Supplemental Material for:

Indoor air quality impacts of residential mechanical ventilation system retrofits in existing homes in Chicago, IL

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Table S1. Field measurement and ventilation system retrofit schedules

Home ID	Initial walk-through	1st visit	2nd visit	3rd visit	4th visit	Vent. System Retrofit	5th visit	6th visit	7th visit	8th visit*
H1	Oct-17	Oct-17	Jan-18	Apr-18	Aug-18	Feb-19	May-19	Sep-19	Jan-20	N/A
H2	Aug-17	Aug-17	Nov-17	Mar-18	Jun-18	Oct-18	Feb-19	Oct-19	Dec-19	Mar-20
H3	Jul-17	Jul-17	Nov-17	Jan-18	May-18	Nov-18	Mar-19	Jul-19	Nov-19	Feb-20
H4	Sep-17	Oct-17	Feb-18	May-18	Aug-18	Jan-19	May-19	Oct-19	Jan-20	N/A
H5	Aug-17	Aug-17	Nov-17	Feb-18	May-18	Oct-18	Feb-19	Aug-19	Nov-19	Feb-20
H6	Jul-17	Jul-17	Oct-17	Jan-18	May-18	Feb-19	Mar-19	Jul-19	Nov-19	Feb-20
H7	Sep-17	Sep-17	Dec-17	Feb-18	Jun-18	Feb-19	Apr-19	Sep-19	Dec-19	N/A
H8	Aug-17	Aug-17	Nov-17	Feb-18	May-18	Sep-18	Apr-19	Sep-19	Dec-19	Mar-20
H9	Aug-17	Sep-17	Dec-17	Feb-18	Jun-18	Oct-18	Feb-19	Jun-19	Nov-19	N/A
H10	Aug-17	Sep-17	Nov-17	Mar-18	Jun-18	Oct-18	Mar-19	Jun-19	Nov-19	Mar-20
H11	Jul-17	Jul-17	Nov-17	Jan-18	Apr-18	Oct-18	Mar-19	Jul-19	Oct-19	Feb-20
H12	Aug-17	Aug-17	Nov-17	Mar-18	Jun-18	Oct-18	Feb-19	Aug-19	Dec-19	Feb-20
H13	Sep-17	Sep-17	Jan-18	Apr-18	Aug-18	Jan-19	May-19	Sep-19	Jan-20	N/A
H14	Aug-17	Aug-17	Nov-17	Feb-18	May-18	Oct-18	Apr-19	Aug-19	Dec-19	Mar-20
H15	Jul-17	Jul-17	Nov-17	Feb-18	May-18	Feb-19	Apr-19	Jul-19	Nov-19	Jan-20
H16	Aug-17	Aug-17	Nov-17	Feb-18	May-18	Feb-19	Mar-19	Jul-19	Dec-19	Feb-20
H17	Aug-17	Aug-17	Nov-17	Mar-18	Jun-18	Oct-18	Apr-19	Jul-19	Dec-19	Feb-20
H18	Oct-17	Oct-17	Jan-18	Apr-18	Aug-18	Jan-19	Jun-19	Oct-19	Feb-20	N/A
H19	Oct-17	Dec-17	Jan-18	Apr-18	Aug-18	Jan-19	Jun-19	Oct-19	Jan-20	N/A
H20	Aug-17	Aug-17	Nov-17	Feb-18	May-18	Feb-19	Mar-19	Aug-19	Nov-19	Feb-20
H21	Sep-17	Sep-17	Nov-17	Mar-18	Jun-18	Feb-19	Jun-19	Sep-19	Jan-20	N/A
H22	Oct-17	Oct-17	Jan-18	Apr-18	Aug-18	Jan-19	Mar-19	Jun-19	Nov-19	N/A
H23	Aug-17	Aug-17	Nov-17	Mar-18	Jun-18	Nov-18	Apr-19	Jul-19	Nov-19	Feb-20
H24	Sep-17	Sep-17	Dec-17	Mar-18	Aug-18	Jan-19	Jun-19	Sep-19	Feb-20	N/A
H25	Aug-17	Aug-17	Nov-17	Mar-18	Jun-18	Feb-19	May-19	Sep-19	Dec-19	Feb-20
H26	Sep-17	Sep-17	Jan-18	Aug-18	Dec-18	Jan-19	May-19	Sep-19	Jan-20	N/A
H27	Aug-17	Sep-17	Jan-18	Apr-18	Aug-18	Sep-18	Jun-19	Sep-19	Jan-20	N/A
H28	Jul-17	Aug-17	Nov-17	Mar-18	Jun-18	Mar-19	Apr-19	Aug-19	Dec-19	N/A
H29	Aug-17	Aug-17	Nov-17	Feb-18	May-18	Oct-18	Mar-19	Aug-19	Nov-19	Feb-20
H30	Oct-17	Oct-17	Jan-18	Apr-18	Aug-18	Jan-19	May-19	Sep-19	Jan-20	N/A
H31	Aug-17	Sep-17	Dec-17	Feb-18	May-18	Oct-18	Feb-19	Aug-19	Dec-19	Mar-20
H32	Jul-17	Jul-17	Nov-17	Feb-18	May-18	Sep-18	Mar-19	Jul-19	Nov-19	Feb-20
H33	Oct-17	Oct-17	Jan-18	Apr-18	Aug-18	Jan-19	May-19	Oct-19	Jan-20	N/A
H34	Jul-17	Jul-17	Oct-17	Feb-18	May-18	Sep-18	Feb-19	Jun-19	Nov-19	Feb-20
H35	Sep-17	Nov-17	Feb-18	May-18	Aug-18	Jan-19	May-19	Oct-19	Jan-20	N/A
H36	Sep-17	Oct-17	Jan-18	Apr-18	Jul-18	Feb-19	May-19	Oct-19	Jan-20	N/A
H37	Sep-17	Sep-17	Dec-17	Mar-18	Jul-18	Feb-19	May-19	Sep-19	Dec-19	N/A
H38	Sep-17	Sep-17	Dec-17	Mar-18	Jun-18	Jan-19	Feb-19	Aug-19	Dec-19	Mar-20
H39	Oct-17	Dec-17	Jan-18	Jun-18	Aug-18	Mar-19	May-19	Oct-19	Jan-20	N/A
H40	Oct-17	Oct-17	Jan-18	Apr-18	Jul-18	Nov-18	May-19	Sep-19	Jan-20	N/A

*There are only 20 visits summarized as 'Visit 8' because field work was stopped in March 2020 due to COVID-19 stay-at-home orders. For all other visits the sample size is 40 approximately weeklong home visits (one per home). Some visits span multiple seasons, as not every quarterly visit at every home aligned in the same season.

Baseline survey and end-line surveys were completed by one adult asthmatic participant in each home at the beginning and the end of the study, respectively. Some examples of survey questions are shown as follows:

1) Please enter your name and participant ID
2) What is your date of birth?
3) What is your gender?
   Answer options: a) male, b) female
4) What is the highest level of school you completed or the highest degree?
   Answer options: a) never completed high school, b) completed high school or GED, c) completed some college no degree, d) completed college undergraduate degree, e) completed graduate degree
5) Approximately what was your total combined household income during the past year?
   Answer options: a) $10,000 to $19,999, b) $20,000 to $29,999, c) $30,000 to $39,999, d) $40,000 to $49,999, e) $50,000 to $75,000, f) more than $75,000
6) What is your race or ethnicity? Please choose all that apply:
   Answer options: a) White, b) Black or African American, c) Hispanic or Latin, d) Asian
7) How many people currently live in your home, including yourself?
8) How many days per week do you typically work away from home? (Please do not count any days you work at home).
9) On a typical workday about how many hours do you spend outside or away from your home?
10) On a typical non-work or weekend day about how many hours do you spend outside or away from your home?
11) Do you have an electric or gas stove in your kitchen?
    11a. If you have a fan over the stove in your kitchen, how often is it used when someone cooks?
    Answer options: a) always, b) frequently, c) sometimes, d) rarely, e) never
12) If you have a fan in one or more bathrooms, how often is it used when someone takes a bath or shower?
    Answer options: a) always, b) frequently, c) sometimes, d) rarely, e) never
13) In the last 2 years, has there been water or dampness in your home due to broken pipes, leaks, heavy rain, floods, or for other reasons?
    Answer options: a) yes, b) no
    13a. Approximately when did you have water or dampness in your home, in the last 2 years?
    13b. About how often in the last 2 years has there been water or dampness in your home, for any reason?
    Answer options: a) always, b) frequently, c) sometimes, d) rarely, e) never
    13c. Please explain what kind of issue led to the water or dampness in your home.
14) In the last 12 months how often have you noticed any musty smells inside your home? (Musty smells are smells of dampness, mold or mildew).
    Answer options: a) always, b) frequently, c) sometimes, d) rarely, e) never
15) Do you use any "air fresheners" or deodorizers in your home, such as scented candles, aerosol cans, or plug-in devices?
    Answer options: a) yes, b) no
16) When weather allows, do you open the window(s)?

16a. About how many windows do you typically open when the weather allows?

16b. When you open the window(s), how often do you use a window fan?

Answer options: a) always, b) frequently, c) sometimes, d) rarely, e) never

17) How satisfied are you currently with the ventilation system we installed in your home?

18) How satisfied are you currently with the temperature in your home?

19) How satisfied are you currently with humidity levels in your home?

20) How satisfied are you currently with air quality (including odors)?

21) How satisfied are you currently with air movement (such as drafts)?

22) How satisfied are you currently with your home's electricity bills?

23) How satisfied are you currently with your home's gas bills?

Questions 17-23 answer options: a) very satisfied, b) satisfied, c) neutral, d) dissatisfied, e) very dissatisfied

24) Did you stay overnight in hospital for asthma, last 12 months?

Answer options: a) yes, b) no

25) Did you visit ER/urgent care for asthma in last 12 months?

Answer options: a) yes, b) no

26) If you have any other chronic health conditions besides asthma, please list them.

2. Measurement Equipment

2.1. Air quality instruments

In considering how to conduct the planned indoor and outdoor measurements, the following instruments were identified as reasonable solutions that balance equipment costs, accuracy, and practicality. The selected instruments are described in Table 1 in the main text and described in more detail below.

A MetOne GT-526 optical particle counter (OPC) with six channels of user-selected particle size bins was used to measure indoor and outdoor fine and coarse particulate matter in several defined size bins: 0.3-0.5, 0.5-1, 1-2.5, 2.5-5, and 5-10 µm. The resulting number concentration data were used to calculate PM_1, $PM_{2.5}$, and PM_{10} mass concentrations by making assumptions for spherical particle shape, particle density (i.e., unit density of 1.5 g/cm^3), and the geometric mean diameter of each particle size bin. Similar procedures have been used successfully in several other recent studies of both indoor and outdoor particulate matter measurements [1–3]. We have also demonstrated in prior work that an assumption of constant particle density does not substantially impact PM mass concentration estimates compared to an assumption of size-varying density [4].

An Aeroqual SM50 OEM gas-sensitive semiconductor (GSS) ozone (O_3) sensor was used to measure indoor and outdoor ozone concentrations. The O_3 sensor has a manufacturer-reported accuracy of

±15%, range of 0-0.5 ppm, and limit of detection (LOD) of 1 ppb. The O_3 sensor output signal was recorded by an Onset HOBO U12 data logger. Prior testing of this device against a federal equivalent method (FEM) instrument (2B Technologies Model 211) demonstrated a higher functional LOD than reported by the manufacturer [5], but strong correlations with ambient FEM O_3 monitors without needing to correct for temperature or RH [6].

An Aeroqual Series 500 IAQ monitor with NO_2 gas-sensitive electrochemical (GSE) sensor head attachment was used to measure indoor and outdoor NO_2 concentrations. The NO_2 sensor has a manufacturer-reported accuracy of ±20 ppb, a resolution of 1 ppb, and a limit of detection of 5 ppb. It has been used successfully in a few recent studies of indoor and outdoor environments [5,7–9]. A recent study reported the measurement uncertainty of this sensor to be outside of conventional accuracy targets (e.g., the National Institute for Occupational Safety and Health (NIOSH) accuracy criterion of <25%) for reading absolute concentrations below ~40 ppb (mean <10 ppb) [10], while another reported reasonably strong correlations against a reference instrument in ambient air, especially after correcting for sensitivity to O_3 concentrations measured by a co-located SM50 sensor [11,12].

A Lascar EL-USB-CO data logger was used to measure indoor and outdoor CO concentrations. The instrument has a manufacturer-reported accuracy of ±6% of reading and a resolution of 0.5 ppm CO. These inexpensive instruments are typically most useful when there are large CO sources from combustion (e.g., environmental tobacco smoke or water pipe smoking) [13,14], but other recent residential indoor investigations have used them with success as well [15].

A GrayWolf Sensing Solutions FM-801 formaldehyde meter was used to measure indoor formaldehyde concentrations (outdoor formaldehyde concentrations are typically low [16] and thus were not measured). The instrument was used by passively exposing its sensor cartridges to indoor air and returning them to the active monitor to read out the concentration. This instrument has been shown to be useful for accurately quantifying indoor formaldehyde concentrations, even at low levels (i.e., less than 30 ppb) [17].

Finally, an Extech SD800 monitor was used to measure indoor and outdoor CO_2 concentrations, with data logged to an internal SD card [18–20]. The instrument has a manufacturer-reported accuracy of ±40 ppm from 0-1000 ppm and ±5% over 1000 ppm.

All instruments were placed inside custom protective cases tailored for indoor (Figure S1a) and outdoor environments (Figure S1b). The indoor monitoring case utilized a rolling portable tool cart [5] and the outdoor monitoring case utilized an outdoor deck box commonly used to store items outdoors while protecting them from rain, snow, and wind. Each monitoring box had holes cut to allow air to be

drawn in from openings using small CPU fans installed in an exhaust configuration, with an uninterruptable power supply (UPS) placed inside (Figure S1c).

Figure S1. Indoor and outdoor monitoring boxes with instrumentation: (a) indoor monitoring box; (b) outdoor monitoring box; (c) air quality instruments (MetOne GT-526S OPCs, Aeroqual SM50 OEM O_3 monitors, Extech SD800 CO_2 monitors, Aeroqual S500 NO_2 monitors, LASCAR CO loggers, and Onset U12-013 HOBO Temperature/Relative Humidity data loggers) along with a small exhaust fan and air intake holes; and (d) all eight indoor and outdoor boxes arranged for a 24-hour co-location test.

