Sun Life Assurance Company
29 North Wacker Renovation Project
By Elara Engineering

ELARA

CHAPTER/REGIONAL TECHNOLOGY AWARD - SHORT FORM

1. Category (Check one and indicate New or Existing, if applicable)

(•) Commercial Buildings	( ) New	or	(•) Existing
Institutional Buildings:			
( ) Educational Facilities	( ) New	or	( ) Existing
( ) Other Institutional	( ) New	or	( ) Existing
( ) Health Care Facilities	( ) New	or	( ) Existing
( ) Industrial Facilities or Processes	( ) New	or	( ) Existing
( ) Public Assembly	( ) New	or	( ) Existing
( ) Residential (Single and Multi-Family)			

2. Name of building or project: 29 N WACKER DR Renovation Project

City/State: CHICAGO/IL

3. Project Description: MECHANICAL SYSTEM UPGRADE

Project Study/Design Period: 06/2009 (Begin date (mm/yyyy)) to 06/2011 (End date (mm/yyyy))

Percent Occupancy at time of submission: 95%

4. Entrant (ASHRAE member with significant role in project):

a. Name: McLauchlan/Swanson (Last) Donald/Matthew (First) J/D (Middle)

Membership Number: 05062094/8043936

Chapter: ILLINOIS

Region: VI

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c. Telephone: (O) 708-236-0300 X122 d. Email: mswanson@elaraeng.com

e. Member's Role in Project: DJM = Principle in Charge; MDS = Senior Mechanical Engr

f. Member's Signature:

5. Engineer of Record: Donald J McLauchlan

By affixing my signature above, I certify that the information contained in this application is accurate to the best of my knowledge. In addition, I certify that I have discussed this entry with the owner and have received permission from the owner to submit this project to the ASHRAE Technology Awards Competition.

Project Background

Located in the Chicago's central business district on the west side of the downtown Loop, 29 North Wacker is a 10-story commercial office building with a basement and single level garage that was constructed in 1962. The total commercial space of the building is approximately 140,000 ft^2 and is made up of 10 above-ground levels for both retail and office space. The basement level and parking garage total 10,000 ft^2; the basement level is used for building and tenant storage. The calculated energy cost intensity (EUI) prior to the implementation of any projects was calculated to be $2.33/$ft^2$ (common area charges), which is 44% higher than current minimum requirements of local building code $1.33/$ft^2$. Finally, the exterior envelope of the building is comprised of concrete, steel and glass.

Project Statement

Due to the increasing utility costs and the recent emphasis on green technology, energy conservation is paramount. In 2010, Elara Engineering was called upon to perform an objective energy audit and assessment of the building systems including the heating ventilation and air-conditioning (HVAC), plumbing and electrical systems at 29 North Wacker. The subsequent master plan report identified opportunities for improvement in energy efficiency, comfort, maintenance and reliability. Shortly after delivery of the report, Elara Engineering was enlisted to design an infrastructure upgrade for the building which included the following energy conservation measures (ECMs):

ECM#1: Steam-to-water conversion and installation of high-efficiency condensing boilers
ECM#2: An overhaul of the chilled water plant including a cooling tower refurbishment, new waterside economizer, replacement of one of the two chillers with a variable speed screw chiller and replacement of the existing chilled water and condensing water pumps
ECM#3: Redesign of the perimeter HVAC system including replacement of induction units with active chilled beams, replacement of the S-1 air-handling unit (AHU), the addition of insulation on the exterior walls and replacement of the exiting dual temperature pump
ECM#4: Retrofit of the interior constant volume reheat system (CVRH) with a pressure dependent variable air volume (VAV) system which including the installation of zone VAV dampers and replacement of the S-2 AHU.
ECM#5: Refurbishment of the S-3 AHU which included installing variable frequency drives (VFDs) on its supply and return fans, replacement of its cooling coil with a new dual temperature coil and replacement of its outdoor air (OA) dampers.
ECM#6: Retrofitting return/exhaust fans E/R-1 and E/R-2 with VFDs
ECM#7: Retrofitting the garage ventilation system with CO controlled exhaust and pressure controlled ventilation.
ECM#8: Upgrade of the existing domestic water system including replacement of the existing pressure booster system, installation of electrical point of use hot water heaters and installation of low-flow faucets, and fixtures
ECM#9: Upgrade of the building's lighting systems to modern systems including T-8. T-5 and LED fixtures.
ECM#10: Replacing the existing building automation system (BAS) with a new web-based direct digital control (DDC) system with BACnet communication protocol.

