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The Sponsors of Energize Connecticut, and in partnership with Connecticut Passive House, are pleased to offer *Passive House & All-Electric Homes Initiative* to support workforce development and help transform the energy efficiency and building construction industries in Connecticut.



For more information, please visit EnergizeCT.com/passive-house
or email PassiveHouseTrainingCT@icf.com

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Take energy efficiency to a new level

Residential New Construction Passive House Multi-family buildings with five units or more



PASSIVE HOUSE INCENTIVE STRUCTURE FOR MULTI-FAMILY (5 UNITS OR MORE)				
Incentive Timing	Activity	Incentive Amount	Max Incentive (Per Unit)	Max Incentive (Per Project)
Pre-Construction	Feasibility Study ¹	Up to 100% of Feasibility Study Costs	N/A	\$5,000.00
	Energy Modeling ²	75% of Energy Modeling Costs (Before 90% Design Drawings)	\$500.00	\$30,000.00
		50% of Energy Modeling Costs (90% Design/50% Construction)	\$250.00	\$15,000.00
Post Construction	Certification ³	Up to 100% of Certification Costs	\$1,500.00	\$60,000.00

1. Feasibility Study will require documentation in the form of a Feasibility Study report and invoice from the Passive House Consultant

2. Incentives will only be awarded prior to 50% Construction Drawings for Passive House projects. No incentives will be granted after 50% Construction Drawing set.

3. Certification may be either through PHIUS, PHI, or EnerPHit certification offerings.

Next steps you can take...

Contact your Energy Efficiency Representative or

Go to [EnergizeCT.com](https://energizeCT.com) or call 1-877-WISE USE for more details.

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energize
CONNECTICUT 



The future of high-performance,
all-electric homes starts here.



	LEVEL 1		LEVEL 2	
	Single Family (Detached Dwellings)	Multifamily (Attached Dwellings)	Single Family (Detached Dwellings)	Multifamily (Attached Dwellings)
Total UA Alternative Compliance or HERS Index Score [†]	Total UA \geq 7.5% better than 2021 IECC or HERS Index Score \leq 55		Total UA \geq 15% better than 2021 IECC or HERS Index Score \leq 45	
Heat pump for space heating ^{††}	Required		Required	
Space Conditioning Connectivity & Controls ^{†††}	Optional		Required	
Heat pump for water heating	Required	Optional	Required ^{††††}	
Hot Water Distribution ^{††††}	Required		Required	
Envelope Infiltration Rate (ACH)	ACH50 \leq 2.5	CFA > 850ft ² : ACH50 \leq 4.0 CFA < 850ft ² : ACH50 \leq 5.0	ACH50 \leq 2.0	CFA > 850ft ² : ACH50 \leq 3.0 CFA < 850ft ² : ACH50 \leq 4.0
Duct Leakage Rate (CFM)	2021 IECC code minimum requirements		All ductwork must be located in conditioned space	
Balanced Ventilation Systems	Optional		Required HRV/ERV (\geq 70% SRE / \geq 40% TRE)	
Induction Cooking	Optional		Required ^{†††††}	Optional
Electric Vehicle Readiness ^{††††††}	Required		Required	

ALL-ELECTRIC HOME INCENTIVE STRUCTURE		
	Level 1	Level 2
Single Family	\$7,500	\$10,000
Single Family Attached	\$3,000	\$5,000
Multifamily	\$1,500	\$2,500

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Thank You

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or email PassiveHouseTrainingCT@icf.com



WHOLE HOUSE MECHANICAL VENTILATION OPTIONS

Single-Family and Low-Rise
Multifamily Buildings and Townhomes



AGENDA

- Why have “whole house” mechanical ventilation?
- What do the International Codes require?
- What are the options for providing WHMV?
- What are the “best practices”? Does climate matter?
- What are common design and installation mistakes?
- What is required for renovations?

WHY HAVE MECHANICAL VENTILATION?

- Why don't we just make the building envelope *looser and let the home breathe?*

How loose should it be?

Where should we put the holes?

How do we design “loose” for windy days?

What about for calm days?



WHY HAVE MECHANICAL VENTILATION?

- Homes have operable windows. Why not just open the windows to let fresh air in?

- When it's 30° outside? Or 90°?
- What about rainy and humid?
- How many windows should I open?
- And where? For how long?



WHY HAVE MECHANICAL VENTILATION?

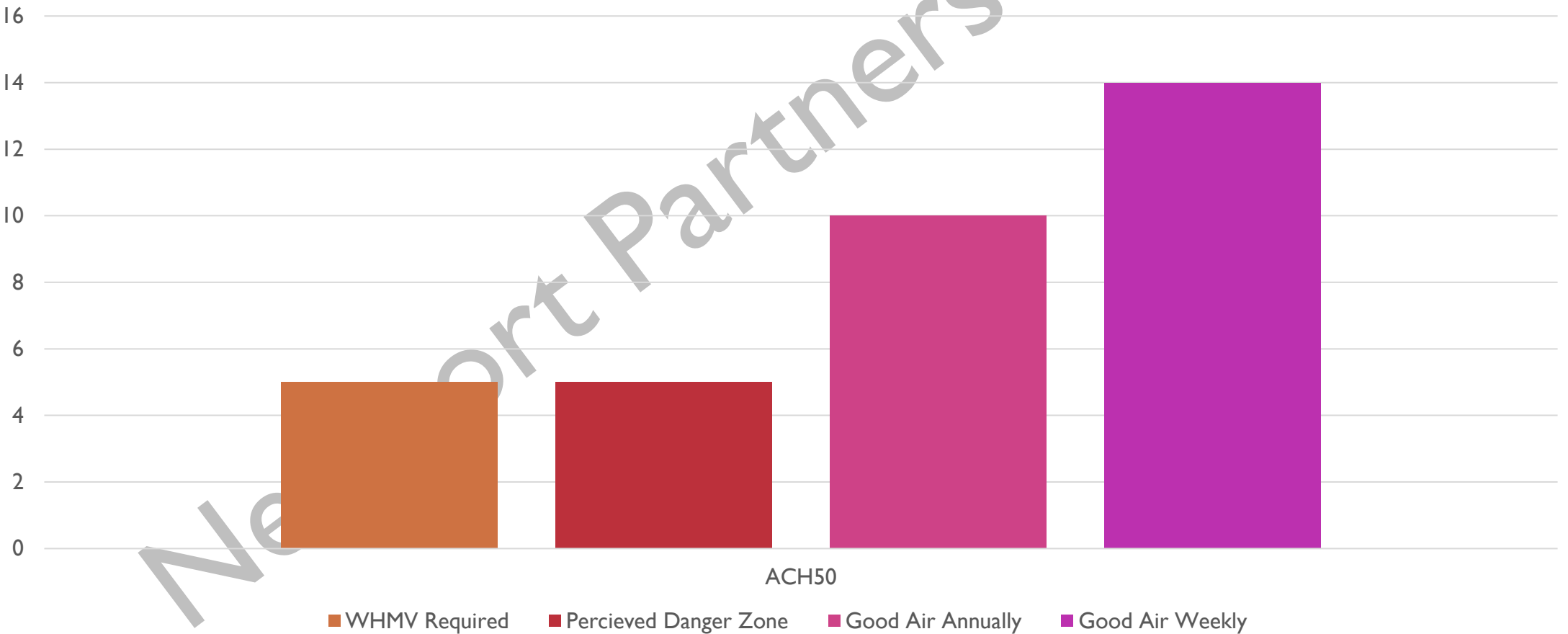
Mechanical ventilation can be:

- Controlled,
- Predicted,
- Designed,
- Sized, and
- Measured.





HOW MUCH FRESH AIR DO WE NEED?



WHAT DO THE CODES REQUIRE?

IECC
R403.6

Mandatory

Building shall
be provided
with ventilation

IRC
R303.4

Air infiltration
 ≤ 5 ACH50 ...

Building shall
be provided
with WHMV

IRC
M1505.4

Supply, exhaust,
or combination

$CFM = (0.01 \times sf) + [7.5 \times (\text{no. bedrooms} + 1)]$

2018
I-Codes

WHAT DO THE CODES REQUIRE?

Table M1505.4.3(1) Continuous WHMV System Airflow Rate Requirements

2018
I-Codes

Dwelling Unit Floor Area (SF)	Number of Bedrooms				
	0-1	2-3	4-5	6-7	>7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 – 3,000	45	60	75	90	105
3001 - 4500	60	75	90	105	120
4,501 – 6,000	75	90	105	120	135
6,001 – 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

$$\text{Ventilation Rate} = 0.01A_{\text{floor}} + 7.5 (N_{\text{br}} + 1)$$

WHAT ABOUT LOW-RISE MULTIFAMILY BUILDINGS?

2018 I-Codes

IMC
403.1

Supply,
exhaust, or
combination

Supply and
exhaust
approx. equal

IMC
403.3.3.1

Continuous
outdoor
airflow rate

$$Q_{OA} = 0.01 \times A_{\text{floor}} + 7.5 \times (N_{BR} + 1)$$

IMC
403.3.3.2

Corridors,
common
areas

Min. 0.06
cfm/sf_{Floor Area}



WHAT ABOUT CODE REQUIREMENTS FOR LOCAL EXHAUST?