2.2. Instruments for in-situ HVAC measurements

Table S2 summarizes the instrumentation used for in-situ HVAC measurements. We measured the operational runtimes of the central HVAC systems in homes that had them by installing a Digi-Sense data logging vane anemometer on a convenient supply register to indicate whether the air handler fan was operating. To separately detect periods of heating, cooling, and ventilating, we attached an Onset HOBO U12 temperature and RH data logger on a convenient supply register. We also attached an Onset HOBO UX90 Motor On/Off data logger on the air handling unit fan to indicate system runtime.

Additionally, airflow rates through the central forced-air air-handling units were measured using the TrueFlow® Air Handler Flow Meter [22], which consists of a calibrated metering plate, a static pressure probe, tubing, and a DG-700 pressure gauge. The metering plate temporarily replaces the existing filter in the air handling unit during the initial airflow measurement procedure, which were conducted during the initial home walkthrough visits. Field personnel then measured the operating pressure in the supply plenum at each site visit, which was used to calculate the airflow rate through the air handling unit during normal operation at each quarterly visit. For homes that received a powered ventilation system at the intervention stage (i.e., a powered CFIS ventilator or an ERV), ventilation system runtime and energy usage was measured using an Onset HOBO UX120 Plug Load Data Logger logging at 10-sec intervals.

Table S2. Instruments used for in-situ HVAC measurements

Parameter	Manufacturer/ Model	Logging Interval	Manufacturer Specifications	Location
HVAC system runtimes	Digi-Sense 20250-22 Vane Anemometer	30-second	• Range: 1.1 to 20 m/s • Accuracy: ±0.2 m/s / ±3% (whichever is greater) • Resolution: 0.01 m/s	Exhaust or supply register
	Onset HOBO U12	30-second	• Temperature range: -20 to 70°C • Temperature accuracy: ±0.35°C (from 0-50°C) • RH range: 5 to 95% • RH accuracy: ±2.5% (from 10-90% RH)	Supply register
	Onset HOBO UX90 Motor On/Off	30-second	• Resolution: 1 pulse • Time accuracy: ±1 minute per month at 25°C • Runtime: 1 second	Motor in AHU
Ventilation rates	TrueFlow® Air Handler Flow Meter	Readings for 2-4 minutes	• Accuracy: ± 7% when used with the DG-700 pressure gauge	Filter in AHU
Power and energy consumption	Onset HOBO UX120 Plug Load	10-second	• Accuracy: 0.5% (<14 Amp); 1% (>14 Amp) • Resolution: 10mV; 0.1mA • Time accuracy: ±1 minute per month at 25°C	CFIS or ERV

3. Co-location Calibrations of Air Quality Instruments

Because multiple versions of each instrument were used indoors and outdoors to measure each parameter simultaneously, instrument calibration via co-location was conducted on a quarterly basis throughout the study duration. For each co-location calibration test, four indoor air quality boxes and four outdoor air quality boxes were placed in an unoccupied room in the Built Environment Research Group Laboratory at Illinois Institute of Technology. A mixing fan was operated to achieve well-mixed conditions inside the room (Figure 1d). One of two co-location calibration methods was performed for each instrument: (1) co-locations against factory-calibrated research-grade instruments (when available), and (2) co-locations against each other (using one instrument as an arbitrary reference). The former calibration approach was applied to ozone (O_3) and nitrogen dioxide (NO_2), allowing an instrument to provide a reasonably accurate measure of the absolute value of the parameter in question. The latter calibration approach was applied to particulate matter (PM) and carbon dioxide (CO_2), and allows an instrument to provide a reasonably accurate measure of the relative value of the parameter (e.g., using one of the eight monitors as a reference for relative comparisons between data collected from other monitors). However, the carbon monoxide (CO) monitors and formaldehyde (HCHO) strips were not calibrated due to instrument limitations.

3.1. Gaseous pollutants: O_3 and NO_2 calibrations

O_3 and NO_2 calibration tests were conducted using co-location against factory-calibrated research-grade instruments. Aeroqual SM50 O_3 monitors were calibrated using co-location measurements with a 2B Technologies Model 211 O_3 monitor as the reference instrument by placing them alongside each other in the room. We considered the Model 211 monitor to be the reference against which other O_3 measurements were compared [23,24]. The Model 211 monitor was calibrated beforehand using a 2B Technologies Model 306 O_3 calibration source. Data were recorded from each instrument at 1-minute intervals (the minimum response time of the SM50 monitor) for approximately three hours while the O_3 concentration was elevated using a UV O_3 generator (CAP Model OZN-1) and then allowed to decay back to background levels. Only those data that fit a straight line on a log-linear concentration versus time scatter plot were used to avoid potential errors in readings and to ensure that reasonably well-mixed conditions had been achieved.

Figure S2 shows an example of the results of O_3 co-location calibration conducted in October 2019. Figure S2a shows time-series raw O_3 concentration data for all eight Aeroqual SM50 O_3 monitors during the injection and decay calibration test along with the same values measured by the 2B

Technologies Model 211 O_3 monitor. It is noticeable that some SM50 monitors have much higher practical limits of detection (LOD) than the Model 211 monitor (e.g., monitor ID #703), which means that the monitors simply record a constant value near zero concentrations below a certain value. On the other hand, some SM50 monitors detect higher values than the Model 211 monitor at steady state or baseline conditions (e.g., monitor ID #731). Figure S2b shows the adjusted ozone concentration after applying co-location calibration factors to provide concentrations that reasonably approximate what is observed by the 2B Technologies Model 211 O_3 monitor. The linear regressions used to calibrate the SM50 O_3 concentration data to the co-located Model 211 O_3 concentration data for this October 2019 test are shown in Figure S2c. Table S2 summarizes O_3 calibration factors for each quarterly calibration test conducted throughout the entire study duration.
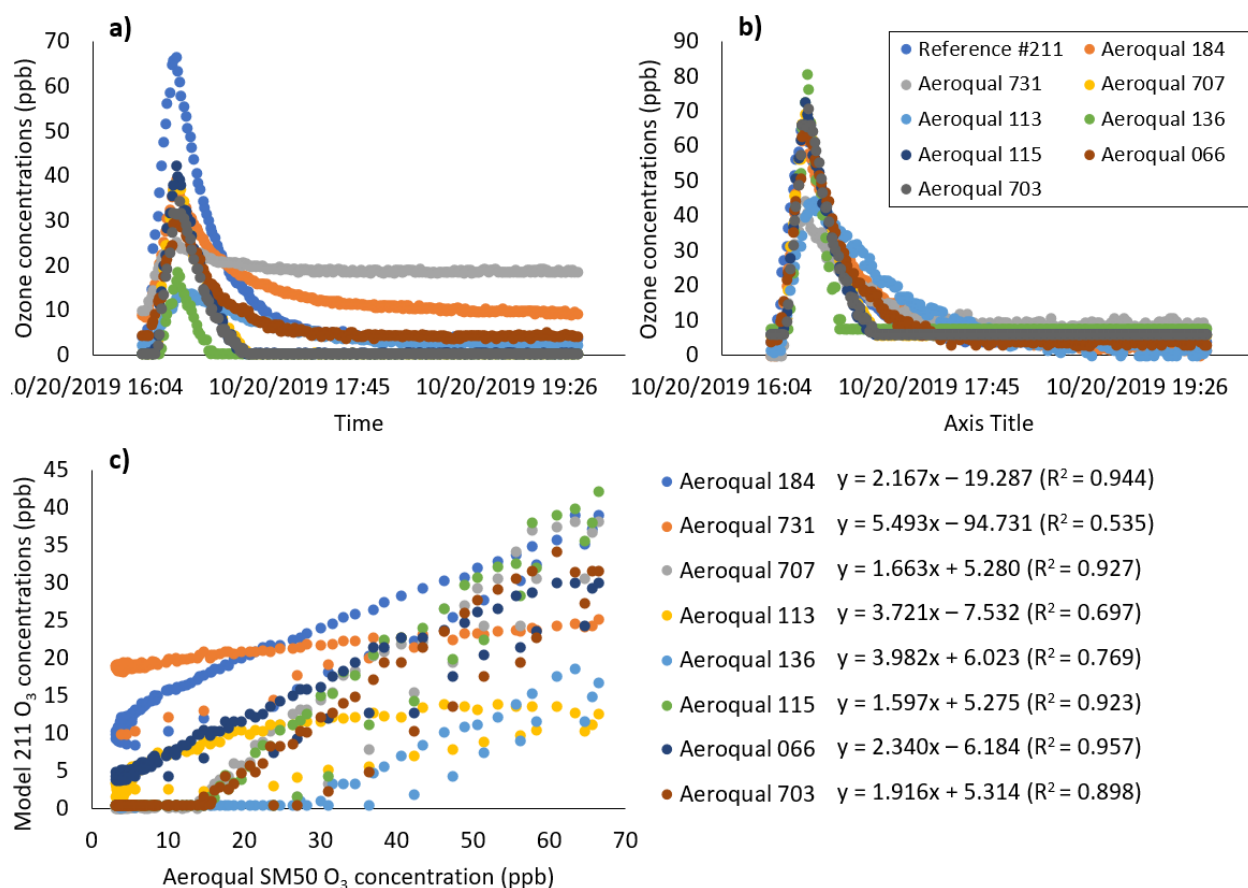
Figure S2. (a) Raw and (b) adjusted O_3 concentrations from the co-location calibration test, and (c) linear regressions between the research-grade instrument (2B Technologies model 211) to the eight Aeroqual SM50 O_3 monitors.

Table S3. Calibration factors for in-field ozone (O₃) monitors resulting from each quarterly calibration test conducted throughout the study duration

Monitor ID	Pre-Intervention Period									Post-Intervention Period								
	Summer '17 − Fall '17			Winter '18			Spring '18 − Summer '18			Winter '19 − Spring '19			Summer '19			Fall '19 − Winter '20		
	a	b	R^2	a	b	R^2	a	b	R^2	a	b	R^2	a	b	R^2	a	b	R^2
083	1.59	-6.30	0.99	1.05	2.48	0.99	1.04	5.08	0.99	-	-	-	0.82	0.03	0.86	-	-	-
091	0.71	23.9	0.58	0.94	1.16	0.99	1.09	-1.07	0.99	0.82	0.29	0.76	1.01	-2.84	0.99	-	-	-
138	1.59	-11.6	0.99	1.17	-5.24	0.94	1.53	-6.93	0.94	0.63	4.29	0.56	0.79	3.44	0.77	-	-	-
136	1.96	18.9	0.82	0.51	12.1	0.96	0.52	13.9	0.92	0.14	13.8	0.60	-	-	-	3.98	6.02	0.77
094	1.68	11.3	0.92	0.37	12.1	0.97	0.43	13.9	0.96	0.11	13.8	0.81	0.94	-0.03	0.95	-	-	-
066	1.18	8.26	0.96	0.29	12.1	0.97	0.28	13.9	0.97	-	-	-	6.31	11.2	0.80	2.34	-6.18	0.96
097	1.22	6.60	0.97	0.38	12.1	0.96	0.26	13.9	0.96	0.13	13.5	0.59	-	-	-	-	-	-
731	-	-	-	-	-	-	0.36	14.0	0.96	0.28	11.0	0.39	20.5	-308	0.82	5.49	-94.7	0.54
184	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.17	-19.3	0.94
707	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.66	5.28	0.93
113	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.72	-7.53	0.70
115	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.60	5.28	0.92
703	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.92	5.31	0.90

Similar to the O₃ monitor calibration procedure, co-location calibration tests were conducted using eight Aeroqual S500 data loggers with NO₂ sensor heads alongside a 2B Technologies Model 405 NO/NO₂/NOₓ monitor. Figure S3 shows an example of the results of an NO₂ co-location calibration test conducted in April 2019. Figure S3a shows time-series raw NO₂ concentration data for all eight Aeroqual S500 NO₂ monitors during the injection and decay calibration test along with the same values measured by the 2B Technologies Model 405 NO₂ monitor. It is noticeable that the eight Aeroqual S500 NO₂ monitors have a positive offset compared to the Model 405 NO₂ monitor. Figure S3b shows the adjusted NO₂ concentration calibrated via co-location to provide concentrations that are reasonably equivalent to the 2B Technologies Model 405 NO₂ monitor. The linear regressions used to calibrate the S500 NO₂ concentration data to the co-located Model 405 NO₂ concentration data are shown in Figure S3c. Table S3 summarizes NO₂ calibration factors for each quarterly calibration test conducted throughout the entire study duration.

a)

NO$_2$ concentrations (ppm)

0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

4/27/2019 13:40   4/27/2019 15:36   4/27/2019 17:31

Time

b)

NO$_2$ concentrations (ppm)

0.35
0.3
0.25
0.2
0.15
0.1
0.05
0

4/27/2019 13:40   4/27/2019 15:36   4/27/2019 17:31

Time

- Reference #405
- Monitor 001
- Monitor 002
- Monitor 003
- Monitor 012
- Monitor 014
- Monitor 015
- Monitor 027
- Monitor 029

c)

Model 405 NO$_2$ concentrations (ppm)

0.3
0.25
0.2
0.15
0.1
0.05
0

0   0.1   0.2   0.3

Aeroqual S500 NO$_2$ concentration (ppm)

- Monitor 001 $y = 1.775x - 0.106$ ($R^2 = 0.985$)
- Monitor 002 $y = 1.812x - 0.058$ ($R^2 = 0.986$)
- Monitor 003 $y = 1.874x - 0.168$ ($R^2 = 0.986$)
- Monitor 012 $y = 3.105x - 0.246$ ($R^2 = 0.970$)
- Monitor 014 $y = 1.888x - 0.183$ ($R^2 = 0.983$)
- Monitor 015 $y = 2.977x - 0.055$ ($R^2 = 0.986$)
- Monitor 027 $y = 2.023x - 0.100$ ($R^2 = 0.985$)
- Monitor 029 $y = 3.201x - 0.175$ ($R^2 = 0.974$)

Figure S3. (a) Raw and (b) adjusted NO$_2$ concentrations from the co-location calibration test, and (c) linear regressions between the research-grade instrument (2B technologies model 405) to the eight Aeroqual S500 NO$_2$ monitors.

