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TechNote

Vapor Retarders: Reducing Moisture Risk in Frame Walls

Vapor retarders are used primarily in cold climates to prevent moisture present in warm indoor air (as water vapor) from entering wall assemblies and condensing on cold exterior sheathing. Where installed properly, vapor retarders such as Kraft paper or polyethylene sheeting have been used successfully for decades in conventional wall assemblies. However, changing wall construction practices which include new energy efficient materials and solutions that dramatically alter the moisture behavior of walls prompted questions from many builders on the appropriate selection of vapor retarders.

This TechNote provides an overview of building code requirements and design considerations for vapor retarders. The focus is on climate-specific recommendations for selecting interior vapor retarder products for frame walls.

Moisture can enter walls (from indoors and outdoors) as water vapor by diffusion or air leakage. It is important that both moisture migration paths are managed to reduce the risk of moisture issues. Vapor retarders – the subject of this Tech Note – are used to manage vapor diffusion. Some vapor retarder membranes help with controlling air flow as well. The reader is referred to a companion Tech Note on Air Sealing for information on practices for controlling air leakage.

A vapor management strategy should balance limiting vapor diffusion into the wall and allowing the wall to dry out should any incidental moisture accumulate in the cavity. The first is achieved by selecting an appropriate interior vapor retarder or installing a layer of exterior insulation to limit the vapor drive. The second is achieved by ensuring that at least one face of the wall is constructed with moderate-to-high permeability materials to avoid a double vapor barrier condition.

Terminology

Vapor Retarder. A material or product that controls the migration of moisture due to vapor diffusion.

Vapor Diffusion. The movement of water vapor through vapor permeable building materials.

Vapor Permeance. A measure of the rate of water vapor diffusion through building materials – a lower “perm” rating indicates the material is less vapor permeable.

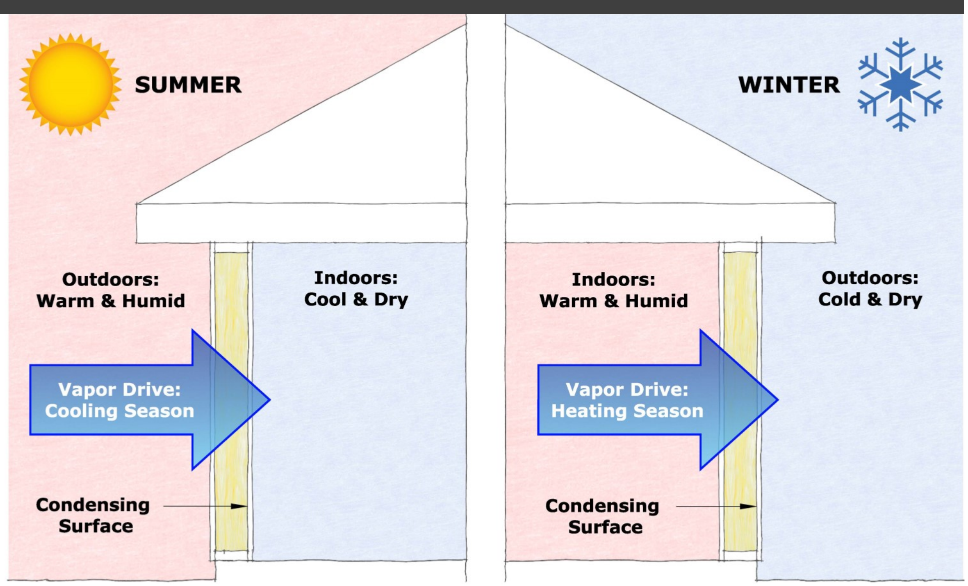
Vapor drive. Describes the direction of vapor diffusion (see Figure 1).

Moisture Migration by Air Leakage. The transport of water vapor contained in air moving through air leakage gaps in the wall assembly.

Double Vapor Barrier. Where vapor impermeable materials are installed on both the interior and exterior wall surfaces.

Figure 1. Vapor Drive

During heating season in cold climates, vapor drive is predominantly outward – from indoors to outdoors through the wall assembly – with the risk of water accumulation and condensation on the cold exterior sheathing. During cooling season in warm-humid climates, vapor drive is predominantly inward with the risk of condensation on the cool drywall surface. In mixed-humid climates, vapor drive occurs in both directions depending on the season, and to some degree in both cold and warm-humid climates as well.



