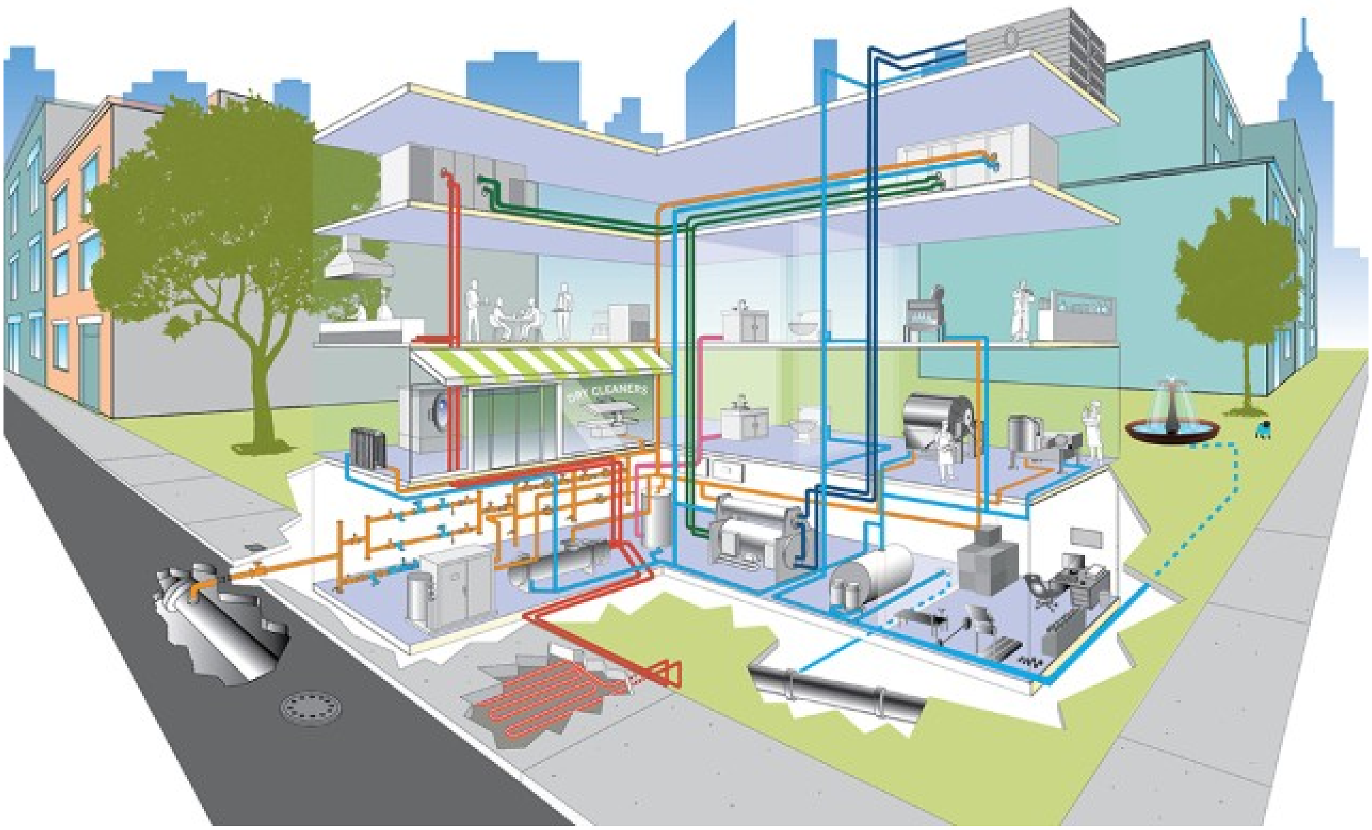
Con Edison Steam
Best Practices Report

Steam Use Efficiency & Demand Reduction



Con Edison Steam Business Development
October 2013

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I. Introduction

The purpose of this document is to provide general guidance on the efficient use of steam. The information contained herein is not intended to be advice or direction applicable to any specific installation. Please consult with a licensed engineer, plumber or steamfitter for the safe and proper operation and maintenance of your specific installation. This document is offered free of charge to current and potential customers of the Steam Business Unit of the Consolidated Edison Company of New York. While great care has gone into the preparation of this document, The Consolidated Edison Company of New York, Inc. does not warrant or guarantee numbers pertaining to operational cost savings, capital cost estimates and overall project payback.

Con Edison's steam system is the largest district steam system of its kind in the world. Its service area extends from the southern tip of Manhattan to 96th Street on the west side and 89th Street on the east side. The Con Edison steam system is a considerable energy business with a customer base of over 1,700 customers.

Con Edison's steam customers include some of the largest, world renowned buildings in Manhattan, landmarked buildings, museums, hospitals, large apartment complexes and even small local facilities, such as restaurants, dry cleaners, and schools. Steam customers use steam in a variety of ways including, but not limited to:

- Heating
- Domestic Hot Water
- Air-conditioning
- Dry Cleaning
- Cafeteria/Kitchen Services
- Food Processing
- Laboratory/Hospital Sterilization
- General Cleaning
- Humidification
- Condensate Collection and Reuse
- Snow Removal

Con Edison has historically encouraged its steam customers to undertake efficiency and conservation efforts. For example, a free monthly seminar class on efficient steam use is available to every customer. Furthermore, Con Edison's website includes many steam conservation and energy efficiency tips. Recently, because more steam customers are eligible for steam demand billing, there is a need for consumer awareness and education concerning measures and practices that will contribute to demand reduction along with more traditional energy efficiency measures.

In order to assist steam customers in adjusting to steam demand rates and to provide information on energy efficiency measures, Con Edison has developed this document. The measures and technologies presented in this Steam Best Practices Report were compiled from a number of sources including Con Edison studies, Con Edison programs, and various equipment vendors, to provide steam customers with an effective steam demand and efficiency management resource. Specific details regarding these studies and programs can be found in the appendix.

For the purposes of this report, Energy Efficiency Measures (EEMs) are those measures that will reduce overall steam consumption and, while not designed to do so, possibly the on-peak steam demand. EEMs focus on overall efficiency and steam use reduction, and should be helpful to demand-billed and non-demand-billed customers alike. Demand Reduction Measures (DRMs) are those measures that will reduce the on-peak demand, but not necessarily overall steam consumption. DRMs should be implemented solely as on-peak steam demand management practices and are intended to help those steam customers who are eligible for steam demand billing.

For information on the latest programs and incentives offered by Con Edison, visit our website, http://www.coned.com/steam/. Customers who would like to supplement the information in this report with more information on these measures or on other steam efficiency and cost optimization opportunities may call the Con Edison Steam Business Development Group at 212-460-2011.

II. Reference Explanation of Demand Billing

Demand billing was introduced to encourage Con Edison's largest steam customers to reduce the peak demand on the Con Edison steam system, which typically occurs on the coldest weekday mornings (6:00 a.m. to 11 a.m., in the winter) through rate structure that would incentivize peak management.[1] Facilities whose steam consumption equals or exceeds 14,000 Mlb[2] for 12 billing periods ending in August are subject to demand charges. Note that if the steam consumption of a demand billed customer does not exceed 12,000 Mlb of steam for 12 monthly billing periods ending in August of that year, the customer will no longer be eligible for demand billing and will be transferred to and billed under non-demand rates commencing with the monthly billing period that terminates within the month of November.

Under demand billing, steam peak demand rates will only be applied during the December through March billing periods. Customer demand will be calculated by averaging the steam demand during the two highest adjacent 15-minute intervals. The demand charge will be comprised of two subcomponents – an On-Peak demand charge and an All-Time Peak demand charge. The On-Peak demand charge will apply on weekdays only, between 6:00 a.m. and 11:00 a.m. The All-Time Peak demand charge will apply to all hours during a given billing cycle. The All-Time and On-Peak demands will vary from month to month.

To offset the demand charges, Con Edison has reduced the steam usage block rates for demand-billed customers during the four demand-billed months. Therefore, customers who have had high monthly load factors (monthly load factor is defined as the average demand during the month divided by the highest on-peak demand during the same month) or customers who are able to reduce their peak demand may see lower steam bills when compared to bills under the previously applicable non-demand rate. Additional details on the steam service tariffs can be found on the Con Edison website.[3]

By reducing the peak demand on the steam system, the need to add steam production capacity and other infrastructure is lessened. This helps to keep steam costs reasonable for all steam customers. It should be noted that there are no current capacity constraints on the steam system. The steam demand rates are intended to provide an incentive for consumers to modify or improve facility operations by reducing steam consumption during the peak steam demand period. While the techniques and technology of demand control and reduction for electrical consumption are well developed and are widely known to facility operators, the same is not true for steam demand control and reduction.

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[1] Demand billing was introduced in 2007 for customers using over 22,000 Mlb for 12 billing periods and was then extended to include customers that used over 14,000 Mlb for 12 billing periods.
[2] Steam is billed in Mlb. One Mlb is equal to 1,000 pounds of steam.
[3] http://www.coned.com/rates/steam.asp. This address is subject to change.

III. Economic Performance Summary

An economic performance summary of the various DRMs and EEMs discussed in this report is provided below in Table 1 and Table 2 to inform steam customers of measures that may be applicable to their own facilities. Table 1 displays the criteria used to determine the average ROI shown in Table 2. Economic performance and other data for the measures presented herein was derived from specific buildings and are provided to encourage customers to consider whether to take advantage of such measures in their facilities. Since the applicability and performance of these measures are based on specific buildings, the Return on Investment (ROI) information is not intended as a basis for investment decisions in other facilities. Before any investment decision is made, a licensed professional engineer should evaluate the various options and determine their economic feasibility.

Table 1 – ROI Categories

Average Return on Investment	Simple Return on Investment	Simple payback (Years)
Very High	Greater than 100%	Less than 1 year
High	34% to 100%	1.0 to 2.9 years
Moderate	21% to 33%	3.0 to 4.9 years
Low	20% or Less	5 years or greater

Table 2 – EEM & DRM Economics Summary

Name of Measure	Type of Measure (EEM/DRM)	Average ROI	Page #
All Schedule-Related DRMs	DRM	Very High	23-27
Reduction of Valve Hunting	DRM	Very High	25
Utilization of Hybrid Chiller Plants	DRM	Very High	28
DHW Recirculation Controls	EEM	Very High	18
Implementation of Night Setback	EEM	Very High	13
Insulation of Steam Distribution Piping, Valves, and Fittings	EEM	Very High	8
Reduction of DHW Temperatures	EEM	Very High	18
Steam Leak Repair	EEM	Very High	9
Application of the STEEMs Method	DRM	High	23
Condensate Heat Recovery	EEM	High	16
Radiator System Optimization	EEM	High	11
Reduction of Winter Operating Temperatures	EEM	High	13
Back-Pressure Steam Turbine Generators	EEM	Moderate	29
Installation of a Building Management System	EEM	Moderate	11
Utilization of a Airside Economizer	EEM	Moderate	15
Utilization of a Waterside Economizer	EEM	Moderate	15
Weatherization of Building Envelope	EEM	Low - Moderate	19
Installation of Window Film	EEM	Low	19
Replacement of Low Pressure Absorption Chillers	EEM	Low	15
Replacement of Single Pane Windows	EEM	Low	19

IV. Energy Efficiency Measures

a. General Energy Efficiency Measures

i. Insulation of Steam Distribution Piping, Valves, and Fittings

Piping in most buildings is generally well insulated. However, in some buildings, there are bare (un-insulated) pipe runs, mechanical fittings and valve bodies. This is often the case for fittings and valves because of the need for periodic access for service (such as traps or unions), need for movement (such as at valve bonnets), or because insulation was not restored after a component was replaced. NOTE: Insulation may contain asbestos or other hazardous fibers. Personnel working with insulation should be trained in proper handling methods and in the use of personal protective equipment.

