The "V" in HVAC: Mechanical Ventilation in ENERGY STAR Certified Homes

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RESNET Building Performance Conference

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Agenda

- Part 1: Ventilation in ENERGY STAR Certified Homes
  - Value of mechanical ventilation and indoor air quality.
  - Three major components of mechanical ventilation.
  - Completing the HVAC System QI Rater Checklist.
- Part 2: Examples of Control Strategies
- Question & answer session

Part 1: Ventilation in ENERGY STAR Certified Homes

Value of mechanical ventilation & indoor air quality

- Consumers place value on indoor air quality.

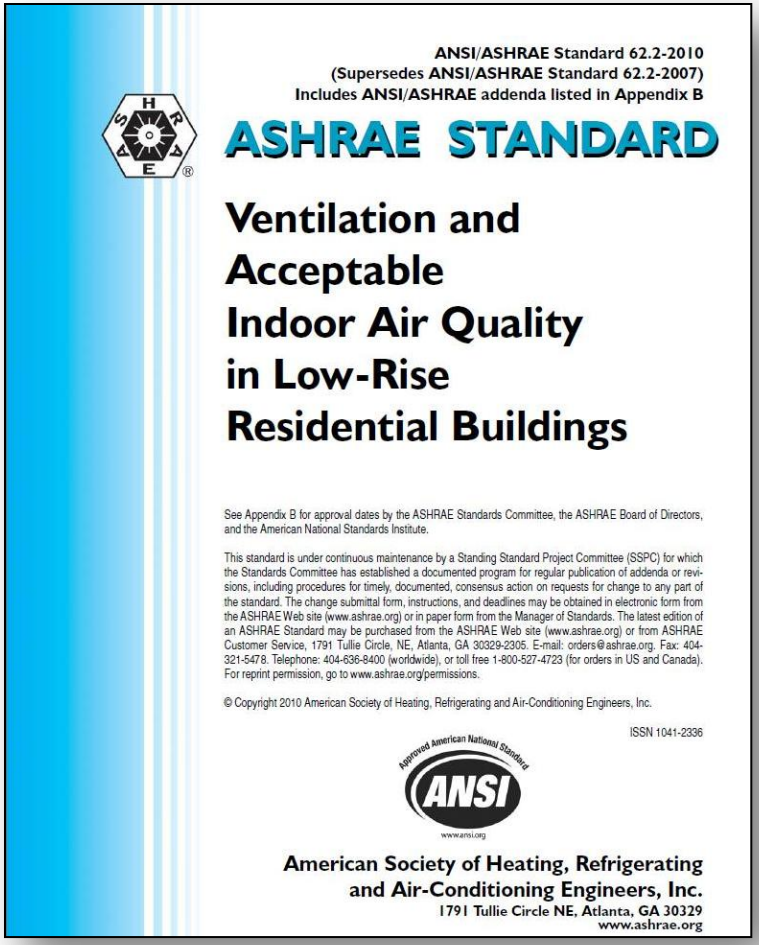
What is indoor air quality?

1. Homeowner is satisfied (e.g., no odors or irritants).

2. Low levels of contaminants known to pose health risks.

What is indoor air quality?

- This is the basic definition of indoor air quality in the industry standard, ASHRAE 62.2-2010.
- A preview of ASHRAE 62.2-2010 is available here.
- Don’t sacrifice indoor air quality in exchange for efficiency.



What indoor air quality means to the consumer

- Give them the option to exhaust smells and cooking moisture out of the kitchen

What indoor air quality means to the consumer

- Homeowners benefit from an automated system for bringing outdoor air into the house.

What indoor air quality means to the consumer

- Give them the option to exhaust moisture from the bathroom
  - Quietly
  - Efficiently

How are the ENERGY STAR & Indoor airPLUS programs related?

- Both are voluntary labeling programs run by EPA.
- ENERGY STAR is better than standard practice, while Indoor airPLUS offers a complete indoor air quality package.
- For more information, visit www.epa.gov/indoorairplus/

Complete IAQ Protection

Non-ENERGY STAR approach

- Some advantages, but mostly disadvantages.
- Advantages of leaky homes:
  - Dilution of contaminants in home.
  - Drying of building components that become wet.

Non-ENERGY STAR approach

- Disadvantages of leaky homes:
  - Rate of outdoor air is not controlled.
  - Source and path of outdoor air is unknown.
  - Outdoor air may cause discomfort if not first conditioned.
  - Excess outdoor air increases energy use.

ENERGY STAR approach

1. Build the home tight to improve efficiency & comfort.
2. Remove contaminants using occupant-controlled exhaust fan in kitchens & bathrooms and a filter in HVAC system.
3. Bring in outdoor air in a controlled way to dilute contaminants.
4. Include key durability details relating to water management.

Summary of value

- Indoor air quality is valued by consumers.
- ENERGY STAR addresses efficiency without sacrificing indoor air quality or durability through:
  - Tight homes.
  - Removal of contaminants.
  - Dilution of contaminants with outdoor air.
  - Durability details related to moisture.

Concepts of
Local Mechanical Exhaust

Local mechanical exhaust: Overview of requirements

- Include an exhaust fan in each kitchen.
- Include an exhaust fan in most bathrooms.
- Two requirements for these fans:
  - Achieve a minimum *measured* air flow rate.
  - Achieve a maximum *rated* sound limit.

Local mechanical exhaust: Bath fans

- Only bathrooms with a bathtub, shower, spa, or similar source of moisture must have an exhaust fan.

Local mechanical exhaust: Bath fans

- Two requirements for bath fans:
  - Achieve a minimum *measured* air flow rate.
  - Achieve a maximum *rated* sound limit.

Summary of Airflow Requirements for Bath Fans		
Fan Type	**Measured Airflow**	**Rated Sound**
Intermittent	≥ 50 CFM	≤ 3 sones

Local mechanical exhaust: Bath fans

- Installation quality impacts the airflow.