2018 I-Codes

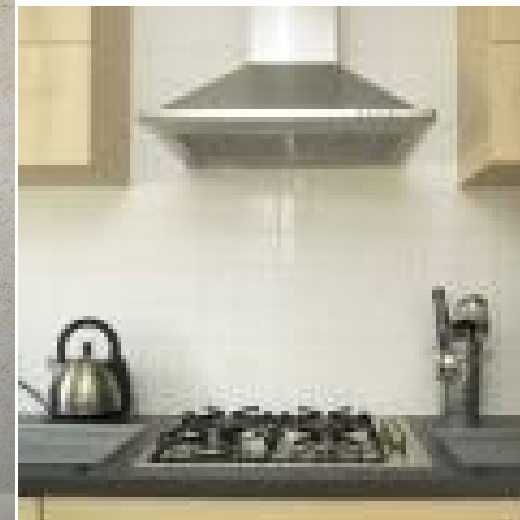
- Requirements for kitchen and bath exhaust are the same for single-family and multifamily buildings and townhomes.

Minimum Required Local Exhaust Rates

Kitchens	100 cfm intermittent 25 cfm continuous
Bathrooms, toilet rooms	50 cfm intermittent 20 cfm continuous



Building America Solutions Center



Building America Solutions Center

FAN EFFICACY – IECC TABLE R403.6.1

2018
I-Codes

Fan Location	Minimum Air Flow Rate (CFM)	Minimum Efficacy (CFM/Watt)	Maximum Air Flow Rate (CFM)
HRV or ERV	Any	1.2 cfm/watt	Any
Range Hood	Any	2.8 cfm/watt	Any
In-Line Fan	Any	2.8 cfm/watt	Any
Bathroom, Utility Room	10	1.4 cfm/watt	< 90
Bathroom, Utility Room	90	2.8 cfm/watt	Any

WHAT CHANGED IN THE 2021 CODES?

IECC Residential

Total Building Performance
Path ERI Path

- Air leakage testing - ≤ 5 ACH50 **OR**
- ≤ 0.28 cfm per sf enclosure area

Air leakage ≤ 0.30 cfm/sf
enclosure area

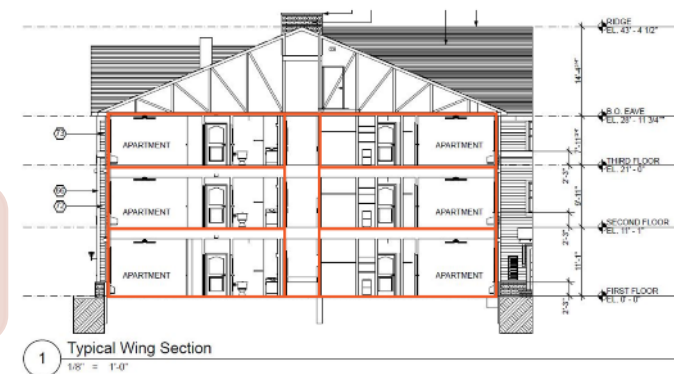
- Attached single-family and multifamily
- Dwelling units $< 1,500$ sf

Climate Zones 7 & 8

- Balanced heat or energy recovery required
- Min. 65% sensible heat recovery

Verification

- Testing required for all mechanical ventilation
- Exception: some range hood installations



Building America
Solutions Center



WHAT CHANGED IN THE 2021 CODES?

IECC Residential

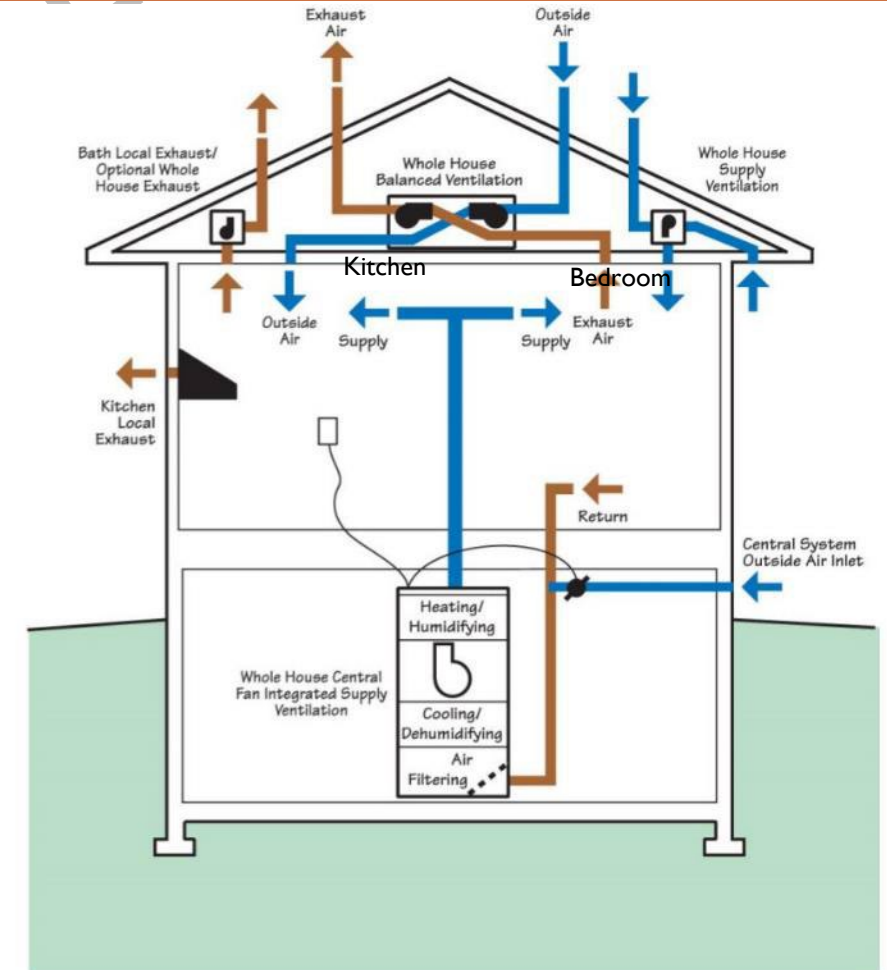
Table R403.6.2 Whole-Dwelling Mechanical System Fan Efficacy

Fan Location	Airflow Rate Minimum (CFM)	Minimum Efficacy (CFM/Watt)
HRV, ERV	Any	1.2 cfm/watt
Inline supply or exhaust fan	Any	3.8 cfm/watt
Other exhaust fan	< 90	2.8 cfm/watt
Other exhaust fan	≥ 90	3.5 cfm/watt
Air handler that is integrated	Any	1.2 cfm/watt

WHAT CHANGED IN THE 2021 CODES?

IRC Chapter M1505 IMC 403.3.2.1

- Ventilation rate can be reduced by 30% if the following comply:
 - A ducted system supplies ventilation air directly to each bedroom and one or more of the following:
 - Living room
 - Dining room
 - Kitchen
- AND**
- The WHMV system is a balanced system.

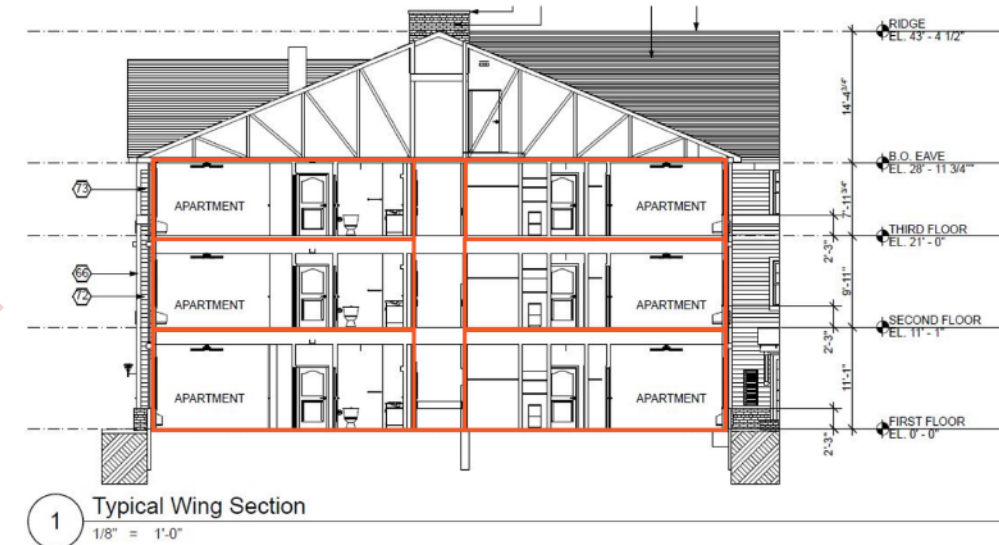


WHAT CHANGED IN THE 2021 CODES

IECC Commercial

Multifamily Dwelling Units

- Energy recovery ventilation
- Cooling – 50% enthalpy energy recovery
- Heating – 60% enthalpy recovery





HIGHER PERFORMANCE CODES, STANDARDS, PROGRAMS

Energy Star

- Efficacy w/filter
- Sone rating
- LED or fluorescents

Indoor Air Plus Version 2 (Proposed)

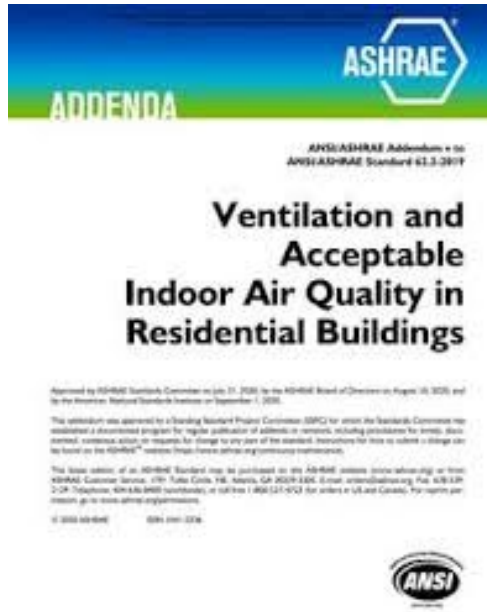
- Balanced ventilation
- MERV 13 filtration
- Bath fans – 30 minute auto-on
- Range hoods exhaust to outside

Passive House

- Envelope air leakage: 0.6 ACH50
- User-controlled ventilation
- All rooms directly or indirectly ventilated
- Noise: ≤ 25 db(A)

WHAT IS ASHRAE 62.2?