Figure 1: Missing piping insulation.

Un-insulated steam system components result in energy waste because they heat up generally unoccupied spaces and do not direct the energy to the intended end use. This heat loss could be avoided and delivered to the parts of the building where it is needed by installing insulation. Because many of these steam system components contain live steam around the clock, steam demand and consumption are affected.

On un-insulated or under-insulated valves and fittings, removable insulation jackets provide a very useful solution to. They are ordered to specific sizes and patterns, strap into place and are easily removed and put back in place.

Figure 2: Un-insulated PRV and shut-off valve.

Figure 3: Insulated valves with removable jackets.

For pipes or areas that do not need to be accessed, it is recommended that insulation be installed to the thickness levels shown in Table 3 below.

Table 3 – Recommended Fiberglass Insulation Thickness (Inches)							
Heating Piping Systems (Steam and Hot Water)	Temperature Range (°F)	Pipe Sizes					
		Up to 1"	1.5" - 2.5"	3" - 3.75"	4" - 5"	5" - 6"	8" and larger
High pressure / temperature	306-450	2.5	2.5	3	3.5	4	4
Medium pressure / temperature	251-305	2	2.5	2.5	3	3.5	3.5
Low pressure / temperature	201-250	1.5	2	2.5	3	3	3
Low temperature	106-200	1	1	1.5	1.5	1.5	1.5

Source – Energy Management & Research Associates (EMRA) recommended levels, categories from Energy Conservation Construction Code of New York State (2002).

As displayed in Table 4 below, properly insulating steam piping and devices has a significant impact on both energy and cost savings. Fiberglass is represented because it is most commonly used. Note that there are other options available.

Table 4 – Potential Annual Savings from Proper Insulation				
Size	Energy Lost, Bare (Mlb)	Energy Lost, Insulated (Mlb)	Energy Savings (Mlb)	Annual Savings ($/ft)
Steam Piping				
12”	18.4	1.8	16.6	**$515**
8”	12.9	1.2	11.7	**$363**
4”	7.1	0.7	6.4	**$198**
Steam Gate Valves				
12”	87.2	8.7	78.5	**$2,434**
8”	58.0	5.8	52.2	**$1,618**
4”	24.7	2.5	22.2	**$688**

Assumptions and Notes:
1. Pipe is in service year-round (8,760 hours/year).
2. Dollar savings based on average 2012 steam charges.
3. Savings are based on data from US Department of Energy Steam Best Practices.

ii. Steam Leak Repair

Steam leaks are a source of significant energy loss. Leaks are most often found at pipe junctions, fittings, or in valves. The leaks may be due to leaking gaskets, loose connections, or pinholes. It is hard to measure the size of a leak and the extent of steam loss. For basic safety and economic reasons, all leaks should be addressed immediately. On occasion, leaks in valves may require that the valves be replaced.

Figure 4: Investing the capital to fix visible steam leaks typically results in a high ROI.

Figure 5: Relief valve leaks are usually overlooked, but can result in significant increases in steam consumption.

As displayed in Table 5 below, repairing steam leaks properly and in a timely manner has a large impact on both energy and cost savings.

Table 5 – Potential Annual Savings from Steam Leak Repair

Leak Pressure (PSI)	Hole Size (inches)	Steam loss (lb/hr)	Consumption Savings (Mlb)	Demand Savings (Mlb/hr)	Annual Savings ($)
165	1/16	22	188.5	0.022	$5,844
165	1/8	86	754.1	0.086	$23,377
45	1/16	6	52.6	0.006	$1,631
45	1/8	23	201.5	0.023	$6,247
15	1/16	2	17.5	0.002	$543
15	1/8	8	70.1	0.008	$2,173

Assumptions and Notes:

1. Leaking pipe/fitting is in service year-round (8,760 hours/year)
2. Dollar savings based on energy and demand charges for a mid-sized commercial office building
3. Dollar savings based on average 2012 steam rates.
4. Source of Consumption savings data: CIBO ENERGY EFFICIENCY HANDBOOK, Copyright 1997 Council of Industrial Boiler Owners. Derived from Table 10-1.

b. *Heating Distribution Energy Efficiency Measures*

i. **Installation of a Building Management System**

In facilities where a Building Management System (BMS) does not currently exist, there are a number of benefits that can be accrued by installing a computerized BMS. Note that a BMS is sometimes referred to as an Energy Management System (or EMS). While a BMS can be costly, it is a valuable tool that can yield significant returns. To optimize such an investment, it is very important that the operators are trained to review, understand, and act upon the information that such a BMS or EMS can provide.

Savings from the installation of a well-designed and maintained BMS will come from a number of areas including the following:

- Personnel cost optimization; reduced time requirements for "rounds" enable personnel to respond to complaints and conduct other activities such as maintenance;
- Essential support for the implementation of other steam DRMs/EEMs:
- Accurate control and feedback on space and/or air handling unit (AHU) supply and return temperatures;
- Greater control and ability to meet the requirements of various areas of the facility and to respond to occupant comfort complaints;
- Reduction/elimination of space overheating; the reduction of system "lag" time
- Trending of various key parameters to identify equipment issues and system inefficiencies; identification of conditions, practices, and equipment that are resulting in less than optimal energy utilization or may require maintenance and replacement;
- Improved utilization of water to cool condensate through monitoring and control of cooling water control valve based on condensate temperature; and
- Documentation of conditions for occupant complaint response/resolution.

If installing a BMS is not economical, at a minimum, facility personnel should manually fill out logs that include information such as steam pressures, space temperatures, outside temperatures, zone valve openings, vacuum readings, return water temperatures, domestic hot water (DHW) temperatures, etc. Spreadsheets could be developed to track the above data and identify operational trends and spot issues before they become significant energy wasting and/or equipment failure problems.

ii. **Radiator System Optimization**

Steam heating is used inefficiently in many buildings—both commercial and residential—due to a lack of localized control. This is especially true in older buildings where the occupants have modified the space layout but the distribution systems have remained as originally designed, which can result in overheating or under-heating. Units in more modern buildings are treated as multiple zones, with each unit being able to control the local space temperature. In contrast, older buildings often heat their spaces as one zone. This approach leads to inefficient building heating since parts of the building get warmer or cooler at different rates. If the temperatures of these cooler areas are below a certain minimum temperature, the entire building is heated since it is treated as one zone. As a result, the remaining areas of the building become too warm. This overheating prompts residents to waste energy by opening windows and/or turning on air conditioning units during the heating season.

Figure 6: Steam Radiator.

Below are some of the many options available to prevent a radiator from overheating a space:

1) *Clear any objects on or near radiators:*

   During warmer seasons, radiators are sometimes used as shelves as objects are placed and/or stored on radiators. When not cleared, these objects may block heat energy from reaching outer areas of a room, resulting in extra steam being used in order to compensate for this hindrance. These objects should be cleared by the start of the heating season to prevent unnecessary energy losses.

2) *Install Thermostatic Radiator Valves:*

   Thermostatic Radiator Valves (TRVs) provide individual zoning control at the radiator level, allowing the occupant to select and set different temperature set points to meet an individual comfort level. Since the valve operation is controlled by the thermostatic element within the valve, once the settings are selected and set, there is no need to manually open and close the steam supply valve to control temperature. The installation of these valves in overheated areas prevents discomfort and provides significant savings. In buildings with large southern exposure or on higher floors, installation of TRVs in these areas will help minimize overheating and help balance the building's heating system. These valves can be linked to a remote thermostat or BMS control for optimal control.

Figure 7: Thermostatic radiator valve.

3) *Adjust controls to more appropriate settings for the building:*

   For buildings employing a two pipe VariVac steam distribution system (with MEPCO DCC-1000 control panels, or similar devices from other manufacturers), the control panels operate as an outdoor reset control which varies the steam supply valve opening based on the outside temperature and temperature feedback from the condensate return system. To reduce overheating, the compensator on the panel should be adjusted to a more appropriate setting for the building.

For buildings employing two pipe steam distribution systems with Heat Timer® control panels, or similar devices from other manufacturers:

- Reset Heat Adjustment (Alpha setting) on the Heat Timer® Panel. The exact setting should be determined by a series of lowering and observational tests (survey of space temperatures) conducted by facilities staff.
- Reset the Heating System Sensor (XYZ knob) to a lower temperature so that the heat timer senses that distribution has been established and the cycle clock has begun. There may also be a need to relocate the sensor to a more appropriate location based on the distribution characteristics of the space. Check the Heat Timer® manual for proper sensor location.
- Institute an occupant/staff educational program, to be carried out either with direct flyers distributed as paycheck stuffers, (or to tenants in rent bills), through the company intranet and email systems, and/or bulletins posted in elevators. Tenants should be advised by building management that radiators can and should be turned down or shut off with a valve when a room becomes too warm (rather than opening windows or turning on air conditioners).

iii. Implementation of Night Setback

In buildings where the temperature settings remain constant around the clock, it is advisable to institute a night setback. To avoid larger than necessary demand charges, it is suggested that the setback operation last from either the end of the business day (in office buildings), or from 10:00 p.m. (in multifamily buildings) through about 4:00 a.m. Ending setback operation no later than 4:00 a.m. will give the demand-billed buildings enough time to heat up before the peak demand period of 6:00 a.m. to 11:00 a.m.

iv. Installation of Programmable Clock Thermostats

In spaces such as restaurants, professional offices and other storefronts that operate independently from main distribution systems, a programmable clock thermostat should be installed on the local heating system. Given that the normal operating hours of such spaces begin during the peak demand period and the normal procedure is to manually switch the system on at that hour, these spaces contribute to the facility's peak demand. The start-up times and early morning settings of such thermostats should be coordinated with the operations of the main building zones to reduce peak demand. In some cases, as determined from experimentation in the facility, it may be more cost effective to preheat these spaces before the 6:00 a.m. start of the on-peak demand period.

v. Reduction of Winter Operating Temperatures

In facilities that have core/perimeter heating and domestic hot water systems, it is possible to reduce equipment temperature set points either during the on-peak demand period or throughout the day without impacting occupant comfort. Often, these systems are programmed at higher settings than required, and a facility may find that these settings can be lowered permanently without affecting comfort conditions. This measure could be applied to domestic hot water heaters, heat exchangers, and AHUs. By reducing these set points by just a few degrees, facilities can reduce their total steam consumption as well as their steam peak during the demand period.

vi. Utilization of Rejected Heat

A facility should investigate the feasibility of allowing data centers and other continuous heat sources to discharge heated air to the return plenums to offset the requirement for steam during the heating season. Based on the building design, this strategy could be done naturally or could be introduced.

vii. Demand Control Ventilation

Currently, most buildings are designed to provide the minimum required outside air based on the maximum occupancy for each space. Demand Control Ventilation is a method of reducing the minimum outside air requirements of a space based on real-time occupancy as opposed to the maximum occupancy for the space. This can be accomplished by using sensors, such as CO_2 sensors, to measure the carbon dioxide concentration within a space. Based on this data, actual occupancy can be determined and ventilation rates can be adjusted appropriately. By minimizing outside air intake to the required minimum based on actual occupancy and recirculating more return air, steam consumption will be lowered.

c. Steam Air Conditioning Energy Efficiency Measures

i. Raise Summer Operating Temperatures

In facilities that have centralized air conditioning systems, it is possible to increase equipment temperature set points throughout the day without impacting occupant comfort. This measure could be applied to chillers and AHUs. By increasing these set points by just a few degrees, facilities can reduce their total steam consumption.

ii. Utilization of a Waterside Economizer

During winter and shoulder months, in facilities where air conditioning is still required, a waterside economizer can be used in lieu of a chiller to provide cooling. By routing condenser water from the cooling tower through a heat exchanger, chilled water can be produced due to the low outside air temperature. This is also referred to as "free cooling." Installing a plate and frame heat exchanger for free cooling will save on energy costs by minimizing chiller operation.