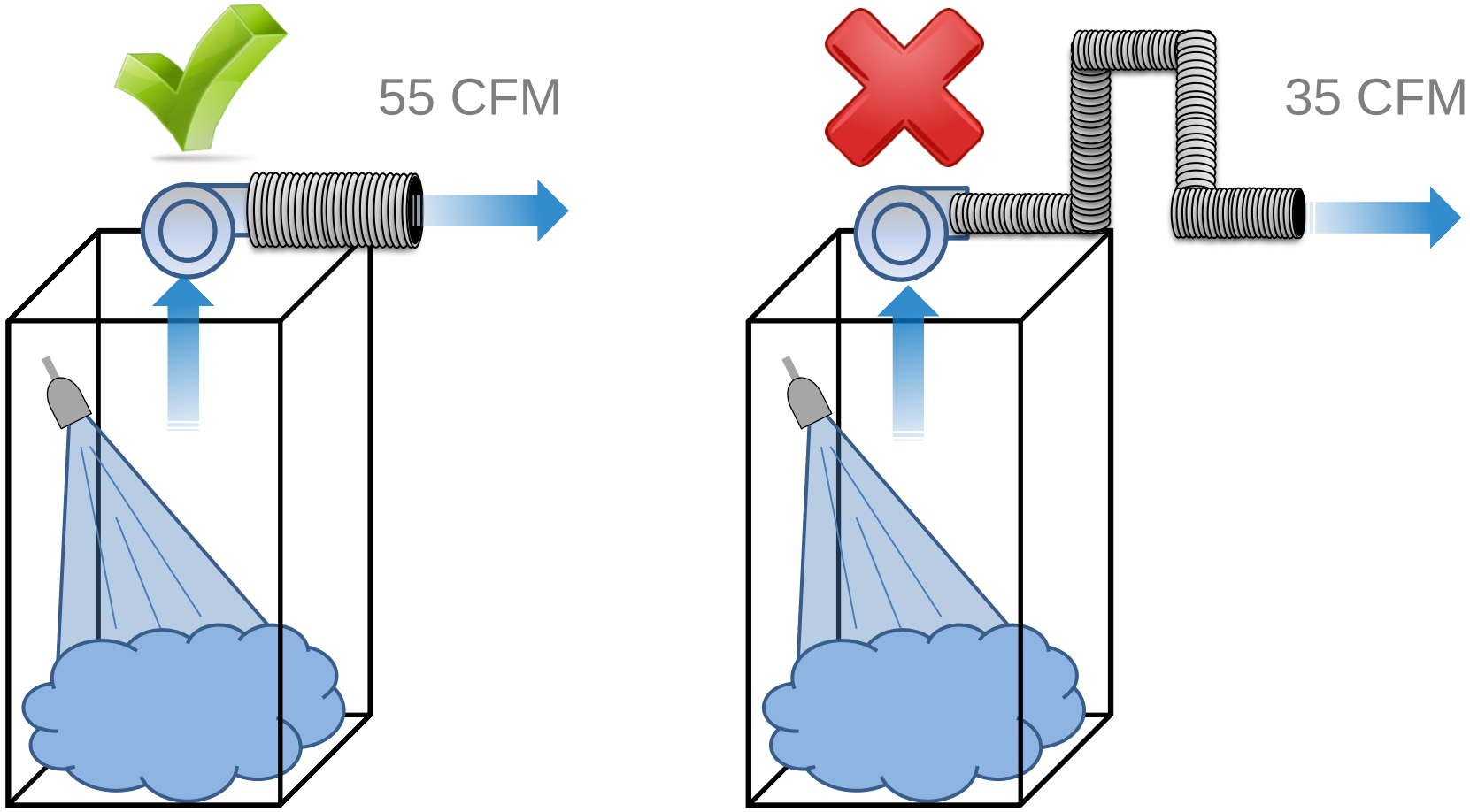
HVI PERFORMANCE

4" Duct				3" Duct			
0.1 Ps - Static Pressure (inH_2O)			0.25 Ps	0.1 Ps - Static Pressure (inH_2O)			0.25 Ps
Airflow (CFM)	Sound (Sones)	Power (Watts)	Airflow (CFM)	Airflow (CFM)	Sound (Sones)	Power (Watts)	Airflow (CFM)
80	1.1	25.7	61	70	1.3	25.7	55.3

HVI-2100 CERTIFIED RATINGS comply with new testing technologies and procedures prescribed by the Home Ventilating Institute, for off-the-shelf products, as they are available to consumers. Product performance is rated at 0.1 in. static pressure, based on tests conducted in a state-of-the-art test laboratory. Sones are a measure of humanly-perceived loudness, based on laboratory measurements.

Local mechanical exhaust: Bath fans

- Measured airflow is usually less than rated airflow.



Local mechanical exhaust: Bath fans

- Sound levels, in sones, quantify how much sound a fan will make.
- Sones don't have to be measured in the field. Instead use the rated value from the product label or documentation.

HVI PERFORMANCE

4" Duct				3" Duct			
0.1 Ps - Static Pressure (inH_2O)			0.25 Ps	0.1 Ps - Static Pressure (inH_2O)			0.25 Ps
Airflow (CFM)	Sound (Sones)	Power (Watts)	Airflow (CFM)	Airflow (CFM)	Sound (Sones)	Power (Watts)	Airflow (CFM)
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Local mechanical exhaust: Bath fans

- Continuous bath fans have different airflow and sound targets.

Summary of Airflow Requirements for Bath Fans		
Fan Type	**Measured Airflow**	**Rated Sound**
Intermittent	≥ 50 CFM	≤ 3 sones
Continuous	≥ 20 CFM	≤ 1 sones

Local mechanical exhaust: Bath fans

- For multispeed fans, at least one setting must meet both the airflow and sound requirements.

Sample Multispeed Fan

Setting	CFM	Sone
1	50	3
2	100	5

Local mechanical exhaust: Kitchen fans

- Like bath fans, kitchen fans must meet a minimum airflow and maximum sound rating.
- Requirements depend on whether the fan is intermittent or continuous, and whether it's integrated with the range.

Summary of Airflow Requirements for Kitchen Fans			
Fan Type	**Integrated with Range?**	**Measured Airflow**	**Rated Sound**
Intermittent	Yes	≥ 100 CFM	≤ 3 sones
Intermittent	No	Greater of ≥ 100 CFM or 5 ACH	≤ 3 sones
Continuous	n/a	≥ 5 ACH	≤ 1 sone

Local mechanical exhaust: Kitchen fans

- Kitchen exhaust requirements not currently enforced.
- Tentatively determined that these requirements will be enforced later this year.
  - Option 1: Meet air flow requirement by measuring air flow.
  - Option 2: Use ASHRAE 62.2 prescriptive duct sizes with rated fan.
  - Option 3: Use prescriptive duct sizes required by EPA for fans that are not rated for air flow.
- Sound level requirements are also not currently being enforced.
- Note that bath exhaust requirements *are* being enforced.