ANSI/ASHRAE



$$Q_{\text{tot}} = 0.03A_{\text{floor}} + 7.5 (N_{\text{br}} + I)$$

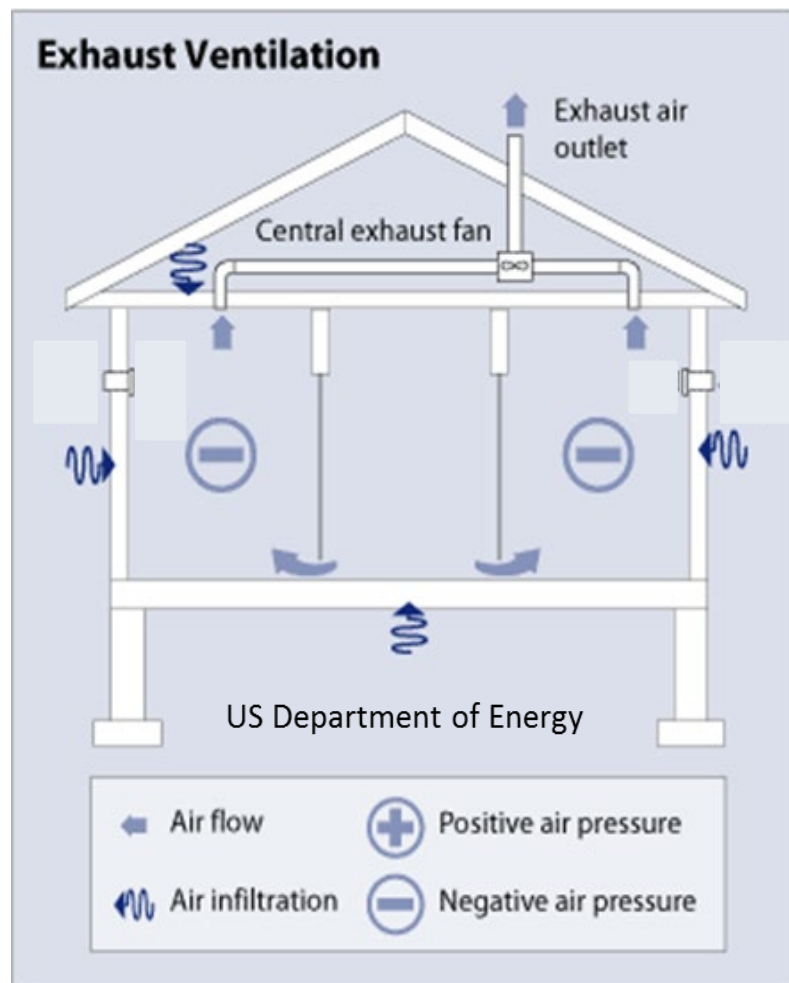
International Code Council



$$Q_{\text{tot}} = 0.01A_{\text{floor}} + 7.5 (N_{\text{br}} + I)$$



WHAT ARE THE OPTIONS FOR WHMV?



house-energy.com

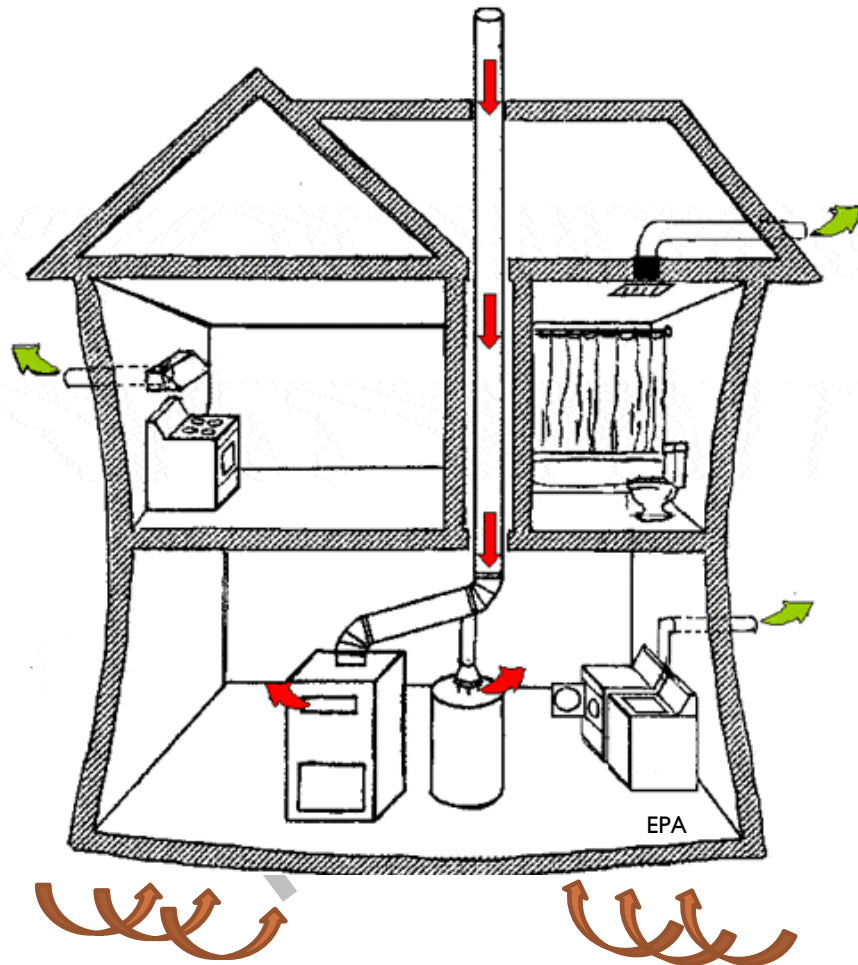
Exhaust-Only - Pros

Exhaust Only

Inexpensive

“Easy” to Design and Install Correctly

WHAT ARE THE OPTIONS FOR WHMV?



Exhaust-Only - Cons

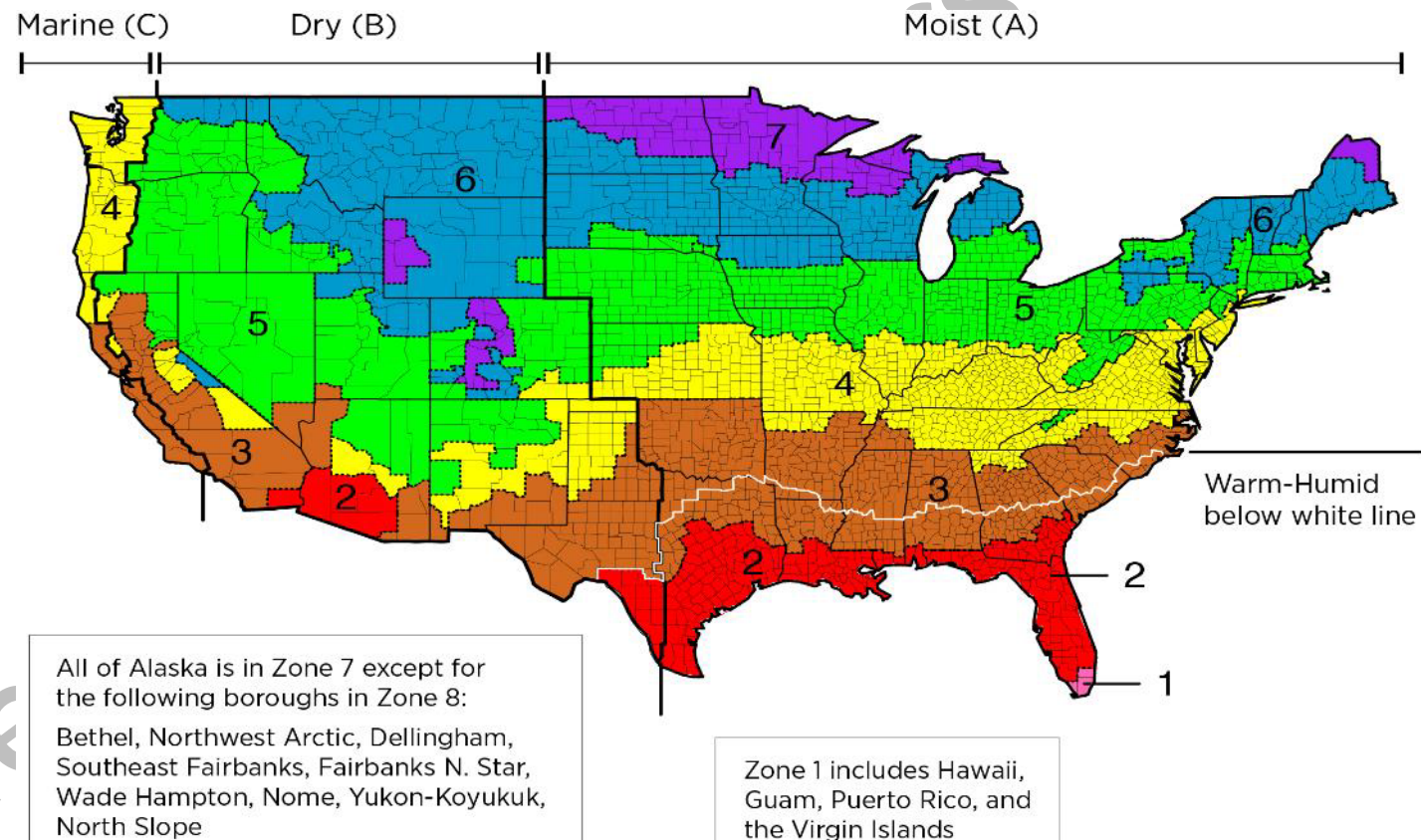
Pulls in “Fresh Air”
Through Infiltration