Figure 8: Plate and Frame Heat Exchanger.

iii. Utilization of an Airside Economizer

During winter and shoulder months, in facilities where air conditioning is still required, an airside economizer can be used in lieu of a chiller to provide cooling. By modulating outside air dampers, cool outside air is allowed to enter AHUs instead of conditioned return air. If outside air temperatures are lower than what is required by the building, return air can be mixed with the outside air to reach the temperature set points. Using this type of "free cooling," the building cooling loads can be met without using chillers and this function can be automated in facilities equipped with a BMS. To accommodate free cooling, the outside air dampers would need to be sized for full air flow.

iv. Replacement of Low Pressure Absorption Chillers

In buildings that utilize low pressure steam absorption chillers, it is possible to replace these units with high pressure steam absorption chillers that use almost 50% less steam. In cases where a facility operates on one chiller with the other as backup, only one of the chillers needs to be replaced to attain the majority of the potential EEM benefits. The new chiller would become the primary unit with the remaining low pressure chiller available as backup. Note that depending on the location of the mechanical rooms that house the chiller, new high pressure steam supply lines may have to be installed to operate the high pressure chillers. New pressure reducing stations may be required if the high pressure riser replaces the low pressure riser.

v. Insulation of Chilled Water Distribution Piping, Valves, and Fittings

All chilled water equipment should be properly insulated. This includes but is not limited to: chiller evaporator sections, piping, fittings, and pumps. If a waterside economizer is used for free cooling, all condenser water components should be insulated as well. Refer to the Insulation of Steam Distribution Piping, Valves, and Fittings section under General Energy Efficiency Measures for more information.

d. Condensate Management

Before implementing condensate management measures, a customer should consult with a competent water treatment vendor or another qualified professional to implement a water treatment plan and/or system design specifications in order to minimize the long-term risks of corrosion and fouling. For reference, condensate management illustrations have been included in the appendix.

In most facilities, hot steam condensate return is collected at approximately 180°F and is tempered with city water before being discharged into the sewer. The discharged condensate must be at a temperature less than 150°F for compliance with DEP requirements and the New York City plumbing code.[4] By doing so, facilities are not only wasting the purchased thermal energy in the condensate but also the city water used to cool it. To avoid this, condensate can be used in a variety of ways.

i. Condensate Heat Recovery

Hot steam condensate return can be used for preheating. In locations where the condensate return is near an existing thermal load and space for the equipment exists, a heat exchanger can be installed to recover the heat from the condensate to preheat incoming domestic water. The hot condensate can also be used for outside air preheating by routing the condensate through coils located in the fresh air intake.

Hot steam condensate can also be used for heating by using the condensate in a hydronic loop. In facilities that have a steam distribution system, the first few floors of a building can be converted to a hydronic system to take advantage of this measure.

These strategies reduce the temperature of the condensate, reduce or eliminate the need for quenching water and reduce steam consumption.

Figure 9: A condensate heat recovery system with a shell and tube heat exchanger.

[4] http://www.nyc.gov/html/dob/downloads/pdf/plumbing_code.pdf. This address is subject to change.

Figure 10: A condensate heat recovery system with a storage tank.

ii. Condensate Reuse

As an alternative to draining condensate water, steam condensate can be reused as greywater for any purpose that does not require potable water.

Below are some greywater uses for condensate:

- Cooling tower water make-up
- Supply water for outdoor fountains
- Toilet water
- Water to wash sidewalks
- Dishwasher/Laundry supply for hotels and restaurants
- Irrigation water for landscape and gardens

To implement some of these methods, the condensate may still need to be tempered with city water prior to reuse. These strategies reduce the amount of city water purchased by a facility and are best if used in conjunction with thermal heat recovery.

Figure 11: To maximize resource recovery, condensate can be used for cooling tower make-up after its heat has been recovered.

When using the condensate for cooling tower make-up, facilities should confirm if the make-up water for the cooling tower is being included on their sewer charges. If so, a sub-meter could be installed to monitor the amount of cooling tower make-up water. This make-up water quantity can then be deducted from a facility's sewer charges.

e. Domestic Hot Water (DHW) Energy Efficiency Measures

i. DHW Recirculation Controls

It is not necessary to run DHW recirculation pumps continuously, which circulate hot water through the pipes around buildings at 130°F - 140°F. Installing and setting a reverse acting aquastat on the return line will reduce the amount of energy used to provide hot water while retaining the quality of the hot water expected by the occupants. Additionally, there will be some electrical cost savings from the reduced run time on the pumps. The aquastat should be installed a few feet upstream of the pump inlet and set at 110°F, with the deadband set at +/- 5°F, and wired into the domestic hot water circulation pump in the building.[5] In some buildings, return line aquastats have already been installed, but are set so high that the pumps are running continuously. The aquastat would need to be reset as described above.

ii. Reduction of DHW Temperatures

In some buildings, the DHW temperature is too hot, often at an average above 130°F. Note that in multifamily buildings, the New York City housing maintenance code requires delivery of 120°F water to taps. The overheating of this water not only wastes steam, but is also a potentially dangerous situation. Hot water at 132°F will scald human skin. The DHW delivery temperature should be adjusted so that it delivers 120°F water to the spaces with taps that are furthest from the mechanical room. This will take some trial and error, as design of piping systems varies, but the temperature of DHW leaving the mechanical room should be somewhere between 125°F and 140°F, depending on the size and configuration of the building.

[5] Goldner, F.S.. DHW Recirculation System Control Strategies, Final Report 99-1. Prepared for New York State Energy Research and Development Authority. Prepared by Energy Management & Research Associates. January 1999.

f. Building Envelope

i. Weatherization of Building Envelope

Windows at some sites are in poor condition, which allows for water and air penetration. Weather-stripping and caulking these windows will minimize air infiltration and heat loss while providing energy savings and greater comfort to building occupants. Similarly, all building exterior doors, specifically main entrances, service entrances, and roof doors, should have weather-stripping and door sweeps installed. Walls and roofs should also be properly insulated to effectively retain energy in the winter and the summer.

Figure 12: Poor building envelope maintenance, as exemplified by this missing AC sleeve cover, contribute to increased energy consumption.

ii. Installation of Window Film

A facility's varying exposures can contribute to imbalances in heating and cooling. Solar gains can be especially troublesome for cooling. Reflective window film technology has advanced significantly and can be applied to create greater shading coefficients to reduce unwanted solar loads. Facades that have heavy morning solar loads should be considered for treatment with high reflectivity window film.

iii. Replacement of Single Pane Windows

Buildings with the original single pane windows still in place should consider replacing them with more energy efficient windows. Double pane windows are insulated, which helps to retain heat in the winter and air conditioning in the summer. Therefore, energy costs will be reduced while occupant comfort is increased.

g. *Facility Maintenance and Management Practices*

i. Integration of Steam Demand Meter Data into BMS

Pulse signals from steam demand meters can be utilized through a facility's BMS to allow building personnel to have a real time display of the building's steam demand. A graphic representation of steam demand data can be a valuable tool for identifying equipment and practices that are resulting in high steam demand and consumption. In addition, the storage of demand data for later analysis will support tracking the effectiveness of EEM or DRM implementation.

Facilities that are interested in obtaining demand data should contact the Steam Business Development Group at (212) 460-2011. In order to participate, the facility will need to submit a completed Program Agreement that will be provided upon request. The installation of isolation relays will need to be completed as per Con Edison Specification S-671 below. Then, an inspection of the completed installation and tie-in to Con Edison's flow computers will need to be scheduled by calling 1-800-75-CONED.

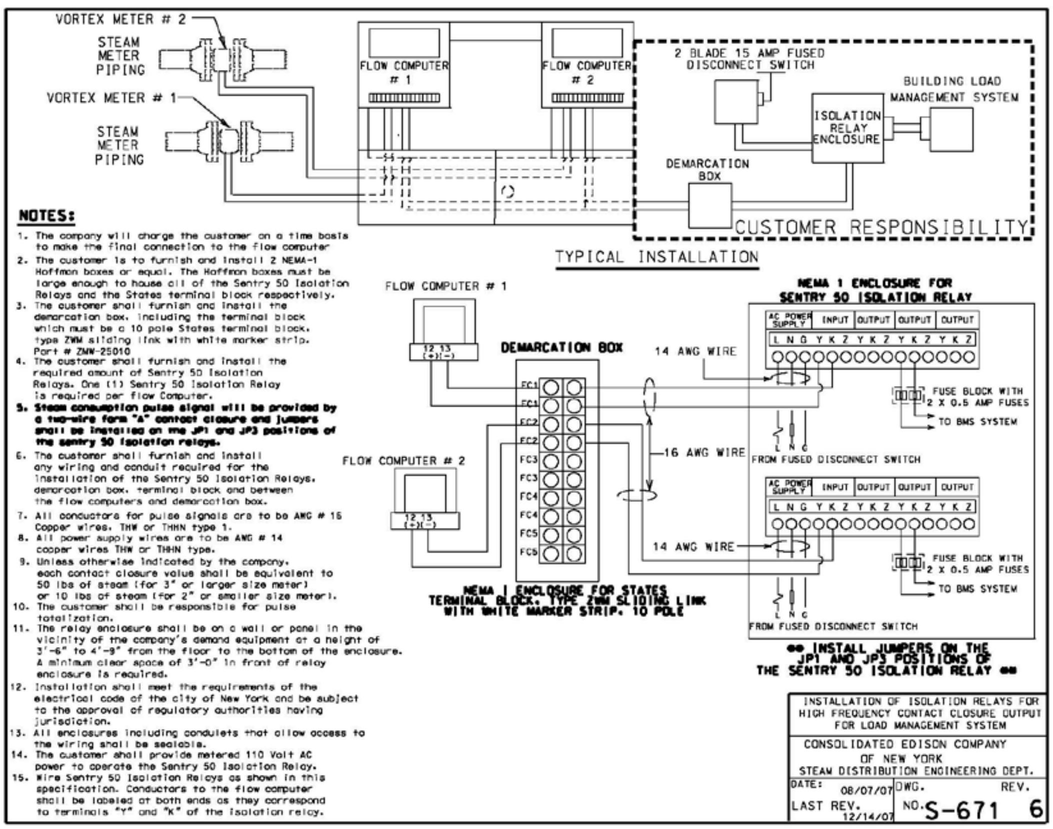


Figure 13: Con Edison Specification S-671- Installation of Isolation Relays.