Local mechanical exhaust: Kitchen fans

- Option 2: ASHRAE 62.2-2010 prescriptive duct sizing alternative.
- Maximum length for smooth ductwork:

Diameter (inches)	Fan Rating (CFM @ 0.25 IWG)			
	50	80	100	125
3	5	X	X	X
4	105	35	5	X
5	NL	135	85	55
6	NL	NL	NL	145
7	NL	NL	NL	NL

- Include 15ft per turn or elbow in the duct.

Local mechanical exhaust: Summary

- An exhaust fan is required for each kitchen and most bathrooms.
- Each fan must meet a minimum measured airflow rate and maximum rated sound level.
- This helps homeowner maintain indoor air quality.

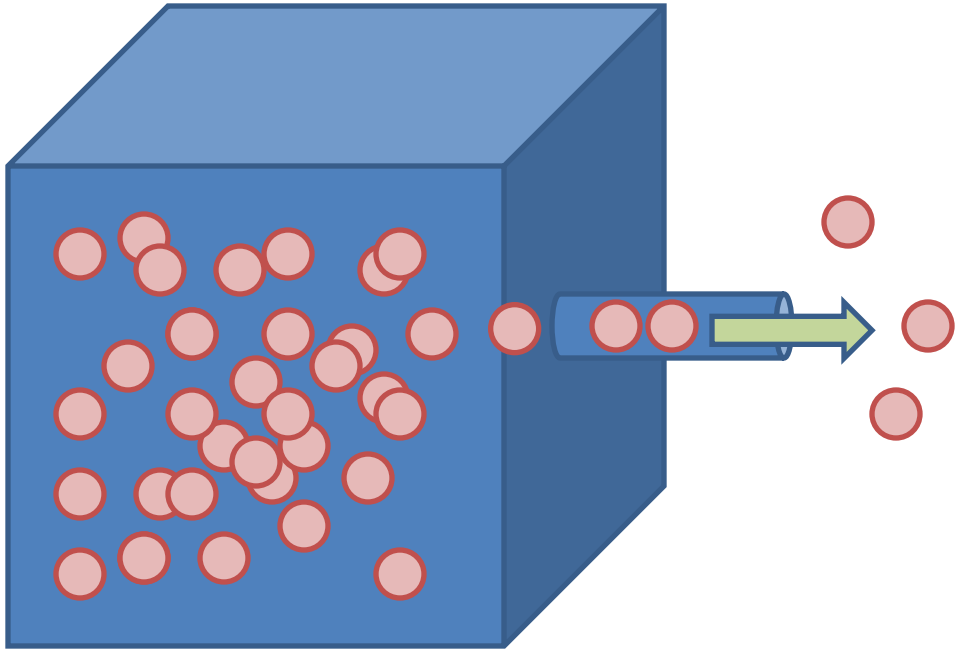
Options for Whole-House Mechanical Ventilation

Whole-house mechanical ventilation: Overview

- Goal is to bring outdoor air into the house in a controlled, *automatic*, way.
- Three ventilation strategies:
  - Exhaust-only ventilation.
  - Supply-only ventilation.
  - Balanced ventilation.

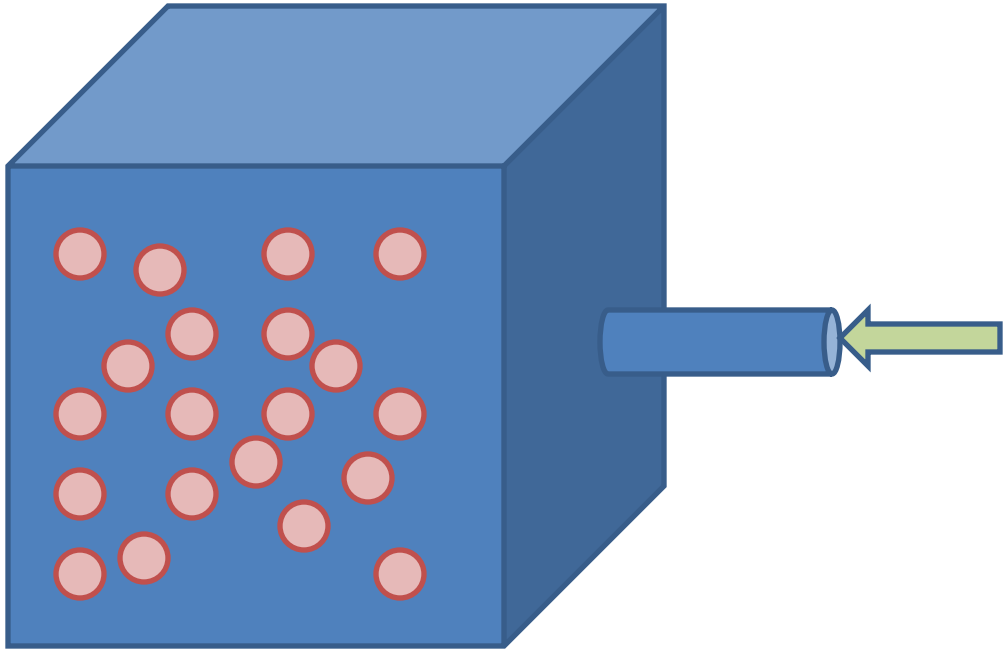
Whole-house mechanical ventilation: Strategy 1: Exhaust-only ventilation

- Use a fan (typically a bath fan) to remove air from the home.
- Draws outdoor air into the home through cracks in the building envelope or a fresh air intake.
- Frequently used in colder climates.