In parallel with the implementation of the above projects, and as a result of the potential energy impact on the building, the final piece of this project includes an application of Leadership in Energy and Environmental Design (LEED) Existing Buildings Operation and Maintenance (EBOM) certification. This will be submitted at the end of October 2013 with the goal of achieving gold status.

Heating Plant: The original heating plant was comprised of (2) scotch-marine steam boilers located in the second floor mechanical room. Each boiler was rated at a maximum capacity of 8,400 MBtu/hr and was equipped with a natural gas fired burner with a 3:1 turndown ratio. These boilers produced low-pressure steam used to heat the building via steam-to-water heat exchangers, steam heating coils and unit heaters. The boilers were original to the building, were over 40 years old at the time of the assessment and also had been converted from #2 fuel oil, to natural gas. In addition to the inherent inefficiencies associated with steam heating (i.e. radiant losses, distribution losses, etc.), the 3:1 turndown ratio and the sizing of the boilers compared to the load profile of the building resulted in frequent cycling and loss of efficiency. As most of the building uses hot water for heat, it seemed a likely candidate for hot water boilers. However, in order for hot water to be feasible, the remaining steam users, S-1 AHU, S-5 AHU and several steam unit heaters needed to be converted to hot water. With that accomplished, the remaining decision involved a choice between condensing or non-condensing boiler technologies. With a goal to maximize energy savings, high-efficiency condensing technology is preferred. However, in order for the savings to be realized, low water temperatures are required (typically less than 130°F). The existing hot water users (perimeter induction system, reheat coils and in floor radiant systems) are all candidates for low water temperatures but the perimeter induction system and reheat coils were designed for 180°F. These systems could be addressed as part of another design and selected for low water temperatures to facilitate the use of high-efficiency condensing technology. As such, Elara recommended a complete steam-to-water conversion and replacement of the steam boilers with new high-efficiency condensing boilers. Elara's design replaced the original two oversized steam boilers with four properly sized (2,000 MBH each) gas-fired, high-efficiency condensing hot water boilers that were installed within the footprint of a single demolished steam boiler. Venting and sealed combustion air was installed as well. To support the new hot water boiler system, two hot water pumps with VFDs were added to supply S-1, S-2 and S-3 AHUs as well as the existing radiant systems and unit heaters (which were converted to hot water). High efficiency condensing boiler technology can increase the seasonal efficiency of a boiler plant by as much as 30%. This results in a reduction of the natural gas used for heating and lowers utility costs. The boilers specified are also capable of 20:1 turndown ratio which allows for increased control and savings at low load conditions.

Cooling Plant: The existing chilled water plant was comprised of two 250 ton centrifugal chillers that provide chilled water to the air handler cooling/dual temp coils and the perimeter induction system. These chillers were not original to the building. The original design was a single absorption chiller with no backup. Although the existing chillers were not original to the building, they were over 25 years old which is over the ASHRAE mean life span of centrifugal chillers. The chillers were located on the 2nd floor mechanical room adjacent to S-1 AHU. The condensing water side of the chilled water plant was comprised of two constant speed pumps and a dual cell two-speed cooling tower. The condensing water pumps were 50 HP and 20 HP respectively and were sequenced in connection with the chillers. The existing cooling tower used two 25 HP two-speed fans. After inspection and analysis of the chilled water plant, several opportunities were noted:

- The capacity of a single chiller (250 tons) was never needed, partially because the building wasn't fully occupied and partially because of conservative design. As a result, the chiller(s) were often required to work below their stable operating point, and often would shut down on surge alarms. This caused loss of comfort, increase energy usage and could lead to premature failure.
- As the cooling tower was designed assuming both existing chillers would need to operate a full capacity and was not equipped with VFDs the fans cycled frequently. This resulted in increased energy usage and frequent fan motor failure.
- Both existing chillers were located within a mechanical space which also had air handling equipment. Although this may have been accepted at the time of construction, the current code did not allow this as there is potential for spreading a refrigerant leak.