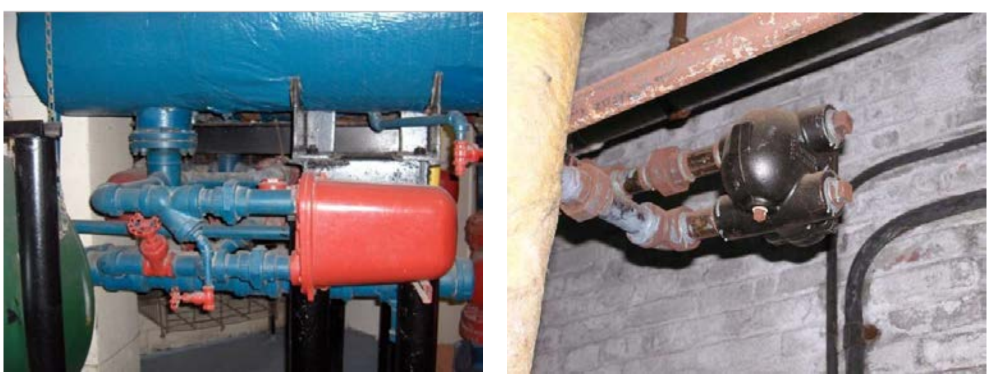
ii. Steam Trap Inspection and Maintenance

Steam traps perform the critical function of removing condensate from steam pipes. When traps are not operating properly, condensate can accumulate in the steam pipe and a condition known as water hammer can occur. Severe water hammer can cause steam pipes or fittings to fail, causing serious property damage and personal injury. Improperly working steam traps can also lead to steam balancing problems, resulting in occupant discomfort. A trap that fails in the open position wastes energy, increases costs, and can cause high indoor temperatures.

To ensure safe and reliable steam system operation, steam traps and other condensate-removal equipment should be inspected regularly to make sure they are working properly. Each radiator located throughout a building should have the steam trap thermostatic element, or "disk" and the trap seat checked for need of replacement as recommended by the trap manufacturer. A program of inspection and repair/replacement of non-working steam traps will increase both overall operating efficiency and occupant comfort.

Figure 14: Radiator steam traps, such as this one, should be inspected at intervals recommended by the manufacturer.

Most buildings do not have a direct indication of steam trap blow-through. As live steam blows through traps, the temperature of the returning condensate will increase. The temperature of the condensate entering a dilution tank and the volume of the water added are both instrumentation points that provide good indications of steam trap performance. These instrumentation points can be added to a facility's BMS for trending, and operating staff should be trained how to interpret the data.



Figures 15 & 16: Main steam traps should be inspected as often as is recommended by the trap manufacturer.

There are various services available to assist facilities in the inspection and maintenance of their steam traps. Remote trap monitoring systems can be installed to automatically monitor traps for failure. These systems can also be linked to a facility's existing BMS. Outside contractor services are also available to survey steam systems and perform maintenance on traps regularly.

iii. Expansion Joint Replacement

In buildings over 30 years of age, all expansion joints should be replaced. After this period of time, it should be expected that these joints are at the end of their expected useful life and either have or will begin to fail, creating leaks in the steam heating distribution system. In vacuum steam distribution systems, the system's ability to pull a proper vacuum is lowered as a result of leaks. It is recommended that these joints be removed and replaced with piping loops. By replacing expansion joint proactively, the efficiency of vacuum as well as gravity drain steam systems will be optimized.

iv. Installation of Sub-Metering

In some facilities, there are tenants that use chilled water, hot water, and DHW from the main building and do not pay directly for their utility use. By installing their own demand and consumption meters for these end users, facilities can fairly assess the tenants' individual use. These meters will serve two purposes. First, they will provide accurate records for invoicing steam usage to the shareholders based on their actual usage. Second, this data will provide the necessary measurement information on demand and consumption, which can be used by facilities to develop future energy conservation measures to reduce both steam demand and consumption.

v. Establishment of a "Green" Policy for Hotels

Hotels should provide in-room notification suggesting that all guests turn down terminal heating/cooling units upon leaving their rooms and re-use towels if possible. Housekeeping staff should be notified to turn off lights and terminal units after servicing rooms.

V. Demand Reduction Measures

a. Heating Distribution Demand Reduction Measures

Note: STEEMs is a patent technique (patent #8955763)

i. Application of the STEEMs Method

The Storage of Thermal Energy in Existing Mechanical Systems (STEEMs) is a steam demand reduction strategy developed by Con Edison for the benefit of demand-billed steam customers. The main element of this strategy involves using a BMS or a special-purpose controller to heat a circulating hot water loop to a higher temperature during unoccupied night hours and using the heat energy stored in the loop to displace steam consumption during the morning start-up. See the Appendix section for more detailed information about this strategy.

A building is a good candidate for implementing STEEMs if it meets all of the following criteria:

- It uses circulating hot water for a significant portion of its space heating.
- Each of its terminal heating units (e.g. induction units, fan coil units, and fan powered boxes) has a local thermostatically controlled valve to avoid space overheating.
- It has a programmable BMS. In the absence of a BMS, a special-purpose controller is required.

Two STEEMs techniques have been developed:

- STEEMs Using Dynamic Response, which require a building steam flow rate signal for feedback. Although this strategy is more difficult to program than STEEMs Using Scheduled Reset (see below), the potential for steam demand reduction using this technique is higher. Furthermore, the water temperature control valves need to be tuned to minimize steam flow rate fluctuations during the STEEMs mode of operation.
- STEEMs Using Scheduled Reset does not require building steam flow rate signal for feedback. It is simpler to program than STEEMs Using Dynamic Response (see above). However, after the programming is complete, it requires experimentation by building engineers to identify an operating configuration that will maximize the amount of on-peak demand reduction. Furthermore, the water temperature control valves need to be tuned to minimize water temperature overshoot and undershoot.

Implementing STEEMs will not necessarily reduce the total amount of steam usage. STEEMs operation will shift when steam is used and result in shaving the steam peak and reducing associated demand costs. Detailed implementation tips are included in the Appendix.

ii. Steam Load Shifting

There are a number of steam demand shifting strategies for facilities to consider. These strategies include:

1) *Preheating the building prior to the demand billed period:*

   By raising heating and hot water temperature set points prior to the peak steam demand period (6:00 a.m.), a facility can meet or slightly exceed space requirements prior to the demand period and then reduce the set points from 6:00 a.m. to 11:00 a.m.

Some building tenants, such as restaurants, open in mid-morning, meaning that their heating systems will start establishing comfortable temperatures during the peak steam period. Pre-heating these spaces before the steam peak or through coordination with other systems based on steam demand (through BMS or local controls) may moderate the demand charges associated with the subject area's heating.

2) *Reducing the heat to non-critical areas:*

Reducing the heat to spaces where heating is not critical, such as loading docks or garages, during the peak steam demand period will reduce the facility's on-peak demand. Facilities with occupant amenities, such as pools and gyms, can also restrict heating to these areas during the peak demand period.

Figure 17: Minimizing the use of non-essential heating, such as this garage heater, during the on-peak period will help reduce demand.

In facilities where there are steam process loads, delaying some or all of the process loads until after the steam peak demand period can reduce demand. As an example, this could be applied to hotels that have on-premises laundries. If possible, laundry operations should be delayed until after 11:00 a.m., or units should be sequenced to avoid the aggregation of coincident loads for a high peak demand. This will help reduce peak steam demand charges.

To the extent possible, these measures should be implemented through automatic scheduling in a BMS, with input from the customer's steam demand meters to determine the level of pre-heating or heat reduction during the steam peak demand period.

iii. Adjustment of Air Handling Unit Schedules in a BMS

In many facilities, the AHU schedules in the BMS were observed to change operating mode to Startup or Occupied mode and operate the AHUs all at the same time or close to 6:00 a.m., which is the beginning of the peak demand period. This mode of operation could cause an unnecessary peak during the demand period. These schedules can be adjusted to stagger the mode change, which will reduce the possibility of a demand peak occurring when these units start all at once and call for heat.

Figure 18: Starting up air handling units before 6:00 a.m. or staggering their start-up will reduce the on-peak demand.

A recommended procedure is to only start up early those AHUs that serve the spaces that get the coldest overnight. Starting up all the AHUs earlier, including those that serve spaces that remain warm through the night, may not be justified due to a more significant increase in electric charges. Alternatively, if the AHUs are already running, set point temperatures should be raised to preheat the building prior to peak hours. From 6:00 a.m. to 11:00 a.m., the set point can be reduced to normal, minimizing steam demand charges.

iv. Reduction of Valve Hunting

Figure 19 shows a typical steam demand profile for a facility in which valve "hunting" is taking place. Hunting, shown by the "sawtooth" pattern of demand oscillation, is often a symptom of a control system requiring coordination adjustment between the control device (e.g. a steam pressure regulator or a water temperature control valve) and the controlling point within the system. Hunting will result in accelerated wear and shortened service lives for components such as the temperature control and pressure reducing valves, as well as steam turbine nozzle controls and linkages if this also occurs during the cooling season.

In addition to the impact on control equipment service life, hunting may result in the peak steam demand being higher than necessary each month. The short, sharp peaks that result from hunting may induce higher recorded demand. A sample of the hunting induced higher peak versus the peak demand estimated from reduced hunting is presented in Figure 20. Actual demand reduction achieved by reducing or eliminating the hunting will depend on the cause and the degree to which the hunting can be smoothed. However, in buildings with BMS systems, this should be a very low cost DRM to implement.

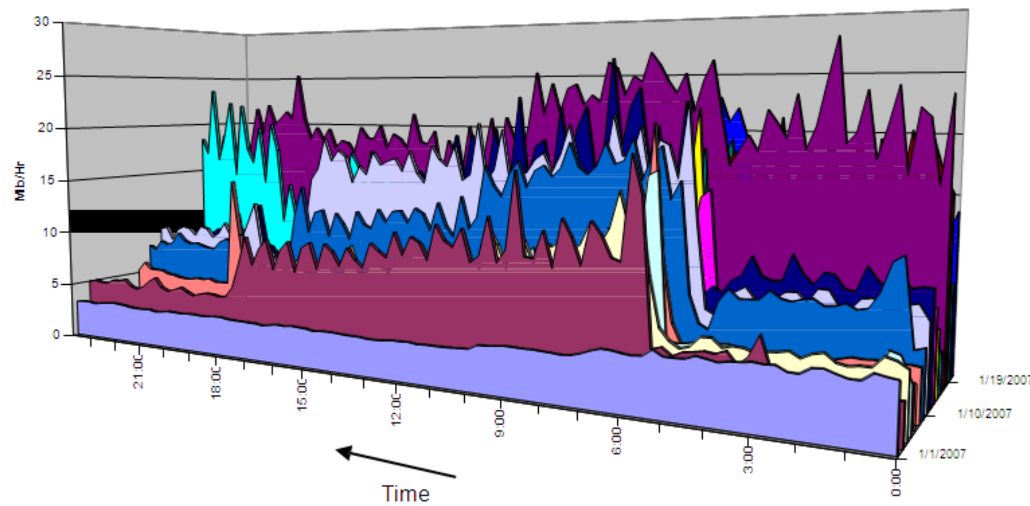


Figure 19: Steam Control Valve Hunting Profile.