Table S4. Calibration factors for in-field NO₂ monitors resulting from each quarterly calibration test conducted throughout the study duration

Monitor ID	Pre-Intervention Period											
	Summer '17 − Fall '17			Winter '18			Spring '18			Summer '18		
	a	b	R^2	a	b	R^2	a	b	R^2	a	b	R^2
001	-	-	-	-	-	-	-	-	-	1.000	0.028	1.00
002	0.971	0.020	1.00	0.996	0.035	1.00	0.975	0.030	1.00	1.000	0.028	1.00
003	0.992	-0.026	1.00	1.157	-0.024	1.00	0.997	-0.017	1.00	1.023	-0.021	0.99
012	1.211	-0.036	0.99	1.407	-0.004	0.99	1.553	-0.068	0.99	1.550	-0.050	0.97
013	1.201	-0.053	0.99	1.415	-0.046	0.98	1.553	-0.079	0.97	-	-	-
014	0.971	-0.038	0.99	0.994	-0.036	0.99	0.997	-0.035	1.00	1.012	-0.028	0.98
015	0.994	0.029	0.99	1.238	0.054	0.99	1.296	0.042	1.00	1.241	0.037	0.99
027	-	-	-	-	-	-	-	-	-	0.873	0.036	0.99
029	1.244	-0.018	1.00	1.323	-0.023	0.99	1.462	-0.029	1.00	1.377	-0.021	0.99
Monitor ID	Post-Intervention Period											
	Winter '19			Spring '10			Summer '19			Fall '19 – Winter '20		
	a	b	R^2	a	b	R^2	a	b	R^2	a	b	R^2
001	-	-	-	-	-	-	-	-	-	1.775	-0.073	0.92
002	0.936	0.026	0.98	1.024	0.027	1.00	0.793	0.034	0.95	1.110	-0.042	0.99
003	0.929	-0.026	0.93	1.059	-0.036	1.00	0.857	-0.017	0.96	1.298	-0.125	0.97
012	0.868	0.001	0.55	1.737	-0.078	0.99	1.456	-0.053	0.97	2.278	-0.182	0.97
014	0.778	-0.013	0.93	1.056	-0.042	1.00	0.971	-0.032	0.97	1.344	-0.135	0.96
015	1.134	0.044	0.83	1.686	0.028	1.00	1.203	0.036	0.98	1.834	-0.039	0.99
027	0.835	0.019	0.96	1.140	0.004	1.00	1.025	0.013	0.98	1.381	-0.056	0.80
029	1.249	-0.011	0.81	1.842	-0.044	1.00	1.508	-0.025	0.98	2.068	-0.120	0.96

3.2. Particulate matter (PM) calibrations

MetOne GT-526S OPCs were calibrated via co-location with one of the OPCs (i.e., Monitor ID: 690) as an arbitrary reference particle counter. Prior internal laboratory investigations with these monitors demonstrated very strong correlations with more expensive research grade equipment (e.g., $R^2 > 0.97$ with slopes near 1.0 when compared to data from a TSI Model 3330 Optical Particle Sizer, or OPS) [5].

We primarily used estimates of PM mass concentrations rather than number concentrations for the calibration and subsequent analyses because of their greater, or at least better known, implications for human health. The mass concentrations of PM_1, $PM_{2.5}$, and PM_{10} were approximated using a procedure described in the main text (i.e., spherical shape with assumed uniform density of 1.5 g/cm³). Figure S4, Figure S5, and Figure S6 show an example of co-location calibration results of PM_1, $PM_{2.5}$, and PM_{10} mass concentrations, respectively, measured by all eight MetOne GT-526S OPCs for a period of approximately 24 hours in October 2017. Here we compare raw and adjusted PM_1, $PM_{2.5}$, and PM_{10} mass concentrations based on the co-location calibration tests. Also, linear regressions are presented which were used to adjust the raw PM concentrations based on those measured by the arbitrary reference monitor based on the co-location calibration test data. During the pre-intervention period, MetOne #690

was used as the reference monitor to adjust the other monitors based on the demonstration from the prior co-location calibration test [5], while MetOne #343 (the most recently factory-calibrated instrument at the time) was selected as the reference monitor during the post-intervention period.
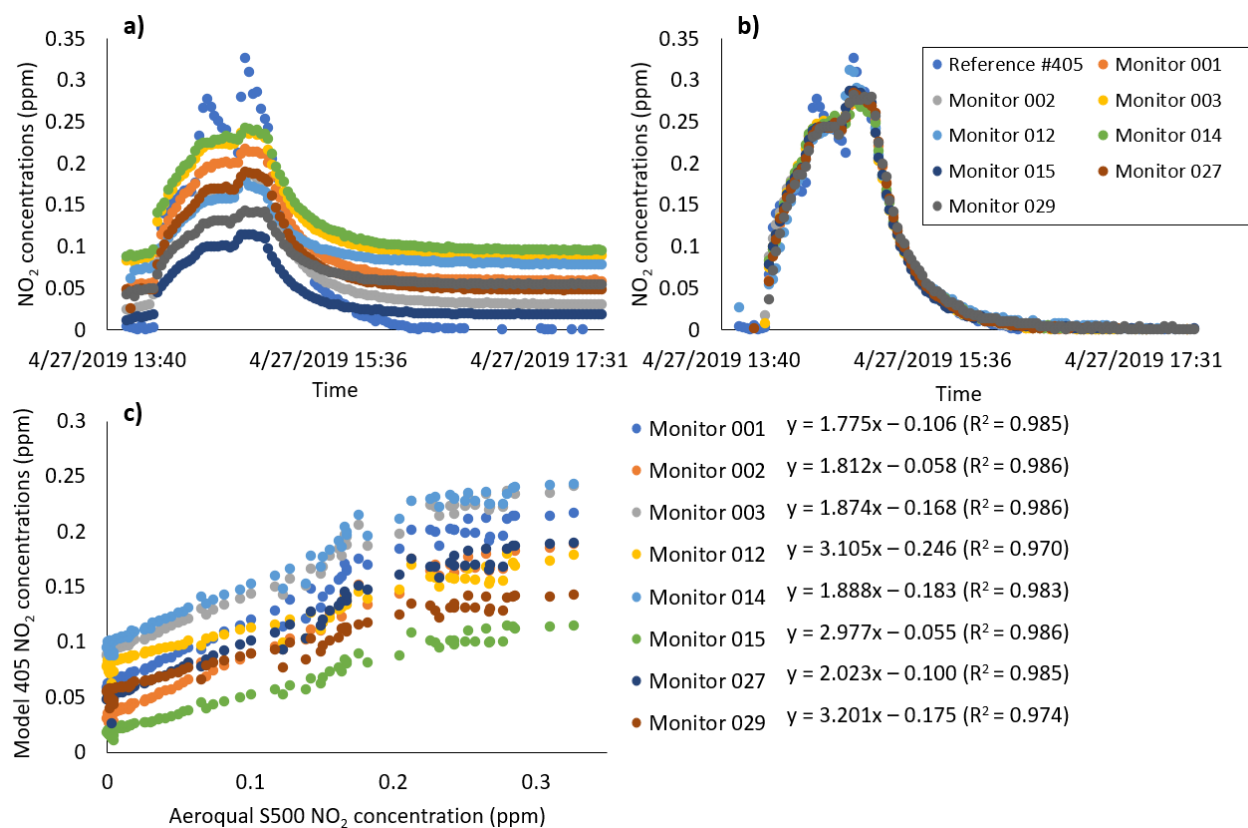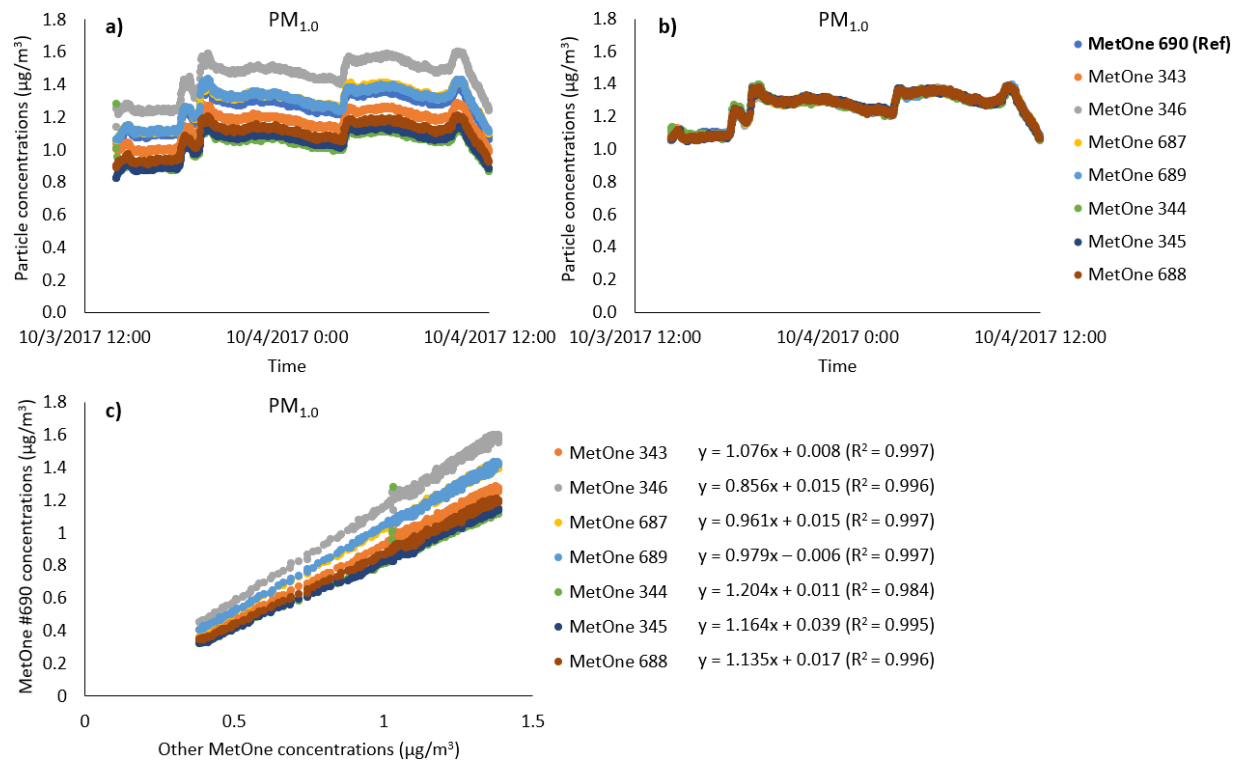

Figure S4. (a) Raw and (b) adjusted PM₁ concentrations from the co-location calibration test, and (c) linear regressions between the reference OPC (#690) to the other seven OPCs.
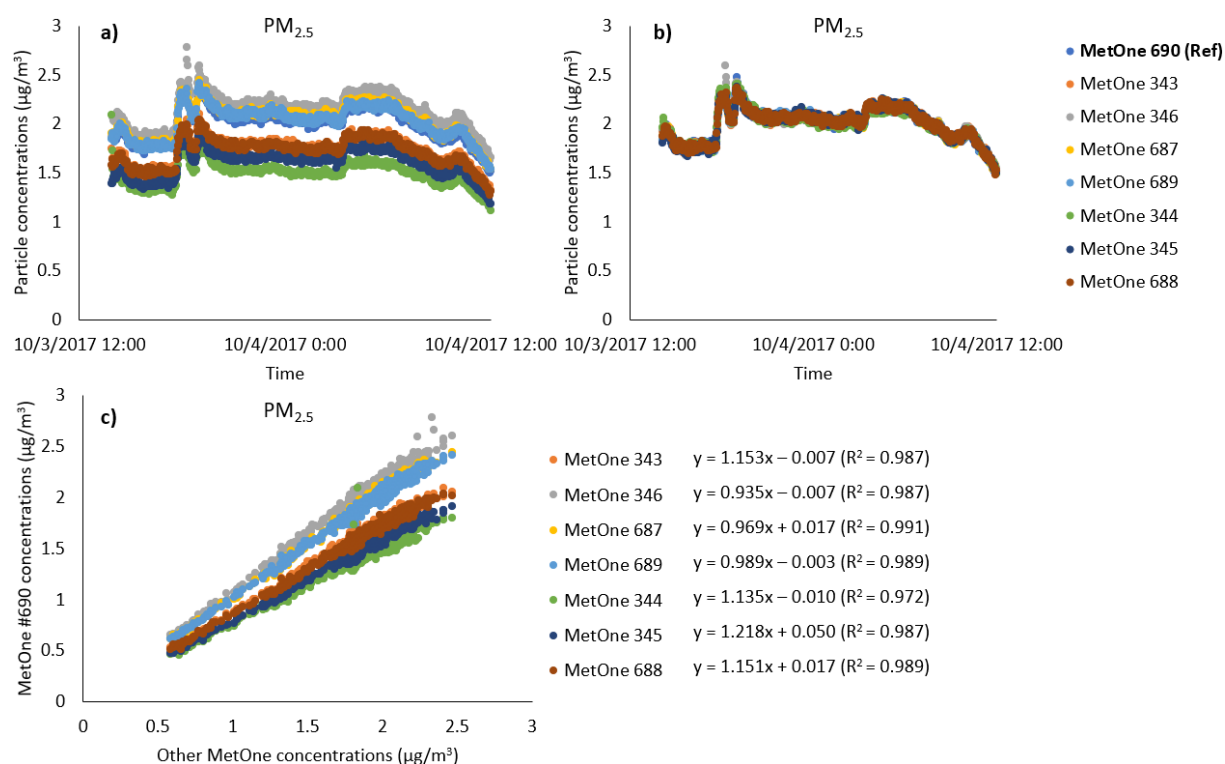
Figure S5. (a) Raw and (b) adjusted PM_{2.5} concentrations from the co-location calibration test, and (c) linear regressions between the reference OPC (#690) to the other seven OPCs.
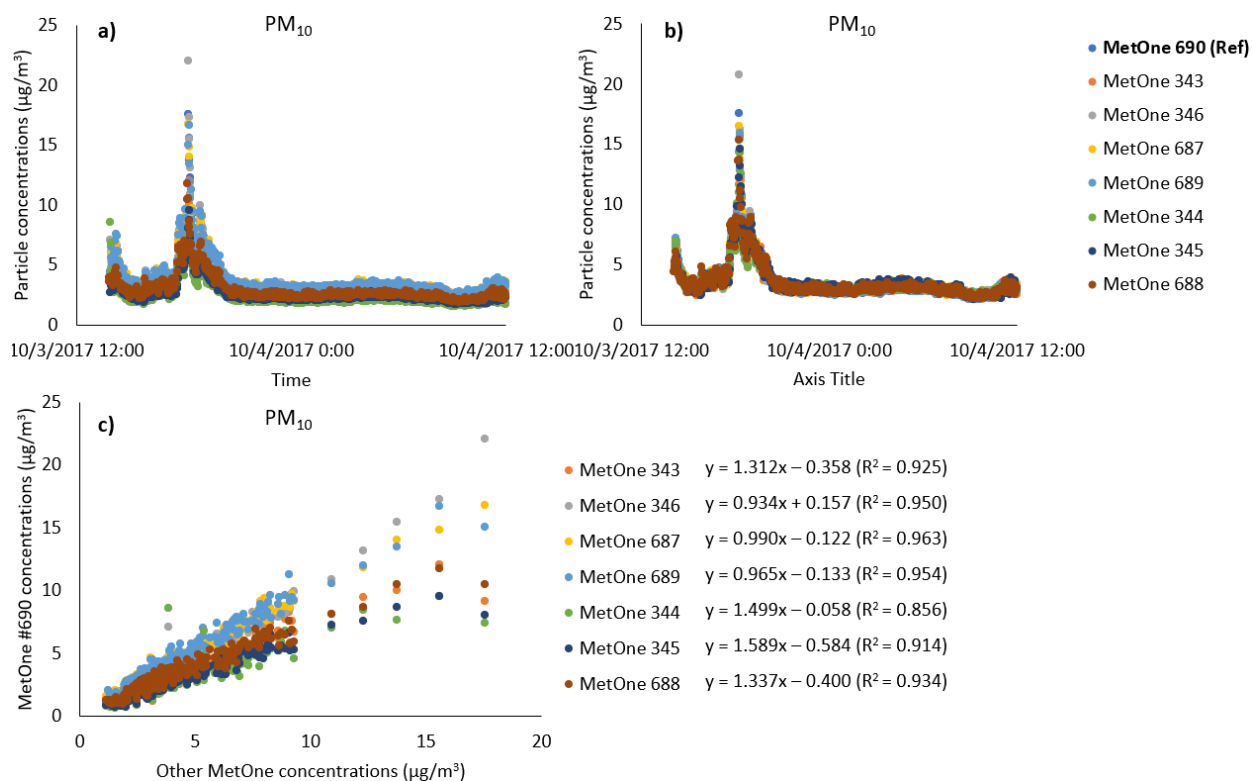
Figure S6. (a) Raw and (b) adjusted PM₁₀ concentrations from the co-location calibration test, and (c) linear regressions between the reference OPC (#690) to the other seven OPCs.

