Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

Building Science

Adventures In Building Science

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Mechanical Systems

Mechanical Systems

Cooling System To Make It Cold

Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm

Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm

Energy Recovery System To Keep It Cold and Dry and Warm and Comfortable

Mechanical Systems

Cooling System To Make It Cold

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Energy Recovery System To Keep It Cold and Dry and Warm and Comfortable

Distribution System To Make It Uniform

Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

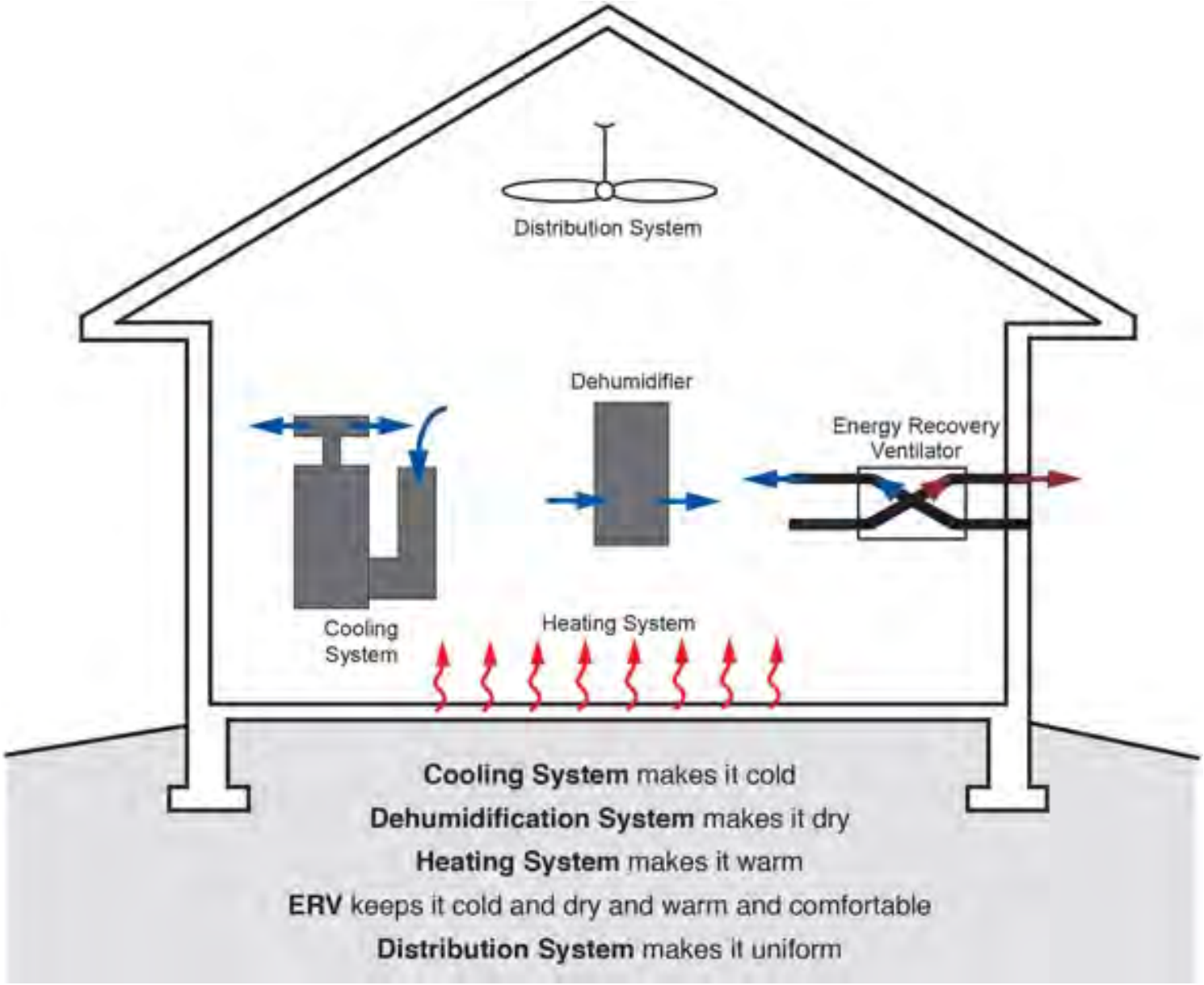
Heating System To Make It Warm

Energy Recovery System To Keep It Cold and Dry and Warm and Comfortable

Distribution System To Make It Uniform

Range Hoods Are A Special Kind of Hell

Don’t Try to Combine Them……


Distribution System
Dehumidifier
Energy Recovery
Ventilator
Cooling
System
Heating System
Cooling System makes it cold
Dehumidification System makes it dry
Heating System makes it warm
ERV keeps it cold and dry and warm and comfortable
Distribution System makes it uniform

Build Tight - Ventilate Right

Build Tight - Ventilate Right

How Tight?

What’s Right?

Air Barrier Metrics

Material	0.02 l/(s-m2) @ 75 Pa
Assembly	0.20 l/(s-m2) @ 75 Pa
Enclosure	2.00 l/(s-m2) @ 75 Pa
	0.25 cfm/ft2 @ 50 Pa

Getting rid of big holes	3 ach@50
Getting rid of smaller holes	1.5 ach@50
Getting German	0.6 ach@50

Best

As Tight as Possible - with -

Balanced Ventilation

Energy Recovery

Distribution and Mixing

Source Control - Spot exhaust ventilation

Filtration

Material selection

Worst

Leaky - with – Nothing

Spot Ventilation in Bathroom/Kitchen

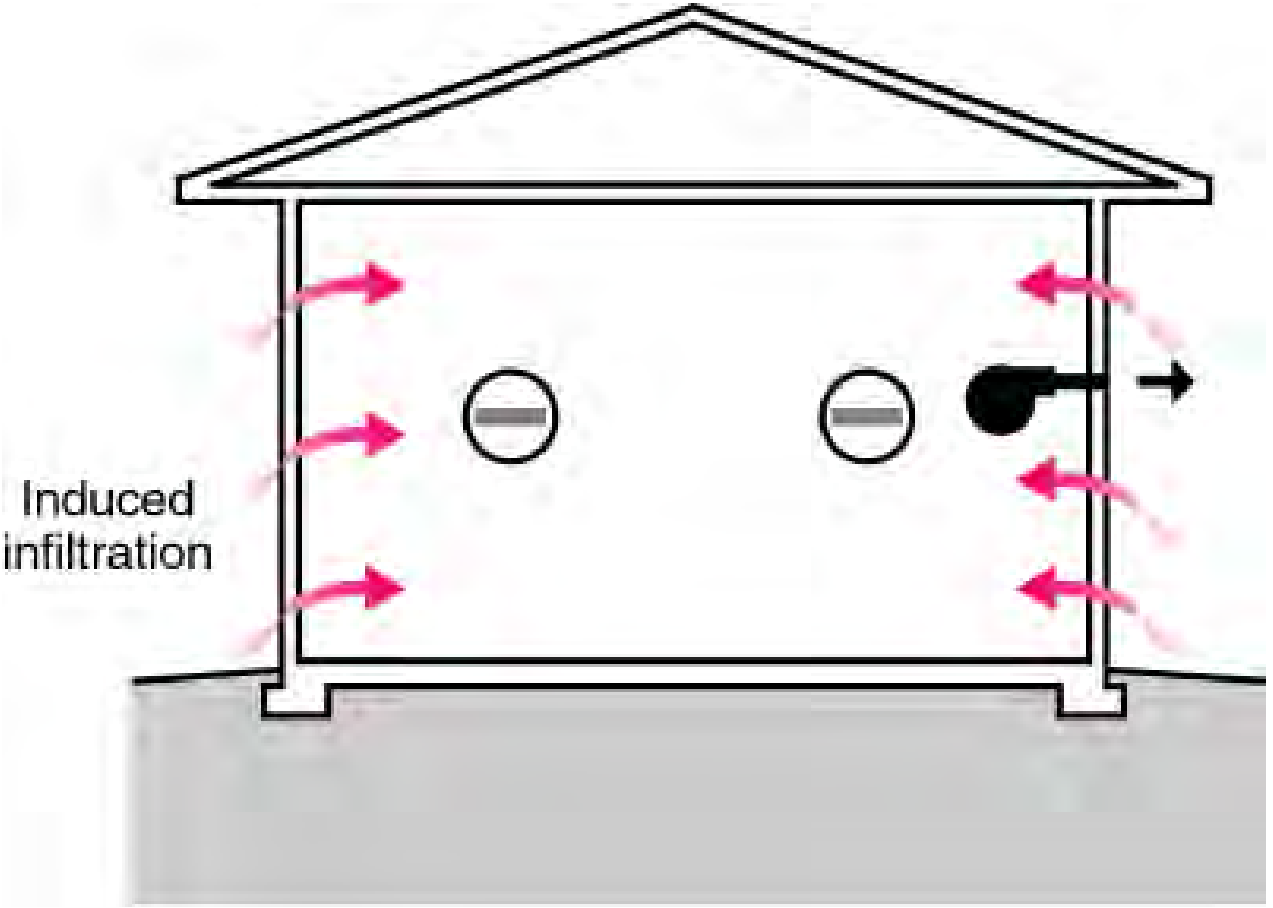
Exhaust Ventilation – with – No Distribution and No Mixing

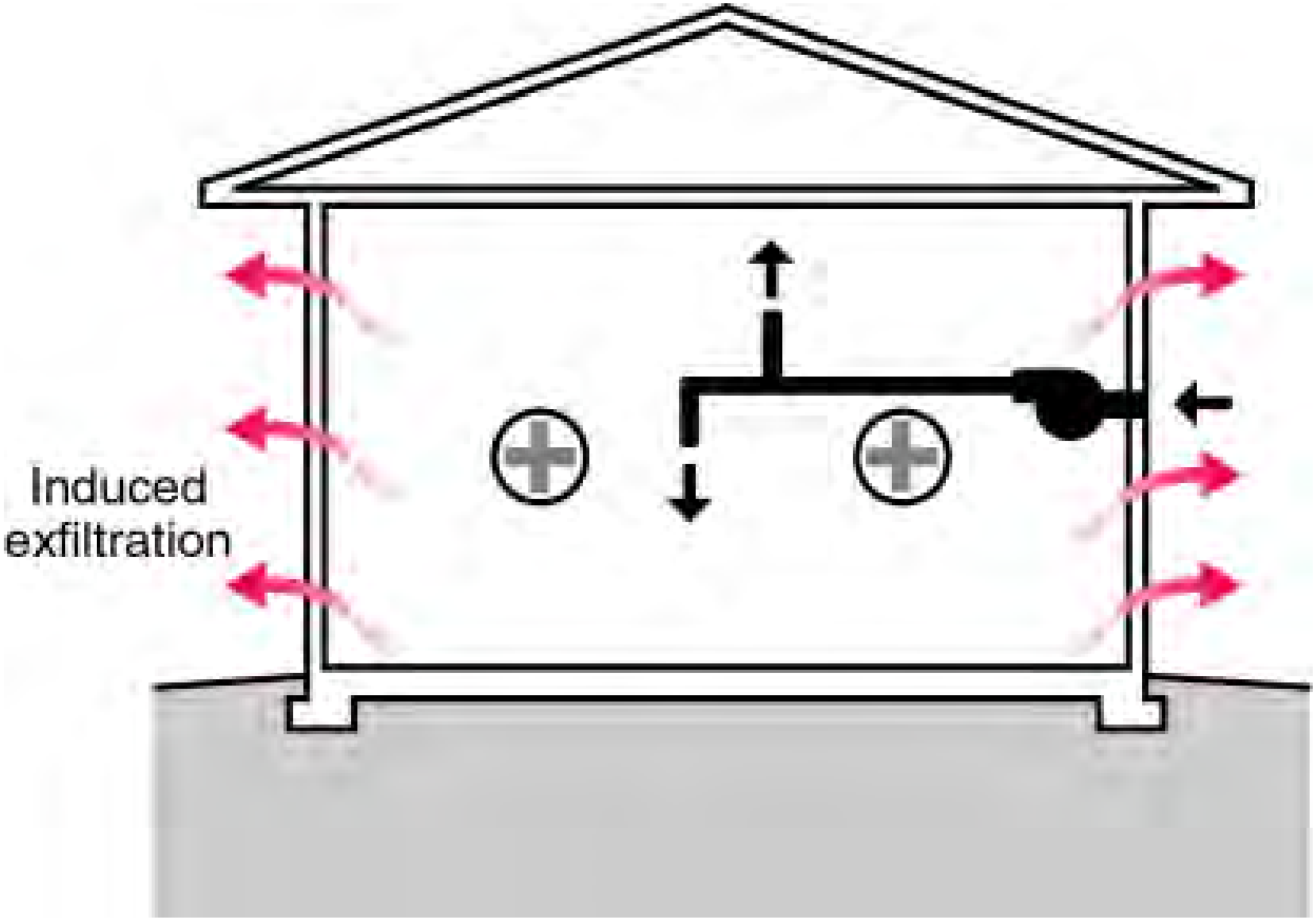
Three Types of Controlled Ventilation Systems

