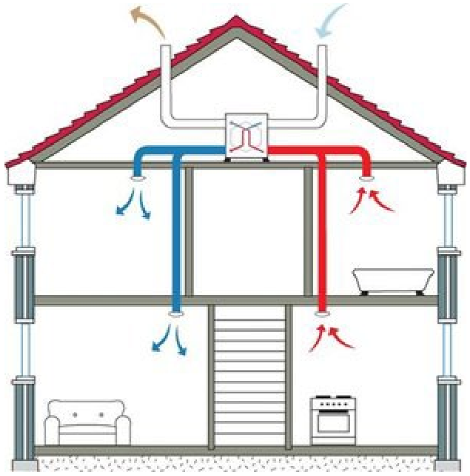
BASIS OF DESIGN

VENTILATION

WHEN TO USE THIS BASIS OF DESIGN SECTION:

This BOD section should be referenced and applied in all new construction projects as well as any projects involving work on ventilation components or systems in POAH developments. This section should also be referenced during planning activities to guide the scope of pending renovation to existing buildings.



Ventilation has significant impact on resident health, resident satisfaction with the living environment and on building energy use. Historical building ventilation approaches are unlikely to provide appropriate ventilation in modern buildings or for modern expectations. It should not be assumed that new systems designed to meet current code standards will deliver effective and efficient ventilation in multifamily buildings.

WHY VENTILATE - GENERAL INFORMATION:

The purpose of ventilation is threefold:

1. to remove airborne contaminants,
2. to dilute airborne contaminants that cannot be effectively removed, and
3. to provide fresh air.

Removing airborne contaminants is the work of **source control ventilation** (ie range hood and bath exhaust fan). Diluting distributed airborne contaminants and providing fresh air is the work of **general background ventilation.**

Historically, buildings relied upon leaks in the building enclosure and open windows to provide ventilation. **Source control ventilation** is often ineffective in this approach. **General background ventilation** rates are neither controlled nor reliable. The random leaks of this approach bring severe detriment to comfort, energy costs and pest control.

More recently, the need for mechanical ventilation was recognized and exhaust fans were used to move air in and out of buildings. While providing more reliable **source control ventilation** and some control of **general background ventilation** rates, these systems still relied on a leaky building enclosure. The air exhausted from the building was replaced by air "leaking" back into the building. The "exhaust-only" approach affords no control of where the make-up air comes from. Instead of being fresh air, the make-up air for apartment exhaust may be drawn through building cavities and from neighboring apartments.

Today, our goal is to make our building enclosures air-tight and avoid reliance on random leaks. Therefore, ventilation systems need to include supply air. Balancing supply and exhaust air in a building supports good **indoor air quality (IAQ)** which is key to providing healthy homes. By removing carbon dioxide, contaminants produced in cooking activites, VOCs and excess moisture/humidity, the ventilation system improves indoor air quality and increases the long-term durability of the building by limiting the opportunity for mold/mildew growth.

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In substantial rehab or new construction, building codes will dictate the amount of fresh air to be supplied to buildings and units **(general background ventilation)**. They also establish the amount of air that needs to be exhausted **(source control ventilation)** from building spaces where airborne contaminants are often generated such as laundry and trash room, as well as kitchens and bathrooms within apartments. While codes dictate the volume rate of ventilation, the codes do not provide for ventilation effectiveness. For example, the code provisions do not ensure that intended fresh air actually reaches apartments nor that source control ventilation actually captures or contains airborne contaminants. The codes also do not require ventilation systems to be optimized for operation expense and energy use.

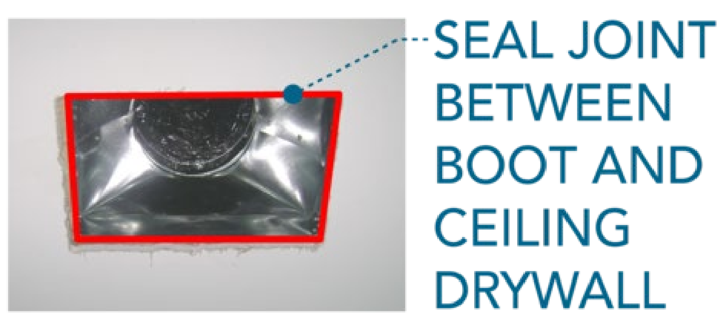
Because of this, POAH needs engineers for substantial rehab or new construction projects to design a ventilation system that is not only code compliant but also effective and energy efficient. The ventilation design will be reviewed by Design & Building Performance and the energy consultant (if applicable). The engineer will also be asked to provide data on ventilation system energy use, flow rates and other system parameters as means to demonstrate the energy efficiency and effectiveness of the design.