PREPARED BY Home Innovation RESEARCH LABS™

DECEMBER 2015

Code Considerations

The 2015 International Residential Code (IRC) defines vapor retarder classes (R202) and identifies common materials that meet the class specification (R702.7.2) as summarized in **Table 1**.

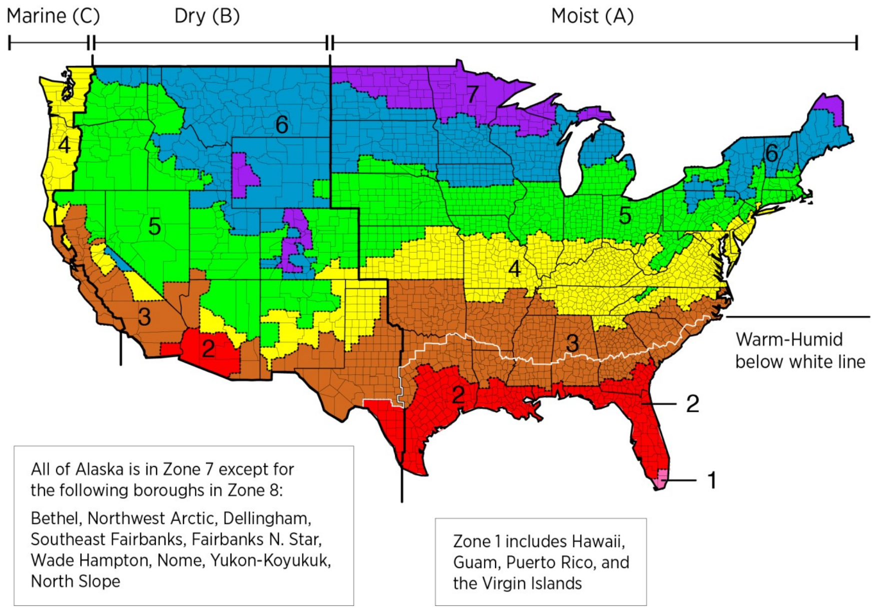
The IRC requires Class I or Class II vapor retarders on the interior side of most above-grade frame walls in Climate Zones 5, 6, 7, 8, and Marine 4. It is permitted to use Class III vapor retarders if continuous exterior insulation is installed in accordance with IRC Table R702.7 or, in Climate Zones 5 and Marine 4, if a vented cladding is installed (R702.7.3). Vented cladding includes vinyl lap siding or brick veneer with a minimum 1 in. airspace. Vented cladding generally does not include stucco, adhered masonry veneer, insulated vinyl siding, or lap siding (such as fiber cement or solid wood) without furring.

The IRC does not specify requirements for vapor retarders in Climate Zones 1-4 (except 4C). It also does not restrict the use of materials with vapor retarding characteristics in any Climate Zone on either face of the frame walls. Therefore, following the IRC provision will not necessarily prevent specifying wall designs that can lead to moisture problems in walls.

Table 1. IRC Water Vapor Retarder Classifications

Class	Vapor Permeance (grains/hr./sq.ft./in.Hg)	Materials that Meet the Class (per the IRC)
Class I	0.1 perm or less	Sheet polyethylene, unperforated aluminum foil
Class II	0.1 < perm ≤ 1.0 perm	Kraft-faced fiberglass batts
Class III	1.0 < perm ≤ 10 perm	Latex or enamel paint

Figure 2. Climate Zone Map (Source: DOE [1])



The IRC defines **warm-humid climates** as Zones 1A, 2A, and portions of 3A below the warm-humid line (N1101.10) (Note: the 2015 IRC modifies the warm-humid line to follow the moist/dry vertical line in lower Texas, Zone 2.) For this TechNote, **cold climates** refer to Zones 5, 6, 7, 8, & 4C, and **mixed-humid climates** refer to Zones 4A & 3A above the warm-humid line.

Design Considerations

Class I vapor retarders are commonly referred to as vapor barriers or vapor impermeable materials. During the cooling season, a Class I product installed at the drywall can trap moisture migrating from the outdoors (a vapor impermeable wall covering such as vinyl wallpaper can have the same effect).

Class II vapor retarders are typically Kraft paper (Kraft-faced insulation). The permeance of Kraft paper increases to Class III levels at higher relative humidity (from 0.3 up to 3 perms).

