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Improved Comfort at Lower Cost Achieved at 180 East Pearson

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Ventilation systems are critical for indoor air quality, comfort and building pressure balance. Typically, these systems are one of the highest energy consumers in a building. This was especially the case at The Residences at Water Tower Place, a high-end Condominium Association located on the upper 40 floors of the famous Water Tower Place shopping mall in downtown Chicago, where the building ventilation system was contributing to significant pressurization issues and extremely high utility costs.

The Association hired Elara Engineering to review the ventilation system to identify opportunities to improve performance and reduce energy consumption while meeting the building's desired standard of occupant comfort.

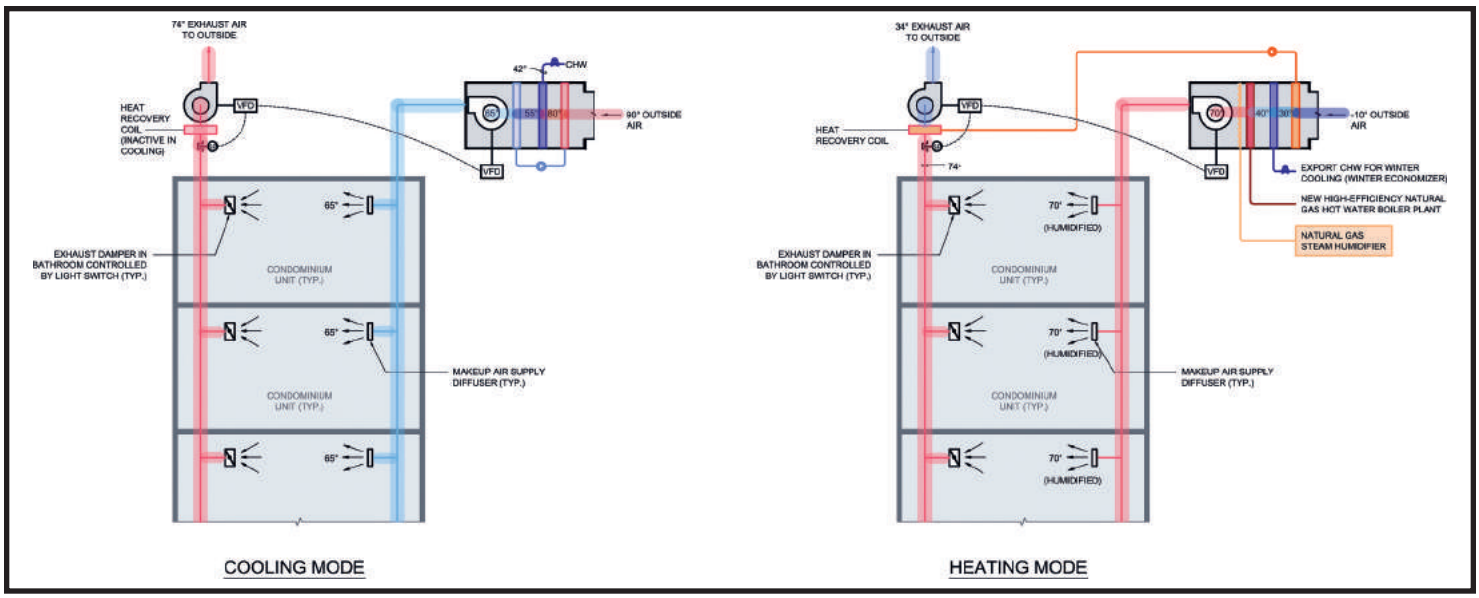
After completing a holistic review of the existing ventilation systems, Elara recommended a two-fold approach to improve the building ventilation: first was to intelligently control building exhaust and makeup air and second was to optimize the makeup air unit operation. This approach resulted in a 50% reduction in building energy costs while at the same time, improving occupant comfort through added humidification and improved building pressurization.

High Rise Ventilation System Overview

Ventilation is a key component to maintaining a healthy and comfortable building. In high rise condominium buildings ventilation is typically accomplished by exhausting air directly from the condominium units through toilet, kitchen, and dryer exhaust systems. However, exhaust systems alone are not sufficient to provide proper ventilation because this exhaust air must be replaced. If there is no mechanical means to replace exhaust air the air will be pulled into the building through entry doors, windows, and cracks in the façade; contributing to building conditions such as stack effect and negative pressurization. Proper ventilation systems "make up" this exhaust air with a central air supply unit referred to as a Makeup Air Unit (MAU). MAUs heat, cool, humidify and/or dehumidify outside air to comfortable conditions before supplying it directly to condominium units or common corridors.

Intelligent Ventilation Control

The first step to improve the ventilation systems at The Residences at Water Tower Place was to manage the exhaust and makeup air quantities. Exhaust from kitchens and bathrooms is necessary to remove odors and introduce outside air into the condominiums; however, fully exhausting from these spaces when they are unoccupied is unnecessary and wastes energy condi-



tioning and transporting makeup air that is not required. A more intelligent system design, often referred to as Demand Controlled Ventilation, includes dampers behind each condominium unit's exhaust grilles. These grilles open when exhaust is required, such as morning and evening times when bathrooms and kitchens are most occupied, and close to stop (or reduce) the airflow when exhaust is no longer needed, such as the middle of the day or late at night when these spaces are often unoccupied. This type of system was implemented at The Residences at Water Tower Place.