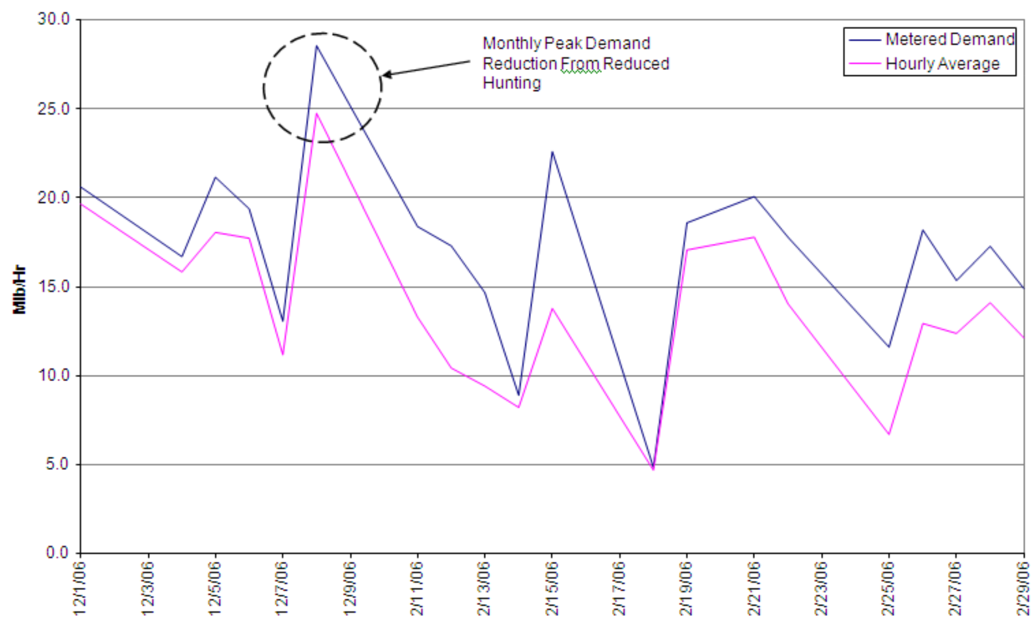


Figure 20: Hunting Demand vs. Estimated Average Demand.

v. Zone Valve Sequencing and Scheduling

In facilities equipped with heating distribution systems that employ zones and zone controls, the operation and scheduling of the zones should be such that they do not simultaneously commence operation, imposing a large spike in steam demand during the steam demand billing period. This concept is the same as the staging of electrical loads such as chillers. In facilities with multiple zones, schedules should be set up so that no more than half of those valves are allowed to be open concurrently during the peak demand period. The figure below illustrates the spike caused at a multifamily complex due to simultaneous start-up of all the zone heating systems.

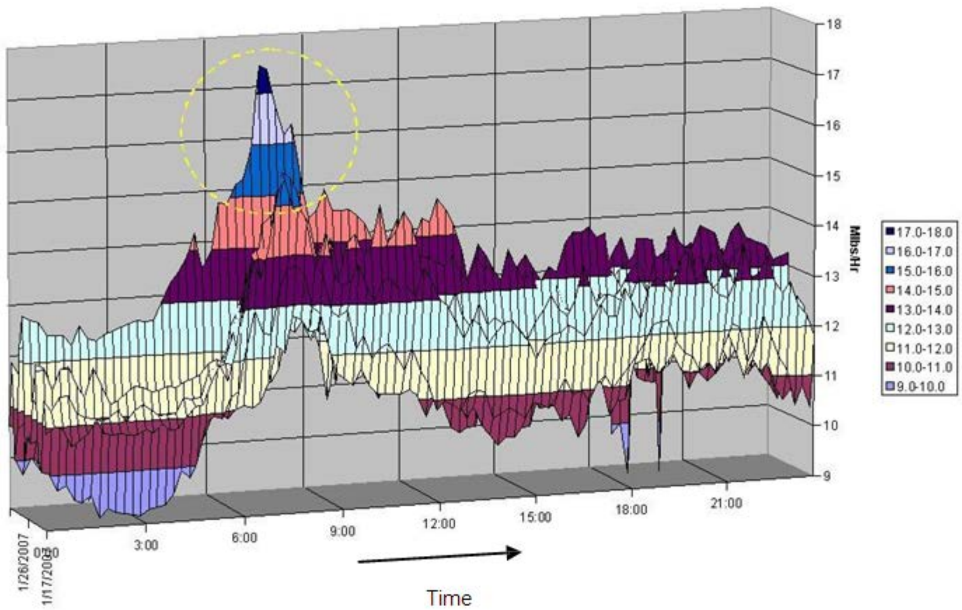


Figure 21: Multiple Zone Induced Peak Demand.

b. Steam Air Conditioning

i. **Utilization of Hybrid Chiller Plants**

By installing a chiller plant that contains both electric-driven and steam-driven chillers, facilities are able to select the commodity that provides the most economical operation. During winter billing periods, steam demand rates are present and chillers are most likely running at part load. Therefore, operating electric chillers is more cost efficient. During summer electric peak periods, when electric demand rates are higher, it is more cost-effective to use steam chillers.

ii. **Steam Load Shifting**

Facilities with areas that require air conditioning during the winter billing periods should consider precooling these areas prior to the demand billed period. By lowering the temperature set points prior to the peak steam demand period (6:00 a.m.), a facility can meet or slightly exceed space requirements prior to the demand period and then reduce the set points from 6:00 a.m. to 11:00 a.m.

VI. New Technologies in Energy Efficiency

The following material is provided as an informational source only. The publication or sharing of this information should not be considered, in any way, to be an endorsement, recommendation or promotion, either expressed or implied, of any of the technologies listed thereon. Accordingly, it is the customer's sole responsibility to investigate and determine the technical capabilities and reliability of the technologies prior to entering into a contract for services provided by these products. This list is not intended to be an all-inclusive list of qualified technologies.

i. Back-Pressure Steam Turbine Generators

Con Edison steam enters customers' locations at approximately 140 psig – 180 psig. In most buildings, the pressure of the incoming steam must be reduced prior to being distributed throughout the facility. For customers using steam for heating, DHW, and/or low pressure air conditioning, the required steam pressures are no more than 30 psig. Typically, facilities use pressure reducing valves to step down the steam pressure. Appropriately sized steam turbine electric generators are available that can be used for steam pressure reduction in parallel with pressure reduction valves. These units use incoming high-pressure steam to produce electricity and output low-pressure steam. By installing this technology, the energy consumed in the pressure reduction can be used to provide some electric cost savings with no impact to a facility's steam system. Small units are capable of producing approximately 100 kW of electric power when operated using a minimum steam load of 3.0 Mlb/hr and a maximum steam load of 5.0 Mlb/hr. Preliminary analysis indicates that a customer location with a base load of 3.0 Mlb/hr for between 1,900 hours to 3,200 hours per year would achieve a simple payback of 3-5 years. Larger units that produce 250 kW of electric power would require over 12.0 Mlb/hr base loads and may be harder to justify for most buildings.

ii. Fully-integrating Steam Chiller Control Systems

Control systems that fully integrate BMS controls with steam turbine chillers are available to increase the efficiency of these units. Since the control system automatically monitors all major components of the steam chiller, steam usage can be optimized and reduced significantly. Steam customers have seen reductions anywhere from 5% to 32% in their steam energy usage upon installation of such control systems, with a simple payback period within one to three years in most cases.

These control systems help reduce the amount of steam needed to run existing chillers by:

1) *Compressor Pre-Swirl Optimization:*
    - Reducing the entering condenser water temperature (ECWT) when reducing chiller load to permit head relief to the compressor
    - Allowing for sloping and de-rating of turbine drive to reduce overall consumption
    - Maintaining the fluidity of gases within the chiller to reduce resistance

2) *Nozzle Optimization Control*
    - Reducing the volume of steam needed to operate turbines

3) *Vacuum Distillation and Filtration of Turbine Oil*
    - Maintaining efficiency of turbine by eliminating foreign matter from the turbine oil

In addition to energy savings, installation of this type of control system results in the following improvements:

- Operational feedback
- Safety controls
- Optimization processes
- Reduction in refrigeration loss
- Environmental benefit of energy use reduction
- Equipment life extension
- Oil quality maintenance

These systems are compatible with most existing steam chiller configurations and manufacturers. An adequate control system for the steam air conditioning chiller ensures longer chiller life and prolongs optimal performance. Table 6 shows the estimated energy savings from an actual installation of this technology.

Table 6 – Estimated Savings from Actual Installation of Control System for Steam Turbine Chiller			
User	**Summer Consumption (Mlb)**		**Savings upon Installation**
	Previous Year	**Installation Year**	**Energy Reduction**
1	12,229	9,885	19.17%
2	34,274	23,021	32.83%
3	25,112	23,113	7.96%
4	23,690	20,860	11.94%
5	21,167	18,909	10.67%
6	32,789	25,636	21.82%
7	30,724	29,074	5.37%

iii. Radiator Covers with Fans

Steam users with older radiators that have poor or fragile valves often suffer from overheating. Thermostatic Radiator Valves (TRVs) are expensive to install as they require significant piping modifications. A future alternative to TRVs for such radiator systems may be temperature-controlled radiator enclosures (TREs). Currently under evaluation, these devices are composed of an insulating cover, built-in fan, wireless controls, and an air vent.

The design of the radiator enclosure allows individual radiator zoning without the need to modify the plumbing of the radiator or the steam circuit. These systems consist of an insulating enclosure around each radiator, which traps the heat inside, with a ducted thermostatically controlled fan. This fan drives heat out of the enclosure on demand. The enclosures can be deployed in a stand-alone installation, where each unit operates to maintain a set point. Alternatively, they may be installed across a whole building using wireless communication. Whole-building installations can monitor the temperature at each radiator and coordinate heat delivery and load use. These systems can be used to affect building preheating, reduce overheating at the radiator level, balance load demand, and ensure constant temperature control building-wide.

VII. Appendix

a. EMRA Energy Audits

In order to assist steam customers in adjusting to steam demand rates, Con Edison retained a building energy systems consultant, Energy Management & Research Associates (EMRA),[6] to perform audits at thirty steam customer locations. The purpose of these audits was to provide site-specific recommendations for potential improvement in steam usage and demand in the audited facilities. The audited locations were selected by Con Edison and included commercial office buildings, large multi-family apartment buildings, and specialty facilities such as hotels and hospitals. These steam audits identified a broad applicable spectrum of steam DRMs and steam EEMs that appeared in multiple individual audits.

Customer Selection Methodology

The number of selected customers for each customer type was chosen to provide a proportionate representation of the Con Edison steam customer base. Table 7 provides a breakdown of the number of the identified customers for each customer type.

Table 7 – Customer Selections	
Customer Type	**No. Selected for Auditing**
Office	15
Residential (multifamily buildings)	10
Combination (office and residential)[7]	2
Hotel	2
Hospital	1

Half of the customers within each customer type category were selected because they had the lowest winter billing season load factors in their respective category (winter billing season load factor is defined as the average demand during the winter billing season divided by the highest on-peak demand during the same period); the remaining customers were selected because they had a high ratio of winter consumption to building area.