Potential for
Condensation

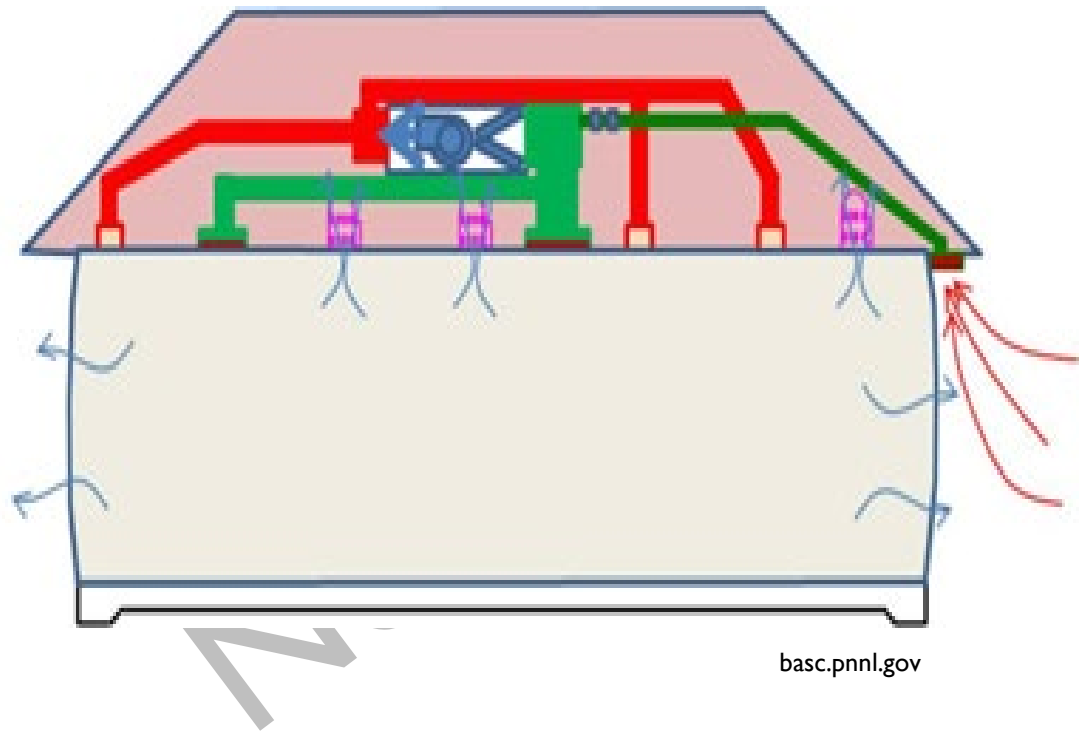
Radon?
Contaminants?

De-Pressurizes
Home

APPROPRIATE CLIMATES FOR EXHAUST-ONLY VENTILATION



WHAT ARE THE OPTIONS FOR WHMV?



Supply-Only - Pros

Supply Only

Inexpensive

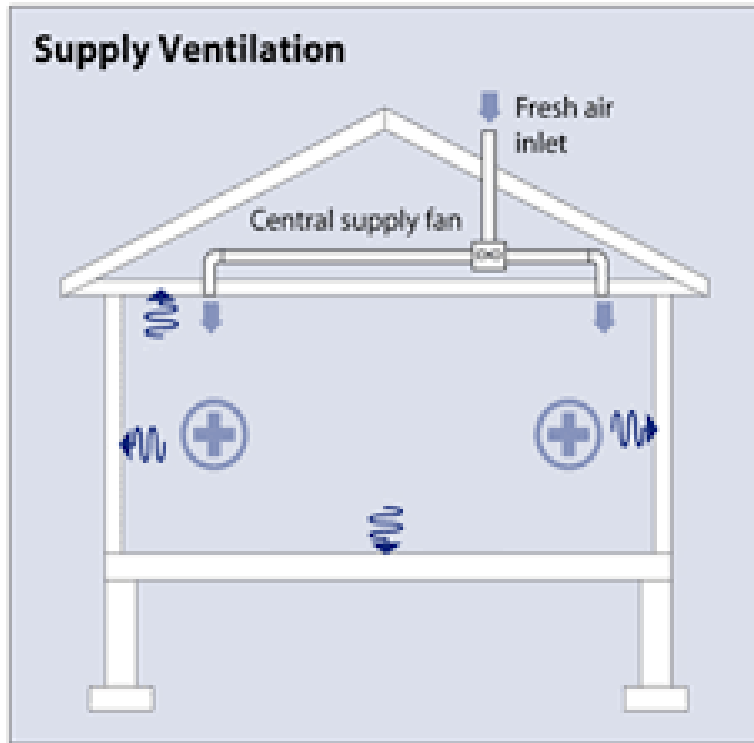
Easy to Design and
Install Correctly

Inhibits entry of
outdoor pollutants

Can be
filtered

WHAT ARE THE OPTIONS FOR WHMV?