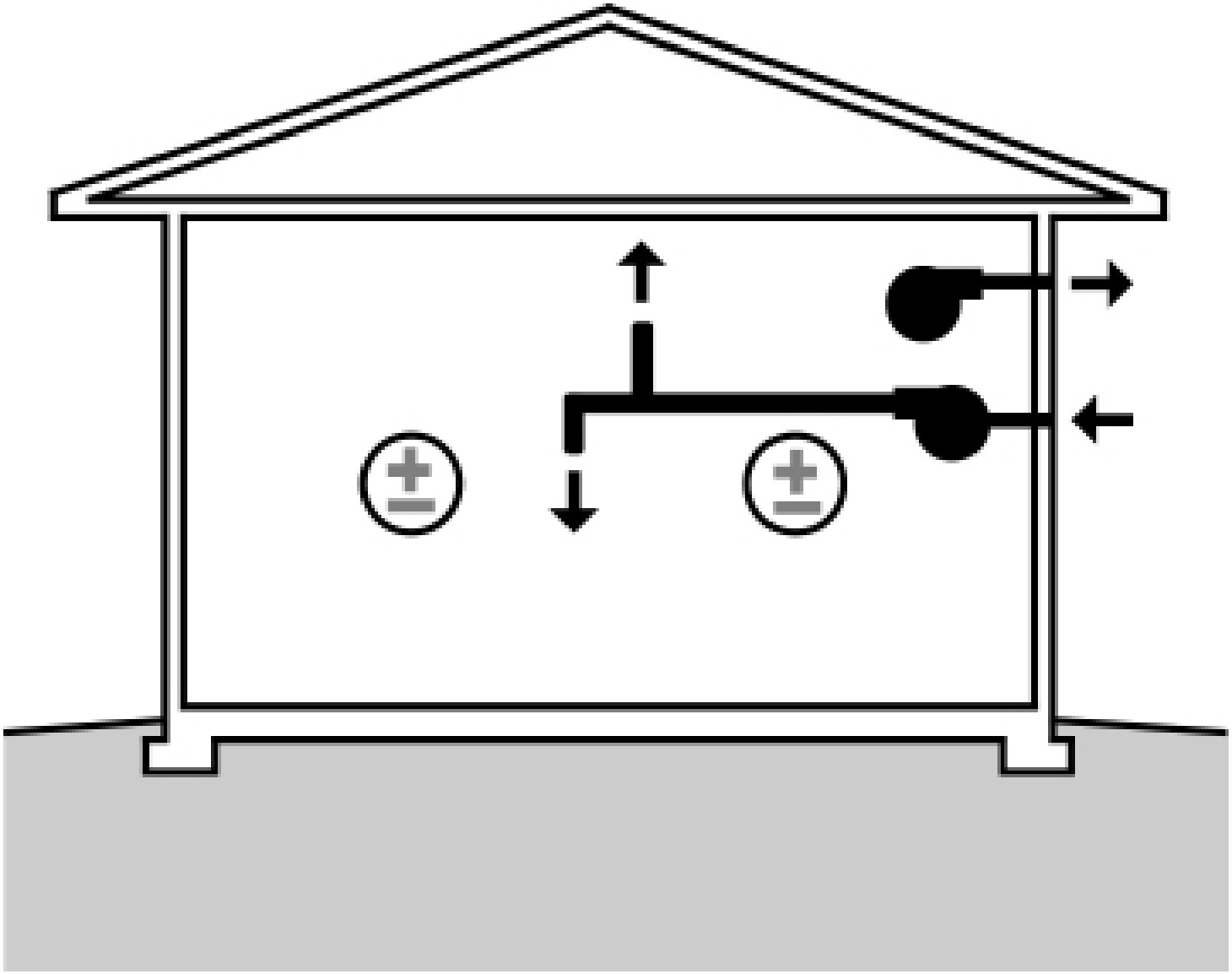
Exhaust Ventilation

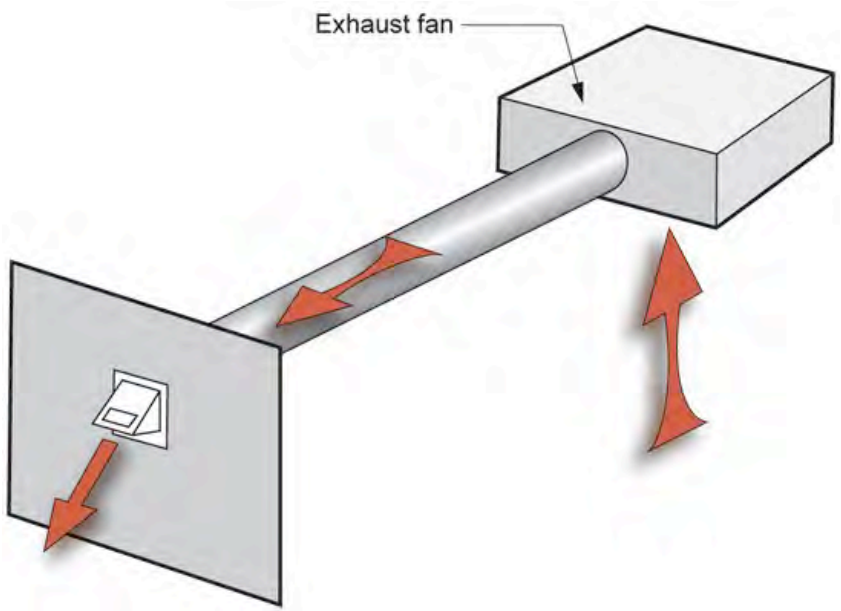
Supply Ventilation

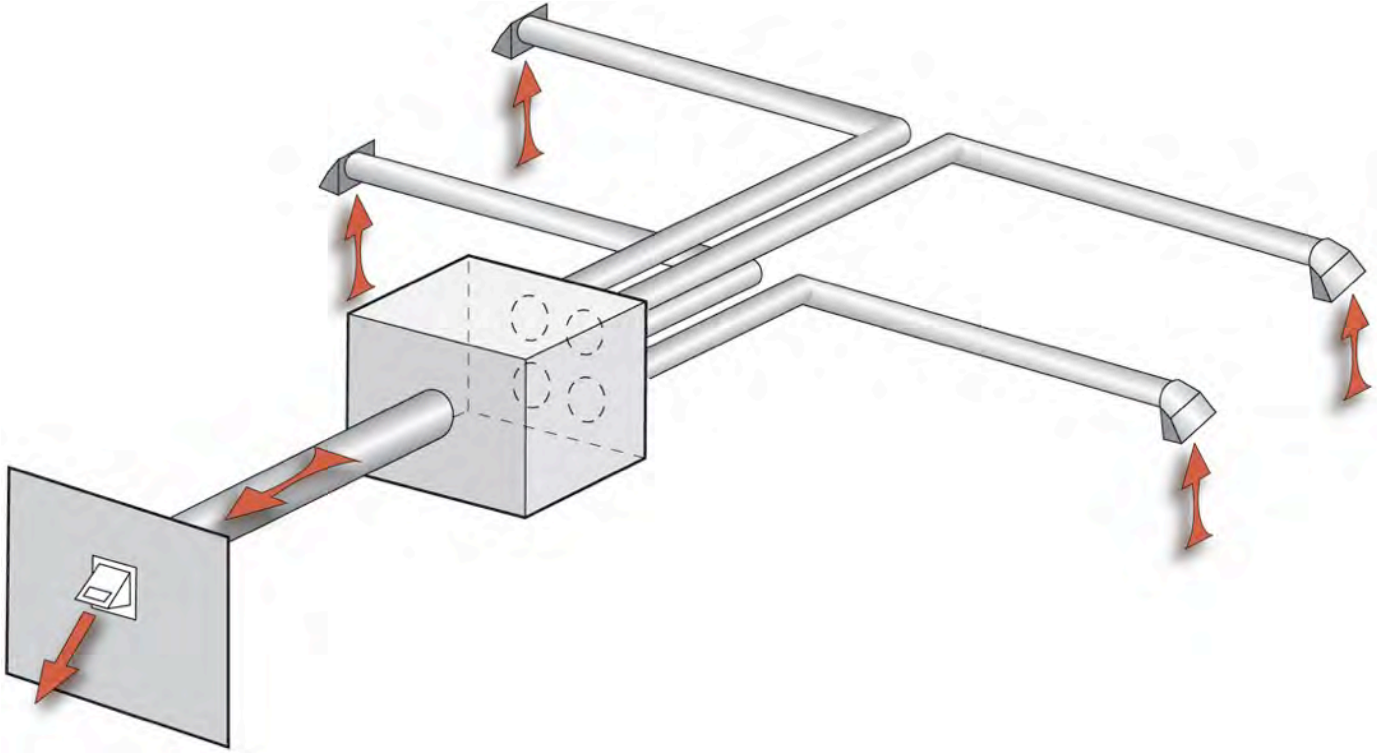
Balanced Ventilation

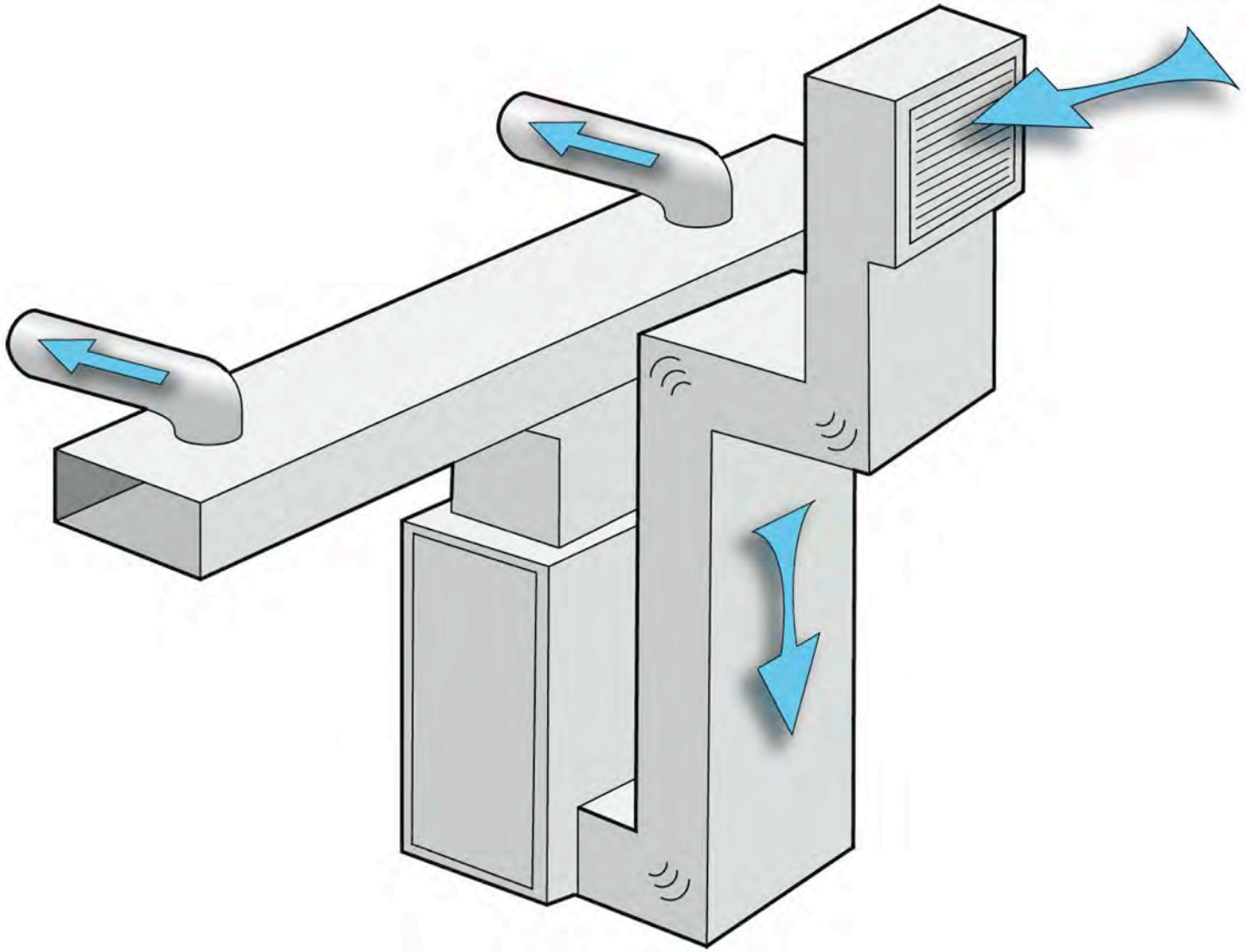

Induced
infiltration

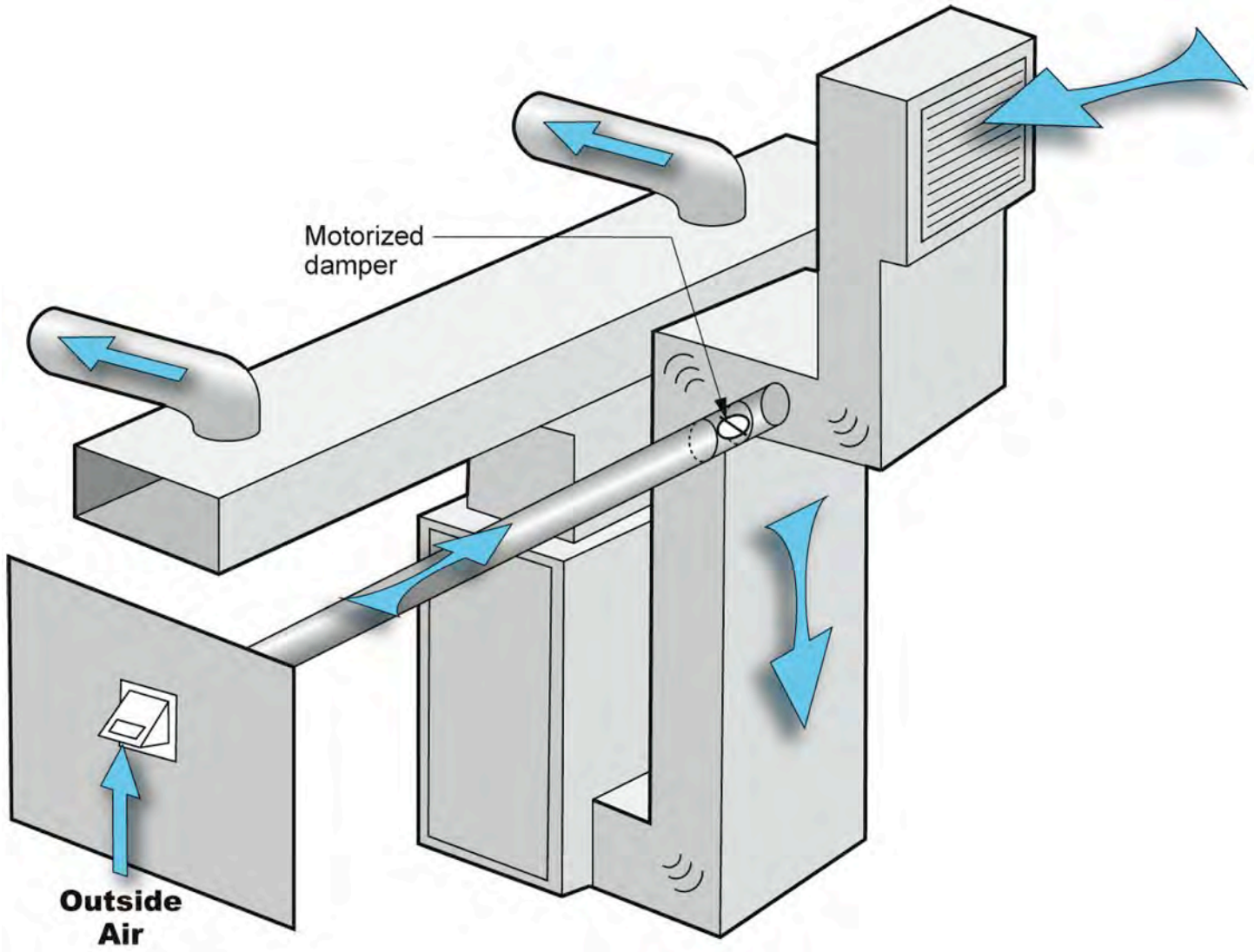

Induced
exfiltration

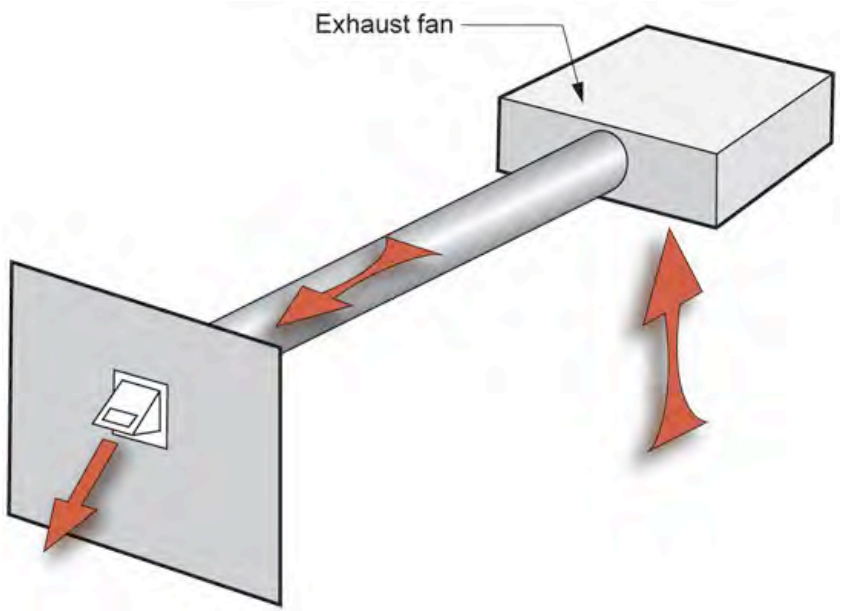


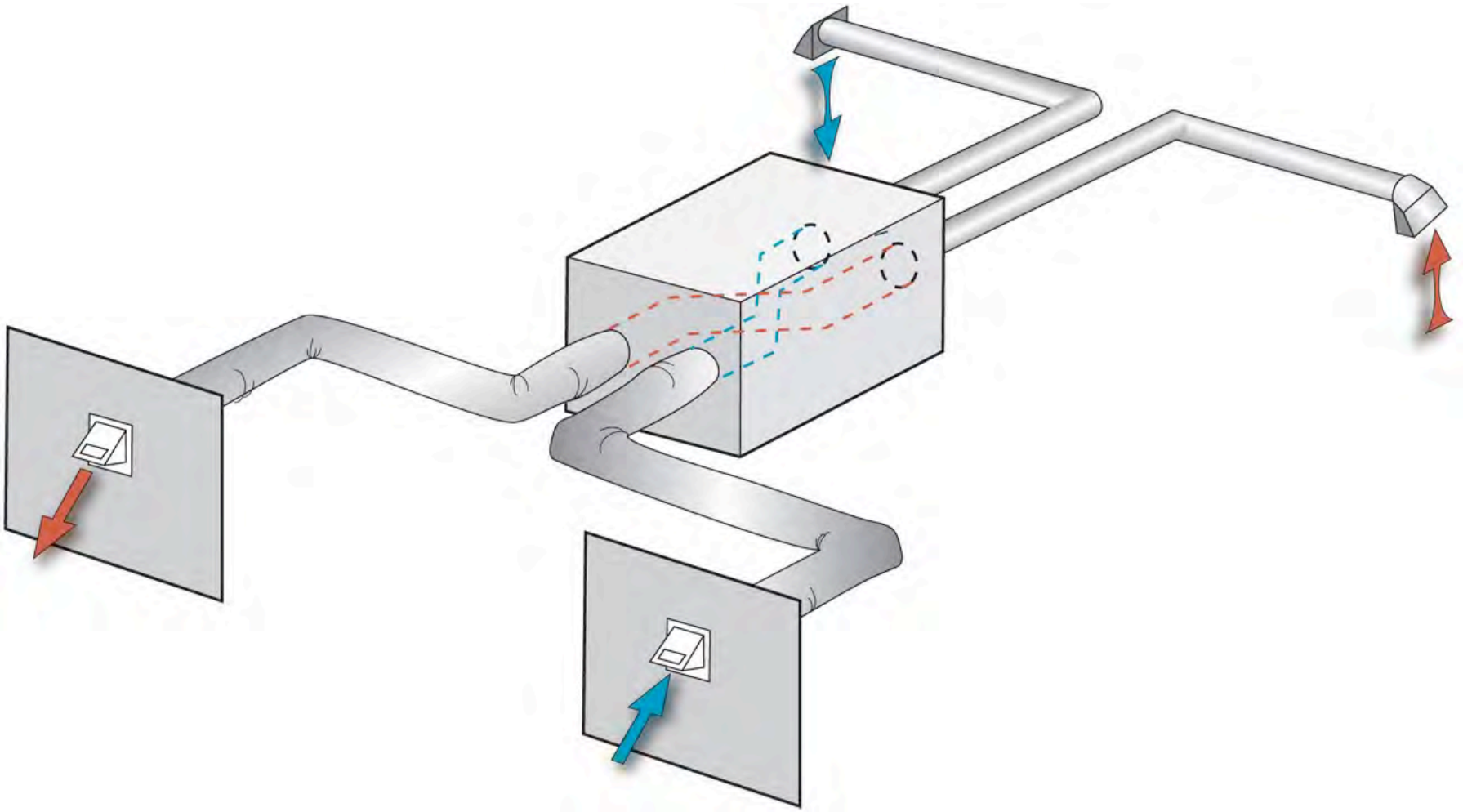

Exhaust fan






Motorized
damper
Outside
Air

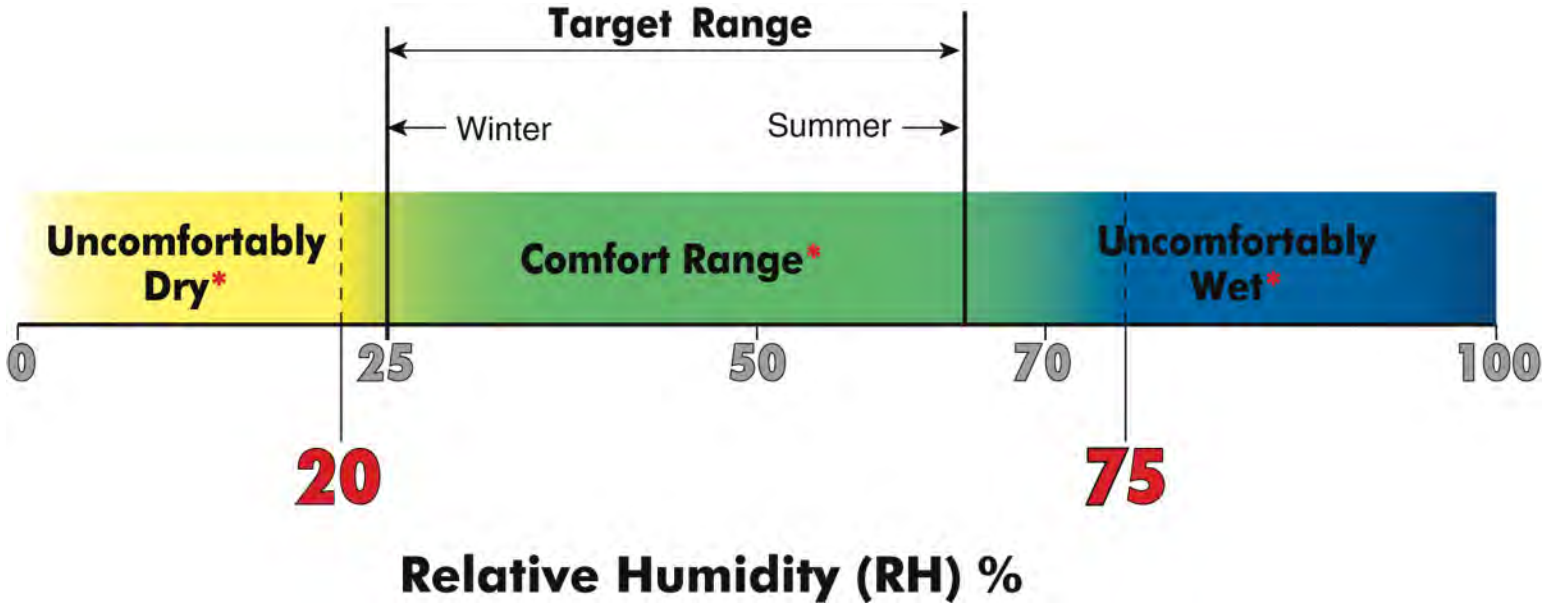

Exhaust fan



- Dilution Is Not The Solution To Indoor Pollution
- Source Control

Dilution For People

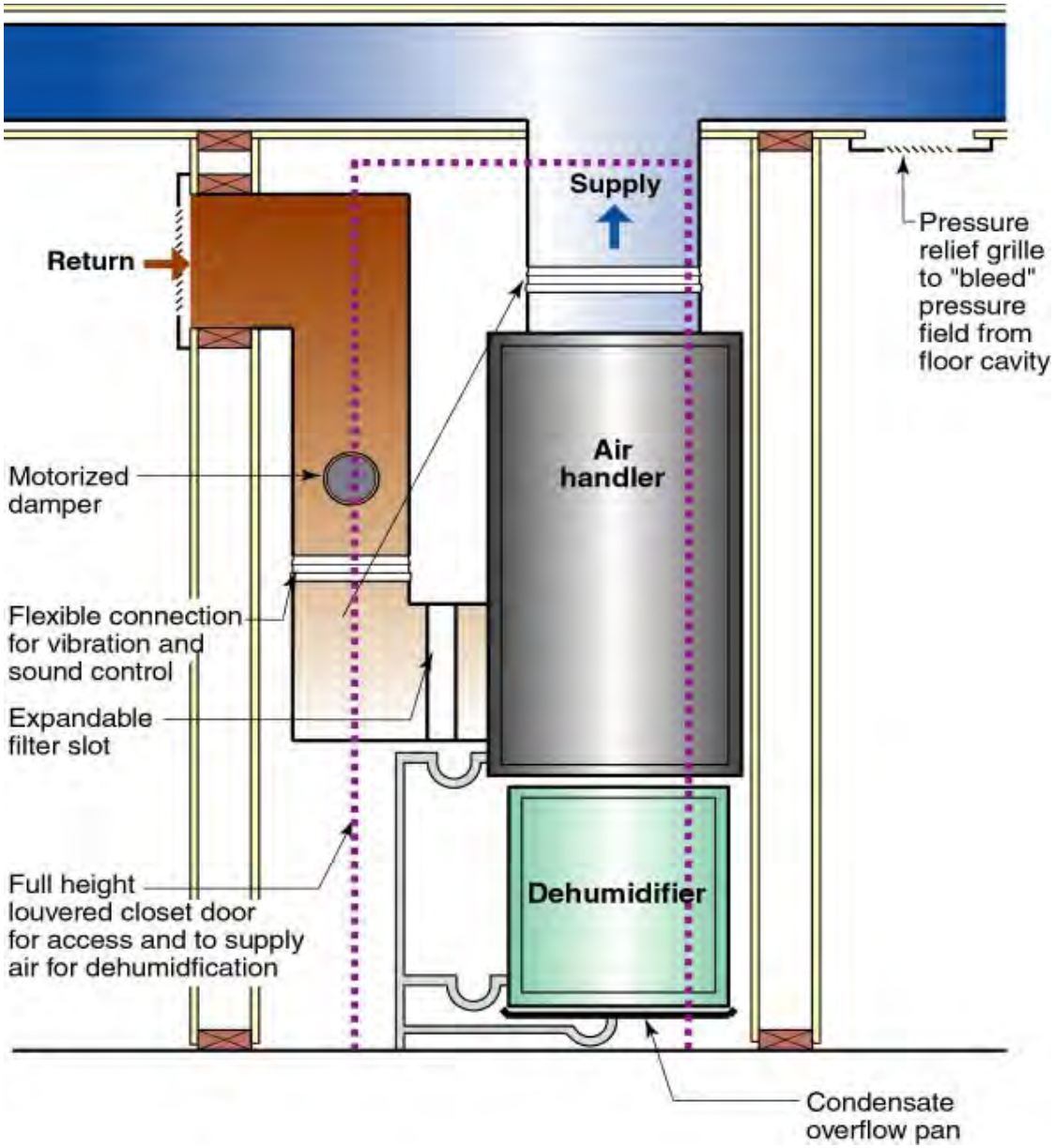
Source Control For The Building


Target Range
Winter
Summer
Uncomfortably Dry*
Comfort Range*
Uncomfortably Wet*
0
25
50
70
100
20
75
Relative Humidity (RH) %