Four figures are included on the following pages that provide samples of typical steam load patterns from the facilities that participated in the steam system survey/audit. Examples of the information provided by these charts are summarized as follows:

Figure 22 is based on steam consumption data from a hotel and shows both the shoulder (autumn) load pattern and the winter load pattern. This facility operates steam heating and cooling systems and has a significant hot water load from the hotel guest usage, restaurant and health/exercise facilities. Because this facility has a relatively steady steam load during the heating season, it could be among those that will see lower total steam costs under demand billing. Energy efficiency and steam demand reduction efforts can yield additional savings.

[6] The audit report was authored primarily by Fredric S. Goldner, CEM and James W. Armstrong, PE, CEM of EMRA.

[7] These were buildings that had a mix of both residential and commercial spaces. In one instance, the commercial portion of the space was made up of offices. In the other site, the commercial area also contained hotel, retail and theater spaces.

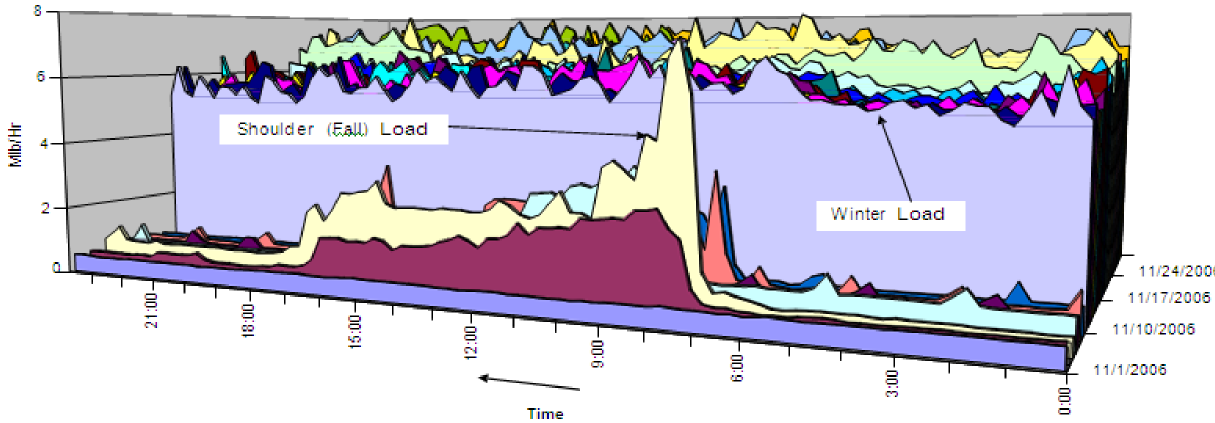


Figure 22: Hotel - Fall to Winter Load Transition

Figure 23 displays the steam load profile of a large multifamily apartment facility that has steam radiators. Once the facility is heated and residents have completed morning routines, which entail peaking domestic hot water (DHW) consumption, the load tends to drop off for the remainder of the day.

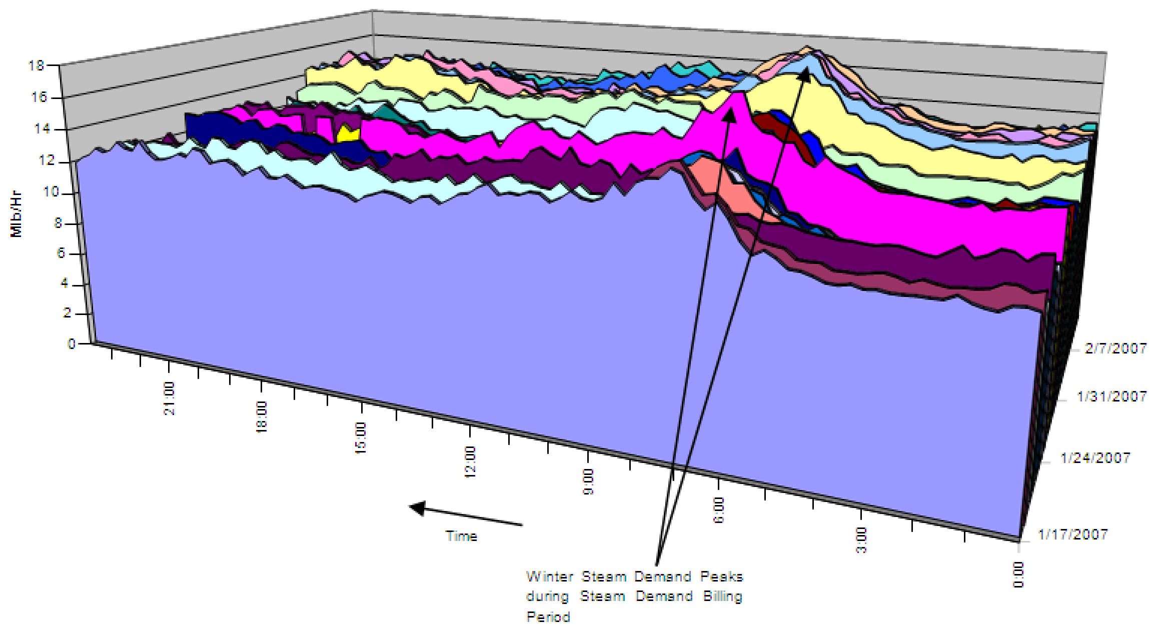


Figure 23: Multifamily Building Winter Load Profile

Figure 24 shows a typical load profile for a commercial office building that uses steam for heating. The initial peak is sharper than that of the residential facility, primarily because the heating systems are started in the morning. Heating requirements typically decline in such a building throughout the day due to increasing heat contributions from the occupants, daytime usage levels for systems such as computers and lighting, and solar heat gain through the windows. If on-peak demand reduction measures are not implemented, this facility is likely to see an increase in steam costs under demand billing because of its sharp peak steam demand profile during the peak steam demand period.

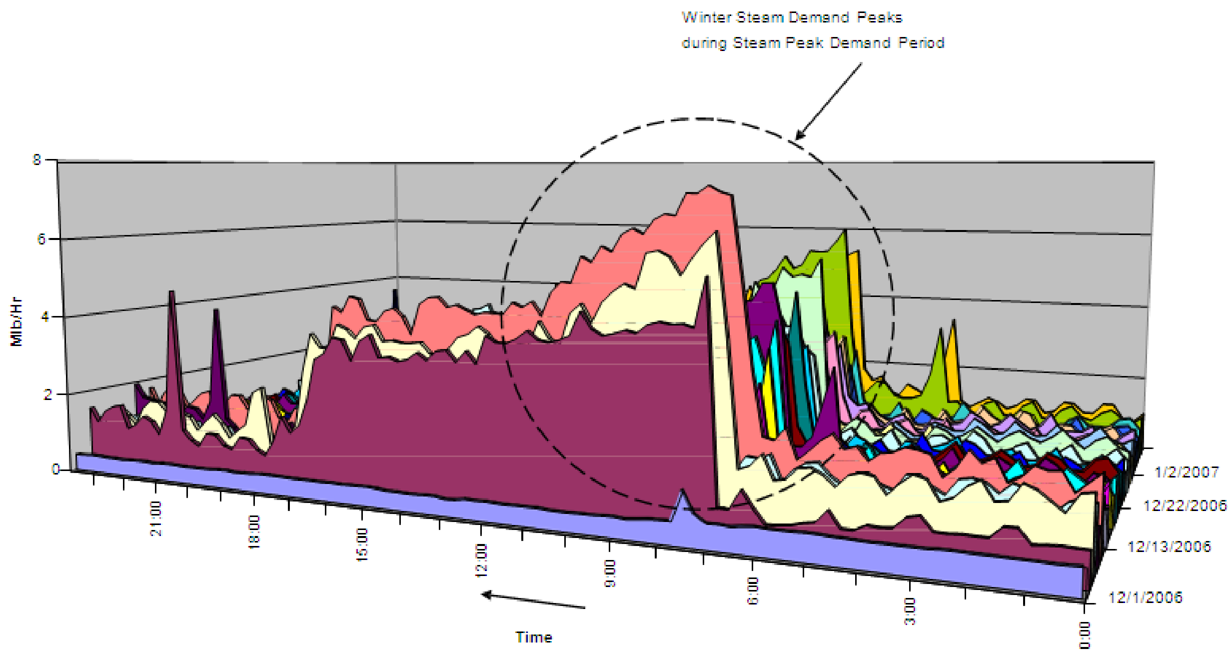


Figure 24: Commercial Office Winter Load Profile

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Figure 25 shows a load profile typically seen in a hospital or a mixed use facility with relatively steady load throughout the 24 hour day. Facilities with steady loads, such as this, may realize lower steam costs under demand billing, although energy efficiency and demand reduction efforts can yield additional savings.

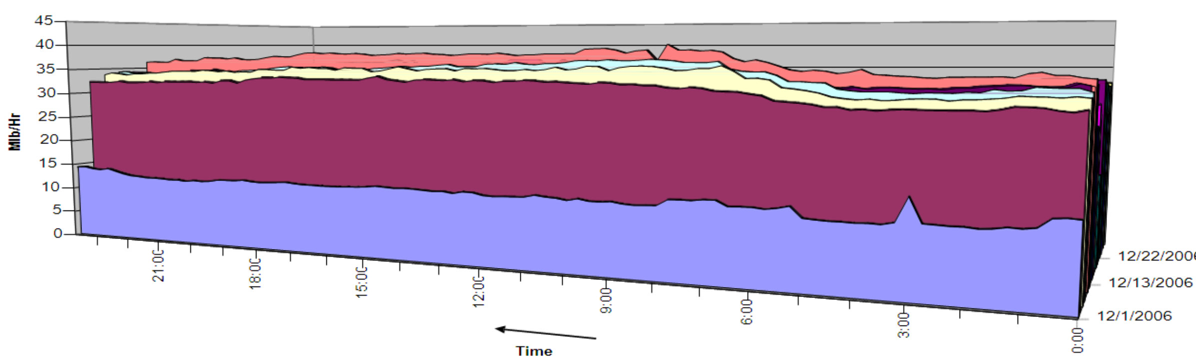


Figure 25: High Load Multi-use Winter Load Profile

Energy Audit Methodology

Site audits of each of the facilities were conducted by teams that included a representative of the Con Edison Steam Business Development Group and one of the consultant team members. The site audits were essential in providing the auditing team with firsthand knowledge of each facility and its steam systems, and provided the auditing team the opportunity to discuss the demand rates in detail with each facility.