Proprietary **"Smart"** vapor retarder products are also available with perm ratings that increase with increasing relative humidity from 1 perm or less at normal conditions (Class II) up to 35+ perms (vapor permeable).

Class II, III, and "smart" vapor retarders limit outward vapor diffusion during heating and allow inward drying during cooling.

Class III vapor retarders are identified by the IRC as latex or enamel paint. However, research shows that standard painted drywall is commonly vapor permeable (greater than 10 perms, up to 40 perms) – a benefit during the cooling season, but a potential concern during the heating season. Painted drywall should not be considered a Class III vapor retarder unless the paint is rated/tested at ≤10 perms – standard paint should be considered vapor permeable (not a vapor retarder).

Wall components have vapor retarding characteristics that can affect moisture migration. Typical perm ratings for common building materials are shown in **Table 2**. Permeance typically decreases with increasing thickness. For some products, permeance increases with increasing relative humidity.

Vented cladding improves the drying potential of walls to the outdoors (e.g., through OSB sheathing, house wrap, and cladding).

Absorptive claddings (e.g., brick, stucco, adhered masonry veneer) may benefit from lower-perm water-resistive barrier (WRB) products to limit moisture due to solar-driven inward vapor drive.

Continuous insulation keeps the wall cavity warmer resulting in reduced condensation potential at the sheathing surface.

Table 2. Typical Vapor Permeance and Class[A] for Common Wall Components (Source: ASHRAE 2013 [2])		
Number 15 felt	About 5 perms up to 50%RH, 10 perms at 70%RH, and 50 perms at 90%RH	Class III
Plastic house wrap	Typically 5-10 for lower-perm products, 30-40 for higher-perm products	Class III
OSB sheathing, ½"	About 1-2 perms up to 50%RH, and 5-7 perms at higher RH	Class III
Plywood sheathing, ½"	About 1-2 perms up to 50%RH, 10+ perms at higher RH	Class III
EPS foam sheathing	Expanded polystyrene foam, 1" thickness (R-4): 2-4 perms	Class III
XPS foam sheathing	Extruded polystyrene foam, 1" thickness (R-5): 0.8 perm for un-faced products	Class II
Polypropylene-faced XPS	Any thickness: 0.1 perm or less	Class I
Foil-faced PIC foam sheathing	Polyisocyanurate foam, any thickness (R-5.7/in.): 0.1 perm or less	Class I
Vapor permeable insulation	Fiberglass, cellulose, mineral wool, any thickness: 40+ perms	Permeable
Closed-cell spray foam insulation (polyurethane)	Typically 2 perms at 1" thickness (R-6), 0.8 perm at 2.5" (R-15)	Class II or Class III
Open-cell spray foam insulation	Typically 25 perms at 3.5" thickness (R-13)	Permeable

[A] Vapor retarder class for typical materials as determined by testing in accordance with ASTM E96, dry cup method.

Table 3. Code Requirements and Recommended Vapor Retarder Practices for Frame Walls Summarized by Climate

Climate Zone	**IRC Interior Vapor Retarder Requirements [A]**	**Vapor Retarder Recommendations**
Cold	Class I or Class II required; Class III permitted with:	Heating dominated: predominant vapor drive is outward, but inward vapor drive during cooling is common
Marine 4	Vented cladding (over wood structural panels, fiberboard, or gypsum) <u>or</u> continuous insulation (≥ R-2.5 over 2x4 wall or ≥ R-3.75 over 2x6 wall)	• Walls with vented cladding and without continuous exterior insulation (**Figure 4**): o Class II is generally recommended o Class I is generally not recommended where air conditioning is operated for an extended period of time during the cooling season • Walls with non-vented cladding and without continuous exterior insulation: o Class II in climates 4C and 5 • Walls with continuous exterior insulation meeting the IRC minimum R-value (**Figure 5**): o Class I or Class II is generally not required o Class I is not recommended in order to avoid a double vapor barrier condition
5	Vented cladding (over wood structural panels, fiberboard, or gypsum) <u>or</u> continuous insulation (≥ R-5 over 2x4 wall or ≥ R-7.5 over 2x6 wall)	
6	Vented cladding (over fiberboard or gypsum) <u>or</u> continuous insulation (≥ R-7.5 over 2x4 wall or ≥ R-11.25 over 2x6 wall)	
7 and 8	Continuous insulation (≥ R-10 over 2x4 wall or ≥ R-15 over 2x6 wall)	
Warm-Humid	Vapor retarders are not required by the IRC	Cooling dominated: predominant vapor drive is inward, and outward vapor drive is considered not significant
1A, 2A, 3A below warm-humid line	No applicable code provisions	• Interior vapor retarders should be avoided to allow drying to the indoors (**Figure 3**), regardless of cladding type or exterior continuous insulation.
Mixed-Humid	Vapor retarders are not required by the IRC	Heating (4A) or cooling (3A) dominated: significant inward and outward vapor drive
3A above warm-humid line	No applicable code provisions	• Interior vapor retarders are generally not necessary, regardless of cladding type or exterior continuous insulation, but vented cladding is still recommended
4A	No applicable code provisions	• Walls with vented cladding or non-vented cladding and without continuous exterior insulation: Class II • Walls with continuous exterior insulation: Vapor retarders are generally not necessary
Other	Vapor Retarders are not required by the IRC	Cooling (2B, 3B, 3C) or heating (4B) dominated: outward vapor drive is not significant except in climate 4B
2B, 3B, 4B, 3C	No applicable code provisions	• Interior vapor retarders are not necessary in 2B, 3B, and 3C • Class II interior vapor retarders are recommended in 4B