Recommended Range of Relative Humidity

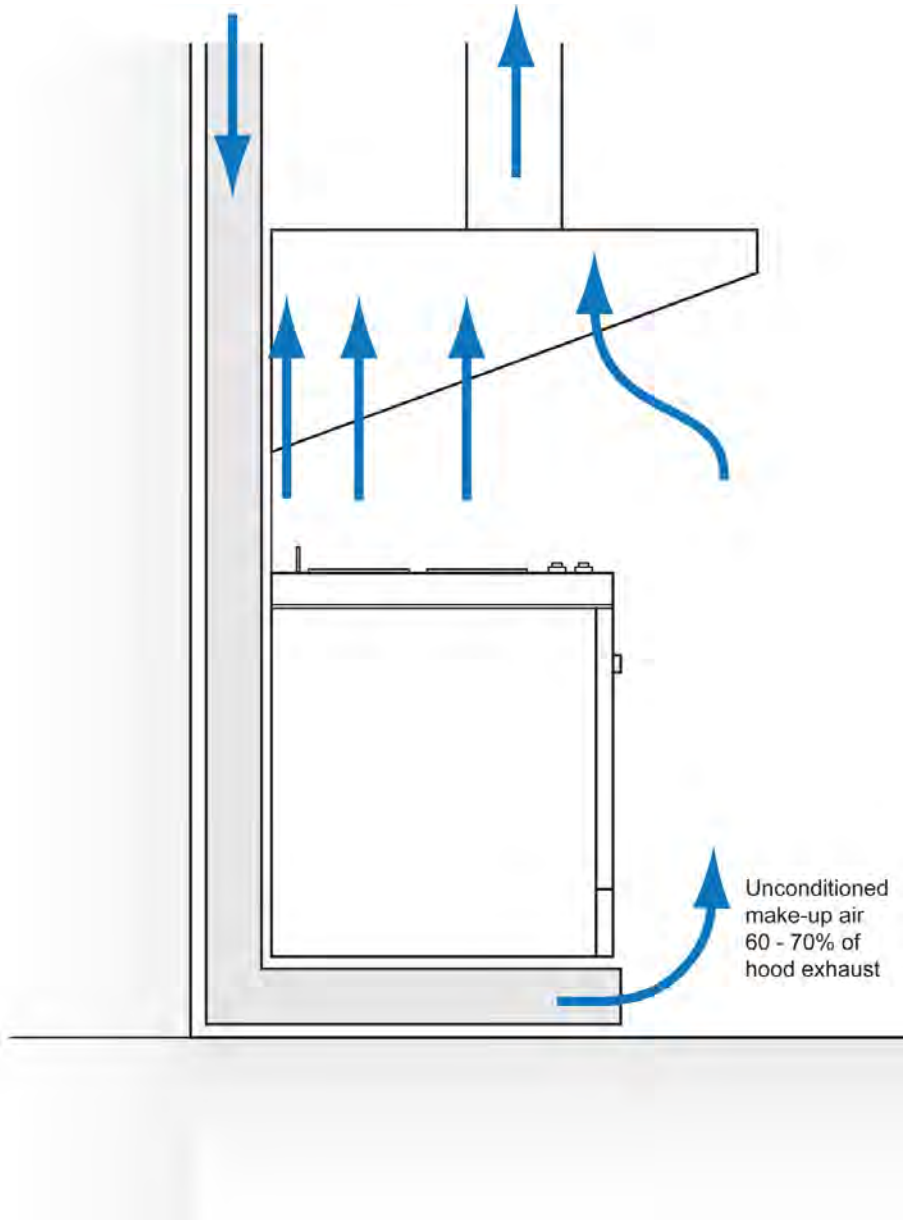
Above 25 percent during winter

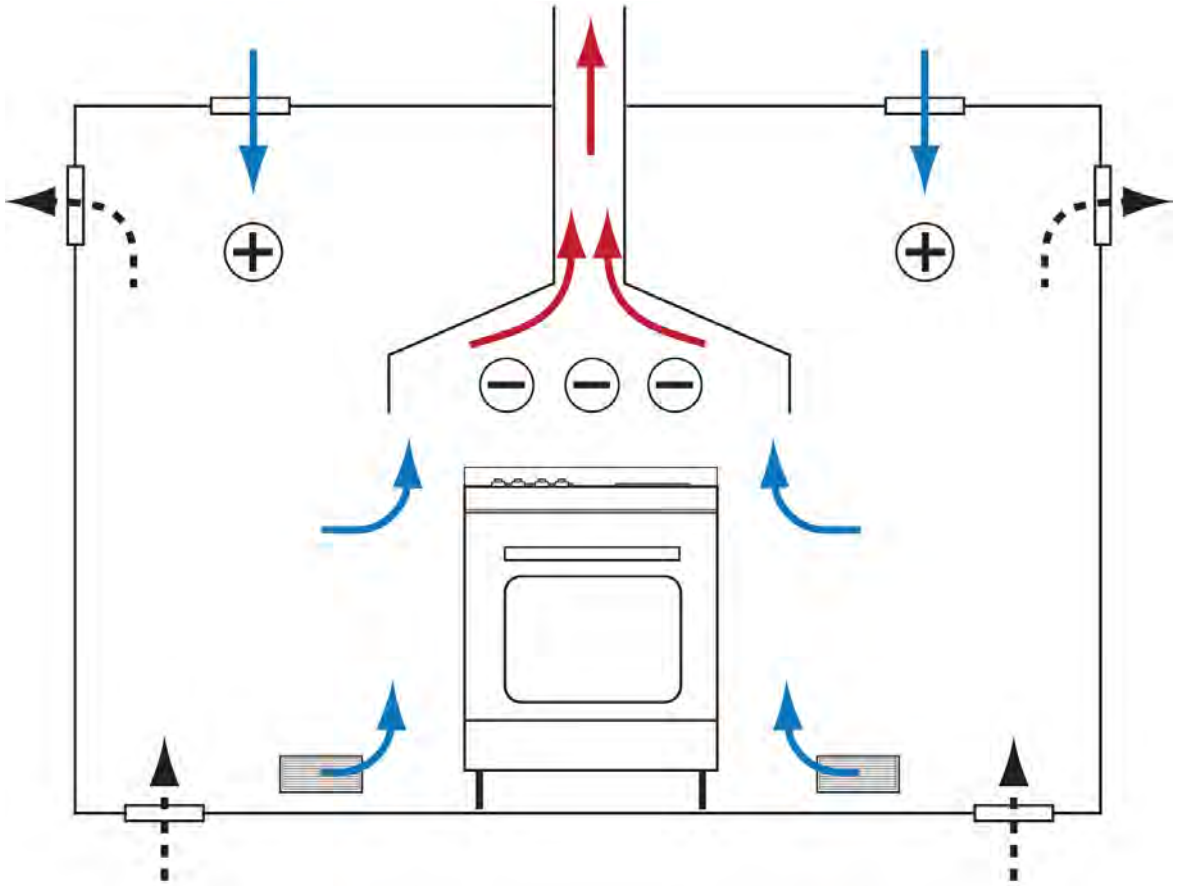
Below 70 percent during summer

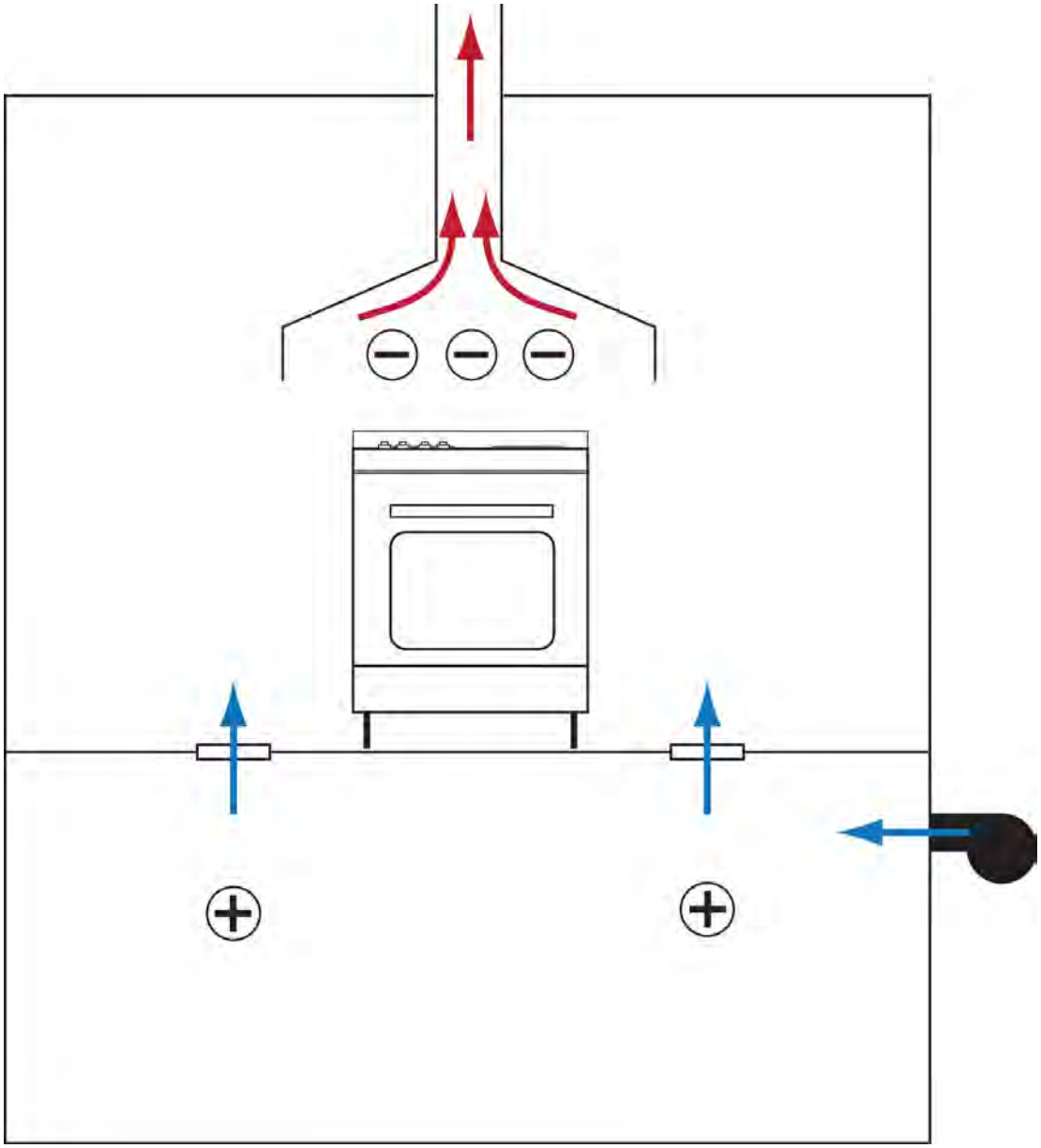

Supply
Return
Pressure relief grille to "bleed" pressure field from floor cavity
Air handler
Motorized damper
Flexible connection for vibration and sound control
Expandable filter slot
Dehumidifier
Full height louvered closet door for access and to supply air for dehumidfication
Condensate overflow pan

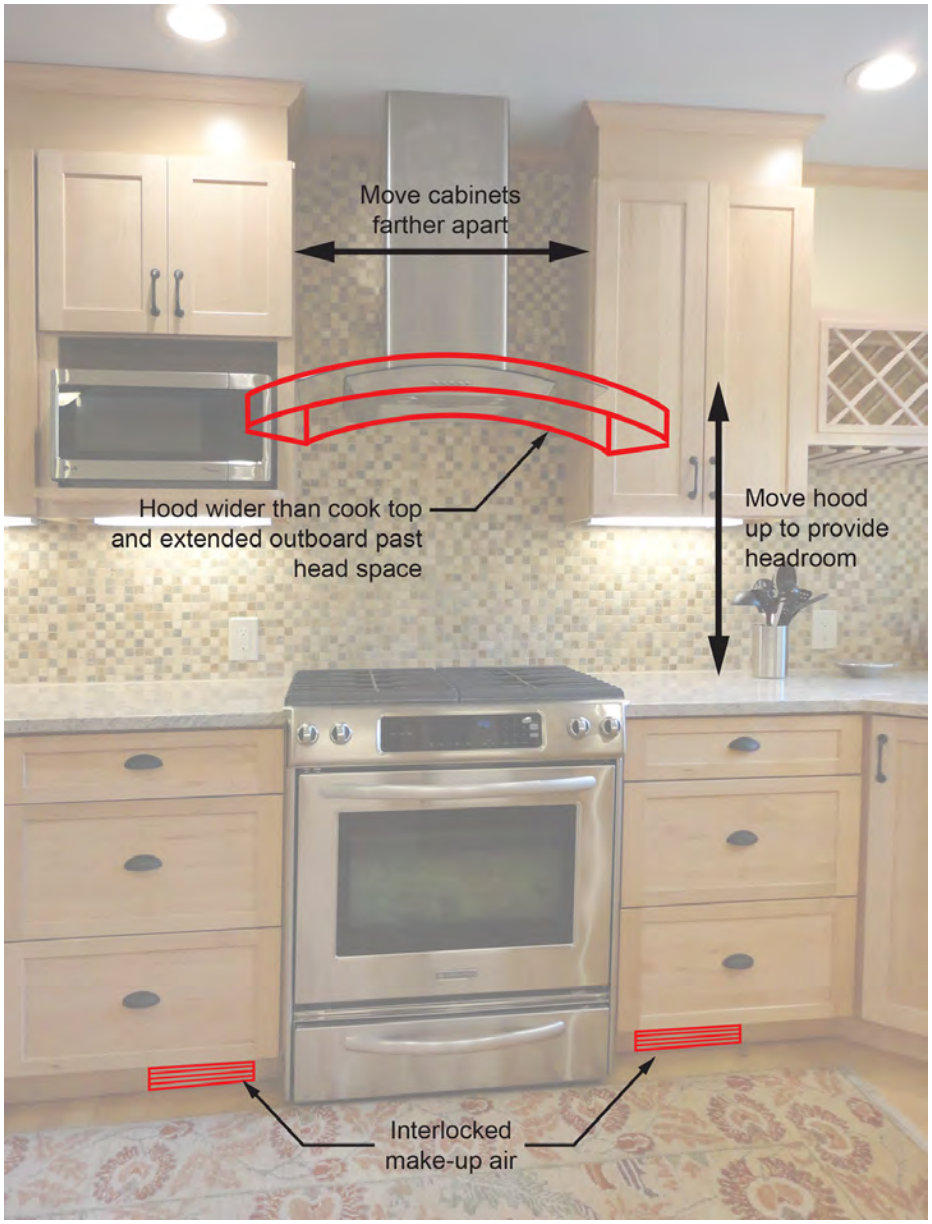

MAXIMUM

Kitchen Exhaust Hoods


Unconditioned
make-up air
60 - 70% of
hood exhaust





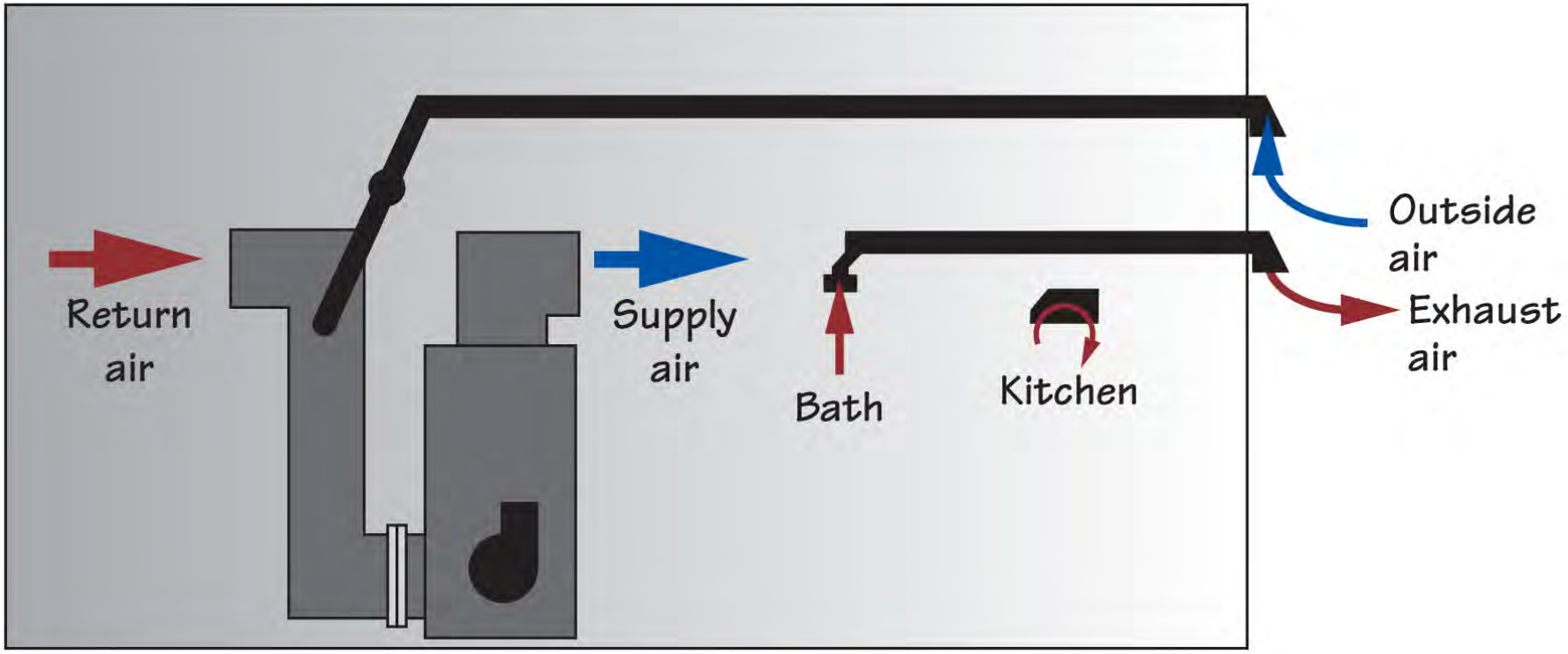

Move cabinets
farther apart
Hood wider than cook top
and extended outboard past
head space
Move hood
up to provide
headroom
Interlocked
make-up air