Not all eight quarterly PM calibration factors over the two-year period (i.e., 4 seasons during the pre-intervention period and 4 seasons during the post-intervention period) were applied to adjust the raw PM concentrations. This is because several seasonal calibration factors showed a poor goodness-of-fit measure for linear regression models, which was especially apparent when we observed low variations in PM concentrations (primarily because we did not artificially elevate particle concentrations – the goal was not to calibrate for a specific aerosols source type but rather for typical background sources). In exploring calibration approaches, we established four criteria for inclusion of calibration tests (Table S4): (C1) the maximum calculated $PM_{2.5}$ concentration of the reference monitor measured during the co-location calibration test must be greater than 2.0 µg/m³; (C2) the maximum $PM_{2.5}$ concentration of the reference monitor must be higher than twice the minimum $PM_{2.5}$ concentration of the reference monitor; (C3) the absolute range of $PM_{2.5}$ concentrations of the reference monitor must be greater than 1 µg/m³; (C4) the coefficients of determination (R^2) for each monitor must be greater than 0.8. Accordingly, only co-location calibration tests in the fall 2017, the winter 2018 and the fall 2019 met all criteria and their PM calibration factors for the pre- and post-intervention periods were applied into the study. Resulting calibration factors from these applicable seasons are shown in Table S5 (data across successful quarterly visits were lumped into either pre-intervention or post-intervention calibration factors). The interceptions of linear regression lines were forced to zero since all monitors were assumed to be successful in zero calibration.

Table S5. Inclusion criteria (C1-4) and performance metrics for PM calibration factors for all quarterly visits using $PM_{2.5}$ as the primary endpoint

Period	Season	$PM_{2.5}$ Min (µg/m³)	$PM_{2.5}$ Max (µg/m³)	$PM_{2.5}$ Max-Min ratio	$PM_{2.5}$ Absolute range	C1	C2	C3	C4	Decision
Pre-intervention	Fall '17	0.58	2.47	4.3	1.9	Yes	Yes	Yes	Yes	Included
	Winter '18	1.29	3.09	2.4	1.8	Yes	Yes	Yes	Yes	Included
	Spring '18	0.54	1.07	2.0	0.5	No	Yes	No	No	Excluded
	Summer '18	1.05	1.38	1.3	0.3	No	No	No	No	Excluded
Post-intervention	Winter '19	0.23	0.71	3.1	0.5	No	Yes	No	No	Excluded
	Spring '19	0.37	1.27	3.4	0.9	No	Yes	No	No	Excluded
	Summer '19	1.47	2.15	1.5	0.7	Yes	No	No	No	Excluded
	Fall '19	0.71	3.32	4.7	2.6	Yes	Yes	Yes	Yes	Included

Period	Monitor ID	PM_1			$PM_{2.5}$			PM_{10}		
		a	b	R^2	a	b	R^2	a	b	R^2
Pre-intervention	690 (Ref)	1	-	1	1	-	1	1	-	1
	343	1.083	-	1.00	1.149	-	0.99	1.204	-	0.92
	346	0.880	-	0.99	0.990	-	0.92	1.205	-	0.92
	687	0.929	-	0.95	0.982	-	0.97	1.098	-	0.96
	689	0.956	-	0.99	1.000	-	0.98	1.064	-	0.96
	344	1.215	-	0.98	1.338	-	0.97	1.478	-	0.86
	345	1.188	-	0.98	1.305	-	0.95	1.677	-	0.91
	686	1.115	-	0.97	1.189	-	0.98	1.466	-	0.88
	688	1.048	-	0.97	1.175	-	0.96	1.386	-	0.96
Post-intervention	689 (Ref)	1	-	1	1	-	1	1	-	1
	690	1.536	-	1.00	1.456	-	0.99	1.399	-	0.98
	343	0.581	-	0.99	0.723	-	1.00	0.887	-	0.98
	346	1.081	-	1.00	1.176	-	1.00	1.341	-	0.98
	344	0.651	-	0.99	0.773	-	1.00	0.962	-	0.98
	345	0.691	-	1.00	0.831	-	1.00	1.102	-	0.98
	686	0.793	-	0.99	0.989	-	1.00	1.405	-	0.97
	688	0.640	-	0.99	0.773	-	1.00	1.071	-	0.98

In addition to these OPC co-location measurements in the laboratory, we also conducted a limited set of in-situ indoor co-location measurements with a size-resolved filter-based gravimetric sampler (Sioutas Cascade Impactor [25]) in a subset of approximately weeklong study home visits. This additional gravimetric sampling approach was deployed for the duration of a total of 20 field visits in 16 homes (4 homes were sampled twice). The Sioutas impactors were operated at 9 L/min (SKC Leland Legacy Pump) and collected gravimetric samples on PTFE filter substrates in the following aerodynamic particle diameter ranges: <0.25, 0.25-0.5, 0.5-1.0, 1.0-2.5, and >2.5 µm. Each size-resolved filter sample was weighed before and after sampling using an A&M BM-20 Microbalance after they had equilibrated over 24-hour periods in a conditioning chamber (which was held at 20-23°C, 35-40% RH). Time-integrated mass concentrations in each size bin were calculated by dividing the pre/post gravimetric readings by the cumulative sample volume from the field deployment. Gravimetric mass concentrations from relevant size bins were compared to weeklong average estimates of indoor PM_1, $PM_{2.5}$, and PM_{10} mass concentrations estimated using the co-located OPC after all previously described co-location calibration factors were applied to all OPCs.

We first compared time-averaged estimates of $PM_{0.3-1}$ concentrations from OPC measurements to co-located gravimetric PM_1 mass concentrations across the sampled homes (Figure S7-a). A linear regression between these two variables suggested that the actual gravimetric PM_1 mass concentrations were approximately ~5 times higher than estimates of $PM_{0.3-1}$ concentrations from the MetOne OPCs (R^2

= 0.86; slope = 5.038), indicating that the $PM_{0.3-1}$ estimates from OPCs miss a large fraction of actual PM_1 mass due to a combination of not measuring below 0.3 µm and other issues in mass estimation from number concentrations. Next, we then compared only the 1-2.5 µm and 2.5-10 µm size bins, producing correlations between estimated $PM_{1-2.5}$ and $PM_{2.5-10}$ mass concentrations from the OPCs to gravimetric mass concentrations of $PM_{1-2.5}$ and $PM_{>2.5}$ size bins. Both comparisons resulted in strong correlations (R^2 = 0.89 and 0.92, respectively) and slopes under 1 (0.638 and 0.418, respectively) (Figure S7-b), which suggests that the OPC mass estimation approach overestimates gravimetric mass in these size bins but that the OPCs can be used to infer PM mass with reasonable accuracy. Therefore, we applied these three size-binned calibration factors to our originally calibrated OPC mass concentration estimates (i.e., for PM_1, $PM_{1-2.5}$, and $PM_{2.5-10}$) to estimate integral mass equivalent concentrations of PM_1, $PM_{2.5}$, and PM_{10} from these co-location samples, as shown in Figure S8. Ultimately, estimated PM concentrations for these three metrics using this calibration approach were strongly correlated with gravimetric measures (all three R^2 values > 0.8).
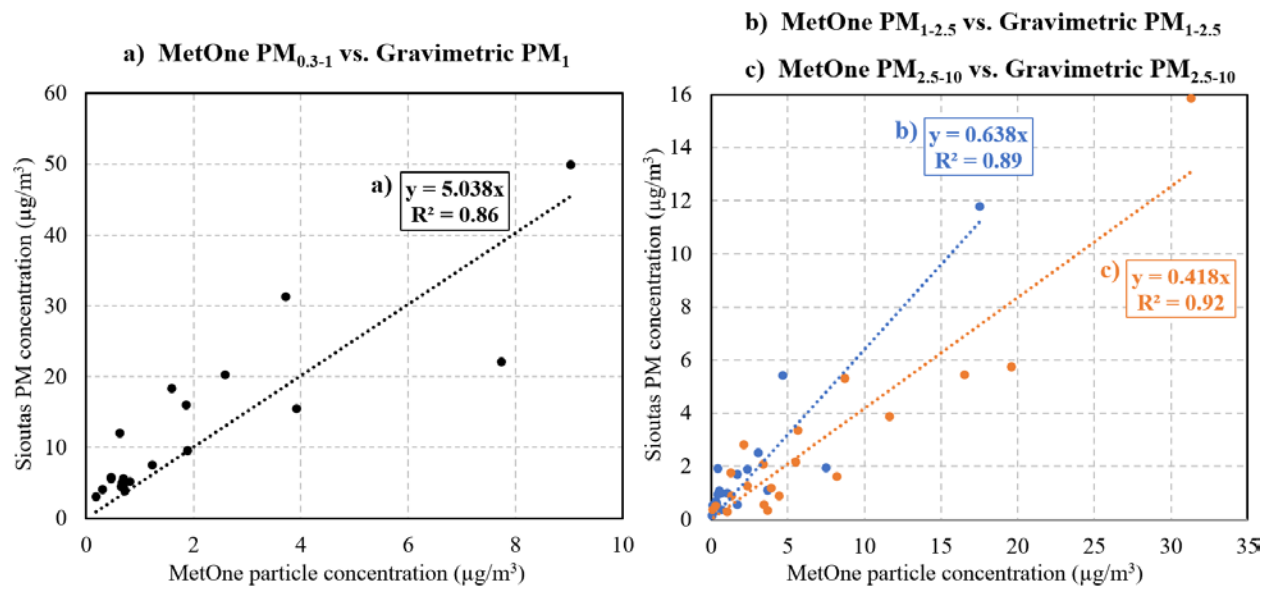
Figure S7. Indoor co-location PM sampling with gravimetric and OPC measurements: a) $PM_{0.3-1}$ mass concentrations estimated using OPCs vs. gravimetric PM_1 concentrations; b) $PM_{1-2.5}$ mass concentrations estimated using OPCs vs. gravimetric $PM_{1-2.5}$ concentrations; c) $PM_{2.5-10}$ mass concentrations estimated using OPCs vs. gravimetric $PM_{2.5-10}$ concentrations
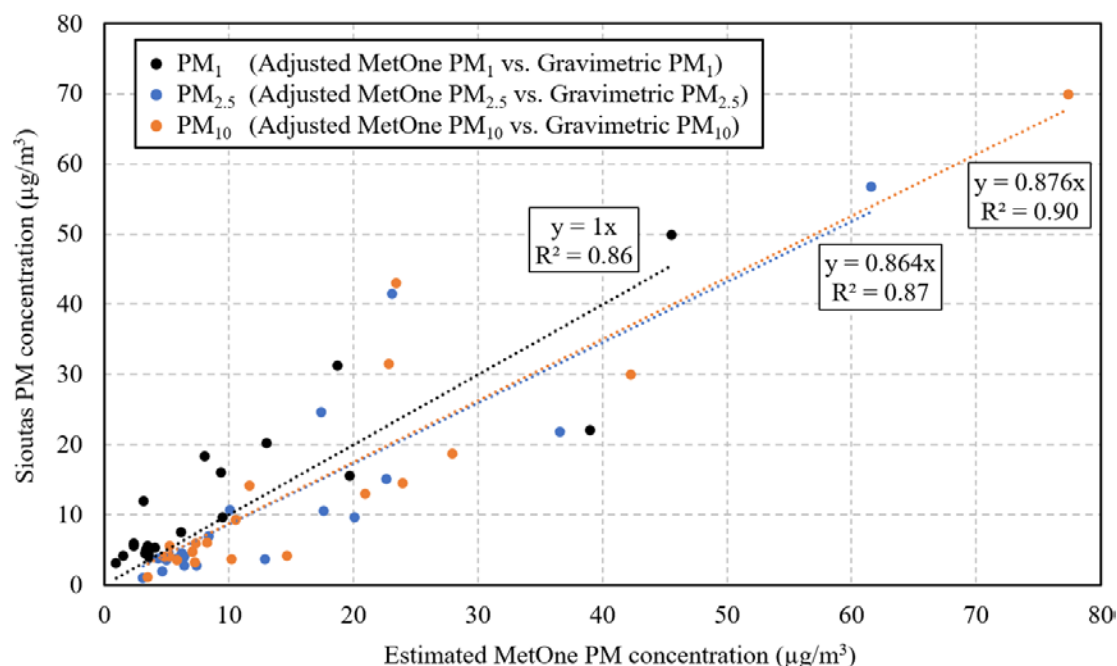
Figure S8. Comparison of PM$_1$, PM$_{2.5}$, and PM$_{10}$ concentrations between adjusted MetOne particle data and gravimetric particle data from in-situ indoor co-location measurements in a subset of study homes