[A] Spray foam at interior side of exterior sheathing meets continuous insulation requirements if ≤1.5 perm at specified R-value

Example Wall Assembly without Vapor Retarder

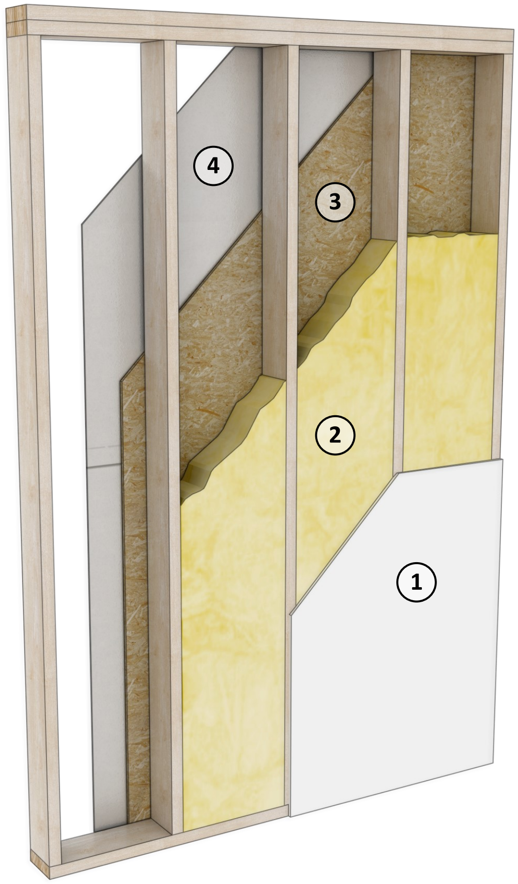


Figure 3. Wall Assembly without Vapor Retarder

Figure 3 shows an example wall assembly with vented cladding and no interior vapor retarder.

- This wall allows drying in both directions.
- The types of vented cladding could include vinyl lap siding, brick veneer, and cement board or wood lap siding over furring strips.
- This wall assembly is recommended in warm-humid climates (climate zones 1A, 2A, and 3A below the warm-humid line).
- Non-vented cladding may be substituted in these climates.

Example Wall assembly:

1. Painted drywall (standard paint)
2. Wall cavity insulation (permeable)
3. OSB structural sheathing
4. Vented cladding and water-resistive-barrier (WRB)

Example Wall Assembly with Vapor Retarder

Figure 4 shows an example wall assembly with vented cladding and a Class I or Class II interior vapor retarder.

- This wall allows drying to the outdoors. A Class II vapor retarder also allows drying to the indoors.
- A Class II vapor retarder is recommended in mixed-humid climate zones 4A and 3A above the warm-humid line and cold climates 4C and 5.
- A Class I or Class II vapor retarder may be installed in cold climates 6, 7, and 8.