It was recommended to upgrade the existing chilled water plant. Elara's design called for a single (400 ton) variable speed screw-type chiller to replace Chiller 1, while Chiller 2 would be left in place as a back-up. The new chiller was located in the boiler room in the place of a demolished steam boiler. Additionally, a waterside economizer was added. These changes would allow the staff to extend the operating window to accommodate comfort during shoulder months and would reduce the amount of energy usage. To support this design, the existing cooling tower was refurbished including new motors with VFDs, and a basin coating. To accommodate the waterside economizer, one cell of the cooling tower was retrofit with low-flow nozzles and isolation valves to isolate flow during waterside economizer use.

Heating and Cooling Distribution: There are currently four main hydronic loops associated with heating and cooling for the facility. A primary dual temperature loop provides the induction units on floors 3-10 with either hot or chilled water depending upon the seasonal mode; the induction units are wall mounted and installed below the windows. The three other loops are hot water only systems with two providing radiant heating, and the third a reheat loop. Supporting these four hydronic loops are associated pumps each ranging in size from 1.5 to 20 HP. The pumps are designed to run at full load simultaneously and operate at constant flow. This presented a clear opportunity for energy savings as the facility is over-consuming electricity to satisfy a pump load even if no demand on the users end is noticed.

The new design called for reuse of existing induction dual temperature piping system through the use of an active chilled beam system to condition the perimeter zones. This provides for the most effective and economical system retrofit because it doesn't require any new primary piping construction. Chilled beams are ceiling-mounted inductive airside equipment which utilizes a much lower pressure drop and lower air volume than traditional induction units. For this reason, the dual temperature loop is already piped correctly for cooling mode integration with higher chilled water temperatures. The new chilled beam system provides heating, cooling and ventilation air to the perimeter zones of the building; additionally, the building benefits from increased insulation of the exterior wall.

Heating Ventilation and Air-Conditioning (HVAC) Equipment: The existing HVAC systems were comprised of six air handling units (AHU's) located on the second floor, four of which are paired with a return/exhaust fan. These fan units provided space heating, cooling and ventilation to the various floors of the building. The vast majority of the building was served by AHU's S-1, S-2 and S-3. S-1 provided ventilation and conditioned air to the perimeter induction system and was equipped with a cooling coil and steam-heating coil. Induction units were located along the perimeter below the windows on floors two through 10 and were fed conditioned ventilation air from S-1 AHU located on the second floor. The perimeter induction system required a high volume of high pressure air (approximately 11"WC) to operate correctly. Although the induction units adequately conditioned the spaces, they were costly to operate, were very noisy and were original to the building. Therefore, it was recommended to replace the perimeter induction system with active chilled beams mounted in the drop ceiling to reduce the static pressure requirements and improve heating and cooling effectiveness. A new insulated knee wall filled in the space under the windows left by the induction system while additional insulation was added along the perimeter above the drop ceilings. As an additional architectural modification, a blind air gap was created along the perimeter using the drop ceiling that acts as a return path for the chilled beams. Since the chilled beams required significantly different airflow and pressure than the induction system, S-1 AHU was replaced with a custom AHU re-engineered for the active chilled beam system with reduced airflow and designed for enhanced dehumidification using internal runaround to deliver very dry air to the chilled beams. AHU S-1's return/exhaust fan was retrofit with a VFD. Finally, since the new chilled beams used zone control valves, the dual temperature pump that served this system was replaced with a new pump with a VFD designed for the new water flow requirements.

