

# **INDOOR AIR QUALITY IMPROVEMENT STUDY**

DECEMBER 18, 2020

**Perkins&Will**

## BMHS BUILDING HVAC DESIGN

- Primary focus of building HVAC systems design was the reduction of energy use, with the goal of achieving a Zero Net Energy building.
- Ventilation design per MA code and meets LEED requirements
- Ventilation design is in line with similar high performance schools

## IMPROVING INDOOR AIR QUALITY IN RELATION TO PANDEMICS

- Increase amount of outside air wherever possible
- Increase filter efficiency
- Modify controls/systems to be able to flush out spaces
- Introduce technologies to break down contaminants

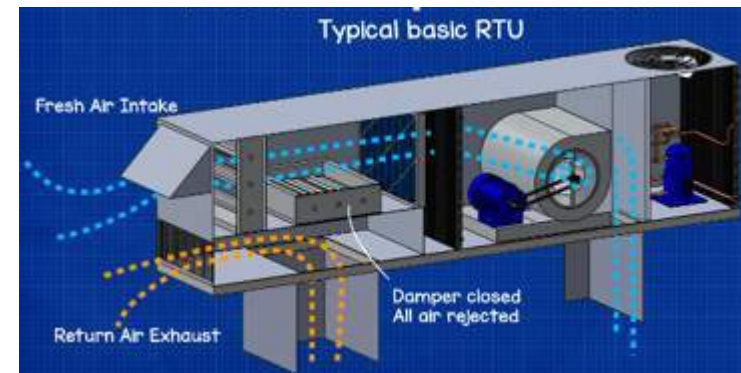


## HVAC SYSTEM DESIGN

## BUILDING HVAC SYSTEM TYPES

### Mixed / Recirculation Systems

- Auditorium/ Stage/ Commons
- Black Box/ Music
- Field House/ Small Gym
- Pool



## CURRENT SYSTEM NOTES

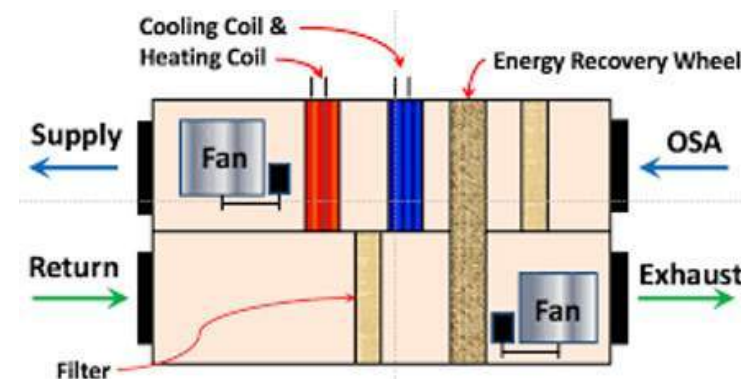
- Ventilation rates in excess of code requirements
- Currently have MERV 13 filters

## POTENTIAL STRATEGIES

- Increase filter to MERV 14
- No Demand Control Ventilation (DCV)
- Extended Hours of Operation
- Increased Outdoor Air
- Bipolar Ionization

### Dedicated Outside Air Systems

- Classrooms
- Administration Offices
- Fitness
- Locker Rooms

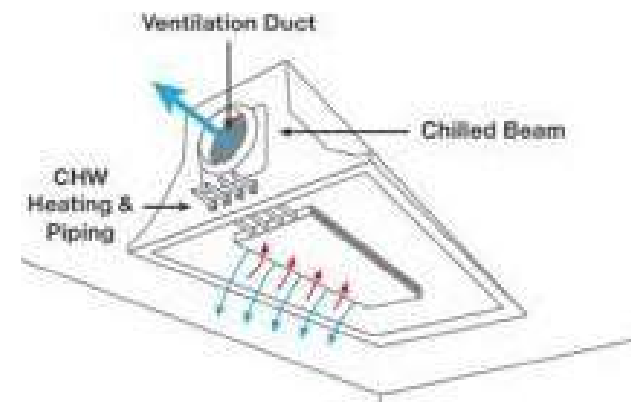


- Ventilation rates in excess of code requirements
- Currently have MERV 13 filters

- No Demand Control Ventilation (DCV)
- Extended Hours of Operation
- Increased Outdoor Air
- Bipolar Ionization

### VAV/ Chilled Beam Units

- Classrooms
- Media
- Work/ Group Spaces



- Optimal energy saving system
- Very quiet
- No filtration at chilled beam

- No Demand Control Ventilation (DCV)
- Extended Hours of Operation
- Bipolar Ionization

### Admin. VRF Fan Coil Units

- Ducted Fan Coil Units
- Ductless Ceiling Cassettes



- Currently have MERV 8 filters (ducted units)
- Allows to operate independent of main system in summertime

- Increase filter to MERV 13
- No Demand Control Ventilation (DCV)
- Extended Hours of Operation
- Bipolar Ionization

## HVAC IAQ IMPROVEMENT STRATEGIES

## CONTROLS STRATEGIES

### No Demand Control Ventilation (DCV)

- Override of demand control ventilation within the spaces to provide the maximum amount of fresh air regardless of space occupancy.
- This strategy can be effective for providing additional fresh air to flush out spaces and lower contaminant concentrations within spaces.