Example wall assembly:

1. Painted drywall (standard paint)
2. Vapor retarder (Class I or Class II)
3. Wall cavity insulation (permeable)
4. OSB structural sheathing
5. Vented cladding and WRB

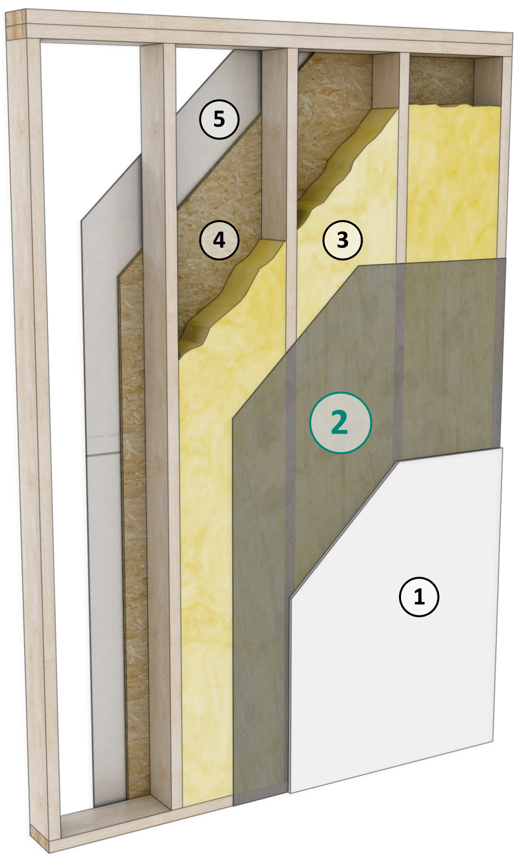


Figure 4. Wall Assembly with Vapor Retarder

Example Wall Assembly with Continuous Insulation

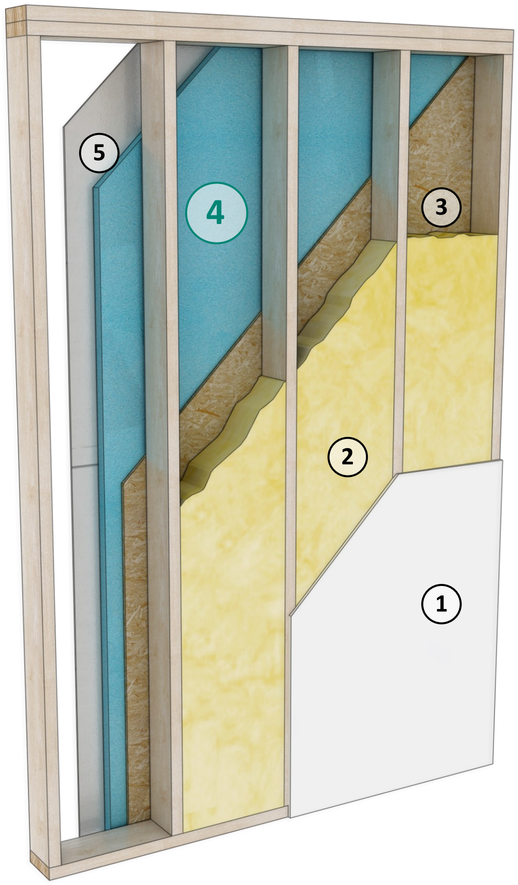


Figure 5. Wall Assembly with Continuous Insulation

Figure 5 shows an example wall assembly with continuous exterior insulation over the OSB sheathing.

- This wall assembly is designed for the primary drying mechanism to the indoors.
- The continuous insulation must meet the code required minimum R-value to prevent condensation.
- Generally, an interior vapor retarder is not required, and a Class I vapor retarder should not be installed to avoid creating a double vapor barrier condition.
- Where continuous insulation is permeable (e.g., mineral wool board) recommend vented cladding to improve outward drying.
- This wall assembly is recommended in any climate.

Example wall assembly:

1. Painted drywall (standard paint)
2. Wall cavity insulation (permeable)
3. OSB structural sheathing
4. Continuous insulation (XPS foam sheathing shown)
5. Cladding and WRB (vented or non-vented)

Example High-R Wall: Double Wall Construction

The term high-R wall refers to a wall with levels of insulation well above building code minimums. High-R walls are becoming more common in cold climates. One example of a high-R wall is “double wall” construction.

Figure 6 shows an example of double wall construction.

- This wall allows drying in both directions.
- The inner OSB sheathing acts as an additional vapor retarder (and air barrier if seams are sealed).
- This wall may be adapted for any climate.