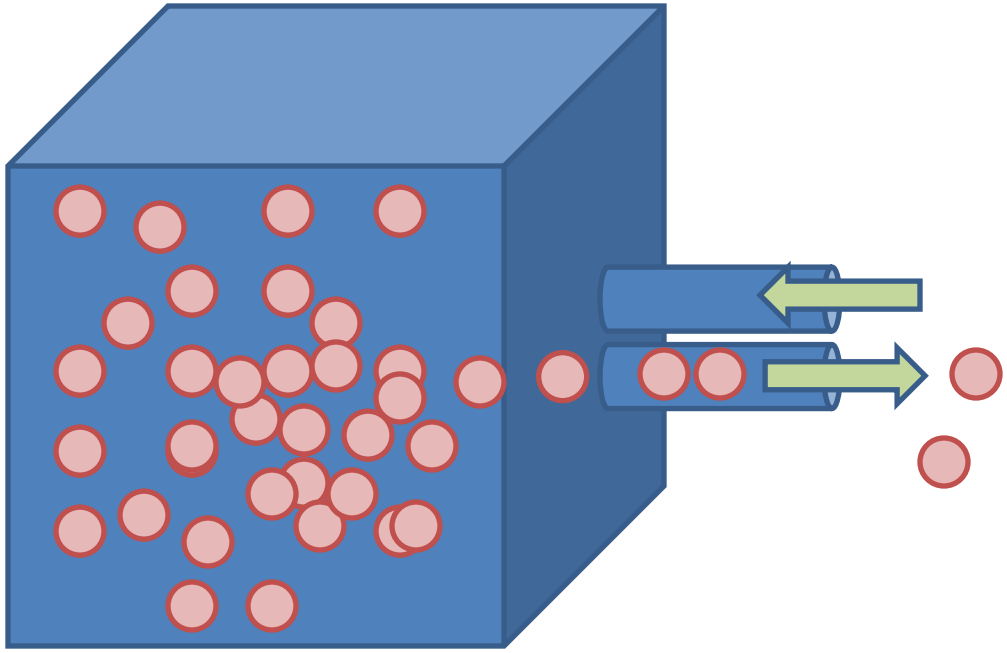
Whole-house mechanical ventilation: Strategy 2: Supply-only ventilation

- Draw in outdoor air on the return side of the air handler.
- Indoor air is forced out through leaks in the building shell.
- Frequently used in warmer climates.



Whole-house mechanical ventilation: Strategy 3: Balanced ventilation

- Draw in outdoor air, while exhausting air from indoors.
- An equal amount of air is exhausted and supplied to the home, so air is not forced through cracks in the home.
- Used in both warm and cold climates.



Whole-house mechanical ventilation: Summary

- Three ventilation strategies:
  - Exhaust-only.
  - Supply-only.
  - Balanced.
- Purpose is to bring outdoor air into the house in a controlled, *automatic* way.

Calculating Whole-House Mechanical Ventilation Air Flow Rate

Whole-house mechanical ventilation: Air flow rate

- Required airflow depends on type of whole-house mechanical ventilation system:
  - Continuous, or,
  - Cycled

Whole-house mechanical ventilation: ***Continuous*** air flow rate

- Conditioned floor area = 2,000 ft^2
- Number of bedrooms = 3

Whole-house mechanical ventilation: ***Continuous*** air flow rate

ASHRAE 62.2-2010 Equation 4.1

Airflow = 0.01 * Floor Area + 7.5 * (Bedrooms + 1)

Airflow = 0.01 * 2,000 + 7.5 * (3 + 1)

Airflow = 20 + 30

Airflow = 50 CFM

Whole-house mechanical ventilation: *Cycled* air flow rate

- Cycled systems turns on and off *automatically* to provide outdoor air in cycles.
- The designer chooses the frequency and length of the ventilation cycles, which dictates the airflow rate.
- Cycled systems can be used to avoid running the system during a fixed period of time (e.g., hottest or coldest hours of the day).
- The ventilation system must run ≥ 10% every 24 hours.

Whole-house mechanical ventilation: *Cycled* air flow rate

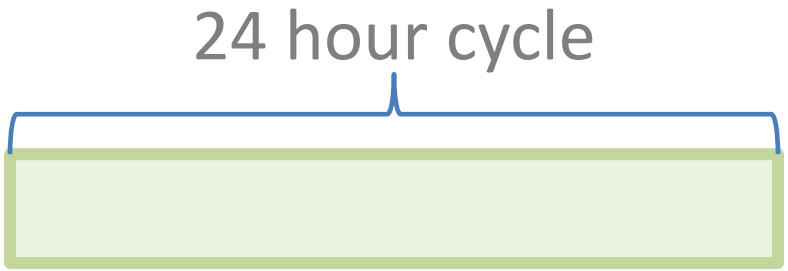
- Calculating the cycled airflow rate is a 5-step process:
  - Step 1: Select cycle time
  - Step 2: Select on-time during cycle
  - Step 3: Calculate fractional on-time
  - Step 4: Use Table 4.2 to lookup Ventilation Effectiveness
  - Step 5: Calculate the flow rate

Whole-house mechanical ventilation: *Cycled* air flow rate

- Conditioned floor area = 2,000 ft^2
- Number of bedrooms = 3
- Continuous ventilation rate = 50 CFM

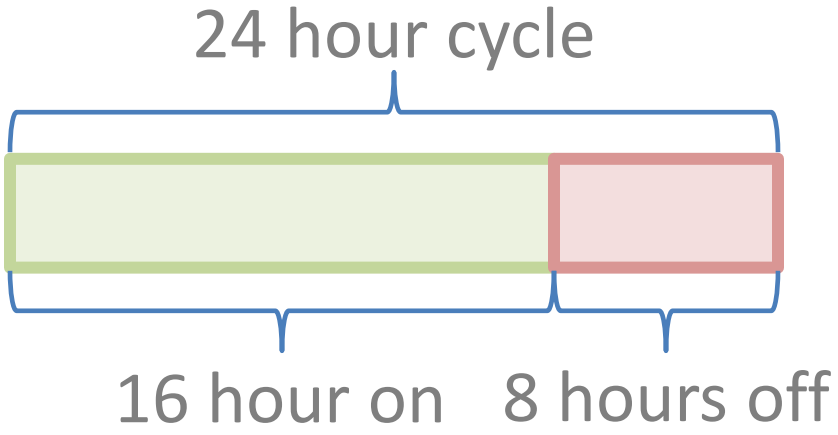
Whole-house mechanical ventilation: *Cycled* air flow rate