For property managers and maintenance staff replacing fans or roof top units, please use the preferred products highlighted below. If new equipment is being installed contact POAH for guidance.

REQUIREMENTS

DESIGN METRICS WILL BE MEASURED DURING AND POST CONSTRUCTION

- **DESIGN PROCESS:** As part of the design work, the mechanical engineer must provide projected energy consumption impact for any modification or new system to be installed. Energy consumption will be verified with energy data post construction.
- **DUCT TIGHTNESS:** When new ductwork is installed the duct leakage shall not exceed the sum of 2.5 CFM50 per register per shaft, and 2.5 CFM50 per floor per shaft during testing. Duct tightness will be measured during construction.
- **FAN EFFICIENCY:** Engineer to provide CFM/watt per specified equipment as well as for the ventilation system in aggregate. Fan efficiency will be measured during building commissioning.
- **AIR CHANGES:** Engineer to provide CFM/bedroom in terms of design ventilation flow to/from apartments as well as for the building ventilation in aggregate. Air flow will be measured during building commissioning.
- **VENTILATION SYSTEM LEAKAGE CONTROL:** For fans installed directly through wall or ceiling finishes (e.g. ceiling bath fan), the fan housing shall be sealed to the interior finish.
- **MOCK UP:** A mock-up must be completed to measure sone level of new fans + existing ductwork.



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PREFERRED STRATEGIES

*****ALL VENTILATION SYSTEM DESIGNS SHOULD BE REVIEWED BY THE DESIGN & BUILDING PERFORMANCE DEPT. USE OF STRATEGIES OTHER THAN THE PREFERRED STRATEGIES REQUIRE APPROVAL FROM THE DESIGN & BUILDING PERFORMANCE DEPT.*****

The sections below outline preferred and acceptable ventilation strategies. The strategies are arranged as follows:

APARTMENT OR IN-UNIT VENTILATION STRATEGIES:

- Apartment Source Control Ventilation
- Apartment Background Ventilation

COMMON AREA VENTILATION STRATEGIES:

- Common Area Source Control Ventilation
- Common Area Background Ventilation

EXISTING CONDITION STRATEGIES:

- Existing Conditions Ventilation

APARTMENT SOURCE CONTROL VENTILATION

BATHROOM EXHAUST:

- **Every bathroom must exhaust to exterior by using one of the following systems:**
  - exhaust fan in the ceiling vented to exterior
  - or, exhaust grill connected to a roof top fan that exhausts to exterior
- Fans should be low noise. **Sone (measurement of sound) should be 0.9 maximum.**
  - Please evaluate ductwork. The low sone cannot be achieved if ductwork is loose, or uninsulated. Exhaust ductwork
    should also be as short and straight as possible, minimizing the number of bends and angles. If flexible duct is used, the flexible duct shall be pulled taught and excess duct length shall be eliminate.
  - A mock-up must be completed to measure sone level of new fans + existing ductwork.

- Bathroom exhaust fans should **run continuously at a low CFM (~30) and be capable of boosting to higher CFM** when switched on. The low speed setting is typically set at the fan. By running the fan at a low speed continuously the humidity can be controlled in the space without resident intervention. Excessive humidity leads to mold.
  - The boost capability shall include a "delay-off" operation whereby the fan continues to operate for an additional ~15 minutes after the boost is turned off.

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- In order to provide separate background and boost capabilities, there must be two wires to the fan. If the project is a simple fan replacement with no re-wiring, the separate boost capability may be achieved through a special wall switch or controller at the switch box. Contact POAH Design + Building Performance for other options.
- The cost to run a bath fan continuously cost less than $3 dollars a month at ¢10 cents a kWh.
- There are add-on modules for the Panasonic fan that can be used instead of continuously running. Occupancy sensors and timers can be programmed to help manage humidity and insure long term durability and good IAQ.
- Airtightness measures:
  - Use mastic or tape to seal any gaps between the ductwork and/or fan housing before installing fan or grill.
  - Seal between ductboot and sheetrock.
- After installation the fan should be measured to confirm appropriate draw.