### Extended Hours of Operation

- Run the ventilation systems 2 hours prior and post occupancy.
- Allows for additional space flush out before and after the school day, and applies to all of the systems

### Increased Outside Air Ventilation

- Increase the amount of outside air provided for the mixed air systems.
- An effective amount of outside air can be provided when outside air conditions are optimal and also if slightly warmer or cooler space conditions are allowed. Only applies to the mixed air systems.

## EQUIPMENT STRATEGIES

### Increase System's Filter Efficiency

- Increase unit final filters from MERV-13 to MERV-14. Increase the VRF Fan Coil units filters from MERV-8 to 2in MERV-13 type filters.
- Can increase the effectiveness for the capture of small particles from 75% to 90%. Comes with slight energy penalty due to higher pressure drop across the filter.

### Add portable air purifiers

- Provide portable air purifiers that include HEPA type filtration (IQAir HealthPro Plus or equal)
- Air purifiers with HEPA filtration effectively capture small particles up to over 99%. Would require periodic changing of numerous filters.

### Add Bipolar Ionization

- Install duct mounted bipolar ionization devices at each single zone air handling unit and at each VAV terminal unit
- Bipolar ionization is very effective at breaking down viruses. Provides heavy particles for the virus to adhere to. This forces the heavier particles to drop out of the airstream and particles that remain are more effectively filtered.



*Portable Air Purifier*



*Bipolar Ionization Applied to Duct*



*Bipolar ionization Bar*

## HVAC IAQ IMPROVEMENT STRATEGIES

	Total Energy (MMBtu)	% Difference	Total Cost (\$)	% Difference	EUI
PROPOSED DESIGN	13,447	0.0%	662,857	0.0%	29.9
No DCV	14,313	-6.4%	705,371	-6.4%	31.8
No DCV + Ext Hours	15,794	-17.5%	769,767	-16.1%	35.1
INCREASE OA	13,626	-1.3%	672,368	-1.4%	30.3
No DCV + Ext Hours + Inc OA	16,065	-19.5%	784,065	-18.3%	35.7
BIPOLAR IONIZATION	13,448	0.0%	662,912	0.0%	29.9
STANDALONE AIR PURIFIERS	13,743	-2.2%	675,310	-1.9%	30.5

### Energy Model Study

- Based on the strategies available, individual study cases were established to compare to the baseline of the current energy model
- Controls strategies are identified as separate options as well as combined if all three are implemented.

### Energy Model Results

- Bipolar and Air Purifiers have little to no impact on energy use
- Increase of Outside Air has minimal impact due to limited allowable systems
- No Demand Control and Extended Hours of operation have biggest impact due to affecting all systems

## STRATEGIES ENERGY MODEL RESULTS

Evaluation Cases	Number of Wells	Peak EWT				Average EWT			
		Max. Peak EWT (°F)	@ Month	Min. Peak EWT (°F)	@ Month	Max. Ave EWT (°F)	@ Month	Min. Ave EWT (°F)	@ Month
Design Case – Jan. 2020 100% CD Loads	280	85.5	357	45.5	1	72.2	357	50.4	1
Baseline - Proposed Nov. 2020	280	80.3	357	45.8	1	69.2	357	50.5	1
Case 1 - Proposed - No DCV	280	79.4	357	45.5	1	68.7	357	50.2	1
Case 2 - Proposed - Ext Hrs + No DCV	280	73.7	357	44.6	1	63.7	357	49.0	1
Case 3 - Proposed - Increased OA	280	79.1	357	45.5	1	68.0	357	50.2	1
Case 4 - Proposed - Ext Hrs, No DCV, Inc OA	280	72.4	357	44.3	1	62.0	357	48.6	1

Consumption (MMBtu)						
CASES	Jan 2020 100% CD Loads	Baseline - Proposed November 2020	Case 1- Proposed - No DCV	Case 2- Proposed - Ext Hrs + No DCV	Case 3 - Proposed - Increased OA	Case 4 - Proposed - Ext Hrs, No DCV, Inc OA
CHW LOOP	5254	4743	4,897	5185	4783	5,251
HW LOOP	(3792)	(3966)	(4,393)	(6397)	(4349)	(6,987)
POOL HTG LOOP	(977)	(761)	(761)	(761)	(761)	(761)
DHW LOOP	(297)	(296)	(296)	(296)	(296)	(296)
Cooling Load on Well Loop	330	408	408	556	406	553
Balance	518	128	(146)	(1714)	(218)	(2,239)

### Geothermal Wellfield Study

- The hourly loads for each case provided by the energy model results were processed for wellfield modeling to evaluate the potential impacts to the performance of the geothermal system.