- Step 1: Select cycle time – **24 hours**



Whole-house mechanical ventilation: *Cycled* air flow rate

- Step 2: Select on-time during cycle - **16 hours**



- Step 3: Calculate fractional on time 16/24 = **0.66**

Whole-house mechanical ventilation: *Cycled* air flow rate

- Step 4: Use Table 4.2 to lookup ventilation effectiveness

Fractional on-time, f	Cycle time (on and off cycle)			
	0-4	8	12	24
0.1	1.00	0.79	-	-
0.2	1.00	0.84	0.56	-
0.3	1.00	0.89	0.71	-
0.4	1.00	0.92	0.81	0.20
0.5	1.00	0.94	0.87	0.52
0.6	1.00	0.97	0.92	0.73
0.7	1.00	0.98	0.96	0.86
0.8	1.00	0.99	0.98	0.94
0.9	1.00	1.00	1.00	0.99
1.0	1.00	1.00	1.00	1.00

Whole-house mechanical ventilation: *Cycled* air flow rate

- Step 5: Calculate the flow rate

ASHRAE 62.2-2010 Equation 4.2

Airflow = Cont. Airflow / (Fractional On-time * Vent Effectiveness)

Airflow = 50 / (0.66 * 0.73)

Airflow = 104 CFM

Whole-house mechanical ventilation: *Cycled* air flow rate

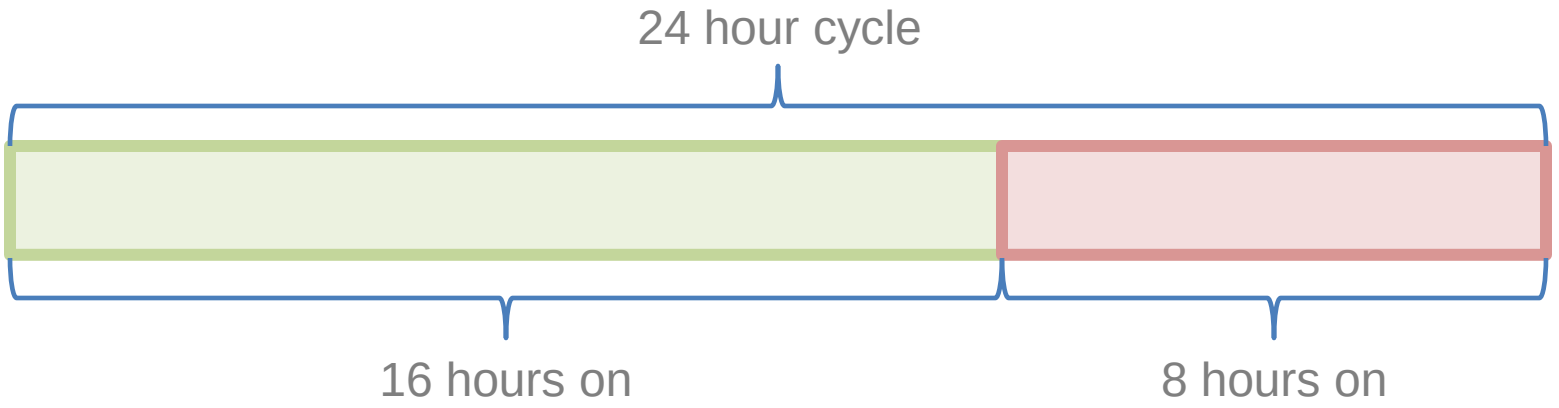
- Ventilation Effectiveness varies based on the cycle selected

Fractional on-time, f	Cycle time (on and off cycle)			
	0-4	8	12	24
0.1	1.00	0.79	-	-
0.2	1.00	0.84	0.56	-
0.3	1.00	0.89	0.71	-
0.4	1.00	0.92	0.81	0.20
0.5	1.00	0.94	0.87	0.52
0.6	1.00	0.97	0.92	0.73
0.7	1.00	0.98	0.96	0.86
0.8	1.00	0.99	0.98	0.94
0.9	1.00	1.00	1.00	0.99
1.0	1.00	1.00	1.00	1.00

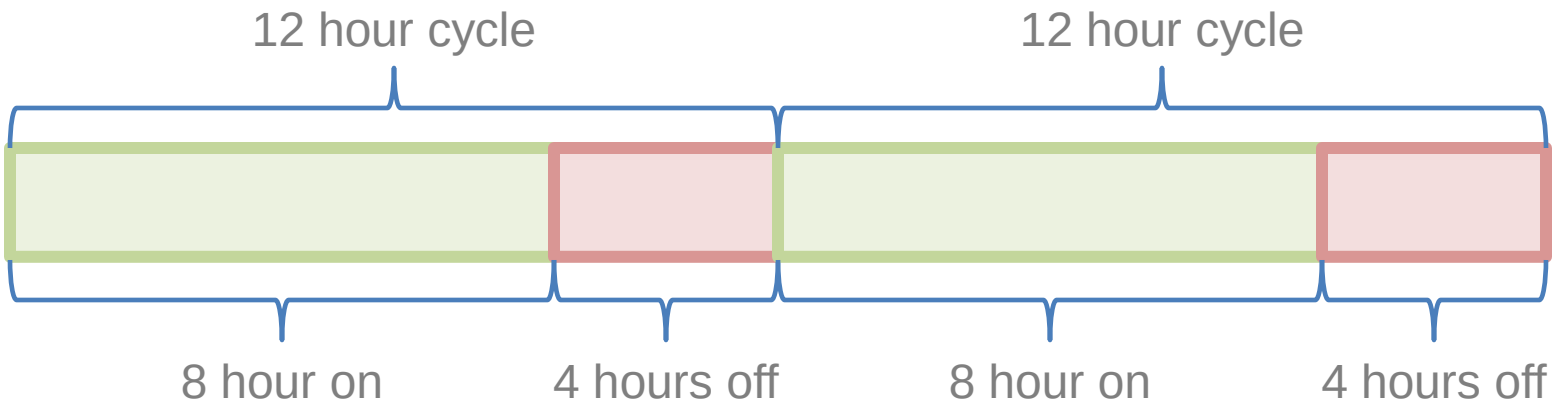
Whole-house mechanical ventilation: *Cycled* air flow rate

