MADISON HOUSE APARTMENTS- MULTIFAMILY, HIGH RISE APARTMENT BUILDING

ASHRAE TECHNOLOGY AWARDS SUBMISSION

Background

Madison house Apartments is a high rise, affordable housing, comprised of a 99 rental apartments, community center, central coin operated laundry, and common areas. The project objective was to increase the building energy efficiency and improve the indoor air quality relying on innovation that allows for the project to qualify for incentives and government programs. This enabled this affordable housing building achieving state of the art technological excellence.

The existing system used to rely on a steam boiler to provide heating and domestic hot water. The efficiency of the old steam boiler was measured at 76%. Leaking steam pipes and malfunctioning steam traps caused overall system efficiency to be significantly lower. Uneven heating was experienced throughout the building in addition to noise & knocking during the steam operation. The single large steam boiler used to operate during summer to provide domestic hot water, extending energy loss year round. Poor indoor air quality was experienced because central exhaust fans were used to serve exhaust grilles that lacked volume dampers, causing cooking and other odors to remain within each apartment and to migrate into adjacent floors and to corridors.

The designed and built system includes the following features:

- Combined Heating and Power (CHP).
- Removing steam boilers and steam pipes throughout the building.
- Providing new high efficiency, condensing hot water boilers.
- Providing new exhaust fans with variable speed motors, and a balanced exhaust system.
- Airflow testing and balancing to achieve compliance with ASHRAE 62.2-2013
- Providing variable speed pumping and thermostatic controls throughout the building.
- Measurements and Verifications, for incentives, which were submitted and granted after one year of full operation.

A comprehensive ASHRAE Level 2 Energy Audit was performed, and was approved by NYSERDA Multifamily Performance Program (“MPP”), which qualified the building to received incentives allowing the owners to achieve the project budget.

Energy Savings	Annual Water Savings	Annual $ Savings
24%	**1,090,000 gallons**	**$50,995**
		*NIC water savings

Picture shows the new CHP, High efficiency boilers, and water tanks

I. Energy Efficiency

The project had to produce energy reduction of at least 15% below ASHRAE 90.1-2007 in order to obtain NYSERDA incentives. The project team set a target of 25% energy reduction over ASHRAE 90.1-2007 and a water use reduction of at least 1,000,000 gallon a year. The project achieved 24% Energy saving and exceeded the water saving target. The project goals were achieved by employing the following strategies:

A. Combined Heating & Power (CHP)

New CHP was designed and installed to operate year round. The CHP was sized based on the thermal load from domestic hot water and space heating. The CHP equipment generates power for common area loads such as elevator, lighting for garage, exterior, and common corridors, laundry room, and community spaces. The waste heat from the CHP is piped to a loop, heating the domestic hot water tank, and providing complete space heating during mild outdoor conditions, and pre-heating throughout the winter season. Please refer to Figure 1: CHP & SPACE AND DOMESTIC HOT WATER HEATIG FLOW DIAGRAM

The design intent is to maximize the number of operating hours for the CHP equipment. The CHP was sized to operate at least 60% of the number of hours each year.

B. Building wide conversion from steam heating to hot water heating

Modular, high efficiency condensing boilers for space and domestic hot water heating were provided. The boilers have a part load efficiency of approximately 99% and full load efficiency of approximately 93%. Each boiler bank is controlled together so that boilers are activated in sequence and operate at part load/ maximum efficiency together before their firing rates increase toward full fire.

C. Interconnection between CHP & High Efficiency Boiler

CHP is the equipment with the highest efficiency, based on second law of thermodynamics and the control sequence takes advantage of this fact by allowing the CHP to be the first equipment to start (prior to the activation of any boiler) and the last to be de-energized (i.e. after all boilers are de-energized). This control sequence is achieved simply by providing a 5°F dead band between the CHP & boiler activation temperatures (see Figure #2 for the reset curves provided as part of the contract documents for the project). The CHP modulates its output to maintain the hot water temperature within the Domestic hot water tanks, and to maintain the supply hot water temperature for space heating based on outdoor temperature reset.

Picture #2: Boiler room, variable speed pumping, boilers, and CHP

D. Lighting and Appliances

Only LED, high efficiency lighting were used within the apartments and LED lighting were used within common areas. Lighting controls within corridors, egress stairs, and car garage are provided to allow 50% of the fixtures to be turned off when motion sensors detect no occupancy. Photo sensors were provided for exterior lighting.