### Geothermal Model Results

- Maximum peak EWT for cooling mode is reduced when the load balance improves or shifts from cooling dominant to heating dominant. (Max. allowable 85.5°F)
- The minimum peak EWT values for heating in the proposed cases reduce slightly or stay the same to the Design Case, but are still above the specified minimum EWT limit (40°F)
- The proposed cases have no impact on the design of the geothermal well field, and in some cases improve the balance of the system. Both the max. and min. peak EWT for all proposed cases are within the EWT constraints specified.

## GEOTHERMAL WELL MODEL RESULTS

	IAQ Improvement Strategy	Description	Effectiveness	Energy Use Intensity (EUI)	EUI Delta from Current Design (%)	Effect on Geothermal Well Field	Operating Cost (Annual)	Operating Cost Delta from Current Design (%)	Additional Estimated Capital Cost	Additional Estimated Design Fee
	<b>Current Design</b>			29.9	N/A	No Impact	\$662,857	N/A	None	None
1	<b>Add Portable Air Purifiers</b>	Provide portable air purifiers that include HEPA type filtration (IQAir HealthPro Plus or equal) Provide 2 units each classroom up to 1,200sf. Provide 1 units for small spaces up to 600sf	Air purifiers with HEPA filtration effectively capture small particles up to over 99%. Units are set at middle/low setting for acoustic purposes. For small to medium sized rooms, such as offices and classrooms, this is an effective way to increase air quality. For large spaces will require a large number of units.	30.5	2.2%	No Impact	\$675,310 \$120,000 additional per yr to change filters (400 units)	1.9%	\$475,000 (includes Skanska markups)	None
2	<b>Increase System's Filter Efficiency</b>	Increase unit final filters from MERV-13 to MERV-14. Increase the VRF Fan Coil units filters from MERV-8 to 2in MERV-13 type filters. Possible to swap out filter types only when needed, instead of always using the higher efficiency filters.	Increasing the unit filters to MERV-14 can increase the effectiveness for capture of small particles from 75% to 90%. This comes with a slight energy penalty due to higher pressure drop across the filter. For the ducted VRF units, increasing the filtration to 2" MERV-13 filters will greatly increase the effectiveness of the terminal units. This will have slight effect on airflow due to larger pressure drop.	Minimal Impact	Minimal Impact	No Impact	Minimal Impact \$20,000 additional premium annually for filters	Minimal Impact	\$25,000	None
3a	<b>No Demand Control Ventilation (DCV)</b>	Override of demand control ventilation within the spaces to provide that maximum amount of fresh air regardless of space occupancy. Can implement the ability and use as needed, instead of all the time (i.e. pandemic mode)	This strategy can be effective for providing additional fresh air to flush out spaces and lower contaminant concentrations within spaces.	31.8	6.4%	Improves balance between ground heating and cooling	\$705,371	6.4%	\$15,000	\$1,500
3b	<b>No DCV + Extended Hours of Operation</b>	Override of DCV noted above Run the ventilation systems 2 hours prior and post occupancy. Can implement the ability and use as needed, instead of all the time (i.e. pandemic mode)	The extended hours strategy applies to all of the systems. Allows for additional space flush out before and after the school day.	35.1	17.5%	Improves balance between ground heating and cooling	\$769,767	16.1%	Included in cost of Option 3a	\$1,500
3c	<b>No DCV + Extended Hours of Operation + Increased Outside Air Ventilation</b>	Strategy includes the two strategies noted above Increase the amount of outside air provided for the mixed air systems. Can implement the ability and use as needed, instead of all the time (i.e. pandemic mode)	The increased ventilation strategy only applies to the mixed air systems capable of economizer mode. An effective amount of outside air can be provided when outside air conditions are optimal and also if the allowable temperature conditions can allow for slightly warmer or cooler space conditions.	35.7	19.5%	Improves balance between ground heating and cooling	\$784,065	18.3%	Included in cost of Option 3a	\$1,500
4	<b>Bipolar Ionization</b>	Install duct mounted bipolar ionization devices at each single zone air handling unit and at each VAV terminal unit (for mult-zone units). Install duct mounted bipolar ionization devices at each ducted fan coil terminal unit. Provide needle-point type bipolar ionization units for each ductless fan coil terminal unit.	Bipolar ionization is very effective at breaking down viruses such as COVID-19 Provides heavy particles for the virus to adhere to. This forces the heavier particles to drop out of the airstream. Particles that remain in the airstream are more effectively filtered.	29.9	0%	No Impact	\$662,857	0%	\$600,000 Excludes additional \$75k for alarming feature	\$24,000

## STRATEGIES SUMMARY