- Ventilation Effectiveness varies based on the cycle selected

Scenario 1
VE = 0.73
104 CFM



Scenario 2
VE = 0.92
82 CFM



Whole-house mechanical ventilation: Overlap with local mechanical exhaust

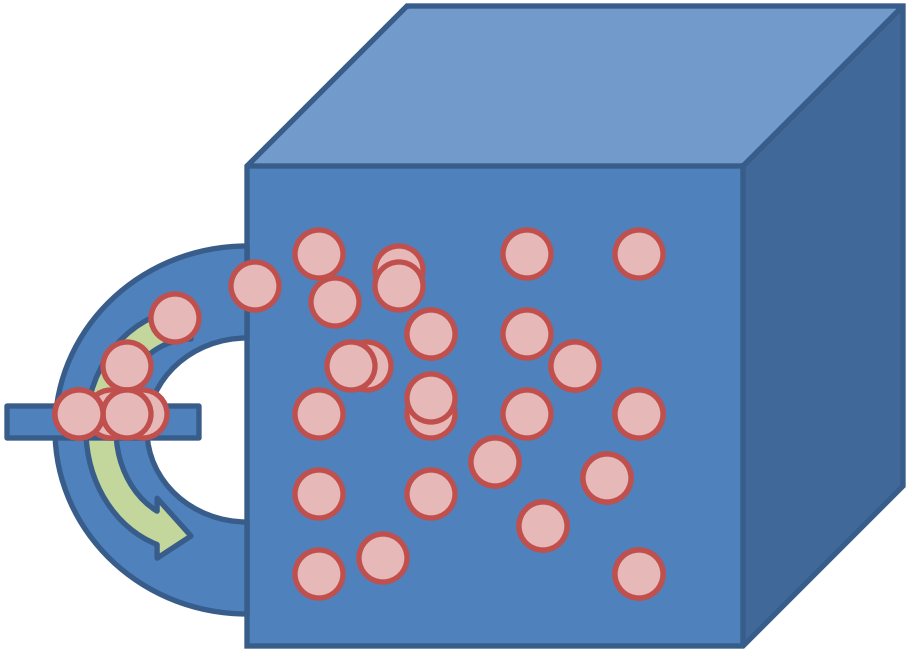
- Local mechanical exhaust system can also be the whole-house mechanical ventilation system.
- For example, a bath fan can be two things:
  1. Local mechanical exhaust for the bathroom. Used by the homeowner when they want.
  2. Exhaust-only whole-house mechanical ventilation system. Fan turns on automatically, without homeowner intervention.
- Designer must ensure that the airflow and sound requirements are met for both functions. For example:

Function	Cycle Type	Min. Measured Airflow	Max. Rated Sound
Local bath exhaust	Intermittent	≥ 50 CFM	≤ 3 sones
Whole-house vent.	Intermittent	Per ASHRAE 62.2-2010	≤ 3 sones

Filtration

Filtration

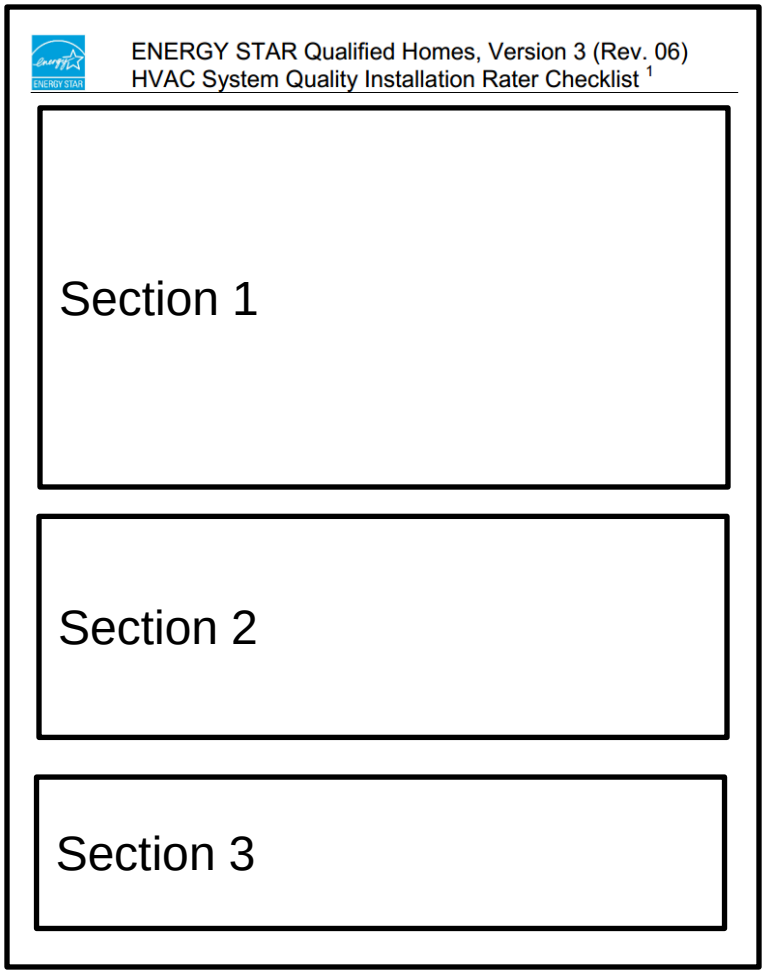
- Purpose is to remove contaminants from the air and protect the HVAC equipment.