3.3. CO$_2$ calibrations

The arbitrary reference approach was also applied to CO$_2$ monitor co-location calibrations. Eight Extech SD800 CO$_2$ monitors were calibrated using co-location measurements by placing them alongside each other with one of the monitors (i.e., Monitor ID: 870) designated as the arbitrary reference monitor. CO$_2$ concentrations were elevated twice using a CO$_2$ tank placed inside the room, and then concentrations were left for decay more than 1 hour. Figure S9 shows an example of the results of CO$_2$ co-location calibration conducted in October 2019, comparing raw (a) and adjusted data (b) from the co-location test. Seven Extech SD800 CO$_2$ monitors were calibrated to provide concentrations that are equivalent to the reference Extech monitor #870, with the calibration factors from linear regressions shown in Figure S7c. Table S6 summarizes the CO$_2$ calibration factors obtained during each quarterly co-location calibration test throughout the entire study duration.
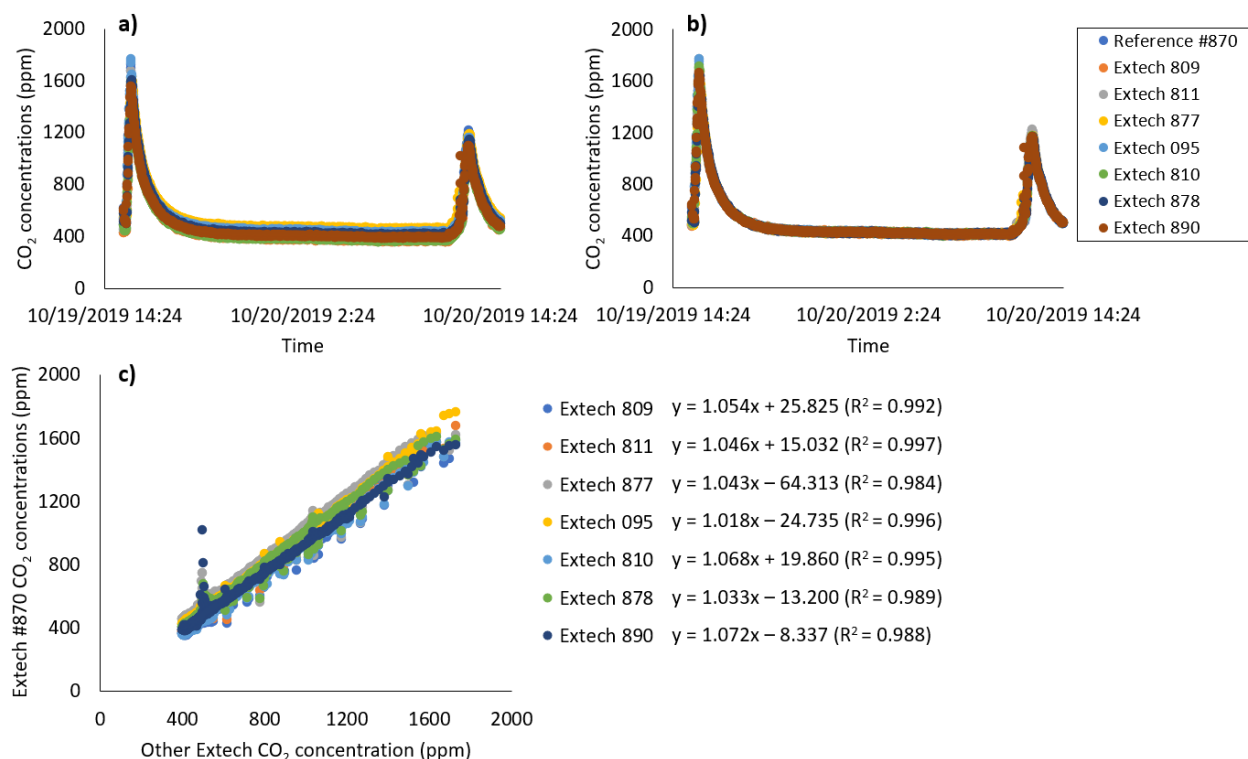
Figure S9. (a) Raw and (b) adjusted CO₂ concentrations from the co-location calibration test, and (c) linear regressions between the reference monitor (Extech #870) to the other seven Extech CO₂ monitors

Table S7. Calibration factors for in-field CO₂ monitors resulting from each quarterly calibration test conducted throughout the study duration

Monitor ID	Pre-Intervention Period											
	Summer − Fall '17			Winter '18			Spring '18			Summer '18		
	a	b	R²	a	b	R²	a	b	R²	a	b	R²
870	1	0	1	1	0	1	0.847	60.69	0.96	1	0	1
809	0.986	57.01	0.99	1.100	6.05	0.99	0.873	93.82	0.96	1.021	38.37	0.99
811	0.987	37.41	0.99	1.058	0.74	1.00	0.867	78.93	0.94	1.015	21.03	0.99
877	0.955	-7.16	0.99	1.135	-106.1	0.99	0.867	18.22	0.96	1.023	-56.75	0.99
095	0.954	26.22	0.99	0.946	19.26	0.99	0.674	134.0	0.83	1.024	-23.63	0.98
810	0.939	81.05	0.98	0.925	72.81	0.99	0.681	165.6	0.84	0.986	44.33	0.97
878	0.855	75.30	0.97	0.879	50.10	0.99	0.712	121.9	0.91	0.951	18.42	0.89
890	0.812	125.1	0.95	0.948	42.39	0.99	0.788	108.2	0.94	0.999	20.99	0.99
Monitor ID	Post-Intervention Period											
	Winter '19			Spring '19			Summer '19			Fall '19 – Winter '20		
	a	b	R²	a	b	R²	a	b	R²	a	b	R²
870	1	0	1	1	0	1	1	0	1	1	0	1
809	1.011	48.11	1.00	1.004	45.17	1.00	1.049	-74.55	0.98	1.054	25.83	0.99
811	1.014	30.48	1.00	1.058	8.62	0.98	1.053	-60.28	0.98	1.046	15.03	1.00
877	1.023	-52.24	1.00	1.077	-83.65	0.98	1.068	12.40	0.99	1.043	-64.31	0.98
095	0.994	-4.49	1.00	0.998	-10.76	0.99	0.996	18.59	1.00	1.018	-24.74	1.00
810	1.015	35.22	0.99	0.919	79.67	0.98	1.097	-96.43	0.97	1.068	19.86	1.00
878	0.995	3.80	0.99	0.976	15.13	0.81	1.166	-80.05	0.97	1.033	-13.20	0.99

| 890 | 1.019 | 14.56 | 0.99 | 1.049 | -2.37 | 0.99 | 1.102 | -74.26 | 0.97 | 1.072 | -8.34 | 0.99 |

4. Supplemental Results: Home Information

4.1. Housing characteristics and indoor environmental conditions

Table S8 summarizes information on housing characteristics and indoor environmental conditions of all homes obtained from the baseline and end-line surveys.

Table S8. Housing characteristics of the 40 study homes

Home ID	Year built	Bedrooms	Occupants	Floor area (m²)	Basement type	Attic type	HVAC system	Filter type
H1	1919	2	1	99	Finished	N/A	Boiler only	N/A
H2	1951	4	5	214	Finished	Finished	Central AHU	MERV 5-8
H3	1902	3	3	284	Finished	Finished	Central AHU	MERV 1-4
H4	1913	2	1	91	N/A	N/A	Central AHU	MERV 5-8
H5	1928	4	2	294	Finished	Crawl space	Central AHU	MERV 1-4
H6	1916	3	2	214	Finished	Finished	Central AHU	MERV 1-4
H7	1919	6	7	441	Half-finished	Finished	Central AHU	MERV 1-4
H8	1919	4	1	180	Finished	Finished	Boiler only	N/A
H9	1922	3	4	64	Unfinished	Crawl space	Central AHU	MERV 5-8
H10	1949	3	3	145	Finished	Crawl space	Central AHU	MERV 5-8
H11	1927	4	3	237	Finished	Unfinished	Central AHU	MERV 5-8
H12	1923	3	4	102	Unfinished	Crawl space	Central AHU	MERV 1-4
H13	1967	3	3	213	Finished	Crawl space	Central AHU	MERV 1-4
H14	1928	3	4	179	Finished	N/A	Boiler only	N/A
H15	1917	3	2	167	Unfinished	Unfinished	Central AHU	MERV 9-12
H16	1917	2	3	127	Unfinished	Unfinished	Central AHU	≥MERV 13
H17	1924	4	6	265	Finished	Finished	Boiler only	N/A
H18	1924	3	4	325	Unfinished	Unfinished	Boiler only	N/A
H19	1925	3	4	200	Finished	Finished	Boiler only	N/A
H20	1926	5	5	199	Finished	Finished	Central AHU	MERV 5-8
H21	1919	2	3	255	Finished	Finished	Central AHU	MERV 5-8
H22	1921	4	2	263	Half-finished	Half-finished	Boiler only	N/A
H23	1923	3	1	296	Finished	Finished	Central AHU	MERV 9-12
H24	1927	3	2	269	Finished	Finished	Boiler only	N/A
H25	1927	4	6	228	Finished	Finished	Central AHU	MERV 9-12
H26	1914	4	2	297	Finished	Finished	Central AHU	MERV 5-8
H27	1922	2	1	141	Unfinished	Finished	Boiler only	N/A
H28	1920	2	2	257	Half-finished	Finished	Central AHU	MERV 9-12
H29	1925	3	5	325	Finished	Finished	Central AHU	MERV 9-12
H30	1929	6	6	267	Finished	Finished	Boiler only	N/A
H31	1954	3	1	160	Finished	Crawl space	Central AHU	MERV 9-12
H32	1927	3	1	167	Half-finished	Unfinished	Central AHU	MERV 9-12
H33	1885	4	3	232	Finished	Finished	Central AHU	MERV 9-12
H34	1928	4	2	176	Unfinished	Finished	Central AHU	MERV 5-8
H35	1915	4	2	177	Finished	Finished	Central AHU	MERV 1-4
H36	1892	4	2	331	Unfinished	Finished	Central AHU	MERV 5-8
H37	1924	2	3	177	Half-finished	Unfinished	Central AHU	≥MERV 13
H38	1912	4	3	253	Finished	Finished	Boiler only	N/A
H39	1920	4	4	228	Finished	Finished	Central AHU	MERV 5-8
H40	1924	3	3	249	Finished	Crawl space	Boiler only	N/A

Table S8. Housing characteristics of the 40 study homes (continued)

Home ID	Stove type	Bathroom fan	Use of stove fan	Use of bathroom fan	Dampness (last 12 months)	Musty smell (last 12 months)	Air freshener (last 12 months)
H1	Gas	Yes	Rarely	Always	Yes	Yes	Yes
H2	Gas	Yes	Never	Sometimes	No	Yes	No
H3	Gas	Yes	Rarely	Sometimes	Yes	Yes	No
H4	Gas	No	Never	Never	No	No	No
H5	Gas	Yes	Rarely	Rarely	No	Yes	No
H6	Gas	Yes	Rarely	Always	Yes	Yes	No
H7	Gas	Yes	Never	Never	No	No	No
H8	Gas	No	Sometimes	Never	Yes	No	Yes
H9	Gas	No	Always	Never	Yes	No	Yes
H10	Gas	No	Rarely	Never	No	No	Yes
H11	Gas	No	Never	Never	Yes	No	Yes
H12	Gas	Yes	Rarely	Always	No	No	Yes
H13	Gas	Yes	Sometimes	Sometimes	No	Yes	Yes
H14	Gas	Yes	Sometimes	Frequently	Yes	Yes	Yes
H15	Gas	No	Never	Never	Yes	Yes	Yes
H16	Gas	No	Always	Never	No	No	Yes
H17	Gas	No	Never	Never	N/A	N/A	No
H18	Gas	Yes	Always	Always	Yes	Yes	No
H19	Gas	Yes	Sometimes	Always	No	No	Yes
H20	Gas	Yes	Sometimes	Always	No	Yes	Yes
H21	Gas	Yes	Sometimes	Always	Yes	Yes	Yes
H22	Gas	Yes	Sometimes	Frequently	Yes	Yes	Yes
H23	Gas	No	Never	Never	No	Yes	Yes
H24	Gas	Yes	Always	Frequently	Yes	Yes	Yes
H25	Elec.	Yes	Always	Always	No	Yes	Yes
H26	Gas	Yes	Sometimes	Frequently	No	Yes	Yes
H27	Gas	No	Sometimes	Never	No	Yes	No
H28	Gas	Yes	Frequently	Always	No	No	No
H29	Gas	No	Frequently	Never	Yes	Yes	No
H30	Gas	Yes	Sometimes	Always	No	Yes	No
H31	Elec.	No	Always	Never	Yes	Yes	Yes
H32	Gas	No	Never	Never	No	No	No
H33	Elec.	Yes	Always	Frequently	No	No	No
H34	Gas	Yes	Sometimes	Sometimes	N/A	No	Yes
H35	Gas	Yes	Sometimes	Frequently	No	No	Yes
H36	Elec.	No	Never	Never	Yes	Yes	Yes
H37	Gas	Yes	Always	Sometimes	Yes	Yes	Yes
H38	Gas	Yes	Sometimes	Sometimes	Yes	Yes	Yes
H39	Gas	Yes	Sometimes	Sometimes	No	No	No
H40	Gas	No	Always	Never	N/A	Yes	Yes

Table S9 summarizes HVAC system runtime for all homes at each season of the entire study period and at pre- and post-intervention period, measured by Digi-Sense data logging vane anemometers installed on a convenient supply register.