This simple change provided numerous benefits:

1. **Reduced Fan Power –** When the exhaust dampers close the exhaust fans are not required to provide as much airflow. With the addition of Variable Frequency Drives (VFDs), the fan motors reduce speed during times of reduced airflow to save significant energy. Fan power has a cubic relationship with airflow, meaning that a reduction in airflow of only 20% translates to almost a 50% reduction in fan power.

2. **Improved Building Pressurization –** Many buildings, including The Residence at Water Tower Place, suffer from negative building pressurization where more airflow is exhausted from the building than is supplied by the makeup air system. Negative building pressure leads to air and water infiltration (which often accelerates façade deterioration), drafty conditions, stack effect, and can even make it difficult to close doors and cause issues with general elevator operation. Intelligently modulating the exhaust airflow according to demand diversity improves the building's pressure balance and helps mitigate or eliminate many of the issues associated with negative building pressure.

3. **Reduced Makeup Air –** The most significant building impact associated with reducing exhaust airflow actually occurs in the makeup air system. If the total exhaust airflow is reduced below the amount supplied by the MAU, the MAU can also reduce its airflow through the use of VFDs to match the exhaust airflow and maintain a neutral building pressure. This leads to energy benefits through fan power reduction. However, the greatest energy savings are achieved because of the reduced volume of outside air that must be heated, cooled, humidified, and/or dehumidified. Even if the makeup air cannot be reduced due to building pressure imbalances, the energy required in the condominium units to condition the infiltration air will similarly be reduced due to reduced infiltration of outside air.

Optimize Makeup Air Unit Performance

Once the building's exhaust and makeup air systems were operating intelligently through Demand Controlled Ventilation, the next step in the process was to improve the makeup air unit (MAU) serving The Residences at Water Tower Place. The existing MAU conditioned the outside air using electric resistance heating in winter and a chilled water coil with electric reheat for cooling/dehumidification in summer. The building also had an electric steam humidifier that was disabled due to the high cost of operation.

Elara designed the new makeup air system to provide improved levels of comfort throughout the year while using only a fraction of the energy. This was accomplished by converting the ventilation system to an intelligently controlled demand orientated system, converting all the electric heat to gas, and adding three forms of heat recovery.

The following is a more detailed description of these strategies in each mode of operation (refer to schematics as well):

MAU Winter Operation

1. **Exhaust Heat Recovery –** In both the high and low ventilation zones for The Residences at Water Tower Place there were large central exhaust fans located in close proximity to the MAUs; meaning that large quantities of warm, conditioned air were being removed from the building only a few feet from where cold outside air was being introduced into the building. An exhaust heat recovery system, consisting of only some small pumps, piping, and coils was designed and implemented by Elara to recover heat from the exhaust air to preheat the incoming makeup air. With this system, the makeup air heating load is reduced by 50% using "free" transferred heat from the exhaust.

2. **Cooling Coil Economizer –** The Residences at Water Tower Place requires the availability of cooling to the condominium units all winter. Previously, the chilled water plant in the base building would send this chilled water to the Association and the Association would reimburse the base building for the cost of chilled water production. However, as part of this project we re-configured the MAU to use cooler outside air that needed to be heated in winter as a cooling source to simultaneously add additional heat to the MAU to further reduce the external heat needed for the system. This was another form of heat recovery implemented on this project that reduced winter chilled water cost and reduced winter make up air heating cost.

3. **Electric to Gas Heating Conversion –** Utilizing electric resistance coils for heating is the most energy intensive and least sustainable form of heat available today. By replacing these coils with hot water coils served by a new high efficiency natural gas fired boiler plant, heat is provided at one-third the cost of electric resistance. Additionally, the previous MAU often failed during the coldest outdoor conditions due to the freeze's thermostat tripping to further exasperate infiltration and stack effect issues. Post retrofit, all of these issues have been resolved with significantly lower operating cost.
4. **New Gas Humidifiers –** The existing MAUs were originally equipped with electric humidifiers to add humidity to the air during the dry winter months for comfort. However, due to high cost of operation, these humidifiers had been non-operational for several years causing the humidification load to be carried by small humidification units located within many of the condominiums. New gas-fired humidifiers were installed with a new Reverse Osmosis water treatment system as part of the MAU upgrade project to restore humidification capabilities to the central makeup air system. The benefits of this new humidification system included better control of the humidity in the building and substantially reduced operating cost and maintenance cost of individual electric humidifiers in each unit.

MAU Summer Operation

1. **Runaround Heat Recovery Loop –** To provide proper dehumidification to the makeup air system during summer, the air must be overcooled to draw out the humidity and then, reheated to prevent overcooling of the corridors. Previously, this was accomplished for The Residences at Water Tower Place using MAU cooling coils and electric resistance reheat coils, which is a very energy inefficient process. The newly installed MAUs are instead equipped with a three coil design and a runaround heat recovery loop. On warm, humid days, the outside air is pre-cooled by the first coil, further cooled by the cooling coil to remove humidity, and then reheated by the third coil using heat recovered from the first coil. This process reduces the system cooling energy and utilizes "free" recovered heat for heating to substantially reduce the energy required for the dehumidification process while maintaining the same high level of occupant comfort.

Summary

The case study described above for The Residences at Water Tower Place is a real-life example of how a high level of comfort can be achieved in an existing building without sacrificing energy efficiency and operational cost. By advocating a holistic approach to the building's ventilation system, Elara was able to maximize both the effectiveness and energy efficiency of the ventilation systems while also replacing aged equipment. The project has exceeded expectations and has saved the building over $210,000 during the time period measured from October 2016 to May 2017.