AHU S-2 served interior zones and was a constant-volume reheat system equipped with a cooling coil only, with reheat coils located on each floor two through 10. AHU S-3 served retail spaces on the first floor and was a constant-volume reheat system.

The design further converted the S-2 constant-volume reheat system to pressure dependent VAV and removed the reheat coils on each floor. Two pressure-dependent control dampers were installed and created a north and south zone on each floor. AHU S-2 was then replaced with a custom AHU engineered for the pressure dependent VAV system and was equipped with a cooling and heating coil. AHU S-2's return/exhaust fan was retrofit with a VFD. As S-3 served retail spaces with dramatically different requirements and not ideal for VAV, only a few simple modifications were made. VFD's were installed on the supply and return/exhaust fans, the outside air dampers were replaced and a new heating coil was added to facilitate the use of high-efficiency condensing boilers. S-6 was equipped with a VFD to manage the air delivered to the parking garage for the newly installed carbon monoxide (CO) controlled exhaust system. Two vane axial fans were installed to properly exhaust the garage.

Domestic Water System: The original building domestic hot water used (3) 85-gallon natural gas-fired hot water heaters located throughout the building. These water heaters provide hot water to the toilet room lavatories and janitor sinks throughout the building. The domestic water system used a (25HP) pump to pressurize water throughout the building for a variety of uses. The duplex system was operating on one pump with zero redundancy. This meant that if the operational pump failed, the building and its occupants would be without water. Additionally, the functional pump was recently underwater when a nearby river overflowed its banks and submerged many of the commercial building basements and subbasements in the area. Having been subjected to these conditions, it was only a matter of time before the pump motor was no longer able to perform its duties.
The conventional system was replaced with a duplex pump system with VFDs for pressure control and electrical energy savings. The system was sized with renovations to the restrooms and the installation of low-flow fixtures in mind.

Lighting: The previous building's lighting system was equipped with various fluorescent lighting fixtures throughout the floors and spaces. Elara's design recommended high-efficiency replacement fluorescent fixtures and new fixtures for previously unoccupied floors to reduce utility usage. In addition to efficient fixture selection, lighting controls are included in any tenant build-out or completion of unfinished space including building common areas and toilet rooms. Occupancy sensors and other building automated controls were installed to reduce energy usage when occupants are no longer in the building.

Building Automation System (BAS): The previous Building Automation System (BAS) was an expandable controls system built on BACnet protocol - an open-source communication language. Although there was an existing automation system, its installation was fairly limited in its usage and didn't encompass the entire building's operation. Further, almost all of the existing damper actuators and control valves were pneumatic. Although pneumatic control can be very precise, it is hard to maintain and wastes energy when compared to modern electronic controls. Along with implementation of the several energy conservation and mechanical upgrades described above, a new BAS was designed and installed. The new design upgraded the BAS system to fully operational direct digital control (DDC) system with a web-based graphical front end to provide increased monitoring capability, remote access and control. In addition, all pneumatic controls were replaced in favor of electronics, eliminating the energy and maintenance cost associated with compressed air. Perhaps more valuable than the onsite monitoring, control and energy savings, are the remote access capabilities. This function allowed for daily looks at functional parameters and increased the effectiveness of commissioning efforts.

Barriers to Implementation

Because 29 N. Wacker is a combination of retail and commercial spaces, the entire mechanical upgrade project needed to be completed with the building occupied throughout construction. To perform the above-referenced retrofits and upgrades, it was necessary to phase the construction and implementation of the new systems and equipment. Installation of the new chiller and boiler plant took place during the shoulder months so that lack of heating and cooling would not affect the building and the occupants. Installations of the active chilled beams were phased so that current unoccupied areas would be retrofit first. This entailed removal of the perimeter induction units, insulation of the exposed exterior wall, and new associated piping and ductwork to the new ceiling-mounted chilled beam unit. Improvements to occupied areas took place during off-hours to minimize disruption of tenants. Chilled beam units were initially installed with a pressure reduction device on the supply duct so that they could receive high static pressure from the existing air handling unit, S-1. After the air handler had been replaced with a low static pressure unit, the pressure reduction devices were removed for normal operation. To provide a seamless changeover to the new air-handling unit, it was necessary to utilize a portion of the boiler room for assembly of the unit.