Table S9. Summary of HVAC system runtime data for each season of the entire study period

HVAC Runtime Data	Pre-intervention					Post-intervention				
	Summer 2017	Fall 2017	Winter 2018	Spring 2018	Summer 2018	Winter 2019	Spring 2019	Summer 2019	Fall 2019	Winter 2020
Average	30.0%	35.6%	33.9%	17.8%	26.6%	34.1%	13.2%	34.2%	33.0%	37.4%
SD	25.1%	24.8%	18.8%	23.4%	21.7%	28.0%	20.7%	33.8%	24.2%	22.2%
Median	19.3%	28.9%	29.9%	7.2%	23.4%	31.1%	6.0%	19.0%	24.0%	32.9%
Min	0.1%	1.5%	3.8%	0.0%	0.2%	0.2%	0.0%	4.6%	4.6%	3.9%
Max	86.2%	88.4%	81.3%	98.0%	65.7%	94.4%	78.6%	99.7%	96.6%	86.1%

Table S9. Summary of HVAC system runtime data for each season of the entire study period (continued)

Summary	Pre-intervention	Post-intervention	Entire duration
Average	28.3%	29.4%	28.8%
SD	23.4%	26.8%	24.8%
Median	25.4%	23.0%	23.5%
Min	0.0%	0.0%	0.0%
Max	98.0%	99.7%	99.7%

4.2. Results of basic building performance and assignment of ventilation system retrofit

Table S10 summarizes the results of blower door tests, TrueFlow meter tests, and both kitchen and bathroom exhaust fan flow tests from initial home walkthroughs.

Table S10. Summary of basic building performance from initial home walkthroughs

Home ID	Blower Door Test, L/s@50Pa (CFM50)	Air Changes per Hour at 50 Pascals (ACH50)	AHU Flow Rate		Exhaust Fan Flow Rate	
			AHU flow, L/s (CFM)	Operating Mode	Bathroom, L/s (CFM)	Kitchen[a], L/s (CFM)
H1	1,285 (2,723)	17.0	N/A	N/A	18 (38)	N/A
H2	1,233 (2,613)	7.6	563 (1,192)	Cooling	17 (36)	N/A
H3	2,582 (5,471)	11.9	441 (923)	Heating	25 (53)	N/A
H4	1,683 (3,567)	24.2	295 (626)	Heating	N/A	N/A
H5	1,486 (3,148)	6.6	419 (888)	Cooling	32 (67)	N/A
H6	1,402 (2,971)	8.6	214 (454)	Cooling	25 (53)	N/A
H7	4,441 (9,411)	13.2	N/A	N/A	18 (38)	N/A
H8	2,179 (4,618)	15.9	N/A	N/A	N/A	N/A
H9	1,258 (2,665)	26.0	289 (612)	Cooling	N/A	N/A
H10	800 (1,695)	7.3	393 (833)	Cooling	N/A	18 (38)
H11	2,345 (4,970)	13.0	577 (1,223)	Cooling	N/A	N/A
H12	1,274 (2,699)	16.4	554 (1,173)	Cooling	12 (26)	N/A
H13	1,800 (3,815)	11.1	417 (883)	Cooling	25 (52)[*]	N/A
H14	2,544 (5,392)	18.7	N/A	N/A	23 (48)	N/A
H15	1,521 (3,224)	12.0	265 (561)	Cooling	N/A	N/A
H16	1,196 (2,534)	12.3	472 (1,000)	Cooling	N/A	49 (104)
H17	940 (1,991)	4.7	N/A	N/A	N/A	N/A
H18	2,093 (4,436)	8.4	N/A	N/A	N/A	57 (121)
H19	1,495 (3,168)	9.8	N/A	N/A	30 (64)	25 (52)
H20	2,496 (5,290)	16.4	470 (995)	Cooling	19 (41)[*]	N/A
H21	1,808 (3,831)	9.3	460 (975)	Heating	47 (100)	N/A
H22	4,017 (8,512)	20.0	N/A	N/A	N/A	N/A
H23	2,955 (6,262)	13.1	353 (747)	Cooling	N/A	N/A
H24	1,363 (2,888)	6.6	N/A	N/A	18 (38)	57 (120)
H25	1,832 (3,882)	10.5	382 (809)	Cooling	16 (33)[*]	N/A
H26	2,172 (4,603)	9.6	569 (1,206)	Cooling	8 (17)[*]	N/A
H27	1,755 (3,720)	16.3	N/A	N/A	N/A	N/A
H28	1,915 (4,058)	9.8	310 (657)	Cooling	21 (44)[*]	42 (90)
H29	2,025 (4,291)	8.2	340 (721)	Cooling	N/A	N/A
H30	2,694 (5,709)	13.3	N/A	N/A	21 (45)	34 (71)
H31	1,176 (2,492)	9.6	318 (673)	Cooling	N/A	N/A
H32	2,092 (4,434)	16.4	405 (859)	Cooling	N/A	N/A
H33	716 (1,517)	4.0	429 (909)	Cooling	14 (29)[*]	124 (262)
H34	N/A	N/A	327 (693)	Fan-only	30 (63)	N/A
H35	806 (1,708)	6.0	431 (913)	Heating	18 (39)[*]	N/A
H36	1,263 (2,677)	5.0	608 (1,289)	Cooling	N/A	N/A
H37	1,178 (2,497)	8.8	395 (837)	Cooling	20 (42)	42 (90)
H38	1,153 (2,443)	6.0	N/A	N/A	33 (69)	N/A
H39	2,146 (4,547)	12.4	378 (800)	Heating	N/A	N/A
H40	1,755 (3,720)	9.3	N/A	N/A	18 (38)	N/A

[*] Average flow rate of two or more bathroom exhaust fans
[a] Kitchen exhaust fan flow rates were measured only for those kitchen fans that ventilated to the outside.

Table S11 summarizes the residential mechanical ventilation system types and models installed in each home, as well as upfront costs to purchase equipment, installation costs (including installation, accessories, painting, drywall work, etc.), ECM install costs, and total costs (including any required health and safety repairs and blower door tests) charged by the local contractors.

Table S11. Summary of residential mechanical ventilation retrofits and upfront/installation costs (USD)

Home ID	Ventilation System Type	Model	Furnace Motor	Upfront Cost	Installation Cost[a]	Misc. Cost[b]	ECM Cost	Total Cost[c]
H1	Exhaust-only (1)	Panasonic FV-0810VSSL1	N/A	$170	$1,725	$100	N/A	$1,995
H2	Balanced (a)	Broan ERV 110S	PSC	$900	$1,545	$100	N/A	$2,545
H3	CFIS	Aprilaire 8140	ECM (1)	$332	$805	$100	$1,275	$2,512
H4	CFIS	Aprilaire 8140	ECM (1)	$332	$720	$100	$1,275	$2,427
H5	CFIS	Aprilaire 8140	ECM (1)	$332	$1,100	$0	$1,275	$2,707
H6	Exhaust-only (1)	Broan ZB110	N/A	$160	$825	$0	N/A	$985
H7	Balanced (b)	RenewAire EV130	PSC	$850	$2,150	$100	N/A	$3,100
H8	Exhaust-only (1)	Broan ZB110	N/A	$160	$825	$0	N/A	$985
H9	CFIS	Aprilaire 8140	ECM (1)	$332	$815	$100	$1,275	$2,522
H10	Balanced (a)	Broan ERV 110T	ECM (1)	$900	$1,545	$0	$1,275	$3,720
H11	CFIS	Aprilaire 8140	ECM (1)	$332	$720	$225	$1,275	$2,552
H12	CFIS	Aprilaire 8140NC	ECM (1)	$332	$720	$125	$1,275	$2,452
H13	Balanced (a)	Broan ERV 110S	ECM (1)	$900	$1,545	$100	$1,275	$3,820
H14	Exhaust-only (1)	Panasonic FV-0810VSSL1	N/A	$170	$825	$100	N/A	$1,095
H15	Balanced (a)	Broan ERV 110T	PSC	$900	$1,545	$100	N/A	$2,545
H16	CFIS	Aprilaire 8140	ECM (1)	$332	$720	$100	$1,275	$2,427
H17	Balanced (b)	RenewAire EV130	PSC	$850	$1,875	$0	N/A	$2,725
H18	Exhaust-only (1)	Panasonic FV-0511VKSL1	N/A	$270	$1,100	$100	N/A	$1,470
H19	Exhaust-only (1)	Panasonic FV-0511VQL1	N/A	$230	$825	$100	N/A	$1,155
H20	CFIS	Aprilaire 8140	ECM (1)	$332	$720	$100	$1,275	$2,427
H21	CFIS	Aprilaire 8140	ECM (1)	$332	$720	$0	$1,275	$2,327
H22	Balanced (b)	RenewAire EV130	PSC	$850	$1,875	$100	N/A	$2,825
H23	CFIS	Aprilaire 8140	ECM (1)	$332	$720	$0	$1,275	$2,327
H24	Exhaust-only (1)	Broan ZB110	N/A	$160	$825	$100	N/A	$1,085
H25	CFIS	Aprilaire 8140	PSC	$332	$720	$0	N/A	$1,052
H26	Balanced (a)	Broan ERV 110T	ECM (1)	$900	$1,545	$0	$1,275	$3,720
H27	Exhaust-only (1)	Broan ZB110	N/A	$160	$825	$0	N/A	$985
H28	CFIS	Aprilaire 8140	ECM (1)	$332	$720	$165	$1,275	$2,492
H29	Exhaust-only (2)	Panasonic FV-0810VSSL1	N/A	$330	$1,650	$100	N/A	$2,080
H30	Exhaust-only (2)	Panasonic FV-0511VKSL1	N/A	$430	$1,650	$100	N/A	$2,180
H31	Balanced (a)	Broan ERV 110S	PSC	$900	$1,545	$100	N/A	$2,545
H32	Balanced (b)	Broan ERV 110S	PSC	$850	$2,775	$100	N/A	$3,725
H33	CFIS	Aprilaire 8140	PSC	$332	$720	$100	N/A	$1,152
H34	Balanced (b)	Broan ERV 110S	PSC	$850	$1,875	$0	N/A	$2,725
H35	CFIS	Aprilaire 8140	PSC	$332	$720	$0	N/A	$1,052
H36	Exhaust-only (2)	Broan ZB110	N/A	$320	$1,650	$100	$1,275	$3,345
H37	Balanced (a)	Broan ERV 110T	ECM (1)	$900	$1,630	$0	$1,275	$3,805
H38	Exhaust-only (2)	Broan ZB110	N/A	$320	$1,650	$100	N/A	$2,070
H39	CFIS	Aprilaire 8140	ECM (2)	$332	$1,240	$100	$2,550	$4,222
H40	Exhaust-only (2)	Broan ZB110	N/A	$320	$1,650	$0	N/A	$1,970

'Exhaust-only (1)': one exhaust fan installed in one bathroom; 'Exhaust-only (2)': two exhaust fans installed in two bathrooms; 'Balanced (a)': Balanced exhaust and supply system with ERV using existing AHU ducts; 'Balanced (b)': Balanced exhaust and supply system with ERV using independent stand-alone ducts; 'ECM (1)': one PSC motor replaced with one ECM; 'ECM (2)': two PSC motors replaced with two ECMs.

[a] Installation costs include drywall, painting, penetration construction costs.

[b] Miscellaneous costs include blower door tests and health & safety costs.

[c] Total costs sum all costs. For the cost of ventilation system installation alone, subtract ECM cost from total cost.

Table S12 summarizes airflow rate measurements through the central AHUs using TrueFlow Plates (in homes that had central HVAC). For homes that received CFIS systems or balanced systems with an ERV, flow rate measurements are reported separately for both pre- and post-intervention periods.

Table S12. Summary of airflow rate measurements through the AHU

Home ID	Pre-intervention		Post-intervention		Airflow Rate Change Rate
	Supply pressure (Pa)	Airflow rate (CFM)	Supply pressure (Pa)	Airflow rate (CFM)	
H1	N/A	N/A	N/A	N/A	N/A
H2	29	872	23	621	-29%
H3	51	1102	47	1122	2%
H4	N/A	N/A	N/A	N/A	N/A
H5	59	931	59	931	0%
H6	148	307	N/A	N/A	N/A
H7	N/A	N/A	N/A	N/A	N/A
H8	N/A	N/A	N/A	N/A	N/A
H9	29	608	9	497	-18%
H10	40	830	43	735	-11%
H11	33	1195	40	1353	13%
H12	48	1092	48	1092	0%
H13	17	888	22	1040	17%
H14	N/A	N/A	N/A	N/A	N/A
H15	38	551	32	468	-15%
H16	61	948	31	761	-20%
H17	N/A	N/A	N/A	N/A	N/A
H18	N/A	N/A	N/A	N/A	N/A
H19	N/A	N/A	N/A	N/A	N/A
H20	20	646	20	646	0%
H21	N/A	N/A	19	962	N/A
H22	N/A	N/A	N/A	N/A	N/A
H23	89	750	116	762	2%
H24	N/A	N/A	N/A	N/A	N/A
H25	6	754	50	526	-30%
H26	34	1187	37	1101	-7%
H27	N/A	N/A	N/A	N/A	N/A
H28	29	583	51	688	18%
H29	N/A	N/A	N/A	N/A	N/A
H30	N/A	N/A	N/A	N/A	N/A
H31	46	664	40	687	3%
H32	42	816	42	816	0%
H33	23	821	23	821	0%
H34	19	693	43	805	16%
H35	7	476	7	476	0%
H36	13	1096	13	1096	0%
H37	N/A	N/A	N/A	N/A	N/A
H38	N/A	N/A	N/A	N/A	N/A
H39	24	808	37	890	10%
H40	N/A	N/A	N/A	N/A	N/A

Table S13 summarizes required and measured outdoor airflow rates, average runtimes, annual delivered flow volumes, and measured ventilation system power draw of each study home.