BATHROOM EXHAUST THROUGH SHARED EXHAUST RISER AND ROOF-TOP FAN:

This approach generally employs continuous exhaust flow to achieve source control of excess humidity and odors. Where a shared exhaust riser and roof-top fan are used to provide continuous exhaust from apartment bathrooms, POAH prefers the following measures:

- Seal the shaft to 5cfm at 50 Pascals per floor or less
- Install constant air flow regulators (CARs) for each exhaust intake grille to control exhaust flow rate provided
- Install direct drive exhaust riser fan with barometric control to maintain duct pressure within parameters for CAR operation.

SAMPLE PRODUCTS:

Panasonic
WhisperGreen Select
CFM: 30 - 110
Sone: 0.3 - 0.8
CFM/Watt: 11.5 - 15.1
Manufacturer Number:
FV-05-11VKS1

Panasonic
WhisperSense

Motion/Humidity Sensor
CFM: 80
Sone: 0.3
CFM/Watt: 5.1
Manufacturer Number:
FV-08VQC5

MAINTENANCE:

- Fan should be cleaned every year at minimum:
  - Grill only: Remove register and clean. Clean inside reachable ductwork.
  - Fan: Remove dust and dirt from the fan body using a vacuum, a dirty fan can cause noise issues and loss of efficiency.

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KITCHEN EXHAUST:

Building codes allow for kitchen exhaust ventilation to be either 1) intermittent or 2) continuous. Intermittent kitchen exhaust is preferred as it 1) provides for more effective source control (capture efficacy) and 2) results in less aggregate ventilation load.

Codes also allow for kitchen exhaust through either a capture hood over the cooking appliance or through a general area exhaust grille located in the cooking area. The capture hood is preferred as this approach has the potential for reasonably effective capture efficacy of cooking effluent. The general area exhaust is not effective.

- **Every kitchen must exhaust to exterior by using one of the following systems:**
  - Range hood with integral fan exhausted directly to exterior
  - or, range hood connected to a shared exhaust riser served by a rooftop fan exhausted to exterior
- Sone sound should be maximum 7.
- Kitchen exhaust fan ductwork should never terminate into attic space.
- Kitchen exhaust fan should include back draft damper.
- CFM rating should be minimum 100.
- Assist capacity required for buildings 3 stories and above. May be accomplished using an In-line fan or a roof top unit (RTU).
- Range hood should be deep enough that Range Queen, when installed, is not visible. Range Queen Product information is found within the Rangehood BOD section. See link below.

SAMPLE PRODUCTS:

Sample products are located in the **RANGEHOOD** page of the **APPLIANCES** section:

SEE SAMPLE RANGEHOODS HERE

https://www.poahbod.org/appliances#appliances-index-range-hood

MAINTENANCE:

- Range hood should be cleaned every year at minimum:
  - Clean grille.
  - Clean filter.

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APARTMENT BACKGROUND VENTILATION

BALANCED VENTILATION WITH RECOVERY:

Balanced energy recovery ventilation (ERV) or heat recovery ventilation (HRV) is preferred in all climates excepting Climate Zone 2a. There are three different general approaches to providing this kind of background ventilation to apartments:

- Individual apartment ERV or HRV
- Floor-by-floor (or other sub-section of the building) ventilation with direct ventilation supply to each apartment
- Central ERV or HRV system with direct supply to apartments

INDIVIDUAL APARTMENT ERV OR HRV

Individual apartment ERV/HRV offers the advantage of apartment-level control, off-the-shelf products and minimized risk of cross-contamination between apartments. It brings the challenges of distributed in-unit equipment that requires periodic maintenance. Ventilation using a separate ERV/HRV for each apartment will require at least one through-wall penetration per apartment for the fresh air intake and stale air vent. However, this approach supports compartmentalization as vertical shafts between floors and penetrations through interior separations are not needed for general apartment ventilation.

SAMPLE PRODUCTS:

DUCTED ERV/HRV WITH CROSS-FLOW OR COUNTER-FLOW ENTHALPY/HEAT EXCHANGE CORE:
These systems will require one or more exterior wall penetrations per apartment. The ducting allows for distribution of ventilation air and can provide a degree of air mixing (to prevent stagnation) within the apartment. (The ventilation may also be integrated with heating and cooling ductwork, provided 1) proper design and controls are implemented to minimize air handler fan energy 2) allow ventilation distribution and 3) prevent short-circuiting of the ventilation supply to the stale air exhaust) If sized properly, these systems can provide bathroom source control ventilation. Typically installation of these systems will occur in soffits or a ceiling plenum in which to run ductwork as well as an area (e.g. upper part of closet) where the equipment could be located. The product shown is RenewAire.