Supply-Only - Cons



paenergycode.com

Pushes Air Out Through Building Envelope

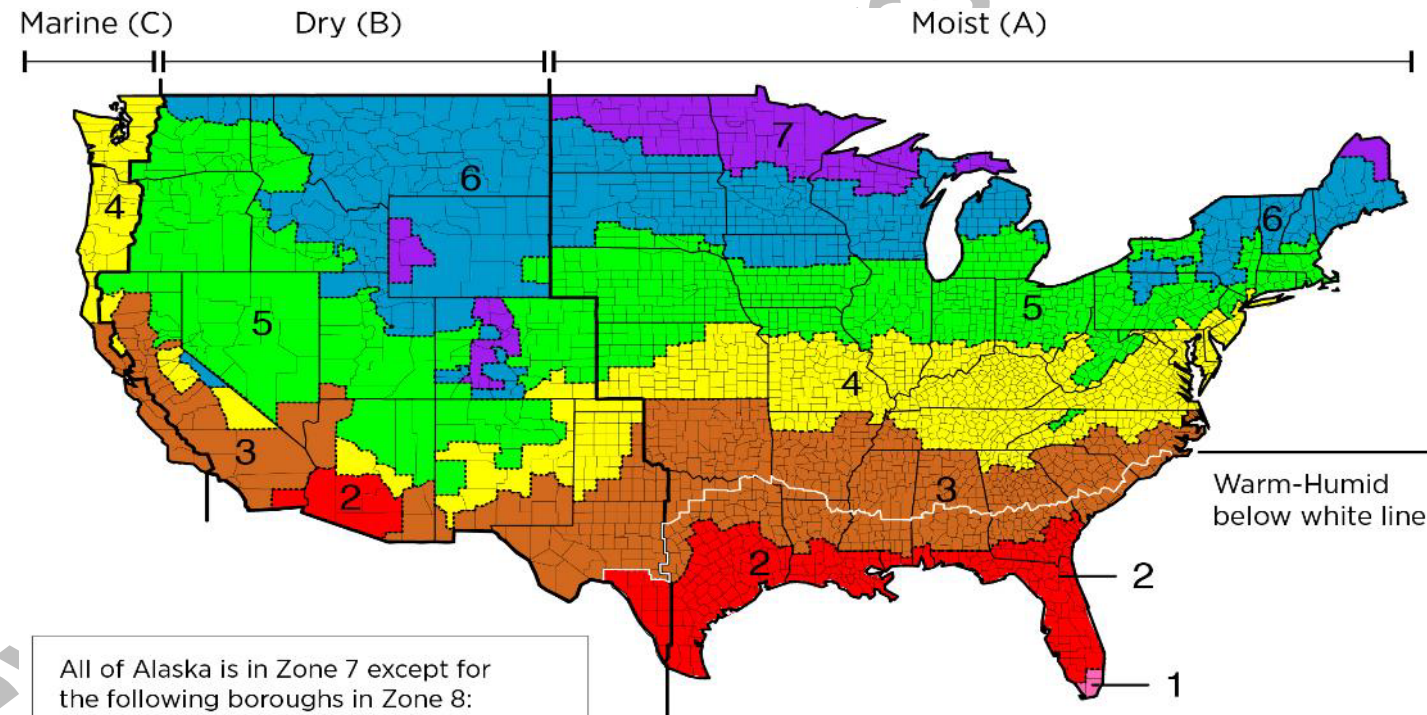
Brings in hot/cold/moist air

Potential for condensation

Uncertain distribution

Can feel drafty

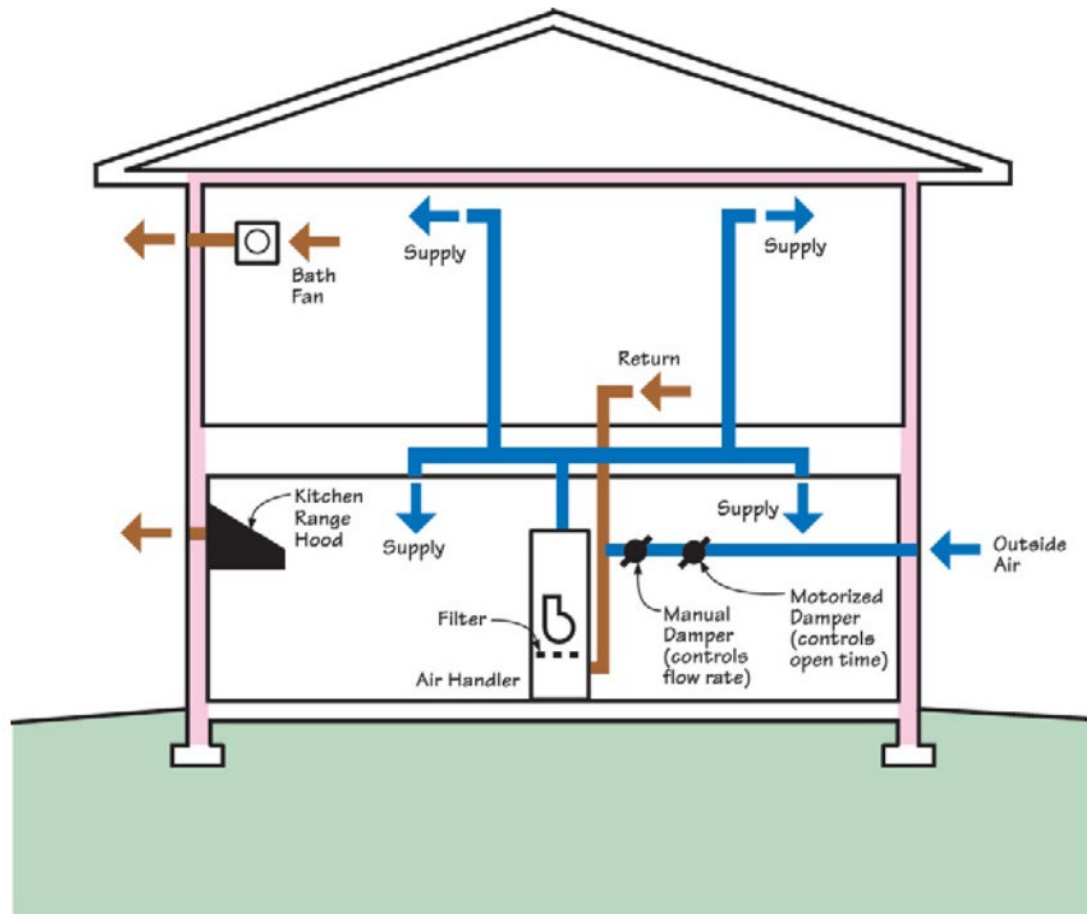
APPROPRIATE CLIMATES FOR SUPPLY-ONLY VENTILATION



All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel, Northwest Arctic, Dillingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

WHAT ARE THE OPTIONS FOR WHMV?



basc.pnnl.com

Balanced Ventilation - Pros

~ equal supply & exhaust airflow

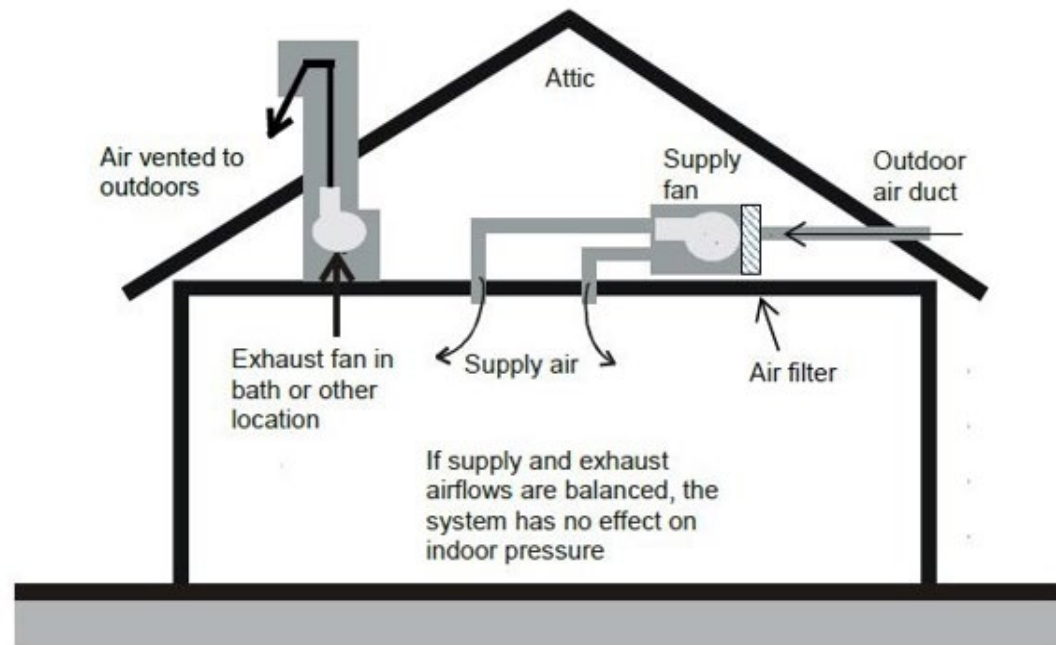
No induced exfiltration or infiltration

No depressurization/pressurization

No impact on combustion

WHAT ARE THE OPTIONS FOR WHMV?

Balanced Ventilation Example – Separate Supply and Exhaust Fan



Source: California Energy Commission

Balanced Ventilation - Pros

Designed points of supply & exhaust

Supply air can be filtered

Designed to minimize comfort issues

WHAT ARE THE OPTIONS FOR WHMV?



Balanced Ventilation - Cons

More expensive

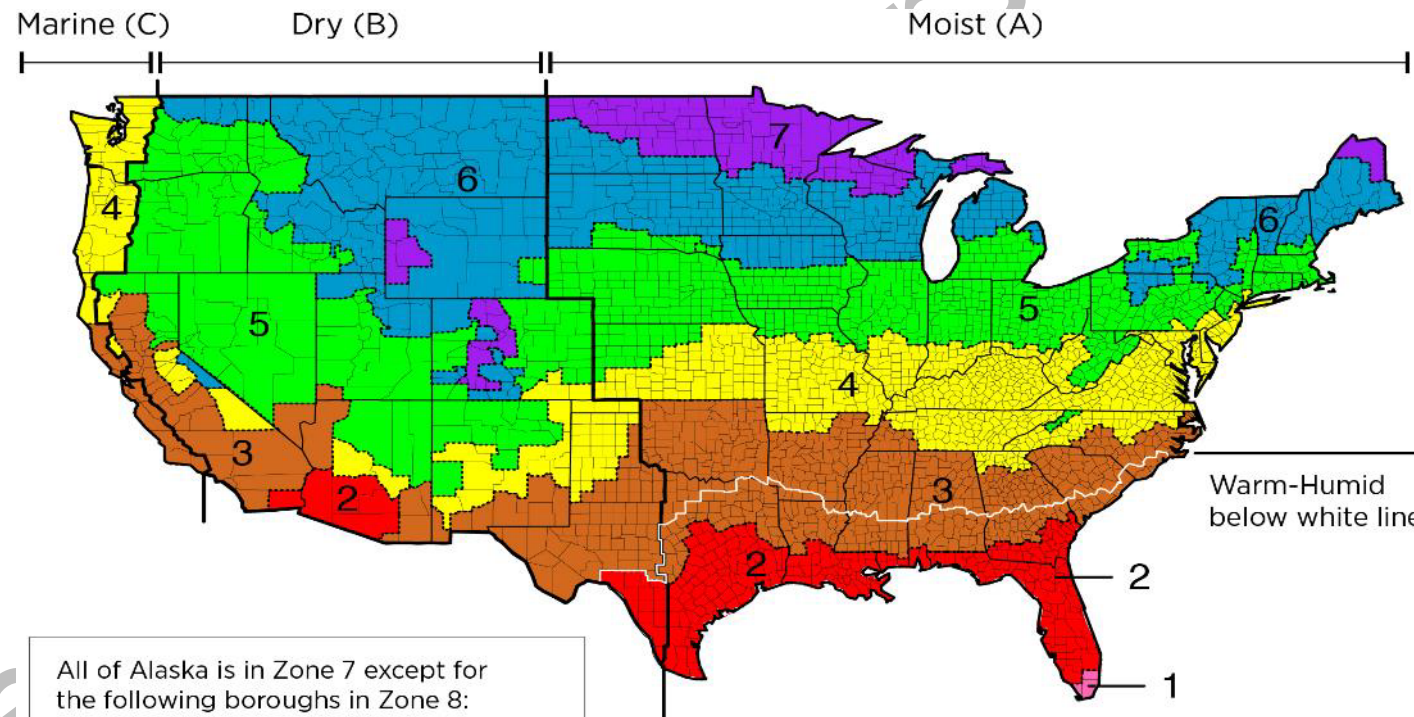


Harder to design properly



pre-conditioning of incoming air?