Table S13. ASHRAE 62.2 ventilation requirements, measured outdoor airflow rate, calculated required average runtime, estimated annual delivered flow volume, and measured power draw of mechanical ventilation systems

Home ID	Ventilation System Type	Ventilation Requirements[a], L/s (CFM)	Measured Flow Rate[b], L/s (CFM)	Required Average Runtime (-)	Estimated Annual Delivered Flow, 10^6 L (10^6 ft^3)	Active Power (W)
H1	Exhaust-only (1)	22 (47)	23 (48)	1	714 (25)	NA
H2	Balanced (a)	50 (107)	51 (108)	1	1607 (57)	Measurement failure
H3	CFIS	54 (114)	71 (150)	0.46	1018 (36)	65
H4	CFIS	21 (45)	92 (195)	0.18	522 (18)	Measurement failure
H5	CFIS	59 (125)	N/A	0.50	NA	70
H6	Exhaust-only (1)	43 (92)	45 (95)	1	1414 (50)	NA
H7	Balanced (b)	89 (188)	57 (120)	1	1786 (63)	Measurement failure
H8	Exhaust-only (1)	42 (88)	42 (88)	1	1310 (46)	NA
H9	CFIS	20 (43)	78 (165)	0.17	422 (15)	70
H10	Balanced (a)	33 (69)	35 (75)	1	1116 (39)	102
H11	CFIS	50 (107)	55 (117)	0.43	745 (26)	70
H12	CFIS	26 (55)	61 (130)	0.22	426 (15)	66
H13	Balanced (a)	43 (91)	52 (110)	1	1637 (58)	49
H14	Exhaust-only (1)	42 (88)	42 (90)	1	1340 (47)	NA
H15	Balanced (a)	36 (76)	41 (88)	1	1310 (46)	108
H16	CFIS	34 (71)	107 (227)	0.28	960 (34)	67
H17	Balanced (b)	65 (138)	41 (87)	1	1295 (46)	116
H18	Exhaust-only (1)	64 (135)	54 (115)	1	1712 (60)	NA
H19	Exhaust-only (1)	45 (95)	52 (111)	1	1652 (58)	NA
H20	CFIS	51 (109)	89 (188)	0.44	1220 (43)	66
H21	CFIS	50 (105)	61 (130)	0.42	813 (29)	70
H22	Balanced (b)	54 (115)	53 (112)	1	1667 (59)	Measurement failure
H23	CFIS	56 (118)	84 (178)	0.47	1250 (44)	64
H24	Exhaust-only (1)	52 (110)	54 (114)	1	1697 (60)	NA
H25	CFIS	52 (111)	80 (170)	0.44	1123 (40)	65
H26	Balanced (a)	59 (126)	72 (153)	1	2277 (80)	100
H27	Exhaust-only (1)	32 (68)	33 (70)	1	1042 (37)	NA
H28	CFIS	46 (98)	94 (200)	0.39	1167 (41)	70
H29	Exhaust-only (2)	64 (135)	64 (135)	1	2009 (71)	NA
H30	Exhaust-only (2)	62 (131)	63 (134)	1	1994 (70)	NA
H31	Balanced (a)	35 (74)	35 (75)	1	1116 (39)	51
H32	Balanced (b)	36 (76)	41 (86)	1	1280 (45)	53
H33	CFIS	50 (105)	75 (158)	0.42	988 (35)	Measurement failure
H34	Balanced (b)	41 (87)	N/A	1	N/A	48
H35	CFIS	41 (87)	76 (162)	0.35	839 (30)	60
H36	Exhaust-only (2)	65 (137)	65 (137)	1	2039 (72)	NA
H37	Balanced (a)	38 (80)	42 (88)	1	1310 (46)	46
H38	Exhaust-only (2)	53 (112)	55 (117)	1	1741 (61)	NA
H39	CFIS	49 (104)	75 (158)	0.42	978 (35)	67
H40	Exhaust-only (2)	52 (110)	52 (111)	1	1652 (58)	NA

'Exhaust-only (1)': one exhaust fan installed in one bathroom; 'Exhaust-only (2)': two exhaust fans installed in two bathrooms; 'Balanced (a)': Balanced exhaust and supply system with ERV using existing AHU ducts; 'Balanced (b)': Balanced exhaust and supply system with ERV using independent stand-alone ducts; 'ECM (1)': one PSC motor replaced with one ECM; 'ECM (2)': two PSC motors replaced with two ECMs.

[a] Minimum required ventilation rates calculated based on ASHRAE Standard 62.2-2016.

[b] Air flow rate measurements after the installation of ventilation systems.

Figure S10 shows an example of each type of ventilation system retrofit installed in the study homes.
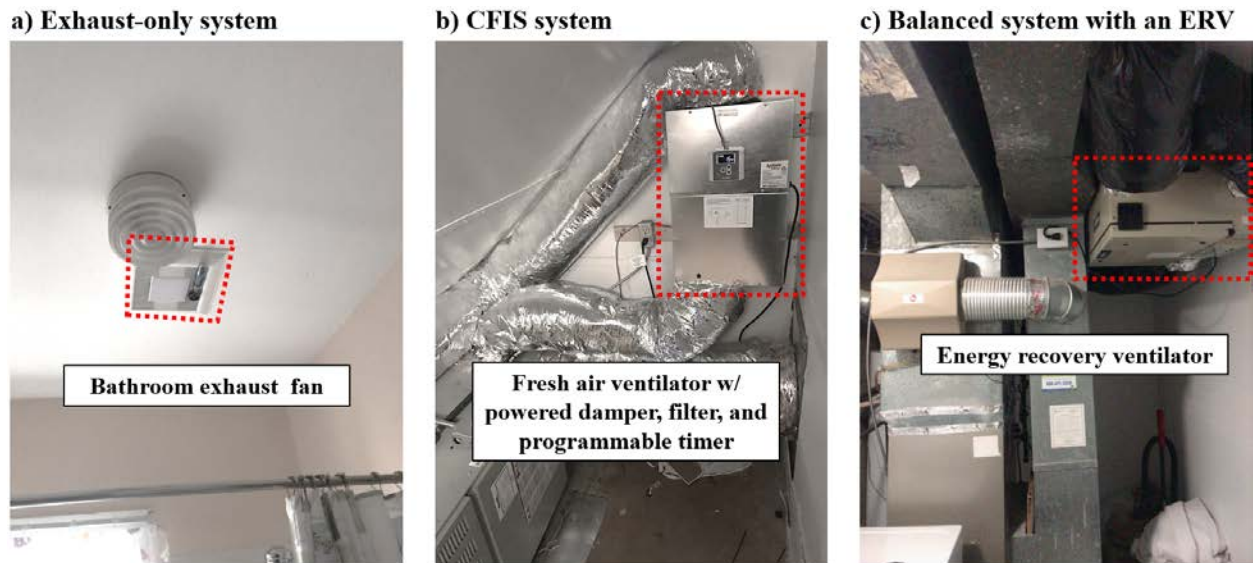
Figure S10. Examples of an exhaust-only system, an intermittent CFIS system, and a balanced system with an ERV

Figure S11 shows an example of time series power draw data for (a) an intermittent CFIS system and (b) a balanced system with an ERV, both measured using plug load data loggers.
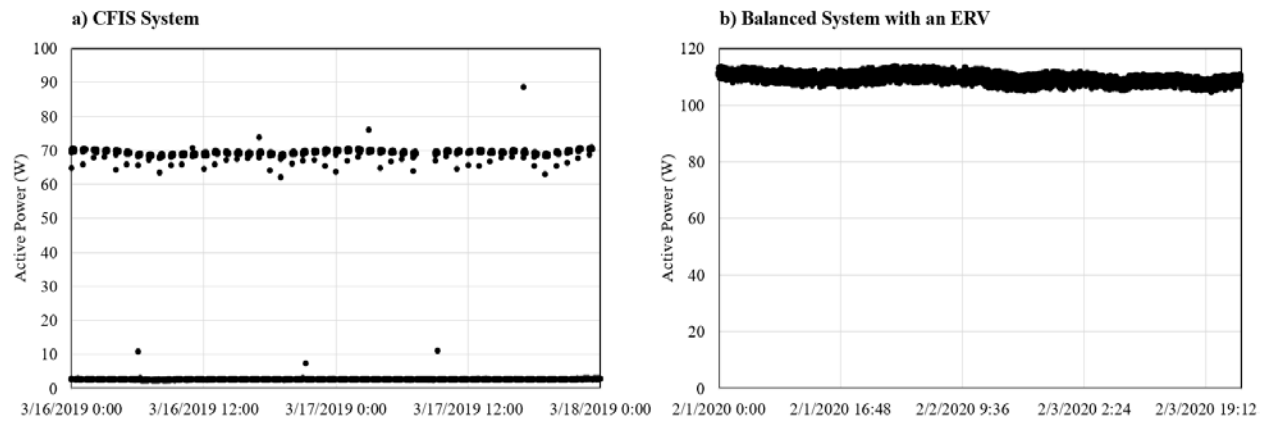
Figure S11. Examples of power draw of an intermittent CFIS system and a continuous balanced system with an ERV

5. Supplemental Results: Indoor/Outdoor Pollutant Concentrations

Summary statistics for indoor and outdoor air pollutant concentrations and temperature and relative humidity measured in all homes at each season of the entire study period are summarized in Table S14. The average indoor and outdoor pollutant concentrations during pre- and post-intervention period for all study home are also summarized in Table S15.

Table 14. Statistical summary of measured pollutant concentrations and environmental conditions during each season, averaged across all study homes

	Pre-Intervention Period					Post-Intervention Period				
	SU '17	FA '17	WI '18	SP '18	SU '18	WI '19	SP '19	SU '19	FA '19	WI '20
Indoors										
HCHO (ppb)	58.6	29.1	21.7	21.2	26.0	26.5	8.4	9.1	9.8	13.1
CO (ppm)	5.01	4.98	5.08	4.57	2.39	4.76	4.31	5.79	2.92	3.70
CO_2 (ppm)	838.6	788.5	786.7	742.8	727.1	699.5	686.9	581.8	719.4	638.5
NO_2 (ppb)	48.8	56.9	65.0	74.6	59.8	68.4	59.0	60.4	60.0	58.7
O_3 (ppb)	2.5	9.5	11.5	11.8	11.8	11.5	11.9	7.9	9.1	9.5
PM_1 ($\mu g/m^3$)	19.8	14.9	14.9	10.0	10.8	10.0	10.5	8.3	8.8	11.3
$PM_{2.5}$ ($\mu g/m^3$)	21.5	16.3	17.0	11.3	11.6	12.3	11.8	9.2	9.9	12.7
PM_{10} ($\mu g/m^3$)	23.6	18.4	20.8	14.2	13.1	15.4	13.3	11.1	11.9	14.4
Temp (°C)	27.0	23.0	22.9	24.9	27.9	22.5	26.0	27.3	24.4	24.4
RH (%)	45.3	36.9	30.8	42.4	49.5	29.6	42.0	49.2	33.0	27.9
Outdoors										
CO (ppm)	0.64	4.00	1.07	0.79	0.14	0.04	1.88	2.67	2.72	2.62
CO_2 (ppm)	431.4	440.1	425.8	417.2	397.6	425.7	411.7	388.6	415.7	409.5
NO_2 (ppb)	49.3	66.7	96.6	94.1	75.8	82.9	83.8	76.0	82.0	86.9
O_3 (ppb)	12.5	11.2	17.9	21.0	12.8	20.3	21.7	14.5	12.2	20.9
PM_1 ($\mu g/m^3$)	14.3	15.2	12.8	14.7	23.1	12.7	11.0	11.9	16.4	12.9
$PM_{2.5}$ ($\mu g/m^3$)	15.1	16.2	13.4	15.6	24.0	13.1	11.6	12.4	17.2	13.7
PM_{10} ($\mu g/m^3$)	19.0	19.7	15.0	18.5	27.2	13.9	13.8	14.9	19.3	15.2
Temp (°C)	27.3	11.5	13.1	22.3	30.5	17.2	22.5	28.1	10.6	7.2
RH (%)	46.0	45.0	32.5	47.3	51.9	27.0	50.2	52.4	49.5	48.8

Table S15. Average indoor/outdoor pollutant concentrations during pre-intervention period