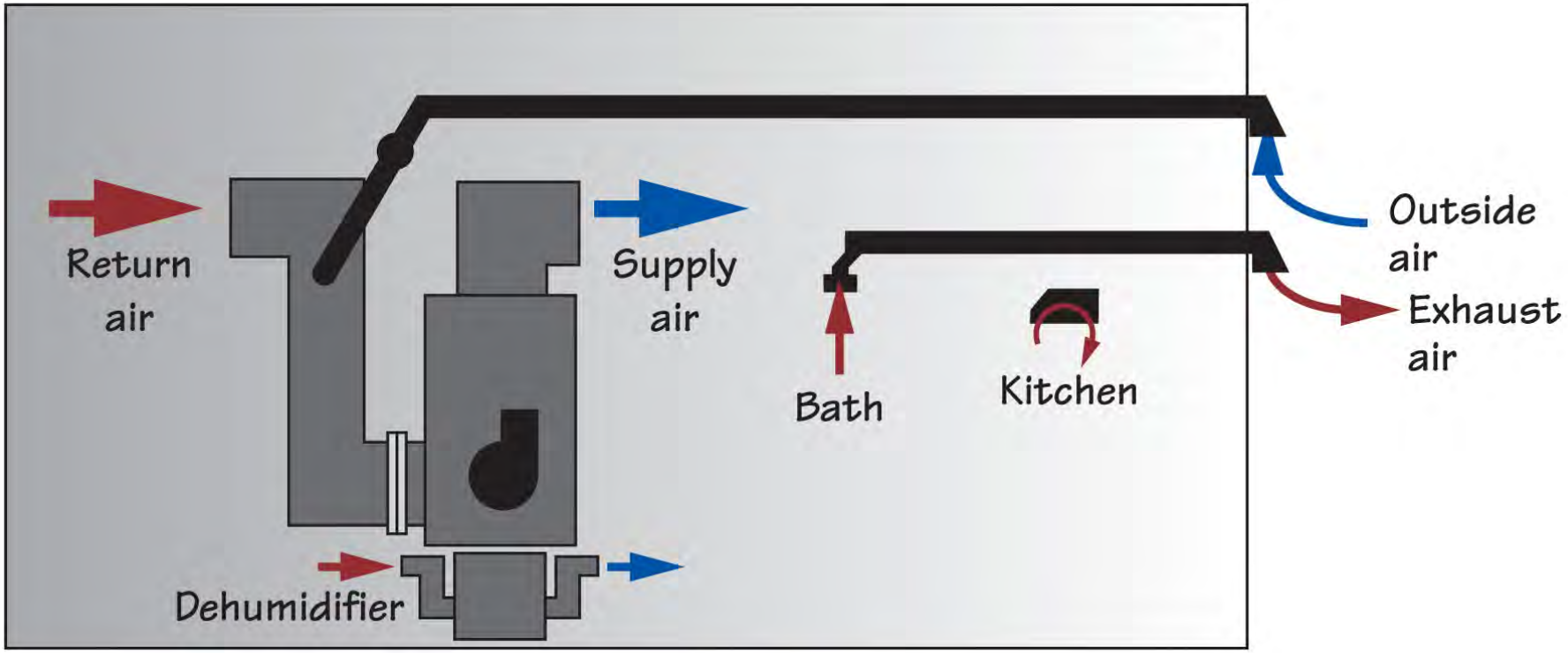
Clothes Dryers

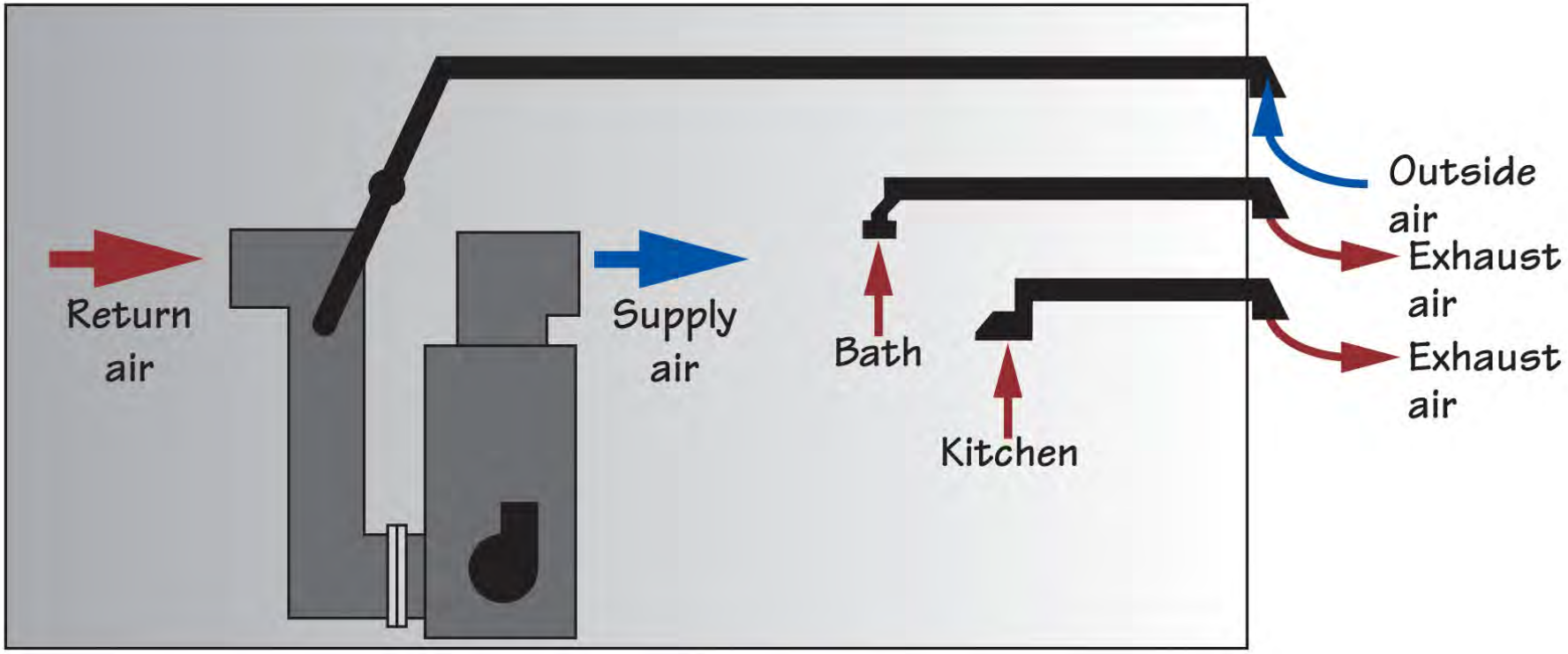

ASKO
ASKO
ENERGUIDE
209

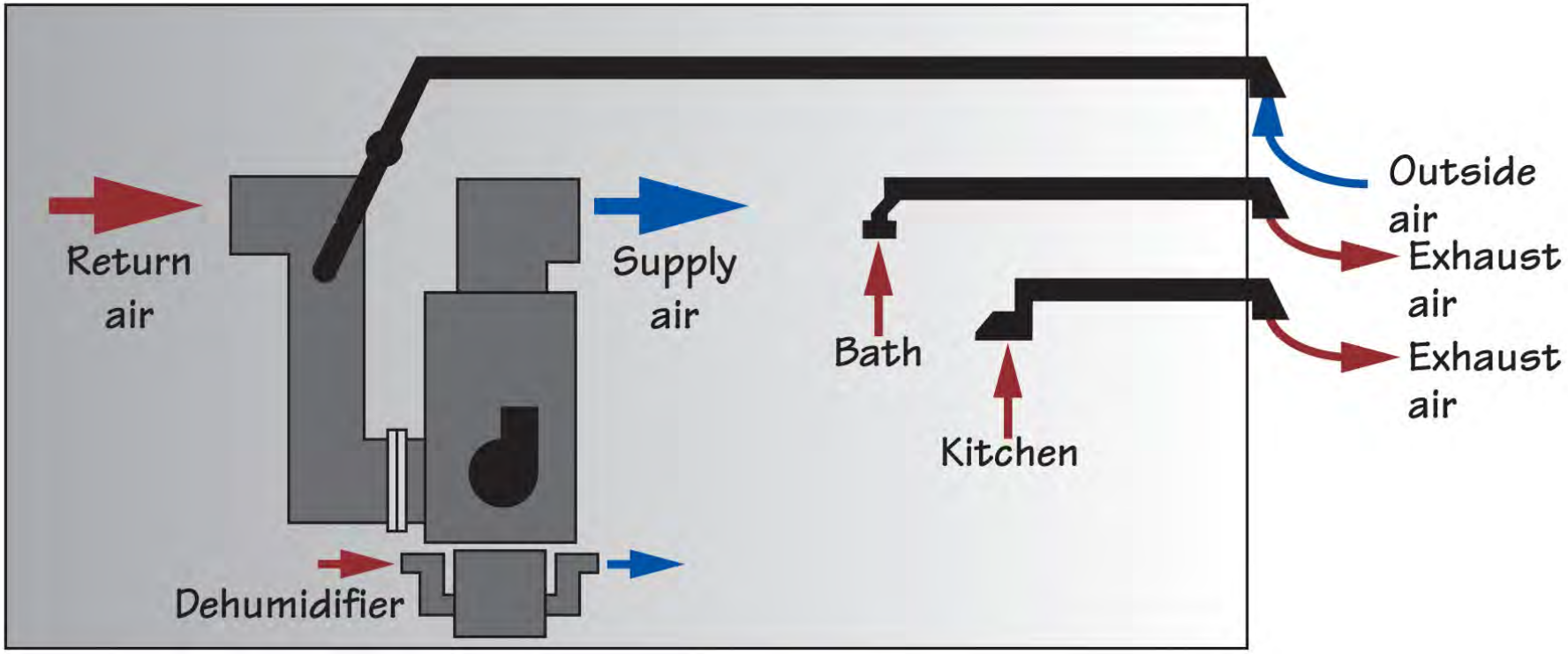
Fireplaces

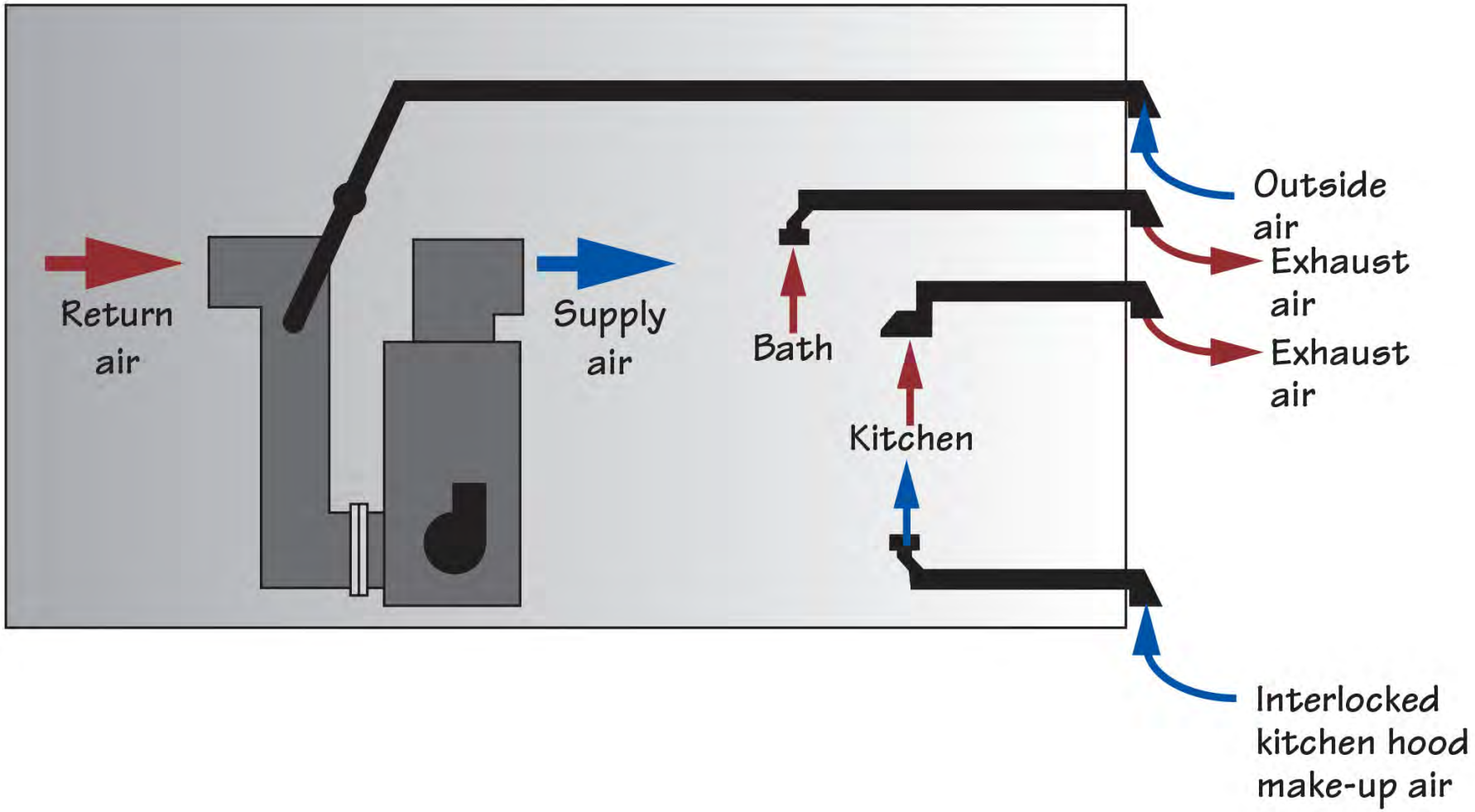
Approaches

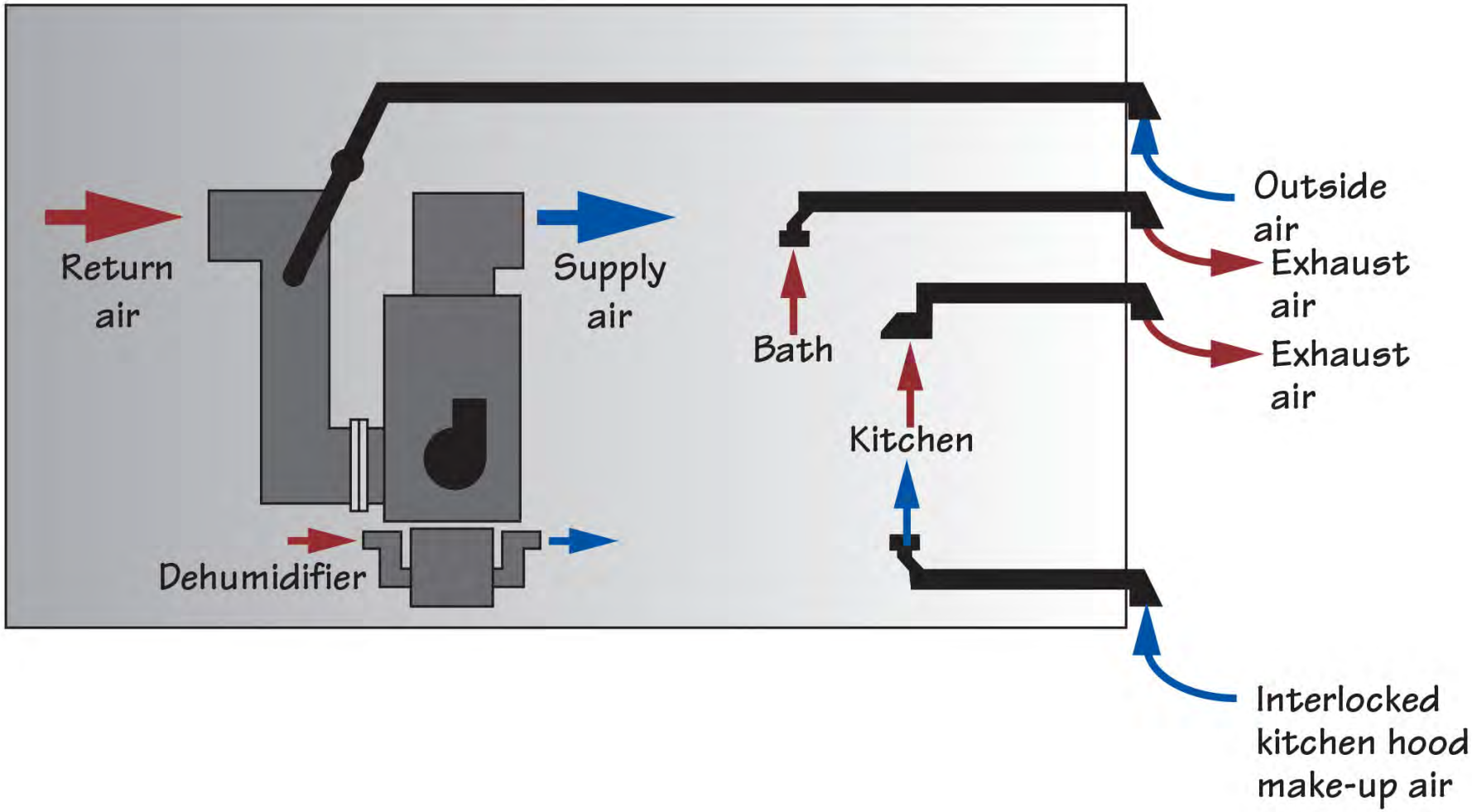

Return
air
Supply
air
Bath
Kitchen
Outside
air
Exhaust
air

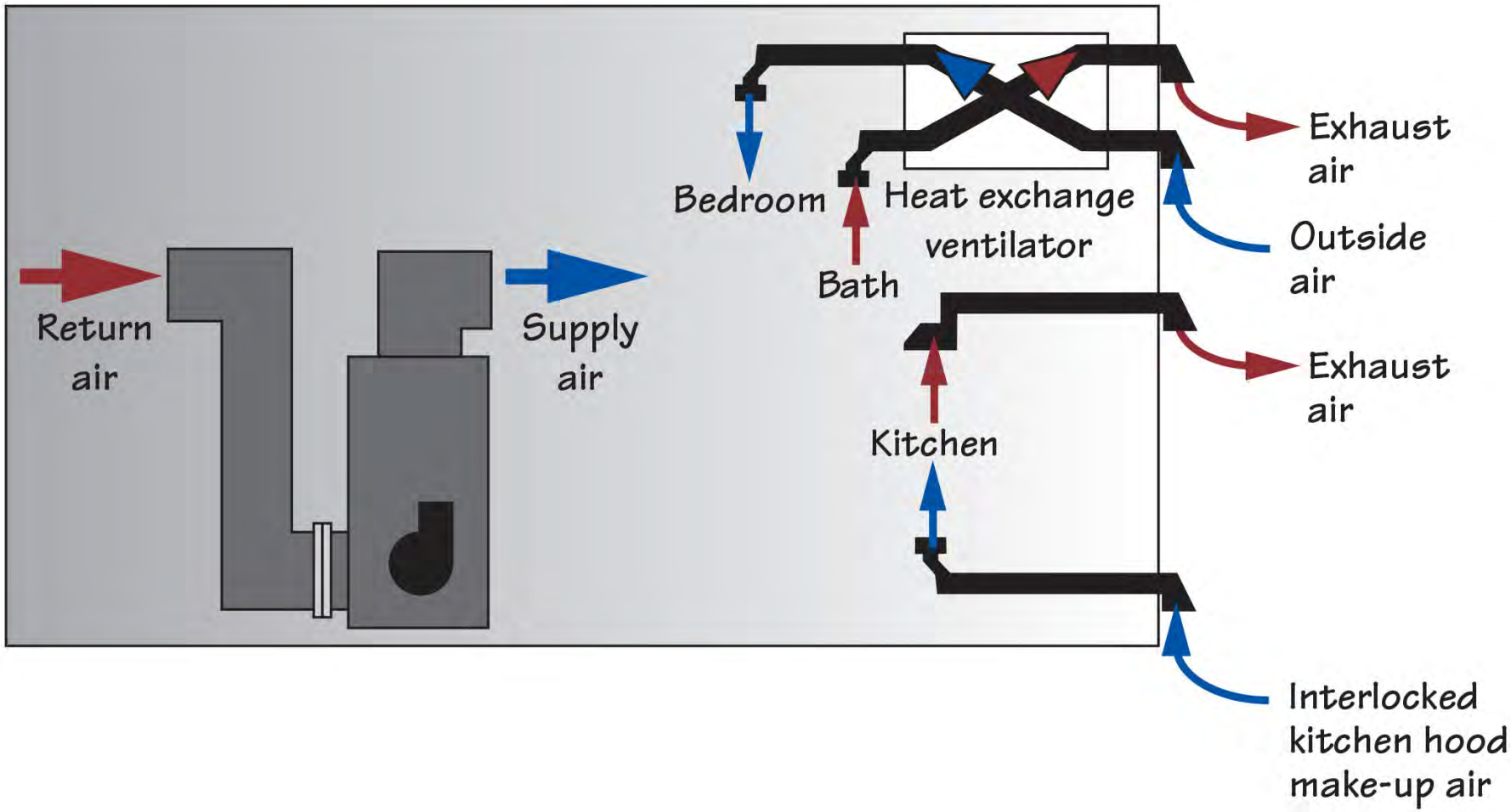

Return air
Supply air
Outside air
Exhaust air
Bath
Kitchen
Dehumidifier

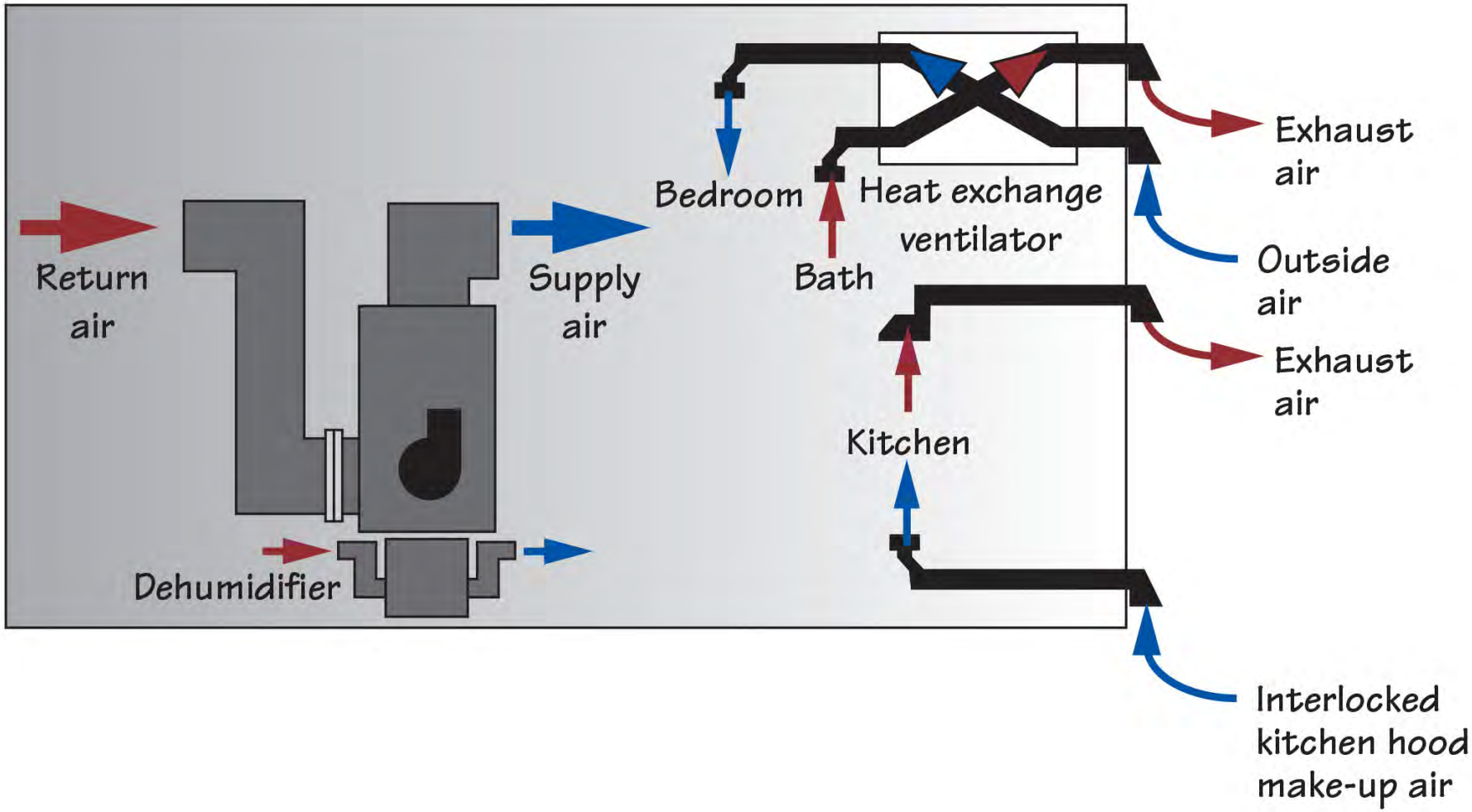

Return air
Supply air
Bath
Kitchen
Outside air
Exhaust air
Exhaust air

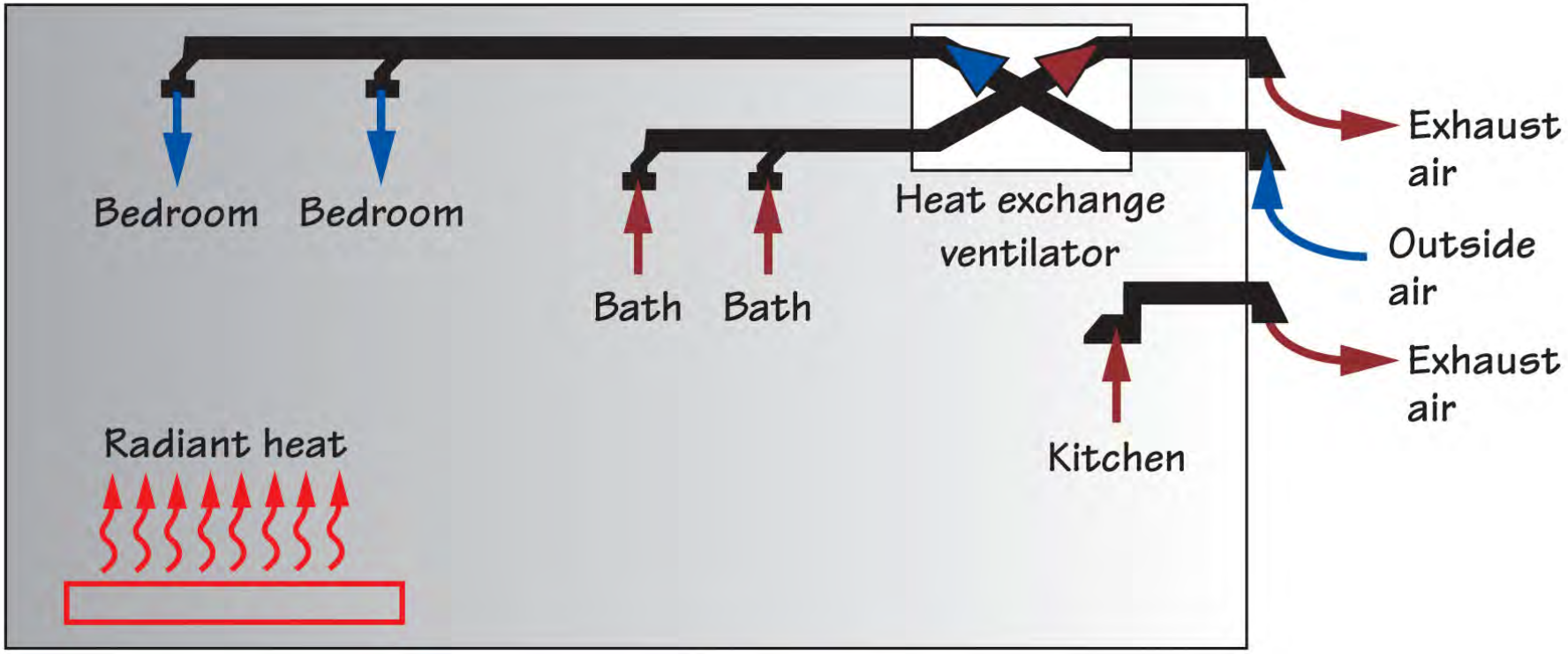

Return air
Supply air
Outside air
Exhaust air
Exhaust air
Bath
Kitchen
Dehumidifier

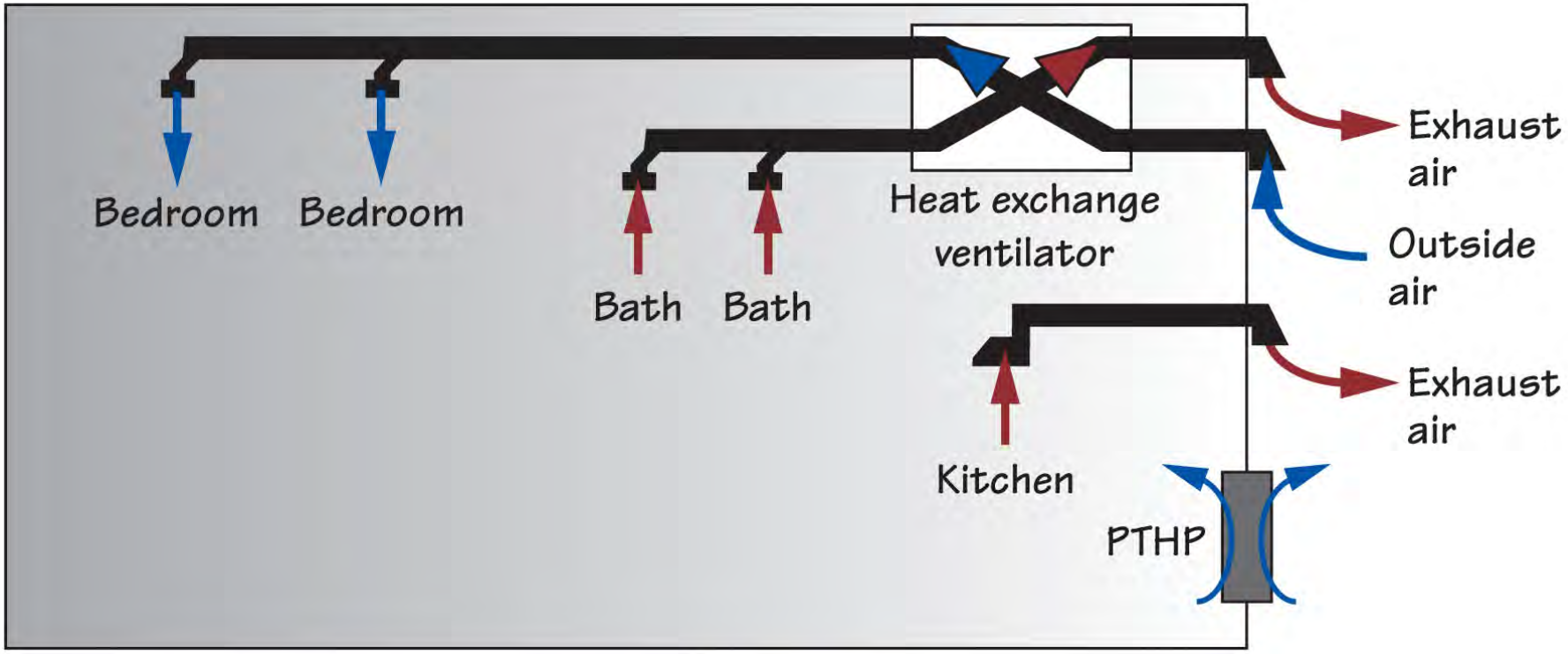

Return air
Supply air
Bath
Kitchen
Outside air
Exhaust air
Exhaust air
Interlocked kitchen hood make-up air