Only Energy Star appliances were provided throughout the building.

E. Building Envelope Modifications

The following strategies were employed for the building envelope, allowing for reducing the size of the heating plant, reducing initial and operational costs, reducing cold draft hence improving thermal comfort

1. All windows were replaced with insulated, low-e Aragon filled-glass
2. Blown cellulose insulation with 12”thickness was added to the roof joist cavity providing an approximate R value of 44.
3. Existing openings within the building envelope were sealed to minimize building infiltration and motorized dampers were provided on the elevator machine room to reduce the stack effect.

F. Water Conservations

The building renovations achieved an annual water savings of 1,090,000 gallon by using low flow plumbing fixtures and dual flush water closets. In addition, water meters were provided for the mechanical rooms so that water leakage can quickly be identified and fixed.

II. Indoor Air Quality

New exhaust fans were provided and programmed to provide continuous ventilation, hence meeting the whole house ventilation values as per ASHRAE Standard 62.2-2013. Each exhaust fan was provide with ECM motor and a potentiometer and each fan speed was adjusted during balancing so that the exhaust grille within each apartment is achieving the required exhaust flow to comply with ASHRAE 62.2 Standards

III. Innovation

A. Using CHP systems allowed for all of the following objectives to be addressed:

i. Onsite emergency generator, which is essential to this site because of power loss during storms and severe weather conditions.

ii. Using waste heat from the CHP to generate domestic hot water and space heating, maximizing the thermodynamic efficiency of the building.

iii. Providing a reliable/back up operation, by using CHP and high efficiency condensing boilers. Failure of the CHP or of condensing boilers will not affect the residents.

B. To maximize the thermal efficiency, potable water is designed to be heated by the CHP in a pre-heating tank (see Figure #1 for the flow diagram). This provides the maximum temperature difference between the incoming cooler, potable water and the waste heat from the CHP. Water from the pre-heat tank is allowed to fill additional domestic hot water tanks, which can be heated by boiler water only if necessary during extreme conditions, or when the CHP unit is down for maintenance.
C. An innovation which has been appreciated by the end user is the simplicity of the controls for this complex system. Figure #2 reflects the reset schedule, which allows for the CHP to be the first to be energized and the last to de-activate and that has been achieved by providing a different reset schedule for the boiler and for the CHP. Simplifying the controls allowed for the boilers to operate using the manufacturer standard controller and allowed for the CHP to use its standard controller, which reduced cost and allowed for building super to continue serving the building without special training.

IV. Environmental Impact

1. The renovation of the building resulted in reducing potable water consumption by 1,090,000 gallons annually
2. The project achieved 24% energy reduction over the baseline, which is ASHRAE 90.1-2007

V. Cost Effectiveness

1. The project achieved an annual cost saving of $50,995 based on first year utility bills.
2. The project qualified for NYSERDA incentive based on operation of CHP that exceeded 60% of the total number of hours. The CHP cost $214,000 and NYSERDA provided an incentive of $135,000, bringing the cost to the owner down to $79,000.
3. Reducing the building energy consumption to 24% below ASHRAE 90.1-2007 enabled the owner to receive additional incentive from NYSERDA.
4. The cost to the owner for the mechanical system after the incentives was approximately $450,000, and with an annual saving of $50,995, the expected simple payback is approximately 8.8 years.

VI. Operation & Maintenance

Replacing existing steam system with new hot water boiler and pipes helped the building avoiding the constant issues related to steam traps operation and maintenance. Steam traps failure used to remain undetected until occupants complain of overheating, noisy operation, or other issues. The new system eliminated this problem.

In addition, the building used to reply on a single steam boiler with a single point of failure to provide both space and domestic hot water heating. The current system provides reliable operation via the CHP, several modular boilers, dual pumps, and three hot water storage tanks.

The simplicity of primary secondary loop, and temperature offset strategies used to activate and deactivate the CHP and Boilers, allowed for using standard controls and the building super is able to understand and operate the building.

The use of sensorless pumping station has been beneficial, in avoiding the issues related to the location and function of remote pressure sensor on the piping system. No bypass was provided on the pumping station, removing unnecessary component, while ensuring continuing energy saving by not allowing the variable speed function to be bypassed.