ON THE HORIZON:
As of Spring 2017, two manufacturers are beginning to offer heat pump heat recovery units to the US market. These units offer ventilation and dehumidification with the ability to provide a modest amount of

heating and cooling. Once these products achieve a successful track record, they will offer an interesting solution for complete apartment-side conditioning and ventilation for low load buildings.

FLOOR-BY-FLOOR ERV/HRV

This approach can reduce or eliminate the need for vertical ventilation ducts in a building. Economies of scale can be achieved by sharing ventilation equipment among several apartments. These economies may afford the installation of high quality and highly efficient equipment. Some ventilation equipment may offer economizer capabilities to provide free cooling. This approach may present challenges in balancing the ventilation airflows to each apartment. If sized properly, these systems can provide bathroom source control ventilation. Maintenance requirements of the ventilation system are met without the need for access to apartments. This approach entails a challenge of routing ductwork horizontally through corridors (above the ceiling) and of crossing fire separation assemblies with ductwork. In existing buildings, the deck-to-deck height may not be able to accommodate horizontal ductwork along corridors.

CENTRAL ERV/HRV

This approach may be most suitable for existing buildings with existing exhaust and ventilation supply risers through the building. This approach allows for minimizing the number of penetrations through the exterior enclosure but will require many penetrations through assemblies within the enclosure. Economies of scale can be achieved by sharing ventilation equipment among several apartments. Larger and more sophisticated equipment may offer useful functionality such as enthalpy economizer functionality, variable speed demand control, etc. Typically, commercial-sized ERV/HRV equipment offers only modest recovery efficiency (note the exception of Ventacity with its exceptional performance). Maintenance and controls may require specialized skills. A central ERV/HRV will require vertical shafts through the building. This approach will present challenges in balancing the ventilation airflows to each apartment. In existing buildings, the deck-to-deck height may not be able to accommodate horizontal ductwork along corridors.

- Bathroom exhaust risers should be connected to the ERV/ HRV.
- Rangehood kitchen exhaust risers should NOT be connected to the ERV/ HRV due to grease buildup.

COMMON AREA SOURCE CONTROL VENTILATION

The following preferred strategies apply to trash rooms, janitor closets, elevator machine rooms and other areas outside of apartments where airborne contaminants are generated.

- Seal the shaft to 5cfm per floor or less (measured at 50 Pascals)
- Install constant air flow regulators (CARs) for each exhaust intake grille to control exhaust flow rate provided
- Install direct drive exhaust riser fan with barometric control to maintain duct pressure within parameters for CAR operation.

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COMMON AREA/CORRIDOR BACKGROUND VENTILATION

Preferred strategies will ventilate corridors as per the requirements of that space plus additional supply airflow commensurate with common area exhaust of spaces such as trash rooms, janitor closets, elevator machine rooms that are directly attached to the corridor. The ventilation design for new and renovation projects shall not employ the corridor as a make-up air plenum for apartment exhaust (unless the project is over 54 ft in height and is in Chicago where physics of air are different – hence "Windy City").

HALLWAY VENTILATION BY ERV/HRV:

Providing hallway ventilation by ERV or HRV will significantly reduce the thermal load of the hallway ventilation air. It will bring a slight increase in fan energy however this may be mitigated by high efficiency equipment.

- **NEW CONSTRUCTION:** do not install combustion equipment with an efficiency rating below 83%
- **REHAB:** do not install a new piece of equipment with an efficiency rating equal to or less than the efficiency rating of the unit it is replacing.

MAINTENANCE:

- The manufactures' guide should be followed for ongoing maintenance. Perform the following at least once a year:
    - Clean/replace filters regularly - typically 3 to 6 times a year depending on equipment.
    - Check belt drives for wear, tension, alignment, debris
    - Tension belt drives per manufacturer's directions
    - Clean motor and lubricate if necessary
    - Clean heating / cooling coils
    - Clear burner orifices

HALLWAY SUPPLY:

- Applies to buildings with corridors
- Across the portfolio the fresh air systems simply supply air into corridors with the expectation that the air will move through the gap below the door. This is against the code in most locations for fire and smoke reasons. It is also ineffective in making up air lost in kitchen and bathroom exhaust systems.
    - If replacing a make-up air unit, size only for the corridor ventilation and make-up of exhaust in directly attached building services such as laundry, trash rooms, elevator machine rooms, etc. This right sizing typically results in a significant reduction in capacity. Do not simply replace the MAU with an in-kind product.
    - Weather-strip all apartment doors.
- The air provided to common spaces is should be tempered or pre-conditioned.
    - The hallway supply may be tempered or "pre-conditioned" by energy recovery from other common area or apartment exhaust