Completing the
HVAC System QI Rater Checklist

HVAC System QI Rater Checklist

Page 1



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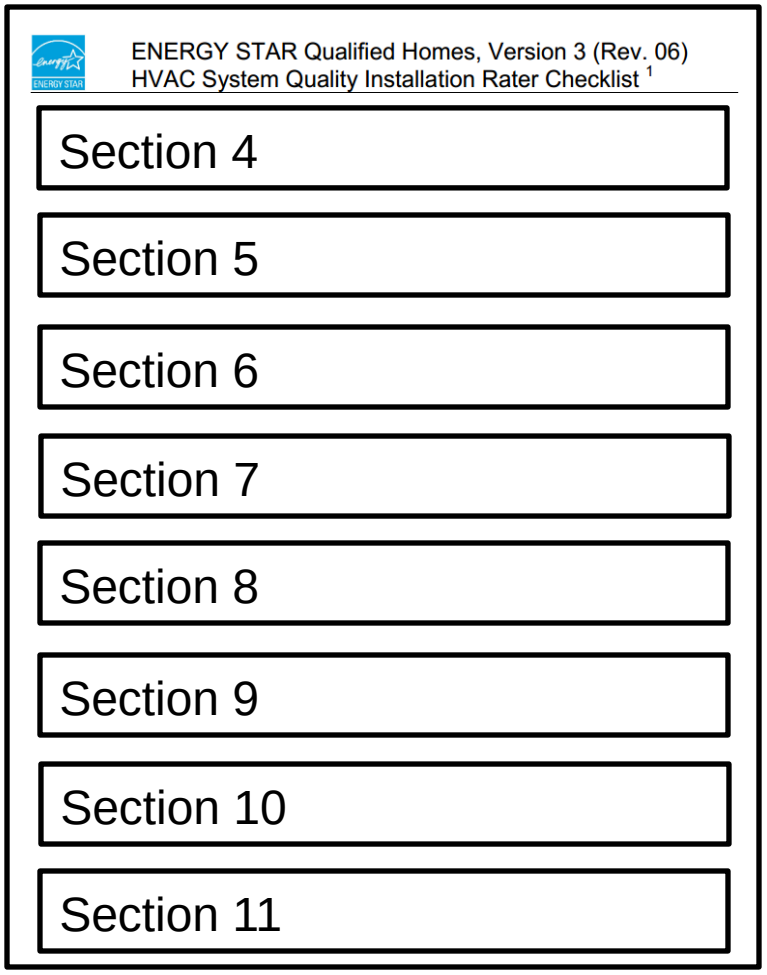


HVAC System QI Rater Checklist

- Section 5: Whole-home delivered ventilation.
- Section 6: Controls.
- Section 7: Ventilation air inlets & ventilation source.
- Section 8: Local mechanical exhaust.
- Section 9: Vent. & exhaust fan ratings.
- Section 11: Filtration.

Section 5:
Whole-home delivered ventilation

- Measure ventilation airflow and verify that it's within 100-120% of the design value.
- If the measured value is outside this range, it must be corrected. This may be easier to do by adjusting the run controls than by adjusting the ventilation rate.
- Many Raters are starting to compare the measured value directly with ASHRAE 62.2.
- A variety of ways to measure ventilation airflow.

Section 5: Measuring ventilation
Powered flow hood

- Advantages:
  - Accurate.
  - Relatively easy to use.
  - Airflow can be measured quickly.
  - Multiple uses.
  - RESNET test procedure exists (Section 804).
- Disadvantages:
  - May not fit over some inlets or in tight spaces.
  - Inlet must be accessible.
- Cost: ~$1,100 (Capture hood only)

Section 5: Measuring ventilation
Exhaust fan flow meter

- Advantages:
  - Accurate.
  - Relatively easy to use.
  - Airflow can be measured quickly.
  - RESNET test procedure exists (Section 804).
- Disadvantages:
  - May not fit over some inlets or in tight spaces.
  - Inlet must be accessible.
- Cost: ~$150

Section 5: Measuring ventilation
Other tools

- Other tools exist, such as anemometers, passive flowhoods, and Pitot tubes.
- Advantages:
  - Can be used for special cases.
- Disadvantages:
  - Can be difficult to take accurate measurements.
  - No RESNET test procedure exists.
- Cost: Varied.

Section 6: Controls

- Quick assessment of heating, cooling, & vent. controls.
- Items 6.1 – 6.3: Check that heating, cooling, and fan settings on thermostat are operational.

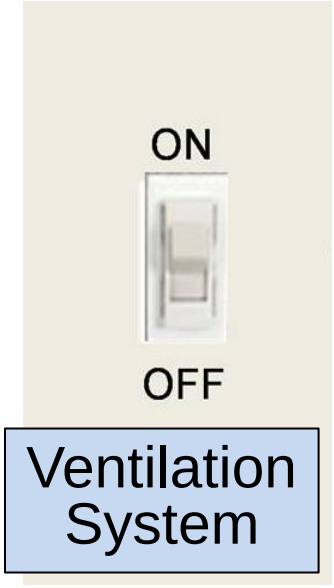
Heat

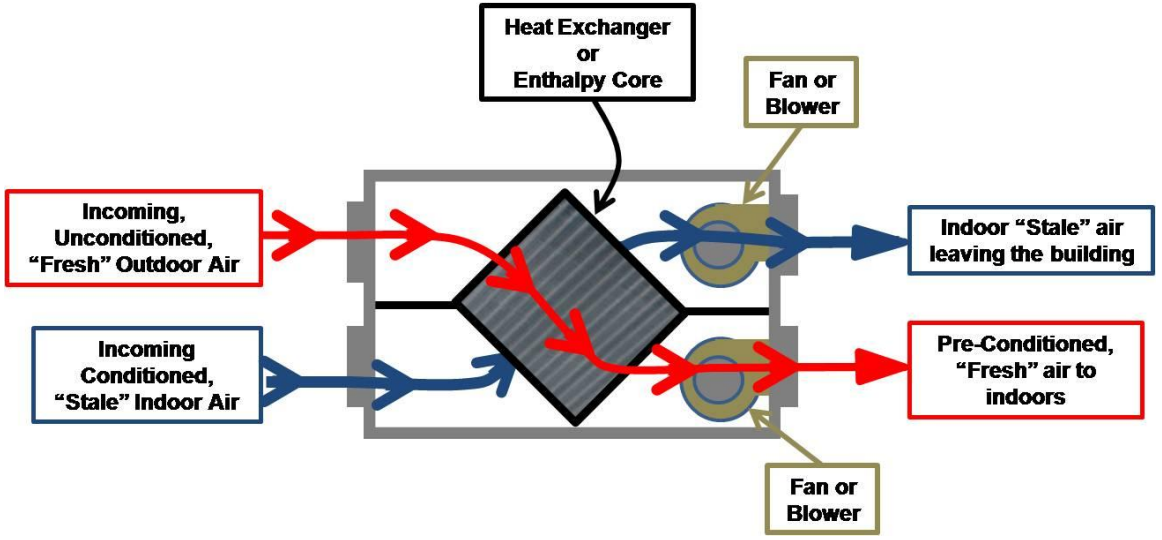
Cool

Fan

Section 6: Controls

- Item 6.4: For each continuous system, verify that there's a readily accessible override control.
- Item 6.5: Verify that the function of the ventilation system controls is obvious (e.g., bathroom fan) or labeled (e.g., over-ride switch for return-side motorized damper).