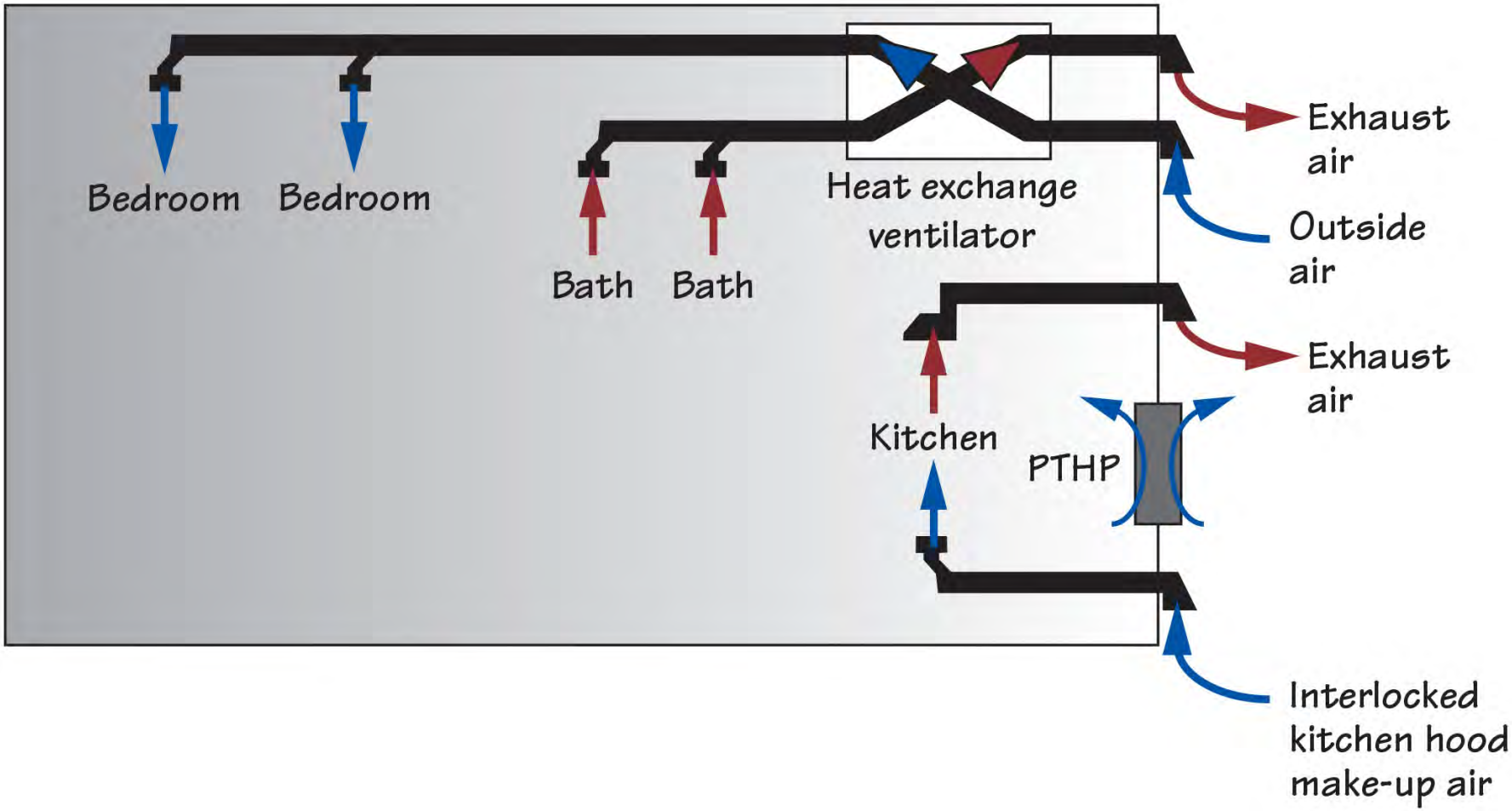

Return air
Supply air
Bath
Kitchen
Dehumidifier
Outside air
Exhaust air
Exhaust air
Interlocked kitchen hood make-up air

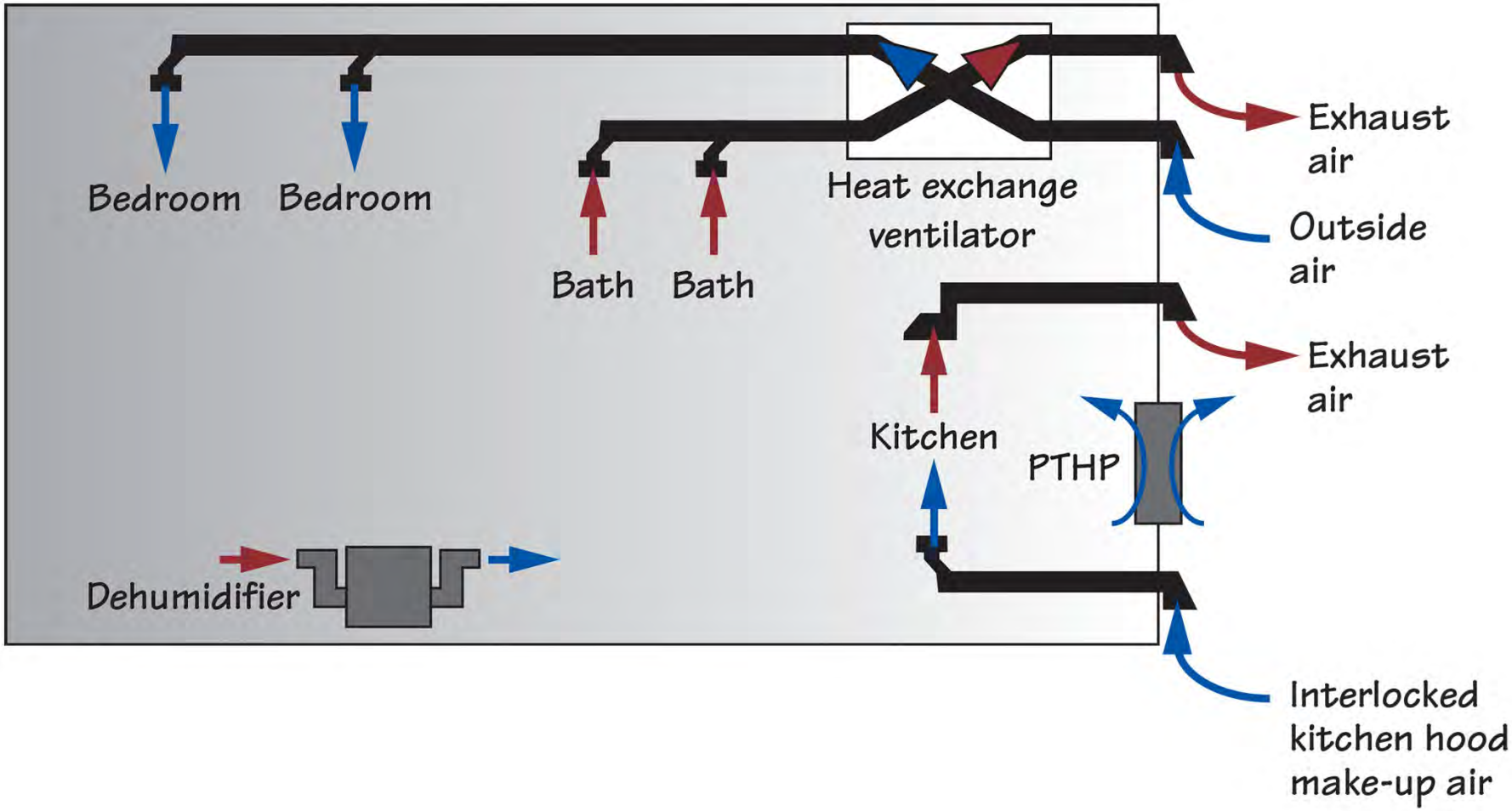

Return air
Supply air
Bedroom
Bath
Heat exchange ventilator
Exhaust air
Outside air
Exhaust air
Kitchen
Interlocked kitchen hood make-up air

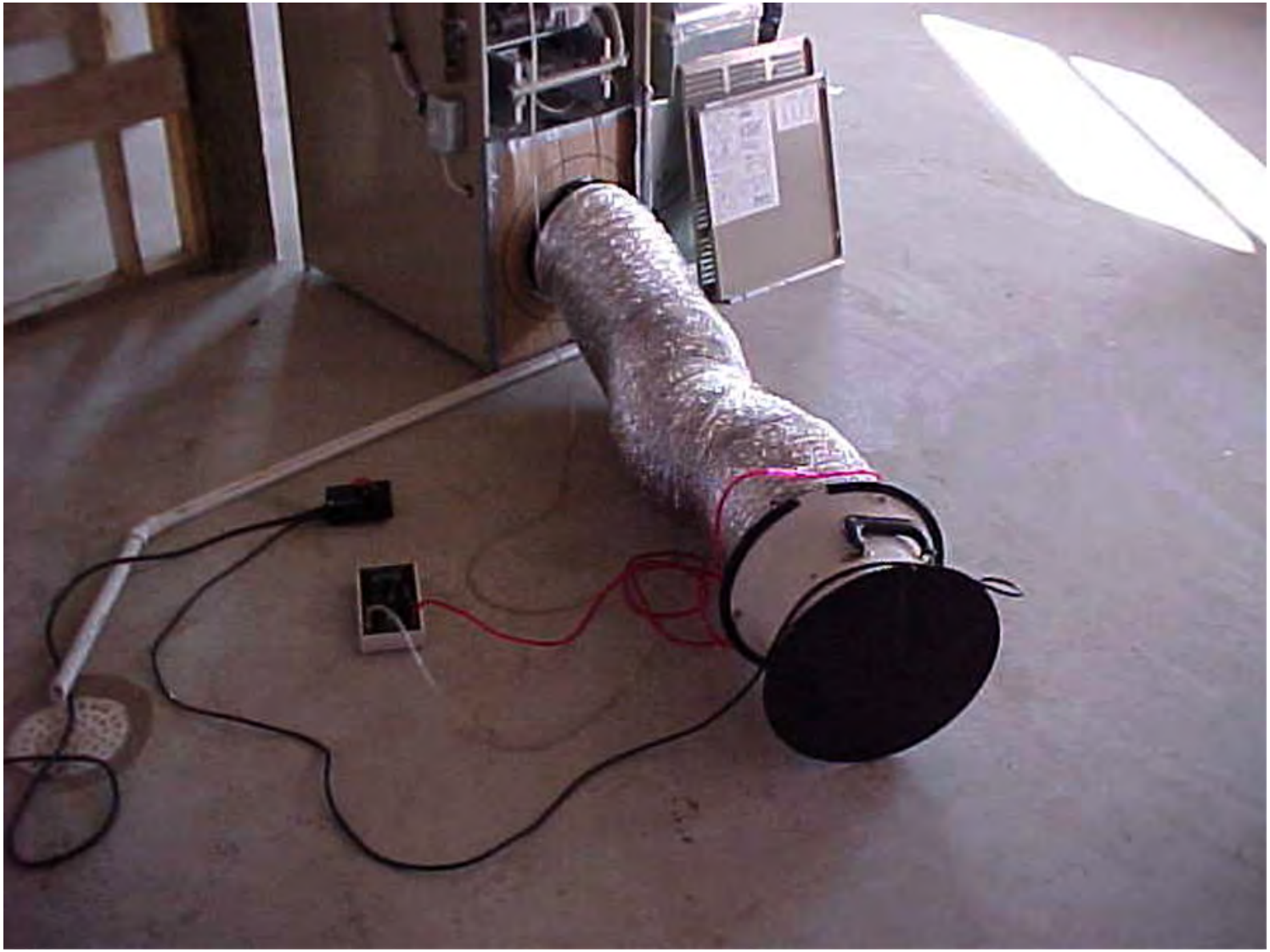

Return air
Supply air
Dehumidifier
Bedroom
Bath
Heat exchange ventilator
Exhaust air
Outside air
Exhaust air
Kitchen
Interlocked kitchen hood make-up air


Bedroom
Bedroom
Bath
Bath
Heat exchange
ventilator
Exhaust
air
Outside
air
Exhaust
air
Kitchen
Radiant heat

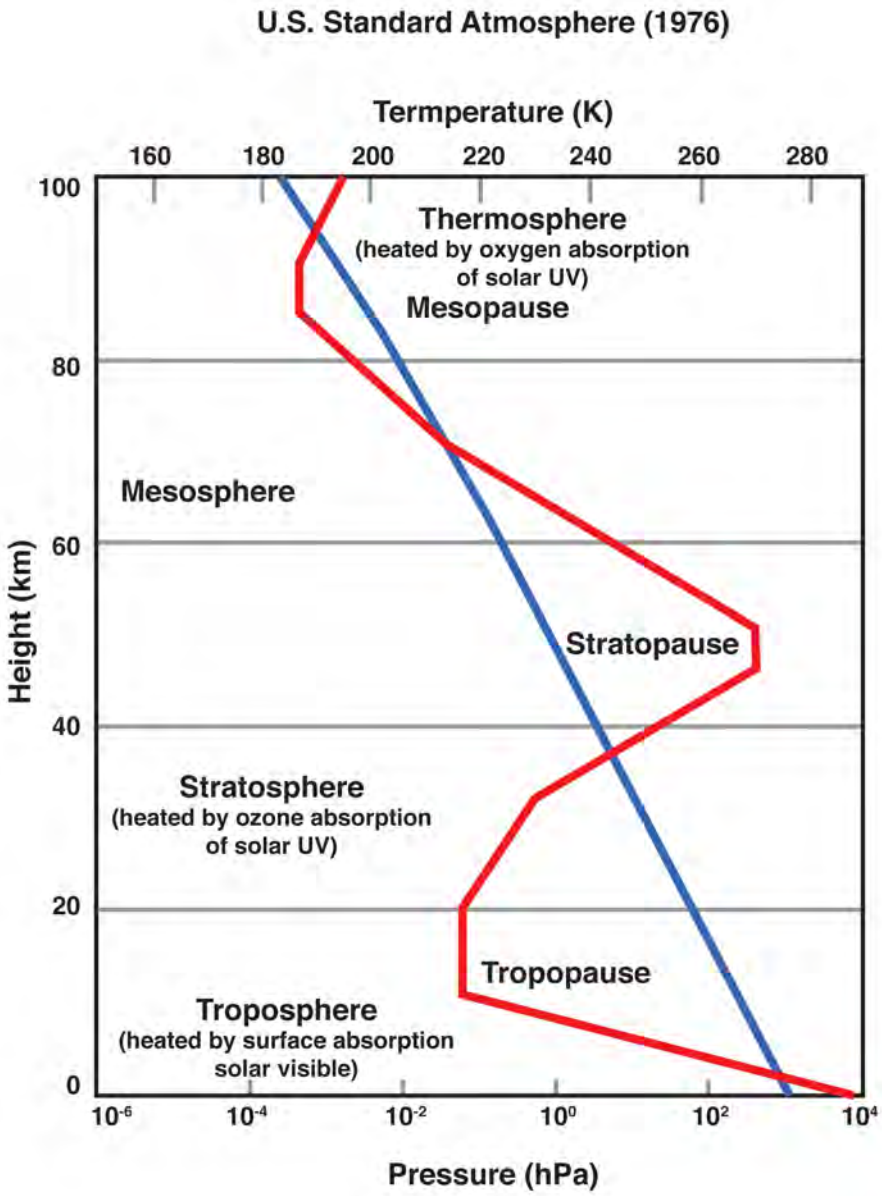

Bedroom
Bedroom
Bath
Bath
Heat exchange ventilator
Exhaust air
Outside air
Exhaust air
Kitchen
PTHP


Bedroom
Bedroom
Bath
Bath
Heat exchange ventilator
Exhaust air
Outside air
Exhaust air
Kitchen
PTHP
Interlocked kitchen hood make-up air


Bedroom
Bedroom
Bath
Bath
Heat exchange ventilator
Exhaust air
Outside air
Exhaust air
Kitchen
PTHP
Dehumidifier
Interlocked kitchen hood make-up air



Lapse Rate


U.S. Standard Atmosphere (1976)
Termperature (K)
160
180
200
220
240
260
280
100
80
60
40
20
0
Height (km)
Thermosphere
(heated by oxygen absorption
of solar UV)
Mesopause
Mesosphere
Stratopause
Stratosphere
(heated by ozone absorption
of solar UV)
Tropopause
Troposphere
(heated by surface absorption
solar visible)
10^{-6}
10^{-4}
10^{-2}
10^{0}
10^{2}
10^{4}
Pressure (hPa)

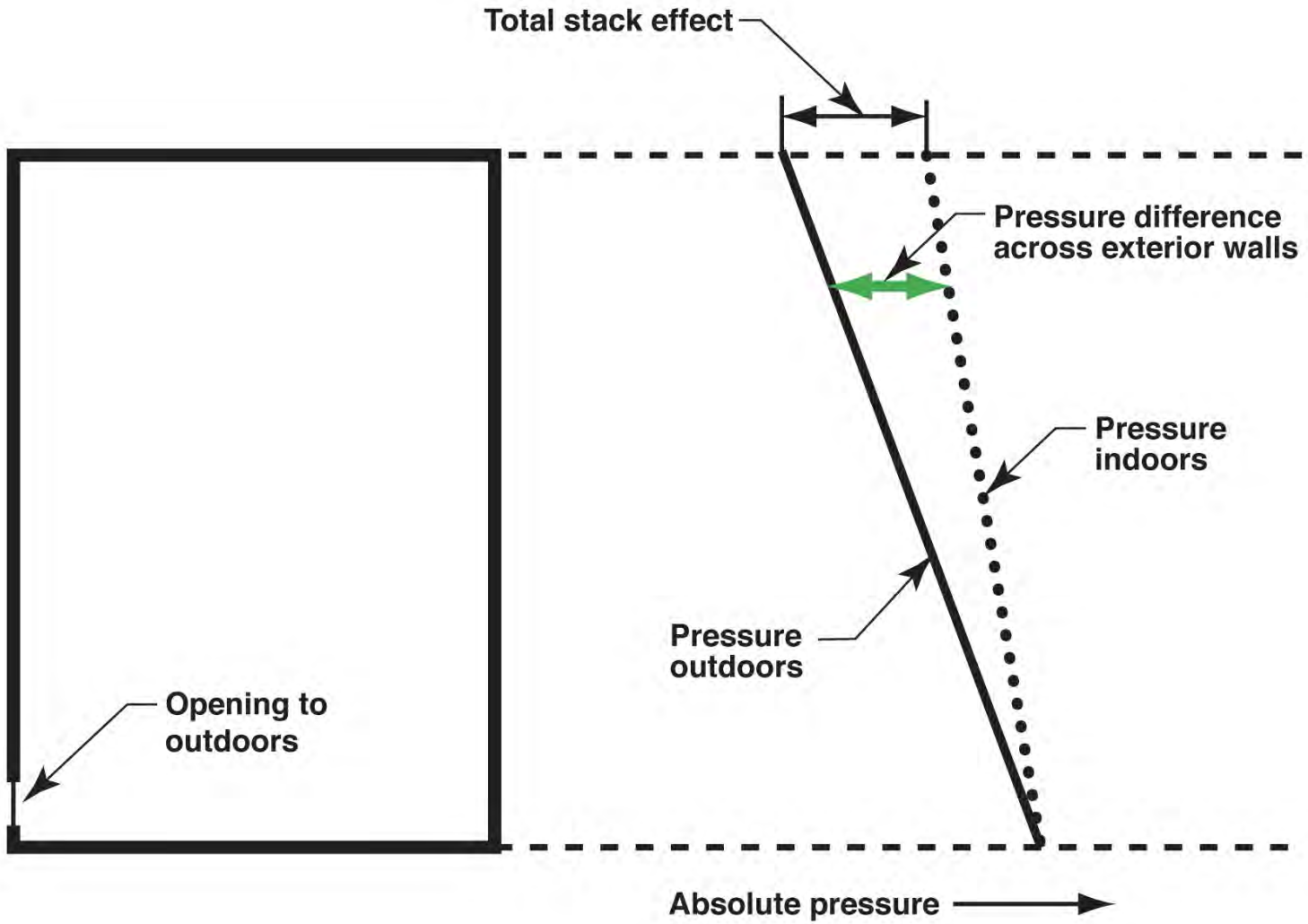


Figure 11.1: Building with no internal separations with opening at the bottom (Adapted from G.O. Handegord, 1998)

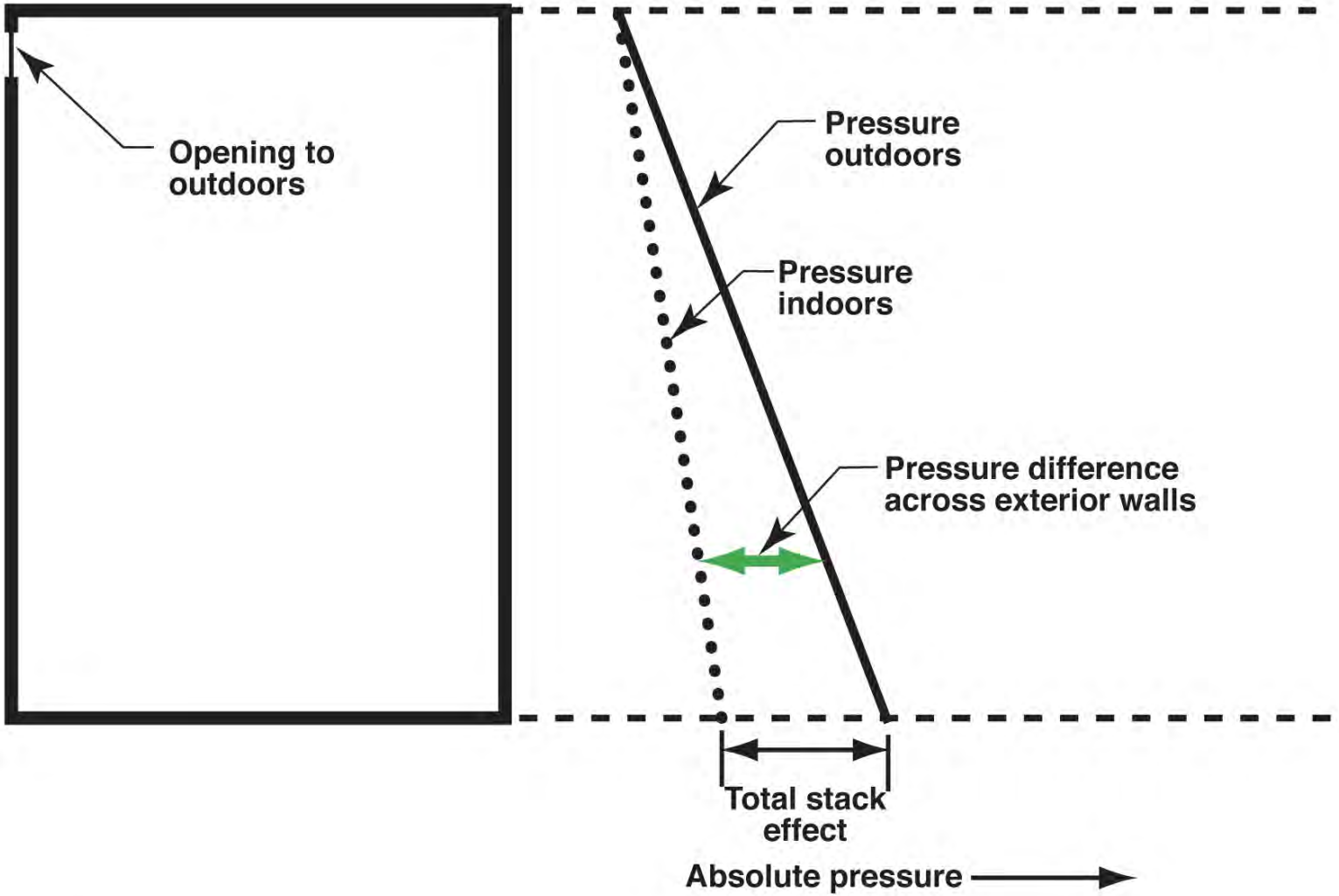


Figure 11.2: Building with no internal separations with opening at the top (Adapted from G.O. Handegord, 1998)