APPROPRIATE CLIMATES FOR BALANCED VENTILATION

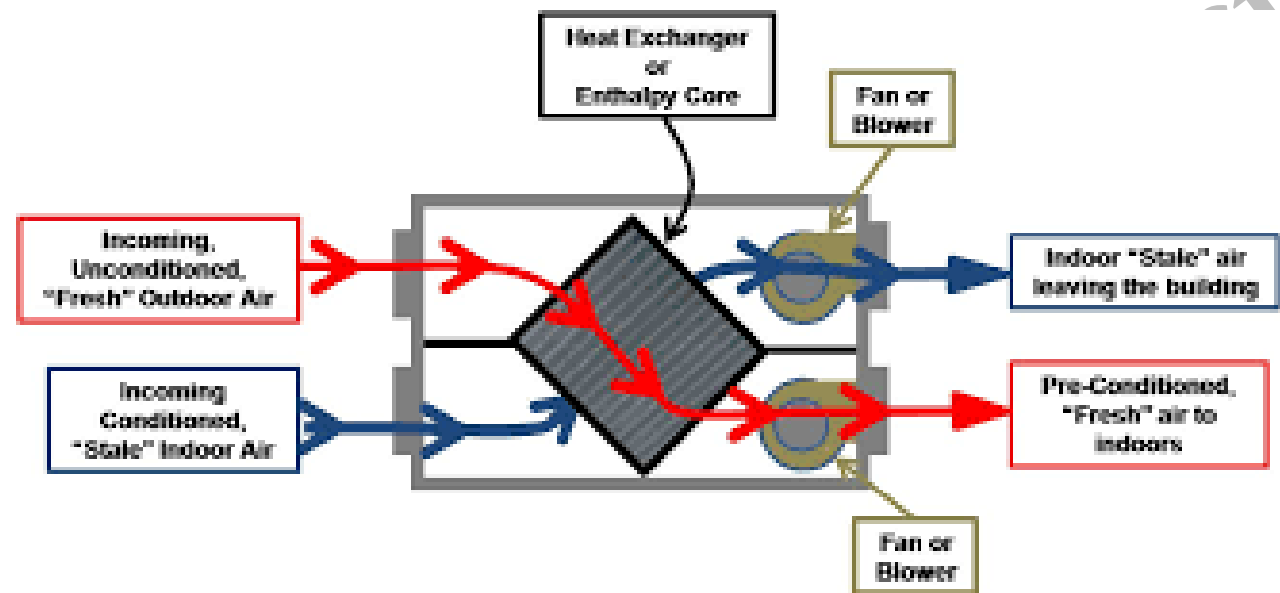


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Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

WHAT ARE THE OPTIONS FOR WHMV?

Balanced with heat/energy recovery - Pros



basc.pnnl.com

Equal supply & exhaust
airflow

Semi pre-heated/cooled
supply air

Semi dehumidified
supply air

No pressurization/de-
pressurization

WHAT ARE THE OPTIONS FOR WHMV?

Exhaust-Only Ventilation

Whole Dwelling Infiltration

Input Type:

Annual Infiltration Value:

Shelter Class:

Code Verification:

Mechanical Ventilation System for IAQ

Type: Hours/Day:

ECM Fan Motor? ☐ Rate (cfm): ☐ Not Measured

Adjusted Sensible Recovery Efficiency (%): Fan watts: ☐ Use Default

Adjusted Total Recovery Efficiency (%):

Annual Energy Costs (\$/yr)	
Heating	1003
Cooling	101
Water Heating	80
Lights and Appliances	1190
Photovoltaics	-0
Service Charge	0
Total	2374

WH Infiltration	
Natural ACH	0.07
ACH50 (Pa)	1.50
CFM50 (Pa)	1321
ELA (sq.in)	72.5
SLA	0.00009
CFM50/sf shell	0.12
WH Ventilation (continuous)	
Type	Exhaust Only
Asls (equiv.cfm)	150
62.2-2010 (cfm)	77
62.2-2013 (cfm)	140

Heat Recovery Ventilation

Whole Dwelling Infiltration

Input Type:

Annual Infiltration Value:

Shelter Class:

Code Verification:

Mechanical Ventilation System for IAQ

Type: Hours/Day:

ECM Fan Motor? ☐ Rate (cfm): ☐ Not Measured

Adjusted Sensible Recovery Efficiency (%): Fan watts: ☐ Use Default

Adjusted Total Recovery Efficiency (%):

Annual Energy Costs (\$/yr)	
Heating	872
Cooling	112
Water Heating	80
Lights and Appliances	1232
Photovoltaics	-0
Service Charge	0
Total	2296

WH Infiltration	
Natural ACH	0.07
ACH50 (Pa)	1.50
CFM50 (Pa)	1321
ELA (sq.in)	72.5
SLA	0.00009
CFM50/sf shell	0.12
WH Ventilation (continuous)	
Type	Balanced
Asls (equiv.cfm)	140
62.2-2010 (cfm)	77
62.2-2013 (cfm)	140

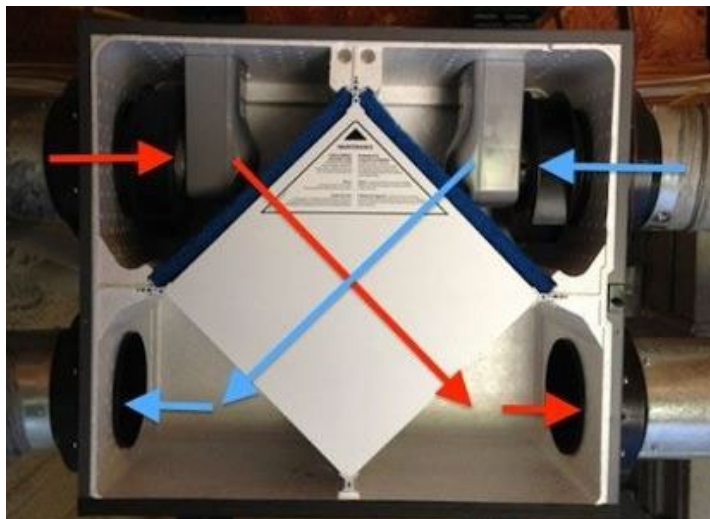
WHAT ARE THE OPTIONS FOR WHMV?

Balanced with heat/energy recovery - Cons

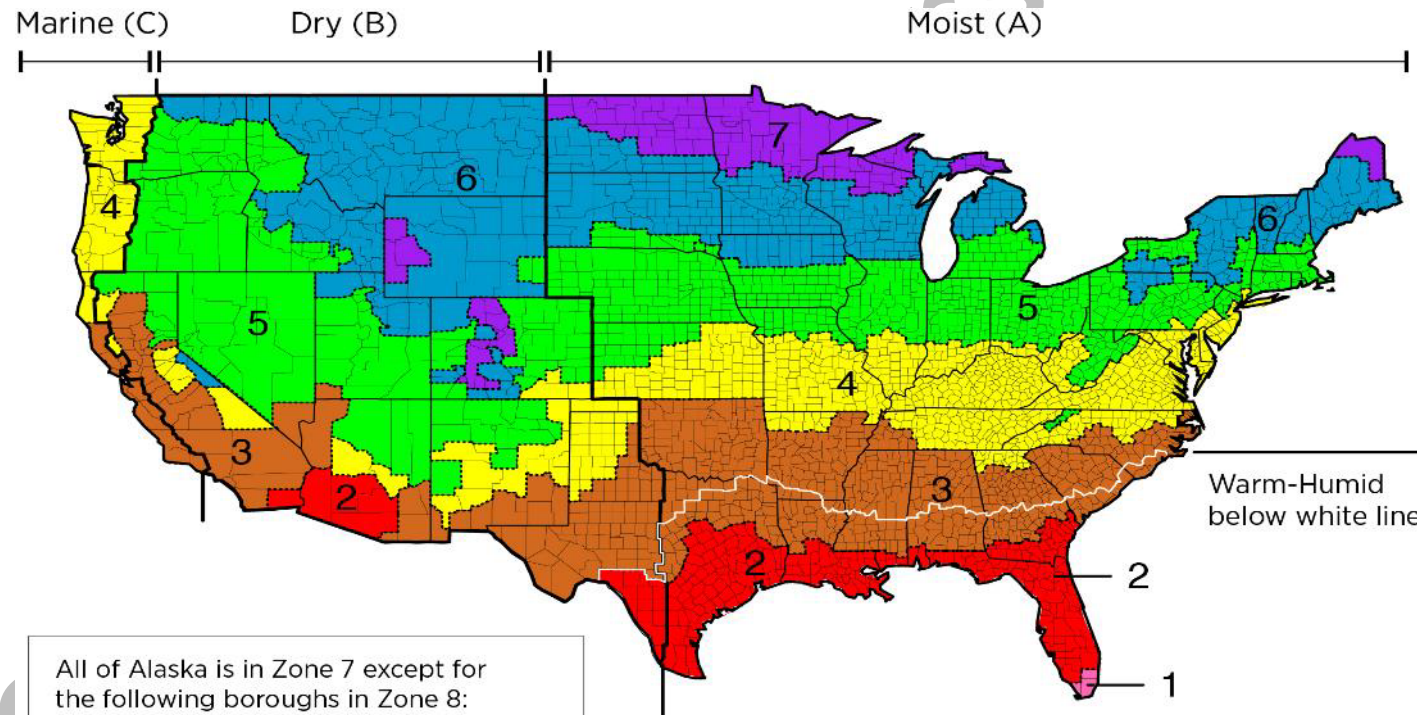
More expensive

Somewhat harder to design

Somewhat harder to install



APPROPRIATE CLIMATES FOR HRVS/ERVS



All of Alaska is in Zone 7 except for the following boroughs in Zone 8:
Bethel, Northwest Arctic, Dellingham, Southeast Fairbanks, Fairbanks N. Star, Wade Hampton, Nome, Yukon-Koyukuk, North Slope

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

Warm-Humid
below white line



OPTIONS FOR DUCTING MECHANICAL VENTILATION

Direct to/from
living space

- Effective
- Measurable
- Comfort issues?