The site audits were conducted during the heating season for 2006-2007. A second visit was conducted during the 2007 summer season for 21 of 30 facilities that also use steam for cooling. The site audits and site-specific report preparation processes are summarized as follows:

- 15-minute interval data from the steam demand meters in the facilities was processed to produce graphs of each facility's steam consumption patterns. These graphs were used to calculate the potential impact of the steam demand rate and to identify conditions that contribute to the steam demand. They were also used during the site audits as part of the review of steam demand rates with facility personnel.
- Historic monthly steam consumption and temperature degree day data for each facility was analyzed to develop baseline consumption for that facility.
- Each facility completed a preliminary audit questionnaire, which was reviewed by the auditing team with facility personnel prior to the initial site visit.
- The site audits were conducted and preliminary reports prepared to summarize the findings for the rest of the project team. The first site audit took place in all facilities during the 2006-2007 winter season to assess heating systems in operation. Depending on the size of the facility, the audit visit lasted anywhere from one to three days.
- A second audit was conducted during the summer 2007 season to assess the facility cooling systems that utilize steam.
- Based on the steam data analysis and the facility surveys, appropriate EEMs and DRMs were identified. For purposes of this report, EEMs are those measures that will reduce overall consumption and possibly the on-peak steam demand. DRMs are those measures that will reduce the on-peak demand, but not necessarily overall consumption. Preliminary implementation costs and the estimated steam cost reductions were calculated, along with return on investment.
- Site-specific reports were prepared for each facility.

b. Storage of Thermal Energy in Existing Mechanical systems (STEEMs)

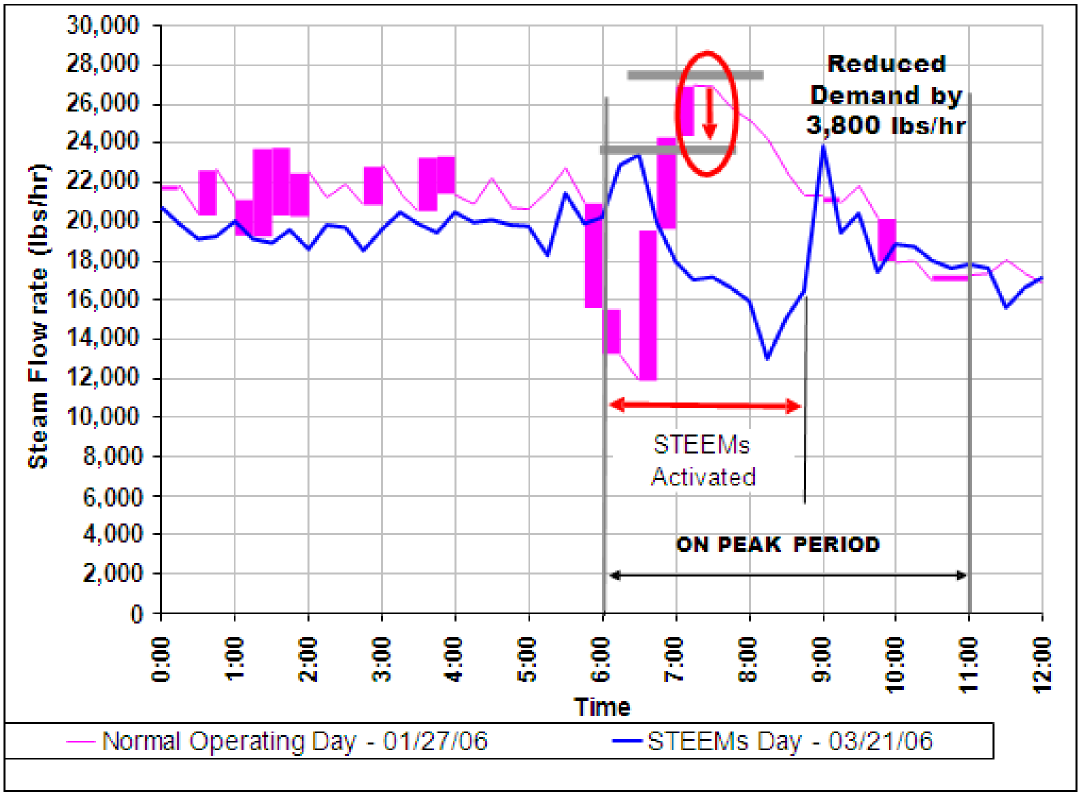
Detailed STEEMs Operational Description - STEEMs Using Scheduled Reset

Storage of Thermal Energy in Existing Mechanical systems (STEEMs) Using Scheduled Reset is a strategy that does not require building steam flow rate signal for feedback. It is simpler to program than STEEMs Using Dynamic Response. However, after the programming is completed, it requires experimentation by building engineers to identify an operating configuration that will maximize the amount of on-peak demand reduction. Table 8 provides a description of operation, and Figure 26 presents the flow rates during the operation.

Table 8 – Description of Operation

Description of Operation	Explanation
Program the BMS to automatically run the building in the STEEMs Using Scheduled Reset mode of operation every weekday during the winter demand-billed months, or when directed by the building engineer: 1. At 4:00 a.m., gradually increase the water temperature set points in all the circulating hot water loops at a constant rate so that the pre-set highest temperature is reached at 6:00 a.m. To maximize the amount of thermal storage, this high temperature value should be as high as practically possible, but should not exceed 190°F.	Slowly store the thermal energy in your circulating hot water loops. You may increase your All-Time Peak Demand charge if you force your loops to heat up quickly. There may not be a need to run your fans at this time.
2. Either at 6:00 a.m. or when specified by the building engineer, start reducing the water temperature in each loop at a constant rate over a duration specified by the building engineer, until the LOW water temperature set point for each loop is reached. The LOW water temperature set point is specified by the building engineer.	The ramp-down of the water temperature set points, in effect, dissipates the stored thermal energy. This should offset steam flow rate into the building. Since the spaces are still receiving the same amount of heat as they would under normal operation, space conditions are not affected.
3. The building engineer may specify different ramp-down start times and durations for different circulating hot water loops to maximize the amount of demand reduction. Once an optimal configuration is identified, the building may continue operating this way every morning.	STEEMs operation does not necessarily need to last for 5 hours, which is the duration of the on-peak period. In some buildings, the morning steam peak naturally subsides after 2 to 3 hours every weekday. In these cases, STEEMs may be activated for that time period only.
4. Normal mode of operation shall resume as a result of any of the following: a. Building Engineer's override for each water loop b. Completion of pre-set duration of STEEMs operation	
Notes: 1. Although the steps described below may be applicable to a variety of building system types, some steps in this sequence may need to be excluded or modified, depending on your specific mechanical system characteristics. 2. It is important to tune the water temperature control valves to minimize overshoot and undershoot during the scheduled reset of water temperature set points.	

Figure 26: *STEEMs Using Scheduled Reset* Result at a Large Office Building



Detailed STEEMs Operational Description - STEEMs Using Dynamic Response

Storage of Thermal Energy in Existing Mechanical systems (STEEMs) Using Dynamic Response is a steam demand reduction strategy that requires a building steam flow rate signal for feedback. Even though this strategy is more difficult to program than STEEMs Using Scheduled Reset, the potential for steam demand reduction using this technique is higher. Furthermore, the success of this strategy is contingent on tuning the water temperature control valves to minimize steam flow rate fluctuations during the STEEMs mode of operation. Table 9 provides a description of operation. Figure 27 displays a control arrangement for a typical circulating hot water loop, and Figure 28 presents the flow rates during the operation.

Table 9 – Description of Operation

Description of Operation	Explanation
Program the BMS to automatically run the building in the STEEMs Using Dynamic Response mode of operation every weekday during the winter demand-billed months, or when directed by the Building Engineer: 1. At 4:00 a.m., gradually increase the water temperature set points in all the circulating hot water loops at a constant rate so that the preset highest water temperature is reached at 6:00 a.m. To maximize the amount of thermal storage, this high temperature value should be as high as practically possible, but should not exceed 190°F.	Slowly store the thermal energy in your circulating hot water loops. You may increase your All-Time Peak Demand charge if you force your loops to heat up quickly. There may not be a need to run your fans at this time. If the thermostatically controlled valves at the terminal units were fully open during the night, at the time of temperature ramp up, they should be activated to regulate room air temperature to prevent overheating.

2. Prior to 6:00 a.m., calculate the building steam flow rate set point using a relationship between outdoor air temperature and average steam flow from 6:00 a.m. to 11:00 a.m. (the "curve") for Mondays and a separate curve for other weekdays. These curves may be calculated using past steam flow interval data and outdoor air temperature data.	A separate curve for Mondays may not be needed if building systems normally operate on Sundays.
3. At 6:00 a.m. or when the steam flow rate reaches the set point flow rate (whichever occurs later), override the temperature control signal to each valve with a master steam flow control signal to all the water temperature control valves.	This override will allow the heat exchanger temperature control valves to modulate all loops in unison to maintain a constant total steam flow rate into the building. This will be referred to as "STEEMs operation" in this document.
4. Building engineers shall input HIGH, MEDIUM and LOW water temperature limit values (to be referred to as HIGH, MEDIUM and LOW temperatures) for the water loops. Initially, HIGH will be the maximum (MAX) temperature. They shall also input the desired duration of STEEMs operation.	STEEMs operation does not necessarily need to last for 5 hours, which is the duration of the on-peak period. In some buildings, the morning steam peak naturally subsides after 2 to 3 hours every weekday. In these cases, STEEMs may be activated for that time period only.
5. If the HIGH temperature is reached in any water temperature loop prior to the end of STEEMs mode of operation, reset the temperature set point in that loop to the MEDIUM temperature minus 10 (this value must be higher than the LOW temperature. This value will be referred to as "the lower temperature set point" or as TMED-10). Once the lower temperature set point is reached in this loop, the valve control will return to the master steam flow control signal.	If the HIGH temperature is reset down to a lower set point temperature in a given loop, the BMS should close the corresponding temperature control valve gradually, until the water temperature in that loop reaches this lower temperature set point. Once the lower temperature set point is reached, the BMS should open the valve in a given loop gradually, to control building steam flow rate. The lower temperature set point should be a lower value than the MEDIUM temperature to reduce the chance of the loop reaching the MEDIUM temperature.
6. If, in the course of STEEMs operation, any loop increases in temperature up to the MEDIUM temperature, the valve in that loop will gradually close until the LOW temperature has been reached.	Having the MEDIUM temperature programmed into the STEEMs operation will help to ensure that spaces do not get overheated due to high water temperatures.
7. If the LOW temperature is reached in any water temperature loops prior to the end of STEEMs operation, the BMS will transfer control from STEEMs to temperature control operation to maintain the LOW temperature. The remaining loops will still be in STEEMs operation.	This step is necessary to ensure that space comfort conditions are not compromised.
8. Normal mode of operation shall resume as a result of any of the following: a. Interruption of the high frequency pulse signal from the steam meters b. Building Engineer's override for each water loop c. Completion of pre-set duration of STEEMs operation	
Refinements to the Control Strategy:	
1. The Building Engineer can apply a positive or negative shift to the calculated steam flow set point (include one "shift" input field for Mondays and another for remaining weekdays). The building engineer can apply a positive shift (increase the calculated set point) if the temperatures in all the loops reach LOW temperature before STEEMs is expected to deactivate, and a	The greater the negative shift, the more the steam demand can be reduced, and the higher the risk of reaching LOW temperatures in all the loops.

negative shift (decrease the calculated set point) if the temperatures in all the loops do not reach the LOW temperature too early.	
2. One loop may lose heat faster than others (such as the one serving northern exposures). To minimize the chance of that loop reaching the LOW temperature prematurely, the building engineer may input a bias for that loop. With a bias, the BMS will still modulate all the valves in unison during STEEMs operation, but it will keep the biased valve more (or less) open than the remaining valves. For example, if the BMS is sending a 70% open master signal to all valves and there is a bias of +10% on the northern loop, the BMS will send a signal of 80% open to that loop.	