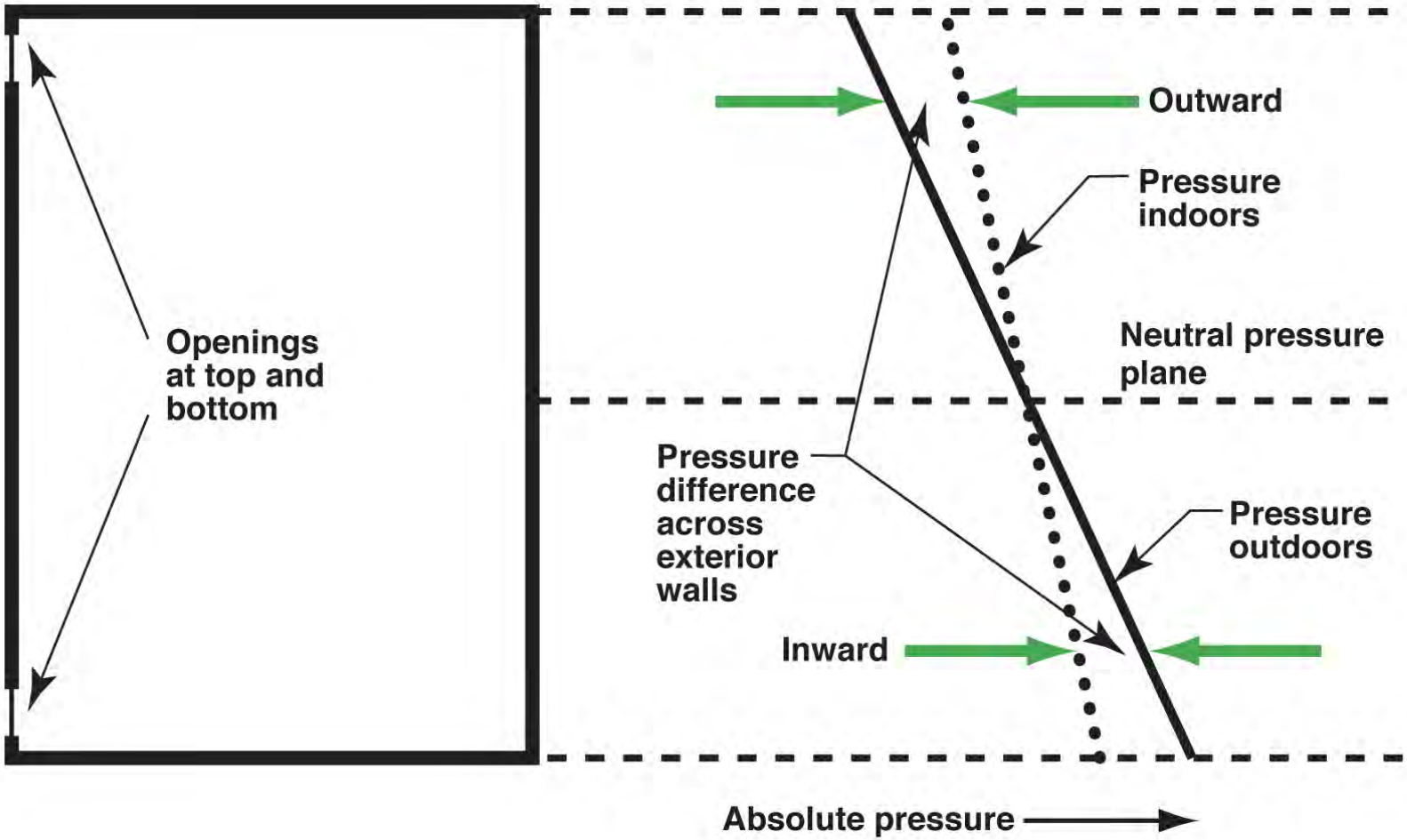


Figure 11.3: Building with no internal separations with openings at top and bottom (Adapted from G.O. Handegord, 1998)

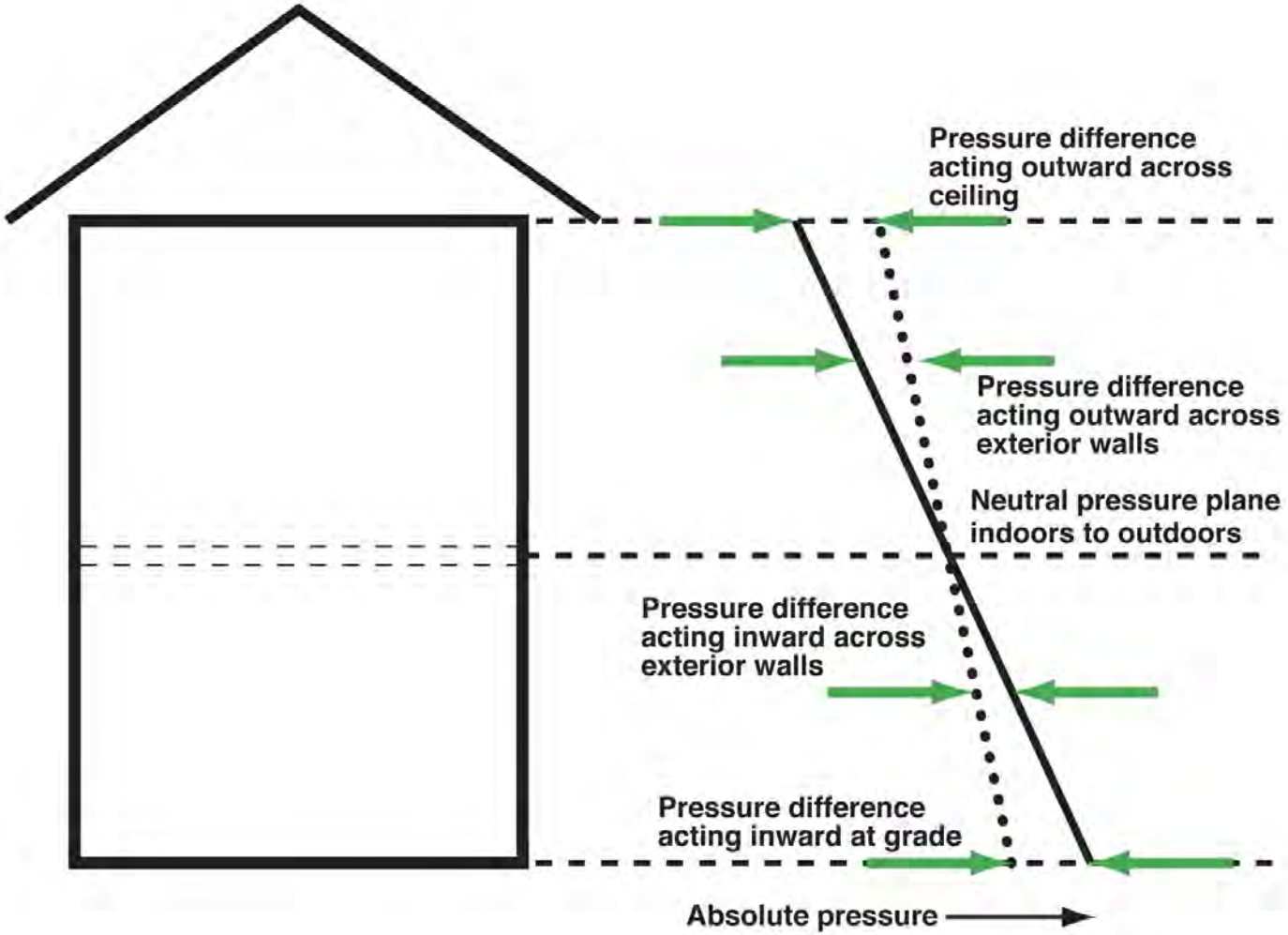


Figure 11.4: Basic two storey house with vented attic (Adapted from G.O. Handegord, 1998)


POMPIERS NO. 3

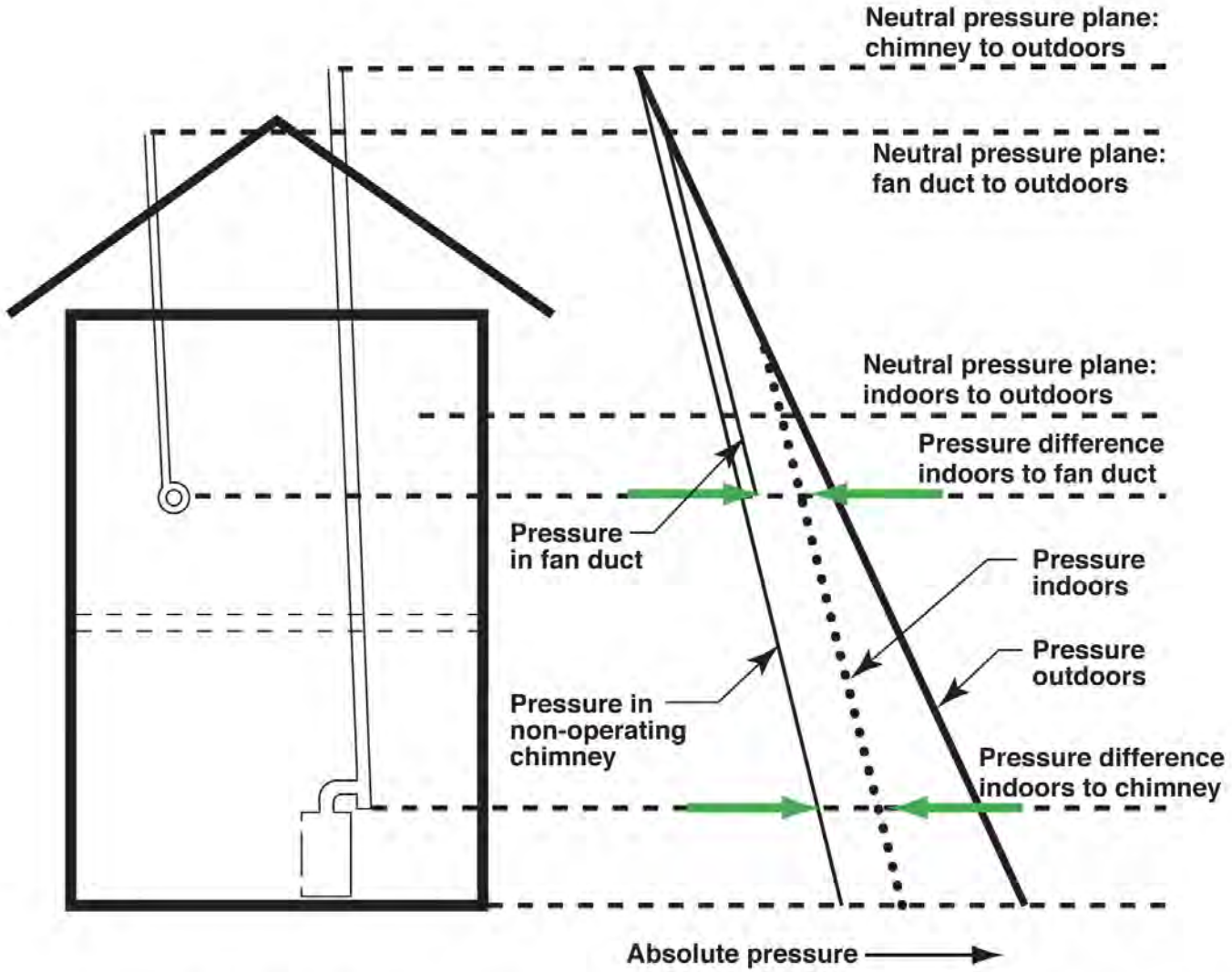


Figure 11.5: Two storey house with non-operating chimney and exhaust fan (Adapted from G.O. Handegord, 1998)

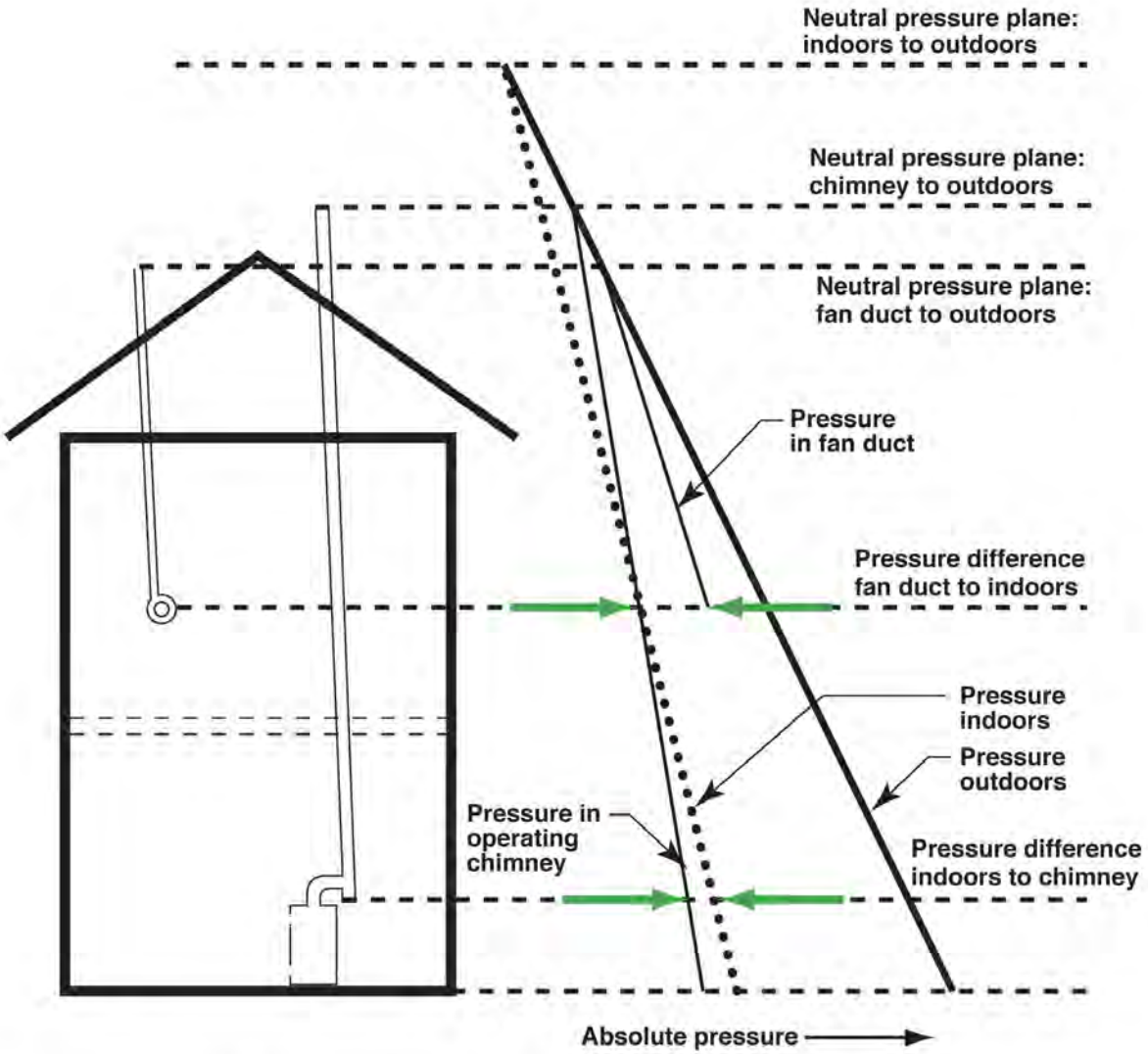
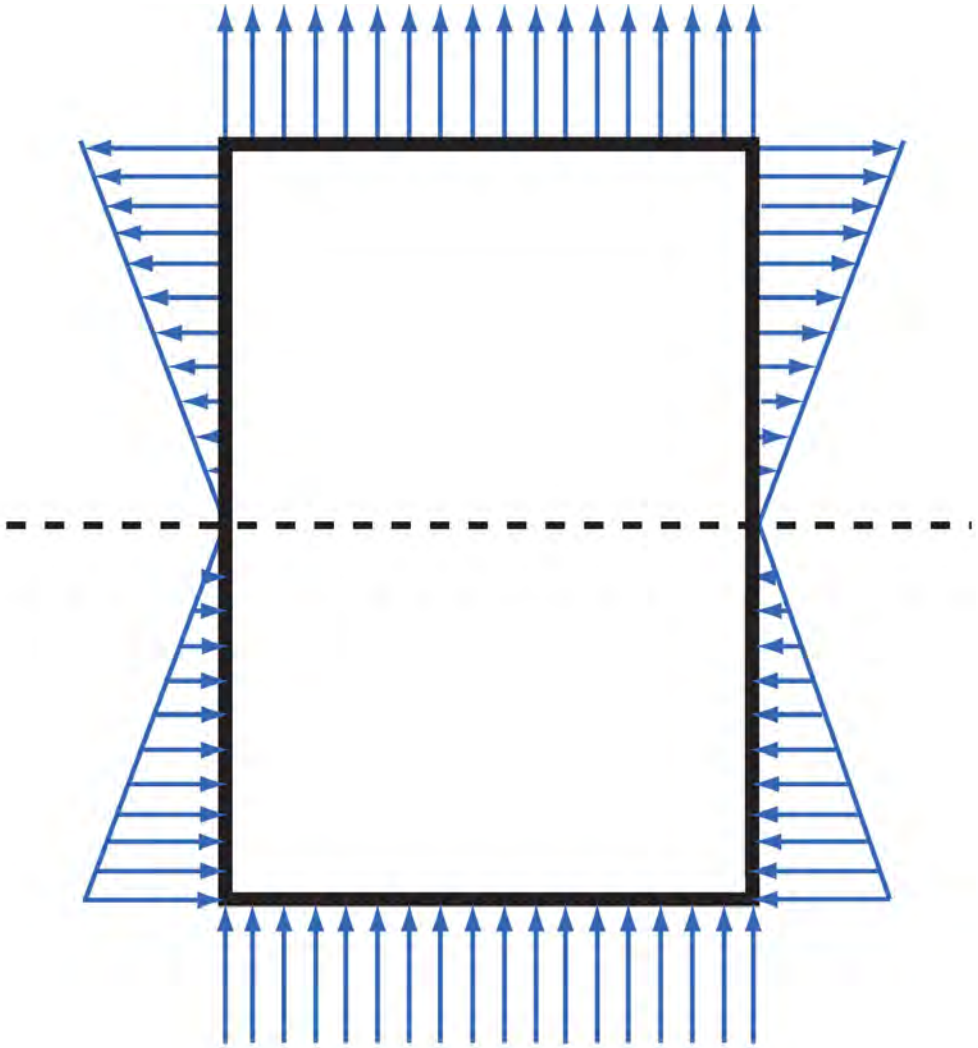
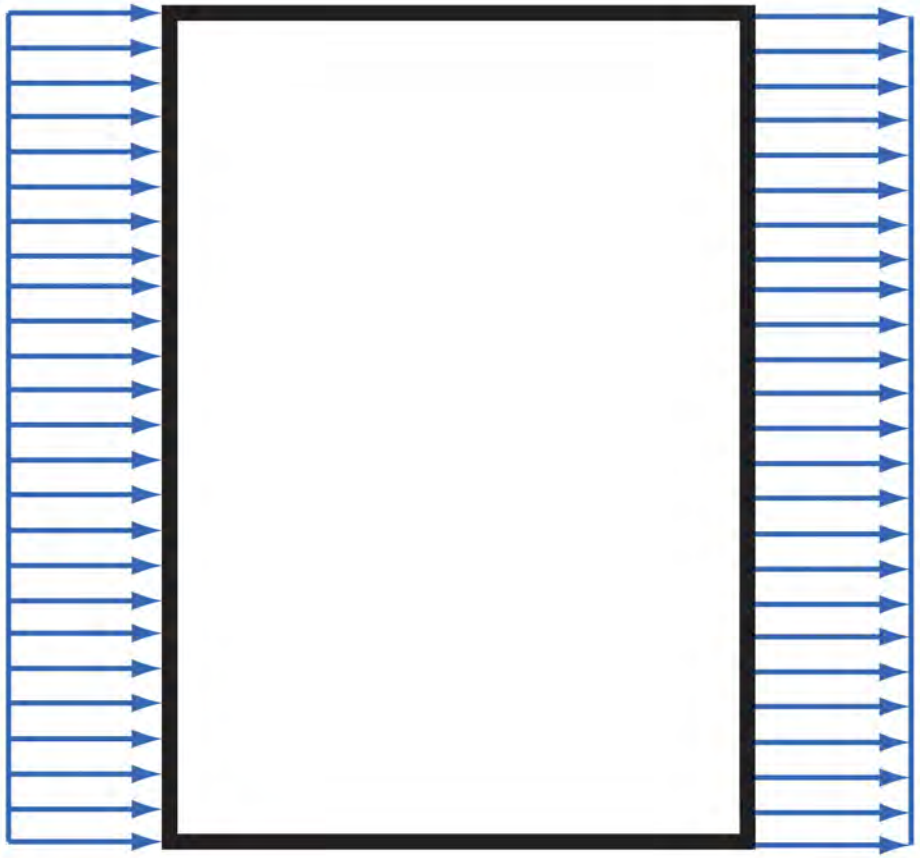


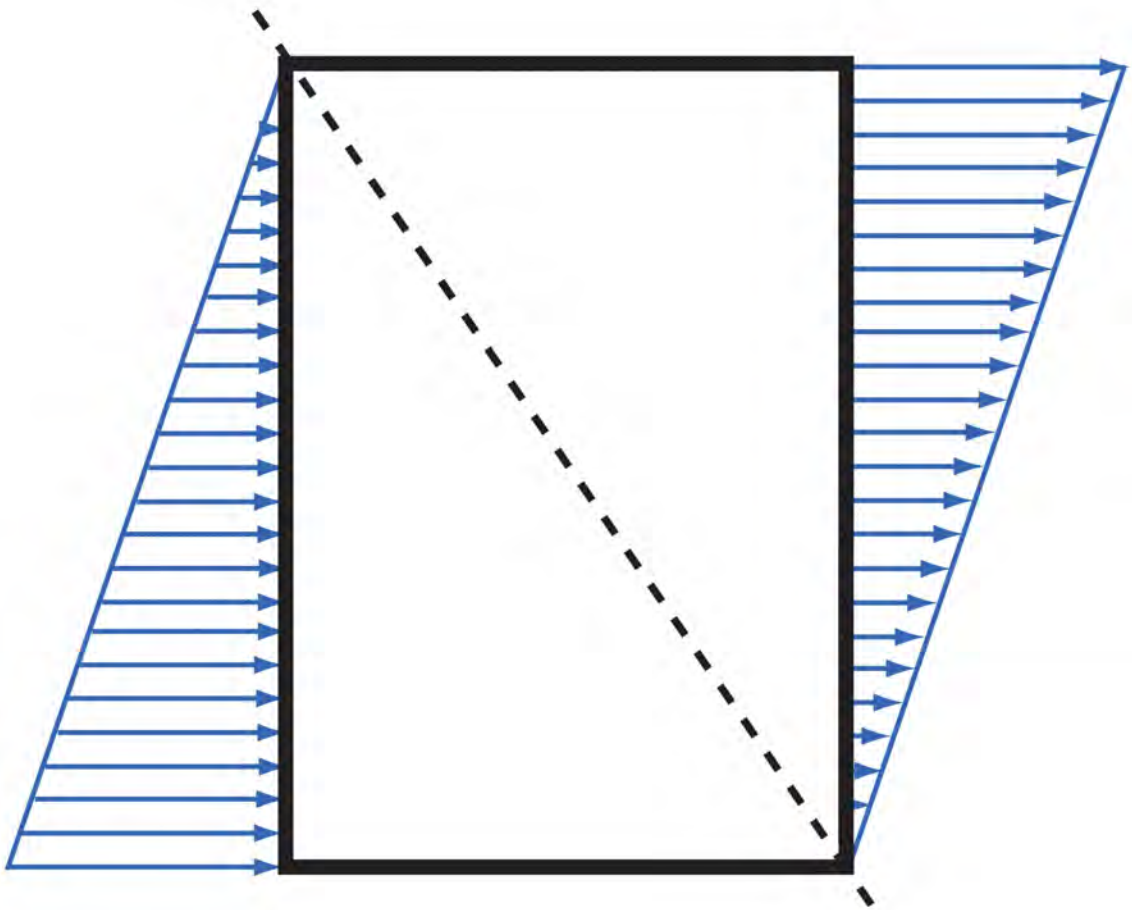
Figure 11.6: Two storey house with operating chimney
(Adapted from G.O. Handegord, 1998)