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   - Cooling and dehumidification capacity should be provided for hallway supply ventilation systems in climate zones 5 or lower.
- Ideally ventilation system replacement work would not be completed on a component by component basis. In most of our properties it is preferred that the following occurs to update and drastically improve the performance, both from an indoor air quality and energy efficiency perspective, at one time
   - Air seal the existing ductwork
   - Right size the roof top exhaust fans with direct drive, ECM fans
   - Install CAR dampers at register locations or branch take-offs (only after ductwork is sealed. Applies to buildings 3 stories and above).
   - Right size the corridor MAU to the required hallway ventilation
   - Individual apartments shall be air sealed and compartmentalized (See Building Enclosure section).

MAINTENANCE:

- The manufactures' guide should be followed for ongoing maintenance. Perform the following at least once a year:
   - Clean/replace filters regularly – typically 3 to 6 times a year depending on equipment
   - Check belt drives for wear, tension, alignment, debris
   - Tension belt drives per manufacturer's directions
   - Clean motor and lubricate if necessary
   - Clean heating / cooling coils
   - Clear burner orifices

WEATHER-STRIP ALL UNIT ENTRANCE DOORS:

Independent of which common are ventilation strategy is used, all unit entrance doors need to be weatherstripped to maintain unit compartmentalization.

SAMPLE PRODUCT:

Q-Lon
Door Weatherstripping
at **Head and Jamb**
Polyethylene-clad urethane foam secured to a PVC carrier.

Pemko
Door Weatherstripping
at **Sill**
36" Fire-Rated Door Sweep Aluminum
Manufacturer Number: 307AV36

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EXISTING CONDITIONS

LAST AND LEAST FAVORABLE OPTION

If there is no feasible way to vent directly into units (ie because hallway ceiling height is too low), the following configuration may be allowed. If air is supplied to the corridor in equal (or more) volume to the volume of air exhausted from the apartment units, this is NOT a balanced system. Instead, it creates an unbalanced supply ventilation system for the corridors and an unbalanced exhaust ventilation system for the apartments. Supplying pre-conditioned, filtered outdoor air to the corridors only marginally improves the situation for the adjacent apartments with the unbalanced exhaust ventilation systems. In very few locations it is permissible to assume air supplied to corridors will enter units though an undercut door. Most fire codes don't allow this. This also eliminates any compartmentalization from unit to hallway.

The steps below are suggested for situations where direct ducted supply air to units or individual/HRV/ERV are not possible.

EXHAUST SYSTEM IMPROVEMENTS:

- Aero seal (or equivalent) all ducts. A big portion of what exhaust fans are pulling from the building is duct leakage. If you can substantially eliminate that, then you could meet the ventilation requirement with smaller equipment and have less air to “balance” on the other side.
- Bathroom exhaust: this can be continuous. This can be the background ventilation for the apartment as well as the source control for the moisture and odor generation in the bathroom. Typically, for anything larger than a studio, the background ventilation rate for the apartment will be larger than the required continuous duty source control needed for a bathroom. Use a constant airflow regulator, sized to the apartment, behind the bath exhaust grille.