Section 7:
Ventilation air inlets & vent. source

- If home has a ventilation air inlet, verify the following:

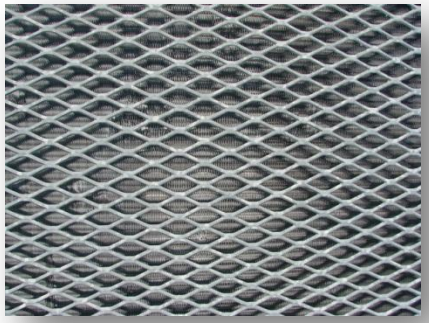
1. Not near contamination sources:
   a) If it's in the wall, ≥ 3 feet from dryer exhausts and contamination sources exiting through the roof.
   b) ≥ 10 feet from other contamination sources.

Section 7:
Ventilation air inlets & vent. source

2. Verify that vent air inlet meets height requirements and is not obstructed at time of inspection:

2009 IECC Climate Zone	Height Above Grade or Roof Deck
1-3	≥ 2 feet
4-8	≥ 4 feet

3. Verify that inlet has screen with ≤ 0.5 inch mesh.



4. Verify that inlet pulls in air directly from the outside.

Section 8:
Local mechanical exhaust

- Include an exhaust fan in each kitchen.
- Include an exhaust fan in most bathrooms.
- Two requirements for these fans:
  - Achieve a minimum *measured* air flow rate.
  - Achieve a maximum *rated* sound limit.
- This helps homeowner maintain indoor air quality.

Section 8:
Local mechanical exhaust requirements

Summary of Airflow Requirements for Bath Fans		
Fan Type	**Measured Airflow**	**Rated Sound**
Intermittent	≥ 50 CFM	≤ 3 sones
Continuous	≥ 20 CFM	≤ 1 sones

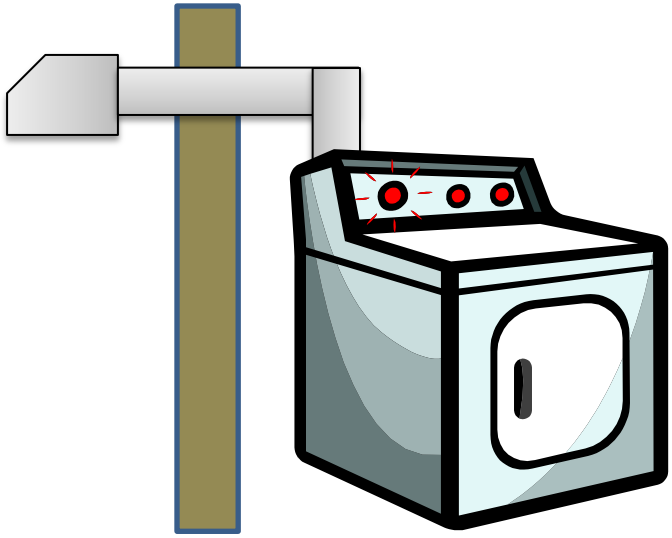
Summary of Airflow Requirements for Kitchen Fans			
Fan Type	**Integrated with Range?**	**Measured Airflow**	**Rated Sound**
Intermittent	Yes	≥ 100 CFM	≤ 3 sones
Intermittent	No	Greater of ≥ 100 CFM or 5 ACH	≤ 3 sones
Continuous	n/a	≥ 5 ACH	≤ 1 sone

Section 8:
Local mechanical exhaust airflow

- To measure airflow, ideally use powered flowhood or exhaust fan flow meter.

Section 8:
Local mechanical exhaust

- Verify that clothes dryer exhausts directly to outdoors.



Section 9:
Ventilation & exhaust fan ratings

- Sound ratings quantify how much sound a fan will make.
- Sones don't have to be measured in the field. Instead use the rated value from the product label or documentation.

HVI PERFORMANCE

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- For bath fans used as a whole-house mechanical ventilation system, verify that it's ENERGY STAR certified; unless rated flow rate ≥ 500 CFM.

Section 11: Filtration

- Verify the four basic filtration requirements:

1. **MERV 6 or better** filter in each ducted mechanical system.
2. All return air and mechanically supplied outdoor air passes through **filter prior to conditioning**.
3. **Filter is accessible** to occupants and able to be serviced.
4. **Filter must be gasketed** to prevent bypass.

Summary

- Let's add up how long verifying these items should take for a typical home:
  - Section 5: Whole-Building Delivered Ventilation
    - **5-20 minutes** (field verification)
  - Section 6: Controls
    - **5 minutes** (field verification & visual inspection)
  - Section 7: Ventilation Air Inlets & Ventilation Source
    - **5 minutes** (visual inspection)

Summary

- Let's add up how long verifying these items should take for a typical home (Continued):
  - Section 8: Local Mechanical Exhaust
    - **5-20 minutes** (field verification)
  - Section 9: Ventilation & Exhaust Fan Ratings
    - **5 minutes** (visual inspection)
  - Section 11: Filtration
    - **5 minutes** (visual inspection)
  - Total: **About 30-60 minutes, but it depends on the house**

Summary

- Don’t sacrifice indoor air quality in exchange for efficiency.
- Three major concepts:
  1. Bath and kitchen fans remove contaminants.
     - Generally, turned on and off by occupants.
     - Must meet airflow and sound requirements.
  2. Whole-house mechanical ventilation removes contaminants and/or dilutes them with outdoor air.
     - System operates *automatically*.
     - System types: exhaust-only, supply-only, & balanced.
     - Must meet airflow requirements.
  3. Filters trap contaminants.

Part 2:
Example Control Strategies

[Content for Part 2 submitted to
RESNET as a separate presentation]

ENERGY STAR Certified Homes

Web:

Main: www.energystar.gov/newhomespartners
Technical: www.energystar.gov/newhomesguidelines
Training: www.energystar.gov/newhomestraining
HVAC: www.energystar.gov/newhomesHVAC

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