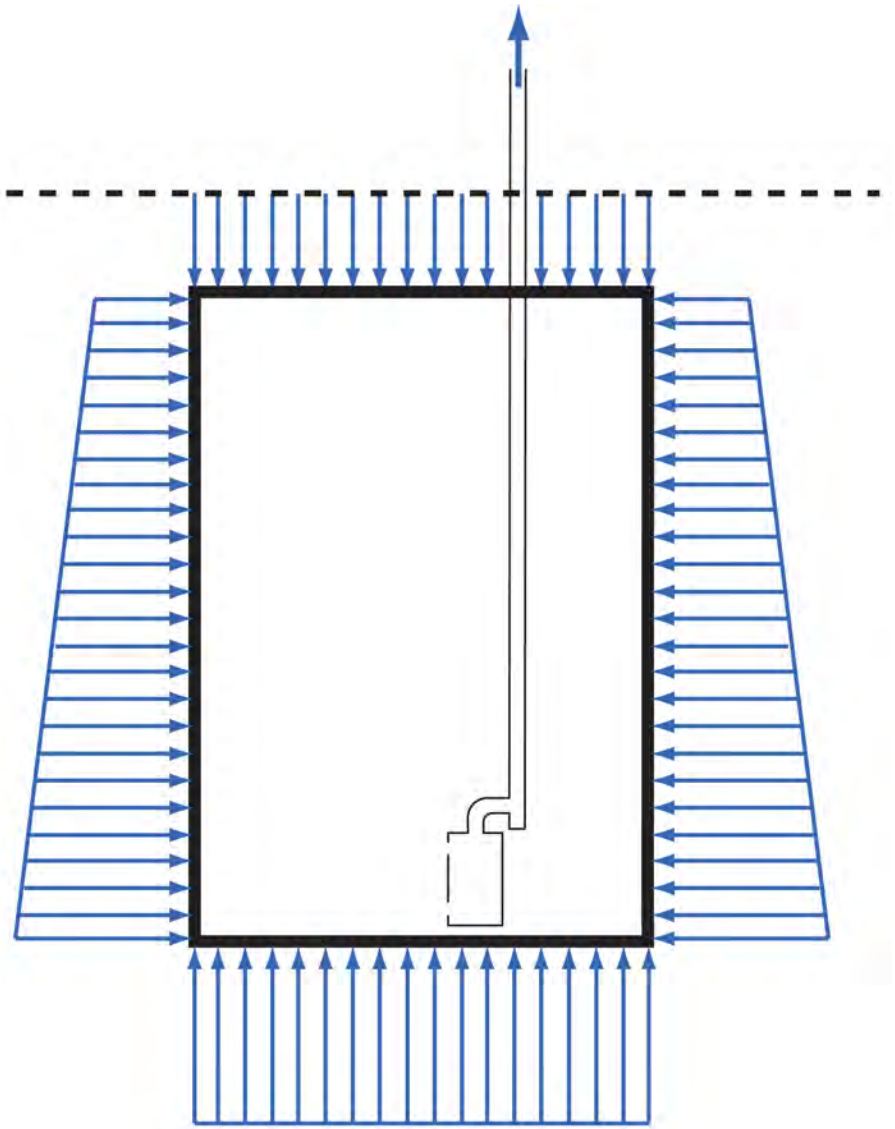
Stack effect



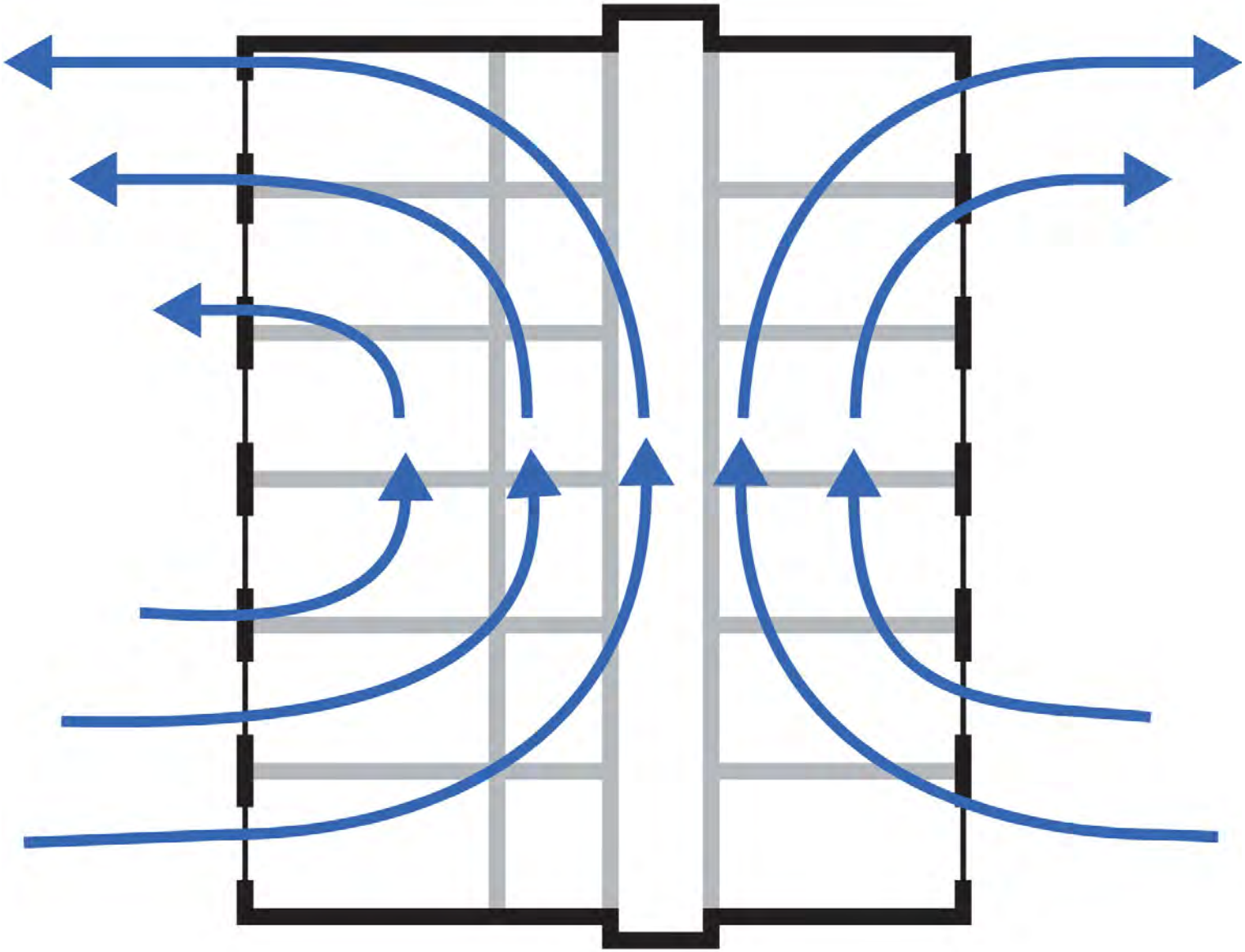
Wind

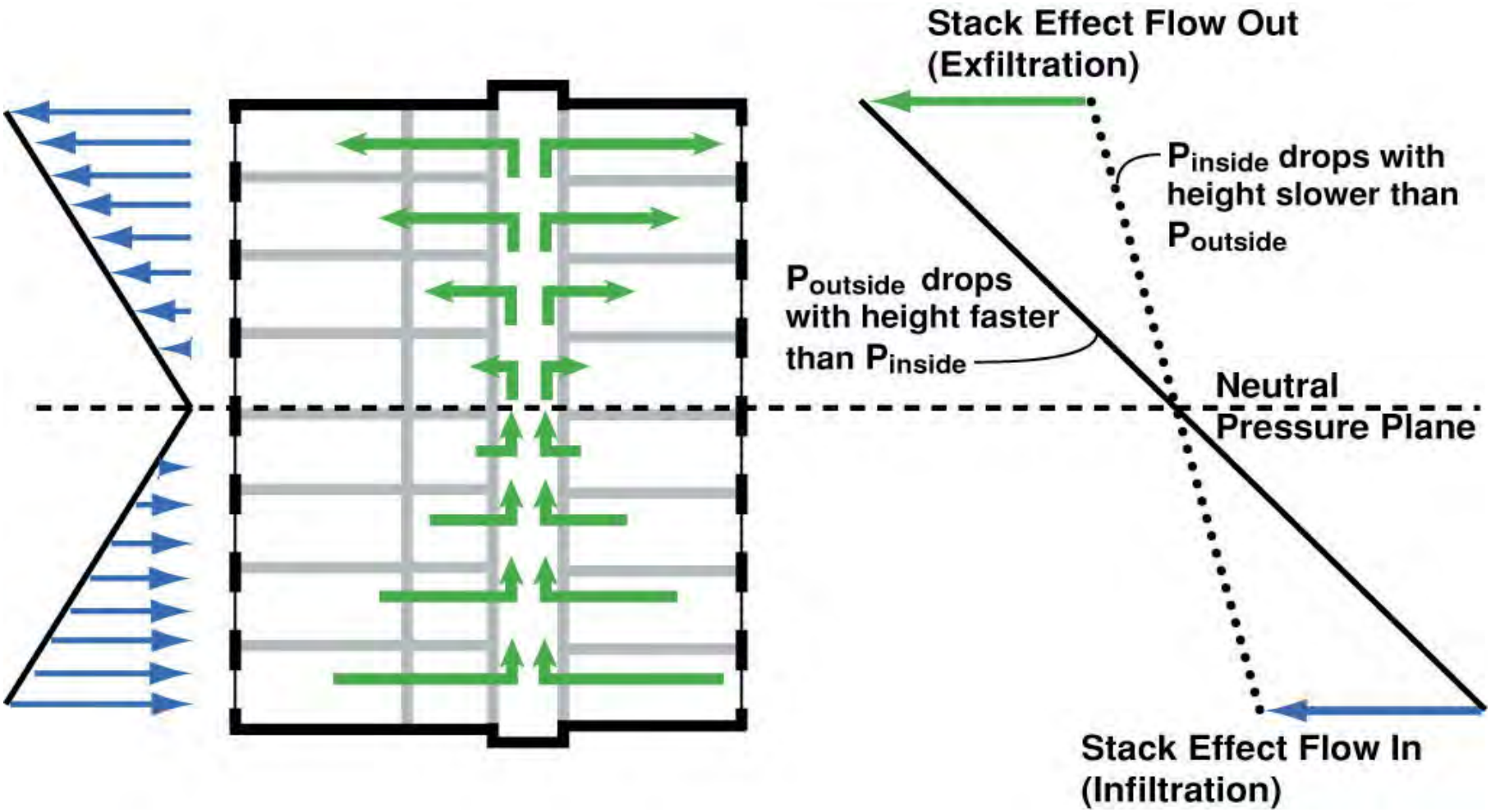


Stack effect and wind



Chimney effect




Stack Effect Flow Out
(Exfiltration)
Pinside drops with
height slower than
Poutside
Poutside drops
with height faster
than Pinside
Neutral
Pressure Plane
Stack Effect Flow In
(Infiltration)

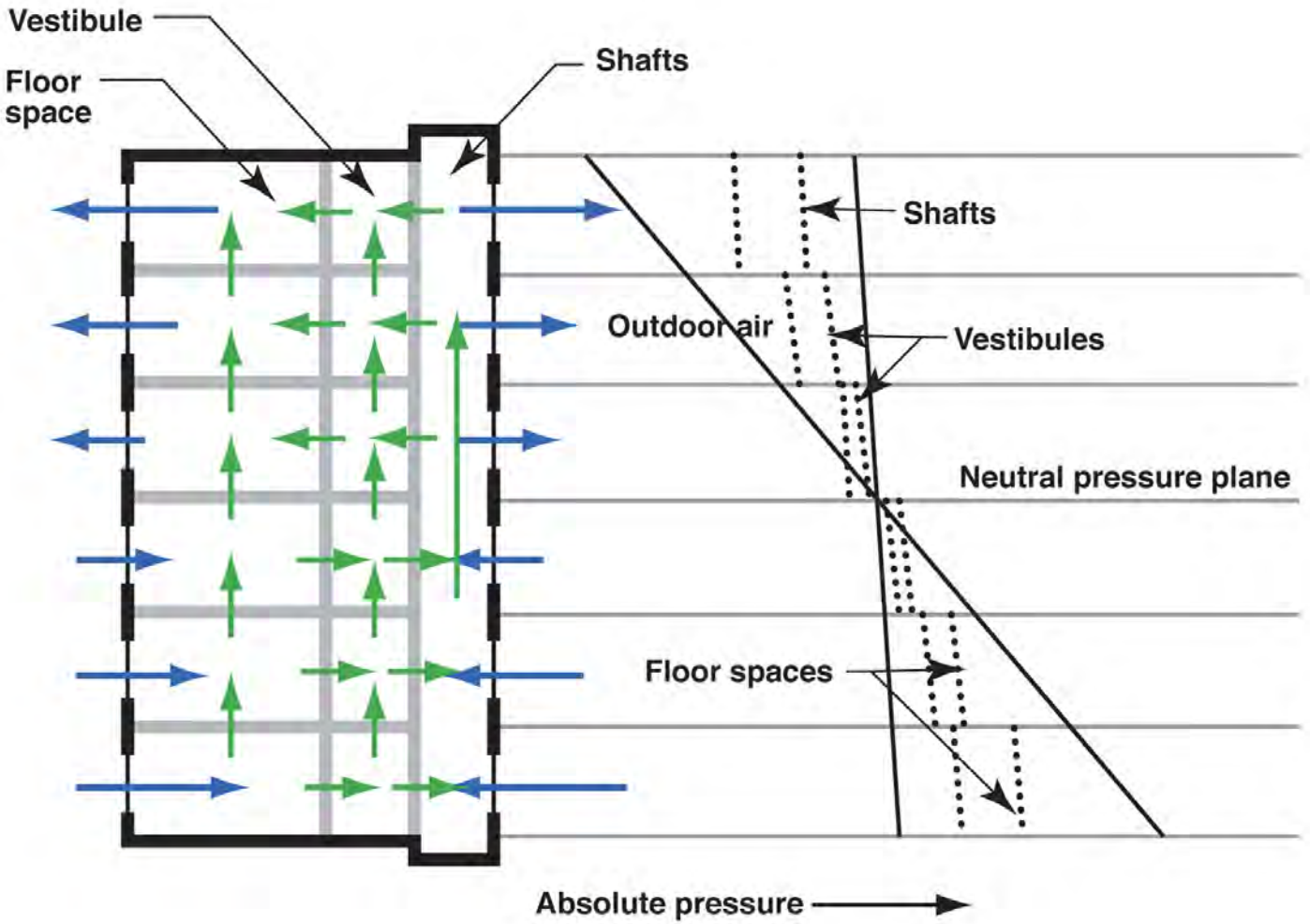


Figure 11.8: Stack effect pressures in high rise office building (Adapted from G.O. Handegord, 1998)

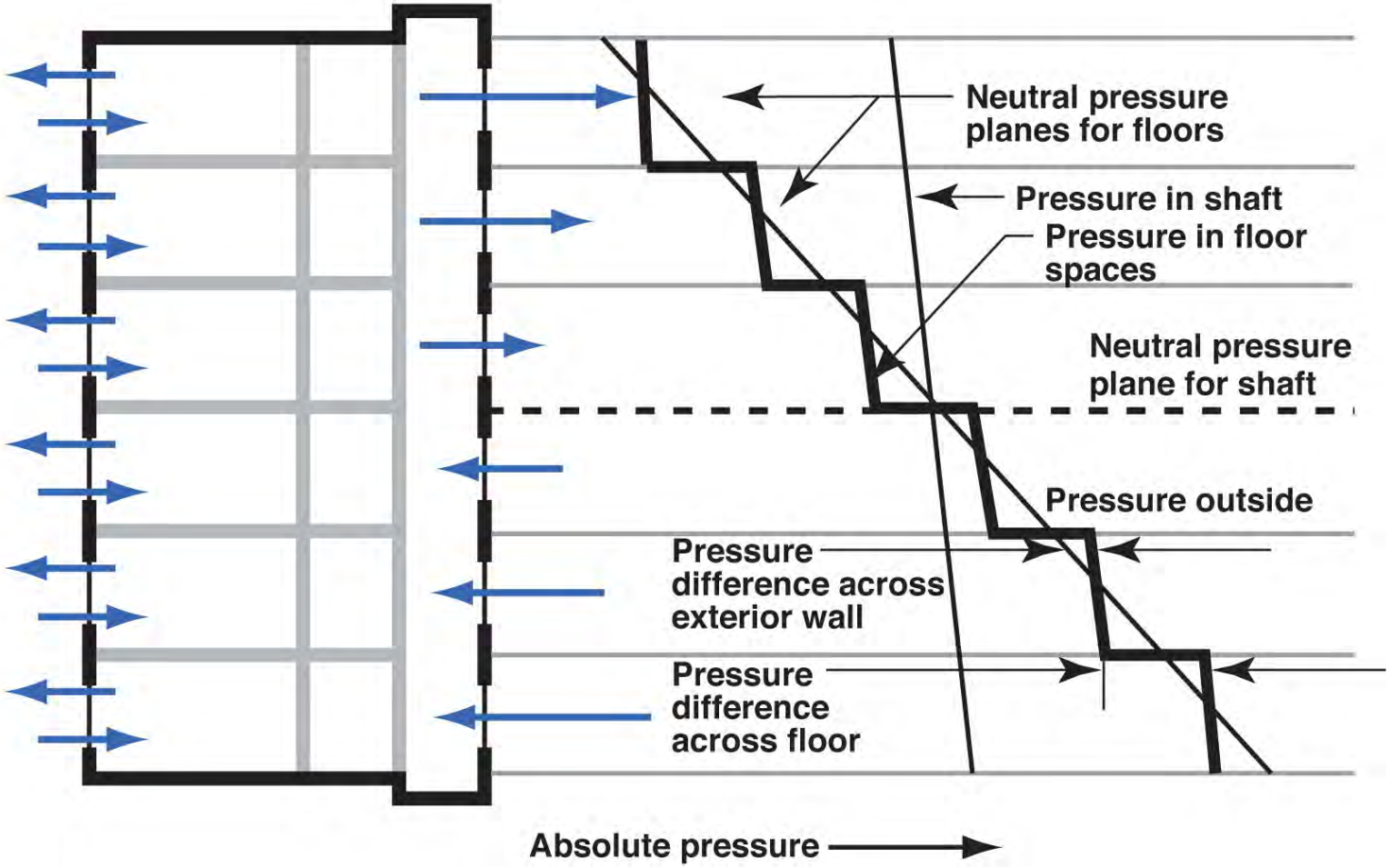


Figure 11.9: Multi-storey building with floor spaces isolated from vertical shafts (Adapted from G.O. Handegord, 1998)