Justification for Claim of Excellence

Energy Efficiency: High-efficiency equipment selection, the elimination of steam, variable pumping and ventilation using sustainable design all contributed to a highly efficient retrofit of mechanical systems. This includes the use of condensing boilers for the boiler plant to take advantage of condensing conditions during the shoulder seasons, upgrading the existing building automation system, and the use of active chilled beam system with reduced airflow. Additional energy savings were realized in the application of variable drives on all pumps and fans to modulate load delivery based on demand.

Indoor Air Quality: Increased ventilation effectiveness provided by the new VFD equipment allows for maximum control on the air delivery side. This new equipment is directly linked to the BAS system for real-time monitoring and control to ensure occupants and space conditions are comfortable and allows for controlled airside management and improved thermal comfort. The pressure-dependent ventilation systems actively control proportions of makeup air to control the buildings pressure and decrease infiltration, thereby protecting the building façade and reducing dynamic thermal conditions.

Innovation: Converting the previous boiler plant from steam to a high-efficiency condensing hot water system allowed for a reduction of fuel input and increased control on the delivery side. The new system provides tempered water at a suitable range for heating and cooling (135-145°F) whereas the previous boiler was essentially overheating. Application of VFDs on all associated pumps and fans throughout the mechanical systems allows for increased thermal control and significantly reduced utility consumption. The project planning and phasing incorporated into Elara's design and construction documents is highly innovative in that it allowed the project to be successfully completed in the allotted timeframe and with minimal shutdown of systems. General examples of this include efficient equipment selection for ease of ingress as well as detailed timing for changeover of new controls and systems.

Operation & Maintenance: The installation of new equipment with more sophisticated control programs and proper service clearances improves overall operation, maintenance and reliability. Minimizing the dynamic pressure of the building reduces future risk to the building façade and eliminates potential associated construction costs. Improvements to the existing DHW system helped to provide redundancy, improve temperature control and reduce associated utility costs; increased lighting control also reduced associated maintenance costs of replacing bulbs and fixtures.