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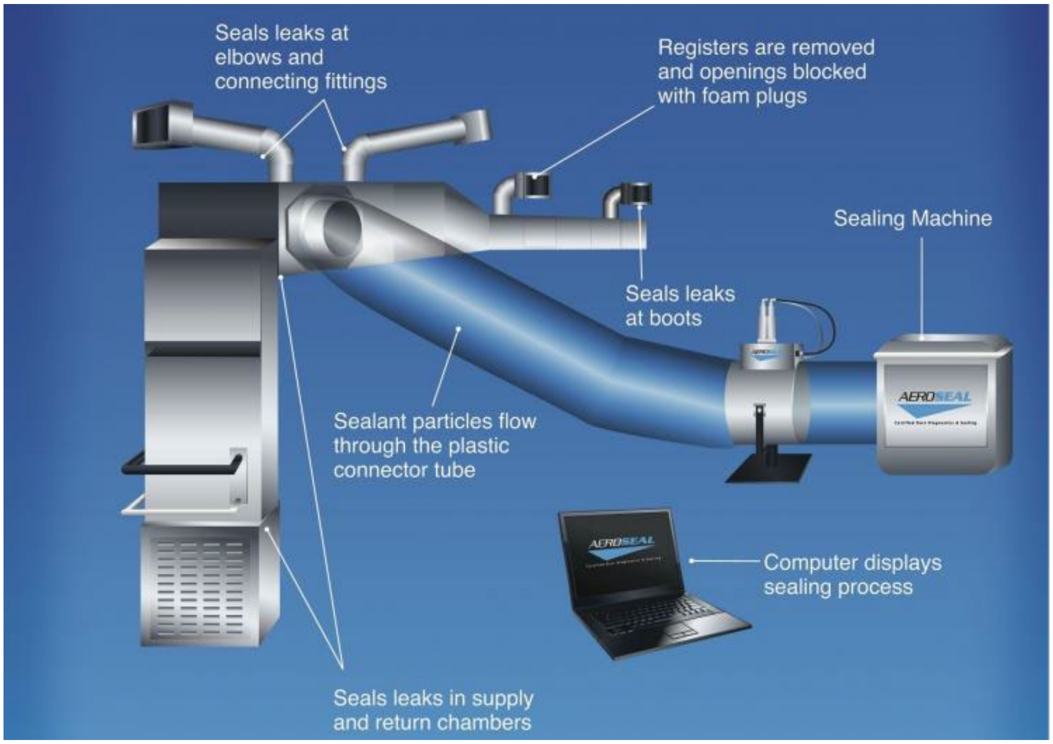

- Kitchen exhaust changes from continuous to intermittent through a range hood. This requires fan powered range hoods. 150-200 cfm of exhaust at a range hood with good capture efficacy can remove odors and contaminants (moisture, heat, fine particles, NOx, SOx, etc) reasonably well. Kitchen exhaust through a grille on the wall of a kitchen is really not much better than cracking a window in the living room. The intermittent exhaust will yield a MUCH lower 24/7 average exhaust rate, (more effective contaminant capture and much less energy use). If an engineer insists on making up this intermittent range hood exhaust flow (150-200 cfm per range hood) make sure a realistic diversity factor is used and that the supply is either averaged over 24hr period or the supply ventilation can ramp up during periods of peak range hood use and then back down. The riser fan should be variable speed and controlled by a barometric sensor in the exhaust riser. Maintain a slight negative in the exhaust riser so that exhaust goes up the riser and not back-flow into another apartment. Not too negative because we don't want range hoods to continually suck at each kitchen. This approach will not work unless ducts are sealed between units and between unit and corridors.
- Compartmentalize between units and between unit and corridors. This will reduce the incidence of airborne stuff being exchanged between units and will make the air in the units and the source of make-up air more likely to be controlled.

With all of these improvements, there is now much less air being sucked out of the building. There would be less fan energy, better contaminant control, less thermal energy to heat the air drawn in by the exhaust, and smaller equipment on the roof.

SUPPLY SYSTEM IMPROVEMENTS:

Supply fresh air to the corridors based on square feet and CFM exhausted from corridor ventilation (something like 6 cfm per 100 sf), trash rooms, janitor closets and elevator machine rooms (if the ventilation supply rate to the corridor is more than the exhaust from connected trash rooms and such, then you shouldn't need to bump up the supply). The design supply ventilation rate drops to about 1/5 or less of what it previously was.

More likely, you're to have a situation (especially in Chicago if the building is over 53ft high) where engineers insist on supplying to the corridors an equal volume to the exhaust from the apartments. This is far from optimal and in no way represents a balanced system.

1. Aero seal (or equivalent) all supply ventilation shafts. A big portion of what supply fans are pushing into the building is not making it to the supply diffusers/grilles. If you can substantially eliminate the leakage, then you could meet ventilation requirement with smaller equipment and have less air to precondition at the building owner's expense.
2. Gather the apartment bathroom exhausts to an ERV that will pre-condition the supply ventilation air. Use a high efficiency ERV (ex: Ventacity) so that the ventilation air is delivered at close to neutral temperature.
3. Carefully balance the supply rates at each grille and periodically re-balance or use CAR devices.
4. Separate heating and cooling from the ventilation air. There is no need for a furnace/DX RTU. Use an ERV that can be carried through a roof hatch or the roof access door.
    - Use fan coils or other heating or cooling in corridors. Source in each corridor making each corridor its own zone (or pair of zones).
    - Dehumidification should be provided. It could be provided either through the central ventilation unit or with the corridor heating and cooling units.

Again, the unit entry doors should be gasketed and weather stripped. And so should doors to stairs, doors to trash rooms, doors to elevator lobbies…