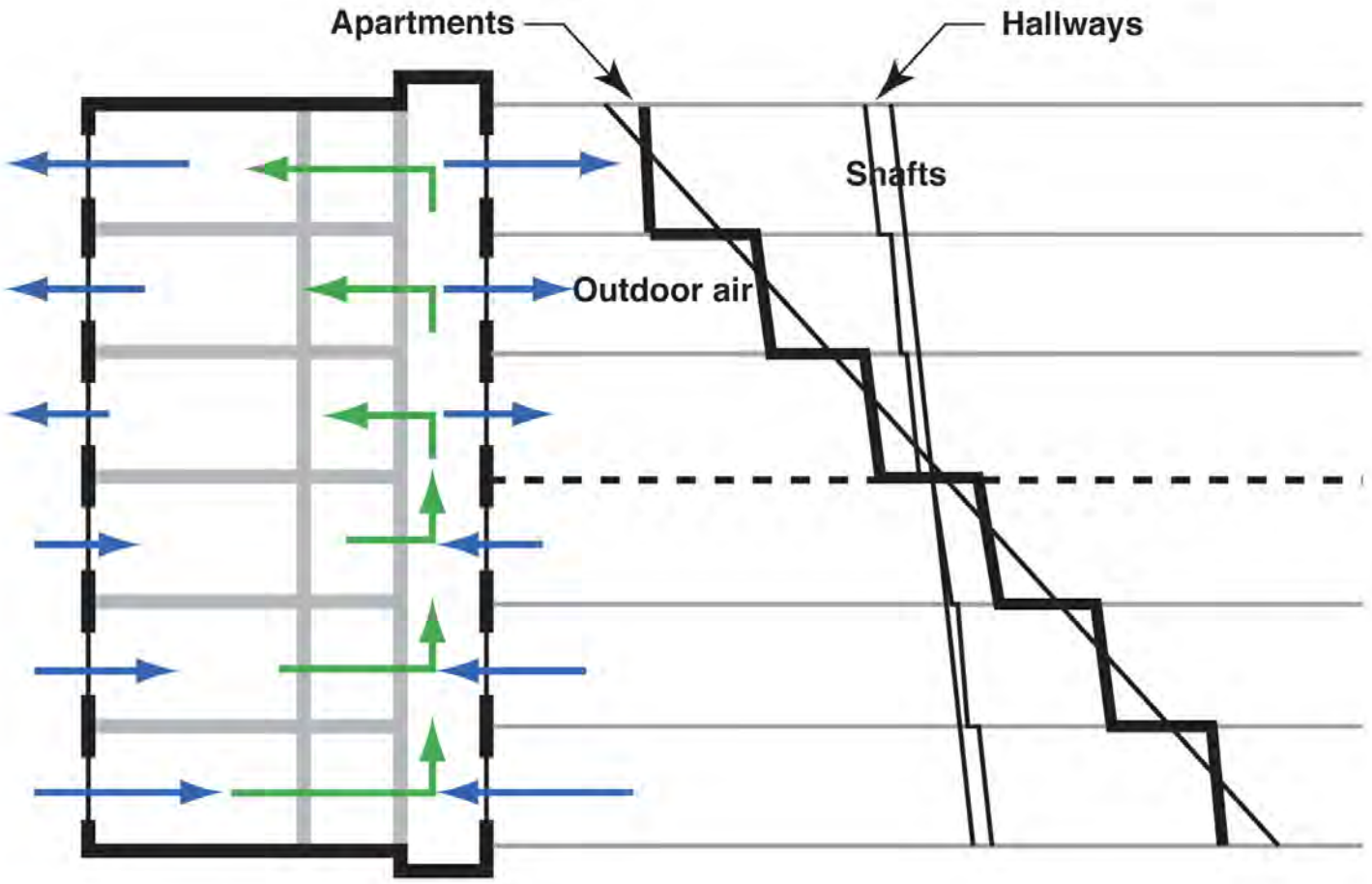
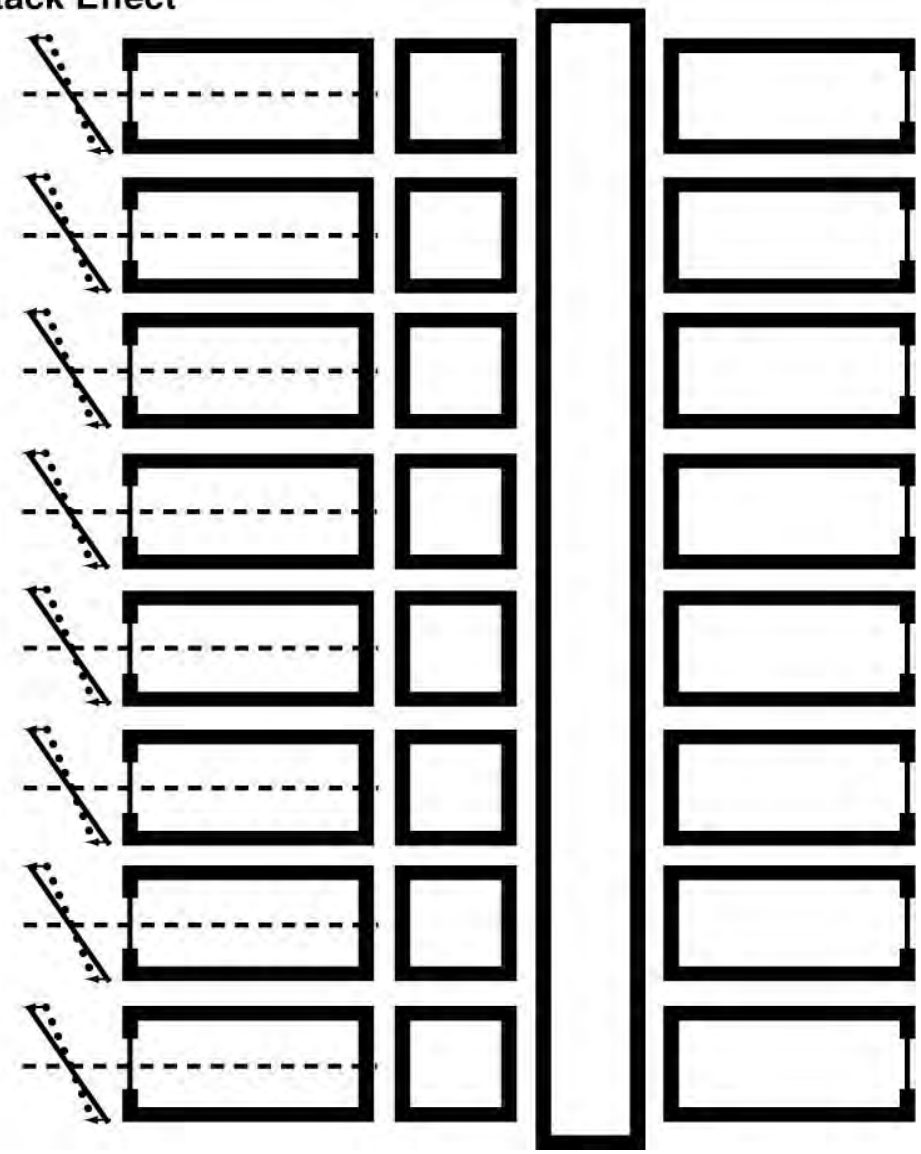
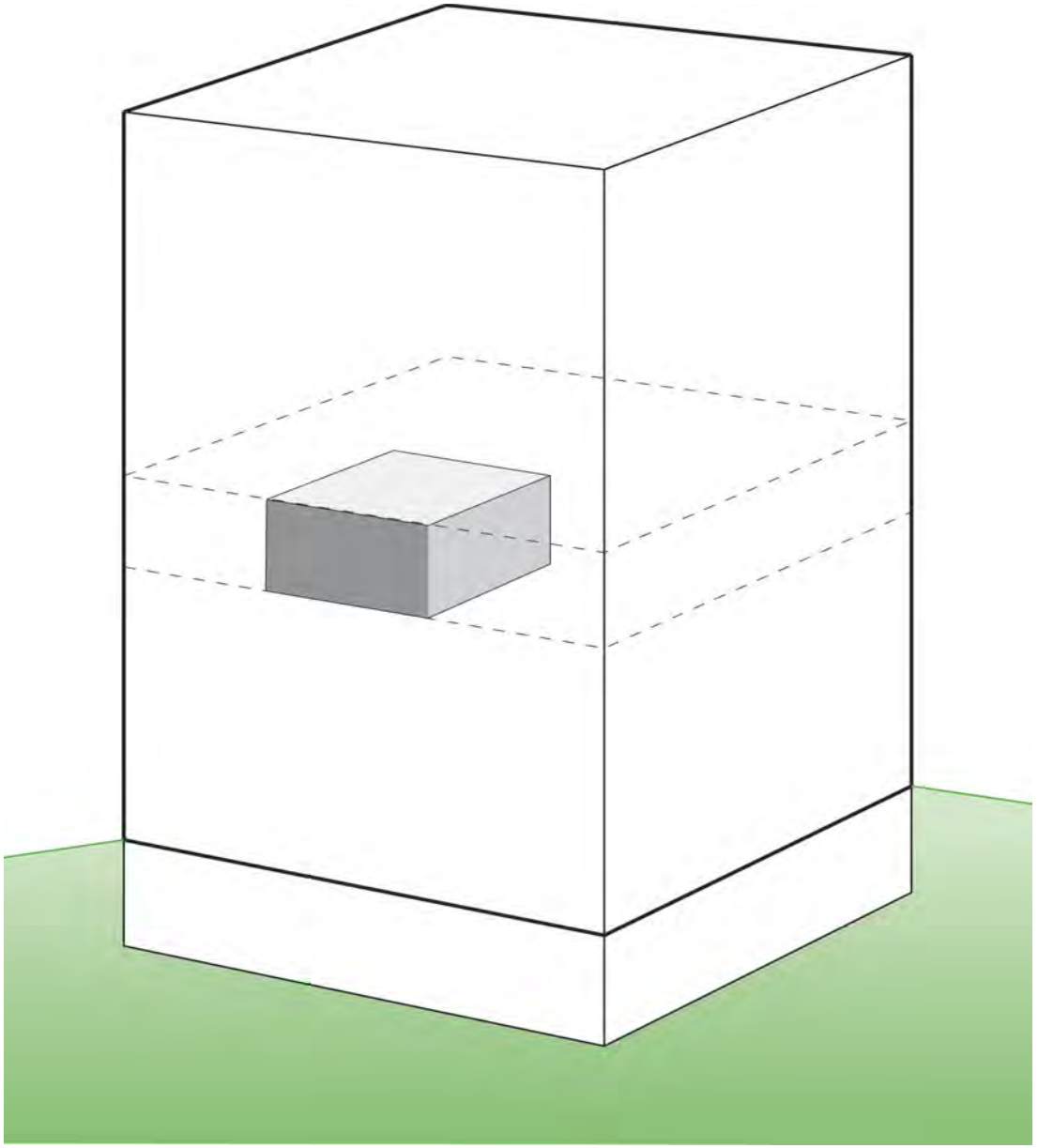
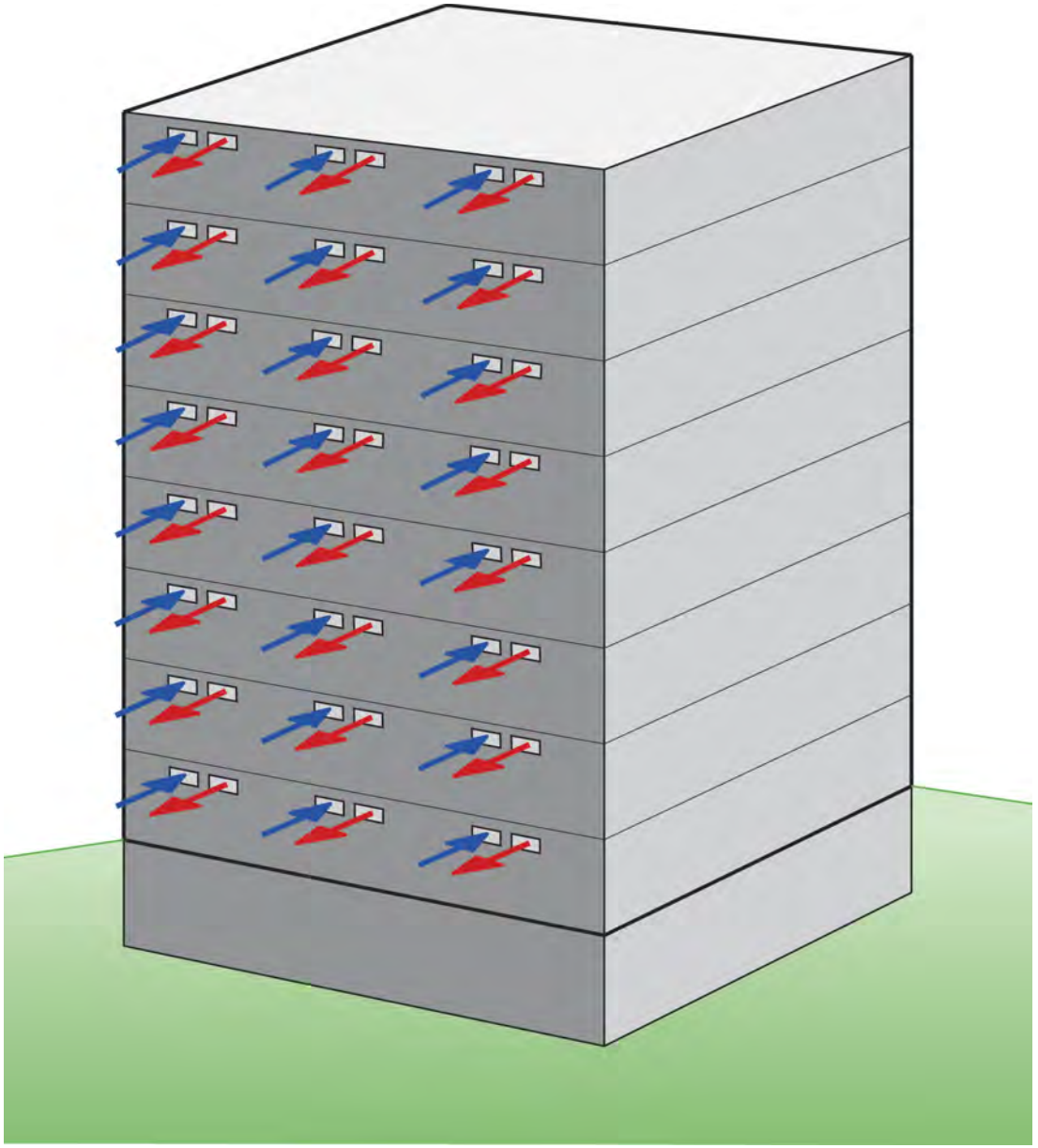


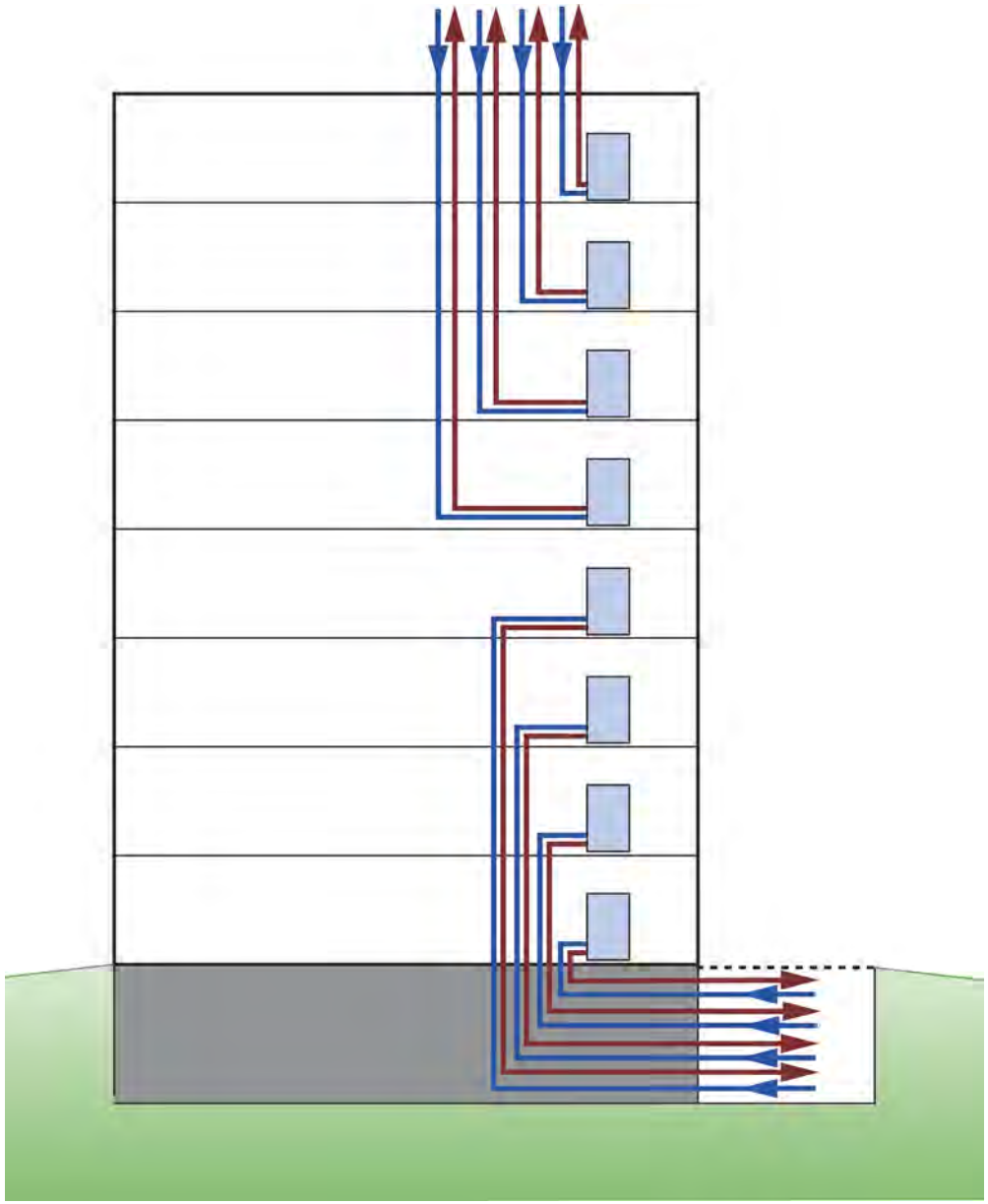
Figure 11.12: Apartment building with tighter apartment entry doors (Adapted from G.O. Handegord, 1998)

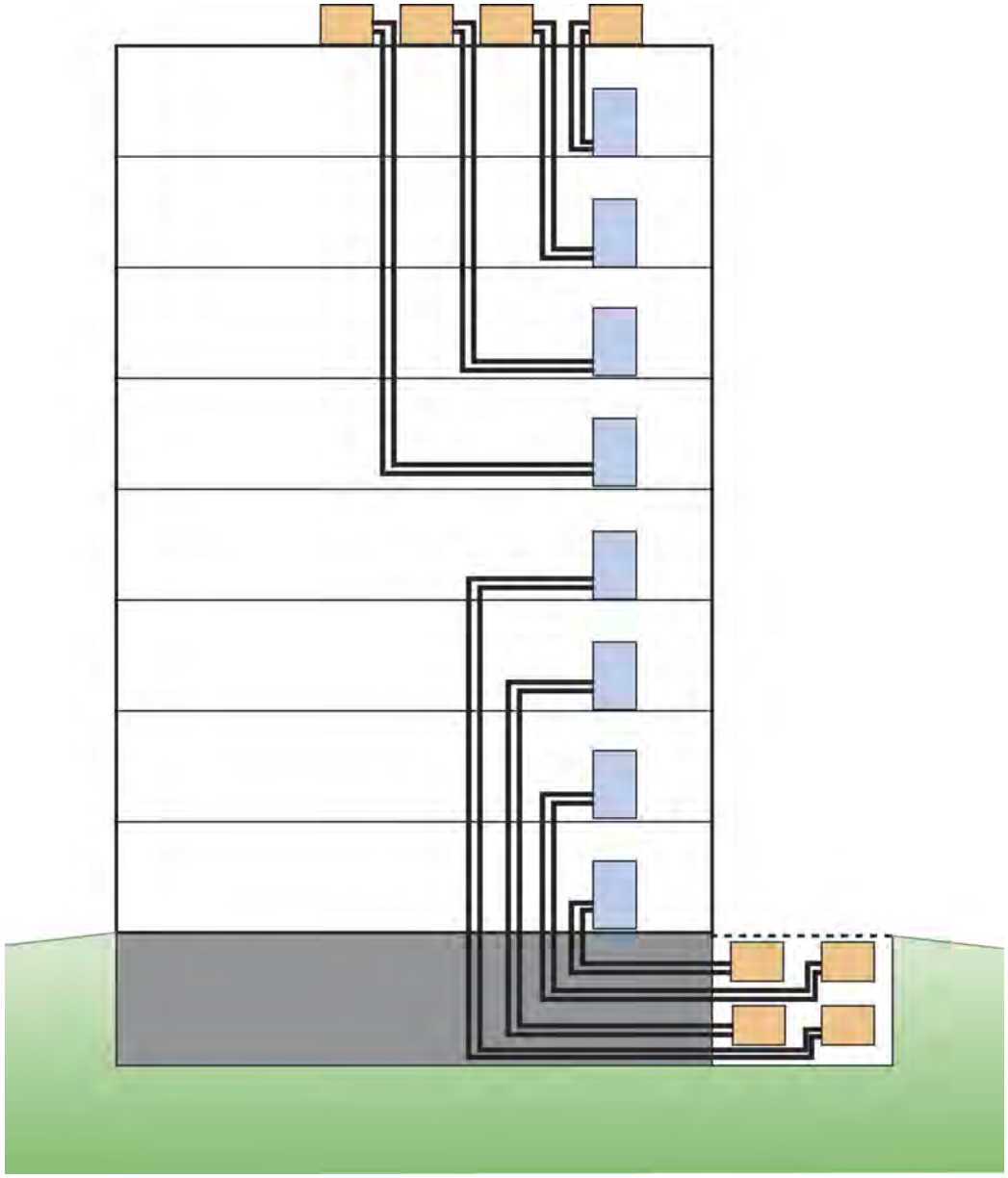
Reduced Individual Unit Stack Effect

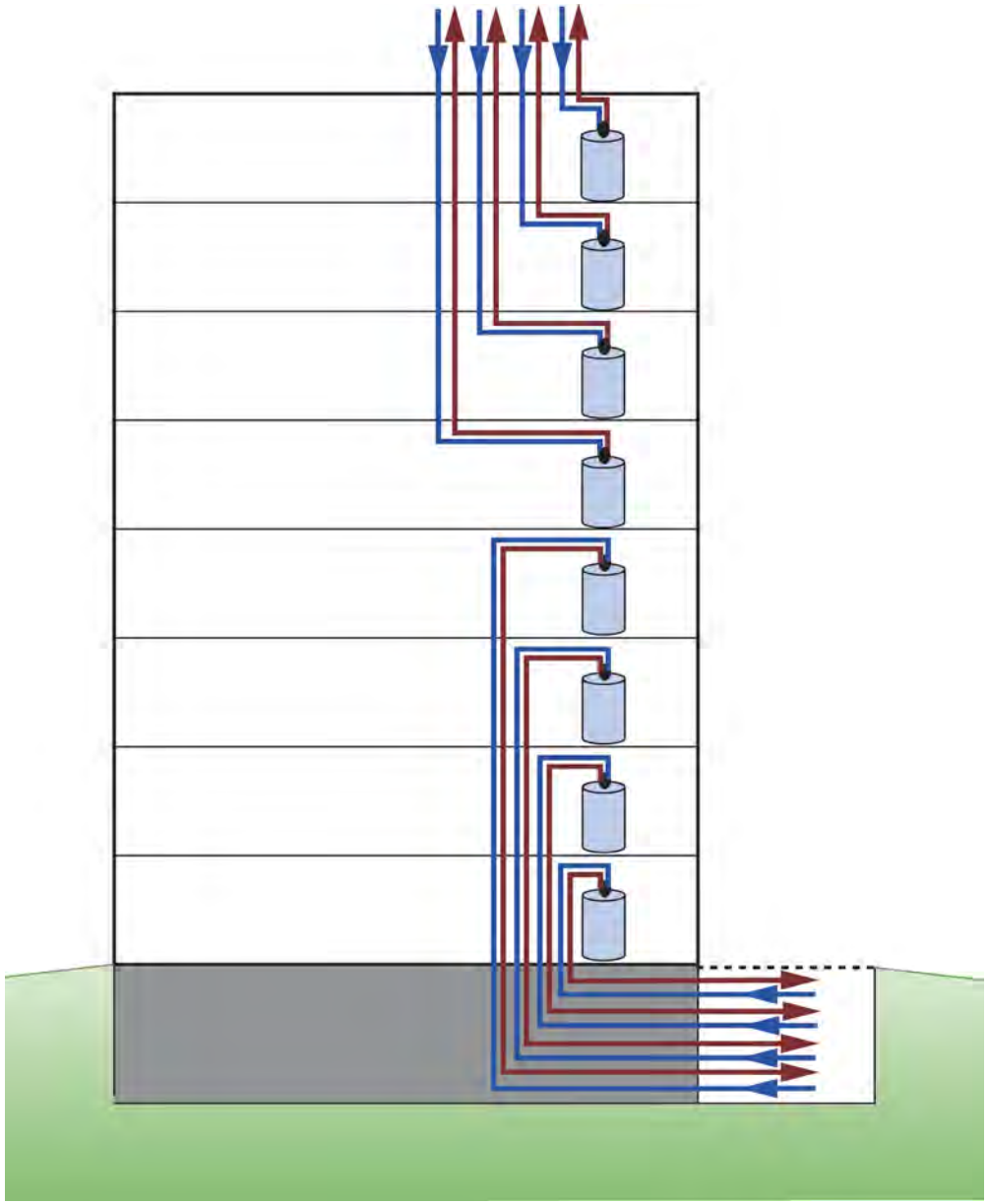










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