Example wall assembly (R-37 total cavity insulation):

1. Painted drywall (standard paint)
2. Class II vapor retarder (“smart” vapor retarder shown)
3. Inner wall cavity insulation (permeable, R-13)
4. Inner OSB sheathing
5. Outer wall cavity and space between walls insulation (permeable, R-24)
6. Outer OSB sheathing (structural for this example)
7. Vented cladding/WRB assembly

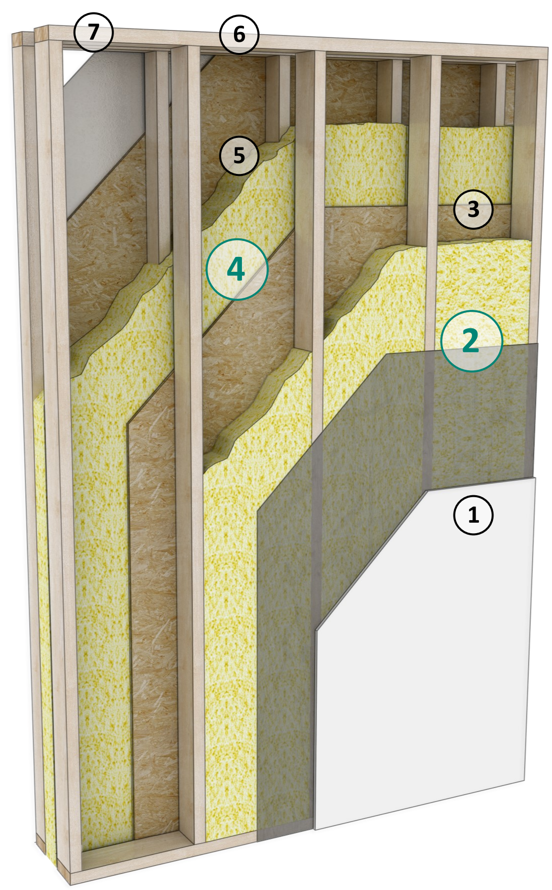


Figure 6. Double Wall Construction

Recommendations

Vapor Barriers. Class I vapor retarders are generally not recommended except in the coldest climates.

Double Vapor Barriers. Generally, do not install vapor impermeable products on both the interior and exterior wall surfaces – this would create a double vapor barrier condition that could trap moisture and reduce the ability of the wall assembly to allow drying of any incidental moisture.

Air Barriers. Control moisture migration due to air leakage with effective air barriers and air sealing. Some vapor retarder products may also have beneficial air barrier characteristics. An interior air barrier (e.g., air-sealed drywall) is recommended in heating dominated climates.

Exterior Moisture/Wetting. Select appropriate cladding, drainage plane, and flashing products that protect walls from bulk moisture.

Interior Humidity. Tighter construction tends to increase indoor relative humidity (less dilution of interior moisture from people, plants, cooking, and showering) which increases moisture load on the building envelope. Ensure the HVAC contractor does not over-size cooling systems so occupants don't rely on "super-cooling" the house to dehumidify. Install heating/cooling ducts inside conditioned space – leaky return ducts could draw humid air indoors, and leaky supply ducts could depressurize the house and increase infiltration. Inform occupants about using kitchen and bath exhaust fans to capture humidity at the source, and to limit adding humidity to the air during the heating season.

Design Phase. The strategy for selecting vapor retarders must take into account the climate, cladding type, and insulation (wall cavity and continuous). Show vapor retarder and water vapor management details and installation requirements on plans, specifications, and scopes of work for subcontractors.

Construction Phase. Install all products in accordance with manufacturer's specifications, local building codes, or (where applicable) specifications established by the licensed design professional. Keep the wall assembly dry, as practical, during construction, and ensure wall cavities are dry before enclosing with drywall (e.g., allow sufficient drying time for water-based, spray-applied cellulose wall insulation).

References

[1] DOE (2015). Pacific Northwest National Laboratory. (2015). *Guide to Determining Climate Regions by County.* Building America Best Practices Series Volume 7.3, August 2015. Washington, D.C.: U.S. Department of Energy. Accessed November 1, 2015: http://energy.gov/sites/prod/files/2015/10/f27/ba_climate_region_guide_7.3.pdf.

[2] ASHRAE (2013). *2013 ASHRAE Handbook of Fundamentals*. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2013; pp. 26.15-26.18.