Notes:

1. Although the steps described below may be applicable to a variety of building system types, some steps in this sequence may need to be excluded or modified, depending on your specific mechanical system characteristics.
2. It is important to tune the water temperature control valves to minimize steam flow rate fluctuations during the STEEMs mode of operation.
3. Con Edison encourages you to install your own steam meters for STEEMs. However, if you are considering using high frequency steam pulse signals from Con Edison's meters, please note the following:
   a. The high frequency pulse signal is provided for steam load or consumption monitoring and for implementation of STEEMs. It is not intended for other control applications.
   b. If you implement STEEMs Using Dynamic Response, you should design the load management system/equipment to automatically switch to an alternate mode of operations in the absence of pulse signals from the isolation relay circuit or in the case of a power supply failure.

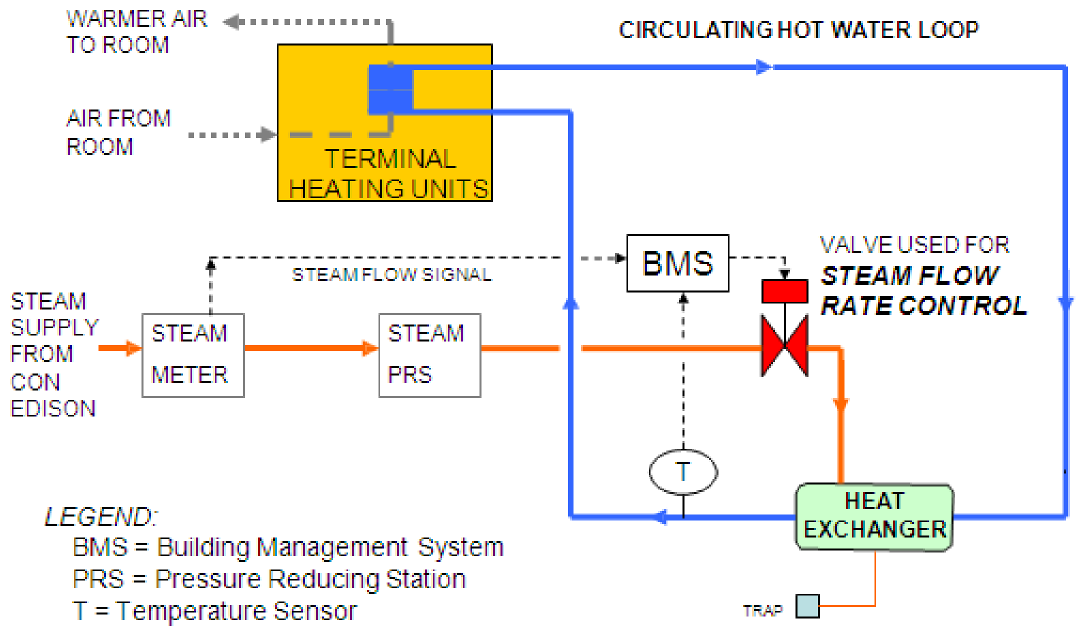


Figure 27: Typical Circulating Hot Water Loop - Control Arrangement for *STEEMs*

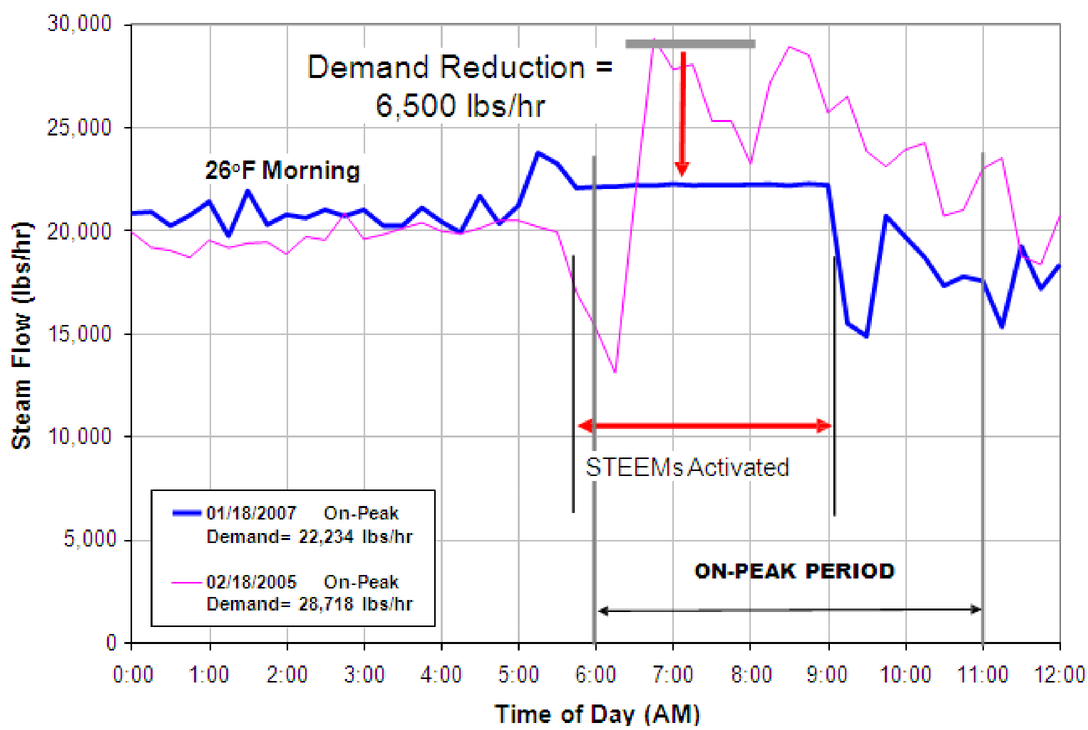


Figure 28: *STEEMs Using Dynamic Response* Result at a Large Office Building

NOTE: The results in your building will vary, depending on the sizing and quality of tuning of your water temperature control valves, the amount of piping in the heating system, and other system characteristics.

d. *Steam Demand Response Pilot Program*

Con Edison recently administered a Steam Demand Response Pilot Program. In this program, participants were asked to reduce their steam demand during designated load relief periods. The program consisted of a winter program and a summer program. The winter program was in effect from January 1, 2012 through March 31, 2012 and from November 1, 2012 through March 31, 2013. The summer program was in effect from April 1, 2012 through October 31, 2012. Con Edison initiated five load relief periods of five hours in duration during each segment of the pilot program.

During the winter segments of the pilot program, participants used a number of demand reduction methods to reduce their steam load. Some common methods included:

- Preheating the building prior to the demand billed period
- Lowering heating hot water/domestic hot water temperature set points
- Lowering supply or return air temperature set points
- Adjusting the steam supply directly by restricting valves
- Reducing outside air intake and recirculating return air
- Shutting steam supply to various building zones

During the summer segment of the pilot program, some common demand reduction methods included:

- Raising circulating chilled water temperature set points
- Raising supply air temperature set points
- Precooling the building prior to the demand billed period
- Utilizing electric chillers (during load reduction periods that did not coincide with an electric demand response event)
- Turning off non-essential equipment
- Lowering steam turbine speed
- Optimizing free cooling during the shoulder months

By conducting the Steam Demand Response Pilot Program, Con Edison gained experience in customer building operations and how they relate to the steam peak demand. The customers were able to test the limitations and effectiveness of certain load reduction strategies and to determine to what extent each strategy impacted tenant comfort. A few of the customers were able to fine-tune their day-to-day business operations and implement permanent changes to their operations.

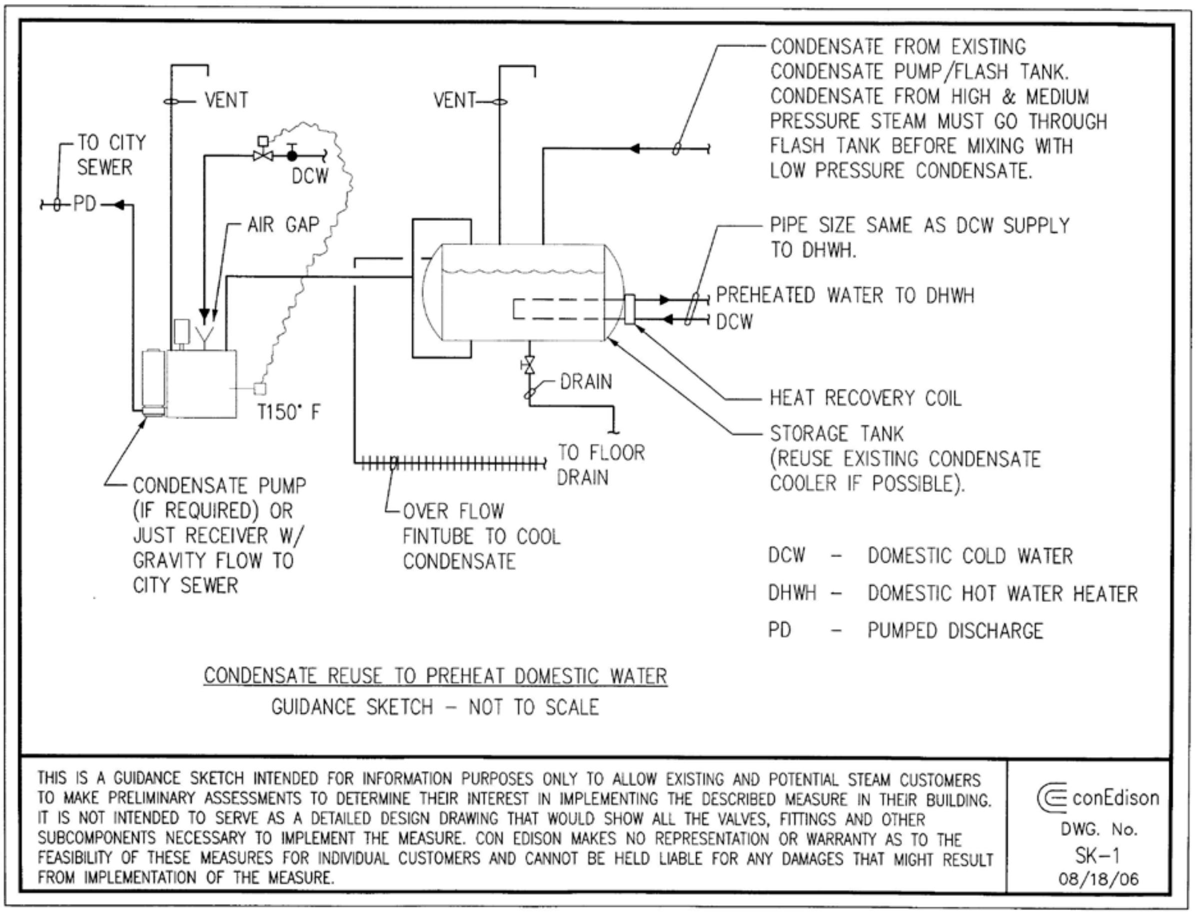
The final report of the program findings has been submitted to the New York State Public Service Commission (PSC) and is available to the public on the PSC website.[8] Useful information from this pilot program for the measures mentioned above has been included in this Best Practices Report.

[8] http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={3444B444-1FD7-4A2A-BFE1-3C392960D0AE}. This address is subject to change.

e. Condensate Management Illustrations

Below are condensate reuse sketches for domestic hot water preheating and condensate make-up provided by Con Edison for your reference.

Condensate Reuse to Preheat Domestic Hot Water



Condensate Reuse for Cooling Tower Make-up