Incorporates
central AHU

- Reduced ductwork and labor
- Not measurable
- Expensive to operate

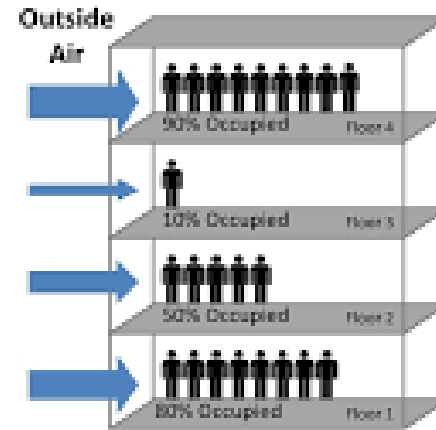
CONTROL OPTIONS FOR MECHANICAL VENTILATION

Code required: Automatic
timer with manual over-ride:

- Continuous
- Intermittent



Demand-Controlled Ventilation (DCV)



Adjust fresh-air
intake based on
occupancy

Ventilation demand
is determined by
CO2 level (ppm)

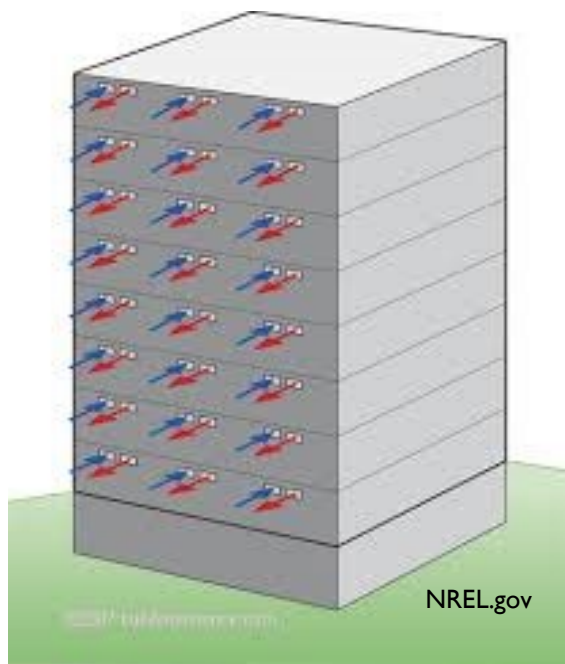


Optional: CO2 demand control

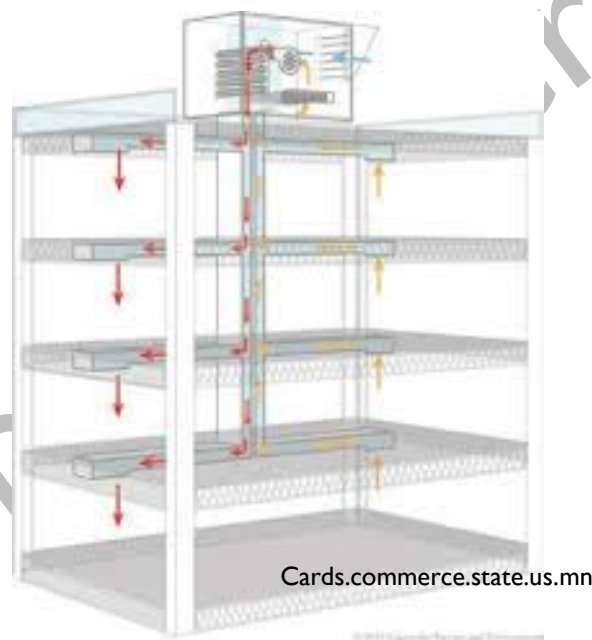
WHAT ABOUT MULTIFAMILY BUILDINGS?



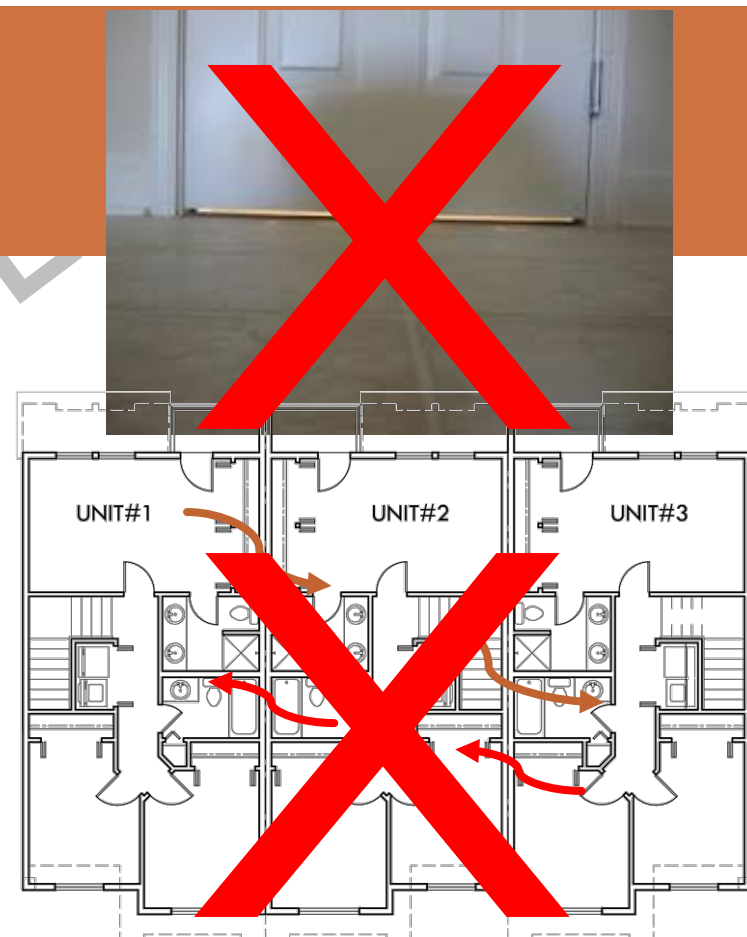
MULTIFAMILY BUILDINGS



Individual fans in
each dwelling unit ✓



Central fan serving
multiple dwelling units ✓

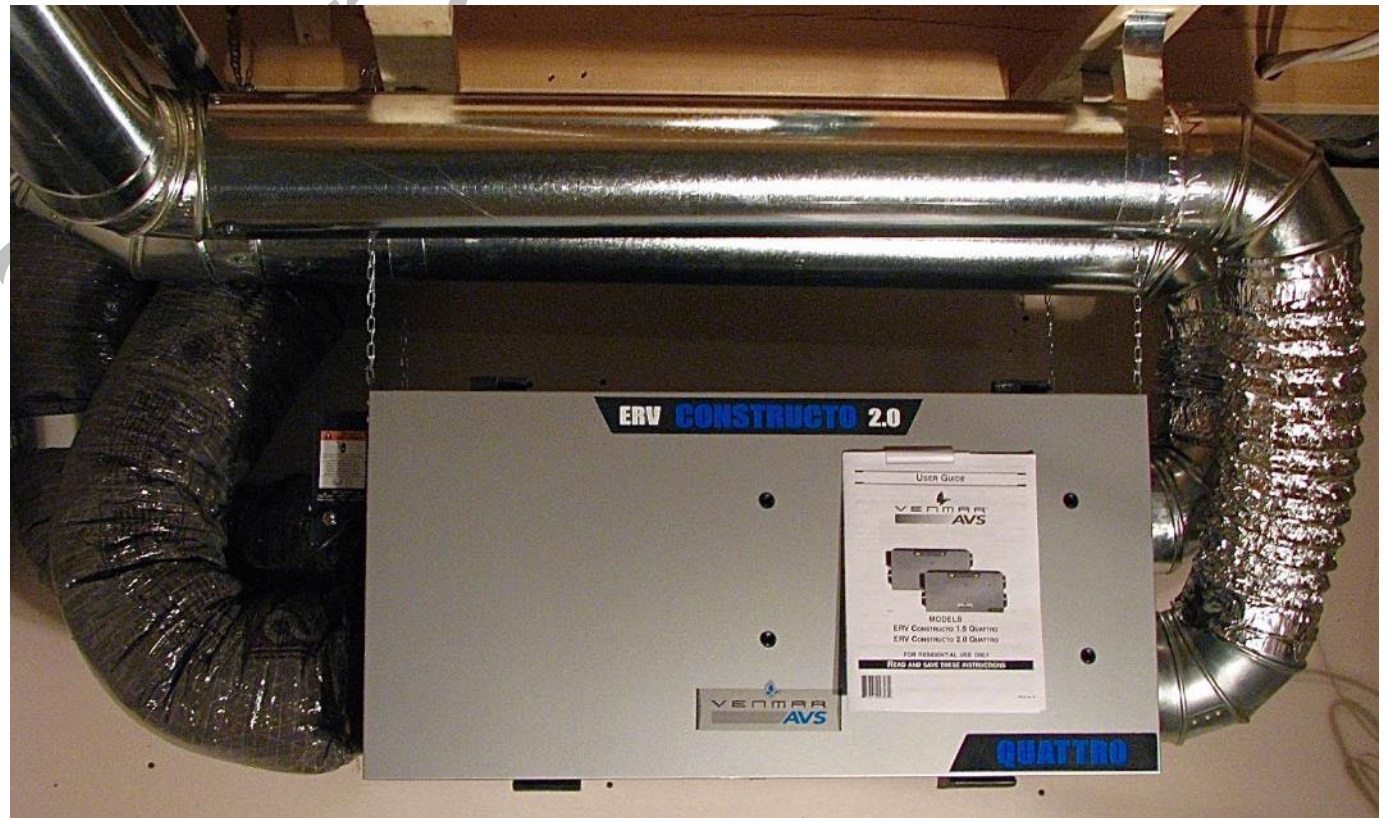


Ventilation air pulled
from corridor or
adjacent dwelling unit

BEST (AND WORST) PRACTICES FOR WHMV



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Center



Building America Solutions
Center

Fans poorly located

BEST (AND WORST) PRACTICES FOR WHMV



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Fans and ductwork improperly fastened and sealed

