compliance Manual, Title 24:

Implementation:

Human Machine Interface (HMI) to the EMCS. The EMCS Human Machine Interface (HMI) shall give commercial building operators the ability to adjust the space temperature setpoints for the entire facility with one command from one location. This is normally implemented by broadcasting a global message (e.g., Enter DR Mode Stage-1) across the EMCS network(s) from the central EMCS HMI targeted at all final space temperature control devices.

Final space temperature control devices: The ability to receive Global Temperature Adjustment (GTA) signals from the EMCS HMI is normally included in the software in all final space temperature control devices. Upon receipt of a global signal from the EMCS HMI, the final space temperature control devices interprets the signal and reacts accordingly (e.g., DR Mode Stage-1 means increase cooling setpoint 3°F).

Final space temperature control devices include:

- Space temperature controllers that adjust variable air volume (VAV) terminal box dampers (all types) (e.g., VAV boxes).
- Space temperature controllers that adjust hot water heating coil valves or chilled water cooling coils (e.g., fan coil units).
- Space temperature controllers that adjust capacity of heat pumps or Direct expansion (DX) units.

Global Temperature Adjustment (GTA) may be implemented on either an absolute or relative basis. An absolute implementation of GTA allows the operator to set the space temperature setpoints for the entire facility to absolute values (e.g., heating setpoints at all final space temperature control devices = 68 º F and cooling setpoints at all final space temperature control devices = 76 º F). A relative implementation of GTA allows the operator to adjust the space temperature setpoints for the entire facility to new values that are offset from the current values by a relative amount (e.g., heating setpoints at all final space temperature control devices should decrease 2 º F from current values and cooling setpoints should increase 2 º F from current values).

Bibliography and Other Research

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Appendices

Site name	Area (ft^2)	Cooling Capacity (Tons)	Strategy Used	# Days of Testing	Climate Zone	Outside temperature at time of peak	Average shed (W/ft^2)*	Peak shed (W/ft^2)
GSA Oakland Federal Building	978,000	3,840	Global Temp Adjustment	4	3	88	0.30	1.10
Contra Costa County 2350 Arnold	131,000	240	Global Temp Adjustment	2	12	90	0.30	0.67
Contra Costa County 50 Douglas	90,000	240	Global Temp Adjustment	2	12	90	0.58	1.34
GSA Santa Rosa Federal Building	80,000	200	Global Temp Adjustment*	20	2	95	1.50	2.40
Sacramento County Building	80,000	180	Global Temp Adjustment*	3	12	70	0.75	1.00
Cisco	4,354,000	24,600	Global Temp Adjustment & other strategies	1	4	90	0.16	0.20
Echelon	75,000	4,800	Global Temp Adjustment & other strategies	2	4	90	0.89	1.22

Table 2. Results from LBNL Demand Response research tests conducted in 2003 and 2004 in Commercial facilities throughout California.