All new exhaust fans are provided with direct drive variable speed motors, allowing for quiet operation while reducing maintenance effort. Maintenance crew used to stock belts and many damaged fan belts used to remain undetected until occupant complain.

Decoupling domestic boiler, space heating boilers, and CHP put operators as ease, because each block is easy to understand with simple interconnections between systems.

Three (CX) commissioning sessions were performed, following a detailed Method of Procedures covering normal operation scenarios, failure modes, and alarm notifications. Cx was repeated until all issues were addressed

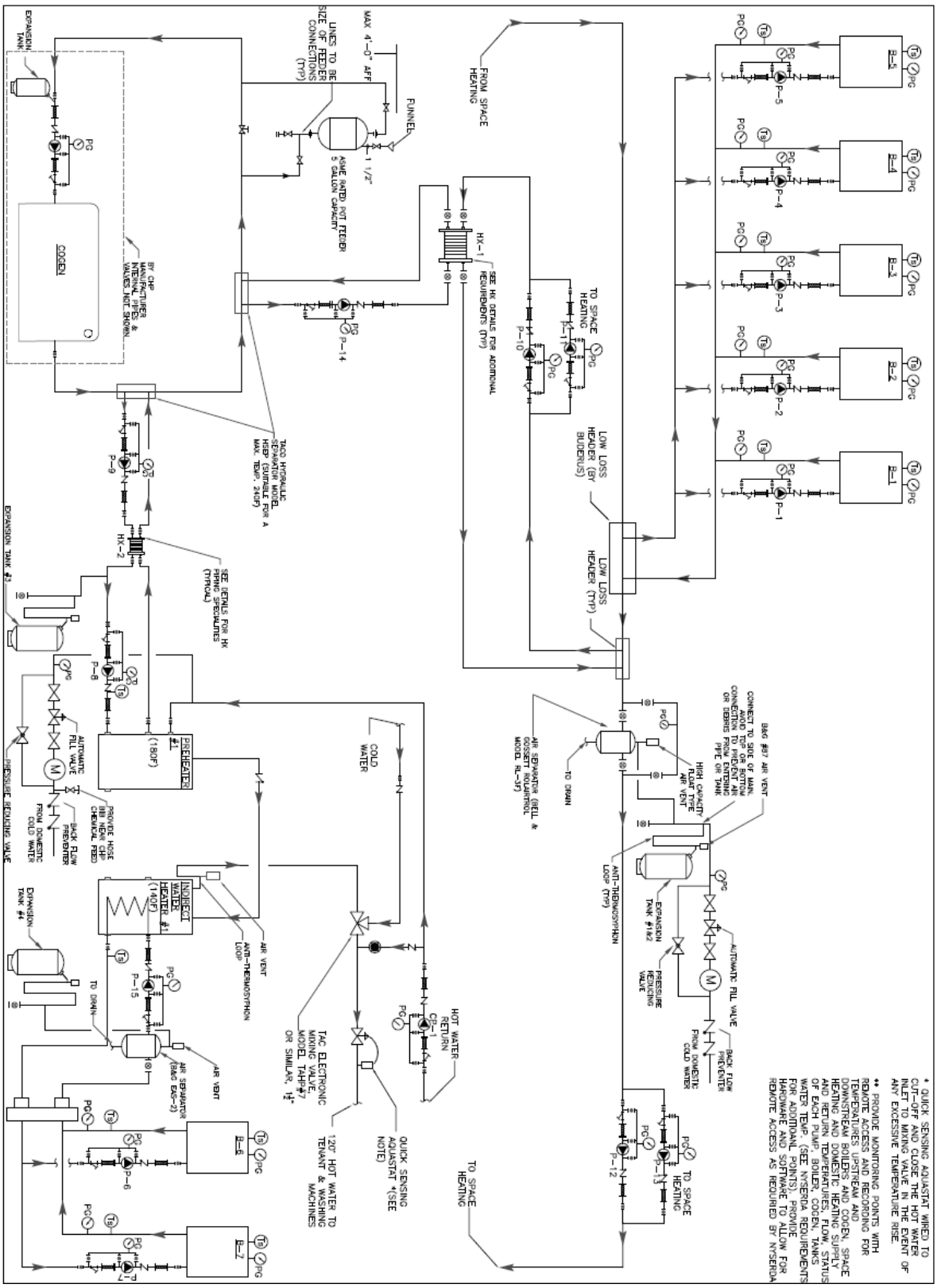

FIGURE #1: CHP & SPACE AND DOMESTIC HOT WATER HEATIG FLOW DIAGRAM

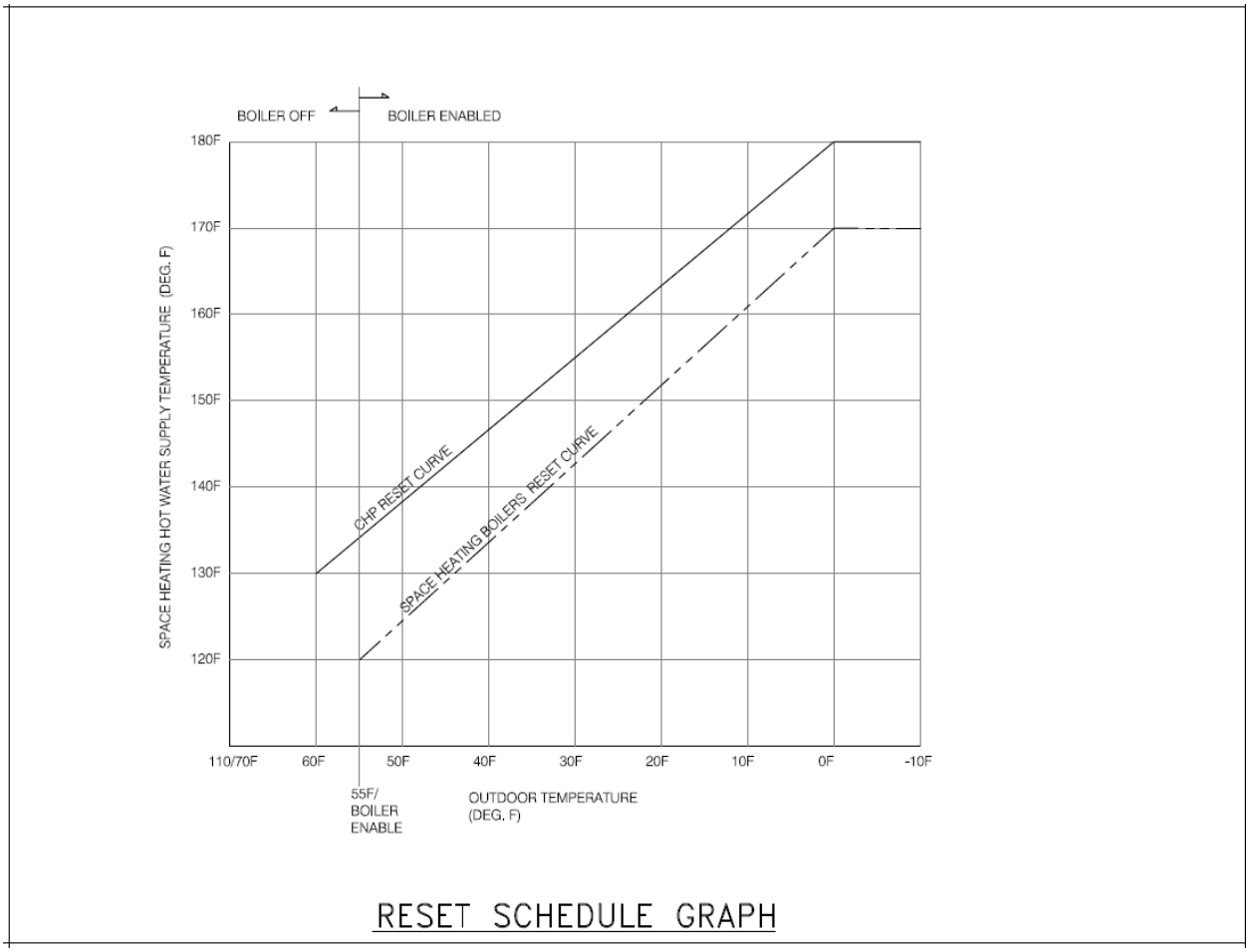

FIGURE #2 – CHP & BOILES RESET CURVES