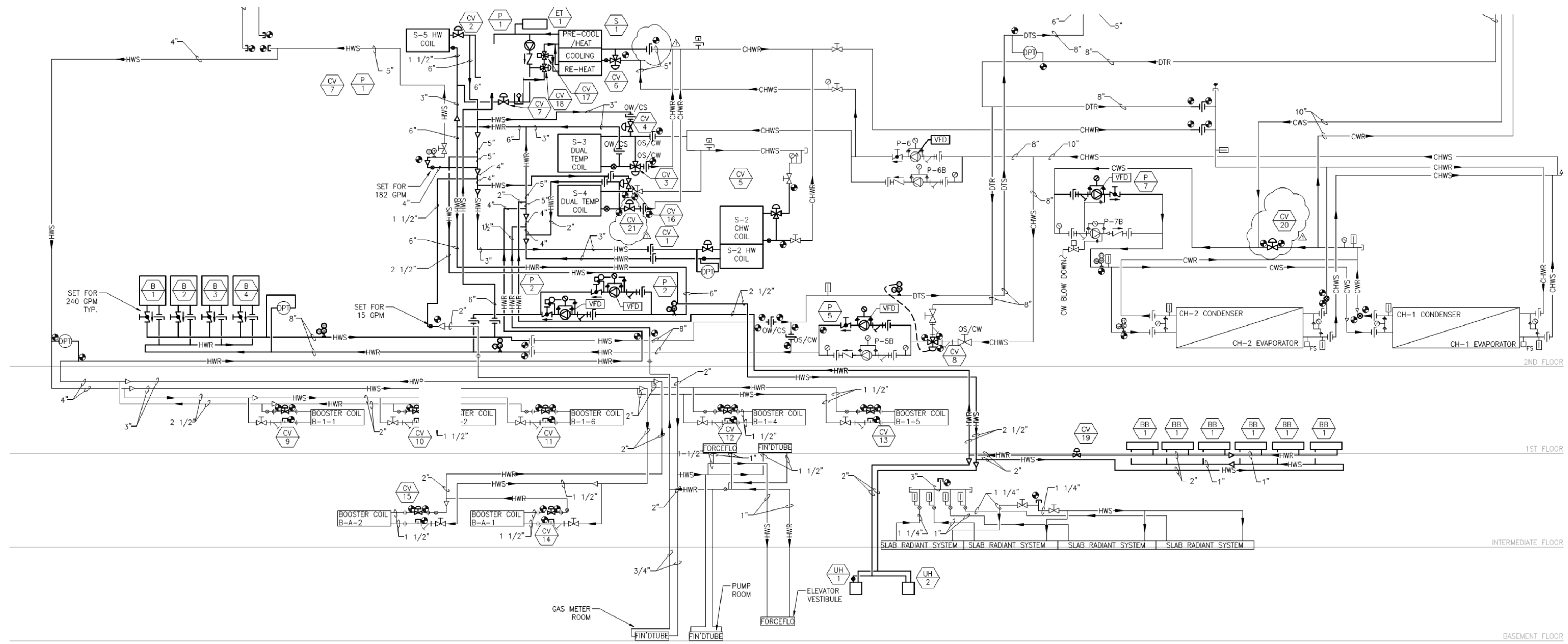
Cost Effectiveness: Conversion of the main floor's air delivery systems from conventional induction units to chilled beam allowed for reduced retrofit costs. Because the new system was able to re-use the dual temperature piping layout, it eliminated extra construction costs. Removing the wall-mounted induction units also allowed the perimeter to be exposed and retrofitted with insulation for enhanced building thermal resistance at little cost. Installing variable drives on all mechanical system pumps and fans throughout the building helped to significantly reduce associated utility costs. Additionally, over $150,000 in utility rebates were procured through the energy savings demonstrated by the functioning systems.

Environmental Impact: The selection of high-efficiency condensing boilers with low NO_x burners reduced the amount of harmful emissions ejected to the environment. Gas and electricity savings are also a result of the mechanical upgrade project, thereby reducing overall carbon emissions. The carbon emission reduction estimated for this project is equivalent to CO_2 emission from 96 passenger vehicles.

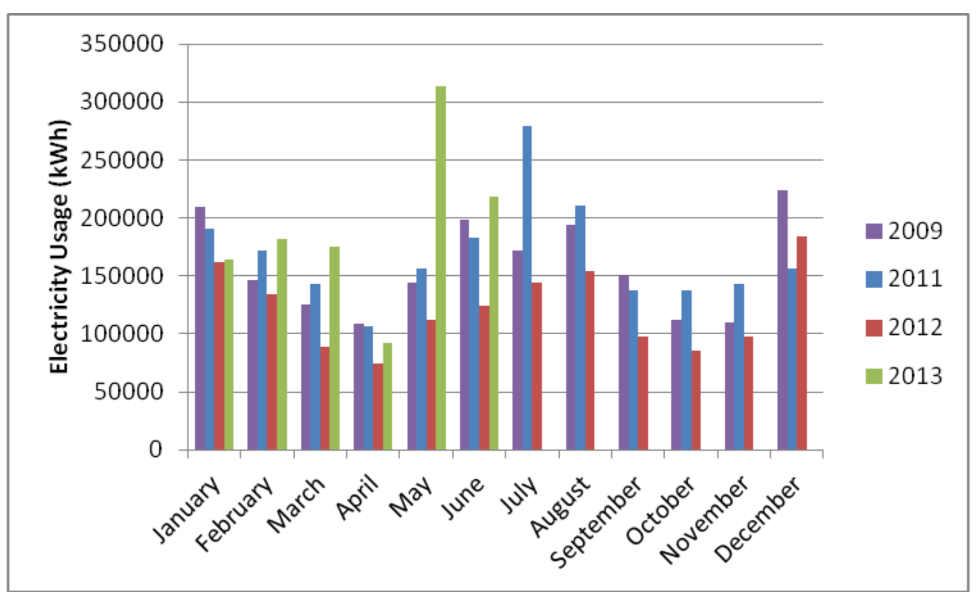
Results:

The most dramatic result of this project is in its energy savings. However during implementing of this project the building occupied areas increased from 40% to 95%, the new upgrades on the building's mechanical systems still allow for a utility cost savings. An energy intensity comparison between the previous mechanical systems and the newly commissioned, high-efficiency systems show a clear reduction in energy usage throughout the building. By using the course of 42 months given the available utility data, the new design reduced the usage intensity from

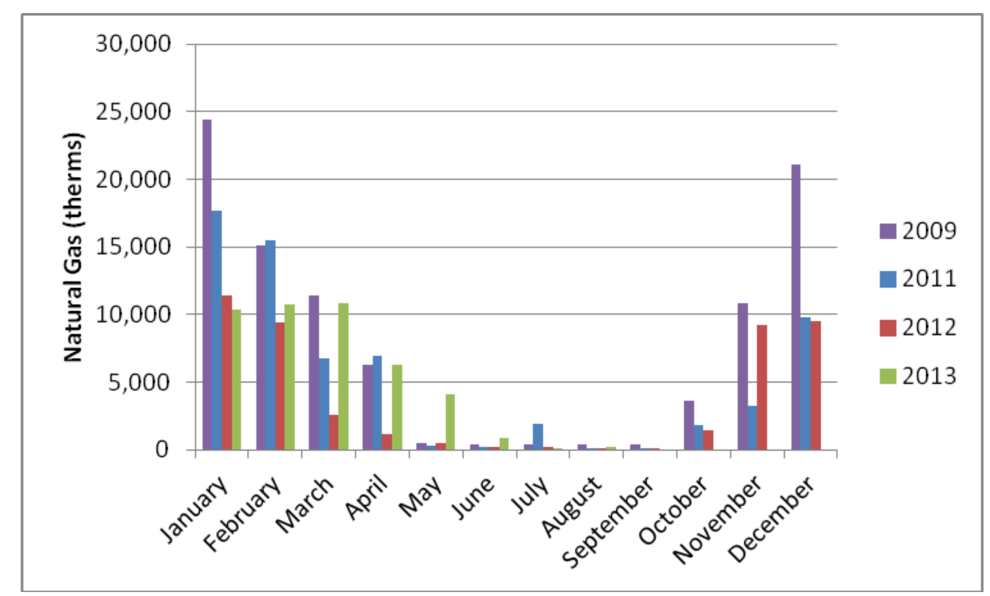
113 kBtu/ft^2 in 2009 when the building was just 40% occupied down to 81 kBtu/ft^2 in 2013 while the building is 95% occupied -- a reduction of 28% no matter the occupancy of building almost doubled since 2009. This results in an Energy Star score of 88 for building and translates into an electrical energy reduction of almost 417,000 kWh per year along with a natural gas energy reduction of 31,000 therms per year. The energy usage over the course of a full year were monitored and revealed that the new system performs at \$1.03/ft^2 versus \$2.33/ft^2 on the old system – a reduction of 50%. Perhaps more valuable results than utility cost savings are the avoided costs such as future equipment repair, increasing maintenance burdens and further damage to the mechanical infrastructure. Although these costs can not be immediately measured, they are undeniable savings. Finally, this project had many immeasurable ancillary benefits such as reduced noise, improved occupant comfort, reduced maintenance, improved indoor air quality, and reduced carbon emissions.



Mechanical Room Piping Schematic



Historical Electrical Energy Consumption*



Historical Natural Gas Energy Consumption*

29 N. Wacker Renovation Project

**It is noted that the building were 40% occupied in 2009 and the occupancy rate went up during 2009 to 2013. In 2013 the building is 95% occupied.*