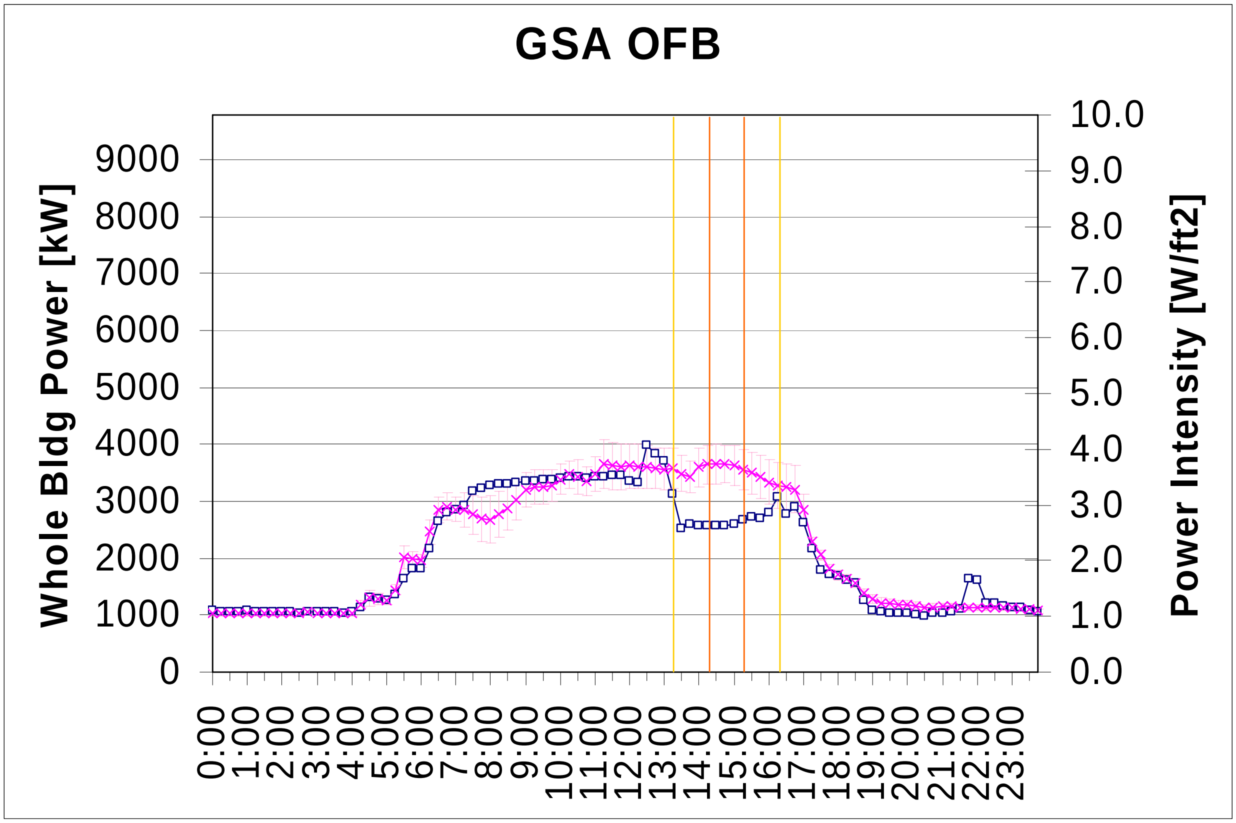

Figure 1. Oakland Federal GSA building on September 8, 2004. Demand response using Global Temperature Adjustment was initiated at 13:00 and returned to normal at 16:00.

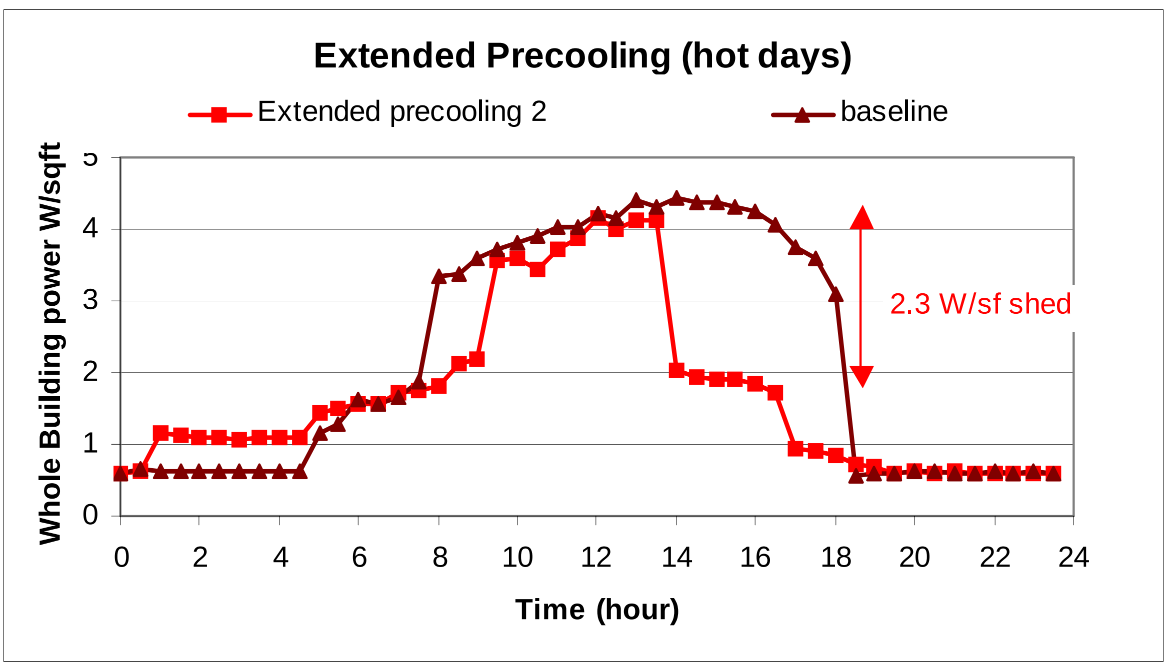

Figure 2. Santa Rosa Federal GSA building in the summer 2004. Global Temperature Adjustment was used to conduct: 1) Pre-cooling before occupancy 2) Increase setpoints at 13:00 3) Return setpoints to normal after occupancy.