BEST (AND WORST) PRACTICES FOR WHMV



Looooong Duct Runs



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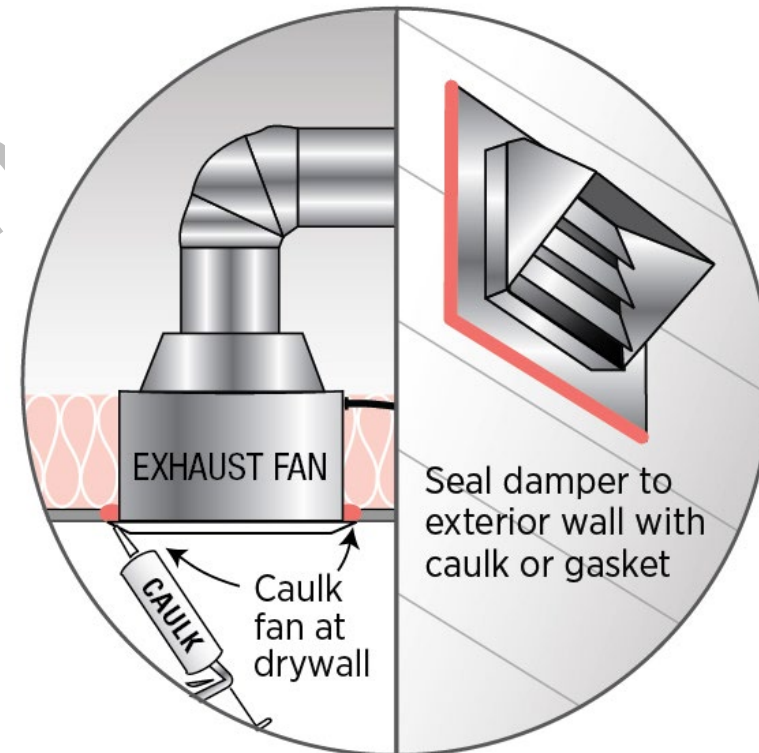


Convolutd Duct
Runs

BEST (AND WORST) PRACTICES FOR WHMV



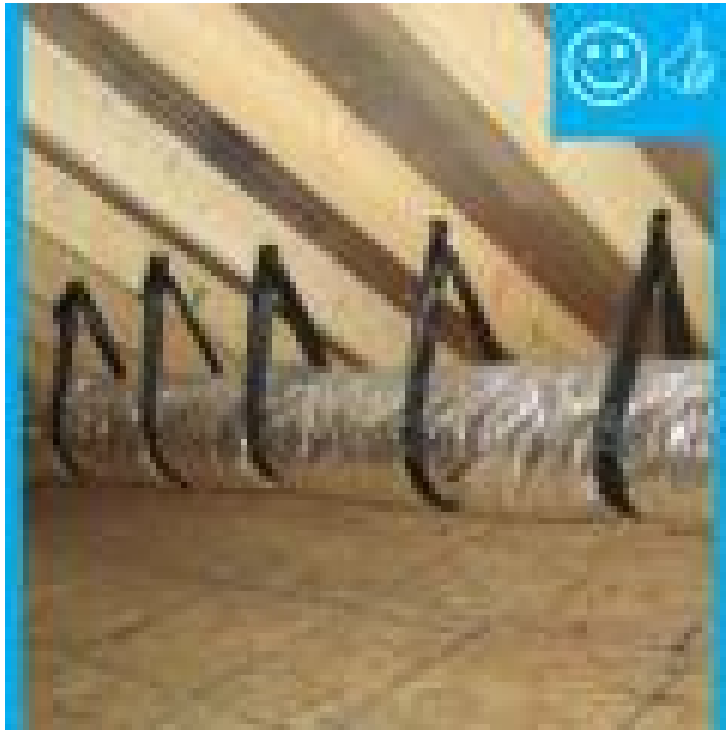
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Ducts properly fastened and sealed

BEST (AND WORST) PRACTICES FOR WHMV



Building America Solutions
Center

Properly supported



Building America Solutions
Center

Straight, uncompressed runs

RENOVATIONS



Always a good idea to insulate and air seal!



As you tighten the home, don't forget about ventilation!

KITCHEN REMODEL

- PM_{2.5}: typically ~10-20x the EPA 24-hour outdoor guideline (35 µg/m³)
- NO₂: Exposure from gas stoves frequently exceeds ~100 PPB 1-hour limit

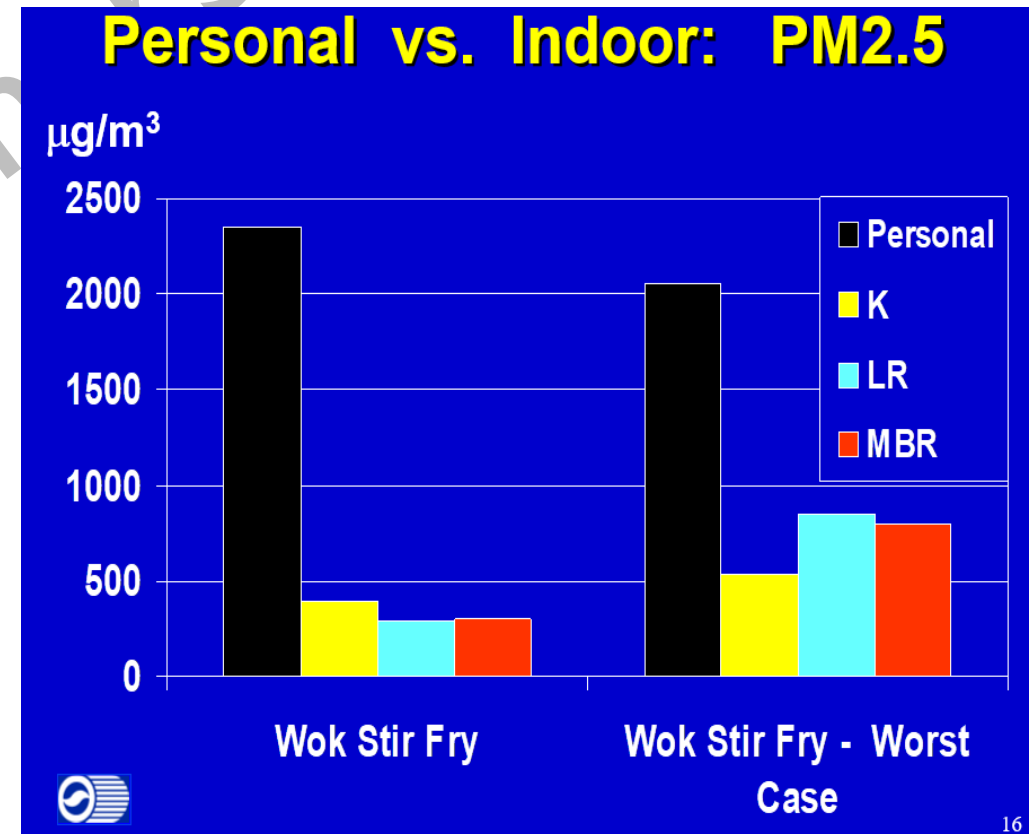


Chart: Fortmann et al. 2000.

KITCHEN REMODEL



Qualities to look for in a range hood:

- Fan speeds
- Exhaust air flow rate
- Thermostat control
- Ducted to the outdoors (code-required)
- Timer?
- Quiet



KITCHEN REMODEL

IRC – Where provided:

- Ducted to outdoors
- 100 cfm intermittent; 25 cfm continuous
- Makeup air if:
 - > 400 cfm and
 - Unsealed combustion equipment in the conditioned space

ASHRAE 62.2 - Required

- Demand-controlled (manual or automatic) or continuous
- 100 cfm (Demand controlled)
- 5 ACH (Continuous)
- If continuous, readily-accessible manual control required.

BATH REMODEL

Bath fans are always a good idea!



Eliminate
moisture

Eliminate
condensation

Reduce mold
potential

Reduce
deterioration
of finishes





BATH REMODEL

IRC – Required if no operable window

- Ducted to outdoors
- 50 cfm intermittent; 20 cfm continuous

ASHRAE 62.2 – Required always

- Demand-controlled (manual or automatic) or continuous
- 50 cfm Demand controlled
- 20 cfm (Continuous)
- If continuous, readily-accessible manual control required.

BATH REMODEL



Noisy, old bath fan



Flex duct poorly installed



Terminates where???

BATH REMODEL



New efficient, quiet
bath fan



Straight, hard
ducted run

Properly terminated



WHAT ABOUT WHOLE-HOUSE MECHANICAL VENTILATION FOR EXISTING HOMES?



CLOSING THOUGHTS

- Air sealing techniques can reduce air leakage to the point that contaminants with known health effects such as formaldehyde, volatile organic compounds, and radon are sealed into the house.
- Ventilation also helps control moisture, which can lead to mold growth and structural damage.
- Code compliance problems. Study shows 48 percent of bathroom exhaust fans evaluated failed to meet ASHRAE 62.2 required airflow.
- As the “old” saying goes....Build tight and ventilate right.



THANK YOU!

NEWPORT PARTNERS, LLC

3760 TANGLEWOOD LANE, DAVIDSONVILLE, MD

JNEBBIA@NEWPORTPARTNERSLLC.COM