Home ID	Pre-Intervention Period														
	Indoor								Outdoor						
	HCHO (ppb)	CO (ppm)	CO_2 (ppm)	NO_2 (ppb)	O_3 (ppb)	PM_1 (µg/m³)	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)	CO (ppm)	CO_2 (ppm)	NO_2 (ppb)	O_3 (ppb)	PM_1 (µg/m³)	$PM_{2.5}$ (µg/m³)	PM_{10} (µg/m³)
H1	7.0	1.71	695	58.3	10.9	5.1	5.6	6.4	N/A	423	86.5	13.6	13.4	14.0	16.4
H2	64.0	4.36	968	62.8	11.5	7.0	8.3	10.8	2.32	412	67.1	16.7	13.9	14.8	17.9
H3	49.5	0.07	536	56.3	10.4	7.0	7.5	9.1	N/A	438	92.1	13.4	20.1	21.3	24.1
H4	26.3	1.65	642	66.2	11.1	20.8	21.9	24.8	0.80	421	79.9	17.9	26.9	28.3	31.1
H5	10.8	0.09	533	57.7	8.6	3.6	3.9	4.9	0.09	428	92.0	16.1	14.8	15.6	17.8
H6	88.8	4.02	1073	61.9	12.5	4.9	5.6	8.1	N/A	425	90.2	17.0	9.0	9.7	12.4
H7	17.5	7.58	642	60.5	12.4	53.3	60.3	71.5	0.19	420	76.0	13.0	17.0	17.9	21.9
H8	41.8	6.88	698	63.3	9.1	8.2	9.0	10.6	2.63	431	71.6	15.0	11.1	11.9	15.3
H9	15.3	0.44	927	61.6	10.5	10.3	11.2	13.0	N/A	424	68.5	15.6	18.0	19.1	23.0
H10	51.7	4.61	1082	51.5	9.1	7.5	8.5	10.1	N/A	433	89.8	14.1	12.6	13.5	16.8
H11	5.0	6.68	646	50.4	12.7	6.0	6.4	7.4	1.01	436	76.2	18.7	14.2	15.0	17.5
H12	12.0	6.37	713	58.3	9.2	46.4	51.8	56.4	1.32	437	76.9	16.5	14.8	15.8	18.7
H13	23.5	8.19	494	62.8	10.1	12.7	13.2	14.1	1.09	427	86.3	14.1	17.4	18.3	20.9
H14	5.0	4.28	957	54.8	7.8	19.8	22.4	30.9	1.33	434	80.1	16.5	15.9	16.9	19.7
H15	58.5	4.75	975	62.0	9.3	7.4	8.8	11.5	2.84	430	71.5	13.6	19.6	20.6	23.1
H16	19.0	6.15	767	58.6	11.0	8.1	8.7	11.6	3.05	430	89.3	15.9	15.4	16.6	19.8
H17	55.3	0.75	1537	56.5	9.3	4.9	5.8	10.0	N/A	422	85.7	16.1	14.1	14.8	17.2
H18	14.5	5.24	759	71.9	12.3	7.2	7.8	10.0	0.92	427	82.2	17.7	19.3	20.0	22.0
H19	14.5	2.17	1056	59.0	11.4	78.2	87.8	92.6	0.33	419	75.3	17.7	15.5	16.4	19.1
H20	90.0	3.86	720	72.3	9.4	8.5	9.2	10.8	1.15	439	82.8	13.7	20.2	21.0	23.6
H21	15.5	1.77	747	69.5	9.9	18.7	19.9	21.8	N/A	419	76.5	14.2	14.3	15.1	18.5
H22	24.3	5.39	573	54.3	11.3	6.2	6.8	9.5	0.11	415	79.9	14.9	9.6	10.1	12.2
H23	29.5	5.09	505	59.7	11.1	5.2	5.8	7.0	4.38	410	70.4	17.8	11.4	12.3	16.2
H24	16.0	2.85	541	53.9	10.6	4.9	5.3	6.5	N/A	422	78.1	15.4	14.7	15.5	17.9
H25	31.3	3.81	834	57.1	8.2	6.8	7.5	9.8	0.35	428	76.0	14.0	15.3	16.2	20.0
H26	41.3	3.85	597	70.4	10.0	12.4	13.7	15.1	0.27	415	64.8	17.4	17.0	18.2	21.6
H27	15.0	5.57	655	57.8	12.9	12.4	13.8	15.6	0.47	424	81.8	18.7	14.7	15.5	18.7
H28	50.3	N/A	530	61.7	8.9	14.8	15.5	17.9	0.07	425	72.6	14.3	19.6	20.8	23.0
H29	43.0	5.71	1046	73.2	12.0	19.0	21.1	24.2	0.92	430	66.9	16.3	16.2	17.0	19.7
H30	41.3	0.07	721	70.1	10.7	6.7	7.4	10.7	N/A	421	100.0	20.1	10.3	10.8	13.9
H31	5.0	6.06	813	56.6	12.0	9.7	11.3	13.1	1.69	416	68.8	13.8	15.4	16.3	19.7
H32	14.0	0.09	688	58.0	11.3	8.4	8.9	10.6	N/A	434	75.4	13.9	19.2	20.2	21.9
H33	90.3	5.16	710	52.0	10.2	4.5	4.8	5.3	0.38	433	79.5	16.0	17.4	18.4	21.4
H34	37.5	5.58	635	64.5	8.5	16.7	19.2	22.9	2.69	411	76.9	14.9	13.4	14.0	17.1
H35	23.5	1.80	623	63.3	12.8	8.8	9.3	10.4	0.50	436	81.9	11.3	14.6	15.5	19.0
H36	21.5	8.43	622	66.5	10.4	5.4	5.9	7.6	4.66	430	73.5	17.2	12.3	13.1	16.1
H37	15.5	1.55	823	53.9	7.7	6.0	6.6	7.7	0.23	428	59.4	13.6	17.9	18.7	22.0
H38	41.8	5.46	1412	105.5	8.3	12.9	14.9	18.1	0.89	418	68.8	18.0	13.1	13.9	17.4
H39	11.3	8.15	964	56.6	11.5	5.8	7.1	15.7	2.71	418	73.8	15.9	8.0	8.7	11.6
H40	8.5	7.62	708	69.3	12.8	7.5	8.3	9.7	1.72	419	77.3	14.9	10.1	10.6	13.0

Home ID	Post-Intervention Period														
	Indoor								Outdoor						
	HCHO (ppb)	CO (ppm)	CO$_2$ (ppm)	NO$_2$ (ppb)	O$_3$ (ppb)	PM$_1$ (µg/m³)	PM$_{2.5}$ (µg/m³)	PM$_{10}$ (µg/m³)	CO (ppm)	CO$_2$ (ppm)	NO$_2$ (ppb)	O$_3$ (ppb)	PM$_1$ (µg/m³)	PM$_{2.5}$ (µg/m³)	PM$_{10}$ (µg/m³)
H1	12.0	3.20	591	59.2	14.3	1.4	1.5	1.7	6.35	411	82.7	18.1	12.9	13.4	14.6
H2	32.0	1.74	812	63.0	6.6	7.9	8.8	10.9	0.06	419	91.5	25.8	7.5	7.9	8.6
H3	8.3	4.74	527	63.3	6.9	6.7	8.0	9.1	0.08	390	85.4	23.5	14.3	14.7	17.2
H4	5.0	4.52	654	57.1	7.9	31.9	37.4	41.2	N/A	408	76.9	19.0	8.6	9.2	10.1
H5	7.0	1.63	634	57.2	7.9	2.3	2.6	3.2	5.61	421	87.9	14.5	13.6	14.1	14.8
H6	27.5	4.56	1140	60.7	8.0	11.4	14.9	21.7	0.09	396	77.7	21.9	18.3	19.1	20.1
H7	5.0	3.83	481	63.6	9.7	3.7	4.2	5.3	5.49	403	83.1	17.8	12.8	13.1	14.0
H8	5.0	2.39	575	59.0	7.0	5.2	5.7	6.5	3.17	416	88.4	19.7	17.4	18.2	20.1
H9	11.3	0.17	700	51.4	8.2	1.4	1.5	1.7	0.38	418	80.5	13.0	27.9	28.5	29.6
H10	18.8	N/A	724	54.8	9.0	3.5	3.8	4.7	3.80	414	81.7	16.4	13.8	14.4	15.0
H11	11.0	4.78	616	70.7	11.6	5.4	6.3	7.4	6.05	415	82.2	14.9	17.0	17.3	17.9
H12	13.0	8.41	600	62.3	8.5	16.3	24.1	25.4	2.92	427	77.0	13.7	16.7	17.3	17.9
H13	15.3	4.26	533	53.2	10.2	4.8	5.8	6.8	0.07	392	85.0	16.5	21.6	22.3	23.3
H14	11.0	2.11	690	57.5	7.8	33.3	38.1	40.4	0.01	402	83.2	25.5	10.9	11.6	12.2
H15	19.0	N/A	698	53.5	9.3	2.2	2.8	3.2	0.02	400	83.4	21.5	14.0	14.6	16.5
H16	23.8	1.09	817	55.9	12.8	3.2	3.8	3.9	5.26	415	82.4	12.2	24.3	25.3	26.8
H17	14.3	4.27	888	59.5	7.2	2.8	3.4	4.6	0.20	417	82.8	13.9	14.3	14.9	15.8
H18	7.0	2.76	746	63.7	12.4	2.6	2.9	3.6	0.27	408	93.1	23.7	9.3	9.6	11.2
H19	7.7	6.90	706	57.7	8.3	2.2	2.9	4.2	0.11	403	87.7	24.0	16.7	17.1	18.5
H20	13.5	5.89	629	68.8	14.1	2.8	3.2	4.1	3.99	417	78.1	21.8	12.2	12.7	13.6
H21	7.3	8.06	554	56.8	9.6	3.4	3.7	3.9	0.39	394	80.7	21.4	15.8	16.4	17.8
H22	5.0	0.47	560	57.8	11.3	0.9	1.0	1.6	2.67	426	87.2	16.4	13.2	13.8	15.0
H23	5.0	4.16	463	54.4	11.6	2.2	2.4	2.6	3.17	422	83.9	18.0	19.3	19.8	20.9
H24	13.7	1.60	485	57.8	11.1	3.7	4.0	4.7	3.16	419	71.3	9.2	15.0	15.5	16.3
H25	10.5	2.67	870	55.5	10.6	2.1	2.5	3.5	0.38	406	83.1	17.5	12.6	13.0	14.0
H26	13.7	5.71	517	56.4	12.6	16.8	18.0	18.4	5.50	416	80.7	12.7	16.6	17.1	18.5
H27	5.0	1.01	528	63.2	6.6	5.0	5.8	6.5	0.17	392	87.8	10.9	21.3	21.5	23.0
H28	8.0	0.16	506	59.6	2.0	4.0	4.2	5.5	N/A	422	85.1	16.4	24.8	26.0	26.7
H29	12.0	7.71	803	69.0	12.9	18.3	23.9	32.2	6.04	404	79.1	26.7	18.0	18.6	19.1
H30	12.3	2.71	685	63.4	12.6	5.2	5.8	7.2	N/A	407	82.7	18.6	13.6	14.1	15.2
H31	6.8	9.14	597	55.9	10.8	2.6	3.1	3.6	5.67	407	77.8	19.5	18.6	19.3	20.5
H32	15.3	2.92	506	61.3	11.8	5.3	6.0	5.9	1.86	427	77.3	10.9	19.7	20.2	21.0
H33	11.3	4.38	694	54.8	11.0	7.0	8.8	11.3	6.50	405	82.6	17.9	9.7	10.6	12.0
H34	14.0	N/A	538	60.9	12.4	8.3	10.4	11.7	0.02	408	93.5	18.3	16.3	16.8	18.4
H35	5.0	0.05	618	66.6	15.0	1.2	1.4	1.9	0.19	418	78.4	14.8	17.7	18.5	19.7
H36	11.3	7.80	511	62.0	8.5	3.0	3.4	4.1	0.07	411	79.8	14.8	12.0	12.8	14.1
H37	9.0	3.87	742	56.2	8.7	3.6	4.3	4.8	0.06	424	77.4	12.5	17.4	18.1	19.2
H38	23.8	5.32	679	82.8	13.3	3.9	4.8	7.0	2.76	402	78.8	17.0	22.0	22.6	23.4
H39	5.0	5.22	1082	59.2	12.9	5.2	5.9	7.4	3.84	410	83.8	16.5	21.2	21.7	22.9
H40	5.0	0.28	663	64.4	12.8	4.4	4.7	5.5	6.31	401	80.7	17.3	5.9	6.2	6.7

6. Supplemental Results: Statistical Power Analysis

Results of statistical power analyses of the one-way ANOVA and the Wilcoxon's signed-rank tests used herein are summarized in **Tables S16-S18**, corresponding to the results in Tables 2, 3, and 4 in the main text. For the one-way ANOVA, the power was calculated based on the error probability (significance level = 0.05), the actual sample size per group, the alternative group means, and the error (within-group) variance. For the Wilcoxon's signed-rank test, the power was calculated based on the error probability (significance level = 0.05), the actual sample size, the mean values of pre- and post-intervention periods, and the standard deviation of the differences between pre- and post-intervention period.

Table S16. Statistical power analysis of the one-way ANOVA for home characteristics

One-way ANOVA	Total (N)	Exhaust-Only (n)	CFIS (n)	Balanced (n)	Statistical Power
Construction year	40	13	15	12	7%
Total floor area	40	13	15	12	5%
Number of bedrooms	40	13	15	12	5%
Number of occupants	40	13	15	12	5%
Airtightness (L/s @ 50 Pa)	39	13	15	11	5%
ACH_{50}	39	13	15	11	5%
Air handler airflow rates	27	3	15	9	5%
Ventilation requirements	40	13	15	12	5%
Measured ventilation airflow rates	38	13	14	11	15%

The statistical power analysis of the one-way ANOVA conducted on home characteristics among each group showed low power (all less than 15%), which, combined with results in Table 2, suggests the pseudo-randomized assignment of ventilation system types was largely successful in distributing homes among groups.

Table S17. Statistical power analysis of the Wilcoxon's Signed-Rank tests for indoor and outdoor pollutant concentrations for all ventilation system types

Indoor (Outdoor) Pollutants	Sample Size		Statistical Power
	Pre-Intervention	Post-Intervention	
HCHO	40 (NA)	40 (NA)	**100%**[***] (NA)
CO	39 (37)	30 (37)	22% **(91%**[*]**)**
CO_2	40 (40)	40 (40)	**99%**[***] **(100%**[***]**)**
NO_2	40 (40)	40 (40)	55% **(99%**[***]**)**
O_3	40 (40)	40 (40)	28% **(99%**[**]**)**
PM_1	40 (40)	40 (40)	**83%**[***] (19%)
$PM_{2.5}$	40 (40)	40 (40)	77%[***] (9%)
PM_{10}	40 (40)	40 (40)	**85%**[***] (44%)

*95% confidence level for a two-tailed Wilcoxon's signed-rank test. P-values: *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$*

The statistical power analysis of the Wilcoxon signed-rank tests on indoor and outdoor constituent concentrations pre- and post-intervention (regardless of ventilation system type) showed a range of statistical power, with comparisons with p < 0.05 generally having statistical power of more than 80%.

Table S18. Statistical power analysis of the Wilcoxon's Signed-Rank tests for the I/O ratio of pollutants for all and specific ventilation system types

Statistical Power of Wilcoxon's Signed-Rank Test for I/O ratios	Exhaust-Only (n=13)	CFIS (n=15)	Balanced (n=12)	Total (n=40)
CO_2	70%[**]	6%	**95%**[***]	**98%**[***]
NO_2	77%	31%	**93%**[**]	**99%**[***]
O_3	34%	28%	37%	**84%**
PM_1	24%[**]	17%[*]	56%[**]	65%[***]
$PM_{2.5}$	21%[*]	11%[*]	51%[**]	58%[***]
PM_{10}	17%	11%[*]	59%[**]	56%[***]

95% confidence level for a two-tailed Wilcoxon's signed-rank test. P-values: *p < 0.1; **p < 0.05; ***p < 0.01

The statistical power for comparisons of I/O ratios of CO_2, NO_2, and O_3 pre- and post-intervention, calculated across the entire sample of 40 homes, was greater than 80%, but was lower (56-65%) for comparisons of the I/O ratios of PM_1, $PM_{2.5}$, and PM_{10} due to the larger variance in the standard deviation of the differences between pre- and post-intervention periods. Statistical power calculations for comparisons of I/O ratios within the smaller group sizes (i.e., within a single type of ventilation system) yielded lower statistical power, as expected, than the larger group, with the greatest power generally associated with the balanced systems (especially for I/O ratios of CO_2 and NO_2), followed by exhaust-only, followed by CFIS systems.